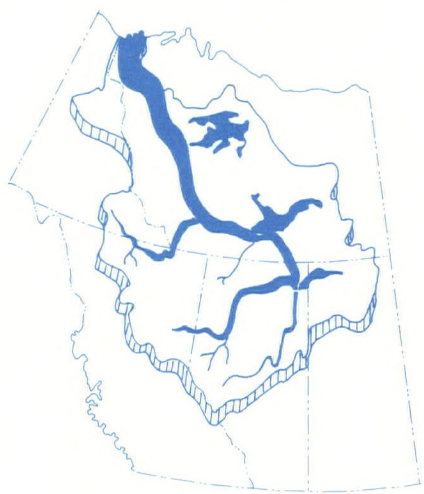
Mackenzie River Basin

CANADA - NORTHWEST TERRITORIES - YUKON - BRITISH COLUMBIA - ALBERTA - SASKATCHEWAN

POTENTIALLY SENSITIVE AREAS

IN THE MACKENZIE RIVER BASIN:

A LITERATURE REVIEW



A report under the 1978-81 Federal - Provincial Study Agreement respecting the water and related resources of the Mackenzie River Basin.

POTENTIALLY SENSITIVE AREAS IN THE MACKENZIE RIVER BASIN: A LITERATURE REVIEW

by
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and
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for: Canadian Wildlife Service
December 1978

PROLOGUE

PROCEDURES AND INFORMATION SOURCES

The following report reviews available information on the natural and socio-economic significance of 37 potentially sensitive areas listed in the Mackenzie River Basin Study Program, 1978-79 (Task 4A)[1]. The report was written in separate segments and under separate contracts of the Canadian Wildlife Service with Allison Enterprises and Mr. W. Nielsen. The synthesis was done by Allison Enterprises.

Methods used in the literature search were agreed upon by Allison and Nielsen. The report was produced to conform with a format and style manual prescribed by the Mackenzie River Basin Task Force. Nielsen contributed sections II A - II F, III A, III B, IV A, V A, V D, VII F - VII H; Allison wrote chapter I and sections III C, IV B, V B, V C, VI A, VI B, VII A - VII E, VII I, VII J, and chapter VIII.

Before a standard approach could be applied to the collection of material, it had to be decided what categories of information are relevant to a discussion of potentially sensitive areas in the Mackenzie River Basin and what level

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[1]Two areas, Trout River and Swan Lake Creek Drainage, were incorrectly located on the Study Program map (Environment Canada 1977, p. 41). Figure 1 shows the corrected locations.

of detail would be useful.

The Mackenzie River Basin Task Force provided a list of topics which it wished to be explored for each area named. These were: hydrological characteristics, natural resources (wildlife, fisheries, vegetation), socio-economic considerations, sensitivity to hydrological change, and knowledge gaps or data deficiencies.

The purpose of this study is to provide a description of the relevant features of all sites, but not to compare sites. Therefore, it was not necessary to have information at the same level of detail for all sites. Some areas of the basin have been explored and studied far more extensively and systematically than others. Level of detail in this report is not necessarily a reflection of the relative importance of the site. It may be only an indication of the amount of material available. However, an attempt has been made to allocate more space to areas considered more important or complex when data are available.

Literature sources used in this study range from site-specific reports to broad studies which cover an entire geographic area. The broad reports and mapping projects were consulted for all areas to provide a minimum data base for at least all areas north of 60°. Therefore comparisons of some features between areas are possible. Such information is available on map series like the Canada Land Inventory (CLI), Land Use Information Map Series, Atlas of Wildlife Inventory

Maps produced by the Canadian Wildlife Service, Arctic Ecology Map Series, and publications produced by the Environmental-Social Committee, Northern Pipelines.

Although the reference list is extensive, it should not be considered complete. The purpose of this study was not to provide a complete bibliography of material available on the Mackenzie Basin. Review material has been used freely and original sources have not always been examined. At the end of each section we have indicated sources we think the Task Force will find most useful if it wishes more detailed information on a specific area.

Information was gathered by a systematic examination of material available at the following libraries:

Calgary	-	Water Survey of Canada
Edmonton	-	Alberta Environment
		Alberta Oil Sands Environmental Research Project
		Boreal Institute for Northern Studies
		Canadian Wildlife Service
		Fisheries and Marine Service
		L.G.L. Ltd. Environmental Research Associates
		Renewable Resources Consultants Ltd.
Regina	-	Inland Waters Directorate
		Saskatchewan Power Corporation
Saskatoon	-	Department of Northern Saskatchewan
		Institute for Northern Studies

Vancouver	-	B.C. Fish and Wildlife
		B.C. Hydro
		B.C. Parks and Recreation
		Canadian Wildlife Service
		Inland Waters Directorate
		Westcoast Transmission
Winnipeg	-	Freshwater Institute, Fisheries and Marine Service
Yellowknife	-	Canadian Wildlife Service
		Department of Indian and Northern Affairs
		Fisheries and Marine Service
		Inland Waters Directorate
		Territorial Game Branch

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Environment Canada | Environnement Canada
Environmental Management | Gestion de l'environnement
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Your file Votre dossier

Our file Notre dossier WLU 401-4 Mackenzie Basin

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February 7, 1979

Mr. Hans Foerstel
Coordinator
Mackenzie River Basin Task Force
Inland Waters Directorate
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Dear Mr. Foerstel:

I am pleased to submit herewith an interim report entitled "Potentially Sensitive Areas in the Mackenzie River Basin: A Literature Review" by L. Allison and W. Nielsen. The report summarizes resource information available on thirty-seven areas identified as sensitive by the Task Force. The study was funded by IWD under the auspices of the Mackenzie River Basin Study Program (Task 4A). It was conducted in accordance with the terms specified in the May, 1978 Letter of Agreement between IWD and CWS. The final (summary) report will be submitted by December 15, 1979, as specified in the Letter of Agreement.

I wish to take this opportunity to thank you for funding and encouraging our participation in this important study.

Yours sincerely,

M.R. Robertson
Regional Director

Enclosed

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CHAPTER I

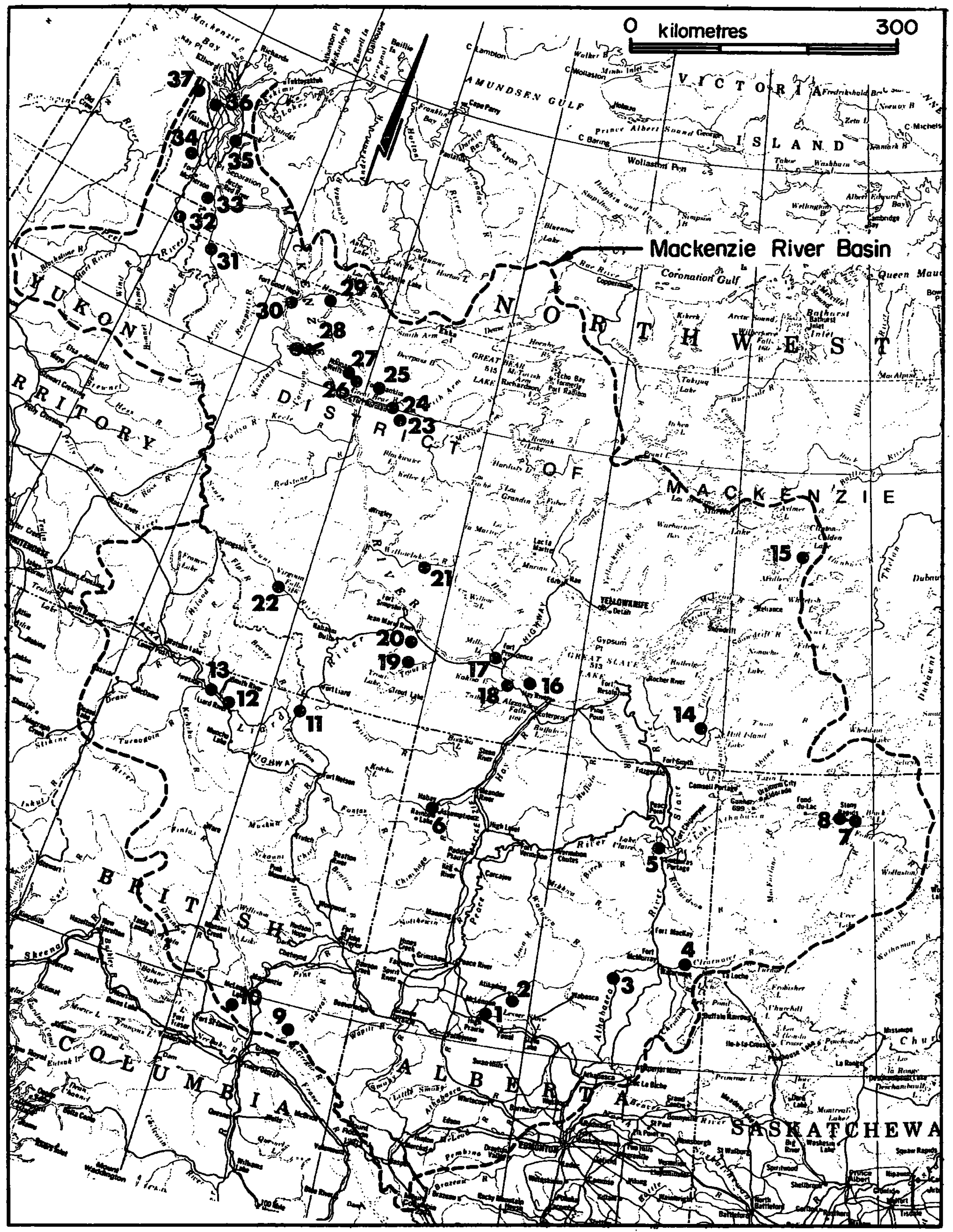
INTRODUCTION

The Mackenzie is the largest northward-flowing river in North America. It drains a land area of approximately 1 787 100 km^2 and occupies parts of British Columbia, Alberta, Saskatchewan, Yukon and Northwest Territories. The extensive basin offers many attractive sites for hydro development. Water destined for the Mackenzie already turns turbines at small installations (on the Taltson River, for example) and at major dams (Bennett Dam on the Peace River). Some projects have resulted in major, and often unforeseen, impacts on sensitive ecosystems (the Peace-Athabasca Delta).

The demand for power is increasing and more dams are proposed and planned for the Mackenzie River. Massive diversion schemes have also been envisaged. One scheme would divert water from the Mackenzie into the Saskatchewan-Nelson system; another would bring water from the Coppermine into the Mackenzie.

A. Criteria for Selection of "Potentially Sensitive Areas"

The 37 potentially sensitive areas (Figure 1) were selected by members of the Task Force. The Task Force believed



Key to Map of Sensitive Areas Studied

1. West end of Lesser Slave Lake
2. Utikuma Lake
3. Athabasca River
4. Clearwater River
5. Peace-Athabasca Delta
6. Hay and Zama Lakes
7. Elizabeth Falls
8. Fond-du-Lac River
9. Hominka Marsh
10. Blackwater Creek Swamp
11. Liard River
12. Liard Hotsprings
13. Whirlpool Canyon
14. Taltson River
15. Lockhart River
16. Brabant Island
17. Mills Lake - Deep Bay
18. Lady Evelyn Falls
19. Trout River
20. Jean-Marie Creek
21. Willowlake River
22. Virginia Falls
23. Porcupine River
24. Great Bear River
25. Wolverine River
26. Brackett Lake
27. Loche River
28. Three Day Lake
29. Hare Indian River
30. Mackenzie Ramparts
31. Arctic Red River
32. Peel River
33. Swan Lake and Swan Creek
34. Rat River
35. Horseshoe Bend
36. Mackenzie Delta
37. Big Fish River

Figure 1. Potentially sensitive areas of the Mackenzie River Basin.

enough information was available to ensure the value of each area as a resource and to assess its potential sensitivity to alterations in existing hydrological regime (Lewis pers. comm.). This has turned out not always to be the case.

In discussions with Task Force members, we discovered that the criteria for area selection were interpreted differently by various individuals. Some members considered development potential when making their choices, others did not; some considered resource use in the local economy, others did not.

We suggest that sensitive areas in the Mackenzie basin be defined as areas which 1) are unique sites or are of particular importance because of their biological productivity or cultural and social value, <u>AND</u> 2) can be expected to suffer serious loss in value if changes are imposed on the hydrological regime.

This report describes 36 areas in sufficient detail for the Task Force to decide whether or not they conform with the above definition. For one area, Blackwater Creek Swamp, no information was available. This list is not exhaustive. Many of the areas were first documented as a result of pipeline impact studies which were confined to a narrow corridor north of 60°. Notable sites which have been excluded are the islands in the Mackenzie River on which migrating waterfowl stage and breed in spring and where moose feed during winter. Further research in the basin will undoubtedly point out other areas.

Chapter VIII discusses in a general qualitative way some effects of changes in hydrologic regime on wildlife and fisheries populations. In addition, notes in some chapters indicate some possible effects of changes in water level which we think are particularly relevant to a particular site. These sections are not exhaustive, nor are they intended to be used for impact statements. Detailed data and time were not available to develop hypotheses of the results of water level changes nor to describe the tolerance to change of the present ecosystem.

B. Report Format

The major divisions in report organization have been based on geographic-hydrologic criteria. Six subbasins are identified as practical operational boundaries for the division of information.

For each study area a sequence of information is presented. The main headings include: general description (location, climate, physiography, geology), hydrology, biological resources, social and cultural values, sensitivity, knowledge gaps, and selected bibliography.

CHAPTER II

ATHABASCA RIVER DRAINAGE

A. The Athabasca River

The Athabasca River (Figures 1, 2), a long, diverse watercourse, is different from other rivers in Alberta. It has no major cities along its route, no developed hydro-electric sites, little farming or other agricultural pursuits, no major resources associated with the river (e.g. hydro-electric potential), no known critical habitat areas and no major flooding problems (Wuite pers. comm.). The areas where hydrologic conditions are noticeably related to wildlife habitat are in the lower reaches below Fort McMurray, particularly in the Peace-Athabasca Delta. The productivity of the delta depends largely on periodic flooding and sedimentation from the Athabasca River (see section II F).

In this section the general characteristics of the entire river are discussed. The lower reaches are dealt with in more detail. It is in the stretch from Fort McMurray to the Peace-Athabasca Delta that existing and proposed developments may have deleterious effects upon the natural hydrologic

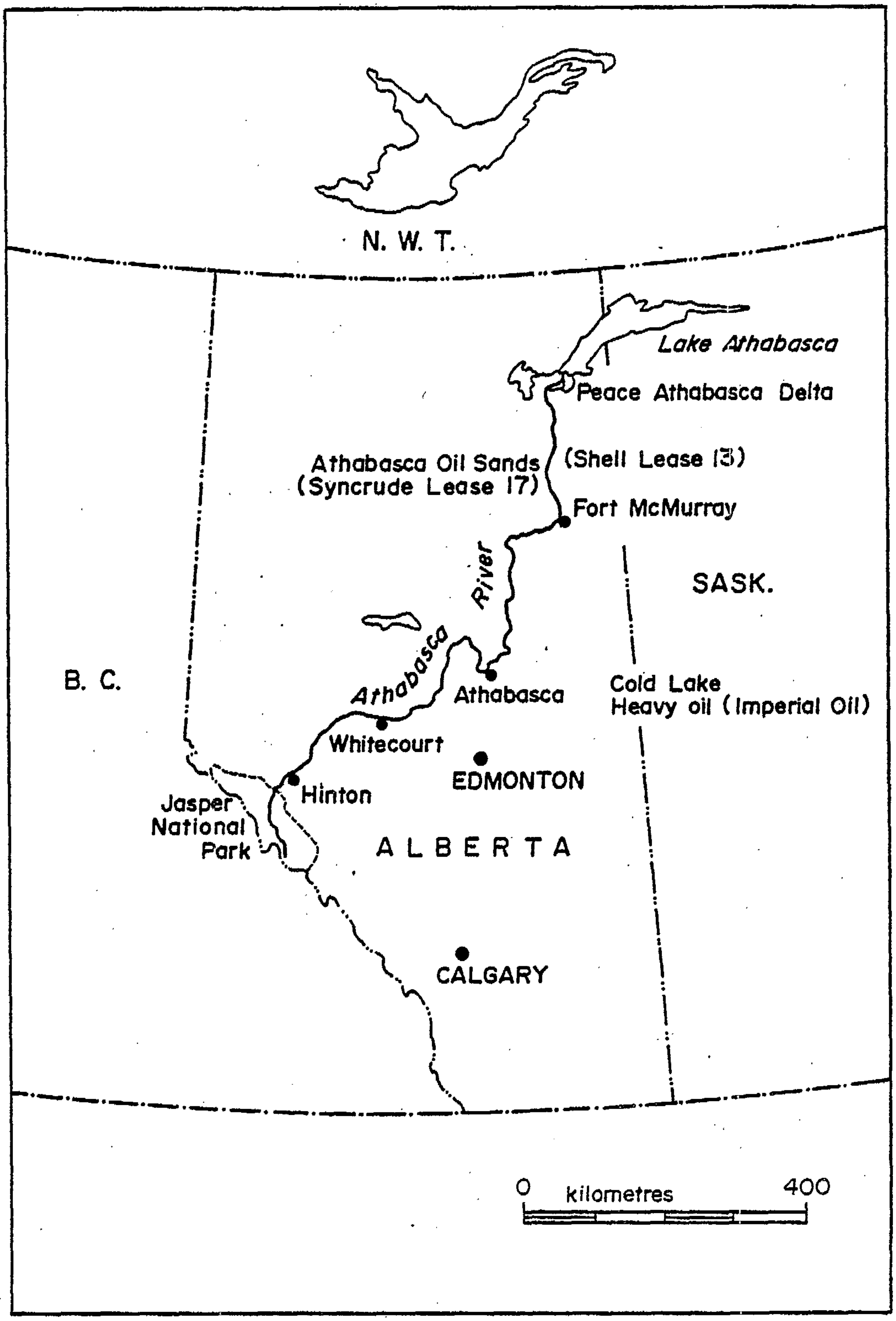


Figure 2. The Athabasca River.

conditions (Wuite pers. comm.). These changes could in turn seriously affect wildlife habitat.

The Athabasca is the only major river which flows unregulated into the Peace-Athabasca Delta (see section II C). The river presents valuable recreation opportunities for canoeing, fishing and observing wildlife; it is on the historic east-west fur trade route; and it is the southern origin of the navigational route to the Mackenzie River. For these reasons the Athabasca River is considered sensitive to changes in hydrologic conditions.

1. General Description: The Athabasca River arises in the Rocky Mountains in the Columbia Icefields and flows approximately 1440 km before entering the west end of Lake Athabasca. The total drainage area of the Athabasca River basin is 156 928 km^2, about 25% of the surface area of Alberta (Bond and Berry 1978).

In the first part of its course the Athabasca River has the characteristics of a large mountain stream with canyons, waterfalls and rapids. From its source to Jasper, a distance of about 96 km, the river drops nearly 457 m. From Jasper, the river flows with a fairly uniform gradient to the town of Athabasca and drops 488 m in 640 km. Along this section it is joined by three large tributaries, the McLeod, Pembina and Lesser Slave rivers (Montreal Engineering Company Ltd. 1955). From Athabasca, the river assumes a more northerly direction. Pelican Rapids, the first steepening of grade in a series of rapids to follow, are 192 km downstream (Camsell and Malcolm 1921). Between Athabasca and Fort McMurray, a distance of 384 km, the river drops 259 m. The largest single drop is at Grand Rapids where the river drops 12.2 m in 0.8 km (Montreal Engineering Company Ltd. 1955). The river in the portion from Jasper to Fort McMurray is from 229 m to 366 m wide and its valley varies from 91 to 122 m in depth (Camsell and Malcolm 1921). At Fort McMurray the river loses its narrower, gorge-like character and is deflected northward by high bluffs of clay and oil sands overlying Devonian limestone. The stream gradient is reduced to about 0.2 m/km, and the channel pattern is straight and sinuous.

The river enters the Peace-Athabasca Delta about 56 km from Lake Athabasca where it divides into several channels. These channels are constantly changing as sediment and other material is deposited by the river (Camsell and Malcolm 1921). The gradient decreases further and the banks soon diminish to the level of the delta (Bond and Berry 1978). Several large tributaries join the river along this section including the Clearwater, Steepbank, Muskeg and Firebag rivers from the east, and the MacKay and Ells rivers from the west (Government and University of Alberta 1969).

The geology and physiography of the Athabasca River Basin are complex. They are characterized by a transition from mountainous terrain, to foothills and then high interior plains (Environment Conservation Authority n.d.). The large town of Fort McMurray, and the small communities of Jasper, Hinton, Whitecourt and Athabasca are located along the streamcourse (Figure 2).

2. Hydrology: The northward flowing Athabasca River is fed by glaciers and snowfields high in the Rocky Mountains. Therefore, peak runoff occurs during June and July, coinciding with snowmelt in the mountains, and break-up occurs from south to north. Long term mean discharge below Fort McMurray is 691 m^3/s. A 1467 m^3/s maximum monthly mean discharge occurs during July, while a 165 m^3/s minimum monthly mean discharge occurs during March (Fisheries and Environment Canada 1976).

Generally no serious flooding problems are associated with the hydrologic regime of the Athabasca River. However, some ice jamming and subsequent flooding does occur at Fort McMurray. Since the source of the Athabasca is in the south and break-up occurs from the south, there is a tendency for ice to build up as it flows north. Flooding can occur in the town of Fort McMurray when the flow of water downstream, obstructed by the ice jam, drains into the Clearwater River and backs up into the low areas of the town. In the 128 km section of river immediately south (upstream) of Fort McMurray, the slope of the river and the rapids which occur in this section can induce flood conditions downstream. When the ice and water mixture enters the broader channel of the Athabasca opposite Fort McMurray, it slows down. The ice then accumulates on the river bed causing a jam to form. The ice jam, occasionally rising to a height of 12.2 m above the river level, remains until the water level builds sufficiently to move the ice on (Cohos, Evamy and Partners 1974).

The Athabasca River and its tributaries serve as a source and recipient of water used for domestic, recreational and industrial purposes. With the increased expansion and development of areas like the Athabasca Tar Sands, water quality in the Athabasca River will become an important issue in the future (Konopasek 1973). However, it is believed that the numerous gauging and monitoring stations scattered throughout the basin provide an excellent network of data sources. This system of stations is sufficient to assess the effects of any major development along the main river channel (Bothe pers. comm.).

3. Biological Resources: The Athabasca River flows through the Subalpine and Boreal Forest regions. Within the Boreal Forest it flows through lower foothills and mixedwood forest sections. White spruce and balsam poplar form the main cover types on alluvial flats bordering the river (Rowe 1972). A well-developed understory of willows, alder and herbs is also characteristic of these riverine stands.

Alberta Fish and Wildlife Division of Alberta Parks, Recreation and Wildlife have designated the Athabasca River as a wildlife corridor, important for habitat in a regional sense. The most important habitat function of the river valley is to provide moose winter range. Animals from the surrounding upland areas depend on the river valley and its cover during winter. The river valley creates an oasis effect (Fish and Wildlife Division 1972-73).

Although the lower river valley is on the Central and Mississippi flyways (Government and University of Alberta 1969), waterfowl are not generally known to use the main river (Fyfe pers. comm.). Occasionally however, some staging occurs in spring when the river breaks up prior to the surrounding water bodies (Ambrock pers. comm.). Canada Land Inventory rated the river as having severe limitations to waterfowl production based on adverse topography and free-flowing water (Canadian Wildlife Service 1969-70).

The habitats required by raptors are present in the section from Jasper to Fort McMurray, but prey species are a limiting factor along the entire river system. The river water is very turbid and exhibits poor potential for fish eating species (Erickson and Armbruster 1974). Erickson and Armbruster (1974) recorded the presence of a number of great blue herons, but heronries were not seen.

With the exception of goldeye and walleye in the Peace-Athabasca Delta, little is known of the life history of any fish species in the Athabasca River. Generally, only the distribution of large fish species is known (Lutz and Hendzel 1976). Northern pike, arctic grayling, white suckers and longnose suckers appear to be widely distributed in both large and small tributary systems. Large numbers of white suckers and longnose suckers have been located spawning in Beaver Creek (Renewable Resources Consulting Services 1973) and in the Muskeg River (Renewable Resources Consulting Services 1974b). Yellow walleye are also widely distributed in the lower Athabasca River region but appear to be restricted to the lower reaches of the larger systems such as the Christina, Clearwater, MacKay, Ells and Firebag rivers (Jantzie 1976).

Lake whitefish were found to spawn during mid-October in the main stem of the Athabasca River from Fort McMurray upstream to Cascade Rapids. This portion of the river has fast water flowing over broken rock, rubble and coarse gravel substrates and is reported to be critical spawning habitat for lake whitefish (Jones et al. 1978).

Arctic grayling are a primary user of small streams and the upper and middle portions of the larger rivers. Arctic grayling have been collected in Poplar, Beaver and Redclay creeks, Tar, Ells and Firebag rivers (Renewable Resources Consulting Services 1975). The Calling River also supports grayling (Ambrock pers. comm.).

In the lower reaches of the basin the Athabasca, Clearwater, Firebag, Ells and Steepbank rivers were rated with exceptionally high importance for fish (Renewable Resources Consulting Services 1975).

An important, yet rather obscure, resource is the periphyton or attached algae. Periphyton are the principal primary producers in waterways such as the Athabasca River (McCart et al. 1977). They form the base of many food chains in the river ecosystem and are also an important source of oxygen (Blum 1956). The periphyton community is an excellent indicator of water quality and is used extensively in the classification and monitoring of water quality (McCart et al. 1977).

4. Social and Cultural Values: The Athabasca River basin has superb recreational potential for fishing, big game hunting, camping, hiking, mountaineering and skiing. It also has a concentration of highly valuable natural resources such as coal, oil and natural gas, timber, water and land for tourist or residential development. Because of the many recreational and resource demands significant developments have already been completed and pressure is now being felt for additional tourist, recreational and extractive industry programs (Environment Conservation Authority n.d.).

a. Land use: Jasper National Park attracts a large number of tourists and vacationists during the months May through September. To accommodate these visitors, there are many commercial establishments such as hotels, motels and bungalow camps, in addition to several park-operated camping areas. Most of the smaller establishments use septic tanks and either subsurface discharge or effluent discharge to streams for the disposal of sewage. However, larger operations discharge sewage, mostly untreated, directly into the Athabasca River (Public Health Engineering Division 1967). The results to water quality have not been serious, but the Department of National Health and Welfare suggest that swimmers be deterred in that portion of the river immediately downstream of Jasper townsite (Public Health Engineering Division 1967).

Industrial water use is increasing. In 1967, 56 448 million litres of water were reported withdrawn from the Athabasca River basin for oil and gas production. Some 97% (54 754 million litres) of this total was discharged back to the river. Only a small proportion of the users reported the breakdown of waste water in terms of industrial effluent, cooling water or sewage (Department of Industry and Tourism 1970).

Forest production is the major land use along the Hinton to Athabasca section of the Athabasca River. Most of this section is included in a Timber Management Agreement area held by North Western Pulp and Power Ltd. who operate a kraft pulpmill at Hinton. Most of the agreement area has either good or moderately good existing forest cover for sawtimber, with significantly greater potential for pulpwood production (Environment Conservation Authority n.d.).

A narrow belt of agriculture extends to the Athabasca River northwest of Edson, and a small area, primarily devoted to livestock grazing, surrounds Hinton (Environment Conservation Authority n.d.). As a result of adverse climate and topography, and poor soils, the potential for agriculture is very limited (Peterson pers. comm.).

Cattle production has recently escalated in the area around the town of Athabasca. Numbers of animals have increased from 30 000 to 85 000 since the early 1970's in this area (Peterson pers. comm.). However the Athabasca River in this area is extremely productive for the blackfly Similium arcticum, an insect that selects cattle and wildlife for the blood meal required to maintain its species. In 1977 10 cattle (valued at approximately $1000 each), were lost due to insect predation. This problem is heightened because the calving period corresponds with the hatching time for this blackfly species. A multi-agency research program was conducted during 1974, 1975 and 1976. The program was designed to determine the potential effects of the use of methoxychlor, a chemical pesticide designed to control the blackfly population in the Athabasca River. Results of this research program are due in spring 1979 (Peterson pers. comm.).

Land use in the Northeast Alberta Region is mainly related to oil sands extraction by Great Canadian Oil Sands (GCOS) and Syncrude Canada Ltd. Uses include mine sites, tailings ponds, roads and other transportation facilities, seismic lines and new townsites. The resulting need for outdoor recreation opportunities creates a major secondary land requirement. A list of completed and ongoing research projects related to the Athabasca River and oil sands development has been completed by Buick (1977).

b. Historical values: The Athabasca River has been an important fur trading route and route of scientific discovery, both westward to the Pacific and northward to the Mackenzie River. Fur trader and geographer, David Thompson, discovered the Athabasca Pass through the Rockies in 1811. Until the mid-1800's, the river served as the regular route of the Hudson's Bay Company's "Columbia Express" which carried passengers and mail between the Pacific coast and Hudson Bay (Wonders 1974). The Athabasca River below Fort McMurray served as a main transportation link to the far north for nearly two centuries. In the early days, trading, trapping and exploration took place along the river (Doyle 1977).

Fort McMurray, located in the valley at the confluence of the Athabasca and Clearwater rivers, is the only major urban centre along the Athabasca River. Established as a Hudson's Bay trading post in 1870, Fort McMurray grew slowly and sporadically to a town of 1200 in the early 1960's. With the onset of oil sands development, the population suddenly leaped to 8000 between 1965 and 1967, and more than doubled to 17 000 in the nine years since GCOS began its operations (Hennan and Munson 1978). The 1977 total of 23 000 is expected to climb to 28 000 by early 1979 when Syncrude is fully operational (Buick 1978).

c. Recreation: Besides the superb recreation opportunities available in Jasper National Park, recreation along the Athabasca River is rated quite low. Canada Land Inventory rates the majority of the rivercourse as poor. Along areas where rapids occur, such as Stoney, Pelican and Grand rapids, a variety of topography, and land and water relationships enhance opportunities for general outdoor recreation (Anderson et al. 1971).

d. Native use: Trapping and hunting are important activities in the river valley from Fort McMurray to the Peace-Athabasca Delta. The mean annual value of fur produced per trapping area for 131 registered trapping areas in the Alberta Oil Sands Environmental Research Project region was $1252. While value of returns varied from $0 to $7900 for the larger Northeast Alberta Region (Renewable Resources Consulting Services 1975), the mean annual income per trapping area for 245 trapping areas was $948 (Buick 1978). Variations in value between trapping areas can be attributed to wildlife habitat quality, furbearer abundance, and trapper effort and skill. Beaver, lynx and muskrat contributed approximately 80% of the total value. Other species trapped include coyote, fox, mink, squirrel, otter, hare, skunk, weasel and wolf (Buick 1978).

Commercial fishery operations are carried out on Lake Athabasca. The fishery, based in Fort Chipewyan, is viable and is an important source of income to that community

(Buick 1978). Walleye, northern pike, cisco, lake whitefish and goldeye are the main species caught, many of which migrate to spawn in the lower Athabasca River basin.

e. Proposed developments: The Athabasca River watershed, comprising a vital part of the northern Alberta biophysical system, will provide the principal source of water for oil sands projects. The Clark hot water process of bitumen extraction, currently used by GCOS and Syncrude, has a high consumption rate for water. For example, the Syncrude plant is designed to use approximately 300 000 litres of water per minute from the Mildred Lake basin (Buick 1978).

Water is used throughout the process of oil sands extraction. First, hot water is mixed with bitumen during primary recovery processing. Next, water is used in the flotation or secondary recovery process. As steam, water is diluted with naptha and added to the product of step two for the final stage of bitumen recovery. The waste water is then pumped to tailings ponds. The build up of large tailings ponds which will be present for the next hundred years or more, is one of the environmental concerns associated with the hot water process (Buick 1978).

Several other developments that could affect water conditions in the Athabasca River are:

1) A third oil sands plant and townsite of 12 000 people near McLelland Lake along the east side of the Athabasca River downstream of Fort McMurray is proposed (Buick 1978).

2) GCOS is currently conducting a $190M plant expansion (Buick pers. comm.).

3) Two major surface coal mining projects are planned. The first at Judy Creek will supply fuel for Imperial Oil's heavy oil industry at Cold Lake, Alberta; and a second, in Fox Creek, will be a Shell Oil development. These projects are massive and will undoubtedly affect the hydrologic conditions in the sub-basins. The extraction process for these developments is also water consumptive (Buick pers. comm.).

4) Preliminary investigations on the Athabasca River suggested possibilities for hydro power development between Lesser Slave Lake and Fort McMurray at a series of five dams. Mirror, Pelican, Grand, Boiler rapids and Fort McMurray are potential sites (Inland Waters Directorate 1973). Dam construction is not considered feasible at this time because of prohibitive construction costs and the availability of other energy sources (Thurber Consultants Ltd. 1975; Wuite pers. comm.).

5. <u>Sensitivity</u>: The possible hydrologic impacts of oil sands industries are discussed in a report by Northwest Hydraulic Consultants Limited (1975). The major impacts expected are: increased soil erosion and associated sedimentation of lakes and watercourses as a result of increased streamflow peaks and more rapid runoff; contamination of surface and groundwater supplies from mining or percolation

of contaminants in tailings deposits to the groundwater system; and, leakage of tailings through dikes to surface watercourses. As well, land use changes imposed by the urban-industrial construction are expected to significantly influence the region's hydrologic cycle (Jantzie 1976). Rainfall-runoff relationships will change with clearing of the vegetation. Subsequently, changes in microclimate are expected as a result of altering the absorbtion-reflection properties (albedo) of the soil surface (Jantzie 1976). Jantzie (1976) gives the details of several changes related to open pit mining and construction.

It has been suggested that with each major development along the lower portion of the Athabasca River there will be a general decline in water quality. This decline will result from increased use of water for oil sands processing and increased emissions into the air and water (Buick pers. comm.).

Other potential problems are more tenuous, but are thought to have the potential to create severe problems in downstream areas. For example, large salt deposits are known to exist under much of the northeastern portion of Alberta (Government and University of Alberta 1969; Laycock pers. comm.). These deposits are dome shaped, with the greatest thickness occurring near Cold Lake. They are often associated with trapped groundwater, a brine solution of high salt content (Buick pers. comm.). Hackbarth, a researcher at

Alberta Research Council, is working on this aspect of oil sands development in relation to groundwater surveys. Results of his research are due in 1979. Preliminary results suggest that emission of highly saline groundwater to waters of the Athabasca River could have serious downstream effects, especially in the Peace-Athabasca Delta (Renewable Resources Consulting Services 1974a; Buick pers. comm.).

Buick (1978) suggested that oil sands development, including new townsite and road construction, can have direct negative effects on animal habitats and subsequent indirect effects on trappers' livelihoods. Because of the importance of trapping and hunting to the native population, consideration should be given to the potential effects of development on these activities (Buick 1978).

Migrating waterfowl appear to be selective in their choice of water bodies for resting and feeding stops. Nevertheless, they will land, especially at night, on any moderately large body of water, regardless of whether or not it contains food. The large sizes of the tailings ponds from oil sands development, and their concentration along a fairly short stretch of the Athabasca River, could result in the attraction of considerable numbers of waterfowl migrating through the general area of the oil sands. Portions of these tailings ponds will be ice-free throughout the year. They would be particularly attractive to waterfowl during the early part of the spring migration and the latter part of the fall migration, when many of the local lakes may be unavailable as stopover sites (Environment Conservation Authority 1975). Evidence of 109 to 119 bird deaths was found in 1974 on or in the immediate vicinity of tailings ponds on the Syncrude and GCOS leases (Environment Conservation Authority 1975).

6. Knowledge Gaps: Information available for the Athabasca River is generally site specific and related to ongoing developments. To date, no attempt has been made to assess the entire river basin as a system. A type of multi-agency basin planning approach is now being developed by the Planning Division of Alberta Environment. The approach has three main steps: 1) utilize expertise from many government agencies, consulting firms, industry and the general public to acquire information; 2) synthesize information and arrange for information transfer between agencies and others involved; and 3) formulate a management plan for the basin. This plan is then reviewed by participants and finalized by Alberta Environment (Wuite pers. comm.).

Basin planning studies may help us to better understand the complex interactions between hydrologic and wildlife resources. Unfortunately, little is known about the long term effects of large scale environmental disturbances, such as those involved in the oil sands extraction industry. Serious changes may occur in the regional water balance. These changes may affect groundwater hydrology and evaporation rates from soils cleared of vegetation, and accelerate erosion (Buick 1978). Research findings from similar large scale industries in other parts of the world such as West Virginia or West Germany could provide insight into the kinds of knowledge we could be missing in our assessments of developments along the Athabasca River.

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B. Clearwater River

1. General Description: The Clearwater River originates in northwestern Saskatchewan and flows 370 km westward to the Athabasca River at Fort McMurray, Alberta (Figure 1). Only the last 114 km of main river is in Alberta. In the 31 660 km^2 drainage area, the Mirror, Fortin and McLean rivers and numerous large Shield lakes are source areas in Saskatchewan. The Hangingstone, Christina and High Hill rivers, plus a few smaller streams, make up the watershed in Alberta (Renewable Resources Consulting Services Ltd. 1975).

The Clearwater River touches three zones of distinctly different bedrock. The headwaters are in the Canadian Shield. This area is largely covered by sandy soils washed down during glacial times from the Athabasca Sandstone formation lying to the north. Near Whitemud Falls, 5.6 km inside the Alberta border, Devonian limestone abuts against the Canadian Shield rocks (Figure 3). This rock type is readily evident, especially at Pine Rapids, where the river winds through a 1.6 km long canyon with cliffs rising 30.5 m above the river (Juurand 1974). The third geological formation is evident along the river near Fort McMurray. Here traces of

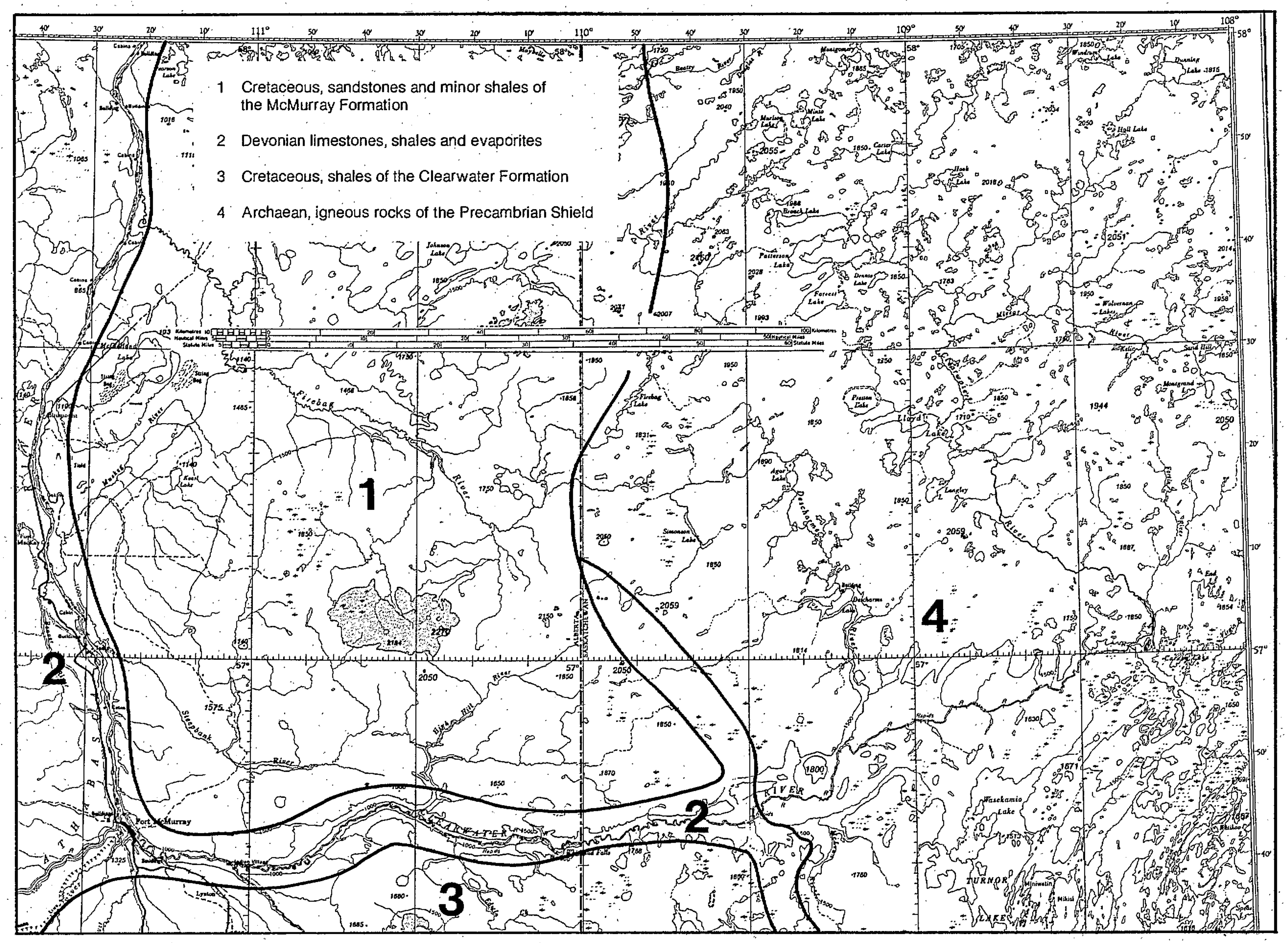

Figure 3. Bedrock geology of the Clearwater River.

bitumen seep out of shales and sandstones of the McMurray Formation, part of which contains the Athabasca Tar Sands (Pollock 1978).

The variable nature of the surficial geology along the river course is an interesting characteristic. Most of the Saskatchewan portion of the basin was covered with ice of the Pleistocene, while in the west, in glacial Lake McConnell, silts, sands and gravels were being deposited (Pollock 1978). Glacial features in the upper reaches include DeGeer moraines, eskers, kames, glacial flutings, drumlins, crag and tail features, and roches moutonnées. The lower reaches in Saskatchewan are in a previous meltwater channel and glacial spillway (Richards and Fung 1969). Kupsch (1977:32) described past glacial history as one might interpret it from Methy Portage (Figure 4):

> A geologist would recognize the valley of the Clearwater River as one carved by running water in early postglacial time when northeastern Saskatchewan was still covered by a glacier but the south and west were already free of ice. Erosion of the valley started perhaps as much as 12 000 years ago. In the beginning when there was much water from the melting glacier this process was very fast but in time it slowed down to its present low rate. The river cut through the tills, clays, sands and gravels previously deposited by the glacier and its meltwaters onto the underlying bedrock. There are no outcrops of bedrock in the valley of the Clearwater River near Portage La Loche but farther downstream sands and clays of Cretaceous age are exposed. Below them in turn lie the older Devonian limestones which are the cause of most of the rapids and falls in the stream.

Fort McMurray, at the confluence of the Clearwater and Athabasca rivers, is the only settlement in the Clearwater basin.

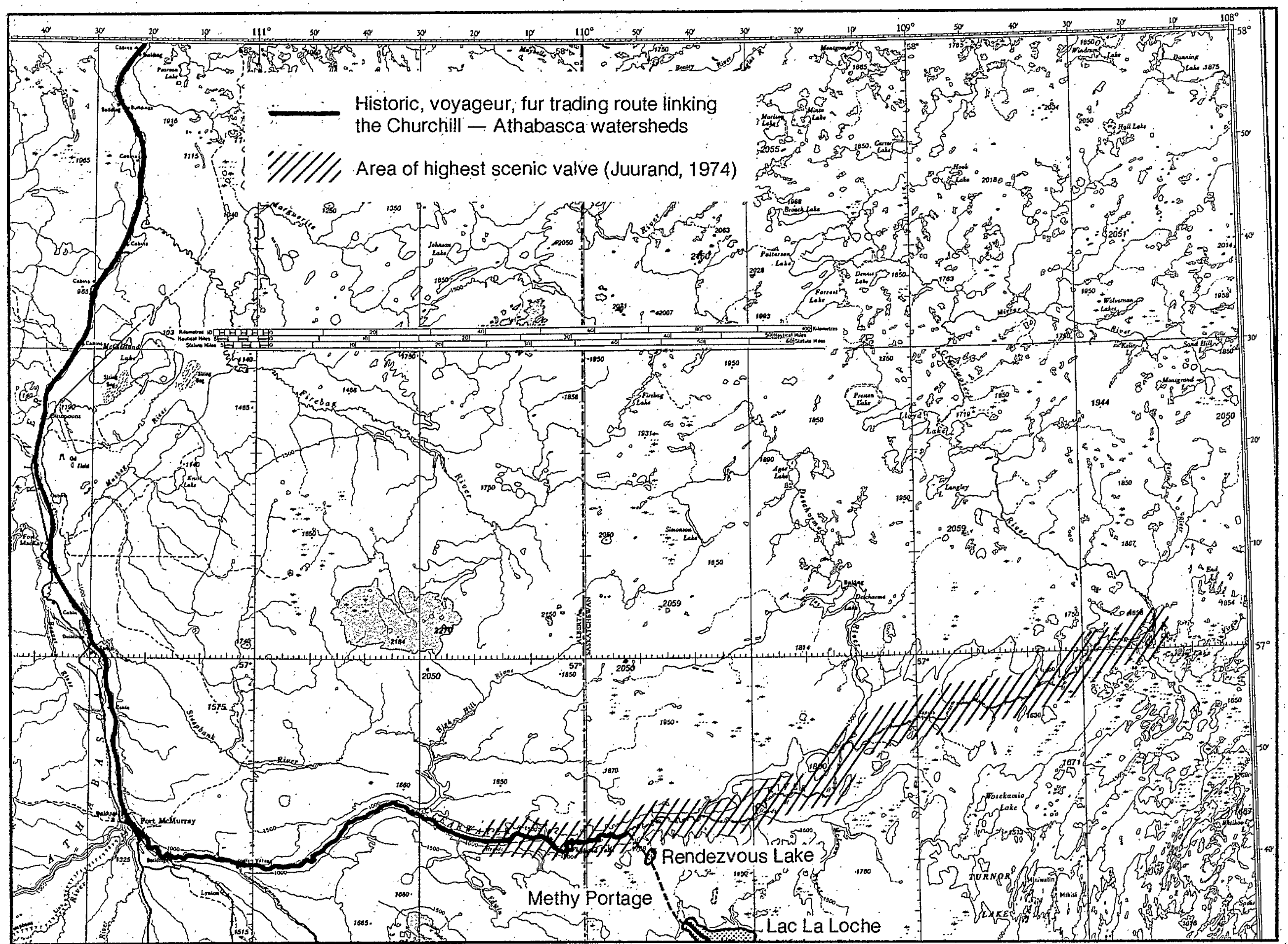

Figure 4. Historic canoe routes along the Clearwater and Athabasca Rivers.

The Clearwater River was chosen as a sensitive area for its extremely important historic and recreational resources (Lewis pers. comm.). These resources are:

1) medium difficulty white water canoeing and historic scenic portages,
2) historic route of early fur traders,
3) clear water and changing geologic features,
4) diversity of forest types and associated fauna, and
5) good sport fishing.

2. <u>Hydrology</u>: The hydrologic regime of the Clearwater River has not been altered by development. Its flow is distinctive of rivers draining the Canadian Shield. Large lakes at the headwaters regulate annual flow so that there is only a small rise in volume during spring break-up. The mean daily flow follows a relatively smooth curve (Figure 5). The water in the upper portions is clear and flows quickly through a narrow channel worn into the Precambrian Shield. In its lower portions, the Clearwater River is very uniform with only minor changes in flow rate, pool depths and bottom type (Rhude 1972). It is a meandering river, deeply incised into the landscape. Numerous rapids and narrow canyons occur in the portion upstream of the confluence of the Clearwater and High Hill rivers. Seven sets of rapids occur in Alberta (Forest Recreation Branch, Energy and Natural Resources 1978). The Christina River carries a heavy silt load and causes the last 25 km of the Clearwater to be quite murky (Pollock pers. comm.).

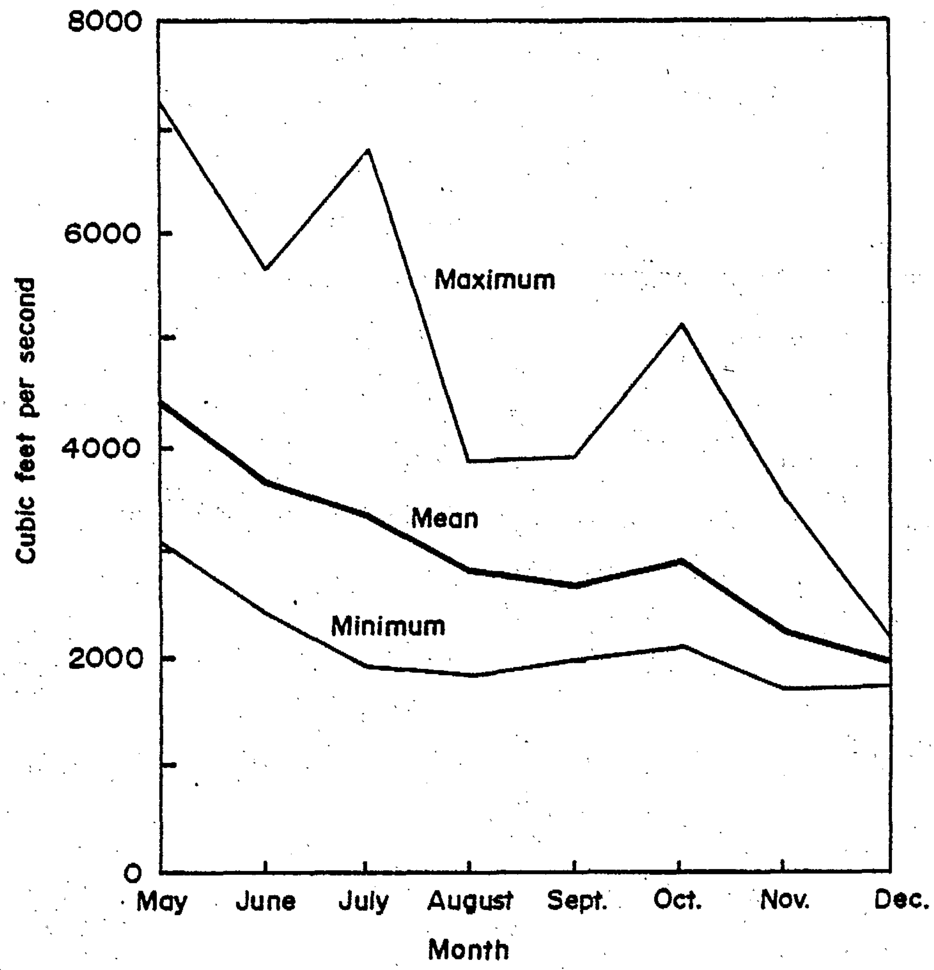

Figure 5. The Clearwater River: Mean daily flows: 1967-1971.

There are three gauging stations in the basin, one on the Christina and two on the lower Clearwater. Two water quality stations are located just above Fort McMurray. There are no stations in Saskatchewan (Mackenzie Reference Binder n.d.).

3. Biological Resources: The Clearwater River basin lies entirely within the Athabasca South section of the Boreal Forest region (Rowe 1972). Sandy soils derived by glacial action from underlying sandstones have favoured the development of forests of jackpine. These are frequently park-like in structure due to rigorous climatic conditions and the frequency of fires (Rowe 1972). Other major forest types are dominated by aspen, balsam poplar, white spruce and black spruce. Aspen stands are extensive along the 165 m high valley walls of the lower Clearwater, while white spruce is common on floodplain sites (Government and University of Alberta 1969). Balsam poplar stands are widespread on the moist river flats and other damp sites in the Clearwater River valley (Pollock 1978).

Although no data are available on mammals in the study area, Snycrude Canada Ltd. has done extensive studies of Tar Sands Lease #17 located a short distance to the northwest. These studies concluded that the general region is an area of moderately low biological productivity. The most productive habitat areas are in the river valley, where large numbers of moose have been reported (Pollock 1978). Marginal potential exists in the upland areas for deer and caribou. Black bear, beaver, hares, wolves, coyotes, lynx, ruffed and spruce grouse and ptarmigan are found as well. The latter species are common to all habitat types (Syncrude Canada Ltd. 1973-1). However, waterfowl capability is low (Ambrock pers. comm.).

The Clearwater River supports excellent fish resources (Pollock pers. comm.). The most common species include walleye, northern pike, arctic grayling, longnose sucker and trout perch (Rhude 1972). Mountain whitefish fry were also found but it is unknown if there is a resident population of larger whitefish (Rhude 1972). In his assessment of the fish resources of the Clearwater River, Rhude (1972:30) described the lower river in general as:

> . . . an excellent looking river. The water is clean with a very good flow rate. The average depth is over 0.6 m with some pools ranging in depth from 2.4 m to 3.0 m. The pool to riffle ratio is approximately 1:1. The bottom substrate of the pools is a combination of sand and silt while riffles substrate is sand, gravel, rubble and tar sand. Refugia for fish is excellent in the form of overhanging brush, logs and deep pools. The banks appear stable with high water marks only 0.6 m to 0.9 m above the present water level. . . . Nutrients appear to be high.

Pollock (pers. comm.) stated that upstream of the Christina River, the water is clear enough to see fish in the pools and in the riffle areas. Abundant benthic organisms in the pools provide an excellent food source and result in a high fish yield capacity (Rhude 1972; Pollock pers. comm.).

4. Social and Cultural Values:

a. Historical: In 1778 Peter Pond used the Clearwater River to start the fur trade in the Athabasca district. The 21 km Methy Portage (or Portage La Loche), in Saskatchewan (Figure 4), was used to connect Alberta rivers to the Churchill River system (Forest Recreation Branch 1978). Kupsch (1977) compiled a detailed account of known travellers in this area.

b. Recreation: Perhaps the most remarkable feature of this area is that it remains virtually unchanged since the days of Frobisher, Pond, Mackenzie and Thompson. Camping, fishing, paddling and portaging along a route that for 50 to 75 years was the trans-Canada highway of its period provides an unforgettable semi-wilderness experience (Pearce 1978). The National and Provincial Parks Association of Canada recommends the establishment of a continuous, wild, scenic and historic waterway having national significance on the Clearwater-Churchill and Sturgeon-Weir systems. Major reasons for the creation of such a waterway are:

1) The role of the route in prehistory and in the history of the Canadian fur trade;
2) The variety of landscape and surficial geology;
3) The presence of many sites of outstanding scenic beauty;
4) The presence of numerous rapids providing white water canoeing;
5) The essentially undeveloped nature of the route through wilderness and semi-wilderness areas;

6) The maintenance of the way of life of the indigenous native people who live along or adjacent to the route and would preserve archeological and other sites for future excavation (Pearce 1978).

The most common modern canoe trip is along the Clearwater from the Alberta-Saskatchewan border. In the 118 km of river in Alberta, 7 sets of rapids are encountered. Depending on one's skill, these may all be run except one. It is necessary to portage around Whitemud Falls. The trip takes the intermediate paddler 5 to 7 days (Forest Recreation Branch, Energy and Natural Resources, Edmonton 1978).

Juurand (1974) noted that the scenic resources are extremely high, especially in the section of river from Careen Lake to the Cascade Rapids (Figure 4). He described the scenic resources at Pine Rapids:

> Although the drop in elevation is steepest at Whitemud Falls, the finest display of limestone cliffs is at Pine Rapids, 3.2 kilometers below. Here the river winds through a canyon 1.6 kilometers long, with cliffs rising 30.5 meters above the river. With the wooded valley walls 150 meters above, acting as backdrop to the Flowerpot Islands and colourful cliffs below, it is one of the finest sites on the Clearwater River. A number of cave entrances half way up the cliffs, are also visible from the river. Although this rapid is runnable by skilled canoeists, an historic portage trail (locally called Portage au Pas) leads around the north bank. This trail leads through beautiful canyons and limestone formations that are similar to those found in the river channel. It is possible that more extensive exploration might reveal some interesting Karst formations (Juurand 1974).

5. <u>Sensitivity</u>: Too little is known of the archaeological and wildlife resources of the Clearwater River to make any assessment of their sensitivity with respect to hydrologic regime. Yet, if we are to maintain the historic flavour of the "voyageur" era, the route should stay much as it was then (McCammon pers. comm.).

6. <u>Knowledge Gaps</u>: Before any development proposals could be assessed, a detailed environmental and archaeological investigation would be required for the Clearwater River basin. Reports to date have been very sketchy and limited to the downstream half of the riverine corridor. Little is known of the regional wildlife resources.

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C. West End of Lesser Slave Lake

1. General Description: The Lesser Slave Lake basin, one of the major contributors to the Athabasca River basin, empties into the Athabasca system through the Lesser Slave River at Smith, about 80 km downstream of the town of Athabasca (Figure 1). Lesser Slave Lake and the numerous tributaries draining into it form a basin which is roughly rectangular in shape and covers an area of some 13 527 km^2.

The basin includes a wide variety of terrain ranging from fairly steep-wooded slopes in the Swan Hills to flat prairie and muskeg in areas adjacent to the lake. The prominent features of the basin are the 736 km^2 Lesser Slave Lake, the second largest lake wholly within Alberta, and the Swan Hills, a range of heavily vegetated, fairly steep slopes whose soil is highly susceptible to erosion. The Lesser Slave Lake basin is unusual in that a large lake rather than a main stem river with numerous tributaries is its focal point.

The west end of Lesser Slave Lake is located in the Lesser Slave Lowland portion of the Alberta Plains physiographic region (Government and University of Alberta 1969). The surface is flat to gently undulating. Surficial deposits are mainly till in the form of ground and hummocky moraine. Smaller areas of lake deposits are composed of silts and clay. Outwash sands and gravels and lake deposits have been worked by wind in some areas along the lakeshore. The study area is underlain by Upper Cretaceous shales and minor sandstone of the Smoky Group geological formation.

Climate is a major factor limiting agricultural and forestry development around the west end of the lake. Winters are long and cold (mean January temperature is $-16^{o}C$), while summers are short and cool (mean July temperature is $16^{o}C$). Frost free days average 100 to 120 per year. Degree days above $5.6^{o}C$ vary between 180 and 210 per year. Annual precipitation is 457 mm, with up to 279 mm falling during the

April to August growing season. The highlands bordering Lesser Slave Lake receive much greater rainfall than lowland points due to the uplift they create. Low elevation stations, like Kinuso and Slave Lake, usually receive about 40% less rainfall than the stations above 915 m. Dark brown, black and dark grey soils predominate and are 60-75 % arable (Atlas of Alberta 1969).

The west end of Lesser Slave Lake was chosen as a potentially sensitive area because of its extremely high wildlife productivity and the dependence of that production upon natural river regimes and lake levels (Ambrock pers. comm.).

2. Hydrology: Five rivers - Swan, East and West Prairie, Driftpile and South Heart - and numerous creeks flow into Lesser Slave Lake, but the Lesser Slave River is the only outlet.

> Lesser Slave Lake is much lower at present than it was in the geological past, resulting in the fact that the first 48 km of the Lesser Slave River flows over the flat sandy terrain which was formerly the lake bottom. Old beach ridges and dune remnants similar to those presently found at the east end of the lake indicate that the shore of the lake may have been many kilometers farther east than it is today. As the lake level fell and the Athabasca River degraded, the Lesser Slave River degraded also. However, the Lesser Slave River at some time encountered a deposit of gravel and cobbles (glacial till) which could not be transported. The result is that the present-day profile of the Lesser Slave River has two distinct slopes. The upper part is at a low slope of 0.0001 where the river slowly meanders over the former lake bottom. The lower part has a slope of 0.0007 where the river flows over gravel and

cobbles. This latter reach is known as a "control" reach in that it is preventing further degradation of the river bed upstream. The point where the two slopes intersect is called the "knickpoint". This knickpoint has been called the Saulteaux Rapids or Saulteaux Weir.

The low slope of the upper reach of the river limits the river's flow capacity. Therefore, large increase in water level on the lake is accompanied by a small increase in discharge down the river. This relationship means that the lake level will rise quickly when there is a large inflow into the lake that greatly exceeds the outflow down the Lesser Slave River. (Quazi and Outhet 1977.)

Flooding around Lesser Slave Lake has been a serious problem for human settlement and agricultural development on numerous occasions, notably 1920, 1935 and 1955. The greatest natural variability to lake levels was 3.6 m (Quazi and Outhet 1977). This 50-year flood caused extensive flooding along the south shore and west end of the lake (Figure 6). Historical hydrologic information for Lesser Slave Lake is available (Montreal Engineering Company Limited 1965, Nemanishen and Cheng 1978).

Average discharge through the Lesser Slave River from 1914 to 1964 was 130 926 hectare-meters per year. Average inflow was calculated for the lake as 143 089 hectare-meters, thereby creating an average annual surplus. This surplus builds with successively wet years creating flood peaks similar to those that occurred in 1920, 1935 and 1955. Evaporation from the lake surface, which may be up to 61 cm annually (Montreal Engineering Company Limited 1965) would add to the calculated inflow values.

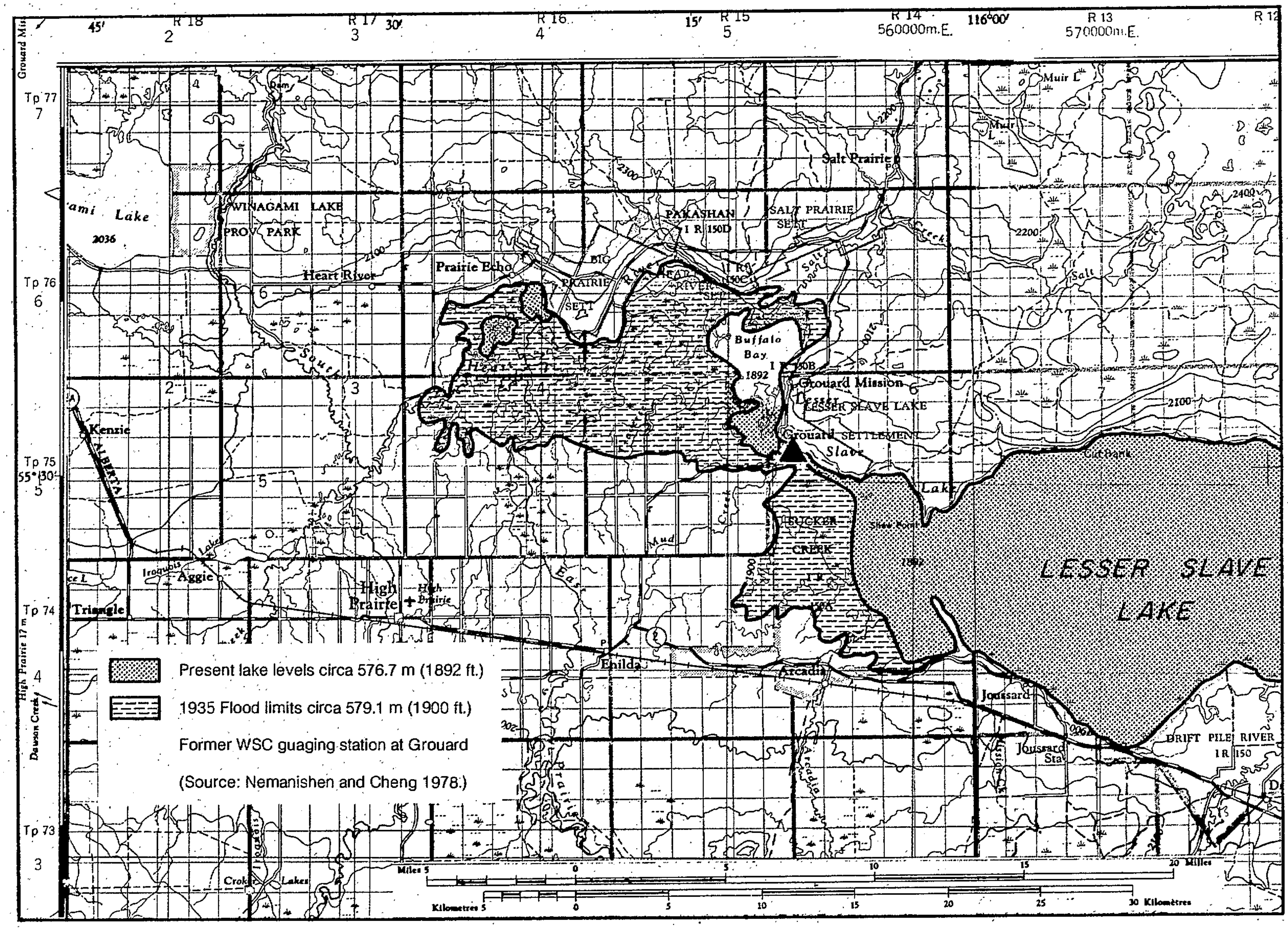


Figure 6. Normal and high water levels on Lesser Slave Lake.

There are no major hydroelectric developments in the basin although several preliminary investigations have been carried out (Athabasca River Basin Planning Unit 1977).

3. Biological Resources: The west end of Lesser Slave Lake is in the Aspen Grove Forest section of the Boreal Forest (Rowe 1972). This parkland ecosystem consists mainly of aspen poplar with a grassy understory on the better drained sites in the immediate area surrounding the west end of the lake. The local vegetation is ensconced in the more regional mixedwood vegetation type (Government and University of Alberta 1969).

Natural flooding plus abundant nutrient inflow from the three tributaries emptying into the west end of Lesser Slave Lake, combine to create an extensive wetland area, highly productive for waterfowl, furbearing mammals and fish. The Canada Land Inventory rates the study area highly for waterfowl production (Figure 7). Limitations are based on adverse climatic conditions and occasional inundation of nesting areas due to rising water levels in Lesser Slave Lake (Weaver 1970). Although the flooding limits nesting success in some years, flooding maintains extensive areas in early successional vegetation, thereby providing superb feeding and resting areas for migrating waterfowl (Doberstein pers. comm.). The west end of Lesser Slave Lake is a major migration stop for waterfowl moving along the Mississippi and Central flyways, and to a lesser extent the Pacific flyway (Government

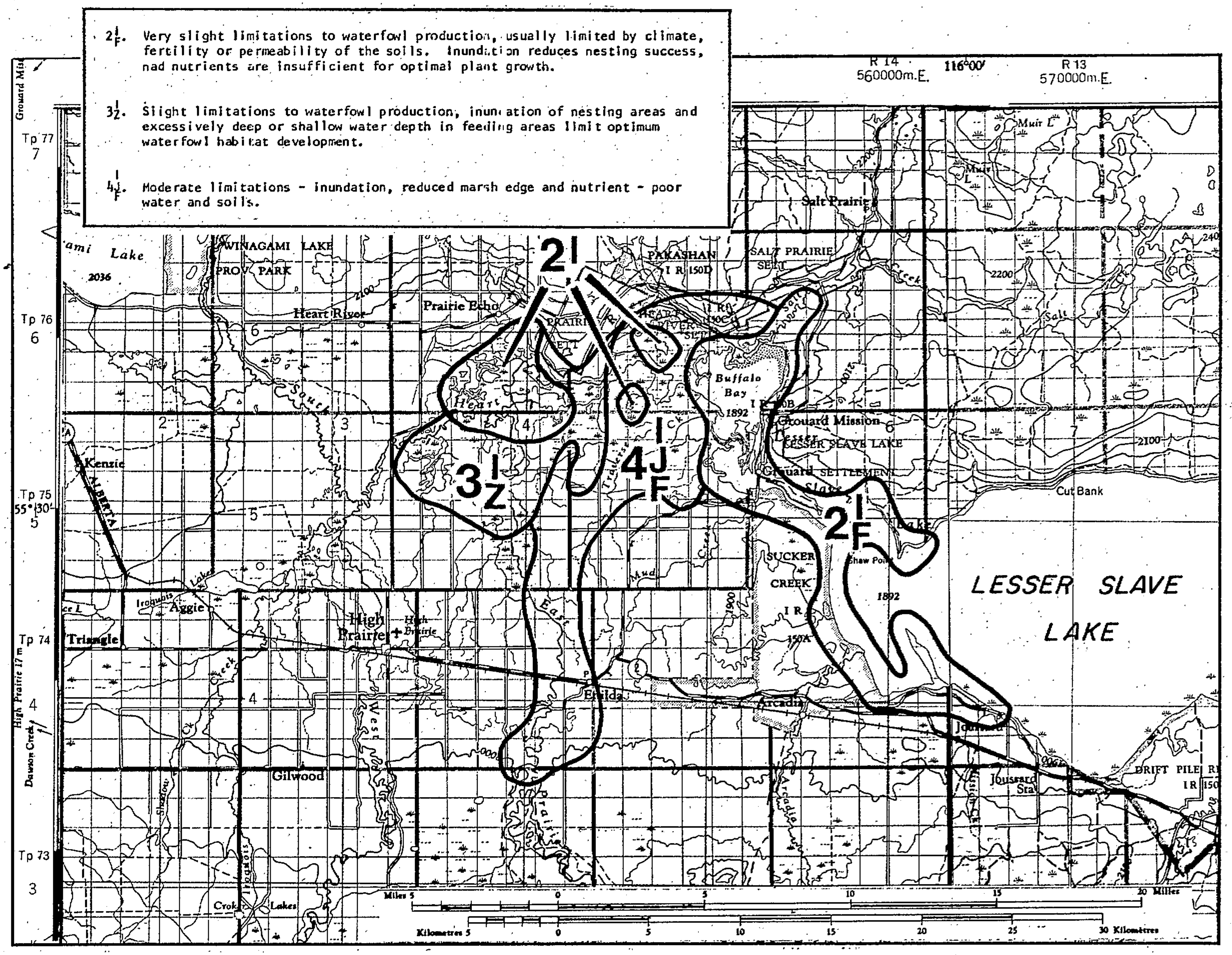


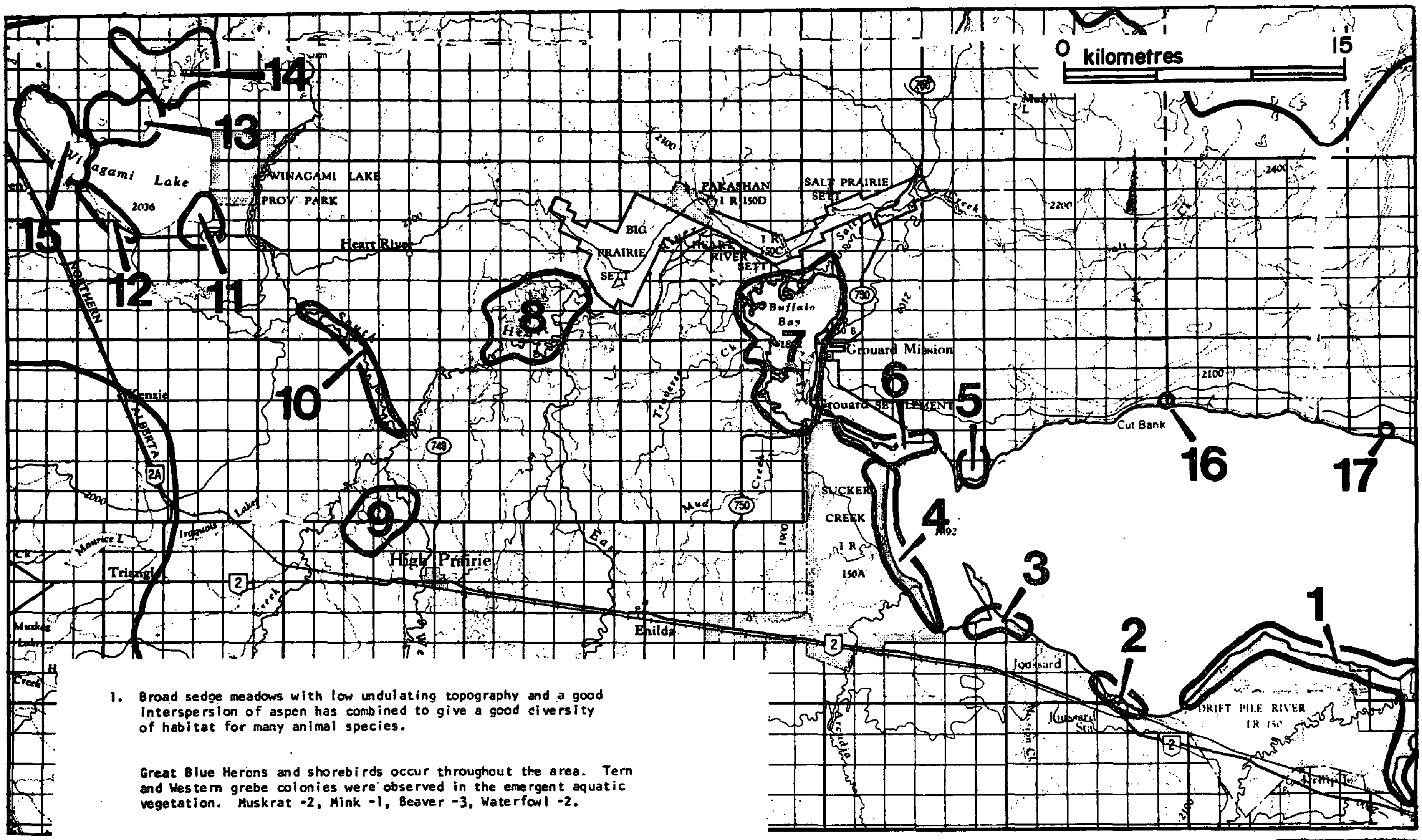
Figure 7. West end of Lesser Slave Lake: waterfowl habitat.

and University of Alberta 1969, Figure 8).

Besides the importance of this shallow wetland area as a migration stop, many species of waterfowl are known to nest here. Mallard, pintail, shoveler, gadwall, American widgeon and blue-winged teal are the most common surface-feeding ducks that nest in the area. Diving ducks, such as the lesser scaup, bufflehead, redhead and common goldeneye nest in the more permanent marshes. The American coot, several species of grebes and various shorebirds occur throughout the area (Weaver 1970). Pelicans and bald eagles are numerous (Doberstein pers. comm.). Dietz (pers. comm.) reported numerous sightings of bald eagles and sandhill cranes. Great blue herons have been sighted (Doberstein pers. comm.) although no nests were located.

Doberstein (pers. comm.) in 1978 aerial surveys, noted that excellent habitat exists for muskrat, mink and beaver along many shoreline locations in the study area (Figure 8). The Buffalo Bay and the South Heart River (Figure 7) contain some of the best muskrat and waterfowl habitat within the basin. Broad expanses of emergent aquatic vegetation, shallow water and flat topography combine to produce excellent habitat for these species (Doberstein pers. comm., Figure 9).

Lesser Slave Lake is a mesotrophic lake that has been commercially fished since the turn of the century. Lake trout were fished out by the 1920's. Other commercial species -



1. Broad sedge meadows with low undulating topography and a good interspersion of aspen has combined to give a good diversity of habitat for many animal species.

Great Blue Herons and shorebirds occur throughout the area. Tern and Western grebe colonies were observed in the emergent aquatic vegetation. Muskrat -2, Mink -1, Beaver -3, Waterfowl -2.

2. Within this area, habitat is restricted to a narrow band along the shoreline. An active bald eagle nest was observed and gulls and terns were seen to frequent a mud bar near Joussard. Habitat is generally fair to poor. Beaver -3, Waterfowl -3, Muskrat -3, Mink -3.

3. Habitat is restricted to the shoreline only. A small amount of willow and sedge occur here. Waterfowl -3, Muskrat -3, Mink -3, Beaver -3.

4. This area is excellent habitat for all species except beaver. The barrier beach protects the inner marsh which had the best diversity of habitat for the entire lake. A large gull colony occurs in the north west part of the area. Muskrat -1, Mink -1, Waterfowl -1, Beaver -3.

5. A sizeable gravel pit operation is located at this point.

6. A narrow band of emergent aquatic vegetation along the lakeshore gives good habitat for some aquatic animals. Muskrat -2, Waterfowl -2, Mink -2, Beaver -3.

7 & 8. These areas contained some of the best muskrat and waterfowl habitat within the basin. Broad expanses of emergent aquatic vegetation, shallow water and flat topography combine to produce excellent habitat.

Ditching, dyking, burning and other landscape modifications have begun to affect the quality. A large gull colony was present on the west side of Buffalo Bay. Waterfowl -1, Muskrat -1, Mink -1, Beaver -2.

9. This area had a series of beaver impoundments throughout the many surface drainages. The undulating topography provided good interspersion of upland to wetland. Aspen and willow occurred in close proximity to the sedge and cattail emergent vegetation of the impoundment areas. Muskrat -2, Mink -2, Beaver -2, Waterfowl -2.

10. The meandering river was of good quality for aquatic furbearers but lacked diversity of habitat. Mink -2, Muskrat -3, Beaver -2, Waterfowl -3.

11 & 12. This area appeared good for all species surveyed except beaver. The interspersion of wetlands to upland was adequate for all species of waterfowl. The cattail and sedge surrounding the wetlands were ideal habitat for mink and muskrat. Mink -1, Muskrat -1, Waterfowl -2, Beaver -3.

13 & 14. The area is characterized by a series of beaver impoundments along the surface drainages. These impoundments had fringes and good sedge and cattail emergent vegetation. Channelization was in evidence along the river to the north east of the lake. Tree cover was excellent to support a sizeable population of beaver. Mink -1, Muskrat -2, Waterfowl -2, Beaver -1.

15. The quality of habitat was excellent for all aquatic anaimals. The diversity of habitat provided by the emergent aquatic vegetation was equal to that of Buffalo Bay and the South Heart River complex (Unit 39 and 40). Waterfowl -1, Muskrat -1, Mink -1, Beaver -3.

16 & 17. Locations of active Bald eagle nests.

Figure 8. Wetland Habitat at the west end of Lesser Slave Lake.

Figure 9. The west end of Lesser Slave Lake, showing extensive marsh vegetation.

K. Ambrock, July, 1978

walleye, cisco, and lake whitefish - have all shown progressive declines in abundance (Alberta Fish and Wildlife Division, Alberta Recreation, Parks and Wildlife unpublished data). In 1965 the whitefish fishery collapsed and was closed until 1972; in 1971 the cisco fishery collapsed and still remains closed (Handford et al. 1977). However, the west end of Lesser Slave Lake remains an extremely important and productive area for fish spawning and rearing (Dietz pers. comm.). Immediately after the ice leaves in late April or early May, walleye spawn in the Heart River delta and up the South Heart River and East and West Prairie rivers. These are the only known walleye spawning and rearing areas in the lake and they are therefore extremely important (Dietz pers. comm.). Whitefish and cisco require gravel, rubble, hard substrate and clear water for spawning and rearing. Big Stony, and similar inshore, shallow areas, are extremely important for rearing (Dietz pers. comm.).

Pike, an important sport fish, spawn primarily in the shallow, inshore, weedy areas of Buffalo Bay and the Heart River delta. Fishermen angle for trophy-sized pike from the Grouard bridge. Spottail and emerald shiners, an important food source for the larger fish species, have extremely high populations in the west end of the lake (Dietz et al. in press).

4. <u>Social and Cultural Values:</u>

a. Settlement and land use: Fur traders began settling near Lesser Slave Lake early in the nineteenth century. In 1818 the Hudson's Bay Company built Fort Waterloo near the present site of Grouard, then a shipping port. Grouard became the centre of one of the earliest settlements in the north. Agricultural settlement became the dominant land use after construction of the Edmonton, Dunvegan and British Columbia Railway in 1914 and 1915.

Currently, agricultural development is expanding along the South Heart River channel and along the south shore of Lesser Slave Lake (Doberstein pers. comm.). Floodplain areas are being burned to prepare sites for grazing. The result of intensified agricultural development has been a loss of waterfowl habitat and fish spawning areas, especially in the low marshy shoreline areas in the west end and along the south shore of Lesser Slave Lake (Doberstein pers. comm.). The local landowners have formed a public interest group known as the Lesser Slave Lake Water Level Control and Development Association. They are exerting pressure for the maintenance of Lesser Slave Lake water levels between 575.8 m and 576.4 m (Primus 1968). Alberta Environment has recently announced that lake levels will be stabilized.

Three paved highways and several gravel highways provide access to the region. Highway 2 provides all-weather access to Grouard and Grouard Mission. Roads associated with lumbering, oil exploration and forestry permit access to the more sparsely populated portions of the area (Tracie and Anderson 1970).

The area is generally considered economically depressed; unemployment is high and per capita income is low. Population is sparse and scattered and a significant proportion of the population is native and Metis (Athabasca River Basin Planning Unit 1977).

However, the Lesser Slave River basin is rich in natural resources. The Swan Hills boast one of the province's larger oil fields and exploration is active. Forest products are another major resource of these hills. Sub-bituminous coal in the Slave Deposits underlie the southern portions of the study area (Government and University of Alberta 1969).

Sport fish and wildlife abound and the basin provides a significant portion of Alberta's sport fishing and hunting resources (Athabasca River Basin Planning Unit 1977).

b. Native use: The natives of the area belong to the Athapaskan linguistic group (Government and University of Alberta 1969). Two native settlements, the Lesser Slave Lake and Big Prairie, and one Indian Reserve, the Pakashan, are located around the north end of the area. The major land uses are agriculture, subsistence hunting and fishing, some trapping and a few commercial fishing operations (Dietz pers. comm.). Fishermen holding commercial licences work out of Faust and Joussard.

c. Hunting and recreation: Recreational hunting is a common use of most of the area. Hunter access into the better waterfowl sites is fair, and the larger lakes, bay areas and marshes receive a moderate amount of hunting pressure (Weaver 1970). Several shorelands have the capability for more intensive recreational use. The eastern side of Shaw Point, for example, has an excellent beach with fine sand, a gentle gradient and an attractive, slightly elevated backshore (Tracie and Anderson 1970).

d. Development proposals: During July 1978, the Minister of Alberta Environment announced that a lake stabilization scheme would proceed. Discussions between Canadian Wildlife Service and Alberta Environment personnel indicate that although the scheme design has been clarified, much more hydrological information is required before a design can be finalized (Ambrock pers. comm.).

5. Sensitivity: Ambrock (memo dated 24 July 1978) postulated the possible effects of Alberta Environment's proposed lake stabilization project on fish and wildlife resources in the west end of Lesser Slave Lake:

> 1) The Heart River "delta" (upstream of Lesser Slave Lake) and Buffalo Bay on the west end of the lake provide several thousand hectares of excellent waterfowl breeding (and probably staging) habitat. These areas are shallow and would be seriously affected by the proposed lowering of the lake level. In addition, it is likely that prime spawning habitat for northern pike and lake whitefish would also be eliminated.
>
> 2) A large, unnamed marsh at the outlet of the lake also provides good quality migratory bird habitat and would be directly affected by the channelization scheme.
>
> 3) A pair of trumpeter swans were found to breed downstream of the lake near the Lesser Slave River. This is a new nesting record for this species. Since details of the project design have

not yet been revealed, it is not known whether this species will be affected.

4) The lake supports large populations of colonial birds, notably white pelicans, western grebes, other grebes species and Franklin gulls. These species are susceptible to lake level fluctuations. The pelican colony has heretofore been unrecorded. To my knowledge the western grebe colony of over 500 nests is the largest colony of this species in Alberta.

5) The lake supports a good raptor population. Approximately seven active bald eagle nests were located during the preliminary field investigation.

Since specific details of the project design have not yet been finalized by Alberta Environment, it is difficult to predict the precise effects the channelization scheme could have. Doberstein (pers. comm.) suggested that regulation of annual water levels to eliminate periodic flooding along the shorelands of Lesser Slave Lake could have profound effects upon the existing fish and wildlife habitat of these areas.

6. Knowledge Gaps: There is a wide range of water resource management problems in the Lesser Slave Lake basin. Severe erosion occurs in the Swan Hills because the steep slopes allow a runoff that is too fast for the highly erodible soils. This situation is worsened by the numerous survey lines that criss-cross the area. The resultant sediment which settles out in the lower reaches of the various streams and in the lake has become a problem during recent years. Discharge problems in the Lesser Slave River, resulting in high lake levels and shoreline flooding, have also been recorded (Athabasca River Basin Planning Unit 1977).

The Lesser Slave Lake basin will be subjected to increased levels of development in the fields of oil and gas exploration, lumbering, recreation, possible hydroelectric development and, to a lesser extent, mixed farming. All of these activities, coupled with past attempts to alleviate flooding problems, will affect the hydrological characteristics of the basin (Ambrock pers. comm.). Therefore it is important that a wildlife data base be acquired to assist planners in developing a multidisciplinary water management plan for the basin before further development takes place (Doberstein pers. comm.).

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D. Utikuma Lake

1. General Description: Utikuma Lake is located in north central Alberta approximately 35 km north of Lesser Slave Lake (Figure 1). It is part of an extensive wetland area (Figure 10) centred in the Utikuma Upland Physiographic region (Government and University of Alberta 1969). Surficial deposits are glacial in origin. Two main types have

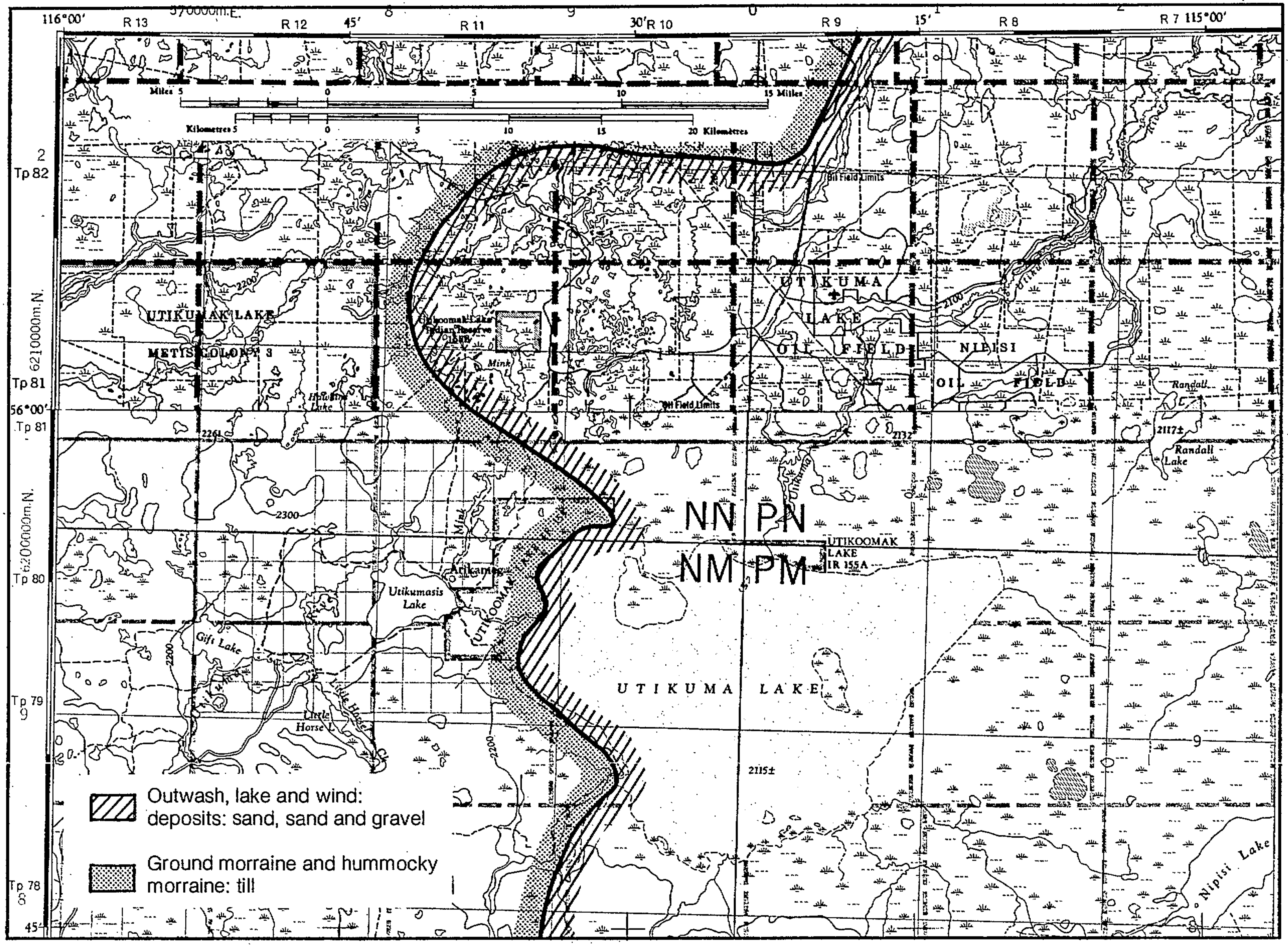

Figure 10. Surficial geology of the Utikuma Lake area.

been identified (Figure 10):

a) outwash lake and wind deposited sand and sand and gravel, and

b) glacial till in the form of ground and hummocky moraine.

Canada Land Inventory has been completed for the Utikuma Lake area (Schick 1970, Wynnyk et al. 1971, Anderson and Dykstra 1972). Surficial geology and related vegetation types have recently been grouped into a biophysical land classification for the Alberta Land Inventory (Bossenberry pers. comm.).

Most of the land surrounding Utikuma Lake is covered with organic wetland deposits and is not productive for forestry. The tills in ground moraine are most evident on small islands of undulating to gently rolling areas along the west side of the lake (Prokopchuk and Archibald 1976).

The climate of the area is continental, consisting of long, cold winters and short, warm summers. Mean temperatures for the coldest month, January, range from -8.9°C to 0.0°C, while for the warmest month, July, the mean temperatures range from 21.1°C to 23.9°C (Government and University of Alberta 1969). The last spring frost occurs before May 15; the fall frost usually occurs between September 1 and September 15. Mean annual precipitation is approximately 500 mm (Government and University of Alberta 1969).

The closest towns are High Prairie, approximately 70 km southwest, and Slave Lake, 100 km southeast.

Utikuma Lake was selected as a potentially sensitive area because it is an extremely important moulting lake for large numbers of waterfowl, particularly canvasback ducks (Turner pers. comm.).

2. Hydrology: No specific hydrologic data were located for this area. General comments on water-vegetation-wildlife relationships are incorporated in the following subsections.

3. Biological Resources: The Utikuma Lake area is located in the mixedwood forest section of the Boreal Forest region (Rowe 1972).

Two major vegetation types occur in the areas surrounding the lake. Mixedwood associations of aspen and balsam poplar, jackpine, white spruce and balsam fir occur on the higher, better drained sites. A black spruce sphagnum moss association is widely distributed on the wetter, lowland sites. The latter association is extensive to the north, east and south of Utikuma Lake. Southwest of the lake, deciduous stands reach productive status for forestry, but the majority of the study area is assessed to be non-productive forest land.

Information on ungulates, bears or furbearers is not available. Canada Land Inventory field surveys have been completed but assessment and map preparation are in progress

(Map Library, Energy and Natural Resources, Edmonton).

The most important wildlife aspect of this area is the use of the extensive wetlands and shallow offshore areas by migrating waterfowl. Use in this area by waterfowl has been documented since the early 1960's (Alberta Aerial Survey 1962, 1963, 1964; Schick 1970; Donaghey 1974; Pryor 1977).

A variety of waterfowl are found in the area. Among the most common nesting ducks are the mallard, blue-winged and green-winged teal, American widgeon, lesser scaup and common goldeneye. The white pelican (Figure 11), merganser, American coot and common loon are also found. Schick (1968) recorded 500 pelicans on a small island in southeast Utikuma Lake (Figure 11). Cormorants nest on the rocky outcrops of a small island in the eastern portion of the lake (Dietz pers. comm.). The great blue heron has often been sighted, but no nesting colony is known in the area (Schick 1970). Large numbers of common terns and California gulls also nest in the area (Dietz pers. comm.).

Numbers of birds observed on this lake are astounding. "Utikuma Lake is absolutely fantastic - I have never seen as many ducks in my life in one area" (Lacy 1962). Concentrations of ducks in the hundreds of thousands are not uncommon. Totals for ducks observed on Utikuma Lake during early Ducks Unlimited surveys were 209 300 (1963), 156 300 (1964 and 151 585 (1965). Of these approximately 30% were canvasbacks. This trend has continued to most recent times.

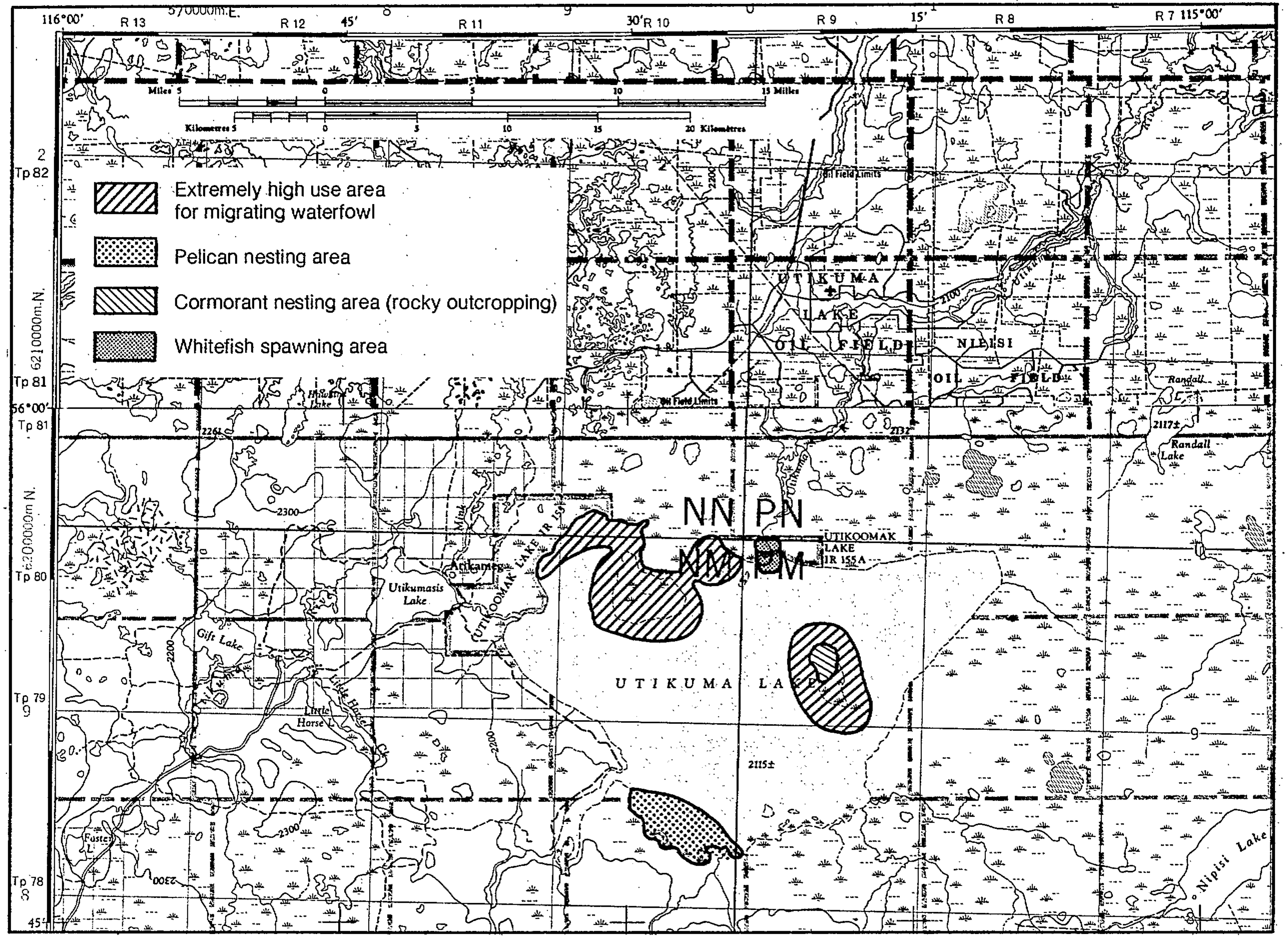

Figure 11. Critical areas for waterfowl and whitefish in the Utikuma Lake area.

Pryor recorded 23 000 moulting canvasbacks during an August, 1977 survey. He also sighted 15-20 000 coots and 1300 pelicans. The canvasbacks may represent a large proportion of the western North American population (Turner pers. comm.).

The habitat is rated as important for migrating waterfowl (Schick 1970, Figure 12). The shorelines are not marshy, but solid and well defined, and have bulrushes as the dominant emergent species. Along many parts of the shoreline, fluctuating water levels and strong wave action have prevented a greater variety of plants from becoming established. The lake has good sedge and grass uplands bordering the shore which provide good nesting cover. The most heavily used areas occur around the two marshy islands and in the bay areas along the northwest shoreline of Utikuma Lake (Turner pers. comm.).

Areas north and west of Utikuma Lake are rated good for migration stops. These smaller sloughs and lakes have a more complex fringe of bulrushes, cattails, sedges, and coarse grasses such as northern reed grass and spangle top. Low soil and water fertility tend to restrict the growth of desirable submergent vegetation. The most abundant species of submergent and floating aquatic vegetation are pondweeds. Among other species found are common coontail, northern water-milfoil, duckweeds, arrowhead and water smartweeds (Schick 1970).

Utikuma Lake is eutrophic. Due to high nutrient

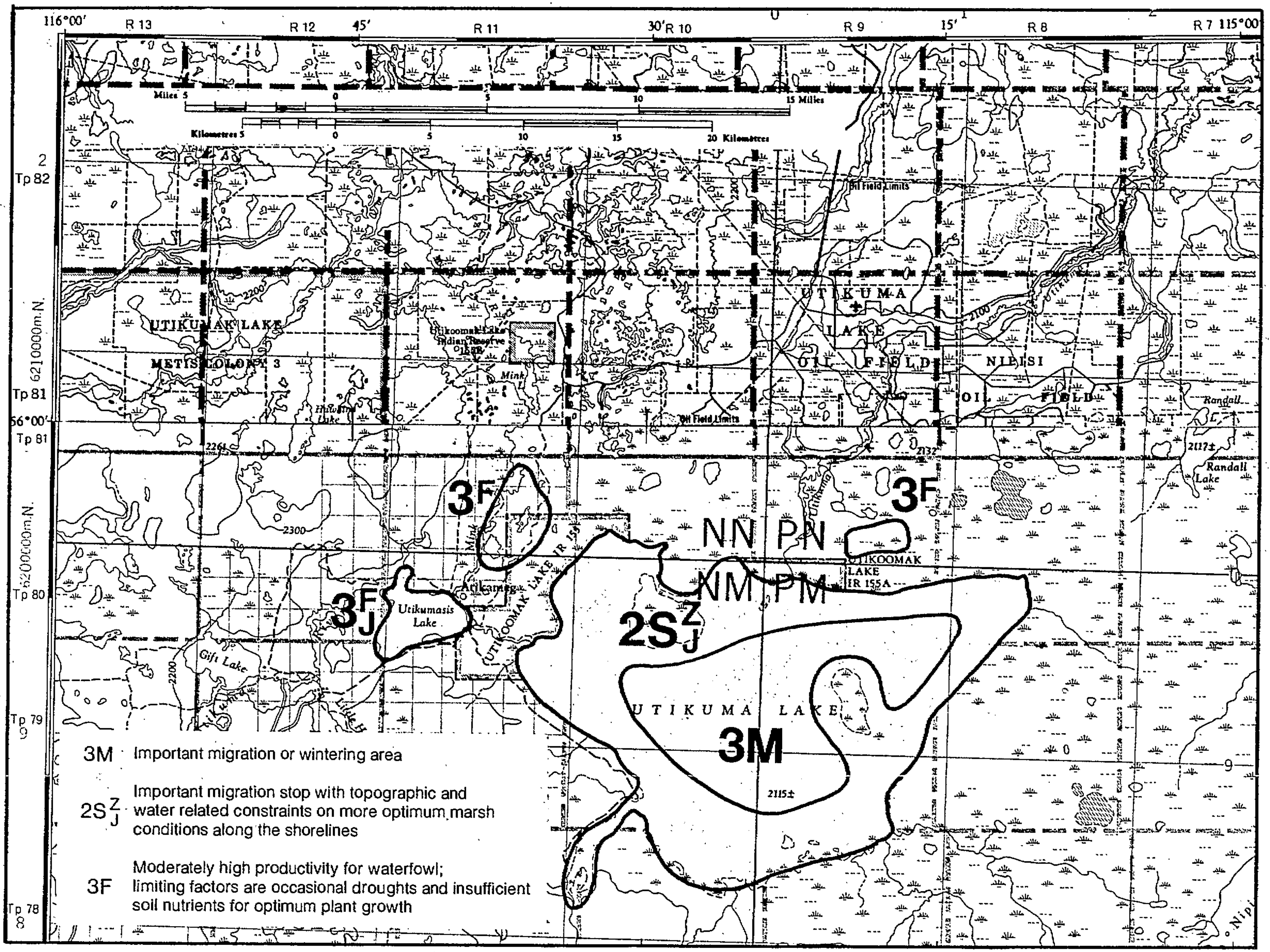

Figure 12. Waterfowl habitat in the Utikuma Lake area.

loading, Utikuma is the most productive lake for whitefish in Alberta. The whitefish of the lake have a higher productivity rate than any recorded in the literature for this species. Whitefish spawn in the outlet of Utikuma Lake in the mouth of the Utikuma River. Northern pike are present in large numbers. Cisco (tullibee), a small herring-like fish, occurs in smaller numbers. Reports on fish populations in Utikuma Lake are in preparation (Dietz pers. comm.).

4. Social and Cultural Values: The main economic activities in the Utikuma Lake area are the petroleum industry and commercial fishing. However, lumbering, mixed farming, mink ranching and outfitting contribute substantially to the regional economy (Schick 1970).

Two oil and gas fields, Utikuma and Nipsi, are being exploited north of Utikuma Lake (Figure 13). Pipelines carry the product to Edson and Edmonton, Alberta, to hook up with trans-Canada petroleum arteries (Figure 13).

The fisheries are being utilized by native fishermen from the area (Figure 14). Commercial fishing also continues on a small scale. Incomes of fishermen are often supplemented by seasonal employment in the petroleum industry. Commercial fishermen are known to travel from High Prairie, Joussard and Slave Lake (Dietz pers. comm.).

Mink ranching, once a large scale industry in the Utikuma Lake area, is now carried on by only three ranchers. The decline was due to over-fishing of tullibee, an important

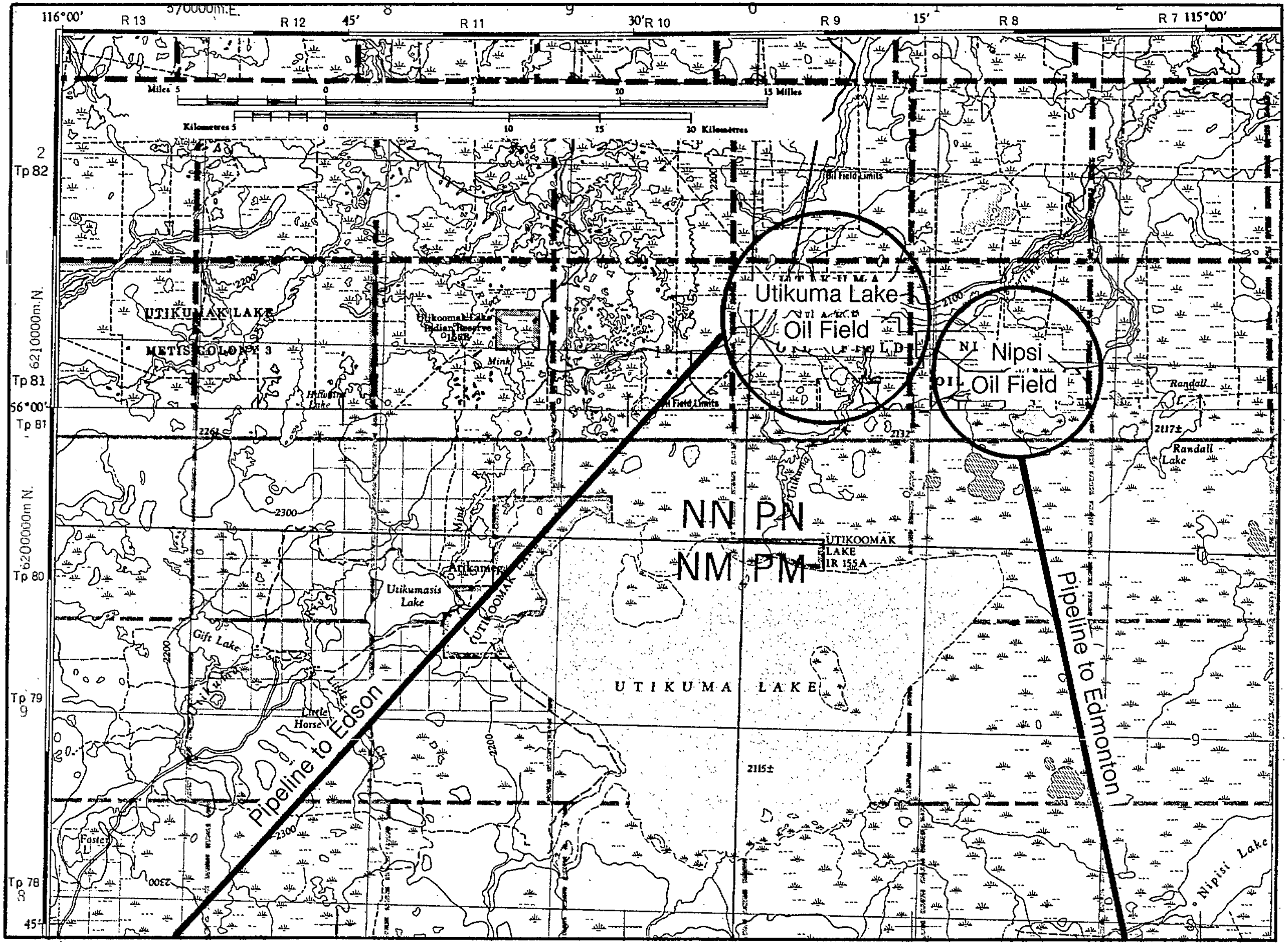

Figure 13. Gas and oil fields in the area of Utikuma Lake.

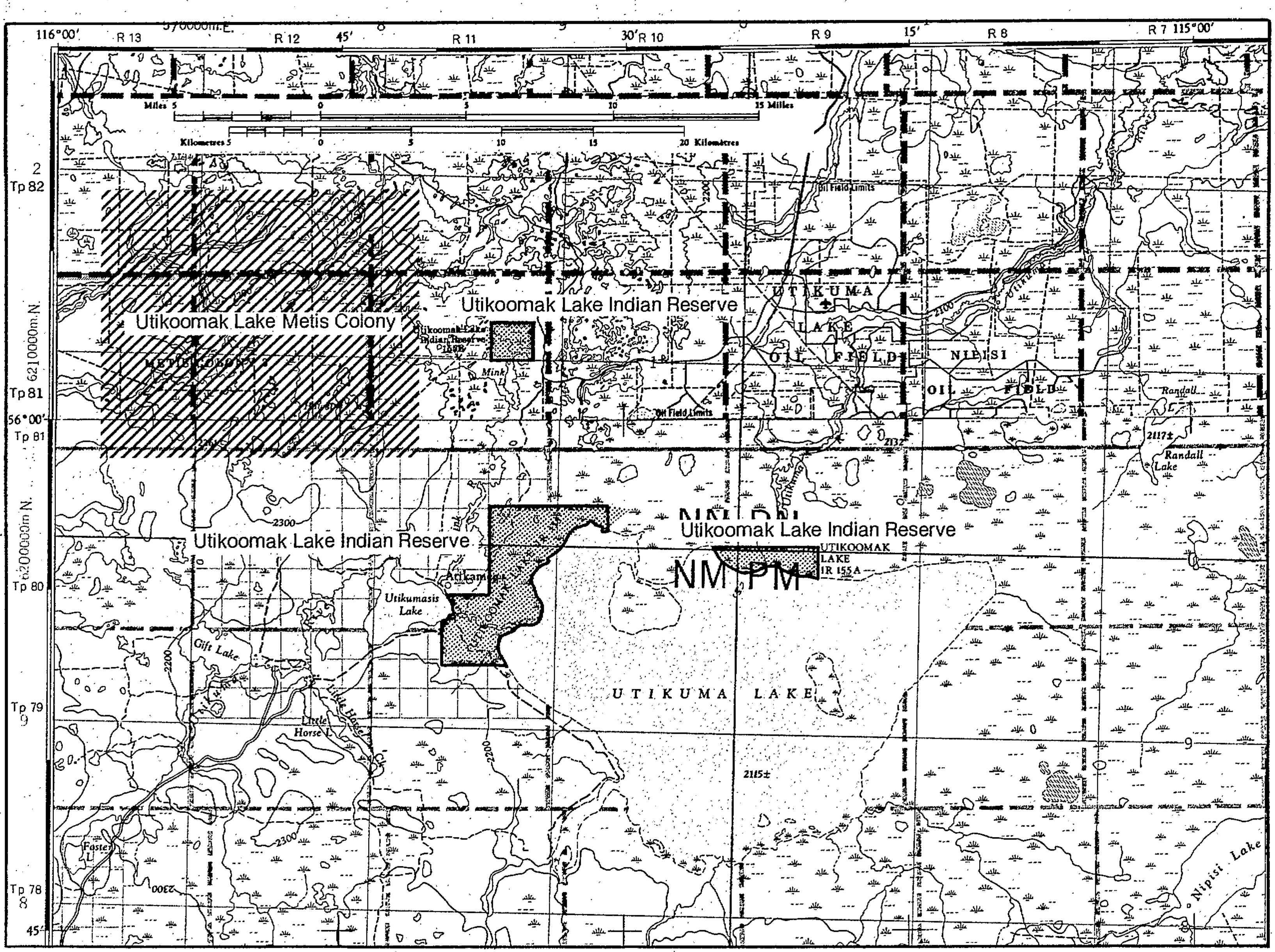

Figure 14. Indian Reserves in the area of Utimuma Lake.

food for mink, in Utikuma Lake (Dietz pers. comm.).

5. Sensitivity: Fluctuating water levels in Utikuma Lake have, in the past, affected its use by moulting, nesting and migrating waterfowl. During high water years, growth of emergent and submergent vegetation is severely impeded and available nesting cover is reduced. During the 1965 Ducks Unlimited aerial surveys, lake levels were reported to be very high. The lake was flooded into the trees and muskegs contained open water. As a result, lower waterfowl utilization was reported (a decrease from 1963 of 25.3%). The increased depth of water may have covered up the sago beds retarding their growth during summer (Lacy 1965).

In some years, drought conditions have been responsible for impeding plant growth and thereby reducing habitat quality (Schick 1970). It is not known how these fluctuations affect the sport and commercial fisheries or the spawning success of whitefish and pike; but lower water levels could reduce available spawning habitat (Dietz pers. comm.).

6. Knowledge Gaps: It is apparent that the natural vegetation-hydrologic relationships in the Utikuma Lake area are extremely important to waterfowl. A more detailed and quantitative study of water levels and vegetation relationships will be required if water-related developments are to be proposed. The prime habitat areas occur where water levels fluctuate; higher levels to prevent succession to shrub and

tree species, and lower levels to allow growth of submergent, emergent and floating vegetation. The natural fluctuations result in highly productive waterfowl habitat in the Utikuma Lake area. Although Alberta Fish and Wildlife Division, Alberta Recreation, Parks and Wildlife are investigating the fisheries of the lake, it is not known how natural fluctuations affect spawning success. Location of spawning areas are also generally unknown (Dietz pers. comm.).

The low, marshy areas surrounding Utikuma Lake should be productive for aquatic furbearers and moose. No data are available on local populations.

In other areas of the Province where waterfowl use is high concern has also been expressed that oil and gas operations and equipment maintenance could interfere with breeding success. For example, during staging and resting periods on Hay-Zama Lakes, restrictions have been placed on helicopter and air boat activities (Ward pers. comm.). Further work could be initiated to monitor the effects of these activities in the Utikuma Lake area.

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E. Hay-Zama Lakes Area

1. General Description: The Hay-Zama Lakes wetland complex, a floodplain of the Hay River, lies approximately 660 km north northwest of Edmonton, Alberta (Figure 1). The area is part of the Alberta Plateau physiographic region, the highest division of the Great Plains region of North America. There are two distinct landscapes: the meadow lowland in the northern portion at an average elevation of about 335 m, and the forested upland in the south which rises to about 760 m. The southwestern part is a till plain of

variable topography which ranges from gently undulating to hilly (Figure 15).

The Hay-Zama floodplain is a complex of shallow marshes and lakes, each surrounded by low levees created by existing or defunct stream channels. The floodplain is composed of silt and clay alluvial deposits plus small, scattered gravel beds.

The northern lowland portion is underlain with glacial lake deposits of silt and clay (Figure 15). Along the Hay and Chinchaga river valleys near Zama and Hay Lakes is a flat, open, marshgrass meadow. Clumps of willow occupy the low, wet sites and stands of aspen cover the drier, better drained elevations. Muskeg areas are scattered throughout. The area immediately adjacent to Hay and Zama Lakes is known as the Hay Lake prairie. It consists of open, level, lacustrine plain covered with lush grass and interspersed with willow groves.

The climate of the area is extreme, with long, cold winters (January mean temperature -12.9°C) and short, warm summers (July mean temperature 16.7°C). Annual precipitation is about 355 mm, occurring mainly during the summer months. The growing season is short, averaging only 75 frost-free days per year (Government and the University of Alberta 1969).

Settlement is dispersed in small, isolated communities. Two small predominantly Slave Indian villages, Habay

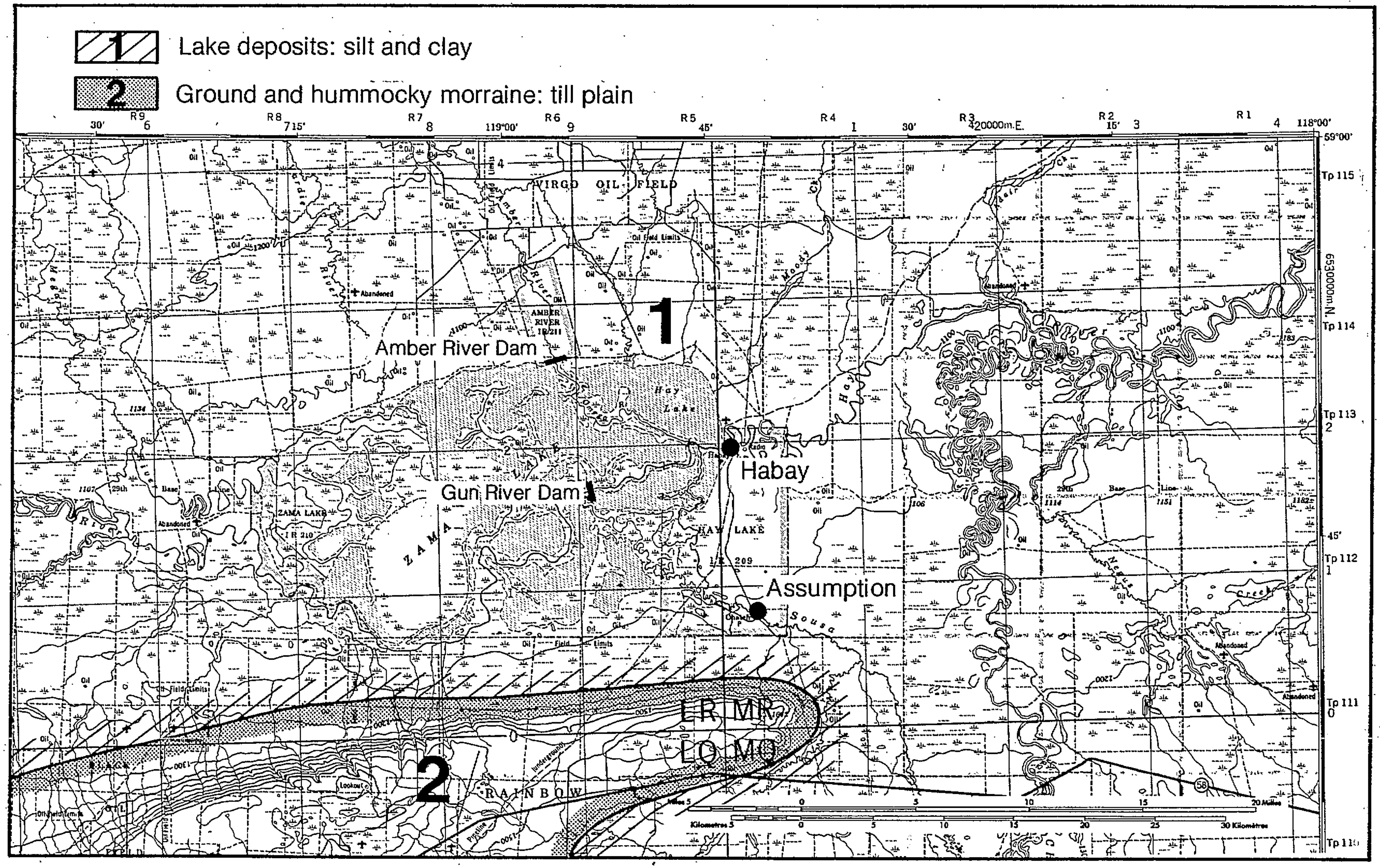

Figure 15. Surficial geology of the Hay-Zama Lake complex.

and Assumption, are located on the Hay Lake Indian Reserve (Figure 16).

The area was chosen because it is an extremely important migration stop for large numbers of ducks and geese using both the Pacific and Central flyways (Stephansson and Turner pers. comm.).

2. Hydrology: The study area is part of an extensive level to depressional lacustrine plain. The region is drained by the Hay River, which flows westward into British Columbia before re-entering Alberta to flow through the Hay-Zama Lakes complex. Tributaries of the northern lowland portion are the Little Hay, Mega, Vardie, Amber, Zama and Chinchaga rivers and Negus, Sausa and Burnt creeks. Stream gradients are low and drainage is poor.

The levels of the lakes and the Hay River are subject to seasonal fluctuations and in some years, because of impeded drainage, parts of the grassland are flooded in the spring.

Canada Water Survey has a station at Hay River near Meander River, and near the village of Hay River. Total discharge data are available at the latter from 1964 to present. There is quite a large year to year fluctuation in volumes of water carried in this river and these fluctuations are reflected in water level fluctuations in the Hay-Zama Lakes complex. During 1976, the total discharge was 193 664 hectare-meters at Hay River, while in 1973 and 1977, during

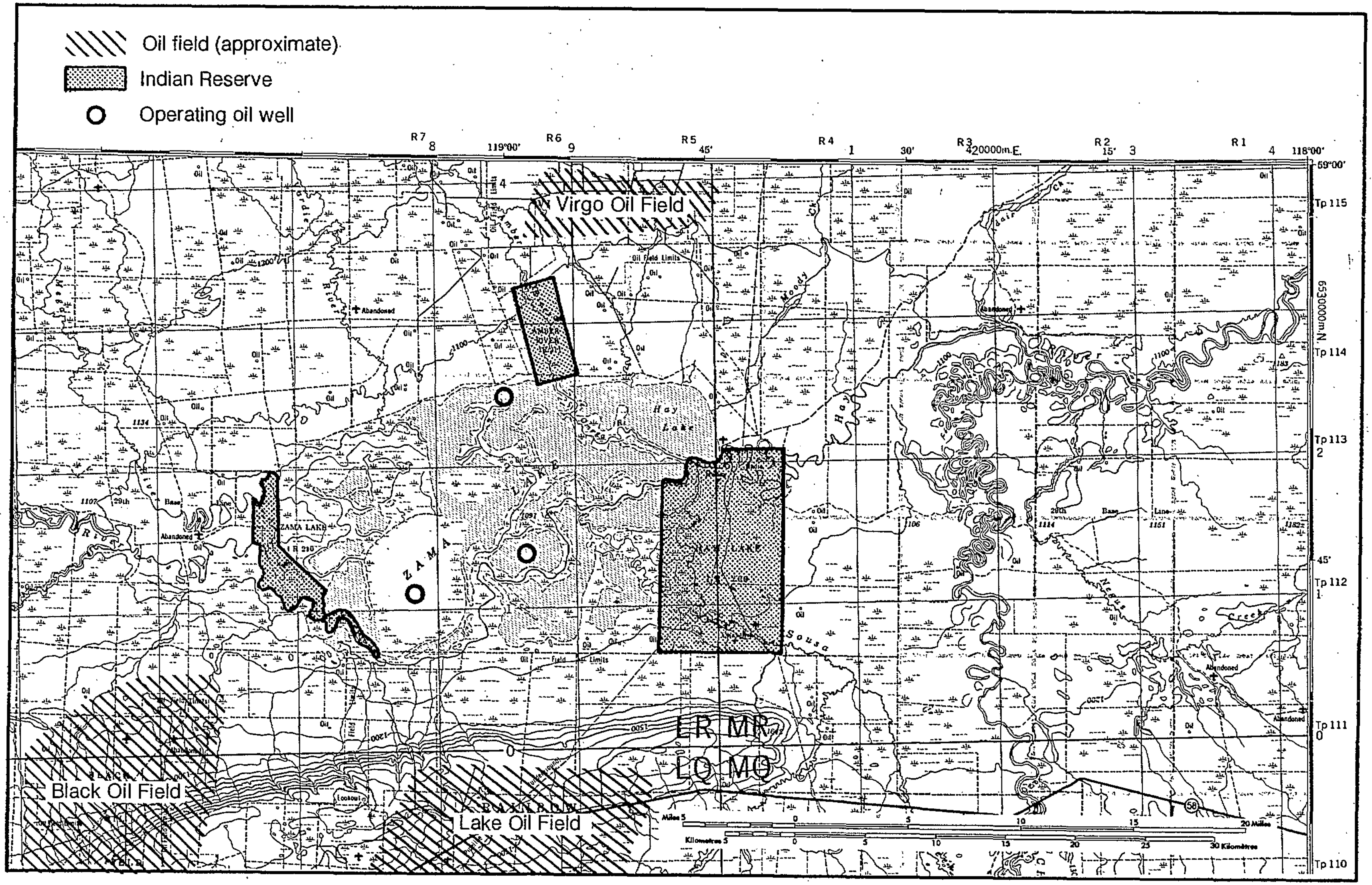

Figure 16. Indian Reserves in the Hay-Zama Lake area.

high flood years, 392 261 and 513 147 hectare-meter annual discharges were recorded at the Hay and Meander River stations respectively (Canada Water Survey 1977).

Within an annual cycle, large variations in flow have been recorded sporadically, with observed effects in the Hay-Zama Lakes complex. For example, Hennan and Macaulay (1974) reported a 3.56 m difference between maximum and minimum water levels on the Hay River in 1973, and differences of 0.76 m, 0.70 m and 0.24 m for their gauges on Zama, North Zama and Duck Lakes. Three peaks were recorded for the Hay River during that year, one shortly after break-up during the third week of May and two in summer attributable to abundant rainfall in the watershed. These extreme hydrologic conditions likely would result in depressed nesting success over an extensive portion of the floodplain (Hennan and Macaulay 1974). The flood and recession qualities for the hydrologic regime of Hay-Zama Lakes complex are analagous to a delta complex. Spring highs flood perched basins such as Duck Lake (Figure 15), adding nutrients and moisture for quick growing emergent vegetation. This prepares excellent, highly productive waterfowl staging and feeding areas throughout the floodplain.

Macaulay (1969:3) reported similar annual variations for earlier years:

> 1967 was a year of very high spring water levels, evidenced by the flooding conditions, which inundated parts of the village of Habay.

> 1968 water levels were considerably lower in the spring (the Hay River was 1.5 m below 1967 levels at the time of high water, which seems to be during the second week of May). The fluctuation in water levels during the summer reaches its peak during late June, and by mid-August has stabilized.
> The total water drop in the marsh complex was 48 cm. This figure was recorded in Zama, East Hay, and West Hay Lakes.

Water fluctuations also create unstable beaches, which change from year to year, limiting their usefulness for development or management of the area for increased habitat value.

Water movement patterns are complex in the Hay-Zama area. Kelland (1967a) explained:

> During very high water periods, such as those experienced during 1962, Hay, Zama, and other lakes contribute water directly to the Hay River. Under lower water conditions drainage is from Zama Lake into West Hay Lake and from West and East Hay Lakes into the Hay, via the Amber River. Sand Lake flows into the Hay via the Gun River. As a result of water action at overflow points, channels have been cut between lakes and rivers. Two dams [indicated in Figure 15] were built [by Ducks Unlimited (Canada)] as water control structures for both Sand and Hay Lakes. Breaks in the dykes adjoining the dams allowed water levels to drop at rates less than would have been observed if the dams were not present at all.

But perturbations to vegetation from annual water level fluctuations have been extremely significant for wildlife habitat.

> Differing water level conditions, in the lakes investigated, have apparently resulted in the observed distribution of plant associations. Length of time of water coverage, relative stability of water level and plant succession seem to have been the most important factors involved. . . . The <u>Agrostis</u>, <u>Calamagrostis</u> and <u>Bechmannia</u> associations around Zama Lake were covered with small amounts of water, for short time periods in

> spring; minor differences in depth, length of time of coverage and probably depth of water table during the [growing] season seem to have been the main causes for the differentiation of these "grassy" associations. (Kelland 1967a)

Extreme flooding may occur one in 10 to 15 years (Macaulay 1969). Relative droughts are occasionally experienced as well. Highly fluctuating water levels result in variable waterfowl utilization. The Ducks Unlimited Hay Lakes dams (Figure 15) provide protection against drought by retaining spring flood waters. However, during high flood years such as 1977, feeding areas for geese are inundated and cannot be used. Hennan and Macaulay (1974) discussed the problem of determining how to remove floodwaters rapidly enough to provide for better habitat management, or alternatively, how to protect portions of the floodplain from extreme water level fluctuations.

3. Biological Resources: The open, level lacustrine plain around the Hay-Zama Lakes complex is one of the largest unoccupied areas of native grassland in northern Alberta. Major components are marsh reedgrass, rough hair grass, sloughgrass, spike rush and manna grass, interspersed with sedge and clumps of willow (Weaver 1971a). (See also Kelland 1967a,b, and Macaulay 1969 for species lists and vegetation types.)

The Hay-Zama Lakes complex provides a large block of waterfowl producing habitat with very good production capability (Weaver 1971). Waterfowl production is slightly restricted by a seasonal fluctuation in water levels and occasional flooding during spring runoff, and by drawdown in late summer. Except for the Hay-Zama Lakes complex, the region has little suitable habitat for nesting or migrating waterfowl. Most of the surrounding landscape is comprised of lands rated poorly for waterfowl production by the Canada Land Inventory (Weaver 1971). The limitations are adverse topography and low soil and water fertility (Figure 17). The dam sites at the Gun and Amber rivers attract large numbers of waterfowl early in the season. This is probably due to early open water in the fast current areas close to the dams (Kelland 1967a).

A few species of diving ducks and nearly all species of surface-feeding ducks common to Alberta nest in this area. The most common are mallard, American widgeon, shoveler, green-winged teal, pintail, lesser scaup and canvasback. An abundant variety of shorebirds, as well as coots, grebes, and a few geese also nest in the area. Total numbers of swans fluctuate greatly both season to season and day to day. A September 1964 survey recorded 88 swans. Thirty-two thousand swans were counted 1 October, 1959. The next day only 12 birds were seen (Sugden 1964).

Fluctuating populations of waterfowl from year to year have been attributed to water levels in the Hay-Zama Lakes complex. "This year, even more land appeared under water than in 1963. Mud flats were nonexistent." Declining use was

2S. Important migration stop; limitation to further habitat functions is excessive water level fluctuations which adversely affects the habitat or the nesting success. (Weaver 1971).

4F. Moderate limitations to waterfowl production; limitation is insufficient nutrients in the soil and water for optimum plant growth.

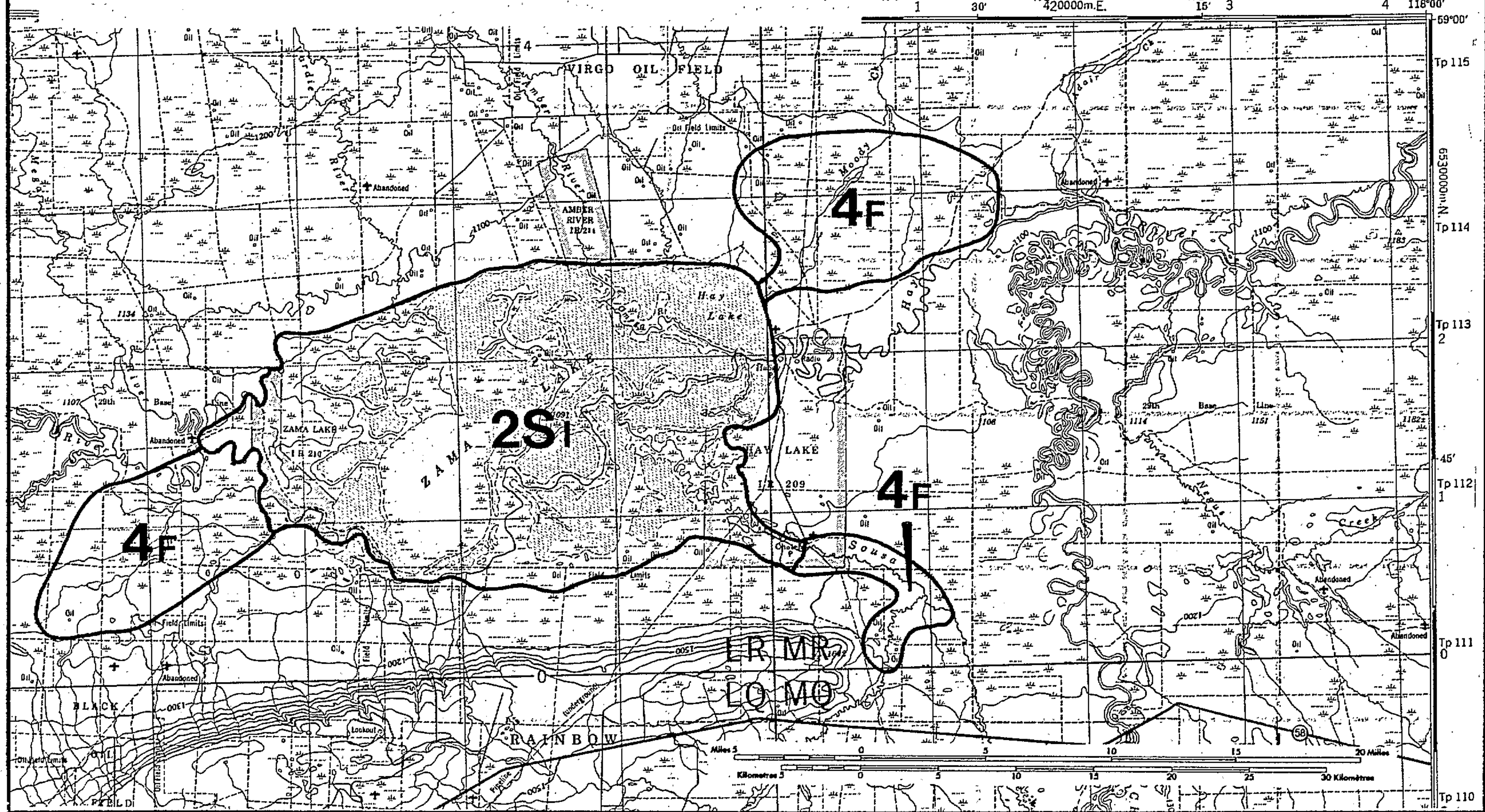

Figure 17. Waterfowl habitat in the Hay-Zama Lake area.

recorded for ducks and geese (Sugden 1964).

This floodplain complex is the most important spring and fall migration stop in nowthwestern Alberta for northern birds. It is estimated that each spring and fall several hundred thousand ducks and many thousand geese visit this group of wetlands (Weaver 1971). Kelland (1967) summarized the results of fall goose surveys between 1959 and 1964. As many as 550 Canadas, 13 200 whitefronts and 130 000 snow geese were seen in single surveys prior to the extreme flood year of 1961.

During a one day waterfowl survey in 1973, 15 000 geese - mostly Canada's with some whitefronted - and 35 000 ducks - mainly pintail and mallard, along with scaup and goldeneye - were seen (Ambrock pers. comm.). During their spring and fall surveys, Ward and Gollop (1978) recorded the following estimates:

	Spring	Fall
Maximum total geese	5 588	13 688
Maximum total ducks	54 032	+160 000

Macaulay (1969) ranked five areas of the floodplain in descending order of duck utilization. North Zama Lake ranked number one for use by staging, moulting and immature ducks. The presence of bulrush cover in the area appeared to be important.

Moose are sparse in the northern meadowlands, but the southern forests contain a large population. There are black bears throughout the area (Sabine et al. 1971).

During mid and late summer, fishing for northern pike, the most numerous species in the area, is excellent in most creeks and rivers, particularly at the confluence of the Chinchaga and Haig rivers (Schmidt pers. comm.). Pickerel, perch and walleye are found in all streams near Zama Lake.

4. Social and Cultural Values:

a. Settlement and land use: The human population of the area is dispersed in small isolated communities (Figure 15), but much use has been made of the area for oil and gas extraction. Three oil and gas fields encroach upon the Hay-Zama Lakes complex (Figure 15). The development of the Rainbow Oil Field was expected to make this region one of Canada's larger oil and gas producers (Weaver 1971), but reserves were not nearly as high as originally expected (Ward pers. comm.). However, extensive oil exploration and development in this area has left a well-developed system of rough roads and airstrips. A trailer town located at Rainbow Lake was to be the forerunner of a new community based on oil extraction (Sabine et al. 1971).

Very little of the area is cultivated, mainly because of climatic limitations. However, much of the land around Hay and Zama Lakes produces wild hay and pasture. Small scale lumbering, trapping and hunting are also important to the local native economy (Schmidt pers. comm.).

Air travel produces the only dependable access to the area between spring thaw and fall freeze-up. Therefore, although waterfowl hunting success is becoming well known, overall hunting pressure is still light (Weaver 1971).

b. Recreation: Hay and Zama Lakes are large shallow sloughs not suitable for motor boats, but the annual late summer and autumn stopover of migrating geese is an interesting phenomenon. Scenic terrain occurs along the Hay River from Rainbow Lake west to the British Columbia boundary, and in the hills to the south. The lower Chinchaga River provides an interesting example of extensive river meandering. The Hay River east from Habay and much of the Chinchaga River may support canoeing. But generally, the area is suited for only extensive forms of recreation; hunting, fishing, canoeing and viewing (Figure 18, Sabine et al. 1971).

5. <u>Sensitivity</u>: Fluctuation of water levels has been shown to be essential to maintaining vegetation in early stages of succession. This interaction of water levels and plant succession has resulted in the six plant associations and six miscellaneous plant communities. Emergent vegetation is an important food source for the tens of thousands of migrating waterfowl that rest and feed in the Hay-Zama Lakes complex (Kelland 1967a).

Alterations of this natural pattern have effectively altered the quality of the shoreline habitat. Hennan and

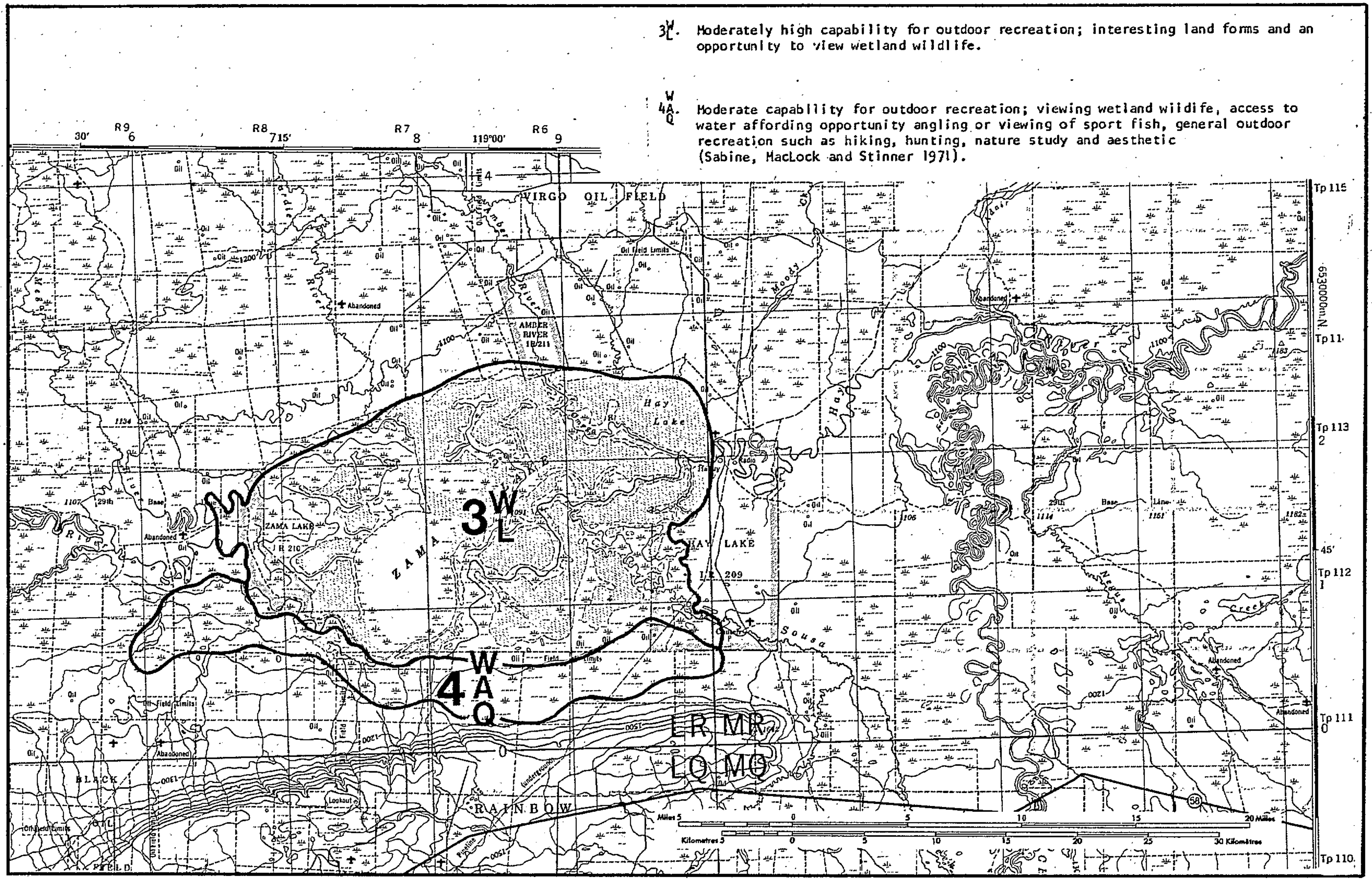

Figure 18. Recreation capability of the Hay-Zama Lake area.

Macaulay (1974) stated that flood control on the larger lakes, as well as some of the peripheral marshes, will allow greatly increased production. First priority in a management scheme should be to prevent extreme water level fluctuations in East and West Hay Lakes. Then the production capacity of the relatively high concentrations of breeding pairs on the larger floodplain can be realized (Hennan and Macaulay 1974).

6. Knowledge Gaps: Use of the area by migratory birds has been well documented (Kelland 1967a,b; Macaulay 1969; Lungle 1972, 1973; Ambrock 1973; Hennan and Macaulay 1974; Ward and Gollop 1978). Ducks Unlimited (Canada) also has had many years of involvement in the area (Hennan and Macaulay 1974). Only very preliminary work in outlining the hydrologic regime has been completed. Factors that contribute to the magnitude and the location of water level fluctuations are not understood. Kelland (1967a) attributed piling up of water to winds over Zama Lake. These, he felt, accounted for most of the observed variation in shoreline, although the slow drop in water level over the season is still indicated. Macaulay (1969) argued that fluctuations in the shorelines of Zama Lake can be attributed to the morphometry of the lake basin. Sugden (1964) suggested that an ecological study should be undertaken. Kelland (1967a) agreed:

> Extensive flooding in the early 1960's has apparently resulted in the destruction and redistribution of emergent vegetation around the lake shores. Subsequent recession has allowed the reestablishment of much plant life. An excellent

opportunity exists for the study of plant succession following a natural drawdown.

Hennan and Macaulay (1974) recommended a management program for this important migration and breeding area. Combined baseline information on the hydrologic regime and vegetational changes of this area would be required.

Due to the presence of easily erodable lacustrine deposits in many of the areas where oil exploration is occurring, it is important that environmental effects of these activities be investigated. It is particularly important to determine if sedimentation of streams and lakes is occurring and if it is detrimental to resident fish and migratory bird populations.

Areas around Hay-Zama Lakes should be highly productive for furbearing mammals, especially muskrat and beaver, but no inventory has been done. Surveys of fish spawning and rearing areas could provide additional information toward an understanding of historic hydrologic relationships and requirements in the Hay-Zama Lakes complex.

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F. Fond du Lac River - Elizabeth Falls

1. General Description: The Fond du Lac River lies in the extreme north-central section of the Province of Saskatchewan and is located in the Canadian Shield (Figure 1). The Fond du Lac River originates at Wollaston Lake and flows in a northwesterly direction, ultimately discharging into Lake Athabasca, draining an area of 81 920 km^2. Elizabeth Falls and the section of the Fond du Lac from Elizabeth Falls to Lake Athabasca are the two areas designated potentially sensitive (Figure 19), because they support a superb sport fishery for arctic grayling. They are also part of an historic waterway (Lewis pers. comm.).

The river follows the interface between two major biogeographical divisions. The northeast portion is Precambrian rock while rock of the later Athabasca formation, a mixture of sandstone and pebble conglomerate, predominates to the southwest (Figure 20). The Precambrian section is considerably folded and faulted with steep hills. Valleys and depressions, commonly occupied by lakes or muskegs, are typical of the area underlain by the Athabasca formation. Ridges and hills seldom rise more than 61 m above the level of nearby lakes (Envirocon Ltd. et al. 1975).

The physiographic regions of the area have been mapped (Richards and Fung 1969, Figure 21).

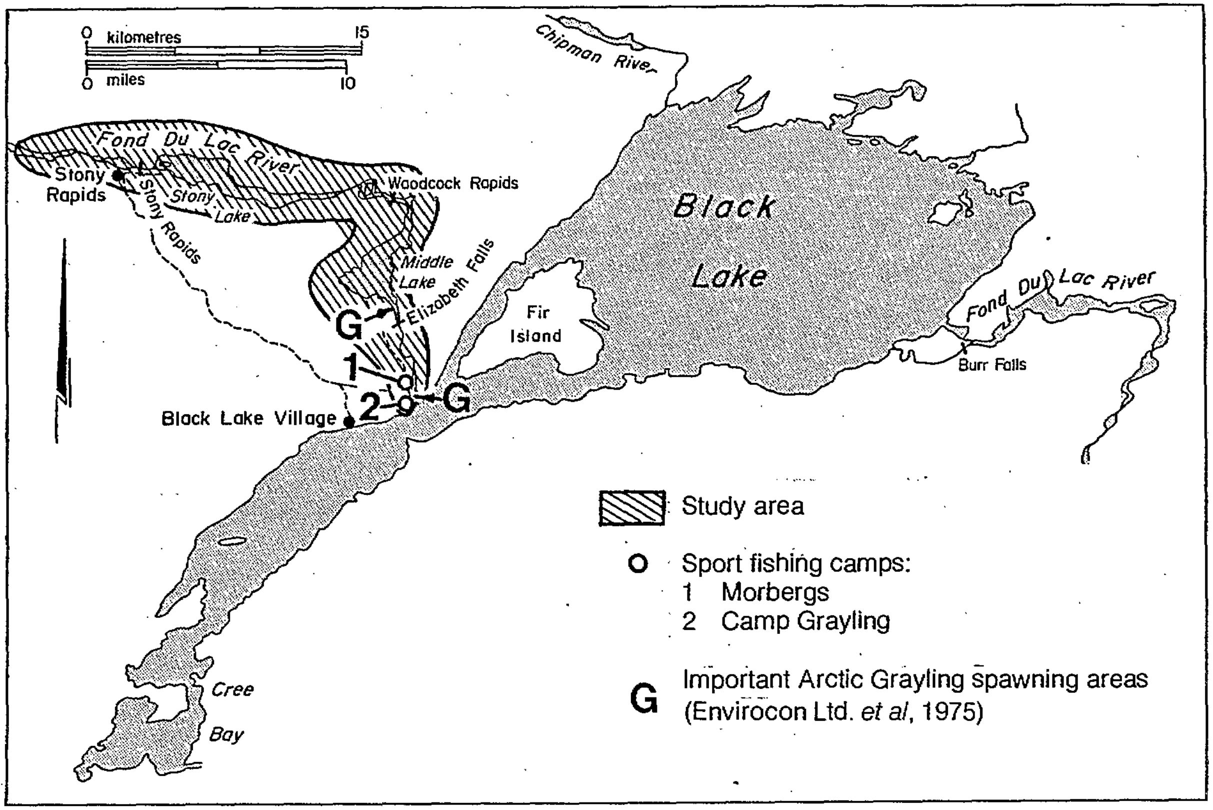

Figure 19. Sport fishing camps and arctic grayling spawning areas of the Fond du Lac River and Elizabeth Falls.

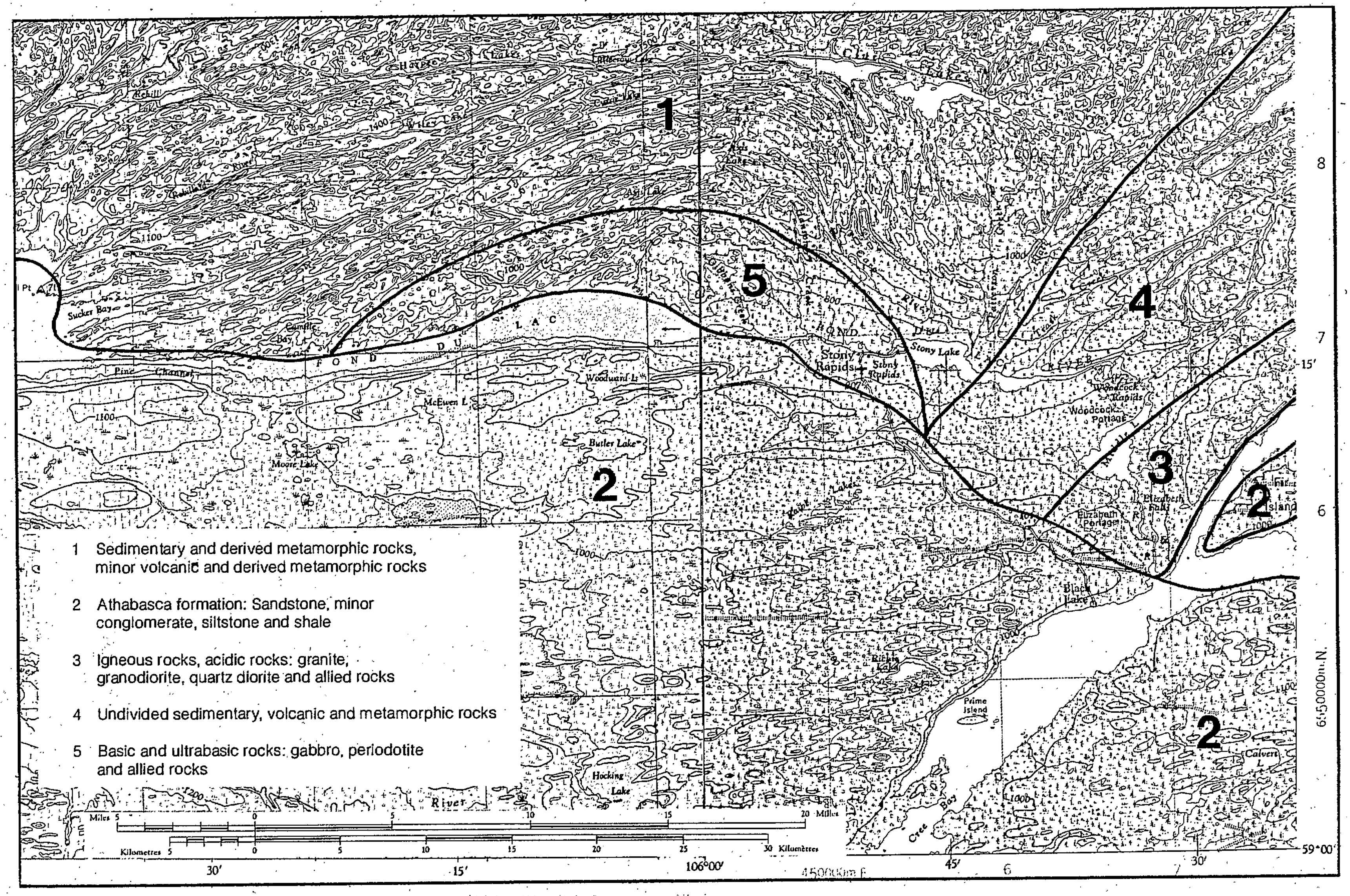

Figure 20. Surficial Geology of the Fond du Lac River area.

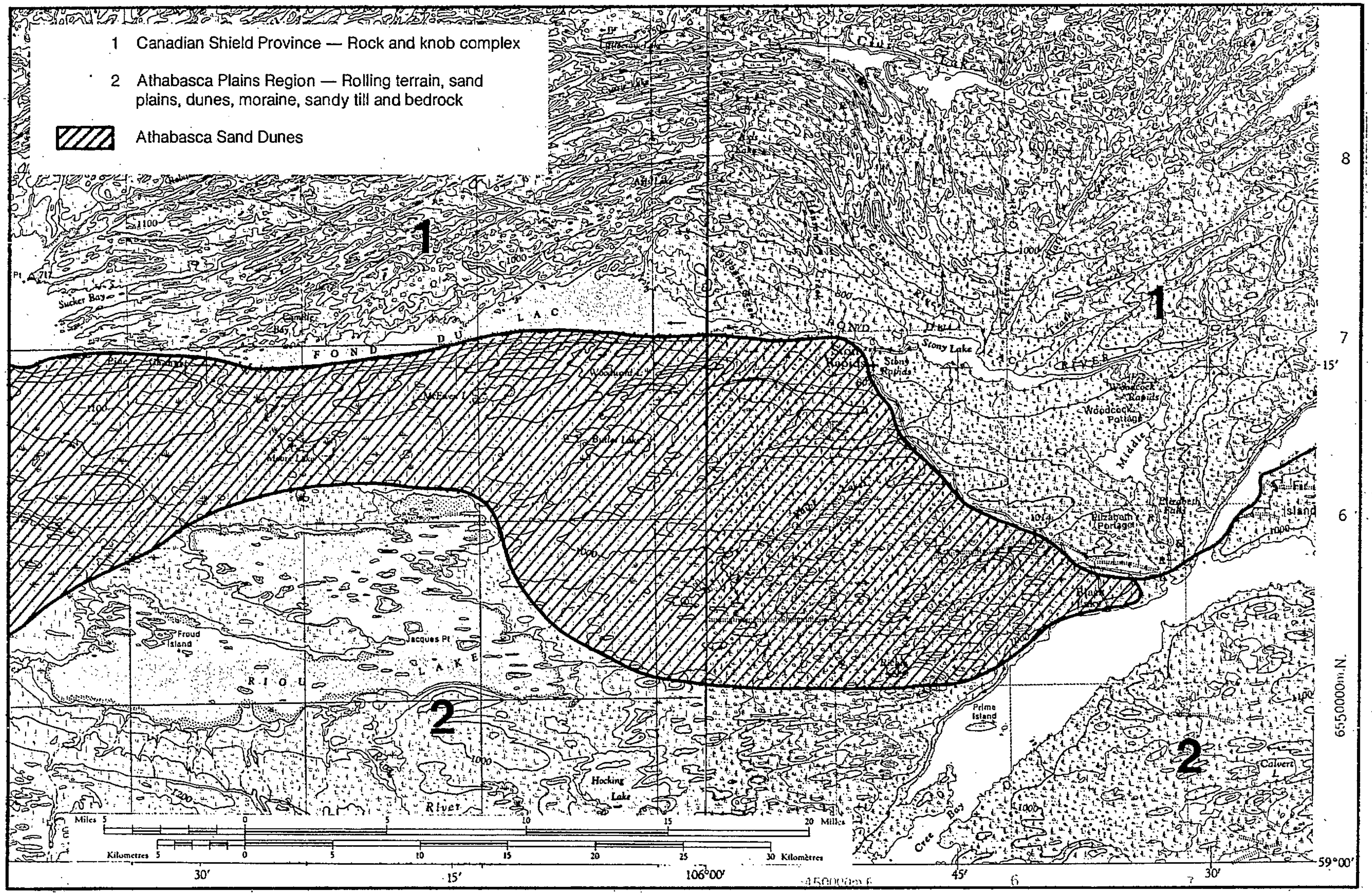

Figure 21. Physiographic Regions of the Fond du Lac River area.

> The southern edge of this physiographic province is roughly demarcated by numerous lakes, many of which lie in the zone of contact between sedimentary and Precambrian rocks. Most lie between 366 and 549 meters above sea level, rising to over 549 meters at a few scattered locations. The lowest area is the Lake Athabasca-Fond du Lac lowland (213 to 366 meters). Local relief rarely exceeds 18 meters but gives an impression of roughness and even ruggedness. Pre-existing structural and lithological variations facilitated the excavation of rock basins and the scouring of rock knobs and roches moutonées by glaciers. Glacial deposition also occurred, the types of deposits including eskers, kames, glacio-lacustrine deposits, and ground moraine, the last mainly sandy and of shallow depth.
>
> Bedrock exposures and wetlands are characteristic features of the Shield. Rock basins and old drainage channels, their outlets blocked by glacial deposits, are occupied by water and, indeed, any depression in the bedrock is likely to be occupied by lake, muskeg, bog or marsh.
>
> The Athabasca Plains Region has been distinguished from the Rock Knob Complex because the former is underlain by sandstones, siltstone and conglomerates of the Athabasca Formation, whereas the latter is an area of metamorphosed igneous and sedimentary rocks. Further, the Athabasca Plains Region is a discontinuous, sandy, drift plain in which eskers, drumlinoid features, glacial lake plains and meltwater channels are locally prominent. Neither bedrock exposures nor lakes are as widespread as in the Rock Knob Complex. (Richards and Fung, 1969)

There are two small native settlements in the area: Stony Rapids, located upstream from Lake Athabasca on the Fond du Lac River, and Black Lake village, located near the outlet from Black Lake (Figure 19). The population of Stony Rapids is approximately 100; the population of Black Lake is about 300, most of whom are natives. A 22.4 km road connects Stony Rapids with the Black Lake settlement as well as Camp Grayling and Morberg's fishing camps on the Fond du Lac

River near Black Lake (Figure 19, Envirocon Ltd. et al. 1975).

The Elizabeth Falls portion of the Fond du Lac River is located between Black Lake and Middle Lake. It is approximately 3.2 km long and flows due north. Along this portion the topography of the eastern shoreline is very rugged, consisting mainly of large granite boulders and numerous cliffs which rise abruptly from the water's edge. The western margin is highly variable but generally shows a lower relief. Granitic outcrops are numerous along the downstream portion of the western shoreline (Envirocon Ltd. et al. 1975, J. D. Mollard and Associates Limited 1970, and Underwood McLellan and Associates Limited 1970).

The Fond du Lac section of the study area enters from the southeastern arm of Middle Lake and exits around numerous islands in the northwest arm on its route to Lake Athabasca. Two small, permanent streams, and four intermittent streams enter Middle Lake from the Precambrian region to the northeast. Two unnamed streams that enter the lake from the south provide outlets for shallow lakes and marshes in the southwestern section of the drainage basin.

Much of this section of the river is stony and shallow, and rapids are common. Stony Lake, a small, shallow, elongated waterbody (essentially a widening in the river) is typical of the morphometry of the river channel. Bedrock geology and physiography along this area are similar to the Elizabeth Falls section as the river flows along the interface between distinctly different landscapes (Figures 20, 21).

2. Hydrology: Only general information is available concerning the hydrologic characteristics of the Fond du Lac River. The discharge regime is moderated by several lakes along the river course, the largest of which is Black Lake upstream of Elizabeth Falls. These lakes act as storage areas and reduce the spring peak, but maintain flows during fall and winter periods. Durable rocks of the Precambrian Shield control the morphometry of the stream channel in many locations. For example, the Elizabeth Falls section has a steep river gradient between Black and Middle Lakes. Here the river drops 36 m through a series of 7 short, steep rapids (Envirocon Ltd. et al. 1975).

3. Biological Resources: The vegetation of the region is classified as boreal forest. North of the river in the Northwestern Transition section, black spruce dominates, accompanied by white spruce on favourable soils. South of the river in the Athabasca South forest section, jackpine dominates on the extensive sandy soils, with black spruce and larch on the finer textured soils. Poplar and white spruce are common along the lakeshore, and the fire-disturbed areas typically support white birch (Rowe 1972). A forest fire in 1973 burned a large area on the shoreline of Middle Lake and along the Fond du Lac River to the Elizabeth Falls area (Envirocon Ltd. et al. 1975).

The Fond du Lac - Elizabeth Falls area does not support high populations of mammals or birds, but moose, barren-ground caribou, black bears, timber wolves and coyotes are common in the area. As well, mink, marten, otter, beaver, muskrat, fisher, fox, wolverine and lynx may be sighted (Envirocon Ltd. et al. 1975).

Bald eagles rely heavily on the Fond du Lac River and associated habitat, and Middle Lake is an important nesting or staging area for whistling swans and other waterfowl. The most important wildlife resources in relation to possible changes in the hydrologic regime are the fish. Species common in the area include arctic grayling, lake trout, northern pike and walleye (Envirocon Ltd. et al. 1975).

At least two distinct arctic grayling populations exist, one at the outlet of Black Lake upstream of Elizabeth Falls and the other at the inlet to Middle Lake below the falls (Figure 19). Although individuals of each population are relatively sedentary, spawning site characteristics were generally the same at both locations. Required conditions included:

1) a rocky, gravel substrate,
2) a period of rising water levels in spring,
3) break-up of ice and an accompanying rise in water temperatures (Envirocon Ltd. et al. 1975).

4. <u>Social and Cultural Values</u>:

a. Current land use: The sport fishing in the

Elizabeth Falls section of the Fond du Lac River is highly regarded by both tourist fishermen and local residents. Here fishing consists of on-shore angling for arctic grayling. The uniqueness and quality of this fishery is exemplified by the fact that the Fond du Lac grayling are reputed to be some of the largest available in northern Saskatchewan (Envirocon Ltd. et al. 1975).

In 1974, approximately 490 sport fishermen spent $410,000 on fishing trips to the Fond du Lac area. Of this, $58,000 to $65,000 contributed to the local economy (Envirocon Ltd. et al. 1975).

A sports fishery also operates during the summer at Black Lake. It offers excellent angling for lake trout, northern pike and walleye. Two fly-in tourist camps with main lodges on Black Lake (Figure 19) are responsible for most of the angling pressure on grayling and lake fish populations (Envirocon Ltd. et al. 1975).

b. Historic values: The area was travelled by explorers as early as 1796. David Thompson and J. B. Tyrell explored some of the area (Figure 22). It is not known if these areas have been proposed for preservation as historic waterways.

Seven archaeological sites are known to exist along the Elizabeth Falls - Fond du Lac section (Envirocon Ltd. et al. 1975, Figure 22).

Two trading posts were located near the outlet of

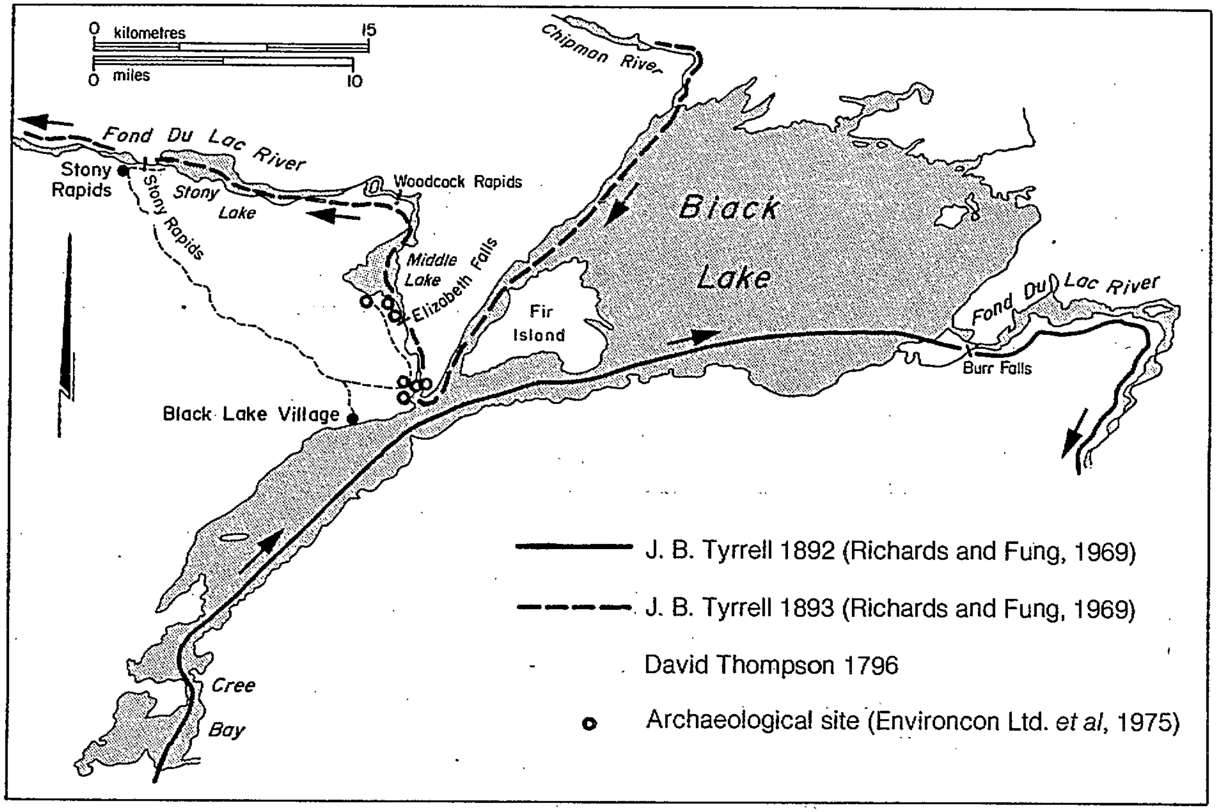

Figure 22. Early travel routes in the Fond du Lac River area.

the Fond du Lac River at the east end of Lake Athabasca. The Northwest Company ran the Fond du Lac post from 1800, while Hudson's Bay Company operated Harrison House around 1819 (Richards and Fung 1969).

c. Proposed development: The only proposed development was a hydro power installation at Elizabeth Falls. This plant was to provide power for uranium mines at Clough Lake and Wollaston Lake, Saskatchewan. The proposal was shelved and the companies switched to diesel plants when discussions over native land use claims tied up development in the entire Fond du Lac area (McClement pers. comm.).

5. <u>Sensitivity</u>: Fish, particularly arctic grayling, are the most important wildlife resource of this area. The fish species in the river and lakes of the adjacent areas are highly dependent on existing hydrologic conditions. Any disruption of this regime, especially to known spawning areas, will greatly affect the grayling populations (Envirocon Ltd. et al. 1975).

6. <u>Knowledge Gaps</u>: The environmental overview and assessment of fisheries resources upon which most of the previous discussion was based, was conducted over a small portion of the Lower Fond du Lac River. Little, if anything, is known of the downstream areas from Middle Lake to Lake Athabasca in terms of wildlife and hydrologic regime. Before development proposals could be assessed, a complete environmental assessment of the Lower Fond du Lac, including the Elizabeth Falls section, would be required.

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CHAPTER III

PEACE RIVER DRAINAGE

A. Hominka Marsh

1. General Description: Hominka Marsh is located in the lower reaches of the Hominka River approximately 160 km north northwest of Prince George, British Columbia (Figure 1). This tributary of the Parsnip River drains 1628 km^2 and provides two distinctly different environments. The upper Hominka valley has a deep, V-shaped cross profile. It has distinctive environmental attributes including a section of dramatic avalanche slopes on both sides of the valley near Hook Lake. The Hominka floodplain is in the Rocky Mountain region. However, it is intimately linked with the Parsnip floodplain, which falls within the Rocky Mountain Trench physiographic region (Trenholme 1978). The upper portion of the Hominka River is productive of Dolly Varden, arctic grayling and rainbow trout. Mountain goats are also found in the alpine areas (O'Riordan 1977). The lower Hominka River valley is, in contrast, broad and U-shaped. Well-developed floodplains have formed in the valley bottoms and contain extensive organic deposits and numerous water bodies.

The climate of the area is cold temperate to subarctic; the winters are long and cold, and the summers are short. Precipitation is moderate in the western plateau and heavy in the Rocky Mountains, much falling in the form of snow. Heavy rains are frequent in the mountains causing rapid snow melt in the spring and occasional freshets in summer and autumn.

Hominka Marsh is a potentially sensitive area because, with the Arctic Lake marshes, it is the only remaining good quality migratory waterfowl habitat in the northern half of the Rocky Mountain Trench. The Trench has long been recognized as an important migration corridor. Previously existing habitat along the lower Parsnip and Finlay rivers was destroyed by Williston Lake, as were extensive marshes by the Mica Creek reservoir (Trenholme 1978).

2. Hydrology: There are no specific hydrological data for the Hominka River (White pers. comm.), but flow regime probably compares with other rivers of the type having origin in the Rocky Mountains; a snow field storage area, early summer melt and fast flowing freshet. The peak runoff occurs in late May and June (British Columbia Fish and Wildlife Branch, Department of Recreation and Conservation 1973).

The Hominka floodplain in its lower 16 km is a slow moving, meandering stream with numerous shallow backwaters. The nutrient level in these backwaters is enhanced by seasonal flooding (Trenholme 1978).

3. <u>Biological Resources</u>: The Hominka River valley is situated in the sub-boreal white spruce-subalpine fir forest zone and the valley walls are covered by a dense forest of spruce and balsam. The vegetation of the floodplain is mainly sedge and willow with some dwarf birch (Lyons et al. 1976). Insectivorous and other unusual marshland plants are common (O'Riordan 1977).

The marsh provides important calving and winter range for moose (Figure 23). Moose can exist in most parts of the valley during the summer months, but in winter they move to traditional ranges in those river valleys where there is forage and where frozen rivers permit easy travel. As spring turns to summer, they forage on the aspen-rose seres of mixed coniferous forests and the riparian communities near sandbars. Riparian vegetation is also important during calving time. Moose calve primarily in wetland areas, especially along the extensive marshes of the river floodplain (British Columbia Ministry of the Environment 1977).

No data are available for annual productivity or harvest in the study area, but it is known that the lower Parsnip area provides more than 400 moose per year to subsistence and recreational hunters (Pearse Bowden Economic Consultants 1973).

Lyons et al. (1976) noted abundant beaver and muskrat sign in the Hominka Marsh complex. Marten, muskrat, mink, fisher, otter, wolverine, lynx, weasel, coyote, wolf and fox

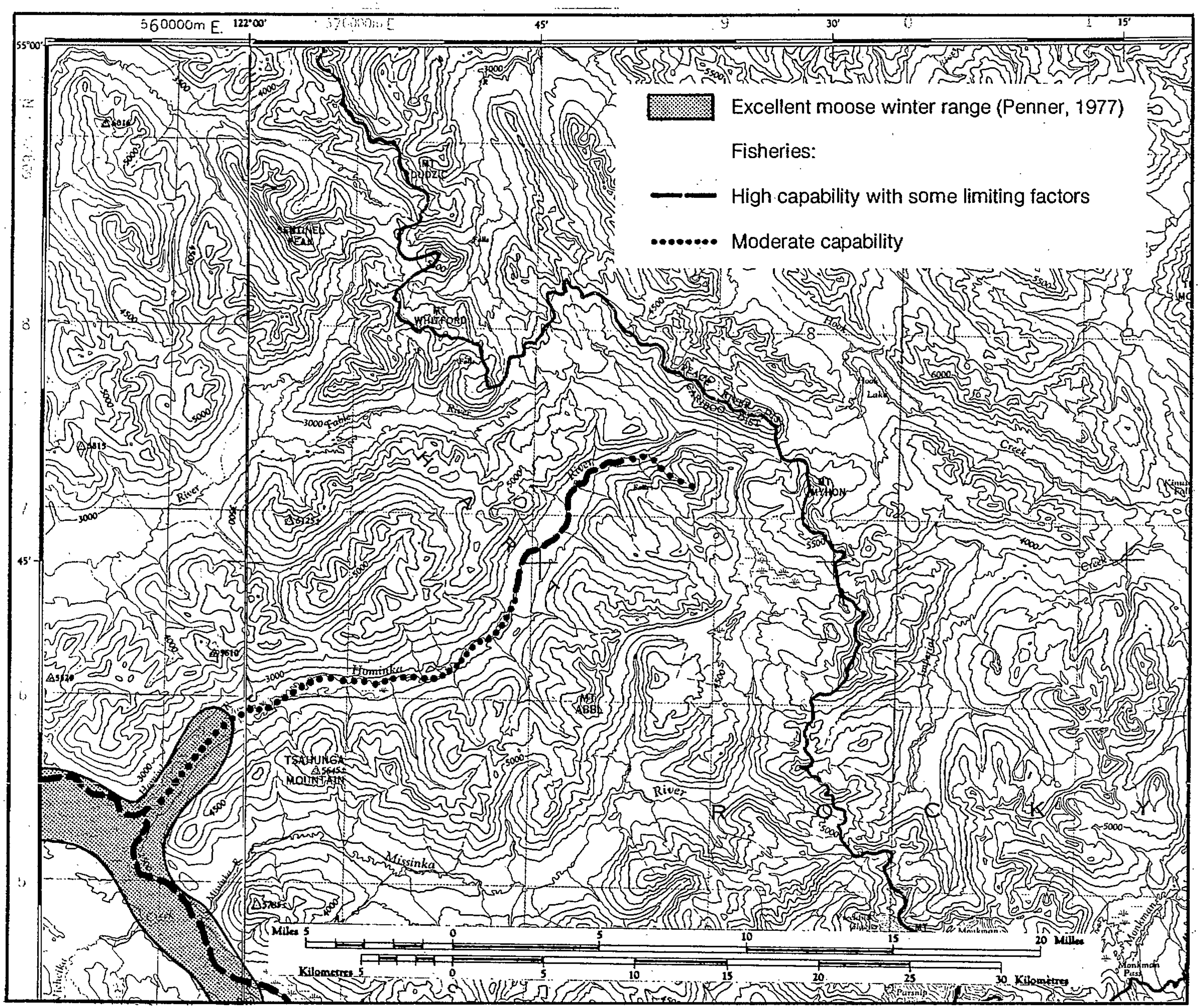

Figure 23. Moose winter Range and Fish Habitat along the Hominka River.

are known to occur in the vicinity (Pearse Bowden Economic Consultants 1973, Penner 1977a).

The marshlands of the Hominka River serve as important spring and fall migration stops for waterfowl (Taylor and Carreiro 1971). British Columbia Fish and Wildlife Branch (1973) stated that large flocks of geese, swans and ducks take advantage of early open water in which they feed and rest during spring migration. In autumn, flocks of Canada geese, ducks and swans congregate and feed in the extensive marshes of the Hominka valley. Fall waterfowl counts within the Parsnip-Hominka floodplain during 1976 yielded maximum totals of 1362 ducks, 1270 Canada geese and 18 trumpeter swans. During the fall of 1977, counts yielded maximum totals of 1420 ducks, 824 Canada geese and 5 trumpeter swans. Total utilization during the fall migration may be much greater (Trenholme 1978).

Migratory shorebirds, particularly lesser yellowlegs, inhabit the Hominka-Parsnip floodplain in August. Data are sparse and it is not possible to estimate population numbers (Trenholme 1978).

Pearse Bowden Economic Consultants (1973) reported that there is excellent sport fishing for rainbow trout and arctic grayling. O'Riordan (1977) assessed the upper reaches of the Hominka River to be most productive for sport fishing, while the slower, more eutrophic marshland waters had only moderate production capability as fish habitat (Figure 23).

Penner (1977b) discussed the extremely high sport fishing potential for the Parsnip-Hominka systems. He noted that in these areas Dolly Varden of trophy size were abundant.

4. Social and Cultural Values:

a. Current land use: British Columbia Fish and Wildlife Branch holds a reserve on the marshlands because the area is deemed extremely important for waterfowl nesting and staging. To the north, Williston Lake has flooded important waterfowl habitat. To the south, there exist no other areas of Canada Land Inventory class 3 or better waterfowl habitat north of Golden, a distance of more than 500 km.

No data are available for subsistence hunting and fishing in the Hominka River, but Pearse Bowden Economic Consultants (1973) assessed the importance of these harvests to local native and white residents in the Parsnip River valley and tributaries. Moose hunting and trapping of marten, muskrat, mink, fisher, otter, wolverine, lynx, weasel, coyote, wolf and fox occur in the vicinity of Hominka Marsh. As Indian trappers are not required to submit annual returns, so record of their harvest is available.

b. Recreation: The entire Hominka River valley is a visual unit of high scenic distinction (O'Riordan 1977). Increasing numbers of recreationists are visiting the Parsnip River valley and major wildlife areas, like Hominka Marsh (Pearse Bowden Economic Consultants 1973). Activities include canoeing, berry picking, bird watching and general wilderness recreation. The pleasures of the wilderness experience are further enhanced for many by the realization that they are, in some small part, traversing the same route as used by Alexander Mackenzie during his historic journey overland to the Pacific Ocean (British Columbia Fish and Wildlife Branch 1973).

5. <u>Sensitivity</u>: Two proposed developments if implemented will affect wildlife habitat in the Hominka-Parsnip area. Most of the available information has been collected in response to these proposals. B.C. Hydro proposes to divert flows from the McGregor River into the Parsnip. This would provide some flood protection within the Fraser River basin and also provide for the generation of additional power at the Bennett Dam on the Peace River. The proposed diversion would generate a total flow in the Parsnip River six times as great as the maximum recorded natural flow (British Columbia Fish and Wildlife Branch 1973). Diversion would significantly change the valley bottom by flooding the marshlands initially, and, in time, by either widening the present river bed or cutting a deeper channel (British Columbia Fish and Wildlife Branch 1973).

The diversion would reduce the moose population of the whole Parsnip drainage by about 50% by eliminating moose habitat on the bottomlands. About 75% of the beaver habitat and 90% of the muskrat habitat would probably be lost in the Parsnip drainage. Nesting populations of ducks and geese would be displaced and migrant waterfowl would lose nesting and feeding areas (British Columbia Fish and Wildlife Branch 1973). Environmental Research Consultants (1975) discussed the effect of possible changes in water levels:

> The effective removal of the Hominka marsh as a staging area by river control and flow modification [on the Parsnip] will result in the large numbers of migrating waterfowl being forced to find substitute staging habitat. The closest alternative areas (Stuart Lake, Bowron Lakes) are some distance away and very much smaller in total area than the Hominka marshes. They may be already fully utilized by other migrating populations. This will force Hominka waterfowl to move greater distances to their next staging site. Direct mortality (due to insufficient energy for the migratory flight) and decreased production (due to low fat reserves on arrival at the northern breeding grounds) will probably result. . . .
>
> Certain actions modifying the regime (modification of habitat, alteration of ground cover, alteration of groundwater hydrology, alteration of drainage, river flow modification) will have detrimental effects over the whole valley floor and will reduce or eliminate bird and mammal populations.

Non-resident hunting, subsistence hunting and fishing, trapping and sport fishing would be severely affected as a result of the diversion. Because the most highly used recreation areas are in the valley bottoms, loss of recreation resources could be expected (Pearse Bowden Economic Consultants 1973).

In addition, the development would allow a transfer of fish parasites from the Fraser system into the Mackenzie system (Arai and Mudry 1978). This transfer has resulted in strong objections from biologists to the proposed development. As a result, the proposal has been shelved at least temporarily (Dundas pers. comm.).

A second development proposal affecting Hominka wetlands is for a rail spur (the Hominka-Tumbler Ridge Corridor) from Anzac to Dawson Creek, British Columbia. The proposed routing is located in the Hominka River valley along the northern side of the wetland area (O'Riordan 1977).

Trenholme (1978:30) outlined possible impacts on the marsh areas in his study of the northeast British Columbia coal development area:

> If the rail line were routed through the Hominka valley to the Wolverine River and Tumbler Ridge, it would pass in close proximity to the most valuable waterfowl breeding and staging habitat in the entire Study Area. Possible adverse impacts could result from siltation, interference with present water flows, filling of wetlands, and general disturbance. The waterfowl habitat at the confluence of the Hominka and Parsnip Rivers is very valuable, and it is not very extensive . . . . Construction disturbances, such as blasting and the use of heavy equipment, could result in the temporary abandonment of the habitat by migrants. Alterations in migration patterns in succeeding years could be one consequence of route development, but this is difficult to predict.

6. Knowledge Gaps: Before proposed and additional developments could be properly assessed, much information is needed on:

a) fish habitat - additional aquatic investigations are required in order to locate preferred winter and prebreakup fish habitats, particularly for arctic grayling.

b) hydrology - continuous streamflow data are not yet available. Stations should be established along the Hominka River to determine its regime characteristics.

c) heritage resources - considerable work is required to determine the archaeological value of the area. No data are available on archaeological sites.

d) recreational use and carrying capacity - information derived during interviews for the northeast British Columbia coal study revealed increased use of the Parsnip-Hominka area by fishermen, hunters and wilderness recreationists. Nothing is known of their impact on wildlife populations or the natural environment in the Hominka Marsh.

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B. Blackwater Creek Swamp

I was not able to find very much information on this area. The general characteristics of the area were interpreted from topographic maps. Limited habitat information was obtained from the Canada Land Inventory capability for waterfowl map. There does not appear to be any specific data for Blackwater Creek Swamp.

1. General Description: Blackwater Creek Swamp is located in northern British Columbia, 45 km south of the confluence of the Finlay and Parsnip rivers and approximately

200 km north northwest of Prince George (Figure 1). The study area is an extensive floodplain west of and parallel to the Parsnip river. The swamp appears to be part of a larger U-shaped valley included in the Rocky Mountain Trench physiographic region. As such, it appears that colluvium, glacial debris and alluvial materials make up the surficial deposits. No specific data are available on climatic conditions or on vegetation in the area. The closest community is Finlay Forks, 50 km north.

2. Hydrology: No information is available on the hydrologic characteristics of the swamp or Blackwater Creek.

3. Biological Resources: The area has severe limitations for production of waterfowl (Canada Land Inventory 1971). The Canada Land Inventory rating suggests that the area may lack flowing water through wetland portions, which results in habitat of poor quality. No field surveys have been done in this area (Taylor and Perret pers. comm.). Nothing is known of other wildlife in the area.

4. Social and Cultural Values: Nothing is known about land use, hunting and trapping, or recreation potential for this area.

5. Sensitivity: No assessment of sensitivity can be made from available information.

6. Knowledge Gaps: A complete biophysical investigation of this area will have to be completed before further assessment of its potential sensitivity can be made. The

area may be one of the few remaining undeveloped wetland areas in the Rocky Mountain Trench (see chapter III A). It may, therefore, be an important migration stop for waterfowl. This should be determined before development proposals along the Parsnip River are assessed.

7. Selected Bibliography:

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C. Peace-Athabasca Delta

1. General Description: Situated in the northeast corner of Alberta, the combined delta of the Peace and Athabasca rivers is one of the better known of the areas in this report. It is bordered by Lake Athabasca and the Pre-Cambrian Shield to the east and north and by the Birch Mountains and Caribou Hills to the west and south (Figures 1,24). Fort Chipewyan, the closest settlement, sits on the fringe of the Delta. Isolated as many settlements farther north, Fort Chipewyan can be reached by scheduled aircraft or by winter road from Fort Smith. Access to the Delta is by boat, over-snow vehicle or chartered aircraft. The Peace-Athabasca Delta covers an area of 3820 km^2. To this area the Athabasca Delta contributes 1968 km^2, the Peace Delta 1683 km^2, and the Birch Delta 168 km^2 (Bayrock and Root 1972).

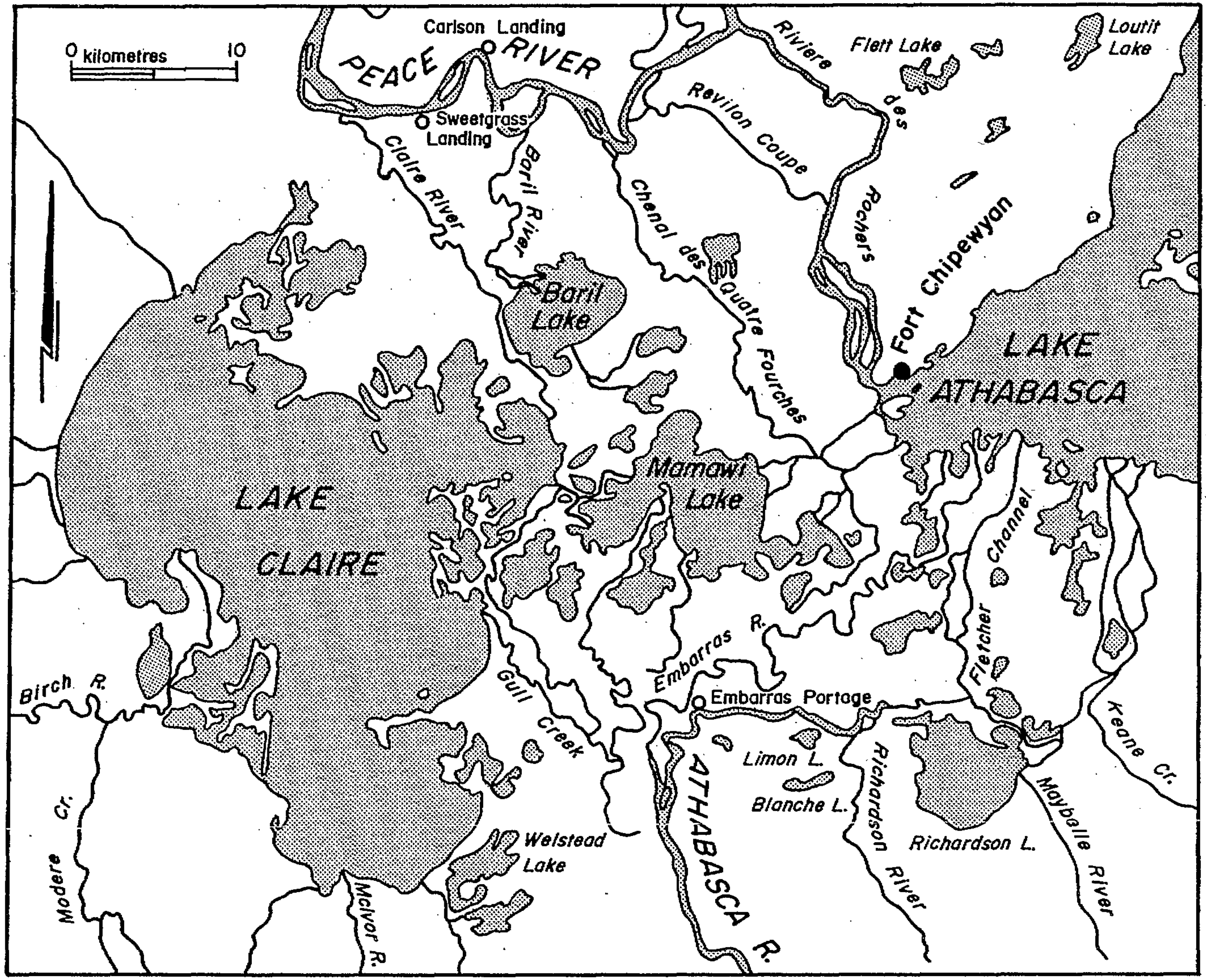

Figure 24. The Peace-Athabasca Delta.

Bayrock and Root (1972) reported on the geology of the Peace-Athabasca Delta. The following description is a summary of their work.

The Peace-Athabasca Delta is underlain by Canadian Shield granites and gneisses, Athabasca sandstone, and Devonian limestone and gypsum. The bedrock surface of the Canadian Shield has a local relief of about 61 m resulting in occasional rock outcrops surrounded by later deposits. The bedrock surfaces of the other rocks are flat.

In general, the climate of the Delta is milder than that of surrounding areas because of its lower elevation and the moderating influence of the large lakes. Surrounding areas are underlain by discontinuous permafrost, but there is no permafrost in the Delta.

In the pre-glacial period (the late Tertiary and early Quaternary) three large rivers converged in the area where the Delta now lies. One entered from the west, a second from the south and the third from the east through the present basin of Lake Athabasca. The three rivers joined and flowed north.

During the Pleistocene period the Wisconsin glacier followed the pre-glacial river valleys. As much as 3 km of ice covered the area of the Delta. The glaciers receded toward the northwest and large lakes were formed behind the retreating ice. Glacial lake beaches can be seen west of Lake Claire, west of the Slave River and on both sides of Lake Athabasca.

After the retreat of the post-glacial lake, which occurred approximately 10 000 years ago, the Peace-Athabasca Delta began to form in the pre-glacial river valleys and the depression left by the lake. Soon (in geologic terms) the entire area will fill with silt and the rivers will flow through the Delta without depositing sediments.

The separate deltas of the Peace and Athabasca rivers, although joined, can be differentiated. In the Peace River Delta deposition occurs only during floods. The Athabasca River is actively extending its delta at a rate of 1 km^2 every 4 years.

The Peace-Athabasca Delta (Figure 24) is a typical "bird's foot" delta, the result of levees building up along the distributaries to elevations above average flood levels. Distributaries commonly split and rejoin to enclose depressions which become lakes and marshes. In all active deltas, the growing part of the delta will migrate. Distributary channels become over-extended and the river abandons them to a shorter, steeper gradient to the lake or ocean. Distributary channels of the Athabasca River are over-extended to the east. Migration of the main flow of the Athabasca River more directly to Lakes Claire or Mamawi is imminent.

2. Hydrology: The hydrology of the Peace-Athabasca Delta is complex. However, an understanding of the factors affecting water levels on the Delta is central to any discussion of the area's natural resources.

Lake Athabasca, east of Fort Chipewyan, is a typical, large Canadian Shield lake. The west end of the lake is very shallow, where aeolian sediments have been distributed over bedrock. Lakes Claire and Mamawi (Figure 24) are sedimentary lakes and, although large, are very shallow. Lake Claire has a maximum depth of about 3 m and in some years is as shallow as 1.5 m. Minimum depth of water under ice in winter is 0.45 m. Mamawi is shallower, and freezes completely in low water years. Baril Lake also may freeze to the bottom. The lakes are joined by the Prairie River and receive water from the Birch and McIvor Rivers to the west and south. They also may receive water from Lake Athabasca (Bennett and Card 1972).

When levels in Lake Athabasca are high, both the Quatre Fourches channel and Prairie River run west, raising the levels of Lakes Claire and Mamawi. Most of the year both channels flow east, draining the Delta. Floodwaters of the Peace River may overflow the banks, reversing the usual flow of the Baril River and flowing overland into the Claire-Mamawi system. Overland sheet flow from floods of the Embarras channel of the Athabasca River may also add water to the Delta (Bennett and Card 1972).

Richardson Lake in the southeast portion of the Delta (Figure 24) is about 1.2 m deep and freezes to the bottom. Jackfish Creek, its connection with the Athabasca River, controls lake levels in low water years. The creek bottom is very unstable, eroding when low levels occur in the Athabasca River, and depositing sediment when levels are high. Levels of the river control direction of flow of the creek (Bennett and Card 1972).

Small lakes and basins in the Delta are among the most productive areas for wildlife. Three types of basins are found in the Delta:

a) basins having an unrestricted hydraulic connection with a large lake or river channel,

b) basins having a restricted connection with another lake or river channel. Water levels in such basins may have a direct relationship to levels of a nearby large water body at high water levels and no connection at low water levels, and

c) perched basins having no inlet or outlet channel. These basins are filled by overland flooding and depleted largely by evaporation and transpiration. In 1971 perched basins averaged a net loss of 0.45 m (Bennett and Card 1972).

Most Delta basins are lined with impermeable clays (Bayrock and Root 1972).

Ice is a major factor influencing water levels in the Delta. Many outlet channels freeze to the bottom in winter, creating a damming effect. Winter levels in Lake Athabasca may be affected by an ice sheet on the shallow west end which restricts outflow. Water levels in the east part of the lake have been recorded as much as 2 m higher than outflow levels. Strong winds also influence water levels on the Delta. A seiche occurs on Lake Athabasca with strong southwest or northeast winds (Card 1972a) resulting in an increase or decrease in the amount of water on the Delta.

Card (1972a) stated that Lake Athabasca is the key to water levels on the Peace-Athabasca Delta. Water flows from the lake via 3 channels - Rivière des Rochers, Chenal des Quatre Fourches and Revillon Coupé, all of which join the lake with the Peace River (Figures 24, 25). Water normally flows into the Peace, but reverses its flow when the level of the Peace River rises above the lake (Card 1972b). Flooding may occur at break-up as a result of ice jams or in July as a result of high runoff (Bayrock and Root 1972).

Low water in the Delta between 1968 and 1971 was caused by low levels in the Peace River. The Bennett Dam controls 50% of the flow of the Peace River where it influences Lake Athabasca. Williston Lake, behind the dam, was filled during that period, reducing the depth of the Peace River by 3 to 3.5 m, and resulting in average levels of 0.75 m lower on Lake Athabasca. This has had a profound influence on the Delta (Card 1972b).

In the winter of 1971-72 a temporary rockfill weir was built on the Quatre Fourches channel to hold water in the Claire-Mamawi system. Permanent rockfill structures on the Rivière des Rochers and Revillon Coupé were completed in 1975

Figure 25. The Rivière des Rochers looking north from Lake Athabasca.

L. Allison, summer 1971

and the Quatre Fourches structure was removed.

Between 1972 and 1974 ice jams on the rivers resulted in inundation of the Delta. High water levels raised Lake Athabasca to pre-dam normal summer peaks. The Quatre Fourches weir caused a prolonged flood and held water in Mamawi Lake as much as 2.5 m higher than Lake Athabasca (Cordes 1975). In 1975 water levels on the Delta were lower, and the levels of Lakes Claire and Mamawi declined to near the level of Lake Athabasca (Cordes 1976).

Although Alberta Environment is continuing to monitor water levels on Lake Athabasca and selected sites on the Delta, no analysis of the geodetic data has been undertaken to evaluate present regime conditions. However, J. Card (pers. comm.) stated that the general effect of the Bennett Dam plus the rockfill weirs will be to dampen the natural fluctuations in levels. Compared with pre-1968 levels, Lake Athabasca will be higher in winter, the magnitude of flooding will be reduced, and flood waters will stay on the Delta longer.

3. <u>Biological Resources</u>:

a. Vegetation: Vegetation complexes in deltas are intimately tied to water levels. Plant succession can be seen to be a function of elevation of the vegetation community in relation to water level or relative age of the delta. Active deltas are constantly growing as the river deposits sediments at the downstream end. The first aquatic communities of a delta develop in open water. As mudflats appear they are colonized by emergent or immature fen communities. These are succeeded by sedge or grass meadows. Subsequently shrub communities dominated by willows invade the meadows and are themselves replaced by deciduous and coniferous forests (Dirschl 1972).

The time frame for long term delta succession is not understood. It is known that the entire development of the Peace-Athabasca Delta has occurred within the last 10 000 years. Records of early explorers and fur traders indicate that the general appearance of the Delta has not changed much in the last 300 years. Periodic flooding of all or parts of the Delta produced almost a dynamic equilibrium of vegetation patterns on much of the Delta. Plant succession proceeded very slowly (Dirschl 1972).

On ponds in a delta, available nutrients are gradually fixed in undecomposed vegetative matter as floating sedge mats grow over the basin. The basin is eventually filled with bog or muskeg. In the Peace-Athabasca Delta, such older sites are found only in higher portions of the Athabasca Delta, and have not developed beyond the floating mat stage. Elimination of spring flooding would speed bog development (Dirschl 1972). This, in turn, would result in less favourable wildlife habitat.

Many of the dynamic aspects of the vegetative associations are very important to the wildlife inhabiting the area. Broad meadows of sedges and grasses provide bison habitat; fluctuating water levels maintain habitats preferred by muskrat and migrating waterfowl. Nesting waterfowl, however, require more stable water conditions during the nesting season.

Under conditions of continually low water levels (1968-1971), newly exposed mudflats passed rapidly through early succession stages but proceeded more slowly to the willow and forest stages (Dirschl 1972).

High water and flooding in 1972 to 1974 eliminated the early successional plant atages which had become established during the dry years. Willow communities, although they exhibited low vigor showed no sign of drowning. Extensive reedgrass and sedge meadows were drowned and replaced by open water or whitetop grass, a rare species on the Delta prior to 1972. This species is evidently not good bison forage. Remaining meadows were in poor condition (Cordes 1975).

A reduction in water levels of almost 1 m in 1974-75 allowed the sedge and reedgrass meadows to expand and increase in vigor (Cordes and Strong 1976). These studies indicated unforeseen effects that man's interference in natural ecosystems may have, even when much is known of the system and when the interference is intended to improve habitats.

b. Wildlife: Most wildlife studies on the Peace-Athabasca Delta were begun in 1971 after the effects of low water levels were already being felt. The studies examined the effects of the Bennett Dam on the Delta and its economically important wildlife species.

Hundreds of thousands of waterfowl funnel through the Peace-Athabasca Delta each year, stopping to rest and feed on their biannual migrations between arctic nesting grounds and southern wintering areas. Birds reach the Delta primarily via the Central and Mississippi flyways, although some Pacific flyway birds also use the Delta. Although use varies from year to year as many as 400 000 waterfowl may stop in spring and 1 000 000 in fall. Huge flocks of Canada geese and lesser snow geese, and smaller numbers of whitefronted geese, whistling swans and Ross' geese are spectacular components of the wildlife scene on the Peace-Athabasca Delta in spring and fall (Hennan 1972, Figure 26).

The Peace-Athabasca Delta is probably the most important northern delta for waterfowl production. It provides a complex variety of shoreline habitat types and a frost-free season long enough to allow successful re-nesting. Nesting success is highest in years which do not have extensive early summer floods. However, numbers of nesting waterfowl are also directly related to length and type of shoreline habitat. As a result, periodic flooding and drawdowns are necessary for optimum production (Hennan 1972).

The Delta is an important retreat for non-breeding birds from the prairies during years of drought in the south. As wetland conditions have steadily deteriorated on the Prairies, a greater proportion of the continental waterfowl population is produced in northern regions. Total production

Figure 26. Thousands of lesser snowgeese, whitefronted geese, and Canada geese stage on the Peace-Athabasca Delta every year.

L. Allison, fall 1971

of dabblers and divers on the Delta annually may exceed 500 000 (Hennan 1972).

Lower water levels on the Delta during 1968-1972 actually improved the attraction of the area to migrant waterfowl as extensive mudflats were uncovered. Lack of summer flooding also produced favourable conditions for waterfowl production. However, the net effect of continued low levels would be to decrease the diversity of habitat, decrease the numbers and size of basins, decrease the number of shoreline miles, and therefore decrease the capability of the area to support waterfowl (Hennan 1972). In 1971 waterfowl use of the Delta approached what is believed to be maximum numbers (Hennan and Ambrock 1977).

Waterfowl surveys continued after the weirs were built on the Delta. Hennan and Ambrock (1977) present a speculative interpretation of the relationship between water levels on the Delta and waterfowl use. In general, numbers are highest when water levels are low, and lowest when water levels are high. The authors note that factors such as "phenological timing of surveys, the continental waterfowl picture, and conditions outside the Delta itself can have tremendous effects" (on waterfowl numbers). Although it is not noted, the authors also assume a water regime which approximates pre-regulation water levels on the Delta.

Bald eagles are known to nest in trees in the Delta area and the only peregrine falcons known in Alberta occur on outcrops on its fringe. The eagles are particularly visible during fall staging when numbers migrate through the Delta.

Muskrats have always been a staple of the fur trade at Fort Chipewyan. Like waterfowl, muskrats depend on fluctuations in water levels to maintain optimum habitat, but reproductive success is best when water levels are fairly stable. Muskrats thrive on the Peace-Athabasca Delta when water levels are relatively high. The relationship between water levels and muskrat numbers was first recorded by early fur traders (Wuetherick 1972).

Muskrats on the Peace-Athabasca Delta live either in houses built of emergent vegetation or bank dens (Ambrock and Allison 1972). Houses require an abundant supply of emergents which are also a primary source of summer food, while bank dens can only be built on steep banks beside deeper water. Adult females produce 2 litters each year on most Delta lakes. However, in some areas, 3 litters were found (Ambrock and Allison 1972).

Winter survival of muskrats is directly related to fall water depths at the house site (Figure 27). At sites which freeze to the bottom, muskrat survival was lower than at sites where water was present all year. "Critical minimum (water) depths required for optimum survival were determined to be 0.75 m in 1971 and 0.6 m in 1972. At present (1972) 70% of Delta lakes do not fulfil this requirement" (Ambrock and Allison 1972).

Figure 27. Trappers on the Peace-Athabasca Delta probe a muskrat house to determine whether it is still active.

L. Allison, November 1971

High water levels in the Delta in 1972, after the weir was constructed, resulted in rapid colonization of newly available habitat. However, it appears that changes in water level since 1972 cannot be directly correlated with muskrat populations although numbers have substantially increased. Mortality of juvenile rats as a result of spring floods and changes in trapping pressure also exert an influence. In the Wood Buffalo Park portion of the Delta alone, muskrat fur harvests increased from 2000 in 1971-72, to 19 166 in 1973-74, to 67 964 in 1976-77 (Stelfox and McGillis 1977).

Moose habitat on the Delta occurs largely in areas where tall shrubs, conifers and deciduous trees are present. Several locations on the margin of the Delta support relatively high densities of moose during winter. Low water levels on the Delta were expected to increase habitat available to moose. Moose numbers are now much lower than the area can support, because of heavy hunting pressure. No population response to increased habitat was anticipated (Allison 1972a).

Bison are an important component of the Delta ecosystem. Animals occurring south of the Peace River are considered to be a hybrid of the native wood bison and the introduced plains bison. Bison are primarily grazers and are dependent on extensive reedgrass and sedge meadows of the Peace-Athabasca Delta. During 1971-72 approximately 10 000 bison used the Peace-Athabasca Delta (Allison 1972b). Since then the herd has declined by about 50% (Tempany and Cooper

1976, Collingwood 1977). Flooding in the spring of 1974 drowned 2000 to 3000 animals as well as reduced their range. Although drownings from floods must be considered natural events, the timing and duration of the flood may affect bison mortality (Figure 28).

c. Fisheries: Lake whitefish, ciscos, northern pike, and, most important, walleye and goldeye inhabit the turbid, shallow water of the Peace-Athabasca Delta and are important to the local economy.

A commercial fishery for walleye has operated in Lake Athabasca since 1943, and walleye have traditionally been harvested for use by people and dogs. The Lake Athabasca walleye population spawns in Richardson Lake in spring (Bidgood 1972), but recent workers have found walleye fry in other locations. Spawning may also occur in Lake Claire, Lake Mamawi, or along the north shore of Lake Athabasca (Summers 1978). During years of low water levels, flow from the Athabasca River must lift the ice of Jackfish Creek to allow walleye to reach Richardson Lake to spawn in early spring (Bidgood 1972, Kristensen and Pidge 1977). Control structures on the Lake Athabasca outflow would affect water levels on suspected spawning areas. Levels in Richardson Lake and Jackfish Creek are independent of these weirs but are strongly influenced by early spring water levels on the Athabasca River. The Richardson Lake spawning population was estimated at 62 800 in 1977 (Summers 1978).

Figure 28. Bison grazing on the extensive sedge meadows of the Peace-Athabasca Delta. Successive successional stages of willow, poplar and spruce can be seen in the background.

L. Allison, fall 1971

Goldeye were commercially fished in the Peace-Athabasca Delta for about 20 years. However, production declined drastically as the population was over-exploited. The population appears to be recovering from the decline in the 1970's and is still used by domestic fishermen (Kooyman 1972). Goldeye found in the Delta migrate into the Claire-Mamawi system from the Peace River via the Chenal des Quatre Fourches, the Revillon Coupé and the Rivière des Rochers (Kooyman 1972, Kristensen 1978). Migrations apparently do not depend on reversal of flow in the channels (Kristensen and Pidge 1977). Some fish overwinter in the Birch River, but most are believed to spend the winter in the Peace River (Kooyman 1972).

The temporary weir at Quatre Fourches, although it contained fish passages, blocked much of the movement of fish in both directions. Permanent structures completed in 1975 on the Revillon Coupé and the Rivière des Rochers have been not entirely successful in allowing movements of fish (Kristensen and Pidge 1977).

4. Social and Cultural Values: The Peace-Athabasca Delta is an important area on international, national and local scales. Wood Buffalo National Park was for many years the largest national park in the world. It supports the largest free-roaming population of bison in the world and provides staging areas for a significant proportion of the continental waterfowl population. It is one of the largest fresh water deltas in the world.

The regional importance of the Delta rests largely on its biological productivity. Residents of Fort Chipewyan - Cree, Chipewyan and Métis - depend heavily on the resources of the Delta, including the Park, to provide them with food and cash income (Church 1976). Fort Chipewyan is the oldest continuously inhabited settlement in Alberta and, located at the hub of intersecting waterways, historically provided an important link with the northern fur trade. From the earliest trading period, the Fort Chipewyan area was known to be rich in furs of fine quality, and the local trade was the center of a bitter trading conflict (Wuetherick 1972).

In 1972 more than 200 men from Fort Chipewyan spent some time trapping. However, intensity of effort, and financial and cultural importance of trapping are hard to define or measure (Moncrieff and Montgomery 1971). Muskrat are responsible for about 75% of trapping earnings in Fort Chipewyan. Since 1972 the trapping success for muskrats, at least in Wood Buffalo National Park, has increased by a factor of 30 (Stelfox and McGillis 1977). The price paid for skins has also risen. The intensity of trapping effort, then, seems directly related to availability of fur, and fur prices. Other factors may also be involved.

The eastern part of the Athabasca Delta is the Chipewyan reserve, on which many Chipewyan band members live during summer. In addition, two parcels totalling 16 800 ha near Embarras and Peace Point have been chosen by the Cree as reserve land (C.B.C. broadcast 1978). Fishing, hunting and trapping occur throughout the entire Delta all seasons of the year except during break-up and freeze-up when travel is difficult.

5. Sensitivity and Knowledge Gaps: The Peace-Athabasca Delta may be the best known area in this review. The Peace-Athabasca Delta Project was a thorough and integrated, but short, research program which began early in 1971 and was completed in 1972. Follow-up monitoring programs have been continued on water levels, vegetation, muskrat, bison, waterfowl, walleye and goldeye. Because of the breadth and detail of documentation available, the Peace-Athabasca Delta provides an excellent example of the magnitude of change that small differences in hydrological events can cause. It shows the dangers of detailed prediction of events from an inadequate data base, and the unforeseen consequences of human activity after even meticulous research. For a general description of the Delta, the Technical Report of the Peace-Athabasca Delta Project is the best reference.

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CHAPTER IV

LIARD RIVER DRAINAGE

A. Liard River, Liard Hot Springs and Whirlpool Canyon

A great deal of development is being proposed for the Liard River basin. Hydroelectric developments, new roads, renewable and non-renewable resource extraction and intensified recreation demands could affect the hydrologic regime of certain areas within the basin. Of these areas, the Liard River, Liard Hot Springs and Whirlpool Canyon are thought to be particularly sensitive (Figure 1).

1. General Description: The 1208 km long Liard River originates in the Pelly Mountains of the Yukon (Figure 29). Its branches spread through four degrees of latitude from 58°N to 62°N, and interlock with those of the Yukon, Stikine, Skeena and Peace rivers (Wenger 1976). From its source the Liard loops south and east through British Columbia and then turns sharply north to empty into the Mackenzie River at Fort Simpson. The Liard has a total drainage area of approximately 268 800 km^2, of which some 138 240 km^2 are located in British Columbia. The remainder of the drainage area is located in the Yukon Territory (60 672 km^2), Northwest Territories (61 440 km^2), and Alberta (8448 km^2), (Environment Canada 1973).

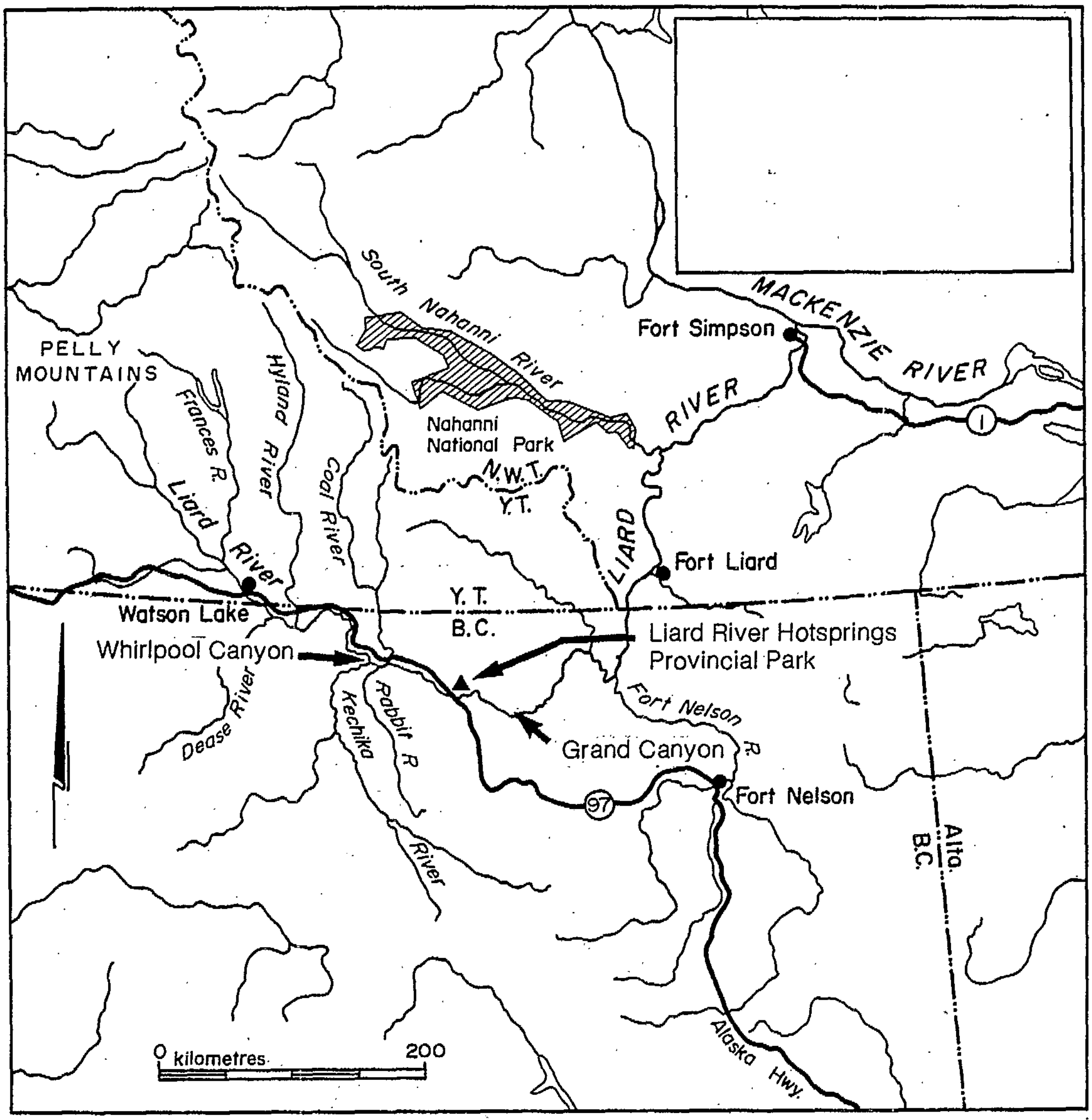


Figure 29. The Liard River, Liard River Hotsprings and Whirlpool Canyon.

Except for the eastern fringe which is drained by the Fort Nelson and Petitot rivers and which forms part of the Interior Plains, most of the Liard basin is part of the northern extension of the Western Cordillera. The basin includes portions of the Mackenzie, Selwyn and Pelly Mountains in the north, and the Cassiar and Rocky Mountains in the south. In the central portion, along the British Columbia-Yukon boundary, are the Liard plain and the Hyland and Liard plateaus (T. Ingledow and Associates Ltd. 1970). Along its length, much of the river is deeply entrenched in the high plains on either side. A detailed description of the Liard River and its tributaries can be found in Ingledow (1970).

Most of the Liard River basin is underlain by a great sedimentary basin. It is composed of bedded rocks ranging from the Proterozoic to the Mesozoic age up to several kilometers thick. Igneous rocks are exposed in a comparatively limited way only in the Selwyn Mountains (Higgens 1968). It is because most of the basin is underlain by easily eroded sedimentary rock that the Liard maintains such high sediment loading.

During the Pleistocene, masses of ice flowed down from the mountainous regions in the north and northwest and spread southward along the present day Liard River valley. Flutings on the land surfaces indicate that the ice probably flowed from the northwest to the southeast. As the ice melted, the areas on the east side of the present river course, higher and irregularly shaped, slowed the ice retreat, resulting in the deposition of a layer of loose waterworked till over the basal till. In these areas, many meltwater channels are evident. The areas to the south and west of the Liard River, being fairly level, had a rapid ice retreat. Here, a pitted outwash plain was formed (Lavkulich 1970).

In the river valley, alluvial soils are composed of well sorted and stratified silts, sands and gravels. In the central portion of the floodplain, especially in the lower gradient downstream areas, the soils are poorly drained and shallow due to the permanent and fluctuating water table (Lavkulich 1970).

The major settlement in the Liard basin is Fort Simpson, located across from the confluence of the Liard and Mackenzie rivers.

2. Hydrology: Because there are numerous major tributaries, draining a variety of physiographic areas, the hydrologic picture of the Liard River basin is complex and poorly understood. Basically, the Liard River undergoes changes from a braided stream at Fort Liard to floodplain to broad meandering plain and outwash delta at its confluence with the Mackenzie River at Fort Simpson (Rostad et al. 1976). Major floods have been recorded in 1896 (Jeffrey 1964), 1909, 1934 and 1963 (Parker and Jozsa 1973). Parker and Jozsa (1973) found ice scarring on trees as much as 16.5 m above the present water level. Water levels in the 1896 flood rose 9.1 m (Jeffrey 1964).

The Liard is a powerful river having a mean annual discharge at Fort Simpson of 12 036 m^3/s. Fluctuating water levels of "a few feet per day" are not uncommon during June and July. In 1975, for example, heavy rain in the mountains combined with runoff from spring snow melt to scour the banks and bring down a heavy load of suspended sediments, silt and debris torn from the banks (Rostad et al. 1976).

Several major studies have been conducted on the hydrologic characteristics along different portions of the Liard River (Unies Ltd. 1966, 1974, 1976; T. Ingledow and Associates Ltd. 1970). In summary, T. Ingledow and Associates Ltd. (1970):

> The runoff regime of the Liard River and most of its tributaries is typical of streams draining a mountainous area with a continental climate. Shielded from the moderating influence and high moisture supply of the Pacific Ocean by the coastal mountains, the Liard Basin experiences cold winters and receives only moderate to low annual precipitation. Spring runoff normally commences during the latter half of April and peak snowmelt flows are reached in late May or early June. Secondary peaks often occur later in June and July as a result of fairly heavy rains falling on the snowmelt-saturated basin. As there is little natural storage in the basin streamflow recession is fairly rapid, and by November discharge in the river is low; during the long winter season stream discharge is supplied mainly from groundwater sources.
>
> The east-west orientation of the Liard River results in a slight time variation in the runoff patterns of its tributaries. Under normal conditions, snowmelt begins in the western mountainous portion of the basin and progresses eastward to the Interior Plains area within one to two weeks. Peak snowmelt flows are also often reached earlier on upstream tributaries, although peak flows may occur within a day or two over the entire basin in some years.

Mean annual runoff on streams draining from the mountains varies from about 305 to 457 mm. Those tributaries originating in the Plains area of the lower Liard Basin have significantly lower yield and peak flows than the mountain streams, chiefly because of lower precipitation and gentler slopes.

During the winter, minimum monthly flows for those streams which rise in the mountains average between 0.007 and 0.015 $m^3/sec/km^2$, and the minimum winter monthly flows drop to very low values of less than 0.0001 $m^3/sec/km^2$ in the Plains area. Lower groundwater contribution because of possible deeper and extensive frost penetration, more severe ice formation on rivers and lower overall precipitation account for the very low flows in the tributaries originating in the Plains area in comparison with those streams draining mountain watersheds.

Data are available for Fort Liard and the mouth of the Liard River for water temperature, particle size (bedload and suspended sediments), ice thickness and stream flow and water levels (Davies 1973, 1974). B.C. Hydro has also summarized the hydrology and river regime characteristics. This summary presents a review of regime, sediment loading, ice conditions and streamflow records available for the Liard River basin (Dundas pers. comm.).

No mention is made in any of these studies of the possible effects of sediment loading and hydrologic regime of the Liard upon downstream ecosystems, most importantly, the Mackenzie Delta. However, break-up in the Mackenzie River is initiated by break-up in the Liard River system. The Liard River begins to melt and flow into the Mackenzie, raising the ice and floating it seaward. This progresses from Fort Simpson north, while the main stem of the Mackenzie above

Fort Simpson is still frozen. Two biologically significant events follow this phenomenon. First, the solar energy that would have been used to melt the ice on the delta becomes available for plant production because the ice has been floated out into the Beaufort Sea. The dark soil of the delta surface absorbs early spring solar energy and raises soil, air and water temperatures. This results in early and rapid plant growth. Second, plant growth is also stimulated by nutrient-laden Liard River waters (MacKay and MacKay 1973).

3. Biological Resources: The Liard River is included in the Upper Liard section of the Boreal Forest region (Rowe 1972). It is characterized by level landforms above the river course, supporting stands of lodgepole pine, black spruce, white spruce and trembling aspen. On the north and west sides of this section, it comes in contact with the sparsely-forested Yukon plateau, and on the east with the more productive Lower Mackenzie and Hay River sections (Rowe 1972).

Good forest growth is found in the river valley, particularly on soils of the alluvial flats. The dominant trees in the latter portion are white spruce and balsam poplar, the two species forming pure stands more frequently than mixtures. The Liard River, Rivière aux Liards, or River of the Cottonwoods (Morritt 1963), is named after the numerous poplars to be found along the floodplains. Above the river floodplains, black spruce and lodgepole pine form extensive pure and mixed stands (Rowe 1972).

Past fires are responsible for an abundance of lodgepole pine stands, particularly on the sandy terraces which border the Liard in the western part of the section. Black spruce and larch occur in low positions, although the former species is also prominent on upland fine-textured soils and on shaded slopes where lodgepole pine is its common associate (Rowe 1972).

The Liard region offers ideal habitat for many species of animals including grizzly and black bear, wolf, caribou, beaver, moose, as well as lynx, otter, mink, muskrat and coloured fox (Wenger 1976, Figure 30). Descriptions of wildlife populations in the Liard River basin are available only in impact studies for proposed developments (e.g. T. Ingledow and Associates Ltd. 1970, Dennington et al. 1973, Synergy West Ltd. 1975, Akhurst 1978, Quinlan 1978). Rostad et al. (1976) provide an excellent summary of available information on wildlife populations.

The most abundant species of big game is moose, which is found throughout the area. Dall's sheep are present in certain areas of both the Liard and Nahanni Ranges. Other mammalian species of particular importance are the furbearers, especially muskrat and beaver (Synergy West Ltd. 1975).

The distribution and movements of moose are mainly determined by the availability and quality of suitable habitat. Moose undertake seasonal migrations or movements in

Figure 30. The Liard River Hot Springs, lower pool.

C. J. Allison, July 1973

the Liard valley. During the winter and spring the moose are concentrated along the river, particularly the floodplains, river banks and mid-channel islands where a mixture of preferred browse species is found. The vegetation also provides shelter. During the summer many moose move up the tributaries where they may browse along the banks and in small oxbow lakes and ponds. Others seek out recently burned (brulé) areas in the uplands where the early successional stages of growth provide more favorable browse.

The beaver is one of the most important furbearers in the Liard valley and is widely distributed throughout the area. Preferred habitats are small streams and ponds, mainly in areas of mixedwood or deciduous forest. Muskrat, mink, lynx, marten, bears and wolves also occur throughout the Liard valley and are trapped in some quantity (Rostad et al. 1976).

The Liard area has generally limited waterfowl nesting habitat. Numerous lakes and ponds are used as incidental stopping areas during spring and fall migrations (Department of Environment 1972). Quinlan (1978) discussed the avian habitats in the area in association with the proposed Liard Highway alignment.

> . . . Although no major migration corridor for swans, geese or cranes occurs in the vicinity of the highway, substantial numbers of ducks and grebes nest in the wetlands adjacent to the right-of-way on adjacent mountain areas, but the Petitot River offers potentially good falcon nesting habitat.

The clear Mackenzie tributaries flowing westward from the Canadian Shield are generally more important for fish production than the larger turbid eastward flowing streams (Hatfield et al. 1972a). In the Liard River fish habitat is best in areas near the mouths of tributaries and near the confluence with the Mackenzie River. At these locations gravel areas are more prevalent, indicating possible spawning and feeding areas. These areas are flooded during May, June and early July when water levels are high in the Liard. Walleye and northern pike are common in the tributaries. Many fish species have been caught at the mouth of the Liard indicating that the river may serve as a migratory route for spawning fish (Hatfield et al. 1972b). These included northern pike, humpback whitefish and longnose sucker. Arctic grayling are found in the less turbid portions of the tributaries (Dryden and Stein 1975).

4. <u>Social and Cultural Values</u>:

a. Current land use: T. Ingledow and Associates Ltd. (1970) reported that mining, hydrocarbon extraction and lumber industries are the most important resource developments in the Liard River basin. Of these, mining is the most important. A large mineralized area of lead-zinc-silver exists in the eastern part of the Yukon Territory, extending from Watson Lake northwestward to Ross River and Mayo. At Tungsten, in the headwaters of the Flat River, Canadian Tungsten Ltd. operate a tungsten mine. Anvil Mine near Ross River has reserves of over 64 billion kilograms of lead, zinc and silver. Hydrocarbon reserves are being developed at

Pointed Mountain. Coal deposits are also known and may provide fuel for thermal power generation in southern and overseas markets.

b. Settlements: Population centres are small and widely scattered throughout the Liard River basin (Higgens 1968). The larger communities are Fort Liard, Watson Lake and Fort Simpson.

A Hudson's Bay Company trading post has operated continuously at Fort Liard since 1805. In addition to the trading post, Fort Liard has a warden station, regional forest protection centre, R.C.M.P. detachment and Roman Catholic mission. The mission has been in existence for over 100 years (Brock 1976).

Domestic fishing continues to be an inexpensive way of gathering food for this community. Gill netting is the principal harvesting method. The catch includes suckers, whitefish, yellow walleye and northern pike. Fisherman Lake and Lake Bovie are the most important fishing lakes for residents of Fort Liard. They are fished year round except for brief periods during break-up, freeze-up and mid-winter (Department of the Environment 1976).

Watson Lake is a growing Alaska Highway community and outfitting point for prospectors, trappers and sportsmen. It has gained prominence primarily because of its proximity to the mining industry in the southeast Yukon. Watson Lake airport played a vital role in the construction of the Alaska Highway and today serves commercial and chartered airlines (T. Ingledow and Associates Ltd. 1970).

Fort Simpson, at the confluence of the Mackenzie and Liard rivers is served by the Northern Transportation Company using barges out of Hay River. There is also an all-weather road from Hay River. A commercial airline serves Fort Simpson and there is an air charter base (T. Ingledow and Associates Ltd. 1970).

There are smaller settlements at Nahanni Butte, Rancheria, Frances Lake and Upper Liard. A mining settlement has been developed at Tungsten in the headwaters of the Flat River. There are also a few fishing lodges and mineral exploration camps in the region (T. Ingledow and Associates Ltd. 1970).

c. Native use: Table 1 summarizes the economic importance of trapping at Fort Liard and Fort Simpson. Of the 18 species recorded, lynx, marten, beaver and mink brought the highest returns and percentage of the total trapping income. Although the prices fluctuate, quite drastically in some years, the total income is significant and contributes substantially to the local economy.

c. Recreational resources: Three areas in the Liard River system are important for recreation and are dependent on existing hydrologic conditions. They are Nahanni National Park, Liard Hot Springs and Whirlpool Canyon (Figure 29). The latter 2 and the Grand Canyon of the Liard

TABLE 1

ECONOMIC IMPORTANCE OF TRAPPING

AT FORT LIARD AND FORT SIMPSON (INCLUDING WRIGLEY) N.W.T.,

FOR THE YEARS 1970 THROUGH 1977 INCLUSIVE

(Akhurst 1978:265-268.)

Year	Fort Liard		Fort Simpson (and Wrigley)	
	No. of Furs	Total Value	No. of Furs	Total Value
1970-71	5192	$21,882.96	8003	$49,729.33
1971-72	2422	30,820.52	5329	77,614.97
1972-73	1968	47,781.28	3946	76,874.41
1973-74	1234	28,943.07	2398	45,168.31
1974-75	2861	27,712.18	3497	63,853.90
1975-76	4280	14,393.91	1900	21,758.75
1976-77	7458	43,034.45	6923	50,694.29
	(59 to 73 trappers) 1974-77		(72 to 115 trappers) 1974-77	

River constitute one of the most spectacular scenic and aesthetic river-based recreational resources in Canada (Wenger 1976).

Nahanni National Park is a "river and canyon park" Higgens 1968). The major attraction in the valley of the South Nahanni River is Virginia Falls with a height of just over 122 m and a discharge in the early summer months of approximately 1700 m^3/s. The extensive canyon feature stretches from the falls to the hot springs about 80 km above Nahanni Butte. This area is described in detail by Baker (1963) and Scotter et al. (1971). More recently, Brook and Ford (1976) discuss the newly created national park:

> . . . Nahanni National Park . . . also promises to become famous for its scientific value. Not only does this part of the southern Mackenzie Mountains contain the most spectacular river canyon scenery of Canada, but it also displays one of the most remarkable limestone landscapes known anywhere in the world.

The Liard River Hot Springs are located in Liard River Hot Springs Provincial Park, an area along the north shore of the Liard River at Liard Crossing (Figure 29). At this location along the Alaska Highway there are two large, hot, spring-fed pools (Figure 30), a "hanging garden" associated with the year round warm temperatures, and many small, clear pools and cascading rivulets. Drainage from the hot springs finds its way to an extensive swamp and muskeg area not far below. The wetland, like the hot pools, has been caused by the natural formation of low, calcarious dams (Reid 1975, Pavlick 1974).

Warm springs are of particular interest to scientists. Plants or invertebrate animals belonging in the floras or faunas of more temperate regions may have survived there as relics from earlier periods when the climate was generally warmer (Porsild and Crum 1961).

The flora of this "oasis" is a rich one (Pavlick 1974). In all, 82 species of vascular plants were recorded as growing near the hot springs or in the meadows and fens affected by the springs (Porsild and Crum 1961).

The animals of the park area include moose, black-tail deer, woodland caribou, elk, wolf, grizzly bear, woodchuck, many species of birds, and numerous toads. The lake chub occurs in pools on the terraces of the Hanging Gardens and in the warm pools and streams below the hot springs (Pavlick 1974).

Aesthetic and recreational values are high in the "Liard Tropical Valley". Impressions which fostered this term may have been the warm temperatures and high humidity around the springs; the sensation of heated baths and swims in a northern area; the ice-free conditions of the pools, brooks and ponded warm swamps in winter; the strongly sulfurous smell of the larger pool and spring; and the fairyland appearance of the rime-covered tree branches draping over the hot spring pools in mid-winter (Pavlick 1974).

Whirlpool Canyon lies approximately 80 km upstream of Liard Hot Springs near the confluence of the Coal and Liard rivers (Figure 29). There appears to be some confusion as to the location of this feature. The sign along the Alaska Highway wrongly calls the Mountain Portage site Whirlpool Canyon. The actual site is several kilometers downstream of the posted feature (Wenger 1976).

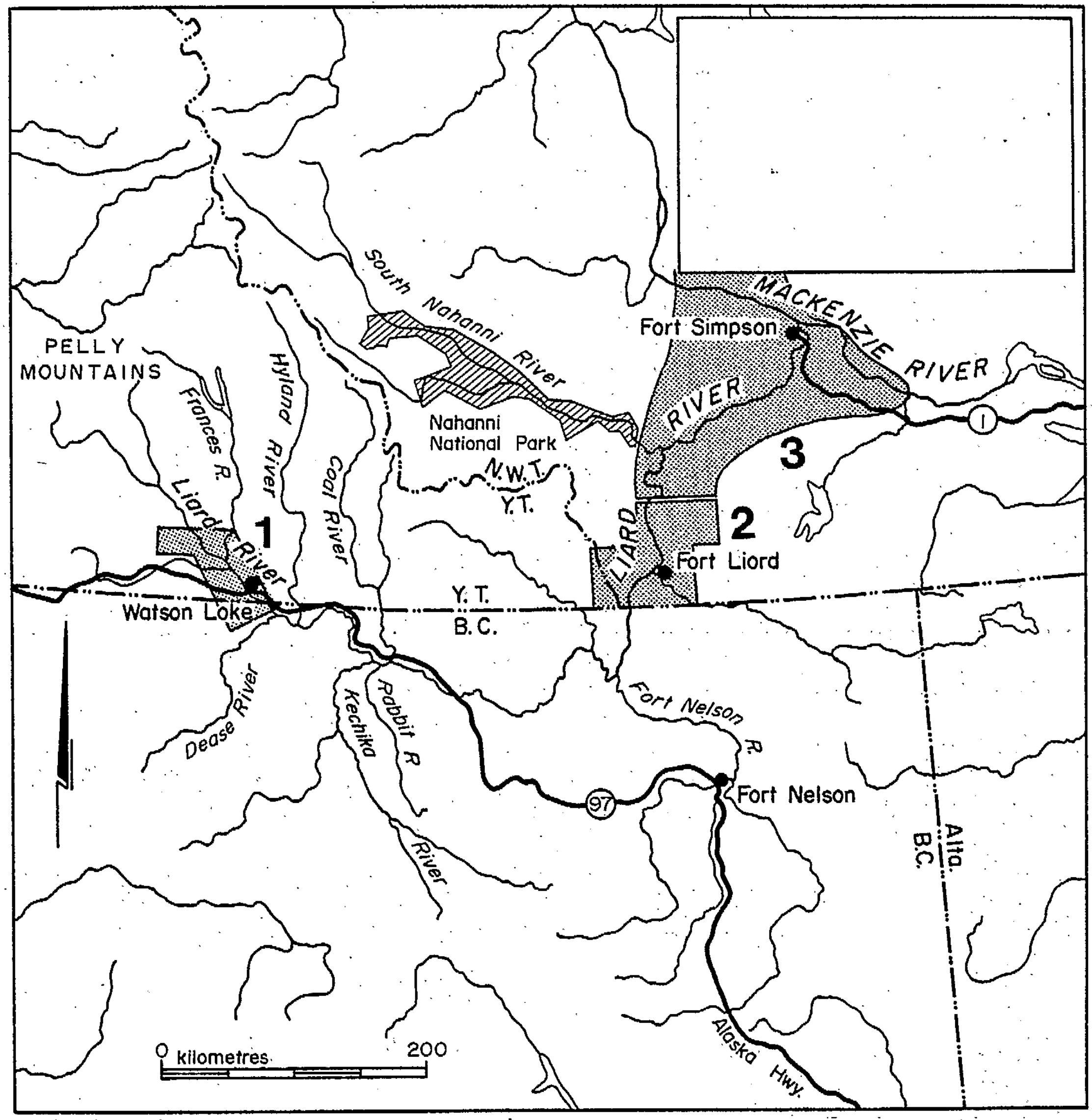
Whirlpool Canyon is a scenic and canoeing attraction created by water moving around broken rock ledges. Two meter-high standing waves, currents running in almost every direction and whirlpools like giant pinwheels occur at the point where the river gushes into a large bay. The section of the Liard River from Watson Lake to the mouth of the Toad River has been proposed as a National Park (Wenger 1976). Wenger (1976) described the area as one of the most beautiful and most impressive parts of the 1208 km long river.

e. Development possibilities: The diverse natural resource base of the Liard River basin can be grouped in various categories: fauna, metallic, hydrocarbon and industrial minerals, merchantable forests, arable land, water, park and recreational lands. This diversity, in combination with the proximity to tide-water via easily extendable lines of communication, is not duplicated elsewhere in the Northwest Territories. Apart from the Pointed Mountain Field and Tungsten, other areas are being explored for development potential. None of the major renewable resources - forestry, agriculture, water, recreation - has been seriously exploited, but there appears to be a significant potential (Higgens 1968).

Three areas have been assessed for potential forestry operations. Area 1 (Figure 31), the Upper Liard River area, is described by Rowe (1959) as climatically the most favourable forest growing area in the Yukon Territory. White spruce attaining sawtimber dimensions grows along the meander system of these rivers. The Upper Liard River and its tributaries possess one of the most accessible and valuable tracts of white spruce sawtimber in the Yukon Territory. The terrain lends itself to easy logging and the location of suitable sites for sawmills is not a problem. With good forest management, the area could produce a continuing supply of white spruce sawtimber for the southern Yukon (Peaker 1968).

A second area covers 2202 km^2 and extends approximately 180 km down the Liard River from latitude $60^{o}N$; it straddles the Yukon-Northwest Territories border and contains perhaps the largest continuous block of merchantable timber found in either of the northern territories (Akhurst 1978). Planned construction of a Liard Highway has created interest in establishing large scale forest operations in the area (Quinlan pers. comm.). At the rate given for allowable cuts, the mature and overmature softwood reserves alone would not be exhausted for 76 years; the mixedwood areas would be exhausted in 19 or 20 years (Wallace and Peaker 1969).

A third area along the Liard River valley will be opened up to logging operations with the completion of the Liard Highway. Residents of Fort Liard have expressed



Area 1 — Upper Liard (Peaker, 1968)

Area 2 — Lower Liard (Wallace and Peaker, 1968)

Area 3 — Liard and Mackenzie River area (Rostad *et al*, 1976)

Figure 31. Forest Resources of the Liard River area.

interest in developing this industry to remedy their depressed economic situation (Akhurst 1978). During the soil survey and land evaluation of the Liard and Mackenzie rivers area, Rostad et al. (1976) noted that some of the best timber stands in the Northwest Territories occur in this lower Liard region (Figure 32). The land best suited for agriculture is also some of the best forest land, particularly the section of the Liard valley south of Nahanni Butte (Rostad et al. 1976).

Recent development proposals including the Liard Highway and hydroelectric development have been assessed (Synergy West Ltd. 1975, Quinlan 1978). Quinlan (1978) described vegetation, invertebrates and waterfowl in wetlands adjacent to the highway alignment and assessed possible changes the highway may impose upon these wetlands and mountain ranges to the west of the Liard River. Quinlan (1978) stated that apart from the impact upon the environment created by the construction, increased access provided by the highway will increase recreational demands for hunting, camping, hiking and back-packing.

Two proposed dams (Figure 33) are the most feasible locations for hydroelectric development along the steeply sloping Whirlpool Canyon-Grand Canyon section of the Liard River (Hurst and St. Pierre pers. comm.). The river section that would be inundated falls about 305 m in 336 km. If these dams are constructed, Liard Hot Springs will be under about 145 m of water, while the Whirlpool Canyon area will be under about 100 m (Figure 33).

Figure 32. During winter moose often feed in areas of early plant succession along river valleys.

L. Allison, February 1972

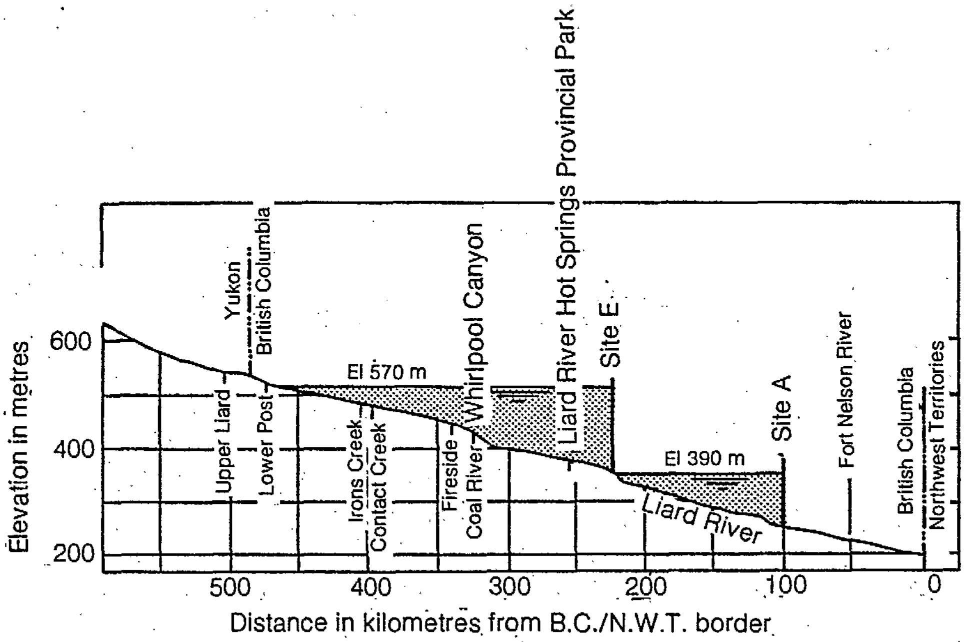


Figure 33. Profile of the Liard River in British Columbia showing proposed dam sites.

5. <u>Sensitivity</u>: Lavkulich (1970) reported that floods on the Liard and its tributaries will undoubtedly become more problematic as human use of the watershed increases. Forestry operations may add to this concern (Akhurst 1978). By removing shade, forest harvesting allows more rapid snowmelt and increases peak rates of discharge from the logged areas. Harvesting also encourages earlier melt. Thus for a large basin that is partly logged and partly under dense forest, the period of the spring freshet may be extended in time and the peak discharge reduced in magnitude in comparison with the same basin entirely forested. An extensive study, including experimental forest cuttings, could allow an appraisal of the probable effects of forest harvesting within the Liard basin on the flood regimes of the river at specified points (Lavkulich 1970).

Forest harvesting along water courses, by reducing shade, tends to increase water temperature. This is generally regarded to be detrimental to fish. Whether this would be true for the cold waters of Liard system and for the fish indigenous to it (grayling and Dolly Varden) may not be known. Some, probably small, changes in the stream content of dissolved solids and oxygen may result from more rapid post-logging decay of organic material and leaching. Research to appraise their significance to fish habitat, aesthetics and the quality of water for more direct human use, may be desirable (Lavkulich 1970).

Animals depending on the forest for habitat include moose, woodland caribou, beaver and marten. Extensive forest harvesting in the Upper Liard could affect populations of these animals as follows:

1) Moose would tend to increase because of browse production in the cut-over land.
2) Caribou would decrease because of the destruction of lichens.
3) Beaver would probably increase because of increase in poplar species.
4) Marten would decrease in number because of a presumed decline in squirrel populations.

A study of the importance of these and other animals and the impact on them of extensive logging has been suggested (Lavkulich 1970).

Clear-cut logging operations change the thermal conditions of the soil in cold regions without permafrost. At the end of the summer, ice was not present in an unlogged area but could still be found in places in a logged section. Ice was also found in some burned areas along the Liard River. Depth of frost penetration may be greater in the logged area, because of thermal insulation offered by the vegetative canopy in the unlogged area. The ice layer could, if severe enough, greatly restrict drainage, promote the formation of a wetter soil, and affect regeneration. A detailed study is needed in order to assess the influence of ground ice as affected by logging practices and fires (Lavkulich 1970).

6. Knowledge Gaps: Sensitive areas in the Liard River system have qualities based on the existing hydrologic regime. Although general environmental information is available for these areas, before proposed developments can be assessed a complete, detailed environmental analysis of possible effects will be required (Price pers. comm.). Insufficient flood data are available. Available data are generally short-term and not comprehensive within an established system of measurement stations (Davies 1974). This data gap will create important problems when attempting to assess the downstream effects of proposed hydroelectric development.

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B. Virginia Falls

1. General Description: Virginia Falls, on the South Nahanni River (Figures 1, 34), was chosen by the Task Force as a potentially sensitive area because of its great aesthetic value and uniqueness. Virginia Falls can be reached by skiff or jet boat from Fort Simpson or Nahanni Butte, by canoe or raft, or by charter aircraft.

2. Hydrology: The South Nahanni River rises in the Ragged Range of the western Mackenzie Mountains and flows east southeast to join the lower Liard River in the Mackenzie Valley. It is 400 km in length and has a catchment of 34 000 km^2. Above Virginia Falls, the South Nahanni River

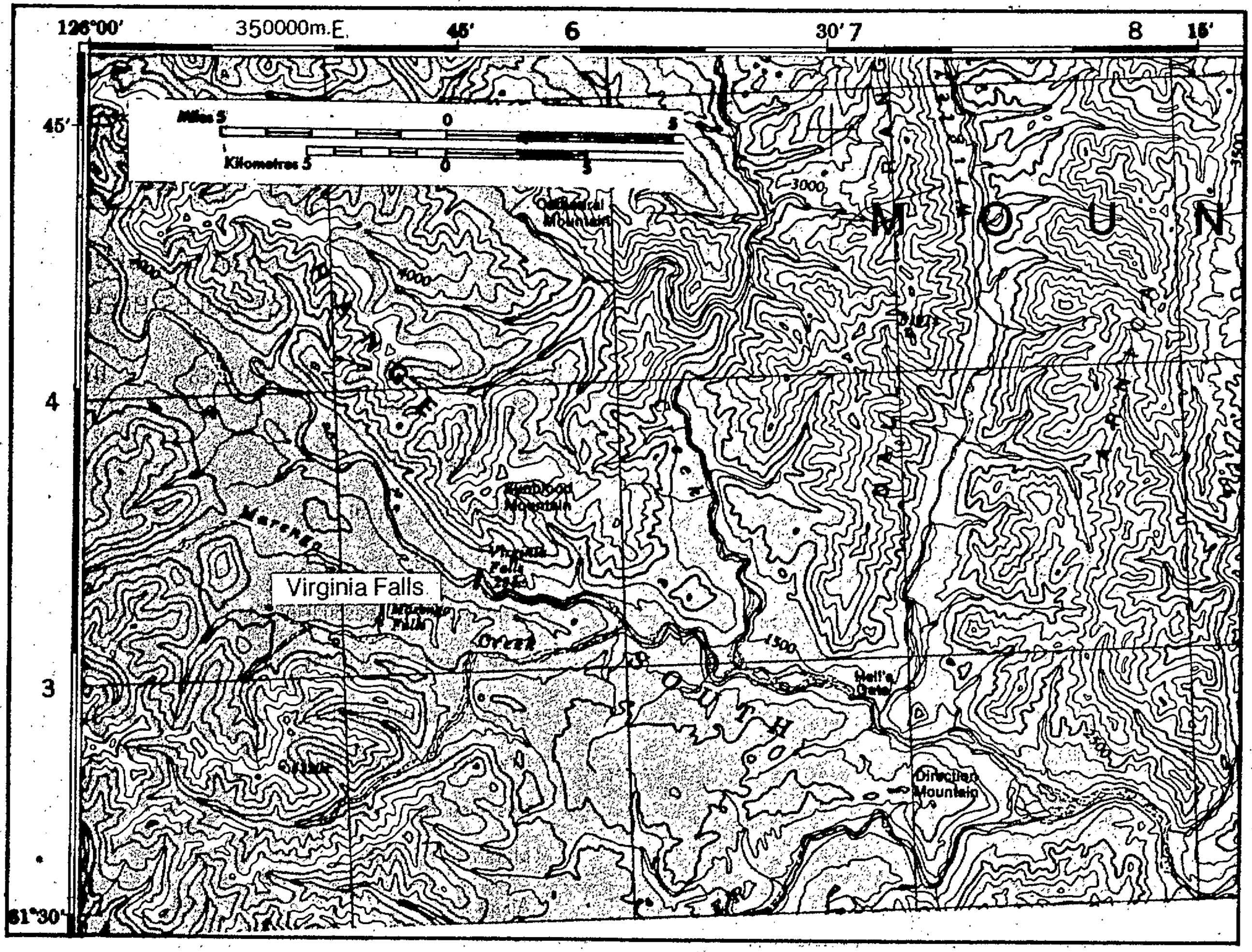

Figure 34. Virginia Falls on the South Nahanni River.

is a smooth, relatively slow moving river entrenched in lacustrine deposits of a glacial river valley. Above the falls is a cataract called the "sluice box" which drops 27 m before the river plunges over the falls - 91.5 m high on the southwest side; 55 m on the northeast (Marsh and Scotter 1975, Figure 35).

Above the falls, the South Nahanni River has a drainage area of 14 690 km^2. Its mean monthly low discharge is 26 m^3/s and mean monthly high is 907 m^3/s. Extreme maximum daily discharge June 12, 1962, was 2296 m^3/s, and extreme minimum was 16 m^3/s (Water Survey of Canada 1974).

Prior to the first glacial advance, the South Nahanni River flowed in a course to the south of its present position, coincident with Marengo Creek. The glacier truncated a spur of Sunblood Mountain and the river was re-routed. The first falls were 0.6 km downslope of the present site. At the base of the falls, the river runs through a steep-walled, water-carved canyon formed by waterfall recession. At the falls, the river has cut into limestone bedrock of Paleozoic age (Marsh and Scotter 1975).

Glacial Lake Nahanni was the result of a dam in First Canyon during the second glaciation. The original falls were buried in deltaic and lake bottom sediments. As the lake receded and the river re-excavated its bed, the falls became established at their present location (Marsh and Scotter 1975).

Figure 35. Virginia Falls: looking over the edge.

L. Allison, July 1973

Ford (1973) stated that much of the area of the Nahanni canyons has been unglaciated for approximately 300 000 years. Canyon formation has been a result of fluvial rather than glacial processes.

3. Biological Resources: The South Nahanni River valley is part of the alpine-forest-tundra vegetation complex (Rowe, 1972), but Marsh and Scotter (1975) consider vegetation of the Virginia Falls site to be taiga in nature. The natural climax of the area is a black spruce-tamarack-feathermoss-lichen association. Willows are the predominant tall shrubs in the area; ericaceous, low-growing plants provide shrub cover, while reindeer lichens produce extensive mats on the ground. Locally, white spruce and paper birch occur (Marsh and Scotter 1975).

Primary succession occurs at the margins of ponds, and the floodplains of the South Nahanni River. Permafrost occurs intermittently around the falls. Feathermosses allow permafrost to develop by insulating the soil. The resulting cold soil and shallow active zone slow conifer development (Marsh and Scotter 1975). Figure 36 shows vegetative associations around Virginia Falls.

The habitat in the vicinity of Virginia Falls appears to be favourable for grizzly bear, but little sign and few animals have been seen. Wolves are common in the area and cougar may be present. Moose are the most abundant ungulate locally. Preferred areas in winter are near wetlands.

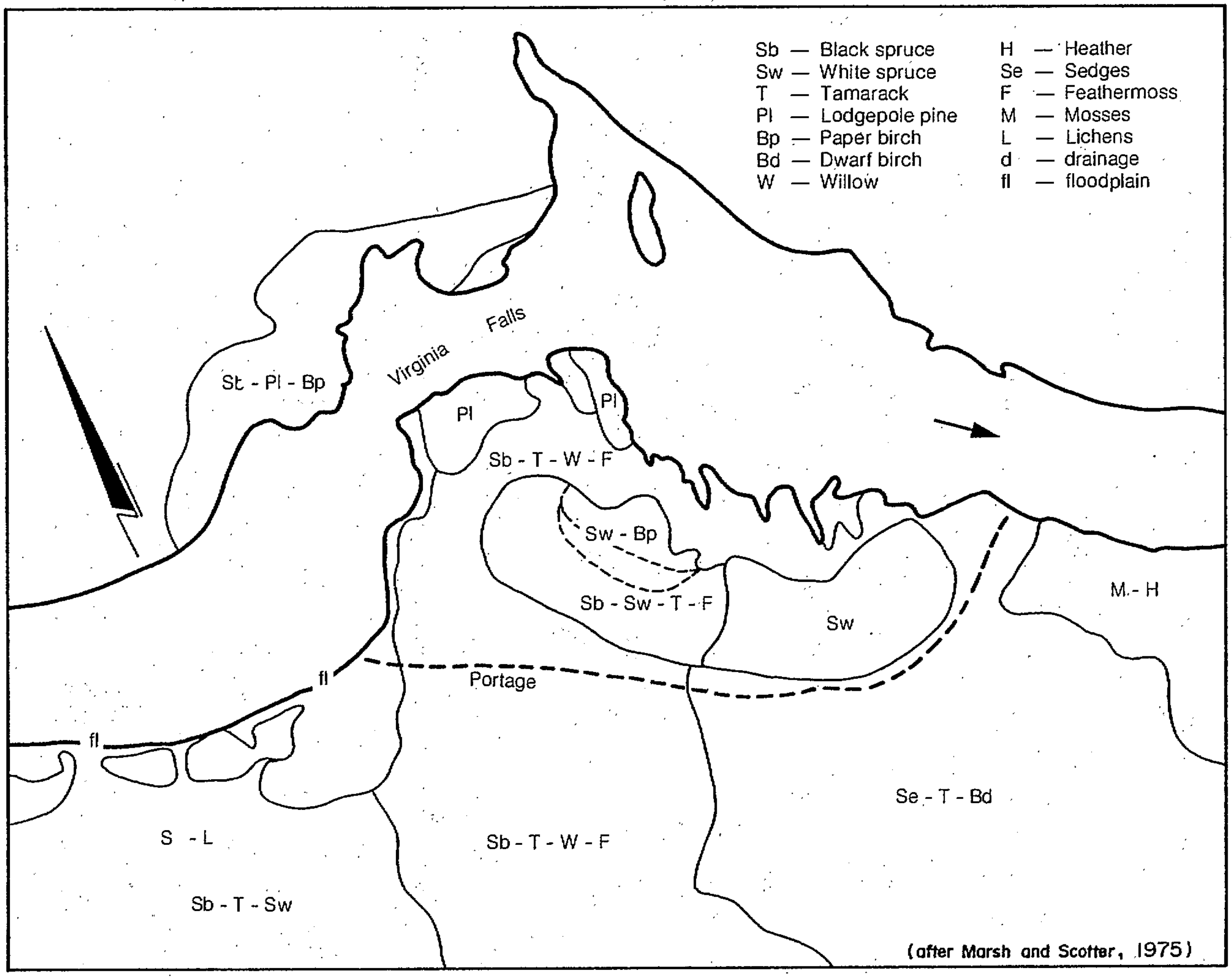

Figure 36. Vegetative associations around Virginia Falls.

Some woodland caribou winter in the open spruce forests immediately north and downstream of the falls (Carbyn 1975).

Canyons such as the one immediately below Virginia Falls should be ideal nesting sites for raptors (Carbyn 1975).

Fish species present in the South Nahanni River include arctic grayling, longnose sucker, Dolly Varden or arctic char, mountain whitefish and slimy sculpin (Jessop et al. 1974). The falls are, of course, a barrier to fish movement and separate populations occur above and below the falls.

4. Social and Cultural Values: The prehistoric visits of Indians to the falls known as the "big drop" were infrequent because of the low wildlife populations in the area (Marsh and Scotter 1975). Even now, residents of Nahanni Butte rarely travel far into the mountains and resource use is low.

The power potential of the Virginia Falls was first considered in 1937, and by 1970 the falls were part of a controversy over "whether the area should be set aside for wilderness recreation and to preserve its unique features or developed for hydroelectric power" (Marsh and Scotter 1975). It was set aside as part of Nahanni National Park. The park is attracting so many visitors every year that the Virginia Falls and downstream areas are now in danger of damage from over-use. In 1974 at least 394 people visited the falls by river, and 23 by chartered aircraft. Winter visitors are infrequent because of the severity of the climate and access problems (Figure 37).

Figure 37. Virginia Falls in winter.

L. Allison, February 1973

The Nahanni, with its legends and mystery-shrouded histories has become part of the vernacular Canadian folklore. Spectacular Virginia Falls is part of that folklore. Patterson wrote of his first visit to the falls in 1927:

> I spent that afternoon passing from side to side over the great pool at the foot of the Falls. The sun slid down the sky and shadows swung and deepened but time, for me, had lost its meaning, for I myself was lost in the fascination of this place of wild, chaotic beauty. I climbed up over the rocks on either side into shadowy, dripping clefts where the ferns and mosses glistened in the never-ending rain; I came out again into the hot sunshine and hunted on the beaches for fossils of strange, queer water beasts, and then crossed over to lie on the sun-warmed rocks of the north shore. The best view was from there, where the shining rim of the Falls cut across the cloudless blue: the drop to the pool was broken by a step springing out from the southern precipice and widening to the north like the step of a turret stair; from this step sprang a glistening tower of rock that reached far above the upper step or rim and cut the Falls in two. A cloud of spray, glittering against the afternoon sun, wreathed and twisted around the sharp peak of this limestone pillar; that would be where the cataract hurled itself against the rock before taking the final plunge. A fine picture it made and a most tumultuous din, for the Nahanni here was at least as big, I thought, as the Rhône at Lyon.
>
> The pool must be tremendously deep, and from its depths there is an upsurge of water, a sort of vertical eddy, which creates a hump of boiling water without any definite current, on which a canoe spins and twists but goes neither up nor down-stream. On the upstream edge of the hump the current sucks back into the Falls, and on its downstream side the water spills out and down the Nahanni. This simple hydrographic law I discovered for myself on my last passage across the river to the south shore. I lingered too long among the boils and eddies of the hump, spinning this way and that and enjoying from far too close the splendid sight of this tumbling curtain of the falling river.

> I woke up just in time and realized that I was in the backlash current and heading for the Falls. Now, by the holy mackinaw, was the time to lay on that paddle as never before! (Patterson 1973)

Any development which threatened the scenic and primitive aspects of the park would receive wide opposition.

5. Knowledge Gaps: The value of Virginia Falls rests heavily on its aesthetic and romantic features. Adequate data are available to assess the impact of a given development in the area of the falls themselves. For a detailed description of the entire park area, see also Scotter et al. 1971.

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CHAPTER V

GREAT SLAVE LAKE DRAINAGE

A. The Taltson River

The Taltson River (Figure 1) bisects an area of contrasting environmental characteristics. It has many scenic waterfalls and rapids, has a high recreation potential related to river-based activities, is important for commercial, subsistence and sport fishing, and provides valuable habitat for a variety of wildlife. These resources are closely interrelated and potentially sensitive to changes in hydrologic regime. The river also has substantial hydroelectric potential.

1. General Description: The Taltson River drainage basin encompasses an area of 64 000 km^2 south and east of Great Slave Lake, Northwest Territories, including portions of northern Alberta and Saskatchewan (Figure 38). The headwaters are in the vicinity of Hostile and Sylvan lakes. From there the Taltson flows north for about 130 km to McArthur Lake and then west for about 70 km to Gray Lake. The river then flows south and west for 256 km through Gray, Nonacho, Taltson, King and Lady Grey lakes, appearing more

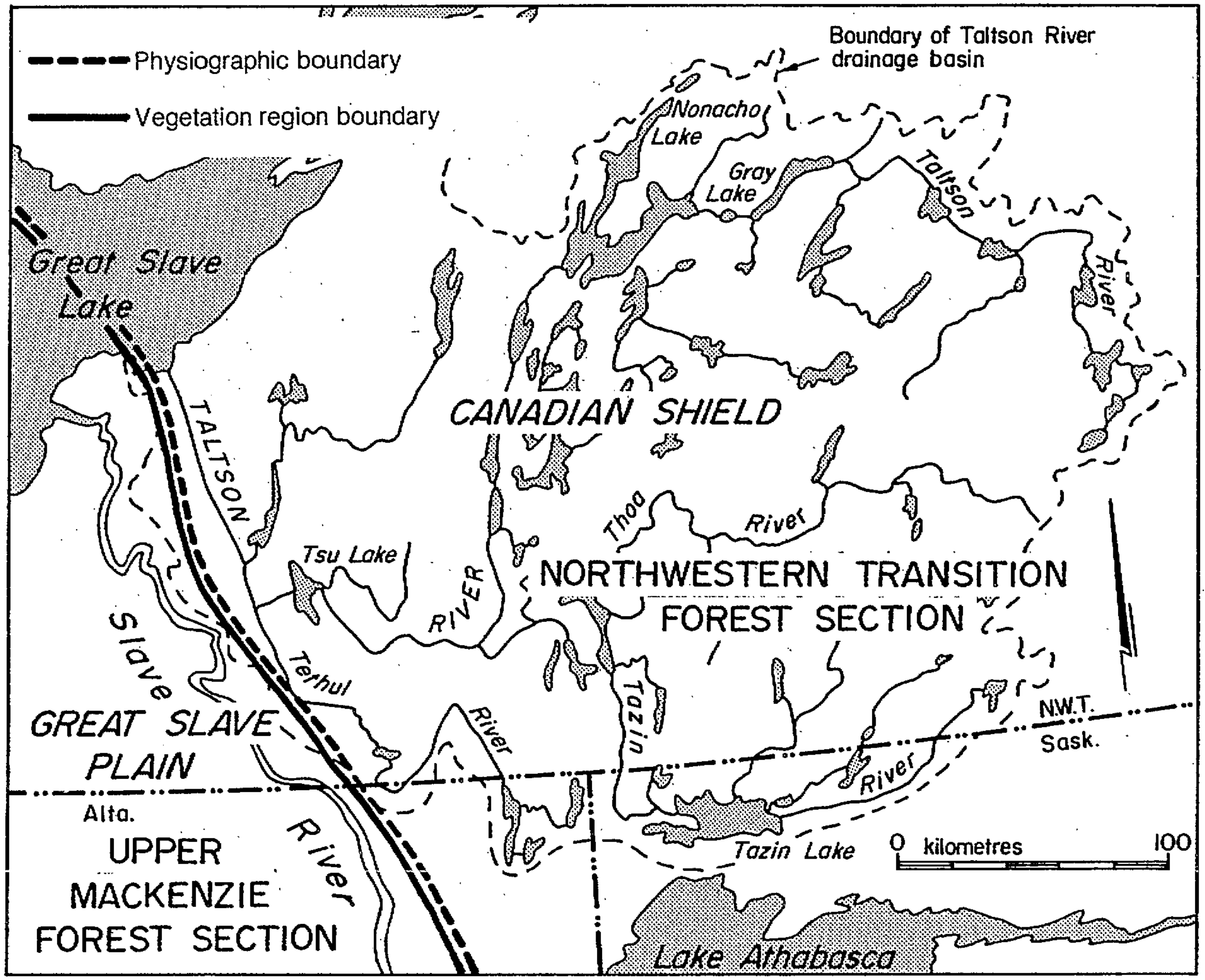

Figure 38. The Taltson River Basin.

as a series of inter-connected lakes than a river in this reach. Below Lady Grey Lake the Taltson is once again recognizable as a river. Flowing for about 160 km south and west, it passes through the small lakes Benna Thy, Kozo and Methleka before entering the larger Tsu Lake. From Tsu Lake the river flows west and then north through the south end of Deskenatlata Lake, then 88 km on to Taltson Bay on Great Slave Lake.

The largest tributaries are the Tazin and Tethul rivers, which drain parts of northern Alberta and Saskatchewan, and the Rutledge River (Envirocon Ltd. et al. 1975).

The Taltson River system drops from elevation 320 m at Nonacho Lake to 157 m at Great Slave Lake. In its upper regions which lie in the Laurentian Plateau or Precambrian Shield, there are few reaches where the Taltson flows through a well defined valley. In this headwater area the river is more or less like a chain of lakes with irregular shorelines connected by short stretches of swift or broken water (Envirocon Ltd. et al. 1975).

Through the rocky, glacially scoured Shield country, the Taltson flows over terrain which has little or no soil and little loose surface material. As a result, the river is clear and picks up little sediment. Those sediments which are picked up as the river passes through a sand plain or deposits of glacial drift, are soon deposited in the lakes which act as settling basins (Envirocon Ltd. et al. 1975).

The character of the Taltson River and the country through which it flows change quite dramatically below Tsu Lake at about the point where the Tethul River joins the Taltson (Figure 38). Here the river encounters the level terrain characteristic of the Slave River Lowlands (Envirocon Ltd. et al. 1975). The terrain in this area is more level with fewer rock outcrops. The largest proportion of the surface materials consists of soils and unconsolidated material believed to be partly glacial lake deposits (Glacial Lake McConnell) and partly deposits laid down by the Slave River (Craig 1965).

In the lower reaches, the river flows almost due north through level country with very few rock outcrops. The surface materials consist of fine sands or silts deposited by the Slave River. The Taltson River flows in a channel it has cut through this material. The eroded fines transported to the mouth of the river have been slowly building a small delta (Envirocon Ltd. et al. 1975).

The Taltson River basin was glaciated during Pleistocene time by the Continental ice sheet which moved westerly and northwesterly from Hudson Bay. The ice sheet had many effects including the denudation of resistant rock hills leaving unweathered rock at the surface, and the scouring of channels in less resistant formations. The wide-spread deposition of glacial debris caused the complete disruption of the then-existing drainage. The present drainage is immature, consisting of innumerable lakes commonly joined by fast-flowing streams. Glacial deposits - till, outwash, drumlins, eskers and lake sediments - now block many pre-glacial stream channels (T. Ingledow and Associates Ltd. 1969).

The entire basin lies in the zone of discontinuous permafrost (Brown 1970).

The main factors influencing the climate of the study area are its northern location, location of the arctic front over the area in winter, continental and maritime influences and the topography of the region.

The climate of the region exhibits the extremes of northern continental weather. Air temperatures in winter may be below 0°C for seven to eight months and are frequently below -20°C during this period. Lows of -50°C are quite common. Summer temperatures are often in the 26°C to 32°C range from May to September. Precipitation in the region is moderately low with about 152 mm of rain and 1320 mm of snow per annum producing an average annual total precipitation equivalent to about 279 mm of rain. In most of the region the last snow has left the ground by early May (Envirocon Ltd. et al. 1975).

2. <u>Hydrology</u>: The hydrology of the Taltson River system has been described by T. Ingledow and Associates Ltd. (1969) and updated in greater detail by Envirocon Ltd. et al. (1975). The following description is paraphrased from these sources.

Because a considerable portion of the Taltson system moves water from east to west, turning north only in the last 120 to 130 kilometers, flows vary little from day to day or within any one month. Consequently, break-up generally occurs in a short time period over the entire basin. This, in conjunction with the many lakes through which the water flows and the constrictions at the outlets which make many of them, in effect, natural storage basins, gives the Taltson a relatively smooth discharge pattern. This discharge pattern is in contrast to that of some northern rivers, such as the Slave and Mackenzie. In the latter, a northward flow of warm water from southern latitudes forces the break-up of ice cover and creates annual floods.

There are three gauging stations on the Taltson River (Mackenzie Reference Binder n.d.). Flow records are available for the outlet of Tsu Lake in the lower reach. Information on the "undeveloped" system is available from 1962 to 1967[1]. Mean annual discharge in the Taltson system has been much reduced in the period 1968-1973 when compared with the period 1962-1967.

Mean annual discharge from Tsu Lake before 1969 was about 227 m^3/s. Since then the mean annual discharge

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[1]These flows have been at least partially affected since 1939 by developments on the Tazin River in northern Saskatchewan. This is believed to have been a minor effect, however, and it was not until 1969 that major developments have significantly affected the discharge pattern.

has been less than 113 m^3/s (Envirocon Ltd. et al. 1975, Water Survey of Canada 1974). This reduction is due in part to the extra water required to fill the Nonacho reservoir. However, it is felt that the major cause has been reduced precipitation in the basin area (Envirocon Ltd. et al. 1975).

Two physiographical characteristics of the Precambrian Shield have an important influence on that region's hydrology and suitability for potential power development. Firstly, because the surface has a high proportion of lake area, flows are fairly well distributed throughout the year even though the winters are very long. Secondly, much of the runoff occurs in small drainage basins of the 12 800 to 640 000 km^2 range (Envirocon Ltd. et al. 1975).

3. <u>Biological Resources</u>: The headwaters of the Taltson lie in the Forest-Tundra section of the Boreal Forest region (Rowe 1972). This portion is well upstream of any effects of proposed developments. The lower Taltson River is basically the dividing zone between the Northwestern Transition Forest Section and the Upper Mackenzie Forest Section.

The Northwestern Transition Forest Section fronts the tundra to the northeast. In this fringe zone, unfavourable climatic conditions, thin soils and frequent fires have combined to reduce the distribution, abundance and size of the tree species. The most abundant tree on all sites is black spruce. White spruce grows with it on well-drained soils. Characteristic of these park-like coniferous stands is a ground cover of light-coloured, foliose lichens and abundant arboreal lichens (Rowe 1972).

The Upper Mackenzie Forest Section to the west (Figure 38) is typical of the riverine forests of the northern Mackenzie drainage. Because the valley floodplain environment is much more favourable for tree growth than that of the upland and Shield terrain, it coincides with some of the best timber producing land in the northwest. White spruce and balsam poplar form the main cover types on the alluvial flats bordering the river (Rowe 1972).

The contrast of these very different forest environments was first recorded by Samuel Hearne in his voyages through the country in 1771. Camsell (1916) reflected:

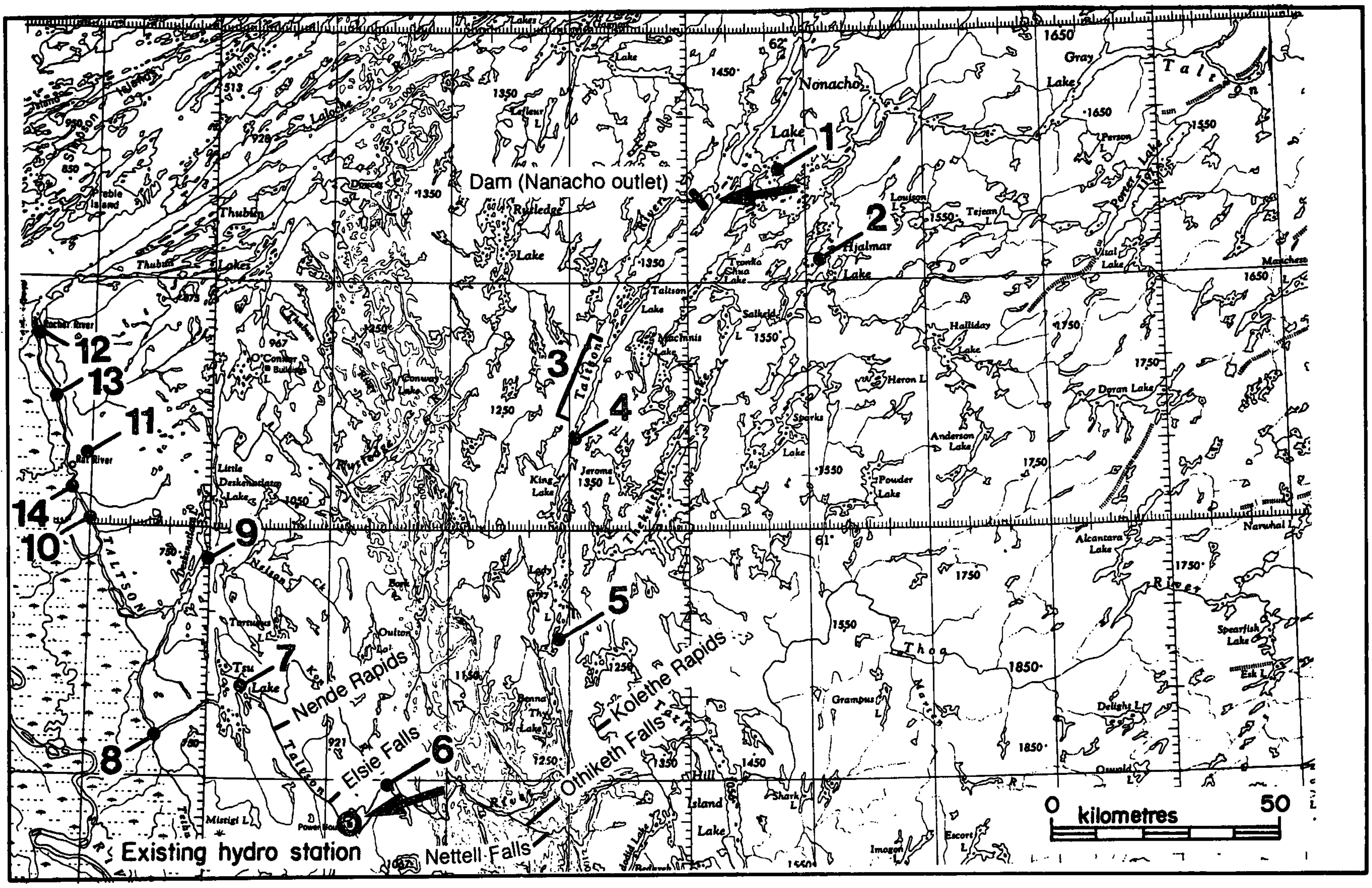
> It is probable that he [Hearne] reached the south shore somewhere in the neighbourhood of the mouth of Taltson river, or to the west of it, for if he had been further to the east he would not have described this shore as "a fine level country in which there was not a hill to be seen or a stone to be found." The shore east of the Taltson river is rough and very rocky, while that to the west forms part of the ancient delta of the Slave River and is consequently level and well wooded.

Wildlife highlight the natural resource base of the Taltson River (Jacobsen pers. comm.). Important wildlife species include large mammals, furbearers, waterfowl, raptors and fish, many of which find habitat in the river valley.

Envirocon Ltd. et al. (1975) summarized wildlife information for the area. As well, Department of Environment Land Use Information Series (1972) provides a detailed description of wildlife and habitat characteristics for the area (Figures 39, 40).

Barren-ground caribou and moose are common in the Taltson River basin. The entire basin is part of a much larger area that serves as the usual winter range for barren-ground caribou of the Beverly herds (Thomas 1969). During the winters of 1957-58, 1958-59 and 1959-60, from 30 000 to 70 000 caribou occupied the larger area. Approximately 30 000 caribou wintered in an area centred on Nonacho Lake in 1957-58. However, only 5000 were in the immediate vicinity of Nonacho in 1959-60 (Kelsall 1968). More recently, Envirocon Ltd. et al. (1974) reported the highest concentrations of caribou in the central portion of Nonacho Lake and in the area adjacent to the lake on the north and west.

Historical accounts indicate that moose were generally more abundant in the level country near the mouth of the Taltson River than in the rocky, broken country to the east Hearne 1792). Fires in recent years have provided vegetation in the early stages of succession which is generally preferred by moose. Despite the apparent suitability of the region as moose habitat, surveys in 1972, 1973 and 1974 all indicated that moose frequent the entire watershed but not in great abundance. The reduced flows in the Tazin River and in the Taltson below the confluence with the Tazin appear to have created limited amounts of the vegetation preferred by moose. Sedges, horsetail and some willows are colonizing the new shoreline zone (Envirocon Ltd. et al. 1975).



1 - Hjalmar Lake has been fished commercially for lake whitefish and lake trout since 1967. An annual quota of 105,000 lb. has been established.

2 - Species caught at this sport fishing lodge include arctic grayling, lake trout, northern pike. Other species found in Nonacho Lake include lake whitefish, lake trout, northern pike, walleye, sucker. Arctic grayling can be found in the rapids of the Taltson River system.

3 - Attractive canoe route, family beach and boating, attractive cottage sites.

4 - The gravel shoals and sand bars found in these sections of the Taltson River may be used as spawning areas for lake trout in September and October. Arctic grayling and walleye are found in this river system during the month of May.

5 - This section of Lady Grey Lake is shallow and weedy with sand and gravel bottom. It is reported to be a spawning and rearing area for lake trout in September and for northern pike in May and June.

6 - Fish caught in the Taltson River include lake trout, lake whitefish, sucker, northern pike, burbot and arctic grayling. This section has rock, gravel and sand bottom and is probably a spawning and nursery area for northern pike sucker and arctic grayling.

7 - Species caught in Tsu Lake include lake whitefish, lake trout, northern pike, walleye and arctic grayling. This lake is now reserved for sport and domestic fishing.

8 - Falls and excellent fishing at the confluence of the Taltson and Tethul Rivers; has high recreation potential.

9 - A native domestic fishery has traditionally been conducted for lake trout and lake whitefish in Deskenatlata Lake by fishermen from Fort Resolution. In 1971 an annual quota of 47,000 lbs. was established. Fish species present include lake trout, lake whitefish, northern pike and walleye.

10 - In spring, the Taltson River serves as a migration route for lake whitefish from Great Slave Lake, where they overwinter, to Deskenatlata Lake.

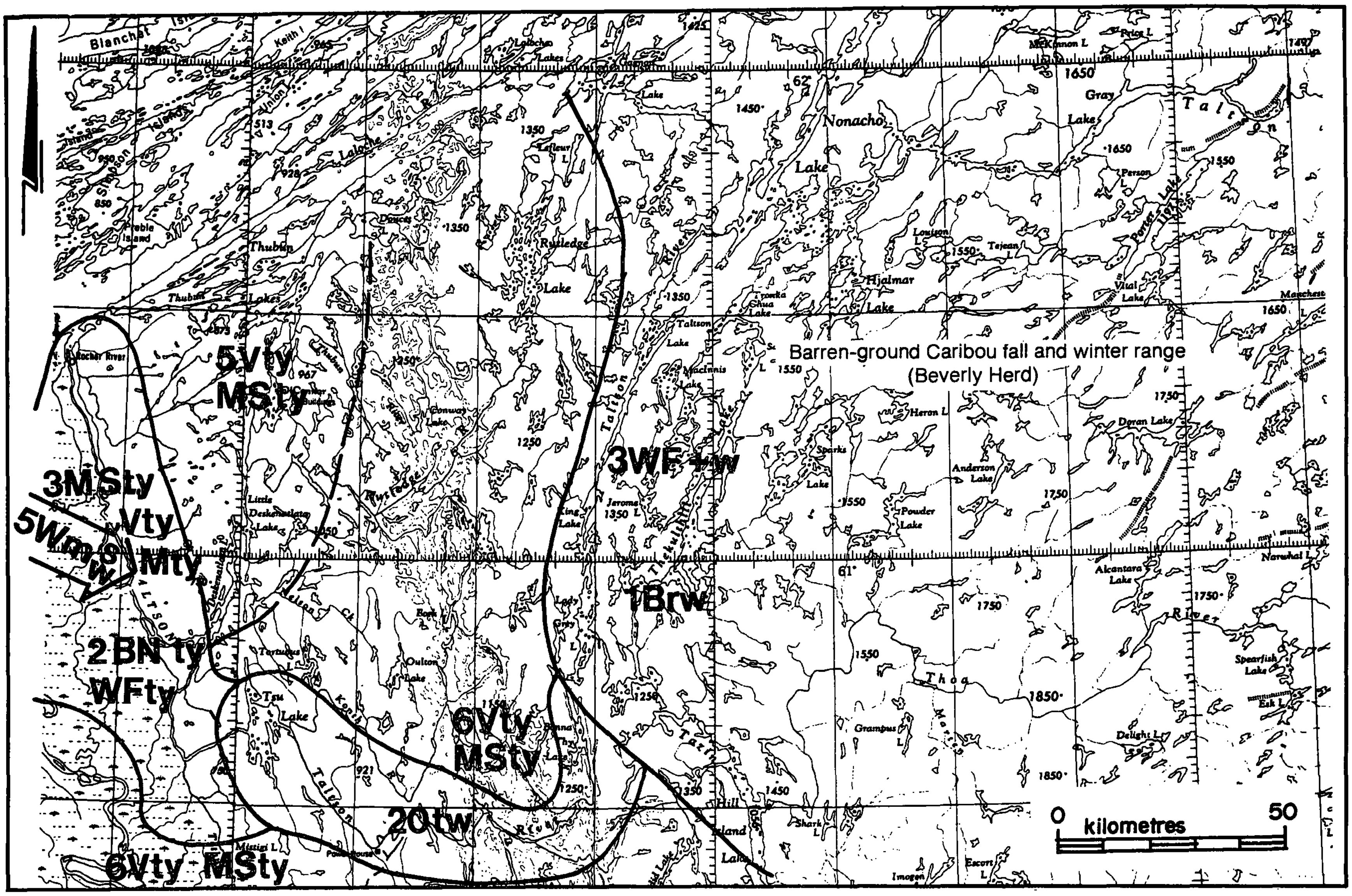
11 - Rat River: an important settlement during the first half of the century because of excellent hunting, trapping and fishing.

12 - Rocher River.

13 - The Taltson River, from the village of Rocher River to the mouth of the Rat River, is fished commercially for walleye. Beginning in the spring and until the month of June, Snuff Channel and the Taltson River serve as spawning areas for walleye.

14 - In October, this section of the Taltson River is used as a spawning area by a large number of lake whitefish.

Figure 39. Resources and Fisheries of the Taltson River basin.



3WFtw - Wolves may be found throughout the barrenground caribou winter range, often following the movement of the caribou herds.

1Brw - This area is part of a large region of mature spruce forest in which large numbers of wintering barrenground caribou feed heavily on the terrestrial and arboreal lichens. These caribou, part of the Beverly herd, migrate into this important range in early winter, and return northeastward again by early spring.

20tw - During winter, numerous rapids on the Taltson River do not freeze and are therefore important feeding sites for otter.

6Vty MSty - This wildlife zone, which encompasses the transition between the Canadian Shield and the Great Slave Plain, has numerous lakes and ponds and an abundance of willows. Beaver and moose are common throughout the zone.

5Vty MSty - This transition zone between Canadian Shield and Great Slave Lake Plain offers excellent habitat for beaver and moose. Numerous lakes, ponds and willows are features of this habitat.

2BNty WFty - The extensive sedge meadows of the Slave River floodplain provide important winter range for over 2000 bison. Wet summer conditions reduce usable summer range to the large sedge meadows north of Hook Lake. These meadows are also very important for moose calving areas in spring. Wolves, abundant in this area, are associated with the large populations of moose and bison.

3MSty Vty Mty - This area, which extends north along the lower Tethul and Taltson Rivers is important for moose, beaver and muskrat.

5Wmw (s) - In summer and fall, large numbers of swans, geese and ducks migrate through this region. They use the numerous small lakes and streams for feeding and resting.

Figure 40. Wildlife and wildlife habitat of the Taltson River basin.

When Samuel Hearne travelled through the region in 1772, great herds of wood bison were reported in country around the mouths of the Taltson and Slave rivers. They apparently did not extend eastward into the rocky Shield area (Hearne 1792). At the time of Camsell's 1914 survey of the area, the wood bison had ". . . long since disappeared from the country east of Slave river and only a remnant of their former numbers is now found on the west side of that stream." (Camsell 1916).

Today a large part of the wood bison range is protected in Wood Buffalo Park, but the bison still wander throughout much of their original habitat. A small herd of about 20 was observed in meadows on the west side of the Taltson River in 1973. Bison also cross to the east side of the Taltson on occasion, feeding in the meadows near the confluence with the Tethul River (Envirocon Ltd. et al. 1975).

Wolves are generally wide-ranging in relation to their prey species. In the Taltson River basin they commonly congregate near the caribou herds (Envirocon Ltd. et al. 1975).

The Taltson watershed is believed to support muskrat, beaver, fox, fisher, lynx, marten, mink, otter, weasel and wolverine, squirrels and hares in abundance related to the availability of suitable habitat. Muskrat and beaver, uncommon in the rocky eastern part of the watershed, are abundant in the lower reaches of the river where both the vegetation and the soils are more suited to their needs (Envirocon Ltd. et al. 1975).

During spring and fall migrations, waterfowl are present throughout the Taltson watershed. Small numbers of ducks breed and nest in the small ponds, lakes and sloughs of the area and in suitable habitats along rivers and streams. In the eastern portion of the watershed, where shorelines tend to be rocky and areas of good nesting habitat are sparse, breeding densities are low. The large oligotrophic lakes provide little waterfowl habitat, and there are few backwaters or sloughs off the rivers which are capable of supporting any number of waterfowl. There are better habitats in the marshes and sloughs in the lower reaches of the Taltson (Envirocon Ltd. et al. 1975).

Geese are common migrants through the area. Snow geese use the mouth of the Taltson River as a spring staging area. Canada geese fly over this area on their southward fall migration. Generally few stop in the Taltson system (Envirocon Ltd. et al. 1975).

A large number of passerine species occur in the area. Bald eagles are common and there are many active eyries along the Taltson and tributary rivers. Although fish form the mainstay of the eagles' diets, this is supplemented with rabbits, ducks and other occasional prey (Envirocon Ltd. et al. 1975).

Other observers report high populations of raptors nesting in the study area. Quinlan (pers. comm.) during a 1978 field excursion sighted 22 bald eagles, 4 with nests at Oracha Falls upstream of Rat River village. He also reports sighting 1 osprey with nest. Decker (pers. comm.) saw over 20 osprey nests on rock islands in the lakes of the upper Taltson River. He stated that 12 to 15 of the nests were active.

Numerous waterfalls, gravel and sand areas, and clear, sediment-free oligotrophic water provide excellent habitat for fish in the Taltson River. The major species are arctic grayling, lake trout, lake whitefish, northern pike and walleye. Lake whitefish is the main commercial and domestic species while lake trout, inconnu, arctic grayling, pike and walleye are the principal sport fishes (Department of Environment 1972).

4. Social and Cultural Values: Hydroelectric development, hunting and trapping, and recreation are the major socio-economic concerns in this area.

a. Hydroelectric development: There are at present two hydroelectric developments on the Taltson system. They were installed to serve the power needs of Fort Smith, Fort Resolution and Pine Point. The sections below are paraphrased from Envirocon Ltd. et al. (1975).

The Tazin River diversion was the first hydroelectric development in the Taltson system. In 1939 Eldorado

Nuclear Limited constructed a rockfill dam at the outlet of Tazin Lake to divert part of the flow into the Charlotte River (part of the Athabasca system). At the same time Cominco Limited constructed a diversion tunnel from Tazin Lake to the Charlotte River.

In 1959 the dam at the outlet of Tazin Lake was raised a further 2 m to increase the firm flow available for diversion. Despite this diversion, peak summer flows continued to be spilled into the Tazin-Taltson system until 1968. Since 1969, however, runoff in the upper Taltson basin has been so low that there have been no flows over this dam into the Taltson system. The present flows in the Tazin River represent leakage through the dam and inputs from tributaries such as the Thoa River.

Because there are no flow data available for the Tazin, it is not possible to estimate the reduction caused by this diversion, or to determine the extent to which flows in the Taltson have been reduced as a consequence. The reduction in flows is believed to have been substantial, however.

Development of storage and electrical generation facilities has taken place at two separate sites on the Taltson River. Electricity is generated at the Twin Gorges plant. A storage reservoir has been created upstream of this plant on Nonacho Lake in order to provide the required firm flow.

Unlike the earlier development of the power plant itself, development of storage on Nonacho Lake had some readily evident environmental effects. The first of these was the raising of the lake levels and accompanying inundation of land. The second effect was an alteration of downstream flows.

Flooding has affected Nonacho, Gray and Hjalmar lakes, which between them have a total shoreline of close to 640 km. The area flooded at any particular point depends on the slope of the shoreline. Around Nonacho Lake there is a narrow fringe of flooded coniferous and deciduous vegetation with many trees still standing but others fallen and submerged. In some areas the flooding has been much more extensive. There is little evidence of extensive slumping of banks, although it has occurred adjacent to eskers.

Gray Lake has been raised to the same elevation as Nonacho, a change in water levels of about 1 m. The flooding around Gray Lake has not been as extensive as on Nonacho.

b. Settlements and native use: Two settlements, Rocher River and Rat River, are located in the lower reaches of the Taltson River (Figure 39). From 1921 until the 1960's Rocher River, located along both banks of the Taltson River near its mouth, was a predominantly Indian settlement of approximately 100 persons. The community supported a school, a church and two free traders. In 1960, the school burned and that, coupled with the centralization of education and health facilities, resulted in most of the residents moving to Fort Resolution by the mid-1960's (Bodden pers. comm.). Good hunting, fishing and trapping are found in the vicinity of Rocher River (Department of Environment 1972). Currently 8 to 10 trappers from Fort Resolution and Snowdrift return to the area in winter (Bodden pers. comm.).

Rat River was an important settlement during the first half of this century because the area was excellent for hunting, fishing and trapping. Trading posts operated there between the years 1928-30 and 1935-45 (Department of the Environment 1972). For the past few years 4 residents of Fort Resolution have travelled to Rat River to trap. As with the trappers from Rocher River, lynx, mink, beaver, marten, wolf and fox are the main species trapped. In order to feed approximately 80 sled dogs, they also net about 44 000 lbs. of whitefish and inconnu per season (Bodden pers. comm.).

As well as these centres, there is an Adult Vocational Training Centre operated each year on Pilot Lake. This centre, operated by Selwyn College, Vancouver, conducts resource management training courses for native and white students. The College keeps wildlife records for the area gathered during educational field trips (Decker pers. comm.).

c. History: The Tazin-Taltson River route (Figure 41) has been used by the Indians of the Lake Athabasca-Great Slave Lake areas as long ago as the 1890's. Camsell (1916) described it, ". . . there is a canoe route through this region to the Thelon river that has been known to the

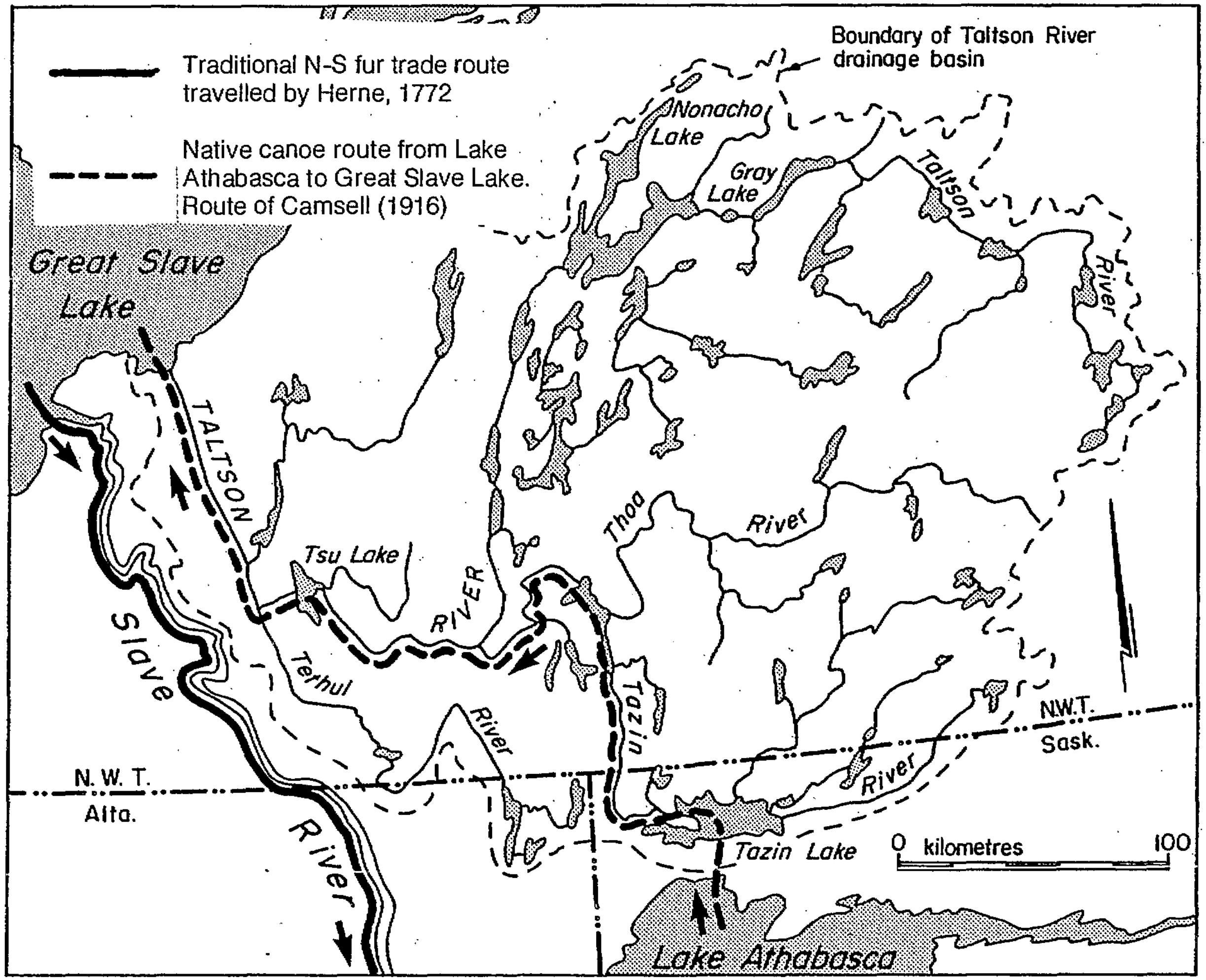


Figure 41. Canoe routes between Lake Athabasca and Great Slave Lake.

Indians and used by them as far back as 80 years ago. Although a route across this region by way of the Tazin and Taltson rivers has been known for many years, we were the first white party to traverse it."

d. Proposed developments: There are numerous sites that have been assessed for hydroelectric development. These areas are discussed in reports by Montreal Engineering Company (1963, 1967, 1970a,b), T. Ingledow and Associates Ltd. (1969), Northern Canada Power Commission (1974, 1975) and Envirocon Ltd. et al. (1975). The most feasible site centres around a further expansion of facilities at the Twin Gorges site (T. Ingledow and Associates Ltd. (1969).

5. Sensitivity: Investigations which have been conducted on the Taltson River have been limited mainly to the aquatic environment, largely upstream of the existing facilities. Downstream effects of the existing control structures have had serious consequences for a number of trappers. At least 5 trappers have been forced out of the Rat River area due to lowering water levels. The area to the west of Rat River used to be an extensive wetland stretching into the Slave River valley. This area was highly productive for beaver, muskrat and moose. Today the water level has dropped and the habitat is succeeding to more mesic vegetation, and the commercial furbearing population has declined sharply (Bodden pers. comm.).

As a result of increased access to the area, plus increased recreational use, many trappers reported heavy losses of equipment and supplies from cabins established along their traplines (Bodden pers. comm.).

Jacobsen (pers. comm.) stated that if further hydro-electric development occurs on the Taltson River, the sensitive environmental concerns will be:

1) the fisheries in the upstream lake, most importantly the spawning and nursery areas;
2) wildlife habitat along the downstream floodplains, namely succession to more mature vegetation communities; and
3) the recreational and historic attributes of the existing lakeshores, falls and rapids.

6. Knowledge Gaps: Although a significant amount of detailed biophysical information is available on the Taltson River system including evaluations of the possible effects of proposed hydroelectric developments, it is apparent that relatively little effort has been put into post-development assessment of changes (Envirocon Ltd. et al. 1975). Geen (1974) stated that this is a general inadequacy of western Canadian hydroelectric projects.

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B. Lockhart River

1. General Description: The Lockhart River describes a large reversed "C" across the Precambrian Shield north of Great Slave Lake (Figures 1, 42). Rising at 417 m, it flows 480 km to its mouth on the east arm of Great Slave Lake. The river drains an area of 26 780 km^2 - primarily in the barrens (T. Ingledow and Associates Ltd. 1969).

There are no communities on the Lockhart River. Reliance, a summer settlement used by native hunters and fishermen is about 15 km from the river mouth. Access to the area is from Yellowknife by chartered aircraft or large boat. The lower portions of the Lockhart River are not navigable.

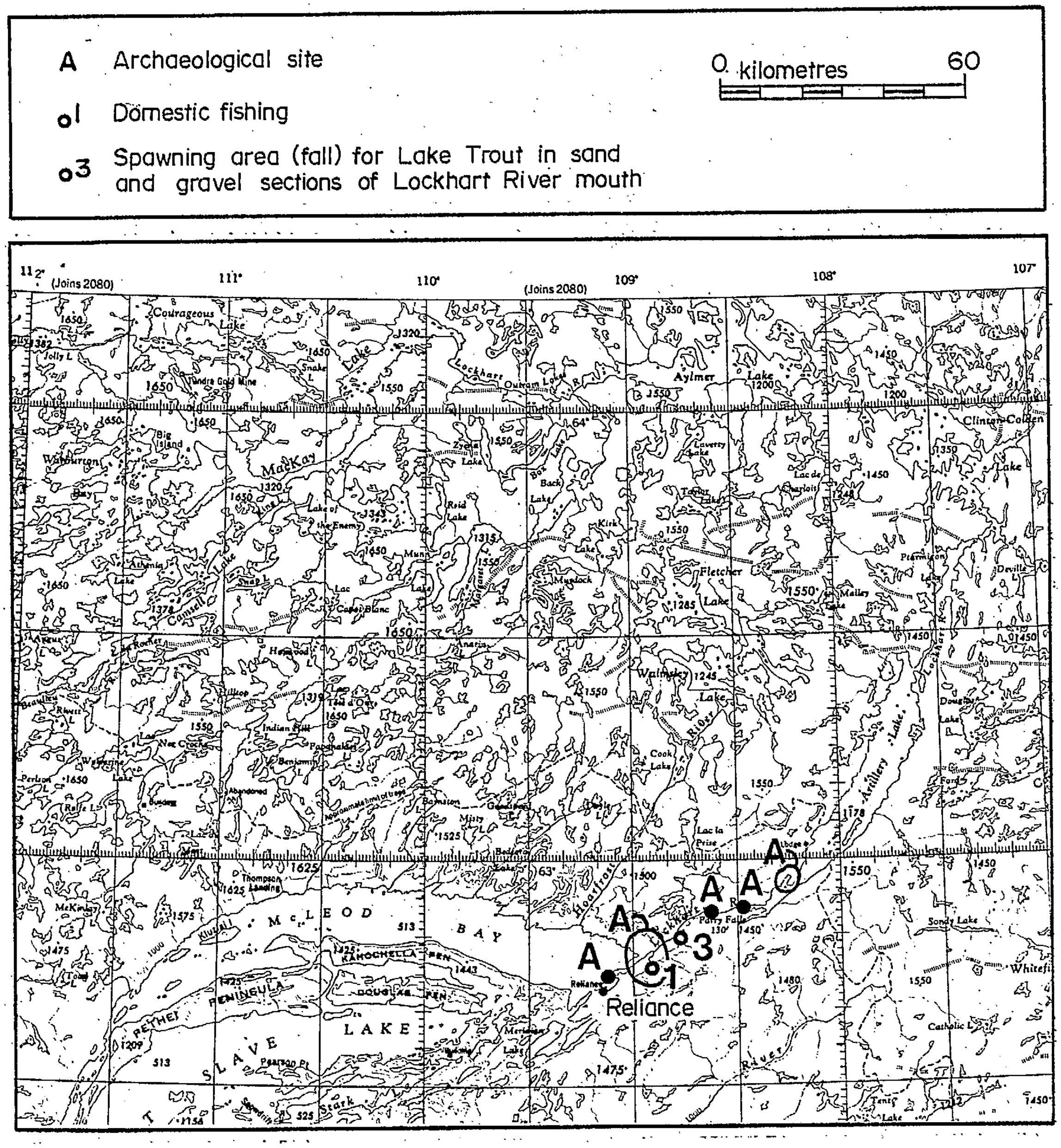

Figure 42. The Lockhart River, showing archaeological sites and fishery resources.

The entire area drained by the Lockhart River lies within the Precambrian Shield. It contains a variety of rock types, with Protozoic and Archaean aged bedrock exposed in many locations. Although prospectors have been active in the area, apparently no strong mineral showings have been found (Kelsall et al. 1972).

Glacial features are prominent on the surface of the area. Granite bedrock dominates the area and has in many places been cracked, scarred or moved by glacial or ice action. Rivers flowing within and under the receding ice of the last glaciation deposited sand and gravel eskers and drumlins. These are particularly notable in the tundra areas. Glacial Lake McConnell was formed in the late Pleistocene period. Raised beaches 150 m or more above current levels of Great Slave Lake show its extent. A large sand deposit about halfway between Artillery Lake and Great Slave Lake was probably a Pleistocene delta. It is not known whether Artillery Lake was confluent with Lake McConnell (Kelsall et al. 1972).

In the forest fringe permafrost occurs intermittently. Peat plateaux 30-60 cm high are interspersed with unfrozen peat deposits. In the tundra ecotone permafrost appears more extensive in poorly drained areas, and permafrost landscape features are present (Kelsall et al. 1972).

The area generally is part of the Northwest Transition of the Boreal Forest region and has cold winters, cool summers and low precipitation (Rowe 1972). Snowfall averages 112 cm, but there is rarely more than 51 cm on the ground (Kelsall et al. 1972).

2. Hydrology: The upper reach of the Lockhart includes a series of large lakes joined by short stretches of river. The stretch of river which is of concern to the Task Force lies between the north end of Artillery Lake and the river mouth. In the final 32 km stretch, the river falls more than 180 m. Here the water tumbles over a variety of rapids, rushes through narrow canyons, backs into quiet pools, and roars over spectacular waterfalls. Tyrrell Falls, the largest waterfall, drops 45 m (Figure 43, T. Ingledow and Associates Ltd. 1969).

A water gauging station was established on the Lockhart River at the outlet of Artillery Lake in 1944. Mean monthly minimum discharge is 86 m^3/s in May. Mean monthly maximum discharge is 156 m^3/s in September. Recorded daily extremes were 245 m^3/s on October 18, 1963, and 62 m^3/s May 1, 1947 (Water Survey of Canada 1974). Because much of the river's hydraulic head is stored in large lakes, the streamflow usually has an annual variation of less than a factor of 2. That is, much of the spring runoff is stored in large lakes and slowly released to the river during the year.

3. Biological Resources: The Lockhart River-Artillery Lake area is part of the Boreal Forest vegetation zone

Figure 43. The Lockhart River valley.

L. Allison, August 1978

(Rowe 1959, 1972). The regions that Rowe calls Northwestern Transition and Forest-Tundra are referred to by Kelsall et al. (1972) as Forest Fringe and Tundra Ecotone. Tundra occurs beyond the Tundra Ecotone (Figure 44). Vegetation descriptions which follow are paraphrased from Kelsall et al. (1972).

Tall spruce trees and a forest floor carpeted with lichens and mosses characterize the Forest Fringe. In favourable locations a closed forest of spruce develops with an understory of feathermoss. Most common tree species are black spruce, white spruce, tamarack and white birch. Ground lichens occur only in places which have not been burned for the last 100 years.

The Tundra Ecotone (Figure 44) has an open spruce-lichen cover on the flats and slopes, and tundra-like vegetation on the low ridges. Although the open hill tops look like tundra, they support species characteristic of southern plant communities. Alder, glandular birch, sweet gale and Labrador tea are important shrubs.

On the Tundra, the only trees present are stunted white spruce which grow on sandy deposits. Ridges and slopes support ericaceous shrubs, while willows, glandular birch and cotton grass are found on the lowlands. Three hundred forty-three species of lichens have been reported from the area - many of the fruticose and foliose types are used by caribou as winter food.

The region contains species of birds and mammals

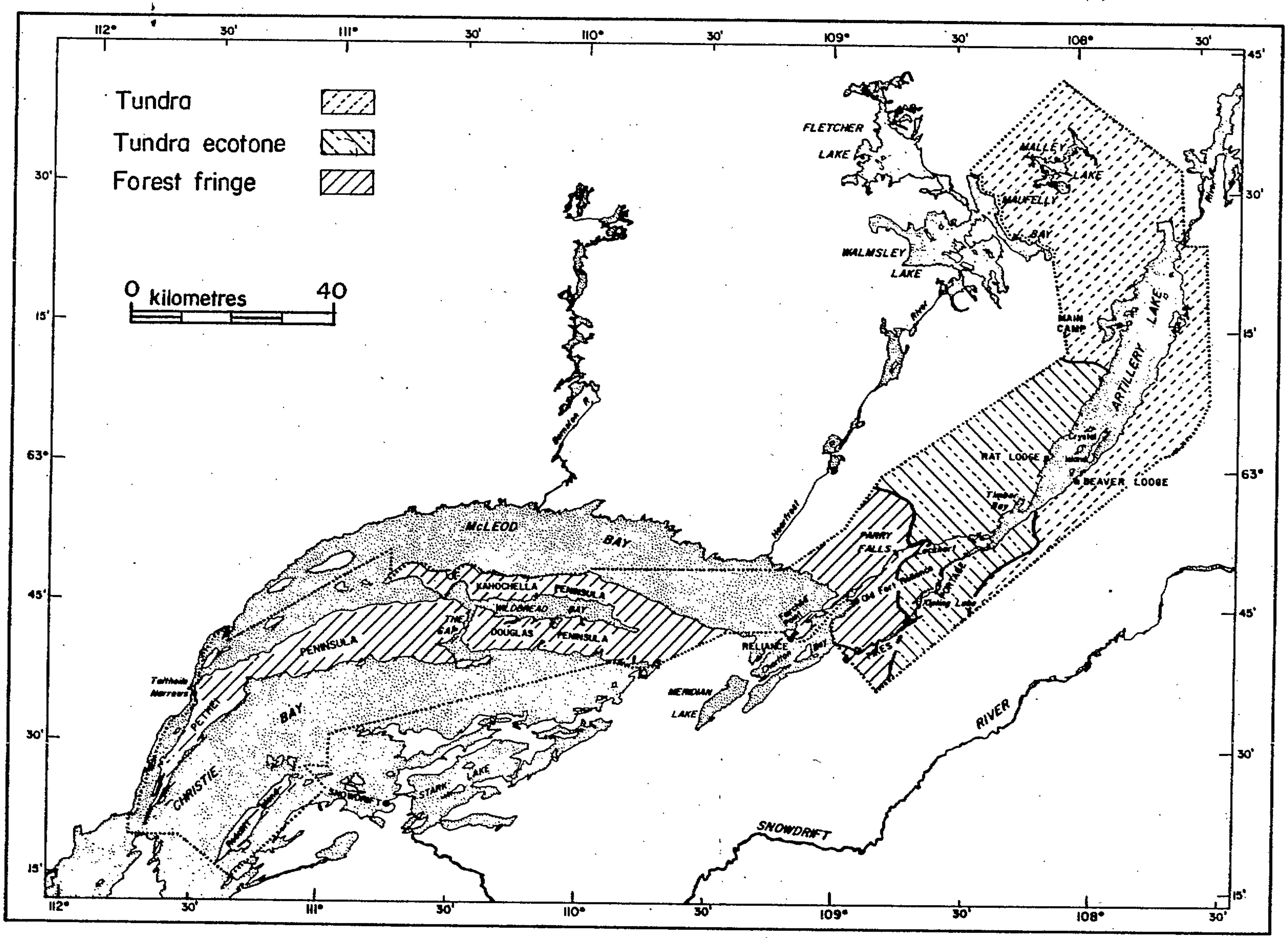

Figure 44. Vegetation zones along the lower Lockhart River after Kelsall *et al.*, 1972.

generally associated with forested and tundra areas. In the Tundra Ecotone, a broad area of overlap, are found small populations of species characteristic of both habitats (Department of the Environment 1975).

The avian fauna of the Lockhart River area has been inventoried very little. The most spectacular and vulnerable species which nest in the vicinity are the raptors. Rough-legged hawks, bald eagles, golden eagles, gyrfalcons, peregrine falcons and merlins all breed in the area. The east arm of Great Slave Lake is identified as particularly important for rare and endangered species (Department of the Environment 1975, Allen pers. comm.). Because most lakes are deep, have rocky shorelines and support little emergent vegetation, breeding waterfowl are scarce. All 4 species of loon occur in the area (Kelsall et al. 1972). Large Canada geese moult along the Thelon River. Some are also seen along the Lockhart (Decker pers. comm.). Some whistling swans migrate through the Lockhart River area on their way to arctic nesting areas, but it is not part of a heavily used migration route. Willow ptarmigan are the most numerous year-long resident (Kelsall et al. 1972).

Among the mammals, the migratory barren-ground caribou is the most widespread and abundant. Even when they are not resident, the frequent pellet groups and myriad of trails point to their impact on the environment. Movements of caribou are erratic and unpredictable, and caribou may bypass any part of their winter range for one or several years. Summer movements may bring large numbers of caribou as far south as the Artillery Lake area in late August. They may reappear around treeline during October, in rutting season. In some years vast numbers of caribou cross the east arm of Great Slave Lake on their fall migration; return movements occur in April and May (Kelsall et al. 1972).

Caribou from the Bathurst herd wintered in the vicinity of the Lockhart River during 1948-49, 1951-52, 1952-53, 1955-56, 1957-58, 1959-60 (6 years out of 11). Only small portions of the total winter ranges of caribou are used in any one year. Winter distribution of a herd of caribou varies almost annually (Kelsall 1968).

Kelsall (1968) suggested that some caribou may shift their allegiance from one calving area to another. Current work suggests that the Lockhart River area is the approximate border of ranges of the Beverly and Bathurst caribou herds (Jacobsen, Decker and Calef pers. comm.). If mixing between herds occurs, it may be in this area.

Moose are particularly common in forested sections but their ranges extend as far as willow tickets in the tundra. Some moose remain in willows along exposed river valleys even in winter. Muskox occurred in the area historically and may still wander through occasionally. Barren-ground grizzly, wolves, arctic fox and coloured fox also frequent the area (Kelsall et al. 1972).

Lake trout are the most widespread and important sport and domestic fish in the area. They are common in Great Slave Lake, Artillery Lake and the Lockhart River. Round whitefish are found in the same locations, but lake whitefish and ciscos are common only in Artillery Lake. Arctic grayling have been caught at Fort Reliance, the mouth of the Lockhart River, and the outlet of the Lockhart River from Artillery Lake. The slimy sculpin is widespread and is an important food for piscivorous fish (Kelsall et al. 1972).

4. <u>Social and Cultural Values</u>: The east arm of Great Slave Lake is closed to commercial fishing, but it and Artillery Lake are favoured for angling from sports lodges in the area. Reliance is generally inhabited only in summer by natives who live yearlong in Snowdrift. Charleton Bay is an important domestic fishing area for these people (Department of the Environment 1975).

In late August and early September, hunters from Snowdrift and Yellowknife hunt caribou in the Pike's Portage area between Fort Reliance and Artillery Lake. If caribou are in the area hunters and their families may stay for several weeks and fish as well as hunt. In some years trappers from Yellowknife use the area. Several trappers from Snowdrift travel to the barrens every winter to trap arctic fox. They also use the Tundra Ecotone region. The lower Lockhart River area was used prior to 1965 by 4 or 5 residents of Snowdrift. They trapped arctic fox, coloured fox, lynx, marten and wolverine, and hunted caribou for food (Department of the Environment 1975).

The east arm of Great Slave Lake, including the Lockhart River-Artillery Lake area is a proposed International Biological Program site and a proposed national park. Prime attractions of the area are considered to be presence of caribou, the mixture of forest, tundra ecotone and tundra, and their plant and animal associations. Excellent angling and spectacular scenery are also provided by the Lockhart River (Kelsall et al. 1972, Beckel 1975, Department of the Environment 1975).

The Chipewyan Indians used to camp along treeline or in the southern tundra in summer, and move back into the forest for winter. The early local economy was tied to the caribou. Starvation and privation resulted during years when caribou failed to appear. Once the traders came, a trapping economy developed. During the peak of the fox trapping era in the 1920's and 1930's native villages were built at the mouth of the Lockhart River and 3.2 km inland from Timber Bay on Artillery Lake (Kelsall et al. 1972).

Archaeological artifacts are common, and several sites have been found (Figure 42). Since the sites which have been located are not stratified it is difficult to determine the chronology of human occupation. However, use of the area may have begun between 2500 and 3000 B.C. (Kelsall et al. 1972).

The Lockhart River-Artillery Lake area was not part of a major travel route for early European travellers, but it was used by some as a route between the Tundra and Great Slave Lake. A series of lakes and rivers known as Pike's Portage was usually used to bypass the rapid-ridden Lockhart River (Kelsall et al. 1972).

5. Sensitivity: Hydro development elsewhere in the Mackenzie Basin would probably not affect the Lockhart River appreciably because of the size of Great Slave Lake. Conversely, local developments possibly could be managed to have largely local effects because Great Slave Lake downstream and Artillery Lake upstream would act as reservoirs. This would restrict most impact to the river section between the two lakes. The relatively steep river valley would also help to contain water within a relatively small area.

In considering effects of a dam built on the Lockhart River, special attention should be paid to possible changes in break-up and freeze-up of both the river and lake. A more detailed knowledge of movements of caribou in the area would help to determine possible effects on caribou, bearing in mind that movements and activities of barren-ground caribou are notoriously unpredictable.

6. Knowledge Gaps: The most important reference work dealing with the area is the 1972 report by Kelsall, Kuyt and Zoltai entitled "Ecology of the Fort Reliance-Artillery Lake Area". It is based on one very short field season and

many educated guesses on the part of its authors. It provides an admirable overview of the area and an exhaustive bibliography. It does not, however, provide the site and population specific data which would be required to predict the effect of any specific development. Current and unpublished work in the area includes only a continuation of the Land Use Information maps to the east, barren-ground caribou surveys (both by the Northwest Territories Wildlife Service), and a study of raptors in the east arm of the lake (by Canadian Wildlife Service). The Lockhart River, then, is one of the areas in this report about which the least is known. A reliable environmental assessment of a specific development in the area would require a study program involving all disciplines.

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C. Lady Evelyn Falls - Kakisa Lake

1. General Description: Lady Evelyn Falls is one of the "potentially sensitive areas" chosen by the Task Force for its aesthetic value. Because information is available, Kakisa Lake and Kakisa River downstream of the lake are also included in this review.

Lady Evelyn Falls is located on the lower reach of the Kakisa River, upstream of the Mackenzie Highway crossing, about 33 km from Fort Providence (Figures 1, 45). A branch road from the Mackenzie Highway follows the south shore of the Kakisa River past Lady Evelyn Falls.

The Kakisa watershed lies within the Great Slave Plain subdivision of the Interior Plain. It is a very flat plain with numerous lakes and is formed of Paleozoic strata (Bostock 1969). Kakisa Lake lies on a plateau between two escarpments.

2. Hydrology: The Kakisa River flows a distance of 493 km, draining an area of 1560 km^2. It is a single channel river. Tathlina and Kakisa Lakes are large enough to exert

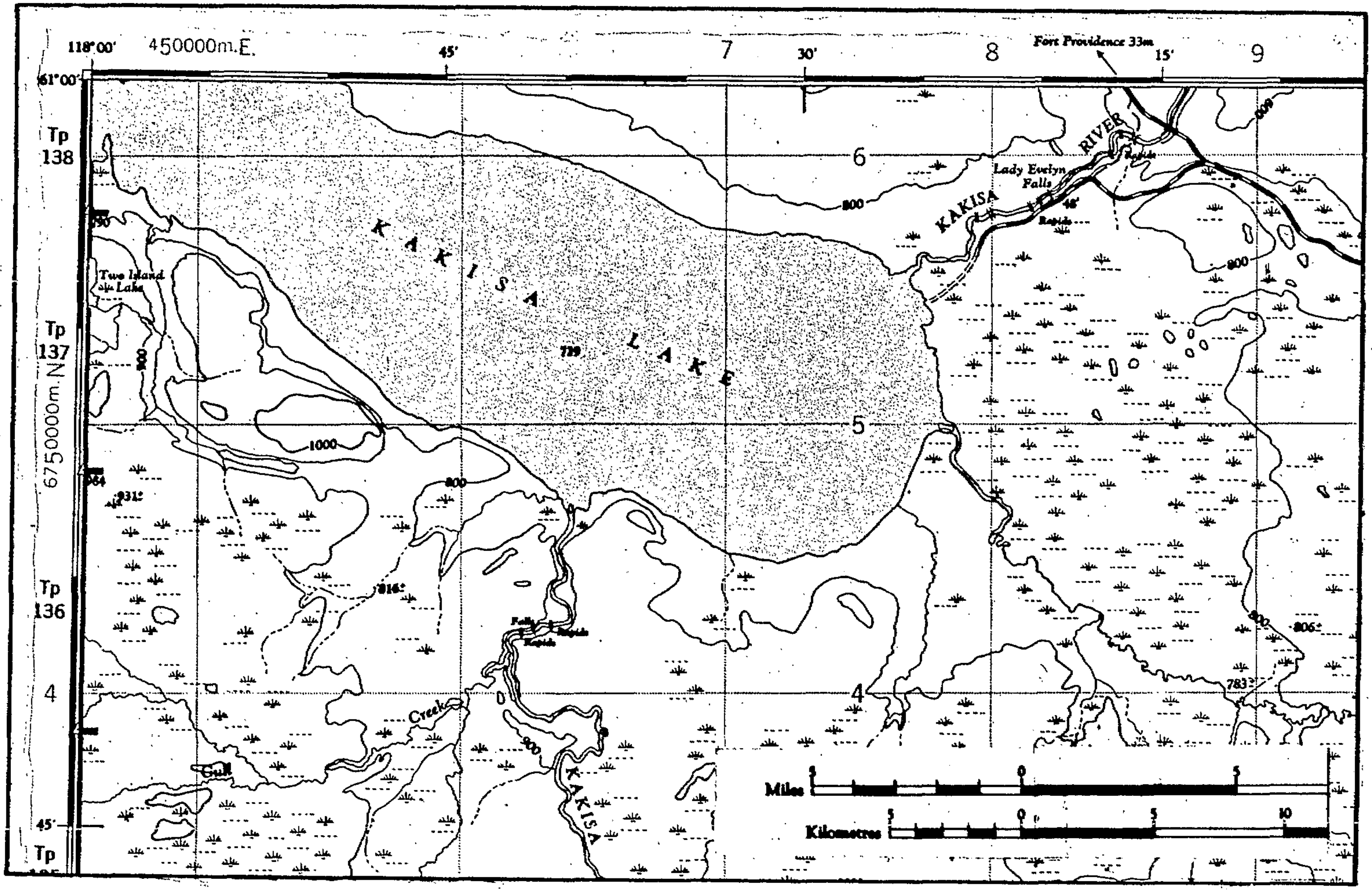

Figure 45. Lady Evelyn Falls.

a dampening effect on Kakisa River flood levels.

The river bottom between the Mackenzie River and Lady Evelyn Falls consists of fine gravel and silt. Above the falls as far as Kakisa Lake the riverbed is plated limestone and shale.

Kakisa River leaves Kakisa Lake and drops over 2 sets of rapids before reaching Lady Evelyn Falls. Below the falls, the river tumbles over more shallow rapids before reaching Beaver Lake, dropping 65 m. At the outlet of the lake, mean discharge is approximately 44 m^3/s. Maximum instantaneous discharge recorded was 202 m^3/s while the minimum daily discharge was 6.5 m^3/s (Stein et al. 1973).

3. Biological Resources: At the east end of Kakisa Lake the terrain is flat and supports a diverse plant community consisting of willow, alder, aspen, black spruce, white spruce and jackpine. Along the south is sparse shrub vegetation and the north shore supports narrow strips of aspen and white spruce. Black spruce muskeg dominates the landscape of the entire area away from the lake. Soils along the river are better drained during growing season than are the lakeshores. Spring floods deposit nutrients and may maintain early successional vegetation. White spruce and black spruce are common, while aspen and birch occur occasionally (Lamoureux 1973).

The outlet of Kakisa Lake is open all year and is therefore available to migrating waterfowl in May. The shallow water supports an abundant food supply for dabblers and divers. Spring migrants use the open river between Kakisa Lake and Lady Evelyn Falls. The most common species include mallard, bufflehead and common goldeneye. Spotted sandpipers and lesser yellowlegs feed heavily on exposed mudflats. Canada geese and whistling swans occasionally stop in the area. Low numbers of nesting ducks occur in favourable habitat, and a colony of 200 California gulls is found on the Tathlina River. The lake receives moderate to heavy use by fall migrants. Use of the area by Canada geese, whistling swans and lesser snow geese is higher in fall than in spring. Bald eagle and osprey occur in the area in relatively high numbers (Lamoureux 1973).

Beaver and muskrat are restricted to small areas of suitable habitat. Although favourable moose habitat is available, numbers are kept low by heavy hunting pressure (Lamoureux 1973)

Benthos in the river is dominated by nymphs of mayflies, caddis flies and stone flies which provide food for fish. Kakisa Lake contains yellow walleye, northern pike, burbot, white sucker, longnose sucker, lake whitefish, round whitefish and other non-economic species. Below Lady Evelyn Falls the river contains arctic grayling, yellow walleye, northern pike and longnose sucker. There is a lake whitefish run up the lower Kakisa River from Beaver Lake in the fall. Walleye, white sucker, whitefish and pike are available in commercial quantities although whitefish are so heavily infested with parasites that they are unmarketable. Commercial quantities of whitefish also occur in the Kakisa River above Beaver Lake. Fish species resident in Kakisa Lake favour the upper Kakisa River (known locally as Tathlina River) for spawning. Between Lady Evelyn Falls and Beaver Lake many potential spawning sites occur, some of which are used by arctic grayling, yellow walleye, and northern pike in late May and early June (Lamoureux 1973).

4. Social and Cultural Values: The main reason for the inclusion of Lady Evelyn Falls as a sensitive area is its spectacular scenic value, which includes the Kakisa River valley above the falls and the cascade immediately above the falls.

Most of the area is hunted, trapped and fished by residents of Kakisa, a small village at the west end of Kakisa Lake. Commercial fishing is the chief source of income for the town; trapping for lynx, beaver, mink and marten is second. Residents of Kakisa use mainly the lake and its inlet streams. In the fall people from Fort Providence fish for whitefish below Lady Evelyn Falls. A small but very popular sport fishery for arctic grayling occurs below the falls (Lamoureux 1973).

5. Sensitivity: Lady Evelyn Falls has been proposed as the site for a hydroelectric development. Lamoureux (1973) presents a fairly detailed prediction of events if the

project at Lady Evelyn Falls was implemented. The following short discussion is abstracted from his paper.

Fluctuations in water level, and their duration and timing profoundly affect biological processes. A hydroelectric development would affect river depths for some distance upstream and would generally lower the water velocity. Slower upstream flows would result in silt deposition above the dam and a reduced, clearer flow downstream of the dam.

If a dam is built, water below Lady Evelyn Falls would be colder, which could delay spawning times of some fish species. Permanent damage could occur to fish stocks of yellow walleye, northern pike and sub-adult grayling which may be resident in the Kakisa River below the falls yearlong.

Open water would no longer be present early in spring, thus eliminating the area's value to spring migrant waterfowl. Reduction in lake and river-edge vegetation and effects of flooding would reduce nesting success for waterfowl. A severe reduction in beaver and muskrat habitat would be expected. Available habitat for moose would be decreased.

The presence of a dam could be expected to seriously impair the scenic attractions of Lady Evelyn Falls as well as degrade the sports fishery (Lamoureux 1973).

6. Knowledge Gaps: The one specific study (Lamoureux 1973) available for the area provides much information and a detailed assessment of effects of changes in hydrological regime. Lamoureux lists the effects of a specific project

but is unable to indicate precise river or lake regimes required to maintain sensitive habitats. To do that for any area requires long term study involving several disciplines. Studies which take place over a single year usually lack an understanding of the extent of normal variation in the ecosystem. Lamoureux's work suffers from that limitation.

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D. Mills Lake, Beaver Lake, Deep Bay and Brabant Island

1. General Description: The Mills Lake, Beaver Lake, Deep Bay, Brabant Island area (Figure 1) is located approximately 190 km southwest of Yellowknife, Northwest Territories and includes the first 110 km of the Mackenzie River downstream from Great Slave Lake. Because of their similar natures and proximity, these sensitive areas are presented together.

The entire upper Mackenzie valley is part of the Great Slave Plain, an area of low-lying, nearly flat, ground covered with muskeg, pothole lakes and slow, meandering streams (Kemper et al. 1975). The area is underlain by Upper Devonian shales and limestones.

During the Pleistocene the area was covered by the Laurentide ice sheet. At the time of deglaciation, the margin of the ice sheet retreated eastward, depositing drift over the entire lowlands region. Glacial eratics are also common throughout the study area. Early in the deglaciation process, the junction of the Liard and Mackenzie rivers was blocked by ice, and a glacial lake formed. Eventually this lake joined with similar lakes in the Great Bear Lake and lower Peace River-Lake Athabasca areas, to form Glacial Lake McConnell (Day 1968).

The soils that developed in the Mills Lake area on these imperfectly drained till and glaciolacustrine deposits are predominantly Luvisols. Brunisols dominate the sandy aeolian deposits and older alluvial terraces (Day 1968, Tarnocai 1973).

Great Slave Lake drains, via the North and South Channels around Big Island, into Beaver Lake. The north shores of the two channels and Beaver Lake are low and marshy while the south shores have a narrow marsh fringe and steep backshore. The water depth is shallow throughout except for the dredged barge channel through the South Channel and the centre of Beaver Lake. There are numerous islands, particularly in the North and South Channels. Downstream from Beaver Lake the banks of the Mackenzie River are steep and rise 60 to 120 m. At Mills Lake, some 50 km downstream, the banks are more gradual and extensive marsh communities are again prevalent. This lake, like Beaver Lake, is essentially a widening of the Mackenzie River (Figure 46) and occupies an area of approximately 300 km^2. Except for the main river channel it has an average depth of only 1 m. The shoreline is generally low and poorly defined. The north side is an extensive floodplain subject to periodic fluctuation in water levels. The south shore is better defined, probably as a result of wave and ice action in combination with river erosion. Few marsh areas are present and a rapid transition to Boreal Forest occurs. On the east shore, where the Horn River enters the lake, an extensive delta has developed, with floodplains, deadwater channels and associated levees.

Climatic data have been recorded at Fort Providence, Hay River and Fort Simpson. Fort Providence has the lowest total annual precipitation, as well as the lowest total rainfall during the growing season, of the three stations. Most of the rivers are ice-free by May 30, while the lakes contain ice until June 15. Except for Beaver Lake, freeze-up occurs for all lakes in the study area by November 15. Beaver Lake remains open, on average, two weeks longer, The Mackenzie River generally remains open two weeks longer than most of

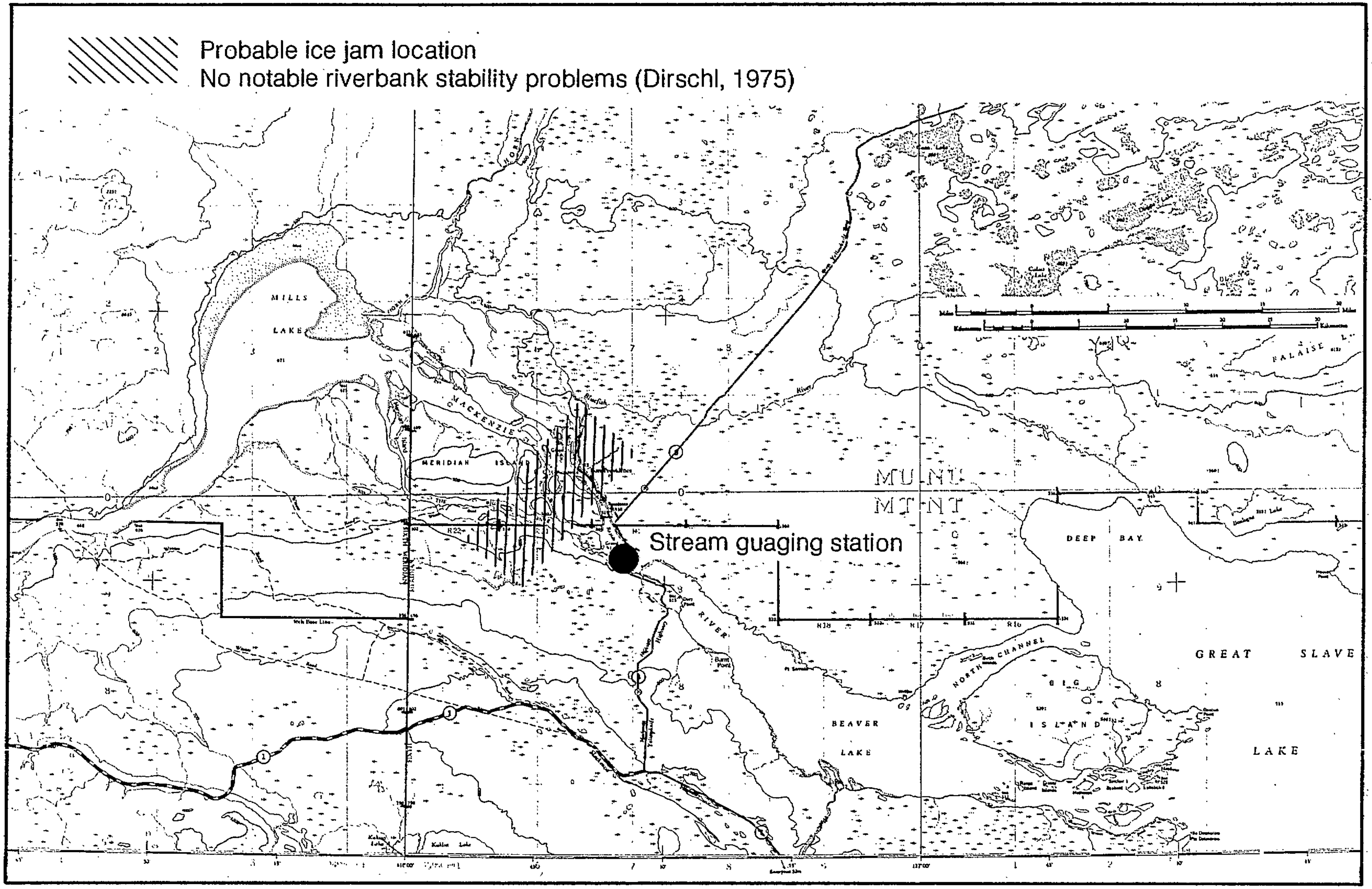

Figure 46. The Mills Lake, Beaver Lake, Deep Bay and Brabant Island areas.

the smaller rivers in the area (Kemper et al. 1975).

There are only two small settlements in the Upper Mackenzie River area, Fort Providence and Kakisa Lake. Mills and Beaver Lakes were chosen as potentially sensitive to change in hydrologic regime because they are major spring and fall staging areas for migrating waterfowl (Kemper et al. 1975), while Deep Bay and the waters around Brabant Island are noted for large northern pike and exceptional grayling fishing (Stephansson pers. comm.).

2. Hydrology: One stream gauging station has been established near Fort Providence. The period of record is only 1 year, and only water level data have been recorded (Renewable Resources Consulting Services Ltd. 1978). The flows through this reach, and as far as the junction with the Liard River, range from 2000 to 8500 m^3/s. Great Slave Lake has a significant regulatory influence on the flow in the upper Mackenzie; the lake acts as a large reservoir and it moderates the summer flows (Renewable Resources Consulting Services 1978). Ice jamming (Figure 46) occurs in the area to the east of Meridian Island in spring.

Aquatic sensitivity is reported to be high in the Deep Bay-Brabant Island and east half of Beaver Lake areas. The Mills Lake area was considered to be only slightly sensitive (Dirschl 1975).

3. Biological Resources: The study area lies within the Upper Mackenzie Forest section of the Boreal Forest

region (Rowe 1972). The dominant forest vegetation of the area consists of white spruce and balsam poplar, which occupy the alluvial flats bordering the river valleys. Other upland vegetation has been mapped by Day (1968) and Tarnocai (1973). Sedge and sedge-grass associations are found on seasonally inundated marshlands on lake shores and deltas within the study region (Kemper et al. 1975).

Several species of mammals and birds occur in the general area and may be locally abundant. Moose, woodland caribou, black bear, lynx and wolves have been seen. The occasional wood bison is reported to cross the Mackenzie Highway from the Mackenzie Bison Refuge (Figure 47). Bald eagle and osprey are both known to nest in the area and to migrate through it in the fall (Allison 1977). Karasiuk (pers. comm.) sighted 25 bald eagles in 1978.

The upper Mackenzie River valley, including the study area, is most important as a fall waterfowl staging area. This is probably due to the late freeze-up characteristics noted previously. It is used to a smaller extent in spring and normally supports few nesters. When drought hits the prairies, it is generally believed that Mills Lake becomes more important both to migrating and to nesting waterfowl as many prairie birds are forced to continue north to nest (Karasiuk pers. comm.).

Kemper et al. (1975) reported on 1974 waterfowl surveys in the Mills Lake-Horn River areas. As that was a

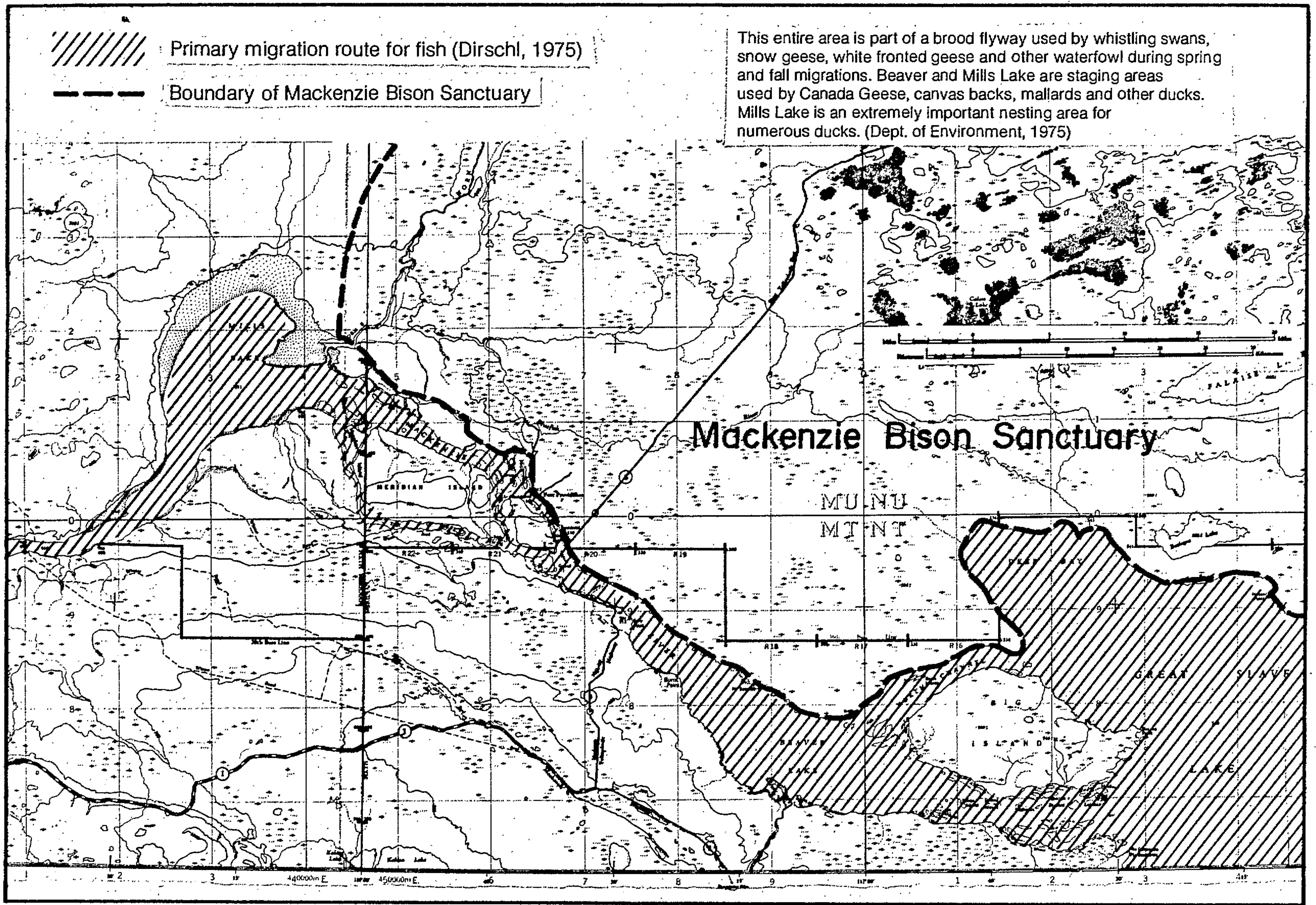

Figure 47. Wildlife and fisheries of the Mills Lake area.

year of unusually high water levels in western Canada, only 1138 ducks and 10 swans were observed. The Horn River delta and north shore of the lake supported mostly ducks. Kemper et al. (1975) reasoned that the high water flooded much of the marsh, forcing birds into areas that would normally be dry. Continued high water severely limited the available nesting sites. Only 25 broods were observed during summer surveys that year.

In the fall, however, observers located 34 087 ducks, 12 148 geese and 122 swans on Mills Lake. Of the goose species, whitefronted geese were most numerous, followed by lesser snow geese and Canada geese. Common duck species sighted were American widgeon, pintail, mallard, common goldeneye, scaup, bufflehead and canvasback. The Horn River itself provided a refuge for migrating swans and ducks after the lakes froze (Kemper et al. 1975). Preliminary results from the most recent 1978 fall aerial surveys in the study area were 18 668 ducks, 3361 geese and 12 whistling swans (Karasiuk pers. comm.).

The study area has large populations of a variety of fish and is on a primary migration route for several species (Figure 47). Great Slave Lake and the area around Big Island have large populations of arctic grayling, northern pike and yellow walleye. Downstream, in the Mills Lake-Horn River delta area, humpback whitefish, yellow walleye, longnose sucker, northern pike and arctic grayling are common (Dirschl 1975).

4. <u>Social and Cultural Values</u>: Both the Indian Brotherhood of the Northwest Territories and the Northwest Territories Métis Association stated that Mills Lake, in particular, is important to people from Hay river and Fort Providence for waterfowl hunting and fishing (Allison 1977). The Horn River area is also extensively used for trapping, hunting and fishing (Figure 48). Trappers from Fort Providence also use the area to the north and west of Mills Lake. Major species taken during the winter trapping season (November to April) include mink, lynx and marten. Wetland areas and rivers such as the Horn are hunted during the spring for beaver. Moose are hunted along the Mackenzie River during summer and fall. The north shore of Mills Lake is reported to be particularly good moose area (Department of the Environment 1972). Kemper et al. (1975) reported on fishing and hunting activities in the area:

> Native fishing camps are prevalent in Beaver Lake, Mills Lake and along the Mackenzie River, downstream from Fort Providence. A concentration of these camps is established each summer and fall at the mouth of the Horn River. It is from these camps that a significant proportion of the waterfowl hunting occurs, both at Mills Lake and to a lesser extent at Beaver Lake. White and native hunters from surrounding centres make use of Mills Lake in the fall, primarily to hunt migrating geese.
>
> Hunting pressure is highest at Mills Lake because the restricted access to Beaver Lake limits hunting to local natives from the summer fishing camps.
>
> Even though hunting of geese and ducks occurs on an almost daily basis throughout the fall season at Mills Lake, the success is low. The vast expanses of sedge marsh with no fall

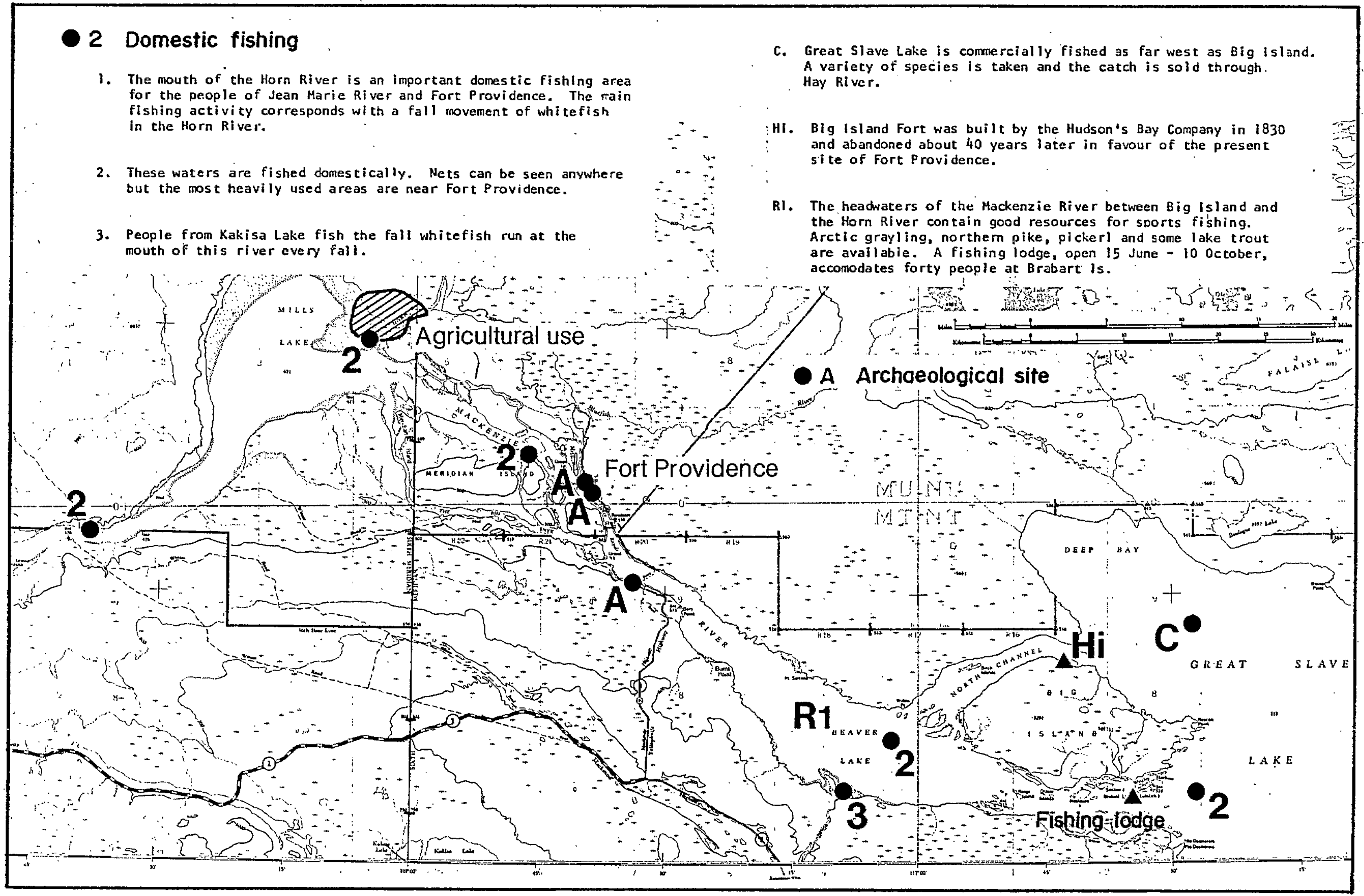

Figure 48 Fisheries, Archaeological sites and Historic sites in the Mills Lake area.

> cover make it almost impossible to approach feeding waterfowl, and the heavy aquatic growth and shallow water greatly restrict the use of boats. The greatest success occurs along the Horn River for two or three miles upstream from the delta.

The recreation value of the area is considered high, including boat cruises along the Mackenzie River, fishing and hunting (Beckel 1975).

Archaeological investigations have been undertaken in the upper Mackenzie River area. Big Island Fort (Figure 48), built by the Hudson's Bay Company about 1830, is an important historic site (Akhurst 1978, Millar and Fedirchuk 1975). Akhurst (1978) stated that known archaeological sites are quite small and easy to avoid.

5. <u>Sensitivity</u>: The most immediate threat to waterfowl productivity in the area of Mills Lake and Horn River delta is agriculture (Kemper et al. 1975). Three agricultural ventures are currently underway in the area (Figure 48), and others have been proposed (Cunningham pers. comm.). Because haying removes the standing crop and tends to allow the subsoil to dry, it encourages the development of grasses at the expense of sedges preferred by geese and nesting ducks. Kemper et al. (1975) also noted that conflicts between agriculture and waterfowl use arise from habitat destruction or alteration caused by cultivation or mowing of the marshlands.

A second, more debatable concern, is the potential effect on riparian habitat of dredging operations in the navigational channels of the Mackenzie River. Renewable Resources Consulting Services Ltd. (1978) stated two impacts dredging could have on aquatic vegetation:

1) mechanical destruction of aquatic and shoreline vegetation, and
2) alteration of species composition on alluvial flats resulting from lowering of present water levels.

For example, as the water level decreases, over a period of several years, transitional vegetation communities would extend into the area previously occupied by emergent vegetation. The emergent communities are simultaneously spreading into previously open water. However, Renewable Resources Consulting Services Ltd. (1978) noted that the dredging is not supposed to produce a change in lake level. Further, water to the north of Brabant Island would probably serve as deposition area for some of the suspended sediment brought up by the dredge. These areas may be important for fish spawning and/or rearing.

Brabant Island Lodge, opened in 1966, depends primarily upon the excellent arctic grayling fishing in the waters of Deep Bay and North and South Channels. Grayling are sensitive to increasing sediment loads in the water, especially in the spawning areas (Jessop and Lilley 1975). Any dredging operations should be carefully monitored so that this valuable resource is not adversely affected (Renewable Resources Consulting Services Ltd. 1978).

Because they are easily harvested, arctic grayling are also susceptible to overfishing. Following their 1974 creel census, Falk and Gillman (1974) determined that the average size and age had declined since the earlier baseline studies conducted by Bishop (1967).

6. Knowledge Gaps: Several important biophysical characteristics essential to understanding wildlife-hydrology relationships in the study area are only generally understood. More information needs to be known about:

1) aquatic vegetation: information on aquatic vegetation is scanty. Mills Lake was studied in 1974 (Kemper et al. 1975):

> A species list of aquatic plants in the Mackenzie River watershed contained only one sampling from the river (Weins et al. 1975). Aquatic vegetation evaluations in the Atlas of Wildlife Habitat Series (Dennington et al. 1973) are cursory. Until a more complete vegetation mapping program is completed, it will not be possible to assess the effects of proposed dredging on these areas.

2) fisheries: more detail on fish spawning areas, populations and productivity should be obtained to assess the effects of dredging on yields for sport and commercial fishing concerns.

3) the hydrologic characteristics of the area in relation to flow regime and annual fluctuations: water depths in spawning areas are especially critical and should be monitored before alterations in upstream areas can be implemented.

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CHAPTER VI

GREAT BEAR LAKE DRAINAGE

A. Great Bear River and Its Tributaries

The Great Bear River originates in Great Bear Lake and flows west to the Mackenzie River, near Fort Norman. Five of the potentially sensitive areas in this review are situated in the Great Bear River drainage: Great Bear River, Wolverine Creek and Porcupine Creek are treated in section A of this chapter; Brackett Lake and Loche River are discussed in section B (Figure 1).

1. General Description: The major settlements of the Great Bear River are Fort Franklin, a small community on Great Bear Lake near the outflow of the Great Bear River, and Fort Norman on the bank of the Mackenzie River (Figure 49). Access to the area is by chartered aircraft, infrequent scheduled flights to the communities, or overland.

The Great Bear River area includes parts of the Great Bear Plain, the Franklin Mountains, and the Mackenzie Plain. The land is predominantly flat to gently rolling and, generally, poorly drained. Maximum relief in the Franklin Mountains is about 300 m (Thurlow and Associates 1973).

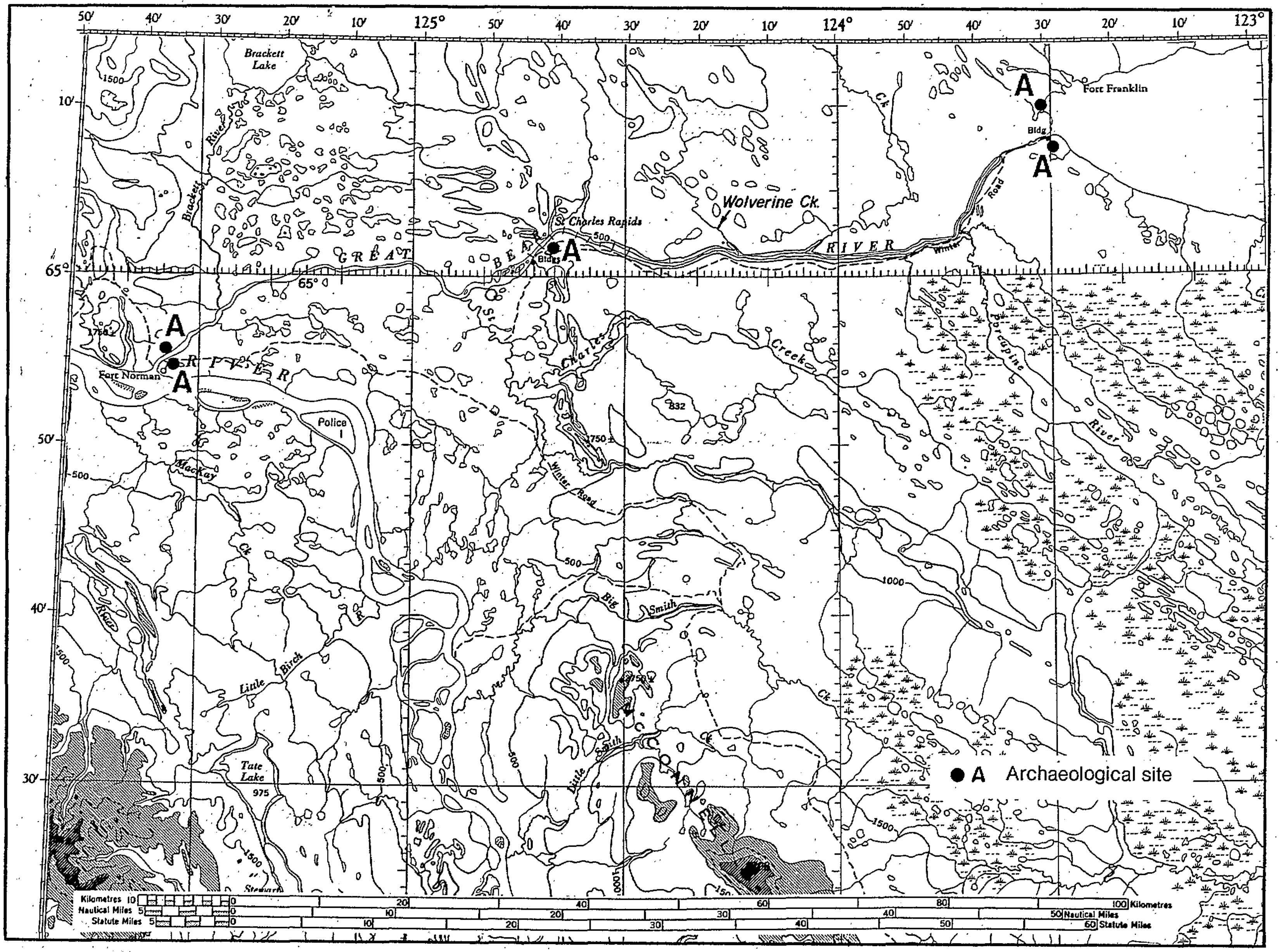

Figure 49. The Great Bear River and its tributaries, showing archaeological sites after Cinq-Mars, 1974.

The Norman and Franklin ranges, parallel curving anticlinal ridges of Paleozoic age, lie in the Mackenzie River basin in the vicinity of Great Bear River. Lowlands are underlain by Cretaceous and Tertiary strata (Thurlow and Associates 1973).

The surficial geology of the area reflects its glacial history. As the Laurentide ice sheet retreated about 10 000 years ago, it left in its wake the huge glacial Lake McConnell. Lake McConnell originally drained to the south. However, an ice jam forced it to drain west where it merged with the Mackenzie River at the present day mouth of the Hare Indian River. The Great Bear River is a very young, fast river, and is full of rapids (Johnson 1966). Extensive lacustrine deposits occur near the junction of the Mackenzie and the Great Bear River; till deposits are widespread elsewhere (Thurlow and Associates 1973).

Before the Great Bear River became incised in its plain, annual flooding resulted in the formation of sand and gravel levees along its banks. Thurlow and Associates (1973) postulated that these levees could protect some low lying areas from flooding in the event of dam construction.

Permafrost occurs throughout the area, with an active layer as deep as 1 m. Slumps and landslides have occurred along the river for many years (Thurlow and Associates 1973), and in some locations have been caused or aggravated by fire.

2. Hydrology: The following description is paraphrased from Chang-Kue and Cameron (1978) except where other references are cited.

The Great Bear River is the only outflow from Great Bear Lake. It extends 125 km to its confluence with the Mackenzie at Fort Norman. The vertical drop between the lake and river is 107 m. The riverbed consists of cobbles, boulders and gravel. The river is navigable by barge except at St. Charles Rapids where the riverbed consists of exposed bedrock.

Great Bear Lake, covering an area of 31 153 km^2, has a relatively small drainage area of 145 817 km^2. There are no major inlets. The annual fluctuation in lake level is about 0.2 to 0.3 m. The discharge of Great Bear River is very stable, ranging from a low of 493 m^3/s to a high of 573 m^3/s.

After it joins the Mackenzie, the clear waters of Great Bear River can be distinguished for many kilometers downstream. The cooling influence of the Great Bear River can be measured for 600 km. Freeze-up occurs between mid-October and late November, while break-up begins in mid-May. Ice jams on the Mackenzie River in spring may back water into the Great Bear River. Schilder (1973) considered the Great Bear River to have excellent potential for hydro development.

3. Biological Resources: The Great Bear River area lies in the Northwestern Transition zone of the Boreal Forest region, a forest fringe in which abundance, distribution and

size of tree species are restricted (Rowe 1972).

Generally, in areas of low relief are stands of dwarfed spruce which surround ponds, lakes, bogs and fens. Where till is present, stands of spruce are denser and of better quality. The largest stands of spruce are found in the protected, deeply incised valley of the Great Bear River and its major tributaries. The spruce communities support a good cover of lichens (Thurlow and Associates 1973).

Waterfowl using 3 of the 4 main North American migration flyways pass through the region biannually. The mouth of the Great Bear River is a particularly important site for spring staging ducks, geese and swans, but the remainder of the river valley is unsuitable for waterfowl (Poston et al. 1973). Waterfowl also stage in summer and fall near the mouth of the Brackett River (Department of the Environment 1976).

The Great Bear River is generally unsuitable habitat for beaver and muskrat (Dennington et al. 1973).

The entire area of the Great Bear River drainage, except the Brackett and Loche River wetlands (see section B), is used by woodland caribou as winter range. Flat lowland sites consisting of spruce forest and muskeg ponds are preferred (Prescott et al. 1973a). The entire area is located outside the indicated winter range of the Bluenose barren-ground caribou herd (Department of the Environment 1976). However, incidental sightings have been recorded and barren-ground caribou have wintered near Fort Franklin and Fort Norman.

The variety of vegetation resulting from fire and alluvial processes along the river provides some habitat for moose. However, the area was rated poor moose range by Prescott et al. (1973b). Riparian vegetation along the Mackenzie River and on islands both upstream and downstream of the Great Bear River is the most important moose winter range in the area (Department of the Environment 1976).

The fish resources of the Great Bear River are the most critical feature of its biota. Populations migrate to the Great Bear River from various other parts of the Mackenzie River drainage and Beaufort Sea. Twenty-five species of fish were recorded in the Great Bear River between Fort Norman and Great Bear Lake. Diversity is lower in upstream sectors. Broad whitefish, least cisco, yellow walleye and goldeye are found only below the Brackett River confluence. Arctic cisco and inconnu occur only as far upstream as St. Charles Rapids (Chang-Kue and Cameron 1978, Figure 49).

Numerically, arctic grayling are the dominant fish in the Great Bear River, consisting of 40% of fish caught by Fisheries and Marine Service while sample netting. Northern pike, longnose sucker and round whitefish were also abundant (Chang-Kue and Cameron 1978).

Arctic grayling spawn in Wolverine Creek. The size of the population is unknown although the run exceeds 10 000

(Chang-Kue and Cameron 1978). The Porcupine River also supports spawning arctic grayling. It is a suspected spawning and nursery area for pike and ninespine stickleback (Dryden et al. 1973).

The Great Bear Lake outlet and the upper 10 km of the river is a summer concentration area for arctic grayling and provides excellent angling. It is also suspected to be a wintering area. Arctic grayling which spawn in Three Day Lake (Figure 1) move up the Great Bear River to Great Bear Lake during July, August and September. Great Bear River is probably a major overwintering area for arctic grayling. Recaptures suggest that individual fish may return to the same spawning ground year after year (Chang-Kue and Cameron 1978).

Chang-Kue and Cameron (1978) stated that arctic grayling from drainages with and without suitable wintering habitat may contribute to the Great Bear River fall and winter population. Fish tagged in Donnelly River have been found in Great Bear River. The Keele, Redstone, Carcajou, Mountain, Oscar and Hanna rivers may have both resident and migratory populations, and fish which spawn in Canyon, Jungle Ridge, Prohibition, Vermillion, Nota and Bluefish creeks may also be found in the Great Bear drainage (Chang-Kue and Cameron 1978).

A resident population of arctic grayling and round whitefish move into the Great Bear River from Great Bear Lake (Department of the Environment 1976).

Dirschl (1975) classified Great Bear River aquatic systems as being highly sensitive to disturbance.

4. <u>Social and Cultural Values</u>: Human settlement in the Great Bear River area may have occurred as early as 7000 years ago. Archaeological sites near Fort Franklin (Figure 49) have produced a variety of tools. Bone fragments of either mastodon or wooly mammoth as well as Peary caribou were found (Cinq-Mars 1973, 1974; Johnson 1975). The present inhabitants are Athapascan Indians who have affinities with the Hare, Mountain, Dogrib and Copper Indians (Johnson 1975).

Domestic fishing provides an important source of income. Fishing occurs all year. In late summer and fall, Fort Norman residents fish near the mouth of the Great Bear River and in the Mackenzie. Domestic fishing also occurs during the post spawning migration of arctic grayling in the Great Bear River. Gill nets are often set at hunting and trapping camps (Department of the Environment 1976).

The Great Bear River is a main summer travel route between Fort Franklin and Fort Norman. Winter travellers between Brackett Lake and Fort Franklin move overland across the Wolverine Creek area. The Mackenzie and Great Bear rivers and adjacent uplands are used at various times of year by residents of Fort Norman and Fort Franklin. Although the area is used primarily as a travel route, camping, hunting, fishing and trapping also occur (Department of the Environment 1976).

The Great Bear River between Fort Franklin and Fort Norman provides an interesting canoe trip for experienced canoeists, with a 15 km portage road at St. Charles Rapids. Angling for lake trout and arctic grayling is excellent (Department of the Environment 1976).

Five fishing lodges have been established on Great Bear Lake (Thurlow and Associates 1973).

5. Sensitivity: Proposals for hydro development involving Great Bear River vary from small dams at one of five possible sites (Thurlow and Associates 1973) to large scale plans involving diversion of the Coppermine River into Great Bear Lake. Thurlow and Associates (1973) provide a *preliminary* analysis of impacts to be expected from dam construction on the Great Bear River. Some possible impacts of development are outlined in section B of this chapter and include the loss of entire populations of fish.

6. Knowledge Gaps: Most of the available information on biotic resources of Great Bear River is of a general overview nature, except for the more detailed work on fisheries reported by Chang-Kue and Cameron. It is obvious that much has yet to be learned of the importance of the Great Bear River to various arctic grayling populations. Specific material about terrestrial wildlife is not available.

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B. Brackett Lake and Loche River

1. General Description: Loche River and Brackett Lake are part of the Great Bear River drainage basin. Loche River rises at Kelly Lake and flows south to Brackett Lake. Brackett Lake is drained by the Brackett River which flows into Great Bear River (Figure 1). The entire system is part of a large wetland complex (Figure 50). Fort Norman is the nearest settlement.

The reader is referred to section A.1. for a detailed description of physiography and geology of the area. The Brackett Lake-Loche River area is located in the zone of discontinuous permafrost and has a sub-arctic climate. Most of the area consists of low relief, glacial till as well as thin silts and clays overlain by organic cover. Drainage is moderate to poor and directly affected by permafrost. Organic material may be up to 1.5 m thick. Shallow thermokarst lakes are numerous. Brackett Lake itself is a thermokarst lake,

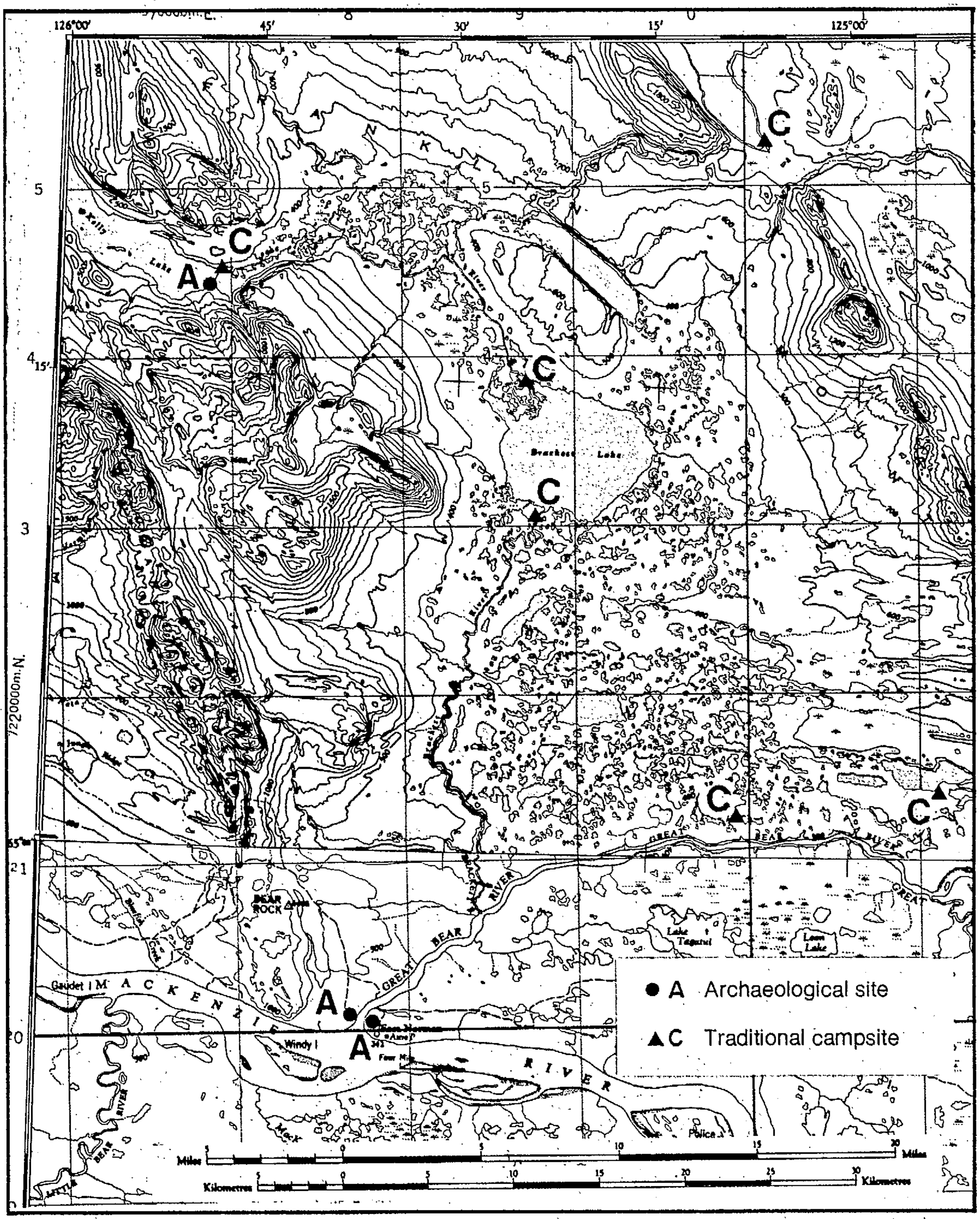

Figure 50. Brackett Lake and Loche River, showing archaeological sites and traditional campsites.

whereas Kelly Lake is deeper and higher (Dickinson 1978).

2. Hydrology: The water table in the area is high. Drainage systems are poorly defined and heavily influenced by permafrost. Ground seepage and ground springs are numerous and, in winter, cause overflow which persists until July in some locations on the east side of the Norman Range (Dickinson 1978).

There have been no records of discharge rates in the Brackett Lake area. The Brackett River is turbid and carries high concentrations of dissolved salts. Portions of the river remain open all winter, and during summer the warm, turbid waters can be distinguished from the cold, clear Great Bear River water almost to the Mackenzie River (Simmons and Cody 1974).

3. Biological Resources: The Loche River-Brackett Lake wetland complex is a riparian community. Emergent fen associations include sedges, willows, dwarf birch and tamarack; in the bogs are found black spruce, sphagnum mosses, lichens and Labrador tea (Dickinson 1978). Because of the great depth of peat, post-glacial vegetative associations can be delineated from soil cores. Examination of such soil cores will allow scientists to determine the spread of plant communities after glacial retreat (Simmons and Cody 1974).

Fire has played an important role in the Brackett Lake area. Three large fires occurred in the wetlands during 1969. They ranged in size from 1036 ha to 10 900 ha. Another undated burn occurred along a 10 km stretch of the Great Bear River. Most fires in the area are caused by lightning (Dickinson 1978). Fires result in changed vegetative associations and the release of nutrients for use by plants. This generally improves habitat for moose and waterfowl.

Break-up conditions in early spring affect the timing and concentrations of migratory waterfowl movements. Hundreds of thousands of migrating waterfowl follow the Mackenzie River in spring and fall. At the mouth of Great Bear River open water occurs early along shallow shorelines, old meander channels, sandbars and islands. Parts of Brackett River and Loche River remain open all winter. These areas of open water are attractive resting sites for spring migrants. Lesser snow geese are particularly common on the islands and areas downstream.

Brackett Lake wetlands support the highest densities of resting ducks recorded in the Mackenzie River drainage north of 60°. Many of the migrants move through the Brackett Lake wetland complex as they fly east of the Franklin Mountains rather than take the longer route along the Mackenzie River. Loons, shorebirds and gulls are also abundant (Poston et al. 1973).

Most of the area is classified as excellent or very good waterfowl nesting habitat, primarily for ducks. Brackett Lake is a critical moulting and/or late summer staging area (Poston et al. 1973). During fall, it is a stopping area for whistling swans, whitefronted geese, ducks, shorebirds and blackbirds. The importance of this wetland area to waterfowl may be increased in years when drought occurs on the prairies. It is an important fall staging area for arctic nesting waterbirds in all years, but may be critical when poor weather conditions prohibit staging along coastal areas (Dickinson 1978).

Peregrine falcons are known to nest in the Franklin Mountains. The Norman Range is also important for raptors (Dirschl 1975).

Beaver populations around Brackett Lake, like those of many other far northern wetlands, have had a variable past and face an undefined future. Beaver occur in relatively small pockets of favourable habitat, and are susceptible to over-exploitation. Fires may be responsible for habitat losses or gains. Beaver require suitable lodge or bank denning sites. Poplar or willow growth sufficient to fulfil winter requirements must be accessible from the den site. The status of beaver in the Brackett Lake-Loche River wetland complex is unknown, but the entire area is rated as excellent habitat. Brackett Lake is the largest of the few wetlands in the Mackenzie River valley capable of supporting a relatively stable population of beaver (Dennington et al. 1973).

Sections of the Brackett and Loche rivers which remain open during winter are important for the maintenance of local otter populations. Fish are abundant, but the size and status of otter populationsare unknown (Dickinson 1978).

Brackett Lake wetland complex provides only fair moose winter range. However, it assumes regional importance because of the lack of other suitable habitat in the vicinity. Forest stands resulting from fire provide an accessible food source for moose (Prescott et al. 1973).

The Brackett River is a spawning and nursery area for longnose suckers, burbot, lake chub, stickleback, slimy sculpin, least cisco, northern pike, inconnu, round whitefish and arctic grayling. Lake trout and mountain whitefish are also present (Department of the Environment 1976). Local residents report a fish migration between Kelly Lake and several lakes along the course of the Loche River. Inconnu and humpback whitefish occur in the river. Kelly Lake itself is a migration route, nursery, feeding and overwintering area for lake trout, humpback whitefish and northern pike (Department of the Environment 1976).

4. Social and Cultural Values: Kelly Lake, Brackett Lake and their associated wetlands are an area which is particularly rich in renewable wildlife resources. The "Willow-lakers" of Fort Norman and some natives who now reside in Fort Franklin have a long tradition of dependence upon these resources. The region is obviously one of high biological productivity in local terms. It supports an abundance of fish, waterfowl, snowshoe hare and edible berries (Dickinson 1978).

Onesmall group of Indians have for 3 generations occupied a campsite where the Loche River empties into Brackett

Lake. Other campsite locations are on small lakes, the outlet of Kelly Lake and the outlet of Brackett Lake (Figure 50). Archaeological sites have been found in the vicinity of existing camps. Residents take many ducks and loons in summer, and hunt moose extensively yearlong (Simmons and Cody 1974).

The entire wetland area is well known as a productive hunting and trapping area. As many as 15 hunter/trappers travel from Fort Norman or Fort Franklin to use the area every year. The heaviest activity involves the spring muskrat and beaver hunt in April and May, although mink and marten are sought earlier in the year. Uplands around Kelly Lake are a marten trapping area used by several residents of Fort Norman (Department of the Environment 1976).

Humpback whitefish are the most important domestic fish species. Northern pike, lake trout and sucker are also taken. Although grayling are abundant they are unimportant to the subsistence economy (Simmons and Cody 1974). In late summer and fall the mouth of the Brackett River is one of the areas of prime importance to the domestic fishery. Brackett and Kelly lakes are restricted to angling and domestic fishing (Department of the Environment 1976).

The Loche River, Brackett Lake and Brackett River form part of a canoe route between Fort Norman and Kelly Lake. The journey may also be made by jet boat. Excellent fishing is found along the entire route. Kelly Lake is accessible by chartered aircraft or jet boat. It supports several fishing lodges (Department of the Environment 1976).

The Brackett Lake area and wetland complex, excluding most of the Loche River, is a proposed International Biological Program site. It was chosen because of its importance to the local subsistence economy, its rich resources, and its peat bog vegetative associations (Figure 51, Beckel 1975).

5. Knowledge Gaps: Dickinson (1978) in her discussion of resource conflicts in the Brackett Lake area, stated a widespread and major problem concerning information gaps succinctly. "There are basically two levels of knowledge gaps: first, how do biotic communities within northern ecosystems function when man plays a relatively small part within those communities; and second, when man plays a significant part, what will be the effects of his actions?" It is not possible to answer questions of the second category adequately without reference to the first. She went on to point out that:

1) we know relatively little about the effects of natural disturbances, rates of change or time scale involved;
2) studies at the level of communities or ecosystems are completely lacking;
3) numbers and distributions of game animals and furbearers are unknown. In a larger context, are the land and its resources capable of supporting the people who wish to maintain a way of life wholly or partly dependent upon

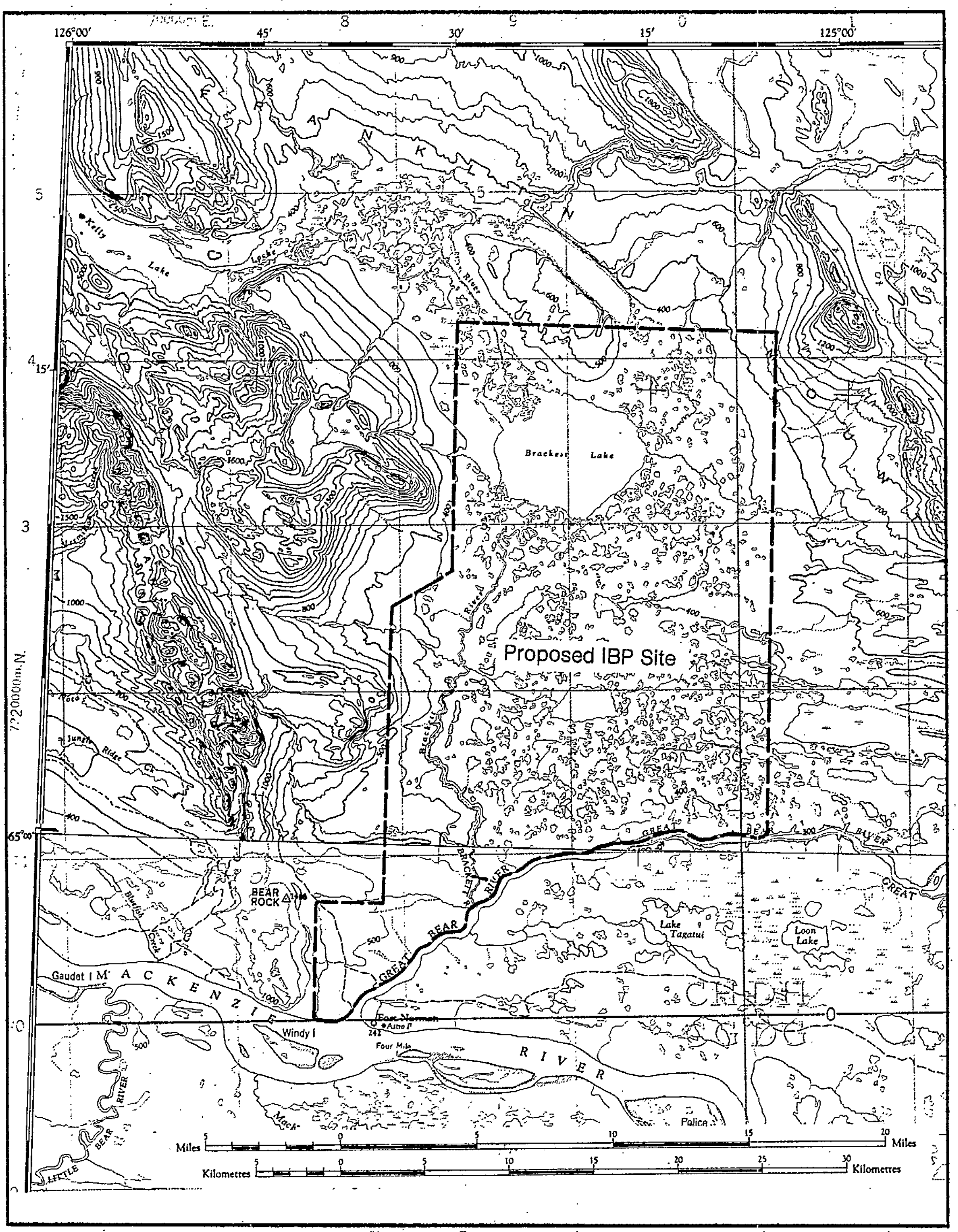

Figure 51. Proposed I.B.P. site in the Brackett Lake area.

the exploitation of renewable resources, even without interference from major "development" projects?

These comments are relevant to almost every area reviewed in this report.

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CHAPTER VII

MACKENZIE RIVER DRAINAGE

A. Trout River and Jean Marie Creek

1. General Description: Although the Trout River and Jean Marie Creek are separate watersheds to the southwest of the Mackenzie River, they have many similarities, and are therefore considered together.

The closest major settlement to both Trout River and Jean Marie Creek is Fort Simpson. Year-round communities also thrive at Jean Marie River, on the Mackenzie River at the mouth of Jean Marie Creek, and Trout Lake. Travel between communities is overland in winter, along the river in summer, or by chartered aircraft yearlong.

Both Trout River and Jean Marie Creek rise in the Cameron Hills, a disconnected escarpment up to 1000 m high. They flow through the flat, lake-filled Great Slave Plain to the Mackenzie River (Figure 1). The Great Slave Plain has an elevation of less than 300 m and is formed of Paleozoic strata.

Dirschl (1975) rated Jean Marie Creek moderately sensitive to riverbank disturbance downstream of the Mackenzie Highway crossing and extremely sensitive upstream of the crossing as far as McGill Lake (Figure 52). The Trout River has high terrain sensitivity for 10 to 15 km upstream of the Mackenzie Highway and moderate to high sensitivity downstream to the river (Figure 53). The upper portions of both rivers have a low sensitivity to erosion (Dirschl 1975).

2. <u>Hydrology</u>: The Trout River flows 375 km and drains an area of 13 170 km^2. It originates at the north end of Trout Lake and its upper reaches flow through muskeg terrain of low gradient. The lower sections are deeply entrenched in bedrock. There are 2 major waterfalls: Whittaker (14 m high) and Coral (5 m high) near the Mackenzie Highway crossing. The river has a boulder and gravel bed along most of its length (Stein et al. 1973, Figure 53).

Jean Marie Creek is 253 km long and has a drainage area of 3713 km^2. It is a slow-moving, single channel river with a sand bed. Small pockets of gravel occur in some locations (Hatfield et al. 1972). In the middle reaches it meanders widely, often forming oxbow lakes and cutoffs. Its tributaries have a relatively low gradient and lie within shallow valleys (Poston et al. 1973, Figure 52).

The Trout River near the Mackenzie Highway has been gauged only intermittently since 1969. The mean monthly minimum flow occurs in March, 0.76 m^3/s. The mean maximum in June reaches 100 m^3/s. The river was frozen completely with no flow on March 6, 1972. Maximum daily discharge recorded was 213 m^3/s July 1, 1973.

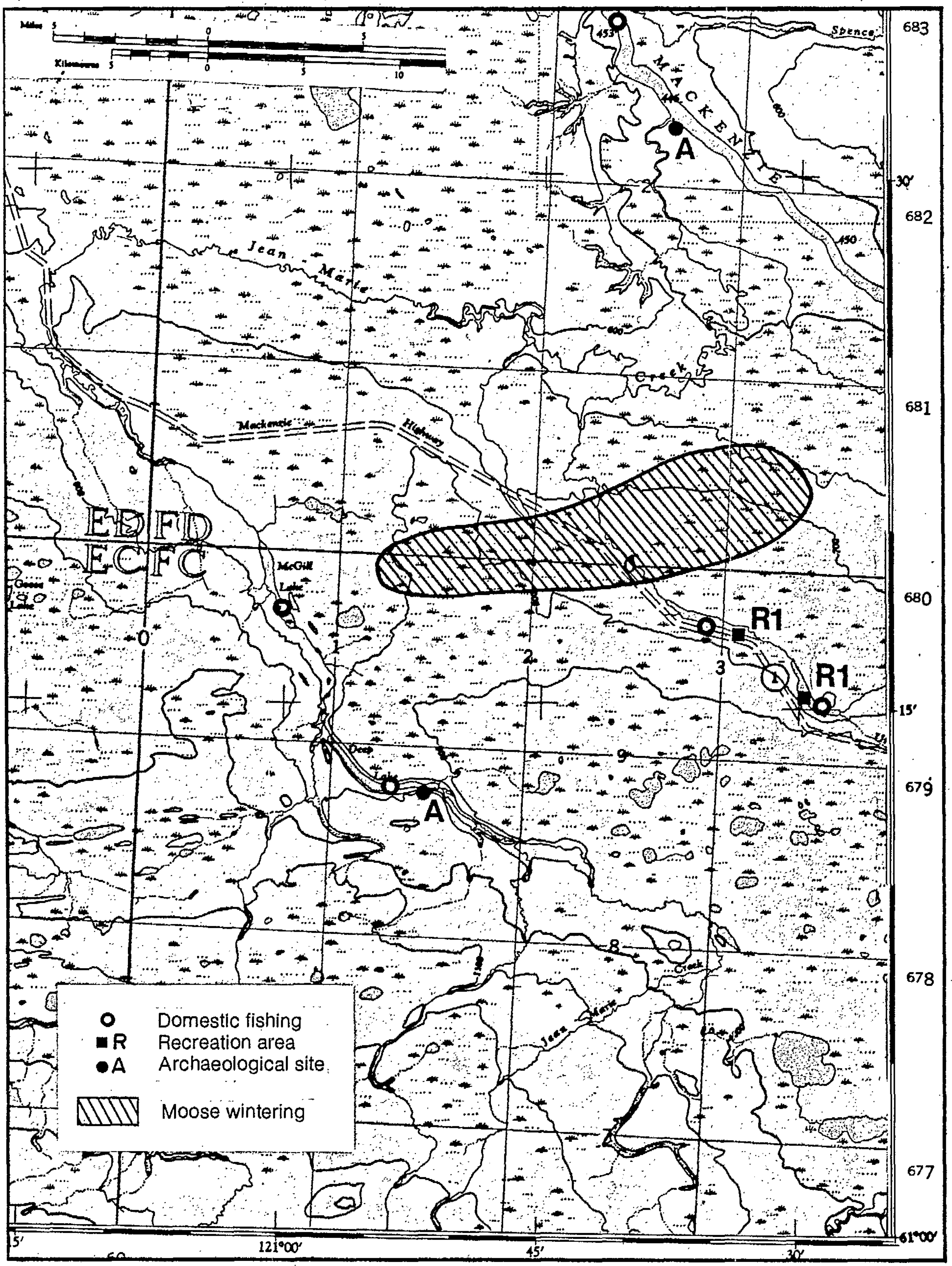

Figure 52. Resources and sensitive areas of the Jean-Marie Creek drainage.

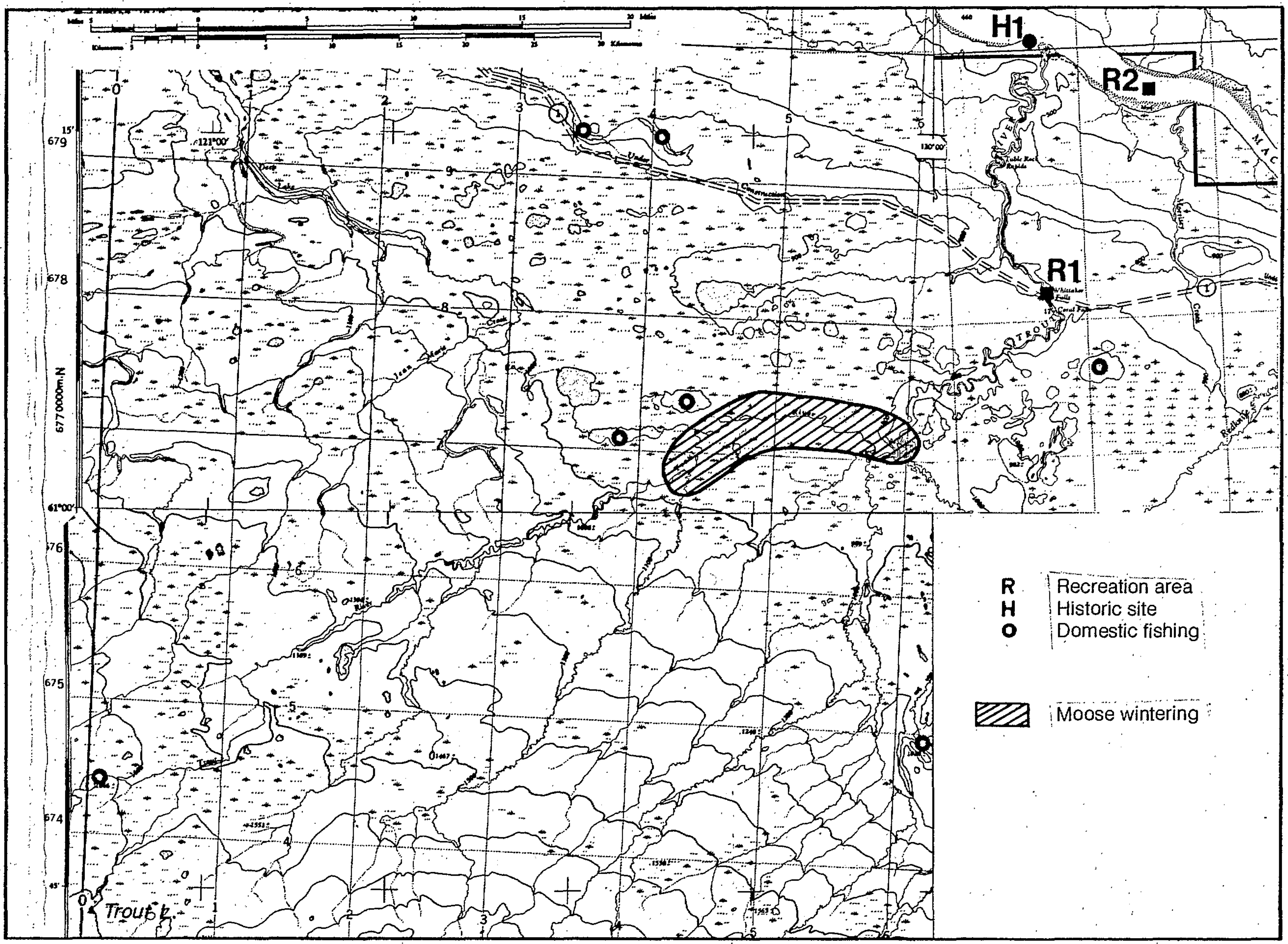

Figure 53. Resources and sensitive areas of the Trout River drainage.

3. <u>Biological Resources</u>: The low, lake-dotted Great Slave Plain supports a variety of vegetation. Shrubs occur near shorelines and the relatively flat uplands support willow, alder and birch thickets. Poplar stands in many areas are surrounded by heavy spruce bog. Spruce forest is the climax vegetation type, but fire has modified the landscape (Prescott et al. 1973).

The Mackenzie valley is an important flyway for migrating ducks, geese, swans and shorebirds. Several avian species stop for short periods on waterbodies in the Trout River and Jean Marie Creek area although neither of these drainages provide important staging habitats for waterfowl (Department of the Environment 1976, Poston et al. 1973). The entire Trout River provides poor habitat for waterfowl, although small nearby upland ponds may be rated good to fair. Jean Marie Creek is also poor habitat. McGill Lake and Deep Lake are deep with steeply sloping shorelines and as such provide fair habitat. Aquatic plant growth is restricted to peripheral flooded areas and shelves adjacent to the stream connecting the two lakes. These areas are good habitat for waterfowl (Poston et al. 1973).

No woodland caribou are found near either the Jean Marie Creek or Trout River drainages, although Trout Lake is located on the north end of caribou range. Small sections along both drainages are noteworthy moose winter ranges (Department of the Environment 1976, Figures 52,53). These river terraces have a good shrub layer of willow, alder and aspen as a result of burns. They do not provide cover. They are particularly important winter range in comparison to surrounding areas which provide little or poor habitat. Other sections of both rivers are less suitable for moose (Prescott et al. 1973).

Jean Marie Creek is considered better beaver habitat than Trout River. It is not as swift and has many more oxbows and fewer bedrock shorelines. It is good habitat, while Trout River is fair. Both areas are considered unsuitable for muskrats (Dennington et al. 1973). Dirschl (1975) outlined important wildlife habitat areas where restrictions on activity are recommended.

Jean Marie Creek and Trout River are both considered potentially sensitive areas primarily because of the fish populations they support.

Jean Marie Creek is particularly important for yellow walleye. The walleye spawn both in the upper and lower reaches of the creek after ice break-up in late May. The entire creek is a major nursery area for yellow walleye, and its lower reaches support spawning arctic grayling. Northern pike and longnose sucker spawn in Jean Marie Creek and it is also a major nursery area for longnose sucker (Stein et al. 1973). Other fish present include whitefish, inconnu, least cisco, shiner, white sucker, slimy sculpin, burbot, lake chub and trout-perch (Department of the Environment 1976). The economic species are fished heavily by natives of Jean Marie village and could not tolerate further disturbance (Stein et al. 1973, Stein pers. comm.).

The Trout River is an excellent fish spawning and nursery river along much of its length between Trout Lake and the Mackenzie River. Upstream movement of fish from the Mackenzie is obstructed by the falls, 16 km from the mouth of the Trout River. Below the falls the river is a spawning and nursery area for arctic grayling, northern pike, yellow walleye and longnose sucker. Fall spawning has not been detected below the falls. Spawning areas for northern pike and longnose sucker are located between Trout Lake and the falls; arctic grayling use the river as a nursery area but it is not known whether the populations are resident in Trout River or Trout Lake (Dryden et al. 1973). Trout Lake is a major nursery area for yellow walleye which may spawn in the Trout River or some tributary of the lake (Stein et al. 1973).

The Trout River is one of the few areas in the Mackenzie drainage considered to have good sport fishing and recreation potential (Stein et al. 1973).

4. <u>Social and Cultural Values</u>: Domestic fishing is an important source of food for many northern residents. It occurs year round but is often intensified in fall and winter when large numbers of fish are preserved by drying or freezing. Gill nets are usually set in lakes or in eddies near river mouths. Whitefish, northern pike, yellow walleye and

sucker are the most important domestic species to the settlements of Jean Marie and Trout Lake (Department of the Environment 1976). Residents of Jean Marie fish at the mouth of the creek between spring and fall. Domestic fishing also occurs in McGill Lake, Deep Lake and unnamed lakes on tributaries of Jean Marie Creek (Figure 52). Domestic species in this drainage are heavily harvested (Stein et al. 1973). Residents of Trout Lake take most of their annual catch near the settlement (Department of the Environment 1976). Populations of fish in the Trout River are not severely stressed by fishing pressure (Stein pers. comm.).

Trapping and hunting occur throughout the area. The Mackenzie River is a major travel route all year, and people often camp on the bank and hunt or trap nearby. Moose is the major large game animal sought. The Mackenzie Plain is important to families who spend much of the year in the bush. Winter trapping for lynx, marten, mink, weasel and otter begins in November and may continue until hunting for muskrat and beaver begins in April and May (Department of the Environment 1976).

Development areas are established by the government of the Northwest Territories to control commercial development in the vicinity of towns and highways. A development area extends 6.5 km on each side of the Mackenzie Highway (Department of the Environment 1976). Whittaker and Coral falls could become an important recreation area to travellers along the highway.

5. <u>Sensitivity</u>: Few specific statements can be made about the likely effects of changing water levels on the fish resources of Jean Marie Creek and Trout River (see chapter VIII for a general discussion on sensitivity of biological resources to hydrolic regime), except in response to a specific proposal. If Mackenzie River levels were to be raised or lowered, the gradient of the lower 16 km of the Trout River and much of Jean Marie Creek might change. Either could result in the loss of spawning beds for several species of fish. The fish populations of Jean Marie Creek are already stressed by the heavy domestic harvest and should not be exposed to further disturbance.

6. <u>Knowledge Gaps</u>: Only information of a general survey nature is available on biological resources of Jean Marie Creek and Trout River. Fish populations are better known than aquatic or terrestrial furbearers or ungulates. However, population dynamics and movements of fish are not understood.

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B. WillowLake River

1. General Description: The WillowLake River has its origin at Willow Lake on the Horn Plateau. It flows west to meet the Mackenzie River between Wrigley and Fort Simpson (Figures 1, 54). The nearest settlements are the small, native community of Wrigley and the more cosmopolitan Fort Simpson, both on the river.

The WillowLake River flows across parts of the

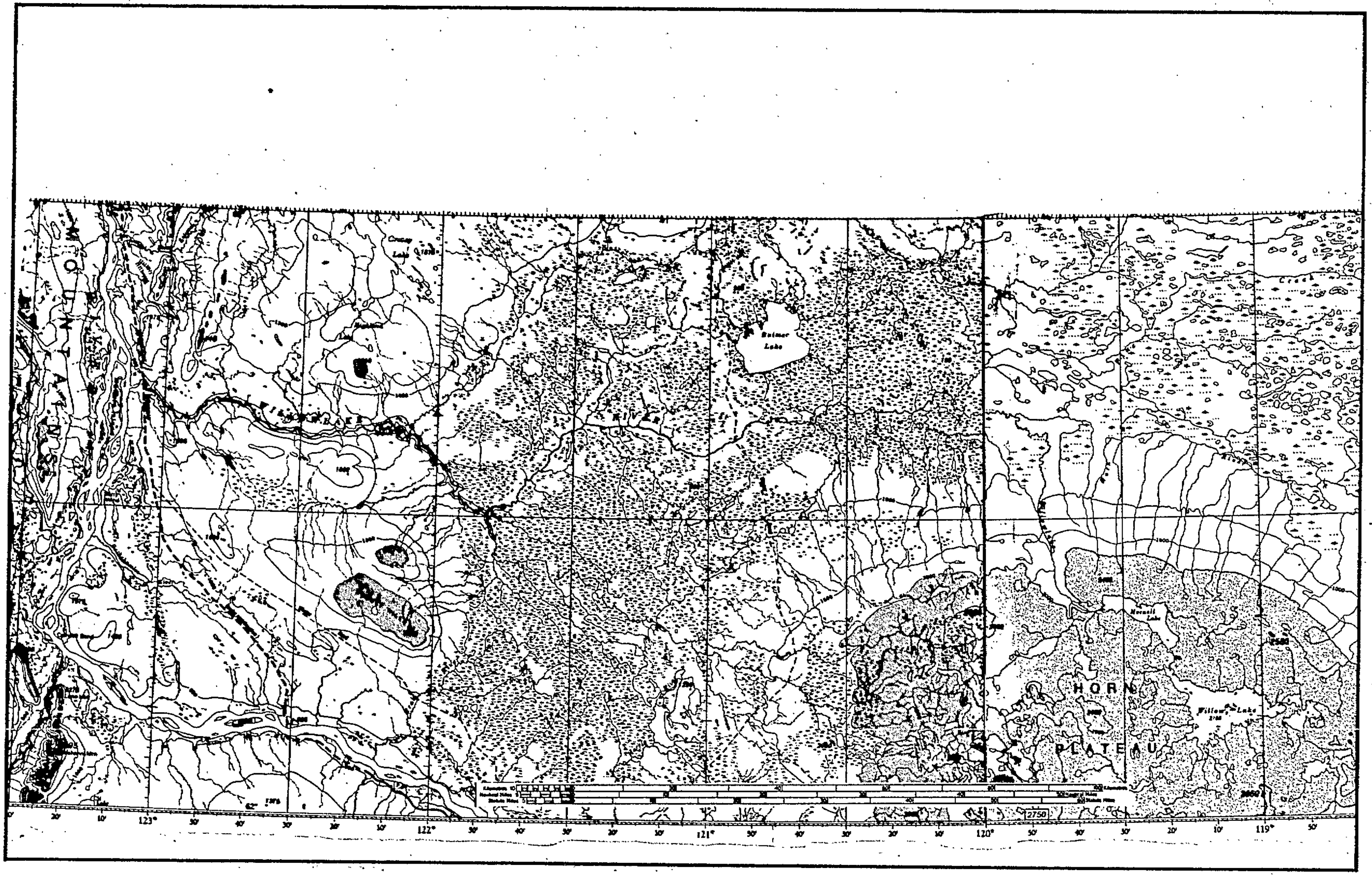

Figure 54. The Willowlake River.

Interior Plain (Bostock 1969). It originates on the Horn Plateau, a block of cretaceous sandstone rising to 460 m above sea level. To the north and west, the river drops to the Great Slave Plain, a very flat lake-dotted plain formed of Paleozoic strata. Near the Mackenzie River it flows between foothills which rise abruptly above the Interior Plain. It reaches the Mackenzie River by crossing the old Mackenzie River floodplain (Mackenzie Reference Binder n.d.).

The area north of the WillowLake River consists of a small erosional terrace adjacent to the Mackenzie River, grading into a moderately-sloping, drumlinized till plain. Two parallel bedrock ridges, the Rocky Mountain Foothills, lie north to south, and further east rises an organic-covered till plain. Eskers, pitted outwash, and water-washed glacial till are present. Glacial tills and drumlinized till plain occur adjacent to the river (Lavkulich 1971-72).

2. Hydrology: The WillowLake River travels 312 km and drains a basin of 20 463 km^2. The river has a gravel and silt bottom, exhibiting little meander. Many pools and rapids are present. Water flows fast and clear through a wide floodplain which shows little evidence of recent flooding (Hatfield et al. 1972, Dryden et al. 1973).

Several tributaries flow from lakes in the headwaters, but the storage is not large enough for them to effect flood levels (Dryden et al. 1973). There is a gauging station on the WillowLake River which has been in service intermittently since 1963. Mean monthly discharge is lowest in March at 5.3 m^3/s and highest in May at 279 m^3/s. The recorded extremes were 1.4 m^3/s March 8, 1966, and 974 m^3/s May 14, 1967 (Water Survey of Canada 1974). The WillowLake River has a low annual runoff, probably as a result of its gentle slopes, permeable soils and subsoils, and dense vegetative cover (Schilder 1973). A small hot spring at the mouth of the river remains open year long. The hydrological characteristics of the WillowLake and Hare Indian rivers might be expected to be similar. They are of approximately similar size, with similar gradient and flow across similar terrain.

3. Biological Resources: Vegetative associations near the junction of the WillowLake River and the Mackenzie River consist of mixed stands of aspen, jackpine, balsam poplar, and white spruce, with an understory of rose, bunchberry and feathermosses. Well drained upland areas support mixed forests of white spruce, jackpine, aspen and alder. The understory consists of bunchberry, crowberry, wintergreen and feathermoss. Poorly drained areas support primarily black spruce with an undergrowth of bog birch, cinquefoil, Labrador tea, crowberry, and blueberry (Lavkulich 1971-72).

Swans, geese and ducks pass through the area on their way to and from arctic nesting areas. Some may stop briefly to feed and rest. The hot spring area at the mouth of the WillowLake River is particularly important to spring migrants. Most of the area provides only fair waterfowl habitat, but small sections of more favourable habitat are rated good (Poston et al. 1973).

Lower parts of the river are unsuitable habitat for beaver and muskrat; however some sections are classed as good beaver habitat (Dennington et al. 1973). Beaver are distributed widely in lowland rivers, streams and lakes (Department of the Environment 1976).

Moose habitat in the area is generally poor, with the south shore of the WillowLake River being preferable to the north shore. Alluvial islands and shorelines of the Mackenzie River, both upstream and downstream of the WillowLake River are subject to frequent flooding and ice scouring. This maintains a unique riparian vegetation complex which is particularly important as moose winter range (Prescott et al. 1973a, Department of the Environment 1976).

The entire drainage of the WillowLake River provides favourable habitat for woodland caribou. Upland areas are centers of activity from which caribou movements appear to radiate (Prescott et al. 1973b). During early winter, woodland caribou concentrate on the Horn Plateau, dispersing to the south in mid-winter. In summer they are scattered throughout the area (Department of the Environment 1975, 1976). Wolves are usually found associated with the wintering caribou.

Fishery resources appear to be the most critical feature of the biota of WillowLake River. Arctic grayling are the key species present. Spawning and nursery areas for this species have been found throughout its entire length. In addition, the lower reaches of the river provide spawning, nursery and feeding areas for yellow walleye, northern pike, longnose sucker and possibly humpback whitefish, round whitefish, mountain whitefish and white sucker. Bulmer Lake and its drainage channel are likely part of a migratory route and spawning area for humpback whitefish. Northern pike and yellow walleye also occur in the lake. Tributaries of Willow-Lake are particularly important as spawning, nursery and feeding areas. Burbot have also been reported to inhabit this drainage (Lilley 1975).

During winter several seepages and spring-fed channels remain open, particularly in lower parts of the river. Deep pools in the lower reaches are also suspected to be overwintering habitat for several species (Lilley 1975).

4. Social and Cultural Values: An archaeological reconnaissance of the lower 8 km of the WillowLake River revealed a few new sites. All were from historical times. The most important location is an old fort on the east side of the Mackenzie River opposite the mouth of the North Nahanni River (Cinq-Mars 1974).

The WillowLake River is part of a traditional canoe route, used until recently by residents of Fort Rae and Lac La Marte for travel to Fort Norman (Department of the Environment 1976).

A small, seasonal, domestic fishery operates at the mouth of the river. The catch includes yellow walleye, northern pike, sucker and burbot. Other fishing camps occur along the river. One family lives at the mouth of the WillowLake River. Its members hunt and trap north of the river, as do some families from Fort Simpson. Lynx, marten, mink, beaver and muskrat are taken. The area is also used for overland travel between Wrigley and Fort Simpson (Department of the Environment 1976).

The Bulmer Lake region is used for winter and spring trapping by a family from Fort Simpson. They harvest marten, mink, lynx, beaver and muskrat for fur; caribou, moose, and a variety of fish for food (Department of the Environment 1976).

Further east the WillowLake River passes through the western portion of an area important to residents of Lac La Marte and Fort Rae. Mink and marten are the main species trapped, but beaver and muskrat are also taken in spring. The Horn River is used as a travel route to and from the area (Department of the Environment 1975)

The Horn Plateau is known particularly as good marten country. Willow Lake and Hornell Lake support a small but locally important domestic fishery (Department of the Environment 1975).

5. <u>Sensitivity and Knowledge Gaps</u>: None of the available information concerning biological resources of the

WillowLake River is either detailed or specific. Existing data were a result of surveys which covered broad geographic areas for the Mackenzie Valley Pipeline Studies or the Land Use Information Map Series. Only general statements about possible effects of changes in hydrologic regime on biological resources can be made (see chapter VIII).

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C. Three Day Lake-Stewart Creek

1. General Description: Three Day Lake is situated in the Mackenzie Plain physiographic region (Bostock 1969) on the west side of the Mackenzie River near Norman Wells (Figure 1). Stewart Creek empties into the Mackenzie River between Norman Wells and Fort Norman. It is accessible by river boat during the summer and over-ice vehicle in winter. Large areas of organic terrain around the lake grade eastward toward alluvial plains in the Mackenzie valley (Dirschl 1975).

2. Hydrology: Stewart Creek is a muddy stream which flows for only 6 km between Three Day Lake and Mackenzie River. The total drainage area of the creek is 479 km^2 (Hatfield et al. 1972). There are no records of flow in Stewart Creek, but it varies widely during the year. Three Day Lake and Stewart Creek are located in a region of glacial drift deposition, a generally level area with poorly developed drainages (Figure 55).

3. Biological Resources: The Mackenzie Plain supports a black spruce forest interspersed with willow, birch, alder and, occasionally, tamarack. The vegetation has been modified by fire in the Three Day Lake-Stewart Creek area; here, mid-successional vegetation is present. The growth of marsh and aquatic plants indicates good soil fertility in wetland areas. The shoreline of Three Day Lake is particularly lush (Dennington et al. 1973, Poston et al. 1973). Stewart Creek is a turbid

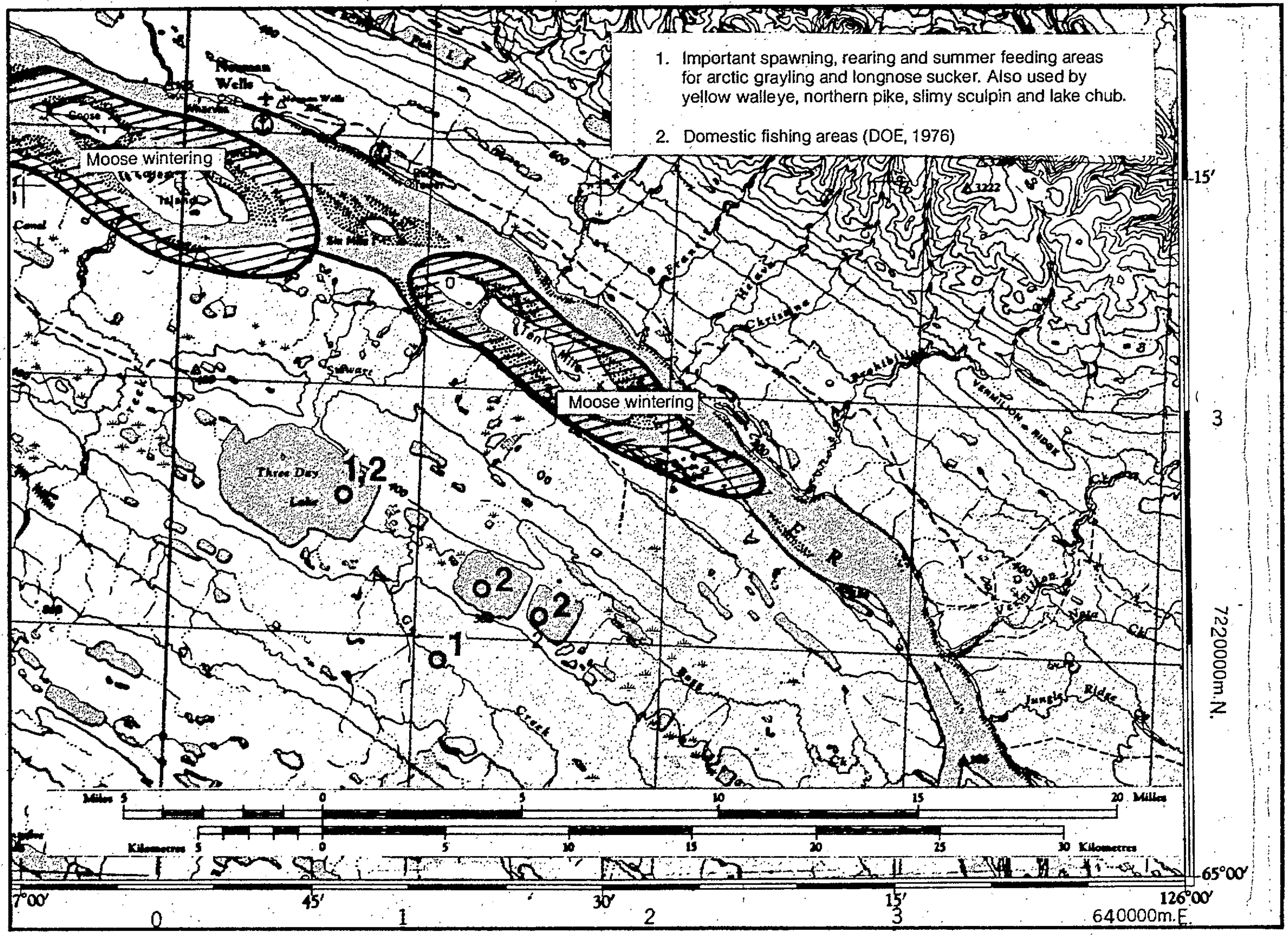

Figure 55. Fish and Wildlife Resources of the Three Day Lake - Stewart Creek area.

narrow stream (Hatfield et al. 1972).

Many species of ducks, geese and swans use the Mackenzie River as a spring and fall migration route. Three Day Lake is variously identified in the literature as a critical area because of concentrations of breeding waterfowl (Dirschl 1975), and as an area of poor waterfowl habitat (Poston et al. 1973). The Land Use Information Series update (Department of the Environment 1976) does not mention breeding waterfowl in the Three Day Lake area.

Riparian vegetation on shorelines and islands of the Mackenzie River provides the best winter moose habitat in the area (Figure 55). However, the wetland area of Three Day Lake-Stewart Creek provides poor habitat for moose, beaver and muskrat (Prescott et al. 1973a, Dennington et al. 1973). Forest fires have resulted in deciduous growth which is beginning to become unattractive to moose (Prescott et al. 1973a). The area is not inhabited by caribou (Prescott et al. 1973b).

The Three Day Lake-Stewart Creek drainage is considered sensitive and important because of its fish populations. This drainage is known to be an important spawning, feeding and rearing area for arctic grayling and longnose sucker (Department of the Environment 1976). Arctic grayling are considered most important because of the size of the population and the length of their migrations. Stein et al. (1973), estimated the number of catchable-size fish in the spawning group to be 13 000 to 17 000. Arctic grayling spawn early in spring. A post spawning movement down Stewart Creek occurs in late June (Stein et al. 1973). The major portion of the Three Day Lake spawning population migrates to the Great Bear River and remains there in summer, fall, and, perhaps, winter. These fish apparently return annually to the same spawning beds (Jessop et al. 1974). Low water levels in Three Day Lake and Stewart Creek are responsible for its unsuitability as a wintering area (Jessop et al. 1974).

Stewart Creek is a nursery area for broad and humpback whitefish (Stein et al. 1972). Yellow walleye, northern pike, slimy sculpin and lake chub are also found (Department of the Environment 1976).

4. Social and Cultural Values: The Mackenzie River is an important local travel route in summer. Temporary hunting and fishing camps are established at suitable sites along its shores. Residents of Fort Norman net fish near the mouth of Stewart Creek and dry their catches at a traditional camp near the mouth of the creek. Trappers from Fort Norman also use the area in winter (Department of the Environment 1976).

5. Sensitivity: Either raising or lowering the Mackenzie River could affect the gradient of Stewart Creek and wipe out spawning beds of arctic grayling (exact areas unknown). Lowering of average spring flood levels on the river might deny grayling access to the creek. This grayling population converges on the area from many areas of the central Mackenzie

and must be considered critical, although much remains to be learned about it (Stein pers. comm.).

6. Knowledge Gaps: Existing information on the biological resources of Stewart Creek and Three Day Lake is all of a general survey nature. Much needs to be learned before even the effects on arctic grayling of changes in hydrologic regime could be assessed, including:

1) whether the Three Day Lake-Stewart Creek drainage has a resident population of arctic grayling,
2) when arctic grayling ascend Stewart Creek and the physical and hydrological conditions required for the ascent,
3) the proportion of Great Bear River grayling population which spawns in Stewart Creek drainage, and
4) the location of spawning beds.

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D. Hare Indian River

1. General Description: The Hare Indian River originates in the Smith Arm of Great Bear Lake. It flows westward to the Mackenzie River near Fort Good Hope (Figure 1). Access to the area from Fort Good Hope is via boat, oversnow vehicle,

or chartered aircraft.

The Hare Indian River flows through the Interior Plain physiographic region (Bostock 1969). Pre-Cambrian sedimentary and crystalline rocks are overlain by Devonian sediments. The whole is capped by a thick mantle of glacial drift which forms plains and plateaux. The upper part of the river traverses the Colville Hills, a rolling till plain of hills and ridges. Elevations rise to about 660 m. The river occupies a glacial canyon incised in the till plain. Small tributary streams enter the valley through rocky canyons.

The lower and middle portions of the river flow through the Anderson Plain. It is an undulating plain of glacial outwash with deeply entrenched runoff channels. Its surface is formed by horizontal beds of Mesozoic strata. Near its confluence with the Mackenzie, it runs through the old Mackenzie River floodplain (Mackenzie Reference Binder n.d.).

2. Hydrology: The Hare Indian River flows 243 km and drains an area of 23 189 km^2. The river has a substratum of silt and sand near its mouth, and fine to coarse gravel further upstream. Throughout most of its length the river is shallow with gentle meanders (Hatfield et al. 1972). The riverbank is generally low and stable (Stein et al. 1973).

Bluefish River, a tributary of the Hare Indian River (Figure 56), is also a meandering stream with many gravel bars. It flows through muskeg in its upper reaches and rolling hills in the lower sections (Hatfield et al. 1972).

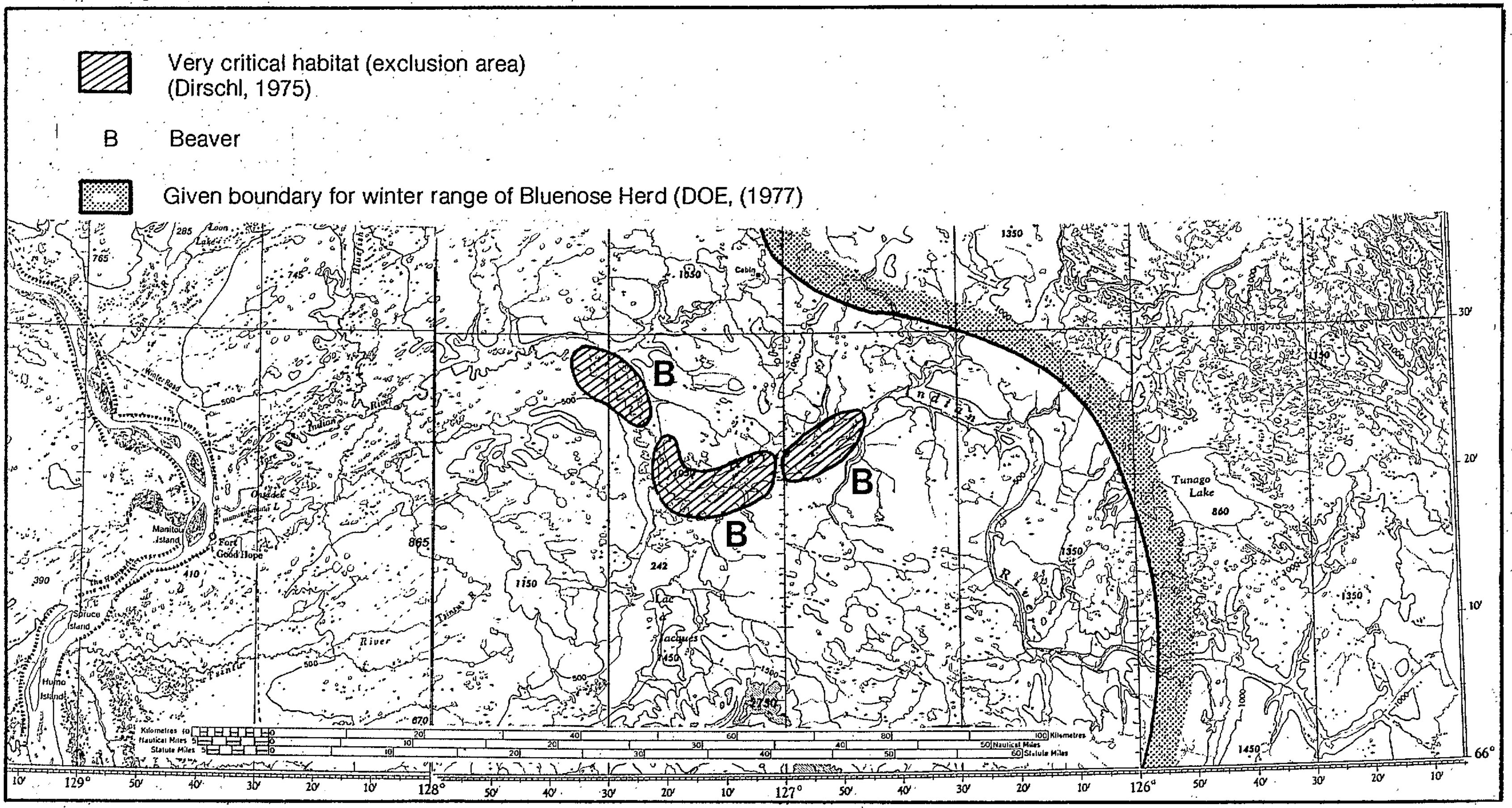

Figure 56. Wildlife Habitat of the Hare Indian River.

No record of streamflow is available for the Hare Indian River, but it may be expected to exhibit approximately the same flow patterns as the WillowLake River.

3. Biological Resources: The Hare Indian River flows through the Boreal Forest (Rowe 1972). Its upper reaches pass through an open spruce forest which supports terrestrial and arboreal lichens. Further west the area is characterized by numerous shallow lakes and large bogs. Black spruce occupies wetter sites and jackpine occurs in dry areas. Large sedge meadows and sedge-willow parklands surround shallow lakes (Department of the Environment 1977). Birch, tamarack and poplar are also present on alluvial terraces and outwash plains (Poston et al. 1973). Shrub understory varies from sparse to abundant (Prescott et al. 1973a). Near the mouth of Bluefish Creek an old burn resulted in riverbank slumping, tree movement and gullying (Lilley 1975).

Most of the Hare Indian River is fair habitat for waterfowl production. Small patches of more favourable habitat in the lower reaches are considered good (Poston et al. 1973). Although hundreds of thousands of migrating waterfowl pass through the area on their biannual migrations along the Mackenzie valley, they generally fly over the Hare Indian River. A few birds stop to rest and feed on the numerous small lakes and streams.

The lower Hare Indian River provides fair moose habitat (Prescott et al. 1973a).

Barren-ground caribou herds frequent large areas of open spruce forest during winter, feeding on terrestrial and arboreal lichens. Only a small percentage of the vast winter range will be used in a given year. The Bluenose Herd's winter range includes the upper Hare Indian River in some years (Figure 56), and some animals may move south and west of the boundaries shown (Department of the Environment 1977).

Woodland caribou are plentiful in the boggy and lake areas to the west of the barren-ground caribou range. Caribou are not seen near the settlement of Fort Good Hope or near favoured human travel routes (Prescott et al. 1973b). Dirschl (1975) outlines "very critical habitat" for beaver and waterfowl in the area (Figure 56).

The Hare Indian River is a "potentially sensitive area" largely because of the populations of arctic grayling and other fish species it supports. The river is a nursery and spawning area for arctic grayling and longnose sucker (Figure 57). Northern pike, round whitefish, humpback whitefish, white sucker and longnose sucker are also found (Department of the Environment 1976).

The Bluefish River, as its name infers, supports arctic grayling. It is a migration route for arctic cisco, humpback whitefish and grayling travelling to and from the Mackenzie River. A nursery area for longnose sucker, arctic grayling and humpback whitefish has been located (Figure 57). It is also suspected to be a spawning area for longnose

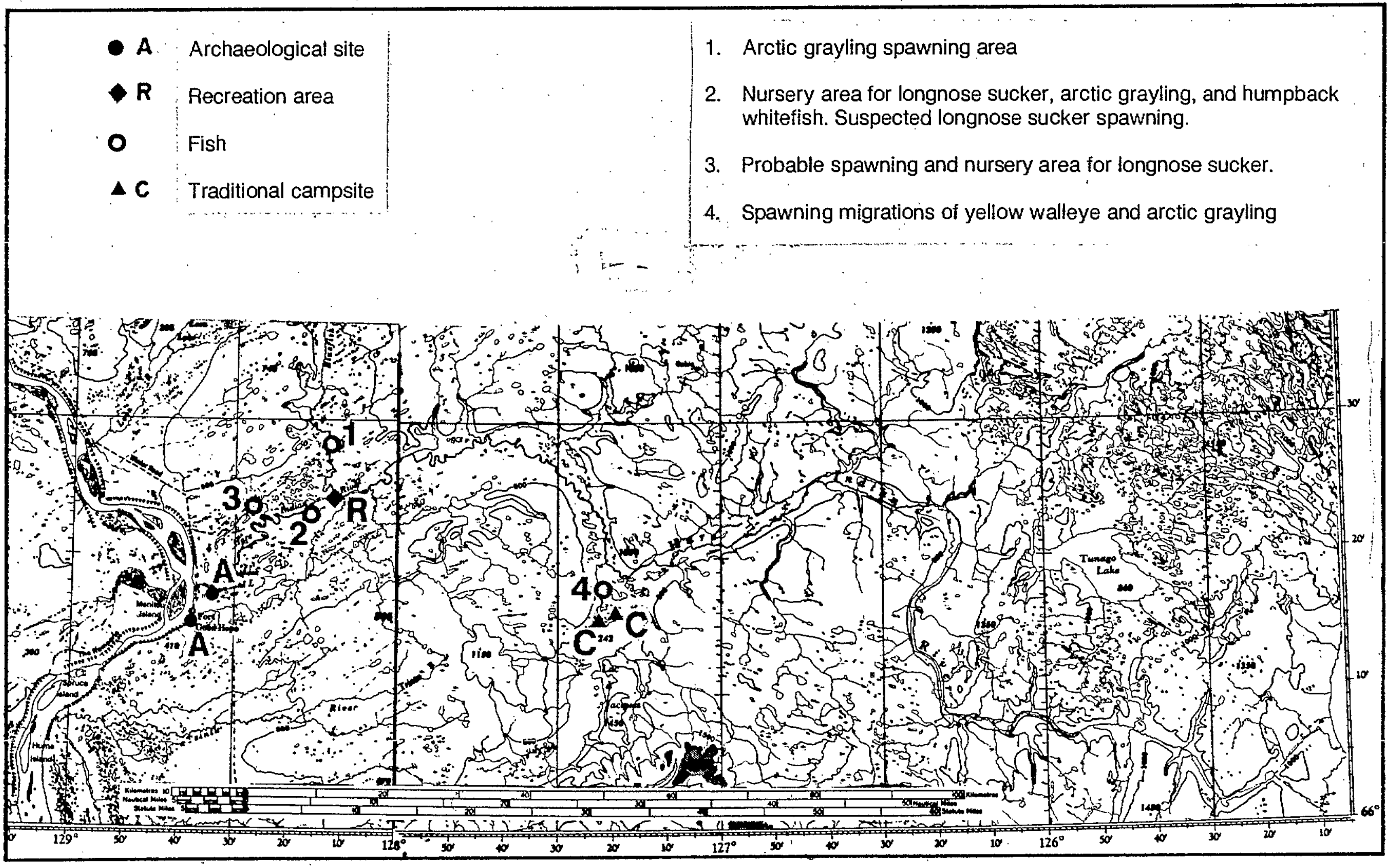

Figure 57. Fishery Resources of the Hare Indian River.

sucker. An unnamed tributary of the Hare Indian River (Figure 57) is a probable spawning and nursery area for arctic grayling (Department of the Environment 1976).

Upper portions of the Hare Indian River are used by many fish species as a migration route to spawning and nursery areas in the headwaters and tributary creeks. Common species are arctic grayling, longnose sucker, yellow walleye, northern pike, whitefish and minnows. Some sections of the river remain open all winter and are probably suitable overwintering habitat for fish. Arctic grayling and yellow walleye also use Lac à Jacques as a migration route to spawning locations in the Hare Indian River (Figure 57, Department of the Environment 177).

4. Social and Cultural Values: The Hare Indian River and surrounding area have social values of regional rather than national or international significance. The Hare Indian River is a major travel route used winter and summer by people from Fort Good Hope. The confluence of the Hare Indian and Bluefish rivers is a local summer campsite and recreation area. Seasonal campsites are located at various sites along the river. From these marten and mink, coloured fox and wolverine are trapped in winter, and beaver and muskrat in spring. Small game and ptarmigan are sought near the settlement. The entire region shown in Figure 56 is part of the Fort Good Hope registered group trapping area. Several families who now reside in Fort Good Hope formerly lived year long

at Lac à Jacques and they have retained traditional ties in that vicinity. Other residents regularly travel as far as Tunago Lake. An overland travel route between Fort Good Hope and Colville Lake runs generally north of the river. Domestic fishing pressure is heavy on the Hare Indian and Mackenzie rivers near Fort Good Hope. Other river locations, Lac à Jacques and Tunago Lake are also fished domestically (Department of the Environment 1976).

5. Sensitivity and Knowledge Gaps: None of the information available on the Hare Indian River is either detailed or specific. Existing data were collected as part of surveys covering broad geographic areas for the Mackenzie Valley Pipeline Studies or, later, the Land Use Information Map Series. Only general statements concerning the effects of changes in hydrological regime on biological resources can be made (see chapter VIII).

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E. Mackenzie Ramparts

1. General Description: Above Fort Good Hope, the Mackenzie River narrows abruptly to flow 13 km between towering limestone cliffs known as the Mackenzie Ramparts. Where the river broadens and the banks are again low, is the community of Fort Good Hope (Figures 1, 58). The Mackenzie Ramparts is one of the "point" sites chosen by the Task Force for its scenic or cultural values.

The Mackenzie Ramparts is formed by spectacular rock bluffs 30 to 60 m high. The exposed bedrock is primarily limestone with dark shale embedded in some locations. At the entrance to the Ramparts the river is only 480 m wide; near the upper end a dip in the bedrock creates an illusion of a steep river gradient (Schilder 1973, Department of the Environment 1976).

The Ramparts rapids are formed by a series of limestone ledges extending southeast from the north bank of the Mackenzie River. When the Mackenzie is high, the rapids are drowned; when the river is low, the rapids form a distinct drop. West of the Ramparts a chain of lakes marks a previous channel of the Mackenzie River. It was used until the river had incised the limestone deeply enough to accommodate the whole flow.

2. Hydrology: Ice jams in the Ramparts are a common feature of break-up on the Mackenzie River. There are no

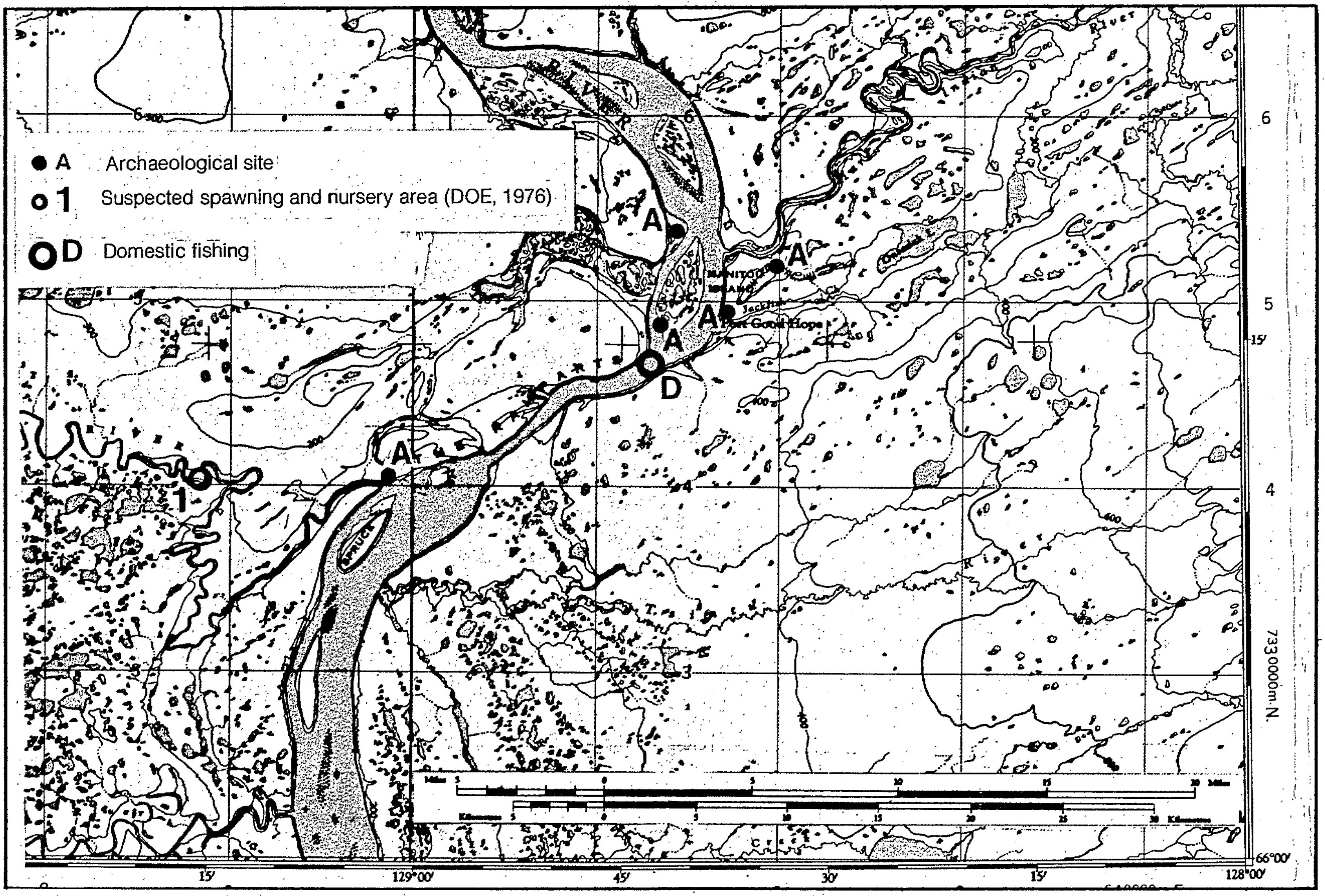

Figure 58. Archaeological sites near the Mackenzie Ramparts.

streamflow data available for the Mackenzie River at the Ramparts.

3. Biological Resources: While the Ramparts itself supports no vegetative community, the poorly drained lacustrine plain which extends back from the cliff is part of the Boreal Forest vegetation zone (Rowe 1972). Uplands are largely black spruce bogs. Large areas, particularly on the west side of the river have been burned and have a greater variety of vegetative types, namely willows, shrubs, alder and balsam poplar. Extensive sedge fens accompany some of the adjacent wetlands. The islands and riverbanks, particularly below the Ramparts, support riparian vegetation communities (Forest Management Institute 1975).

The exposed cliffs of the Ramparts are very important nesting habitat for a variety of raptors including rare and endangered species such as the peregrine falcon (Fyfe and Kemper 1975, Dirschl 1975, Department of the Environment 1976). The Mackenzie valley is a major flyway for ducks, geese, swans and some shorebirds. Islands and shoreline areas upstream of the Ramparts are staging sites.

Above the river, the old Mackenzie floodplain provides good habitat for muskrat, beaver and moose. Riparian vegetation on islands and shorelines above and below the Ramparts provide excellent moose wintering habitat although heavy hunting pressure from the settlement of Fort Good Hope reduces moose numbers (Department of the Environment 1976, Dirschl 1975). Dirschl (1975) identified shoreline areas upstream of the Ramparts as "very critical exclusion areas" because of their importance to wildlife (Figure 59).

The Mackenzie River is a primary migration route for several species of fish. Whitefish, least cisco, arctic cisco and inconnu travel from the Beaufort Sea, through the Mackenzie Delta, and up the river to largely unknown spawning locations in tributary drainages. The species listed above pass Fort Good Hope. The Ramparts River is known to harbour burbot, chub, yellow walleye, arctic grayling, whitefish, sucker and slimy sculpin. It is also a suspected spawning and nursery area (Stein et al. 1973, Department of the Environment 1976).

4. Social and Cultural Values: The Mackenzie Ramparts is a spectacular viewpoint and a major scenic site for river travellers. Archaeological sites have also been located along this section of river (Figure 58). Residents of Fort Good Hope hunt, fish and trap extensively in the area. One of the best used domestic fishing areas is at the outflow of the Ramparts where migrating fish are intercepted (Department of the Environment 1976, Dirschl 1975).

The Mackenzie River is a major travel route for residents and vacationers, particularly in summer. Small boats can navigate the Ramparts readily, but the Northern Transportation Company, Limited (N.T.C.L.) must relay barges because of low water levels. Dredging is proposed to eliminate

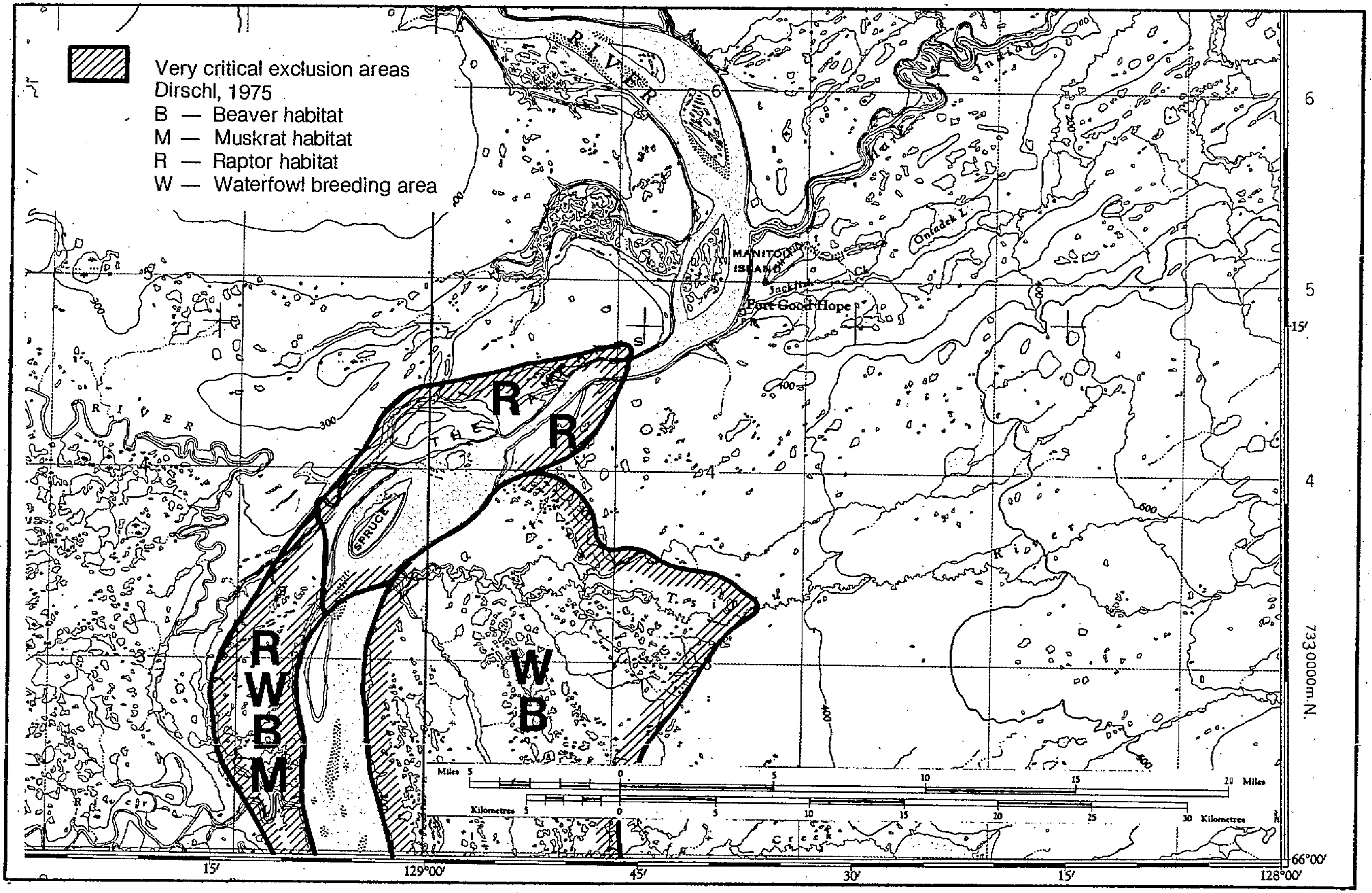

Figure 59. Important wildlife habitat at the Mackenzie Ramparts.

this problem (Renewable Resources Consulting Services Ltd. 1978).

The Ramparts has "very good" potential for hydro development. The favoured location is at the head of the Ramparts (Schilder 1973).

5. Sensitivity: The two major values of the Ramparts could be destroyed by developments at that site: its scenic/ cultural value and its value as a nesting site for rare or endangered raptors. Even if changing water levels do not directly threaten nest sites, raptors are known to be sensitive to noise and activity near their nest sites (Windsor 1977). Hydro development at the Ramparts could result in loss of significant nesting habitat for birds of prey. It could also significantly impair the scenic value of the area.

Other possible effects of development include: drowning of archaeological sites and fish spawning areas; blockage of fish migrations; gradual disappearance of riparian habitat downstream; flooding of important waterfowl staging areas upstream; and loss of some waterfowl, beaver and muskrat habitat. The reader is referred to chapter VIII for a general discussion of some effects of changes in water levels.

6. Knowledge Gaps: Enough is known of the Ramparts itself to predict the effects of a given development on its scenic and biological values. We do not know whether the cliffs have spiritual significance to the Hare Indians. Chief

Frank T'Seleie used the Ramparts as a symbol of the unchanging land in his testimony before the Berger Inquiry:

> We know that our grandchildren will speak a language that is their heritage, that has been passed on from before time. We know they will share their wealth and not hoard it, or keep it to themselves. We know they will look after their old people and respect them for their wisdom. We know they will look after this land and protect it and that five hundred years from now someone with skin my colour and moccasins on his feet will climb up the Ramparts and look over the river and feel that he too has a place in the universe, and he will thank the same spirits that I thank, that his ancestors looked after his land well and he will be proud to be a Dene.

Biological information on the surrounding area is of a general nature and is the result of surveys which were undertaken in anticipation of pipeline applications. Detailed effects of a given project should be predicted only after more detailed studies have been undertaken.

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F. Arctic Red River

1. General Description: The Arctic Red River is located in the northwest Mackenzie District, Northwest Territories (Figure 1). It originates in the Mackenzie Mountains and flows 370 km north to meet the Mackenzie River at the village of Arctic Red River. It has a drainage area of 14 950 km^2 (Mackenzie Reference Binder n.d.). The area was chosen because

of important fish habitat at the river mouth (Stein pers. comm.). The wildlife areas discussed in this report are in its lower reaches.

The lower Arctic Red River is incised into the Peel Plain physiographic region. The Peel Plain has broad, shallow muskeg flats, with very low upland areas. Both are cut by meandering streams that headwater in the northern-most Mackenzie Mountains (Millar and Fedirchuk 1975). Large areas of organic deposits are present, as in the area around Fishing Lakes (section VII G). Terrain sensitivity is high along the river valley. The sensitivity rating is high because the steeply sloping banks are formed of easily eroded alluvial deposits in an area of discontinuous permafrost (Dirschl 1975).

The only settlement in the study area is Arctic Red River (Figure 60).

2. Hydrology: Water Survey of Canada has a stream gauging station near the mouth of the Arctic Red River. Data are available for the period 1970-75 (Mackenzie Reference Binder n.d.).

The maximum monthly discharge of 21 177 m^3 was recorded in June. A minimum monthly flow of 260 m^3 was recorded in February (Davies 1974). This flow regime appears to be typical of northward flowing rivers having their origins in mountain snow fields (refer to section VII H).

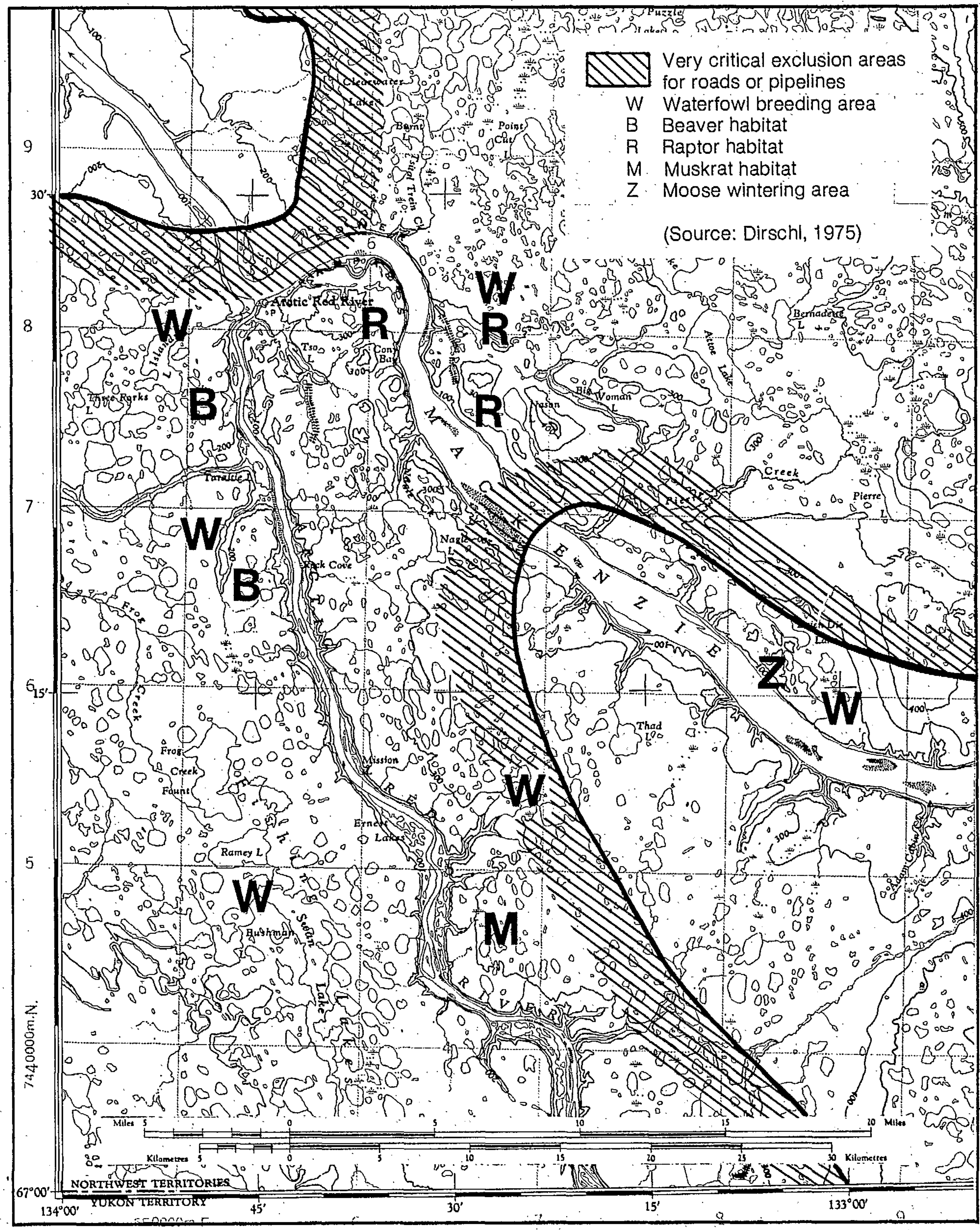

Figure 60. Important wildlife habitat along the Arctic Red River.

3. <u>Biological Resources</u>: The river valley lies in the Lower Mackenzie Forest and Grassland section of the Boreal Forest region (Rowe 1972). Boreal-tundra ecotonal vegetation types are found on the upland areas surrounding the river valley (Millar and Fedirchuk 1975).

The dominant environmental feature limiting tree growth is permafrost which underlies all soils at depths depending on texture and topographic position, moistness of site and vegetative cover. Where the permafrost table is not high, as on some of the well-drained benchlands, white spruce attains sawlog size. On fine textured alluvium, the growth of trees is poor, and scrubby types of forest composed of willows and alders with stunted white spruce prevail. There are great expanses of stunted black spruce on the more level, poorly drained terrain. In general through this region, there is far more non-forested than forested land (Rowe 1972).

The major natural resource of this area is wildlife. It is highly productive of beaver, moose, muskrat and waterfowl (Dirschl 1975, Figure 60).

Fish species recorded for the study area include arctic and least cisco, inconnu, northern pike, yellow walleye, arctic grayling and longnose sucker (Dirschl 1975). Jessop et al. (1973), Jessop et al. (1974), Jessop and Lilley (1975) and Stein et al. (1973) have summarized the results of a three-year fish tagging program in the lower Mackenzie River and its major tributaries. In the Arctic Red River:

1) Arctic grayling spawn during early to mid-June depending on break-up dates, streamflows and water temperatures (Jessop and Lilley 1975).

2) Burbot are thought to migrate upstream to spawning areas (Jessop and Lilley 1975).

3) Inconnu migrate along the river as part of a long, annual migration which takes them into the Liard River (Jessop and Lilley 1975).

4) Most important, the mouth of the Arctic Red River and back eddies of the Mackenzie River are spawning areas for humpback and broad whitefish during October and November. Turbidity and silt levels in these rivers have declined by this period (Jessop et al. 1974, Figure 61).

4. <u>Social and Cultural Values</u>: The most important land uses in this study area are wildlife related; primarily they are domestic and subsistence fishing, hunting and trapping (Bissett 1967, Department of the Environment 1976). Traditional fisheries are primarily in the vicinity of the river mouth (Figure 62). The estimated annual catch records for the domestic fishery in the Arctic Red River indicate a strong dependence on the fish resource. Estimated annual catch for the 96 residents of the Arctic Red River area was 58 725 kg (Jessop et al. 1974). Broad whitefish, humpback whitefish and inconnu were the main species caught (Jessop et al. 1974). Besides supplementing the human diet, much of

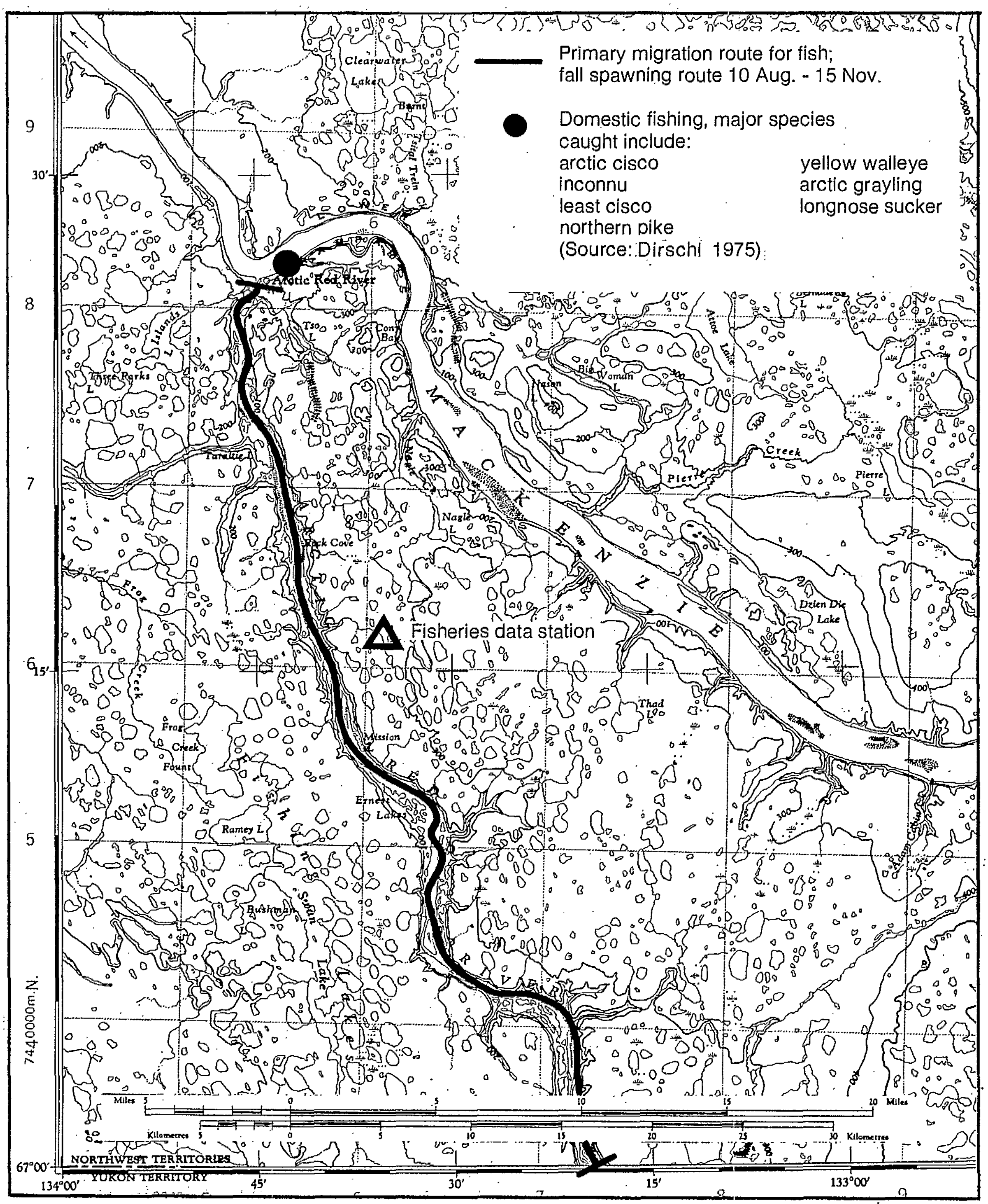

Figure 61. Migration routes of fish in the Arctic Red River.

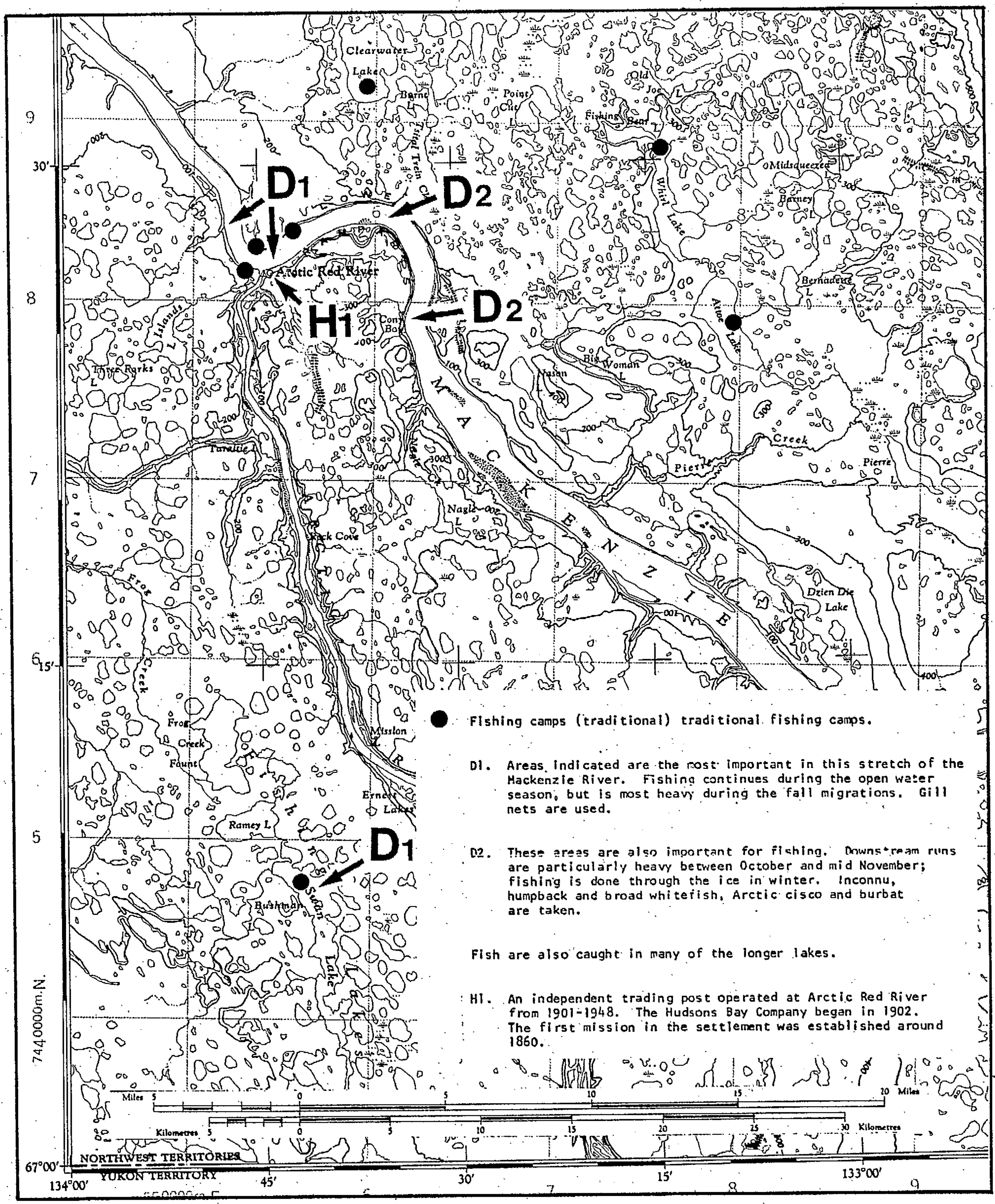

Figure 62. Fishing camps in the Arctic Red River area.

the catch was used as dog food.

The lowland areas on both sides of Arctic Red River are used by trappers from Fort McPherson and Arctic Red River. Large numbers of beaver and muskrat are hunted from April to June. Lynx, marten, beaver and wolverine are the bulk of the winter catch. Black bear are hunted along the Arctic Red River in spring (Department of the Environment 1976).

Traditionally, trappers from Arctic Red River village have moved up the Arctic Red to Martin House or up the Mackenzie River to Tree River (Wolforth n.d.). Historically, residents of Aklavik have also visited the area (Department of the Environment 1976).

Forestry has not been exploited to any extent, but the Arctic Red and Peel rivers are known to contain merchantable timber (Bissett 1967). Spruce is the major commercial species. Its distribution is limited by flooding and depth of permafrost. Sawtimber stands of softwood occur along the Arctic Red and Tree rivers (Department of the Environment 1976).

No proposed developments are known for this area.

5. Sensitivity: The fish resources of the Arctic Red River are biologically sensitive to construction of roads or pipelines (Jessop et al. 1974). Increased silt from construction in the area could be deleterious to the whitefish eggs. Therefore, if construction is proposed for the mouth of the

river or upstream, restrictions on construction techniques and scheduling will be required (Jessop et al. 1974).

6. Knowledge Gaps: More hydrologic data are required before we can determine the flood regime in the Arctic Red River, especially as it relates to fish migration and spawning activity, and the creation of moose and other wildlife habitat along the floodplain zone. Wildlife habitat and fish spawning areas upstream are generally unknown. Because of the large study area, spawning grounds located to date have been mainly limited to those accessible by boat from base camps along the proposed Mackenzie Valley Pipeline route. Secondary migration routes to spawning areas on tributaries remain unknown. The overwintering habits of many species remain unknown and require additional study (Jessop and Lilley 1975).

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G. Swan Creek Drainage

1. General Description: Swan Creek flows southward from a large lakeland area known as Fishing Lakes, 40 km southwest of Arctic Red River village, Northwest Territories (Figure 1). This lake area contains Ramey, Bushman and Swan Lakes, which all drain into Swan Creek. The drainage is sensitive to changes in hydrologic regime and water quality because it is a prime spawning and rearing area for arctic grayling (Department of the Environment 1976).

Physiographic, climatic and vegetational characteristics of this area are similar to those described for Arctic Red River (see section VII F).

2. Hydrology: No data are available for flows, fluctuations or water quality in this area.

3. Biological Resources: The primary biological resource of this area is the arctic grayling population. Swan Creek is an integral part of the habitat for this population. It is reported to be a primary migration route for arctic grayling (Dirschl 1975). It is also reported to be a spawning area for a large population of this species (Jessop and Lilley 1975, Figure 63).

Movement of arctic grayling in this drainage is important throughout the year. In the spring, grayling migrate upstream to spawn; in summer, they move into Swan Lake to feed and; in fall, they return to overwinter in the Arctic

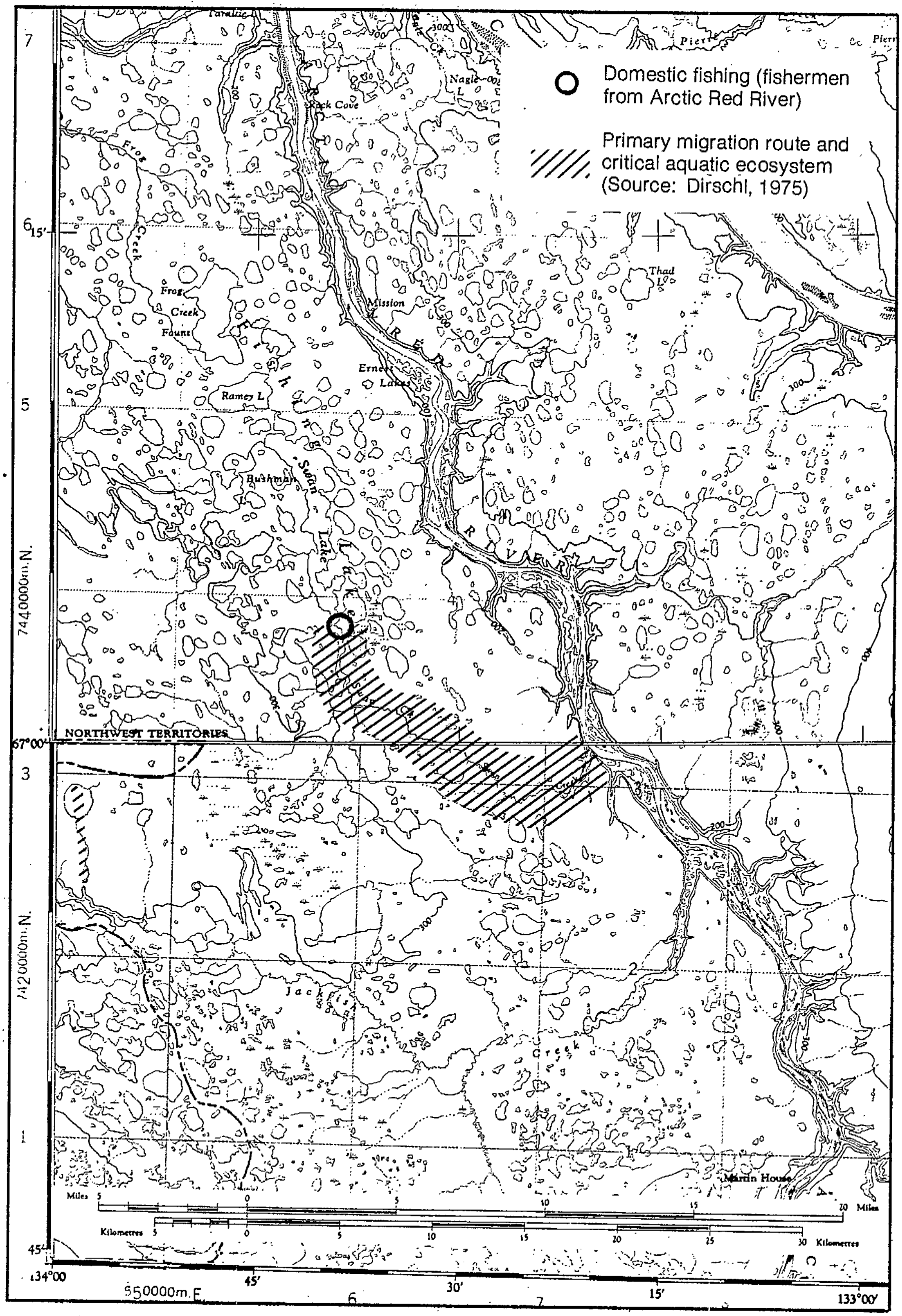

Figure 63. Fishery resources of Swan Creek.

Red River (Jessop et al. 1974).

Swan Creek is also a spawning area for longnose sucker and northern pike (Jessop and Lilley 1975). Other species present in the creek and lake complex are yellow walleye, whitefish, arctic cisco and burbot (Department of the Environment 1976).

The region surrounding this lake-creek complex is reported to be a waterfowl breeding area (Dirschl 1975). No data were available on species or numbers of waterfowl. No information was found dealing with other possible wildlife resources in the area.

4. Social and Cultural Values: Domestic fishing for grayling by the residents of Arctic Red River is the only known use of the Swan Creek (Jessop et al. 1974). The Fishing Lakes are fished for both domestic use and for sport (Figure 63). Northern pike and humpback whitefish are the main species taken (Department of the Environment 1976).

5. Sensitivity: "Arctic grayling require clear waters of large, cold rivers, rocky creeks and lakes . . . and they avoid turbid parts of the Mackenzie River." Their ease of capture, late maturity and slow growth, in addition to their need for clear, cold, unpolluted water, endanger them in populous areas (Scott and Crossman 1973).

A tentative list of stream systems in which the fish resources are sensitive to construction activities in any form included Swan Creek (Stein et al. 1973). The sensitivity was based primarily on the biological fragility of the resource as well as the significance of fish populations to existing or potential fisheries. It was recommended, therefore, that the creek be avoided in any pipeline routing (Jessop and Lilley 1975). The lower portion of the creek valley appears to be most sensitive to environmental change. This portion is deeply incised into the Peel Plain and, although the slopes are treed, a rapid flow of water creates slope stability problems. The surrounding upland areas are moderately sensitive to disturbance based on the vast, easily disturbed organic deposits and organics over till plain (Dirschl 1975). No specific data are available for these environmental concerns.

6. Knowledge Gaps: Research needs to be conducted in the Swan Creek drainage area to determine hydrologic characteristics, terrain sensitivity, wildlife populations and specific locations and quality of fish spawning areas before the effects of any type of development can be assessed.

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H. Peel River

1. General Description: The 585 km Peel River originates in the Yukon Territory in the Ogilvie Mountains, flows east across the Porcupine Plateau and then generally north across the Peel Plateau, onto the Peel Plain in the District of Mackenzie. It finally empties into the Mackenzie River 65 km south southeast of Aklavik (Figures 1, 64).

The upper reaches of the Peel River flow through an alpine and subalpine region. Altitudes range from 2350 m above sea level in the upland regions to 670 m in the valleys. The principal mountain ranges in the south are the Mackenzie, the Wernecke and the Ogilvie Mountains. The northern region includes the south end of the Richardson Mountain Range and the critical wildlife area encompassed by the Old Crow Flats (Department of the Environment 1976).

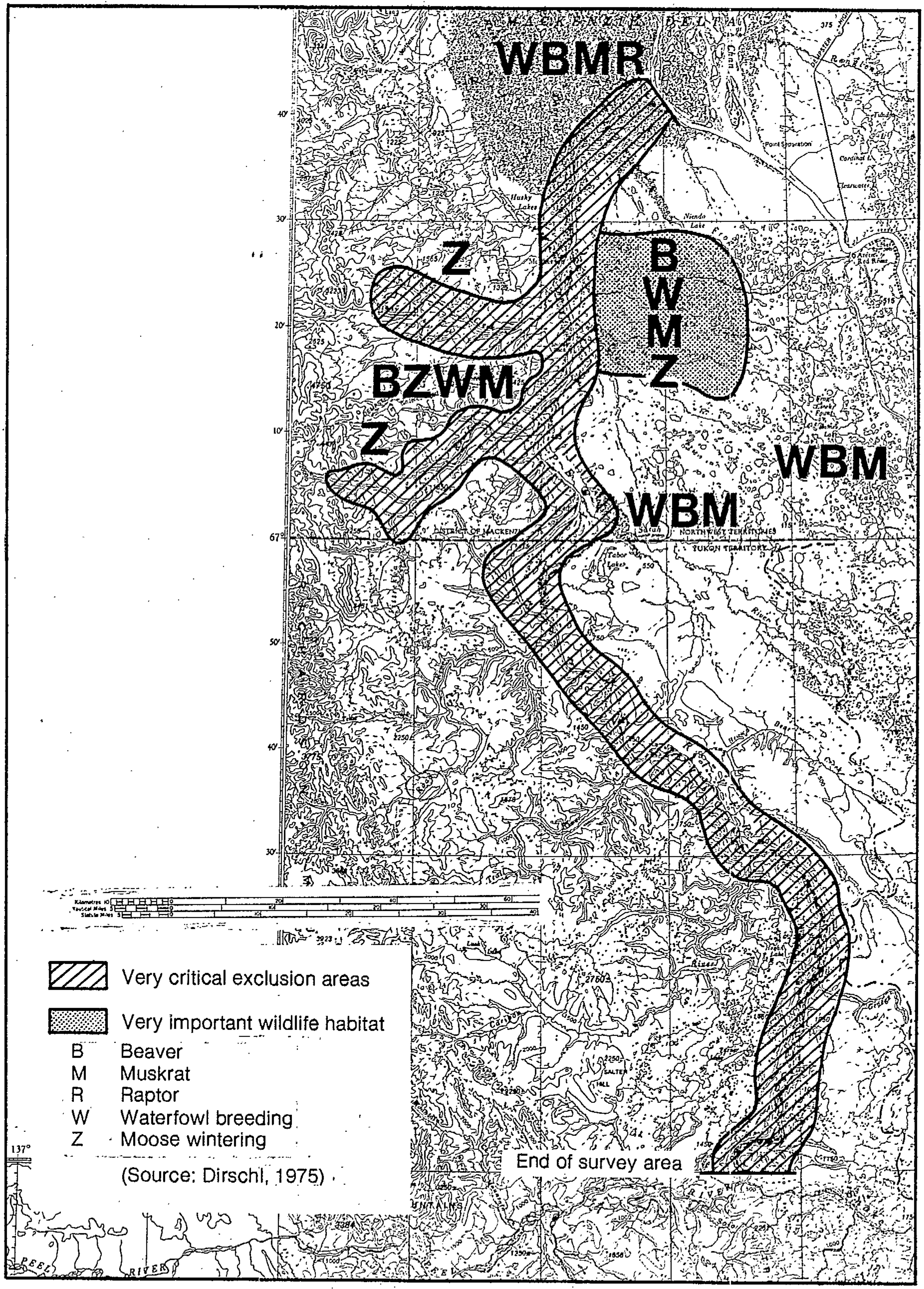

Figure 64. Wildlife Habitat of the Peel River area.

The lower reaches of the Peel River and its tributaries lie within four physiographic regions: the Richardson Mountains, the Peel Plateau, the Peel Plain and the Mackenzie Delta. The mountains are generally rounded and vary from tundra-covered to barren. The Peel Plateau, a flat-surfaced area incised by stream channels, forms a bench between the Richardson Mountains and the Mackenzie River. In the southeast, the Peel Plain consists of a series of gently sloping steppes which contain many lakes and ponds. The flat surface of the Mackenzie Delta, pocked with numerous lakes, ponds and bogs is laced by a maze of meandering channels. Above Fort McPherson, the Peel River flows at roughly 3.2 km an hour in a broad valley between 60 m high bluffs. Near the delta, both the Peel and Mackenzie occupy broad channels and flow more slowly (Department of the Environment 1976).

Surficial deposits are generally glacial in origin consisting of till plains and hummocky till in the uplands. Alluvial deposits mantle the river valleys (Dirschl 1975).

Climatic data applicable to the study area have been gathered at three sites. Aklavik, Fort McPherson and Old Crow are settlements at low elevations and represent the most moderate climate for the area because of their topographic position. The meteorological data do not give accurate indications of climatic conditions in the mountainous regions. The study area is almost entirely underlain by permafrost.

The short growing season is compensated by the 24 hours of sunlight for at least part of the summer (Hettinger et al. 1973).

The Peel River is thought to be potentially sensitive to changes in hydrologic regime because it is known to provide important spawning areas for a number of fish species. However, the detailed information on spawning sites and site conditions is generally unknown.

2. Hydrology: At Fort McPherson, the Peel River has a drainage area of 74 074 km^2. North of Fort McPherson, the Peel River flows through a many-channel delta to join the Mackenzie River. The main stem of the river has a total drop of about 381 m from its headwaters at the junction of the Ogilvie and Blackstone rivers to its mouth on the Mackenzie River. In addition to the Ogilvie and Blackstone rivers, which rise in the Ogilvie Mountains, the other principal tributaries of the Peel River are the Wind and Bonnet Plume rivers, which drain the Selwyn Mountains; and the Snake River, which has its headwaters in both the Selwyn and Mackenzie mountains. The Rat River, together with many small streams, originates in the eastern slopes of the Richardson Mountains and drains directly into the Peel River (Department of Northern Affairs and National Resources, Water Resources Branch 1965).

A variety of hydrometric data are available for the Peel River above Fort McPherson. Information has been gathered since 1968 (Mackenzie Reference Binder n.d.). Some information is also available from the Department of Northern Affairs and National Resources, Water Resources Branch (1965) station established in 1961, 16 km upstream from Aberdeen Falls. It is not known if this station is still in operation.

The runoff conditions of the Peel River are controlled by its northern location and its mountainous source areas. Most of the winter precipitation is retained in the region as snow. Consequently, a large part of the annual runoff occurs during the snowmelt period, which usually begins about mid-May and ends about mid-June. It is estimated that about 50% of the annual runoff occurs in this period (Department of Northern Affairs and National Resources, Water Resources Branch 1965). Because of the relatively short summers, about 90% of the annual runoff is concentrated into the five-month period from May to September. Runoff in the winter months is very low. Beginning in late September, freezing weather quickly reduces runoff to the point where streamflow is believed to be sustained mainly by ground water discharge (Department of Northern Affairs and National Resources, Water Resources Branch 1965).

On the main stream, the peak flow for the year usually occurs within 1 or 2 weeks of break-up, with snowmelt providing the major portion of the flood runoff. On the smaller streams, peak flow may result from heavy summer rainstorms. Since much of the source areas are underlain with permafrost, the infiltration losses are at a minimum, and runoff following rainstorms is very rapid. This condition causes extreme fluctuations in the summer hydrographs of streamflows (Department of Northern Affairs and National Resources, Water Resources Branch 1965). It may also be the reason that the maximum total monthly flow of 29 829 m^3/s occurred in September (Davies 1974).

3. Biological Resources: Between the Mackenzie lowlands and the mountains along the Yukon-Mackenzie boundary, an elevational transition from forest to alpine tundra takes place, analogous to the latitudinal transition in central and eastern Canada from forest to arctic tundra. Open, park-like stands of stunted white spruce, alternating with patches of grassy or shrubby vegetation, or with rocky barrens, are characteristic of the mountain slopes up to treeline at about 1067 to 1164 m. On northern and eastern aspects the alpine fir is usual at the treeline transition to alpine tundra, and on the same aspects but at lower elevations the black spruce has its greatest representation, either alone or mixed with white spruce (Rowe 1972).

The area between the Peel River and Richardson Mountains is rich in wildlife resources including migrating barren-ground caribou, lynx, marten, mink, coloured fox, wolf, wolverine and moose (Figure 64). Areas such as the Vittrekawa River and Stony Creek are important moose wintering areas (Dennington et al. 1973, Department of the Environment 1976).

The chief wildlife species of the mountainous regions are resident Dall's sheep, woodland caribou and grizzly bear. Grizzly bear and wolverine are generally distributed throughout the area as well as migrant and wintering populations of barren-ground caribou from the Porcupine herd (Miller pers. comm.).

The lowland area east of the Peel River, including the Peel River Game Preserve, is important habitat for large numbers of beaver and muskrat. These are hunted and trapped by Fort McPherson residents between April and June. Lynx, marten, beaver and wolverine make up most of the catch between November and March. This wetland area is also important as a waterfowl breeding area for Canada geese and a variety of ducks (Department of the Environment 1976, Figure 64).

A three-year tagging program for fish has provided much information on primary migration routes and times in the lower Mackenzie River system (Jessop et al. 1973, Jessop et al. 1974, Jessop and Lilley 1975, Stein et al. 1973a,b). Inconnu and broad whitefish are known to migrate up the Peel River as far as Fort McPherson. Spawning times occur during October and November (Jessop and Lilley 1975). Large upstream migrations of least cisco and arctic cisco occur in this river during July and August (Jessop et al. 1974). Arctic char range into the Peel River and Peel Channel. A significant population was reported in the Rat River (Jessop et al. 1973). The entire length of the Peel River from where it crosses $66^{o}N$ latitude is assessed to be critical for fish spawning (Dirschl 1975, Figure 65).

4. Social and Cultural Values: The Peel River and adjacent lowlands are used at various times of the year by most residents of Fort McPherson and the other Mackenzie Delta communities. Besides using the river as a main travel route, many people also establish temporary camps along the river while fishing and hunting. More permanent camps have also been established (Department of the Environment 1976).

Moose are often hunted along the river in late summer. The pond-filled lowlands east of the Peel River at Shiltee Rock, and along the Satah River, are especially important spring hunting and trapping areas for beaver and muskrat (Department of the Environment 1976).

The region between the Peel River and the Richardson Mountains is an important hunting and trapping area for many Fort McPherson residents. The area is rich in resources and has traditionally supported those who wish to live off the land (Department of the Environment 1976, Figure 66).

The main community in the study area is Fort McPherson. This community, a Loucheux Dene settlement, is located on the east bank of the Peel River, about 40 km from its junction with the Mackenzie River. A fur trading post was first established on the site in 1840. The economy of the community depends largely on hunting, trapping and fishing.

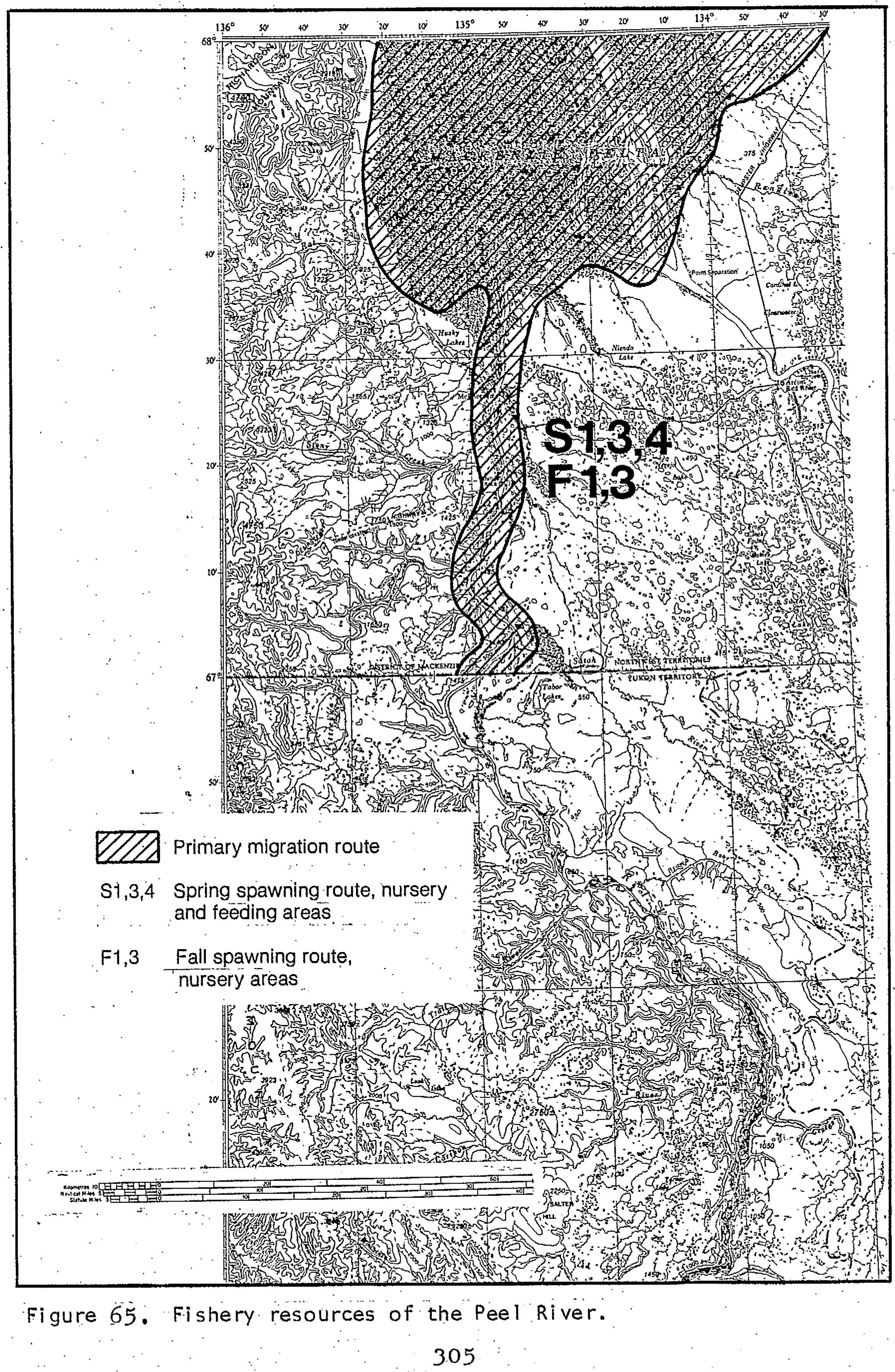

Figure 65. Fishery resources of the Peel River.

Figure 66. Domestic fishing provides many native families with protein.

J. Hunt, July 1975

In recent years opportunities for employment in oil and gas exploration and construction on the Dempster Highway have increased greatly (Department of the Environment 1976).

Historically, the lower Peel River is part of a lengthy canoe route from the Ogilvie River to Fort McPherson. A village at the mouth of the Peel, now a summer fishing camp, was previously a collection centre for the fur trade (Department of the Environment 1976, Figure 67).

5. <u>Sensitivity</u>: Wildlife populations are a vital northern resource. Each species has specific habitat requirements and some species are less adaptable to habitat changes than others. For example, the greatest danger to fish are delays during migratory runs and the destruction of spawning areas. The main channel of the lower Peel River is a primary migration route and contains nursery areas, and spring feeding areas for fish (Figure 65). In the lower reaches of the Peel, bank slopes are gentle and riverbank stability is assessed to be low. Slopes greater than 35^{o}, common in upstream areas, are considered highly sensitive (Dirschl 1975).

Terrain sensitivity is also extremely high in the critical moose winter range areas of the Vittrekawa River and Stony Creek (Dirschl 1975).

Stream beds are a source of gravel for construction purposes, but the extraction from certain localities can result in the alteration or elimination of a critical spawning area. Jessop et al. (1974) discussed spawning and

Figure 67. Fish caught in spring and summer are often preserved by drying.

L. Allison, July 1975

migration concerns for a variety of fish species in the Peel River and its tributaries. Sedimentation of streams as a result of seismic work, road or pipeline construction or other construction may be detrimental to fish populations. Near the mouth and along sections of the lower Peel, deep pools occur that do not freeze to the bottom. These areas are often vital to the maintenance of fish populations (Jessop and Lilley 1975). A reduction in stream velocity may cause these pools to freeze solid.

Altering the quality of habitat for fish can have serious, long term consequences. Growth of most fish at high latitudes is slow and long periods of time are required to replenish fish stocks. Also, habitat requirements are specific and available management alternatives for currently utilized areas are very few (Scott and Crossman 1973).

Since the greatest concentrations of domestic fishing effort on the Mackenzie system are found in the Peel and Arctic Red River areas, and the Mackenzie Delta (Jessop et al. 1974), the resource is extremely valuable to the regional economy.

6. Knowledge Gaps: The Peel River is a northern river about which very little quantitative information is available. Baseline data on its hydrologic regime is essential for an improved understand of the interaction of water with wildlife habitat in the Peel River valley. Also, identification of fish spawning and rearing sites and a clearer

understanding of the fisheries characteristics of the Peel River, would aid in managing this very important resource. A thorough inventory of biophysical characteristics and socio-economic factors throughout the system is required.

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I. Rat River and Big Fish River

1. General Description: The Rat River and Big Fish River are both found in the extreme northwest part of the Mackenzie basin (Figure 1). They originate in the Richardson Mountains in the west and flow to the Mackenzie Delta. Big Fish River is located north of Aklavik and the Rat River lies between Aklavik and Fort McPherson. Access to both

areas is by boat, oversnow vehicle or aircraft (Figures 68, 69).

The Richardson Mountains are a straight, narrow belt of Mesozoic sedimentary sandstones and shales which overlie Devonian sandstones and quartzites (see chapter VII J). The Richardson Mountains were an important factor in the formation of the Mackenzie Delta. The mountains effectively blocked the westward expansion of the Laurentide ice sheet, allowing the development of the thalweg now being filled by the Mackenzie Delta (Bostock, 1969).

2. Hydrology: Big Fish River and Rat River are both typical northern mountain rivers. They have steep slopes, a high channel density and a wide variation in annual flow. Natural storage within the drainage is low, so minimum flows occur just before break-up. Peak flows occur in early June.

The Rat River, which empties into the Husky Channel of the Mackenzie Delta, is 129 km long and drains 688 km^2 of the Richardson Mountains. The downstream portion of the river flows through the Delta in a series of single, meandering channels with steep mud banks. In this area, the river carries a heavy silt load. The middle portion of the river is a typical multi-channelled braided stream, flowing through a wide valley. The river bottom consists of boulders, gravel, sand and silt. In the upper portion the river flows quickly through a single channel, with gravel banks. The water is usually clear (Jessop et al. 1973). Fish Creek, a tributary

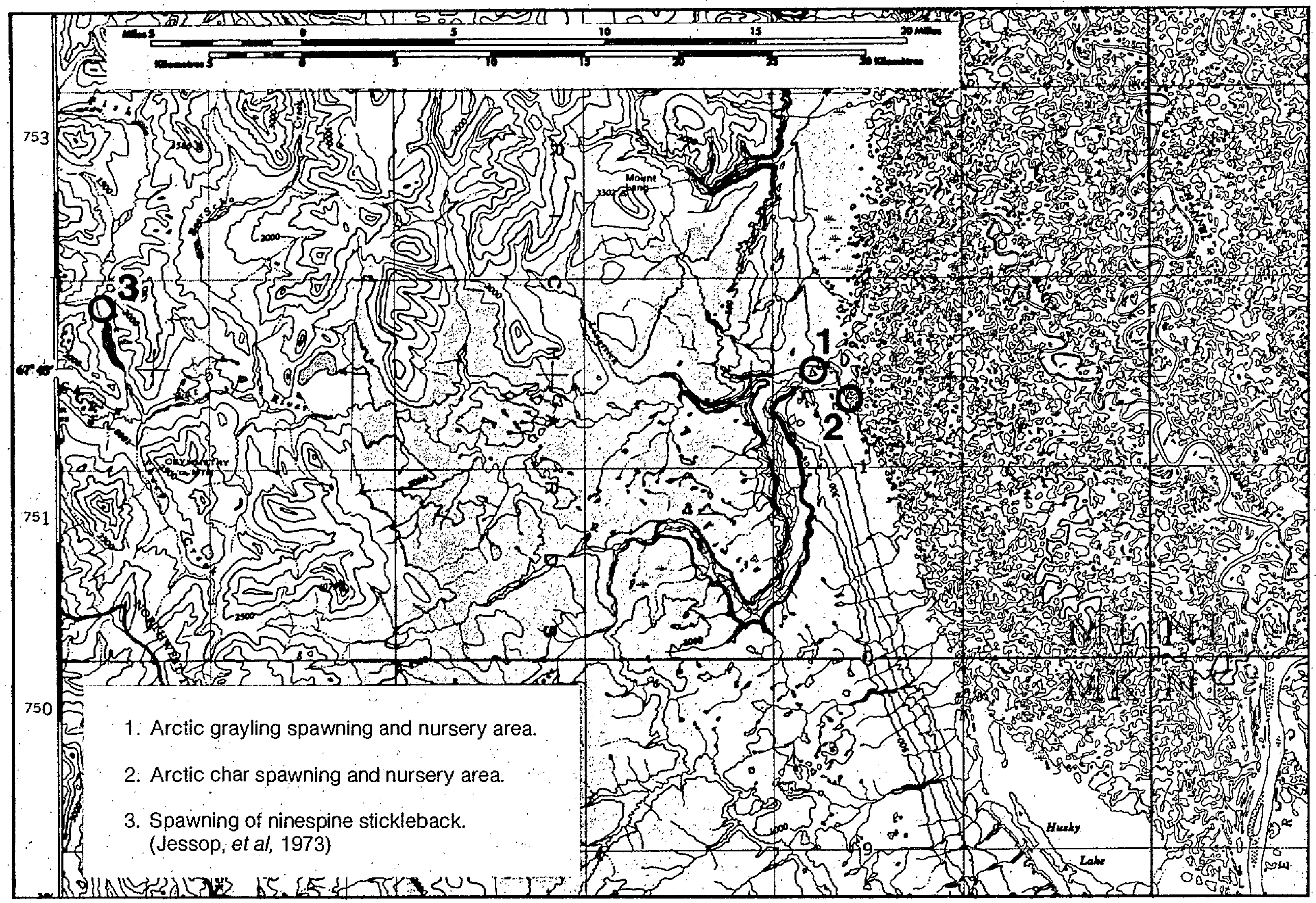

Figure 68. Fishery resources of Rat River.

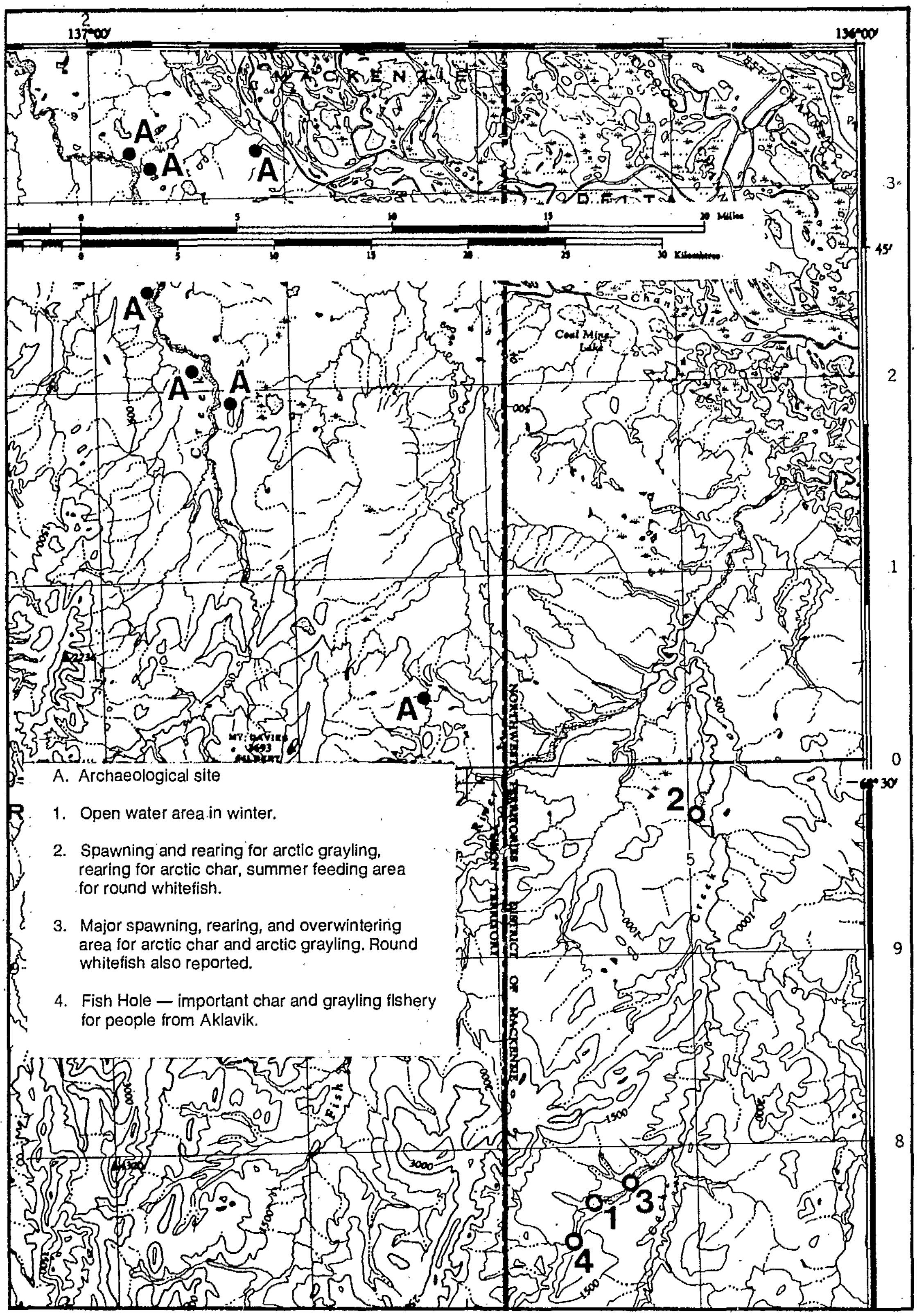

Figure 69. Fishery resources and Archaeological sites of the Big Fish River area.

of the Rat River, is a clear stream with deep, extensive pools and gravel bottom. Groundwater maintains open water year long at one location on Fish Creek (Figure 68, Hatfield et al. 1972).

Big Fish River is a mountain stream. This river and its main tributary, Cache Creek, have clear water, gravel substrate and stable banks (Figure 69). Big Fish River has a length of 109 km, while Cache Creek has a length of 77 km. The upper reaches of Big Fish River are deeply incised in a steep-walled gorge. Cache Creek flows through a wide valley cut through hilly terrain (Stein et al. 1973). Much of the stream freezes completely in winter (McCart 1972). A warm mineral spring in the headwaters of Cache Creek has a daily discharge of at least 30 m^3/s year long (McCart and Bain 1974).

3. Biological Resources: Rat River and Big Fish River are both located primarily in the Tundra vegetation biome. Vegetation along the Rat River varies from river lowland communities to alpine tundra. Summit Lake, where the river originates, supports communities of riparian spruce and spruce uplands as well as tundra. The vegetation in this area is particularly interesting because adjacent areas which were, and were not, glaciated are represented (Beckel 1975). Birch, willow, alder and sedge grow along the banks of the Rat River. Willow and alder have colonized the higher gravel bars. Along Big Fish River the vegetation on more stable areas consists of

willow and alder with an understory of sedges and grasses (Poston et al. 1973).

Steep banks and cliffs along the shorelines of both rivers provide attractive nesting sites for raptors, including peregrine falcons, gyrfalcons, golden eagles, bald eagles and osprey (Dirschl 1975, Department of the Environment 1976). Dirschl (1975) classified the entire Rat River drainage and adjacent uplands, and the shores of Big Fish River and Cache Creek, as "very critical exclusion areas" because of their importance as raptor habitat.

Populations of large mammals are more important in the Rat River drainage. The northernmost population of Dall's sheep in Canada occurs in the vicinity of Mt. Goodenough. The area is excellent grizzly habitat and supports an estimated 1 bear per 65 km^2 (Pearson and Goski 1974). Barren-ground caribou, members of the Porcupine Herd, often migrate through the Richardson Mountains in spring. Scattered groups of caribou can be found in either drainage during winter and along the coast during summer. Willow-thicketed river valleys provide important shelter and food to the few moose which live in tundra habitats.

Both the Rat River and Big Fish River systems are considered sensitive to changes in water levels primarily because of the arctic char populations they support. Other fish populations are also important.

Fourteen species of fish have been caught in the

Rat River drainage. Arctic char are by far the most numerous species, but other abundant species include broad whitefish, round whitefish, arctic grayling and northern pike (Jessop et al. 1973).

Broad and round whitefish are common only on the fringes of the Mackenzie Delta; northern pike are distributed throughout the system. Jessop et al. (1973) speculate that there may be a resident arctic grayling population at "Fish Hole" on Fish Creek. (Note that spawning areas in both Rat River and Big Fish River are called "Fish Hole".)

Arctic char are found throughout the drainage. Past studies indicated that the numbers of fish peaked in mid-June and mid-September. Arctic char spawn in Fish Creek in September and October. Portions of the spring-fed creek remain open all winter and provide overwintering and nursery habitat. Extensive migrations may not be necessary for this population, but one char tagged in the Rat River was recaptured in "Fish Hole" on Cache Creek - 277 km from its original capture point. Char tagged in Rat River have also been recaptured in Husky, Peel and West Channels on spawning runs (Jessop et al. 74, Figure 68).

A separate population of char migrates into Big Fish River to spawn each fall. "Fish Hole" on Cache Creek is the major spawning and nursery area (Figure 69, Stein et al. 1973). The river also supports a resident population of arctic grayling (Jessop et al. 1974). The population of "catchable arctic char" is estimated to be 12 000 to 17 000 fish (Stein et al. 1973). Arctic char leave the Beaufort Sea in mid-August and reach "Fish Hole" during late September and October (Stein et al. 1973), where they spawn a month later than the Rat River population. This presumably occurs because the water is warmer in Cache Creek as a result of the influence of a warm mineral spring above "Fish Hole" (Jessop et al. 1974). Big Fish River is also reported to be a good overwintering area for char (Jessop et al. 1974).

A non-migratory population of arctic char occurs above the falls at "Fish Hole". Exchange between the groups is prevented by the falls which are 8 to 10 m high. During winter the habitat used by these fish has a much higher temperature, higher dissolved solids content and lower oxygen content than wintering areas selected by char populations elsewhere. Winter water temperatures may rise as high as 15°C, but abruptly fall to 0°C during the spring freshet. This population evidently spawns in November or later (McCart and Bain 1974).

Besides char, Big Fish River is a summer feeding area for round whitefish as well as a spawning and rearing area for arctic grayling and burbot (Figure 69, Department of the Environment 1976).

4. <u>Social and Cultural Values</u>: McDougall Pass is a traditional and current travel route for hunting parties moving between the Mackenzie Delta and the interior Yukon.

The Porcupine, Bell and Rat Rivers are part of an historic canoe route from Fort McPherson, Northwest Territories, to Dawson City, Yukon Territory, or Fort Yukon, Alaska. The route was first used extensively during the gold rush, but now is a wilderness trip for seasoned canoeists (Department of the Environment 1976).

The Rat River, Bell River and Summit Lake areas are proposed International Biological Program sites. They were chosen as representatives of glaciated and unglaciated tundra terrain, and of northern alpine tundra big game populations (Beckel 1975).

The Richardson Mountains north of the Rat River are hunted by residents of Inuvik, Aklavik, Fort McPherson and Arctic Red River. Barren-ground caribou are the target species, but Dall's sheep are also taken. The Rat River bed is used in winter as a travel route into the area (Department of the Environment 1976).

The mouth of the Rat River is heavily fished with gill nets during the char run (Stein et al. 1973, Jessop et al. 1973).

The entire Big Fish River drainage is important year round to native residents, particularly from Aklavik. Caribou are hunted along the coast in summer and fall, and inland in winter. The drainage becomes an important moose hunting area when barren-ground caribou are not in the area. Lesser snow and whitefronted geese are hunted along the coastline and in the Delta in fall. Major traplines for coloured fox and wolverine are established along the rivers.

A large domestic fishery at "Fish Hole" and the mouth of Big Fish River may take 5000 to 7000 arctic char a year (Stein et al. 1973).

5. Sensitivity: Char populations using both drainages are particularly sensitive to disturbance and stress because they are heavily exploited by the domestic fishery.

6. Knowledge Gaps: All biological information on drainages in the Richardson Mountains is derived from baseline surveys conducted as part of the Mackenzie Valley Pipeline studies. The most intensive work was done by Jessop et al. on Rat River (1973). The Rat River has potential at several locations for hydroelectric power development. Before the effects of these or other developments could be predicted in any more than a general way detailed biological information would be required (see chapter VIII).

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J. Mackenzie Delta and Horseshoe Bend

1. General Description: At the apex of the Mackenzie basin, which drains 17% of Canada's total land area, is the Mackenzie Delta (Figure 1). Water flowing through its channels travels as far as 4200 km before it reaches the Arctic Ocean. The Mackenzie Delta is by far the largest delta in Canada, covering 12 000 km^2. The communities of Aklavik and Inuvik are located on the Delta; nearby are Fort McPherson and Tuktoyaktuk (Figure 70). Scheduled aircraft fly to all communities.

The Mackenzie Delta is a subdivision of the Arctic Coastal Plain. This physiographic region includes the present-day Delta as well as remnants of earlier deltas and fluviatile marine features such as Cape Bathurst. The Delta is underlain by rocks of Cenozoic and Cretaceous ages (Bostock 1969).

The modern Mackenzie Delta is composite in origin. It has been formed largely from sediments of the Mackenzie River, but the southwest sector also receives sediments of the Peel and Rat Rivers (MacKay 1963, Gill 1973).

During the most recent glaciation, the Laurentide ice sheet entered the Delta from the south and extended north along the Richardson Mountains but did not penetrate them. Local ice sheets formed in the Richardsons and flowed east to meet the main mass of ice (MacKay 1963).

The evidence suggests that the Delta area was

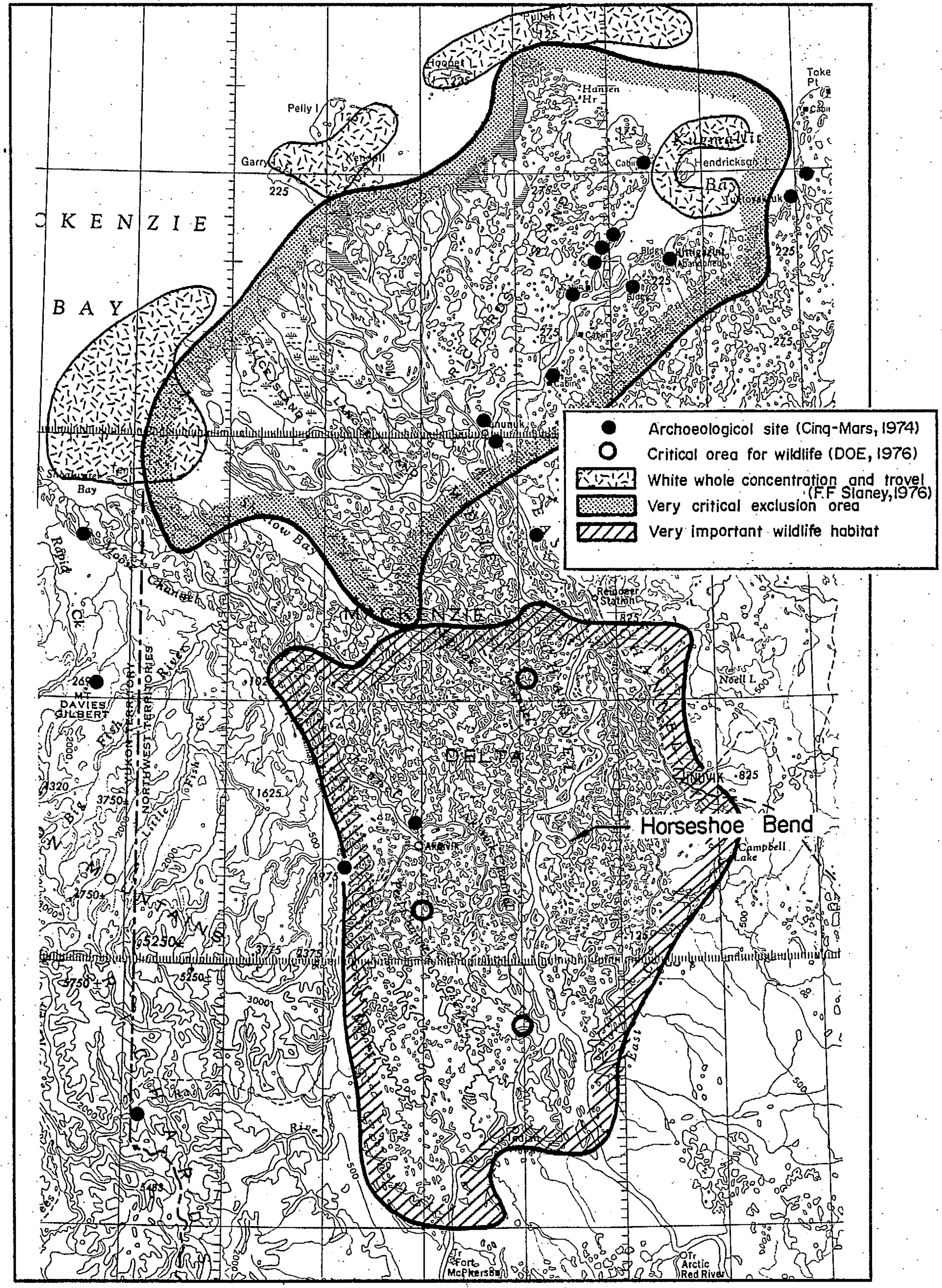

Figure 70. Wildlife habitat of the Mackenzie River Delta.

submerged during post glacial times. Approximately 10-12 000 years ago, the Mackenzie Delta trough was probably 60-90 m below present sea level. The land rebounded faster than the sea level rose, and rivers cut deep valleys across the area. River valleys were subsequently filled with sediments during a slight submergence (MacKay 1963).

Post glacial submergence is also strongly suggested by the fact that present areas of active sedimentation are seaward of, rather than at, distributary mouths. Except for Mason Bay, Mallik Bay and major river channels the immediate offshore is generally 3 m or less in depth (Percy 1975). Nearshore portions of the Beaufort Sea are shallow; depths for as much as 32 km offshore are 6 m or less (MacKay 1963). This shallow continental shelf, formed by alluvial processes, is one of the key areas in the offshore search for oil (Milne and Smiley 1975).

On the outer (seaward) parts of the Mackenzie Delta, "new" and "old" sections can be distinguished. The new Delta consists of recent fine-grained sediments which form floodplains and low bordering terraces. Flooding occurs frequently during break-up and summer storms. New sediments are currently being deposited seaward and northwest of Richards Island and Kugmallit Bay (F. F. Slaney and Company Ltd. 1973).

The old Delta consists of exposed Pleistocene sediments of till, gravel and sand. This includes most of Richards Island and the Tuktoyaktuk Peninsula to the east. The area is hilly with numerous ridges and terraces. Older fluvial and marine sediments are covered by glacial deposits. Sand and gravel form gently sloping benches interrupted by shallow channels and low scarps. Lakes are deeper than in the new Delta (F. F. Slaney and Company Ltd. 1973).

The Mackenzie Delta occupies a zone of discontinuous permafrost, where the permafrost table is very irregular. The frozen level is absent or dipped under channels, lakes, recent alluvial deposits, and offshore areas. Permafrost influences a wide variety of processes occurring on the Delta, including drainage, channel behaviour, erosion and vegetative growth (Gill 1973, Reid and Calder 1977).

Ground ice in the Delta may be important locally, making up more than 50% of "soil" volume in some places. Tabular sheets of ground ice are less common but may also be present. Other permafrost features are pingos, ice-cored, conical hills. They occur in low flat spots, usually former lakes. Tundra polygons occur in the southern and western Delta, and west of Richards Island. They are patchy along the coast and sparse in the mid-Delta (MacKay 1963).

2. Hydrology: During winter, most of the flow entering the Mackenzie Delta is contributed by the Peel, Arctic Red and Mackenzie rivers, with most of the water being carried by the middle channel (83% in summer, up to 94% in winter - Davies 1975). Shallow Bay receives 33-62% of the outflow to the ocean, and Mackenzie Bay receives 25-35% (Anderson and Anderson 1974).

Snowfall and snow cover decrease northward in the Delta. Ice cover is therefore thickest near the arctic coast. On smaller channels, as water levels recede under the ice, the weight of snow and ice cause cracking and dropping which may result in overflow. On other channels ice may completely block and divert the flow of water (Anderson and MacKay 1973).

During break-up small ice jams are frequent. They occur at sharp bends and channel constrictions causing diversions, flow reversal and flooding. The flow becomes more widely distributed northward in the Delta and the height of the flood diminishes (Anderson and MacKay 1973).

Ice covers the Mackenzie Delta for 8 months of the year. The small Delta lakes freeze first, followed by small tributary and distributary channels, and finally the larger channels. The first sign of break-up occurs in April when traces of meltwater can be seen along the edges of the channels. Flow under the ice increases in volume as flood water from upstream areas reaches the Delta. Break-up generally occurs first in the southwest sector of the Delta, and is usually 10 days later on central and eastern channels. The first ice movement occurs about one week prior to peak spring flood. Maximum stage averages 4.6 m above winter ice level (MacKay 1967).

MacKay (1963) states that discharge from the MacKenzie is roughly 8400 m^3/s in summer. During spring floods it may peak at 14 000 m^3/s, and in late winter the flow may be below 2800 m^3/s. Milne and Smiley (1975) however, record spring floods to be 25 000 m^3/s, twice the flow of the Fraser River.

When the Mackenzie River reaches Point Separation the water divides into distributary channels of differing lengths, flow rates and gradients. Most of the major channels are quite stable and have not changed significantly in the past 150 years. As the channels radiate from Point Separation they branch - all of the channels at that point are distributaries. However, they do not continue simply branching into ever smaller channels until salt water is reached. Cross-linkages and recombinations of channels form a network (MacKay 1963).

Some lakes are connected to the main flow through the Delta by channels which receive water only when levels are high. Other lakes are closed basins and receive water only during flooding (see chapter II C for a description of lakes in deltas). Flooding of lakes in any year can be detected by the presence of silty water; clear lakes have not been flooded (MacKay 1963). The extent of lake flooding depends on proximity to active channels, debris, ice bridges, and weather during break-up (Poston et al. 1973). Delta lakes are formed by a variety of processes including levee building, infilling, thermokarst melting and lateral cutting of channels (MacKay 1963).

Offshore the distribution of suspended sediment from the Mackenzie River reflects the combined effects of current and wind on the silty plume of fresh water which extends into the Beaufort Sea. Generally the plume, which may be 2 to 5 m thick, is carried eastward along the coast of the Tuktoyaktuk Peninsula (Bornhold 1975) where the band of turbid water can be readily distinguished on satellite photographs. The plume indicates which fresh water of Mackenzie River origin forms a layer overlying higher salinity, more dense offshore water of Arctic Ocean origin (Grainger 1975).

Storm surges are the result of a strong onshore wind sweeping across a wide expanse of open ocean and piling water up on the Delta. These are most frequent during late summer. Under extreme conditions a surge may be as high as 3 m; 1 and 2 m surges occur relatively often. A 3 m surge can cover approximately 3900 km^2 of the Delta (Lewis and Forbes 1975). Stevens (1953) noted that the effect of storm tides may be felt as far as 144 km inland. Frequent inundation of the coastal area during the ice-free period results in rapid shoreline attrition (Poston et al. 1973).

The Mackenzie Delta itself is quite stable, but is advancing very slowly. Wave action of the Beaufort Sea is probably low, but the river cannot overcome the erosive force of the Beaufort Sea. Pleistocene delta deposits along Richards Island and the Tuktoyaktuk Peninsula are being eroded rapidly (Lewis and Forbes 1975).

3. <u>Biological Resources:</u>

a. Vegetation: As a delta expands outward, its upper reaches mature and the progression of plant succession can be seen as one traverses the area. Young sites are aquatic and nutrient rich. As the site develops emergent species are successively replaced by a series of dry-tolerant communities. The evolution of the physical landscape is the main driving force of this succession.

The vegetation zones of the Mackenzie Delta, proceeding from south to north, are Boreal Forest, Forest-Tundra transition, and Tundra. Microtopographic variation over very short distances results in several distinct plant communities occurring side by side (Lambert 1963). The Mackenzie Delta supports the northernmost extension of the boreal forest in Canada.

South of 68°45' black spruce is the dominant tree. Trees are confined to high ground above usual flood levels. Balsam poplar is also present. The understory consists of woody shrubs, ericaceous plants, grasses, mosses and lichens. The continual erosion and deposition of material resulting from lateral channel migration usually restrict the coverage of black spruce in any area to 50% or less (Lambert 1963). The complete successional sequence on any site is estimated to take 100 to 150 years (Gill 1976).

Willow and alder occur throughout the Delta in moist areas, often along channel banks. They are instrumental in stabilizing alluvial bars against the effects of ice scouring, erosion and sedimentation. Lower slopes and channel banks are dominated by horsetails and sedges (Lambert 1963).

Lakes and ponds cover 15 to 50% of the surface area. The margins and shallow basins are colonized by tall willows, alder, sedges, horsetail, burreed, pondweed and water milfoil. Deep lakes with slumping shorelines and conifer borders show thermokarst activity (Poston et al. 1973).

The central Delta is lower and may be flooded by storm surges or high water in spring. It supports extensive areas of alder and willow thickets. Openings support species characteristic of dry tundra, while sedges and horsetails are found around lake margins and on wet sites (Lambert 1963).

The mouth of the Delta consists of very wet flat alluvium and alluvial islands. Large areas consist of mud flats; other broad areas may be dominated by a single species of horsetail or sedge. Drier, hummocky areas have developed a community of low willows, sedges and horsetails (Lambert 1963). Shallow Bay is greatly influenced by tides and wind seiche. The water is shallow, turbid, and without vegetation. Extensive mudflats are exposed during low tide but may be under 2 m of water in a wind-driven high tide (Poston et al. 1973).

From the foregoing description, it may be inferred that the Mackenzie Delta flora, because of its dynamic nature, is fairly resilient, and that the activities of man would hardly be noticed. Such an inference would be incorrect. Gill (1973) showed that almost every point bar is occupied by a plant community dominated by balsam poplar which is unique to those sites. The dry location and the presence of firewood produce an attractive camping site. Disturbance by humans and dogs has removed trees and shrubs and allowed exotic pioneer species to move in. Gill (1973) estimated that 75 to 100 years would be required before the plant cover will revert to its undisturbed state.

b. Birds: Millions of birds, representing 139 species, are found in the Mackenzie Delta-Beaufort Sea region. The Mackenzie Delta is an important area for waterfowl. Large numbers of swans, geese, ducks, gulls, terns and other species converge on the Mackenzie Delta each spring. On their semi-annual migrations they travel between the Delta and wintering areas as far south as South Africa and Antarctica (Berger 1977). Most arrive on the Delta between early May and late June. For many species the Delta is a very short spring stopover enroute to nesting areas further north and east.

Four islands in the Kendall Island Migratory Bird Sanctuary support the nesting area of the smallest lesser snow goose colony in the western Arctic (Figure 71). The islands are largely sedge-covered. Levees formed by ice pressure during break-up and entrapment of silt provide the

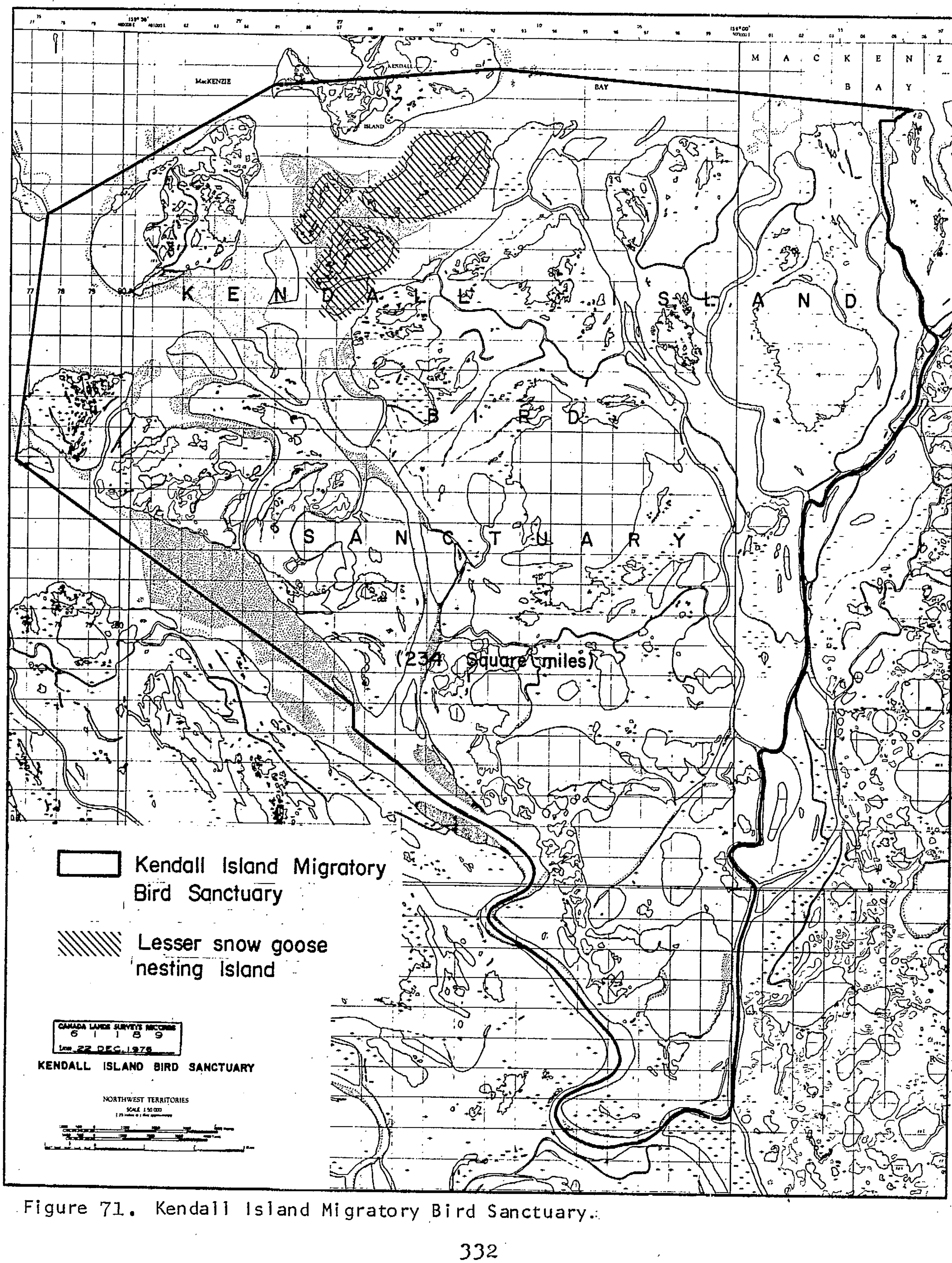

Figure 71. Kendall Island Migratory Bird Sanctuary.

driest locations for nesting. In recent years, the nesting colony of 400 to 500 adults has been almost totally unsuccessful (Barry, cited by Allison 1977). Apparently in 1978 nesting and brood raising was successful for the first time in 9 years (Goodman, pers. comm.).

It is generally unknown to what extent activities of man are responsible for the poor breeding record of the Kendall Island lesser snow goose colony. Adverse weather conditions or disturbance by bears and other predators may account for losses of nests and/or young up to 100% in some years. Martel (1976) commented that waterfowl populations may be more sensitive to disturbance in years of adverse weather because of the poor physiological condition of the birds. It is worth noting that the Kendall Island colony has been less successful than other lesser snow goose nesting areas. During this same period it has been subjected to disturbance from oil exploration activities.

The outer Mackenzie Delta is also an important nesting area for whistling swans. Although swan nests are spaced along the shores of tundra ponds, nesting swans reach the highest densities recorded in the western Delta (Barry pers. comm.), an estimated 20 000 (Campbell and Weber 1973, Bellrose 1976). The Harry and Swan Channel regions to the east of the Kendall Island sanctuary are also critical habitat for nesting and moulting waterfowl, including whistling swans, whitefronted geese, sandhill cranes, and various shorebirds (Barry 1976).

The most dramatic concentration of waterfowl on the Mackenzie Delta occurs in fall. The entire western Arctic population of lesser snow geese stages on the Yukon/Alaska north slope. When snow appears early along the western coast, as many as 500 000 geese stop on the outer Delta prior to heading south.

Barry (cited in Allison 1977) considered a coastal zone of the Delta about 25 km wide to be more important to migratory birds than interior areas. However, the Delta itself does support several species of nesting waterfowl. Among the dabbling ducks, pintail and mallard are most common; greater scaup, surf scoters and American widgeon represent the divers (Searing et al. 1975). Concentrations of ducks on the Delta are highest during years of drought on the prairies. Many of the ducks move into Shallow Bay where they are hunted in fall (Searing et al. 1975). The entire length of the main channel is also used for staging (Poston et al. 1973).

The rare Hudsonian godwit, a shorebird, is found in relatively concentrated numbers in the Delta (McTaggart-Cowan 1976). Some raptors also nest in the Mackenzie Delta. Rough-legged hawks are found in the outer Delta, particularly Richards Island. Bald eagles reach the northern limits of their inland ranges when they nest on the Delta. Merlin are found in specific areas of the Delta (Searing et al. 1975), and peregrine falcon in the Campbell Hills near Inuvik.

Large numbers of sandhill cranes migrate through the Delta and a few nest along the coast. Shorebirds of various species are a major component of the avifauna of the Delta (Searing et al. 1975).

Dirschl (1975) designates the entire outer Delta as a "very critical exclusion area" on the basis of its importance to nesting and staging waterfowl (Figure 70).

c. Mammals: The more important Delta mammals to residents of the area are the Beluga, or white whale, and the muskrat.

White whales are small, toothed whales without dorsal fins. They are temporary summer visitors to estuarine areas offshore of the Delta. After break-up (about the end of June) approximately 4000 to 5000 white whales move into the turbid Mackenzie River estuary. The whales are thought to be attracted to the estuary by the warm water (up to 15°C) which they may require for calving. Little feeding occurs in the estuary (F. F. Slaney and Company Ltd. 1976). Peak numbers occur in late July, but many whales remain in the vicinity until mid-August.

This relatively small group of whales is the only white whale population in the western Canadian Arctic. The Mackenzie estuaries, although their function in the life history of the white whale is not understood, are believed to be critical to the survival of the population. There is no alternate habitat of equivalent size anywhere in the western Arctic (Sergeant 1976).

Wintering areas of the western Arctic white whales have not been located. The whales leave the Delta apparently travelling east in some years and west in others (F. F. Slaney and Company Ltd. 1976).

A very small number of Bowhead whales can be found in the Beaufort Sea during summer. However, they rarely enter the portions influenced by the Mackenzie River.

Within the area of influence of the Mackenzie River, seal numbers are very low.

The muskrat is another mammal of major importance in the Mackenzie Delta area. The upper Delta as far north as tree line is excellent muskrat habitat. The only other section of the Mackenzie basin north of 60°N which equals it is the Brackett Lake wetland (see chapter VI B). Muskrat are present in most permanent bodies of standing water. Optimum water depth for winter survival is 2 m (Stevens 1953). Since deep lakes do not produce appropriate vegetation for food and ice averages 0.75 m thick, muskrats have a narrow range of lakes in which to live. Unlike the muskrats of the Peace-Athabasca Delta, most of which build houses of emergent vegetation, the populations in the Mackenzie Delta are restricted to bank dens. Because muskrats are prolific and colonize new habitats quickly, temporary disturbance of small areas of their habitat will have only temporary effects.

However, stabilization of muskrat habitat or long-term declines in water levels can result in serious declines.

Muskrats are present on Richards Island but the remainder of the outer Delta is unsatisfactory habitat. The inner Delta is also considered good beaver habitat although the populations fluctuate widely. Three general areas of the inner Delta are considered particularly important to local populations of muskrat and beaver (Department of the Environment 1976, Figure 70). Dirschl (1975) considers the entire inner Delta "very important wildlife habitat" for waterfowl, raptors, muskrat and beaver.

The history of beaver on the Delta has been strongly influenced by trapping. Declines from relatively high numbers to low populations were attributed to heavy trapping pressure, particularly when the populations recovered under the protection of the Mackenzie Beaver Sanctuary. More recent declines have been found to be associated with a degradation of food supplies over time. This suggests that overtrapping may not have been responsible for historic declines (Hawley and Aleksiuk 1973).

When populations are high, beaver densities of 0.75 colonies per square mile have been recorded in parts of the Delta. Most beaver in the Delta use bank burrows, and are found in lakes rather than channels which are subjected to unstable water levels. Preferred habitat for beaver in the Delta is generally restricted to areas of poplar and willow. Overuse of habitat occurs frequently and colonies may move every 1 or 2 years (Hawley and Aleksiuk 1973).

The Tuktoyaktuk Peninsula and Richards Island support a small population of barren-ground grizzly bear which are considered to be endangered by over-hunting (Pearson, pers. comm.). Grizzly bears roam widely and their denning habitat is considered to be sensitive. Ten dens were found on Richards Island in 1974-75, and 5 in 1975-76 (Wooley 1977).

Ellice, Langley and Richards Islands all are potential habitat for the reindeer herd which ranges east of the Mackenzie Delta. Biting insects and heat stress are important problems in summer. Coastal areas are preferred summer range. A small group of feral reindeer resides on Richards Island year round (Wooley 1977).

Martel (1976) reported that the historic range of the Bluenose barren-ground caribou herd included the Caribou Hills, Ellice Island, Kendall Island and Richards Island, and the Arctic coast of the Tuktoyaktuk Peninsula. Hawley (pers. comm.) stated that the Bluenose Herd is rapidly expanding its numbers and range. In the future it could engulf the reindeer herd, and reach the fringes of the Delta. The Porcupine Herd, to the west, currently includes the east side of the Richardson Mountains and the Yukon North Slope at the west edge of the Delta within its range.

Arctic fox have been reported from Garry, Pelly, Hooper and Pullen Islands as well as Richards Island. Department of the Environment (1976) reported that potential denning habitat is present although dens have not been found.

The Mackenzie Delta provides poor moose habitat. Although food is abundant, frequent flooding and a lack of protection from prevailing winds severely limit its potential. In addition, heavy hunting has virtually eliminated moose from the Delta (Prescott et al. 1973). The occasional animal ventures onto the Delta from populations on the east, south and west margins.

d. Fisheries: The Mackenzie Delta and its estuaries are an extremely complex series of aquatic habitats. Offshore, in the turbid water of the Mackenzie River plume there is a low primary production rate resulting from restricted light penetration. Both number of species and biomass are low. Benthic species are virtually absent. Offshore in the clear, colder waters of the Beaufort Sea, nutrients are limiting (Grainger 1975).

On the Delta itself, productivity is higher: the entire modern Delta and estuarine area must be considered a critical aquatic ecosystem which is highly sensitive to disturbance (Dirschl 1975, Berger 1977). Stein (pers. comm.) stated that the Mackenzie Delta is the most important waterbody to fish in the Mackenzie basin.

Many of the fish species which use the Mackenzie Delta have complex life histories and migration patterns.

> Unfortunately because of the turbidity of the water, the multitude of channels and small water bodies, the large size of the main channels and the long period of ice cover, there are critical gaps in our information about these fish resources. . . . There are few details available concerning the location and timing of critical life situations, such as spawning, overwintering and migration, in which the fish populations are at greatest risk from industrial activities. (Berger 1977)

The species present in the Delta and estuarine areas include fresh water forms which stay in the Delta throughout their lives, marine forms which always remain in the ocean, and anadromous species. Anadromous groups of fish hatch and spend varying lengths of their juvenile lives in fresh water. They then move out to the ocean where they remain until reaching maturity. As adults they return to fresh water and embark on major spawning migrations annually or biannually. Over 30 species of fish are present at some time of year in the freshwater habitat alone (Hatfield et al. 1972). We will discuss here primarily those species which are important to the domestic fishery.

The Mackenzie Delta is important to both resident fish populations and to anadromous populations as a spawning area and migration route.

Between mid-August and early October major upstream spawning migrations of inconnu, humpback whitefish, broad whitefish and least cisco occur. It has not been determined whether some major channels are more important for these migrations than others. Fish travel to spawning areas in the

Peel River, Arctic Red River and other upstream tributaries of the Mackenzie River. Some arctic cisco may travel further than Norman Wells, a distance of over 700 km (Stein 1973). Inconnu from Horseshoe Bend have been captured as far upstream as Wrigley (857 km, Jessop et al. 1974).

Horseshoe Bend: Horseshoe Bend (Figure 70) is a cutoff of the middle channel of the Mackenzie River in the Delta. It is listed as one of the potentially sensitive areas in this review. Horseshoe Bend is one of a few locations which are known to be spawning areas for fish inhabiting turbid water. Humpback whitefish spawn at Horseshoe Bend and broad whitefish are suspected spawners. Northern pike and inconnu are also common. Other locations in the Delta which are known or suspected spawning areas for anadronmous species include Peel Channel and Husky Channel for arctic cisco and least cisco (Jessop et al. 1974, Stein et al. 1973). Horseshoe Bend is also an important nursery and overwintering area.

Arctic char are found only in the western Delta. The two anadromous populations in the area spawn in tributaries of Big Fish River and Rat River (see chapter VII I). Char migrate along Husky Channel. However, fish tagged in Husky Channel have been recaptured both upstream at Rat River and downstream at Big Fish River (Stein et al. 1973).

Post spawning runs of anadronmous fish returning to their wintering areas are also important. They begin in mid-October with arctic cisco and continue into mid-November. Like the upstream runs, downstream migrations occur in all channels. They often occur after freeze-up.

Northern pike spawn in relatively warm, often weedy, shallow water in many Delta lakes and creeks. Between mid-August and freeze-up both pike and burbot move out of lakes and creeks into larger channels for winter (Stein et al. 1973). Burbot spawn in mid-winter. Lake trout are another resident species, found in clear lakes on the Delta (Percy 1975, Jessop et al. 1974).

Many small channels and channel-connected lakes in the Delta are nursery and feeding sites for juvenile fish of a variety of species. Near Aklavik, for example, inconnu, broad whitefish, humpback whitefish, least cisco, arctic cisco, burbot and northern pike are found (Jessop et al. 1974).

The outer Delta and estuary is also important for overwintering. Whitefish and least cisco are found in deeper lakes. Mallik Bay supports least cisco, arctic cisco, arctic flounder, burbot, boreal smelt, inconnu and fourhorn sculpin. Mallik Bay is also a nursery area. Harry Channel, Langley Channel, East Channel, Kugmallit Bay and Mason Bay are also winter areas (Percy 1975, DeGraff and Machniak 1977). Shallow Bay is unsuitable for overwintering fish (Percy 1975). Other than arctic grayling and arctic char, fish found in lagoons along the Yukon coastline are almost all from the Mackenzie Delta or upstream (Kendel 1975).

Four marine and brackish water species are also found in and near the influence of the Mackenzie River plume. Fourhorn sculpin are widely distributed in the nearshore zone. Arctic flounder occur northeast of Richards Island, in Mallik Bay and offshore areas. Pacific herring occur in lagoons and bays on the northeast side of Richards Island during the ice-free period. They congregate nearshore in winter and spawn in brackish bays and river mouths in spring (Percy 1975). Fishing for herring in the bay has been important to people of Tuktoyaktuk. Saffron cod are also found in brackish water (Stein 1976).

It may appear that the life histories and movements of fish species in the Delta and Mackenzie River are relatively well understood. However, it must be remembered that the distribution of known areas of importance to fish in this drainage corresponds very closely with the geographical distribution of the research and inventory effort. Stein (pers. comm.) stated "we don't even know that we have identified the secondary drainages of major importance to fish, and we know relatively little about populations using the Mackenzie Delta."

4. Social and Cultural Values:

a. Land disposition: Most of the Mackenzie Delta is considered to be "unoccupied crown land" even though the area has been used by aboriginal people since the retreat of the Laurentide ice sheet. The towns of Inuvik and Aklavik were both established in the modern Delta (Figure 72). The Mackenzie Reindeer Grazing Preserve, established in 1933, borders the Delta on the east, as does the proposed National Wildlife Area at the Campbell Hills. The Mackenzie Delta Beaver Sanctuary was in effect from 1940 to 1958 (Wolforth 1971). North of Inuvik are the Middle Mackenzie Delta proposed International Biological Program Site and the Caribou Hills Site. The areas have been chosen because the steep westerly eroding slope of the Caribou Hills and the warming effect of the Mackenzie River have allowed the development of an interesting plant community. Bordering East Channel is the Southern Mackenzie Delta proposed International Biological Program site. This area of the Delta is noted for its muskrat and beaver populations (Beckel 1975).

The Kendall Island Migratory Bird Sanctuary was established in 1961, primarily to protect its small colony of lesser snow geese (Figure 71). Berger (1977) recommended that the sanctuary be extended to the west. He also suggested that a white whale sanctuary be proclaimed in Mackenzie Bay to protect white whales from disturbance in at least part of the estuary.

The federal government has recognized that aboriginal people who are not included in any of the treaties have special rights in areas they traditionally used. On October 31, 1978, the federal government and the Committee for Original People's Entitlement (who are acting on behalf

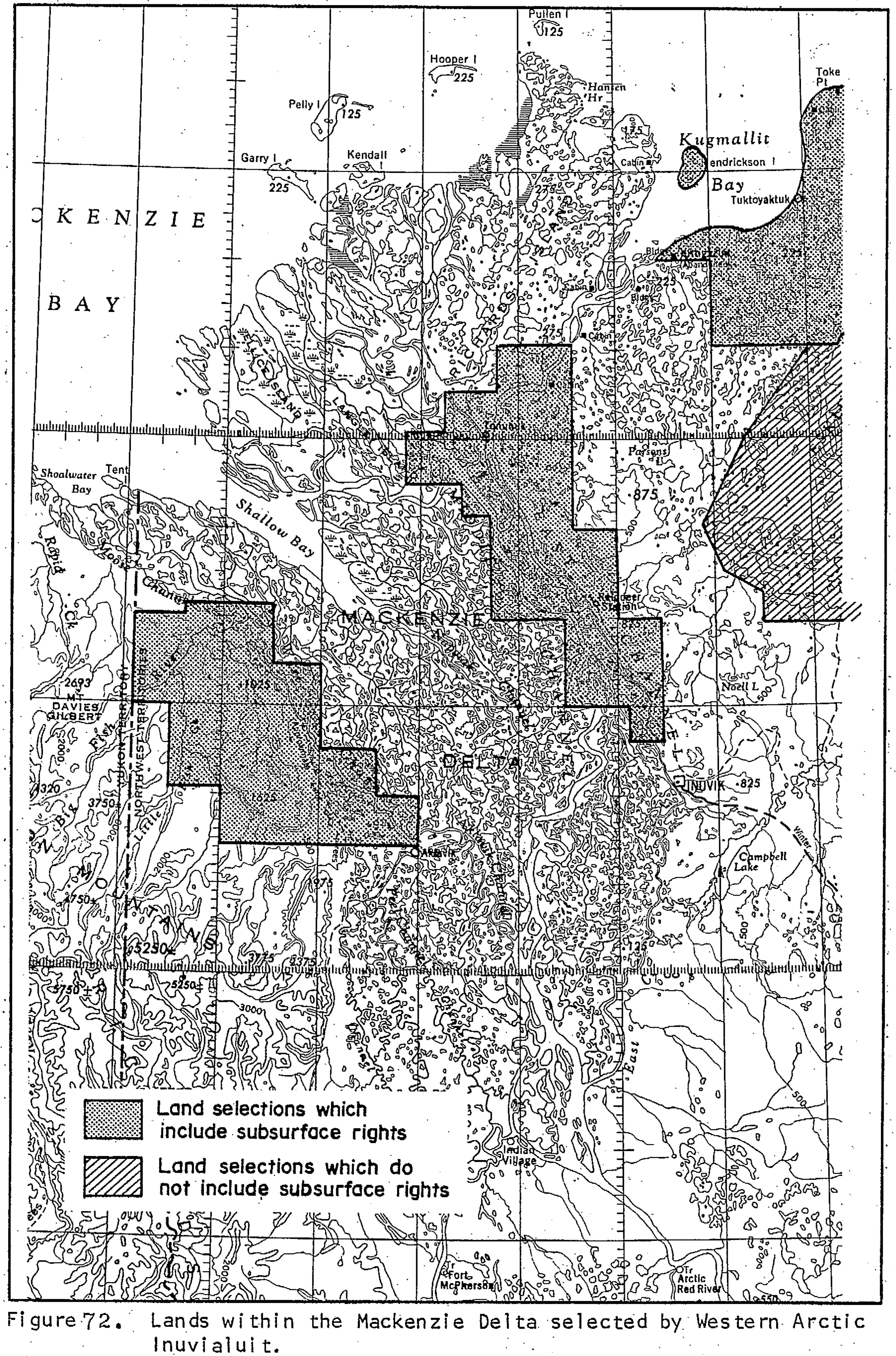

Figure 72. Lands within the Mackenzie Delta selected by Western Arctic Inuvialuit.

of the Inuvialuit - Inuit of the Western Arctic) signed an Agreement in Principle on the Inuvialuit Land Rights claim. The paper is to form the basis for settlement legislation between the government and the Inuvialuit.

The settlement provides the Inuvialuit with 12 950 km^2 of land under fee simple absolute title which includes all minerals whether solid, liquid or gaseous and all granular materials. Part of this land is to be in a block of 1813 km^2 in the vicinity of each community. Each of the communities has made a tentative selection. The selections of Aklavik and Inuvik have each included parts of the Delta. Tuktoyaktuk's land approaches the modern Delta (Figure 72). In the event of major oil developments in the Delta area, a new community north of Aklavik may be established. It will have 1554 km^2 of land including subsurface rights and the holdings of other communities will be decreased accordingly.

In addition, the Inuvialuit will have fee simple absolute title less minerals to a further 82 880 km^2 of land which remain to be selected from traditional lands of the Inuvialuit. Selections made to date do not include the modern Delta (Figure 72). It must also be remembered that the Kutchin of Fort McPherson and Arctic Red River are also making a land claim which may include parts of the Delta.

b. Archaeology: Historical and archaeological records place the cultural boundary between Dene and Inuit just within the upper Delta. The Delta Inuit are better known prehistorically than the Delta Athapaskan (Gordon 1972).

The Mackenzie Eskimo were evidently riverine rather than sea-hunting people. They travelled well inland to hunt caribou, but also hunted beluga whale. The archaeological site on Moose Channel on the northwest of the Delta is early Thule or late Bernik (Gordon 1972).

Historically the Mackenzie Eskimo were decimated by disease and largely replaced by people of Alaskan origin. Prior to the development of the fur trade, areas around the Delta were used more intensively than the Delta itself. Fishing camps were established on the outer Delta. The vagaries of the fur trade controlled the ebb and flow of people in the Delta. By the 20th century, the Delta was the focus of the annual activities of most Kutchin and many Inuit. In 1947 the Delta was divided into individual registered trapping areas. These were abandoned in favour of group trapping areas in 1958-59 (Wolforth 1971), but some individuals continue to use "their" areas.

c. Land use: Usher (1976) traced the use of the Delta by Inuit of the western Arctic over the last 70 years. Inuit used very similar parts of the Delta since the 1920's when Alaskan Inuit began to use the area. Generally a line south of Inuvik and Aklavik is considered to mark the southern boundary of Inuit interest (Figure 73) although there is considerable overlap with lands used by the Dene.

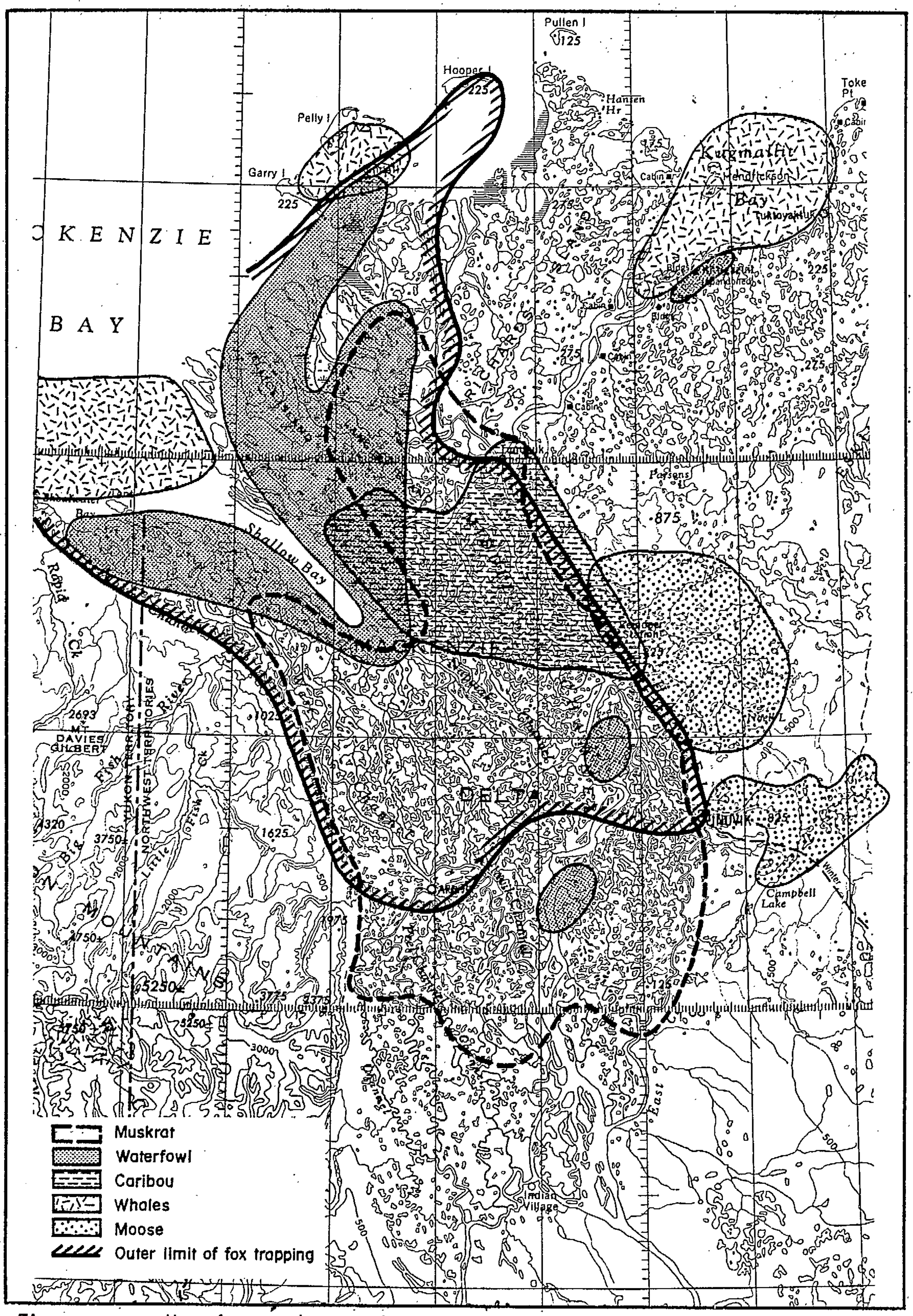

Figure 73. Hunting and trapping areas of Western Arctic Inuvialuit within the Mackenzie Delta.

Muskrat trapping and hunting after break-up is a very important aspect of the Delta economy. Probably all lakes and many channels in the upper and middle Delta have been exploited for muskrat. Geese are sought particularly along the northwestern shores of the Delta in fall. Whale hunting in July continues to be an important annual event in the Delta. Hunting camps are located at West Whitefish, on Moose Channel, Kendall Island, Tuktoyaktuk and other sites in Kidluit Bay (Figure 74). Activities at the whaling camp include the whole family. Fishing nets are tended when whales are unavailable.

Domestic fishing in the Delta is timed to take advantage of migration runs and concentrations of fish. Gill nets are the preferred method of catching fish, although jigging is an effective way to catch burbot in mid-winter. Species of major importance to the domestic fishery include broad and humpback whitefish, cisco and inconnu; northern pike, arctic char, herring, burbot and suckers are also taken (Withler 1975). Catches are usually dried, smoked or frozen for later use. Small commercial whitefish fisheries have operated at Holmes Creek and on East Channel near Inuvik on an "on-again, off-again" basis. They are currently not operating because the local market is not large enough, and transportation costs are prohibitive (Peet pers. comm.). Usher (1976) stated that with the development of the settlements, there was a temporary abandoning of some of the land

Figure 74. Whaling camp on the Mackenzie Delta:
Drying muktuk, Mackenzie Delta

L. Allison, July 1975

area traditionally used. However, widespread use of the snowmobile allows the Inuit "to cover their traditional hunting areas as effectively from the one settlement as they did many years ago from various camps." (Usher 1976).

5. Sensitivity: Any hydro development on the Mackenzie River will occur above the Delta. This would probably lower flows reaching the Delta or affect their seasonal distribution. Experts on various aspects of delta ecology are not always able to predict the effects of even relatively minor fluctuations in water level on the delta environments, as we saw in chapter III C. Much of the research and most of the concern for the environment of the Mackenzie Delta has been geared toward an understanding of the effect of oil and gas development.

However, some of the work does apply to hydro development and its effects on the Mackenzie Delta and estuary. First, a caution: deltas are among the most complex active environments in the world because of the interaction of riverine, terrestrial and marine factors. In the Mackenzie Delta, the effects of an arctic environment must be included: this combination of interacting forces is little understood when influenced only by natural events. Disruption of these natural events could result in widespread and unforeseen change. Effects of changes in Mackenzie River flow would not be restricted to the Delta. They would extend into the Beaufort Sea which Grainger (1974) regarded as a sump to the Mackenzie River. The most important changes in the river which could influence the Beaufort Sea are changes in the river flow or the composition of river water.

The Environmental-Social Committee (1974) warned that organisms in the Delta channels can tolerate high silt levels during spring floods, but that effects of silt in winter are unknown. Overwintering areas for most fish species in the entire system are critical and severely limited.

Grainger (1975) emphasized some subtle influences of the Mackenzie River on the Beaufort Sea:

> The two layered estuarine structure of the southern Beaufort Sea is expected to encourage rapid spread of pollutants through the system whether originating at offshore, onshore, terrestrial or river locations. Much of the character of the system is determined by river influences, so much so that quantitative changes in the river will be expected to alter the biological composition of the southern Beaufort Sea. Even temporary elimination of the plume would wipe out estuarine flora and fauna. Qualitative changes would also be expected, and pollutants from the river would quickly spread at least to the limit of the plume.

Gill (1976) discussed specifically the effects which hydroelectric developments upstream of the Delta might have on the natural functioning of this system. The following description paraphrases his paper.

Northern rivers are generally characterized by a variable annual runoff and the Delta has evolved in response to this variation. Impoundments of water are built to regulate the flow and therefore alter the annual flow - generally reducing the spring flood with serious implications to downstream alluvial environments.

Since the early series in the successional sequence are most productive, and depression or removal of the spring flood seriously limits deposition of alluvium and erosion of mature sites, the effect is to reduce the overall productivity of the area.

Further, without the annual flood, the river is unable to create the disturbance required for "biological renewal". The value of alluvial habitats to waterfowl diminishes with the elimination of the first spring flood. (Work on the Peace-Athabasca Delta suggests that elimination of spring floods may temporarily actually improve waterfowl habitat, but the effect is short-term. Stable water levels and exposed mudflats provide secure habitat until different plant species invade the area.)

Beaver and muskrat, too, would be adversely affected. Their habitat would be degraded by declining water levels and the replacement of successional communities they depend on.

Several fish populations in the Delta could be adversely affected by upstream impoundments. Northern pike invade many high Delta lakes to spawn during floods. Their fry follow small drainage channels out of these lakes in summer. Reduction of the spring flood would eliminate many lakes as spawning areas for pike as they would be inaccessible.

Adults of fall spawning species would not be as severely affected, but their spawning areas may be limited or their fry suffer from winter kill when water levels decline (Gill 1976).

Gill outlined only some of the changes to be expected in the Delta from lower water levels. Colder water temperatures below a dam could result in a later break-up, with consequent effects on local climate; a reduced rush of warm water in spring may result in restriction or elimination of white whale habitats in the Delta. The possibilities of other change in the Delta from elimination or redistribution of sediment deposition and changes in other phenomenae are almost innumerable.

6. Knowledge Gaps: Although the Mackenzie Delta has been the subject of many scientific investigations, the complex delta environment is not well understood. Predictions of some of the kinds of changes which would accompany manipulations of the natural hydrologic regime can be made. However, a more sophisticated response to a specific proposal would require extensive work.

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CHAPTER VIII

RELATIONSHIP OF BIOLOGICAL RESOURCES TO HYDROLOGIC REGIME

This chapter presents a general discussion of the dependence of biological resources on hydrologic regime in the Mackenzie River basin. It is intended to point out the magnitude and variety of some of the possible consequences of alterations in flow regime. It is not intended to discuss the impacts of specific developments on biological resources but rather to point out the sensitivity of these resources in relation to the regime.

In general, natural flows are disrupted by dams or diversions which form reservoirs and which force the flow below the impoundments to follow a demand pattern. Alterations to the environment follow from:

1) evening out of the flow over the year. Spring and summer flows are often smaller than normal; fall and winter flows are higher.
2) decline of flow,
3) blockage of flow,
4) changes in current and discharge rate,
5) changes in temperature, and
6) changes in stream gradient.

Gill (1973) suggested that the mesoclimate of the Mackenzie Delta could be changed by variations in annual flow patterns. The Mackenzie Delta is warmer than any other area in North America at that latitude. Ice in the Mackenzie Delta is lifted, broken and flushed out toward the ocean by the spring flood, and the warm sunny days which often follow result in rapid warming of the area. Ice could stay on the Delta for several weeks longer if the lower Mackenzie River were regulated. A hydroelectric project, with higher than normal flows prior to freeze-up might partly compensate for this change by delaying freeze-up. Such compensation would not occur if water was diverted from the system (Gill 1973).

Reduction in water level and depth of lakes could allow increases in the rate of permafrost aggradation.

Permafrost may also invade spruce forests which develop on floodplains. Active silting on floodplains discourages the growth of mosses. Alluvium is drier and warmer and allows deeper root penetration than soils with a heavier organic content which are covered with an insulating layer of moss. A reduction in flooding would reduce deposits of alluvium and facilitate this kind of change (Gill 1973).

Changes in hydrologic regime affect many species of animals. Fish populations will be adversely affected if spawning runs are blocked. If the block is permanent, whole populations could be totally eliminated; a partial block could result in severely reduced populations. Spawning below the obstruction may be limited by unsuitable habitat or overcrowding (Dryden and Stein 1975). Such effects could be particularly serious in the Mackenzie drainage where some species travel hundreds of miles on spawning migrations.

Siltation can also affect fish populations by covering spawning beds or affecting fish movements. Effects of siltation will be temporary if the annual freshet can remove accumulated silt and if the project does not result in continued deposition of silt. All instream construction results in siltation. Exposure of ice-rich slopes prior to construction may result in heavy siltation from mass wasting (Dryden and Stein 1975).

Dryden and Stein (1975) noted that fish are susceptible to injury when passing through culverts or fish ladders. Many spawners are in poor condition and increased stresses could lead to death.

Declines in river flows or a poor flow regime could destroy spawn by freezing or dessication. Tributaries of the main stream could become inaccessible to spawning fish (Glazier 1971). Stein and Chang-Kue (pers. comm.) stated that several arctic grayling spawning areas are trickles above the level of the main stem of the Mackenzie River much of the year. However, during spawning runs, flood-level water allows the grayling to enter and leave these small systems.

Water level, water quality and heat budget, even of large bodies of water such as Lake Athabasca and Great Slave

Lake are influenced by river inflow. Reductions in volume of inflow will significantly alter limnological conditions - including length of winter ice cover (Glazier 1971).

River bottoms are important winter habitat for moose, deer and elk. They are avenues of continuous waterfowl habitat, often providing open water early in spring. Changes in the hydrologic regime of rivers affect mammals and birds as well as fish.

Deltas are generally the parts of watersheds which support the most productive and diverse flora and fauna. The Mackenzie basin includes 3 large deltas; the Mackenzie, the Peace-Athabasca and the Slave, which could be or have been affected by changes in natural flows. Reduction in the flooding of any of these deltas would result in a net trend in plant succession toward a stable and less productive ecosystem dominated by black spruce (Stevens 1971).

Both muskrat and beaver are negatively affected by abnormal fluctuations in water level. Particularly after freeze-up, either raising or lowering water levels results in widespread mortality. Reduction or elimination of floods in delta basins reduces the available habitat for both species. as plant succession proceeds, the removal of mudflats and early successional areas reduces the appeal of an area to migrating waterfowl (Stevens 1971).

White whales apparently require the warm water of the Mackenzie River plume for calving. If the temperature, timing or extent of the warm water is changed, the entire western Arctic population could be lost (Sergeant 1976).

The northern deltas described here cover an area of only 1 456 000 km^2, and represent breeding areas for 1 000 000 to 2 000 000 ducks and 675 000 geese (Stevens 1971), plus staging areas for many more. In addition they provide assured wetland habitat during years of drought on the Canadian prairie. Much of that habitat could be destroyed by river development.

River channels are structured by "periods of peak flows of high frequency", that is, by floods. Along the length of a river the dynamic interaction of flooding and sedimentation is reflected in the successional sequence of plants bordering the bank. Northern floodplains exhibit a high primary productivity as a direct consequence of the constant destruction of older areas and deposition of new alluvium (Gill 1973, Stevens 1971).

Early successional stages are important winter feeding areas for ungulates and snowshoe hares. Hares may move into such areas from as far as 8 km away. Open sandbars and mudflats are used by waterfowl, which are protected from predators by the lack of vegetation.

When rivers are regulated the annual flood is dampened and plant succession proceeds rapidly, with a net decrease in both the diversity and productivity of wildlife habitat unless some other factor such as fire is also influencing the system (Stevens 1971, Gill 1973).

Dickinson (1978) discussed our general inability to come to grips with the effects of regime alterations on biotic resources. Some of her comments are discussed in chapter VI B.

Dams and other modifications of the hydrological regime can have severe effects on archaeological resources and are usually anticipated to be more devastating than oil and gas development. The damage is restricted to actual construction sites and areas which are flooded or subject to wave action. Damage is particularly severe because aboriginal occupation was often along banks of rivers and shores of lakes (Wilmeth 1973).

Each of the earlier chapters in this report discusses the importance of an area to the indigenous people, usually in terms of their use of the land for hunting, fishing and trapping. No dollar values have been assigned to these areas when used for pursuits which form part of the "traditional economy"; losses as a result of changes in hydrologic regime can not be deduced from this review. Various techniques have been devised for imputing the value of such resources and the methodologies used are the subject of considerable academic debate (Usher 1978a, 1978b; Stabler 1977). The important consideration to keep in mind is that standard economic techniques almost inevitably undervalue such resources because they operate over a period of only

15 to 20 years, while the wildlife and fishery resources, properly managed, will be available indefinitely.

Measuring the magnitude of the loss of certain resources to the local and regional economies if changes in hydrological regime are anticipated is not within the terms of reference of this report. We simply mention that it is a complex issue and that the data now available throughout the study area, with the possible exception of the northern part of the Mackenzie Delta, are unquantified and unquantifiable.

Major research efforts on this subject would be required prior to any hydro development being anticipated and would require the active involvement and co-operation of the people concerned.

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