PRELIMINARY ENVIRONMENTAL EVALUATION

FOR

WINTER ACCESS ROAD

CADILLAC EXPLORATIONS LIMITED
PRAIRIE CREEK PROJECT, N.W.T.

FILE NO. 1561
MAY 1980

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KER, PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA BURNABY ABBOTSFORD PORT HARDY

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1. SUMMARY

The proposed development of the Prairie Creek property of Cadillac Explorations Limited, will encompass an underground mine development program (currently underway), expansion of the existing camp, construction of a flotation mill, and the establishment of a 100-mile winter road from the property to the Liard Highway. It is the last item which is the subject of this report, prepared in order to outline the project concept and the potential environmental impacts of the road to government officials and the general public.

The Cadillac property is located at approximately 61°33'N latitude and 124°48'W longitude, adjacent to Prairie Creek, 27 miles upstream from its confluence with the South Nahanni River. The proposed winter access route heads generally southeasterly from the mine, crossing in turn the eastern portion of the Mackenzie Mountains, the Mackenzie Plain, the Nahanni Mountains, and the western portion of the Interior Plateau prior to crossing the Liard River and joining up with the Liard Highway, about 20 miles northeast of Nahanni Butte. The viability of the route will be enhanced by the completion of the Liard Highway south to Fort Nelson from Fort Simpson, scheduled for 1982.

An alternate 180-mile long winter road connecting the mine with Fort Simpson via the Mackenzie Highway, has been utilized in the past for the transporation of equipment and supplies. Upgrading of this route has been studied, but it is not presently considered to be a feasible alternative in view of its length, construction problems, unsuitable grades and the environmental impact of following a large river system (the Ram) for much of its length.

Once constructed, the proposed road would be usable for approximately three months each year. It is during this period that large construction vehicles, mill equipment, and supplies would be transported to the site. Movement of material during the remainder of the year would be restricted to items which could be handled by small aircraft utilizing the existing 3000 foot gravel airstrip at the site.

Because the access road is to be constructed for winter use only, many of the environmental considerations relative to all-weather routes are not pertinent. For this road, no permanent bridges or culverts are proposed and water crossings are to be carried out on snow or ice bridges. Traffic will occur over frozen ground, hence organic deposits and vegetation should be minimally disturbed. Whenever possible, existing seismic lines or winter roads will be utilized.

The water courses traversed by the proposed route are contained within the South Nahanni, Liard or North Nahanni drainage basins. Fish of commercial or sporting significance in these systems include Arctic grayling, whitefish, northern pike, burbot, sucker, walleye, chum salmon, and Dolly Varden char.

However, the only streams of any size which are parallel or crossed by the proposed winter road are Prairie Creek at the western end and the Liard River at the eastern end. Smaller streams include Grainger River, Fishtrap Creek, and Tetcela River. Of these, only the Liard is considered to possess a high potential for fish utilization during open water periods. The others have moderate or low potential according to a brief survey carried out in April 1980.

No detailed studies of wildlife populations are known to have been carried out in the area of the proposed road corridor, although information is available from other nearby highway and pipeline projects. One hundred twenty-two avian species, 48 mammalian species, and 2 herptiles potentially inhabit the region; an additional species may be added to this list upon possible introduction of a wood bison herd in June 1980.

Birds in the area which are considered to be rare, endangered, or highly sensitive include the bald eagle and trumpeter swan. Of the mammals, 22 are exploited recreationally or commercially (6 ungulates and 16 furbearers). None of the mammals is considered to be rare or endangered, although some forms such as woodland caribou, Dall's sheep and grizzly bear are considered sensitive.

In the vicinity of Prairie Creek, a two-day surveillance (April, 1980) resulted in the direct or indirect observation of the following wildlife species: Dall's sheep, golden eagle, ptarmigan, moose, marten and squirrel. Infrequent sightings of wolverine, wolf, black bear and grizzly bear have also been reported by mine personnel. No evidence could be found of a herd of woodland caribou reported to have been seen in past years in an area midway between the mine and the South Nahanni River.

To the east of Prairie Creek, along the proposed road corridor, lesser evidence of wildlife was noted. Sightings over a two day period included golden eagles, beaver, swans, snow geese, mallard, one moose, and one black bear. Dall's sheep habitat is reported to exist along Grainger River Pass in the Nahanni Range but no animals were sighted.

Traplines are known to be in operation east of the Ram Plateau; species harvested include beaver, marten, mink, lynx, weasel, and wolverine.

The greatest potential for environmental degradation is considered to be during the construction phase of the project when care will have to be exercised with respect to clearing operations, deposition of slash and rock, vehicle movements off the proposed right-of-way, the stability of cuts and fills, drainage alterations, disturbance of organic soils and permafrost, and proper disposal of garbage. The only potentially toxic substance expected to be used during road construction would be diesel fuel. The handling, storage and transportation of this material will be carried out with due regard for its potential for damage to aquatic systems. All of these factors must be controlled in order to ensure a minimal impact on aquatic resources, wildlife, vegetation and soils along the route. The Proponent is committed to such action.

The major negative social impact of the road, as determined by interviews with citizens and government officials in these communities, was seen to be possible random settlement along or near the route and increased access to a wilderness area. The latter may be a negative impact with respect to the success of guides and trappers, but might be considered positive for the general population.

In summary, it can be stated that the proposed road will have minimal negative impact, both sociologically and environmentally. This is due to the construction to winter standards only, the few water-crossings of significance to be carried out, a limited utilization of the area by wildlife and fish, and the economic spin-offs from the project such as employment, further diversification of the economic base of nearby communities, and utilization of local supplies and services.

Studies relative to the mining development and the proposed winter road will continue with the further reporting of environmental data collected during the summer of 1980.

2. PROJECT RATIONALE

2.1 Introduction & Acknowledgements

Cadillac Explorations Limited propose to construct a 100-mile winter access road from the Liard River to the site of their exploration camp on Prairie Creek during 1980 (Fig. 1). The road is an essential feature of any decision to construct a mill for preparation of metal concentrates from the Prairie Creek orebody.

This report represents the preliminary phase of an environmental evaluation which will carry on through 1980. It has been prepared for the purpose of outlining to government agencies the project concept, the present state of the environment and methods for mitigating any negative effects of the development. A companion document is currently under preparation which will outline, in a similar way, information relative to the mine, mill and camp. These reports will be followed by a complete Initial Environmental Evaluation (I.E.E.) that will bring together all relevant desk studies, spring and summer field work, and concerns of government agencies arising from the preliminary reports.

Several consultants have participated in the preparation of this report. Golder Associates advised on geotechnical and road construction matters. Environmental input relative to vegetation, aquatics, wildlife, terrain and socio-economics originated with Beak Consultants Ltd. Ker, Priestman & Associates Ltd. acted as project manager for the environmental work and, in addition, carried out the hydrology and climate analysis.

Use has also been made of reports on the project prepared by other consultants. Noteworthy among these are the preliminary engineering feasibility study by Kilborn Engineering Ltd. in association with H. Brodie Hicks, P. Eng., and the study by Watts, Griffis and McOuat concerning the feasibility of alternate access routes; the text of the latter forms Appendix D of this report.

A list of the consultants mentioned above is provided in Appendix A.

This report was commissioned by Cadillac Explorations Limited, who assume responsibility for the statements contained herein:

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2.2 The Need

Year-round access to the Cadillac property (61°33'N, 124°48'W) is currently provided by air transportation from Fort Nelson, B. C., Fort Simpson, or Yellowknife, to a 3000 ft. gravel airstrip located approximately one-half mile north of the mine camp, alongside Prairie Creek.

A 180-mile winter road (hereinafter called the 'original' winter road) which follows a route northeasterly from the mine to Fort Simpson has been utilized in the past for the transportation of equipment and fuel. This road joins up with the Mackenzie Highway at the crossing of the Mackenzie River, 43 miles northwest of Fort Simpson (Fig. 1.).

An alternate, more southerly, route is made possible by the new Liard Highway which now extends south along the Liard River from Fort Simpson almost as far as Nahanni Butte. Ultimately this highway is to be completed to Fort Liard and beyond, to Fort Nelson. Planning is underway for the construction of a 100-mile winter road from the mine to the Liard River to join up with the Liard Highway. This winter road is the subject of this report (Fig. 1, 2 & 3).

The proposed new winter road will commence (at the eastern end) from the Liard River approximately 20 miles northeast of Nahanni Butte, pass through the Nahanni Mountain Range by way of the Grainger River Pass, cross the headwaters of the Tetcela and Sundog Waterways and traverse the Tundra Ridge of the Mackenzie Mountains to Prairie Creek.

Road access to the property is an essential requirement if development of the mine is to proceed because the short length of the existing airstrip and its confined approaches preclude its use by the large aircraft which would be required for transportation of large construction and milling equipment.

The new winter road is expected to be open for 100 days a year between the end of December and the end of March. During the remaining nine months of the year, access will be by light aircraft to the Prairie Creek Airstrip for transport of personnel and small quantities of supplies.

During the plant construction phase of the project, scheduling will be arranged for the shipment of all major equipment and much of the bulk construction materials during the first three months of 1981. With the closure of the winter road in the spring of 1981, materials which cannot be air-freighted will have to be left for transport by truck in 1982.

Production is scheduled for the late fall of 1981. It is currently envisaged to ship lead and zinc concentrates in trucks during the three months that the winter road is open. Trucks would be utilized for back-hauling supplies to the mine. Copper concentrate is to be flown from the site.

2.3 Alternatives

The two alternatives (discussed above) for road access to the Prairie Creek property are:

1) a new more southerly, 100-mile winter road to the Liard River
2) the original 180-mile winter road to Fort Simpson via the Mackenzie River,up-graded as required.

Alternative #1 is considered to be the only feasible approach.

Although it is expected that concentrates from the mine will be transported to market via rail from Fort Nelson, B.C. (assuming that the Liard Highway is extended to this point by 1982 as scheduled), the possibility remains that the rail link to the east at Enterprise will be utilized. The southern alternative allows choice of either option with shorter haul distances.

Past use of alternative #2, the original winter route, reveals the presence of poor grades and narrow valleys with considerable risk of washouts in a number of locations. In addition, the northern route follows the Ram River over much of its length, which might raise environmental concerns.

Construction of the winter road is expected to result in minimal damage to the environment if proper design and good construction practices are followed. For this reason, and because the road is necessary for the development of the property no consideration has been given to other alternative methods of access.

2.4 Associated Projects

The Cadillac project and the proposed winter road stand by themselves in terms of any other known projects which might benefit from improved access. Although no mining or other potential resource developments have been identified, it is expected that there will be increased exploration in the area resulting from successful activities at Cadillac. In addition, the orebody considered for production by Cadillac represents only one of a series of zones potentially exploitable and it is conceivable that development of these will follow in due course.

Nevertheless, it must be appreciated that the winter road will not be providing new access but rather improved access since both the winter road via the Mackenzie and the Prairie Creek airstrip have been in place for a number of years.

In order to provide a convenient link with large aircraft for both construction and supply purposes, consideration has been given to construction of an airstrip near the eastern terminus of the winter road. Alternatively, the existing strips at Fort Simpson or Fort Liard could be utilized at the expense of longer road travel. These options are presently being evaluated and will be subject to further discussion between the proponent, the consultants and government agencies.

3. PROJECT DESCRIPTION

3.1 Introduction

Golder Geotechnical Consultants Ltd. were retained to undertake a preliminary study of the proposed southern winter road to the property with respect to route alignment, geotechnical considerations and construction practices. Section 3 of this report represents their assessment.

The general locations of the mine, the original winter access route and the proposed new winter access route are shown on Figure 1.

The route alignment, as shown at a larger scale (Fig. 2 & 3), was selected on the basis of low level air reconnaissance of the area and on office studies of available air photographs (scale approximately 1:60,000) and topographic maps (scale 1:50,000).

3.2 Criteria for Route Selection

The following major criteria were used as guidelines for route selection:

a) It is understood that mine access requirements can be met by a winter road.

b) Construction of the roadway in difficult terrain to allow for only one-way traffic will be adequate.

c) Maximum grades should not exceed 8 per cent (8%) in steepness.

d) Final alignment and construction should be such that cuts and fills are minimized.

e) South aspect slopes should be used where possible to minimize the effects of excavation in permafrost.

f) Roadway construction in areas where disturbance can lead to degradation of permafrost and consequent ground subsidence should be minimized.

g) No permanent stream or river crossings are to be constructed.

h) Existing seismic lines and/or winter roads are to be used where possible.

3.3 Route Alignment

The recommended route alignments are shown on Figures 2 & 3 with minor variations. The alignments were chosen on the basis of a low-level air reconnaissance of the area and office studies of available air photos and topographic maps. The alignments on the figures are annotated with approximate mileages. Stream crossing locations and sections where travel will be done over frozen stream courses during the winter months are also shown on these figures.

The exact alignment of the proposed winter road east of the Nahanni Range has not been determined, but it will follow existing winter roads and/or seismic lines to the Liard River. An existing winter road constructed for access to an airstrip (now abandoned) at Grainger Pass might be partially utilized. This portion of the route is not shown on the appended drawings. The air reconnaissance indicated that there would be few if any problems with respect to either construction or maintenance of this section of the route.

Table 1 is a summarization of route mileages, grades and general comments for the selected and alternate routes. Table 2 is a summarization of route percentages for various grade intervals and Table 3 presents the major comparative points between the alternatives presented.

3.4 Pre-Construction Details

No pre-construction work such as ground surveys, geotechnical investigation or line clearing has been undertaken.

3.5 Construction Details

The proposed access between the Cadillac Mine and the Liard River is to be a winter road and as such will be limited with respect to construction effort; if done properly, it will have a minimal impact on the physical environment. The following paragraphs provide brief descriptions of each section of the proposed alignment.

0.0 5.9 km

a) Mile 0.0 to Mile 3.7 (approximately)

Most of the route between Mile 0.0 and 3.7 approximately, can be constructed on the Prairie Creek floodplain with the exception of the portion between Mile 1.9 and 2.4 approximately, in which excavation into the valley wall will be required unless travel on the river ice over this section is acceptable. Annual maintenance to repair damage due to wash-outs during spring or other heavy run-off periods will probably be required along some portions of this section of the route.

5.9 16.0 Km

b) Mile 3.7 to Mile 10.0 (approximately)

The south facing valley wall between approximately Mile 4.0 and 4.6 is being actively undercut by stream erosion. Consequently, construction of a roadway on the north side of the stream in this section is considered inadvisable. Experience in the area with cuts made in north facing slopes indicates that permafrost degradation after excavation is quite rapid and the resulting stability problems difficult to overcome. Hence, between Mile 4.0 and 4.6 approximately, travel over ice in the water course will be necessary.

Cuts into rock, weathered rock or overburden can begin on the south facing valley wall at approximately Mile 4.6 and continue to approximately Mile 10.0. Mine experience indicates that ground ice in the south facing slopes in the area is not generally sufficient to cause excessive degradation and/or stability problems.
The section of the route between Mile 4.6 and 10.0 can be largely one lane in width to minimize excavation.

Some maintenance due to occasional snow avalanche damage and/or small stability failures along this portion of the route should be anticipated.

16.0 33.4

c) Mile 10.0 to Mile 20.9 (approximately)

Winter road construction can be undertaken on the south facing valley wall of either the 'South' or 'North' Stream valleys. The north alternative is slightly more favourable in terms of its gradient which averages approximately 3.7 per cent as compared to approximately 4.0 per cent in the 'South' Stream valley. However, the north alternative involves five small stream crossings as compared to one stream crossing for the 'South' alternative. Excavations for the roadway cuts in either case would be principally weathered rock or overburden except in the vicinity of the falls along the 'South' Stream and a small rock escarpment in the 'North' Stream valley where some rock work would probably be necessary.

Some maintenance to repair spring or storm wash-out and/or snow avalanche damage should be anticipated.

33.4 37.44

d) Mile 20.9 to Mile 23.4 (approximately)

Between Miles 20.9 and 23.4 approximately, the proposed route is on the floodplain of the Sundog Creek tributary. No difficulties with respect to construction of this portion of the route are anticipated. However, annual maintenance due to wash-outs will almost certainly be required.

37.4 86.4

e) Mile 23.4 to Mile 54.0 (approximately)

Km 37.4

At approximately Mile 23.4 the proposed route enters a small stream valley and ascends to the Ram Plateau. There are numerous stream crossings along this portion of the route, but no serious difficulties with respect to construction are anticipated. However, there are several areas which appear to be predominantly muskeg, and it is suggested that construction in these areas be carried out after freeze-up.

Annual maintenance in preparation for winter travel may be required over muskeg areas.

86.4 88.3

f) Mile 54.0 to Mile 55.2 (approximately)

The terrain between Mile 54.0 and 55.2 approximately, along the southern alternate is muskeg and road construction should be carried out over this stretch of the route during the winter season to avoid unnecessary physical and environmental damage. The northern alternate at this location crosses similar terrain between Miles 54N and 55.6N approximately.

Annual maintenance in preparation for travel over the muskeg may be required.

88.3 94.4

g) Mile 55.2 to Mile 59.0 (approximately)

The section of the proposed roadway between Miles 55.2 and 59.0 approximately, involves the ascent to, and passage through, the Silent Hills Pass. Construction will involve cutting into overburden and possibly some weathered rock along this section of the route for both the north and south alternatives.

Little if any maintenance need be anticipated for this portion of the route.

94.4 112.

h) Mile 59.0 to Mile 70.0 (approximately)

The proposed route alignment between Miles 59.0 and 70.0 approximately, crosses what is probably the remains of a glacial lake basin which likely consists of highly frost-susceptible soils, particularly between Miles 59.0 and 63.0, approximately. Depending upon closer examination in the field, it may be prudent to reserve this four-mile section of the route for winter construction. Most of the remainder of this section of the proposed route is on relatively gentle slopes on the west side of the Nahanni Range.

Annual preparation may be necessary along some sections where lake basin soils predominate. Little, if any, maintenance requirement is envisaged for those portions of the road on the low mountain slope.

112 115.2

i) Mile 70.0 to Mile 72.0 (approximately)

The proposed route follows the Grainger River Pass through the Nahanni Range between Miles 70.0 and 72.0. The proposed route can be placed on the Grainger River floodplain gravels along this section. On the basis of field observation it is possible that occasional maintenance due to wash-outs may be required.

115.2 156.8

j) Mile 72.0 to Mile 98.0 (approximately)

After leaving the Grainger River Pass the proposed route alignment crosses nearly flat ground to the Liard River. Some of the area traversed may be swampy during part of the summer in this area, but there does not appear to be a significant amount of muskeg. The proposed route alignment will follow existing winter road construction and/or seismic lines wherever possible. For example, a winter road constructed in past years to provide access to an airstrip (now abandoned) at Grainger Pass could be partially utilized. This section of the alignment is not shown on Figures 2 and 3.

Annual preparation of some portions of this section of the route may be necessary before travel is permitted. The soils are probably dominantly glacial lake basin deposits, which may be frost susceptible. Hence, construction or upgrading of the existing winter roads or seismic lines may be best done after freeze-up.

3.6 General Comments Regarding Construction

Approximately 23 miles of the proposed route will involve cut and/or fill construction. As a general rule, in the interests of stability, the roadway should not be placed on sidehill fills if the natural gradient tranverse to the roadway alignment is in excess of approximately 3 horizontal to 1 vertical. Fill slopes, where they are used, should be no steeper than 2 horizontal to 1 vertical transverse to the roadway. In areas where the excavated materials contain excess water or ice these criteria will, of necessity, be made more conservative.

Measures must be taken to assure that rain and melt water have access to the downslope side of the roadway so that stability of cuts and fills is not reduced by build-ups of pore water pressures due to ponding of water on the road surface or at the toes of road cut back slopes.

Roadway construction over muskeg areas or areas which are underlain by highly frost susceptible soils should be undertaken during the winter season after freeze-up so that the risks of environmental damage due to roadway construction are minimized.

3.7 Abandonment

It is expected that abandonment of the winter road will not take place for many years. At such a time, the matter will be reviewed with appropriate government bodies so that the abandonment is carried out consistent with regulations and good environmental practices.

4. EXISTING ENVIRONMENT

4.1 Climate

4.1.1 General

The area of the mine site and the winter road route is characterized by a continental climate pattern with a very low mean daily temperature.

The temperature changes associated with the beginning and end of the summer season (June - August) are typically rather abrupt. Precipitation is low, with the annual peak occuring in July.

The temperature sequence during the melt period can be a dominant influence on the production of major spring floods.

4.1.2. Records

Long-term temperature and precipitation records are available from the Atmospheric Environment Service for several centres including Fort Simpson, Wrigley, Watson Lake and Fort Nelson. These stations and others within the area are listed in Table 4 and their locations are shown on Figure 4.

Snow cover data has also been recorded at various locations since the early 1960's.

Rainfall data and the Intensity-Duration-Frequency curves are only available for Watson Lake, Fort Simpson and Fort Nelson, and are based on 8 to 11 years of records.

The Atmospheric Environment Service recorded weather at Cadillac Minesite for approximately one year in 1970. Other data has been recorded sporadically since that time.

Evaporation data is very limited.

At the time of writing this report, the long-term abstracts, for all stations except Watson Lake, and the snow cover data were not available.

4.1.3 Temperature

The monthly and annual mean temperatures for the Cadillac Minesite and proposed access road route for the 30 year period 1931 - 1960, have been taken from Department of Transport climate maps and are given in Table 5. The mean annual temperature for this location is 23^{o}F (-5^{o}C). The minimum monthly temperature of -15^{o}F (-26.1^{o}C) occurs in January and the maximum monthly temperature of 58^{o}F (14.4^{o}C) occurs in July.

4.1.4 Precipitation

The monthly and mean annual precipitation for the Study Area has also been taken from Department of Transport mapping, as shown on Table 5. The mean annual precipitation is 16 inches. About 2 inches/month falls during the summer and the annual low of 0.7 inches/month occurs in April.

The climate summary for Watson Lake (Table 5) gives values similar to those obtained from the Climate Maps with a ratio of rain to total precipitation of about .50.

Intensity-duration-frequency rainfall curves for Fort Simpson, Fort Nelson and Watson Lake are reproduced in Figures 5, 6 & 7. The curves for Fort Simpson and Fort Nelson are considered to be more representative of the conditions in the Study Area, in terms of their positions relative to the MacKenzie Mountains.

4.1.5 Evaporation

Mean monthly and annual evaporation for the area is given in Table 5. Again, Climate Mapping was utilized. The maps provide average rates of evaporation from small, natural, open water bodies having negligible heat storage. It is considered that these values could vary ± 25% in any given year.

Evaporation from snow and ice, although small, can represent a significant portion of annual evaporation. However, data for evaporation from snow and ice is not available.

4.2 Hydrology

4.2.1 General

The Cadillac mine is located on Prairie Creek, a tributary of the South Nahanni River. The winter access road route crosses several creeks and rivers (or their tributaries) including Sundog Creek, Tetcela River and Grainger River. There are also several overland sections of the route which are distant from any watercourses. A number of creek or river crossings including a crossing of the Liard River between Nahanni Butte and Fort Simpson will be required. However, since the crossings will utilize snow or ice bridges, construction of permanent bridges, culverts and fill crossings is not proposed.

Runoff shows a marked peak in June, decreasing through the summer and fall to a low in February and March. Groundwater storage would be low in winter due to frozen ground, hence extremely low winter flows occur. For Prairie Creek, the ratio of the June: March average flows is 73:1. The index hydrograph, Figure 8, for flows on Prairie Creek illustrates this seasonal fluctuation.

Periods of ice cover are indicated. Smaller creeks will have a more extreme variation and larger creeks, less extreme. Annual peak flows on the larger drainage basins such as Prairie Creek are usually due to spring snowmelt, but may also be due to widespread rain, whereas, the smaller creeks will produce flash floods as a result of localized thundershower activity.

4.2.2 Records

Published runoff data is available from the Water Survey of Canada. Additional data is being collected by the Water Resources Division of the Department of Indian & Northern Affairs, but no reference index is available at this time.

The relevant stream-gauging stations are listed in Table 6, with their locations shown on Figure 4.

Data from Station 10EC002 (Prairie Creek at Cadillac Mine), and Station 10EC001 (South Nahanni River near Hot Springs) is considered to be the most pertinent to this study.

Because of a shortage of data having a reasonable period of record for small basins (i.e. less than 50 sq.miles), runoff characteristics for small catchments are not known.

4.2.3 Mean Flows

Based on the Prairie Creek and South Nahanni River gauges, the long term water yield for the Study Area is 1.1 cfs per square mile. Mean annual flow in the South Nahanni River is 14900 cfs with a minimum monthly average of 2000 cfs and a maximum monthly average of 50500 cfs.

Mean annual flow in Prairie Creek is 204 cfs, with a minimum monthly average of 10 cfs and a maximum monthly average of 696 cfs, respectively.

The mean annual yield ratio is defined as equivalent inches of annual runoff divided by inches of total annual precipitation. For the Study Area it is equal to 0.9.

4.2.4 Peak Flows

Information presented in this section is based on streamflow records, discussions with J. N. Jasper (Hydrologist for Water Resources Division, Dept. of Indian & Northern Affairs, Yellowknife), and use of empirical calculations such as the Rational Method. The estimation of peak flows for small basins is very uncertain due to the unavailability of reliable data. A full investigation of the mechanics of runoff from small creeks is beyond the scope of this report.

A Gumbel plot was prepared from the recorded peak flows in Prairie Creek and the South Nahanni River (Fig. 9). These curves, extrapolated to a 100-year return period, provided estimates of peak flows as follows:

$Q_5 = 0.8\ Q_{10}$ where Q_5 = flood flow with 5 year return period
$Q_{25} = 1.3\ Q_{10}$
$Q_{50} = 1.5\ Q_{10}$ where Q_{10} = flood flow with 10 year return period, etc.
$Q_{100} = 1.7\ Q_{10}$

The unit peak flows (cfs/mi^2) for the two recording stations were plotted for the 10-year return period (Fig. 10). Instantaneous flows for typical small basins of 1 and 10 square mile catchment areas, calculated by the Rational Method, were also plotted on this graph.

The Rational Method gives estimates of peak flows by a formula relating rainfall intensity, runoff coefficient and drainage area. Rainfall intensity was determined from the Fort Nelson I-D-F curves for a 10-year return period, assuming a 50-minute time of concentration for the 1 mi^2 basin and 90-minute time of concentration for the 10 mi^2 basin:

1 mi^2 basin - rainfall intensity 30 mm/hr. (1.2 in./hr.)
10 mi^2 basin - rainfall intensity20 mm/hr. (0.8 in./hr.)

These times of concentration and corresponding rainfall intensities were based on estimates of overland and creek flow velocities at times of peak flow for typical basins in the Study Area.

Runoff coefficient (C) values of 0.3 and 0.5 were considered to be representative of ground conditions during peak rainfalls in the summer. The Suggested Design Curve (Fig. 10) has been drawn through C=0.3 because a value greater than this would likely only result from an infrequent combination of events (i.e. less frequently than once in 10 years).

Comparisons were also made with work done previously by others, including the Department of Indian & Nothern Affairs (1979) for the Tungsten, N.W.T. area.

Generally the Suggested Design Curve for the Cadillac Study Area is more conservative than the curves suggested for the Tungsten area. This may be reasonable based on geographical location but, in any case, a more detailed hydrological analysis would be required to give a more confident prediction of peak flows for small basins.

Design criteria for N.W.T. roads as outlined in the above-mentioned report are listed below:

Class of Road	Type of Use	Suggested Design Return Period (Years) Small Streams (culverts)	Larger or fish Streams (culverts or bridges)
1. Secondary	mine development	25	25 (50 for fish)
2. Access			
a) year round	private use	10-15	10-15 (50 for fish)
b) seasonal	winter roads, initial access, construction, private use	Cross streams on ice or pad of logs; as underdesigned culverts will ice up and wash out each spring.	

For fish passage requirements at culverts and other structures refer to design requirements specified by the Fisheries and Marine Service, Department of Fisheries and Oceans.

4.2.5 Minimum Flows

Minimum annual flows for South Nahanni River and Prairie Creek have been plotted on Gumbel paper (Fig. 11). From this, minimum unit flows for various return periods can be derived. Creeks draining less than 200 square miles (e.g. Prairie Creek) will apparently freeze completely during the 20 year return period low. The frequency at which a creek will freeze solid will increase as the creek drainage area decreases.

4.3 Aquatics

4.3.1 Fish

The watercourses traversed by the proposed route are contained within the South Nahanni, Liard or North Nahanni drainage basins (Table 7 and Fig. 12). Fish species reported in these drainage basins as well as the upper Mackenzie River are presented in Table 8.

Site-specific information is lacking for the fishery resources of watercourses crossed by the proposed alignment. Limited fishery investigations have been conducted at locations downstream of the proposed crossings on the Liard River, Grainger River, Prairie Creek and the "Mosquito Lakes" region (near Mile Post 40). There is no information or literature pertinent to the fish fauna of the remaining streams crossed by the proposed route.

The majority of the studies conducted on the Liard River to determine utilization by fish were associated with Mackenzie Valley Pipeline Studies (Hatfield et al. 1972a,b). These investigations were located near the mouth of the Liard River approximately 75 mi. downstream of the proposed crossing site. A list of fish species reported from the Liard River is presented in Table 8.

The Liard River is utilized as an overwintering area and a suspected spawning migration route for many fish species (Hatfield et al. 1972b, McCart et al. 1974). Longnose sucker, northern pike, yellow walleye, lake cisco and lake whitefish are reported to be the most common fish in the Liard River (Land Use Info. Ser. 95G, Hatfield et al. 1972a).

Approximately 6 mi. below the proposed crossing site, the Grainger River is reported to be utilized by Arctic grayling, northern pike, longnose dace and longnose sucker as a rearing area (Hatfield et al. 1972b). Longnose sucker are also reported to utilize the Grainger River as a nursery area (Land Use Info. Ser.95G). Beaver activity, downstream of the proposed crossing, may provide a barrier to upstream movement of fish into the crossing region (Hatfield et al. 1972b). Low water levels after mid-July may reduce the overwintering potential in the Grainger River. Hatfield et al. (1972b) roughly mapped the Grainger River and noted that gravel areas, which may provide suitable spawning habitat, exist up and downstream of the proposed crossing site. The crossing region was judged to consist primarily of slow water areas and pools.

Studies have recently been conducted in the "Mosquito Lakes" region and a list of fish species and their utilization of the lakes and streams in the immediate area may soon be available (R.D.Wickstrom, pers. comm.).

Prairie Creek, although not crossed by the proposed winter road, is closely paralleled from Mile Post 0 to 3.5. Dolly Varden char and whitefish sp. have been angled from the creek in this region (R.Fast, pers.comm.). Investigations conducted along the lower reaches of the stream within Nahanni Park resulted in the observation or capture of the following fishes:

> Arctic grayling, dolly Varden char, round whitefish, burbot, white sucker and slimy sculpin (R.D.Wickstrom, pers. comm., Scotter et al. 1971).

There is no literature available on the food habits of fish species found within the study area. Hatfield et al. (1972b) reported that invertebrates contribute significantly to the diet of the following prominent fish species: Arctic grayling, lake whitefish and burbot. White and longnose sucker are also expected to heavily utilize invertebrates as a food source. A list of important orders and families of invertebrates utilized by prominent fish species is included in Table 9.

4.3.2 Aquatic Invertebrates

Very little information is available on the benthic fauna of watercourses scheduled to be crossed by the proposed winter road. Some benthic invertebrate information has been gathered in conjunction with fisheries or water quality studies on the Liard River, Grainger River, "Mosquito Lakes" and Prairie Creek. These data, in general, refer to areas downstream of the proposed road crossing sites.

Brunskill *et al*. (1973) have reported that the following orders and families of aquatic invertebrates are found in the Liard River near the mouth: Trichoptera, Plecoptera, Ephemeroptera, Simulidae (Diptera) and Chironomidae (Diptera). Wiens *et al*. (1975) reported a more comprehensive and detailed list of aquatic invertebrates from various downstream sampling points on the Liard River (Table 10). As the benthic habitat of the Liard River is relatively similar throughout its lower reaches, many of the aquatic invertebrates reported by Wiens *et al*. (1975) may be expected in the region of the proposed crossing.

Trichoptera, Plecoptera and Ephemeroptera are reported to be present in the Grainger River at a study site approximately 6 miles below the proposed crossing (Hatfield *et al*. 1972b).

Relatively extensive work has been conducted on the benthic invertebrates in the "Mosquito Lakes" region (near Mile Post 40) and it is expected to be available in the near future (R.D. Wickstrom, pers. comm.).

The lower reaches of Prairie Creek (within Nahanni National Park) are reported to be utilized by the following aquatic invertebrates:

Gastropoda	Ephemeroptera
Lymnaeidae	Baetidae
Lymnaea spp.	*Baetis* sp.
Plecoptera	Diptera
	Chironomidae

4.3.3 Fish Habitat Survey

On April 17 and 18, 1980, BEAK conducted visual observations and water sampling of watercourses scheduled to be crossed by the proposed winter road. Although investigations were generally conducted at the site of the proposed crossings, a refinement of the route alignment following the field studies resulted in the investigation of several watercourses one to three miles up- or downstream of the actual crossing. These streams were assessed and categorized as having nil, low, moderate or high potential for fish utilization during open water periods. As some of the watercourses investigated were frozen or had meltwater flowing over ice frozen to the stream substrate, habitat assessment was often difficult. The overwintering potential for fish was also evaluated where possible. Observations were recorded regarding factors which would appear to have a limiting influence on the utilization of these streams by fish. The limiting factors and a brief description of each follows:

Steep gradient:	gradient too steep to allow upstream movement of fish.
Obstructions:	logjams, beaver dams or waterfalls which would provide barriers to upstream fish movement.
Inadequate Discharge or Low Water Level:	stagnant water, shallow water
Dry:	no water present.

An evaluation of the fish habitat potential, together with factors limiting the habitat in terms of fish utilization is presented in Table 11.

Water sampling was conducted in watercourses which were judged to be capable of supporting fish. Water temperatures were measured with hand-held mercury thermometers ($\pm 0.5^{\circ}C$) and chemical parameters were determined by using a model OX-9 Hach kit (DO - $\pm$ mg/l; ph - $\pm$ 0.2). In addition, a qualitative assessment of water colour was made at each sampling site. The results of the water sampling of watercourses crossed by the proposed winter road are summarized in Table 12.

4.4 Vegetation

The proposed winter road corridor extends a distance of nearly 100 miles between the Liard River east of Nahanni Butte and Prairie Creek in the Mackenzie Mountains. This area lies within the Boreal forest on the transition between the Upper Mackenzie and alpine Forest-Tundra Sections (Rowe 1972). The following description summarizes Rowe's (1972) account of these sections.

The Upper Mackenzie section encompasses the flood-plain environment of the Mackenzie River watershed. White spruce (Picea glauca) and balsam poplar (Populus balsamifera) are the dominant species on alluvial flats. Surrounding the flats are benches which are characterized by jack (Pinus banksiana) and lodgepole pine (Pinus contorta) on sandy sites, black spruce (Picea mariana) and tamarack (Larix laricina) in moist locations. White spruce is far less abundant than on the alluvial flats, however, it is very abundant and of merchantable quality along the flood plain of the Liard.

Lodgepole pine, white birch (Betula papyrifera), aspen (Populus tremuloides) and white spruce occur on rocky till slopes and sandy terraces above the Liard. Black spruce is common to muskegs and is found on slopes as well as the alluvial flats.

The Alpine-Forest-Tundra occurs as transition from the forest described above, to open scattered specimens of stunted White spruce alternating with grass, shrub or bare rock areas. This is common up to treeline at 3,500 to 3,800 ft. On north and east aspects, the alpine fir dominates whereas at lower elevations with the same aspects, black spruce alone or together with white spruce predominates. Alaska birch, tamarack, trembling aspen and balsam poplar are scattered throughout. In this location, lodgepole pine is the dominant species on mountain slopes (Rowe, 1972).

Although a number of vegetation studies have been conducted in the Upper Mackenzie Valley, none of these are directly applicable to the Study Area. Forest cover maps have been produced for nearby areas in Nahanni National Park and in the Mackenzie Valley; however, neither of these mappings cover the Study Area.

The most useful information relating to the Study Area is the landscape survey in the Upper and Central Mackenzie Valley (Crampton 1973). The mapping in that report covers roughly two-thirds of the extent of the road. This landscape mapping takes into account not only the landform, but also vegetation and permafrost characteristics.

The proposed road corridor is shown in Figure 13a superimposed on the landscape mapping of Crampton (1973), and a topographic map of the unclassified section of road.

Most of the area covered by this mapping is within the Fort Simpson Land Region. The predominant soils are degraded dystric brunisols; the dominant parent materials are silty clayey morainal, silty clayey lacustrine and shallow bedrock in their order of abundance. Towards the northwest the land region of predominance is the Horn Plateau, where Alpine eutric brunisols dominate. The dominant parent material in this area is shallow bedrock.

The mapped portion of the proposed winter road crosses landscape units as shown in the table below; these units are a combination of landform, drainage and vegetation characteristics. The letters indicate susceptibility to disturbance. The legend for Figure 13a (Figure 13b) describes the susceptibility classes, ranging from A - least suspectible to D - most susceptible.

Landscape Units	Road Distance Miles	km	% of Mapped Road	Vegetation Type
1	8.7	14)	78%	Mountain outcrops
3A	42	68)		predominantly white spruce/sphagnum understory
8C	2.5	4	4%	predominantly black spruce/sphagnum understory
11D	4.4	7)	18%	predominantly black spruce/sphagnum understory
13D	7.5	12)		

The land systems identified in the above landscape units have been described as follows:

1. Mountain rock outcrops and screes:

   These occur on bare slopes in mountainous areas. The vegetation is characterized by a thin ground flora of ericaceous shrubs and lichens.

3. Seasonally waterlogged lands without near-surface permafrost:

   These areas occupy the greatest distance along the proposed winter road. These lands are usually peaty and are dominated by somewhat stunted trees and a mossey ground flora. The treed areas merge into treed bogs, willow flats, sedge meadows and open peat bogs. Black spruce, tamarack and white birch are common tree species. The ground flora is dominated by ericaceous shrubs and sphagnum mosses. These areas are generally unfrozen in the summer although some patches of permafrost may occur.

8. Peat plateaus with labrador tea (Ledum palustre) locally with near-surface permafrost and scattered depressions containing summer pools:

   The vegetation in these areas is characterized by the sphagnum plateaus which are in turn dominated by labrador tea. Minor components of the flora are shrubby cinquefoil (Potentilla fruticosa), lingonberry (Vaccinium vitis-idaea) cloudeberry (Rubus chamaemorus) and horsetails (Equisetum spp.). Tree species are predominantly dwarfed black spruce, tamarack and white birch.

   Frozen peat is a common feature at about 20 - 30 inches depth in summer.

11. Gentle, coarsely lineated slopes with near-surface permafrost:

   The vegetation of this system is similar to system 3. The trees are predominantly found in closely-spaced runnels; the rest of the land is wet and dominated by sphagnum and sedges. Birches and willows are abundant locally. The permafrost table occurs at about 20 inches.

13. Rocky plateaus and finely lineated slopes with near-surface permafrost:

    This occurs in areas where the underlying rock structure is visible through a thin veneer of moraine. This area is similar to that of system 11; however, the substrate does not contain ice.

For further details on these land systems the reader is referred to Crampton, 1973.

Extrapolation of this mapping onto the rest of the Study Area was not possible in the time frame of this initial study.

Based on interpretation from maps it appears that of the remaining portion of the winter road not covered by the landscape survey, 14 mi. are above tree line and would probably fall into category 1, an area of minimum susceptibility to damage. The remaining 20 mi. are forested land and appear to form a continuum with the land systems on the rest of the Ram Plateau.

4.5 Wildlife

4.5.1 Introduction

This section outlines the results of a cursory literature review and field investigation of the wildlife, and the identification of potential areas of concern relating to wildlife in the vicinity of the proposed Cadillac Exploration Limited winter road.

Objectives of this work were as follows:

1. To assess, within the area of development, the abundance and general distribution of the amphibian, reptilian, avian and mammalian wildlife considered to be of significance with respect to sport, commercial, scientific or aesthetic value.

2. To identify rare or endangered species which may be affected by the proposed development.

3. To identify areas which may be critical to the life cycle of wildlife species.

4. To collect available information regarding trapping and game harvests in the area.

The Study Area was loosely defined as the corridor of the proposed winter road plus those areas (A,B,C,D,E & F) which had previously been identified as containing specific wildlife populations (Fig. 14).

A field programme was conducted April 15 - 18, 1980, during which time discussions were held with N.W.T. government biologists in Yellowknife and cursory aerial reconnaissance of the Study Area was carried out.

Aerial reconnaissance was conducted in a Bell 206 helicopter. Three observers were used - the pilot and two biologists (positioned on opposite sides of the aircraft). All observations of wildlife were plotted on 1:250,000 scale topographical maps and information relevant to each sighting was recorded on cassette tape.

4.5.2 Sources of Information

The wildlife resource in the immediate vicinity of the proposed winter road is not well known. Published biological information is only regionally applicable and comes primarily from three general sources: a) unquantitative species lists for herptiles (Hodge 1976), birds (Godfrey 1966) and mammals (Banfield 1974, Youngman 1968, 1975); b) published documents regarding Nahanni National Park (Scotter et al. 1971, Addison 1974); and c) reports directed at assessing potential impacts of other northern linear developments.

Investigations of the latter category include studies conducted in both the Northwest Territories and adjacent Yukon Territory. For example, Slaney and Company Limited (1971) prepared an environmental impact assessment on the Pointed Mountain Natural Gas Pipeline in the southeast Yukon.

Terrestrial breeding birds were studied by Wisely and Tull (1977) along the Fort Simpson realignment of the proposed Arctic Gas Pipeline route. Information from this same region is also available on moose, woodland caribou and furbearers (Wooley and Wooley 1976) and on small mammals (Wooley 1974).

Substantial biological investigation has taken place in regard to proposed gas pipeline development in the Mackenzie Valley, (Bietz and Whitney 1976; Rutton and Wooley 1974; Wooley 1972) and some work has been done in assessing potential effects of the Liard Highway (presently under construction to the south of the Study Area) (Donaldson and Fleck 1979; Synergy West Ltd. 1975).

Another nearby facility which has been assessed in some detail is the Mackenzie Highway. (Special Habitat Evaluation Group, 1972; Lombard North Group Limited 1972, 1973, 1974; L.G.L. Limited 1973; Renewable Resources Consulting Services Limited 1973; Slaney and Company Limited 1974).

More recently, a general review of environmental literature regarding impacts of several linear facilities in Northern Canada was prepared by Beak Consultants (Environment Canada, Environmental Protection Service, Northwest Region 1979).

Although the above investigations do not define the wildlife resource in the specific area through which the proposed development may travel, they do provide a regional picture with which findings made during the present study may be compared.

4.5.3 Wildlife Reported

A list of all wildlife documented by Beak along the proposed winter road alignment (and adjacent areas) is provided in Table 13 and provisional checklists of mammals and birds potentially occurring in the area are given in Tables 14 and 15 respectively. All observations of wildlife made during this reconnaissance, plus information gleaned from discussions with camp personnel and government biologists are noted in Figure 14.

One hundred and twenty-two avian species, forty-eight mammalian species and two herptiles potentially inhabit the region transected by the proposed development. An additional species may be added to this list upon introduction of a wood bison (*Bison bison athabascae*) herd, June, 1980.

Birds noted in Table 15 which are considered to be rare, endangered or highly sensitive, include the Bald Eagle and Trumpeter Swan. Both are known to occur in the Nahanni area. Of the 48 potentially occuring mammals, 22 comprise a group which is exploited either recreationally or commercially (6 ungulates and 16 furbearers). Other mammal groups include the insectivores (shrews), chiropterans (bats), nicrotines (voles), scuirds (squirrels) and several minor taxa. None of these 48 species is considered to be rare or endangered although some forms such as woodland caribou, Dall's sheep and grizzly bear are considered sensitive due to their susceptibility to disturbance.

Particular concern is expressed for wood bison. Although there are presently no bison in the area, the Canadian Wildlife Service plans to release a herd of 28 animals in the Nahanni Butte area, north of the Liard River, during June, 1980. This subspecies is recognized by three agencies as endangered (Canadian Committee on the Status of Endangered Wildlife in Canada, I.U.C.N. Red Data Book and the Convention on International Trade in Endangered Species of Wild Flora and Fauna).

Only two amphibians are widely distributed in the Northwest Territories, the Wood Frog (*Rana nylvatica*) and Boreal Chorus Frog (*Pseudacris tristeriata maculata*) (Hodge 1976). The former is exceptional for an amphibian, in that its range extends above the Arctic Circle to 68^{o}N in Alaska and east into Labrador (Martoff and Humphries 1959). Although the precise factors which limit the northern ranges of anurans (frogs and toads) are imprecisely known, one of the major constraints is a low summer temperature, which reduces the growing season, rather than low winter temperatures. In this respect, the Wood Frog is adapted to northern climates, in having a low embryonic temperature tolerance, a high developmental rate and a high developmental Q_{10} at low temperature (Herreid and Kinney 1967).

In the absence of corroborative literature, it is suspected that only the above two herptile species occur in the vicinity of the proposed road and only in localized populations.

4.5.4 Wildlife Observations

Area[1] A & E — Dall's sheep have been recorded along the west slopes of Tundra Ridge (Scotter et al. 1971). During Beak's field programme five wildlife species were directly (actual sightings) or indirectly (tracks, pers. comms.) documented as utilizing habitat in the Caribou Flats (Area A). A single Dall's sheep ewe was observed on the eastern border of Caribou Flats (on the low slopes of the Tundra Ridge); one golden eagle and nine ptarmigan were observed in the valley and three sets of moose tracks plus a single marten trail were noted on the west side of the valley (Beak observations). Woodland caribou have also been frequently seen in this area, and a number of wolf predations on these animals have been noted over the period 1968 - 79 (R. Fast, 1980 pers. comm.). A mineral lick situated in the northwest portion of Caribou Flats is known to be used by caribou (ibid.).

Area B — Dall's sheep herds consisting of ewes and up to 8 - 9 lambs, have been observed in the area locally known as Folded Mountain (Mr. R. Fast, pers.comm.).

Area C — One Gray Jay, two Arctic ground squirrels and three red squirrels were observed by Beak personnel in the vicinity of the Cadillac camp on Prairie Creek. Discussions with Mr. R. Fast suggest large-mammal movement through this area is irregular. Mr. Fast (pers.comm.) noted the following animals in the vicinity of camp during the 12 years he has been involved with the mine development:

1968	-	Black bear and 1 cub
1969	-	Black bear
1968-1979	-	Three wolverine
1975	-	Grizzly bear
1979-80 (winter of)	-	1 wolf.

Area D — Mr. Fast suggested that up to 100 woodland caribou have been seen in this region, however the pattern of usage of the area by these animals is unknown. No woodland caribou and no tracks or cratering were observed here during helicopter flights by Beak, however 2 ptarmigan and a small flock of Snow Buntings were observed.

Area F — Grainger River Pass. Presence of Dall's sheep habitat on both sides of this pass has been noted in the Canadian Land Inventory Series (Dept. of the Environment 1976). During helicopter overflights by Beak, relatively well-used trails were observed to both the north and south of the pass, however no animals were observed.

[1] See Figure 14 for location of Areas A - F.

The following additional observations were made along the proposed road alignment:

1. One Golden Eagle observed along Fishtrap Creek in the Silent Hills.

2. Two beaver lodges were noted on the Fishtrap Creek Drainage, immediately south of the proposed crossing site.

3. Two swans, five Snow Geese and eight mallard pairs were seen on a small lake in the Silent Hills, south of the alignment.

4. A single moose was noted along the Grainger River, east of the pass.

5. One beaver lodge and dam were observed north of the alignment on an unnamed tributary of the Grainger River.

6. Several large beaver dams and a lodge were observed on the Grainger River west of the airfield.

7. One Golden Eagle was observed near the Grainger River during aerial reconnaissance of the proposed route (Fletcher and Wilson, pers.comm.).

8. A single beaver lodge was seen on the Grainger River between the airfield and the Liard River.

9. A black bear was observed on a cutline in the vicinity of the Grainger River north of the Liard River.

4.5.5 Furbearers/Trapping

Three trapping areas occur on lands transected by the proposed road (D. Bentley, 1980 pers.comm.). These traplines are situated as follows:

1. East of the Nahanni Range between Bluefish Lake ('1st Gap') and the '3rd Gap' to the north (inclusive of the Grainger River Pass, or '2nd Gap').

2 & 3. These traplines are operated west of the Nahanni Range, between the 1st and 3rd gaps (in a north-south line) and between the Nahanni Range and the Tetcela River (in an east-west line), including the Silent Hills.

Yearly fur harvest for these trapping areas ranged from $8,700 to $22,000 for the 1978-79 trapping season. None are operated by single individuals. Major species harvested include beaver, marten, mink, lynx, weasel and wolverine (few). In addition, 5 moose and 9 woodland caribou were harvested on licences of the above trappers.

4.5.6 Waterfowl

There appear to be few concerns regarding waterfowl in the area (D. Karasiuk, 1980 pers.comm.), although there is the potential that swans may breed in the vicinity (note Beak observations).

4.5.7 Raptors

Although Golden Eagles have been documented along the route (Beak observations) no nests were observed during aerial reconnaissance in April, and no raptor nest sites have previously been reported in the area (R. Fyfe, 1980 pers.comm.).

4.5.8 Grizzly Bears

The N.W.T. Wildlife Service has stated that grizzly bears are considered to be a 'high profile' species and that hunting of these animals may soon be illegal in the Mackenzie Mountains (S. Miller, 1980 pers.comm.).

4.5.9 Wood Bison

Wood bison do not presently occupy range in the vicinity of the proposed road, however, the Canadian Wildlife Service is planning to transfer 28 of those animals from Elk Island National Park to a site north of the South Nahanni River near Nahanni Butte during June, 1980 (H. Reynolds, 1980 pers.comm.). This area was chosen for a release site because of its suitability as bison habitat. Range evaluation for this project has taken place to the east and west of the Nahanni Range as far north as the Grainger River Pass, and it is considered possible that once introduced, the herd may utilize this entire area (Fig. 14).

Although little concern exists regarding disturbance of bison habitat, concerns have been expressed regarding development of additional linear facilities in the area (H.Reynolds, 1980 pers. comm.). Bison are known to follow cutlines and other cleared linear developments and concern has been registered that further development of this type may encourage the bison to travel out of the area (ibid). In addition, increased access may lead to illegal hunting.

4.6 Geology and Soils

4.6.1 Physiography

The proposed access route to the Prairie Creek property crosses, from east to west, the western part of the Interior Plains, the Nahanni Range of the Franklin Mountains, the Mackenzie Plain and the Mackenzie Mountains (Bostock 1948). The Mackenzie Plain section can be divided into the Silent Hills, on the east and the Tetcela River Plateau on the west.

The Interior Plains section varies from 550 to 1500 ft. in elevation. The terrain is heavily wooded and consists of muskegs, for the most part, interspersed by numerous shallow lakes. The principal streams in the area are the Liard River and its tributary, the Grainger River.

The Nahanni Range is the southernmost range of the Franklin Mountains. Its width in the Study Area is between 2 and 3 miles with elevations ranging from 2000 to 5000 ft. The proposed route crosses the Nahanni Range through the Grainger River Pass.

West of the Nahanni Range, the proposed route crosses the Mackenzie Plain. The area may have been part of the Interior Plains at one time but has been separated from them by the emergence of the Nahanni Range. In the Study Area, the Mackenzie Plain is a north-south trending valley about 30 miles wide dissected by the Silent Hills and the Tetcela Plateau. Elevations along the proposed route vary from 1000 to 3500 ft. The Silent Hills rise about 1300 ft. above the poorly drained plains while the Tetcela Plateau, an informal name for the area south of the Ram Plateau, exhibits relief of about 1000 ft. The principal streams in the Mackenzie Plain are Fishtrap Creek, west of the Silent Hills, Tetcela River on the Tetcela Plateau, and a tributary to Sundog Creek on the western side of the Plain.

The final portion of the proposed route crosses the Mackenzie Mountains which range in elevation from 3000 to 5600 ft. The easternmost range of the mountains is crossed through the informally-named South Pass, with the proposed route reaching its western terminus at the camp, located on Prairie Creek.

4.6.2 Bedrock Geology

The bedrock geology along the proposed route was mapped by the Geological Survey of Canada as part of Operation Mackenzie in the late 1950's (Douglas and Norris 1960) with a final map published in 1976 (Douglas and Norris 1976).

The eastern terminus of the proposed route is underlain by Quaternary alluvial sands and silts of the Liard River floodplain. West of the Liard floodplain, bedrock in the remainder of the Interior Plains region consists of shales and siltstones of Cretaceous and Upper Devonian age. The Nahanni Range consists of massive and resistant carbonates of Middle Devonian age. On the Mackenzie Plain, the proposed route crosses Upper Devonian shales and siltstones for the most part. In the Silent Hills, the Yohin Syncline, consisting of siltstones, mudstones, shale, limestones and sandstones of Carboniferous and Permian, Mississippian and Devonian age is crossed. In the western portions of the Mackenzie Plain, the proposed route crosses Devonian shales and limestones. Through the Mackenzie Mountains, the bedrock along the proposed route consists of Devonian and Silurian carbonates with a few shales.

The structural geology of the area, as described by Douglas and Norris (1960) consists of dominantly north trending homoclinal thrust sheets, faulted folds, and broad, elongate uplifts and depressions. The proposed route crosses the Nahanni Thrust, which forms the boundary between the Interior Plains and the Nahanni Range, the Yohin Syncline in the Silent Hills and follows the axis of the Ram Syncline in the western portion of the Mackenzie Plain. As the proposed route enters the Mackenzie Mountains, it crosses the Sundog Fault.

4.6.3 Surficial Geology

Information on the surficial geology along the proposed route is incomplete. Both Crampton (1973) and Monroe (1973) have published terrain classification and sensitivity maps for the Sibbeston Lake map sheet, while Rutter et al. (1973) have published a surficial geology and geomorphology map of the same area. The geomorphology and glacial history of the South Nahanni River area, south of the present Study Area, has been discussed by Ford (1973, 1976) and Scotter et al. (1971). Information on the surficial deposits of that portion of the proposed routes on the Virginia Falls map sheet is lacking. The following discussion on the surficial geology along the proposed routes is taken from the above-mentioned publications with extrapolations into the unmapped area.

The region of the Northwest Territories in which the Study Area lies has been glaciated by both Cordilleran and Laurentide ice sheets. Laurentide ice, originating from the east, deposited clayey till as far west as the Mackenzie Mountains. Cordilleran ice, originating from the mountains probably advanced only as far as the Funeral Range, to the west of Prairie Creek. Thus it appears that Cordilleran glacial deposits are not traversed by the proposed route. The area between the eastern limit of the Mackenzie Mountains and Prairie Creek is believed by Ford (1976) to be unglaciated except for local alpine glaciers. Lacustrine deposits, associated with ice dammed glacial lakes are present throughout the area.

The landforms crossed by the proposed route are those associated with glacial and periglacial activity, rivers, organic deposition and mountainous regions. Periglacial landforms are restricted to a few occurrences of patterned ground. The dominance of fractured limestone and dolomite as bedrock in the area has resulted in the development of extensive cave systems in the mountains.

The following is a brief description of the terrain along the proposed route using data from Monroe (1973).

In the vicinity of its eastern terminus, the proposed route crosses the floodplain of the Liard River and the lower reaches of the Grainger River near its confluence with the Liard. The deposits are fine silts and silty sands that are between 5 and 100 ft. thick in this area. The topography of the landform is relatively flat, with between 3 and 15 ft. of relief. Peat cover is negligible on the active floodplain, but abandoned channels may have deposits up to 15 ft thick. Much of the floodplain is wet with numerous marshy areas. Bogs with more than 6 ft. of peat may support permafrost and ground ice may be present in the fine-grained materials of the floodplain.

Lake deposits are present between the Liard and Grainger River floodplains. These are silts and clays, often with a covering of sand or silty sand and a discontinuous organic cover. The terrain is flat to gently sloping, has a deranged drainage pattern and has permafrost in some of the bogs.

The remainder of the Interior Plains portion of the proposed route is a till plain. The surficial material is a clayey to silty Laurentide till which forms a veneer over bedrock. Thicknesses are as great as 20 ft. The terrain is a sloping to rolling bedrock controlled plain with a discontinuous peat cover. Water is often present in depressions and localized permafrost with a moderate ground ice content is present.

At the Grainger River Pass, coarse-grained river deposits can be found. These are indicative of the high-energy streams emerging from the mountains. The materials consist of between 10 and 75 ft. of gravels and sands, commonly with a veneer of silt. The topography is level to gently sloping and local relief is up to 10 ft. The surface is dry for the most part, and permafrost is probably absent.

The terrain between Grainger River Pass and the Silent Hills includes till plain and hummocky till, gravel-sand hills and ridges with some mountainous and rocky areas. The hummocky till is clayey to gravelly-sandy with local gravel lenses. The topography is characterized by individual and coalescent hummocks with slopes between 5° and 30°. Small areas of organics are also present. Drainage varies between well-drained hills and poorly-drained depressions. Localized areas of permafrost with moderate ice contents are present, chiefly on north-facing or shaded areas, higher elevations, poorly-drained areas and areas with thick organic cover.

Areas of gravel-sand hills and ridges consist of deposits between 50 and 75 ft. thick and relief up to 30 ft. These coarse-grained deposits are dry, for the most part, and within these hills permafrost is present only in organic deposits.

The mountainous and rocky areas consist of rock outcrop or rock thinly covered by rubble or till. Slopes are moderate to steep and the ground is dry. Permafrost may be present in some fine-grained colluvium.

The Silent Hills are composed of mountainous and rocky terrain. West of the hills is an area of lake deposits, followed by gravel-sand hills and mountainous and rocky areas.

The unmapped terrain west of the Tetcela River is expected to consist of till, lake deposits and gravel-sand hills to the front of the Mackenzie Mountains, followed by mountainous and rocky terrain through the mountains to Prairie Creek.

4.6.4 Soils

Information on the soils along the proposed route is lacking. Day (1966) discussed the soils along the Liard River while Crampton (1973) discussed the soils in the Sibbeston Lake map area. Clayton et al. (1977) gave a general description of the soils throughout the region and the following description of the soils is based on their publication.

The soils along the Liard River floodplain are dominantly (greater than 40% of the area) Orthic Eutric Brunisols with Cumulic Regosols and Fibric Cryosols as subdominant (greater than 20% of the area) soils. The Brunisols are found on the well-drained inactive floodplain and the Regosols on the active floodplain. The Fibric Cryosols are present in organic deposits with permafrost. Soil climate is Subarctic very cold to Cryboreal cold. Soils in these classes have a mean annual soil temperature of -7 to less than 8°C and mean summer soil temperature of 5 to less than 15°C. The growing season (days with the temperature greater than or equal to 5°C) is less than 220 days. The soils are humid (soil not dry in any part for as long as 90 consecutive days in most years) with subaquic inclusions (soil saturated for short periods).

On the steeper terrain west of the Liard River floodplain, the soils are still dominantly Orthic Eutric Brunisols, but the subdominant groups are now Cumulic Regosols and Rockland. Both stony and rocky phases of these soil subgroups are present in the mountainous region. The soil climate is Subarctic, very cold (mean annual soil temperature -7 to less than 2°C; mean summer soil temperature 5 to less than 8°C) with a growing season less than 120 days. The soils are humid.

4.6.5 Relative Stability of the Deposits

Field sampling and laboratory analysis of surficial deposits along the proposed access route to the Prairie Creek property have not been carried out. However, information on the relative stability of the deposits in the Sibbeston Lake map area is available (Monroe 1973) and those zones crossed by the proposed route will be included here.

The lacustrine plains, formed of silt and clay, commonly fail along scarps. These deposits have a poor bearing capacity and the deranged drainage pattern of the landform results in further problems with respect to construction. However, this landform is variable with respect to suitability for construction and potential hazards.

Fine-grained river deposits offer the potential for ice slumping and gullying on margins of lakes and channels, undercutting and bank collapse along channels during high water, flooding during break-up and summer storms and channel shifting. The potential for the presence of permafrost with high ground-ice contents in the fine-grained material renders this landform as fair to poor with respect to suitability for construction.

Coarse-grained river deposits are more stable than fine-grained ones although several of the potential hazards are similar. Minor slumping may be expected on lake margins and river channels in areas with a veneer of silt; undercutting and bank collapse may occur along channels at high water times; flooding may occur during break-up and summer storms and channel shifting may occur. The coarse-grained nature of the material greatly decreases the chance of ice-rich permafrost being present and results in an overall stable landform.

The gravel-sand hills and ridges are prone to gullying on hillsides and sloping banks, principally in the finer-grained material. As with the coarse-grained river deposits, the texture of this landform results in a low ice-rich permafrost hazard and a generally stable landform.

Till plains and hummocky till are moderately susceptible to gullying. Ground ice slumps and mudflows may develop on slopes of medium-grained till, while large flow slides are a potential hazard in sloping areas of clay-rich till. These potential hazards, coupled with the possibility of localized permafrost with a moderate ground ice content render these landforms only fair, at best, with respect to development.

Mountainous and rocky areas offer the potential for the numerous types of mass wasting common to mountain environments. Steep slopes are prone to rockfalls, slides and active creep while gullying is common in soft materials. Steep gullies may be the site of mudflows and flash floods. Areas of shale are inherently unstable and subject to mass wasting. In areas where the organic cover is removed or altered, detachment slides and rotational slumping may occur. However, if flat-lying bedrock areas are present away from active slopes, they offer good sites for development.

Eroded and/or eroding river banks and valley walls, whether in bedrock or unconsolidated materials, are subject to mass wasting, if on slopes, and are, for the most part, unstable.

Although the preceeding descriptions were summarized from Monroe's (1973) work in the Sibbeston Lake area (Map Area 95G), similar landforms and hazards are expected in the area to the west (Virginia Falls, 95F).

5. POTENTIAL ENVIRONMENTAL IMPACTS AND MITIGATIONS

In general, it is recognized that the construction and operation of northern roads must be carried out with a great deal of care if environmental damage is to be avoided. However, favourable route selection and winter-only operation are the two most important factors which will limit the degree of impact. Only one major river crossing is proposed (the Liard) and winter operation will facilitate the use of ice or snow bridges in lieu of permanent crossings.

Specific potential impacts are discussed below, along with recommendations for mitigations by the Consultants on the project.

5.1 Aquatics

Construction-related alterations to aquatic ecosystems could potentially affect both spring and fall spawning fish species. These fish will be most sensitive during the interval between the beginning of adult spawning migrations and the time when the fry have developed to a stage that they are less likely to be adversely affected by habitat alteration. Overwintering areas are also highly susceptible to habitat alteration, as many individuals may occur in restricted areas. In north temperature climates the fish fauna of smaller watercourses congregate in the larger waterbodies resulting in regional aggregations of fish populations within localized areas. Therefore adverse impacts on such areas may be of regional significance. Fish populations tend to congregate in deep pools to overwinter and, as flow rates decrease, movement between such pools may be precluded. Potentially high mortality rates may then result from the inability of fish to avoid temporary adverse conditions.

Sensitive time periods in the life histories of the prominent fish species reported from the study region are presented in Table 16. Dryden and Stein (1975) have considered the following fish species to be "numerically significant or form the basis of existing or potential domestic, sport or commercial fisheries in the upper Mackenzie Valley: Arctic grayling, lake whitefish, northern pike, burbot, white sucker, longnose sucker and yellow walleye. Chum salmon and Dolly Varden char may also be included on the above list due to their potential importance in the sport or domestic fisheries within the study region.

Potential aquatic impacts and their mitigations are as follows.

a) Debris Impact

Restrictions of water flow may result from deposition of slash and spoil in aquatic systems during right-of-way clearing operations. Fish movement could be disrupted or important spawning, nursery and rearing areas covered. During winter, ice-covered streams incur an oxygen deficit which may be aggravated by winter construction activities. The introduction of organics is likely to increase biochemical oxygen demand through bacterial and fungal activity, thus reducing available oxygen levels. A reduction of dissolved oxygen below critical levels may result in mortality of fish or invertebrate fauna.

Debris Mitigation

Slash or spoil should not be intentionally introduced into water bodies. All materials which enter streams, rivers or lakes should be removed, with consideration being given to aquatic fauna. This may necessitate removal by hand.

b) Siltation Impact

The increase of silt loads is the most obvious and potentially one of the most adverse effects of road construction and operation. Increased siltation may enter watercourses as a result of:

1) clearing of stream beds and resultant erosion;
2) grading and ditching activities;
3) installation of crossing structures;
4) borrow operations in or near watercourses;
5) stream bank failure and erosion of banks.

Many of the invertebrates upon which fish feed are sensitive to siltation and may drift away from the area of disturbance or die if loads are too high (Rosenberg and Snow 1975). Although all life history stages of fish species inhabiting a waterbody may be affected by siltation, the early life history stages of fish are particularly sensitive to sedimentation. In severe cases, eggs may be covered, fry incapable of avoiding heavy concentrations of silt will die and many fry will die due to a reduction of in-stream cover. Fish populations tend to congregate in deep pools to overwinter and, as flow rates decrease, movement between such pools may be precluded. During the winter, higher silt loads could cause increased oxygen demand. This may result in potentially high mortality rates due to the inability of fish to avoid temporary adverse conditions. Fish migrations may also be blocked or delayed as some fish species avoid entering turbid waters.

Critical habitats may be rendered unsuitable for use by clear-water organisms until they are dispersed by natural scour (likely at the time of the next freshet). Dependent upon the particle size and discharge rate of the system, the fine materials that do not settle out immediately will be deposited at varying distances downstream of the area of disturbance. These fines will generally settle along shorelines or in backwater areas where natural silt loads settle out.

The severity of the introduction of silt to the watercourse will vary considerably with the timing, location and quantity of silt released.

Siltation Mitigation

At waterbody crossings, a buffer zone of uncleared land between construction activity and the crossing should be maintained for as long as is practical. Once water crossing activities commence, preferred stream bank clearing is by hand. Instream traffic should be kept to a minimum and crossing structures installed quickly and efficiently. Stabilization of stream banks should be completed immediately if a bridge or culvert has been installed. Cuts and fills should be kept to a minimum in regions of unstable soils.

Cross drainages should be established where possible to facilitate the directing of runoff during the post-construction period into non-erodible areas.

During the operation/maintenance phase, stream banks should be observed periodically and restorative measures taken when necessary. In order to reduce potential impacts of siltation, a buffer zone of undisturbed land should be retained between the right-of-way and aquatic systems exhibiting fishery potential or having documented utilization which are paralled by the road. The width of the buffer zone may be increased in regions where the slope of the land entering the waterway is steep, or reduced where the slope is slight (Case and Rowe 1978).

c) Substrate Removal Impact

The removal of stream substrate or floodplain materials as sources of gravel for use in road construction will increase the silt load in the watercourse. This might result in the mortality of incubating eggs and newly-hatched fry, or in loss of important spawning and nursery habitat. Alterations of the stream bed may also interfere with passage of migrating fish.

Substrate Removal Mitigation

Borrow material should be obtained from upland sites where possible. The use of stream bed or floodplain material must be carefully controlled as it may cause damage to the watercourse.

d) Toxic Substances Impact

Watercourses which are subject to the release of toxicants or pollutants will be adversely affected by mortality of aquatic organisms or the deterioration of habitats. The severity of the impact would depend on the volume, toxicity and timing of the release of the substance involved, and the chemical characteristics of the stream. Substances likely to cause adverse effects include fuels, domestic wastes and mill reagents.

Toxic Substance Mitigation

In order to avoid accidental spills, all potentially toxic materials should be stored well away from any waterbody, and/or enclosed by impermeable dykes. Machinery maintenance, refueling or washing should not take place in or near streams, rivers, or lakes. Contingency plans should be formulated in case of an accidental spill.

Care should be taken to avoid introduction of heavy metals in aquatic systems due to overfilling of haul trucks, although sulphide metal concentrates are not particularly reactive or toxic. Should accidental spills occur at or near watercourse crossings, clean-up should be completed prior to break-up.

e) Explosives Impact

The use of explosives creating shockwaves near a stream could result in the mortality of all life history stages of fish species inhabiting the watercourse. Adverse effects will depend on the force of the charge, the proximity of the watercourse and the physical properties of the materials being blasted.

Explosives Mitigation

Blasting should be conducted with consideration for fish populations and should be avoided near important aquatic habitat.

f) Drainage Alteration Impact

The alteration of surface and subsurface drainages may disrupt or modify existing drainage patterns. This could result in the reduction of available water in important aquatic habitats. Drainages in muskeg, peatland and wetlands are likely to be most susceptible to alteration or disruption. Heavy sediment loads may be introduced into streams as a result of poorly designed road cuts on the approach to stream crossings.

Drainage Alteration Mitigation

Efforts should be made to retain natural drainage patterns. Temporary watercourse blockages or diversions should be considered only where critical habitat will not be affected by dewatering or stagnation and where fish fauna will not be isolated by these practices. At the end of the operating season, snow bridges should be removed in order to encourage proper drainage during thaw. Grades and approaches to crossings should be low (less than 5%).

g) Bridges and Culverts Impact

If bridges or culverts are required, then proper installation, site selection and alignment of these structures must be insured. Although in extreme cases, bridges or culverts may be installed in critical habitat areas, the disruption of fish movements is of greater concern. Factors which would preclude, limit or delay fish movement include improper culvert placement, ice dams, accumulation of debris at the upstream ends of these structures and velocity barriers. Scour at the downstream end of a culvert will increase the sediment load of the watercourse and result in deterioration of downstream aquatic habitat. The creation of an impassable drop at the downstream end of a culvert will develop if scouring is severe. Culverts which are inadequate to carry peak flows will cause flooding on the upstream end. The resultant ponding could produce bank collapse, washouts of stream crossing embankments and flooding of previously undisturbed ground.

Bridges and Culverts Mitigation

Streams and rivers should be traversed at right angles, and stream banks at crossing sites should be stabilized with non-erodible material. If crossing structures are required, bridges are the preferred structures. During construction, care should be taken that no building materials enter aquatic systems. Bridges should not be designed in such a way that they cause accumulation of debris during the post-construction period.

Culvert types, in order of preference for fish passage, are arch, horizontal, ellipse, and circular. Culverts should be installed at a uniform slope, following the stream gradient. The bottom of the culvert should be placed at least 6 inches below the existing stream bed. Where fish movements are known or anticipated to occur, the depth of the water in the culvert should approximate natural conditions. All crossing structures should be designed to accommodate peak natural stream flows anticipated to occur during the stream-crossing interval. "The discharge for which fish passage is required or the fish migration discharge" for Liard Highway streams has been defined as "the mean annual flood" (Katopodis n.d.). With respect to culverts, crosssectional water velocities should not exceed 3 feet/second for more than three continuous days (Dryden and Stein 1975). Crossing structures should be maintained free of debris in order to prevent stream blockage. Dryden and Stein (1975), Katopodis (n.d.) and Dane (1978) provide more detailed guidelines for various designs, length requirements, and installation requirements for culverts.

h) Increased Accessibility of Watercourses Impact

Some increase in fishing pressure by construction crews during summer construction may occur.

Increased Activity of Watercourses Mitigation

Fishing regulations should be adhered with.

5.2 Vegetation

Based on the landscape classification discussed in Section 4.4 and map interpretation, it appears that approximately 66% of the total proposed winter road traverses vegetation and terrain which is the least susceptible to damage from disturbance. Moderately to strongly susceptible areas are covered by 2% of the route while the most susceptible areas are covered by 12%. The susceptibility of the remainder of the route is undeterminable from presently available information; however, based on extrapolation it is likely much of this area would fall into the most susceptible category for a further 20%.

Impacts

The potential concerns for vegetation lie in the loss of rare or valuable species; however, the most important feature is the disturbance of surface vegetation in permafrost terrain. The latter results in a change in surface reflectivity and a thawing of permafrost. The end result is thermokarst erosion.

In general, winter activities are less harmful than summer ones as disturbance is reduced through a cushion of snow and frozen ground is less easily disturbed. Most of the area through which this winter road is proposed does not contain extensive permafrost. Extreme care should be taken in those areas identified as most sensitive to either avoid areas of permafrost or to take measures to avoid disruption of the ground flora.

Mitigation

Mitigation measures for vegetation impacts would include restricting the width of the right-of-way to the minimum possible, retention of the organic mat, and the preservation of natural drainage patterns.

5.3 Wildlife

5.3.1 Introduction

Little specific information is available regarding wildlife in the area of the proposed development. In addition, despite documentation on the effects of roads in northern areas (e.g. Banfield 1972; Cowan 1972; Jackman 1973; Theberge 1973), data specifically on winter roads is lacking.

Much of the literature on birds relates to road-related deaths (Baker 1965; Case 1978; Coulter 1975; Davis 1940; Donovan 1975; Leedy 1975) but documentation is lacking for northern areas. Birds may also be attracted to various resources provided by roads and avian populations may be modified as a result of habitat alteration (Lindsdale 1929; Goodwin 1978; Smith 1973; Weedy 1975). Predation on birds by mammalian predators searching such corridors may increase (Martz 1967, Joselyn *et al.* 1968; Carbyn 1968). Kemper *et al.* (1977) concluded that roads need not adversely affect waterfowl if proper road construction practices were followed. A major concern in any hitherto inaccessible area is access. Linsdale (1929) noted that opening of roads into new areas could endanger conspicuous species through increased access by man. In support of this contention, Kemper *et al.* (1977) noted an increase in harassment and illegal shooting of birds along the Mackenzie Highway. Weeden (1972) studied the influence of a highway on the hunting of ptarmigan, and the problems associated with illegal hunting along new roadways has been noted by Jackman (1973) and Canada Department of Public Works and U.S. Department of Transportation (1977).

To help minimize associated effects of roads on raptors or their nests, recommendations have been made to leave buffer areas around these sites (Gerrard and Gerrard 1975; Foods *et al.* 1974; Fyfe and Kemper 1975a, b; and Fyfe and Prescott 1973).

Information on reactions of mammalian populations to winter roads is also scarce. Most information documenting the responses of mammalian wildlife to cleared linear facilities relates to caribou using cleared rights-of-way as movement corridors (Klein 1971, 1972, Bergerud 1974, Renewable Resource Consulting Services Ltd. 1971, Calef & Lortie 1973, Jakimchuk 1974, Banfield 1974b, Riewe 1977).

Other ungulates such as deer and moose may be attracted to cleared rights-of-way due to early successional shrub growth which forms a major component of their diet (Kelsall & Telfer 1974, LeResche et al.1974). Some furbearers including wolves, red foxes, Arctic foxes and weasels are known to use rights-of-way for travel or hunting (Riewe 1977), whereas marten tend to avoid open areas (Wooley 1974a, Riewe 1977). Carnivores may be attracted to cleared rights-of-way as a result of the usage of seismic lines by small mammals during dispersal phases. Other effects of cut lines on small mammals include replacement of one microtine species by another (Martell 1977, cited in Mackenzie 1976; Bodner and Wooley 1974).

Potential effects of road developments on wildlife include the following and are discussed individually along with mitigation in the sub-sections below:

1) Creation of access into previously remote areas.
2) Direct disturbance to wildlife during construction or operation of the facility (particularly in nesting, critical wintering, calving or lambing areas).
3) Habitat alteration.
4) Attraction of wildlife to the new development (either to the right-of-way, or to camp facilities).
5) Interference with seasonal movements.

5.3.2 Aquatic Habitat Impact

Drainage-system integrity is critical for aquatic furbearers, waterfowl and shorebirds. General concerns for aquatic habitat relate primarily to the potential for disruption of normal drainage patterns, or to the emergent, submergent or riparian vegetation.

Waterfowl and shorebirds require aquatic habitat for both food procurement and nesting. Modification of drainage patterns or destruction of associated vegetation can seriously compromise nesting success and feeding.

For muskrat, the inter-relationship between water levels and preferred plant food species (emergents and submergents) defines habitat quality. Water level stability is critical for these animals since substantial fluctuations disrupt aquatic flora used as food, and may result in inundation of dens (high water) or freeze-out of houses and pushups (low-water).

Although beaver are to a degree capable of controlling (maintaining) water levels in a local area, their survival is also highly dependent on the integrity of existing drainages. Freeze-out may occur if water levels fall drastically, whereas sudden increases in water levels may flood bank dens. In addition, deciduous vegetation bordering these waterbodies is very important to local populations since it forms virtually the entire utilizable food source of these animals.

Mitigation

Careful attention to drainage alterations is the key to preventing loss of aquatic habitat.

5.3.3 Terrestrial Habitat Impact

Concern for terrestrial habitat centres on three major issues: fire control, protection of raptor nests (tree or cliff) and protection of ungulate winter range.

Any habitat loss due to fire is considered important. Breeding areas of those birds (primarily raptors) which habitually return to the same nest or area can be damaged, forcing the birds to relocate. Along riparian habitats, the short term impact of fire on shoreline vegetation can force beaver to abandon the area since they require deciduous forage for survival. However, it is the probability of fire damage to critical wintering habitat for ungulates which is viewed as the most serious. Fire damage to summer range may locally displace animals, however, unless the burn is extensive, they are usually capable of finding replacement range during this season, and survival is not jeopardized. However, if winter range is destroyed local populations may be seriously threatened, due to the difficulty of finding replacement range.

Severe cold, combined with restricted mobility due to snow results in particularly stressful conditions for ungulates during winter months. At this time many ungulate populations migrate to winter ranges (usually valley bottoms, or south-facing, wind-cleared slopes) where forage is relatively abundant and easily procured. Accumulating snow is usually the most influential factor in dictating the pattern of migration to winter range, and, as the snow-pack develops, animals are forced onto increasingly restricted portions of their range. These restricted, high-quality forage areas are termed "critical winter ranges" and it is on these that ungulates may concentrate or "yard" during mid to late winter, and which are generally important to local populations. In years of low snowfall or generally mild winter conditions, these islands of critical habitat may not be heavily utilized; however, in the long term they provide an essential ecological requirement for survival.

Mitigations

Where possible, critical wintering areas should be avoided by routing. In those cases where engineering or construction constraints preclude alternate route selection, right-of-way clearance (particularly of deciduous shrubs) should be minimized.

5.3.4 Disturbance and Access Impacts

Winter road construction and operation could contribute to disturbance either directly (e.g. by truck traffic or low flying aircraft), or indirectly, through increased numbers of people in sensitive areas. Population declines resulting from overhunting are often associated with new access in previously remote areas. Summer construction of the facility could disturb nesting birds. All raptor nests should be left intact. Published information on the effects of disturbance on mammals relates primarily to ungulates and identifies a range in impact severity from mild to critical (Klein 1971; Geist 1971a, 1971b, 1975; Calef & Lortie 1973; Calef 1974; Mackenzie 1976; Ward *et al.* 1973; Allen 1974; Dorrance *et al.* 1975). This literature suggests that mild disturbances may precipitate temporary withdrawal of wildlife from the area of disturbance. Animals which are continuously or more intensively stressed, however, may alter migration routes or may permanently abandon traditional range. Direct and deliberate harassment such as that from low flying aircraft has been known to result in injury, accidental death, increased energy expenditure resulting in temporary negative energy balance (with possible longer term effects), reduced feeding, spontaneous abortions and social group fragmentation, all or any of which may result in lowered reproductive rate and overall survival. In addition, harassment may increase susceptibility to diseases such as emphysema and necrobacillosis.

The effects of increased disturbance due to access and harassment are most detrimental during sensitive periods in the life cycle of wildlife populations such as nesting, rearing of young, pregnancy, calving/lambing, late winter, or when disturbing stimuli are unfamiliar, irregular, sudden, or similar to natural stimuli which evoke a disturbance response (Geist 1975).

Mitigations

Harassment of wildlife due to low-level aircraft flights should be strictly avoided. In addition, the possession of firearms and the usage of vehicles in unauthorized zones by construction personnel should be controlled and all staff responsible for road construction, trucking or mine operation should be educated to the problems involved.

5.3.5 Attraction of Animals Impact

Of prime concern is that bears and other opportunistic carnivores should not be attracted to development activities by garbage.

Mitigations

Measures such as incineration or collection and disposal of all garbage at approved sites should be adopted in order to minimize this concern. If plans are made to use salt along any portions of the road (e.g. on side hills where traction could be improved by its use) tire-chains should be used in preference, to avoid the possibility of attracting ungulates to the road. Also, personnel should not be permitted to attract, feed, pursue, or otherwise disturb any animal.

5.4 Geology and Soils

The impact of a road on the geology and soils (hereafter referred to as terrain) of an area will vary with the type and size of the road to be built. Winter roads are generally considered less destructive to the terrain than all-weather roads because of their restriction to use in the winter and the fact that a covering of snow protects the surficial materials from disturbance. However, certain precautions are still required in order to minimize the potential adverse effects. Although a winter road is used only in winter, the cleared right-of-way is present year-round and the environmental concerns must be viewed for the whole year.

The following is a summary of potential effects of the winter road on the terrain, together with pertinent mitigations:

5.4.1 Surveying and Clearing Impact

Surveying and clearing the right-of-way, particularly if carried out in the summer months, may result in the erosion of unstable surficial deposits. Permafrost terrain with a high ice content is especially sensitive due to the possibility of adversely affecting its thermal regime during clearing, thus causing the ice to melt and thermal erosion to be initiated.

Mitigation

Measures to minimize damage from surveying and clearing would include:

1) Confining equipment to the right-of-way.
2) Keeping the clearing width to the minimum required for the right-of-way.
3) Felling timber onto the right-of-way.
4) Preserving the organic mat wherever possible as it acts as an insulator and preserves the permafrost.

5.4.2 Earthwork Impact

If earthwork is required to prepare the road surface, the potential for terrain disturbance is increased considerably. Blasting will result in the destruction of certain landforms and can decrease the stability of some slopes through the removal of support at their toes. Improper disposal of rock and slash can lead to the disruption of drainage and the initiation of mass movements. Borrow and gravel pit operation results in the partial or total destruction of the landform used as a borrow source and offers the potential for erosion of borrow areas that are not reclaimed. Cuts and fills with gradients greater than the angle of repose for the given material may be affected by mass wasting and water erosion. Improper drainage facilities can allow the ponding of water and increased erosion during the summer, and the formation of icings during the winter. As with surveying and clearing operations, permafrost terrain is extremely sensitive during any earthwork phase. Levelling an area containing ice-rich permafrost in order to have a flat road bed will result in the removal of vegetation which insulates the permafrost and will lead to subsequent thermal erosion and mass movement.

Environmental damage to stretches of the road crossing organic deposits may result if road use commences prior to the freezing of the muskeg and development of a suitable snow cover.

Mitigation

Measures proposed to minimize damage from earthwork include:

1) Disposing all slash and rock debris from cuts by windrowing at the toes of fills where possible. This will create a sediment trap and help to control erosionduring the summer.
2) Excavating borrow pits so that the final contours blend with the natural landscape, where feasible.
3) Constructing fill slopes with gradients less than the angle of repose for the material.
4) When crossing areas underlain by permafrost, placing fill material directly on the undisturbed vegetation layer using end haul techniques.
5) Disposing of excess excavation material in stable locations well above high-water levels.
6) If possible, not carrying out earthmoving activities when soils are saturated.
7) Assuring that adequate drainage is provided for the road, keeping in mind that during the summer when the road is not in use, the cleared rightof-way is going to serve as a drainageway.
8) Keeping drainageways clear of woody debris.
9) Restricting construction across organic deposits until a suitable snow cover is established and the muskeg is frozen.

5.4.3 Snow Disposal Impact

Snow disposal may result in problems if large snow dumps are allowed to form, especially on poorly drained materials. Snow melt will result in saturation of these materials and possible mass wasting.

Mitigation

Snow dumps should be made as small as possible.

5.5 Socio-Economics

5.5.1 Introduction

Social and economic concerns are not specifically dealt with in government guidelines but general principles have been established by the N.W.T. Government and the Federal authorities.

In essence, the requirements of government with respect to social and economic issues are intended to minimize the disruption of existing communities and to maximum the social and economic benefits resulting from any proposed project, at both the local and regional levels. These objectives would be realized primarily by controlling the nature and location of settlements arising from resource development, by encouraging the employment of local labour, and by making use of local goods and services.

5.5.2 Study Methods

The study was carried out as a field exercise, supported by limited review of documents and publications which offered information on government requirements and descriptions of the Study Area. The field study programme involved two visits to Yellowknife, where discussions were held with various departments of the N.W.T. Government and Federal Agencies, and a more limited visit to the Study Area itself, where discussions were held with local officials and interested citizens. Contacts were made in Fort Simpson and Fort Liard, and the interests of Nahanni Butte were assumed to be represented by the contacts made in the two major communities.

The interview - discussions were carried out by two senior professionals, who made 25 contacts over a period of 6 days in total. The contacts are listed in Appendix C.

Although the spokesman for the Dene Nation in Fort Simpson declined to meet with the interviewer, contact has been made with the Dene Council in both Fort Simpson and Fort Liard by Cadillac Explorations Limited; Mr. Deneron (Fort Liard) has expressed support for the proposal. Due to limitations of time it was not possible to meet with the outfitter operating the corridor area, but, similarly, previous contact by Cadillac has not revealed any strong opposition. The Superintendent of Nahanni Park was not available during the period of the field trip.

5.5.3 Impacts - Issues and Concerns

The study identified the following areas of concern regarding the proposed winter road:

- new access to the road corridor area
- extended access into the area generally
- possible settlement in the corridor

- possible settlement at the Liard Highway junction
- possible loss of benefits by not having the road terminate at an existing community and by not using one of the existing airstrips (Fort Simpson and Fort Liard)
- possible problems with air service due to variable weather conditions in the air corridor between the Mine and an airstrip
- possible problems for trappers due to increased air and road traffic
- desire to have local businessess benefit from the road-airstrip construction and maintenance.
- desire to have employment offered to local residents.

The question of access into new areas and the corridor itself appears to be more pertinent to the future than to the present. The issue would become more important when the Liard Highway was completed and some measure of tourist traffic was generated.

The question of settlement in the corridor and at the road terminus is one which could create some concern. At Prairie Creek the mine ownership of the property should discourage other settlement. Within the corridor, the attractiveness of the potential settlement locations is a function of the road access rather than of the natural attributes of the corridor itself. The eastern terminus at the Liard River, however, could attract some settlement by virtue of its location at a transport node if an airstrip should be built. The population which could contribute to such settlement is not large, if the new settlement results from an outflow from existing communities. However, this potential source of settlement could be augmented from beyond the immediate region as well as from the work force employed at the Cadillac mine.

The alignment of the road and its terminus are of importance relative to the desire to have new developments integrated with existing communities. On the surface, the establishment of a new airstrip at a location between two existing strips, one of which is at a larger design capacity and the other of which is currently being expanded, might be questioned. However, the economic consequences of terminating the road and constructing an airstrip at either Fort Simpson or Fort Liard would be substantial. A more southerly route than planned might require additional river crossings and would lengthen the route considerably; a more northerly alternative would lengthen the haul distance from both the mine to the road terminus and from the terminus to the final destination.

Any problem of air safety in the flight corridor, as related to weather conditions, is not restricted to this particular corridor. So far as is known, the corridor does not have a unique weather regime, and the problems of variable weather over small sub-areas are common to much of the Territory. Consequently, the problem, to the extent it exists, is not amenable to solution by realignment, but can be dealt with by the usual procedures of carrying out weather observations, exchanging information between points of observation, and acquiring experience with local conditions.

The impact on the trappers running lines in the area traversed by the eastern end of the proposed road is related to the traffic flow anticipated on the road and to the improved access provided. Some concerns might be felt regarding the noise of flights although this would likely only be significant in the immediate vicinity of the strip, and evidence elsewhere indicates that air traffic of moderate volume does not influence the productivity of traplines. The matter of access is double-edged; it does allow easier access and so raises the possible level of harvesting which may affect game and fur-bearer populations, but at the same time the improved access aids the trapper working the area by reducing the time and cost of getting to his lines.

The last issues addressed are the employment of local labour and the utilization of local goods and services. These concerns are central to the N.W.T. Government's policy on resource development. The region contains five communities, only two of which are significant in terms of population and infrastructure:

Population in Study Region

	1977	1978	1979
Fort Simpson	1,103	1,080	1,001
Jean Marie River	49	48	49
Wrigley	174	175	163
Nahanni Butte	96	94	92
Fort Liard	325	327	344

Conditions in these centres are favourable for the implementation of government policy regarding use of local services.

The current construction programme on the Liard Highway and other activities have encouraged the development of local managerial and operation skills, and a good potential exists for securing maintenance and construction contracts on the road and airstrip projects.

5.5.4 Summary of Socio-Economic Impacts

The concerns identified in Section 5.5.3 cover a wide range of topics. However, only a few of the concerns were either expressed by a large number of those interviewed or considered to have major implications.

In general, the proposed winter road corridor was not seen as a major source of problems. The small local population, the present satisfactory pattern of resource use in other areas and the uncertainties regarding the eventual impact of the Liard Highway, all tend to reduce the levels of concern of this winter road.

The concerns related to potential settlement in the corridor or at a possible airstrip were raised primarily by government officials. The expressed desire was to forestall any haphazard settlement that could lead to the establishment of a new community by accretion, with resulting problems of servicing.

At both Fort Simpson and Fort Liard, there appeared to be a general acceptance of the proposed alignment decision. In these communities, the concern was directed more toward spin-off benefits that could be anticipated than a wish to have the road terminate at one or other of the two communities.

Additionally, in the case of Fort Liard, there was a suggestion that growth pressures were already substantial, and that growth at this time could prove more harmful than beneficial.

The respondents were unanimous over the use of local goods, services and labour. Fort Liard has hosted a substantial employment-training camp, organized as part of the HIRE NORTH programme. Under this programme people have been trained for highway construction. The government is looking for follow-up activities to support the continuation of the programme. In Fort Liard, Beaver Enterprises has been successfully handling various contracts ranging from clearing to maintenance. This firm has been able to employ and train a significant number of local residents, and experience has been accumulated on the management and operational sides.

Mitigation

Although the sociological impact of the winter road is expected to be minimal, the following measures would maximize the benefits to the local economy:

1) Through discussions with Hire North and with local businessmen such as Beaver Enterprises, the Proponent should invite local interests to bid on contracts related to the project.
2) The Proponent, in co-operation with local business and government, should offer employment to suitable residents and provide training and counselling if required.
3) The Proponent should utilize local goods and services wherever possible.

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TABLE 1

Route Details

Mile	Km	Elevation (ft.)	Average Grade (%)	Comments	
0	0	2875		Mine site.	
			+ .7	Mile 0 to 1.9 - road principally on Prairie Creek floodplain.	
1		2910		Mile @ 1.9 to 2.3 - cut.	
			+ .8		
2		2950		Mile @ 2.3 to 3.8 - road on Prairie Creek floodplain.	
			+ .5	Mile @ 3.8 to 4.8 - road on ice in Prairie Creek tributary valley bottom.	
3		2975			
			+1.4	<u>Note</u>: approximately 0.4 miles of cut in rock, weathered rock and overburden between mile 0 and 4.8.	0.4 mi 0.64 km
4		3050			
			+4.7	Mile @ 4.8 - begin roadway cut in south facing slope of stream valley.	
5	8	3300			
			+6.6		
6		3650		Mile @ 6.2 - ice bridge or native fill to cross small gulley.	
			+8.0		
7		4100			
			+8.0	Km 12.8	
8		4550		Mile 8.0 - first pass - elevation @ 4500 ft.	
			+4.7	5.9	
9		4800		<u>Note</u>: approximately 3.7 miles of cut in weathered rock and/or overburden and rock between miles 4.8 and 11.0.	4.1 mi 6.6 km
			+3.8	Km 16.0 - 17.6	
10	16	5000			
			-3.8	Mile @ 10.0 to 11.0 - second pass - maximum elevation @ 5000 ft. 1524 m	

(Table 1 - cont'd)

	Km			
11		4800		Mile @ 11.0 - cross headwaters of "South" Stream to alignment on north bank of the stream.
			-7.1	
12		4425		
			-5.2	
13		4150		
			-5.7	
14		3850		
			-4.3	Km 24.3
15	24	3625		Mile @ 15.2 - some rock work may be necessary when passing the falls (excarpment) on the "South" stream.
			-3.3	
16		3450		
			-3.8	
17		3250		Mile @ 17.5 - stream crossing.
			-2.4	13.0 Km
18		3125		Note: approximately 8.1 miles of cut in overburden, weathered rock and rock between miles 11.0 and 19.3. 12.2 mi 19.5 km
			-2.8	Km 17.6 Km 30.9
19		2975		Mile @ 19.3 - enter floodplain of Sundog Creek tributary. Mile @ 19.3 to 23.4 - roadway on floodplain.
			-1.4	
20	32	2900		Mile @ 20.7 - crossing of "North" Stream onto floodplain of Sundog Creek tributary.
			-1.9	
21		2800		
			- .9	
22		2750		
			-1.9	Mile @ 22.2 - crossing of mouth of tributary stream.
23		2650		
			0	Mile @ 23.4 - stream crossing and enter valley of tributary stream.
24		2650		

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	Km			
			+ .9	Mile @ 24.0 to 24.6 several stream crossings and/or alignment in stream course.
25	40	2700		
			+1.9	
26		2800		Mile @ 26.0 to 26.2 - two stream crossings.
			+ .9	
27		2850		Mile @ 27.1 stream crossing.
			-4.3	Mile @ 27.7 stream crossing.
28		2625		Mile @ 27.9 stream crossing. [5.6 km]
			-1.4	Note: approximately 3.5 miles of cut and/or fill in overburden and weathered rock between miles 23.4 and 27.9. [15.7 mi] [25.1 km] [Km 37.4] [Km 44.6]
29		2550		Mile @ 29.2 stream crossing.
			0	
30	48	2550		Mile @ 30.2 stream crossing.
			-1.9	
31		2450		Mile @ 31.0 stream crossing.
			0	Mile @ 31.6 stream crossing.
32		2450		Mile @ 32.0 stream crossing.
			+2.4	
33		2575		
			+5.2	
34		2850		Mile @ 34.0 stream crossing.
			+2.8	
35	56	3000		Mile @ 35.9 stream crossing.
			+3.8	[6.6 km]
36		3200		Note: approximately 4.1 miles of moderate cut and/or fill in overburden or weathered rock between miles 34.0 and 36.5. [19.8 mi] [31.7 km] [Km 54.4]
			+ .5	[Km 58.4]
37		3225		
			-2.4	
38		3100		
			0	
39		3100		
			0	

(Table 1 - cont'd)

	Km			
40	64	3100	+ .9	
41		3150	-1.4	
42		3075	- .5	
43		3050	-1.9	
44		2950	-6.6	
45	72	2600	+1.9	Mile @ 45.2 - stream crossing. Sundog Trib.
46		2700	-4.7	
47		2450	-8.0	
48		2000	-7.6	
49		1600	-5.7	Km 79.8 Mile @ 49.9 - stream crossing. Tetcela
50	80	1300	-3.8	
51		1100	-3.8	Km 81.9 Mile @ 51.2 - stream crossing. Tetcela Mile @ 51.8 - stream crossing. Km 82.9
52		900	0	
53		900	- .9	Note: muskeg area between approximately miles 54.0 and 55.2.
54		850	-1.9	
55	88	750	+5.7	Mile @ 55.1 stream crossing. Fishtrap
56		1050	+8.0	

(Table 1 - cont'd)

	Km			
57		1500		[4.6 km]
			+4.7	**Note:** approximately 2.9 miles of cut and/or fill between miles 55.2 and 58.1 (top of Silent Hills Pass). [Km 98.3 - 93.0] [22.7 mi 36.3 km]
58		1750		
			-2.8	
59		1600		
			- .9	
60	96 km	1550		Mile @ 59.5 - stream crossing.
			0	
61		1550		
			0	
62		1550		
			+ .5	
63		1575		Mile @ 63.0 - stream crossing.
			0	Mile @ 63.3 - stream crossing.
64		1575		Mile @ 63.9 - stream crossing.
			+ .5	Mile @ 64.4 - stream crossing.
65	104	1600		Mile @ 64.6 - stream crossing.
			+2.8	
66		1750		
			+3.8	
67		1950		[2.1 km]
			-1.4	**Note:** approximately 1.3 miles of cut and/or fill between miles 65.7 and 67.0. [km 105.1] [24.0 mi 38.4 km]
68		1875		[km 107.2]
			-1.4	
69		1800		[km 110.9]
			- .5	Mile 69.3 - stream crossing.
70	112	1775		
			-2.4	Grainger Pass.
71		1650		
			-1.4	
72		1575		

(Table 1 - cont'd)

NOTES

1. Existing winter roads and seismic lines will be used between Grainger Pass and the Liard River (approximately 26 miles @ elevation approximately 700 ft.).

2. Total length of road between the Cadillac Mine and the Liard River crossing - approximately 98 miles. 156.8 km

3. Approximately 23 miles of this route require cut and/or fill construction in rock, weathered rock or overburden.

36.8 km

23% cut & fill

(Table 1 - cont'd)

NORTHERN ALTERNATES

Mile	Elevation (ft.)	Average Grade (%)	Comments
10N	4900		
		-4.3	
11N	4675		
		-6.2	Mile @ 11.5N - cross headwaters of "North" Stream to alignment on north bank of stream.
12N	4350		
		-3.8	
13N	4150		
		- .9	
14N	4100		
		-2.8	
15N	3950		Mile @ 15.6N - stream crossing.
		-3.8	
16N	3750		Mile @ 16.1N - some rock work may be necessary at escarpment.
		-3.8	
17N	3550		Mile @ 17.9N - stream crossing.
		-4.7	
18N	3300		
		-4.7	
19N	3050		Mile @ 19.4N - stream crossing.
		-1.9	
20N	2950		Mile @ 20.9N - enter floodplain of Sundog Creek tributary. Note: approximately 9.3 miles of cut in weathered rock, rock and overburden between miles 11.5N and 20.9N.
35N	3000		Mile @ 34.9N - stream crossing.
		+3.8	
36N	3200		Mile @ 36.2N - stream crossing.
		- .9	

(Table 1 - cont'd)

37N	3150		<u>Note</u>: approximately 2.5 miles of cut and/or fill in rock, weathered rock and overburden between miles 34.9N and 39.0N.
		-1.9	
38N	3050		
54N	850		
		- .9	
55N	800		
		+3.8	Mile @ 55.6N - stream crossing.
56N	1000		
		+4.7	Mile @ 56.7N - stream crossing.
57N	1250		Mile @ 57.0N - stream crossing.
		+1.9	
58N	1350		<u>Note</u>: approximately 2.7 miles of cut and/or fill in weathered rock, rock and overburden between miles 55.0N and 59.0N.
		+3.8	
59N	1550		

TABLE 2

Grade Breakdown for Main (South) Route (Measured from Mine Site)

Grade	Per Cent of Route	Comments
+8% to +5%	6.3%	Upgrade for loaded trucks from mine.
+5% to +2%	9.5%	
+2% to -2%	63.1%	
-2% to -5%	13.7%	Upgrade for empty trucks to mine.
-5% to -8%	7.4%	

TABLE 3

Comparison of Route Variations with Main Route

Mileage	Average Gradient	Comments
10 - 21	Main (south) route - 4.0% Alt. (north) route - 3.7%	Alternate (north) route is approximately 0.1 miles shorter, has slightly shallower gradients and fewer difficulties with construction over the rock escarpment (falls on main (south) route.
34.5 - 38.5	Main (south) route - 2.2% Alt. (north) route - 2.2%	Both routes essentially the same length. "Loaded" grades on alt (North) route are slightly better.
53 - 57	Main (south) route - 5.2% Alt. (north) route - 3.0%	Alternate (north) route is approximately 2 miles longer than main (south) route, but grades on alternate are more favourable.

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Table 4

CLIMATOLOGICAL STATION DATA CATALOGUE

Station Number	Station Name (+ Indicates part of record under another name.)	Province	Latitude ° '	Longitude ° '	Elevation (feet)	Periods with no change in program, location or name (*indicates summer only) Began year mo.	Ended year mo.	OBSERVING PROGRAMME: Synoptic Report	Hourly Weather	Temperature	Precipitation	Rate of Rainfall	Wind Mileage	Soil Temperature	Evaporation	Sunshine	Radiation	Ozone	Upper Air	Snow Survey	Tower	Air Quality	1	2	3	4	Region
2100610	FRANCES LAKE	YT	61 17	129 24	2425	1941 10	1947 09	X	P	X	X		B														W
2100610	FRANCES LAKE	YT	61 17	129 24	2425	1947 10	1948 05	X	P	X	X																W
2100610	FRANCES LAKE	YT	61 17	129 24	2425	1948 09	1949 05			X	X																W
2100612	FRANCES RIVER	YT	60 29	129 08	2274	1973 10						S															W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1938 10	1938 10	X	P	X	X																W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1938 11	1942 02	X	P	X	X		B														W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1942 04	1964 11	X	X	X	X		B														W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1964 12	1966 12	X	X	X	X		B							V							W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1967 01	1969 05	X	X	X	X									V							W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1969 06	1969 09	X	X	X	X					S				V							W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1969 10		X	X	X	X	X		D		S				V							W
2200597	CADILLAC MINE	NWT	61 32	124 45	2850	1970 01	1970 11			X	X																W
2200620	CAN TUNG	NWT	62 01	128 21	6000	1973 10						S															W
2202098	FORT SIMPSON	NWT	61 52	121 13	572	1943 03	1943 07	X	P	X	X																W
2202098	FORT SIMPSON	NWT	61 52	121 13	572	1944 02	1946 07	X	P	X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1875 05	1875 11			X																	W
2202099	FORT SIMPSON	NWT	61 52	121 35		1876 11	1877 03			X																	W
2202099	FORT SIMPSON	NWT	61 52	121 35		1877 12	1878 03			X																	W
2202099	FORT SIMPSON	NWT	61 52	121 35		1878 10	1879 05			X																	W
2202099	FORT SIMPSON	NWT	61 52	121 35		1895 11	1895 12			X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1897 03	1902 12			X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1903 05	1904 06			X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1905 01	1908 06			X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1908 07	1921 06	X	P	X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1922 08	1927 10	X	P	X	X																W

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(Table 4 - cont'd)

CLIMATOLOGICAL STATION DATA CATALOGUE

Station Number	Station Name (+ Indicates part of record under another name.)	Province	Latitude ° '	Longitude ° '	Elevation (feet)	Periods with no change in program, location or name (*indicates summer only) Began year mo.	Ended year mo.	Synoptic Report	Hourly Weather	Temperature	Precipitation	Rate of Rainfall	Wind Mileage	Soil Temperature	Evaporation	Sunshine	Radiation	Ozone	Upper Air	Snow Survey	Tower	Air Quality	1	2	3	4	Region
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1927 06	1952 01	X	B	X	X																W
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1952 02	1952 08	X	B	X	X					S											W
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1952 09	1952 12	X	B	X	X		B			S											W
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1953 01	1954 02	X	B	X	X		B														W
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1954 03	1955 03	X	B	X	X		B				A										W
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1955 04	1963 10	X	X	X	X		B			S	A										W
2202100	FORT SIMPSON	NWT	61 52	121 21	432	1963 11	1964 05									S	A										W
2202100	FORT SIMPSON	NWT	61 52	121 21	432	1964 06										S											W
2202101	FORT SIMPSON A	NWT	61 45	121 14	576	1963 11	1966 10	X	X	X	X		B														W
2202101	FORT SIMPSON A	NWT	61 45	121 14	576	1966 10	1966 12	X	X	X	X		B							V							W
2202101	FORT SIMPSON A	NWT	61 45	121 14	576	1967 01	1969 05	X	X	X	X									V							W
2202101	FORT SIMPSON A	NWT	61 45	121 14	576	1969 05		X	X	X	X	X								V		B					W
2202723	NAHANNI BUTTE	NWT	61 05	123 23	4500	1974 06 *				X	X																W
2202725	NAHANNI HOT SPRINGS	NWT	61 15	124 02	2000	1973 08						S															W
2202727	NAHANNI VALLEY	NWT	61 03	123 22	700	1974 05				X	X																W
2203922	TUNGSTEN	NWT	61 57	128 15	3750	1966 10	1975 06			X	X																W
2203922	TUNGSTEN	NWT	61 57	128 15	3750	1975 06				X	X	X	B														W
2203943	VIRGINIA FALLS	NWT	61 38	125 48	2000	1973 08						S															W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1943 08	1946 09	X	P	X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1946 10	1946 10		P																		W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1947 06	1947 10	X	P	X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1948 07	1950 09	X	P	X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1950 10	1952 10			X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1953 03	1955 09			X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1955 10	1956 12		D	X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1957 01	1957 06		D	X	X		B														W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1957 07	1958 04		D	X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1958 05			D	X	X		B														W

Table 5

Climate Summary

Station		J	F	M	A	M	J	J	A	S	O	N	D	Year
Cadillac Study Area [1]	T	-15	-9	8	23	43	55	58	54	42	23	1	-10	23
	P	0.9	0.9	0.8	0.7	2.1	2.0	2.2	2.0	1.5	1.0	1.0	1.0	16.1
	E	-	-	-	-	< 1	3	4	3	2	< 1	-	-	13
Watson Lake [2]	T	-14	-1	13	31	45	56	59	55	46	32	8	-9	27
	R	-	-	-	0.1	0.8	1.9	2.1	1.8	1.6	0.6	0.1	-	9
	P	1.4	1.1	0.9	0.7	0.9	1.9	2.1	1.8	1.7	1.4	1.5	1.6	17

Legend

T - mean daily temperature, ^{o}F

R - monthly rainfall, inches

P - monthly precipitation, inches

E - monthly lake evaporation, inches

1 - from Atmospheric Environment Service, Climate Maps (formerly Department of Transport, Meteorological Branch).

2 - from Atmospheric Environment Service, long term abstract listings

Table 6 Surface Water Data - Reference Index

NORTHWEST TERRITORIES

STATION NO.		DRAINAGE AREA (km²)	GAUGE LOCATION	DISCHARGE RECORDS (*-STAGE ONLY #-MISC.MEAS.) TYPE OF GAUGE , OPERATION	REMARKS
10FA002	. TROUT RIVER AT FORT SIMPSON HIGHWAY	9 090	61 08 00 119 49 30	69-79 RC	6 NAT
10FB005	. JEAN-MARIE RIVER AT FORT SIMPSON HIGHWAY	1 310	61 27 00 121 15 00	72-73 M# 74-79 MC	NAT
10ED001	. LIARD RIVER AT FORT LIARD	222 000	60 14 35 123 28 45	42-58*HS 59 MS 60-62 MC 63-64 MS 65 MC 66-79 RC	7 5 NAT
10ED002	. LIARD RIVER NEAR THE MOUTH	277 000	61 44 50 121 13 25	72-79 RC	6 NAT
10ED004	. . RABBIT CREEK AT FORT LIARD HIGHWAY	120	60 27 45 123 24 15	78-79 RC	NAT
10EB001	. . SOUTH NAHANNI RIVER ABOVE VIRGINIA FALLS	14 600	61 38 00 125 48 00	60-63 RS 64-65 RC 66-67 RS 68-79 RC	7 NAT
10EC001	. . SOUTH NAHANNI RIVER NEAR HOT SPRINGS	33 400	61 15 10 124 02 10	59-62 RS 63-79 RC	5 NAT
10EB002	. . . . MAC CREEK NEAR THE MOUTH	214	62 12 00 128 45 10	78-79 RC	NAT
10EA002	. . . FLAT RIVER AT CANTUNG CAMP	152	61 57 40 128 13 00	59 # 60-62 MS 63 # 73-79 RC	5 NAT
10EA003	. . . FLAT RIVER NEAR THE MOUTH	8 500	61 32 00 125 24 20	60-65 RC 66-71 RS 72-79 RC	5 NAT
10EC002	. . . PRAIRIE CREEK AT CADILLAC MINE	495	61 33 40 124 48 25	74-79 RC	NAT
10ED003	. . BIRCH RIVER AT FORT LIARD HIGHWAY	505	61 20 10 122 05 20	74-79 RC	NAT
10GC002	. HARRIS RIVER NEAR THE MOUTH	570	61 52 41 121 17 36	72 R# 73-79 RC	6 NAT
10GC003	. MARTIN RIVER NEAR THE MOUTH	2 040	61 53 10 121 37 05	72-79 RC	6 NAT
10GA001	. ROOT RIVER NEAR THE MOUTH	9 840	62 28 40 123 25 45	74 RS 75-79 RC	7 NAT
10HB003	. WRIGLEY RIVER NEAR THE MOUTH	1 260	63 14 15 123 36 20	76-79 RC	NAT
10HB001	. REDSTONE RIVER NEAR THE MOUTH	15 400	63 55 37 125 18 07	63-64 RC 65-70 RS 71-79 RC	5 NAT
10HA002	. . TSICHU RIVER AT CANOL ROAD	222	63 18 10 129 47 30	75-79 RC	NAT
10AA001	. LIARD RIVER AT UPPER CROSSING	33 400	60 03 00 128 54 00	60-76 MC 77-79 RC	5 NAT
10AB001	. . FRANCES RIVER NEAR WATSON LAKE	12 800	60 28 26 129 07 08	62 M# 63-79 RC	5 NAT
10AB003	. . . KING CREEK AT KILOMETRE 20.9 NAHANNI RANGE ROAD	13.7	60 56 50 128 55 40	75-79 RC	NAT
10AA002	. . TOM CREEK AT KILOMETRE 34.9 ROBERT CAMPBELL HIGHWAY	435	60 17 26 129 01 14	74-79 RC	NAT
10AD002	. . HYLAND RIVER AT KILOMETRE 108.5 NAHANNI RANGE ROAD	2 150	61 29 00 128 14 10	76-79 RC	NAT
10BD001	. . BEAVER RIVER BELOW WHITEFISH RIVER	7 280	60 07 52 124 53 21	77-79 RC	NAT

M - MANUAL GAUGE
R - RECORDING GAUGE

C - CONTINUOUS OPERATION
S - SEASONAL OPERATION

5 - WATER QUALITY DATA AVAILABLE

7 - SATELLITE DATA COLLECTION PLATFORM INSTALLED

NAT - NATURAL FLOW
REG - REGULATED SINCE 19 . . (YEAR SHOWN IF KNOWN)

TABLE 7

SIGNIFICANT SIZE AQUATIC SYSTEMS TRAVERSED BY THE PROPOSED WINTER ROAD

LIARD RIVER SYSTEM

Watercourse	Location (mi.)	Watercourse	Location (mi.)
Liard River	97.7	unnamed creek	83.4
unnamed creek	90.9	unnamed creek	81.4
Grainger River	85.0	unnamed creek	79.8
unnamed creek	84.9	unnamed creek	78.1

NORTH NAHANNI RIVER SYSTEM

Watercourse	Location (mi.)	Watercourse	Location (mi.)
***unnamed creek	59.5	*unnamed creek	26.0
*Tetcela River	51.2+51.8	*unnamed creek	24.3
***unnamed creek	32.0	***unnamed creek	23.1
*unnamed creek	29.2	***unnamed creek	22.2
		*unnamed creek	20.7
*unnamed creek	27.8	***unnamed creek	17.9N

SOUTH NAHANNI RIVER SYSTEM

Watercourse	Location (mi.)
**Fishtrap Creek	55.1
*unnamed creek	4.0
Prairie Creek	(not crossed)

*Inspected Upstream of Final Alignment Selected

**Inspected Downstream of Final Alignment Selected

***Not Inspected

TABLE 8

FISH SPECIES REPORTED FROM DRAINAGE SYSTEMS OF THE PROPOSED WINTER ROAD

COMMON NAME	SCIENTIFIC NAME	SOUTH NAHANNI	LIARD	NORTH NAHANNI	MACKENZIE
arctic lamprey	*Lampeta japonica*				X
chum salmon	*Oncorhynchus keta*		X		X
Dolly Varden char	*Salvelinus malma*	X	X		X
lake trout	*Salvelinus namaycush*	X	X		X
lake cisco	*Coregonus artedii*		X		X
arctic cisco	*Coregonus autumnalis*				X
least cisco	*Coregonus sardinella*			X	X
lake whitefish	*Coregonus clupeaformis*	X	X	X[1]	X
broad whitefish	*Coregonus nasus*				X
pygmy whitefish	*Prosopium coulteri*		X		X
round whitefish	*Prosopium cylindraceum*	X	X	X	X
mountain whitefish	*Prosopium williamsoni*		X		X
inconnu	*Stenodus leucichthys*	X	X		X
arctic grayling	*Thymallus arcticus*	X	X	X	X
goldeye	*Hiodon alosoides*		X		X
northern pike	*Esox lucius*	X	X		X
northern redbelly dace	*Chrosomus eos*				X
finescale dace	*Phoxinus neogaeus*		X		X
lake chub	*Couesius plumbeus*	X	X	X	X
emerald shiner	*Notropis atherinoides*		X		X
spottail shiner	*Notropis hudsonius*	X	X		X
flathead chub	*Platygobio gracilis*		X	X	X
longnose dace	*Rhinichthys cataractae*	X	X	X	X
longnose sucker	*Catastomus catastomus*	X	X	X	X
white sucker	*Catastomus commersoni*	X	X		X
burbot	*Lota lota*	X	X		X
brook stickleback	*Culaea inconstans*		X		X
ninespine stickleback	*Pungitius pungitius*		X		X
trout-perch	*Percopsis omiscomaycus*	X	X		X
yellow walleye	*Stizostedium vitreum vitreum*		X		X
slimy sculpin	*Cottus cognatus*	X	X	X	X
spoonhead sculpin	*Cottus ricei*		X		X

[1] At mouth.

Sources: Scotter *et al.* 1971; Stein *et al.* 1973; Hatfield *et al.* 1972b; Dryden *et al.* 1973; R.D. Wickstrom (pers. comm.).

TABLE 9

INVERTEBRATE ORDERS AND FAMILIES FOUND TO BE IMPORTANT FOOD ITEMS (TEN PERCENT OR MORE BY PERCENT OCCURRENCE) IN THE MACKENZIE VALLEY FOR PROMINENT FISH SPECIES

ARCTIC GRAYLING	LAKE WHITEFISH	NORTHERN PIKE
Hymenoptera	Diptera	Ephemeroptera
Ephemeroptera	Chironomidae	
Trichoptera	Hemiptera	
Copepoda	Corixidae	
Collembola		
Diptera		
Chironomidae		
Coleoptera		
Staphylinidae		
Hemiptera		
Corixidae		
Arachnidae		

WHITE SUCKER	YELLOW WALLEYE	BURBOT
Diptera	Trichoptera	Plecoptera
Chironomidae	(less than 10 percent)	Nemouridae
(less than 10 percent)		Diptera
		Chironomidae

TABLE 10

AQUATIC INVERTEBRATES OF THE LIARD RIVER

INSECTA

Ephemeroptera

Baetis sp.
Caenis sp.
Ephemerella sp.
Heptagenia sp.

Plecoptera

Arcynopteryx compacta McLachlan
Hastaperla sp.
Isogenus frontalis Newman
Isogenus sp.
Nemoura sp.
Perlodidae
Pteronarcella badia Hagen

Trichoptera

Arctopsyche sp.
Hydropsyche sp.

Diptera

Chironomidae
Tanypodinae
Nilotanypus sp.
Chironominae
Stictochironomus sp.
Cladotanytarsus sp.
Orhtocladiinae
Brillia sp.
Corynoneura sp.
Crictopus sp.
Eukiefferiella sp.
Eurycnemus sp.
Orthocladius sp.

TABLE 10 (Continued)

Thienemanniella sp.
Orthorcladiinae
Diamesinae
Prodiamesa sp.
Diamesinae
Simuliidae
Simulium arcticum Mall.
Simulium sp.
Empididae
Hemerodromia sp.

From Wiens *et al.* 1975

TABLE 11

SUMMARY OF APRIL, 1980 OBSERVATIONS OF SIGNIFICANT SIZE WATERCOURSES CROSSED BY THE PROPOSED WINTER ROAD

		OPEN WATER HABITAT POTENTIAL					OVERWINTERING POTENTIAL			LIMITING FACTORS			
Watercourse	Mileage Post	High	Mod.	Low	Nil	Undeter.	Suspected	Nil	Undeter.	Steep Grad.	Obstruc.	Inadequate Disch. or Low Water Lev.	Dry
Liard River	97.7	x	x				x						
unnamed Creek	90.9				x			x					x
Grainger River	85.0		x						x				
unnamed creek	84.9				x			x					x
unnamed creek	83.4				x			x			x	x	
unnamed creek	81.4			x			x				x		
unnamed creek	79.8					x			x	x			
unnamed creek	78.1			x					x	x			
***unnamed creek	59.5					x			x				
**Fishtrap Creek	55.1		x	x					x		x		
*Tetcela River	51.2+51.8		x						x				
***unnamed creek	32.0					x			x				
*unnamed creek	29.2				x			x					x
*unnamed creek	27.8					x			x				
*unnamed creek	26.0				x			x					x
*unnamed creek	24.3				x			x					x
***unnamed creek	23.1					x			x				
***unnamed creek	22.2					x			x				
*unnamed creek	20.7				x			x					x
***unnamed creek	17.9N					x			x				
*unnamed creek	4.0				x			x		x			
Prairie Creek	(not crossed)		x	x			x						

*Inspected upstream of final alignment selected

**Inspected downstream of final alignment selected

***Not inspected

TABLE 12

WATER QUALITY OF SELECTED SIGNIFICANT SIZE WATERCOURSES CROSSED BY THE PROPOSED CADILLAC MINES WINTER ROAD

Watercourse	Alignment Mileage Post	pH	Dissolved O_2 (Mg/l % sat).	Temp. (C°)	Water Color
Liard River	97.7	7.8[1]	12[1]/97	5[1]	light grey[1]
unnamed creek	90.9	dry			
Grainger River	85.0	7.6	11/78	0	colorless
unnamed creek	84.9	dry			
unnamed creek	83.4	dry			
unnamed creek	81.4	7.4	12/84	0	pale yellow
unnamed creek	79.8	7.4[2]	13[2]/95	0[2]	pale yellow
unnamed creek	78.1	7.4	13[2]/95	0[2]	pale yellow
**Fishtrap Creek	55.1	7.0	10/73	0	pale yellow
* Tetcela River	51.2+ 51.8	7.4	13/96	0	pale yellow
***unnamed creek	32.0	frozen			
*unnamed creek	29.2	dry			
*unnamed creek	26.0	dry			
*unnamed creek	24.3	dry			
***unnamed creek	22.2				
*unnamed creek	20.7	dry			
Prairie Creek	(NOT CROSSED)	7.7	12/89	0	colorless

1 Water quality results from meltwater side channel.

2 Water samples taken below confluence of unnamed creeks at MP 79.8 and 78.1

* Inspected Upstream of Final Alignment Selected

** Inspected Downstream of Final Alignment Selected.

*** Not inspected

TABLE 13

CHRONOLOGIC OBSERVATIONS[1] OF BIRDS AND MAMMALS (AND MAMMAL TRACKS) DURING RECONNAISSANCE OF THE CADILLAC MINESITE AND PROPOSED WINTER ROAD (APRIL 14-16, 1980)

OBSERVATION[2]			LOCATION
1 Dall's sheep (ewe)	Area[4]	A	Caribou Flats
1 Golden Eagle	Area	A	Caribou Flats
9 Ptarmigan	Area	A	Caribou Flats
Marten tracks	Area	A	Caribou Flats
Moose tracks	Area	A	Caribou Flats
1 Gray Jay	Area	C	Cadillac Minesite and Camp
2 Arctic Ground Squirrel	Area	C	Cadillac Minesite and Camp
3 Red Squirrel	Area	C	Cadillac Minesite and Camp
2 Ptarmigan	Area	D	Southwest of Camp
1 Moose	—		Grainger River, east of Grainger River Pass
1 Golden Eagle[3]	—		East of Airfield (southeast of Grainger River Pass)
1 Black Bear	—		In vicinity of proposed alignment, along Grainger River, east of Bluefish Lake.

1 Observations made by BEAK biologists unless otherwise noted. All observations are given in Figure 14.

2 See Tables 14 and 15 for scientific names.

3 Observed by B. Fletcher and R. Wilson, Golder Associates, Vancouver Ltd. April 15, 1980.

4 See Figure 14 for delineation of areas.

MAMMALS

TABLE 14

PROVISIONAL CHECK LIST OF MAMMALS IN THE VICINITY OF THE PROPOSED CADILLAC MINES WINTER ROAD, N.W.T.[1]

COMMON NAME	SCIENTIFIC NAME[2]
SORICIDAE	
Masked Shrew*	*Sorex cinereus*
American Water Shrew*	*Sorex palustris*
Arctic Shrew	*Sorex arcticus*
Vagrant Shrew*	*Sorex vagrans*
Pygmy Shrew	*Microsorex hoyi*
VESPERTILIONIDAE	
Little Brown Bat*	*Myotis lucifugus*
LEPORIDAE	
Snowshoe Hare*	*Lepus americanus*
OCHOTONIDAE	
Collared pika*	*Ochotona collaris*
SCIURIDAE	
Least Chipmunk*	*Eutamias minimus*
Woodchuck	*Marmota monax*
Hoary Marmot*	*Marmota caligata*
American Red Squirrel*	*Tamiasciurus hudsonicus*
Northern Flying Squirrel*	*Glaucomys sabrinus*
Arctic Ground Squirrel*	*Spermophilus parryii*

1 Based on distributional information contained in Banfield (1974), Youngman (1968, 1975), Scotter et. al. (1971)

2 Nomenclature from Banfield (1974).

* Direct observations (actual sighting), or indirect observations (tracks, lodges, dens, dams etc) by BEAK personnel or by those noted in footnote 1.

Table 14(Continued)

CASTORIDAE	
American Beaver*	Castor canadensis
MURIDAE	
Deer Mouse*	Peromyscus maniculatus
Bushy-tailed Wood Rat*	Neotoma cinerea
Northern Bog Lemming	Synaptomys borealis
Heather Vole	Phenacomys intermedius
Northern Red-backed Vole*	Clethrionomys rutilus
Gapper's Red-backed Vole	Clethrionomys gapperi
Meadow Vole*	Microtus pennsylvanicus
Tundra Vole*	Microtus oeconomus
Long-tailed Vole	Microtus longicaudus
Chestnut-cheeked Vole	Microtus xanthognathus
Muskrat*	Ondatra zibethicus
DIPODIDAE	
Meadow Jumping Mouse	Zapus hudsonius
ERETHIZONTIDAE	
American Porcupine*	Erethizon dorsatum
CANIDAE	
Coyote	Canis latrans
Wolf*	Canis lupus
Red Fox*	Vulpes vulpes

Table 14 (Continued)

URSIDAE	
Black Bear*	Ursus americanus
Grizzly Bear*	Ursus arctos
MUSTELIDAE	
American Marten*	Martes americana
Fisher*	Martes pennanti
Ermine (Short-tailed Weasel)*	Mustela erminea
Least Weasel	Mustela nivalis
American Mink*	Mustela vison
Wolverine*	Gulo gulo
Striped Skunk	Mephitis mephitis
River Otter*	Lontra canadensis
FELIDAE	
Lynx*	Lynx lynx
CERVIDAE	
Mule Deer*	Odocoileus hemionus
White-tailed Deer*	Odocoileus virginianus
Moose*	Alces alces
Woodland Caribou*	Rangifer tarandus
Dall's Sheep*	Ovis dalli
BOVIDAE	
Mountain Goat*	Oreamnos americanus

BIRDS

TABLE 15

Provisional Check List of Birds in the Vicinity of the Proposed Cadillac Mines Winter Road, N.W.T.[1]

COMMON NAME	SCIENTIFIC NAME[2]
Common loon*	Gavia immer
Red-necked grebe	Podiceps grisegena
Horned grebe*	Podiceps auritus
Trumpeter swan*	Olor buccinator
Whistling swan*	Olor columbianus
Canada goose*	Branta canadensis
Mallard*	Anas platyrhynchos
Pintail*	Anas acuta
Green-winged teal*	Anas carolinensis
Blue-winged teal	Anas discors
American wigeon*	Anas americana
Northern shoveler*	Anas clypeata
Canvasback	Aythya valisineria
Greater scaup*	Aythya marila
Lesser scaup*	Aythya affinis
Common goldeye*	Bucephala clangula
Bufflehead	Bucephala albeola
White-winged scoter	Melanitta deglandi
Surf scoter*	Melanitta perspicillata
Common merganser*	Mergus merganser
Red-breasted merganser	Mergus serrator
Goshawk*	Accipiter gentilis
Sharp-shinned hawk*	Accipiter striatus
Red-tailed hawk*	Buteo jamaicensis
Golden eagle*	Aquila chrysaetos
Bald eagle*	Haliaeetus leucocephalus
Marsh hawk*	Circus cyaneus
Merlin	Falco columbarius
American Kestrel	Falco sparverius
Blue grouse*	Dendragapus obscurus
Spruce grouse*	Canachites canadensis
Ruffed grouse*	Bonasa umbellus
Willow ptarmigan*	Lagopus lagopus

1. Based on distributional information contained in Godfrey (1966), Scotter et al (1971), Slaney Co. Ltd. (1971).
2. Nomenclature from American Ornithologists Union (1957 and revisions by Eisenmann et al (1973, 1976).

* Species observed in the region, by Beak or during studies noted in footnote 1.

Table 15 (Continued)

Rock ptarmigan	*Lagopus mutus*
White-tailed ptarmigan*	*Lagopus leucurus*
Sharp-tailed grouse*	*Pedioecetes phasianellus*
Sora*	*Porzana carolina*
American coot*	*Fulica americana*
Common snipe	*Capella gallinago*
Spotted sandpiper*	*Actitis macularia*
Solitary sandpiper*	*Tringa solitaria*
Wandering tattler*	*Heteroscelus incanus*
Lesser yellowlegs*	*Tringa flavipes*
Herring gull*	*Larus argentatus*
Mew gull*	*Larus canus*
Bonaparte's gull*	*Larus philadelphia*
Arctic tern*	*Sterna paradisaea*
Great horned owl*	*Bubo virginianus*
Hawk owl	*Surnia ulula*
Great gray owl	*Strix nebulosa*
Long-eared owl	*Asio otus*
Short-eared owl	*Asio flammeus*
Boreal owl	*Aegolius funereus*
Common nighthawk*	*Chordeiles minor*
Belted kingfisher*	*Megaceryle alcyon*
Common (Yellow-shafted) flicker*	*Colaptes auratus*
Pileated woodpecker	*Dryocopus pileatus*
Yellow-bellied sapsucker*	*Sphyrapicus varius*
Hairy woodpecker*	*Picoides villosus*
Downy woodpecker	*Picoides pubescens*
Black-backed three-toed woodpecker	*Picoides arcticus*
Northern three-toed woodpecker	*Picoides tridactylis*
Eastern kingbird	*Tyrannus tyrannus*
Eastern phoebe	*Sayornis phoebe*
Say's phoebe	*Sayornis saya*
Yellow-bellied flycatcher	*Empidonax traillii*
Least flycatcher	*Empidonax minimus*
Western wood pewee	*Contopus sordidulus*
Olive-sided flycatcher	*Nuttallornis borealis*
Horned lark*	*Eremophila alpestris*
Violet-green swallow*	*Tachycineata thalassina*
Tree swallow*	*Iridoprocne bicolor*
Bank swallow	*Riparia riparia*
Barn swallow	*Hirundo rustica*
Cliff swallow*	*Petrochelidon pyrrhonota*

Table 15(Continued)

Gray jay*	*Perisoreus canadensis*
Common raven*	*Corvus corax*
Common crow	*Corvus brachyrhynchos*
Black-capped chickadee*	*Parus hudsonicus*
Red-breased nuthatch	*Sitaa canadensis*
American robin	*Turdus migratorius*
Varied thrush	*Ixoreus naevius*
Hermit thrush	*Catharus guttatus*
Swainson's thrush	*Catharus ustulatus*
Townsend's solitaire*	*Myadestes townsendi*
Ruby-crowned kinglet*	*Regulus calendula*
Bohemian waxwing	*Bombycilla garrulus*
Northern shrike	*Lanius excubitor*
Red-eyed vireo	*Vireo olivaceus*
Warbling vireo	*Vireo gilvus*
Tennessee warbler	*Vermivora peregrina*
Orange-crowned warbler	*Vermivora celata*
Yellow warbler	*Dendroica petechia*
Magnolia warbler	*Dendroica petechia*
Yellow-rumped (Myrtle) warbler	*Dendroica coronata*
Bay-breasted warbler	*Dendroica castanea*
Blackpoll warbler	*Dendroica striata*
Palm warbler	*Dendroica palmarum*
Ovenbird	*Seiurus aurocapillus*
Northern waterthrush	*Seiurus noveboracensis*
Wilson's warbler	*Wilsonia pusilla*
American redstart	*Setophaga ruticilla*
Red-winged blackbird*	*Agelaius phoeniceus*
Rusty blackbird	*Euphagus carolinus*
Brown-headed cowbird*	*Molothrus ater*
Western tanager*	*Piranga ludoviciana*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
Evening grosbeak*	*Hesperiphona vespertina*
Purple finch	*Carpodacus purpureus*
Pine grosbeak	*Pinicola enucleator*
Pine siskin	*Carduelis pinus*
Red crossbill	*Loxia curvirostra*
White-winged crossbill	*Loxia leucoptera*
Savannah sparrow	*Passerculus sandwichensis*
Dark-eyed (Slate-colored) junco*	*Junco hyemalis*
Chipping sparrow*	*Spizella passerina*
White-crowned sparrow*	*Zonotrichia leucophrys*
White-throated sparrow*	*Zonotrichia albicollis*
Fox sparrow	*Passerella iliaca*
Lincoln's sparrow	*Melospiza lincolnii*
Swamp sparrow	*Melospiza georgiana*
Song sparrow*	*Melospiza melodia*

TABLE 16

SENSITIVE TIME PERIODS OF PROMINENT FISH SPECIES PRESENT IN WATERCOURSES TRAVERSED BY THE PROPOSED WINTER ROAD

SPECIES	LIFE HISTORY PHASE Migration	Spawning	Incubation and Emergence	Nursery	Overwintering
Chum salmon	late September - late October	late September - early November	late April - early May	-	-
Dolly Varden char	mid-August - mid-September	late August - late September	late April - late May	late April - mid-July	early October - early May
Arctic grayling	early May - mid-June	early May - mid-June	late May - late June	early June - mid-July	early October - early May
Lake whitefish	late September - late October	early October - December	early October - May	-	early October - early May
Northern pike	mid-April - early May	mid-May - early July	early June - late July	-	early October - early May
Burbot	-	January - March	May	-	early October - early May
White sucker	early May - early June	early May - mid-June	early June - mid-July	-	early October - early May
Longnose sucker	late April - early May	early May - mid-June	early June - mid-July	-	early October - early May
Yellow walleye	late April - late June	late April - late June	mid-April - mid-July	mid-June - early August	early October - early May

Sources: McPhail and Lindsey (1970), Scott and Crossman (1973) and Foothills Pipe Lines (South Yukon) Ltd. (1979).

TABLE 17

MEAN CONCENTRATION (ppm) OF LEAD, ZINC, COPPER AND CADMIUM IN THE MUSCLE TISSUE OF FISH FROM THREE MACKENZIE RIVER STUDY AREAS, MACKENZIE RIVER, 1971

SPECIES	BASE	N	WT. RANGE (gm)	Pb	Zn	Cu	Cd
Lake whitefish	FS[1]	4	656-2056	0.05	4.70	0.24	0.09
	AR	3	653-2270	0.13	6.99	0.47	0.03
	all	7		0.07	5.34	0.34	0.06
Inconnu	AR	4	398-3547	0.00	3.64	0.28	0.01
Arctic cisco	NW	4	439-662	0.03	8.78	0.56	0.02
	AR	2	539-908	0.01	8.55	0.60	0.02
	all	6		0.02	8.70	0.57	0.02
Northern pike	FS	4	592-2380	0.05	5.00	0.28	0.18
	NW	4	203-1002	0.03	9.02	0.32	0.05
	AR	2	227-284	0.00	6.06	0.27	0.005
	all	10		0.03	6.81	0.29	0.09
Longnose sucker	FS	4	478-1226	0.14	5.38	0.31	0.13
	NW	4	322-1301	0.04	9.51	0.42	0.12
	all	8		0.06	7.44	0.37	0.12

[1] FS - Fort Simpson
NW - Norman Wells
AR - Arctic Red River

Source: Hatfield *et al*. 1972b

TABLE 18

MEAN CONCENTRATION (ppm) OF LEAD, ZINC, COPPER AND CADMIUM IN THE LIVERS OF FISH FROM THREE STUDY AREAS, MACKENZIE RIVER, 1971

SPECIES	BASE	N	WT. RANGE (gm)	Pb	Zn	Cu	Cd
Lake whitefish	FS[1]	6	700-1662	0.03	33.52	10.38	0.40
	AR	3	1135-1589	0.06	46.96	29.20	0.00
	all	9		0.04	38.00	16.65	0.27
Broad whitefish	AR	6	1844-2298	0.00	32.79	20.10	0.20
Inconnu	AR	3	3547-	0.21	26.27	11.45	0.05
Arctic cisco	NW	3	662-814	0.00	30.43	3.87	0.08
Northern pike	FS	7	928-3552	0.02	28.64	5.42	0.03
Longnose sucker	FS	5	759-1916	0.17	27.17	2.90	0.29
	NW	3	856-1301	0.00	35.51	5.48	0.54
	all	8		0.10	30.30	3.87	0.38

1 FS - Fort Simpson
NW - Norman Wells
AR - Arctic Red River

Source: Hatfield *et al*. 1972b

APPENDIX A

LIST OF CONSULTANTS

1.	Beak Consultants Ltd. 602 - 1550 Alberni Street Vancouver, B. C. V6G 1A5	G. Nieminen, P. Eng.
2.	H. Brodie Hicks Engineering Ltd. 1199 West Pender Street Vancouver, B. C. V6E 2R1	H. Brodie Hicks, P. Eng.
3.	Golder Geotechnical Consultants Ltd. 224 West 8th Avenue Vancouver, B. C. V5Y 1N5	R. M. Wilson, P. Eng.
4.	Ker, Priestman & Associates Ltd. 300 - 2659 Douglas Street Victoria, B. C. V8T 4M3	N. I. Guild, P. Eng.
5.	Kilborn Engineering (B.C.) Ltd. 101 - 1199 West Pender Street Vancouver, B. C. V6E 2R1	D. R. Beaumont, P. Eng.
6.	Watts, Griffis and McOuat Ltd. 911 - 159 Bay Street Toronto, Ontario M5J 1J7	

APPENDIX B

CONTACTS RELATIVE TO WILDLIFE

During the course of this programme, discussions were held with the following people whose observations or knowledge of the wildlife of the Nahanni area contributed to this report:

J. Donihee	Environmental Assessment Biologist, Government of the Northwest Territories, Yellowknife.
R. Bell	Supervisor, Wildlife Management, N.W.T. Wildlife Service, Yellowknife, N.W.T.
S. Miller	Research Scientist, N.W.T. Wildlife Service, Yellowknife, N.W.T.
R. Fast	Camp Foreman, Cadillac Explorations Limited Prairie Creek camp.
B. Fletcher	Golder Associates, Vancouver, B. C.
R. Wilson	Golder Associates, Vancouver, B. C.
R. Fyfe	Research Scientist, Canadian Wildlife Service, Edmonton, Alberta.
H. Reynolds	Research Scientist, Canadian Wildlife Service, Edmonton, Alberta.
D. Karasiuk	Research Scientist, Territorial Wildlife Service, Yellowknife, N.W.T.
D. Bentley	Horsman and Associates (Consulting Services), Richmond, B. C.

APPENDIX C

CONTACTS RELATIVE TO SOCIO-ECONOMICS

T. Auchterlonie	May 9/80	Government of the Northwest Territories, Programme Co-ordinator, Hire North, Department of Economic Development and Tourism, Yellowknife, N.W.T.
E. S. Bies		Indian & Northern Affairs Regional Engineer, Transportation Division, Engineering and Architecture Branch, Edmonton, Alberta.
L. Brintnell	May 9/80	Government of the Northwest Territories. Employment Division Officer, Manpower Development Division, Department of Economic Development and Tourism, Yellowknife, N.W.T.
C. Cook	May 8/80	Wildlife Officer, Wildlife Service, Fort Simpson, N.W.T.
D. Cormier	Apr.17/80	Land Use Administration, NWTG.
H. Deneron	May 7/80	Beaver Enterprise, Fort Liard.
M.E.S. Donihee	Apr.17/80	Government of the Northwest Territories, Environmental Assessment Biologist, Department of Natural and Cultural Affairs, Yellowknife, N.W.T.
T. Foster	May 9/80	Northwest Territories Canada. Head, Mineral & Petroleum Resources, Planning & Resource Development Division. Department of Economic Development and Tourism.
W. Fournier	May 8/80	Hire North Project Supervisor. Local Counsellor, Fort Simpson.
G. Gallant	May 9/80	Indian & Northern Affairs, Director of Economic Development, Yellowknife, N.W.T.
J. Ganski	Apr.17/80	Land Use Administration, N.W.T.G.
H. Gerein	May 9/80	Government of Northwest Territories. Head, Special Projects, Yellowknife, N.W.T.

D. Hamilton	May 8/80	Sec./Treas., Village of Fort Simpson.
C. Hope	May 9/80	Beaver Explorations, Fort Liard.
B. Larson	May 9/80	Department of Local Government, Government of the Northwest Territories, Yellowknife, N.W.T.
A. MacQuarvie	May 8/80	Interprovincial Pipeline, Fort Simpson.
L. Matthews	Apr.17/80	Government of the Northwest Territories Head,Regional Planning, Department of Planning and Programme Evaluation.
A. Menard	May 9/80	Government of the Northwest Territories. Chief, Town Planning and Lands Division, Department of Local Government, Yellowknife, N.W.T.
R. Milligan	May 9/80	Government of the Northwest Territories. Co-ordinator, Business Development Department of Economic Development and Tourism, Yellowknife, N.W.T.
F. Norwegain		Manpower and Immigration, Canada Manpower Centre, Fort Simpson, N.W.T.
A. Praamsma	May 9/80	Employment and Immigration Canada. Employment Counsellor, Canada Employment Centre, Yellowknife, N.W.T.
H. Reynolds	May 8/80	Environment Canada. Canadian Wildlife Service, Wildlife Biologist - Bison Programme, Edmonton, Alberta.
L. Vertes	May 9/80	Department of Local Government, Government of the Northwest Territories, Yellowknife, N.W.T.
G. Watsyte	May 9/80	Mayor, Village of Fort Simpson.
P. Wood	May 8/80	Water Survey, Environment Canada, Fort Simpson, N.W.T.

APPENDIX D

ACCESS ROUTES TO THE PRAIRIE CREEK PROPERTY OF CADILLAC EXPLORATIONS LIMITED

Watts, Griffis and McOuat Limited
Consulting Geologists and Engineers

(Text Only)

Toronto, Canada

January, 1980

I. INTRODUCTION

Watts, Griffis and McOuat Limited (WGM) was retained by Cadillac Explorations Limited to carry out a study of its Prairie Creek property during October, 1979. One aspect of that study was to examine alternate road access routes. Because this study involves a large number of maps and photographs, the results are presented here as a separate report.

The Prairie Creek camp is located at 61°34'N latitude 124°47'W longitude in the Northwest Territories. It is situated west of the Liard River and north of the South Nahanni River. To date, ground access has been limited to a winter road.

One major factor which has hindered serious efforts to develop the property is the general concept that access to the property is difficult. In large part this concept was ill-founded in that little systematic investigation of possible road routes has been carried out. It is hoped that this report will provide a basis for factual consideration and further, detailed study.

Road construction by the Canadian government significantly improved access to the Prairie Creek property. The Mackenzie Highway has been completed to a point 43 miles west of Fort Simpson, while the year-round Liard Highway has been extended south almost to Nahanni Butte.

The investigations carried out by WGM were based on studies of existing government aerial photographs and published topographic maps. Extensive low level route selection was carried out from a helicopter.

There are four sets of maps and photographs with this report. Maps at a scale of 1 : 250,000, maps at a scale of 1 : 50,000, vertical airborne photographs taken from an elevation of 30,000 feet above sea level with a scale somewhat greater than 1 inch : 1 mile, and oblique photographs taken from a helicopter or on the ground.

The routes are plotted on both sets of maps and on the photographs, but as the photographs are all stereo pairs the routes are only plotted once to avoid interfering with the sterio view.

The location and direction of the oblique photographs is plotted on the 1 : 50,000 maps and the vertical photographs.

2. SUMMARY AND CONCLUSIONS

The Nahanni Range runs north-south about half way between the property and Fort Simpson. It is too steep for a road over most of its length; the only negotiable passes are at or near its north and south ends.

There are therefore two feasible access routes, both of which permit a number of variations. One, which has been used as a winter road in previous years, goes northeast from the property to the point where the Mackenzie Highway crosses the Mackenzie River, thence by existing highway to Fort Simpson, across the Liard River to Creek Bend and on to the railhead at Enterprise and to Hay River. The other goes southeast to the Liard River about 20 miles northeast of Nahanni Butte, and across the river to the Liard Highway, and along this highway to Creek Bend and Enterprise.

The distance to Creek Bend is somewhat shorter by the southern route, but the difference is not great. If the Liard Highway is completed as far as the railhead at Fort Nelson (possibly by 1982), the southern route will be much shorter to Fort Nelson.

Both routes involve some canyon travel passing through the Mackenzie Mountains and the Ram Plateau. This is greater at present on the northern winter road route, but a substantial reduction could be made.

Both routes could be utilized for winter roads or permanent roads. Neither route involves tunnelling or substantial rock work.

A good site for an airstrip exists at Ram Flats 30 miles by road northeast of the camp. This could accommodate Hercules aircraft with no difficulty.

The decision as to which route is finally chosen will be essentially dependent upon the ultimate destination of mineral production and the costs of reaching the markets once either the Liard or Mackenzie Highways are reached and upon governmental and local preferences.

Either route could be successfully developed into a high capacity winter road with one summer's work.

3. POSSIBLE ROUTES

As shown on Figure 1 the Prairie Creek property is located in the Northwest Territories at 61°34'N, 124°47'W in the Mackenzie Mountains some 88 miles southwest of Camsell Bend on the Mackenzie River and 72 miles west-northwest of Nahanni Butte at the junction of the Nahanni and Liard Rivers.

The closest points of access to existing highways are where the Mackenzie Highway crosses the Mackenzie River west of Fort Simpson, and the Liard Highway near its present southern end about 20 miles northeast of Nahanni Butte. The closest points of access to water transportation are at Camsell Bend on the Mackenzie River and the Liard River northeast of its junction with the South Nahanni.

The Liard Highway continues as a winter road to Fort Liard. It is hoped that the highway will be extended to the railhead near Fort Nelson, B.C. by 1982.

There are three mountain ranges between the minesite and the highway; the eastern part of the Mackenzie Mountains, the Nahanni Range, and between them the Ram Plateau in the north and the Silent Hills in the south. They are very different in character. The Mackenzie Mountains have a normal (dendritic) drainage pattern and although they are high and steep (2,000 to 3,000 feet of relief) it is possible in many places to find potential road routes in valley bottoms, along side hills and through mountain passes. The Ram Plateau and the Silent Hills are much lower and on maps they appear to form no barrier, but they are largely composed of limestone, with the result that the streams form steep gorges with near vertical walls. As a result long sections are impassible. The Nahanni Range is long and narrow and very steep, especially on the eastern side. It is impassible except at three locations and at the two ends, but a road at the south end would require considerable work.

East of the Nahanni Range the country is flat and is traversed by numerous seismic trails.

The main obstacle to road routes is the Nahanni Range, which extends south from the Mackenzie River to the South Nahanni River. It is very steep and does not have any negotiable passes over most of its length. The shores of the two lakes which cut the range, Cli Lake and Little Doctor Lake, have near-vertical cliffs.

There is a completely flat gap near the north end of the range 5 miles south of Camsell Bend through which the northern route passes. There is no alternative route in this area other than to the river at Camsell Bend.

Near the south end there are three possibilities, the Grainger River Pass, Bluefish Lake, and between the south end of Nahanni Butte and the South Nahanni River. The last two would require a little rock work.

Because there is only one pass through the northern part of the Nahanni Range, there is only one possible northern route, with, of course, local variations.

The selected southern route is through the Grainger River Pass and thence by the shortest path to the Liard River and Highway, but there are two possible variations. An all-year road would avoid a lot of swampy ground by following the Nahanni Range along the foothills to its southern end. However this would increase the distances other than to Fort Nelson, and it would mean crossing an extensive area of swamp south and east of the junction of the South Nahanni and Liard Rivers. The other route starts from the South Nahanni River and joins the selected route near the headwaters of Sundog Creek. It was traversed by a D-6 tractor in 1966. It has no particular advantage except that it has been demonstrated that it can be travelled. It is effectively eliminated by the fact that it enters the Nahanni National Park.

4. ROAD CONSTRUCTION

About half of the total length of both routes from the camp to existing highways is on flat ground. This includes all the area east of the Nahanni Range, and intermittent stretches between the Nahanni Range and the Mackenzie Mountains.

Much of this ground will be swampy during part of the summer, but there does not appear to be any significant amount of muskeg. Winter road construction will be simple, to a considerable extent existing seismic lines can be used.

A permanent road will require considerable fill. Good material is certainly available along the Mackenzie Highway where many borrow pits can be seen, but no investigations were made along the proposed routes, so the haulage distances are unknown.

In the mountainous areas the simplest course for a winter road would be to follow the river valleys. This would not require much rock work. One exception for both winter and permanent roads along the southern route is a small escarpment on the east slope of the Mackenzie Mountains. This has already been traversed by a D-6, so it is not a major obstacle. The northern route has been used extensively in the past as a winter road. No rock work will be essential, but a certain amount might be desirable.

A permanent road would avoid the canyon floors as much as possible in order to eliminate spring washouts. This would involve problems leaving and entering the valleys, but they do not seem to be serious along the selected routes.

It would seem that a good winter road could be cleared and upgraded where necessary with a maximum of two bulldozers, one front-end loader and two trucks. Little or no blasting would seem to be required. The work should be carried out in the summer and fall; some areas will be more workable in the summer while others will not be accessible before freeze-up. Once constructed only relatively annual upkeep will be required, mainly consisting of repairing spring washouts in the canyons.

Good evidence that road construction and maintenance are not a big problem in the mountainous western half of the area is provided by the roads around the property. These total 10 to 15 miles in length and were built by good bulldozer operators from site available material - without site testing, surveying or detailed route selections. Some of them are over 10 years old and have received little maintenance. Virtually no rock work and no haul of fill was required for their construction.

Even the old winter road which runs primarily down the canyons is in relatively good shape where it has not been subjected to washouts in the canyons.

In the flat eastern half of the area there are numerous old roads and seismic lines which only require brushing to be used as winter roads.

5. SELECTED ROUTES

The two routes selected are plotted on 1 : 50,000 and 1 : 250,000 scale maps and on aerial photographs, generally 1 inch : 1 mile, but the scale of photographs in mountainous areas varies substantially with ground elevation. The photographs are in sterio pairs; the route is only plotted on one photograph to avoid interference when viewing stereoscopically.

The oblique helicopter photographs give continuous coverage for much, but not all of the routes. Their locations are plotted on the maps. They are numbered consecutively for each route according to the location of the camera, but they were taken in various directions.

Gradients were measured from the 1 : 50,000 maps.

5.1 NORTHEASTERN ROUTE

The present winter road goes north up the east branch of Prairie Creek then crosses to the Ram River, which it follows in a general way to the North Nahanni. Where the North Nahanni meets the Nahanni Range, the road can go either north to Camsell Bend or east along seismic lines to the Mackenzie Highway and on to Fort Simpson.

From the camp north to the Ax claim (the former Samantha claims), 13¼ miles, the road is along Prairie Creek and its east fork. There are no major problems for a winter road, but washouts would be numerous during the spring flood. The valley is broad until about 3 miles north of the east fork is reached (Photos 1-4) a distance of 8 miles, but north of this fork for about 3 miles (Photos 5-11) an all-year road would be very difficult to maintain (Note that some photographs are taken going out and some going in. The direction is given in each case.).

At 8¼ miles north of the fork the road turns east across the Ax claim and reaches the top of the pass in a relatively easy 2¼ miles. It then passes down a branch of the Ram

River for 13¾ miles to Ram Flats. This stretch is reasonably straight and fairly easy going. There would be problems with spring floods but they would not be as severe as in the east fork of Prairie Creek. Ram Flats (Photos 12-15) is a wide flood plain in the Ram River Valley which the road follows for 6¾ miles due east. This area could accommodate a major airfield. The approach is clear to the east and good to the west. A short cross strip could accommodate light aircraft.

At the east of Ram Flats the road has to traverse the Ram Plateau. There are various alternatives, but whichever ones are taken, this is the most difficult section of the route. The present road goes southeast of the Ram River for 5¾ miles (Photos 16-19) to a point near Sundog Creek, where it descends into the river bed and follows it to a point where it makes a sharp bend to the south (15 miles, Photos 20-24); it then follows a tributary of the Ram northward for 2¾ miles (Photo 25), then east for 25 miles where it again meets the Ram River, now flowing north (Photos 26-39).

There is some difficulty making the final descent into the Ram Valley, but only earthwork is required; there is generally no rock.

Once in the Ram Valley the ground is flat and the road follows a seismic line to where it crosses the North Nahanni, then another seismic line to where the road crosses the Ram (16½ miles) and passes through the Nahanni Range (Photos 40-50). From here there are seismic lines or winter roads to the point where the Mackenzie Highway reaches the river, and thence to Fort Simpson. From the final descent into the Ram Valley to the Mackenzie Highway is 54 miles on existing winter roads and seismic trails (this could be shortened to 46 miles very easily) and a further 43 miles into Fort Simpson.

There is only one place where the route could be shortened appreciably. This would involve cutting off the north bend in the Ram River by leaving the river bed at Sundog Creek. This could cut off as much as 10 miles. It would require considerable work, but once done it would eliminate a number of annual washouts along the Ram River as well as shortening the overall distance.

The total distance from the camp to Fort Simpson is now 137 miles which could be reduced easily on the flat land east of the Nahanni Range to 129 miles, and with considerable work to 119 miles.

5.2 SOUTHEASTERN ROUTE

The best exits from Prairie Creek for a southeasterly route are about 5 miles north of camp just north and just south of the main fork. To the south Prairie Creek has vertical cliffs on both sides in places, which would add considerable cost for an all-year road. Furthermore the only suitable exit, which is quite steep in places, leaves Prairie Creek going north, and it ultimately meets the routes from the more northern exits. There is therefore no apparent advantage in going south, while to the north there is an old road to the fork, and one of the exits was travelled all the way by D-6 in the 1960s.

There are three valleys which enter Prairie Creek from the east near the fork. The middle one seems steeper and rougher, but there is little to choose between the other two. At the top, which is 5 miles from Prairie Creek, there are two valleys descending due east for 11 miles to the foot of the Mackenzie Mountains. It appears that all five valleys could be interconnected along the height of land without too much trouble.

Both valleys are straight, with a moderate grade, and appear to be good road routes except for a few rough spots. Photo 51 shows the northern valley near its entrance. In the southern valley there is a point marked "Falls" on the map (Photos 52 and 53) and there is a corresponding rocky zone in the northern valley (Photos 54 and 55), probably caused by the same geological formation. Some rock work will be needed on one or other of these spots, but it need not be extensive; a D-6 has already been up one of these valleys, probably the northern one, but the tracks, if such they are, are very faint.

From the point where these valleys meet, the route follows a tributary of Sundog Creek, itself a tributary of the Ram River, for 5 miles in a northeasterly direction, and then heads east across the Ram Plateau. The D-6 trail follows a valley for 4 miles and could not be traced any further, but its route could be continued another 8 miles to the head of the Tetcela River. An alternative route about a mile further north might be preferable. A route southeast down the Tetcela River seems feasible, but the valley is narrow and rocky, and although no major obstacles were seen a more detailed examination would be necessary. A feasible alternative would be to keep on the plateau south of the river (Photos 56-60). Where the Tetcela meets its south fork, 18 miles from its head, and swings north, there is an easy route round the north end of Yohin Ridge and across Fishtrap Creek to a pass in the Silent Hills, a distance of 8 3/4 miles. A short detour to the north would take the road north of the headwaters of Fishtrap Creek and thus avoid all drainage into the Nahanni Park.

There is an existing winter road through this pass, which can be seen in Photos 61, 62 and 65-67, but it appears to be somewhat steep for trucks on the west side. However improvements would not be difficult; a side-hill view is seen in Photos 63 and 64.

Once through the pass there are several alternatives. The road could go north on either side of the Silent Hills, ultimately joining up with the northeastern route. This would add 30 miles to the total distance, but the additional mileage would all be on flat ground, and the difficult passage through the Ram Plateau would be eliminated. The most obvious route is through the Grainger River pass in the Nahanni Range (Photos 72-77). This is all flat, and there are several seismic lines. The distance to the pass is 12 miles, then 22 miles to the Liard River, and the highway is 2 miles away on the other side. The distance from this point to Creek Bend on the Mackenzie Highway is 60 miles. From camp, Creek Bend is 160 miles by this route compared with 176 by the northeastern route. However the latter route could be reduced by between 10 and 20 miles, so there is little to choose between them on a mileage basis. However the southeastern route is a much easier one, and would be much cheaper to operate. Unless a barge operation at Camsell Bend or an airfield at Ram Flats were planned, the southeastern route has a clear overall advantage.

The southeastern road could also cross the Nahanni Range at the Bluefish Lake pass (Photos 78-80) or go round the south end at Nahanni Butte (Photos 81 and 82).

There would be no advantage if the shipping route were overland through Creek Bend to Hay River, but there might be a slight advantage if shipping were through Fort Nelson or by barge along the Liard River. With a permanent road it would be necessary to cross the Nahanni Range at some point or two ferries would be needed, one across the South Nahanni and one across the Liard.

5.3 GRADIENTS

Prairie Creek has very little gradient. From the camp to the Ax claim, a distance of 12 miles, the difference in elevation is only 600 feet, giving an average and generally steady grade of only 1 in 88 or 1.1%.

The steepest gradients occur between the Prairie Creek valley and the top of the Mackenzie Mountains passes. On the northeastern route there is a stretch of 1.7 miles at 4.5%, then a third of a mile at 11.75%. The descent on the east side is not steep. The first 4 miles is at a grade of 1 in 17.5, or 6%. The remaining 7.9 miles to Ram Flats is less than 2%.

Along Ram Flats the grade is negligible. From the east end of Ram Flats the overall grade along the Ram River is small, less than 1% on average, but if the road is to climb out of the river valley on to the plateau there will be some short, steep sections. Climbing out of the east end of Ram Flats is not too steep, but the descent back into the valley near Sundog Creek has some short stretches which appear to be about 10%. However these are included in an overall distance of about a mile for which the average grade is only 7 or 8%. It should be possible to eliminate the steepest parts with a moderate amount of work.

An overland route to cut off the northern loop of the Ram River would cross Sundog Creek about 1.5 miles south of its junction with the Ram. The descent into the creek is easy, but climbing out would involve 0.7 miles at a 10% grade. Where this route crosses the Ram River on its southward reach the descent is easy and although the rise on the other side will be devious it should be possible to reduce the worst part to 1 mile at 8%.

The present winter road goes north from the northernmost bend of the Ram along a flat valley and then goes east across the Ram Plateau. The grades are reasonably steady. Going up involves 4.5 miles at 6.5%, going down the grades are much less, only 2% on average until the final escarpment into the Ram Valley. This escarpment is low, not much more than 100 feet, but there is no easy way down it. However there do not seem to be any fundamental problems that could not be overcome under the right conditions, namely dry ground without deep frost.

From this point to Fort Simpson the route is flat all the way, even at the two crossings of the North Nahanni River.

On the southeastern routes the climb to the top of the Mackenzie Mountain passes is 4 miles with a gradient of 1 in 15 or 6.7% in both passes. The steepest sections are 1.25 miles at 1 in 9.4 (10.6%) in the north pass and 0.95 miles at 1 in 7.2 (13.9%) in the south pass.

The descent on the eastern side is not as steep; 9.2 miles of 1 in 29 (3.4%) in the north pass and 8 miles of 1 in 22 (4.5%) in the south pass. The worst sections, both near the top, are 0.95 miles of 1 in 12.5 (8.0%) and 1 mile of 1 in 9.5 (10.5%) respectively. These do not include the falls in the south and the corresponding rocky section in the north. In both of these locations the problem is rock work rather than grades.

Crossing the headwaters of Sundog Creek it is possible to stay on flat ground but it may be preferable to go on to higher and drier ground, especially for a permanent road. There are several possible ways of doing this, one of which involves 1.55 miles at 1 in 10.

The climb up on to the Tetcela Plateaus going east is short. It involves 1.1 miles at 6% and 1 mile at 4% separated a mile of almost flat ground.

Going down the Tetcela River valley is no problem as far as grades are concerned; the average grade over 7.5 miles is less than 4% and there are no noticeably steep portions. If it becomes preferable to route the road along the plateau along the southwest side of the river, the overall climb will be much the same but it will not be possible to make it as regular without considerable deviation. About 4.3 miles of road in the lower part would have an average gradient of 7.5%, while the upper part would be almost level.

The route across the Tetcela Valley to the Silent Hills pass is flat provided that the road swings north to avoid the northern tip of Yohin Ridge. There is already a winter road straight through the pass, but as it stands it is too steep for trucking. On the east side the steepest part is only 7%, but on the west there is a stretch of 0.93 miles of 20%. Fortunately there is no exposed rock, so there does not appear to be any problem in making a side-hill road at any required gradient.

From the eastern side of the Silent Hills through the Grainger River pass it is flat all the way to the Liard River.

5.4 RELATIVE MERITS OF THE TWO ROUTES

If the concentrates are sent south to the railhead at Fort Nelson the southeastern route is the only choice, but if they are sent east the choice is more difficult. The northeastern route is longer, but it could be reduced to about the same distance as the southeastern route by short cuts across the Ram Plateau. The grades involved are much the same for both routes at present, but if the northeastern route is reduced in length there will be some steep sections crossing the Ram Plateau instead of following the Ram River.

The northeastern route follows rivers for a greater proportion of its length than the southeastern route, and these tend to have narrow valleys where there would be considerable risk of washouts in the spring. The southeastern route does not follow any rivers of any size except for the first few miles along Prairie Creek, which is common to both routes. It crosses from the Mackenzie Mountains to the Nahanni Range very close to the divide between the South Nahanni and the Mackenzie. In the mountains it appears to be generally close to bedrock and on the eastern side of the mountains the section of Sundog Creek which it travels appears to consist of well-washed gravel.

Fill would be needed in the northeastern route climbing out of Prairie Creek, but little work would be needed descending to and crossing Ram Flats. Crossing the Ram Plateau and Silent Hills a certain amount of fill would be required on both routes to provide a summer road. In the south, provided that a road down the Tetcela River proves feasible, there are only two relatively short swampy stretches, but in the north there would be considerable work crossing the Ram Plateau. This could be reduced by following the Ram River as much as possible, but this would increase the distance and increase the problem of spring washouts.

Further east both routes cross flat land for about 50 miles which will require considerable fill. Much of this might be eliminated on the southeastern route by going south along the foothills of the Nahanni Range as far as Nahanni Butte. The crossing of the Liard River would then be made a few miles east of Nahanni Butte. If the Government could be persuaded to route the Liard Highway closer to the river at this point (where it would also serve the Nahanni Butte community) this route would provide a road which could be operated for most of the year at a minimum cost.

The southern route is somewhat shorter and there would be less problems from washouts and from descents into and ascents from the valleys. With our present knowledge, it appears to be the best route. On the other hand the northern route is known to be feasible, and it crosses the Liard River at an existing ferry.

If a winter road is required in order to carry out a limited amount of work on the property, the northern route could be rehabilitated at a minimum cost, but once a decision has been reached to go into production a detailed study should be made of the southern route, and unless unexpected problems arise a winter road should be constructed along this route which can be upgraded to a permanent road later.

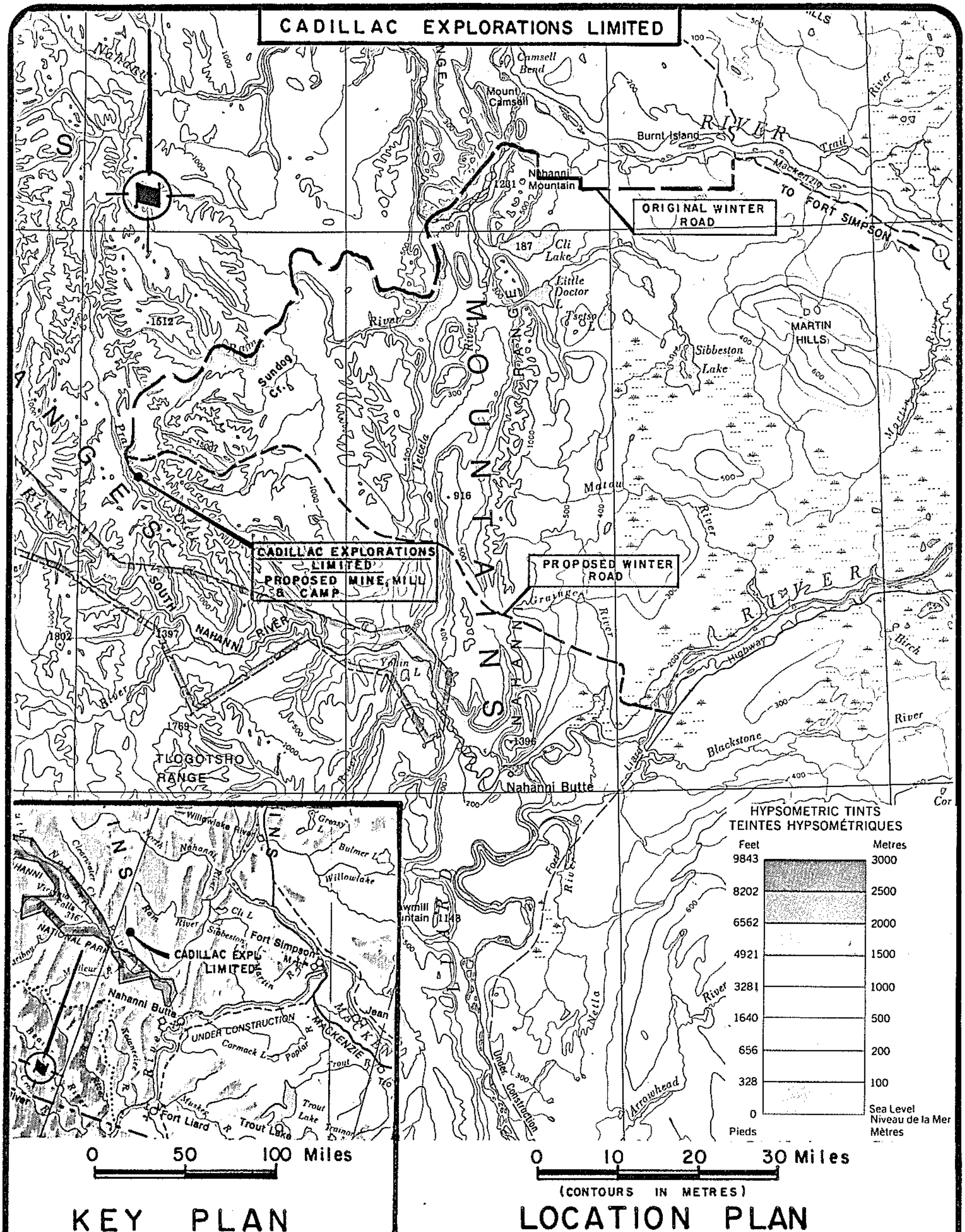


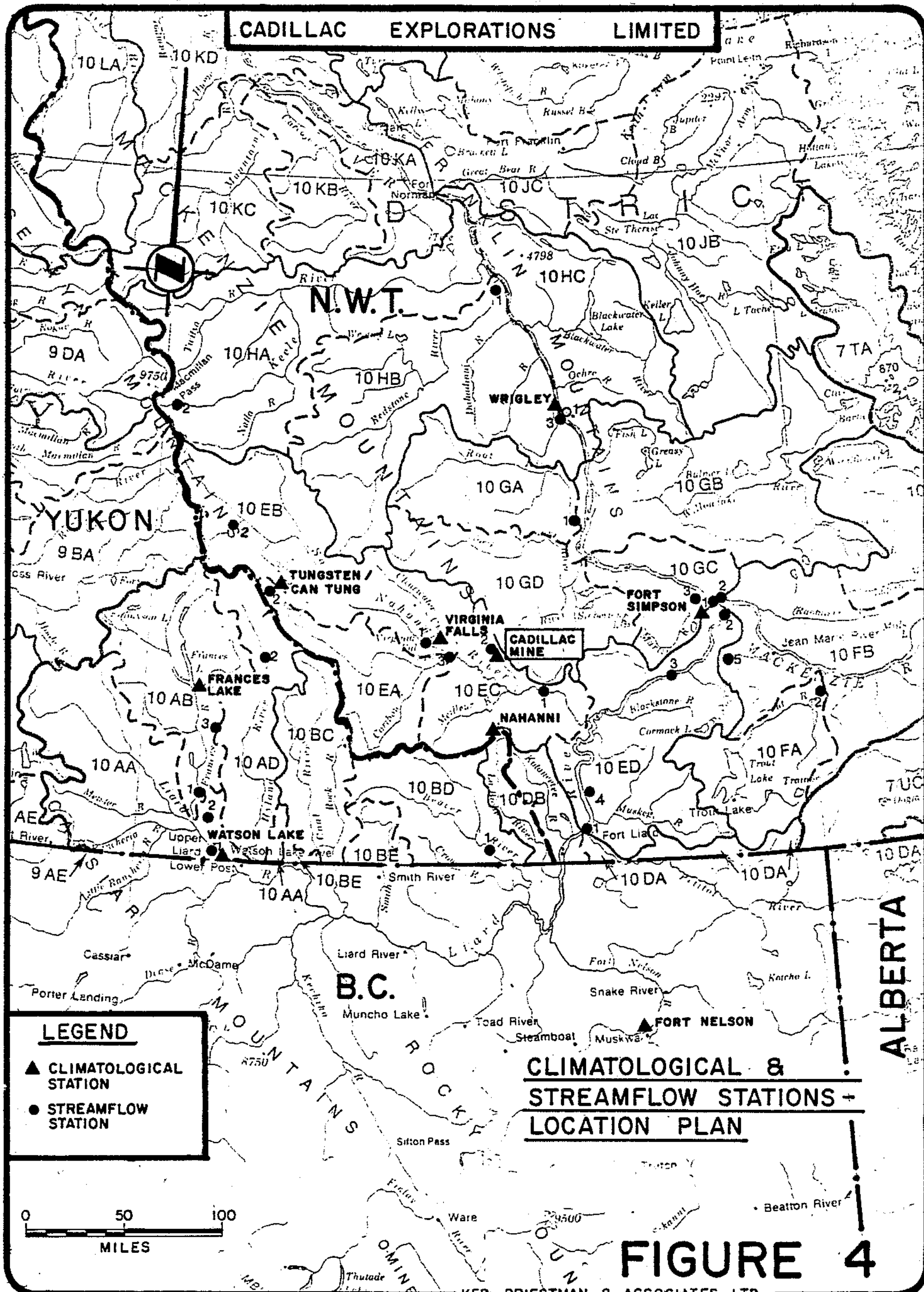
FIGURE I

KER, PRIESTMAN & ASSOCIATES LTD

VANCAL-2988

Figures 2 and 3

(in envelope at back)


CADILLAC EXPLORATIONS LIMITED
N.W.T.
YUKON
B.C.
ALBERTA
MACKENZIE MOUNTAINS
FRANKLIN MOUNTAINS
ROCKY MOUNTAINS
WRIGLEY
TUNGSTEN / CAN TUNG
VIRGINIA FALLS
CADILLAC MINE
FORT SIMPSON
FRANCES LAKE
NAHANNI
WATSON LAKE
FORT NELSON
Macmillan Pass
Fort Norman
Fort Liard
Lower Post
Upper Liard
Smith River
Liard River
Muncho Lake
Toad River
Steamboat
Muskwa
Snake River
Cassiar
McDame
Porter Landing
Sifton Pass
Ware
Beatton River
10 LA
10 KD
10 KA
10 KB
10 KC
10 JC
10 JB
10 HC
10 HA
10 HB
9 DA
7 TA
10 GA
10 GB
10 EB
9 BA
10 GC
10 GD
10 FB
10 EA
10 EC
10 AB
10 BC
10 FA
10 AA
10 AD
10 BD
10 DB
10 ED
10 BE
10 DA
9 AE
LEGEND
CLIMATOLOGICAL STATION
STREAMFLOW STATION
0 50 100
MILES
CLIMATOLOGICAL & STREAMFLOW STATIONS - LOCATION PLAN
FIGURE 4
KER, PRIESTMAN & ASSOCIATES LTD

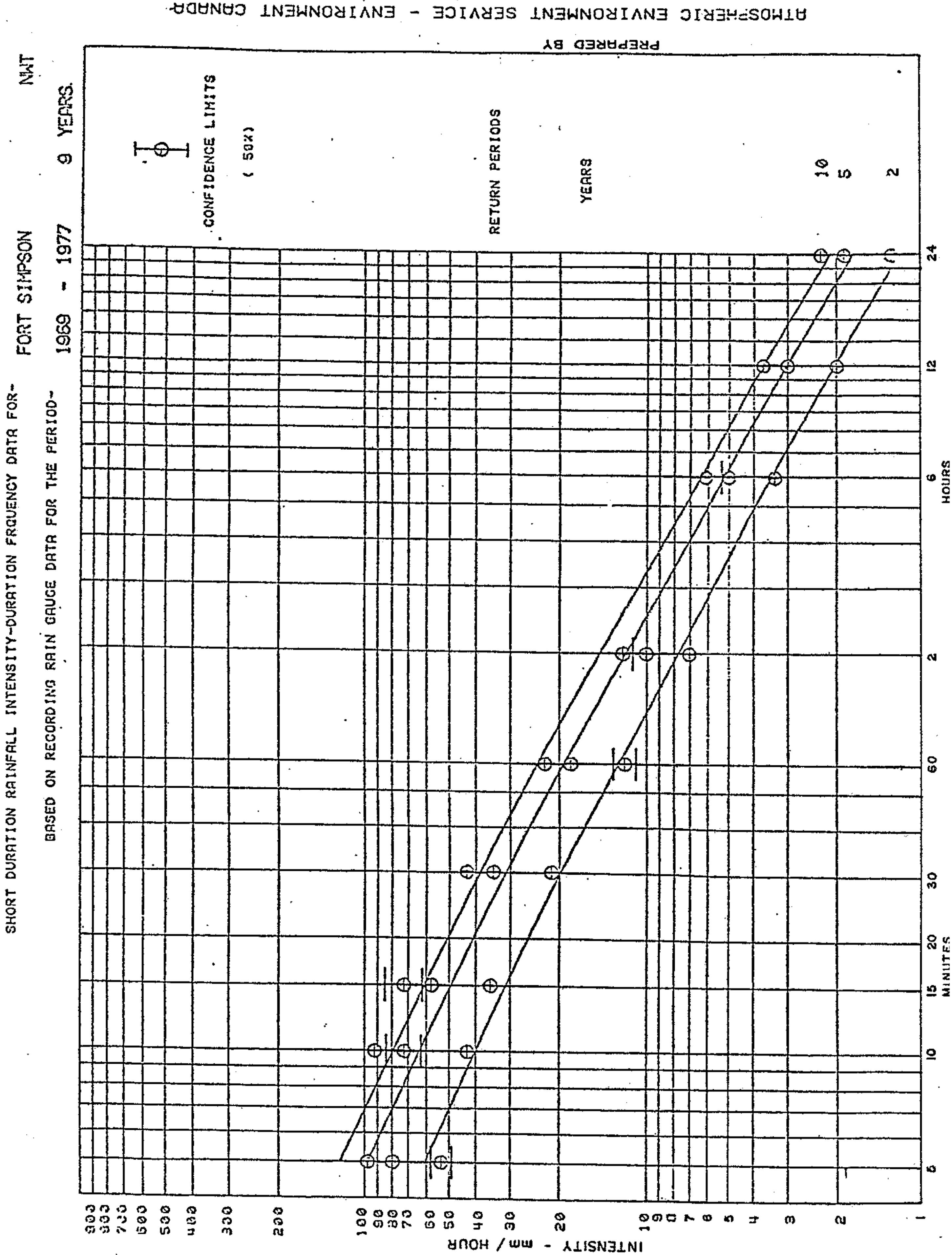

SHORT DURATION RAINFALL INTENSITY-DURATION FRQUENCY DATA FOR- FORT SIMPSON NWT
BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD- 1969 - 1977 9 YEARS.
CONFIDENCE LIMITS
(50%)
RETURN PERIODS
YEARS
10
5
2
PREPARED BY
ATMOSPHERIC ENVIRONMENT SERVICE - ENVIRONMENT CANADA
INTENSITY - mm / HOUR
1 2 3 4 5 6 7 8 9 10 20 30 40 50 60 70 80 90 100 200 300 400 500 600 700 800 900
5 10 15 20 30 60 MINUTES
2 6 12 24 HOURS

FIGURE 5

SHORT DURATION RAINFALL INTENSITY-DURATION FRQUENCY DATA FOR- FORT NELSON A BC

BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD- 1966 - 1977 11 YEARS

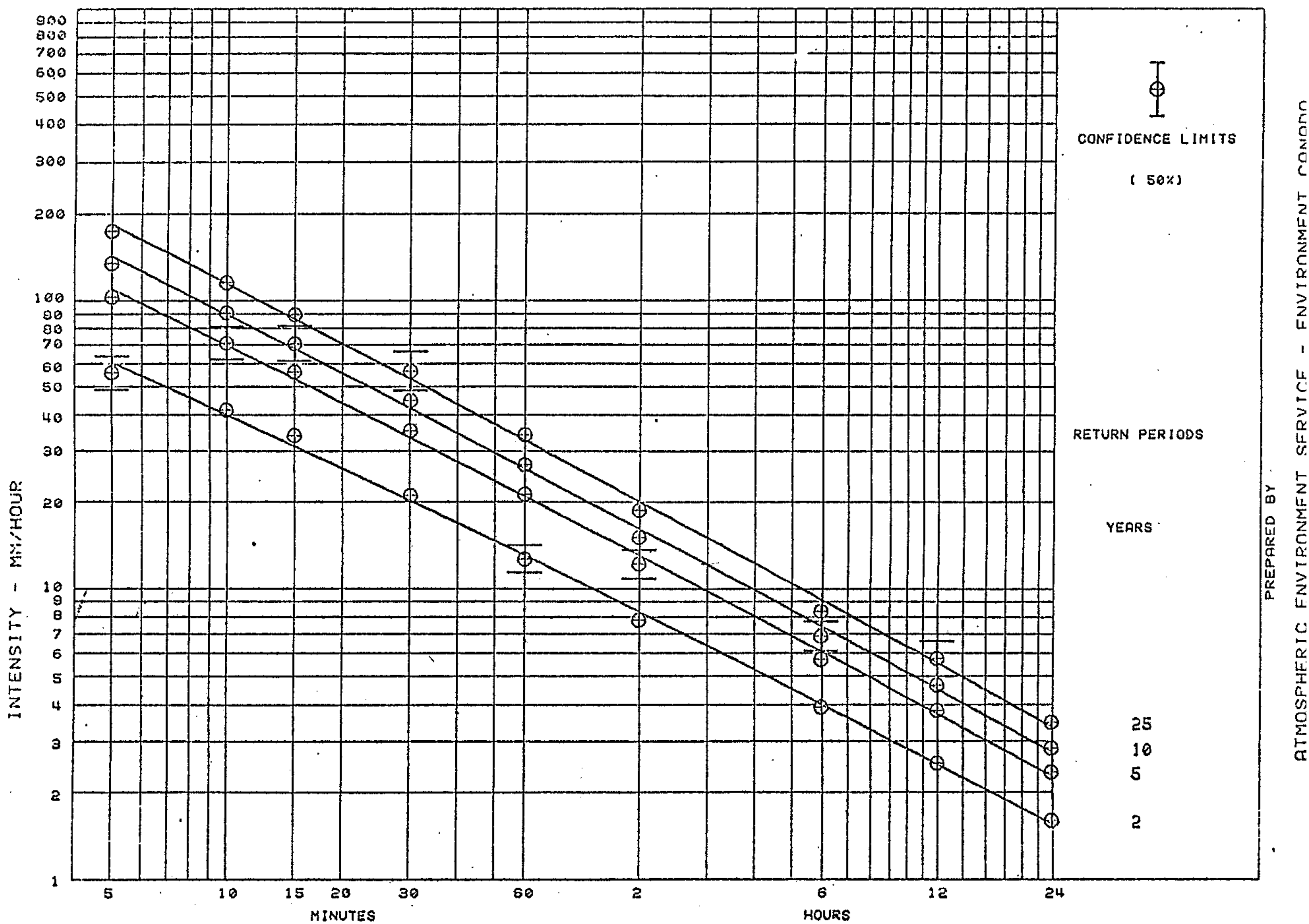


FIGURE 6

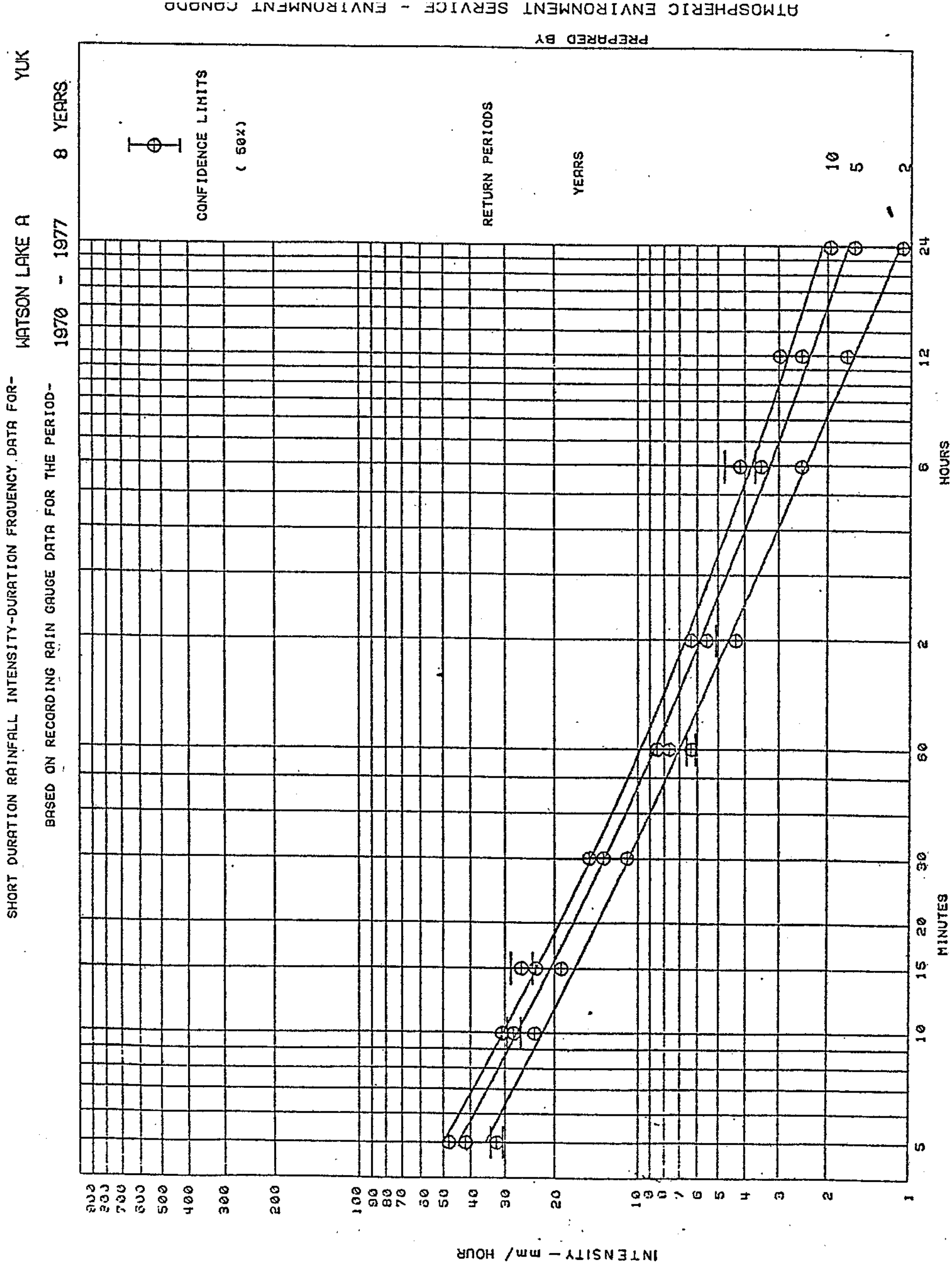
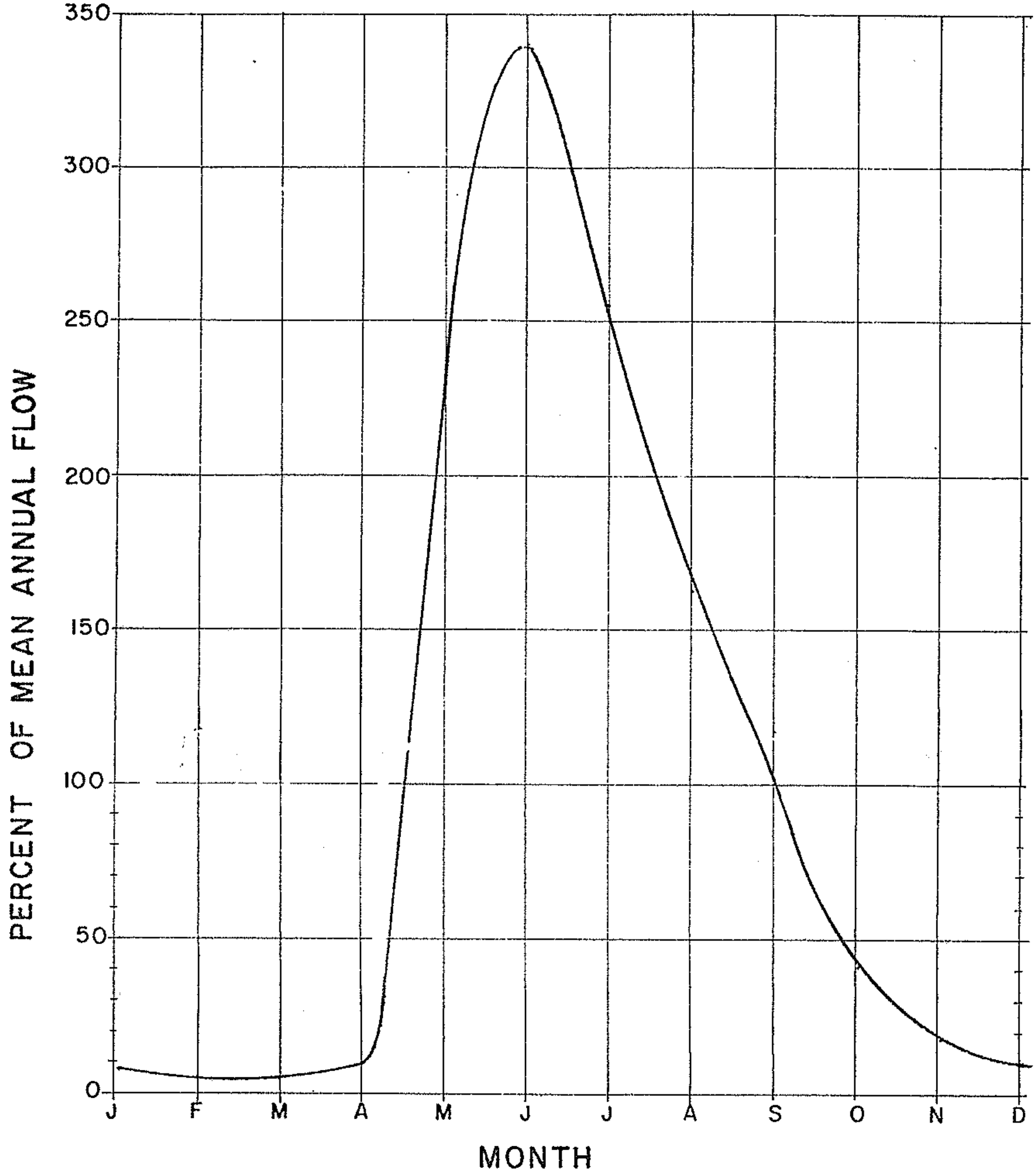

SHORT DURATION RAINFALL INTENSITY-DURATION FRQUENCY DATA FOR- WATSON LAKE A YUK
BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD- 1970 - 1977 8 YEARS
CONFIDENCE LIMITS (50%)
RETURN PERIODS YEARS
10
5
2
5 10 15 20 30 60 2 6 12 24
MINUTES
HOURS
INTENSITY — mm/ HOUR
1 2 3 4 5 6 7 8 9 10 20 30 40 50 60 70 80 90 100 200 300 400 500 600 700 800 900
PREPARED BY
ATMOSPHERIC ENVIRONMENT SERVICE - ENVIRONMENT CANADA

FIGURE 7

CADILLAC EXPLORATIONS LIMITED



MEAN ANNUAL MAXIMUM DAILY FLOW = 970 % OF MEAN ANNUAL FLOW
MEAN ANNUAL MAXIMUM INSTANTANEOUS FLOW = 1600 % OF MEAN ANNUAL FLOW

NOTE

ICE CONDITIONS PRESENT FROM OCTOBER TO EARLY MAY.

INDEX HYDROGRAPH

PRAIRIE CREEK AT CADILLAC MINESITE

VANCAL - 2988

FIGURE 8

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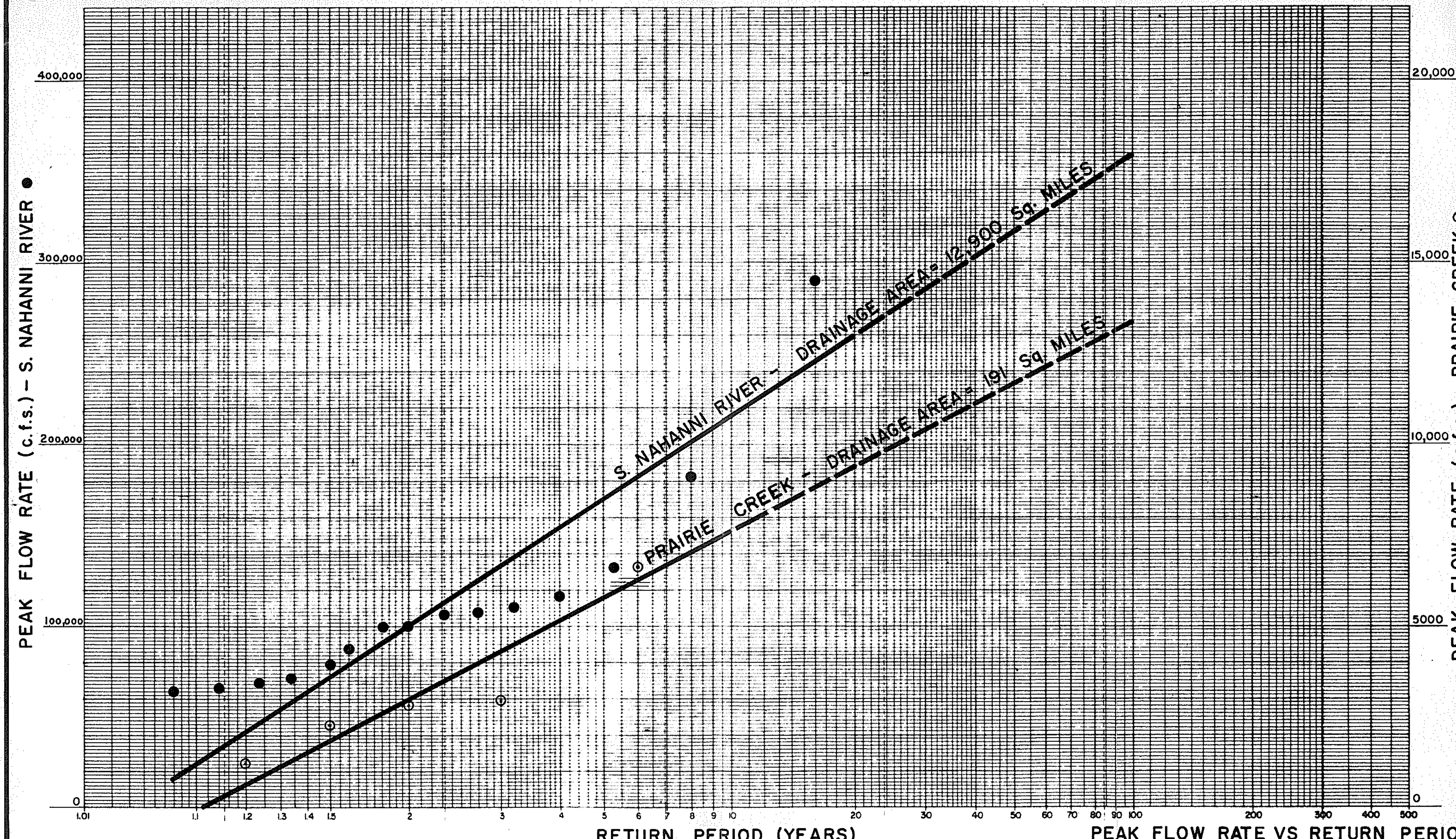
CADILLAC EXPLORATIONS LIMITED



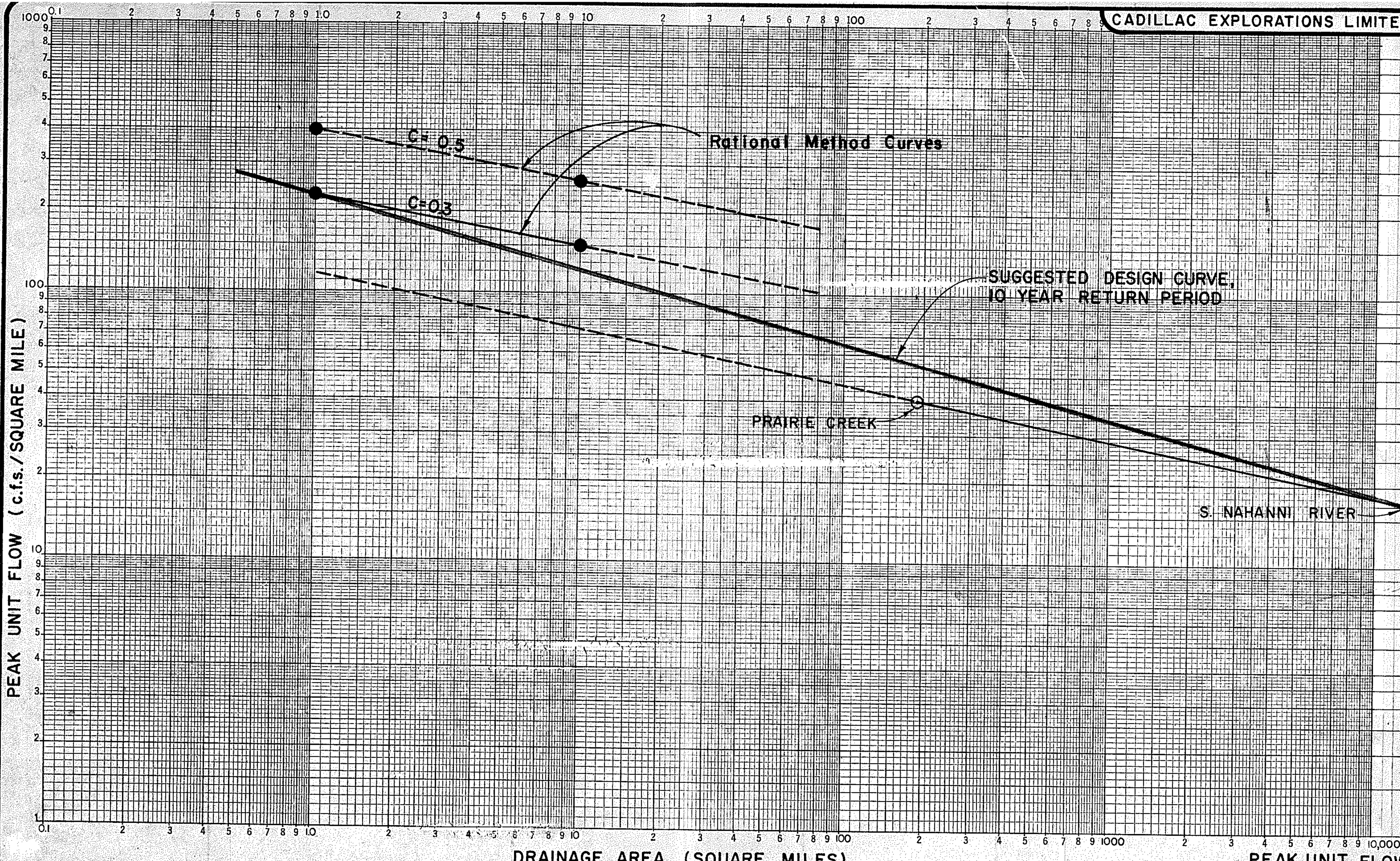
PEAK FLOW RATE VS RETURN PERIOD

S. NAHANNI RIVER & PRAIRIE CREEK

FIGURE 9

KER, PRIESTMAN & ASSOCIATES LTD.

CADILLAC EXPLORATIONS LIMITED



LEGEND

⊙ BASED ON FREQUENCY ANALYSIS OF STREAMFLOW DATA (SNOWMELT)

● BASED ON RATIONAL METHOD (RAINFALL)

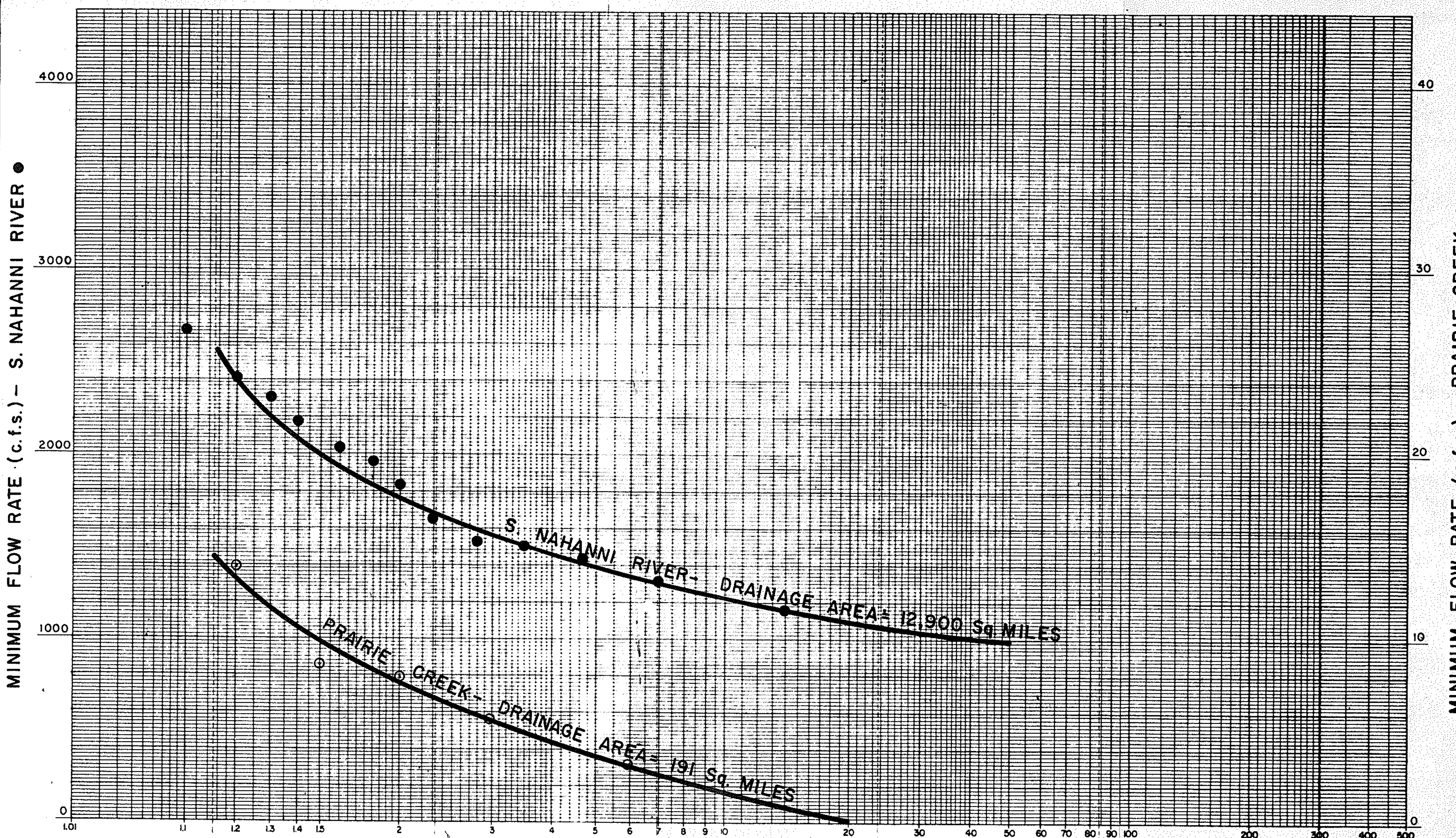
NOTES

1. ON THE BASIS OF THE STREAMFLOW ANALYSIS, THE FACTORS FOR RETURN PERIODS FOR OTHER THAN 10 YEAR ARE :
   $Q_5 = 0.8Q_{10}$; $Q_{50} = 1.5\,Q_{10}$
   $Q_{25} = 1.3Q_{10}$; $Q_{100} = 1.7\,Q_{10}$
2. C= RUNOFF COEFFICIENT FOR RATIONAL METHOD.

PEAK UNIT FLOW VS DRAINAGE AREA

FIGURE 10

KER, PRIESTMAN & ASSOCIATES LTD.



MINIMUM FLOW RATE VS RETURN PERIOD

S. NAHANNI RIVER & PRAIRIE CREEK

FIGURE 11

Figure 13 b

Legend for land systems mapping (from Crampton 1973)

LAND REGIONS (1st digit) (climatic zones) Characterized by the soils on the most constantly similar sites from Region to Region, the (near-drained mineral soil sites. The profound climatic change from the tundra Mackenzie Mountain Land Region in the NW, to the boreal Trout Lake Land Region in the S. is best illustrated by:	LAND DISTRICTS (2nd digit) (dominant parent material) 1. silty-clayey morainal 2. sandy-gravelly morainal 3. silty-clayey lacustrine 4. sandy-clayey lacustrine 5. eolian 6. shallow bedrock	rock flora	mostly white spruce, up to 75 ft. high herbaceous-grassy		mostly white spruce, up to 50 ft. high sedgy-sphagnaceous		sphagnaceous-lichenous mostly scattered black spruce up to 25 ft. high				widely scattered black spruce up to 15 ft. high (sphagnaceous in surficial runnels, but otherwise increasingly lichenous)			
1. MACKENZIE MOUNTAIN "Turbic" regosol	16	16 1						16 7						16 13	
2. CARCAJOU CANYON Cryic regosol	21 22 24 26	21 1 24 1 26 1			21 4	21 5 22 5 24 5 26 5	21 6	21 7 24 7 26 7		21 9 22 9 24 9 26 9	21 10 24 10 26 10	21 11 26 11	21 12 26 12	21 13 24 13 26 13	21 14 26 14
3. HORN PLATEAU Alpine eutric brunisol	31 32 33 36	31 1 36 1	31 2 32 2 33 2 36 2		31 4 33 4 36 4	31 5 32 5 36 5	31 6 36 6		31 8 33 8 36 8	31 9 33 9 36 9	31 10 33 10 36 10	31 11 32 11 36 11	31 12 33 12 36 12	31 13 36 13	
4. NORMAN WELLS Degraded eutric brunisol	41 42 43 44 45	41 1 43 1	41 2 43 2 44 2 45 2		41 4 43 4 44 4 45 4	41 5 42 5 43 5	41 6 43 6		41 8 43 8 45 8	41 9 43 9	41 10	41 11	41 12		
5. FORT SIMPSON Degraded dystric brunisol	51 52 53 54 55 56	51 1 56 1	51 2 53 2 54 2 56 2	51 3 52 3 53 3 54 3 55 3 56 3		51 5 52 5	51 6 53 6 54 6 56 6		51 8 52 8 53 8 56 8						
6. TROUT LAKE "Podzolized" dystric brunisol	61 62 63 64	61 1	61 2 62 2 64 2	61 3 62 3 63 3 64 3		61 5 62 5	61 6 62 6 63 6		61 8 62 8 64 8						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14

increasing latitude, elevation or distance from large water bodies

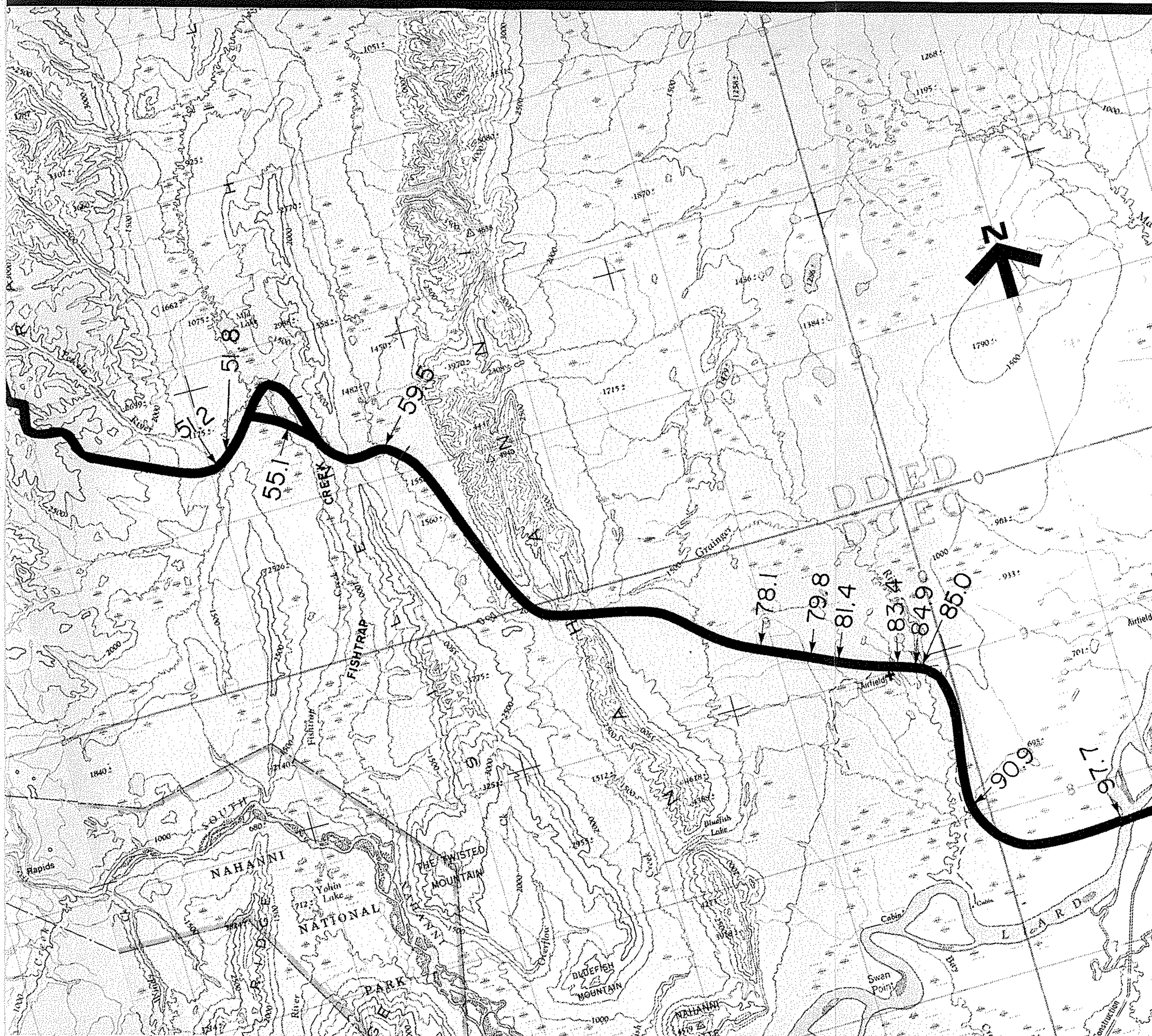
*For identification of Land Systems, see "Grouping of similar Landscape Units"

LEGEND FOR LANDSCAPE SURVEY AND DAMAGE SUSCEPTIBILITY MAP (based on landscape surveys in the southern and central Mackenzie River valley during 1971 and 1972, using air-photo interpretation, supplemented by ground observations)	Mountain outcrops and screes	Least susceptible	Moderately susceptible	Strongly susceptible	Most susceptible
		Steeply sloping to flat lands, with the summer permafrost table at about 60" depth or greater; locally ice lenses nearer the surface. Not especially susceptible to damage, except where ice lenses are near the land surface when thermal subsidence may occur. Grassy flora often pioneers damaged areas	Steeply sloping to flat lands, with the summer permafrost table at about 30"-60" depth, locally irregularly distributed, susceptible to damage where the permafrost table or ice lenses occurring locally near the land surface allow the possibility of thermal subsidence, and where slopes, for example those dropping to rivers, allow gully erosion. *Sphagnum* mosses often pioneer damaged areas.	Mostly flat lands, except for peripheral bluffs, with the summer permafrost table at about 10"-30" depth, more widespread where textures are silty. After the vegetative and organic cover is pierced by a damaging agent, the permafrost table lowers from about 20"-36", naturally-occurring depressions enlarge through thermal subsidence, and gullying erosion may occur on peripheral bluffs. Sedges and willows often pioneer damaged areas.	Sloping lands with the summer permafrost table at about 10"-30" depth. After the vegetative and organic cover is pierced by a damaging agent, the permafrost table lowers from about 10"-36", and gullying erosion can be severe and widespread, usually leaving bare ground. Once the thermal insulation given by the vegetative and organic cover is removed from a sufficiently large area, the erosional process can be self-perpetuating, until the slopes become stable enough for revegetation to commence.
	not differentiated	A	B	C	D

(Before averaging, all depths measured to the permafrost table were adjusted to the mid A[illegible]

All [illegible] in Land Regions 5, 1 are [illegible]

////////// Boundary between mapped and unmapped land systems



CADILLAC EXPLORATIONS LTD. PROPOSED WINTER ROAD

WATERCOURSE CROSSING LOCATIONS

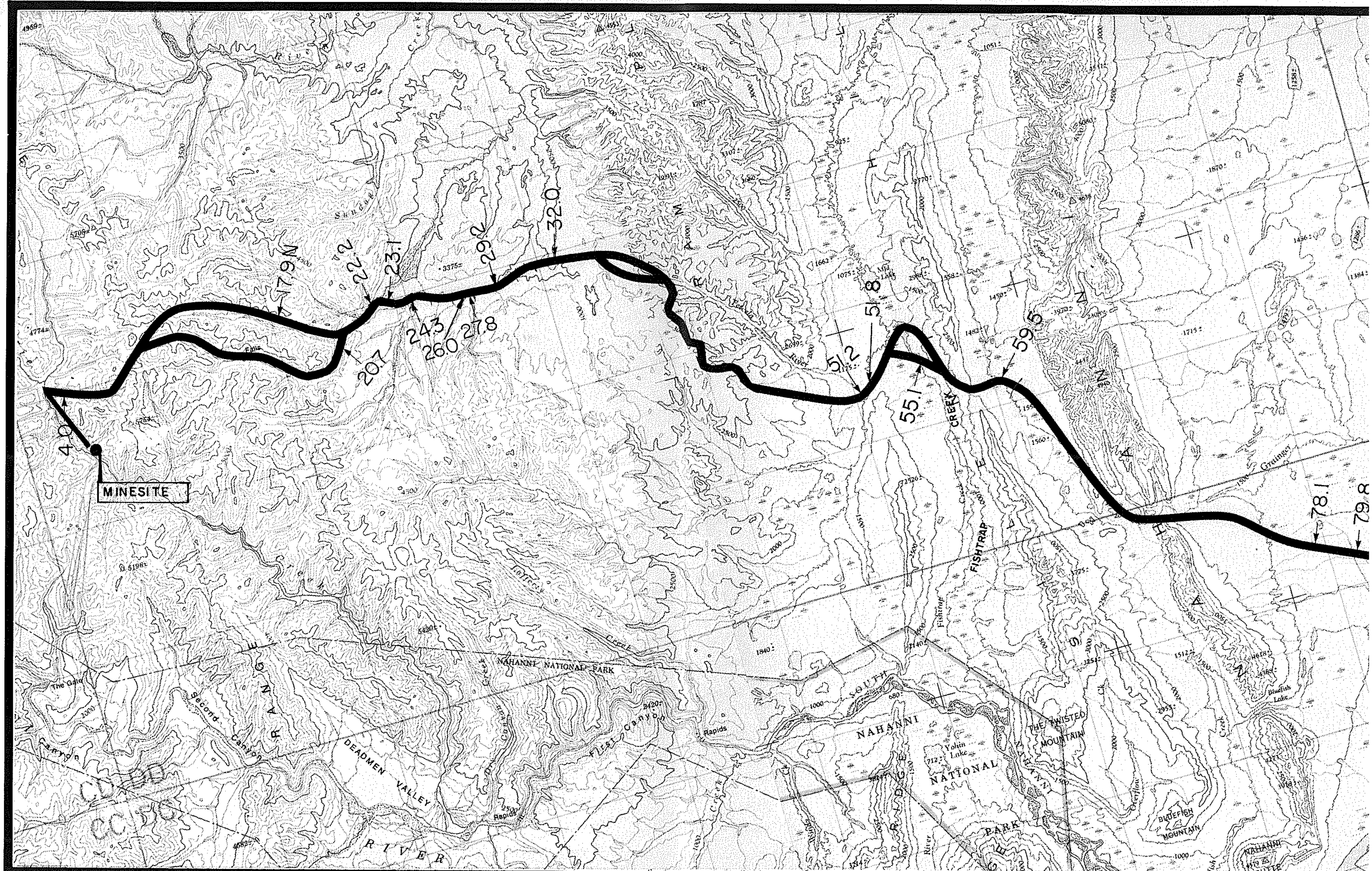
ROAD ALIGNMENT

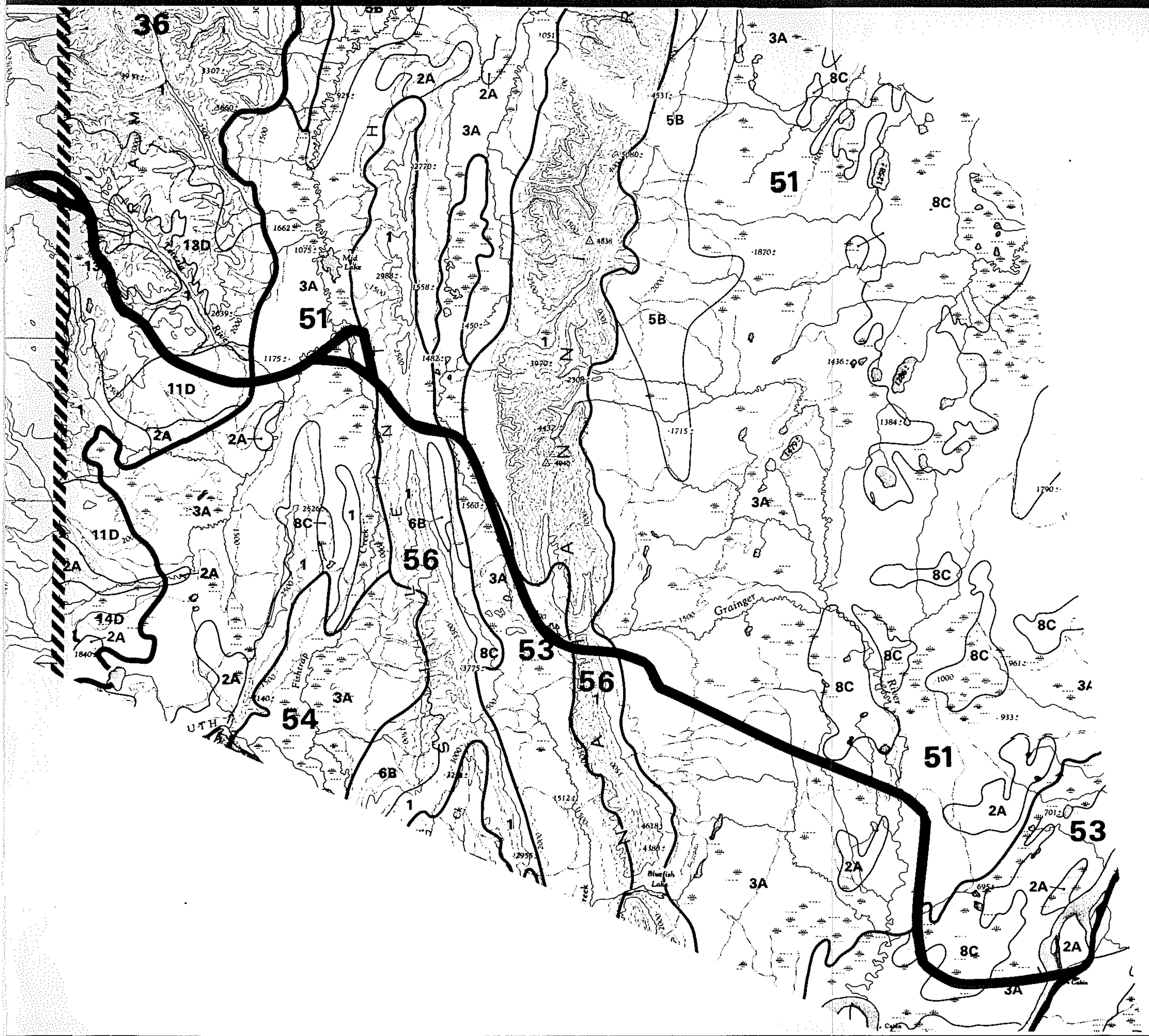
figure 12

MILES
0 5 10

km
0 5 15

beak


MINESITE
4.0
17.9N
20.7
22.2
23.1
24.3
26.0
27.8
29.2
32.0
51.2
51.8
55.1
59.5
78.1
79.8
CREEK
FISHTRAP
NAHANNI NATIONAL PARK
SOUTH
NAHANNI
NATIONAL
PARK
DEADMEN VALLEY
RIVER
RANGE
THE TWISTED MOUNTAIN
BLUEFISH MOUNTAIN
First Canyon
Second Canyon
The Gate
Rapids



CADILLAC EXPLORATIONS LTD. PROPOSED WINTER ROAD

PROPOSED WINTER ROAD CORRIDOR SHOWING LANDSCAPE CLASSIFICATION OF THE EASTERN SECTION OF THE ROUTE.

ROAD ALIGNMENT

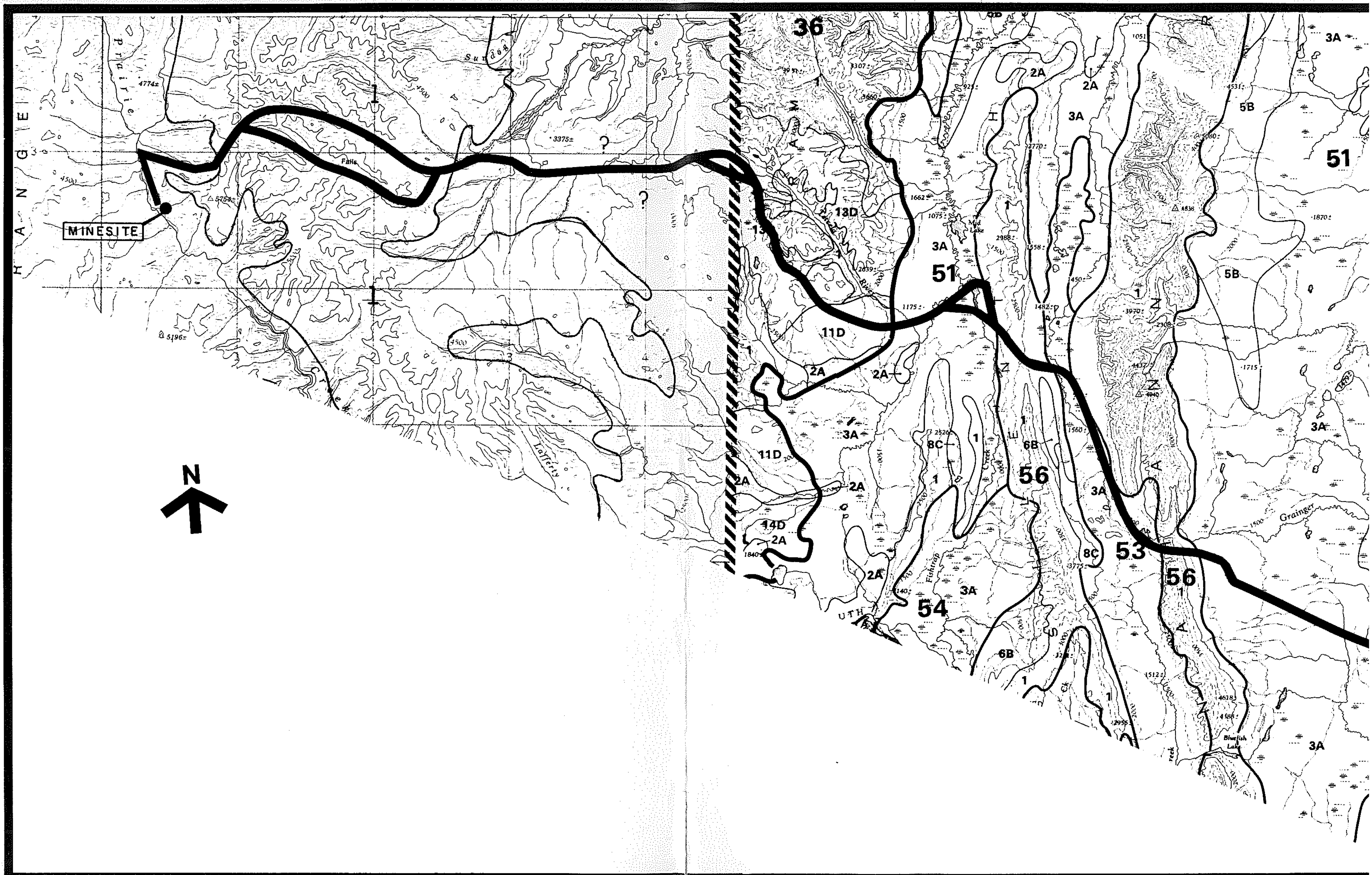
(KEY ON FIG. 13b)

figure 13a

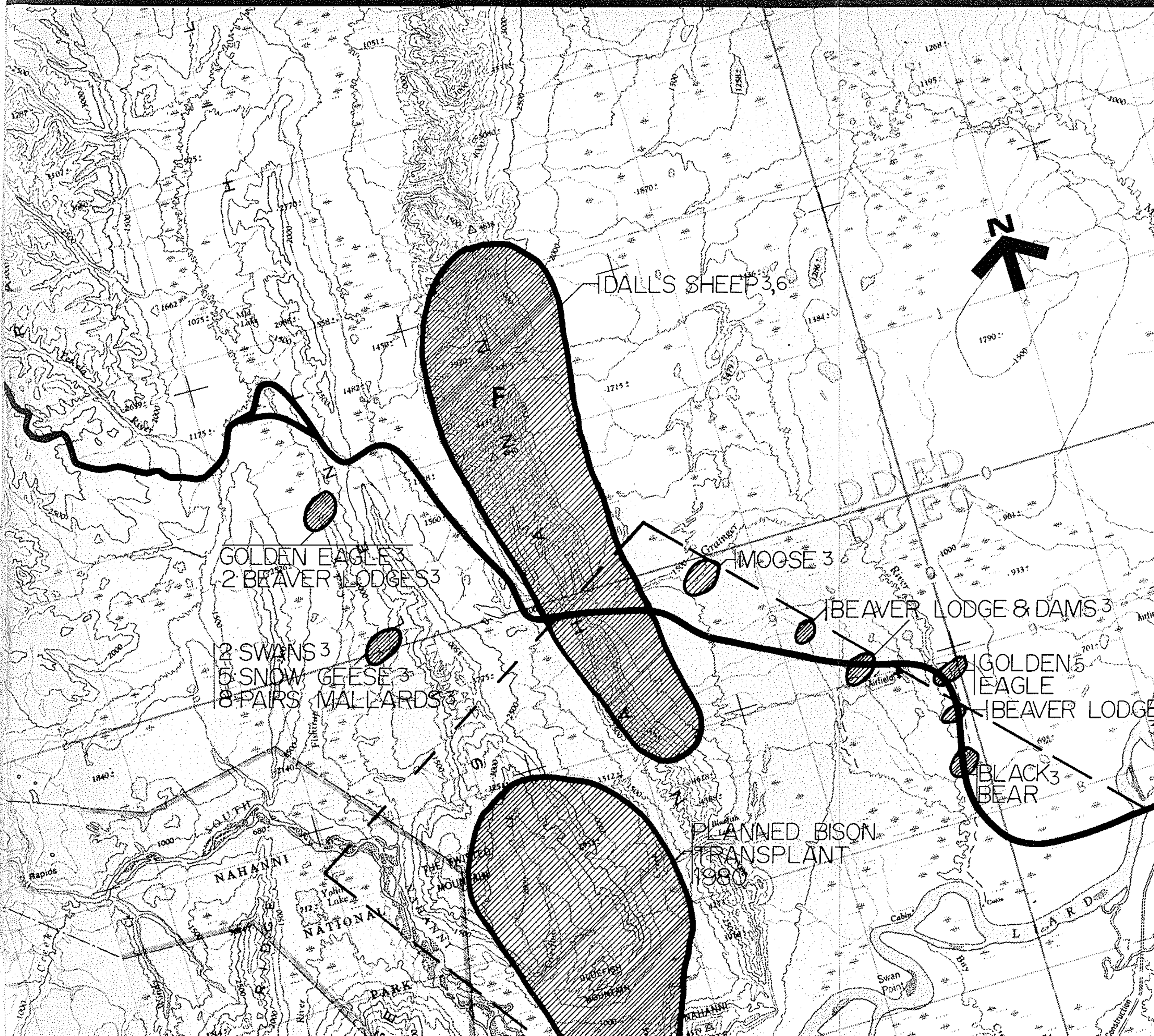
MILES 0 5 10

km 0 5 15

beak



MINESITE
N
36
13D
11D
14D
2A
3A
5B
51
56
53
54
6B
8C
Mid Lake
Bluefish Lake
Grainger



CADILLAC EXPLORATIONS LTD. PROPOSED WINTER ROAD

WILDLIFE INFORMATION LEGEND

ROAD ALIGNMENT

RANGE EVALUATION RE= WOOD BISON TRANSPLANT C.W.S6

NOTES.

1) SCOOTER ET AL. 1971
2) MR. R. FAST, PERS. COMM. CADILLAC MINES FOREMAN. 1980
3) BEAK CONSULTANTS LIMITED, FIELD RECONNAISSANCE, APRIL 1980
4) DR. B. FLETCHER & MR. R. M. WILSON. 1980 PERS. COMM. GOLDER ASSOCIATES, VANCOUVER, B.C.
5) DEPARTMENT OF THE ENVIRONMENT, INDIAN & NORTHERN AFFAIRS LAND USE INFORMATION SERIES. 1976
6) CANADIAN WILDLIFE SERVICE PROJECT, MR. H. REYNOLDS, PERS. COMM. 1980

FOR DESCRIPTION OF OBSERVATIONS SEE SECTION 4.5.4

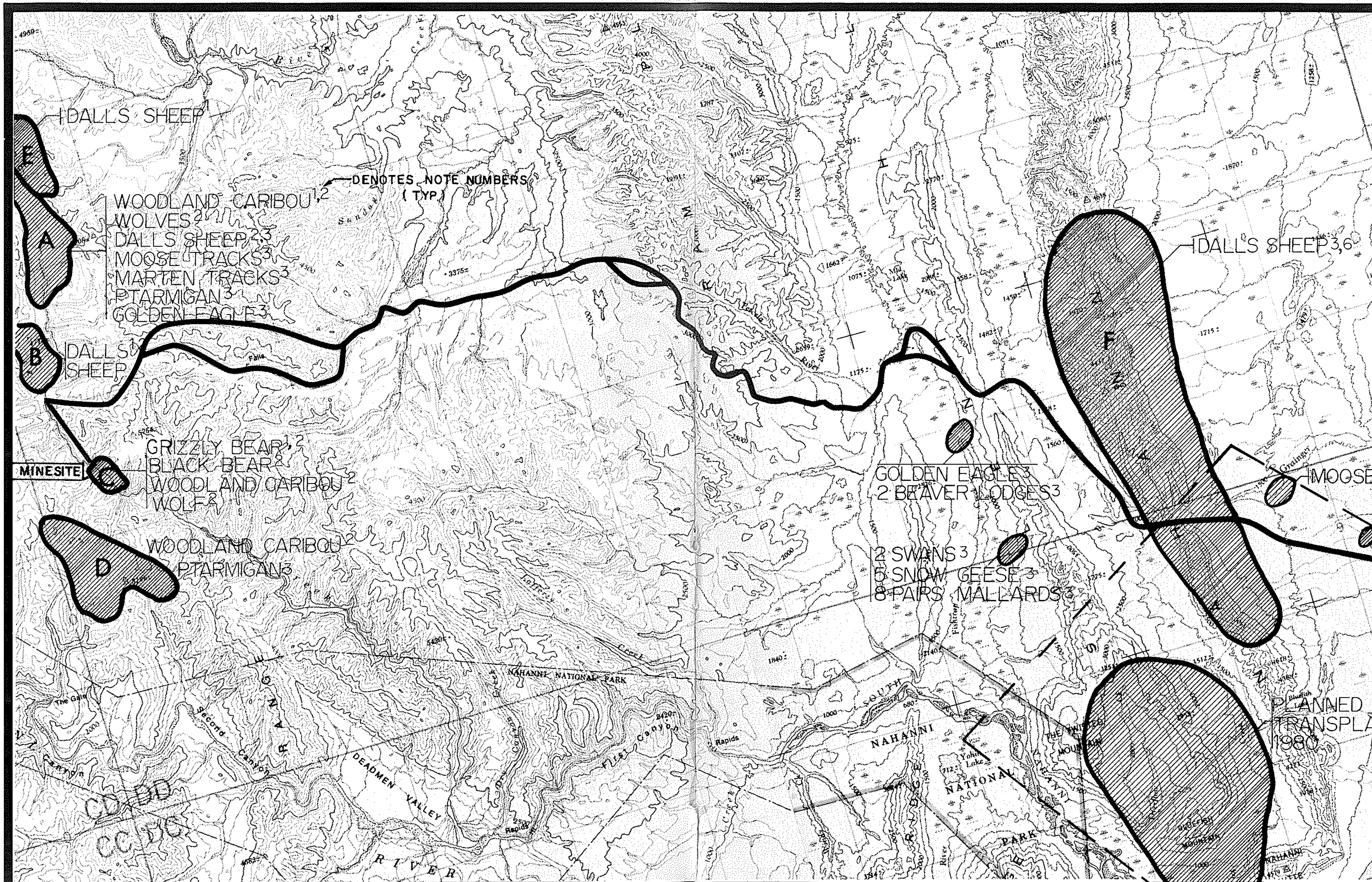
AREAS A TO F HAVE PREVIOUSLY BEEN DEFINED AS CONTAINING WILDLIFE POPULATIONS.

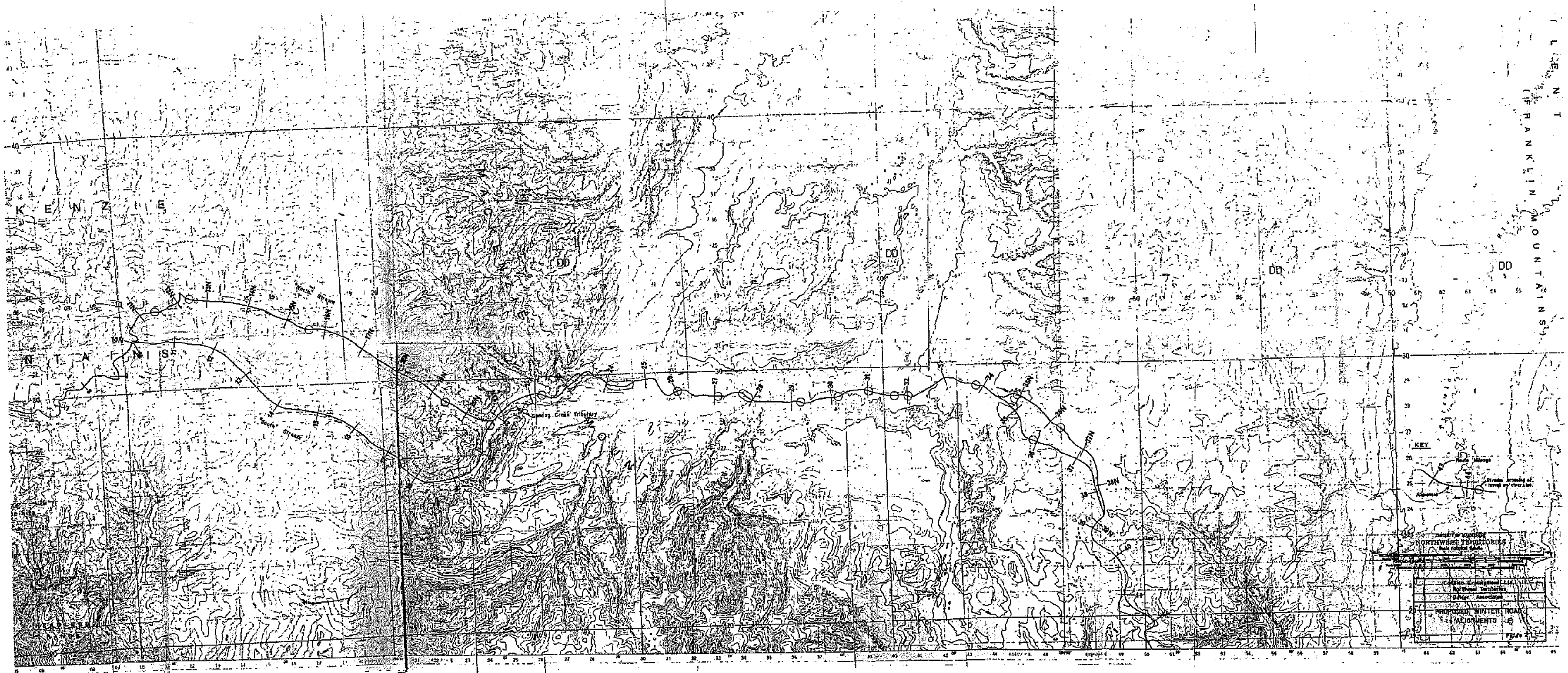
figure 14

MILES
0 5 10

km
0 5 15

beak


DALLS SHEEP
E
A
WOODLAND CARIBOU 1,2
WOLVES 2
DALLS SHEEP 2,3
MOOSE TRACKS 3
MARTEN TRACKS 3
PTARMIGAN 3
GOLDEN EAGLE 3
DENOTES NOTE NUMBERS (TYP)
B
DALLS SHEEP 1
MINESITE
C
GRIZZLY BEAR 1,2
BLACK BEAR 2
WOODLAND CARIBOU 2
WOLF 2
D
WOODLAND CARIBOU 2
PTARMIGAN 3
GOLDEN EAGLE 3
2 BEAVER LODGES 3
2 SWANS 3
5 SNOW GEESE 3
8 PAIRS MALLARDS 3
DALLS SHEEP 3,6
F
MOOSE
1980
NAHANNI NATIONAL PARK
DEADMEN VALLEY
First Canyon
Second Canyon
RIVER
SOUTH
NAHANNI
NATIONAL
PARK
THE TWISTED MOUNTAIN
CD DD
CC DC


KENZIE
FRANKLIN MOUNTAINS
DD
KEY
NORTHWEST TERRITORIES
PROPOSED WINTER ROAD
ALIGNMENTS