3.4.2 Primary Producers

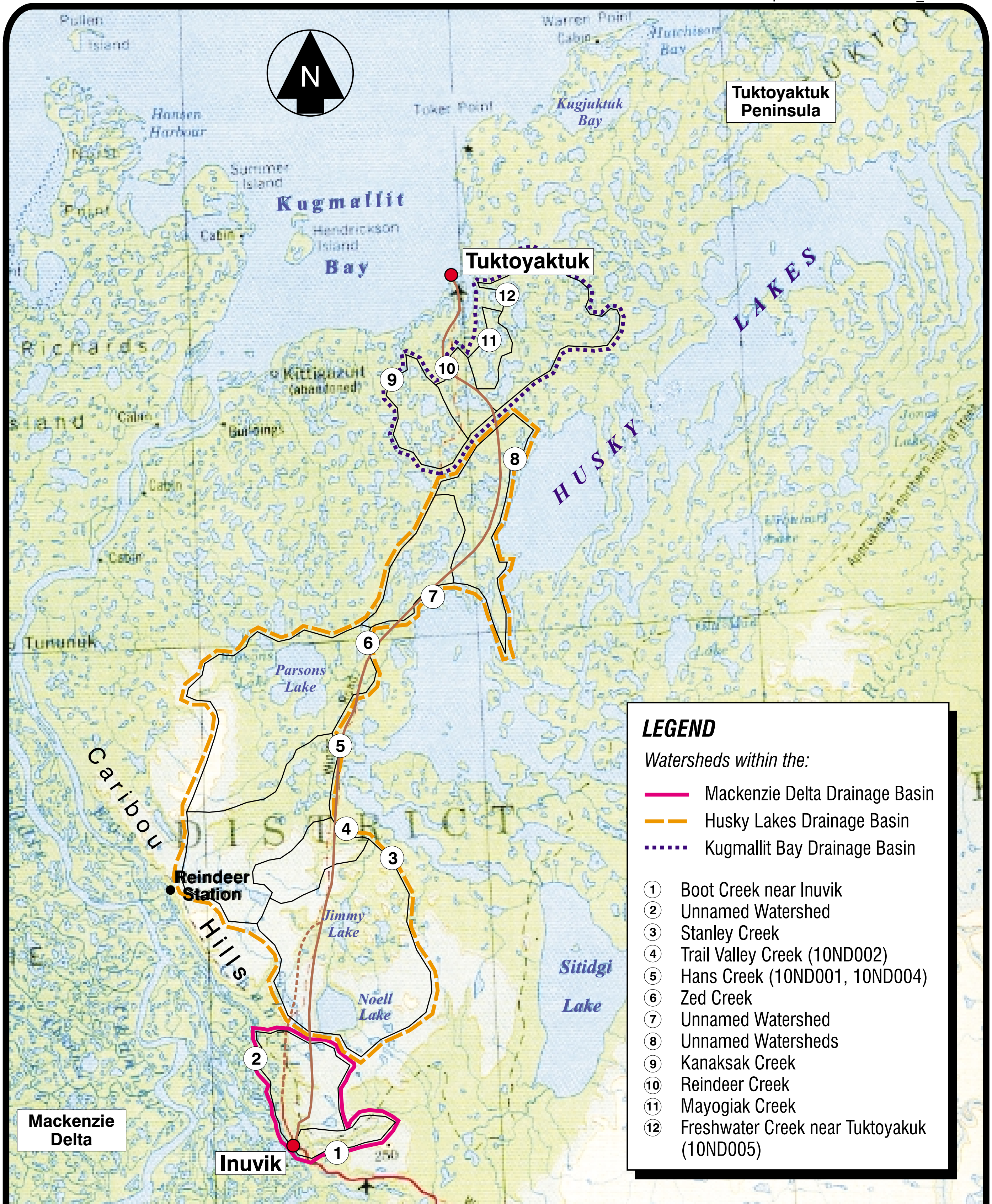
Primary production in peninsula lakes is comprised of several communities of plant and plant-like organisms. These include phytoplankton (free-floating algae), periphyton (algae attached to substrate), macrophytes (aquatic plants), tycoplankton (microscopic algae neither planktonic nor attached to the substrate but associated with macrophytes and debris in the littoral zone) and benthic algae (Ramsey and Ramlal, 1985). Primary producers take up elemental nutrients and produce organic matter through photosynthesis. Early studies of Tuktoyaktuk Peninsula lakes in the 1970's found that phytoplankton communities were dominated by Chrysophyceae and Cryptophyceae, with peak biomass and production in mid-July and late August (Sheath *et al.*, 1975, Sheath and Hellebust, 1978). During the mid-July peak, euplankton production slightly exceeded tycoplankton production but during the late August peak, tycoplankton production was five times the euplankton production (Sheath *et al.*, 1975, Sheath and Hellebust, 1978). The late August peak in tycoplankton was suggested to be the result of nutrient release by the macrophytes (Ramsey and Ramlal, 1985). Water chemistry data collected by Bond and Erickson (1982, 1985) suggest that primary production in peninsula lakes are probably phosphorus limited.

3.4.3 Secondary Producers

Secondary producers are comprised of the zooplankton (free-floating or weakly swimming invertebrates) and the benthos (invertebrates that dwell on the bottom). These organisms feed on primary producers and other secondary producers and are in turn fed upon by fishes, providing the final link between nutrients and fish production.

The zooplankton community of peninsula lakes are comprised of a number of invertebrate groups. Rotifers were found to be an important component of these communities (McCart *et al.*, 1976). Crustaceans were also important, especially cyclopoid copepods, cladocerans, and calanoid copepods (McCart *et al.*, 1976). Zooplankton abundance peaked in mid-July, with the fauna dominated early in the summer by cyclopoid copepods and then switching to rotifer dominance from mid-July to autumn (Taylor *et al.*, 1982). Winter zooplankton was sparse, suggesting that most species overwintered in resting stages (McCart *et al.*, 1976; McCart, 1980).

Figure 3.4-1 Watersheds within the Project Area



Northwest Territories

Watersheds within the Project Area

FIGURE 3.3-1

Rescan

Source: Department of Energy, Mines and Resources, Ottawa, Canada, 1976. Firth River NR - 7/8/9

With respect to abundance, benthos communities in peninsula lakes were dominated by chironomids and molluscs, with gastropods and oligochaetes found in lesser densities (Brunskill *et al.*, 1973; McCart *et al.*, 1976, Taylor *et al.*, 1982). Bond (1982) conducted a reconnaissance survey of the benthos in the Reindeer Creek estuary in Tuktoyaktuk harbor and found amphipods, ostracods, isopods, pelecypods, polychaetes, oligochaetes, nematodes, and foraminiferans. Stream benthos has seen less effort with respect to research. However, McCart *et al.* (1974) found that the benthos of the Noell Lake outflow was comprised of plecopterans, ephemeropterans, dipterans (Tipulidae, Chironomidae, Empidiae), oligochaetes, nematodes, arachnids, and other miscellaneous invertebrates.

Tuktoyaktuk Peninsula lakes were found to have intermediate benthos production in comparison to the low productivity of silty Mackenzie Delta lakes and the higher productivity of clear lakes (Brunskill *et al.*, 1973; Bond and Erickson, 1985). Though quantitative analyses were not conducted, a review of the subject offered two possible explanations for the differences in secondary production between Delta and peninsula lakes. The first suggestion was that higher suspended solids in Delta lakes reduced water clarity, which reduced primary production and resulted in lower densities of secondary producers (Ramsey and Ramlal, 1985). However, a subsequent study found that differences in primary production did not account for the observed differences in secondary production (Fee *et al.*, 1988). Predation pressure by fishes was also suggested as a reason for the lower secondary production in Delta lakes. A more recent synthesis suggests that the more stable flood regime of peninsular lakes provides a more hospitable habitat for secondary producers (Chang-Kue and Jessop, 1991).

3.4.4 Fish Resources

Considerable research was conducted into the fishes of the Mackenzie River, Delta, and adjacent marine environments as a result of the exploration and proposed development of hydrocarbon reserves in the area. Though the hydrocarbon reserves remain essentially undeveloped, the environmental research conducted by federal government agencies, the oil industry, Aboriginal organizations and consultants has left the region with substantial data on the biology of the fishes inhabiting the region. Based on this work, a total of 20 species of fishes have been recorded from the waters along or adjacent to the proposed road alignment.

Table 3.4-1
Common and Scientific Names of Fish Captured in the Streams Crossed by the Proposed Inuvik to Tuktoyaktuk Road [1]

Family	Common Name[2]	Scientific Name[2]	Unnamed Creek 1	Jimmy Creek	Second Jimmy Creek	Trail Valley Creek	Hans Creek	Parsons Creek	Unnamed Creek 2	Reindeer Creek and Estuary
Clupeidae	Pacific herring	*Clupea pallasi*								X
Esocidae	Northern pike	*Esox lucius*		X						
Osmeridae	Fry spp.			X						
	Pond smelt	*Hypomesus olidus*								X
	Rainbow smelt	*Osmerus mordax*								X
Salmonidae	Arctic cisco	*Coregonus autumnalis*								X
	Lake whitefish	*Coregonus clupeaformis*		X				X		X
	Broad whitefish	*Coregonus nasus*								X
	Least cisco	*Coregonus sardinella*								X
	Round whitefish	*Prosopium cylindraceum*						X		
	Lake trout	*Salvelinus namaycush*						X		
	Inconnu	*Stenodus leucichthys*								
	Arctic grayling	*Thymallus arcticus*		X			X	X		
Cyprinidae	Fry spp.			X						
Catostomidae	Longnose sucker	*Catostomus catostomus*								
Gadidae	Saffron cod	*Eliginus gracilis*								X
	Burbot	*Lota lota*								X
Gasterosteidae	Ninespine stickleback	*Pungitius pungitius*	X	X				X	X	X
Cottidae	Slimy sculpin	*Cottus cognatus*					X	X		
	Fourhorn Sculpin	*Myocephalus quadricornis*								X
Platichthiidae	Starry flounder	*Platichthyes stellatus*								X
	Arctic flounder	*Pleuronectes glacialis*								

[1] **Data compiled from: Bond, 1982; Percy and Hoban, 1975; McCart *et al.*, 1974.**
[2] **Common and scientific names were updated to follow the currently accepted nomenclature presented in Eschmeyer (Ed.), 1998 andRobins *et al.*, 1991.**

Table 3.4-2
Common and Scientific Names of Fish Captured in the Lakes Adjacent to the Proposed Inuvik to Tuktoyaktuk Road [1]

Family	Common Name[2]	Scientific Name[2]	Unnamed Lake 1	Noell Lake	Jimmy (Island) Lake	East Hans Lake	Parsons Lake	Zed Lake	Husky Lakes	Unnamed Lake 2	Unnamed Lake 3	Unnamed Lake 4	Unnamed Lake 5
Clupeidae	Pacific herring	*Clupea pallasi*							X	X			
Esocidae	Northern pike	*Esox lucius*			X		X				X		
Osmeridae	Fry spp.										X	X	
	Pond smelt	*Hypomesus olidus*											
	Rainbow smelt	*Osmerus mordax*											
Salmonidae	Arctic cisco	*Coregonus autumnalis*					X						
	Lake whitefish	*Coregonus clupeaformis*			X			X	X	X			
	Broad whitefish	*Coregonus nasus*			X		X		X	X		X	X
	Least cisco	*Coregonus sardinella*				X		X	X	X			
	Round whitefish	*Prosopium cylindraceum*											
	Lake trout	*Salvelinus namaycush*		X								X	X
	Inconnu	*Stenodus leucichthys*											
	Arctic grayling	*Thymallus arcticus*		X		X							
Cyprinidae	Fry spp.												
Catostomidae	Longnose sucker	*Catostomus catostomus*					X						
Gadidae	Saffron cod	*Eliginus gracilis*							X				
	Burbot	*Lota lota*							X				
Gasterosteidae	Ninespine stickleback	*Pungitius pungitius*	X			X	X				X	X	X
Cottidae	Slimy sculpin	*Cottus cognatus*											
	Fourhorn Sculpin	*Myocephalus quadricornis*								X			
Platichthiidae	Starry flounder	*Platichthyes stellatus*							X				X
	Arctic flounder	*Pleuronectes glacialis*											

[1] **Data compiled from: Bond, 1982; Bray, 1975; Percy and Hoban, 1975; McCart *et al.*, 1974 and Falk and Lawrence, 1973.**
[2] **Common and scientific names were updated to follow the currently accepted nomenclature presented in Eschmeyer (Ed.) 1998 and Robins *et al.* 1991.**

Table 3.4-3
Common and Scientific Names of Fish Captured in the Lakes, Streams, and Estuaries within the Region Potentially Affected by the Proposed Inuvik to Tuktoyaktuk Road [1]

Family	Common Name[2]	Scientific Name[2]	Douglas Creek	Unnamed Creek 3	Unnamed Creek 4	Noell Outflow	Unnamed Lake 6	Keneksek System	Canyanek System	Peter Lake	Wolverine Lakes
Clupeidae	Pacific herring	*Clupea pallasi*						X			
Esocidae	Northern pike	*Esox lucius*					X				X
Osmeridae	Fry spp.										
	Pond smelt	*Hypomesus olidus*						X	X		
	Rainbow smelt	*Osmerus mordax*						X	X		
Salmonidae	Arctic cisco	*Coregonus autumnalis*	X				X	X	X		
	Lake whitefish	*Coregonus clupeaformis*						X	X		
	Broad whitefish	*Coregonus nasus*					X	X	X		X
	Least cisco	*Coregonus sardinella*						X	X	X	
	Round whitefish	*Prosopium cylindraceum*									
	Lake trout	*Salvelinus namaycush*								X	X
	Inconnu	*Stenodus leucichthys*						X	X		
	Arctic grayling	*Thymallus arcticus*		X		X	X	X	X		
Cyprinidae	Fry spp.										
Catostomidae	Longnose sucker	*Catostomus catostomus*						X			
Gadidae	Saffron cod	*Eliginus gracilis*						X			
	Burbot	*Lota lota*						X	X		X
Gasterosteidae	Ninespine stickleback	*Pungitius pungitius*	X					X	X		
Cottidae	Slimy sculpin	*Cottus cognatus*									
	Fourhorn Sculpin	*Myocephalus quadricornis*						X	X		
Platichthiidae	Starry flounder	*Platichthyes stellatus*						X	X		
	Arctic flounder	*Pleuronectes glacialis*							X		

[1] **Data compiled from: Golder, 1997; Lawrence *et al.*, 1984; Mann ,1974 and McCart *et al*, 1974.**
[2] **Common and scientific names were updated to follow the currently accepted nomenclature presented in Eschmeyer, 1998 and Robins *et al.*, 1991.**

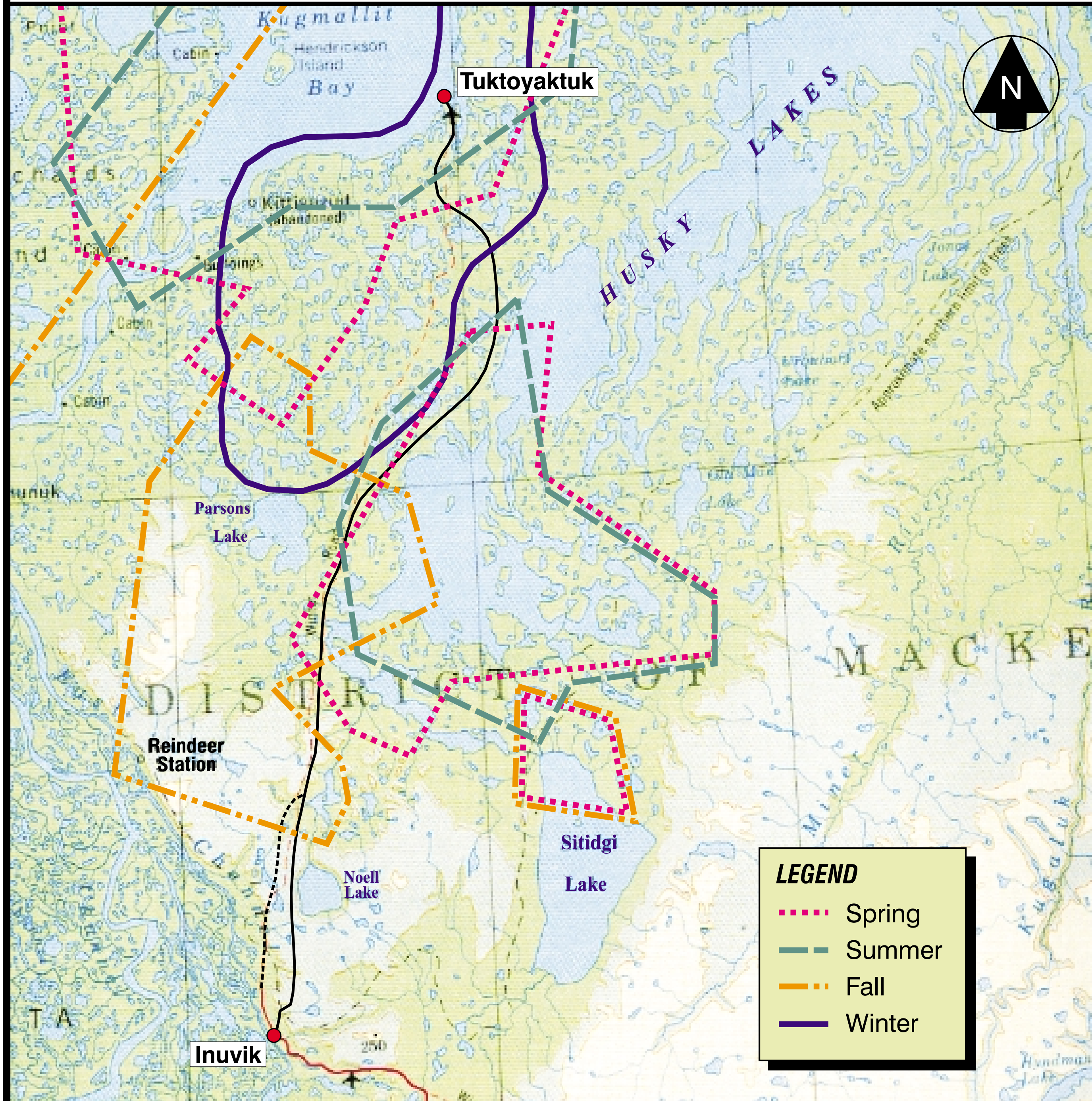


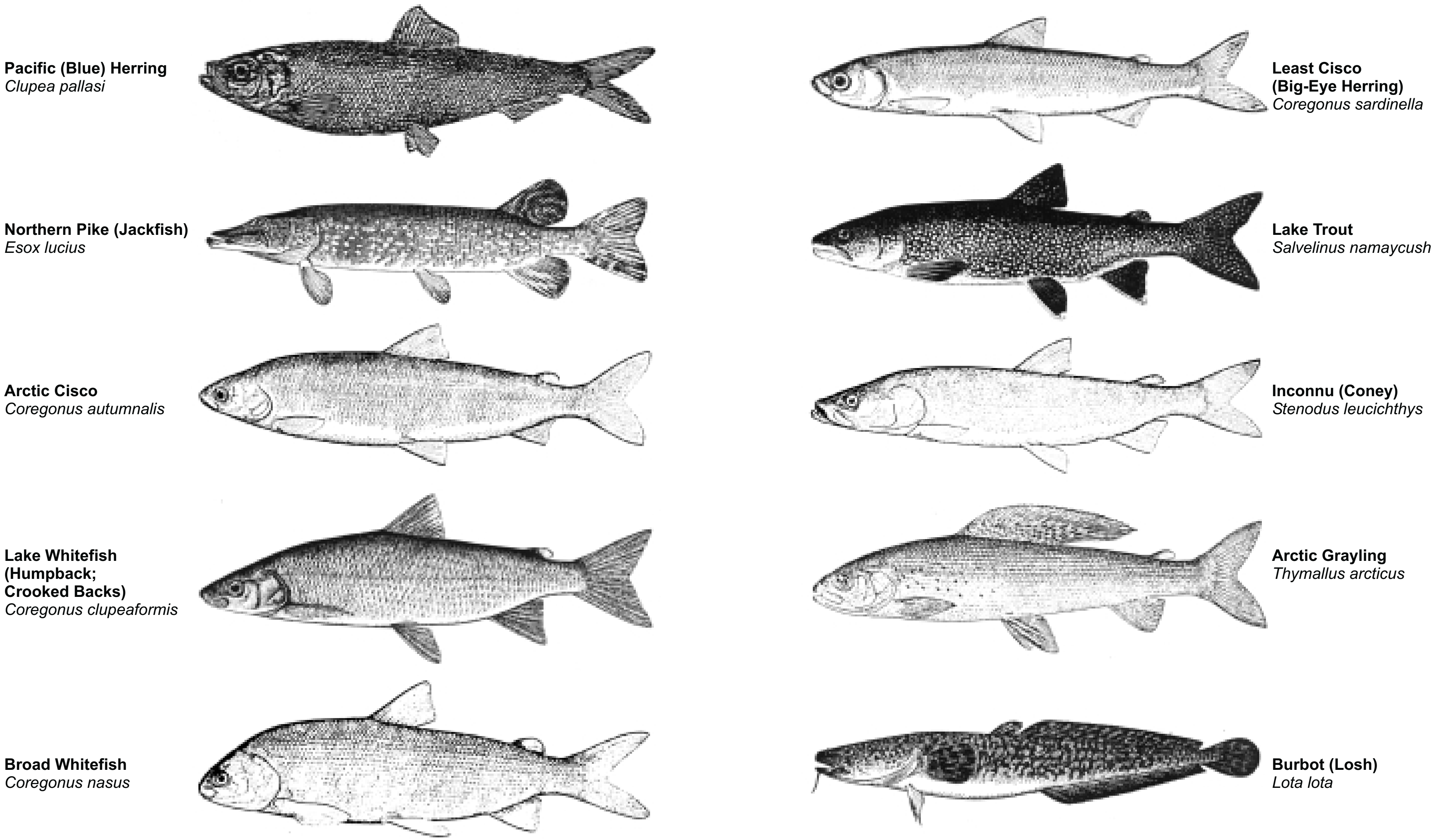
FIGURE 3.4-2

Traditional Use Areas for Fishing

Northwest Territories

Rescan

Source: *Inuvik and Tuktoyaktuk Community Conservation Plans*



Northwest Territories

Important Fishes Found Along the Proposed Inuvik to Tuktoyaktuk Road Alignment

FIGURE 3.4-3

Rescan

3.4.4.1 Traditional Fisheries

The proposed Inuvik–Tuktoyaktuk road alignment passes through a region of interest to the Aboriginal people of both communities. The Tuktoyaktuk planning area encompasses the majority of the proposed road alignment, including the entire area north of Noell Lake. Within this region, the Tuktoyaktuk Community Conservation Plan (Tuktoyaktuk, 1993) identifies local areas for traditional seasonal fisheries that require special protection (Figure 3.4-2). Together with the Inuvik Community Working Group, the Tuktoyaktuk Community Working Group identified an additional area, consisting of several lake systems, as an important traditional fishery (Inuvik, 1993). It is important to note that the areas identified not only contain lakes and stream adjacent to or crossed by the proposed road alignment but also downstream areas which receive water from areas through which the road alignment would pass. The community consultations and elder interviews also confirmed the importance of the areas outlined in Figure 3.4-2 as important traditional use areas.

The traditional fisheries of the region includes a variety of species that are harvested based upon seasonal availability. The community of Inuvik has identified a number of species that are considered important to the traditional fisheries (Inuvik, 1993). They prepared a list of the ten most important species, including identifying areas of important fish habitat, management and conservation plans, and goals with respect to maintaining the populations. To familiarize the reader, Figure 3.4-3 provides illustrations of these ten most important fish species of the traditional fisheries. Tables 3.4-1 to 3.4-3 summarize the species of fish found in the streams, lakes and estuaries of the proposed development area. The reader should refer to Figure 3.4-1 and Tables 3.4-1 to 3.4-3 for stream and lake locations relative to the following fish descriptions.

3.4.4.1.1 Pacific (Blue) Herring - *Clupea pallasi*

Pacific herring are distributed throughout coastal habitats from the western Arctic seas to the northern Pacific Ocean (Whitehead 1985). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, Pacific herring have been found in the Reindeer system, the Freshwater system, Husky Lakes, unnamed lake 2, and the Keneksek system.

Pacific herring are a coastal fish that inhabit primarily marine and brackish water but also venture into freshwater (Allen and Smith 1988; Hart 1973). However, landlocked populations have been documented (Hart 1973). They are a pelagic (mid-water) fish, inhabiting shallow coastal areas. Pacific herring enter Tuktoyaktuk Harbour in large numbers during the autumn (Bond, 1982). They overwinter in the harbour, spawn in June and appear to leave the bay immediately after spawning.

In the spring, pacific herring move into shallow waters and estuaries to spawn over marine vegetation or bare rocks in low salinity water, 10 to 21‰ (Whitehead 1985) when the temperature reaches 2.5 to 3.5 °C (Gillman and Kristofferson, 1984). Fry form schools on the surface, feeding on ostracods, copepods, fish larvae, euphausids, and diatoms, and then migrate to deeper water to feed on crustaceans, small fishes, marine worms, and larval clams (Hart 1973). They mature at four years of age and 210 mm in length, joining the adult spawning migration and switching to a diet of crustaceans and small fishes. Maximum size and age appears to be 450 mm and 18 years, respectively.

Pacific herring have been included along with Arctic cisco and least cisco and are collectively identified as “herring” in the Inuvik Inuvialuit Conservation Plan (1993). The importance of these species is not only as food used by local people but as forage by more preferred food species such as beluga whales, seals, lake trout, and northern pike. Though research into the biology and ecology of Pacific Herring is considered important, the abundant population is considered to be in adequate supply. Current conservation measures include identifying and protecting important habitat areas, and prohibiting development in areas of population concentrations, and closely monitoring development activities.

3.4.4.1.2 Northern Pike (Jackfish) - *Esox lucius*

Northern pike can be found in a wide range of habitat types through out their extensive circumpolar (around the northern polar regions of the world) distribution (Scott and Crossman 1973). In Canada, the Mackenzie Delta is the northern edge of the pike distribution. In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, pike have been found in Jimmy Creek, Jimmy lake, Parsons Lake, unnamed lake 3, unnamed lake 6, and the Wolverine lakes.

Pike are usually found in slow, meandering rivers or the shallow vegetated areas of lakes. Within these habitat types, pike will usually establish vague territories that incorporate areas of shelter and prey items. Pike undergo limited seasonal migrations, moving to shallower waters in the spring and fall, and deeper during the summer. Pike undertake spring migrations to preferred spawning habitat of heavily vegetated areas of rivers, marshes, and bays of large lakes. In the winter, pike continue to feed and remain somewhat active. Pike are also known to take advantage of brackish water habitats, occurring in salinities of up to 10‰ and spawning in salinities as high as 7‰.

Pike spawn early in the spring when the water temperature is between 4.5º and 11ºC. Young pike initially feed on immature aquatic insects and zooplankton but switch over to a diet of primarily fish by the time they reach the length of 50 mm. Adult pike are opportunistic omnivores, consuming almost any living vertebrate available that is within their ability to engulf. However, the primary diet constituent is fish.

Growth in northern populations of pike is slower than southern populations, however, in general the northern fish have greater longevity. Life expectancy for northern populations is 24 to 26 years of age at a length of more than 1100 mm. Young pike grow rapidly but unlike southern populations, there is no apparent difference in rate of growth between genders in pike of northern populations. Female pike tend to mature at six years of age (340-470 mm) while males mature at five years of age (300-411 mm).

Under the Inuvik Inuvialuit Conservation Plan (1993) pike are considered locally abundant and as such no specific management plans or agreements have been developed. However, the population goal is to maintain pike populations levels such that they can sustain subsistence harvesting. Current conservation measures include harvesting only what is needed, identifying and protecting important habitats from disruptive land uses, and harvesting within quotas where applicable.

3.4.4.1.3 Arctic Cisco - *Coregonus autumnalis*

Arctic cisco occur in the coastal waters of North America from as far east as Cambridge Bay to as far west as Point Barrow, Alaska. They are not circumpolar in distribution, however their distribution is much more extensive in Siberia (Scott and Crossman 1973). They also ascend the Mackenzie River as far south as Camsell Bend. In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, Arctic cisco have been found in the Reindeer system, the Freshwater system, Parsons Lake, Douglas Creek, unnamed lake 6, the Keneksek system, and the Canyanek system.

Arctic cisco are truly anadromous (spawning in freshwater and maturing in saltwater), migrating from the sea and estuaries in the spring and summer to spawn in rivers and then returning to the sea and estuaries. Although they spend more of the year at sea than other whitefishes, the waters frequented are less saline than the southern coasts of North America. Arctic cisco were the dominant fish species captured by the Department of Fisheries and Oceans near the west coast of Liverpool Bay in 1991 (Bond and Erickson, 1993) and Bond (1982) reported that Tuktoyaktuk Harbour was a major overwintering area for Arctic cisco.

Adults begin migrating upstream in July to spawn over gravel beds in swiftly flowing water. After spawning, the adults move downstream and back out to sea. For Mackenzie River fish, the return can be as late as December. The eggs hatch in spring and the young move downstream to the estuaries. Arctic cisco mature at five to ten years of age (depending upon the population) and attain a length of 305 to 455 mm and a weight of 1350 g. The diet of Arctic cisco consists mainly of crustaceans and small fishes.

Arctic cisco have been included along with least cisco and pacific herring and are identified collectively as “herring” in the Inuvik Inuvialuit Conservation Plan (1993). The importance of these species is not only as food used by local people but as forage by more preferred food species such as beluga whales, seals, lake trout, and northern pike. Arctic cisco are considered an important species and rivers, lakes, and estuaries flowing into Kugmallit and Tuktoyaktuk bays have been identified as important habitat for spawning, rearing, and overwintering. Although continuing research into the biology and ecology of Arctic cisco is considered important, the abundant population is considered to be in adequate supply. Current conservation measures include identifying and protecting important habitat areas, and prohibiting development in areas of population concentrations, and closely monitoring development activities.

3.4.4.1.4 Lake (Humpback; Crooked Backs) Whitefish - *Coregonus clupeaformis*

Lake whitefish occur across northern North America from Labrador to Alaska (Scott and Crossman 1973). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, lake whitefish have been found in Jimmy Creek, Parsons Creek, the Reindeer system, the Freshwater system, Jimmy Lake, Zed Lake, Husky Lakes, unnamed lake 2, the Keneksek system, and the Canyanek system. During Department of Fisheries and Oceans studies of area lakes between 1978 and 1980, Lake Whitefish were among the more abundant fish captured (Lawrence, Lacho and Davies, 1984).

They are primarily a freshwater fish, inhabiting lakes and larger rivers, however they will enter brackish water (Scott and Crossman 1973). Lake whitefish are a schooling fish that in the northern extent of their range, where thermal stratification of lakes is rare, tend to remain in the shallow areas of lakes. Lake whitefish are also known to show a wide range of overlapping physical and genetic variation across their distribution, leading researchers to conclude that lake whitefish are a species complex of a number of closely related species (Lindsey *et al.* 1970).

In the fall, lake whitefish move into shallow (less than 7.6 m) lake areas and rivers to spawn over hard, stony, and sometimes sandy substrates. Spawning occurs once the water temperature has dropped below 7.8 ° C. The eggs hatch in spring and by mid-summer the young whitefish leave the shallow areas for deeper waters. Whitefish are fast growing, maturing between six and nine years of age. However, once maturity is attained, growth tapers off with a maximum size approaching 10 kg. In the north, whitefish are long-lived, with ages of over 60 years reported in the Northwest Territories and the Ungava Peninsula (Powers 1978; Rescan 1998). Males mature younger but die earlier than females.

For the most part, lake whitefish are demersal (bottom feeding) fish feeding on a wide variety of bottom-living invertebrates. Young whitefish begin by feeding on copepods, and cladocerans as they grow, and by the time they move to deeper waters in the summer, they have switched to a diet similar to the adult fish. Diet items at that stage include fingernail clams, gastropods, aquatic insect larvae, amphipods, isopods, ostracods, fish eggs, and occasionally small fish.

Lake whitefish are an important commercial fish in the north and have been extensively studied both in the laboratory in the wild. Whitefish are also an important component of domestic fisheries, both as human food and as dog food. The Inuvik Inuvialuit Conservation Plan (1993) identifies the streams of Tuktoyaktuk Peninsula as an important area for management. Though there are currently no lake whitefish management plans in place, the population goal is to maintain the locally abundant populations at such a level as to support the subsistence harvest. Current conservation measures include identifying and protecting important habitat areas and harvesting only what is needed.

3.4.4.1.5 Broad Whitefish - *Coregonus nasus*

The majority of the distribution of the broad whitefish is in Asia extending as far west as western Russia. In North America, broad whitefish are distributed from just east of Bathurst Inlet and continuing west to the Bering Strait (Scott and Crossman 1973). Broad

Whitefish are distributed as far upstream as Camsell Bend on the Mackenzie River. In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, broad whitefish have been found in the Reindeer system, the Freshwater system, Jimmy Lake, Parsons Lake, Husky Lakes, unnamed lake 2, unnamed lake 4, unnamed lake 5, unnamed lake 6, the Keneksek system, the Canyanek system, and the Wolverine lakes. Broad Whitefish were commonly found in area lakes by the Department of Fisheries and Oceans during studies conducted in 1978 to1980 (Lawrence, Lacho and Davies, 1984).

Broad whitefish inhabit the fresh and brackish waters of the Arctic drainages. Anadromous populations enter the mainstem Mackenzie River in the summer in July and August to spawn (Chang-Kue and Jessop 1983), spawning somewhat earlier than lake whitefish, and then return to the sea (Chang-Kue unpub. data).

Broad whitefish eggs hatch in the spring and the young eventually move downstream to the sea. The young-of-the-year fish migrate to freshwater lake and stream systems along the Tuktoyaktuk Peninsula where they reside for several years (Chang-Kue and Jessop 1991a). At four years of age the young fish join the annual juvenile run to the sea for overwintering and return to the lakes in the summer to feed (Chang-Kue and Jessop 1991b). These whitefish mature around seven years of age but have a slower growth rate than broad whitefish populations in Alaska and Asia (Tallman 1997). Like lake whitefish, broad whitefish are demersal fish, foraging for bottom dwelling invertebrates such as aquatic insect larvae, molluscs, and crustaceans.

Broad whitefish are an important component of domestic fisheries, both as human food and as dog food. The Inuvik Inuvialuit Conservation Plan (1993) identifies the streams of Tuktoyaktuk Peninsula as an important area for management. Though there are no management plans in place, the population goal is to maintain the locally abundant populations of broad whitefish at such a level as to support the subsistence harvest. Current conservation measures include identifying and protecting important habitat areas and harvesting only what is needed.

3.4.4.1.6 Least Cisco (Big-Eye Herring) - *Coregonus sardinella*

Least cisco have a distribution similar to that of the broad whitefish: the majority of the distribution of the species is in Asia extending as far west as western Russia (Scott and Crossman, 1973). In North America, the least cisco distribution begins near Cambridge Bay and continues west to the Bering Strait. In the upland Mackenzie Delta and

Tuktoyaktuk Peninsula region, least cisco have been found in the Reindeer system, the Freshwater system, East Hans Lake, Parsons Lake, Husky Lakes, unnamed lake 2, the Keneksek system, the Canyanek system, and Tuktoyaktuk Harbour. Least cisco were commonly found in area lakes by the Department of Fisheries and Oceans during studies conducted in 1978 to 1980 (Lawrence, Lacho and Davies, 1984).

Within this range, least cisco inhabit the fresh and brackish waters of the Arctic drainages. They also occur as inland, landlocked populations. Anadromous populations enter freshwater rivers in the spring and summer prior to the fall spawning, returning to the sea immediately following spawning (Stein *et al.*, 1973).

Least cisco spawn over sand or gravel in the shallows of rivers or along shorelines of lakes. The eggs hatch in the spring and, in the case of migratory populations, the larvae immediately move downstream to the sea, inhabiting important nursery sites in the Mackenzie Delta and coastal areas (Chang-Kue and Jessop, 1991c). Anadromous populations have greater apparent growth rates and tend to attain a higher maximum age (approximately 26 years of age). Both migratory and non-migratory fish forage mainly on planktonic crustaceans, however river populations will also include aquatic and terrestrial insects in their diet.

Least cisco have been included along with Arctic cisco and pacific herring and are identified collectively as "herring" in the Inuvik Inuvialuit Conservation Plan (1993). The importance of these species is not only as food used by local people but as forage by more preferred food species such as beluga whales, seals, lake trout, and northern pike. The Inuvik Inuvialuit Conservation Plan (1993) identifies the inland lakes in the Mackenzie Delta – Tuktoyaktuk region as important least cisco habitat. Research into the biology and ecology of least cisco is considered to be a high priority but no management plans or agreements have been developed to date. Least cisco populations are considered abundant and in adequate supply at present. Current conservation measures include identifying and protecting important habitat areas, and prohibiting development in areas of population concentrations, and closely monitoring development activities.

3.4.4.1.7 Lake Trout - *Salvelinus namaycush*

The lake trout is a North American fish, distributed across mainland Canada and on to some of the southern islands of Canada's Arctic. They are ubiquitous through out the mainland lakes and rivers of the Northwest Territories (Scott and Crossman, 1973). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, lake trout have been found in Parsons Creek, Noell lake, Parsons Lake, Husky Lakes, unnamed lake 4, unnamed lake 5, Peter Lake, and the Wolverine lakes.

Considered the least salinity tolerant of the chars, they have been known to occur in brackish water of up to 13 ‰, including the Husky Lakes system. Though primarily a lake fish, river populations do exist in the Northwest Territories. In the autumn, lake trout move into rocky shallows of lakes, spawning in redds (nests) or cleaned rocks when the water temperature falls to 8.9 ° C. After spawning fish disperse through the lake. Some populations show spawning site fidelity. In the spring, lake trout will move into shallow lake areas and inflow rivers and streams. During the summer months, they retreat to deeper lake waters.

The eggs hatch in late spring with the young remaining inshore amongst the cover of boulders and sometimes entering inflow streams in the summer. Lake trout likely do not spawn every year. Throughout the lifecycle of the lake trout they are opportunistic omnivores with prey items depending more upon availability. Young lake trout feed on a broad range of prey items, including crustaceans, aquatic and terrestrial insects, sponges, and fish. They switch to a more piscivorous diet near the age of maturity, at nine to eleven years of age. However in lakes with only lake trout, the invertebrate diet is maintained into the adult stage of life. In these lakes, lake trout will inhabit several tiers in the trophic food chain, with a few large cannibal trout foraging on the smaller, invertevore adult and juvenile trout. The maximum size is 47 kg and ages of over 30 years are common.

Commercial and domestic fisheries for lake trout are conducted in the Mackenzie Delta but the Inuvik Inuvialuit Conservation Plan (1993) has not identified any important lake trout habitat within the proposed road alignment. The populations within the area appear to be stable. Current conservation measures include mesh size restrictions and protection of important habitat so as to ensure that the harvest is sustainable.

3.4.4.1.8 Inconnu (Coney) - *Stenodus leucichthys*

Inconnu are another species of whitefish that has a distribution extending from northern Europe to Canada. In North America inconnu inhabit coastal and inland waters between the Bering Strait and the Mackenzie Delta and as far south as Great Slave Lake and its tributaries (Scott and Crossman, 1973). In the upland Mackenzie Delta and Tuktoyaktuk

Peninsula region, inconnu have been found in the Freshwater system, the Keneksek system, the Canyanek system, and Tuktoyaktuk Harbour (Bond, 1982).

In the coastal areas, inconnu are anadromous, making prolonged migrations up freshwater streams in summer and immediately returning to the sea in the autumn after spawning (Scott and Crossman, 1973). In freshwater populations, adults undertake similarly timed seasonal migrations. It is during the return runs that the majority of inconnu are caught by fishermen.

The eggs hatch in the spring and young inconnu tend to remain in the natal streams for a minimum of two years before migrating downstream to the lakes or sea. For the first four years, juvenile inconnu feed on planktonic crustaceans and aquatic insect larvae. Once they enter the lakes or sea, they switch to the adult diet of fish which accelerates growth. Inconnu mature between seven and ten years of age. They are the largest whitefish species, with a maximum weight of 28 kg and a maximum age of 26 years. Once mature, inconnu spawn only every two to four years.

Inconnu are caught both as human food and dog food. Fishing effort and catches peak during the July upstream migration to spawning grounds and the October post-spawning downstream migration (DFO, 1998). The Inuvik Inuvialuit Conservation Plan (1993) identifies the Mackenzie Delta and estuaries as important rearing habitat. Inconnu are locally common and a multi-stakeholder management plan for inconnu is being developed (DFO, 1998). The goal of the plan is to maintain the populations so that sustainable subsistence harvesting may continue. Current, conservation measures include harvesting only what is need and identifying and protecting important habitat.

3.4.4.1.9 Arctic Grayling - *Thymallus arcticus*

Arctic grayling are circumpolar in distribution, occurring in freshwater drainages across northern North America from Hudson Bay to the Bering Strait (Scott and Crossman, 1973). Grayling are ubiquitous through out the mainland Northwest Territories. In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, Arctic grayling have been found in Jimmy Creek, Hans Creek, Parsons Creek, the Freshwater system, Noell Lake, East Hans Lake, unnamed creek 3, Noell outflow, unnamed lake 6, the Keneksek system, and the Canyanek system.

Grayling inhabit clear waters of large, cold rivers, rocky streams, and lakes. Though not demonstrated in Canada, some grayling populations in Asia are known to enter saltwater.

Arctic grayling enter small gravel- or rock-bottomed tributaries of lakes or larger rivers in May to June and spawn just as the ice is breaking up and the water temperature has reached 7° C. Development is rapid, with the eggs hatching within weeks and the young growing rapidly, feeding on zooplankton. Juvenile fish gradually shift to immature insects such as caddisflies, mayflies, and midges. Adults feed on a broad range of aquatic and terrestrial insects, plankton, fish eggs, and occasional fishes and lemmings. They mature between six and nine years of age. The maximum size of grayling is 2.7 kg and they can live for more than 12 years.

Arctic grayling have been historically taken in large numbers during spring spawning runs for dog food and, to a lesser degree, as human food. The Inuvik Inuvialuit Conservation Plan (1993) does not identify any areas along the proposed road alignment of special importance. Grayling are considered locally common in some streams and populations are at adequate levels, but standard conservation measures such as harvesting only what are needed and identifying and protecting habitats from disrupted land uses have been adopted.

3.4.4.1.10Burbot (Losh) - *Lota lota*

Burbot are circumpolar in distribution, occurring in freshwater systems of northern North America from Quebec to the Bering Strait (Scott and Crossman, 1973). Burbot in the Northwest Territories are ubiquitous through most of the mainland region, inhabiting primarily lakes and large, cool rivers, but also smaller streams. In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, burbot have been found in the Reindeer system, the Freshwater system, Husky Lakes, the Keneksek system, and the Canyanek system.

Burbot spawn in midwinter in shallow water over sand and gravel when the water temperature is between 0.6° and 1.7° C. The eggs hatch in about a month and the young fish grow rapidly on a diet of immature aquatic insects, amphipods, and molluscs. Females grow faster than males, a condition that accentuates after the onset of maturity at four years. Adult fish are voracious predators that consume a wide variety of fishes. However, adults will also consume invertebrates if forage fish are unavailable. Burbot have been known to attain a size of 34 kg and an age of 15 years.

Burbot have not been exploited commercially in Canada, however there are some domestic fisheries. The Inuvik Inuvialuit Conservation Plan (1993) has identified the freshwater stream mouths, especially those of Kugmallit Bay, as important burbot habitat. Populations appear to be common and stable and the goal of maintaining abundant populations in order to support subsistence harvesting will be done by taking only what is needed and identifying and protecting important habitat.

3.4.4.1.11 Other Fishes

There are a number of other fish species that occur in the Inuvik-Tuktoyaktuk region that, although not explicitly identified as an interest to domestic fishing, are important as they form part of the total fish community. These species have been captured either in waterbodies along the proposed road alignment, or have been reported from waters adjacent to the alignment.

Pond Smelt – *Hypomesus olidus*

Pond smelt occur in the Mackenzie River system, from the Tuktoyaktuk Peninsula to Great Bear Lake (Scott and Crossman, 1973). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, pond smelt have been found in the Reindeer system, the Freshwater system, the Keneksek system, and the Canyanek system. In addition, smelt fry have been found in Jimmy Creek, unnamed lake 3, and unnamed lake 4.

Pond smelt are a freshwater, short lived (three years) fish that spawns in streams in the spring. They forage on pelagic (mid-water) invertebrates and likely compete with the juvenile fish of other species for forage. Pond smelt can be very abundant when present, however, there is no commercial fishery and limited domestic fishing.

Rainbow Smelt – *Osmerus mordax*

In Arctic Canada, the densest populations of rainbow smelt occur in the Mackenzie Delta (Scott and Crossman, 1973). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, rainbow smelt have been found in the Reindeer system, the Freshwater system, the Keneksek system, the Canyanek system, and Tuktoyaktuk Harbour (Bond, 1982).

Rainbow smelt are an anadromous species that spawn in freshwater streams in the spring. Rainbow smelt are voracious, pelagic carnivores which feed primarily on invertebrates but are also known to feed on small fish and fish larvae. They are preyed upon by other fishes, especially lake trout. Though commercially and domestically important in southern Canada, they are not fished commercially in the north.

Round Whitefish – *Prosopium cylindraceum*

Round whitefish occur across the freshwater drainages of the mainland Northwest Territories (Scott and Crossman, 1973). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, round whitefish have been found in Parsons Creek.

Round whitefish are primarily a freshwater fish, inhabiting lakes and streams but are also known to enter brackish water in the Mackenzie Delta. They spawn in lakes and streams in the autumn. They feed on benthic (bottom dwelling) invertebrates and are preyed upon by carnivorous fish such as lake trout. Round whitefish are not an important commercial species but are occasionally captured during domestic fisheries.

Longnose Sucker – *Catostomus catostomus*

Longnose sucker are present throughout the Mackenzie River system and in some streams of the Tuktoyaktuk Peninsula (Scott and Crossman, 1973). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, longnose sucker have been found in Parsons Lake, and the Keneksek system.

Longnose sucker are primarily a freshwater fish, inhabiting clear cool lakes and streams, but are also known to occur in brackish water off the mouths of Arctic streams. They spawn in tributaries in the spring and forage exclusively on benthic invertebrates, while in turn providing forage to a wide variety of fish and birds.

Saffron Cod – *Eliginus gracilis*

In the north, saffron cod are found from Dease Strait to the Chukchi Sea (Cohen *et al.*, 1990). They are primarily a marine and brackish water fish, inhabiting shallow inshore areas, but can also be found in freshwater. In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, saffron cod have been found in Husky Lakes, the Keneksek system, and Tuktoyaktuk Harbour (Bond, 1982).

Ninespine Stickleback – *Pungitius pungitius*

Ninespine stickleback are present throughout the Mackenzie River valley and relatively ubiquitous in the lower Northwest Territories (Scott and Crossman, 1973). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, ninespine stickleback have been found in unnamed creek 1, Jimmy Creek, Parsons Creek, unnamed creek 2, the Reindeer system, the Freshwater system, unnamed lake 1, East Hans Lake, Parsons Lake, unnamed lake 3, unnamed lake 4, unnamed lake 5, Douglas Creek, the Keneksek system, the Canyanek system, and Tuktoyaktuk Harbour (Bond, 1982).

Ninespine stickleback are a small, high saline tolerant fish that are often found in estuaries and coastal regions. Because of their size, they are able to exploit shallow tundra lakes where larger fishes cannot overwinter (Rescan in prep.). The importance of this species is that they provide a large portion of the forage for predatory fish, such as lake trout and burbot, which are more important to commercial and domestic fisheries.

Slimy Sculpin – *Cottus cognatus*

Slimy sculpin are found through the mainland regions of the Northwest Territories (Scott and Crossman, 1973). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, slimy sculpin have been found in Hans Creek and Parsons Creek. However, their presence is likely more ubiquitous as most fish surveys that have been conducted used collection methods that selected for larger, more economically important fish species.

Slimy sculpin prefer deeper lake waters and cooler rivers but in the north are most frequently found on the rocky bottoms of perennial streams and lakes, feeding on benthos (Scott and Crossman, 1973). They are a common forage item for predatory fish such as lake trout and because of their ubiquitous presence are an important link in the food chain between benthos and predatory fish community.

Fourhorn Sculpin – *Myoxocephalus quadricornis*

Fourhorn sculpin have a circumpolar distribution, inhabiting cold, salt, and brackish waters (Scott and Crossman, 1973). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, fourhorn sculpin have been found in the Reindeer system, the Freshwater system, unnamed lake 2, the Keneksek system, and the Canyanek system.

Starry Flounder – *Platichthyes stellatus*

In Arctic North America, starry flounder are found along the northwest coast of Alaska, Yukon, and the Northwest Territories (Eschmeyer *et al.*, 1983). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, starry flounder have been found in the Reindeer system, the Freshwater system, unnamed lake 2, unnamed lake 5, the Keneksek system, the Canyanek system and Tuktoyaktuk Harbour (Bond 1982). Starry flounder are primarily marine but have a high tolerance for low salinity (Hart, 1973). They inhabit shallow, sandy, nearshore areas and estuaries (Eschmeyer *et al.*, 1983).

Arctic Flounder – *Pleuronectes glacialis*

Arctic flounder are found throughout marine Arctic waters, except for Greenland (Nielsen, 1986). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, Arctic flounder have been found in the Canyanek system. They are primarily marine, being found in shallow, muddy, nearshore areas, but will also enter brackish water and freshwater rivers (Nielsen, 1986).

Cyprinids

Cyprinids are the group of fish known as minnows. At least two species are found in the Mackenzie Delta, lake chub (*Couesius plumbeus*) and flathead chub (*Hybopsis gracilis*; Scott and Crossman, 1973). In the upland Mackenzie Delta and Tuktoyaktuk Peninsula region, cyprinid fry have been found in Jimmy Creek.

Cyprinids are found in their highest densities in temperate to tropical distributions. Lake chub are unusual as a cyprinid species in that they are found in cool lakes. Flathead chub are more associated with riparian environments. Through most of their extensive distribution, cyprinids are an important forage fish for larger, more predatory fishes

3.4.5 Important Waterbodies

There are several waterbodies along the proposed road alignment that have been identified as important with respect to aquatic resources.

3.4.5.1 Noell Lake

Noell Lake is a major regional freshwater lake, discharging through Jimmy Lake into Husky Lakes. It supports populations of Arctic grayling and lake trout. Lake trout populations in the upland Mackenzie Delta and Tuktoyaktuk Peninsula are patchy. Lake trout are also a prized sport-fish and are also desirable in the domestic fishery.

3.4.5.2 Jimmy (Island) Lake

Jimmy Lake receives the outflow of Noell Lake and discharges through Stanley Creek into Husky Lakes. Jimmy Lake supports a diverse fish community consisting of at least seven species. Highly valued sport-fish such as Arctic grayling, lake trout, and northern pike are resident in the lake. The presence of broad whitefish indicates that Jimmy Lake may serve as a nursery for anadromous whitefish accessing the lake from Husky Lakes, via Stanley Creek.

3.4.5.3 Hans Creek

Hans Creek discharges water from East Hans Lake and associated tributaries into Husky Lakes. The presence of least cisco in East Hans Lake indicates that Hans Creek may be used as a migration channel by anadromous ciscoes.

3.4.5.4 Parsons Lake and Zed Creek

Parsons Lake discharges into Husky Lakes through Zed Creek. Parsons Lake supports a diverse fish community consisting of at least ten species. Highly valued sport-fish such as Arctic grayling, lake trout, and northern pike are resident in the lake. The presence of broad whitefish and Arctic cisco indicate that Parsons Lake may serve as a nursery for anadromous whitefish and cisco accessing the lake from Husky Lakes, via Zed Creek.

3.4.5.5 Husky Lakes and tributaries

The Husky Lakes are an important traditional year round fishing area. The fish community is complex and consists of marine, brackish, and freshwater fishes. Some freshwater species, such as lake trout, occur as one of the few known populations living in brackish water conditions. The tributaries along the west shore of the lakes provide migration channels to lakes which support important nurseries for anadromous whitefishes, ciscoes, herring, and smelt. These fish are very important for domestic fishing, are also valued as forage for seals and whales.

3.4.5.6 Reindeer system

The proposed road alignment passes to the east of the headwater lakes for the Reindeer system and eventually crosses the creek before connecting with the existing local road system near Tuktoyaktuk. The Reindeer lakes, creek, and estuary support a diverse community of marine, brackish, and freshwater fishes. This system supports not only valued sport-fish such as Arctic grayling and lake trout, but additional species of importance to the domestic fishery. A variety of anadromous whitefish and ciscoes use the lakes for nurseries, the creek as a migration channel, and the estuary for feeding and overwintering.

3.4.5.7 Mayogiak and Freshwater systems

The proposed road alignment passes to the southwest of the headwater lakes for these systems. Like the Reindeer system, these lakes, creeks, and estuaries support diverse communities of marine, brackish, and freshwater fishes. These systems support not only important sport-fish such as Arctic grayling and lake trout, but additional species valued in the domestic fishery. A variety of anadromous whitefish and ciscoes also utilize the lakes for nurseries, the creeks as migration channels, and the estuaries for feeding and overwintering.

3.4.5.8 Keneksek and Canyanek systems

These systems drain the upland Mackenzie Delta, west of the northern section of the proposed road alignment, into the south end of Kugmallit Bay. They have diverse fish communities consisting of marine, brackish, and freshwater species. Though the proposed road would not pass through the Keneksek and Canyanek watersheds, they have been identified as important to the domestic fishery and improved access to these systems would likely result in increased resource harvesting.

3.4.6 Development Effects

The Mackenzie Environmental Monitoring Program (MEMP) was established in 1985 to recommend monitoring and research programs that, among other objectives, would address significant potential impacts associated with the development of hydrocarbon resources in the Mackenzie Valley and Delta. This program was an initiative of Indian and Northern Affairs Canada and Environment Canada, along with the Department of Fisheries and Oceans, the Government of the Northwest Territories, and the Yukon Territorial Government. Workshops were organized that included scientists and specialists knowledgeable of the resources in the development area and a number of impact hypotheses relevant to hydrocarbon development and the natural resources were examined. Most relevant to the proposed Inuvik-Tuktoyaktuk road were the discussions of the effects of linear corridors, both pipeline and road (INAC *et al.*, 1986).

The first relevant hypothesis discussed the effects of land disturbances on fish quality. This hypothesis was concluded to be invalid as there has been no evidence to indicate that disturbance has ever affected the palatability of northern fishes and, though increased sports fishing may exhaust fishes, there have been no reports to link decreased quality in sport-caught fish with exhaustion from increased sport-fishing pressures (INAC *et al.*, 1986).

The second hypothesis examined was that improved access and fishing pressure would lead to a decrease in the abundance of fish and affect their distribution (INAC *et al.*, 1986). This hypothesis was found to be valid and a commonly observed effect. A number of conclusions were drawn. For example, it was concluded that increased accessibility would lead to greater pressures on lake trout and reduced transportation costs with respect to commercial fisheries, thereby leading to a potential expansion of the commercial fisheries. Similarly, improved access was projected to lead to greater domestic fishing pressures on lake trout and whitefishes. Among the recommendations was further work to distinguish and define broad whitefish stocks, Arctic grayling stocks, lake trout populations, the collection of data on local fishing activities, and the determination of the total annual catch by sport, commercial, and domestic fisheries in each of the waterbodies and the establishment of an index monitoring of the catch and fish populations.

The third and final hypothesis was that the construction and presence of linear corridors would affect the number, distribution and quality of fish, and fishing success. It was concluded that this was a valid hypothesis but the extent of possible effects could be mitigated through a number of methods (INAC *et al.*, 1986). Among these were careful route selection and design, the development of appropriate mitigation strategies, site supervision during construction, and post-construction monitoring.

A preliminary environmental assessment of the aquatic resources along the proposed Inuvik-Tuktoyaktuk road concluded that there could be a number of unavoidable disruptions of drainage patterns along the proposed route (Percy and Hoban, 1977). One possible effect predicted was that several smaller lakes may dry up as the drainage was altered to accommodate the road. Another possible effect was stream bed migration at the Hans Creek crossing should its banks be used for borrow. Percy and Hoban (1977) recommended that the stream crossings be constructed in winter when most of the streams are frozen to the bottom so as to avoid silt damage. Finally, the increased accessibility to the region was also identified as a potential effect on the fish population in the region.

More recent work, based upon the information collected during the years of hydrocarbon exploration, has demonstrated that the streams draining into the Mackenzie River and Beaufort Sea from the upland Mackenzie Delta and Tuktoyaktuk Peninsula play an important role in the lifecycle of several coregonid species (Chang-Kue and Jessop, 1991a). The connecting streams which link several lakes in a small watershed to the sea, though appearing minor at first, are important migration corridors for coregonids utilizing the lakes as nurseries (Chang-Kue and Jessop, 1991a). Blockages of these corridors could disrupt the life-history development of some populations of several important species (*e.g.* broad whitefish, least cisco). This effect could be exacerbated because the complex coregonid populations of the Mackenzie Delta are still not well known (Reist and Bond in Chang-Kue and Jessop, 1991a). It is therefore important that stream crossings for migration streams be properly designed so as not to interfere with coregonid migrations.

3.4.7 Conclusions

The freshwater lake and stream systems of the Tuktoyaktuk Peninsula and upland Mackenzie Delta provide important spawning, nursery, and feeding habitats for Broad whitefish, lake whitefish, and least cisco (Bond and Erickson, 1982, 1985; Lawrence *et al.*, 1984).

Tuktoyaktuk Peninsula lakes, those that drain into Kugmallit Bay and those that drain into Husky Lakes are important in the early life history of coregonid fishes, especially broad whitefish and least cisco, which as adults utilize the Mackenzie Delta are thus captured in the commercial and domestic fisheries.

The greatest direct potential impact of the proposed road development would be the obstruction or siltation of fish migration corridors between important freshwater lake and stream systems and the saline waters of Husky Lakes and Kugmallit Bay. However, properly designed stream crossings and timing of construction can minimize or negate these impacts.

The greatest indirect impact of the proposed road development would be the facilitation of increased domestic and sport fishing in the lakes and streams along or adjacent to the proposed road alignment. Regulation, monitoring, and enforcement by the stakeholder communities can mitigate these impacts.

3.4.8 Data Gaps

The use of the freshwater lake and stream systems in the upland Mackenzie Delta and Tuktoyaktuk Peninsula is well documented with respect to other regions of the Northwest Territories. Though a reconnaissance survey of the lakes and streams along the proposed road alignment has provided valuable information as to the potential amenability of these waterbodies to use by migratory species (Percy and Hoban, 1977), actual migrations and utilization of these waterbodies, particularly along the southern 82 % of the proposed road alignment, have not been as well documented as other systems in the region. However, the information provided by other studies in the region provide valuable information that can be used to infer potential impacts and therefore aid in preventing impacts and/or developing mitigation strategies prior to development and therefore minimizing any potential impacts. Data gaps therefore exist where there is a potential for use of lake and stream systems by migratory species but where migrations have not been actually documented.

3.5 Vegetation

3.5.1 General

Most studies on the vegetation of the Tuktoyaktuk Peninsula and Mackenzie Delta areas were undertaken during the early 1970's in connection with onshore oil and gas exploration activities and proposed hydrocarbon pipeline projects. The available information was well summarized in the preliminary environmental assessment for the proposed Inuvik-Tuktoyaktuk road produced by Public Works Canada in 1975 (PWC, 1975).

Accordingly, the following section draws heavily on the information reported in PWC, 1975, updated as appropriate to reflect more recent data where possible.

The vegetation of the Tuktoyaktuk Peninsula, as with other regions of the Arctic, has adapted to take advantage of more favourable conditions and to avoid damage from the harsh arctic conditions. In the Arctic generally, the main controls on plant development are an abbreviated growing season (70 to 95 days) desiccation and mineral nutrition limitations (Bliss 1963; Johnson, 1969).

The south and west facing slopes of the caribou hills generally mark the northern edge of the treeline along the proposed road corridor between Inuvik and Tuktoyaktuk. However, patches of stunted trees are found within a matrix of tundra communities south of Husky Lakes. The remainder of the vegetation on the peninsula is comprised of arctic tundra (Zoltai *et al.*, 1979) (Dome Petroleum, 1982). Table 3.5-1 lists the common and scientific names of plant species found in the coastal area between Inuvik and Tuktoyaktuk (Dome Petroleum, 1982).

3.5.2 Vegetation Units

The distribution of discrete vegetation units within the arctic tundra of the Tuktoyaktuk Peninsula is largely controlled by drainage, which in turn is locally controlled by topography and zonally by surface materials (PWC, 1975). The PWC study reported the following vegetation units in the vicinity of the proposed road corridor. Each unit is described in terms of vegetation structure, species composition and landform.

Table 3.5-1
Common and Scientific Name Equivalents of Plant Species Found in the Tuktoyaktuk Peninsula Area

Tree Species	
Aspen	*Populus tremuloides* Michx.
Birch, white	*Betula papyrifera* Marsh
Spruce, black	*Picea mariana* (Mill.) B.S.P.
Tamarack	*Larix laricina* (Du Roi) K. Koch
Shrub Species	
Alder, green	*Alnus crispa* (Ait.) Pursch
Birch, dwarf	*Betula nana* Michx.
Birch, shrub	*Betula glandulosa* Michx.
Labrador tea	*Ledum groenlandicum* and *L.decumbens* (Ait) Lodd.
Rose, prickly	*Rosa acicularis* Lindl.
Rosemary, bog	*Andromeda polifolia* L.
Soapberry,	*Shepherdia canadensis* (L.) Nutt
Willow	*Salix* spp. L.
Willow, Alaska	*Salix alaxensis* (Anderss.) Cov.
Willow, Bebb's	*Salix bebbiana* Sarg.
Willow, glaucous	*Salix glauca* L.
Willow, plane-leaf	*Salix planifolia* Pursh
Willow, sandbar	*Salix interior* Rowlee
Willow, Scouler's	*Salix scouleriana* Barratt
Herb and Dwarf Shrub Species	
Arnica	*Arnica* spp. L.
Asphodel, false	*Tofieldia coccinea* Richards.
Avens, mountain	*Dryas integrifolia* M. Vahl. and *D. octopetala* L.
Baked-apple berry	*Rubus chamaemorus* L.
Bearberry, alpine	*Arctostaphylos rubra* (Rehd. & Wils.) Fern.
Bistort,	*Polygonum viviparum* L.
Blueberry, alpine	*Vaccinium uliginosum* L
Bluegrass	*Poa glauca* M. Vahl. and *Poa* spp. L.
Buckbean	*Menyanthes trifoliata* L.
Bunchberry	*Cornus canadensis* L.
Cassiope, lapland	*Cassiope tetragona* (L.) D. Don
Cloudberry	see "baked-apple berry"
Coltsfoot	*Petasites frigidus* (L.) Fris; also *P. hyperboreus* Rydb.
Cottongrass	*Eriophorum* spp. L.; may include *E. vaginatum* L., *E. scheuchzeri* Hoppe
Crowberry	*Empetrum nigrum* L.
Douglasia	*Douglasia arctica* Hook.
Draba	*Draba cinerea* Adams; alos *D. corymbosa* R. Br.
Fireweed	*Epilobium angustifolium* L.
Gale, sweet	*Myrica gale* L.
Grass, hair	*Deschampsia caespitosa* (L.) Beaur.
Grass, polar	*Arctagrostis latifolia* (R. Br.) Griseb.
Grass, trisetum	*Trisetum spicatum* (L.) Richt.
Grass, tundra	*Dupontia fischeria* R. Br.
Grass	*Calamogrostis* spp.

(continued)

Table 3.5-1
Common and Scientific Name Equivalents of Plant Species Found in the Tuktoyaktuk Peninsula Area (Completed)

Herb and Dwarf Shrub Species (Continued)	
Groundsel	*Senecio residifolius* Less
Hedysarum	*Hedysarum alpinum* L.
Hornwort	*Ceratophyllum* sp. L.
Horsetail, common	*Equisetum arvense* L.
Larkspur	*Delphinium glaucum* Wats.
Leather leaf	*Chamaedaphne calyculata* (L.) Moench
Lingonberry	*Vaccinium vitis-idaea* L.
Locoweed	*Oxytropis deflexa* (Pall.) D.C.
Lousewort	*Pedicularis lanata* Cham. & Schlecht.
Lupine, Arctic	*Lupinus arcticus* S. Wats
Mare's-tail	*Hippuris vulgaris* L.
Marigold, marsh	*Caltha palustris* L.
Milfoil, water	*Myriophyllum* sp. L.
Milkvetch	*Astragalus alpinus* L.
Minuarta	*Minuarta biflora* (L.) Schinzl. & Thell.
Moss campion	*Silene acaulis* L.
Mustard	*Draba hirta* (L.)
Saxifrage	*Saxifraga* spp. L.
Sedge	*Carex* spp. L.
Sedge, aquatic	*Carex aquatilis* Wahlenb.
Sedge, maritime	*Carex maritima* Gumm.
Sorrel, mountain	*Oxyria digyna* (L.) Hill
Spike moss	*Selaginella sibirica* (Milde) Hieron
Starwort, water	*Callitriche* sp. L.
Sundew	*Drosera anglica* Huds. and *D. rotundifolia* L.
Thoroughwax	*Bupleurum triradiatum* Adams
Twinflower	*Linnaea borealis* L.
Wintergreen	*Pyrola* spp. L.
Moss and Lichen Species	
Feathermoss	*Pleurozium schreberi* (Brid.) Mitt., *Hyclocomium splendens* (Hedw.) B.S.G., *Ptilium crista-castrensis* (Hedw.) De Not.
Feathermoss, layered	*Hylocomium splendens* (Hedw.) B.S.G.
Lichen	general; includes one or several of: *Alectoria* spp., *Cetraria* spp., *Cladina* spp., *Cladonia* spp., *Parmelia* spp. *Stereocaulon paschale*, *Thamnolia subuliformis* (Ehrh.) W. Culb.
Moss, aulacomnium	*Aulacomnium acuminatum* (Lindb. Et Arn.) Par.
Moss, dicranum	*Dicranum* spp. Hedw.
Moss, drepanocladus	*Drepanocladus* sp. (C. Mull.) Roth
Moss, scorpidium	*Scorpidium scorpoides* (Hedw.) Limpr.
Moss, sphagnum	*Sphaghum* spp. L.

(continued)

Source: Dome Petroleum, 1982

3.5.2.1 Sedge-Herb Vegetation Unit

This vegetation unit is limited in location to recent river deposits and is found in areas which are covered with shallow water throughout the summer. Primary plant species found are sedges (*Carex aquatilis, Eriophorum spp*) and horsetail (*Equisetum arvense*). Seasonal deposition of silt makes the soils in these areas relatively fertile, and because of the organic material present, there is a relative abundance of nitrogen. Slaney (1974) noted that often associated with sedge-herb soils is "… a distinctive swampy odour, a reddish precipitate on the surface and a thin film of oil-like substance on the water. These are presumably products of soil microbial activity." This unit is not common in the study area.

3.5.2.2 Willow-Sedge Vegetation Unit

This unit is also restricted to recent alluvial deposits which are subject to flooding but where siltation is limited. Dwarft Willow (*Salix* spp.) and sedges (*Carex glauca*) as well as some mosses are the plant species most commonly found in this unit. Soil nitrogen is generally poor and the soils are usually alkaline.

3.5.2.3 Meadow Vegetation Unit

This vegetation unit is found on poorly drained areas of lacustrine deposits. Meadow vegetation consists for the most part of sedges, heaths and mosses. The wettest sites have much the same cover as that of sedge-herb, and the better drained sites may include species common to *Eriophorum* tussock and dwarf shrub-heath units. Soil nitrogen is typically relatively low and soil pH ranges from 6.5 to 7.5. The active layer is usually restricted to less than 30 cm.

3.5.2.4 Eriophorum Tussock Vegetation Unit

This vegetation unit, consists primarily of cottongrass (*Eriophorum vaginatum*) and is common on lacustrine deposits which are poorly drained. In the wetter sites the cover may resemble meadows or dwarf-shrub heath in drier sites. Soils in this unit are relatively unfertile with an active layer of less than 30 cm. The *Eriophorum* tussock vegetation unit is a common component for much of the road corridor.

3.5.2.5 Alder Vegetation Unit

Generally, this unit is found on gentler slopes that receive moisture from late melting snow. Alder (*Ainus crispa*), the diagnostic shrub for this unit prefer moist conditions in an aerated soil and the moisture regime is reflected by high moss cover with occasional *Sphagnum* dumps, a luxuriant heath growth. The understory may vary from *Eriophorum* tussocks in the wet areas to dwarf-shrub-heath on drier sites. The soils for this unit are very fertile and the pH varies from extremely acid (4.5) to near neutral.

3.5.2.6 Medium Willow Vegetation Unit

The medium willow vegetation unit is used to describe areas where extremely lush shrub vegetation is found. Growing conditions on steep slopes and in stream beds are relatively excellent (for this area) because soil moisture and aeration are adequate and the vegetation is protected from desiccating winds. In these areas, woody vegetation often forms dense stands that may exceed two metres in height.

On steep slopes, usually slump scars on lake banks, the vegetation is commonly comprised of willow, birch and alder, with an understory of ericaceous shrubs, mosses and lichens.

In depressional areas willows form the canopy and sedges dominate the understory. The soils are relatively fertile and pH is 6.5 to near neutral.

3.5.2.7 Black Spruce Vegetation Unit

Most of the study area is north of the tree line and as such this vegetation is very restricted in location. Usually the stunted spruce are confined to large stream beds or south-facing hillsides with an understory of mostly heaths and sedges.

3.5.2.8 Dwarf Shrub-Heath

The dwarf shrub-heath dominates morainal and glaciofluvial landforms and covers most of the upland tundra. Dwarf shrub-heath vegetation can be divided into two major varieties according to the degree of drainage. On the coarser glaciofluvial deposits where drainage is rapid, heaths and fruticose lichens (*Cetraria* and *Cladonia*) are dominant. This is a common ground cover around Parson's lake. Where drainage is impeded, as on morainal or lacustrine deposits, heath, birch and willows dominate and there is a complete moss cover. Soil pH for this unit varies from 4.5 to near neutral, dependent on the organic (humic or fibric) nature of the soils.

3.5.2.9 Xeric Gravel Vegetation Unit

In some sections of the proposed road corridor extremely dry conditions result from rapid drainage of coarse soils and exposure to dessicating winds and high solar angles. The ridges and crests of gravel eskers and kames are the most common locations for this vegetation unit. Many of the species found in the xeric gravel unit are restricted to this unit in corridor but are common in other alpine and high arctic sites. The soils are well-drained and warmer during the summer than wet soils, and as a result, active layer depths often reach one metre. Fertility of the soil is low and pH ranges into mild alkalinity (7.5).

3.5.2.10 Low-Centred Polygon Vegetation Unit

This unit is usually found in areas of poor drainage and sedges (*Carex aquatilis* and *Eriophorum scheuchzeri*) with brown mosses (*Drepanocladus* spp.) are usually abundant. The soil in the center of the polygon is typically regosolic but grades into an organic cover (15 cm) at the rim over mineral soil. Variations in active depth range from 15 to 20 cm in the centre to 30 cm around the rim.

The low-centered polygon with peat mounds units is similar to the low-centered polygon unit except for comparably well-drained mounds.

3.5.2.11 High-Centered Polygon Vegetation Unit

High-centered polygons are common on lacustrine sediments. Drainage is improved with standing water found only in the peripheral areas created by ice-wedge development. At the centre of the unit the soil and vegetation typically resembles the dwarf shrub-heath unit and grades into the meadow unit along the periphery.

3.5.3 Lake and Stream Bed Vegetation

The streams of the road corridor, like Parsons Creek and Hans Creek, are generally clear and shallow with a fairly strong current. The stream banks are usually vegetated with either hydrophilic sedges of medium shrubs with few vascular plants growing on the stream bottom. *Selaginella selaginordes* was found only on stream banks (Slaney 1974) and several other vascular plants (*Pinguicula spp* and *Spirea Beauverdina*) are common.

Upland Lakes generally do not carry concentrations of mineral nutrients and are subject to ice scouring. As a result they do not support dense submergent growth. *Potomergeton perfoliatus* and *Chara* spp. were collected by Slaney, 1974, in deeper upland lakes while other species of *Potomergeton* were found in shallower waters.

3.5.4 Plant Succession

The process of plant succession for the area of the proposed road corridor may be seen as a two step process (PWC, 1975).

Primary succession, or development of vegetation on denuded areas is controlled either by physical (allogenic) or biological (autogenic) forces, or a combination of the two. In those areas of the proposed corridor where seasonal variations in water level, siltation, ice scour *etc*. are great, autogenic factors have almost no effect on vegetation. Allogenic plant succession occurs usually where a lake recedes because of some alteration in its hydrological regime. In this case, distinct vegetation zones develop with ericaceous shrubs on the abandoned shoreline, grading into Cottongrass (*Eriophorum vaginatum*) on the drained lacustrine deposits and grading into sedges (*Carex aquatilis*) around open water. Succession related to biological (autogenic) forces is found in stagnant ponds. Accumulated, undecomposed organic material will gradually fill in the pond. An extreme example of this was noted by Slaney (1974) where a meadow several acres in extent had developed on floating peat soil. The roots of *Carex aquatilis* extended below the peat into 10 cm of water. The resultant increase of organic cover in these situations often leads to ground ice development and reduction of the active layer depth because of the insulating qualities of the organic material. This often leads to thermokarst activity with associated features such as polygons and pingos.

Secondary succession takes place when plant species such as grasses, fireweed, cloudberry and sedges invade areas where the primal vegetation covered was destroyed. Native grass species such as *Calamogrostis* spp., and *Arctagrostis latifolia* are not found in dwarf shrub-heath vegetation but commonly occur around animal burrows, and on exposed peat and mineral soils of old seismic lines and winter roads (Strang, 1973).

3.5.5 Data Gaps

The existing baseline vegetation information for the Tuktoyaktuk Peninsula in the vicinity of the proposed road corridor indicates that the vegetation units and plant species found are typical of this region.

However, to assist in establishing the optimal location of the proposed road and associated infrastructure, a baseline ecosystems (terrain and vegetation) survey should be undertaken for the corridor area in the future. The survey results, expressed in map form, will provide an integrated inventory of terrain, soil and vegetation resources, which can be used to identify terrain and vegetation sensitivities that should be avoided or protected. In addition, the community consultation sessions and traditional knowledge interviews confirmed that portions of the corridor area are rich in berries which are harvested annually by the local residents.

3.6 Wildlife and Habitat

3.6.1 Background: Effects of Road Development on Wildlife

The following background section is derived from a recent review by Jalkotzy *et al.* (1997). Of all linear developments that humans create, roads probably have the greatest impact on wildlife populations. The effects of road development on wildlife can be subdivided into 6 major categories: individual disruption, social disruption, habitat avoidance, habitat disruption or enhancement, direct and indirect mortality, and population effects. The existence or significance of any particular effect is dependent on the species of wildlife and the structure of the development.

The road itself or activities associated with it may disturb wildlife resulting in wildlife leaving the area or altering patterns of use, responses that carry with them costs in terms of energy expenditure and possibly lost opportunities (*individual disruption*). Road corridors and activities associated with them may lead to wildlife avoiding habitats close to the road (*habitat avoidance*). Habitat in the vicinity of the road in this case is effectively lost. Fragmentation of the landscape may occur if avoidance of the road prevents wildlife from fully using land on either side. *Social disruption* refers to any changes to the social structure of a population as a result of the development. This disturbance may take several forms such as the displacement of wildlife from the vicinity of the road into adjacent habitats that are already occupied by other individuals of the same species, changes in group structure for gregarious species, or differential mortality of classes as a direct or indirect result of the road.

Development of roads may remove or provide additional habitat for wildlife. Examples of *habitat disruption* include the construction of all types of road or entire road rights-of-way if they are fenced. *Habitats* may be *enhanced* for wildlife if new habitat features are created along roads that were not present prior to the construction. New habitat may be beneficial to wildlife residing in the surrounding habitat or it may provide opportunities for new wildlife species to colonize an area.

Activities associated with roads may result in mortalities. Examples of *direct* sources of *mortality* include wildlife-vehicle collisions. Roads may also be important contributors to *indirect mortality.* Indirect mortality is typically associated with human access. Human access generally leads to additional mortality due to hunting, trapping, poaching, and management actions. Finally, behavioural responses to disturbance may lead to *population effects,* typically a reduction in the population. Population effects don't necessarily follow even from significant behavioural responses. Conversely, it is possible that population effects may occur even though no behavioural response to a disturbance was detected. To confirm the presence of a population effect, the demographics of the population must be studied.

In the case of most road developments, the most important effects are direct and indirect mortality and the loss of habitat effectiveness as a result of habitat avoidance in the vicinity. This is also likely to be the case with the proposed Inuvik-Tuktoyaktuk road. In part this is because of the general habitat types in the area and the fact that little habitat will be directly altered to create a corridor for the road.

Collisions with vehicles are a source of direct mortality for wildlife living in the vicinity of roads. Virtually all species of wildlife including birds suffer from collisions. However, species and individuals that do not avoid roads are more likely to be victims than those that are not frequently found in their vicinity. Some wildlife species may be attracted to roads because of maintenance treatments (*e.g.*, plowing or salting) that make them appealing, further increasing their vulnerability. Additionally, roadside verges may support different plant species, or may green-up earlier, than adjacent areas, and thus serve as an attractant.

Most sources of indirect mortality along roads are related to human access. Wildlife populations that are subjected to hunting and trapping sustain increased mortalities as a result of better access (*e.g.*, caribou, grizzly bears, wolves, wolverines). Other sources of indirect mortality include poaching, and management actions (especially bears). Increased predation arising from carnivore use of roads is another potential indirect cause of mortality for some prey species (*e.g.*, wolves and caribou).

Wildlife will frequently avoid habitats in the vicinity of roads because of repeated disturbances along the road or as a result of the death of less wary animals. The degree of avoidance is again species-specific. This becomes increasingly important in areas of preferred or relatively high-quality habitat.

3.6.2 Terrestrial Mammals

At least 33 species of terrestrial mammals are known to occur within the Mackenzie Delta and coastal areas adjacent to the Canadian Beaufort Sea (Table 3.6-1). The local and regional abundance and distribution of these species varies considerably depending upon habitat availability and access to terrain suitable for various life history phases, such as calving and denning. The following discussion emphasizes those species which are considered most important to the subsistence hunting and trapping economy of the Mackenzie Delta and the Arctic Coastal Plain.

3.6.2.1 Reindeer

Since the mid- 1930’s the Tuktoyaktuk Peninsula and adjacent land have been home to a herd of semi-domesticated reindeer initially introduced to the area by the Government of Canada. Since 1974 the herd has been owned by private interests, in particular Canadian Reindeer Ltd. The size of the herd has fluctuated over the years, ranging from 3,000 to a peak of 13,000 animals around 1980 (Nasogaluak and Billingsly, 1981).

Table 3.6-1
Terrestrial Mammals in the Mackenzie Delta and Arctic Coastal Plain

Common Name	Scientific Name
Masked shrew	*Sorex cinereus*
Dusky shrew	*Sorex monticolus*
Arctic shrew	*Sorex arcticus*
Collared Pika	*Ochotona collaris*
Showshoe hare	*Lepus americanus*
Arctic hare	*Lepus articus*
Arctic ground squirrel	*Spermophilus parryii*
American red squirrel	*Tamiasciurus hudsonicus*
American beaver	*Castor canadensis*
Northern red-backed vole	*Clethrionomys rutilus*
Brown lemming	*Lemmus sibiricus*
Collared lemming	*Dicrostonyx torquatus*
Muskrat	*Ondatra zibethicus*
Singing vole	*Microtus miurus*
Meadow vole	*Microtus pennsylvanicus*
Tundra vole	*Microtus oeconomus*
Coyote	*Canis latrans*
Wolf	*Canis lupus*
Arctic fox	*Alopex lagopus*
Red fox	*Vulpes vulpes*
American black bear	*Ursus americanus*
Grizzly bear	*Ursus arctos*
American marten	*Martes americanus*
Ermine	*Mustela erminea*
Least weasel	*Mustela nivalis*
American mink	*Mustela vison*
Wolverine	*Gulo gulo*
River otter	*Lutra canadensis*
Lynx	*Lynx canadensis*
Moose	*Alces alces*
Caribou	*Rangifer tarandus*
Dall’s sheep	*Ovis dalli*
Muskoxen	*Ovibos moschatus*

Source: Dome Petroleum, 1982.

The herd currently numbers 4,000 and a new private group led by Mr. Lloyd Binder of Inuvik is presently finalizing arrangements to purchase and take over the management of the herd (Binder *pers. comm.*). Upon completion of the deal, the new owner plans to relocate the herd from its current range on the eastern portion of the Tuktoyaktuk Peninsula, to new summer and winter ranges as shown in Figure 3.6-1. When that occurs, the proposed Inuvik to Tuktoyaktuk road will traverse through the center of the proposed new winter range. However, recent discussions with Mr. Binder (Binder *pers. comm.*, February 1999) indicated that he was confident that possible concerns related to the future road and road users could be effectively managed to ensure the long-term integrity of the reindeer herd.

3.6.2.2 Caribou

The Bluenose herd is the only herd of wild caribou with a distribution that includes the Inuvik-Tuktoyaktuk corridor (Figure 3.6-2). This herd was estimated to number 140,000 in 1992 (GNWT files). Winter range for the Bluenose herd is generally east of the corridor, east and northeast of Inuvik. Most winters, few Bluenose caribou are found west of the Miner River (Wooley and Mair, 1977, Latour 1989). The typical calving and summer area is east and west of Paulatuk, in the vicinity of the Hornaday, Brock, and Horton Rivers. However, a group of caribou which may include Bluenose animals and estimated between 1,000 and 2,000, winters near Travaillant Lake and summers near Husky Lakes (Prescott *et al.*, 1973a).

Although caribou of the Porcupine herd are also economically important to people living in the Inuvik-Tuktoyaktuk area, the usual distribution of the Porcupine herd is almost exclusively west of the Mackenzie River, well removed from the Inuvik-Tuktoyaktuk road corridor.

In some years, the Inuvik-Tuktoyaktuk corridor traverses the spring and winter caribou hunting areas of residents of Tuktoyaktuk (Community of Tuktoyaktuk, 1993). These areas, however, are not consistent from year to year, and vary with the current distribution of caribou.

The physical presence of roads does not appear to be a problem to caribou (*e.g.*, Dempster Highway; Miller 1985), but the traffic and in particular, people outside of cars, may cause disturbance to individuals. Forty-eight percent of animals reacted to vehicles on the Dempster Highway by running away, while another 38% trotted away

(Horejsi 1981). Duration of flight was almost twice as long for females as for males, and fast-moving vehicles were particularly frightening to caribou. Other studies (*e.g.*, Dean and Tracy 1978) showed that vehicles can be disruptive to caribou, but also that caribou can become habituated to traffic (Singer and Beattie 1986, Whitten *et al.* 1992).

Caribou may avoid habitat in the vicinity of roads or other linear developments such as pipelines. Although the area physically disturbed by a road development may be very small, especially in relation to an annual range of thousands of square kilometres, the effect can be magnified by including the area *avoided*. This is particularly true if the area affected includes critical habitat features (Donihee and Gray 1982). Caribou, especially parturient females and females with calves, avoided disturbed areas including roads associated with the Trans-Alaska Pipeline (Cameron *et al.* 1979) and the Prudhoe Bay oilfield (Smith and Cameron 1983, Cameron *et al.* 1992, Cameron *et al.* 1995, Nelleman and Cameron 1996). If the proposed Inuvik-Tuktoyaktuk road traverses important caribou habitat and caribou respond to traffic in the way demonstrated in Yukon and Alaskan studies, then a local net loss in habitat effectiveness will result.

Avoidance of development corridors by migrating caribou has not been unequivocally documented. Bergerud *et al.* (1984), in their summary of various caribou herds across North America, believed that all documented changes in migration patterns could be attributed to changes in population size and concurrent shrinkage in range sizes. They cited numerous cases where migrating caribou cross highways in Alaska and elsewhere in spite of intensive hunting pressure along these development corridors.

Figure 3.6-1 Proposed New Herding Range with Respect to Inuvialuit Lands in ISR

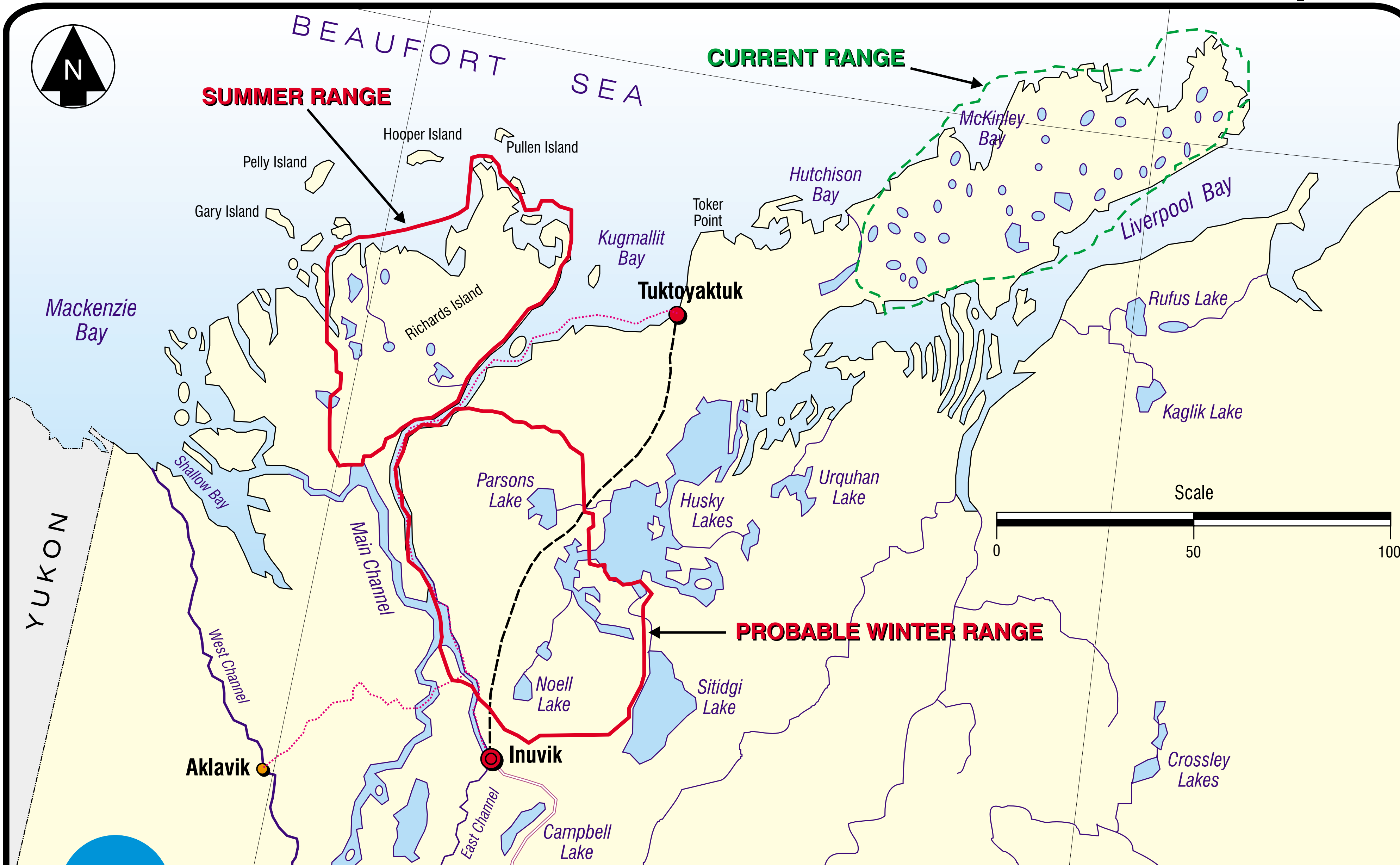


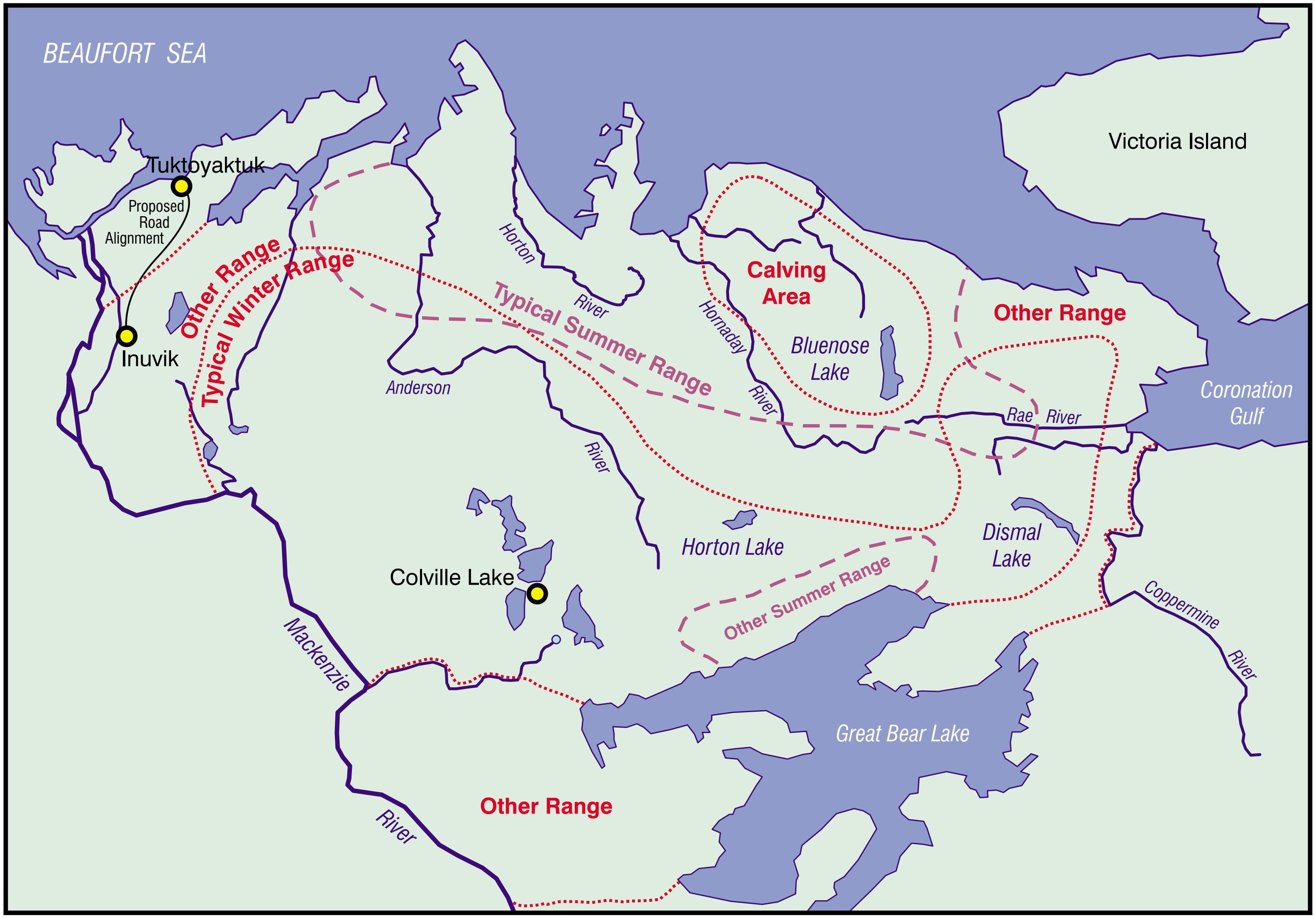
FIGURE 3.6-1

Proposed New Reindeer Herding Range

Northwest Territories

Rescan

Source: Binder, Personal Communications, 1999



Note: Additional calving areas occur in the vicinity of the Horton River.

FIGURE 3.6-2

Usual Distribution of Bluenose Caribou Herd in Recent Years

Northwest Territories

Rescan

Source: Hall 1989

Some direct mortality or caribou can be expected by collisions with vehicles. However, greater potential mortality will result from indirect causes, especially better access for hunters. Roads have adversely affected caribou numbers by improving hunter access (Donihee and Gray, 1982, Bergerud *et al.*, 1984). These effects, however, can be minimized and mitigated through diligent regulation and enforcement.

3.6.2.3 Moose

Moose occur in the Mackenzie Delta as far north as Richard's Island. However, their distribution is restricted to patches of suitable habitat, none of which is found in the immediate vicinity of the Inuvik-Tuktoyaktuk corridor. Poor-quality but occupied habitat occurs to the east of Inuvik, in the Kugaluk-Miner rivers area, and in the Rengleng River area (Prescott *et al.*, 1973b).

Occasionally, however, moose may come into contact with the proposed Inuvik-Tuktoyaktuk road corridor. The corridor is adjacent to the spring moose hunting area (Community of Tuktoyaktuk, 1993). Because the corridor does not generally consist of suitable habitat, it is doubtful that moose habitat effectiveness will be altered. However, it will be possible that direct and indirect mortality factors will be influenced by construction, maintenance, and use of a road.

3.6.2.4 Grizzly Bear

The grizzly bear is an economically and ecologically important species in the Mackenzie Delta area. The Inuvik-Tuktoyaktuk corridor is known to include occupied grizzly bear habitat (Pearson and Nagy, 1976; Nagy *et al.*, 1983; Community of Inuvik, 1993; Community of Tuktoyaktuk, 1993). Although the bear density calculated for the proposed road area (1 bear/200 km^2) was lower than that determined elsewhere in the Mackenzie Delta area (Pearson and Nagy, 1976), at least 7 individual radiocollared bears used home ranges which traversed the proposed route (Nagy *et al.*, 1983). Grizzly bear sightings were also common within the Inuvik-Tuktoyaktuk corridor. Grizzly habitat quality was rated as Class 2 (common use but less than optimum habitat) for the entire Inuvik-Tuktoyaktuk corridor (Nolan *et al.*, 1973a).

In the central Canadian Arctic, grizzlies showed a strong preference for shrub willow habitat during early and mid-summer (Gau, 1998). Tall shrub communities in the Inuvik-Tuktoyaktuk area are likely to be similarly important during this season.

Denning areas are an important ecological attribute for grizzly bears, because bears can spend up to 50% of their lives in dens. Grizzly bears rarely re-use dens. Denning areas can be identified by the presence of old dens, but actual den sites are not traditional as they are with wolves and foxes.

Typical denning habitat in the Mackenzie Delta areas has been on lake or channel embankments, on slopes of at least 30°, and in substrates that could be readily excavated but which provided stability (Nagy *et al.* 1983). Of 101 old and recently-excavation dens located in the Mackenzie Delta area, nine were in the area generally between Tuktoyaktuk and Inuvik (Figure 3.6-3; Nagy *et al.* 1983). Den sites were not felt to be limiting to the grizzly bear population in the Inuvik-Tuktoyaktuk area (Pearson and Nagy, 1976).

Current data on denning areas are not available, but it is likely that the area is still used. Potential local sources of construction materials, especially gravel, may occur in preferred denning habitat, and such sites should be surveyed for dens.

Grizzly bears are sensitive to disturbance and are particularly susceptible to habitat disruption. Even in protected areas, grizzlies avoid roads (Tracy 1977, Purves *et al.*, 1992). In cumulative effects models for grizzly bears in southern, mountainous regions, zones of influence for roads range from 200 to 1,600 m in areas with hiding cover, and 800 to 3,200 m in open habitats (Weaver *et al.*, 1986). In the open habitats typical of the proposed Inuvik-Tuktoyaktuk road corridor, this suggests that grizzly bear habitat lost or reduced in effectiveness could be as much as 6.4 km wide. This effect can substantially reduce the amount of habitat available within the area bisected by even a narrow, low-use road. Like most species, grizzly bears have the capacity to reduce their sensitivity to disturbance through habituation (Bader, 1989). However, with this species habituation may not be desirable as it may lead to increased occurrence of negative bear-human interactions.

Figure 3.6-3 Location of Grizzly Bear Dens in the Vicinity of the Proposed Inuvik-Tuktoyaktuk Road

Northwest Territories

Location of Grizzly Bear Dens in the Vicinity of the Proposed Inuvik-Tuktoyaktuk Road (1983)

FIGURE 3.6-3

Rescan

Source: Nagy et al. 1983

Grizzly bears are vulnerable to roadkill mortality (*e.g.*, Gibeau and Heuer, 1996), but it is doubtful that traffic on the Inuvik-Tuktoyaktuk road would claim many bears. Direct mortality could also arise if bears are displaced from their dens during construction activities. Displaced bears could undergo severe nutritional stress which may result in mortalities, or they may be driven into conflict with humans, resulting in control mortality (*e.g.*, Harding, 1976).

A far greater potential threat would come by way of indirect causes, especially shooting mortality facilitated by improved human access (McLellan, 1990). In many studies, most grizzly bear mortality, legal and illegal, occurred within 1.6 km of roads (*e.g.*, Aune and Kasworm, 1989). It is likely that development of the Inuvik-Tuktoyaktuk road would similarly increase legal and illegal hunting of grizzlies within the road corridor (Pearson and Nagy, 1976). Mitigation of this effect requires planning for restrictions on hunting within the roadside corridor, in conjunction with effective enforcement.

An additional potential source of indirect mortality to grizzly bears would be management actions arising from bear-human interactions, which could be expected to increase with development of a road in the absence of strict controls. This effect could be minimized by effective safety training for construction and maintenance crews, in conjunction with proper handling of food and garbage.

3.6.2.5 Wolf

Wolves are found throughout the Mackenzie Delta area, including the vicinity of the Inuvik-Tuktoyaktuk corridor. In this area they are economically important as furbearers, and ecologically important as a top-level predator, especially of caribou.

Wolf habitat requirements are closely tied to those of their primary prey. Therefore, in the Mackenzie Delta area, wolf habitat is largely determined by the distribution of caribou and reindeer and greater wolf densities can be expected to occur in areas presently occupied by those animals. Specific habitat requirements include den sites, which are typically on embankments with stable soils which can be excavated. These sites may be considered as local sources for construction materials, so they should be surveyed for wolf activity.

In ways similar to the grizzly bear, wolves are susceptible to habitat displacement arising from road developments. Habitat avoidance in the vicinity of roads has not been reported as frequently for wolves as for bears. However, the avoidance of open roads by wolves can be inferred from the absence of wolves in landscapes with road densities >0.6 km/km^2 (Thiel, 1985).

Roadkill can be an important mortality factor for wolf populations (Paquet, 1993). However, indirect mortality is much more likely to affect wolves if the Inuvik-Tuktoyaktuk road is developed. Improved access for hunters and trappers could substantially increase the wolf harvest in the vicinity of the road (*e.g.*, Peterson *et al.*, 1984). Regulation and enforcement can control legal and illegal harvest of wolves.

3.6.2.6 Wolverine

The wolverine is another important furbearer throughout its range and including the Mackenzie Delta area (Community of Inuvik, 1993). The Inuvik-Tuktoyaktuk corridor lies within the winter wolverine hunting area of residents of Tuktoyaktuk (Community of Tuktoyaktuk, 1993).

Wolverines are susceptible to the same types of road effects as wolves are. Few studies have examined these effects, but wolverines have appeared to avoid roads and other human activities (Banci, 1994; Copeland, 1996). However, predominant among the impacts of a road development on wolverines would be the expectation of increased harvest facilitated by improved access. Once again, mitigation of this effect would depend on effective control on harvesting within the road corridor.

3.6.2.7 Red Fox and Arctic Fox

Foxes are also important furbearers. In some years, the total harvest for Arctic foxes from Inuvik and Tuktoyaktuk is several thousand (Martell *et al.*, 1984). In the Mackenzie Delta area, red foxes are considered widespread below treeline, whereas Arctic foxes are widespread above treeline (Community of Inuvik, 1993). There is some, perhaps extensive, overlap in the distributions of the two species (Martell *et al.* 1984). In general, considerably more Arctic foxes than red foxes are harvested annually in this area.

Aside from den sites, habitat requirements for foxes are general, and linked to their food sources: carrion, birds, and small mammals. Denning habitat consists of well-drained, stable soils (Martell *et al.*, 1984). Arctic fox dens described by Nolan *et al.* (1973) were in open areas with little relief. Overall, Arctic fox habitat within the Inuvik-Tuktoyaktuk corridor has been rated as fair to good, with the most northerly two-thirds of the route traversing good quality habitat (Nolan *et al.*, 1973b).

Nolan *et al.* (1973b) suspected that denning habitat for Arctic foxes may be limited in the Delta area. Therefore, it is possible that suitable den sites could be lost by construction of the Inuvik-Tuktoyaktuk road. Particular attention should be directed to identification of potential denning habitat during the design and construction phases.

Although some roadkill mortality could occur if the Inuvik-Tuktoyaktuk road is constructed, greater potential mortality would likely arise from indirect effects. Foxes could be attracted to construction and maintenance camps (Eberhardt *et al.*, 1983), thereby increasing their vulnerability to harvest of management control. The road itself is likely to enhance access to trappers and hunters, with the potential for an increase in harvest.

3.6.2.8 Muskrat

Muskrats are a relatively common and economically important furbearer in the Inuvik-Tuktoyaktuk corridor. Habitat ratings for the proposed road route were poor for the southern one-third, fair for the central one-half, and poor for the northernmost portion (Dennington *et al.*, 1973). Within these general area ratings, however, muskrat habitat requirements are quite specific and centred around standing water bodies. Critical habitat features include steep banks for tunneling, and water depths exceeding maximum ice thickness.

Construction of the Inuvik-Tuktoyaktuk road must consider the importance of muskrats in the local economy, and suitable habitat should be avoided. The potential for increased harvest as a result of enhanced access should be mitigated with harvest controls.

3.6.2.9 Beaver

Beaver occur in the Inuvik-Tuktoyaktuk corridor, particularly nearer to the Mackenzie Delta, and are harvested in relatively low numbers by members of both communities. The entire corridor was classed as poor quality habitat (Dennington *et al.*, 1973). Better quality habitat is found to the west in the Delta proper.

Beaver habitat is generally recognizable by evident signs of beaver activity. Construction of the Inuvik-Tuktoyaktuk road should consider these indicators and avoid areas of beaver activity if present.

3.6.2.10 Other Mammals

Many other mammal species occur within the Inuvik-Tuktoyaktuk corridor, and all possess high ecological value. Economically important species include lynx, marten, mink, weasel, and snowshoe hare. The first four are commercially valuable furbearers, and snowshoe hares are an important source of food and fur. All are harvested by members of each community. However, their occurrence within the corridor is generally in small numbers, especially in comparison to other areas of the Mackenzie Delta region. It is unlikely that development of the Inuvik-Tuktoyaktuk road would substantively affect the regional populations of any of these species.

3.6.3 Birds

More than 100 species of birds are known to occur regularly in the Mackenzie Delta and Tuktoyaktuk Peninsula area and many other species have been recorded irregularly or accidentally. The following are brief descriptions of the more important species harvested by the residents of the region in the vicinity of the proposed Inuvik-Tuktoyaktuk road corridor.

3.6.3.1 Geese and Swans

The Mackenzie Delta area is important for nesting and staging of geese—including Canada geese, brant, snow geese, and white-fronted geese—and tundra swans. All goose species are highly important as a food source for the people of the region. Parts of the Inuvik-Tuktoyaktuk corridor lie within the spring goose hunting area (Community of Tuktoyaktuk, 1993; Community of Inuvik, 1993), which includes all of the Husky Lakes area and the coastline near Tuktoyaktuk.

Most of the Inuvik-Tuktoyaktuk corridor lies within the Upland Tundra habitat zone (Martell *et al.*, 1984). Important nesting areas for white-fronted geese, Canada geese, and tundra swans within this zone include the Husky Lakes and Parson's Lake areas. Husky Lakes are also known to be important moulting areas for these species.

General habitat quality was rated for the Delta area (Canadian Wildlife Service, 1973), and these ratings for the Inuvik-Tuktoyaktuk corridor are shown in Figure 3.6-4. Most of the corridor is rated as good habitat, including nearly all of the northern one-half. The entire portion of the corridor adjacent to the west end of Husky Lakes is rated as good habitat. Poor habitat quality is found mostly in the southern one-third and especially between Inuvik and Noell Lake.

Nesting habitat for tundra swans can include wet sedge meadows as well as ponds, lakes, and slow rivers. However, brood rearing usually requires deeper water (Palmer, 1976). Canada geese and brant prefer small islands in ponds, lakes, and rivers as nesting sites, and brant also commonly nest on the edge of freshwater or tidal pools (Bellrose, 1976). White-fronted geese are secretive nesters which prefer dispersed, higher, and drier nesting sites. Snow geese are primarily colonial nesters. Their preferred nesting habitat includes low grassy tundra and islands in shallow lakes (Bellrose, 1976).

Like mammals, waterfowl can be subject to various effects associated with the construction, maintenance, and use of roads. Loss of habitat effectiveness can be an important effect resulting from physical habitat disruption or by disturbance arising from human activity. In the Arctic National Wildlife Refuge, incubating tundra swans were easily disturbed by ground observers and left their nests when researchers were 500-2,000 m from the nest (Monda *et al.*, 1994). Although undisturbed swans always covered eggs with nesting material prior to recessing, disturbed swans did not cover eggs with nest material prior to departure, leaving the eggs vulnerable to predation and thermal stress (Henson and Grant, 1991). In southcentral Washington, Canada goose broods avoided areas of human habitation in their home ranges, particularly during the first few weeks after hatching when broods appeared most sensitive to human disturbance (Eberhardt *et al.*, 1989). Potentially, however, a greater impact may be incurred by goose populations in the Inuvik-Tuktoyaktuk corridor because of increased access for hunters throughout the year.

3.6.3.2 Loons and Ducks

Four species of loon occur in the Delta area: common, yellow-billed, Pacific, and red-throated. All probably nest in the area, although only the latter two likely breed commonly in the Inuvik-Tuktoyaktuk corridor. Loons are not used economically, but are important elements of the Arctic ecosystem. Nesting habitat for Pacific loons consists primarily of shorelines of lakes and ponds. The red-throated loon may prefer smaller, shallower waterbodies that are close to larger lakes for foraging.

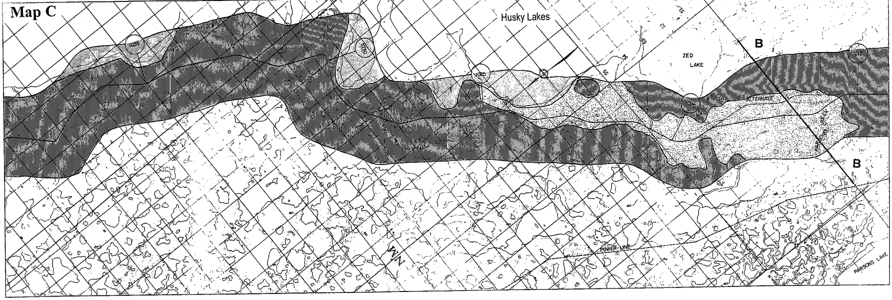
Ducks are economically important to residents of the Mackenzie Delta area as a spring and fall food source, and several species occur and nest there. Predominant among these are king and common eiders, scaup, mallard, scoters, wigeon, oldsquaw, and pintail.

In the upland tundra habitat zone, which accounts for most of the Inuvik-Tuktoyaktuk corridor, scoters were by far the most common species during nesting surveys, followed by pintails, scaup, and mallards in roughly equal proportion, and trailed by wigeon and other species (Martell *et al.*, 1984).

Most duck nests are dispersed and occur in low-lying to upland habitats, and may be hundreds of metres from water. Diving ducks such as scaup may nest on shorelines or in emergent vegetation. Eider nests are often found on small islands close to the coast or on inland tundra ponds (Bellrose, 1976).

General habitat ratings for loons and ducks in the Inuvik-Tuktoyaktuk corridor are included in Figure 3.5-3. The larger lakes (*e.g.*, Noell, Parson’s, and Husky lakes) are likely of higher importance to loons than they are to most duck or goose species.

Loons are known to be susceptible to human disturbance, particularly at nesting sites (Zimmer, 1979; Kertell, 1996). Human disturbance has also been shown to affect the distribution and behaviour of ducks (*e.g.*, Thompson, 1973). Eider nests



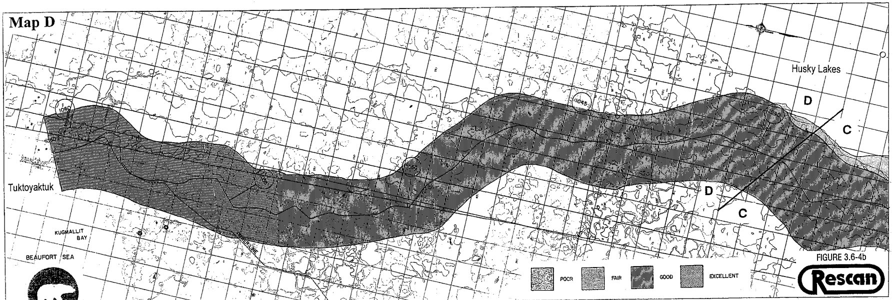


FIGURE 3.6-4b

Rescan

Northwest Territories

1977 PWC Surveyed Route - Waterfowl Habitat Rating

Source: Rampton 1972 cited in PWC 1975