APPENDIX A
Environmental Baseline (Ecofor 2016)

CNFL – PHASE 1 DEMPSTER HIGHWAY PROJECT
Environmental Field Assessment

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1 Introduction

This project provides a basic field assessment of the environmental issues associated with the laying of a fiber optic cable from Dawson to Inuvik. The objectives were to identify the location (start and end coordinates) of wetlands that may be an obstacle in laying the fiber cable, potential impacts to species at risk, and additional notes on other environmental issues. Locations for withdrawal of water for use in horizontal direction drilling are also identified.

The fiber route follows established public highways (Klondike Highway and Dempster Highway) except for a short section east of Dawson that follows a resource road and a power transmission line. The route is through discontinuous permafrost areas in the southern end, with near-surface permafrost on north-aspect slopes, hollows, and flat wet areas. The permafrost becomes more continuous further north along the Dempster Highway. Thawing of permafrost is an issue any time the surface vegetation is disturbed, and may result in instability for the fiber optic line itself, instability of adjacent infra-structure (the highways), and sediment and erosion control issues. Permafrost is the primary issue of concern.

Wetlands are abundant in some parts of the route. Streams are frequent in some areas, but in general should not provide significant difficulties. A key ecological feature is tundra – areas where permafrost is near the surface, resulting in wet to dry herbaceous vegetation, shrub vegetation, or black spruce bogs. The permafrost in many areas is at temperatures barely below 0^{o}C; hence even a very small increase in its temperature may result in its melting and creating ‘thermokarst’ ponds or wetlands. Permafrost, wetlands, ponds, lakes, tundra of all kinds, and streams are strongly linked throughout the permafrost area.

2 Methods

The route of the fiber optic line was driven by senior biologist Crispin Guppy, MSc, PBiol (Alberta), RPBio (British Columbia), with the exception of the 7 km section that follows the transmission line between Hunker Creek Road and the Klondike Highway. That transmission line section was reviewed using orthophotos; only the north end appeared likely to have environmentally sensitive areas. That north end was walked from the Klondike Highway to the base of the hill to the south. The assessment was completed between July 27 and August 5, 2016.

The route was assessed for environmental issues, with the start and end locations of wetlands being the primary objective. Other environmentally sensitive features, especially tundra and black spruce on permafrost were recorded. The apparent existing interactions between permafrost and fiber line installation were observed, and the potential for interactions between the fiber line installation and permafrost considered, while recognizing that the observer (Crispin Guppy) is not an expert on permafrost. Stream crossings and locations where a stream or river was against the road bed were noted.

The Ministries of Transportation in both territories use truck loads of water during road maintenance, to assist in compacting the gravel road surface; resulting in a requirement for water withdrawal sites. Their established water withdrawal locations were recorded for potential use during fiber line installation.

3 Results and Discussion

3.1 General

The fiber route follows established public highways except for a short section east of Dawson that follows a resource road and a power transmission line. The route is through discontinuous permafrost areas in the southern end, with near-surface permafrost on north-aspect slopes, hollows, and flat wet areas. The permafrost becomes more continuous further north along the Dempster Highway. Thawing of permafrost is an issue any time the surface vegetation is disturbed, and may result in instability for the fiber optic line itself, instability of adjacent infra-structure (the highways), and sediment and erosion control issues.

Permafrost is likely the primary issue of concern. Wetlands are abundant in some areas, especially the NWT part of the route, and will likely result in a need for considerable drilling. Streams are frequent in some areas, but in general should not provide significant difficulties.

3.2 Species at Risk

In the NWT, no known locations of species at risk are near the highway right-of-way, with the exception of raptor (falcons, eagles) nests. These are all too far from the highway to be of concern during fiber line installation.

In the Yukon the known locations of species at risk were reviewed. The Conservation Data Centre did not provide the locations or identifications of 'sensitive' species, in particular raptors and large mammals such as sheep. The species at risk locations at Dempster Km 74, 89-96, and 147 – 163.5 are likely the general areas of raptor nest and large mammal areas. Raptor nest concerns can be addressed during nesting bird surveys during summer construction. The raptor nests are very unlikely to be within the right-of-way due to disturbance from highway traffic, and the large mammals will be observable by the Inspectors.

At Km 129.5 and 145.7 there are a species at risk living in a stream, or on its banks, which the Conservation Data Centre did not release the information for. Since the streams will be drilled under, there is no risk of impact to the rare species.

The species at risk occurrence at Km 203 was not released by the Conservation Data Centre. It is uphill from the highway right-of-way, away from the project area, and so should not be impacted.

Showy Alpine Forget-me-not, *Eritrichium splendens*

National Conservation Status N2 – Imperilled (COSEWIC)
Yukon Conservation status S3 – Vulnerable
Habitat – Rocky ledges, rock bluffs and stony heathlands around the Ogilvie River. Flowers in May/June.
Location – CDC lists it as Dempster Hwy Km 226 – 236. This is about 10 km further north than any suitable habitat occurs. I assume this should be Km 211 – 225, where patches of suitable habitat occur. The recorded species at risk site at Km 211.5 is apparently this species, growing on the cliffs at that point.
Recommendation – If the fiber line will be placed on the west side of the highway from Km 211 – 225, a qualified biologist should search for Showy Alpine Forget-me-not in suitable habitats in late May - June prior to ground disturbance. If the plant is found, impacts to concentrations of the plant (one or two plants are not critical) should be avoided (drill under its habitat, or move to the other side of the highway).

Showy Alpine Forget-me-not, *Eritrichium splendens*

Photo: Bruce Bennett, Yukon Conservation Data Centre

Hudson Bay Sedge, *Carex heleonastes*

National Conservation Status N3 – Vulnerable
Yukon Conservation status S1 – Critically Imperilled
Habitat – Not stated by CDC; likely moist to wet soil.
Location #1 – CDC lists the sedge as roadside along the Dempster Hwy near Wolf Creek (= near Km 29). This location is too vague to pin point without actually searching for the plant and finding exactly where it is growing, other than it is in the road right-of-way. There are many sedge species that are quite similar in appearance; hence it is anticipated that a full day on site for searching during the best growing period will be required. A preliminary search for the sedge was done in August 2016, and the sedge was not found. However there was insufficient time to do a thorough search. Highway maintenance is likely routine in this area, without consideration of the sedge.

Recommendation – A qualified biologist should search for Hudson Bay Sedge in non-forested habitats (primarily the cleared right of way) from Km 28 to 30 in mid-June to mid-July prior to ground disturbance. If the sedge is found, impacts should be avoided (drill under its habitat, or trench around it). Its occurrence is likely to be very local, so once detected it should be easy to avoid; if it is widespread and abundant then complete avoidance will likely be unnecessary.

Location #2 – CDC lists it as growing in hygric mesotrophic soil along a stream in the vicinity of North Fork Pass, along the Dempster Hwy (= near Km 81-82). This location is too vague to pin point without actually searching for the plant and finding exactly where it is growing. However, it may not have been found in the road right-of-way, the stream will be drilled under in any case, and there is abundant apparently suitable habitat in the area. Hence searching for the exact plant location is not warranted – the probability of significant impacts is too low.

Recommendation – Do not search for the plants; proceed without special precautions.

Woodchuck, *Marmota monax*

National Conservation Status N5 – Secure
Yukon Conservation status S2S3 – Imperilled to Vulnerable
Habitat – Lives in burrows in dry slopes.
Location – Along Dempster Hwy at mountain creek (Benson Creek), crossing gravel highway in boreal forest (sight observation). A search for burrows was made within the highway right-of-way, but none were found. The habitat is generally poor for Woodchuck burrows, except right at the stream crossing. The animial seen may have been travelling through the area, rather than being resident.

Recommendation – No further action is required, because the only suitable burrow habitat is right at Benson Creek, and the stream and immediately adjacent areas will be protected drilling under them.

Rusty Blackbird, *Euphagus carolinus* (a bird that nests in trees and shrubs)

National Conservation Status N4B – Apparently Secure, Breeding
Yukon Conservation status S3B – Vulnerable, Breeding
Habitat – Nests in wetland edges and adjacent forest.
Location – A wetland complex in tundra habitat north of Two Moose Lake (= Km 103.5), along the Dempster Hwy. Blackbirds use different nesting sites each year; hence protection of an exact site is not critical. Also, they are very unlikely to nest near to the high disturbances resulting from the highway.

Recommendation – Do not search for the birds, other than ensuring that nesting birds in general are not impacted.

Phoebus Parnassian, *Parnassius phoebus* (a butterfly)

National Conservation Status N3N4 – Vulnerable to Apparently Secure
Yukon Conservation status S3S4 – Vulnerable to Apparently Secure

Habitat – Lives in wetlands. Male patrolling moss-sedge fen; female ovipositing at same site. Larvae found in moss-sedge pond-stream (i.e. slow-moving water through fen system).
Location: – North Fork Pass area (= near Km 81-82), Anglecomb Mountain, moist meadow in mountain cirque. This location is far from the highway, and the project will not affect the habitat of the butterfly.
Recommendation – Do not manage for the butterfly, it will not be afffected.

Emerald Spreadwing, *Lestes dryas* (a damselfly, in the same group as dragonflies)

National Conservation Status N5 – Secure
Yukon Conservation status S3 – Vulnerable
Habitat – Lives in wetlands.
Location – Klondike Highway, 7 km west of Dempster Hwy (Klondike Hwy Km 681.8). Probably breeding in a roadside sedge marsh. Field review found a series of small pools and sedge marshes along both sides of the highway that would likely be good habitat. The damselflies had already finished their flight period for the year, and so were not seen.
Recommendation – Do not search for the damselfly, protection of wetlands in general will be sufficient to protect it.

Whitehouse's Emerald, *Somatochlora whitehousei* (a dragonfly)

National Conservation Status N5 – Secure
Yukon Conservation status S4 – Apparently Secure
Habitat – Lives in wetlands. Male patrolling moss-sedge fen; female ovipositing at same site. Larvae found in moss-sedge pond-stream (i.e. slow-moving water through fen system).
Location: – Dempster Highway Km 206. A complex fen system dominated by sedges and fen mosses in limestone hill country. Field review and Google Earth review found that the complex fen system does not extend into the right-of-way at Km 206.
Recommendation – Do not search for the dragonfly, protection of wetlands in general will be sufficient to protect it.

Treeline Emerald, *Somatochlora sahlbergi* (a dragonfly)

National Conservation Status N3N4 – Vulnerable to Apparently Secure
Yukon Conservation status S3S4 – Vulnerable to Apparently Secure
Habitat – Lives in wetlands. Male patrolling moss-sedge fen; female ovipositing at same site. Larvae found in moss-sedge pond-stream (i.e. slow-moving water through fen system).
Location #1: Dempster Highway Km 215, Ogilvie River. Oxbow pond. Field review and Google Earth review found that the descriptor "oxbow pond" does not apply well to features near Km 215. Given the clear error of over 10 km for the Showy Alpine Forget-me-not (above), it is likely that the highway km posts have changed since the observation was made.

Recommendation – Do not search for the dragonfly, protection of wetlands in general will be sufficient to protect it.

Location #2: Dempster Highway Km 182, mossy oxbow pond of Engineer Creek. Field review and Google Earth review found that the descriptor "oxbow pond" does apply to features near Km 182.

Recommendation – Do not search for the dragonfly, protection of wetlands in general will be sufficient to protect it.

Location #3: Dempster Highway Km 175, roadside peatland pond of Engineer Creek. Field review and Google Earth review found that the descriptor "roadside peatland pond" does not apply well to features near Km 175; this location may not be where the modern "Km 175" is located.

Recommendation – Do not search for the dragonfly, protection of wetlands in general will be sufficient to protect it.

Location #4: Eagle River at Dempster Highway (= Km 378), Carex/Equisetum oxbow marsh. Field review and Google Earth review found that all "oxbow marsh" habitats are outside the right-of-way.

Recommendation – Do not search for the dragonfly, protection of wetlands in general will be sufficient to protect it. In any case, the habitat is outside the alignment of the fiber line.

3.3 American Beaver and Muskrat

No beaver lodges or dams, or muskrat lodges, were located in a place where installation of the fiber line would impact them. Their wetland, pond, and lake aquatic habitat will either be avoided or drilled under. In the few water withdrawal sites where beaver lodges are present, the lakes are large enough that the water level will not detectably drop during water withdrawal (and water withdrawal is already occurring; hence withdrawal for the fiber line will not result in a change). Beavers were not observed to make significant use of the willow and other deciduous vegetation in the right-of-way, likely because of the high level of disturbance due to highway traffic. Therefore, in both the NWT and Yukon there will be no impact of vegetation clearance or laying of the fiber line on beavers or muskrats.

Recommendation: No special actions are required to avoid impacts to beavers or muskrats.

3.4 Wetlands

Wetlands vary from being open water less than 2 m deep (the commonly accepted difference between a wetland and a lake) to being dry enough in the summer to operate equipment on. They may be entirely herbaceous vegetation, covered in shrubs, or forested with spruce and/or tamarack. For the purpose of the field review, wetlands were noted when they were wet enough to prevent the use of low ground pressure tracked machinery. Wetlands drier than that were treated as being 'terrestrial' – the dryness of wetlands may be variable depending on weather conditions. Open water wetlands were called 'ponds', to emphasize the open water. Lakes were noted as well, and most large streams have wetlands associated with them.

Wetlands are very common along parts of the Klondike Highway and the Dempster Highway. However, wetlands are uncommon in central part of the Dempster Highway (north and south of Eagle Plains), because in that area the highway follows ridgelines. In that area most wetlands appear to have resulted from small local areas of melting permafrost beside the highway. The tundra is dry, because of thin, rocky, well drained soils.

Along the Klondike Highway, most wetlands reach the toe of the road fill. Where the wetland edge was far enough back that there appeared to be room to insert the fiber line a few meters out from the toe of the road fill, the wetland was not noted. There are many small (5-20 m long) wetlands adjacent to the highways, often entirely within the right-of-way, either resulting from permafrost melting or ditch excavation.

Along the Klondike Highway, teal and other ducks with young were in most of the ponds, but not along the Dempster Highway. Therefore, nesting ducks will be along the entire Klondike Highway part of the fiber line, up to early August. The shrub-dominated wetlands in that area are likely to result in other nesting birds being abundant as well.

Recommendation: For the Klondike Highway section of the route, fiber line construction should occur before May 1 and after August 30, to avoid delays and extra costs due to nesting and fledgling ducks and songbirds. A nesting bird survey may be able to reduce this period by 2 weeks at either end.

Consideration should be given to winter construction of the 15 km section between Klondike Hwy Km 689 (the north end of the transmission line part of the route) and 675 (the junction with the Dempster Highway), so that the wet ditches and wetlands can be more easily trenched. Alternatively, the machinery could remain on the road bed and reach out to the side.

3.5 Whitehorse to Dawson Fiber Line

In 2016, the route of the Whitehorse to Dawson fibre line (under construction) was mowed, and both sides of the highway were mowed down the side of the road fill. Installation of the cable was being actively worked on in late July and early August.

The Whitehorse to Dawson fiber line is generally along the west side of the Klondike Highway, and along the power transmission line parallel to the Highway. West of Henderson's Corner, where the highway is pinched between cliffs and the river, the Whitehorse to Dawson line is being drilled into the surface of the shoulder of the highway, as close as 0.5 m from the pavement edge.

Recommendations: Consider doing the same thing, using the other road shoulder – it is more vulnerable due to the adjacent river, but it would save a lot of distance over using the Hunker Creek road and transmission line route. Also, consider using more of the transmission line right-of-way, where it is parallel to the highway, to avoid some wet areas near the highway and to make use of the wider corridor.

3.6 Permafrost

Permafrost is widespread throughout the Project area, primarily on north-aspect slopes and bogs in the south and is continuous in the north. South of Windy Pass (Km 153), permafrost is primarily at higher elevations, in hollows, and on north slopes. North of Windy Pass the permafrost is more or less continuous, although it is locally not of significance in some rocky areas.

The hydrology (maximum and minimum flows, including frequent floods) and stream channel stability of some watersheds are apparently heavily influenced by the presence of permafrost. Installation of the fiber line has the potential to initiate or accelerate permafrost melting adjacent to the highways. Natural permafrost effects will likely continue to impact a wide range of aquatic and terrestrial values indefinitely into the future. Embedding the fiber line, and potentially constructing camps, will need to be done so as to minimize potential effects on the permafrost layer.

Demspter Hwy Km 0 to 153 (Windy Pass) – the right of way was originally cleared of vegetation. Recent mowing (< 2 years) has occurred for the road fill; the rest of right of way has had vegetation cleared a variable amount (zero to full clearance) since that time. In the Engineer Creek area, the extensive wetlands are black spruce bogs on permafrost. In dry conditions it may (or may not) be possible to walk machinery on them.

Dempster Hwy Km 153 (Windy Pass) to Inuvik -- the right of way was originally cleared of vegetation, but it has never been brushed since then. Vegetation ranges from zero shrubs through to 10+ m trees.

Tundra Areas – 'Tundra' is typically defined as treeless habitats in high-latitude regions (or high elevations further south), having permanently frozen subsoil (permafrost) and supporting low-growing vegetation such as grasses, sedges, lichens, mosses, and shrubs. For the purpose of this project, tundra with shrubs was not included in the term 'tundra'; only 'grassy' tundra was included.

Permafrost melting creates significant highway maintenance problems, is ecologically undesirable, and is esthetically questionable. North of Windy Pass there are three basic types of roadside vegetation:

(1) 'Grassy' tundra. Areas of 'grassy' tundra (no trees, and only very low shrubs) were generally not touched during the original road construction. The roadbed fill was added directly on top of the tundra without any sign of machines being used on the tundra (no summer machinery use, but possibly winter use on snow pack). The tundra is smooth and unmarked – which means they will need to stay that way, or the tourism industry will be upset by the change in esthetics. Also damage to the surface of the tundra may result in permafrost melting that will create wetlands and ponds beside the highway. Ideally the fiber line should go into the road fill; alternatively, limiting the impact on the tundra to the trench of the fiber line (no machine tracks) might be acceptable.

    In the areas of grassy tundra the permafrost is near the surface of the ground in the summer (around 0.5 m), which is why in many areas the tundra remains wet even on slopes. The base of the road fill provides increased soil depth over the permafrost, resulting in the growth of willows along the edge of the road fill in some areas. Where there are willows there should not be a concern with esthetics, because the willows will presumably grow up again and hide the trench and machine tracks (unless temporary shrub removal causes permafrost melting, resulting in subsistence issues).

    The tundra areas south of the Ogilvie River (Km 195) are wet tundra that can be considered to be wetlands. In contrast, the tundra areas on the ridgelines north of Km 246 are generally well drained and dry, with wet tundra only in small scattered patches. The ridgeline tundra is dry because it is based on thin, rocky, well-drained soil with the permafrost generally below the surface of the bedrock.

    Recommendations: In 'grassy tundra' areas, base all machinery on the road surface. Try to obtain approval to insert the cable into the roadbed. That would avoid most potential esthetic and permafrost issues. Alternatively, base the machines on the road and reach out to the side to trench for the cable to minimize ground disturbance.

Consult a permafrost expert to determine what long-term impacts digging a trench for the cable might have on the permafrost and the tundra above it and the shrubs along the road base. My observations are those of a biologist, not of a permafrost expert.

(2) Shrub regeneration. The shrubs in the right-of-way are frequently mowed along the Klondike Highway, and occasionally mowed on the Demspter south of Windy Pass (Km 153). North of Windy Pass, shrub regrowth in the right-of-way is dense and frequently tall; vegetation has never been mowed since the highway was constructed. In local areas trees (black spruce, tamarack, birch) have regrown in the right-of-way and are quite tall (up to 10+ m).

It appears that clearing the vegetation in the right-of-way results in permafrost melting, especially if the surface moss/grass/sedge layer is also disturbed. There were many locations where it appeared permafrost melting beside the road after construction resulted in the development of 'thermokarst' wetlands and ponds, and those wetlands and ponds appeared to still be expanding – there were dead trees along the edge that appeared to have recently drowned as the permafrost under them melted. These small local wetlands and ponds were almost entirely along the right-of-way, and were not a natural feature of the undisturbed landscape, indicating that they are the result of the highway construction. In some areas they are very common and will be a significant obstacle to burying the cable in the right-of-way. It should be noted that many of the natural lakes and ponds in tundra areas are also thermokarst features resulting from local melting of permafrost.

Recommendations: In all areas north of Windy Pass (Km 153), and permafrost areas south of there, base all machinery on the road surface, and reach out to the side to trench for the cable; this will minimize the requirement for brushing and minimize ground disturbance.

Consult a permafrost expert to determine what long-term impacts digging a trench for the cable might have on the permafrost and the land above it. My observations are those of a biologist, not of a permafrost expert.

(3) Forested bogs. Forested bogs in this project area generally consist of permafrost with a fairly thin unfrozen surface layer, with black spruce forest cover ranging from scattered trees to quite dense forest. They are wetlands that range from very wet to quite dry in late summer. Most of the trees were cleared from the right of way during the construction of the right-of-way, but there has been no brushing since that time. They are similar to 'grassy' tundra, except due to lower elevations they support some tree growth.

In the southern end of the project area forested bogs are uncommon and occur in shaded gullies on north slopes. The area occupied by the bogs increases as one moves north along the highway, with the largest areas being in the Ogilvie Mountains and the Mackenzie River delta.

Recommendations: The bogs are quite similar to grassy tundra, except, due to lower elevations, they grow trees and shrubs. The same recommendations apply.

4 Potential Water Withdrawals

Water withdrawals must be done in a manner that does not cause environmental harm. Limiting factors are:

1. No beaver or muskrat lodges should be present in ponds or wetlands – if the water level in ponds or wetlands drops in habitats where beavers or muskrats are living, stress will definitely occur and mortalities may also occur. A permit is required to make changes to beaver and muskrat lodges and dams.
2. Fish and fish habitat must not be adversely affected – this is achieved by using “fish screens” on pump intakes http://www.dfo-mpo.gc.ca/Library/223669.pdf, and not significantly affecting the water level and water flow in a fish-bearing stream / pond / lake.
   a. Water withdrawals from fish-bearing ponds / lakes should not exceed those permitted in the *Application of the NWT Winter Water Withdrawal Protocol with Bathymetric Profiles of Select Small Lakes in the Mackenzie Delta Region* http://www.dfo-mpo.gc.ca/Library/319678.pdf. This requires bathymetric surveys.
   b. Water withdrawals from fish-bearing streams should not exceed those permitted in the document http://www.dfo-mpo.gc.ca/Library/271849.pdf.
3. Ponds / lakes / wetlands should not have their depth lowered significantly, even if not fish-bearing, to protect amphibians, water birds, aquatic plants, and species at risk.
4. Manmade water sources (gravel pits, sumps, etc.) have no limitations on water withdrawal under the legislation in both territories, providing they do not support game fish.

During the field review, only established water withdrawal sites in current use or with indications of recent use during highway maintenance activities were recorded. These site require no access development, and, because of their current or recent use, are can be assumed to be acceptable as water sources.

A total of 44 water withdrawal sites were recorded; most were in active use. Two sites were recorded for the Klondike Highway – as a paved highway, water withdrawal is not required for routine road maintenance – the remainder were along the Dempster Highway. There are 15 excavated pits used for water withdrawal, most are old borrow pits but a few may have been excavated specifically for water withdrawal; however, all were recorded as ‘borrow pit’. The volume of water at some sites is limited; however, little drilling is likely to be required in those sections of the route because the route is dry.

Table 1. Water Withdrawal Sites

Site	Highway	Yukon / NWT	UTM Zone	Easting	Northing	Side of Hwy	Feature	Hwy Km	Comments
276	Klondike	Yukon	7	590415	7100575	Both	Borrow Pit		Placer ponds - one on each side of Hunker Creek Road, no inflow stream, not in use, with good water withdrawal sites. Unlimited water. Contact placer claim holder before using?

133	Klondike	Yukon	7	611155	7095910	East	River		Klondike Hwy 2.4 km south of Dempster Jct, Klondike River, established site
62	Dempster	Yukon	7	618289	7102152	East	River	10.0	Access to river but truck would have to back down hill for 200m.
32	Dempster	Yukon	7	618946	7119463		Stream	29.5	Benson Creek, on side road, U-shape turn-around; pump present.
41	Dempster	Yukon	7	623328	7136751		Stream	47.0	Scoutcar Creek; short side road; obviously used for pumping.
42	Dempster	Yukon	7	625052	7139325		Stream		Wolf Creek; short side road; obviously used for pumping
48	Dempster	Yukon	7	629776	7145218		Stream	58.0	Grizzly Creek; short side road; obviously used for pumping.
57	Dempster	Yukon	7	634364	7151749	East	River		Established camp in old gravel pit, water withdrawal site from river
63	Dempster	Yukon	7	627210	7167231		River		Established water withdrawal from river
67	Dempster	Yukon	7	624953	7179324	East	River	101.0	Short side road. In use for water withdrawal from river
68	Dempster	Yukon	7	625177	7184317	East	Borrow Pit	106.0	In use for water withdrawal; supersacks stored on site
69	Dempster	Yukon	7	625382	7185979		River	109.0	In use for water withdrawal
70	Dempster	Yukon	7	625138	7192113		River	115.0	Blackstone River; narrow, muddy access road for the trucks
111	Dempster	Yukon	7	628649	7197459	East	River		Access road with water truck visible on Google Earth. Not checked in field because believed (incorrectly) to be private property access. Blackstone River
265	Dempster	Yukon	7	630369	7207338		River		Possible water withdrawal site - depends on flows at the time; water shallow
71	Dempster	Yukon	7	635089	7218490		River	145.0	Established water withdrawal site on short side road
136	Dempster	Yukon	7	624187	7222328	East	River		Pull-off between Hwy and river; established site
142	Dempster	Yukon	7	625361	7234697		Stream		Established water withdrawal site on short side road
264	Dempster	Yukon	7	625319	7251253		River		Water withdrawal site in Highway's Ogilvie River Camp - full water truck seen coming our of access road. Site was not confirmed because of extensive truck traffic due to construction work.
163	Dempster	Yukon	7	629516	7263455		River		Established water withdrawal site on short side road. Stream was too shallow when observed.
168	Dempster	Yukon	8	392621	7317026	East	Borrow Pit	298.0	Old gravel pit with some water; in use by Highways; one truckload only?
169	Dempster	Yukon	8	397306	7333111	West	Borrow Pit	307.0	Excavated reservoir in active use by Highways; wide spot in highway
170	Dempster	Yukon	8	396875	7333728	East	Borrow Pit	321.5	Old gravel pit with some water; in use by Highways; one truckload only?

172	Dempster	Yukon	8	423271	7356783		Borrow Pit	363.0	Excavated reservoir; lots of water
174	Dempster	Yukon	8	423552	7370366	West	River	378.0	Established water withdrawal site on short side road. Eagle River. Km 378
177	Dempster	Yukon	8	435555	7379894	West	Borrow Pit		Excavated reservoir (gravel pit) on side road; 5 truckloads?
178	Dempster	Yukon	8	442277	7385030		Borrow Pit		Excavated reservoir (gravel pit) on side road; 5 truckloads?
179	Dempster	Yukon	8	441362	7392374		Stream		Established water withdrawal site on short side road. Glacier Creek.
210	Dempster	NWT	8	447742	7434987	West	Borrow Pit		Excavated reservoir beside highway; 2 truckloads?
209	Dempster	NWT	8	452608	7443548	West	Stream		Established water withdrawal site on short side road.
211	Dempster	NWT	8	505924	7479135	East	Lake		Established water withdrawal site on short side road. Lake on east side of the highway
190	Dempster	NWT	8	506035	7475128	West	Borrow Pit		Old gravel pit with unlimited water
191	Dempster	NWT	8	536426	7474195	East	Borrow Pit		Old gravel pit with unlimited water; pump present - being used for water withdrawal; large stream providing in-flow (therefore use counts towards the 100 m3)
192	Dempster	NWT	8	546107	7478629	West	Pond		Natural lake with established water withdrawal site.
246	Dempster	NWT	8	546108	7478629	West	Lake		Lake with short access for water withdrawal; beaver lodge nearby but lake large enough that water level will not drop
234	Dempster	NWT	8	547368	7512221	West	Borrow Pit		Old gravel pit with unlimited water
237	Dempster	NWT	8	548886	7504834	West	Borrow Pit		Old gravel pit with unlimited water
231	Dempster	NWT	8	554904	7525930		Stream		Neilo Creek crossing; water withdrawal possible; pull-off is wide road shoulder
230	Dempster	NWT	8	556059	7527675		Stream		Lynx Creek crossing; water withdrawal possible; pull-off is wide road shoulder
222	Dempster	NWT	8	562819	7553517		River		Established water withdrawal site on short side road; pump present. Vadzaih van tshik Territorial Campground
223	Dempster	NWT	8	563036	7548409		Borrow Pit		Old borrow pit, now a lake. Established water withdrawal site; unlimited water.
224	Dempster	NWT	8	563951	7544176		Borrow Pit		Old borrow pit, now a lake. Established water withdrawal site; unlimited water.
214	Dempster	NWT	8	570814	7576556	East	Lake		Established water withdrawal site on road shoulder; pump present. Lake on east side of the highway
216	Dempster	NWT	8	571666	7573060	West	Stream		EhJuu Njik Territorial Day Use Area; suitable for water withdrawal, but no indication that it is used for that
215	Dempster	NWT	8	572159	7575773	West	River		Boat launch, no sign of water withdrawal use, but would work OK

5 Summary

The potential for permafrost to melt in response to clearance of shrubs and/or soil surface disturbance, creating new thermokarst ponds and wetlands adjacent to the Dempster Highway, is the greatest concern. The second greatest concern is likely to be impacts on esthetics of ‘scarring’ the grassy tundra adjacent to the highway. A permafrost specialist should be consulted regarding the potential for impacts, and potential mitigation strategies.

Wetlands should be fairly routine to deal with, except some are quite long. Some can be avoided by moving the cable to the other side of the highway. Some will be dry enough to walk machinery on the wetland to trench. Streams will also be routine to drill under.

Species at risk are mostly associated with wetlands, and so will not be impacted. There are two rare plants that should be surveyed for in early – mid summer, where their habitat may be impacted. The rare plants are Showy Alpine Forget-me-not and Hudson Bay Sedge.

APPENDIX B

Heritage Resource Overview Assessment
(Ecofor 2019)

Heritage Resource Overview Assessment: Dempster Fibre Project Summary of Previous Work and 2019 Updating – Yukon

(SUITABLE FOR YESAB SUBMISSION– CONTAINS NO SENSITIVE SITE DATA)

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June 4, 2019

EXECUTIVE SUMMARY

On behalf of Hemmera, Ecofor Consulting Ltd. (Ecofor) has conducted a review of previous heritage resource assessment work related to the proposed Dempster Fibre Project (formerly known as the Canada North Fibre Loop project), conducted new Heritage Resource Assessment (HROA) work along revised components of the proposed right-of-way (ROW), and updated heritage site inventory searches associated with previous phases of assessment to ensure all documented heritage resource sites within the study area are known. Previous phases of assessment include an unpermitted desktop HROA study (Mooney and Bennett 2016) and preliminary heritage field assessment (PHFA) conducted under Yukon Government Heritage Resource Unit permit 16-16ASR (Bennett 2016a) and NWT Prince of Wales Northern Heritage Center permit 2016-14 (Bennett 2016b). This report focuses on portions of this ROW within the Yukon, with the assessment of lands within the NWT reported separately. **Note: All specific geographic references to heritage site locations, photographs, and some site details have been removed from this version of this report so that it can be issued publicly while protecting sensitive site data.**

The goal of this report is to summarize the results obtained through previous phases of heritage resource assessment associated with the Yukon portion of the Dempster Fibre Project, update these previous results with any relevant information that has emerged since the previous phases of assessment were finalized, and present this compiled data as a single set of results that should be seen as superseding all previous phases of assessment.

In total, 13 areas of specific heritage resource concern were identified along the Yukon portion of the proposed ROW corridor during the PHFA fieldwork. These areas were identified as having elevated potential for impacts to heritage resources due to: 1) their proximity to previously recorded heritage resource sites, 2) their proximity to high potential landscape features for the identification of currently undocumented heritage resources, or 3) a combination of elevated potential factors 1 and 2. Specific avoidance and/or impact mitigation strategies are presented in this report. The remainder of the project area was found to either have low potential for heritage resources, or to have small areas of elevated potential that can be easily avoided by following the general avoidance strategies presented in this report.

If the project area footprint is modified in the future to include additional unassessed lands, those areas should also be reviewed for possible impacts to heritage resources. Moreover, although all efforts were made during the production of this report and all previous phases of assessment to make the results as comprehensive and accurate as possible, small undocumented areas of

heritage resource potential may be present and chance finds of heritage resources may be made in areas of perceived low heritage resource potential within the study area. As such, the recommendations contained herein are intended to be used for planning purposes only.

CREDITS

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LIST OF FIGURES

1.0 INTRODUCTION

On behalf of Hemmera, Ecofor Consulting Ltd. (Ecofor) has conducted a review of previous heritage resource assessment work related to the proposed Dempster Fibre Project (Figure 1; formerly known as the Canada North Fibre Loop project), conducted new Heritage Resource Assessment (HROA) work along revised components of the proposed right-of-way (ROW), and updated heritage site inventory searches associated with previous phases of assessment to ensure all documented heritage resource sites within the study area are known. Previous phases of assessment include an unpermitted desktop HROA study (Mooney and Bennett 2016) and preliminary heritage field assessment (PHFA) conducted under Yukon Government Heritage Resource Unit permit 16-16ASR (Bennett 2016a) and NWT Prince of Wales Northern Heritage Center permit 2016-14 (Bennett 2016b). The study area crosses portions of the traditional territories of the Na-Cho Nyak Dun First Nation (Yukon), the Tr'ondëk Hwëch'in First Nation (Yukon), the Vuntut Gwitchin First Nation (Yukon), and the Gwich'in Tribal Council (NWT). This report focuses on portions of this ROW within the Yukon, with the assessment of lands within the NWT reported separately. **Note: All specific geographic references to heritage site locations, photographs, and some site details have been removed from this version of this report so that it can be issued publicly while protecting sensitive site data.**

1.1 HROA Updating Objectives

The goal of this report is to summarize the results obtained through previous phases of heritage resource assessment associated with the Yukon portion of the Dempster Fibre Project, update these previous results with any relevant information that has emerged since the previous phases of assessment were finalized, and present this compiled data as a single set of results that should be seen as superseding all previous phases of assessment.

1.2 Report Format

The report begins with a basic outline of the project and the objectives of the work undertaken. The proposed activities and their impacts are then discussed in Section 2.0. Section 3.0 describes the methods employed in assessing the archaeological potential. Section 4.0 provides a description of the physical/environmental and cultural/historical setting of the study area. Section 5.0 presents an evaluation of the heritage resource potential within the various localities being considered within the study area, Section 6.0 provides a summary of this analysis and a series of heritage resource management recommendations for the study area, and Section 7.0

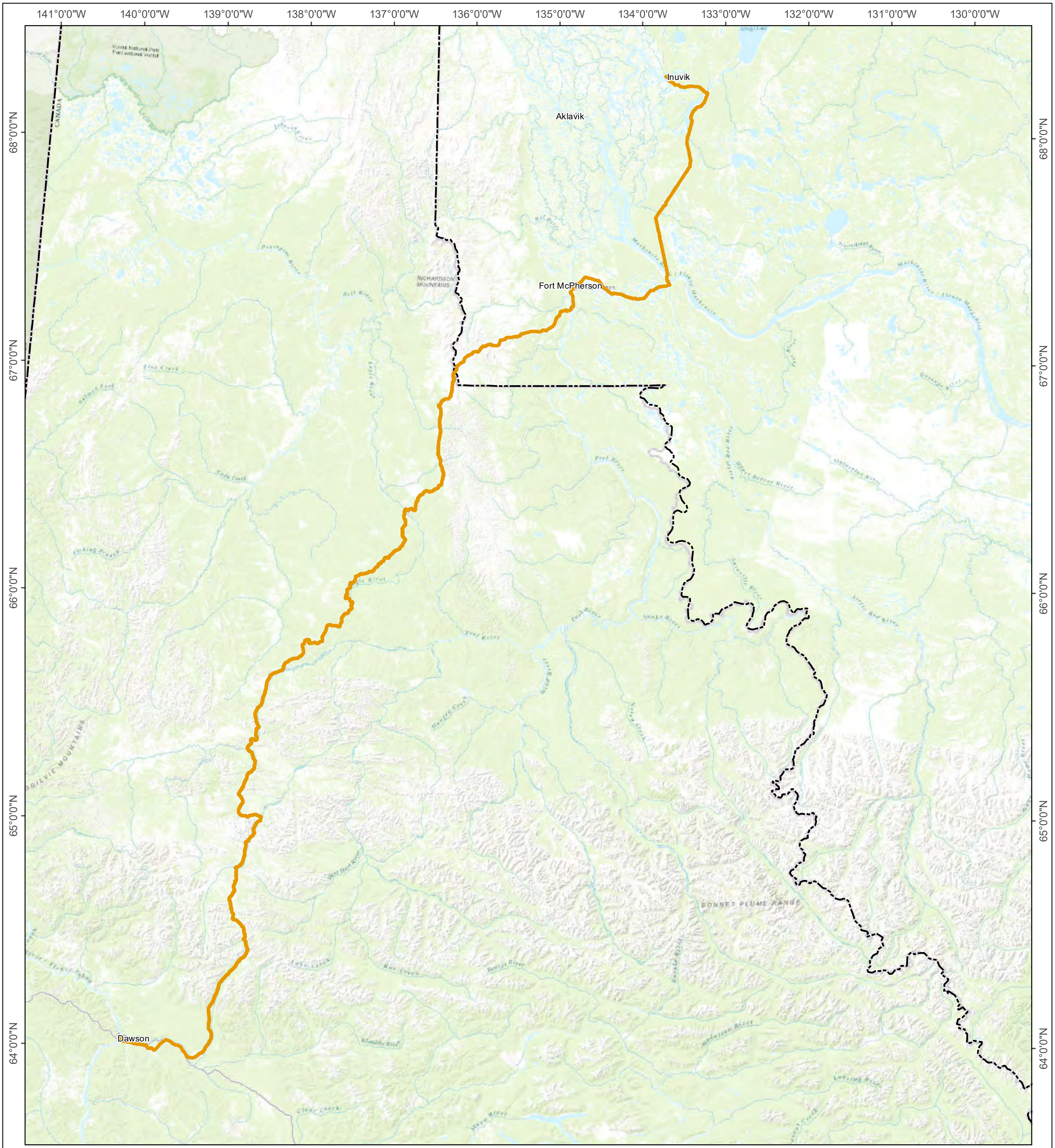
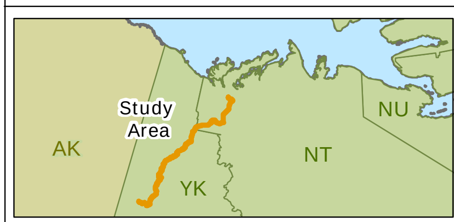


FIGURE 1
Dempster Fibre Project

ECOFOR natural and cultural resource consultants

Ecofor Consulting Ltd. May 6, 2019 (JM)



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NAD 1983 UTM Zone 8N

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Project Centerline

YK / NT Border

lists the references cited. Four appendices are included at the end of the report[1]. Appendix A presents maps showing identified areas of elevated potential for heritage resources, Appendix B provides photographs from the previous PHFA work, Appendix C give a summary of known heritage resource sites, and Appendix D presents the Guidelines Respecting the Discovery of Human Remains and First Nation Burial Sites in the Yukon.

[1] Note: Appendices A, B, and C have been removed from this version of this report so that it can be issued publicly while protecting sensitive site data.

2.0 PROJECT DETAILS AND PROPOSED ACTIVITIES WITHIN THE STUDY AREA

The proposed project consists of the installation of a fibre optic communication line running from Dawson City, YT to Inuvik, NWT (see Figure 1). The Dempster Fibre Project alignment extends approximately 780 km. Within the Yukon, the fibre optic line begins at Dawson City, runs eastward generally following the existing Klondike Highway (Yukon Highway 2) ROW, until turning northward at the Dempster Highway (Yukon Highway 5). The proposed line will diverge from this route briefly to the east of Dawson (along the Highway 2 portion of the alignment) when it instead follows Hunker Creek Road then an existing power transmission corridor before reconnecting to the Klondike Highway. Once heading northward from the junction of the Klondike and Dempster Highways, the fibre optic line follows the existing Dempster Highway corridor until reaching the NWT border where the Dempster Highway continues along NWT Highway 8 ROW. Installation will be facilitated by a number of different methodologies including, plough burial, shallow depth plough burial, horizontal directional drilling, and aerial suspension. As such, ground impact related to this project should be minimal, but will include trenching and drilling, and possible impacts related to mobilizing trenching, drilling, and cable laying/hanging equipment to the work areas.

3.0 METHODOLOGY

3.1 Review of Previous Phases of Assessment

The results of previous phases of assessments, including the unpermitted 2016 desktop HROA study (Mooney and Bennett 2016) and the PHFA conducted under Yukon Government Heritage Resource Unit permit 16-16ASR (Bennett 2016a) and NWT Prince of Wales Northern Heritage Center permit 2016-14 (Bennett 2016b), were reviewed to ensure they remain relevant to the revised 2019 Dempster Fibre Project footprint. To do so, the general and specific heritage resource management recommendations made in the above cited reports were compared to the revised 2019 Dempster Fibre Project footprint. Those recommendations that were found to be relevant to the revised footprint are included in Section 5.0 of this report. Any recommendations that were found to no longer apply due to changes to the proposed footprint have been removed.

3.2 New HROA along revised components of the proposed ROW

This report presents the results of a desktop study designed to predict the potential for encountering heritage resources within the Dempster Fibre Project area. The methodology used in this desktop HROA to develop these predictions is described below.

The desktop review relies on two primary lines of evidence, the physical/environmental and cultural/historical setting of the study area:

1. The first line of evidence is predicated upon attributes of the physical/ environmental setting. These attributes are derived from an analysis of the biogeoclimatic zones, physiography, hydrology, bedrock and surficial geology, and vegetation and wildlife distributions. Aerial photographs were also reviewed. This approach relies on the assumption that specific geographic features, such as elevated landforms (e.g. ridges, knolls, terraces, etc.), water features (e.g. lakes, rivers, creeks, wetlands, and their associated banks/margins), and resource patches (e.g. hunting and foraging locales, quarry sources), can be linked to specific settlement and resource exploitation patterns. Close proximity to these types of landforms is considered to be an indicator of high potential for heritage resources regardless of whether previous heritage resources studies have identified sites of interest in the vicinity.

2. The second approach is built upon a review of previous heritage resource management research conducted within the study area and adjacent lands aimed at understanding the area's cultural/historical setting. The review includes a general overview of the culture historical context of the study area, and a detailed

review of previous archaeological studies, and historical records. In this stage of the analysis, closer proximity to previously recorded heritage resource sites is considered to be evidence for human use of the area, and it is therefore interpreted as an indicator of elevated potential for heritage resources.

The data obtained through these reviews will then be used to assess the potential for development related impacts to both known and previously undocumented heritage resource sites. In terms of the physical/environmental setting, the analysis will be based upon the criteria described in section 3.2.1 of this report. A list of potential site types expected for the study area, and the physical/environmental attributes they are expected to be correlated with, are presented below in Section 3.2.2. The cultural/historical assessment will be based on a general review of the documented Precontact (Section 4.2.1), Protohistoric (Section 4.2.2), and Historic (Section 4.2.3) periods in the broader region and modern First Nations whose traditional territory overlaps with the proposed project area (Section 4.3), as well as specific reviews of previous heritage resource studies, documented archaeological site inventory, and Historic sites on file with the Yukon Government Heritage Resource Unit (Section 4.4).

3.2.1 Landforms and Geographic Features with High Heritage Resource Potential

In addition to the areas around known sites, a number of landforms and landscape features can be used to help identify areas of heightened heritage resource potential. They include:

1. Elevated landforms such as valley edges, terraces, ridges, mid-slope benches, and knolls. These landforms are considered areas of potential for heritage resources because they often offer better drained soils, relative proximity to water and game, and larger viewsheds. Elevated landforms with south-facing margins are considered especially high potential because of their warmer temperatures and better airflow which helps reduce insects. These types of landforms are associated with a wide variety of site types including campsites, lookout sites, cache sites, etc.

2. Areas within close proximity to water are also considered to be areas of potential for heritage resources. The potential of these areas is bolstered both by human water needs, but also those of large game animals, fish, and bird species. The easy access to water makes these areas ideal for habitation and hunting sites.

3. Areas near lithic raw material sources are considered to have potential for heritage resources due to their value as quarry sites.

4. Caves, rockshelters, and tors, are listed as possessing increased potential for heritage resources due to possible use as temporary shelters from poor weather, as possible quarries for lithic raw materials, and as special places on the landscape that may be associated with spiritualism, ritual practices, and rock art in traditional cultures.

5. Sedimentary rock beds with the potential to contain palaeontological remains.

6. A final component of assessing the physical environment is determining the level of previous disturbance in the area. If areas have been severely disturbed in the past it reduces the potential of finding intact archaeological remains. Disturbance can include previous activities such as mining, oil and gas exploration, winter road or airport construction, etc. Disturbance is determined through analysis of the maps and historical information which indicate locations of previous known industrial activities. Professional judgment is used to determine the level of impact resulting from a given disturbance.

3.2.2 Potential Site Types Expected in Study Area

Eleven broad site types are considered in this heritage resource assessment for their likelihood to be present within the study areas. Definitions of these site types, and the physical/ environmental attributes they are expected to be correlated with, are presented below. These general assumptions are extrapolated from previous archaeological studies and known sites in the larger area. Please note these broad site types overlap and are not mutually exclusive (e.g. a habitation site may also have been used as a hunting or fishing site).

3.2.2.1 Permanent/Long-Term Habitation Sites

Permanent/long-term habitation sites would indicate prolonged or repeated occupation of a locality. In this area, permanent/long-term habitation sites could be considered those sites which are returned to seasonally year after year, such as a summer campsite. Based on previous archaeological and ethnographic research, these sites are considered most likely to be associated with high, well-drained, south-facing landforms with grassy margins and/or open, pine dominated forests, and good access to water. Essentially, permanent/long-term habitation sites are only expected in optimal locations.

3.2.2.2 Temporary Habitation/Subsistence Sites

Temporary habitation sites tend to be associated with resource gathering activities such as hunting and foraging, but can sometimes be related to ceremonial activities. Subsistence related sites are typically represented by lithic tools, evidence of tool production/maintenance, hearths, hunting blinds, and possibly faunal remains. Ceremonial sites related to puberty and shamanistic rituals are often represented by cairns, isolated hearths, and lithics. The locations of hunting related temporary habitation sites are heavily influenced by landforms that also attract animals (e.g. water features) or that offer a commanding view of areas where animals are likely to congregate (e.g. elevated lookouts). Foraging related temporary habitation sites will be focused on areas that support commonly foraged resources such as berries. The exact criteria for these sites will vary depending on the resource being foraged. Ceremonial sites will not necessarily be connected to any specific type of resource, but are often found in difficult to reach places such as high elevation ridges and plateaus. One final area of potential for temporary habitation sites is along travel corridors such as trails. Typically, if found along a travel corridor, these sites will also be associated with some other noteworthy geographic feature such as a lookout or clearing (anything to make the area stand out relative to its surroundings).

3.2.2.3 Quarry Sites

These sites are found in areas where natural stone was quarried for the fabrication of stone tools. Desirable qualities in raw material types for stone tool manufacture include conchoidal fracture properties and low occurrences of internal flaws and inclusions. Such materials are typically found in a number of contexts including natural veins in bedrock, volcanic formations, or in secondary deposits (e.g. riverbeds).

3.2.2.4 Rock Art Sites

Rock art is man-made markings or etchings/peckings on natural stone surfaces. Rock art tends to be located along major watercourses, trails, or at boundaries of traditional territories.

3.2.2.5 Fishing Sites

Fishing sites typically include fish weirs or natural narrowing of major rivers and streams where fish could be caught more easily. Some potential also exists in lakes, but most lakes in the study area are not associated with waterways that are utilized by high yield fish resources such as salmon.

3.2.2.6 Human Remains

Unexpected human remains are rarely encountered during heritage resource studies, however the potential for their presence always exists, especially in areas where higher densities of people are known to have congregated in the past. Prior to the influence of Christian missionaries, First Nations people would often place graves and spirit houses on prominent points or terraces near village/camp sites, or on low, level ground near trails. Once Christian practices became commonplace, graveyard burials became the norm for most people.

3.2.2.7 Culturally Modified Trees

Culturally modified trees (CMTs) are trees that have been altered by humans for a variety of purposes including cambium, sap, kindling, and/or bark collection, marking trails (blazes), and communicating messages. Most documented CMTs in the Yukon are pine trees, however certain types of CMT, such blazes, trap trees, and Historic trail markers may be found in stands of spruce and/or aspen.

3.2.2.8 Trails

Trails are pedestrian travel routes that may be marked by a well-worn trail bed, blazed trees and/or other CMT types, and/or cairns. Trails are often associated with natural corridors such as rivers and elevated ridges.

3.2.2.9 Historic Sites

European trading began in the region in the 1840s, and it is likely that Europeans stuck closer to their trading routes (rivers and trails), relying on First Nations to procure items from further away. Gold prospectors have worked within the study area, but their presence would likely post-date AD 1860. As such, Historic Period sites are expected to be most frequently encountered along documented travel corridors and settlement sites. This however, does not preclude the possibility of encountering isolated Historic Period materials associated with early European trapping and prospecting activities. Moreover, artifacts of European origin could have been traded to First Nations persons then transported to locations generally considered to be more indicative of Precontact sites.

3.2.2.10 Isolated Finds

Isolated finds are small scale archaeological sites, typically of a single artifact. Due to the scale of these sites, they offer little behavioural insight into the people who created them, but they do document human use of the land in the past.

3.2.2.11 Palaeontological Sites

Pre-Pleistocene palaeontological remains are typically found in areas with sedimentary bedrock exposures. Late Pleistocene and Holocene palaeontological remains may be found in areas with placer deposits and/or permafrost exposures.

3.3 Heritage Site Inventory Search Updates

To ensure all documented heritage resource sites within the study area are known, new heritage site inventory search requests were submitted to the Yukon Government Heritage Resource Unit.

These searches focused on a 100 m buffer zone on either side of the proposed fibre optic cable alignment and included both the archaeological site inventory and Yukon Historic Site Inventory (YHSI) listings. Staff at the archaeology branch of the Yukon Government Heritage Resource Unit also included several sites that are located outside of the 100 m buffer search area, but are located upon landforms that extend into the search area. Summaries of these sites are provided in Appendix C.

4.0 ANALYSIS OF STUDY AREA

4.1 Environmental Setting

The Yukon portion of the study area is located within Boreal Cordillera and Taiga Cordillera Ecozones (see Smith et al. 2004 for full discussion). Within the Boreal Cordillera Ecozone, the study area crosses portions of two ecoregions: Klondike Plateau and Yukon Plateau – North. Within the Taiga Cordillera Ecozone, the study area crosses an additional four ecoregions: British-Richardson Mountains, Eagle Plains, Mackenzie Mountains, and North Ogilvie Mountains. Further detail regarding these ecoregions is presented below.

4.1.1 British-Richardson Mountains Ecoregion

The British-Richardson Mountains Ecoregion is characterized by steep, V-shaped valleys in the higher ranges and gently sloping pediments where the valleys are broader (Smith et al. 2004). It includes the British, Barn, and Richardson mountain ranges (Rampton 1982). Collectively, these mountain ranges are often referred to as the Arctic Mountains or Ranges (Bostock 1948; Hughes 1987). These mountains have remained largely unglaciated throughout the Quaternary Period, with the exception of minor alpine glaciation in the British Mountains and on the eastern flank of the Richardson Mountains (Smith et al. 2004). Elevation ranges from 40-1610 m a.s.l. Several large rivers flow through the British-Richardson Mountains Ecoregion, including the Malcolm, Firth, Babbage, Blow and Big Fish Rivers which drain the northern portion northward into the Beaufort Sea and the Porcupine, Bell and Eagle Rivers which drain more southerly lands into the Peel River watershed (Smith et al. 2004).

Due to the latitude, the sun remains above the horizon from early June to mid-July, and below the horizon from early December to early January. Mean annual temperatures in the British-Richardson Mountains Ecoregion are near -7.5°C (Smith et al. 2004). In January, mean temperatures typically range from -20 to -25°C, but can climb to -5°C or drop to -40°C, particularly in the lower valley floors (Smith et al. 2004). Mean summer temperatures reach 10°C in July, but can vary from near freezing to 25°C (Smith et al. 2004). Spring or summer conditions are generally delayed until early June. Precipitation is relatively moderate, ranging from 250 to 400 mm annually (Smith et al. 2004). The heaviest precipitation is from June through August over the Richardson Mountains. Precipitation remains moderate through to December, and falls mainly as snow from September onwards.

The bedrock geology of this ecoregion largely consists of well-exposed sedimentary rocks, including sandstones, limestones, and shales, of Proterozoic to Cretaceous age and small Devonian granite intrusions (Smith et al. 2004). Three distinct geological structures are spanned by the British-Richardson Mountains Ecoregion: the British and Barn mountains consist of continental margin sediments and are part of the Arctic–Alaska Terrane (Wheeler and McFeely 1991), the region east of the mountains consists of a mid-Cretaceous extension basin called the Blow Trough (Smith et al. 2004), and the Richardson Mountains were formed when Paleozoic deep-water clastic sediments were uplifted by outward-verging thrust faults located at an interpreted westward-dipping crustal ramp (Lane 1996) in latest Cretaceous or early Tertiary time. Multiple mineral types have been identified within the ecoregion, including lazulite, phosphatic iron manganese, uranium, molybdenum, tungsten, copper, magnetite, gypsum, and gold (Smith et al. 2004). Sedimentary rocks, such as chert and siltstone, with potential value as raw materials for stone tool production are also reported (Smith et al. 2004).

Surficial geology here is characterized by high relief created by frost action, mass wasting, and weathering of the areas unglaciated sedimentary bedrock (Smith et al. 2004). Tors, pinnacles, and dyke-like ridges are common features at high elevations. Middle and low elevation areas are typically covered by residual or weathered rock, or by soliflucted and colluvial materials which form fans and long, gentle pediment slopes. Modern processes affecting the surficial geology of the British-Richardson Mountains Ecoregion include colluviation, solifluction, and sheetwash (Smith et al. 2004). Soil formation has been heavily influenced by the available surficial geologic parent materials, as well as the subarctic climate and high relief of the ecoregion. Near surface permafrost is nearly continuous throughout the ecoregion except for localized occurrences of unfrozen ground along alluvial systems, glacio-fluvial terraces, and some well-drained south-facing slope deposits (Smith et al. 2004). Published data on permafrost thickness in this ecoregion is not available, but data from neighbouring areas suggest depths of 200 to 300 m (Burgess et al. 1982). The active permafrost layer is typically less than 0.5 m deep on pediments and lower slopes, but has been reported to reach 2.5 m at favourable well-drained upland sites (Rampton 1982).

As noted above, much of the British-Richardson Mountains Ecoregion remained unglaciated throughout the Pleistocene glaciations. Exceptions to these glacier free conditions are found in some high alpine areas (Smith et al. 2004), at the headwater of Malcolm River in the British Mountains (Duk-Rodkin et al. 2004), and east of Bell River in an unnamed peak in the Richardson Mountains (Duk-Rodkin and Hughes 1992). At its maximum extent, the Laurentide Ice Sheet extended up to 970 m a.s.l. in the southern Richardson Mountains, descending to 880 m a.s.l. in McDougall Pass (Smith et al. 2004).

Vegetation in the British-Richardson Mountains Ecoregion is largely dominated by shrub tundra with trees being limited to river valleys such as the Firth, Big Fish, Bell, and lower slopes with favourable aspects (Smith et al. 2004). The tree line ranges from 300 m a.s.l. in the northern part of the ecoregion to 600 m a.s.l. in the south (Zoltai and Pettapiece 1973; Ritchie 1984; Loewen and Staniforth 1997). On mountain and ridge crests, ranging from 330 to 1,600 m a.s.l., the vegetation is dependent on the soil parent material. A sparse cover of shrub willow, arctic bearberry, dryas, locoweed, and shrub birch is typical in shale and sandstone areas, but often occurs on only 10 to 20% of the ground surface (Ritchie 1984; Loewen and Staniforth 1997). Areas with calcareous soil parent materials a sparse, but floristically rich, dryas–sedge alpine community is typical with numerous forbs, including moss campion, northern sweet-vetch and anemone, and ground shrubs (Ritchie 1984). Tamarack and white spruce is sometimes found near the treeline on moist calcareous soils in the Richardson Mountains (Smith et al. 2004). Lower slopes often hold willow, shrub birch, alder, and ericaceous shrubs including mountain heather, blueberry, lingonberry, mosses, and forbs (Kennedy 1990; Smith et al. 2004). Pediments on the lower slopes tend toward sedge tussock communities, with Cottongrass, sedges, shrub birch, Labrador tea, blueberry, lingonberry, and mosses (Smith et al. 2004). The sheltered environments created by major river valleys can support white spruce, and recently affected floodplains can contain Balsam poplar (Smith et al. 2004).

Wildlife in the British-Richardson Mountains Ecoregion includes a number of large mammal species. It includes the primary Canadian calving area of the Porcupine barren-ground caribou herd (Fancy et al. 1994). Other large mammals include Dall sheep, moose, grizzly bear, and wolverine, with small mammals typically represented by singing vole and varying lemming (Smith et al. 2004). A wide variety of birds can also be found, including Surfbird, Baird's Sandpipers, Hoary Redpolls, Horned Larks, Northern Wheatears, and Gray-Crowned Rosy Finch (Frisch 1975, 1987; Godfrey 1986) in the largely barren uplands, Rock Ptarmigan, American Golden-Plover, Whimbrel, Long-tailed Jaeger, and American Pipit in the sedge tussock tundra (Frisch 1975, 1987; Weerstra 1997), Willow Ptarmigan, Northern Shrike, American Tree, Savannah and White-crowned Sparrows, Smith's Longspur and Common Redpoll in lower elevation shrubby tundra (Godfrey 1986; Frisch 1987; Weerstra 1997), Upland Sandpipers in sparsely treed subalpine bogs (Frisch 1987), and Gray Jay, Townsend's Solitaire, Gray-cheeked Thrush, American Robin, Yellow-rumped Warbler and Fox Sparrow, Gray-Headed Chickadee, and Common Raven in more heavily forested areas (Frisch 1987; Weerstra 1997; Sinclair et al. 2003). Rough-legged Hawk, Golden Eagle, Peregrine Falcon, Gyrfalcon and Say's Phoebe breed along the cliffs, banks, and canyon walls of the Firth River (Theberge et al. 1979; Canadian Wildlife Service 1995) and numerous water birds, including Harlequin Duck, Wandering Tattler, Loon, Tundra Swan, Northern Pintail, Long-tailed Duck, and Rednecked Phalarope (Frisch 1987; Godfrey 1986) exploit the ecoregion's streams and rivers.

4.1.2 Eagle Plains Ecoregion

The Eagle Plains Ecoregion is characterized as is an intermontane basin of modest relief between the Richardson Mountains to the east and the North Ogilvie Mountains to the west (Smith et al. 2004). It includes the Eagle Lowland as defined by Matthews (1986), or part of the Porcupine Plateau and Porcupine Plain as defined by Bostock (1948) and Hughes (1987). The majority of the rolling low-relief terrain falls between 300 and 600 m a.s.l. (Oswald and Senyk 1977), although some mountainous areas reach as high as 1000 m a.s.l. and some river valleys as low as 250 m a.s.l. (Smith et al. 2004). The majority of the ecoregion drains to the north through the Whitestone, Porcupine, and Eagle River systems to eventually end up in the Yukon River watershed with the exception of the southeast corner which drains east via the Ogilvie, Peel, and Wind rivers to the Mackenzie River (Smith et al. 2004). Lakes are relatively rare in the Eagle Plains Ecoregion, but some oxbow and thermokarstic lakes are located within the floodplains of the Whitestone, Porcupine, and Eagle Rivers (Smith et al. 2004).

Due to its latitude, the Eagle Plains Ecoregion does experience periods of continuous daylight and darkness, however these periods are brief. Mean annual temperatures are near –7.5°C, but the area exhibits strong seasonal temperature variation (Smith et al. 2004). In January, average temperatures typically range from -31°C in lower valleys to -25°C at higher elevations (Smith et al. 2004). Summer temperatures are less affected by elevation, and average 13°C (Smith et al. 2004). Recorded extreme temperatures range from -60°C during winter to 30°C in summer (Smith et al. 2004). Precipitation is relatively moderate, with an annual average of 400 mm annually (Smith et al. 2004). The majority of this precipitation falls as rain during the summer months, primarily in showers, with the period between September and April being the driest part of the year (Smith et al. 2004).

The ecoregion's bedrock geology is characterized by Devonian through Cretaceous sedimentary rocks, including sandstones, siltstones, limestones, and shales, representing an intermontane basin sandwiched between the uplifted Richardson, North Ogilvie, and Dave Lord Mountain ranges (Smith et al. 2004). Lands within this ecoregion are not known for metallic minerals or significant coal deposits, but it does contain proven hydrocarbon reserves. Three of 11 test wells drilled before an exploration moratorium in 1968 intersected porous Carboniferous and Permian sandstone in the Chance and Dagleish anticlines in the southern and southeastern part of the ecoregion are estimated to contain 2.8 x 10^9 m^3 of gas and 3.1 x 10^6 m^3 of oil (T. Bird, in Hamblin 1990).

Surficial geology is characterized by colluvial deposits throughout most of the ecoregion, with the remainder consisting of alluvial sediments along river systems and a few glaciofluvial and glaciolacustrine deposits associated with meltwater generated by glacial activity outside the ecoregion (Smith et al. 2004). Modern processes affecting the surficial geology include thermokarst subsidence and soil creep, cryoturbation, solifluction, and active layer detachment slides on shale (Smith et al. 2004). Permafrost is discontinuous, but can be up to 200 m thick in places, with taliks focused in major river valleys (Thomas and Rampton 1982).

The majority of the Eagle Plains Ecoregion is composed of unglaciated terrain with some exceptions to this trend in parts of the Nahoni Range where there is scattered evidence of a past local glaciation of undetermined age (Smith et al. 2004). However, glacial processes in neighbouring ecoregions have influenced the major rivers in Eagle Plains, with up to three levels of glacially controlled terraces present along some drainages (Thomas and Rampton 1982). Major meltwater outlets exited the eastern slopes of the North Ogilvie Mountains and the northern slopes of the South Ogilvie Mountains via Ogilvie, Miner, Whitestone, Blackstone, and Hart Rivers channels (Smith et al. 2004). Moreover, during the Late Wisconsinan glacial maximum (ca. 30 ka; Hughes et al. 1981; Schweger and Matthews 1991) the Laurentide Ice Sheet blocked drainage of the Peel River and its southern tributaries forming Glacial Lake Hughes, which diverted the drainage northward through the Eagle River discharge channel (Duk-Rodkin and Hughes 1995). Glacial Lake Hughes received all the water exiting the Mackenzie and Wernecke mountains and the Ogilvie, Blackstone, and Hart river basins. Consequently, the Eagle and Porcupine rivers were the two major contributors to the inundation of the Old Crow, Bluefish, and Bell basins (Smith et al. 2004).

In terms of vegetation, black spruce-tussock/shrub tundra with understories including shrub birch, Cottongrass tussocks, bog cranberry, cloudberry, Labrador tea, crowberry, lingonberry, spirea, lichen, and moss is typical on the lower slopes (Zoltai and Pettapiece 1973). Upland areas are dominated by black and white spruce woodlands with understories of Labrador tea, shrub birch, willows, alder, blueberry, rose, lowbush cranberry, spirea, moss, and lichen (Smith et al. 2004). Here white spruce is most common in better drained areas (Russell et al. 1992; D. W. Murray 1997). Forest fires are a significant factor in these wooded areas. Pioneer species important in recolonizing burn areas include paper birch, aspen, and balsam poplar (Zoltai and Pettapiece 1973). The highest elevation in the Eagle Plains Ecoregion, above approximately 800 m a.s.l., are typified by shrub tundra dominated by scrub birch, willow, and prostrate shrubs with some Cottongrass tussocks (Smith et al. 2004).

Mammalian biodiversity is relatively low in the Eagle Plains Ecoregion compared to other Taiga Cordillera ecoregions due to a lack of suitable habitats for many of the rodent and ungulate species found elsewhere (Smith et al. 2004). However, representative species present do include several predators including wolf, wolverine, grizzly and black bear, marten, ermine, and red fox (Smith et al. 2004). Barren-ground caribou of the Porcupine herd also utilize this area primarily in the fall and winter, and several species of vole can be found (Smith et al. 2004). Bird populations are more diverse, with riverine areas providing habitats for Common Merganser, Spotted Sandpiper, Herring and Mew Gulls, Bald Eagle, Belted Kingfisher, and Bank and Cliff Swallow colonies, as well as key nesting habitat for Peregrine Falcon along the Porcupine and Eagle rivers (Hayes and Mossop 1978; Frisch 1987; Peepre and Associates 1993). Wetland areas are inhabited by small numbers of Pacific and Red-throated Loons, Tundra Swan, Greater White-fronted Goose, Canada Goose, American Widgeon, Green-winged Teal, Bufflehead, Lesser Yellowlegs, Solitary Sandpiper, and Common Snipe (McKelvey 1977; Frisch 1987). Swift mountain streams support breeding populations of Harlequin Duck and American Dipper, while riparian thickets provide breeding habitat for Willow Ptarmigan, Alder Flycatcher, Yellow Warbler, Wilson's Warbler, American Tree Sparrow, and Lincoln's Sparrow (Frisch 1987). Upland forests provide year round homes for Northern Goshawk, Spruce Grouse, Northern Hawk Owl, Three-toed Woodpecker, Gray Jay, Common Raven, Boreal Chickadee, Pine Grosbeak, Whitewinged Crossbill, and Common Redpoll (Frisch 1987). Other species, such as Gyrfalcon and Willow Ptarmigan, migrate to these forests to winter, while other, including Swainson's, Gray-cheeked, and Varied Thrushes, Bohemian Waxwing, Yellow-rumped and Blackpoll Warblers, and Dark-eyed Junco migrate north each spring to breed in these forests (Frisch 1987). High elevation alpine tundra areas support low numbers of Golden Eagle and Rock Ptarmigan, and may be used in summer by small numbers of Horned Lark, American Pipit, and Gray-crowned Rosy Finch (Frisch 1987). Upland Sandpiper and Townsend's Solitaire breed in the subalpine zone (Frisch 1987).

4.1.3. Klondike Plateau Ecoregion

The Klondike Plateau Ecoregion is characterized by smooth topped ridges with some outcrops of exposed rock known as Tors. These ridges are dissected by deep, narrow, V-shaped valleys (Smith et al. 2004). Its boundary conforms fairly well to the Klondike Plateau physiographic subdivision of the Yukon Plateau (Bostock 1948; Matthew 1986), although north of the Willow Hills it does not extend as far eastward. Elevation ranges from approximately 290 m a.s.l. to over 2,000 m a.s.l. with its highest point at the summit of Apex Mountain at 2,026 m a.s.l. (Smith et al. 2004). Most ridges peak at 1,200 to 1,700 m asl, with local relief ranging from 450 to 700 m a.s.l. (Smith et al. 2004). Unlike other ecoregions in the area, this plateau has not been glaciated in the recent past (Smith et al. 2004). The Dawson Range is the most distinct topographic feature within this ecoregion. It also contains the Wellesley Depression in the southwest and part of the Tintina Trench. Several major rivers drain the Klondike Plateau Ecoregion, including Yukon, Klondike, Stewart, Pelly, Fortymile, Nisling, Donjek, White Rivers.

The climate in the Klondike Plateau has a strong seasonal variation. Mean annual temperatures are -5°C, but it is also home to the coldest recorded temperature in North America at -62.8°C (Smith et al. 2004). Mean temperatures for January are -23 to -32°C, and in July from 10 to 15°C (Smith et al. 2004). Precipitation is moderate with annual amounts of 300 to 500 cm, with generally higher levels in the southeast compared to the northwest (Smith et al. 2004). The winter months have mean amounts of 10 to 20 mm while the summer months can expect rainfall amounts of 50 to 90 mm (Smith et al. 2004). The heaviest precipitation originates from rain showers and thunderstorms in the summer months. Paleoclimate reconstruction from the southern Yukon indicates higher temperatures and/or drier conditions from 6,700 to 4,700 before present (BP), followed by a long period of reduced temperatures and/or increased precipitation (Farnell et al. 2000). A warm period is speculated from 1,440 years before present (BP) to 1,030 BP, followed by the colder temperatures of the Little Ice Age.

The ecoregion's bedrock geology constitutes a large part of the Yukon–Tanana Terrane, a composite of crust blocks that include former volcanic island arc and continental shelf depositional environments (Mortensen 1992). These metasedimentary rocks are intruded and overlapped by granitic and volcanic rocks, and overlain by fault-bounded slices of serpentinized ultramafic rock of the Slide Mountain Terrane (Smith et al. 2004). This base has been exposed and weathered for at least 15 million years, resulting in the creation of tors atop broad ridges mantled with fields of large angular, frost-heaved rock fragments (Smith et al. 2004). Volcanic processes have also contributed to the Klondike Plateau bedrock geology. The gold that the Klondike is famous for largely originates from quartz veins (Knight et al. 1994) that have been eroded and the gold concentrated by pre-Ice Age rivers (>3 Ma) in placer deposits. The principal formation containing placer gold is the White Channel gravel, but a few bedrock gold veins have also been documented in the ecoregion (Mortensen et al. 1992). This bedrock bound gold and the placer gold deposits are actively sought by the mining industry. Copper and chrysotile asbestos have also been the focus of mining efforts in the Klondike (Smith et al. 2004).

Surface cover is dominated by colluvium, with alluvium and glacial outwash terraces found along major river systems (Smith et al. 2004). Colluvial sediments in the lower valleys tend to be thick, silty, and often capped with peat or mud whereas upland colluvium tends to be rubble from degraded bedrock (Smith et al. 2004). Aeolian silts are also common at the surface in many areas, and periglacial features, such as cryoplanation terraces, patterned ground and solifluction lobes, can be found at higher elevations (Smith et al. 2004).

The modern Klondike Plateau Ecoregion is largely unglaciated, with the exception of localized glaciers that originating from the headwaters of the Sixtymile River Valley, and local peaks in the eastern Dawson Range and Kluane Ranges into the Wellesley Basin (Smith et al. 2004). However, the topography and hydrology have been impacted by glacial processes in the past, including the formation/disappearance and resulting outwash of Glacial Lake Yukon >3 Ma and Glacial Lake Dawson during the Reid Glaciation (Smith et al. 2004). The McConnell Glaciation was restricted to mountain valleys beyond this ecoregion, but outwash from affected areas did flow through the Klondike Plateau Ecoregion and related deposits are found in the lower Klondike River Valley (Smith et al. 2004).

The flora of the Klondike Plateau ranges from boreal forest in the valleys and low slopes, to alpine and tundra on the ridge crests. Black and white spruce forests dominate this ecoregion, in both pure and mixed stands (Smith et al. 2004). Other tree types include balsam poplar, paper birch, pine, water birch, and trembling aspen. Foliose lichens, Reindeer lichen, black spruce sphagnum, and feathermoss dominate the ground layer while shrub birch, willow, Labrador tea, alder, alpine blueberry, and ericaceous ground shrubs dominating the shrub layer. The highest frequency of lightning strikes in the Yukon occurs in this ecoregion. Forest stands are often taken by fire disturbance, with young immature stands more common than mature stands over much of the ecoregion (Smith et al. 2004).

The wildlife in the area contains barren-ground and woodland caribou (namely the Fortymile Caribou herd). Other mammals native to the area include moose, black bear, grizzly bear, wolf, mule deer, lynx, wolverine, marten, woodchuck, and snowshoe hare (Smith et al. 2004). This ecoregion was historically one of the more biologically productive in the Yukon. The Fortymile caribou herd was estimated at having been as large as 500,000 in the mid-19th century and ranged from Fairbanks, AK to Whitehorse, YT. However, in 2001 the herd was estimated at only 40,000 individuals. Many factors have contributed to this decline, including wildfires, overharvesting, and food limitations. A management plan has been put into place in an attempt to rebuild the herd and restore the once highly active biological productive ecoregion.

4.1.4 Mackenzie Mountains Ecoregion

The Mackenzie Mountains Ecoregion is characterized by broad u-shaped valleys and bare mountain ridges (Smith et al. 2004). It includes the portions of the Mackenzie Mountains, including the Bonnet Plume Range and the Knorr Range in northeastern Yukon, and the northern portions of the Backbone and Canyon ranges, as well as the South Ogilvie and Wernecke mountains (Matthews 1986; Smith et al. 2004). Terrain ranges from 400 m a.s.l. to 2,750 m a.s.l. in elevation with the majority falling between 750 and 1,500 m a.s.l. (Smith et al. 2004). Mount McDonald is the highest of the mountains within the ecoregion. The mountain ranges here form part of the Mackenzie–Yukon hydrologic divide. Major rivers in the northern part of the ecoregion, including the Ogilvie, Blackstone, Hart, Wind, Bonnet Plume, and Snake, drain north into the Mackenzie River and Beaufort Sea (Smith et al. 2004). In the southern part of the ecoregion the Stewart, Nadaleen, McQuesten, and Klondike Rivers flow to the Yukon River and Bering Sea (Smith et al. 2004). Lakes are uncommon, and tend to be small where they do occur.

Mean annual temperatures in the Mackenzie Mountains Ecoregion are near –6°C. Seasonal variability is less extreme than in many other ecoregions in the Yukon. In January, average temperatures fall around -25°C while July temperatures average 8°C (Smith et al. 2004). Recorded extreme temperatures range from -50°C during winter to 30°C in summer on the valley floors, but only range from -35°C to 15°C at higher elevations (Smith et al. 2004). Frost and/or thawing temperatures can occur year round in the ecoregion. Precipitation is relatively heavy with 450 mm to 600 mm annually with July and August being the wettest months and the period between December and May being the driest (Smith et al. 2004). Snow is possible year round.

In terms of bedrock geology, the entire ecoregion lies within the Cordilleran Foreland Fold and Thrust Belt (Gabrielse and Yorath 1991). Sedimentary carbonate rocks form as steep and rugged ridges, with clear mountain-scale folds, while recessive siltstone, shale, and major faults underlie the intervening valleys (Smith et al. 2004). The oldest of these rocks date to as long as 1.6 billion years ago, forming in the Early Proterozoic (Smith et al. 2004). These oldest rocks are overlain in places by somewhat younger rocks (Late Proterozoic ~750 Ma to 600 Ma) belonging to the Wernecke Supergroup (Delaney 1981), the Mackenzie Mountain Supergroup (Smith et al. 2004), the Fifteenmile Group (Thompson 1995), and Pinguicula Group (Thorkelson and Wallace 1995), then even younger materials of Upper Paleozoic through Jurassic age (Smith el al. 2004). A multitude of metallic minerals are known in the Mackenzie Mountains Ecoregion, including uraniferous mineral brannerite, abundant iron as hematite, copper, barium, cobalt, lead, zinc, lead, nickel, platinum, arsenic, uranium, and gold (Archer and Schmidt 1978; Turner and Abbott 1990; Bremner 1994; Smith et al. 2004). Coal seams are also common in the northeast and northwest portions of the ecoregion (Smith et al. 2004).

Colluvial deposits related to long exposed and weathered surfaces dominate the majority of the surficial geology of the Mackenzie Mountains Ecoregion with approximately 70% coverage (Smith et al. 2004). Glacial deposits, primarily within glaciated valleys, cover an additional 25%, with the remaining 5% being organic, alluvial, and lacustrine deposits (Smith et al. 2004). Modern processes affecting the surficial geology include landslides, rotational slumps, rock fall, and debris flows in areas of exposed rock, solifluction and soil creep in permafrost areas, and active rock glaciers (Smith et al. 2004). The southern boundary of the continuous permafrost zone runs through this ecoregion, with some thawed areas resulting in thermokarstic lakes (Smith et al. 2004).

Several pre-Reid glaciations recorded within the Mackenzie Mountains Ecoregion in the Tintina Trench and along the northern slopes of the South Ogilvie Mountains (Duk-Rodkin 1996). Further evidence from younger glaciations, the Reid (ca. 200 ka) and the McConnell (ca. 23 ka), can be found in most mountain valleys (Duk-Rodkin 1996; Kennedy and Smith 1999). The Wernecke Mountains portion of the ecoregion was largely covered by the Cordilleran Ice Sheet that merged with local glaciers from the South Ogilvie Mountains (Smith et al. 2004). The Snake and Bonnet Plume river valleys, in the northern part of the ecoregion, were affected by the Late Wisconsinan Laurentide Ice Sheet (ca. 30 ka; Hughes et al. 1981; Schweger and Matthews 1991), which blocked the drainage of all streams in the Mackenzie and Wernecke mountains, creating a meltwater channel system that exited through a meltwater channel connecting the Arctic Red, Snake, and Bonnet Plume Rivers and the Bonnet Plume Depression, and drained into Glacial Lake Hughes (Duk-Rodkin and Hughes 1995).

Vegetation within the Mackenzie Mountains Ecoregion generally consists of alpine tundra at higher elevations with valleys of taiga forest (Smith et al. 2004). The treeline sits at approximately 1,200 m a.s.l. (Smith et al. 2004). Areas above 1,500 m a.s.l. are typically bare rock or rubble with lichens and sparse forbs, graminoids, and bryophytes in sheltered pockets (Kennedy and Smith 1999). Some gentler high elevation slopes may also include dwarf willow and ericaceous shrubs (Jingfors and McKenna 1991). Mid-elevation mountain slopes and subalpine river valley terraces are dominated by shrub birch-willow communities (Russell et al. 1992; MacHutcheon 1997; Kennedy and Smith 1999), with understories of net-veined willow, lowbush cranberry, Labrador tea and lichen in drier areas and moss, lichen, and commonly bearberry, lowbush cranberry, alpine blueberry, cloudberry, and sometimes horsetail in wetter areas (Smith et al. 2004). At low elevations, stands of black and white spruce or mixed stands of spruce, aspen, paper birch and balsam poplar are common, with understories including Labrador tea, willow, rose, soapberry and alpine blueberry, horsetail, lupine, and bear root (LGL 1981; Stanek et al. 1981; Kennedy 1992; MacHutcheon 1997). Lodgepole pine and subalpine fir are largely absent from the ecoregion (Smith et al. 2004).

A number of large mammals populate the Mackenzie Mountains Ecoregion, including grizzly bear, wolverine, Dall sheep, and Stone sheep (Barichello et al. 1989; Smith et al. 2004). Woodland caribou of the Bonnet Plume, Hart River, and Redstone herds. The Bonnet Plume herd (n=~5,000 individuals) and the Redstone herd (n=~10,000 individuals) are among the largest woodland caribou herds in the Yukon (Smith et al. 2004). Smaller mammals include collared pika, singing vole, and Ogilvie Mountains lemming, deer mouse, least chipmunk, and hoary marmot (Smith et al. 2004). Bird populations in higher elevations include a wide range of species such as Townsend's Solitaire, Willow Ptarmigan, Northern Shrike, Wilson's Warbler, American Tree, White-crowned, Golden-Crowned Sparrows, Rock Ptarmigan, White-tailed Ptarmigan, Northern Wheatear, Gray-crowned Rosy Finch, Horned Lark, Surfbird, Short-eared Owl, American Pipit, Golden Eagle, and Gyrfalcon (W. H. Osgood 1909; Frisch 1975, 1987; Sinclair 1995, 1996; Canadian Wildlife Service 1995). Lower elevation forests provide homes for Merlin, Northern Flicker, Swainson's Thrush, Yellow-rumped Warbler, Blackpoll Warbler, Dark-eyed Junco, Peregrine Falcon, Northern Goshawk, Northern Hawk Owl, Three-toed Woodpecker, Gray Jay, Common Raven, and Boreal Chickadee (W. H. Osgood, 1909; Frisch, 1975, 1987; Canadian Wildlife Service 1995). Although waterbird populations are low due to limited suitable habitat, Harlequin Duck, Wandering Tattler, American Dipper, Trumpeter Swans, Mew Gull, Belted Kingfisher, and Solitary and Spotted Sandpipers (W. H. Osgood 1909; Frisch 1987, McKelvey and Hawkings 1990) can be found within the Mackenzie Mountains Ecoregion. And finally, riparian thickets support several species of songbird including Alder Flycatcher, Orange-crowned Warbler, Yellow Warbler, Northern Waterthrush, Savannah Sparrow, and Lincoln's Sparrow (Frisch 1987).

4.1.5 North Ogilvie Mountains Ecoregion

The North Ogilvie Mountains Ecoregion is characterized by low relief mountains with strata of light grey limestone and dolostone, unvegetated summits, and cliff bands (Smith et al. 2004). It includes North Ogilvie physiographic region, the Keele Range, part of the Dave Lord Range, and the Central Ogilvie Mountains (Smith et al. 2004). Terrain ranges from 280 m a.s.l. to 1,860 m a.s.l. (Smith et al. 2004), with the northern portion consisting primarily of flat-topped hills and eroded remnants of a former plain (Oswald and Senyk 1977) whereas the southern portion holds higher mountains with deep cut valleys providing as much as 1,200 m of topographic relief (Smith et al. 2004). Rivers within the ecoregion include the Ogilvie, Blackstone, Hart, Whitestone, Miner, Fishing Branch, and Bluefish Rivers. Lakes and wetlands are rare (Smith et al. 2004).

Mean annual temperatures in the North Ogilvie Mountains Ecoregion range from -7°C to -10°C (Smith et al. 2004). Seasonal variability is considerable due to the elevation. Winters last from October to May, with January mean temperatures of -30°C and extremes of -50°C to -60°C and rare warm winds that can bring temperatures above freezing (Smith et al. 2004). At high elevations, winter temperatures are often 10° higher than in lower valleys (Smith et al. 2004). Summers are brief, with average July temperatures of 12°C in low valleys and 6°C at higher elevations (Smith et al. 2004). Summer extremes can reach 30°C, but frost can occur at any time. Precipitation is relatively moderate, with an annual ranging from 300 mm to 450 mm (Smith et al. 2004). June through August is the wettest period with 40 mm to 60 mm per month typically as showers or thunderstorms with February to May being the driest (Smith et al. 2004). Snow is the main form of precipitation from September to May (Smith et al. 2004).

The bedrock geology of the North Ogilvie Mountains consists almost entirely of sedimentary rocks with no known granitic rocks (Smith et al. 2004). It incorporates the Keele Range and the Taiga–Nahoni Fold Belt, which extends through the Nahoni Range and the North Ogilvie Mountains (Smith et al. 2004). The oldest exposed rock includes calcareous shale, quartzite, red and green siltstone, and thin-bedded dolostone that resembles other successions of the Late Proterozoic-to-Cambrian Windermere Supergroup (Smith et al. 2004). This material is overlain in places by Devonian formations of limestone, mudstone, siltstone, and sandstone, with notable shell and conglomerate beds (Norris 1997), Jurassic siltstone with softer shale and harder sandstone intervals, and Early Cretaceous sandstone and quartzite (Smith et al. 2004). At least six classes of mineral deposits are known in the North Ogilvie Mountains Ecoregion. Known minerals include galena, sphalerite, oolitic magnetite, banded iron, copper, cobalt, arsenide, silver, copper, and zinc (Smith et al. 2004). Coal seams are present in the Cretaceous Kamik Formation (Smith et al. 2004).

Bedrock exposures account for roughly 20% of this ecoregion's surficial geology, with many tors at summits and mid- to high-elevation slopes formed from eroded shales, sandstones, and dolomites (Smith et al. 2004). Approximately another 30% of the surface is covered by colluvium on pediments and other eroded slopes, with gentler slopes frequently overlain with loess and/or silty colluvium and capped with organic material (Smith et al. 2004). Glacial deposits, including till and glaciofluvial outwash, account for an additional 35% of the ecoregion (Smith et al. 2004). The remainder, often represented by low-lying valley bottoms, is characterized by earth hummocks and tussock fields (Smith et al. 2004). Modern processes affecting the surficial geology are typically associated with landslides, rockslides, debris flows, and periglacial processes such as soil creep, solifluction, and active layer detachment slides (Smith et al. 2004).

The North Ogilvie Mountains Ecoregion contains glaciated terrain in some areas, but has been largely unglaciated for at least two million years (Smith et al. 2004). In pre-Reid glacial periods, a discontinuous ice-free corridor existed between extensive alpine glaciers that formed in the at high elevations, resulting in extensive pediments in unglaciated areas, and subdued highly colluvial moraines, drainage diversions, and outwash plains or terraces in once glaciated places (Smith et al. 2004). Similar features associated with the more recent Reid and McConnell Glaciations tend to be similar, but better defined (Smith et al. 2004). The unglaciated nature of most lands within the North Ogilvie Mountains Ecoregion has resulted in the development of largely continuous permafrost with an estimated depth of 300 m to 700 m (Smith et al. 2004). Paleomagnetic data from stalagmites in caves south of Old Crow suggests that this permafrost formed in the early Quaternary and has been present ever since (Lauriol et al. 1997).

The vegetation communities in the North Ogilvie Mountains Ecoregion are influenced by the high incidence of calcareous sedimentary bedrock, which fosters numerous calcium-loving plants; many of these are considered rare glacial relicts (Kennedy and Smith 1999). Alpine tundra vegetation dominates the higher elevations, while lower valleys are characterized by spruce taiga communities (Smith et al. 2004). The treeline sits at approximately 900 m a.s.l. (Oswald and Senyk 1977). Common plants in the sparsely vegetated higher areas include sedges and forbs, typically including *Dryas integrifolia*, *Saxifraga tricuspidata*, *Parrya nudicaulis*, and rare *Eritrichium aretioides* (Stanek et al. 1981; Brooke and Kojima 1985). Where the underlying bedrock is more acidic, willow-ground shrub-lichen communities predominate (Stanek 1980). Lower ridges are dominated by low shrub tundra with shrub birch, low willows, blueberry, and lichens, while shrub-tussock tundra is primary on pediment slopes with near-surface permafrost (Smith et al. 2004). Below the treeline, well drained south facing slopes support white spruce–shrub–forb communities while flatter, wetter, areas tend toward black spruce–shrub–sedge tussock communities (Smith et al. 2004). The most productive vegetation zones are found on alluvial terraces as well as some protected, well drained, permafrost-free sites that support white spruce–feathermoss forests with trees reaching 30 m in height and an understory including willow, alder, rose, and Labrador tea, shade feathermosses, ground shrubs, diverse forbs, and horsetail (Smith et al. 2004). Fluvial and frequently flooded areas are dominated by dense stands of balsam poplar and willow (Stanek et al. 1981; MacHutcheon 1997; Kennedy and Smith 1999).

Large mammals include grizzly bear, wolverine, Dall sheep, Stone sheep, and woodland caribou of the Hart River and Porcupine herds (Barichello et al. 1989; Smith et al. 2004). Small mammals, such as Ogilvie Mountains lemming and collared pika are also common (Smith et al. 2004). Riverine and wetlands areas support a wide range of birds, including Canada Goose, Red-breasted and Common Mergansers, Mew Gull, Harlequin Duck, Red-throated Loon, Long-tailed Duck, Horned Grebe, American Widgeon, Mallard, Northern Shoveler, Northern Pintail, Green-winged Teal, Greater, Lesser Scaup, Bufflehead, Barrow's Goldeneye, Bald Eagle, Northern Harrier, Lesser Yellowlegs, Least Sandpiper, Common Snipe, Yellow Warbler, Savannah Sparrow, and Rusty Blackbird (Williams 1925; McKelvey 1977; Frisch 1987). Spruce forest birds include Northern Flicker, Say's Phoebe, Ruby-crowned Kinglet, American Robin, Yellow-Rumped Warbler, Fox Sparrow, Dark-eyed Junco, Gray Jay, Common Raven, and Boreal Chickadee (Williams 1925; Frisch 1987). Bogs and willow thickets near the treeline host Upland Sandpiper and Orange-crowned and Wilson's Warblers, while Northern Shrike, and Townsend's Solitaire reside in the adjacent subalpine forests (Frisch 1975, 1987). Higher elevation upland willow, alder, and low shrub birch areas provide habitat for Willow Ptarmigan, American Tree Sparrow, Whitecrowned Sparrow, and Common Redpoll (Brown 1979; Frisch 1987). Alpine meadow avians include American Golden-Plover, Baird's Sandpiper, Long-tailed Jaeger, Short-Eared Owl, American Pipit, and Smith's Longspur, while more barren uplands host Horned Lark, Northern Wheatear, and Surfbirds (Frisch 1987). And finally, raptors nesting on cliffs and rocky outcrops include Golden Eagle, Peregrine Falcon, and Gyrfalcon (Frisch 1987; Canadian Wildlife Service 1995).

4.1.6 Yukon Plateau – North Ecoregion

The Yukon Plateau – North Ecoregion is the largest ecoregion entirely inside the Yukon and contains a large portion of the Tintina Trench. The ecoregion generally consists of relatively rolling highlands with an east-west orientation. It includes the Stewart Plateau, the Macmillan Highland, and the Ross Lowland (Matthews 1986). Terrain ranges from 320 m a.s.l. to 2,160 m a.s.l., with an average elevation of 995 m a.s.l. (Smith et al. 2004). Rivers within the ecoregion include the Pelly, Ross, Macmillan, Stewart, Hess, McQuesten and Klondike (Smith et al. 2004).

The mean annual temperature in the Yukon Plateau – North Ecoregion is near -5°C, but seasonal variability is pronounced (Smith et al. 2004). Mean temperatures for January range from below -30°C in the lower valleys to above -20°C in higher terrain (Smith et al. 2004). This is drastically different by July as mean temperatures in the lower valleys are 15°C and close to 8°C in higher terrain (Smith et al. 2004). Frost can occur at any time of the year, but is less likely from mid-June to late July (Smith et al. 2004). Precipitation is moderate with an increase in higher elevation sections in the eastern part of the ecozone. Annual precipitation ranges from 300 to 600 mm (Smith et al. 2004). The winter months have mean precipitation of 20 to 30 mm while the summer months can expect 40 to 80 mm of rainfall (Smith et al. 2004). Winds are generally light, however they may increase to moderate/high during unusually active weather systems or thunderstorms (Smith et al. 2004).

The bedrock geology of this ecoregion includes sections of two geological provinces of metamorphosed sedimentary rock. In the northern half of the ecoregion, variably deformed sedimentary rocks have been deposited on the outer continental shelf of ancestral North America, the Selwyn Basin. The bedrock geology in the southeast part of the ecoregion includes siliceous sedimentary and volcanic rocks of the Yukon-Tanana terrane and metabasaltic flows of the Slide Mountain terrane. The origin of these materials is not well-known due to deformation before and during transportation onto the Selwyn Basin strate (Smith et al. 2004). The southeast section of the ecoregion between Faro and Ross River also includes exposed river and stream cut banks along the Tintina Trench (a 450 km fault) that contains rhyolite and olivine basalt which may have provided materials for prehistoric stone tool making. Also of interest in the northern Anvil Range are jet-black or gun steel-blue weathering siliceous siltstone and conglomerate containing chert pebbles. These materials may also have been used for making stone tools.

Soils in the valleys of this ecoregion tend to be underlain by glacial parent materials. Soil development also reflects the presence of extensive discontinuous permafrost and a strong continental climate (Smith et al. 2004). Of interest is the presence of the Wounded Moose and the Diversion Creek palaeosols. These two palaeosols are buried soils formed a great deal of time before the current environmental conditions and may reflect past stable ground surfaces. The Wounded Moose palaeosol developed on glacial surfaces of pre-Reid age and the Diversion Creek palaeosol developed between the Reid and the McConnell glaciations. Both of these palaeosols would predate the known cultural history in the Yukon.

The glacial history of the Yukon Plateau – North Ecoregion was dominated by the actions of the Cordilleran ice sheet and local glaciers. More recent glaciations were less extensive. Most current glacial features are remnants from the McConnell glaciation (Smith et al. 2004), however some older features and glacial erratics are present from the older Reid and pre-Reid glaciations. Some uplands and valley floors were extensively eroded into "whalebacks" or rock drumlins by the glacial flow. The western edge of the ecoregion was approximately the terminus for the ice sheet of the McConnell glaciation. As the ice retreated through regional stagnation and wasting it left behind kame and kettle topography and glacial lake deposits in many valleys (Smith et al. 2004).

The vegetation of the Yukon Plateau – North ranges from boreal to alpine. Northern boreal forest exists at elevations up to 1500 m a.s.l. (Smith et al. 2004). Open black spruce with a moist moss, or drier lichen understory is the dominant forest type in the boreal zone (Smith et al. 2004). Shrub and lichen tundra dominate the higher elevations (Smith et al. 2004). The alpine vegetation is characterized by low ericaceous shrubs, prostrate willows, and lichens. In the subalpine areas, shrub birch, with scattered pine, white spruce, subalpine fir, and a lichen understory is extensive (Smith et al. 2004). Extensive shrub lands exist at mid-elevations and on valley bottoms that are subject to cold air drainage. Black spruce is the dominate tree type in the ecoregion, however white spruce, occasionally with aspen or lodgepole pine, occur in warmer, better-drained areas and in forest fire burn areas (Smith et al. 2004).

The Yukon Plateau–North Ecoregion supports wildlife populations typical of Yukon's boreal forest. Moose, woodland caribou, Stone sheep, Dall sheep, grizzly bear, black bear, wolverine, and marten are all abundant. This ecoregion supports the greatest proportion of brown-coloured black bears in the Yukon, occurring between the Stewart and Pelly rivers (Yukon Department of Renewable Resources 1988). Lynx, beaver, chestnut cheeked vole, mule deer, coyotes, and red fox are also present in some sections of the Yukon Plateau – North (Smith et al. 2004). Of particular interest in the larger area are the Tay River Caribou herd, and an overlap of Stone and Dall Sheep, while mountain goats are uncommon. The Tintina Trench forms an important part of a migration corridor for Sandhill Crane and waterfowl (Smith et al. 2004). Wetlands provide habitat for Pacific, Red-throated and Common Loons, Trumpeter Swan, Canada Goose, American Widgeon, Green-winged Teal, scaup, and scoters (Dennington et al. 1983; Dennington 1985; McKelvey and Hawkings 1990). Osprey and Bald Eagle also breed around lakes (Dennington et al. 1983). Forested areas host Ruffed, Blue, and Sharptailed Grouse, Common Nighthawk, Yellow-bellied Sapsucker, Hairy Woodpecker, Western Wood-Pewee, Hermit Thrush, Townsend's Warbler, Spruce Grouse, Great Horned Owl, Three-toed Woodpecker, Black-capped and Boreal Chickadees, Gray Jay, Common Raven, Red-tailed Hawk, Northern Flicker, Olive-sided Flycatcher, Rubycrowned Kinglet, Swainson's Thrush, Varied Thrush, Yellow-Rumped Warbler, Blackpoll Warbler, and Dark-eyed Junco (W. H. Osgood 1909; Rand 1946; Johnston and McEwen 1983; Frisch 1987). And finally, in alpine areas Gyrfalcon, Rock and White-tailed Ptarmigan, Wandering Tattler, Gray-Crowned Rosy Finch, American Pipits, Willow Ptarmigan, Wilson's Warbler, American Tree Sparrow, and Golden-Crowned Sparrow can be found (W. H. Osgood 1909; Beckel 1975).

4.2 CULTURAL HISTORY

The following is an overview of the culture history for the broader region surrounding the study area including portions of the central and northeastern Yukon. Many researchers have reviewed the cultural history of this broader area and have presented the information using a variety of terms and temporal ranges (Clark 1981, 1983; West 1996; Workman 1978; Gotthardt 1990; J. V. Wright 1995, 1999).

4.2.1 Precontact Period (ca. 11,000 BP to ca. AD 1700s)

The earliest documented Precontact occupation of lands crossed by the study area, which dates to early post-glacial times, is known as the Northern Cordilleran Tradition (Clark 1983; Gotthardt 1990; Hare 1995). The earliest Northern Cordilleran Tradition occupation known at present is a site located near Beaver Creek, dated to 10,670 BP (Heffner 2002). The majority of sites associated with this tradition appear to date older than 7,000 to 8,000 BP. The Northern Cordilleran Tradition, with some overlap, predates the introduction of microlithic technology from Alaska into the interior of the central and southern Yukon (Clark 1983; Hare 1995).

The Northern Cordilleran Tradition is followed by the Little Arm Phase which dates from approximately 7,000 BP to 4,500 BP (Clark and Gotthardt 1999; Workman 1978), and can be defined by the use of microlithic technologies. After about 4,500 BP, there is less evidence of microblade use in the Yukon, and an increase in the use of notched projectile points, and a variety of scraping and carving tools, labeled the Taye Lake Phase in southwest Yukon, or more broadly in Yukon and Alaska, the Northern Archaic Tradition (Hare 1995; Workman 1978).

The most recent archaeological culture of southern Yukon is that of the Aishihik Phase (Workman 1978). This phase is thought to be a cultural development from the earlier Taye Lake culture, although there are some significant differences in technology. Key amongst these technological innovations are native copper tools, small stemmed Kavik points, end- and sidescrapers, and ground adzes (Hare 1995), but perhaps most notable is the introduction of the bow and arrow which replaced a type of throwing spear known as an atlatl as the primary hunting weapon (Hare et al. 2004). This transition from atlatl to bow and arrow technology has been clearly documented by recent finds from high elevation ice patches in the southern Yukon (Hare at al. 2004). These Aishihik Phase sites are found above the White River Volcanic ash layer (also known as Tephra) that is dated to about 1,250 radiocarbon years BP (Clague et al. 1995), and are correlated with the appearance of Athabaskan peoples who are thought to be the direct ancestors of the current Na-Cho Nyak Dun, Tr'ondëk Hwëch'in, and Gwich'in First Nations peoples (see below).

4.2.2 Protohistoric Period (A.D. 1700s to ca. AD 1840s)

The Protohistoric Period, as presented here, also overlaps with late Precontact/Athabaskan Period. It is defined by the appearance of non-native goods, other early trade items, and foreign (western or eastern) influences, but not the documented accounts of contact between indigenous North American peoples and European/Russian/Asian peoples themselves. Other indicators of the Protohistoric Period are the arrival of the first non-native diseases and information concerning non-natives. This period spans the time between the first introduction of non-native influences or artifacts, and the recording of first hand or primary written accounts. Unlike other cultural periods with more specific temporal ranges it is difficult and perhaps impossible to determine when the first ‘outside’ influences of European, Russian, Asian, or other cultures began to impact First Nations people in the Yukon interior.

Some of these far reaching effects may have been passed along from Russian exploration in the early and mid-1700s (Veniaminov 1984) and other Asian and European (Andreev 1944, Quimby 1985) exploration and contact with coastal communities. The Chilkat Tlingit from the Northwest Coast travelled and traded with many interior First Nation peoples throughout this Protohistoric

Period including the Kaska and the Northern Tutchone from the Dawson and Mayo areas, and occasionally the Mountain Dene people from as far away as Fort Norman on the Mackenzie River. The Tlingit protected and controlled the trading routes into the interior and fiercely defended those routes when they were threatened. News of early non-native explorers and traders would have travelled inland along with foreign items such as metals, cloths, glass beads, and later tobacco and other goods.

In some of the earliest cases, the impacts of these foreign cultures could have had significant impacts even without the presence of the foreigners themselves. Such is the case for what is called 'drift-iron' whereby metals and other materials from Asian or European shipwreck wash ashore. Historical accounts of shipwrecks have been reported in the mid-1700s, but much earlier wrecks were possible. Metals and other foreign trade items have been derived from shipwrecks off what is now British Columbia, Southeast Alaska, and perhaps the Northwest Alaska as well.

4.2.3 Historic Period (post-A.D. 1840s)

During the early years of this period the Russians were expanding their exploration and trade network along the Pacific coast and up the major rivers of the Alaskan interior, while the British were exploring eastward into what would become Canada's Northwest and Yukon Territories, as well as Alaska. The North American based explorers and traders entered the Yukon through two main routes: from the north via Fort McPherson and from the south via Fort Liard. In the 1840s, representatives of the Hudson Bay Company established trading posts near portions of the study area, including those at Lapierre House (1846) and Fort Yukon (1847). The next year Robert Campbell established Fort Selkirk southeast of the project area on the upper Yukon River and then relocated to an improved location in 1851. This upset the Chilkat native trading population from the coastal area, who had controlled trade to the interior for many generations, and by 1852 increasing supply-line pressures, trade competition from the Chilkat traders, and flooding forced the Anglo traders to flee.

In 1867, US Secretary of State William Seward was able to focus increasing American interests, and he convinced the United States Senate to purchase Alaska from Russia. Soon after the purchase, the US Army sent Captain Raymond up the Yukon River on the first stern-wheel steamer to reach Fort Yukon (Grauman 1977). Raymond surveyed the location of Fort Yukon and proved that it was within U.S. territory. The British sold the Fort to the U.S. Government and relocated east across the 141st Meridian.

The inland fur industry continued to drive exploration and settlement into the late 1800s, but mining would shift the focus to the placer gold found in streams and alluvial deposits. Mining in the second half of the nineteenth century was a risky, but often very lucrative enterprise. The impacts of mining spread quickly and drastically changed the project area.

Mineral prospecting and mining efforts in the second half of the nineteenth century were, in some ways, dependent on the existing infrastructure of the fur trading and missionary efforts. As the competition for the inland fur trade grew, so would the number of stern-wheelers on the Yukon River. These steamers could better supply the small number of trading posts along the Yukon and its tributaries and reduce the risk of prospectors running short of supplies. Therefore, more of the fur traders and other explorers turned their attention to search for gold and other minerals. Three key prospectors to the north were L. S. (Jack) McQuesten, Al Mayo, and Arthur Harper. They wrote to miners in the United States to encourage them to come north. They also established outposts along the Yukon River, including Fort Reliance, established in 1874 near the confluence of the Klondike River (what would become Dawson City) (A. A. Wright 1976).

Harper and another man may have been the first to travel up the Fortymile River in search of gold in 1881 (Buzzell 2003). They collected a very rich sample, but were unable to relocate the exact location. In 1886, McQuesten, Harper, and Mayo built a post on the confluence of the Stewart and Yukon Rivers which provided supplies for additional prospectors. Also in 1886, Howard Franklin made a richer find on the Fortymile River. Others rushed in and these claims along the Fortymile River attracted miners from across Central, Eastern Alaska, and Southeast Alaska. Fortymile was the first town to grow to over a thousand people by the mid-1890s (Buzzell 2003), and in 1887 the Stewart River post was deserted. Some prospectors that did not find easy success in Fortymile returned to the Stewart and continued work in the area. In 1890, Harper re-established a trading post at the site of the old HBC post at Selkirk as interest in the area grew. This was followed by Jack Dalton who developed a series of existing First Nation trails from tide water at Haines Alaska, into Fort Selkirk. Then, on August 16, 1896, George Carmack, Skookum Jim, and Tagish Charlie discovered a very rich claim on Bonanza Creek, a tributary to the Klondike River near Dawson. This discovery sparked one of the largest gold rushes in history.

It would take almost a year for the news of the Klondike gold fields to spread south, even to places relatively close by in southeast Alaska. Most of the prospectors and traders in the Alaskan and Yukon interior had already converged on the Dawson area during the winter and spring, and supplies ran dangerously low. That would quickly change in the summer of 1897 and spring of 1898 as new towns and supply posts sprang up along the Gold Rush routes to cash in on the increased demand.

The population of Dawson City grew very fast and in 1898 reached a peak of over 30,000. However, the boom period did not last long and the vast majority of population moved on very quickly with the news of other discoveries and hopes of other bonanzas. The Gold Rush period saw greatly increased steamer traffic on the entire Yukon River drainage basin and across the interior. Just prior to the Gold Rush there were only a few steamers, while at its peak there would be hundreds of vessels working the rivers. These shallow draft steamers were supported by a network of wood camps, shipyards, and a large workforce which kept the river traffic moving. This network provided the infrastructure backbone for trading posts, fish camps, missionaries, and mail routes, while meeting the needs of the growing number of prospectors and traders.

Since Dawson City is located on a flood plain at the confluence of the Klondike and Yukon Rivers it has had a long history of fighting with rising water levels. Flooding here is the result of either open water flooding at peak river flows, or the more dangerous spring ice jam events. Dawson City has been the victim of over twenty floods since 1898 (McCreath et al. 1988, Whitehorse Star 1979). The most significant of these were in 1925, 1944, 1966, 1969 and 1979. After flooding in the 1940s and 1950s Front Street was raised in an attempt to keep the waters out, but this did little to stop the flooding. A protective dyke was built around the City in 1959 and was later increased in 1968. The last major flood of Dawson City occurred in 1979 when ice jams on the Indian, Klondike, and the Yukon Rivers caused the spring waters to back up across the City. This prompted the construction of the improved dyke (to the 200 year flood level) in 1987 (McCreath et al. 1988). Dawson City served as the capital of the Yukon government from 1898 until 1952, when the seat was moved to Whitehorse.

The Yukon has also been host to oil and gas exploration efforts since the 1950s. The first well was drilled in the Eagle Plains Basin in 1957, but was declared dry in 1958 (Yukon Government Oil and Gas Resources Branch, n.d.). Exploration activity picked up again in the 1960s and 1970s, which played an important role in motivating the construction of the Dempster Highway (see Section 3.4). Interest in exploration has continued intermittently ever since, with 76 wells having been drilled to date in five of eight Yukon sedimentary basins (Eagle Plain, Beaufort Mackenzie, Peel Plateau and Plain, Kandik, and Liard Basins) between 1957 and 2013 (Yukon Government Oil and Gas Resources Branch, n.d.). Over 10,000 line-km of 2D and 3D seismic surveys have been conducted as part of these exploration efforts (Yukon Government Oil and Gas Resources Branch, n.d.). Six oil and gas pipelines have also been constructed in the Yukon, including four built during World War II as part of the Canol project, one built in the 1950s to supply American Air Force bases in Alaska during the Korean War, and the 2012 Spectra Energy pipeline built in 1972 to move natural gas from the Kotaneelee gas field in southeast Yukon to southern markets (Yukon Government Oil and Gas Resources Branch, n.d.).

4.2.4 The Dempster Highway

The Dempster Highway was first conceived in 1958 when the Canadian government committed to the construction of 671 km of new highway running from Dawson City, YT to Inuvik, NWT. At that time, oil and gas exploration was already underway in the Mackenzie Delta, and when additional reserves were discovered the following year in Eagle Plains the new highway became a priority for the government. Construction began at Dawson City in 1959, but high costs and disagreements between the Federal and Yukon governments resulted in the project being abandoned in 1961 after only 115 km had been completed (Yukon Info, n.d.). However, interest in the project was renewed in 1968 as a means of asserting Canadian sovereignty in the north following the discovery of oil and gas reserves by the Americans in Prudhoe Bay, Alaska (Yukon Info, n.d.). Funding was resumed in the early 1970s, and the highway was completed in 1978 then officially opened on August 18, 1979.

The Dempster Highway takes its name from Royal Canadian Mounted Police Inspector William John Duncan Dempster, who, as a young constable, frequently ran the dog sled trail from Dawson City to Fort McPherson, NWT that preceded the highway. In March 1911, Inspector Dempster was dispatched with two other constables to find fellow inspector Francis Joseph Fitzgerald and his team of three men who had failed to report at Dawson City when expected. Fitzgerald and his men became lost while searching and succumbed to exposure and starvation. Dempster and his men found the bodies on March 22, 1911 (North 2008).

4.3 Modern First Nations

4.3.1 Na-Cho Nyak Dun First Nation

The Na-Cho Nyak Dun First Nation (NND) are part of the Northern Tutchone language and culture group. In the past, the Tutchone peoples were highly mobile, travelling in small groups in order to exploit the greatest number of resources. They would modify their movements depending on the patterns of large game animals and fish, or in later years to trade their furs with Westerners. In the summer, small domestic units gathered together to catch fish so that they could dry and store it for the winter months. By mid-summer several family groups moved upland together in order to kill large game mammals that they would dry and store in caches scattered in a variety of areas. From there some units moved away independently during the coldest months to trap and live off of the cached foods. The leanest months were March and April. In spring, several units often came together at this point to catch spawning whitefish or trap muskrat and beaver. May was the most plentiful month, with migrating waterfowl, fat ground squirrels, larger and more abundant fish, as well as the arrival of the Coastal Tlingit traders (McClellan 1981).

The principal ethnographic descriptions of the Tutchone are available in Cruikshank (1974, 1975), Johnson and Raup (1964), McClellan (1950, 1964, 1970a, 1970b, 1975), and Tanner (1966). Additional information on camp and village locations can be found in Schwatka (1885a). Although villages were not inhabited year round, people would return to good fishing and/or hunting spots year after year. This would eventually change with the influence of Westerners. Watercraft were constructed for use, however during the summer months Tutchone people preferred to walk overland, rather than brave the sudden winds on the large lakes or the treacherous river rapids. Boats were not the preferred method of transport.

The NND First Nation remained somewhat isolated until the discovery of gold in the area in 1883 (Mayo Historical Society 1999). The NND are known to have used many traditional camps, lookout sites, hunting areas, berry patches, and trails in the larger project area with extensive use of rivers. McClellan (1981) summarized the common seasonal activities beginning in the spring with grayling fishing following spring break up. The NND people remained almost completely isolated from non-First Nation people, except for a few explorers passing through, until miners set up a supply post along the McQuesten River in 1886. The supply post soon turned into a village and from then on permanent camps and villages have existed in the larger area surrounding Mayo Lake. During the Duncan Creek gold rush, a trading post called Gordon Landing was established near the confluence of Janet Creek and the Stewart River. From there a trail allowed people to travel north partially along Davidson Creek to the confluence of Duncan Creek on the Mayo River. The Town of Mayo was established in 1903 and the people of McQuesten and a few other small encampments moved there or to the “Old Village” just outside of town (Mayo Historical Society 1999). This village made it possible for people to receive a western education, live close to Mayo, and continue their preferred way of life and cultural celebrations. Eventually the “Old Village” was abandoned when in 1958 the local health officials determined the drinking water was polluted and the NND were requested to move to the Town of Mayo. The First Nations people in the Mayo area officially chose the name “Na-Cho Nyak Dun” in 1987 which means “Big River People” in reference to the now named Stewart River.

4.3.2 Tr'ondëk Hwëch'in First Nation

The Project crosses portions of the traditional territory of the Tr'ondëk Hwëch'in (TH) based in Dawson City and the traditional gathering site of Moosehide. The TH are descendants of the Hän, an Athapaskan language speaking group, as well as a mix of Gwich'in, Northern Tutchone, Tagish, and Upper Tanana. This diversity reflects the importance of the Dawson and Moosehide area as a focal point for trade and the wide range of people drawn into the area in the late 19th Century (Crow and Obley 1981). The oral traditions and ethnographies of the TH were documented by C.

Osgood (1971), A. H. Murray (1910), and Schwatka (1885b) among others. The name Hän was introduced by C. Osgood (1936a) as a shortened form of the name Han-Kootchin or People of the Water or People of the River.

The southernmost of three local Hän bands was known to be centered around the Klondike River near its confluence with the Yukon River. This band was associated with the gathering site of Moosehide and later, Dawson City (Crow and Obley 1981). The name of the village near the mouth of the Klondike River (on the west bank of the Yukon River) was written in a variety of recordings including Noo-klak-ó, Nu-kla-ko, and Nuklako while the Hän name for the Klondike River was recorded as "stone-for-driving-in-fish-trap-poles river" and čon-dik (Crow and Obley 1981), while the Hän name for the Klondike band is Tr'ondëk Hwëch'in.

The Hän people relied heavily on the variety and abundance of fish, and of these salmon played a critical role. The major salmon fisheries consisted of King spawning runs starting in June and July and Chum in August. The Hän people prepared for the runs and gathered on the Yukon River and its tributaries from early spring thru summer. Salmon were harvested in weirs, traps, gill nets, dip nets, and with spears and harpoons. Following the last run families dispersed into smaller fall season groups and hunted and collected resources before returning to river camps in October. Hunting methods included the bow with a variety of arrows (for small and large game as well as birds), spears for large game, and a variety of snares and traps for small and large game.

A focal part of the fall hunt was moose hunting and the return trips were often made downstream in moose hide boats. Travel was also dependent on birch bark canoes, snowshoes, and sleds. The river camps were used through most of the winter with the exception of trips into the higher elevations to hunt and bring back cached meat. The Hän where known to use two main types of housing structures. The moss house was a semi-subterranean square structure made with split wood poles and insulated with moss. While temporary structures used for traveling was a domed skin house. Caribou hunting was common in February and March, and the Fortymile caribou herd played a major role at this time of year. This would be followed by preparations for spring fishing and repairing equipment for the return of the salmon.

Contact with neighboring Nations was vital to First Nations economies. For example, interior First Nations traded hides, furs, and other resources great distances to coastal groups for fish oil, dentalium, woodwork, and blankets. Trails and travel corridors were an intrinsic part of this economy and traditional subsistence as a whole.

4.3.3 Gwich’in Nation

The Gwich’in Nation is an Athapaskan speaking group that includes First Nations/Native American peoples in the Yukon, Northwest Territory, and Alaska (VGFN 2009). Members of the greater Gwich’in Nation include the Vuntut Gwitchin and Tetlit Gwich’in in the Yukon, the Teetl’it Zheh Gwich’in, Gwichya Gwich’in, Ehdiitat Gwich’in, and Nihtat Gwich’in in the NWT (represented in this study collectively by the Gwich’in Tribal Council [GTC]), and the Dendu Gwich’in, Draan’jik Gwich’in, Danzhit Hanlaih Gwich’in, Gwich’yaa Gwich’in, and Neets’ąįį Gwich’in in Alaska (McFadyen Clark 2016). Of particular significance to this project are the Vuntut Gwitchin, Teetl’it Zheh Gwich’in, Gwichya Gwich’in, and Nihtat Gwich’in, whose traditional territories/modern community centers are crossed by the proposed project. Oral traditions and ethnographies of Gwich’in people have been documented by Krech (1976), Osgood (1933, 1934, 1936b), Petitot (1876, 1889), and Savishinsky and Hara (1981) among others.

Collectively, the traditional lifeways of the Gwich’in people depended on hunting and fishing. Moose and caribou were of vital economic importance providing both food and hides for clothing and shelter, but salmon, white fish, hare, and plant foods such as berries and rhubarb were also significant sources of subsistence (McFadyen Clark 2016). Their traditional toolkit was similar to other subarctic Athapaskan groups, and included the bow and arrow, traps, snares, deadfalls, and nets for fishing. People also utilized caribou drift fences and pounds to improve hunting yields. Snowshoes, sleds, and canoes were all employed for greater mobility. Hide covered tents provided the primary source of shelter.

Many Gwich’in people continue to rely on hunting and fishing for subsistence. While this practice is important to most Gwich’in people for purely cultural reasons, it is especially relevant to the Vuntut Gwitchin (which translates to “people of the lakes”), who are based in Old Crow, YT; the only community in the Yukon without road access (VGFN 2009). The Teetl’it Zheh Gwich’in (which translates to "people of the head waters") are based in Fort McPherson, NWT, which was established in 1852 when Old Fort, a Gwich'in village, was moved from six kilometers upriver to the present town site (Gwich’in Council International 2009). Fort McPherson represents the largest Gwich'in settlement in the NWT with over 80% of its population being of Gwich'in descent (Gwich’in Council International 2009). Gwichya Gwich’in (which translates to "people of the flats") are centered in Tsiigehtchic, NWT, and the Nihtat Gwich’in, meaning "mixed nations", is a group comprised of Gwich'in from various Gwich'in communities that reside in Inuvik (Gwich’in Council International 2009).

4.4 Previous Heritage Investigations

Lands within and/or nearby the Yukon portion of the proposed Dempster Fibre Project alignment have been assessed by several previous permitted heritage resource studies. Permitted studies include 78-11ASR (Van Dyke 1979), 85-01ASR (Bussey 1985), 89-04ASR (Greer 1989), 93-11ASR (Gotthardt 1993), 94-21ASR (Greer 1994), 99-15ASR (Gotthardt 1999), 03-07ASR (Gotthardt 2003), 11-17ASR (Heffner 2012), 11-21ASR (Hare and Gotthardt 2013), and 16-16ASR (Bennett 2016a). As a result of these studies, 61 archaeological sites have been identified within, or very near, the proposed ROW. Also, 85 historic sites recorded in the YHSI were identified. Seventy-nine of these sites are located within Dawson City, with only six along the remainder of the study area. Summaries of these sites are provided in Appendix C.

5.0 RESULTS AND RECOMMENDATIONS

This section presents the results of the review and updating of all previous phases of heritage resource assessment. As this report combines all relevant previous results with updated results that reflect the Dempster Fibre Project as proposed in 2019, these results supersede all previous results. All planning decisions should therefore be informed by the recommendations made in this report and not any of the reporting submitted in 2016.

5.1 Summary of Previous Heritage Resource Work Conducted for the Dempster Fibre Project

The initial phase of heritage resource assessment conducted specifically for the project was an HROA completed in 2016 (see Mooney and Bennett 2016). This HROA covered both the Yukon and NWT portions of the Dempster Fibre Project alignment. In total, the HROA identified 598 landform-based areas of potential (AOPs; 321 of which are located within the Yukon), 606 water feature-based AOPs (392 of which are located within the Yukon), and 33 previously recorded archaeological sites (30 of which are located in the Yukon) located within a 100 m buffer to either side of the Dempster Highway centerline[2]. Six historic sites recorded in the YHSI were also identified (note: YHSI sites within Dawson were not individually discussed in the previous phases of reporting due to their high number and because they are not expected to be impacted by development – if any structures will be impacted in the final build plan further work to determine their YHSI status and develop impact mitigation strategies will be required).

This PHFA work was aimed at ground truthing the heritage resource potential predictions made by the preceding HROA study. In addition to the heritage resource potential areas discussed above, three culturally sensitive areas (two in the Yukon and one in the NWT) brought forth by the Gwich'in Tribal Council during the permitting process for the PHFA were investigated. In total, 13 areas of specific heritage resource concern were identified along the Yukon portion of the proposed ROW corridor during the PHFA fieldwork. These areas were identified as having elevated potential for impacts to heritage resources due to: 1) their proximity to previously recorded heritage resource sites, 2) their proximity to high potential landscape features for the identification of currently undocumented heritage resources, or 3) a combination of elevated potential factors 1 and 2.

Specific avoidance and/or impact mitigation strategies are presented in this report. The remainder of the project area was found to either have low potential for heritage resources, or

[2] Note: These numbers have been updated with the results of the 2019 site inventory search.

to have small areas of elevated potential that can be easily avoided by following the general avoidance strategies presented in this report.

5.2 General Results and Recommendations

The majority of the proposed fibre optic line route was found to have low potential for heritage resources related to:

1. High levels of previous ground disturbance within the existing Dempster Highway ROW
2. Large areas of low-lying, flat, wet, spruce dominated forest and wetland areas
3. Large portions of the study area that cross side slope (especially south of Tombstone Territorial Park)

However, while the majority of the study area is considered to have low potential for encountering previously undocumented heritage resource sites, several localized areas of moderate to high potential were also recognized. As indicated in the preceding HROA studies (see Mooney and Bennett 2016; Bennett 2016a, 2016b), these moderate to high potential areas are typically associated with specific types of landform (e.g. ridges and terraces where high, flat terrain breaks to downward slopes, and raised landforms near water). Dryland locations with good access to water, especially those that also share the landform attributes described above, are also often considered to have elevated potential for the presence of heritage resource sites. And lastly, the areas surrounding previously recorded heritage resource sites are also considered to have heightened potential for the identification of additional associated heritage resources.

The following points are considered as broad best practice recommendations for avoiding heritage resource impact concerns at the above mentioned general moderate to high potential areas along the entire length of the ROW:

1. **To avoid most landform related high potential areas:**
    a. **Stay close to existing Dempster Highway roadbed (within 10 m of roadway edges)**
    b. **In cases where the proposed line must move more than 10 m from the existing roadbed,**
        i. **Stay within the vegetation control zone along the highway**
        ii. **Avoid the tops of any elevated landforms; stay on side slopes instead**
2. **To avoid most water feature related high potential areas:**

   a. **Stay close to existing Dempster Highway roadbed (within 10 m of roadway edges) with fibre optic cable crossing waterways in areas with currently engineered banks (e.g. reinforced areas at culvert crossings, slopes of built up portions of roadbed across deeper drainage channels)**
   b. **All drilling related ground disturbance should maintain a 30 m setback from banks of rivers, creeks, lakes, wetlands, etc.**
3. **To avoid known heritage sites:**
   a. **Maintain a 30 m buffer around the recorded site area**

With the above general impact mitigation strategies in mind for the overall study area, 13 areas of specific impact concern where also identified within the Yukon that require specific avoidance/mitigation strategies to be followed during the planning and construction of the Dempster Fibre Project. These specific strategies are discussed in the following section of this report. Areas not specifically mentioned in the following section should be considered to not present any significant heritage resource concerns provided that the above general recommendations are followed (note: there are a large number of YHSI sites recorded within Dawson, YT that fall within the 100 m study area buffer. It is assumed that this project will not be impacting standing structures in Dawson, so these sites are not discussed. However, should impacts to any standing structures near the riverfront in Dawson be deemed necessary for this development, Hemmera should contact Ecofor to determine the heritage status of the building to be impacted).

5.3 Specific Areas for Avoidance and/or Further Mitigative Work

In total, 13 areas of specific heritage resource concern were identified along the Yukon portion of the proposed fibre optic line route during the PHFA fieldwork. These areas were identified as having elevated potential for impacts to heritage resources due to: 1) their proximity to previously recorded heritage resource sites, 2) their proximity to high potential landscape features for the identification of currently undocumented heritage resources, or 3) a combination of elevated potential factors 1 and 2. This section of this report identifies these areas, and proposes recommendations for avoidance and/or mitigative strategies to avoid impacts related to the proposed Dempster Fibre Project.

5.3.1 – Archaeological Sites LfVg-5 and LfVg-17

Previously recorded archaeological sites LfVg-5 and LfVg-17 (see Appendix A mapsheet 7 of 18) present the greatest concern related to heritage resource impacts along the proposed Dempster

Fibre Project alignment. These sites are located approximately 30 m from one another, and approximately 15 m east of the existing Dempster Highway roadbed on a terrace above the Blackstone River (Photo 1).

LfVg-5 is a First Nations burial site (Photo 2 and Photo 3). It is one of the areas of cultural significance brought forth by the Gwich'in Tribal Council during the permitting process for this study (see also Section 5.2.15). It is described as a

> Gwich'in grave site from early 20th century marked by a large grave fence of pickets and carved posts. This is not an actual grave but a reconstructed grave fence. The original group of graves was destroyed by the Department of Public Works during the Dempster Highway construction. Parts of the destroyed grave fences were brought here and reconstructed as one large fence. It is likely that the human remains are widely scattered. The destroyed graves were those of a woman and her 7 children (Greer 1989). Site revisited and photographed in 2003 by Gotthardt, and again in 2011 by Heffner (see Gotthardt 2003 and Heffner 2012). This is the relocated grave site of Selea (wife of Old Neil) and her seven children who died in 1910s or 1920s when influenza and tuberculosis claimed many lives (Greer 1989; Gotthardt 2003).

LfVg-17 is a small scale lithic scatter. It was identified by Heffner in 2011 (see Heffner 2012; Photo 4 and Photo 5).

Both of these sites should be avoided by the Dempster Fibre Project alignment. Both are located on the opposite (east) side of the Dempster Highway, but are within 30 m of the 2019 proposed fibre cable alignment. It is recommended that the cable alignment be moved farther west to maintain a full 30 m avoidance buffer around these sites. Moreover, burial sites are often of the highest significance to First Nations, and therefore further consultation with the Tr'ondëk Hwëch'in First Nation (whose traditional territory the site is located upon) and the Gwich'in Tribal Council (who specifically cited concerns related to the site in their review of the permit for this PHFA work) should be conducted before finalizing avoidance/mitigation strategies related to these sites. Due to the potential for widely scattered human remains throughout this area related to the initial disturbance of LfVg-5 during the construction of the Dempster Highway, **it is also recommended that a heritage resource monitoring program be in place during any ground disturbing activities in this area with heritage resource management professionals and First Nations representatives both present**.

5.3.2 – Archaeological Site LfVg-4

Archaeological site LfVg-4 (see Appendix A mapsheet 7 of 18) is a First Nations burial site. This site was not revisited during the PHFA efforts due to an error in site coordinates that placed it outside of the 100 m assessed buffer zone. However, communication with staff at the Yukon Government Heritage Resources Unit, who are familiar with the site's location, has subsequently confirmed its presence approximately 20 m east of the Dempster Highway and very close to an existing gravel pit used in the maintenance of the highway. Despite these nearby disturbance factors, the site area is intact. Greer (1989; see also Gotthardt 2003) described LfVg-4 as the

> Grave site of Jemima Josie, a Tukudh Gwich'in woman who died in the winter or spring of 1908. Her husband, Esau Josie, had died the previous year and was buried at Moosehide. Mrs. Josie, pregnant with her first child, was living/travelling in the Hyssop Creek area and injured herself while working on a hide. The accident brought on an early labour. The child was Mrs. Mary Vittrekwa. Mrs. Josie did not recover and died a short time later. The grave is marked by a picket fence with log corner posts. A headboard reads "June 11 Jemima". The June 11 date refers to the date the fence was constructed. Today a spruce tree is growing in the middle of the grave.

As a grave site, LfVg-4 is considered to be of high cultural significance. **The site is located on the opposite (east) side of the Dempster Highway, but is just within 30 m of the 2019 proposed fibre cable alignment. It is recommended that the cable alignment be moved farther west to maintain a full 30 m avoidance buffer around the site.**

5.3.3 – Archaeological Site LaVh-5

Archaeological site LaVh-5 (see Appendix A mapsheet 3 of 18) is an abandoned miner's diversion ditch. It was recorded without being directly observed by Greer in 1989 based on information obtained from Yukon Heritage Inventory files (Photo 6). During the PHFA study, a drainage appearing to be man-made was observed approximately 110 m south of the recorded location of LaVh-5 (Photo 7). No ditch features were observed at the recorded site location (see Photo 6). As such, it is proposed that the observed drainage is the ditch referred to by the Borden number LaVh-5. Since 2016, it has been determined that the ditch is actually associated with historic hydro electrical generation infrastructure. A new hydro project has proposed to put the ditch back into use for electrical generation purposed. **Because this site is a ditch feature, and no subsurface artifacts are expected, directional drilling beneath the ditch, following the 30 m setback general recommendation for waterways listed above, should represent adequate avoidance to prevent impacts to heritage resources**.

5.3.4 – Archaeological Site LbVh-1

Archaeological site LbVh-1 (see Appendix A mapsheet 4 of 18) is a lithic scatter recorded in a bulldozer scrape along a road cut for the Dempster Highway (west side of highway). Subsequent attempts to relocate LbVh-1, including the PHFA study, have failed to relocate the site. During the PHFA study, the site area was found to be heavily disturbed, and the site was almost certainly destroyed if it was not completely collected when first identified (Photo 8). As such, this study finds little call for concern related to this site. **All indications are that this site has been destroyed by the construction of the Dempster Highway. As such there are no significant concerns. However, to ensure avoidance of the site area, best practice will be to route the Dempster Fibre Project alignment along the east side of the Dempster Highway, maintaining a 30 m avoidance buffer, or to directionally drill beneath the site area with drilling operations maintaining a 30 m setback in both directions from the site location**.

5.3.5 – Archaeological Sites Near Tombstone Territorial Park Interpretive Center

Several archaeological sites have been previously recorded near the Tombstone Territorial Park Interpretive Center. These sites include LdVg-9, LdVg-13, LdVg-14, LdVg-16, LdVg-18, LdVg-19, LdVg-23, LdVg-24, LdVg-36, LdVh-1, and LdVh-4 (note: LdVh-1 is also recorded in the YHSI listing as 116B/09/003; see Appendix A mapsheet 5 of 18). These sites are located upon elevated landforms that overlook the Klondike River valley, tributaries, waterbodies of the Klondike River (Photo 9 and Photo 10). The primary area of concern through this area runs along portions of the Dempster Highway corridor approximately between highway kms 72-86. Although many sites and high potential landforms are present through this area, high levels of previous disturbance are also present near the highway corridor related to the roadway itself, highway pull offs, and highway maintenance sites (e.g. gravel pits/storage areas). Moreover, all sites are located away from the immediate margins of the Dempster Highway roadbed. **It should be possible to avoid many of these sites by keeping the Dempster Fibre Project alignment close to the existing highway (within 10 m). Sites that will not be avoided through this strategy are LdVg-13, LdVg-14, LdVg-16, JdVg-18, LdVg-19, LdVg-23, LdVg-36, and LdVh-4. Rerouting the proposed 2019 alignment is recommended to avoid these sites and their 30 m avoidance buffers.**

5.3.6 – Dago Hill Pumphouse 1 – YHSI Site 116B/03/481

The Dago Hill Pumphouse 1 (see Appendix A mapsheet 1 and 2 of 18) is a historic structure located on the north side of Hunker Creek Road, less than 10 m from the roadside (Photo 11). Murals have been painted on the interior walls of the structure, presumably subsequent to its time as a functioning pumphouse (Photo 12 and Photo 13). **To avoid impacts to this structure,**

it is recommended that the proposed 2019 Dempster Fibre Project alignment be revised to stay to the south side of Hunker Creek Road at this point, giving a 30 m buffer around the pumphouse.

5.3.7 – Dawson to Fort McPherson Trail – YHSI Site 116B/16/014

YHSI Site 116B/16/014 relates to the old Dawson to Fort McPherson Trail (see Appendix A mapsheet 7 of 18). It is recorded as a specific waypoint in the YHSI listing, but being a trail running hundreds of kilometres, it certainly extends beyond this singular point. Unfortunately, the YHSI form does not include historic mapping of the trail showing its alignment relative to the modern Dempster Highway. As such, **further research and/or consultation with Yukon Heritage and First Nations (listed on YHSI form as crossing Tr'ondëk Hwëch'in First Nation settlement lands, but may also cross the lands of other First Nations) to confirm the location of the trail and whether there are any ongoing heritage resource concerns associated with it that are relevant to the Dempster Fibre Project alignment should be conducted prior to the commencement of construction**.

5.3.8 – Goring Creek – YHSI Site 116B/02/019

YHSI Site 116B/02/019 refers to the heritage landscape associated with Goring Creek (Photo 14, Photo 15, and Photo16; see Appendix A mapsheet 2 of 18). Several abandoned trucks were observed on the southwest banks, and several structures are located near the southeastern bank area. It is recorded as a specific waypoint in the YHSI listing, but being that it relates to a landscape associated with a creek, it certainly extends beyond this singular point. Moreover, impacts to heritage landscapes may be viewed with different levels of concern by those who recognize them depending on the specific portion of that landscape that is to be impacted and the nature of those impacts. As such, **further consultation with the Tr'ondëk Hwëch'in First Nation is recommended before finalizing plans for the Dempster Fibre Project alignment through this area**.

5.3.9 – Dognose Creek – YHSI Site 116B/02/020

YHSI Site 116B/02/019 refers to the heritage landscape associated with Dognose Creek (Photo 17 and Photo 18; see Appendix A mapsheet 2 of 18). It is recorded as a specific waypoint in the YHSI listing, but being that it relates to a landscape associated with a creek, it certainly extends beyond this singular point. Moreover, impacts to heritage landscapes may be viewed with different levels of concern by those who recognize them depending on the specific portion of that landscape that is to be impacted and the nature of those impacts. As such, **further**

consultation with the Tr'ondëk Hwëch'in First Nation is recommended before finalizing plans for the Dempster Fibre Project alignment through this area.

5.3.10 – Shed Alongside Hunker Creek Road

This structure is not currently listed in the YHSI listing, but appears to be of sufficient age that it could likely be considered a historic structure (Photo 19; see Appendix A mapsheet 2 of 18). As such, it is considered best to be avoided by the Dempster Fibre Project alignment. It is located on the south side of Hunker Creek Road. **To avoid this structure, the Dempster Fibre Project alignment should stay on the north side of Hunker Creek Road**.

5.3.11 – Trailers/Structures Alongside Hunker Creek Road

This group of structures and trailers is not currently listed in the YHSI listing, but some features at the site may be of sufficient age, and were observed in reasonable context, such that they could likely be considered a historic in nature (Photo 20; see Appendix A mapsheet 2 of 18). Moreover, the site appears to be currently occupied, so regardless of whether this site possesses potential heritage resources, it is best avoided. The structures and trailers are located on the north side of Hunker Creek Road. **To avoid this area, the Dempster Fibre Project alignment should stay south of Hunker Creek Road**.

5.3.12 – Gwich'in Tribal Council Areas of Cultural Sensitivity Concern

During the permitting process for this study, the Gwich'in Tribal Council brought forth three areas of cultural sensitivity concern that they felt should be assessed ahead of any ground disturbance related to the Dempster Fibre Project, two of which are located in the Yukon. One of these areas was the gravesite associated with LfVg-5 which was discussed above in Section 5.2.1 of this report).

The second Yukon area of concern brought forth by the Gwich'in Tribal Council, also a grave site, is located near the Gwazhàl area upon the Ogilvie Ridge (see Appendix A mapsheet 11 and 12 of 18). Unfortunately, more specific spatial data related to this site has not been recorded, and attempts to contact people associated with the initial reporting of the site were unsuccessful. Information provided by the Gwich'in Tribal Council is as follows:

> Yukon grave site in the Horseshoe Bend area of the Dempster Highway. This is a summary of the only information we have: The graves originally came to our attention in October 2004 via Robert Alexie Sr. Robert said that he had been speaking to Richard Nerysoo who said that his brother Dennis Blake and (?) had been out caribou hunting in late Sept/early October 2004 and ran across two graves (one small,

> one large) in the Ogilvie area near Joe Henry's cabin, past Gwazhàl and below a gravel pile on the east side of the road. It sounded like it was in a high area versus in the river valley and that they saw some burial items – spear points and beads. Gwich'in elders have indicated that they were people from Eagle, Alaska - one young kid and one older person (Kristi Benson [GTC], personal communication 2016).

With only this information and broad potential locational data available, these graves were not relocated during the PHFA study (see Bennett 2016a). Instead, the PHFA work focused on identifying areas within the existing Dempster Highway corridor where heritage impacts would not be a concern. The previously disturbed areas immediately adjacent to both sides of the highway were found to be quite wide throughout the Gwazhàl area (Photo 21 and Photo 22). **Concerns related to these graves should be adequately avoided if the Dempster Fibre Project alignment stays within 10 m to either side of the highway roadbed, in previous disturbance, from Dempster Highway km 252.7 to km 274.8. This does represent a large area, but with the existing uncertainty as to the exact location of these graves it is considered best practice to allow for a large control area to avoid accidental impacts**.

5.3.13 – Hunker Creek Transmission Line Corridor Diversion

The Hunker Creek Transmission Line Corridor Diversion runs between where the fibre optic line turns east off of Hunker Creek Road to where it rejoins the Klondike Highway. Although the eastern half of this area is low-lying wetland with limited heritage resource potential (Photo 23), the eastern portion climbs over a large hill and contains several areas of elevated heritage resource potential (Photo 24; see Appendix A mapsheet 2 of 18). The primary area of potential is located where flat terrain breaks to a steep slope and offers a commanding view of the Klondike valley to the northeast (Photo 25 and Photo 26). Other smaller terraces and viewpoints are present further east (see Appendix A).

At present (as of May 24, 2019), the proposed fibre cable installation methodology is to suspend the cable from existing electrical transmission lines, with no need for developing additional access routes. As such, no new ground disturbance will be required and no impact to potential unidentified heritage resources is expected. **Provided that this low impact methodology is followed**, **no further heritage resource assessment is recommended. However, should the cable installation methodology be revised to include sections of buried cable, or if new access routes are deemed to be necessary, then further assessment of any ground disturbance areas is recommended.**

6.0 SUMMARY

On behalf of Hemmera, Ecofor Consulting Ltd. (Ecofor) has conducted a review of previous heritage resource assessment work related to the proposed Dempster Fibre Project (formerly known as the Canada North Fibre Loop project), conducted new Heritage Resource Assessment (HROA) work along revised components of the proposed right-of-way (ROW), and updated heritage site inventory searches associated with previous phases of assessment to ensure all documented heritage resource sites within the study area are known. Previous phases of assessment include an unpermitted desktop HROA study (Mooney and Bennett 2016) and preliminary heritage field assessment (PHFA) conducted under Yukon Government Heritage Resource Unit permit 16-16ASR (Bennett 2016a) and NWT Prince of Wales Northern Heritage Center permit 2016-14 (Bennett 2016b). This report focuses on portions of this ROW within the Yukon, with the assessment of lands within the NWT reported separately.

As this report combines all relevant previous results with updated results that reflect the Dempster Fibre Project as proposed in 2019, these results supersede all previous results. All planning decisions should therefore be informed by the recommendations made in this report and not any of the reporting submitted in 2016.

The results of this HROA review and updating report have led to a set of three general recommendations intended to facilitate the avoidance of areas of elevated heritage resource potential related to landform related high potential areas, water feature related high potential areas, and known heritage resource sites. Fourteen areas of specific heritage resource concern were identified along the Yukon portion of the proposed 2019 Dempster Fibre Project alignment. Accordingly, specific recommendations for heritage resource management are provided for these localities.

Lastly, if the project area footprint is modified in the future to include additional unassessed lands, those areas should also be reviewed for possible impacts to heritage resources. Moreover, although all efforts were made during the production of this report and all previous phases of assessment to make the results as comprehensive and accurate as possible, small undocumented areas of heritage resource potential may be present and chance finds of heritage resources may be made in areas of perceived low heritage resource potential within the study area. As such, the recommendations contained herein are intended to be used for planning purposes only.

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APPENDIX A: Project Mapping – NOT INCLUDED IN PUBLIC VERSION OF REPORT

APPENDIX B: Photographs – NOT INCLUDED IN PUBLIC VERSION OF REPORT

APPENDIX C: Known Heritage Resource Sites – NOT INCLUDED IN PUBLIC VERSION OF REPORT

APPENDIX D: Guidelines Respecting the Discovery of Human Remains and First Nation Burial Sites in the Yukon

Guidelines Respecting the Discovery of Human Remains and First Nation Burial Sites in the Yukon

With approvals as of August 1999

This document was prepared pursuant to provisions of
Yukon First Nation Final Agreements
and the Yukon Transboundary Agreement with the Gwich'in Tribal Council

Yukon
Tourism
Heritage Branch

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Introduction and Background

The treatment of every burial site requires respect. Legislation of various types protects burial sites and cemeteries from being disturbed. Government agencies and First Nations keep and consult records of known sites so that land use plans or proposals can avoid such sites.

There are many historic and First Nation graves in the Yukon however which are no longer marked and which may be disturbed accidentally through land use or development. Other sites may be disturbed by natural forces, such as erosion, leading to the exposure of human remains.

As more people travel in backcountry areas, for work or pleasure, it is expected that the number of such discoveries may increase. It is important therefore to have guidelines for reporting, investigating and managing such sites in a coordinated and effective manner, to give them proper respect.

Yukon First Nation (YFN) Final Agreements (Section 13.9.0) and the transboundary agreement with the Gwich'in Tribal Council (Tetlit Gwich'in) (Section 9.5) require the development of procedures to protect and manage YFN or TG burial sites, and specify certain actions when such sites are discovered.

Consistent with these obligations, these guidelines were developed at two workshops held jointly in March and October l998, involving First Nation Elders, heritage and implementation staff, the RCMP, Coroner and other Yukon and federal government officials.

Purpose

To provide direction on the reporting, identification, treatment and disposition of human remains found outside of recognized cemeteries in the Yukon, to ensure these remains are respected and protected consistent with legislation and Yukon land claims agreements.

Scope and Application

These guidelines apply to anyone who discovers human remains or grave goods outside of recognized cemeteries in the Yukon, and to the Yukon, Federal and First Nation government officials involved in protecting and caring for such sites.

The guidelines reflect existing practices in many ways. They do not replace legislation or regulations protecting burial sites, but are intended to integrate obligations contained in Yukon land claim agreements with land use permitting regimes and the Development Assessment Process . These guidelines may apply on Settlement Lands at the discretion of each First Nation. Government approval is required for management plans for sites on non-Settlement Land.

Existing known burial sites that are marked or otherwise recorded are protected by existing legislation. Management plans for these sites may be developed on a case by case basis.

Burial sites discovered within the boundaries of a designated heritage site may be subject to the management plan for that site.

The guidelines do not apply within National Historic Sites or National Parks. Parks Canada has its own guidelines respecting burial sites and human remains.

Evaluation and Revision of Guidelines

The implementation of these guidelines will be evaluated as necessary to ensure that they are fulfilling their purpose.

GUIDING PRINCIPLES

All human remains, and items found at graves (grave offerings, markers etc.) shall be treated with respect and dignity regardless of their cultural affiliation.

Actions taken following the discovery of sites will be consistent with Yukon and transboundary land claim agreement provisions respecting Yukon First Nation and Tetlit Gwich'in Burial Sites.

Each discovery will be handled on a case by case basis in consultation with the affected parties, in a coordinated and timely manner.

Definitions - see Appendix 1
References - see Appendix 2
Land claims provisions - see Appendix 3

Guidelines Respecting the Discovery of Human Remains and First Nation Burial Sites

See also Figure 1.

These guidelines cover five steps: discovery and notification; site protection and investigation; investigation and reporting; and site disposition or management agreements. A final step, arbitration, is provided for where no disposition agreement is reached.

1. Discovery and Notification

If human burial remains are accidentally discovered the following guidelines apply:

a) The finder will immediately cease any further activity at the site and report the site to the RCMP.

b) *If the finder is operating under a land use licence or permit*, the site must also be reported immediately to the land manager/permitting authority, as set out on the permit. The land manager/permitting authority shall confirm that the site is reported to the RCMP.

c) Based on the information it receives, the RCMP will notify: 1) the Coroner's office if the site is of a forensic or criminal nature; or 2) both the First Nation(s) in whose Traditional Territory the Site is located and the Heritage Branch, if the site is a suspected historic or First Nation burial site.

2. Site Protection and Identification

a) the land manager/permitting authority shall take reasonable measures to protect the site from environmental factors and any form of unauthorized interference or disturbance.

b) based on the evidence reported at the scene, the RCMP/Coroner will investigate the site and make a preliminary determination as to the nature of the remains.

c) *if the site is of a criminal or forensic nature* (potential crime scene or missing person), then the Coroner's office and police will assume authority over the site/remains.

d) Heritage Branch may recommend that an archaeologist assist police or coroner in the preliminary assessment of the site.

e) *If the site is* ***not*** *of police/coroner interest* then the Director, Heritage Branch, the affected First Nation(s) and the land manager will assume interim responsibility for protection and investigation of the site. If it's a suspected First Nation site, the Heritage Branch and First Nation would assume this responsibility.

f) the Director, Heritage Branch, the affected First Nation(s) and land manager shall take reasonable measures to restrict access and ensure that the human remains and any grave offerings are not further disturbed pending the investigation and identification of the remains. The RCMP may be consulted about protecting the site.

Figure 1

Guidelines respecting the Discovery of Human Remains and First Nation* Burial Sites

2. Site Protection and Investigation
-protection/no disturbance or access

If not a criminal matter, Heritage Branch takes lead with affected FN or transboundary group. RCMP may assist if requested.

- *First Nation, Minister*
- *permitting authority - person may continue activity with FN consent. If consent is not provided, proceed according to terms and conditions of arbitrator(UFA 26.7.0 TG Ch.18)*

or

- *rebury, relocate or remove remains*
- *restrict/specify access if necessary and possible*
- *may designate existing or new site as burial site/cemetery or heritage site*
- *management plan (jointly prepared/approved by FN and Government on Non-Settlement Lands)*

Maps, inventories, reports, plans, agreements.

**the Tetlit Gwich'in will be involved in steps to protect and manage Tetlit Gwich'in burial sites discovered within their Primary Use Area (Fort McPherson Group Trapping area within the Peel River Basin).*

g) Where human remains are at risk of being destroyed or damaged, the Minister of Tourism for Heritage may issue a stop work order prohibiting any further activities and may make an agreement with the First Nation or the Tetlit Gwich'in or land owner or user for any investigation, excavation, examination and preservation and removal of the remains, consistent with land claim provisions. (s.*72, Historic Resources Act- This would address concerns about unknown remains.)*

Existing site inventories, land use records, affected First Nations and community elders, and military authorities, should be consulted as soon as possible about possible identification of the remains. Some examination of the site/remains may be required to determine its cultural affiliation and age, and whether or not the site is modern or historic.

3. Investigation and Reporting

a) The Heritage Branch/land manager will direct an archaeologist or qualified examiner to carry out an investigation under any required permits, in consultation with the affected First Nation and other affected parties, to make an initial report citing, if possible*, the cultural affiliation of the human remains.

b) Within a reasonable time to be specified by the Minister, and the affected First Nation(s), the archaeologist or qualified examiner shall deliver a written report and any notification not yet made, to:

- the Minister, and the affected First Nation(s) if appropriate;
- the Director of the Heritage Branch;
- the land manager/permitting authority;
- any other representative of the interred, if known.

c) The written report shall attempt *to identify:

- the representative group of the interred;
- the geographic boundaries of the site;
- the grave offerings or other heritage resources that may be associated with the remains or the site.

d) The archaeologist or examiner may, with the agreement of the proper authority and the representative of the interred, if known, remove all or part of the human remains for further analysis or for temporary custody where the remains may otherwise be at risk.

e) Any exhumation, examination and reburial of human remains from a YFN/TG burial site shall be at the discretion of the affected YFN/TG; and if ordered by an arbitrator pursuant to land claim provisions, will be done or supervised by the YFN or Tetlit Gwich'in.

*it is often difficult to determine the cultural ancestry or affiliation of fragmentary human remains

3.1 Reporting

a) If the site is determined to be a Yukon First Nation Burial Site, or Tetlit Gwich'in burial site, the appropriate representative will be contacted in writing to provide further direction on the disposition of the remains. *

b) A person carrying out Government or First Nation authorized activity where a First Nation site is discovered can continue that activity with the consent of the First Nation in whose Traditional Territory the Yukon site is located. The consent of the Tetlit Gwich'in is required if the site is in the Tetlit Gwich'in primary use area. If consent is denied, the person can seek terms and conditions from an arbitrator about continuing the activity (see Section 5).

c) If after the final report, the human remains are found to be those of a different aboriginal people than those mentioned previously, the proper authority of that group shall be notified in order that they may assume the role of the representative.

d) Where a site is **not** found to be a Yukon First Nation or Tetlit Gwich'in burial site, or a military or mariner's burial site, the Director, Heritage Branch may publish notice of the discovery in a newspaper or other public notice seeking information on the remains.

4. Site Disposition Agreement (Management Plan)

4.1 When the site or remains are identified

a) The site shall not be disturbed and the Director, Heritage Branch or First Nation if on Settlement Land, shall initiate discussions towards entering into a site disposition agreement with the representative of the interred.

b) If the site is a Yukon First Nation Burial Site or a Tetlit Gwich'in burial site on non-settlement land, there must be joint approval of the site management plan by the Yukon First Nation in whose Traditional Territory the site is located and the Government. If the site is a Tetlit Gwich'in burial site located off Tetlit Gwich'in land but in the primary use area, the management plan must be jointly approved by the Tetlit Gwich'in and the Government.

c) Decisions regarding reburial, relocation or other disposition should be determined on a case by case basis in consultation with those concerned and in a timely manner.

Site disposition agreements shall determine such things as:

1. the interim care of the human remains*;*

2. the scope and extent of analysis to be performed on the human remains, if any;
3. the exact location of the place where the human remains are to remain or to be interred;
4. the style and manner of disinterment, if applicable;
5. the style and manner of reinterment, if applicable;
6. the time period in which disinterment and reinterment is to take place;
7. the procedures relating to, and the final disposition of any grave offerings discovered with the human remains and any additional analysis of them;
8. the provision for future maintenance of the cemetery or site where the human remains are to be located;
9. access to the site and ways to prevent disturbance;
10. any other issue agreed upon.

*it is often difficult to determine the cultural ancestry or affiliation of fragmentary human remains

4.2 When no representative is identified or no disposition is specified:

If disposition is not specified by a representative, or the remains are not claimed or no affiliation is established within a reasonable time, the Minister, or First Nation if on Settlement Land, shall with the necessary permits and approvals provide for the following disposition:

a) cover and leave the remains where they were found and have the site recorded as a burial site/ heritage site, if on land suitable for a burial site; or
b) have the remains disinterred and reinterred in the nearest appropriate cemetery; or
c) remove the remains from the site for analysis and may have them reinterred in a recognized cemetery or;
d) may act as the temporary repository of the remains.

(Where the remains were found on Settlement Land but are not considered First Nations remains, the Government may remove the remains in consultation with the First Nation.)

5. Arbitration

a) If no disposition agreement or management plan is reached within a reasonable time the matter may be referred to arbitration for settlement. If this matter concerns a Yukon First Nation Burial Site, this shall be done pursuant to 26.7.0 of the UFA; or Chapter 18, if the matter concerns a Tetlit Gwich'in site in the primary use area.

6. Records

a) A record of the site and a report of the discovery and disposition plan shall by kept by the Government and the affected First Nation(s)/representative for future reference to protect the site.

b) Access to information about discovered sites will be addressed in any site management plan developed under these guidelines, and will be protected under the *Access to Information and Protection of Privacy Act*, and the *Historic Resources Act* or *any similar First Nations legislation.*

Appendix 1

Definitions

burial site

the location of any human grave or remains that have been interred, cremated or otherwise placed, and include ossuaries, single burials, multiple burials; rock cairns; cave or cache burials etc. not situated within a cemetery

First Nation Burial Site

This refers to a Yukon First Nation Burial Site or a Tetlit Gwich'in burial site, which is defined as: a place outside a recognized cemetery where the remains of a cultural ancestor of a Yukon Indian Person (or the Tetlit Gwich'in) have been interred, cremated or otherwise placed."

[from the Definitions section of the *Umbrella Final Agreement for the Council for Yukon Indians (now Council of Yukon First Nations) and the Transboundary Agreement between Canada and the Gwich'in Tribal Council*]

human remains

mean the remains of a dead human body and include partial skeletons, bones, cremated remains and complete human bodies that are found outside a recognized cemetery" *(adapted from Historic Resources Act)*

grave offering

any object or objects associated with the human remains which may reflect the religious practices, customs or belief system of the interred.

historic

under the Historic Resources Act this generally means something older than 45 years.

land manager

Agency responsible for the administration of the land on which the site is located. For example, currently territorial parks are managed by Yukon Parks and Outdoor Recreation; gravel pits and rural airports are administered by Community and Transportation Services. Settlement Land is administered by the First Nation. Private land is administered by the land owner. (Burial sites may not be disturbed on any land without proper authorization.)

Recognized cemetery

a defined area of land that is set aside for the burial of human bodies.

representative

means a descendant of the interred or of the person whose remains are found, or where no descendant survives or is identified, an official representative of the appropriate First Nation in whose Traditional Territory the burial site is located or the closest culturally affiliated group, religious denomination, military or marine authority as evidenced by the location or mode of burial.

Where no representative can be determined the Minister shall act as the representative on Non-Settlement Lands and on Settlement Lands at the discretion and with the consent of the First Nation

representative group

means the appropriate Yukon First Nation or the closest culturally affiliated group, religious denomination, military or marine authority as evidenced by mode and style of burial which is willing to act as a representative.

Site disposition agreement

means a written agreement to be reached between the Director of the Heritage Branch and the representative of the interred regarding the disposition of the remains, including any disinterment and reinterment, and management plan

Management plan

means a plan to identify the roles of the representative, Government and land owner or manager respecting the care and protection of the site, including a consideration of site records, site access, and ways to protect a site from disturbance.

Appendix 2

References

The following include requirements to protect burial sites and were considered in the development of these Guidelines.

Umbrella and Yukon First Nation Final Agreements, Sections 13.9.0 and 26.7.0, and Implementation Plans
Yukon Transboundary Agreement (Gwich'in Tribal Council), Sections 9 and 18, and Implementation Plan
Yukon Historic Resources Act, Part 6
Criminal Code
Cemeteries and Burial Sites Act
Coroner's Act
Territorial Land Use Regulations
Yukon Archaeological Sites Regulations
Yukon Quartz Mining Act, and Regulations
Yukon Placer Mining Act, and Regulations
Yukon Surface Rights Act
Vital Statistics Act

Appendix 3

Land Claims Provisions Relating to Burial Sites

13.9.0 Yukon First Nation Burial Sites*

13.9.1 Government and Yukon First Nations shall each establish procedures to manage and protect Yukon First Nation Burial Sites which shall:

13.9.1.1 restrict access to Yukon First Nation Burial Sites to preserve the dignity of the Yukon First Nation Burial Sites;

13.9.1.2 where the Yukon First Nation Burial Site is on Non-Settlement Land, require the joint approval of Government and the Yukon First Nation in whose Traditional Territory the Yukon First Nation Burial Site is located for any management plans for the Yukon First Nation Burial Site; and

13.9.1.3 provide that, subject to 13.9.2, where a Yukon First Nation Burial Site is discovered, the Yukon First Nation in whose Traditional Territory the Yukon First Nation Burial Site is located shall be informed, and the Yukon First Nation Burial Site shall not be further disturbed.

13.9.2 Where a Person discovers a Yukon First Nation Burial Site in the course of carrying on an activity authorized by Government or a Yukon First Nation, as the case may be, that Person may carry on the activity with the agreement of the Yukon First Nation in whose Traditional Territory the Yukon First Nation Burial Site is located.

13.9.3 In the absence of agreement under 13.9.2, the Person may refer the dispute to arbitration under 26.7.0 for a determination of the terms and conditions upon which the Yukon First Nation Burial Site may be further disturbed.

13.9.4 Any exhumation, examination, and reburial of human remains from a Yukon First Nation Burial Site ordered by an arbitrator under 13.9.3 shall be done by, or under the supervision of, that Yukon First Nation.

13.9.5 Except as provided in 13.9.2 to 13.9.4, any exhumation, scientific examination and reburial of remains from Yukon First Nation Burial Sites shall be at the discretion of the affected Yukon First Nation.

13.9.6 The management of burial sites of a transboundary claimant group in the Yukon shall be addressed in that Transboundary Agreement.

*This is an excerpt from the Umbrella Final Agreement between Canada, the Council for Yukon Indians and the Government of the Yukon (l993),Ch. 13, pp. 128-129, and subsequent Yukon First Nation Final Agreements.

9.5. Tetlit Gwich'in Burial Sites*

9.5.1 Government and Tetlit Gwich'in shall each establish procedures to manage and protect Tetlit Gwich'in burial sites which shall:

(a) restrict access to Tetlit Gwich'in burial sites to preserve the dignity of Tetlit Gwich'in burial sites;

(b) where the Tetlit Gwich'in burial site is outside the primary use area *(Fort McPherson Group Trapping Area)*, require the joint approval of government and the Yukon First Nation in whose traditional territory the Tetlit Gwich'in burial site is located for any management plans for the Tetlit Gwich'in burial site;

(c) where the Tetlit Gwich'in burial site is on land in the primary use area which is not Tetlit Gwich'in Yukon land, require the joint approval of government and the Tetlit Gwich'in for any management plans for the Tetlit Gwich'in burial site; and

(d) provide that, subject to 9.5.2, where a Tetlit Gwich'in burial site is discovered, the Yukon First Nation in whose traditional territory the Tetlit Gwich'in burial site is located or the Tetlit Gwich'in, if the Tetlit Gwich'in burial site is in the primary use area, shall be informed and the Tetlit Gwich'in burial site shall not be further disturbed.

9.5.2 Where a person discovers a Tetlit Gwich'in burial site in the course of carrying on an activity authorized by government, a Yukon First Nation or the Tetlit Gwich'in, as the case may be, that person may carry on the activity with the agreement of the Yukon First Nation in whose traditional territory the Tetlit Gwich'in burial site is located or the Tetlit Gwich'in if the Tetlit Gwich'in burial site is in the primary use area.

9.5.3 In the absence of agreement under 9.5.2, the person may refer the dispute to arbitration under chapter 18 of this appendix for a determination of the terms and conditions upon which the Tetlit Gwich'in burial site may be further disturbed.

9.5.4 Any exhumation, examination and reburial of human remains from a Tetlit Gwich'in burial site ordered by an arbitrator under 9.5.3 shall be done by, or under the supervision of, the Tetlit Gwich'in.

9.5.5. Except as provided in 9.5.2 to 9.5.4, any exhumation, scientific examination and reburial of remains from Tetlit Gwich'in burial sites shall be at the discretion of the Tetlit Gwich'in**.**

*This is an excerpt from Appendix C - Yukon Transboundary Agreement between Canada and the Gwich'in Tribal Council, (l992), p. 32.

APPENDIX C

Preliminary Heritage Field Reconnaissance
(Ecofor 2017)

Preliminary Heritage Field Assessment:
Canada North Fibre Loop
(16-16ASR)

(To Be Included in YESAA Materials – No Sensitive Site Data)

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Na-Cho Nyak Dun First Nation
Tr'ondëk Hwëch'in First Nation
Vuntut Gwitchin First Nation
Gwich'in Tribal Council (NWT)

March 8, 2017

EXECUTIVE SUMMARY

On behalf of LTS Infrastructure Services, Ecofor Consulting Ltd. (Ecofor) conducted preliminary heritage field assessment (PHFA) along the proposed route of the Canada North Fibre Loop between the dates of August 25 to September 1, 2016. The proposed project consists of the installation of a fibre optic communication line running from Dawson City, YT to Inuvik, NWT. This report focuses on portions of this ROW within the Yukon (the results of the assessment of lands within the NWT are reported separately under Prince of Wales Northern Heritage Center permit 2016-014). **Note: All specific geographic references to heritage site locations, photographs, and some site details have been removed from this YESAA ready version of this report so that it can be issued publicly while protecting sensitive site data.**

This PHFA work was aimed at ground truthing the heritage resource potential predictions made in a preceding Heritage Resource Overview Assessment (HROA) study conducted by Ecofor (see Mooney and Bennett 2016). Based on the results of the HROA, the PHFA phase of this project focused on the in-field assessment of 598 landform-based areas of potential (AOPs; 321 of which are located within the Yukon), 606 water feature-based AOPs (392 of which are located within the Yukon), and 31 previously recorded archaeological sites (29 of which are located in the Yukon) located within a 100 m buffer to either side of the Dempster Highway centerline. Seven historic sites recorded in the Yukon Historic Sites Inventory (YHSI) were also assessed (note: YHSI sites within Dawson are not individually discussed in this report due to their high number and because they are not expected to be impacted by development – if any structures will be impacted in the final build plan further work to determine their YHSI status and develop impact mitigation strategies will be required). Finally, three culturally sensitive areas brought forth by the Gwich'in Tribal Council (two in the Yukon and one in the NWT) during the permitting process for this study were investigated.

In total, 16 areas of specific heritage resource concern were identified along the Yukon portion of the proposed ROW corridor during the PHFA fieldwork. These areas were identified as having elevated potential for impacts to heritage resources due to: 1) their proximity to previously recorded heritage resource sites, 2) their proximity to high potential landscape features for the identification of currently undocumented heritage resources, or 3) a combination of elevated potential factors 1 and 2. Specific avoidance and/or impact mitigation strategies are presented in this report. The remainder of the project area was found to either have low potential for heritage resources, or to have small areas of elevated potential that can be easily avoided by following the general avoidance strategies presented in this report. If the project area footprint

is modified in the future to include additional unassessed lands, those areas should also be reviewed for possible impacts to heritage resources.

CREDITS

Permit Holder:	Tim Bennett, MA
Report Author:	Tim Bennett, MA
Field Crew:	Tim Bennett, MA (Ecofor)
Report Editing:	James Mooney, MA Cherie Kenya, MA
Graphics/GIS Technicians:	Margie Massier, BA/BSc

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1.0 INTRODUCTION

On behalf of LTS Infrastructure Services, Ecofor Consulting Ltd. (Ecofor) conducted preliminary heritage field assessment (PHFA) along the proposed route of the Canada North Fibre Loop between the dates of August 25 to September 1, 2016 (Figure 1). The proposed project consists of the installation of a fibre optic communication line running from Dawson City, YT to Inuvik, NWT. The study area crosses portions of the traditional territories of the Na-Cho Nyak Dun First Nation (Yukon), the Tr'ondëk Hwëch'in First Nation (Yukon), the Vuntut Gwitchin First Nation (Yukon), and the Gwich'in Tribal Council (NWT). This report focuses on portions of this ROW within the Yukon (the results of the assessment of lands within the NWT are reported separately under Prince of Wales Northern Heritage Center permit 2016-014). **Note: All specific geographic references to heritage site locations, photographs, and some site details have been removed from this YESAA ready version of this report so that it can be issued publicly while protecting sensitive site data.**

1.1 Project Overview

The proposed project consists of the installation of a fibre optic communication line running from Dawson City, YT to Inuvik, NWT (see Figure 1). The Canada North Fibre Loop alignment extends approximately 780 km. Within the Yukon, the fibre optic line begins at Dawson City, runs eastward generally following the existing Yukon Highway 2 ROW, until turning northward at the Dempster Highway (Yukon Highway 5). The proposed line will diverge from this route briefly to the east of Dawson (along the Highway 2 portion of the alignment) when it instead follows Hunker Creek Road then an existing power transmission corridor before reconnecting to Yukon Highway 2. Once heading northward from the junction of the Yukon Highway 2 and Yukon Highway 5, the fibre optic line follows the existing Dempster Highway corridor until reaching the NWT border where the Dempster Highway continues along NWT Highway 8 ROW. Installation will be facilitated by a number of different methodologies including, plough burial, shallow depth plough burial, horizontal directional drilling, and aerial suspension. As such, ground impact related to this project should be minimal, but will include trenching and drilling, and possible impacts related to mobilizing trenching, drilling, and cable laying/hanging equipment to the work areas.

This PHFA work was aimed at ground truthing the heritage resource potential predictions made in a preceding Heritage Resource Overview Assessment (HROA) study conducted by Ecofor (see Mooney and Bennett 2016). Based on the results of the HROA, the PHFA phase of this project focused on the in-field assessment of 598 landform-based areas of potential (AOPs; 321 of which are located within the Yukon), 606 water feature-based AOPs (392 of which are located within

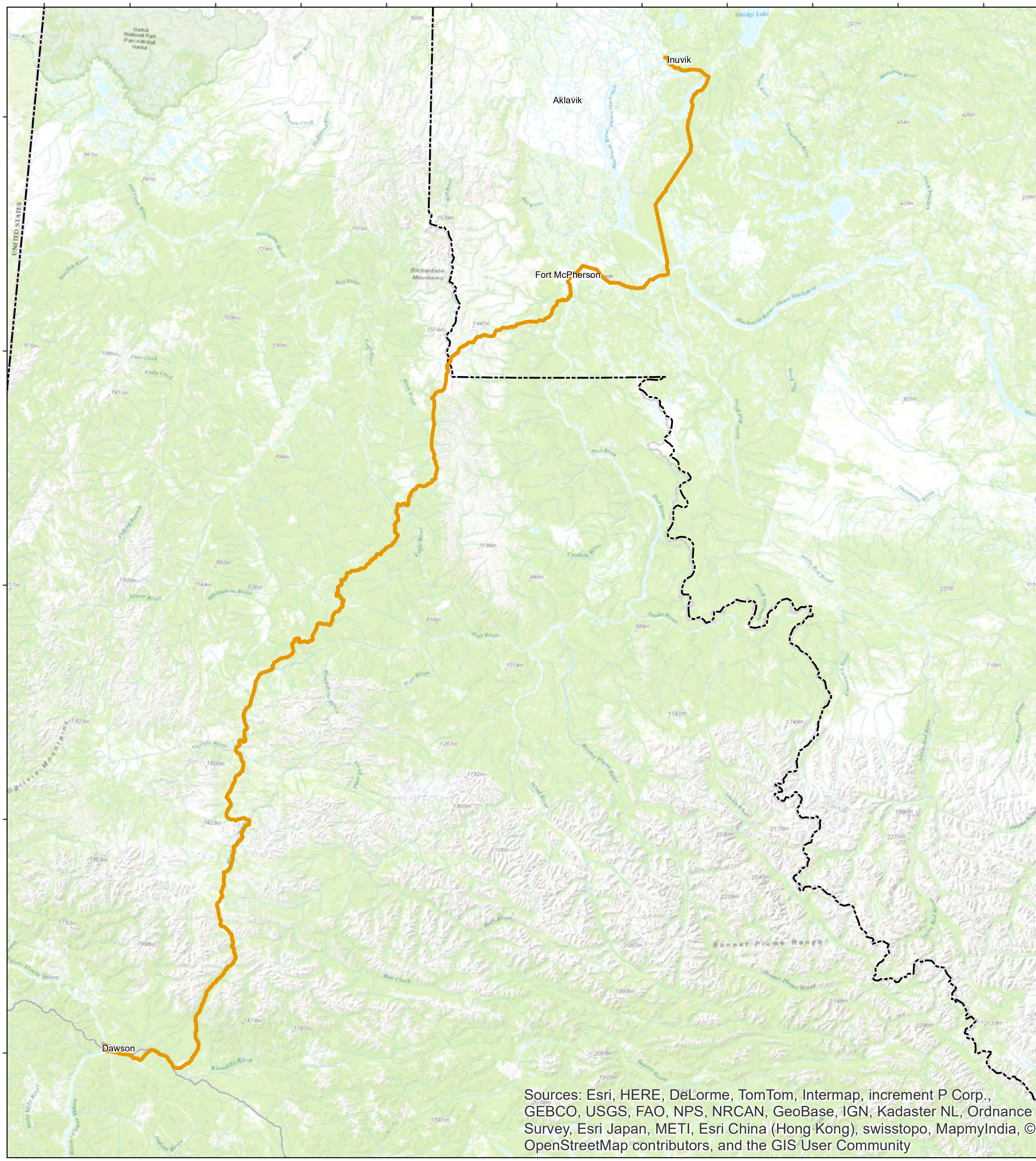

FIGURE 1

Canada North Fiber Link – Phase 1 Dempster Highway Project Overview

Ecofor Consulting Ltd. February-01-17 (MM)

1:2,500,000

0 50 100Km

NAD 1983 UTM Zone 8N

Disclaimer: This product is for informational purposes only and may not have been prepared for or be suitable for legal, engineering, or surveying purposes.

Project Centerline

YK / NT

the Yukon), and 31 previously recorded archaeological sites (29 of which are located in the Yukon) located within a 100 m buffer to either side of the Dempster Highway centerline. Seven historic sites recorded in the Yukon Historic Sites Inventory (YHSI) were also assessed (note: YHSI sites within Dawson are not individually discussed in this report due to their high number and because they are not expected to be impacted by development – if any structures will be impacted in the final build plan further work to determine their YHSI status and develop impact mitigation strategies will be required). Finally, three culturally sensitive areas brought forth by the Gwich'in Tribal Council (two in the Yukon and one in the NWT) during the permitting process for this study were investigated.

1.2 Personnel

The project area was assessed by Ecofor employee Tim Bennett (permit holder).

1.3 Report Format

Following this introduction in Section 1.0, Section 2.0 provides a discussion of the environmental setting that the study area is located within, Section 3.0 discusses the culture history of the area in which the proposed development is located, Section 4.0 details the methodologies employed in completing this work, Section 5.0 presents the results of this PHFA, Section 6.0 provides a summary and recommendations for the ongoing management of heritage resources within the assessed project area, and Section 7.0 closes the report with a listing of references cited. Three appendices are included at the end of this report[1]. Appendix A shows project mapping, Appendix B provides project photographs, and Appendix C includes the project field notes.

[1] Note: These appendices have been removed from this YESAA ready version of this report so that it can be issued publicly while protecting sensitive site data.

2.0 ENVIRONMENTAL SETTING

The Yukon portion of the study area is located within Boreal Cordillera and Taiga Cordillera Ecozones (see Smith et al. 2004 for full discussion). Within the Boreal Cordillera Ecozone, the study area crosses portions of two ecoregions: Klondike Plateau and Yukon Plateau – North. Within the Taiga Cordillera Ecozone, the study area crosses an additional four ecoregions: British-Richardson Mountains, Eagle Plains, Mackenzie Mountains, and North Ogilvie Mountains. Further detail regarding these ecoregions is presented below.

2.1 British-Richardson Mountains Ecoregion

The British-Richardson Mountains Ecoregion is characterized by steep, V-shaped valleys in the higher ranges and gently sloping pediments where the valleys are broader (Smith et al. 2004). It includes the British, Barn, and Richardson mountain ranges (Rampton 1982). Collectively, these mountain ranges are often referred to as the Arctic Mountains or Ranges (Bostock 1948; Hughes 1987). These mountains have remained largely unglaciated throughout the Quaternary Period, with the exception of minor alpine glaciation in the British Mountains and on the eastern flank of the Richardson Mountains (Smith et al. 2004). Elevation ranges from 40-1610 m a.s.l. Several large rivers flow through the British-Richardson Mountains Ecoregion, including the Malcolm, Firth, Babbage, Blow and Big Fish Rivers which drain the northern portion northward into the Beaufort Sea and the Porcupine, Bell and Eagle Rivers which drain more southerly lands into the Peel River watershed (Smith et al. 2004).

Due to the latitude, the sun remains above the horizon from early June to mid-July, and below the horizon from early December to early January. Mean annual temperatures in the British-Richardson Mountains Ecoregion are near –7.5°C (Smith et al. 2004). In January, mean temperatures typically range from -20 to -25°C, but can climb to -5°C or drop to -40°C, particularly in the lower valley floors (Smith et al. 2004). Mean summer temperatures reach 10°C in July, but can vary from near freezing to 25°C (Smith et al. 2004). Spring or summer conditions are generally delayed until early June. Precipitation is relatively moderate, ranging from 250 to 400 mm annually (Smith et al. 2004). The heaviest precipitation is from June through August over the Richardson Mountains. Precipitation remains moderate through to December, and falls mainly as snow from September onwards.

The bedrock geology of this ecoregion largely consists of well-exposed sedimentary rocks, including sandstones, limestones, and shales, of Proterozoic to Cretaceous age and small Devonian granite intrusions (Smith et al. 2004). Three distinct geological structures are spanned by the British-Richardson Mountains Ecoregion: the British and Barn mountains consist of continental margin sediments and are part of the Arctic–Alaska Terrane (Wheeler and McFeely 1991), the region east of the mountains consists of a mid-Cretaceous extension basin called the Blow Trough (Smith et al. 2004), and the Richardson Mountains were formed when Paleozoic deep-water clastic sediments were uplifted by outward-verging thrust faults located at an interpreted westward-dipping crustal ramp (Lane 1996) in latest Cretaceous or early Tertiary time. Multiple mineral types have been identified within the ecoregion, including lazulite, phosphatic iron manganese, uranium, molybdenum, tungsten, copper, magnetite, gypsum, and gold (Smith et al. 2004). Sedimentary rocks, such as chert and siltstone, with potential value as raw materials for stone tool production are also reported (Smith et al. 2004).

Surficial geology here is characterized by high relief created by frost action, mass wasting, and weathering of the areas unglaciated sedimentary bedrock (Smith et al. 2004). Tors, pinnacles, and dyke-like ridges are common features at high elevations. Middle and low elevation areas are typically covered by residual or weathered rock, or by soliflucted and colluvial materials which form fans and long, gentle pediment slopes. Modern processes affecting the surficial geology of the British-Richardson Mountains Ecoregion include colluviation, solifluction, and sheetwash (Smith et al. 2004). Soil formation has been heavily influenced by the available surficial geologic parent materials, as well as the subarctic climate and high relief of the ecoregion. Near surface permafrost is nearly continuous throughout the ecoregion except for localized occurrences of unfrozen ground along alluvial systems, glacio-fluvial terraces, and some well-drained south-facing slope deposits (Smith et al. 2004). Published data on permafrost thickness in this ecoregion is not available, but data from neighbouring areas suggest depths of 200 to 300 m (Burgess et al. 1982). The active permafrost layer is typically less than 0.5 m deep on pediments and lower slopes, but has been reported to reach 2.5 m at favourable well-drained upland sites (Rampton 1982).

As noted above, much of the British-Richardson Mountains Ecoregion remained unglaciated throughout the Pleistocene glaciations. Exceptions to these glacier free conditions are found in some high alpine areas (Smith et al. 2004), at the headwater of Malcolm River in the British Mountains (Duk-Rodkin et al. 2004), and east of Bell River in an unnamed peak in the Richardson Mountains (Duk-Rodkin and Hughes 1992). At its maximum extent, the Laurentide Ice Sheet extended up to 970 m a.s.l. in the southern Richardson Mountains, descending to 880 m a.s.l. in McDougall Pass (Smith et al. 2004).

Vegetation in the British-Richardson Mountains Ecoregion is largely dominated by shrub tundra with trees being limited to river valleys such as the Firth, Big Fish, Bell, and lower slopes with favourable aspects (Smith et al. 2004). The tree line ranges from 300 m a.s.l. in the northern part of the ecoregion to 600 m a.s.l. in the south (Zoltai and Pettapiece 1973; Ritchie 1984; Loewen and Staniforth 1997). On mountain and ridge crests, ranging from 330 to 1,600 m a.s.l., the vegetation is dependent on the soil parent material. A sparse cover of shrub willow, arctic bearberry, dryas, locoweed, and shrub birch is typical in shale and sandstone areas, but often occurs on only 10 to 20% of the ground surface (Ritchie 1984; Loewen and Staniforth 1997). Areas with calcareous soil parent materials a sparse, but floristically rich, dryas–sedge alpine community is typical with numerous forbs, including moss campion, northern sweet-vetch and anemone, and ground shrubs (Ritchie 1984). Tamarack and white spruce is sometimes found near the treeline on moist calcareous soils in the Richardson Mountains (Smith et al. 2004). Lower slopes often hold willow, shrub birch, alder, and ericaceous shrubs including mountain heather, blueberry, lingonberry, mosses, and forbs (Kennedy 1990; Smith et al. 2004). Pediments on the lower slopes tend toward sedge tussock communities, with Cottongrass, sedges, shrub birch, Labrador tea, blueberry, lingonberry, and mosses (Smith et al. 2004). The sheltered environments created by major river valleys can support white spruce, and recently affected floodplains can contain Balsam poplar (Smith et al. 2004).

Wildlife in the British-Richardson Mountains Ecoregion includes a number of large mammal species. It includes the primary Canadian calving area of the Porcupine barren-ground caribou herd (Fancy et al. 1994). Other large mammals include Dall sheep, moose, grizzly bear, and wolverine, with small mammals typically represented by singing vole and varying lemming (Smith et al. 2004). A wide variety of birds can also be found, including Surfbird, Baird’s Sandpipers, Hoary Redpolls, Horned Larks, Northern Wheatears, and Gray-Crowned Rosy Finch (Frisch 1975, 1987; Godfrey 1986) in the largely barren uplands, Rock Ptarmigan, American Golden-Plover, Whimbrel, Long-tailed Jaeger, and American Pipit in the sedge tussock tundra (Frisch 1975, 1987; Weerstra 1997), Willow Ptarmigan, Northern Shrike, American Tree, Savannah and White-crowned Sparrows, Smith’s Longspur and Common Redpoll in lower elevation shrubby tundra (Godfrey 1986; Frisch 1987; Weerstra 1997), Upland Sandpipers in sparsely treed subalpine bogs (Frisch 1987), and Gray Jay, Townsend’s Solitaire, Gray-cheeked Thrush, American Robin, Yellow-rumped Warbler and Fox Sparrow, Gray-Headed Chickadee, and Common Raven in more heavily forested areas (Frisch 1987; Weerstra 1997; Sinclair et al. 2003). Rough-legged Hawk, Golden Eagle, Peregrine Falcon, Gyrfalcon and Say’s Phoebe breed along the cliffs, banks, and canyon walls of the Firth River (Theberge et al. 1979; Canadian Wildlife Service 1995) and numerous water birds, including Harlequin Duck, Wandering Tattler, Loon, Tundra Swan, Northern Pintail, Long-tailed Duck, and Rednecked Phalarope (Frisch 1987; Godfrey 1986) exploit the ecoregion’s streams and rivers.

2.2 Eagle Plains Ecoregion

The Eagle Plains Ecoregion is characterized as is an intermontane basin of modest relief between the Richardson Mountains to the east and the North Ogilvie Mountains to the west (Smith et al. 2004). It includes the Eagle Lowland as defined by Matthews (1986), or part of the Porcupine Plateau and Porcupine Plain as defined by Bostock (1948) and Hughes (1987). The majority of the rolling low-relief terrain falls between 300 and 600 m a.s.l. (Oswald and Senyk 1977), although some mountainous areas reach as high as 1000 m a.s.l. and some river valleys as low as 250 m a.s.l. (Smith et al. 2004). The majority of the ecoregion drains to the north through the Whitestone, Porcupine, and Eagle River systems to eventually end up in the Yukon River watershed with the exception of the southeast corner which drains east via the Ogilvie, Peel, and Wind rivers to the Mackenzie River (Smith et al. 2004). Lakes are relatively rare in the Eagle Plains Ecoregion, but some oxbow and thermokarstic lakes are located within the floodplains of the Whitestone, Porcupine, and Eagle Rivers (Smith et al. 2004).

Due to its latitude, the Eagle Plains Ecoregion does experience periods of continuous daylight and darkness, however these periods are brief. Mean annual temperatures are near –7.5°C, but the area exhibits strong seasonal temperature variation (Smith et al. 2004). In January, average temperatures typically range from -31°C in lower valleys to -25°C at higher elevations (Smith et al. 2004). Summer temperatures are less affected by elevation, and average 13°C (Smith et al. 2004). Recorded extreme temperatures range from -60°C during winter to 30°C in summer (Smith et al. 2004). Precipitation is relatively moderate, with an annual average of 400 mm annually (Smith et al. 2004). The majority of this precipitation falls as rain during the summer months, primarily in showers, with the period between September and April being the driest part of the year (Smith et al. 2004).

The ecoregion's bedrock geology is characterized by Devonian through Cretaceous sedimentary rocks, including sandstones, siltstones, limestones, and shales, representing an intermontane basin sandwiched between the uplifted Richardson, North Ogilvie, and Dave Lord Mountain ranges (Smith et al. 2004). Lands within this ecoregion are not known for metallic minerals or significant coal deposits, but it does contain proven hydrocarbon reserves. Three of 11 test wells drilled before an exploration moratorium in 1968 intersected porous Carboniferous and Permian sandstone in the Chance and Dagleish anticlines in the southern and southeastern part of the ecoregion are estimated to contain 2.8 x 10^9 m^3 of gas and 3.1 x 10^6 m^3 of oil (T. Bird, in Hamblin 1990).

Surficial geology is characterized by colluvial deposits throughout most of the ecoregion, with the remainder consisting of alluvial sediments along river systems and a few glaciofluvial and glaciolacustrine deposits associated with meltwater generated by glacial activity outside the ecoregion (Smith et al. 2004). Modern processes affecting the surficial geology include thermokarst subsidence and soil creep, cryoturbation, solifluction, and active layer detachment slides on shale (Smith et al. 2004). Permafrost is discontinuous, but can be up to 200 m thick in places, with taliks focused in major river valleys (Thomas and Rampton 1982).

The majority of the Eagle Plains Ecoregion is composed of unglaciated terrain with some exceptions to this trend in parts of the Nahoni Range where there is scattered evidence of a past local glaciation of undetermined age (Smith et al. 2004). However, glacial processes in neighbouring ecoregions have influenced the major rivers in Eagle Plains, with up to three levels of glacially controlled terraces present along some drainages (Thomas and Rampton 1982). Major meltwater outlets exited the eastern slopes of the North Ogilvie Mountains and the northern slopes of the South Ogilvie Mountains via Ogilvie, Miner, Whitestone, Blackstone, and Hart Rivers channels (Smith et al. 2004). Moreover, during the Late Wisconsinan glacial maximum (ca. 30 ka; Hughes et al. 1981; Schweger and Matthews 1991) the Laurentide Ice Sheet blocked drainage of the Peel River and its southern tributaries forming Glacial Lake Hughes, which diverted the drainage northward through the Eagle River discharge channel (Duk-Rodkin and Hughes 1995). Glacial Lake Hughes received all the water exiting the Mackenzie and Wernecke mountains and the Ogilvie, Blackstone, and Hart river basins. Consequently, the Eagle and Porcupine rivers were the two major contributors to the inundation of the Old Crow, Bluefish, and Bell basins (Smith et al. 2004).

In terms of vegetation, black spruce-tussock/shrub tundra with understories including shrub birch, Cottongrass tussocks, bog cranberry, cloudberry, Labrador tea, crowberry, lingonberry, spirea, lichen, and moss is typical on the lower slopes (Zoltai and Pettapiece 1973). Upland areas are dominated by black and white spruce woodlands with understories of Labrador tea, shrub birch, willows, alder, blueberry, rose, lowbush cranberry, spirea, moss, and lichen (Smith et al. 2004). Here white spruce is most common in better drained areas (Russell et al. 1992; D. W. Murray 1997). Forest fires are a significant factor in these wooded areas. Pioneer species important in recolonizing burn areas include paper birch, aspen, and balsam poplar (Zoltai and Pettapiece 1973). The highest elevation in the Eagle Plains Ecoregion, above approximately 800 m a.s.l., are typified by shrub tundra dominated by scrub birch, willow, and prostrate shrubs with some Cottongrass tussocks (Smith et al. 2004).

Mammalian biodiversity is relatively low in the Eagle Plains Ecoregion compared to other Taiga Cordillera ecoregions due to a lack of suitable habitats for many of the rodent and ungulate species found elsewhere (Smith et al. 2004). However, representative species present do include several predators including wolf, wolverine, grizzly and black bear, marten, ermine, and red fox (Smith et al. 2004). Barren-ground caribou of the Porcupine herd also utilize this area primarily in the fall and winter, and several species of vole can be found (Smith et al. 2004). Bird populations are more diverse, with riverine areas providing habitats for Common Merganser, Spotted Sandpiper, Herring and Mew Gulls, Bald Eagle, Belted Kingfisher, and Bank and Cliff Swallow colonies, as well as key nesting habitat for Peregrine Falcon along the Porcupine and Eagle rivers (Hayes and Mossop 1978; Frisch 1987; Peepre and Associates 1993). Wetland areas are inhabited by small numbers of Pacific and Red-throated Loons, Tundra Swan, Greater White-fronted Goose, Canada Goose, American Widgeon, Green-winged Teal, Bufflehead, Lesser Yellowlegs, Solitary Sandpiper, and Common Snipe (McKelvey 1977; Frisch 1987). Swift mountain streams support breeding populations of Harlequin Duck and American Dipper, while riparian thickets provide breeding habitat for Willow Ptarmigan, Alder Flycatcher, Yellow Warbler, Wilson's Warbler, American Tree Sparrow, and Lincoln's Sparrow (Frisch 1987). Upland forests provide year round homes for Northern Goshawk, Spruce Grouse, Northern Hawk Owl, Three-toed Woodpecker, Gray Jay, Common Raven, Boreal Chickadee, Pine Grosbeak, Whitewinged Crossbill, and Common Redpoll (Frisch 1987). Other species, such as Gyrfalcon and Willow Ptarmigan, migrate to these forests to winter, while other, including Swainson's, Gray-cheeked, and Varied Thrushes, Bohemian Waxwing, Yellow-rumped and Blackpoll Warblers, and Dark-eyed Junco migrate north each spring to breed in these forests (Frisch 1987). High elevation alpine tundra areas support low numbers of Golden Eagle and Rock Ptarmigan, and may be used in summer by small numbers of Horned Lark, American Pipit, and Gray-crowned Rosy Finch (Frisch 1987). Upland Sandpiper and Townsend's Solitaire breed in the subalpine zone (Frisch 1987).

2.3 Klondike Plateau Ecoregion

The Klondike Plateau Ecoregion is characterized by smooth topped ridges with some outcrops of exposed rock known as Tors. These ridges are dissected by deep, narrow, V-shaped valleys (Smith et al. 2004). Its boundary conforms fairly well to the Klondike Plateau physiographic subdivision of the Yukon Plateau (Bostock 1948; Matthew 1986), although north of the Willow Hills it does not extend as far eastward. Elevation ranges from approximately 290 m a.s.l. to over 2,000 m a.s.l. with its highest point at the summit of Apex Mountain at 2,026 m a.s.l. (Smith et al. 2004). Most ridges peak at 1,200 to 1,700 m asl, with local relief ranging from 450 to 700 m a.s.l. (Smith et al. 2004). Unlike other ecoregions in the area, this plateau has not been glaciated in the recent past (Smith et al. 2004). The Dawson Range is the most distinct topographic feature within this ecoregion. It also contains the Wellesley Depression in the southwest and part of the Tintina Trench. Several major rivers drain the Klondike Plateau Ecoregion, including Yukon, Klondike, Stewart, Pelly, Fortymile, Nisling, Donjek, White Rivers.

The climate in the Klondike Plateau has a strong seasonal variation. Mean annual temperatures are -5°C, but it is also home to the coldest recorded temperature in North America at -62.8°C (Smith et al. 2004). Mean temperatures for January are -23 to -32°C, and in July from 10 to 15°C (Smith et al. 2004). Precipitation is moderate with annual amounts of 300 to 500 cm, with generally higher levels in the southeast compared to the northwest (Smith et al. 2004). The winter months have mean amounts of 10 to 20 mm while the summer months can expect rainfall amounts of 50 to 90 mm (Smith et al. 2004). The heaviest precipitation originates from rain showers and thunderstorms in the summer months. Paleoclimate reconstruction from the southern Yukon indicates higher temperatures and/or drier conditions from 6,700 to 4,700 before present (BP), followed by a long period of reduced temperatures and/or increased precipitation (Farnell et al. 2000). A warm period is speculated from 1,440 BP to 1,030 BP, followed by the colder temperatures of the Little Ice Age.

The ecoregion's bedrock geology constitutes a large part of the Yukon–Tanana Terrane, a composite of crust blocks that include former volcanic island arc and continental shelf depositional environments (Mortensen 1992). These metasedimentary rocks are intruded and overlapped by granitic and volcanic rocks, and overlain by fault-bounded slices of serpentinized ultramafic rock of the Slide Mountain Terrane (Smith et al. 2004). This base has been exposed and weathered for at least 15 million years, resulting in the creation of tors atop broad ridges mantled with fields of large angular, frost-heaved rock fragments (Smith et al. 2004). Volcanic processes have also contributed to the Klondike Plateau bedrock geology. The gold that the Klondike is famous for largely originates from quartz veins (Knight et al. 1994) that have been eroded and the gold concentrated by pre-Ice Age rivers (>3 Ma) in placer deposits. The principal formation containing placer gold is the White Channel gravel, but a few bedrock gold veins have also been documented in the ecoregion (Mortensen et al. 1992). This bedrock bound gold and the placer gold deposits are actively sought by the mining industry. Copper and chrysotile asbestos have also been the focus of mining efforts in the Klondike (Smith et al. 2004).

Surface cover is dominated by colluvium, with alluvium and glacial outwash terraces found along major river systems (Smith et al. 2004). Colluvial sediments in the lower valleys tend to be thick, silty, and often capped with peat or mud whereas upland colluvium tends to be rubble from degraded bedrock (Smith et al. 2004). Aeolian silts are also common at the surface in many areas, and periglacial features, such as cryoplanation terraces, patterned ground and solifluction lobes, can be found at higher elevations (Smith et al. 2004).

The modern Klondike Plateau Ecoregion is largely unglaciated, with the exception of localized glaciers that originating from the headwaters of the Sixtymile River Valley, and local peaks in the eastern Dawson Range and Kluane Ranges into the Wellesley Basin (Smith et al. 2004). However, the topography and hydrology have been impacted by glacial processes in the past, including the formation/disappearance and resulting outwash of Glacial Lake Yukon >3 Ma and Glacial Lake Dawson during the Reid Glaciation (Smith et al. 2004). The McConnell Glaciation was restricted to mountain valleys beyond this ecoregion, but outwash from affected areas did flow through the Klondike Plateau Ecoregion and related deposits are found in the lower Klondike River Valley (Smith et al. 2004).

The flora of the Klondike Plateau ranges from boreal forest in the valleys and low slopes, to alpine and tundra on the ridge crests. Black and white spruce forests dominate this ecoregion, in both pure and mixed stands (Smith et al. 2004). Other tree types include balsam poplar, paper birch, pine, water birch, and trembling aspen. Foliose lichens, Reindeer lichen, black spruce sphagnum, and feathermoss dominate the ground layer while shrub birch, willow, Labrador tea, alder, alpine blueberry, and ericaceous ground shrubs dominating the shrub layer. The highest frequency of lightning strikes in the Yukon occurs in this ecoregion. Forest stands are often taken by fire disturbance, with young immature stands more common than mature stands over much of the ecoregion (Smith et al. 2004).

The wildlife in the area contains barren-ground and woodland caribou (namely the Fortymile Caribou herd). Other mammals native to the area include moose, black bear, grizzly bear, wolf, mule deer, lynx, wolverine, marten, woodchuck, and snowshoe hare (Smith et al. 2004). This ecoregion was historically one of the more biologically productive in the Yukon. The Fortymile caribou herd was estimated at having been as large as 500,000 in the mid-19th century and ranged from Fairbanks, AK to Whitehorse, YT. However, in 2001 the herd was estimated at only 40,000 individuals. Many factors have contributed to this decline, including wildfires, overharvesting, and food limitations. A management plan has been put into place in an attempt to rebuild the herd and restore the once highly active biological productive ecoregion.

2.4 Mackenzie Mountains Ecoregion

The Mackenzie Mountains Ecoregion is characterized by broad u-shaped valleys and bare mountain ridges (Smith et al. 2004). It includes the portions of the Mackenzie Mountains, including the Bonnet Plume Range and the Knorr Range in northeastern Yukon, and the northern portions of the Backbone and Canyon ranges, as well as the South Ogilvie and Wernecke mountains (Matthews 1986; Smith et al. 2004). Terrain ranges from 400 m a.s.l. to 2,750 m a.s.l. in elevation with the majority falling between 750 and 1,500 m a.s.l. (Smith et al. 2004). Mount McDonald is the highest of the mountains within the ecoregion. The mountain ranges here form part of the Mackenzie–Yukon hydrologic divide. Major rivers in the northern part of the ecoregion, including the Ogilvie, Blackstone, Hart, Wind, Bonnet Plume, and Snake, drain north into the Mackenzie River and Beaufort Sea (Smith et al. 2004). In the southern part of the ecoregion the Stewart, Nadaleen, McQuesten, and Klondike Rivers flow to the Yukon River and Bering Sea (Smith et al. 2004). Lakes are uncommon, and tend to be small where they do occur.

Mean annual temperatures in the Mackenzie Mountains Ecoregion are near –6°C. Seasonal variability is less extreme than in many other ecoregions in the Yukon. In January, average temperatures fall around -25°C while July temperatures average 8°C (Smith et al. 2004). Recorded extreme temperatures range from -50°C during winter to 30°C in summer on the valley floors, but only range from -35°C to 15°C at higher elevations (Smith et al. 2004). Frost and/or thawing temperatures can occur year round in the ecoregion. Precipitation is relatively heavy with 450 mm to 600 mm annually with July and August being the wettest months and the period between December and May being the driest (Smith et al. 2004). Snow is possible year round.

In terms of bedrock geology, the entire ecoregion lies within the Cordilleran Foreland Fold and Thrust Belt (Gabrielse and Yorath 1991). Sedimentary carbonate rocks form as steep and rugged ridges, with clear mountain-scale folds, while recessive siltstone, shale, and major faults underlie the intervening valleys (Smith et al. 2004). The oldest of these rocks date to as long as 1.6 billion years ago, forming in the Early Proterozoic (Smith et al. 2004). These oldest rocks are overlain in places by somewhat younger rocks (Late Proterozoic ~750 Ma to 600 Ma) belonging to the Wernecke Supergroup (Delaney 1981), the Mackenzie Mountain Supergroup (Smith et al. 2004), the Fifteenmile Group (Thompson 1995), and Pinguicula Group (Thorkelson and Wallace 1995), then even younger materials of Upper Paleozoic through Jurassic age (Smith el al. 2004). A multitude of metallic minerals are known in the Mackenzie Mountains Ecoregion, including uraniferous mineral brannerite, abundant iron as hematite, copper, barium, cobalt, lead, zinc, lead, nickel, platinum, arsenic, uranium, and gold (Archer and Schmidt 1978; Turner and Abbott 1990; Bremner 1994; Smith et al. 2004). Coal seams are also common in the northeast and northwest portions of the ecoregion (Smith et al. 2004).

Colluvial deposits related to long exposed and weathered surfaces dominate the majority of the surficial geology of the Mackenzie Mountains Ecoregion with approximately 70% coverage (Smith et al. 2004). Glacial deposits, primarily within glaciated valleys, cover an additional 25%, with the remaining 5% being organic, alluvial, and lacustrine deposits (Smith et al. 2004). Modern processes affecting the surficial geology include landslides, rotational slumps, rock fall, and debris flows in areas of exposed rock, solifluction and soil creep in permafrost areas, and active rock glaciers (Smith et al. 2004). The southern boundary of the continuous permafrost zone runs through this ecoregion, with some thawed areas resulting in thermokarstic lakes (Smith et al. 2004).

Several pre-Reid glaciations recorded within the Mackenzie Mountains Ecoregion in the Tintina Trench and along the northern slopes of the South Ogilvie Mountains (Duk-Rodkin 1996). Further evidence from younger glaciations, the Reid (ca. 200 ka) and the McConnell (ca. 23 ka), can be found in most mountain valleys (Duk-Rodkin 1996; Kennedy and Smith 1999). The Wernecke Mountains portion of the ecoregion was largely covered by the Cordilleran Ice Sheet that merged with local glaciers from the South Ogilvie Mountains (Smith et al. 2004). The Snake and Bonnet Plume river valleys, in the northern part of the ecoregion, were affected by the Late Wisconsinan Laurentide Ice Sheet (ca. 30 ka; Hughes et al. 1981; Schweger and Matthews 1991), which blocked the drainage of all streams in the Mackenzie and Wernecke mountains, creating a meltwater channel system that exited through a meltwater channel connecting the Arctic Red, Snake, and Bonnet Plume Rivers and the Bonnet Plume Depression, and drained into Glacial Lake Hughes (Duk-Rodkin and Hughes 1995).

Vegetation within the Mackenzie Mountains Ecoregion generally consists of alpine tundra at higher elevations with valleys of taiga forest (Smith et al. 2004). The treeline sits at approximately 1,200 m a.s.l. (Smith et al. 2004). Areas above 1,500 m a.s.l. are typically bare rock or rubble with lichens and sparse forbs, graminoids, and bryophytes in sheltered pockets (Kennedy and Smith 1999). Some gentler high elevation slopes may also include dwarf willow and ericaceous shrubs (Jingfors and McKenna 1991). Mid-elevation mountain slopes and subalpine river valley terraces are dominated by shrub birch-willow communities (Russell et al. 1992; MacHutcheon 1997; Kennedy and Smith 1999), with understories of net-veined willow, lowbush cranberry, Labrador tea and lichen in drier areas and moss, lichen, and commonly bearberry, lowbush cranberry, alpine blueberry, cloudberry, and sometimes horsetail in wetter areas (Smith et al. 2004). At low elevations, stands of black and white spruce or mixed stands of spruce, aspen, paper birch and balsam poplar are common, with understories including Labrador tea, willow, rose, soapberry and alpine blueberry, horsetail, lupine, and bear root (LGL 1981; Stanek et al. 1981; Kennedy 1992; MacHutcheon 1997). Lodgepole pine and subalpine fir are largely absent from the ecoregion (Smith et al. 2004).

A number of large mammals populate the Mackenzie Mountains Ecoregion, including grizzly bear, wolverine, Dall sheep, and Stone sheep (Barichello et al. 1989; Smith et al. 2004). Woodland caribou of the Bonnet Plume, Hart River, and Redstone herds. The Bonnet Plume herd (n=~5,000 individuals) and the Redstone herd (n=~10,000 individuals) are among the largest woodland caribou herds in the Yukon (Smith et al. 2004). Smaller mammals include collared pika, singing vole, and Ogilvie Mountains lemming, deer mouse, least chipmunk, and hoary marmot (Smith et al. 2004). Bird populations in higher elevations include a wide range of species such as Townsend's Solitaire, Willow Ptarmigan, Northern Shrike, Wilson's Warbler, American Tree, White-crowned, Golden-Crowned Sparrows, Rock Ptarmigan, White-tailed Ptarmigan, Northern Wheatear, Gray-crowned Rosy Finch, Horned Lark, Surfbird, Short-eared Owl, American Pipit, Golden Eagle, and Gyrfalcon (W. H. Osgood 1909; Frisch 1975, 1987; Sinclair 1995, 1996; Canadian Wildlife Service 1995). Lower elevation forests provide homes for Merlin, Northern Flicker, Swainson's Thrush, Yellow-rumped Warbler, Blackpoll Warbler, Dark-eyed Junco, Peregrine Falcon, Northern Goshawk, Northern Hawk Owl, Three-toed Woodpecker, Gray Jay, Common Raven, and Boreal Chickadee (W. H. Osgood, 1909; Frisch, 1975, 1987; Canadian Wildlife Service 1995). Although waterbird populations are low due to limited suitable habitat, Harlequin Duck, Wandering Tattler, American Dipper, Trumpeter Swans, Mew Gull, Belted Kingfisher, and Solitary and Spotted Sandpipers (W. H. Osgood 1909; Frisch 1987, McKelvey and Hawkings 1990) can be found within the Mackenzie Mountains Ecoregion. And finally, riparian thickets support several species of songbird including Alder Flycatcher, Orange-crowned Warbler, Yellow Warbler, Northern Waterthrush, Savannah Sparrow, and Lincoln's Sparrow (Frisch 1987).

2.5 North Ogilvie Mountains Ecoregion

The North Ogilvie Mountains Ecoregion is characterized by low relief mountains with strata of light grey limestone and dolostone, unvegetated summits, and cliff bands (Smith et al. 2004). It includes North Ogilvie physiographic region, the Keele Range, part of the Dave Lord Range, and the Central Ogilvie Mountains (Smith et al. 2004). Terrain ranges from 280 m a.s.l. to 1,860 m a.s.l. (Smith et al. 2004), with the northern portion consisting primarily of flat-topped hills and eroded remnants of a former plain (Oswald and Senyk 1977) whereas the southern portion holds higher mountains with deep cut valleys providing as much as 1,200 m of topographic relief (Smith et al. 2004). Rivers within the ecoregion include the Ogilvie, Blackstone, Hart, Whitestone, Miner, Fishing Branch, and Bluefish Rivers. Lakes and wetlands are rare (Smith et al. 2004).

Mean annual temperatures in the North Ogilvie Mountains Ecoregion range from -7°C to -10°C (Smith et al. 2004). Seasonal variability is considerable due to the elevation. Winters last from October to May, with January mean temperatures of -30°C and extremes of -50°C to -60°C and rare warm winds that can bring temperatures above freezing (Smith et al. 2004). At high elevations, winter temperatures are often 10° higher than in lower valleys (Smith et al. 2004). Summers are brief, with average July temperatures of 12°C in low valleys and 6°C at higher elevations (Smith et al. 2004). Summer extremes can reach 30°C, but frost can occur at any time. Precipitation is relatively moderate, with an annual ranging from 300 mm to 450 mm (Smith et al. 2004). June through August is the wettest period with 40 mm to 60 mm per month typically as showers or thunderstorms with February to May being the driest (Smith et al. 2004). Snow is the main form of precipitation from September to May (Smith et al. 2004).

The bedrock geology of the North Ogilvie Mountains consists almost entirely of sedimentary rocks with no known granitic rocks (Smith et al. 2004). It incorporates the Keele Range and the Taiga–Nahoni Fold Belt, which extends through the Nahoni Range and the North Ogilvie Mountains (Smith et al. 2004). The oldest exposed rock includes calcareous shale, quartzite, red and green siltstone, and thin-bedded dolostone that resembles other successions of the Late Proterozoic-to-Cambrian Windermere Supergroup (Smith et al. 2004). This material is overlain in places by Devonian formations of limestone, mudstone, siltstone, and sandstone, with notable shell and conglomerate beds (Norris 1997), Jurassic siltstone with softer shale and harder sandstone intervals, and Early Cretaceous sandstone and quartzite (Smith et al. 2004). At least six classes of mineral deposits are known in the North Ogilvie Mountains Ecoregion. Known minerals include galena, sphalerite, oolitic magnetite, banded iron, copper, cobalt, arsenide, silver, copper, and zinc (Smith et al. 2004). Coal seams are present in the Cretaceous Kamik Formation (Smith et al. 2004).

Bedrock exposures account for roughly 20% of this ecoregion's surficial geology, with many tors at summits and mid- to high-elevation slopes formed from eroded shales, sandstones, and dolomites (Smith et al. 2004). Approximately another 30% of the surface is covered by colluvium on pediments and other eroded slopes, with gentler slopes frequently overlain with loess and/or silty colluvium and capped with organic material (Smith et al. 2004). Glacial deposits, including till and glaciofluvial outwash, account for an additional 35% of the ecoregion (Smith et al. 2004). The remainder, often represented by low-lying valley bottoms, is characterized by earth hummocks and tussock fields (Smith et al. 2004). Modern processes affecting the surficial geology are typically associated with landslides, rock slides, debris flows, and periglacial processes such as soil creep, solifluction, and active layer detachment slides (Smith et al. 2004).

The North Ogilvie Mountains Ecoregion contains glaciated terrain in some areas, but has been largely unglaciated for at least two million years (Smith et al. 2004). In pre-Reid glacial periods, a discontinuous ice-free corridor existed between extensive alpine glaciers that formed in the at high elevations, resulting in extensive pediments in unglaciated areas, and subdued highly colluvial moraines, drainage diversions, and outwash plains or terraces in once glaciated places (Smith et al. 2004). Similar features associated with the more recent Reid and McConnell Glaciations tend to be similar, but better defined (Smith et al. 2004). The unglaciated nature of most lands within the North Ogilvie Mountains Ecoregion has resulted in the development of largely continuous permafrost with an estimated depth of 300 m to 700 m (Smith et al. 2004). Paleomagnetic data from stalagmites in caves south of Old Crow suggests that this permafrost formed in the early Quaternary and has been present ever since (Lauriol et al. 1997).

The vegetation communities in the North Ogilvie Mountains Ecoregion are influenced by the high incidence of calcareous sedimentary bedrock, which fosters numerous calcium-loving plants; many of these are considered rare glacial relicts (Kennedy and Smith 1999). Alpine tundra vegetation dominates the higher elevations, while lower valleys are characterized by spruce taiga communities (Smith et al. 2004). The treeline sits at approximately 900 m a.s.l. (Oswald and Senyk 1977). Common plants in the sparsely vegetated higher areas include sedges and forbs, typically including *Dryas integrifolia*, *Saxifraga tricuspidata*, *Parrya nudicaulis*, and rare *Eritrichium aretioides* (Stanek et al. 1981; Brooke and Kojima 1985). Where the underlying bedrock is more acidic, willow-ground shrub-lichen communities predominate (Stanek 1980). Lower ridges are dominated by low shrub tundra with shrub birch, low willows, blueberry, and lichens, while shrub-tussock tundra is primary on pediment slopes with near-surface permafrost (Smith et al. 2004). Below the treeline, well drained south facing slopes support white spruce–shrub–forb communities while flatter, wetter, areas tend toward black spruce–shrub–sedge tussock communities (Smith et al. 2004). The most productive vegetation zones are found on alluvial terraces as well as some protected, well drained, permafrost-free sites that support white spruce–feathermoss forests with trees reaching 30 m in height and an understory including willow, alder, rose, and Labrador tea, shade feathermosses, ground shrubs, diverse forbs, and horsetail (Smith et al. 2004). Fluvial and frequently flooded areas are dominated by dense stands of balsam poplar and willow (Stanek et al. 1981; MacHutcheon 1997; Kennedy and Smith 1999).

Large mammals include grizzly bear, wolverine, Dall sheep, Stone sheep, and woodland caribou of the Hart River and Porcupine herds (Barichello et al. 1989; Smith et al. 2004). Small mammals, such as Ogilvie Mountains lemming and collared pika are also common (Smith et al. 2004). Riverine and wetlands areas support a wide range of birds, including Canada Goose, Red-breasted and Common Mergansers, Mew Gull, Harlequin Duck, Red-throated Loon, Long-tailed Duck, Horned Grebe, American Widgeon, Mallard, Northern Shoveler, Northern Pintail, Green-winged Teal, Greater, Lesser Scaup, Bufflehead, Barrow's Goldeneye, Bald Eagle, Northern Harrier, Lesser Yellowlegs, Least Sandpiper, Common Snipe, Yellow Warbler, Savannah Sparrow, and Rusty Blackbird (Williams 1925; McKelvey 1977; Frisch 1987). Spruce forest birds include Northern Flicker, Say's Phoebe, Ruby-crowned Kinglet, American Robin, Yellow-Rumped Warbler, Fox Sparrow, Dark-eyed Junco, Gray Jay, Common Raven, and Boreal Chickadee (Williams 1925; Frisch 1987). Bogs and willow thickets near the treeline host Upland Sandpiper and Orange-crowned and Wilson's Warblers, while Northern Shrike, and Townsend's Solitaire reside in the adjacent subalpine forests (Frisch 1975, 1987). Higher elevation upland willow, alder, and low shrub birch areas provide habitat for Willow Ptarmigan, American Tree Sparrow, Whitecrowned Sparrow, and Common Redpoll (Brown 1979; Frisch 1987). Alpine meadow avians include American Golden-Plover, Baird's Sandpiper, Long-tailed Jaeger, Short-Eared Owl, American Pipit, and Smith's Longspur, while more barren uplands host Horned Lark, Northern Wheatear, and Surfbirds (Frisch 1987). And finally, raptors nesting on cliffs and rocky outcrops include Golden Eagle, Peregrine Falcon, and Gyrfalcon (Frisch 1987; Canadian Wildlife Service 1995).

2.6 Yukon Plateau – North Ecoregion

The Yukon Plateau – North Ecoregion is the largest ecoregion entirely inside the Yukon and contains a large portion of the Tintina Trench. The ecoregion generally consists of relatively rolling highlands with an east-west orientation. It includes the Stewart Plateau, the Macmillan Highland, and the Ross Lowland (Matthews 1986). Terrain ranges from 320 m a.s.l. to 2,160 m a.s.l., with an average elevation of 995 m a.s.l. (Smith et al. 2004). Rivers within the ecoregion include the Pelly, Ross, Macmillan, Stewart, Hess, McQuesten and Klondike (Smith et al. 2004).

The mean annual temperature in the Yukon Plateau – North Ecoregion is near -5°C, but seasonal variability is pronounced (Smith et al. 2004). Mean temperatures for January range from below -30°C in the lower valleys to above -20°C in higher terrain (Smith et al. 2004). This is drastically different by July as mean temperatures in the lower valleys are 15°C and close to 8°C in higher terrain (Smith et al. 2004). Frost can occur at any time of the year, but is less likely from mid-June to late July (Smith et al. 2004). Precipitation is moderate with an increase in higher elevation sections in the eastern part of the ecozone. Annual precipitation ranges from 300 to 600 mm (Smith et al. 2004). The winter months have mean precipitation of 20 to 30 mm while the summer months can expect 40 to 80 mm of rainfall (Smith et al. 2004). Winds are generally light, however they may increase to moderate/high during unusually active weather systems or thunderstorms (Smith et al. 2004).

The bedrock geology of this ecoregion includes sections of two geological provinces of metamorphosed sedimentary rock. In the northern half of the ecoregion, variably deformed sedimentary rocks have been deposited on the outer continental shelf of ancestral North America, the Selwyn Basin. The bedrock geology in the southeast part of the ecoregion includes siliceous sedimentary and volcanic rocks of the Yukon-Tanana terrane and metabasaltic flows of the Slide Mountain terrane. The origin of these materials is not well-known due to deformation before and during transportation onto the Selwyn Basin strate (Smith et al. 2004). The southeast section of the ecoregion between Faro and Ross River also includes exposed river and stream cut banks along the Tintina Trench (a 450 km fault) that contains rhyolite and olivine basalt which may have provided materials for prehistoric stone tool making. Also of interest in the northern Anvil Range are jet-black or gun steel-blue weathering siliceous siltstone and conglomerate containing chert pebbles. These materials may also have been used for making stone tools.

Soils in the valleys of this ecoregion tend to be underlain by glacial parent materials. Soil development also reflects the presence of extensive discontinuous permafrost and a strong continental climate (Smith et al. 2004). Of interest is the presence of the Wounded Moose and the Diversion Creek palaeosols. These two palaeosols are buried soils formed a great deal of time before the current environmental conditions and may reflect past stable ground surfaces. The Wounded Moose palaeosol developed on glacial surfaces of pre-Reid age and the Diversion Creek palaeosol developed between the Reid and the McConnell glaciations. Both of these palaeosols would predate the known cultural history in the Yukon.

The glacial history of the Yukon Plateau – North Ecoregion was dominated by the actions of the Cordilleran ice sheet and local glaciers. More recent glaciations were less extensive. Most current glacial features are remnants from the McConnell glaciation (Smith et al. 2004), however some older features and glacial erratics are present from the older Reid and pre-Reid glaciations. Some uplands and valley floors were extensively eroded into "whalebacks" or rock drumlins by the glacial flow. The western edge of the ecoregion was approximately the terminus for the ice sheet of the McConnell glaciation. As the ice retreated through regional stagnation and wasting it left behind kame and kettle topography and glacial lake deposits in many valleys (Smith et al. 2004).

The vegetation of the Yukon Plateau – North ranges from boreal to alpine. Northern boreal forest exists at elevations up to 1500 m a.s.l. (Smith et al. 2004). Open black spruce with a moist moss, or drier lichen understory is the dominant forest type in the boreal zone (Smith et al. 2004). Shrub and lichen tundra dominate the higher elevations (Smith et al. 2004). The alpine vegetation is characterized by low ericaceous shrubs, prostrate willows, and lichens. In the subalpine areas, shrub birch, with scattered pine, white spruce, subalpine fir, and a lichen understory is extensive (Smith et al. 2004). Extensive shrub lands exist at mid-elevations and on valley bottoms that are subject to cold air drainage. Black spruce is the dominate tree type in the ecoregion, however white spruce, occasionally with aspen or lodgepole pine, occur in warmer, better-drained areas and in forest fire burn areas (Smith et al. 2004).

The Yukon Plateau–North Ecoregion supports wildlife populations typical of Yukon's boreal forest. Moose, woodland caribou, Stone sheep, Dall sheep, grizzly bear, black bear, wolverine, and marten are all abundant. This ecoregion supports the greatest proportion of brown-coloured black bears in the Yukon, occurring between the Stewart and Pelly rivers (Yukon Department of Renewable Resources 1988). Lynx, beaver, chestnut cheeked vole, mule deer, coyotes, and red fox are also present in some sections of the Yukon Plateau – North (Smith et al. 2004). Of particular interest in the larger area are the Tay River Caribou herd, and an overlap of Stone and Dall Sheep, while mountain goats are uncommon. The Tintina Trench forms an important part of a migration corridor for Sandhill Crane and waterfowl (Smith et al. 2004). Wetlands provide habitat for Pacific, Red-throated and Common Loons, Trumpeter Swan, Canada Goose, American Widgeon, Green-winged Teal, scaup, and scoters (Dennington et al. 1983; Dennington 1985; McKelvey and Hawkings 1990). Osprey and Bald Eagle also breed around lakes (Dennington et al. 1983). Forested areas host Ruffed, Blue, and Sharptailed Grouse, Common Nighthawk, Yellow-bellied Sapsucker, Hairy Woodpecker, Western Wood-Pewee, Hermit Thrush, Townsend's Warbler, Spruce Grouse, Great Horned Owl, Three-toed Woodpecker, Black-capped and Boreal Chickadees, Gray Jay, Common Raven, Red-tailed Hawk, Northern Flicker, Olive-sided Flycatcher, Rubycrowned Kinglet, Swainson's Thrush, Varied Thrush, Yellow-Rumped Warbler, Blackpoll Warbler, and Dark-eyed Junco (W. H. Osgood 1909; Rand 1946; Johnston and McEwen 1983; Frisch 1987). And finally, in alpine areas Gyrfalcon, Rock and White-tailed Ptarmigan, Wandering Tattler, Gray-Crowned Rosy Finch, American Pipits, Willow Ptarmigan, Wilson's Warbler, American Tree Sparrow, and Golden-Crowned Sparrow can be found (W. H. Osgood 1909; Beckel 1975).

3.0 CULTURAL HISTORY

The following is an overview of the culture history for the broader region surrounding the study area including portions of the central and northeastern Yukon. Many researchers have reviewed the cultural history of this broader area and have presented the information using a variety of terms and temporal ranges (Clark 1981, 1983; West 1996; Workman 1978; Gotthardt 1990; J. V. Wright 1995, 1999).

3.1 Precontact Period (ca. 11,000 BP to ca. A.D. 1700s)

The earliest documented Precontact occupation of lands crossed by the study area, which dates to early post-glacial times, is known as the Northern Cordilleran Tradition (Clark 1983; Gotthardt 1990; Hare 1995). The earliest Northern Cordilleran Tradition occupation known at present is a site located near Beaver Creek, dated to 10,670 BP (Heffner 2002). The majority of sites associated with this tradition appear to date older than 7,000 to 8,000 BP. The Northern Cordilleran Tradition, with some overlap, predates the introduction of microlithic technology from Alaska into the interior of the central and southern Yukon (Clark 1983; Hare 1995).

The Northern Cordilleran Tradition is followed by the Little Arm Phase which dates from approximately 7,000 BP to 4,500 BP (Clark and Gotthardt 1999; Workman 1978), and can be defined by the use of microlithic technologies. After about 4,500 BP, there is less evidence of microblade use in the Yukon, and an increase in the use of notched projectile points, and a variety of scraping and carving tools, labeled the Taye Lake Phase in southwest Yukon, or more broadly in Yukon and Alaska, the Northern Archaic Tradition (Hare 1995; Workman 1978).

The most recent archaeological culture of southern Yukon is that of the Aishihik Phase (Workman 1978). This phase is thought to be a cultural development from the earlier Taye Lake culture, although there are some significant differences in technology. Key amongst these technological innovations are native copper tools, small stemmed Kavik points, end- and sidescrapers, and ground adzes (Hare 1995), but perhaps most notable is the introduction of the bow and arrow which replaced a type of throwing spear known as an atlatl as the primary hunting weapon (Hare et al. 2004). This transition from atlatl to bow and arrow technology has been clearly documented by recent finds from high elevation ice patches in the southern Yukon (Hare at al. 2004). These Aishihik Phase sites are found above the White River Volcanic ash layer (also known as Tephra) that is dated to about 1,250 radiocarbon years BP (Clague et al. 1995), and are correlated with the appearance of Athabaskan peoples who are thought to be the direct ancestors of the current Na-Cho Nyak Dun, Tr'ondëk Hwëch'in, and Gwitch’in First Nations peoples (see below).

3.2 Protohistoric Period (A.D. 1700s to ca A.D. 1840s)

The Protohistoric Period, as presented here, also overlaps with late Precontact/Athabaskan Period. It is defined by the appearance of non-native goods, other early trade items, and foreign (western or eastern) influences, but not the documented accounts of contact between indigenous North American peoples and European/Russian/Asian peoples themselves. Other indicators of the Protohistoric Period are the arrival of the first non-native diseases and information concerning non-natives. This period spans the time between the first introduction of non-native influences or artifacts, and the recording of first hand or primary written accounts. Unlike other cultural periods with more specific temporal ranges it is difficult and perhaps impossible to determine when the first 'outside' influences of European, Russian, Asian, or other cultures began to impact First Nations people in the Yukon interior.

Some of these far reaching effects may have been passed along from Russian exploration in the early and mid-1700s (Veniaminov 1984) and other Asian and European (Andreev 1944, Quimby 1985) exploration and contact with coastal communities. The Chilkat Tlingit from the Northwest Coast travelled and traded with many interior First Nation peoples throughout this Protohistoric Period including the Kaska and the Northern Tutchone from the Dawson and Mayo areas, and occasionally the Mountain Dene people from as far away as Fort Norman on the Mackenzie River. The Tlingit protected and controlled the trading routes into the interior and fiercely defended those routes when they were threatened. News of early non-native explorers and traders would have travelled inland along with foreign items such as metals, cloths, glass beads, and later tobacco and other goods.

In some of the earliest cases, the impacts of these foreign cultures could have had significant impacts even without the presence of the foreigners themselves. Such is the case for what is called 'drift-iron' whereby metals and other materials from Asian or European shipwreck wash ashore. Historical accounts of shipwrecks have been reported in the mid-1700s, but much earlier wrecks were possible. Metals and other foreign trade items have been derived from shipwrecks off what is now British Columbia, Southeast Alaska, and perhaps the Northwest Alaska as well.

3.3 Historic Period (post-A.D. 1840s)

During the early years of this period the Russians were expanding their exploration and trade network along the Pacific coast and up the major rivers of the Alaskan interior, while the British were exploring eastward into what would become Canada's Northwest and Yukon Territories, as well as Alaska. The North American based explorers and traders entered the Yukon through two main routes: from the north via Fort McPherson and from the south via Fort Liard. In the 1840s, representatives of the Hudson Bay Company established trading posts near portions of the study area, including those at Lapierre House (1846) and Fort Yukon (1847). The next year Robert Campbell established Fort Selkirk southeast of the project area on the upper Yukon River and then relocated to an improved location in 1851. This upset the Chilkat native trading population from the coastal area, who had controlled trade to the interior for many generations, and by 1852 increasing supply-line pressures, trade competition from the Chilkat traders, and flooding forced the Anglo traders to flee.

In 1867, US Secretary of State William Seward was able to focus increasing American interests, and he convinced the United States Senate to purchase Alaska from Russia. Soon after the purchase, the US Army sent Captain Raymond up the Yukon River on the first stern-wheel steamer to reach Fort Yukon (Grauman 1977). Raymond surveyed the location of Fort Yukon and proved that it was within U.S. territory. The British sold the Fort to the U.S. Government and relocated east across the 141st Meridian.

The inland fur industry continued to drive exploration and settlement into the late 1800s, but mining would shift the focus to the placer gold found in streams and alluvial deposits. Mining in the second half of the nineteenth century was a risky, but often very lucrative enterprise. The impacts of mining spread quickly and drastically changed the project area.

Mineral prospecting and mining efforts in the second half of the nineteenth century were, in some ways, dependent on the existing infrastructure of the fur trading and missionary efforts. As the competition for the inland fur trade grew, so would the number of stern-wheelers on the Yukon River. These steamers could better supply the small number of trading posts along the Yukon and its tributaries and reduce the risk of prospectors running short of supplies. Therefore, more of the fur traders and other explorers turned their attention to search for gold and other minerals. Three key prospectors to the north were L. S. (Jack) McQuesten, Al Mayo, and Arthur Harper. They wrote to miners in the United States to encourage them to come north. They also established outposts along the Yukon River, including Fort Reliance, established in 1874 near the confluence of the Klondike River (what would become Dawson City) (A. A. Wright 1976).

Harper and another man may have been the first to travel up the Fortymile River in search of gold in 1881 (Buzzell 2003). They collected a very rich sample, but were unable to relocate the exact location. In 1886, McQuesten, Harper, and Mayo built a post on the confluence of the Stewart and Yukon Rivers which provided supplies for additional prospectors. Also in 1886, Howard Franklin made a richer find on the Fortymile River. Others rushed in and these claims along the Fortymile River attracted miners from across Central, Eastern Alaska, and Southeast

Alaska. Fortymile was the first town to grow to over a thousand people by the mid-1890s (Buzzell 2003), and in 1887 the Stewart River post was deserted. Some prospectors that did not find easy success in Fortymile returned to the Stewart and continued work in the area. In 1890, Harper re-established a trading post at the site of the old HBC post at Selkirk as interest in the area grew. This was followed by Jack Dalton who developed a series of existing First Nation trails from tide water at Haines Alaska, into Fort Selkirk. Then, on August 16, 1896, George Carmack, Skookum Jim, and Tagish Charlie discovered a very rich claim on Bonanza Creek, a tributary to the Klondike River near Dawson. This discovery sparked one of the largest gold rushes in history.

It would take almost a year for the news of the Klondike gold fields to spread south, even to places relatively close by in southeast Alaska. Most of the prospectors and traders in the Alaskan and Yukon interior had already converged on the Dawson area during the winter and spring, and supplies ran dangerously low. That would quickly change in the summer of 1897 and spring of 1898 as new towns and supply posts sprang up along the Gold Rush routes to cash in on the increased demand.

The population of Dawson City grew very fast and in 1898 reached a peak of over 30,000. However, the boom period did not last long and the vast majority of population moved on very quickly with the news of other discoveries and hopes of other bonanzas. The Gold Rush period saw greatly increased steamer traffic on the entire Yukon River drainage basin and across the interior. Just prior to the Gold Rush there were only a few steamers, while at its peak there would be hundreds of vessels working the rivers. These shallow draft steamers were supported by a network of wood camps, shipyards, and a large workforce which kept the river traffic moving. This network provided the infrastructure backbone for trading posts, fish camps, missionaries, and mail routes, while meeting the needs of the growing number of prospectors and traders.

Since Dawson City is located on a flood plain at the confluence of the Klondike and Yukon Rivers it has had a long history of fighting with rising water levels. Flooding here is the result of either open water flooding at peak river flows, or the more dangerous spring ice jam events. Dawson City has been the victim of over twenty floods since 1898 (McCreath et al. 1988, Whitehorse Star 1979). The most significant of these were in 1925, 1944, 1966, 1969 and 1979. After flooding in the 1940s and 1950s Front Street was raised in an attempt to keep the waters out, but this did little to stop the flooding. A protective dyke was built around the City in 1959 and was later increased in 1968. The last major flood of Dawson City occurred in 1979 when ice jams on the Indian, Klondike, and the Yukon Rivers caused the spring waters to back up across the City. This prompted the construction of the improved dyke (to the 200 year flood level) in 1987 (McCreath et al. 1988). Dawson City served as the capital of the Yukon government from 1898 until 1952, when the seat was moved to Whitehorse.

The Yukon has also been host to oil and gas exploration efforts since the 1950s. The first well was drilled in the Eagle Plains Basin in 1957, but was declared dry in 1958 (Yukon Government Oil and Gas Resources Branch, n.d.). Exploration activity picked up again in the 1960s and 1970s, which played an important role in motivating the construction of the Dempster Highway (see Section 3.4). Interest in exploration has continued intermittently ever since, with 76 wells having been drilled to date in five of eight Yukon sedimentary basins (Eagle Plain, Beaufort Mackenzie, Peel Plateau and Plain, Kandik, and Liard Basins) between 1957 and 2013 (Yukon Government Oil and Gas Resources Branch, n.d.). Over 10,000 line-km of 2D and 3D seismic surveys have been conducted as part of these exploration efforts (Yukon Government Oil and Gas Resources Branch, n.d.). Six oil and gas pipelines have also been constructed in the Yukon, including four built during World War II as part of the Canol project, one built in the 1950s to supply American Air Force bases in Alaska during the Korean War, and the 2012 Spectra Energy pipeline built in 1972 to move natural gas from the Kotaneelee gas field in southeast Yukon to southern markets (Yukon Government Oil and Gas Resources Branch, n.d.).

3.4 The Dempster Highway

The Dempster Highway was first conceived in 1958 when the Canadian government committed to the construction of 671 km of new highway running from Dawson City, YT to Inuvik, NWT. At that time, oil and gas exploration was already underway in the Mackenzie Delta, and when additional reserves were discovered the following year in Eagle Plains the new highway became a priority for the government. Construction began at Dawson City in 1959, but high costs and disagreements between the Federal and Yukon governments resulted in the project being abandoned in 1961 after only 115 km had been completed (Yukon Info, n.d.). However, interest in the project was renewed in 1968 as a means of asserting Canadian sovereignty in the north following the discovery of oil and gas reserves by the Americans in Prudhoe Bay, Alaska (Yukon Info, n.d.). Funding was resumed in the early 1970s, and the highway was completed in 1978 then officially opened on August 18, 1979.

The Dempster Highway takes its name from Royal Canadian Mounted Police Inspector William John Duncan Dempster, who, as a young constable, frequently ran the dog sled trail from Dawson City to Fort McPherson, NWT that preceded the highway. In March 1911, Inspector Dempster was dispatched with two other constables to find fellow inspector Francis Joseph Fitzgerald and his team of three men who had failed to report at Dawson City when expected. Fitzgerald and his men became lost while searching and succumbed to exposure and starvation. Dempster and his men found the bodies on March 22, 1911 (North 2008).

3.5 Modern First Nations

3.5.1 Na-Cho Nyak Dun First Nation

The Na-Cho Nyak Dun First Nation (NND) are part of the Northern Tutchone language and culture group. In the past, the Tutchone peoples were highly mobile, travelling in small groups in order to exploit the greatest number of resources. They would modify their movements depending on the patterns of large game animals and fish, or in later years to trade their furs with Westerners. In the summer, small domestic units gathered together to catch fish so that they could dry and store it for the winter months. By mid-summer several family groups moved upland together in order to kill large game mammals that they would dry and store in caches scattered in a variety of areas. From there some units moved away independently during the coldest months to trap and live off of the cached foods. The leanest months were March and April. In spring, several units often came together at this point to catch spawning whitefish or trap muskrat and beaver. May was the most plentiful month, with migrating waterfowl, fat ground squirrels, larger and more abundant fish, as well as the arrival of the Coastal Tlingit traders (McClellan 1981).

The principal ethnographic descriptions of the Tutchone are available in Cruikshank (1974, 1975), Johnson and Raup (1964), McClellan (1950, 1964, 1970a, 1970b, 1975), and Tanner (1966). Additional information on camp and village locations can be found in Schwatka (1885a). Although villages were not inhabited year round, people would return to good fishing and/or hunting spots year after year. This would eventually change with the influence of Westerners. Watercraft were constructed for use, however during the summer months Tutchone people preferred to walk overland, rather than brave the sudden winds on the large lakes or the treacherous river rapids. Boats were not the preferred method of transport.

The NND First Nation remained somewhat isolated until the discovery of gold in the area in 1883 (Mayo Historical Society 1999). The NND are known to have used many traditional camps, lookout sites, hunting areas, berry patches, and trails in the larger project area with extensive use of rivers. McClellan (1981) summarized the common seasonal activities beginning in the spring with grayling fishing following spring break up. The NND people remained almost completely isolated from non-First Nation people, except for a few explorers passing through, until miners set up a supply post along the McQuesten River in 1886. The supply post soon turned into a village and from then on permanent camps and villages have existed in the larger area surrounding Mayo Lake. During the Duncan Creek gold rush, a trading post called Gordon Landing was established near the confluence of Janet Creek and the Stewart River. From there a trail allowed people to travel north partially along Davidson Creek to the confluence of Duncan Creek on the Mayo River. The Town of Mayo was established in 1903 and the people of McQuesten and a few other small encampments moved there or to the "Old Village" just outside of town (Mayo Historical Society 1999). This village made it possible for people to receive a western education, live close to Mayo, and continue their preferred way of life and cultural celebrations. Eventually the "Old Village" was abandoned when in 1958 the local health officials determined the drinking water was polluted and the NND were requested to move to the Town of Mayo. The First Nations people in the Mayo area officially chose the name "Na-Cho Nyak Dun" in 1987 which means "Big River People" in reference to the now named Stewart River.

3.5.2 Tr'ondëk Hwëch'in First Nation

The Project crosses portions of the traditional territory of the Tr'ondëk Hwëch'in (TH) based in Dawson City and the traditional gathering site of Moosehide. The TH are descendants of the Hän, an Athapaskan language speaking group, as well as a mix of Gwich'in, Northern Tutchone, Tagish, and Upper Tanana. This diversity reflects the importance of the Dawson and Moosehide area as a focal point for trade and the wide range of people drawn into the area in the late 19th Century (Crow and Obley 1981). The oral traditions and ethnographies of the TH were documented by C. Osgood (1971), A. H. Murray (1910), and Schwatka (1885b) among others. The name Hän was introduced by C. Osgood (1936a) as a shortened form of the name Han-Kootchin or People of the Water or People of the River.

The southernmost of three local Hän bands was known to be centered around the Klondike River near its confluence with the Yukon River. This band was associated with the gathering site of Moosehide and later, Dawson City (Crow and Obley 1981). The name of the village near the mouth of the Klondike River (on the west bank of the Yukon River) was written in a variety of recordings including Noo-klak-ó, Nu-kla-ko, and Nuklako while the Hän name for the Klondike River was recorded as "stone-for-driving-in-fish-trap-poles river" and čon-dik (Crow and Obley 1981), while the Hän name for the Klondike band is Tr'ondëk Hwëch'in.

The Hän people relied heavily on the variety and abundance of fish, and of these salmon played a critical role. The major salmon fisheries consisted of King spawning runs starting in June and July and Chum in August. The Hän people prepared for the runs and gathered on the Yukon River and its tributaries from early spring thru summer. Salmon were harvested in weirs, traps, gill nets, dip nets, and with spears and harpoons. Following the last run families dispersed into smaller fall season groups and hunted and collected resources before returning to river camps in October. Hunting methods included the bow with a variety of arrows (for small and large game as well as birds), spears for large game, and a variety of snares and traps for small and large game.

A focal part of the fall hunt was moose hunting and the return trips were often made downstream in moose hide boats. Travel was also dependent on birch bark canoes, snowshoes, and sleds. The river camps were used through most of the winter with the exception of trips into the higher elevations to hunt and bring back cached meat. The Hän where known to use two main types of housing structures. The moss house was a semi-subterranean square structure made with split wood poles and insulated with moss. While temporary structures used for traveling was a domed skin house. Caribou hunting was common in February and March, and the Fortymile caribou herd played a major role at this time of year. This would be followed by preparations for spring fishing and repairing equipment for the return of the salmon.

Contact with neighboring Nations was vital to First Nations economies. For example, interior First Nations traded hides, furs, and other resources great distances to coastal groups for fish oil, dentalium, woodwork, and blankets. Trails and travel corridors were an intrinsic part of this economy and traditional subsistence as a whole.

3.5.3 Gwitch'in Nation

The Gwitch'in Nation is an Athapaskan speaking group that includes First Nations/Native American peoples in the Yukon, Northwest Territory, and Alaska (VGFN 2009). Members of the greater Gwitch'in Nation include the Vuntut Gwitchin and Tetlit Gwitch'in in the Yukon, the Teetl'it Zheh Gwich'in, Gwichya Gwich'in, Ehdiitat Gwich'in, and Nihtat Gwich'in in the NWT (represented in this study collectively by the Gwitch'in Tribal Council [GTC]), and the Dendu Gwich'in, Draan'jik Gwich'in, Danzhit Hanlaih Gwich'in, Gwich'yaa Gwich'in, and Neets'ąįį Gwich'in in Alaska (McFadyen Clark 2016). Of particular significance to this project are the Vuntut Gwitchin, Teetl'it Zheh Gwich'in, Gwichya Gwich'in, and Nihtat Gwich'in, whose traditional territories/modern community centers are crossed by the proposed project. Oral traditions and ethnographies of Gwitch'in people have been documented by Krech (1976), Osgood (1933, 1934, 1936b), Petitot (1876, 1889), and Savishinsky and Hara (1981) among others.

Collectively, the traditional lifeways of the Gwitch'in people depended on hunting and fishing. Moose and caribou were of vital economic importance providing both food and hides for clothing and shelter, but salmon, white fish, hare, and plant foods such as berries and rhubarb were also significant sources of subsistence (McFadyen Clark 2016). Their traditional toolkit was similar to other subarctic Athapaskan groups, and included the bow and arrow, traps, snares, deadfalls, and nets for fishing. People also utilized caribou drift fences and pounds to improve hunting yields. Snowshoes, sleds, and canoes were all employed for greater mobility. Hide covered tents provided the primary source of shelter.

Many Gwitch’in people continue to rely on hunting and fishing for subsistence. While this practice is important to most Gwitch’in people for purely cultural reasons, it is especially relevant to the Vuntut Gwitchin (which translates to “people of the lakes”), who are based in Old Crow, YT; the only community in the Yukon without road access (VGFN 2009). The Teetl’it Zheh Gwich’in (which translates to "people of the head waters") are based in Fort McPherson, NWT, which was established in 1852 when Old Fort, a Gwich'in village, was moved from six kilometers upriver to the present town site (Gwitch’in Council International 2009). Fort McPherson represents the largest Gwich'in settlement in the NWT with over 80% of its population being of Gwich'in descent (Gwitch’in Council International 2009). Gwichya Gwich’in (which translates to "people of the flats") are centered in Tsiigehtchic, NWT, and the Nihtat Gwich’in, meaning "mixed nations", is a group comprised of Gwich'in from various Gwich'in communities that reside in Inuvik (Gwitch’in Council International 2009).

3.6 Previous Heritage Investigations

Lands within and/or nearby the proposed study area have been assessed by several previous permitted heritage resource studies. Permitted studies include 78-11ASR (Van Dyke 1979), 85-01ASR (Bussey 1985), 89-04ASR (Greer 1989), 93-11ASR (Gotthardt 1993), 94-21ASR (Greer 1994), 99-15ASR (Gotthardt 1999), 03-07ASR (Gotthardt 2003), 11-17ASR (Heffner 2012), and 11-21ASR (Hare and Gotthardt 2013). As a result of these studies, 22 archaeological sites have been identified within, or very near, the proposed ROW. These sites are dominated by lithic scatters, and include LaVh-1, LaVh-10, LaVh-2, LaVh-5, LaVk-9, LbVh-1, LcVg-1, LcVg-10, LcVg-12, LcVg-13, LcVg-14, LcVg-15, LcVg-16, LcVg-17, LcVg-4, LcVg-5, LdVh-1, LdVh-4, LfVg-15, LfVg-17, LhVg-1, and MfVb-5.

4.0 METHODOLOGY

4.1 Field Methodology

Following the completion of a comprehensive desktop review of the proposed project area (Mooney and Bennett 2016), PHFA was conducted by traveling along the entire proposed fibre optic line route by truck and/or on foot to assess the accuracy of the desktop assessment and look for any additional areas of possible heritage resource concern that may have been missed during the initial overview. Areas both with and without predicted potential for heritage resources were observed, photographed, and recorded with GPS tracks and waypoints to assess and document the presence or absence of heritage resource concerns along the proposed route. PHFA work was conducted under Yukon and NWT class 2 heritage resource study permits to allow for any artifact collection or subsurface testing that may have been deemed necessary during the fieldwork discussed in this report, however no such collection or testing was conducted during the completion of this PHFA.

5.0 RESULTS AND RECOMMENDATIONS

5.1 General Results and Recommendations

The majority of the proposed fibre optic line route was found to have low potential for heritage resources related to:

1. High levels of previous ground disturbance within the existing Dempster Highway ROW
2. Large areas of low-lying, flat, wet, spruce dominated forest and wetland areas
3. Large portions of the study area that cross side slope (especially south of Tombstone Territorial Park)

However, while the majority of the study area is considered to have low potential for encountering previously undocumented heritage resource sites, several localized areas of moderate to high potential were also recognized. As indicated in the preceding HROA study (see Mooney and Bennett 2016), these moderate to high potential areas are typically associated with specific types of landform (e.g. ridges and terraces where high, flat terrain breaks to downward slopes, and raised landforms near water). Dryland locations with good access to water, especially those that also share the landform attributes described above, are also often considered to have elevated potential for the presence of heritage resource sites. And lastly, the areas surrounding previously recorded heritage resource sites are also considered to have heightened potential for the identification of additional associated heritage resources.

The following points are considered as broad best practice recommendations for avoiding heritage resource impact concerns at the above mentioned general moderate to high potential areas along the entire length of the ROW:

1. **To avoid most landform related high potential areas:**
    a. **Stay close to existing Dempster Highway roadbed (within 10 m of roadway edges)**
    b. **In cases where the proposed line must move more than 10 m from the existing roadbed,**
        i. **Stay within the vegetation control zone along the highway**
        ii. **Avoid the tops of any elevated landforms; stay on side slopes instead**
2. **To avoid most water feature related high potential areas:**
    a. **Stay close to existing Dempster Highway roadbed (within 10 m of roadway edges) with fibre optic cable crossing waterways in areas with currently engineered banks (e.g. reinforced areas at culvert crossings, slopes of built up portions of roadbed across deeper drainage channels)**
    b. **All drilling related ground disturbance should maintain a 30 m setback from banks of rivers, creeks, lakes, wetlands, etc.**
3. **To avoid known heritage sites:**
    a. **Maintain a 30 m buffer around the recorded site area**

With the above general impact mitigation strategies in mind for the overall study area, 16 areas of specific impact concern where also identified within the Yukon that require specific avoidance/mitigation strategies to be followed during the planning and construction of the Canada North Fibre Loop. These specific strategies are discussed in the following section of this report. Areas not specifically mentioned in the following section should be considered to not present any significant heritage resource concerns provided that the above general recommendations are followed (note: there are a large number of YHSI sites recorded within Dawson, YT that fall within the 100 m study area buffer. It is assumed that this project will not be impacting standing structures in Dawson, so these sites are not discussed. However, should impacts to any standing structures near the riverfront in Dawson be deemed necessary for this development, LTS Infrastructure Services should contact Ecofor to determine the heritage status of the building to be impacted).

5.2 Specific Areas for Avoidance and/or Further Mitigative Work

In total, 16 areas of specific heritage resource concern were identified along the Yukon portion of the proposed fibre optic line route during the PHFA fieldwork. These areas were identified as having elevated potential for impacts to heritage resources due to: 1) their proximity to previously recorded heritage resource sites, 2) their proximity to high potential landscape features for the identification of currently undocumented heritage resources, or 3) a combination of elevated potential factors 1 and 2. This section of this report identifies these areas, and proposes recommendations for avoidance and/or mitigative strategies to avoid impacts related to the proposed Canada North Fibre Loop project.

5.2.1 – Archaeological Sites LfVg-5 and LfVg-17

Previously recorded archaeological sites LfVg-5 and LfVg-17 present the greatest concern related to heritage resource impacts along the proposed Canada North Fiber Loop alignment. These sites are located approximately 30 m from one another, and approximately 15 m east of the existing Dempster Highway road bed on a terrace above the Blackstone River.

LfVg-5 is a First Nations burial site. It is one of the areas of cultural significance brought forth by the Gwich'in Tribal Council during the permitting process for this study (see also Section 1.15). The site is described as a

> Gwich'in grave site from early 20th century marked by a large grave fence of pickets and carved posts. This is not an actual grave but a reconstructed grave fence. The original group of graves was destroyed by the Department of Public Works during the Dempster Highway construction. Parts of the destroyed grave fences were brought

> here and reconstructed as one large fence. It is likely that the human remains are widely scattered. The destroyed graves were those of a woman and her 7 children (Greer 1989). Site revisited and photographed in 2003 by Gotthardt, and again in 2011 by Heffner (see Gotthardt 2003 and Heffner 2011). This is the relocated grave site of Selea (wife of Old Neil) and her seven children who died in 1910s or 1920s when influenza and tuberculosis claimed many lives (Greer 1989; Gotthardt 2003).

LfVg-17 is a small scale lithic scatter. It was identified by Heffner in 2011 (see Heffner 2011).

Both of these sites should be avoided by the Canada North Fiber Loop alignment. The best avoidance strategy is to route the alignment as far to the west as is possible. Following this strategy, and staying within the current Dempster Highway ROW, the trench for the cable install should be able to maintain a >30 m buffer around the recognized site boundaries. That said, burial sites are of the highest significance to First Nations, and therefore further consultation with the Tr'ondëk Hwëch'in First Nation (whose traditional territory the site is located upon) and the Gwich'in Tribal Council (who specifically cited concerns related to the site in their review of the permit for this PHFA work) should be conducted before finalizing avoidance/mitigation strategies related to these sites. Due to the potential for widely scattered human remains throughout this area related to the initial disturbance of LfVg-5 during the construction of the Dempster Highway, **it is also recommended that a heritage resource monitoring program be in place during any ground disturbing activities in this area with heritage resource management professionals and First Nations representatives both present**.

5.2.2 – Archaeological Site LfVg-4

Archaeological site LfVg-4 is a First Nations burial. This site was not revisited during the PHFA efforts due to an error in site coordinates that placed it outside of the 100 m assessed buffer zone. However, communication with staff at the Yukon Government Heritage Resources Unit, who are familiar with the site's location, have subsequently confirmed its presence approximately 20 m east of the Dempster Highway and very close to an existing gravel pit used in the maintenance of the highway. Despite these nearby disturbance factors, the site area is intact. Greer (1989; see also Gotthardt 2003) described LfVg-4 as the

> Grave site of Jemima Josie, a Tukudh Gwich'in woman who died in the winter or spring of 1908. Her husband, Esau Josie, had died the previous year and was buried at Moosehide. Mrs. Josie, pregnant with her first child, was living/travelling in the Hyssop Creek area and injured herself while working on a hide. The accident brought on an early labour. The child was Mrs. Mary Vittrekwa. Mrs. Josie did not recover

and died a short time later. The grave is marked by a picket fence with log corner posts. A headboard reads "June 11 Jemima". The June 11 date refers to the date the fence was constructed. Today a spruce tree is growing in the middle of the grave.

As a grave site, LfVg-4 is considered to be of high cultural significance. **To ensure avoidance of the site area, best practice will be to route the Canada North Fiber Loop alignment along the west side of the Dempster Highway, maintaining a 30 m setback in all directions from the site**.

5.2.3 – Archaeological Site LaVh-5

Archaeological site LaVh-5 is an abandoned miner's diversion ditch. It was recorded without being directly observed by Greer in 1989 based on information obtained information from Yukon Heritage Inventory files. During this PHFA study, a drainage appearing to be man-made was observed approximately 110 m south of the recorded location of LaVh-5. No ditch features were observed at the recorded site location. As such, it is proposed that the observed drainage is the ditch referred to by the Borden number LaVh-5. **Because this site is a ditch feature, and no subsurface artifacts are expected, directional drilling beneath the ditch, following the 30 m setback general recommendation for waterways listed above, should represent adequate avoidance to prevent impacts to heritage resources**.

5.2.4 – Archaeological Site LbVh-1

Archaeological site LbVh-1 is a lithic scatter recorded in a bulldozer scrape along a road cut for the Dempster Highway (west side of highway). Subsequent attempts to relocate LbVh-1, including this PHFA study, have failed to relocate the site. During this study, the site area was found to be heavily disturbed, and the site is almost certainly destroyed if it was not completely collected when first identified. As such, this study finds little call for concern related to this site. **To ensure avoidance of the site area, best practice will be to route the Canada North Fiber Loop alignment along the east side of the Dempster Highway or to directionally drill beneath the site area with drilling operations maintaining a 30 m setback in both directions from the site**.

5.2.5 – Archaeological Sites Near Tombstone Territorial Park Interpretive Center

Several archaeological sites have been previously recorded near the Tombstone Territorial Park Interpretive Center. These sites include LdVg-9, LdVg-13, LdVg-14, LdVg-16, LdVg-18, LdVg-19, LdVg-23, LdVg-24, LdVg-36, LdVh-1, and LdVh-4 (note: LdVh-1 is also recorded in the YHSI listing as 116B/09/003). These sites are located upon elevated landforms that overlook the Klondike River valley, tributaries, waterbodies of the Klondike River. Although many sites and high potential landforms are present through this area, high levels of previous disturbance are also present near the highway corridor related to the roadway itself, highway pull offs, and highway maintenance sites (e.g. gravel pits/storage areas). Moreover, all sites are located away from the immediate margins of the Dempster Highway roadbed. **It should be possible to avoid these sites by keeping the Canada North Fiber Loop alignment close to the existing highway (within 10 m)**.

5.2.6 – Dago Hill Pumphouse 1 – YHSI Site 116B/03/481

The Dago Hill Pumphouse 1 is a historic structure located along Hunker Creek Road. Murals have been painted on the interior walls of the structure, presumably subsequent to its time as a functioning pumphouse. **To avoid impacts to this structure, the Canada North Fiber Loop alignment should stay to the south side of Hunker Creek Road at this point, giving a 30 m buffer around the pumphouse**.

5.2.7 – Two Below Garage – YHSI Site 116B/03/583

The Two Below Garage is a historic structure located along Hunker Creek Road. **To avoid impacts to this structure, the Canada North Fiber Loop alignment should stay to the south side of Hunker Creek Road at this point, or remain very close to the roadway on the north side of the road, giving a 30 m buffer around the building**.

5.2.8 – Bob Russell Cabin – YHSI Site 116B/08/002

The Bob Russell Cabin is a group of historic structures located on the west side of the Dempster Highway. Consultation with Lee Whalen at the Tr'ondëk Hwëch'in First Nation Heritage Department revealed that this known to them as the Joe and Annie Henry's cabins (confirmed through site photographs). To avoid this site, **the Canada North Fiber Loop alignment should stay to the east side of the Dempster Highway at this point, giving a 30 m buffer around the building**.

5.2.9 – Dawson to Fort McPherson Trail – YHSI Site 116B/16/014

YHSI Site 116B/16/014 relates to the old Dawson to Fort McPherson Trail. Unfortunately, the YHSI form does not include historic mapping of the trail showing its alignment relative to the modern Dempster Highway. As such, **further research and/or consultation with Yukon Heritage and First Nations (listed on YHSI form as crossing Tr'ondëk Hwëch'in First Nation settlement lands, but may also cross the lands of other First Nations) to confirm the location of the trail and whether there are any ongoing heritage resource concerns associated with it that are relevant to the Canada North Fiber Loop alignment should be conducted prior to the commencement of construction**.

5.2.10 – Goring Creek – YHSI Site 116B/02/019

YHSI Site 116B/02/019 refers to the heritage landscape associated with Goring Creek. Several abandoned trucks were observed on the southwest banks, and several structures are located near the southeastern bank area. Being that this YHSI listing relates to a landscape associated with a creek, it certainly extends beyond the singular coordinate point recorded on the site form. Moreover, impacts to heritage landscapes may be viewed with different levels of concern by those who recognize them depending on the specific portion of that landscape that is to be impacted and the nature of those impacts. As such, **further consultation with the Tr'ondëk Hwëch'in First Nation is recommended before finalizing plans for the Canada North Fiber Loop alignment through this area**.

5.2.11 – Dognose Creek – YHSI Site 116B/02/020

YHSI Site 116B/02/019 refers to the heritage landscape associated with Dognose Creek. Being that this YHSI listing relates to a landscape associated with a creek, it certainly extends beyond the singular coordinate point recorded on the site form. Moreover, impacts to heritage landscapes may be viewed with different levels of concern by those who recognize them depending on the specific portion of that landscape that is to be impacted and the nature of those impacts. As such, **further consultation with the Tr'ondëk Hwëch'in First Nation is recommended before finalizing plans for the Canada North Fiber Loop alignment through this area**.

5.2.12 – Shed Alongside Hunker Creek Road

This structure is not currently listed in the YHSI listing, but appears to be of sufficient age that it could likely be considered a historic structure. As such, it is considered best to be avoided by the Canada North Fiber Loop alignment. It is located along Hunker Creek Road. **To avoid this structure, the Canada North Fiber Loop alignment should stay on the north side of Hunker Creek Road**.

5.2.13 – Trailers/Structures Alongside Hunker Creek Road

This group of structures and trailers is not currently listed in the YHSI listing, but some features at the site may be of sufficient age, and were observed in reasonable context, such that they could likely be considered a historic in nature. Moreover, the site appears to be currently occupied, so regardless of whether this site possesses potential heritage resources, it is best avoided. The structures and trailers are located along Hunker Creek Road. **To avoid this area, the Canada North Fiber Loop alignment should stay south of Hunker Creek Road**.

5.2.14 – Maintenance Shed Near Archaeological Site MfVb-6

This structure, a large steel framed shed that appears to have been associated with highway maintenance equipment and supplies, is not currently listed in the YHSI listing, but appears to be of sufficient age, and was observed in reasonable context, such that it could likely be considered a historic structure. The structure is located at the foot of the landform atop which archaeological site MfVb-6 is located (MfVb-6 should not be at risk for being impacted by the proposed development). Yukon Government tourist information signage providing information about traditional caribou hunting is posted in the pull out area in front of the structure. As such, it is considered best to be avoided by the Canada North Fiber Loop alignment. The shed and signage are located on the west side of the Dempster Highway. **To avoid this area, the Canada North Fiber Loop alignment should stay on the west side of the Dempster Highway, giving a 30 m buffer around the building**.

5.2.15 – Gwich'in Tribal Council Areas of Cultural Sensitivity Concern

During the permitting process for this study, the Gwich'in Tribal Council brought forth three areas of cultural sensitivity concern that they felt should be assessed ahead of any ground disturbance related to the Canada North Fiber Loop project, two of which are located in the Yukon. One of these areas was the gravesite associated with LfVg-5 which was discussed above in Section 1.1 of this interim report).

The second Yukon area of concern brought forth by the Gwich'in Tribal Council, also a grave site, is located near the Gwazhàl area upon the Ogilvie Ridge. Unfortunately, more specific spatial data related to this site has not been recorded, and attempts to contact people associated with the initial reporting of the site were unsuccessful. Information provided by the Gwich'in Tribal Council is as follows:

> Yukon grave site in the Horseshoe Bend area of the Dempster Highway. This is a summary of the only information we have: The graves originally came to our attention in October 2004 via Robert Alexie Sr. Robert said that he had been speaking to Richard Nerysoo who said that his brother Dennis Blake and (?) had been out caribou hunting in late Sept/early October 2004 and ran across two graves (one small, one large) in the Ogilvie area … on the east side of the road. It sounded like it was in a high area versus in the river valley … Gwich'in elders have indicated that they were people from Eagle, Alaska - one young kid and one older person (Kristi Benson, personal communication 2016).

With only this information and broad potential locational data available, these graves were not relocated during the PHFA study. Instead, the PHFA work focused on identifying areas within the existing Dempster Highway corridor where heritage impacts would not be a concern. The previously disturbed areas immediately adjacent to both sides of the highway were found to be quite wide throughout the Ogilvie Ridge area. **Concerns related to these graves should be adequately avoided if the Canada North Fiber Loop alignment stays within 10 m to either side of the highway roadbed, in previous disturbance, within the Ogilvie Ridge area. This does represent a large area, but with the existing uncertainty as to the exact location of these graves it is considered best practice to allow for a large control area to avoid accidental impacts**.

5.2.16 – Hunker Creek Transmission Line Corridor Diversion

The Hunker Creek Transmission Line Corridor Diversion runs between where the fiber optic line turns east off of Hunker Creek Road to where it rejoins the Klondike Highway. Although the eastern half of this area is low-lying wetland with limited heritage resource potential, the eastern portion climbs over a large hill and contains several areas of elevated heritage resource potential. The primary area of potential is located at the top of a large hill, where flat terrain breaks to a steep slope and offers a commanding view of the Klondike valley to the northeast. Other smaller terraces and viewpoints are present a few hundred metres further east of this primary area, and at the far west end, above the junction with Hunker Creek Road.

At present, the construction methodology that will be employed through this are remains unclear (e.g. buried cable or suspended cable utilizing existing utility poles; whether additional access roads will be required to move equipment to the top of the hill). As such, the scope of the ground disturbance associated with this portion of the project area cannot be determined, and thus specific recommendations for mitigative heritage resource work cannot be given beyond a general statement that further heritage assessment work will likely be required if the areas cited above are impacted. **To allow for more specific recommendations to be proposed, and evaluated by staff at Yukon Heritage, it is recommended that LTS Infrastructure Services determine their preferred construction methodology and whether additional access roads will be required. With that information, specific recommendation for further heritage work can be drafted for submission and evaluation by Yukon Heritage.**

6.0 SUMMARY

On behalf of LTS Infrastructure Services, Ecofor Consulting Ltd. (Ecofor) conducted preliminary heritage field assessment (PHFA) along the proposed route of the Canada North Fibre Loop between the dates of August 25 to September 1, 2016. The proposed project consists of the installation of a fibre optic communication line running from Dawson City, YT to Inuvik, NWT. The PHFA work was aimed at ground truthing the heritage resource potential predictions made in a preceding Heritage Resource Overview Assessment (HROA) study conducted by Ecofor (see Mooney and Bennett 2016). This report focuses on portions of this ROW within the Yukon (the results of the assessment of lands within the NWT are reported separately under Prince of Wales Northern Heritage Center permit 2016-014).

Based on the results of the HROA, 321 landform-based areas of potential (AOPs), 392 water feature-based AOPs, 29 previously recorded archaeological sites, seven YHSI sites, and two culturally sensitive areas brought forth by the GTC were assessed within the Yukon portion of the study area. In total, 16 areas of specific heritage resource concern were identified along the Yukon portion of the proposed ROW corridor during the PHFA fieldwork. Specific avoidance and/or impact mitigation strategies are presented in Section 5.2 of this report. The remainder of the project area was found to either have low potential for heritage resources, or to have small areas of elevated potential that can be easily avoided by following the general avoidance strategies presented in Section 5.1 of this report.

If any additional development areas are added to the project, then those new areas should also be reviewed for possible impacts to heritage resources. This follow-up heritage review may be conducted through desktop overview and/or field study along with First Nations consultation.

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APPENDIX A: Project Mapping – NOT INCLUDED IN YESSA READY/PUBLIC VERSION OF REPORT

APPENDIX B: Photographs – NOT INCLUDED IN YESSA READY/PUBLIC VERSION OF REPORT

APPENDIX C: Project Field Notes – NOT INCLUDED IN YESSA READY/PUBLIC VERSION OF REPORT

APPENDIX D

Conceptual Design Brief (Stantec 2019)

Yukon	DFL Conceptual Design Brief (FINAL)	Stantec

DFL CONCEPTUAL DESIGN BRIEF – OUTSIDE PLANT ENGINEERING – FUNCTIONAL DESIGN GUIDE

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Appendices:

1. Purpose

The purpose of this document is to provide a high-level Outside Plant Engineering (OPE) design scope and basis for the DFL routing along the Dempster highway and into the key NorthwesTel microwave integration, breakout sites and termination sites along the route.

This document is to be read in conjunction with current and past basic engineering and design basis documentation produced by Ledcor Technical Services (LTS), Palmer Environmental Consulting Group, Kryotek, Northern Climate Exchange (NCE), Tetra Tech and a host of other consultants who have in past work, assesed the various geohazards along the Dempster highway.

2. Introduction

The Yukon currently has a single fibre-optic line that connects Whitehorse, YT to southern Canada provided by a single telecommunications provider (NWTEL) with no diverse or alternate route for communications infrastructure originating out of Whitehorse. The existing fibre route from Whitehorse to Carcross to Watson Lake, YT to Fort Nelson, BC is subject to damage from climatic conditions as well as mechanical damage due to construction work and other operations undertaken by a variety of agencies within the existing fibre right-of-way. This culminates in service interruptions for residents, businesses and the government.

The design development of the DFL network at this conceptual stage reflects project requirements and assessment based on Stantec's review of client documents, previous preliminary design work completed by others, meeting and discussions with key Dempster highway stakeholders and our experience with long haul high capacity fibre networks.

Discussions with project stakeholders continues and although design information is flowing back to us, some key information is still missing in order to further develop and solidify the details of the construction strategy required for the fibre network infrastructure. A good portion of this Conceptual Design Brief has been developed form the geotechnical assessment work done by Tetra Tech in their Final Geotechnical Design Brief which has been attached in Appendix A.

This Conceptual Design Brief identifies current and required documents as well as construction methodologies to be referenced for the design and engineering of the DFL. There is also a high-level costing study which has been developed from the review of earlier estimates from Stantec and also from the LTS design documents. The study will be submitted as a separate document in support of the conceptual design.

The Fibre Optic Cable Infrastructure will be established between the NorthwesTel Dawson Central Office termination point, travel along Klondike highway #2 to the Dempster highway #5 turnoff. From there, the fibre route continues along the highway #5 ROW until it reaches the NWT border at which point, the route continues along the highway #8 ROW and finally terminates in the NorthwesTel Inuvik Central Office. A total highway route distance of approximately 775Km.

Along the Dempster portion of the route, the Fibre Optic Cable Infrastructure (FOCI), will have breakout points where future connections to the network will be possible. Further, there is a need to amplify or regenerate the optical signals travelling over the fibre cable along the route. This is accomplished through termination points at NorthwesTel microwave sites and other specific amplification points along the route.

3. Scope

The scope of this document applies to the outside Plant Engineering FOCI design, the Optical Platform requirements will be dealt with in a separate and the associated construction methodologies within the following project components:

1. Termination at the NWTEL Dawson Central Office in Dawson City, YT.
2. Construction within Dawson City, YT to the edge of town meeting up with Klondike highway #2.
3. Construction along YT Klondike highway #2 to the Dempster highway #5 turnoff.
4. Construction along the Dempster highway (YT #5) from Km Post 0 through to Km post 464 at the NT border.
5. Construction along the Dempster highway (NT #8) from Km Post 0 through to Km post 271 at Inuvik, NT.
6. Termination at the NWTEL Inuvik Central Office in Inuvik, NT.
7. High level design of NWTEL network breakout and amplification points along the route between Dawson City, YT and Inuvik, NT.
8. High level optical Network platform design oversight required to terminate at up to eight (8) NWTEL microwave sites and other amplification points along the proposed Dempster highway route.
9. High level Optical Network platform design oversight required to terminate at the NWTEL Dawson and Inuvik Central Offices.
10. The costing study component captures and estimates the total cost of constructing the DFL FOCI components based on our latest conceptual design work. Also, it does not include any construction estimate for any new breakout points along the route. Further, it does not reflect any estimates for the optical platform which will light the fibre network as this information has not been made available from NWTEL.

Refer to document “DFL-PJM-STAN-REG-000005” the DFL project Document Plan for a listing of all the required Fibre Network Infrastructure scope documents to support the various project design phases.

4. Definitions and Abbreviations

The following provides a listing of all the acronyms and abbreviations used throughout this document.

Table 4-1 Definitions and Abbreviations

Term	Definition
ADM	Add-Drop Multiplexer
ADSS	All Dielectric Self-Supporting Fibre Cable
AEUC	Alberta Electrical Utility Code
A/E	Aerial Installation
ATCO	ATCO Energy – Canadian Utilities Ltd.
ATV	All Terrain Vehicle
CO	Telecom Provider Central Office
CPE	Customer Premise Equipment
CSP	Corrugated Steel Pipe
DTS	Distributed Temperature and acoustic Sensing
DFL	Dempster Fibre Link (Diverse Fibre Link)
DFO	Department of Fisheries and Oceans
ECCC	Environment and Climate Change Canada
EDFA	Erbium Doped Fibre Amplifier
FN	First Nations
FOCI	Fibre Optic Cable Infrastructure
FOSC	Fibre Optic Splice Closure
GIS	Graphical Information System
HDPE	High Density PolyEthylene

HROA	Heritage Resource Overview Assessment
HSRP	Hot Standby Router Protocol (HSRP)
HVAC	Heating Ventilation and Air Conditioning
HVT	High Voltage Transmission
IFC	Issued for Construction
ILA	In-Line Amplifier
IXP	Inter Exchange Provider
Km	Kilometres
LTS	Ledcor Technical Services
LVD	Low Voltage Distribution
NCE	Northern Climate Exchange
NT	Northwest Territories
OPE	Outside Plant Engineering
OSP	Outside Plant
OTDR	Optical Time Domain Reflectometry
m	Meters
MPLS	Multi Protocol Label Switching
NT	North West Territories
MVFL	Mackenzie Valley Fibre Link
MVLWB	Mackenzie Valley Land and Water Board
NWTEL	NorthwesTel
N/A	Not Applicable
ROW	Right-Of-Way

SDR	Standard Dimension Ratio
SME	Subject Matter Expert
TBD	To be Determined
U/G	Underground Installation
WAN	Wide Area Network
WKA	Wildlife Key Areas
WMMP	Wildlife Management and Migration Plan
YESAB	Yukon Environmental and Socio-economic Assessment Board
YEC	Yukon Energy Corporation
YG	Yukon Government
YHSI	Yukon Historic Sites Inventory
YT	Yukon Territory

5. Design Codes and Standards

All design scope shall comply with all the DFL Fibre Optic Cable Infrastructure Specifications, related codes and standards contained within the Basic Engineering documents.

The following Industry Codes and Standards are applicable to this DFL project.

- All electrical products shall be Underwriter's Laboratories Certified (ULC) and products and workmanship shall comply with the Canadian Electrical Code.
- ANSI Z136.2 Safe Use of Optical Fibre Communication System, Utilizing Laser Diode and LED Sources
- ANSI/SCTE 77 2007 Specification for Underground Enclosure Integrity
- ANSI TIA/EIA-455-59-A FOTP-59 Measurement of Fibre Point Defects Using an OTDR
- ANSI TIA/EIA 526-7 Measurement of Optical Power Loss of Installed Single-Mode Fibre Cable Plant
- ANSI/TIA-568-C.1 Commercial Building Telecommunications Cabling Standard – Part 1 – General Requirements
- ANSI/TIA-568-C.3 Optical Fibre Cabling Components Standard

- ANSI/TIA-598-D Optical Fibre Cable Color Coding
- ASTM F 1962, Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings
- ASTM F 1055 Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing
- ASTM D1248 Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
- ASTM F-2160 specified a modulus for HDPE used in conduit at 80,000 to 160,000 psi.
- ASTM D2657 Heat Fusion Joining of Polyolefin Pipe and Fittings
- ASTM D-3035-14 Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
- ASTM D 3350 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
- ASTM D 3261 Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
- CAN4-S115 "Standard Method of Fire Tests of Firestop Systems"
- CSA C22.1 Canadian Electrical Code, Part 1 – Safety Standard for Electrical Installations
- CSA C22.3 No 1-15 Canadian Electrical Code Part III – Overhead Systems
- CSA C22.3 No 7-10 Canadian Electrical Code Part III – Underground Systems
- CSA C22.3 No 7-94 Canadian Electrical Code Part III – Underground Systems
- CSA Z462-08 Workplace Electrical Safety
- CSA C22.2 No. 60529-05 Degrees of Protection Provided by Enclosures (IP Code)
- EIA – 359 Fibre Color Identification and Coding
- FOTP-3, Procedure to Measure Temperature Cycling Effects on Optical Fibre, Optical Cable, and Other Passive Fibre Optic Components
- FOTP-25, Repeated Impact Testing of Fibre Optic Cables and Cable Assemblies
- FOTP-33, Fibre Optic Cable Tensile Loading and Bending Test
- FOTP-37, Fibre Optic Cable Bend Test
- FOTP-38, Measurement of Fibre Strain in Cables Under Tensile Load
- FOTP-41, Compressive Loading Resistance of Fibre Optic Cables
- FOTP-59
- FOTP-82, Fluid Penetration Test for Fluid-Blocked Fibre Optic Cable

- FOTP-85, Fibre Optic Cable Twist Test
- FOTP-104, Fibre Optic Cable Cyclic Flexing Test
- NEMA TC 7 for HDPE Electrical Conduit (Various Types)
- ITU-T G.650.3 Test Methods for Installed Single-Mode Fibre Cable Sections
- ITU-T G.652 Characteristics of a Single-Mode Optical Fibre and Cable
- Telcordia GR-3108 - Generic Requirements for Network Equipment in the Outside Plant (OSP) and Telcordia Standards for splice vaults, splice closures, cabinets, conduit and cable.
- TIA -455-25-A FOTP-25 Impact Testing of Fibre Optical Cables
- TIA -455-28-C FOTP-28 Method of Measuring Dynamic Tensile Strength and Fatigue Parameters of Optical Fibres by Tension
- TIA -455-33-A FOTP-33 Fibre Optic Cable Tensile Loading and Bending Test
- TIA -455-37-A FOTP-37 Low or High Temperature Bend Test for Fibre Optic Cable
- TIA -455-41-A FOTP-41 Compressive Loading Resistance of Fibre Optic Cables
- TIA -455-59-A FOTP-59 Measurement of Fibre Point Deflects Using an OTDR
- TIA -455-82-B FOTP-82 Fluid Penetration Test for Fluid-Blocked Fibre Optic Cable
- TIA -455-85-A FOTP-85 Fibre Optic Cable Twist Test
- TIA-455-98-A FOTP-98 Fibre Optic Cable External Freezing Test
- TIA-455-104-A FOTP-104 Fibre Optic Cable Cyclic Flexing Test
- TIA-455-A Standard Test Procedures for Optical Fibres, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fibre Optic Components (FOTPs);
- TIA-604-3A Fibre Optic Connector Intermateability Standard, FOCIS-3 (Type SC)
- TIA-604-10A Fibre Optic Connector Intermateability Standard, FOCIS-10 (Type LC).
- TIA-526-7 OFSTP-7 Measurement of Optical Power Loss of Installed Single Mode Fibre Cable Plant
- TIA-569-B Commercial Building Standard for Telecommunications Pathways and Spaces
- TIA-604-3 FOCIS 3 Fibre Optic Connector Intermateability
- TIA-590-A Standard for Physical Location and Protection of Below Ground Fibre Optic Cable Plant
- TIA-598-C Optical Fibre Cable Color Coding
- TIA-758-A Customer Owned Outside Plant Telecommunications Infrastructure Standard

- Legislative environmental requirements which are relevant to this DFL project need to be considered and include the following:
    I. Environmental considerations consider requirements to adhere to federal and territorial legislation proscribing environmental protection of valued biophysical resources.

    II. Where feasible, the design basis will incorporate environmental protection measures to ensure compliance with legislation and foreseeable permit/licence conditions

    III. Where environmental effects are reasonably predicted, the design will incorporate mitigation measures to minimize effects

6. Reference Documents

The following documents are directly applicable to the Fibre Optic Cable Infrastructure scope and should be referenced initially in order to maintain and possibly accelerate design:

Table 6-1 Basic Design and Engineering Documents

Reference	Title
DFL-ELE-STAN-DSD-103001	Conceptual Design Brief
DFL-ELE-STAN-DSD-103002	Construction Decision Matrix
DFL-ELE-STAN-RSC-103000	Construction RISK Assessment
DFL-ELE-STAN-DSD-103003	DFL Linear Design Schematics
DFL-GEO-STAN-DBF-101002	Geotechnical Design Brief
DFL-ELE-STAN-SCH-103006	Permit Drawing List
DFL-ELE-STAN-RPT-103005	Schematic Design Report
DFL-ELE-STAN-DSD-103004	Topology and Network Architecture Logic Diagrams

Table 6-2 DFL Detailed Design and Engineering Documents

Reference	Title
DFL-ELE-STAN-SPC-103007	Fibre Optic Cable Infrastructure Material Specification
DFL-ELE-STAN-SPC-103008	Fibre Optic Cable Infrastructure Installation Specification
DFL-ELE-STAN-DRW-103100	IFC A/E Fibre Construction Drawing Set

DFL-ELE-STAN-DRW-103599	IFC U/G Fibre Construction Drawing Set
DFL-ELE-STAN-DRW-103011	Major River(s) Crossing Details
DFL-ELE-STAN-DRW-103012	Culvert(s) Crossing Details
DFL-ELE-STAN-DRW-103013	Watercourse(s) Crossing Details
DFL-ELE-STAN-DRW-103014	Bridge Attachment Details
DFL-ELE-STAN-DRW-103015	Handhole and FOSC Details
DFL-ELE-STAN-DRW-103850	Microwave Site(s) – NorthwesTel - Measured Drawings Set
DFL-ELE-STAN-DRW-103951	Dawson City – NorthwesTel CO – Measured Drawing Set
DFL-ELE-STAN-DRW-103953	Inuvik CO – NorthwesTel CO – Measured Drawing Set
DFL-ELE-STAN-DRW-103950	Dawson CO - Fibre Entrance and Termination Details
DFL-ELE-STAN-DRW-103952	Inuvik CO – Fibre Entrance and Termination Details
DFL-ELE-STAN-DRW-103016	Fibre Cable Splicing Tables

7. DFL Network Design

7.1 Network Design Approach

The design approach will focus on the installation of a robust highly resilient submarine grade harsh environment fibre cable alongside the Klondike and Dempster highways within the existing established highway ROW. Installed away from the highway road embankment, to the extent possible, always minimizing ground level disturbance. The alignment of the cable will attempt to be located at the edge of the brushed area, away from the road embankment but within a 15-20m distance from the road centre line. This will reduce the likelihood of damage to a surface-laid or shallow-buried cable due to highway maintenance activities. It will also allow for a reasonable level of constructability for the installation contractor.

A linear design guideline schematic has been developed based on an earlier schematic created by LTS in their 2016 CNFL Phase 1 Summary Report documents package. This design guideline will be used to capture and organize the different construction methods and techniques required along the proposed fibre cable route as crossings and hazards are encountered. It is based on route chainage using Km post references in both YT and NT Dempster highway jurisdictions. Much of the data used has in this conceptual design been gathered by previous consultants through reference Km post locations for hazards and crossings along the route. This document will serve us well in further developing and refining the DFL design.

At this early stage of design, the linear guide is not fully populated as there is still missing information and further design development is required to fully complete the document. Once completed, and finalized, the document will become the design basis for the required construction drawings and associated construction support documents.

A snapshot of the linear guideline workbook is provided in Appendix B.

7.2 **Proposed Routing**

From the LTS Design Basis and other YG and NWTEL preliminary design documentation, as well from current discussions with the key stakeholders of this project, the route has been essentially defined.

Stantec agrees with the preliminary route design and supports the work which was done by previous consultants. At this conceptual design phase, the route will be established as depicted in the following map.

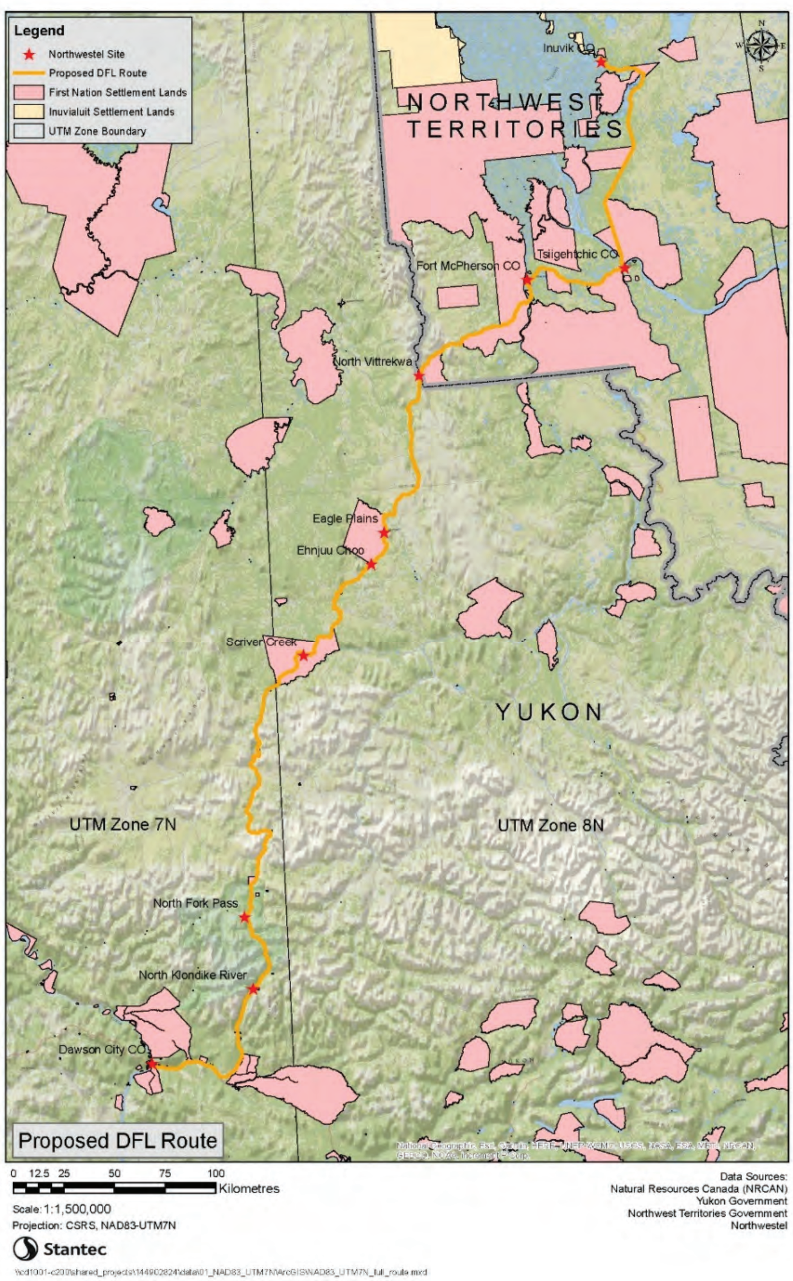


Table 7-1 Proposed Cable Route for the DFL

7.3 Design Basis and General Assumptions

The design of the DFL FOCI Infrastructure is being developed reflecting project requirements and assessment based on Stantec's review of client documents, previous preliminary design work completed by others, meeting and discussions with key Dempster highway stakeholders and our experience with long haul high capacity fibre networks. We have also considered previous construction experience from similar projects such as the newly constructed MVFL which highlighted how important the environmental and geotechnical considerations are in a permafrost rich environment.

For this DFL deployment, the design considers the following key FOCI design assumptions.

These include the following;

- Install the cable outside the road structure whenever possible. The risk to both the proposed fibre cable and the road structure were deemed excessive by installing the cable within the road prism. It has been decided to reroute the proposed cable alignment away from the road structure to the extent practical. At this early design point, the cable alignment has been set at 15-20m from the highway centre line.
- Minimize interaction between the cable and road prism.
- Minimize crossing of the road embankment and the highway itself.
- Utilise HDD crossing techniques as required to cross the highway, major rivers without bridges, any flowing waterways, streams, creeks and registered access roads along the route.
- Utilize existing poles where suitable for aerial portions as much as possible.
- Install new poles where required, as a last resort, due to high ground risk conditions along the route. Maintain sufficient distance from the road prism to avoid risk from non-intended vehicular interaction.
- Where multiple NWTEL fibre facilities exist, such as Dawson and Inuvik entry points, ensure that no single point of failure exists for the fibre network.
- At all selected NWTEL microwave site termination and amplification points, ensure that no single point of failure will exist in reaching the sites along their access roads. Specifically, as much as possible, maintain 10m physical separation between the incoming and outgoing fibre cables.

The following table summarizes the key assumptions which were used in developing this Conceptual Design Brief. These assumptions have been developed from discussions within Stantec Northern SME's, some limited discussions with NWTEL and the client. Also, from the review of client document resources, and from discussions with the YT and NT highway jurisdictions. As further discussions continue with the highway's jurisdictions, and with NWTEL, the intended operator of the network, the design will continue to evolve and some of these assumptions may change as a result.

Table 7-2 Key Design Basis Assumptions

Item	Category	Assumption
1.0	General	The DFL project is divided into three (3) major highway components: The YT Klondike highway #2 section, the YT Dempster highway #5 section and the NT Dempster highway #8 component. Stantec have subdivided the three highway components into five (5) overall linear design segments for this early stage conceptual design based on initial design and construction considerations. • Segment #1, (From Dawson NWTEL CO, along highway #2 to Dempster highway #5 turn-off and along Dempster highway #5, Km-0 to Km-80) • Segment #2, YT: Dempster highway #5, Km-80 to Km-403 • Segment #3, YT: Dempster highway Km-403 to NT Border (Km-474.5) and NT Border, Km-0 to NT: Dempster highway #8, Km-73 • Segment #4, NT: Dempster highway #8, Km-73 to Km-143.9 • Segment #5, NT: Dempster highway #8, Km-143.9 to Km-274 (Inuvik) These five (5) segments will be reworked for the detailed design phase to align with the eight (8) geography-based route segmentation plan as detailed in the Final Geotechnical Design Brief attached in Appendix A.
		The DFL will originate at the NWTEL DAWSON CITY CO in the YT and terminate at the NWTEL INUVIK CO. in the NT.
		The Klondike highway route segment will have the fibre cable installed on the existing Yukon Energy Pole Line highway depending on where existing NWTEL fibre facilities from Whitehorse to Dawson are installed. The objective is to ensure a high level of diversity and redundancy between the two critical fibre runs. A minimum physical separation of 10m is recommended.
		This DEMPSTER fibre cable segment in the YT shall be installed within the existing highway #5 ROW to the extent feasible.
		This DEMPSTER fibre cable segment in the NT shall be installed within the existing highway #8 ROW to the extent feasible.

Item	Category	Assumption
2.0	YT highway Considerations	To maintain the integrity of the Dempster highway #5 road prism, the fibre cable should be installed away from the road prism but when the ground, circumstances or the risk is justified, then within the road embankment. This will require highway approval.
		The fibre cable is not to be installed within or near the highway #5 toe as this is generally the most unstable point along the road: this is evident in the tension cracks along the shoulder, oversteep banks and the formation of ponds at the toes. An in-toe alignment is **NOT** acceptable as the primary alignment.
		There are many Geotechnical hazards along the Dempster #5 route and these present significant road maintenance challenges today.
		There are ~1200 culverts along the Dempster #5 route to the NT border. Many of these culverts are near their end-of-life and therefore will be scheduled for replacement within the 20-year DFL project lifecycle.
		Wetlands – some areas are considered melt areas but may resemble wetlands now. these areas should be captured in the functional plan. Aerial crossings at these locations may be appropriate but wetland sites are likely melting/ expanding.
		Attachment of conduits or cable raceways to existing bridges may be allowed, depending on their replacement schedule.
		Highway crossings – depending on the site conditions, HDD may be appropriate. HDD may form a channel where ground water is able to flow and may pose a risk to the highway foundation. A mitigation strategy to prevent ground water channels from forming on HDD work will be required.
		Aerial crossings – from HPW's perspective, aerial crossings are viable. Tourism may have a different opinion. Poles are to be placed away from culvert inlet/outlets and near the outside edges of the highway ROW. This is to ensure culvert replacement or repair activity will not impact the fibre cable.
3.0	NT highway Considerations	Fibre Cable placement is NOT allowed within the Dempster highway #8 road prism and not allowed at the toe of embankment.
		Attachment of the fibre cable to existing bridges will only be allowed on the Campbell Creek bridge where there are existing conduits, however the MVFL fibre cable is contained within the existing bridge conduit, therefore for reliability reasons, the Campbell Creek bridge will **NOT** be used by the DFL and the creek will be crossed using HDD. No attachments allowed on the Caribou Creek concrete bridge so this creek will also need to be HDD.

Item	Category	Assumption
		Surface-laid cable will be allowed within the ROW. The preferred construction method on the NT side will be shallow bury to depths of 100-150 mm within the organic layer with no disturbance to the active permafrost layer. This can only be achieved if the organic layer is deeper than 150 mm. If this condition is not met, then the default approach will be to surface lay the cable and/or conduit.
		Road Prism Crossings will be HDD with a minimal sized drill to reduce risk of disturbance to the road subsurface. Drill entrance and exit holes must not be established within the road prism. The HDD highway road crossing bore holes will enter and exit with a min distance of 15 m from the centre of the road.
		There are ~300 culverts along the Dempster #8 route from the NT border to Inuvik. Many of these culverts are near their end-of-life and therefore will be scheduled for replacement within the 20-year DFL project lifecycle.
		Aerial crossings will be allowed as a last resort, if poles are installed away from culvert inlet/outlets and near the outside edges of the highway ROW. This is to ensure culvert replacement or repair activity will not impact the fibre cable. If poles are required, they will be placed within +/-5 m of the cable alignment.
4.0	Permitting Considerations	Route Permitting considerations; • The Permitting process and submissions, follow-up etc. will be provided by Hemmera. Stantec will support Hemmera through Drawing and Document support. • First Nation and Indigenous groups. permitting, engagement and consultation is being undertaken by YG in both YT and NT jurisdictions.
5.0	Geotechnical Considerations	Geotechnical considerations are covered in depth in the Geotechnical Design Brief included in Appendix A.
6.0	Environmental Considerations	Species at Risk in Yukon; • If fibre is placed on west side of highway between Km 211 and 225, a qualified biologist should inspect for Showy alpine forget me knot plants in late May or June • A Qualified biologist should inspect for Hudson Bay sedge in non-forested area of KM 28- 40 in mid-June - July • Section 3.4 Wetlands, for Klondike highway Section construction should occur before May 1 and after August 30 to avoid nesting and fledgling ducks. A nest survey may result in this period being reduced.
		Water withdrawal sites;

Item	Category	Assumption
		• Work during frozen conditions will include trail clearing/mulching, horizontal directional drilling, cable placement • Work during non-frozen conditions will include plowing of cable and conduit and HDD in areas where the ground can support construction equipment, shallow burial plowing, surface placement of cable and conduit. Hand trenching and aerial installation. • Effects on permafrost to be managed by design and construction considerations • Effects on water quality and quantity to be managed by design and construction considerations • Effects on fish and fish habitat to be managed by design and construction considerations • Effects on vegetation to be managed by design and construction considerations • Effects on wildlife to be managed by design and construction considerations • Breeding bird season - need to schedule activities to avoid this season (varies by location but generally early- mid May to early August) or take mitigations such as nest surveys prior to activity
		Heritage Resource Considerations; • To avoid high heritage resource potential areas, stay within 10 m of edge of roadbed, where this cannot be avoided stay within vegetation control zone and avoid the tops of any elevated landforms or stay on side slopes. Drilling sites should be 30 m away from banks of watercourse. • Avoid known heritage resource sites by 30 m
		Other; • Placing cable within highway/utility line ROW as much as possible • Avoiding interaction with water and fish habitat as much as possible. Yukon and NWT guidelines specifying preferred practices for mitigating effects to water and fisheries will be followed if works are required around streams. • Conducting work outside sensitive periods for vegetation and wildlife as much as possible • Implementation of invasive species control measures

Item	Category	Assumption
		• Following geotechnical consultant's recommendations for minimizing terrain and permafrost disturbance • It is also recommended that the practice of laying the cable on surface in wetlands, be discussed with various Authorities, (DFO, Yukon Environment, ECCC) to determine if this is an acceptable practice. • Any alteration of the proposed route (e.g., to go outside of the highway ROW corridors) there may be a need for further environmental and archaeological analysis to determine if there are other environmental or archaeological concerns present that may require additional mitigations not specified to date.
7.0	Optical Platform	Design of the Optical Platform will be provided by NWTEL.
		Design oversight of the Optical Platform will be provided by Stantec
		Termination of the fibre; amplification and breakout of the Optical signals will occur at select NWTEL microwave sites along the Dempster highway in both the YT and the NT. Additional future breakout points may also be required along the Dempster highway route.
		Optical Platform end-point terminations will occur at the NWTEL CO's in Both Dawson City and in Inuvik.
		Optical Platform should consist of a redundant bi-directional folded ring architecture operating in a hot-standby configuration. This configuration will ensure that if a fibre cable is cut, connectivity is maintained to both sides of the cut or for specific fibre section cable failures. NWTEL optical design to be discussed and reviewed during schematic design phase.
		Electronic redundancy should exist at all equipment and termination sites to facilitate a hot-standby fail-over architecture.
		Potential for future breakout points will be possible at the nearest FOSC handhole location along the fibre route. Interest in future breakouts has been shown by First Nation and Indigenous group jurisdictions.
		Considerations should be given to utilizing a fibre cable with additional spare capacity, possibly 72 count fibre strands versus 48 count to meet future breakout needs along the proposed route.
8.0	DFL Operations	Future Operations and maintenance for the DFL shall be provided by NWTEL.
		The FOCI field components will be selected based on NWTEL Outside Plant Standards, once those standards are made available to Stantec.

Item	Category	Assumption
		The planned Operational Lifecycle of the DFL network shall be 20 years.
9.0	Construction Phase Considerations (Along Dempster highway in both the YT and NT jurisdictions)	All HDD will be completed using the smallest drill size possible to minimize soil, roadway and permafrost disturbance. Small diameter SDR-9, Schedule 40 or Schedule 80, HDPE conduits will be used in all HDD crossings.
		HDD activity may be separated and completed according to a different schedule profile and possibly with a different contractor from normal cable installation activity along the route. This approach will be finalized as the design progresses beyond conceptual design.
		All cable installation methods and techniques will ensure that clearing or removal of any vegetation along the alignment will be kept to a minimum to reduce potential long term environmental and permafrost impacts
		To minimize potential erosion and sedimentation issues during construction, the contractor will implement appropriate best management practices for permafrost protection and erosion and sediment control.
		Organic layer and soil conditions along the proposed route are not predictable and vary significantly in depth of cover. This suggests that the design and ultimately the installation contractor must undertake an adaptive approach to the construction strategy. A simple rule-set will be developed to provide the required field direction for when to shallow bury and when to surface lay the cable/conduit.
		All major rivers will be crossed utilizing HDD techniques. The only other consideration may be the Arctic Red river which separates Tsiigehtchic from the Dempster highway. This consideration will be finalized as the design progresses beyond conceptual design.
		Construction Camps locations within the DEMPSTER highway #5 corridor will be allowed to situate within on the highway gravel Quarries but their size must stay below a trigger level of approximately 50 people. On the NT side, there is similar thinking that construction camps could be situated within the gravel quarry locations. The locations will be finalized in the final construction level documents.
		Construction Field Equipment; • All site equipment to be used during the construction phase must meet all highway regulatory weight and size limits. • Drill rigs over 500kg cannot be utilized without obtaining permits from YESAB or MVLWB.

Item	Category	Assumption
		Mineral licks; Avoid placement of temporary camps and staging areas within 1 Km of known mineral licks.
		Thinhorn sheep; • Avoid performing construction activities, including the establishment of camps, within a 5 Km radius of Angelcomb Mountain and Km 180 of the Dempster highway during May and June, as these areas are known sheep lambing sites.
		Wolves; • The fibre optic cable is to be installed on the west side of the Dempster highway near Engineer Creek to avoid disturbing a known wolf den located near the highway ROW on the east side.
		Moose; • Temporary camps will not be placed near the Ogilvie or Blackstone Rivers in May, as these river corridors are known for moose calving.
		Caribou; • A 1 Km buffer will be established for working in areas where caribou are present. If caribou come within 1 Km of any work site, work activities will cease until the caribou have moved safely beyond the buffer. A wildlife monitor will be present during construction activities to ensure this mitigation is implemented. • Absolutely no activities will act as a block, or in any way cause a diversion to migration of caribou. A wildlife monitor will be present during construction activities to ensure this mitigation is implemented.
		Breeding birds; • Breeding birds are not to be disturbed. Clearing vegetation will occur outside of the migratory bird nesting season (i.e., May 15 to August 15). If clearing must occur after May 15, then nest surveys shall be conducted by qualified and experienced personnel prior to clearing. If active nests are discovered, the proponent shall postpone activities in the nesting area until nesting is completed. • A project-specific Bird Nest Mitigation Plan will be developed to reduce the risk of incidental take and to provide direction on survey methodologies and establishing appropriate setbacks. • No construction activities shall take place within 300 m of known raptor nests from April 1st to July 31st, where possible.

Item	Category	Assumption
		Bears; • Bear safety training will be provided, and den sites will be avoided, and any new den sites will be recorded. If bears are present in the area, work will cease until the bears have moved safely out of the area. All bear-human interactions will be reported. • All waste will be managed in a way that it is not a bear attractant. It will be temporarily stored in bear-proof locations until it is properly disposed in a Waste Management Facility.
		Miscellaneous; • A project-specific Wildlife Management and Mitigation Plan (WMMP) will be developed. • The contractor will retain a wildlife monitor to be present during construction to ensure that mitigation measures in the WMMP are applied. • No personnel shall carry or discharge firearms for the purpose of hunting wildlife. • The contractor will educate all staff regarding the WMMP to ensure the mitigations are observed. • No project personnel will be allowed to hunt or fish while employed with or working on the DFL project. • The fibre optic trench will be backfilled immediately as required to avoid wildlife injury.

7.4 Construction Level Drawings

This section provides a short discussion on what information will be required on the Drawing set for the construction contractor. The contractor’s core competencies relate to construction techniques in installing the fibre optic cable. The IFC drawings and the associated Material and Installation specifications will provide all the information the contractor requires to construct and install the FOCI to create the DFL. Any environmental or archaeological mitigation strategies that are required are to be implemented in consultation with the owner’s consultants.

In summary, the drawings and specification documents will need to capture the following information;

- Alignment along the route - Indication of where the cable/conduits, handholes and poles must be installed, referenced to centre of road. GPS record information will be required from the contractor.
- Depth of cable required along the alignment.

- Cable placement strategy for surface-laid, shallow burial, conventional plow and aerial construction. GPS record information required from the contractor.
- Number and size of cables along the route and in the trench.
- Clear Indication of all the hazard areas – location and methods for crossing and construction impact mitigation requirements. GPS record information required from the contractor.
- Identification of all crossings, location, conduit requirements, pull strings, construction method and depth of crossing. Construction impact mitigation requirements. Detail drawings to support type of crossing. GPS record information required from the contractor.
- Location of all handholes, FOSC and pole placement locations. GIS based references. GPS record information required from the contractor.
- Construction schedule and timing of work based on construction impact mitigation requirements.
- Complete FOCI installation requirements detailed in the Material and Installation specifications. All relevant reference drawings and documents to be identified.
- Cable splicing tables for all FOSC locations referenced on the drawings.
- Continuation key map included on the drawings.

Refer to Appendix D for a sample of the construction level drawing content.

7.5 Fibre Cable and Conduit Options

7.5.1. Direct Buried Cable

Cable buried directly into the ground is specifically designed with various measures of protection to withstand harsh environments without the need for external conduit, sheathing or piping for protection. Such measures include medium density polyethylene outer jacket (single or dual), dielectric or steel strength elements (steel, glass, Kevlar or Glass Reinforced Plastic Rods (GRP)) and armoured protection (corrugated steel tape or steel taped single or dual).

The advantages of using direct-buried cable for the DFL application includes lower initial installation costs and design engineering. Disadvantages include inflexibility of future expansion and corrective maintenance costs, due to risk of damage during cable replacement or repairs to OSP infrastructure, as well risks in physical protection of the cable outer jacket from the elements. It is pertinent to note that when there are a large number of crossings whether roadway, wetlands, creeks and streams or rivers, there is a need to locate vaults on each side of the crossing.

Further, in order to continue with the placement of the cable after the crossing, the cable must be unspooled from the reel temporarily on the entrance side of the crossing and then pulled through the crossing conduit, then it must be re-spooled back on the reel in order to continue with the placement on the crossed side. This spooling and un-spooling process can add considerably to the labour component of the installation and add risk to the cable integrity through excessive handling.

If a conduit is used, then the spooling and unspooling of the cable at all crossings is eliminated, thereby improving contractor run rates and labour efficiencies. Also, significant reduction in the cable handling risk.

Due to terrain, vegetation and permafrost constraints on this project, a harsh environment single or double armoured fibre cable configuration would be the minimum required in order to protect the fibre cable sufficiently from rocky backfill expected along many sections of the Dempster highway route. Even with a double armoured cable though, the possibility of outer jacket damage through kinks, dents, excessive forces through ice buildup, winter/summer heaving, and potential rodent damage are all real possibilities which could occur.

The drawback of using a heavily armoured steel reinforced cable for the DFL application is that in discussions with the fibre based acoustic sensitivity and temperature detection vendors, the sensitivity performance is negatively impacted with double armoured or steel re-enforced cables. This may eliminate the ability to consider using the fibre cable as a fibre optics distributed temperature and acoustic sensing (DTS) device to study permafrost temperature regime along the Dempster highway.

Fibre strand counts will be determined as the design progresses, although it is important to note that the fibre strands are the least costly components of a robust direct buried underground cable. Depending on the internal fibre tube configuration, the physical cable size will not change for strand capacities of 24 count through to 72 count cable. The following is a sample of the type of cable mechanical construction which will be considered for our direct buried and surface-laid application.

Dimensions	Inch	mm
316L SS tube	0.126	3.20
Galvanized Steel Wire	0.130	3.30
Outer Metal Tube (Incoloy 825)	0.250	6.35
Outer Jacket (HDPE)	0.492	12.5

Figure 1 – Typical direct buried armoured fibre cable

7.5.2. **Cable Installed in Conduit**

It is common in the Telecom Industry for cables to be buried in conduit to provide further protection and allow for ease of repair and future expansion. Cable in a protective conduit allows for a less robust cable to be used, thus reducing the cost of the cable and cable weight, however in our DFL scenario, we prefer to use a heavier cable along the Dempster highway ROW as the majority component of the route will likely be constructed using a surface-laid or shallow buried cable installation strategy. Also, a conduit can be joined using fused couplers along the way thus creating a continuous corridor for the cable to be pulled in or jetted at a later date. This is advantageous when the number of crossings becomes substantial. After reviewing the Palmer and the NCE reports on the number of hazards which have been encountered along the proposed route, a conduit-based solution is now favoured and will be less expensive overall than a direct buried cable solution.

The disadvantage of placing cable in a conduit includes some added initial installation costs as it creates a two (2) pass construction approach, specifically the first pass to place the conduit and then a second pass to install the cable within the conduit. Additional engineering and documentation is also required and conduits can potentially provide a path for water ingress and migration into handholes and generally adds to installation time and in-field resource requirements, but with all things considered, we anticipate a net positive impact to the overall budget and schedule with a conduit based solution.

7.5.3. **Aerial Plant Considerations**

The aerial OSP components are anticipated between the NWTEL Dawson CO and the South West Edge of Dawson City. In town, the fibre Cable will be attached to Yukon Power (YEC) low voltage distribution (LVD) poles via a route that provides a minimum of 10m of separation between the DFL cable and the NWTEL Network fibre Cable. The specific alignment and route are to be determined after discussions and consultation with NWTEL. Those discussions have started but specific network details have not been provided.

Further, depending on the alignment of the existing NWTEL cable along the Klondike highway #2 route, the DFL cable may be installed aerially from the South edge of town to the highway #5 turn-off on highway #2. We have learned that there is a parallel YEC High Voltage Transmission (HVT) pole line which goes from the Dempster Highway turn-off on Highway #2 to the power sub-station in Dawson. The design at this conceptual stage will assume that the DFL can use the full 41 Km or aerial pole line to get to Dawson.

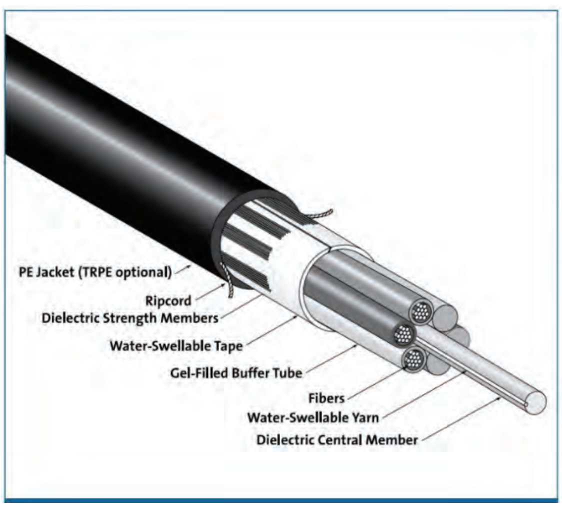
On the NT side, we anticipate an aerial route in two (2) locations, The first at the entry point to the Fort McPherson breakout location and the second, from the Inuvik Water Supply and Pump Station located just outside of town, through the community on North West Power Corporation poles terminating at the NWTEL Inuvik CO. There is potential route conflict with the MVFL cable on highway #8 near Inuvik and also on the aerial pole line into town. The aerial routing in town to the Inuvik CO will need to be coordinated with GNWT. A minimum separation of 10m is recommended to improve reliability and reduce redundancy risk.

The fibre cable which should be used in these aerial attachments will be an All Dielectric Self Supporting (ADSS) light-weight cable, with the following key characteristics;

- The ADSS optical cable shall be of non-metallic Aerial type designed for installation on up to 220 kV / 132 kV Power transmission lines with span length capability of 150m to 200m. This will allow the same cable to be used throughout all aerial components of the DFL build.
- The cable shall be designed to withstand all prevailing environmental conditions including the effects of high electric and magnetic fields produced by the proximity of live power conductors.

- The cable shall have a very low Electrical Conductivity to avoid currents on the surface of the cable in all situations.
- The mechanical structure of the ADSS cable shall be designed to withstand the wind, ice loading and other environmental conditions prevailing within YT and NT climatic environments.
- The cable structure shall be such that the fibres are protected against water, hydrogen, ultraviolet radiation and other environmental hazards encountered in the Canadian North.
- The cable should be chemically modified to provide a measure of rodent protection.
- Fibre strand attenuation characteristics will align with the underground cable performance for long haul single mode optical transmission. Fibre strand counts will be determined as the design progresses, although it is important to note that the fibre strands are the least costly components of a robust ADSS cable. Depending on the internal fibre tube configuration, the physical cable size will not change for strand capacities of 24 count through to 72 count cable.

The following are typical samples of ADSS aerial cable which will be considered for the aerial portions of the DFL build.



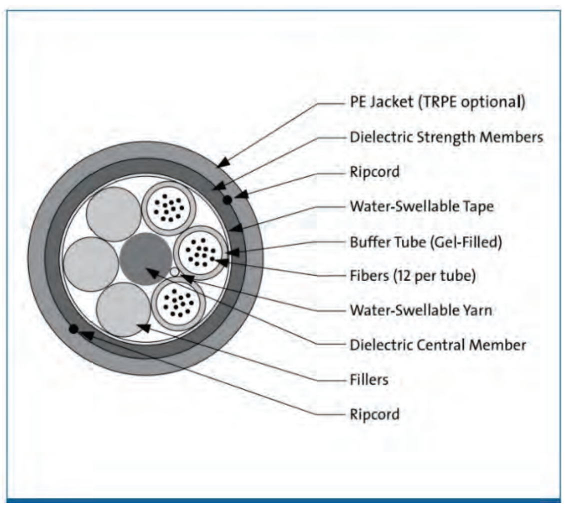


Figure 2 – Typical ADSS aerial fibre cable

7.5.4. **Optical Network Considerations**

The optical network design will be completed by NWTEL for this project. Stantec will provide design oversight to ensure that the NWTEL design will meet all the YG requirements. The DFL project objective is primarily to be used as a secondary or diverse connection to the outside world. The following map depicts the improved northern connectivity that the DFL will help facilitate.

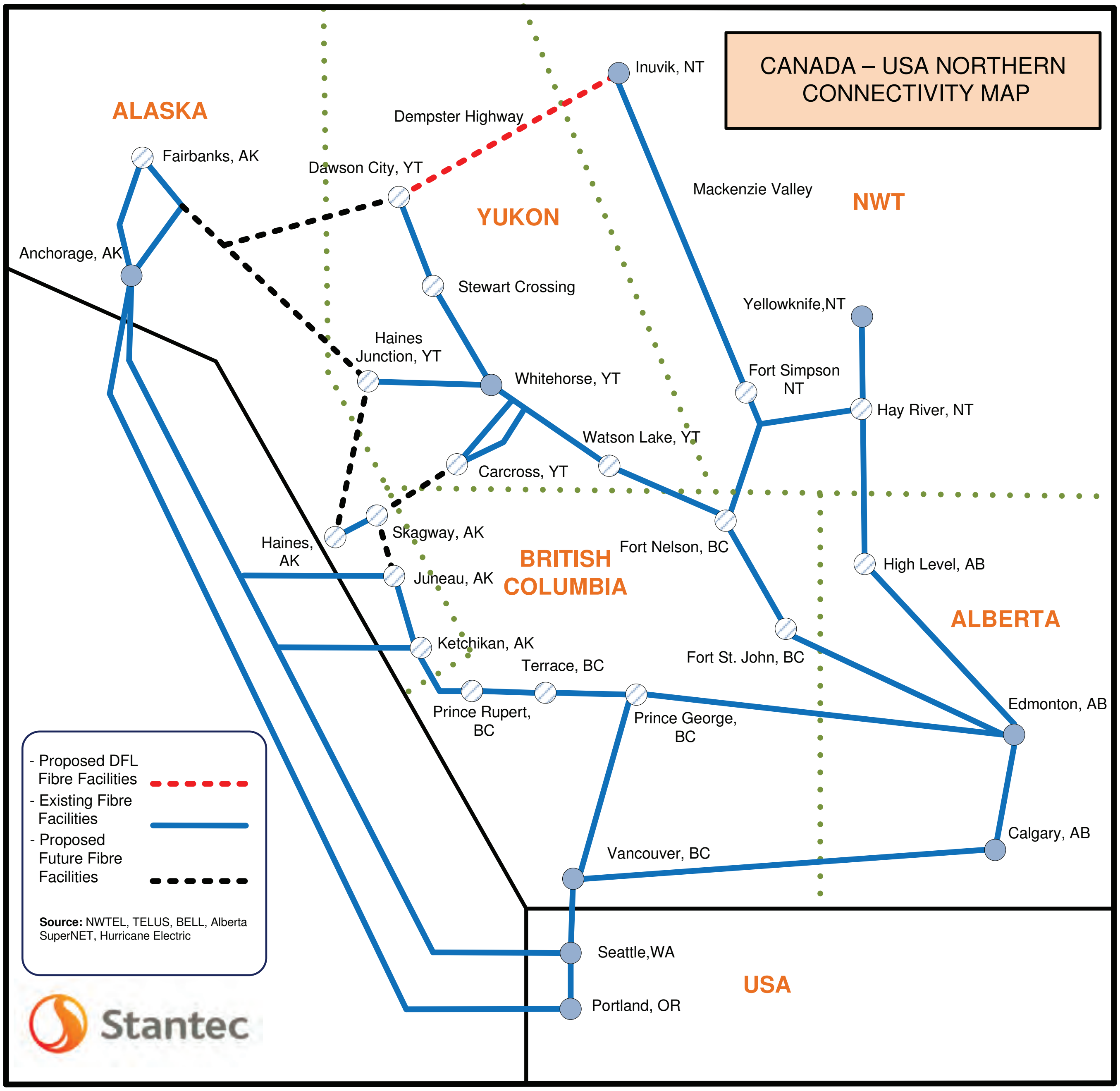


Figure 3 – Network Connectivity Canada North

7.5.5. **Topology and Network Architecture**

The topology design for the DFL network architecture is in progress and the final design will be determined by NWTEL Engineering. In Stantec's opinion, the design must include components which support electronic redundancy at each active amplification, end-point termination or add-drop (ADM) site along the route, as well as some level of physical route diversity and industry best practice failover protection strategy. Multi-WAN connectivity and an auto and seamless fail-over functionality is required to ensure maximum connectivity and minimum service interruption in the overall network. Symmetrical bandwidth capacity should be allocated in the failover functionality to allow for full transfer of all primary channel network data.

The most reliable failover scenario is "hot standby," where both systems permanently run in parallel and data on both systems is 100% synchronized at all times. Users will not be aware of any failures. This level of failover protection is the minimum required for the DFL. To run both with systems in complete synchronicity, the connections must be mirrored 100%.

A highly reliable end-to-end network configuration, with a system reliability >99.990%, fifty-two (52) minutes maximum downtime per year, is important to support critical customer services added and/or dropped off along the network between Dawson and Inuvik. As well, bi-directional redundancy is highly recommended since the DFL vision is to serve as a North-to-South and South-to-North redundant connectivity pathway to the outside world. The NWTEL optical platform design will support a highly reliable "Hot Standby" configuration.

At the physical layer, the network architecture essentially resembles two stacked bi-directional concentric rings, with network elements along the route terminating at two end locations. Data would travel simultaneously in both directions of the fibre link on different fibre strands within the cable.

The data links will operate in "hot-standby" mode to ensure connectivity to both CO locations simultaneously. Automatic Hot Standby Router Protocol (HSRP) switching or other network recovery failover mechanisms would be used between the primary and back-up data links to recover the network within fifty (50) milli-seconds across the entire network. This will create a fully redundant, failsafe routing topology. A ring topology strategy is proposed irrespective of what optical transport technology is ultimately selected in the final design.

7.5.6. **Network Logic Diagrams**

The following logical diagram provides a high-level schematic view of the proposed architecture. At this early stage, Stantec has had only preliminary design discussions with NWTEL engineering, therefore this view reflects only Stantec's perspective on how the network topology could be architected. A high-resolution version has been included in Appendix C.

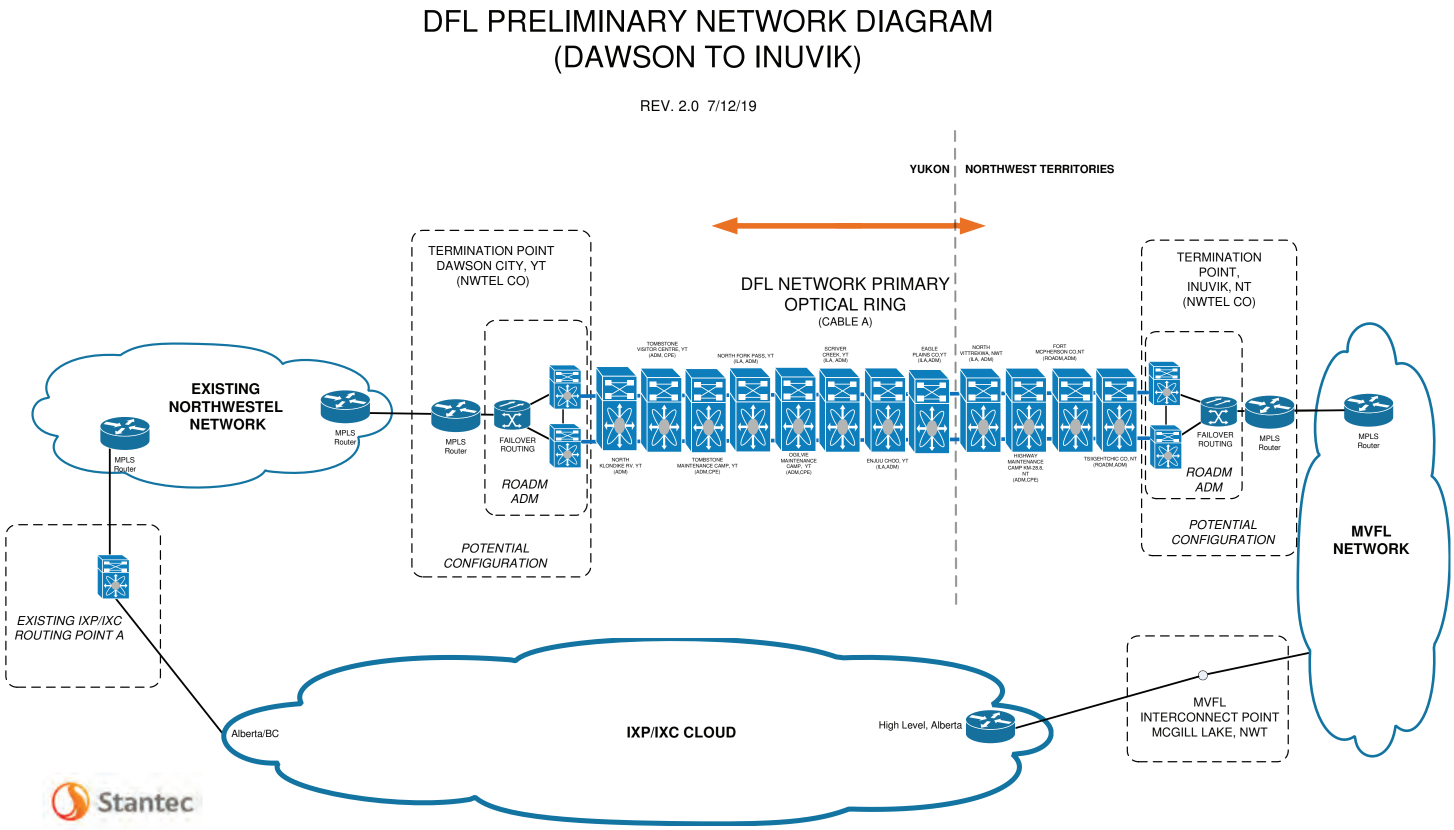


Figure 4 – DFL High Level Network Diagram

8. Construction Methodologies

The following sections will discuss the various construction techniques to be considered for the installation of the fibre cable along the Dempster highway. At this conceptual stage, there are still open questions as to the best approach for some of the more difficult and challenging construction areas. The design will need to balance the potential long term environmental and highway integrity impacts against the feasibility and constructability of the network. In order to achieve this, the contractor will need to undertake an adaptive construction approach in completing the deployment of the DFL.

An adaptive approach would involve the use of alternative construction methods (as required and directed by the owner's consultant) to mitigate for uncertainties encountered in the field that apply, but are not limited to, the following construction techniques:

- Shallow bury - direct-buried (typically 150-400 mm depth) cable and/or conduit using cable plowing or trenching techniques in non-frozen conditions, in areas of the route where the active permafrost and surface organic layer has coverage greater than 200-400 mm. Objective is to maintain the cable and/or conduit placement above the permafrost with minimal disturbance.
- Shallow bury - direct-buried (typically 100-150 mm depth) cable and/or conduit using cable plowing or trenching techniques in non-frozen conditions, in areas along the route where the active permafrost and surface organic layer has a minimal coverage of 200 mm. Objective is to maintain the cable and/or conduit placement above the permafrost with minimal disturbance.
- Surface-laid cable and/or conduit in sensitive terrain and wetland areas in frozen and non-frozen conditions. Objective is to minimize permafrost active layer disturbance in continuous permafrost areas along the route. Ideally using a small trencher to just bury the cable and/or conduit within the vegetative layer and folding the vegetation back over the shallow trench.
- Horizontal Directional Drilling (HDD) of all fish-bearing streams, rivers, other waterbodies and challenging sections. Objective is to minimize surface disturbance in challenging areas of the route.
- New aerial cable installation in selected sensitive or challenging construction areas. Objective is to minimize disturbance and maximize cable protection when crossing areas of highly sensitive terrain or areas of severe geological instability or hazards along the route.
- Aerial cable installation along existing Yukon Energy Corporation (YEC) Transmission Line poles for approximately 41 Km parallel to the Klondike highway. Objective is to leverage existing pole lines for a more cost-effective build but to also create a diverse pathway into Dawson from the Dempster turn-off along Highway #2.
- Aerial cable installation along existing pole lines in selected sections within the communities of Fort McPherson, Tsiigehtchic, and Inuvik, NT.

Further discussions and review with the YT and NT highway's jurisdictions and with NWTEL will help to finalize the best construction methods for the eventual construction of the DFL.

9. Geotechnical Considerations

Geotechnical considerations will be discussed in depth in the Geotechnical Design Brief, which was completed by our sub-consultant, Tetra Tech. It is reasonable to conclude however that the geotechnical challenges are significant on this project as described in numerous consultant reports and assessments completed for the YG over the last few years. As clearly indicated in the Tetra Tech Geotechnical Brief, the Dempster highway continues to deteriorate as northern climatic conditions change and meander encroachments increase along the highway. Significant disturbance of the road prism must not occur with any of the construction methods deployed on this project. Refer to the attached Geotechnical Design Brief in Appendix A for a very detailed in-depth assessment of the geotechnical considerations on this project.

9.1 Erosion and Sedimentation Controls

This section has been extracted from Tetra Tech's Geotechnical Design Brief and has been specifically included in this document to more strongly focus this important issue. Erosion and Sedimentation control strategies and appropriate monitoring will be required by the construction contractor to mitigate potential irreversible environmental impacts during the construction of the DFL.

There were numerous erosion, sedimentation and drainage related issues which surfaced environmentally after the MVFL was constructed. This DFL design will focus efforts to minimize those concerns and mitigate the potential for long term environmental damage during the construction phase.

Several construction activities associated with cable installation have the potential to contribute to erosion and the introduction of sediments into local watercourses. To minimize potential erosion and sedimentation issues during construction, the contractor will implement appropriate best management practices for permafrost protection and erosion and sediment control. As a minimum standard, the contractor will follow the practices for erosion and sediment control detailed the Yukon Government guidance document Preferred Practices for works affecting Yukon waters (Government of Yukon 2019).

Surface erosion techniques are important to absorb precipitation and runoff impacts, reduce runoff velocity, improve infiltration and bind the soil particles with roots. To minimize potential impacts leading to erosion and sedimentation, suggest completing most of the necessary ROW clearing and HDD stream crossing activities in the frozen ground conditions.

For erosion-prone activities to be undertaken during non-frozen conditions, implement various temporary and permanent surface protection techniques based on site-specific surfaces and slopes including:

- Shallow plowing to avoid permafrost exposure and disturbance;
- Surface lay cable were required;
- Hand clearing of riparian areas:
- Mulching during clearing;
- Maintaining root-wads;
- Erosion control matting when applicable; and
- Restoration of riparian areas if necessary, using willow cuttings and other native plantings.

Slope protection techniques are typically determined by the type of material and slope grade. If erosion and sediment control measures are required along slopes during construction, the Contractor will employ appropriate control measures such as:

- Applying applicable surface erosion protection;
- Maintaining vegetative strips (where appropriate);
- Installing wattles, straw bales, silt fences, etc.

To avoid erosion concerns related to permafrost, the contractor shall employ installation methods that reduce the likelihood of disturbing or exposing permafrost and thaw-sensitive mineral soils. The contractor will coordinate with the design team to confirm such sensitive areas along the alignment.

9.2 Road Prism Installation

Significant disturbance of the road prism must not occur with any of the construction methods deployed on this project. Both YT and NT highway jurisdictions have raised concerns over installation of the cable anywhere within the Dempster highway road prism. There has been a substantial history of road prism degradation along the Dempster and allowing a cable to be installed within the road prism will potentially make the problem worse.

There may be locations however when the ground and/or terrain circumstances or the risk is justified, then installation within the road embankment may be the only acceptable option. This special exception was acceptable to the YT and NT jurisdictions provided that they can review the specific circumstances and make the final determination for approval.

This conceptual design brief is focused on construction solutions which do not include cable installation within the road prism along the Dempster highway. However, in some circumstances the only economically practical installation method may be to install the cable within the existing road prism. This is typically recommended in cases where the project corridor is bound by a river on one side and steep mountain slope on the other which will be limited mostly to some southern portions of the route in YT.

When cable installation is required within the road prism, it will be installed in a small 32 mm conduit which will be placed in a shallow trench, backfilled and compacted or as otherwise dictated by the jurisdictional highway authority. The cable will then be jetted or pulled through the conduit. In instances that pose a high risk of erosion of the road base such as the presence of an adjacent river, the cable will be installed on the upslope side of the road.

9.3 Conventional Plowing

Conventional plowing of direct buried fibre cables can be done with large static plows or smaller vibratory plows, but they need to be plows specifically designed and rated for pulling fibre optic cables.

Conventional vibratory plowing is an effective way to increase construction output and is used extensively in areas where there is significant depth of cover and the soil conditions are sandy with minimal gravel and rock content. The vibratory plow vibrates the blade behind the pulling machine to cut the trench while at the same time installing the conduit or cable within that trench. It has capacity for significant depth and because the blade vibrates vertically, this requires less horsepower to cut the soil material. The machines however are quite large and would require a sizable cable alignment clearing, estimated at 3-4 m in width.

Static plowing on the other hand requires greater horsepower as it is effectively brute-force dragging the plow blade to cut the trench. Since considerable horsepower is required, the pulling machines are usually D-6 or D-8 type machines sometimes using tandem bulldozers and they create a significant amount of topsoil disturbance and destruction of the surrounding terrain. They can produce significant construction build Km/day output, but they are not suitable or recommended for permafrost sensitive terrain such as in the DFL.

Plowing in underground cable requires careful feeding of the cable into the cable chute of the plow to reduce stress. A capstan feed is used on many plows to synchronize the cable feed. The cable reel and feed chute should be isolated from vibration to minimize potential damage to the fibre cable as it is being installed. Plowing in fibre cables is a process that demands care and experience. The plow operator and crew need to know what they are doing and exercise great caution in handling the cable and avoiding personal harm from the plow machinery.

In this project, the Dempster highway terrain and heavy permafrost conditions will dictate that if a vibratory plow will be used, it must be a smaller machine as it will need to cross the road prism threshold numerous times to get to and from the cable alignment position which will be closer to the outside edge of the highway ROW, than it will be to the road itself. Also, the construction design must result in minimal disturbance of the permafrost active layer and organic top layer.

Vibratory plowing could be used effectively on this project where there is negligible discontinuous permafrost and the soil conditions are sandy with minimal gravel and rock content. Specifically, between Dawson and the Tombstone Park region on the Dempster highway, approximately Km 0-80. Beyond Tombstone park, to the north, the levels of rocky soil and continuous permafrost increase considerably thereby dictating the use of a different Construction methodology.

9.4 Conventional Trenching and Cutting

Trenching involves digging a trench using a backhoe or trencher, laying the cable and then backfilling the trench. All sizes of trenchers are available, and don’t need to be fibre specific equipment unlike plows. The contractor needs to be careful about sharp objects or rocks in the trench or filler since they may damage the cable. If the ground is rocky, burying the cable in sand before filling the trench will provide protection, however bringing in a sizable amount of fill sand to a remote site, such as in this project can slow the installation process and increase costs dramatically.

Microtrenching is another technique used for underground installation of cable and/or conduit, generally on roadways or on private property for fibre to the home connections in urban environments. Microtrenching involves digging a narrow and shallow trench about 25-50 mm (1-2 inch) wide and 200-250 mm (8-10 inches) deep using a special cutting tool. Tools are available that can cut through asphalt or concrete roadways or sidewalks or for cutting in bare ground. After cutting the trench, one can install the cable directly or using smaller diameter ducts or conduits in which the cable can then be installed by blowing or jetting it in. A typical trench can accommodate up to a 63.5 mm conduit which can easily accommodate a 25 mm fibre cable. We are recommending that a smaller 32 mm conduit be used in order to optimize jetting installation and minimize the organic layer disturbance. Microtrenchers are smaller machines which also align better with a narrow cable alignment such as we will have in this project. The following sketches detail the typical shallow bury installation we foresee for the DFL.

Another variation of a smaller trenching machine includes the chain trencher where the cutting blade resembles a wood cutting chain sawblade. This machine comes in various sizes and can be operated by hand or driven by an operator depending on the depth of cut required. The blade can cut from a 50 mm (2”) wide trench to a 100 mm (4”) wide trench. The greatest benefit is that for extremely shallow trenching, 100-150 mm, the blade can be rotated to cut at various off-vertical angles which in the DFL case, could be used to create a shallow cut into the organic or vegetative layer for minimal disturbance allowing for the ability to fold the vegetation back thereby closing the trench and requiring a minimal backfilling component.

Saw-Cutting techniques use a large diameter diamond saw to cut a small 75-100 mm (3-4 inch) wide slot into the ground, allowing for placing of conduits or direct buried cable. Cutting is normally used in extremely rocky soil and bedrock conditions where conventional plowing and trenching is not practical or possible. Cutting machines are quite large is size and would require larger 4m-5m clearing of the vegetation for the alignment. Further, to prevent the trench from caving in on itself, cutting is normally done in winter months when the soil and ground is frozen. This is also required as the weight of the machines would cause significant ground surface damage and contractor productivity issues in melted permafrost and wet muddy soils. Winter construction of this magnitude would also cause significant schedule and further contractor productivity issues.

This approach is not recommended for this DFL application, as the environmental consequences and project cost implications and delays would be considerable.

9.5 Shallow Burial Techniques

Burial of the fibre cable was originally proposed to a depth of 600 -1,000 mm in previous consultant design basis documents. Installation outside the road prism however would involve disturbing the permafrost and the active layer above it. Stantec’s previous experience as well as experience of other consultants has identified that this disturbance of the active layer has significant adverse environmental consequences. Therefore, this conceptual design basis recommends that the cable be buried at a shallow depth of from 100-150 mm or 150-400 mm depending on the organic layer depth of cover. We are also recommending that in less vegetative areas with shallow organic layer depth of cover, that the cable be surface-laid as much as possible. This is expected to be a larger construction component on the NT side of the route due to the levels of continuous permafrost that exist.

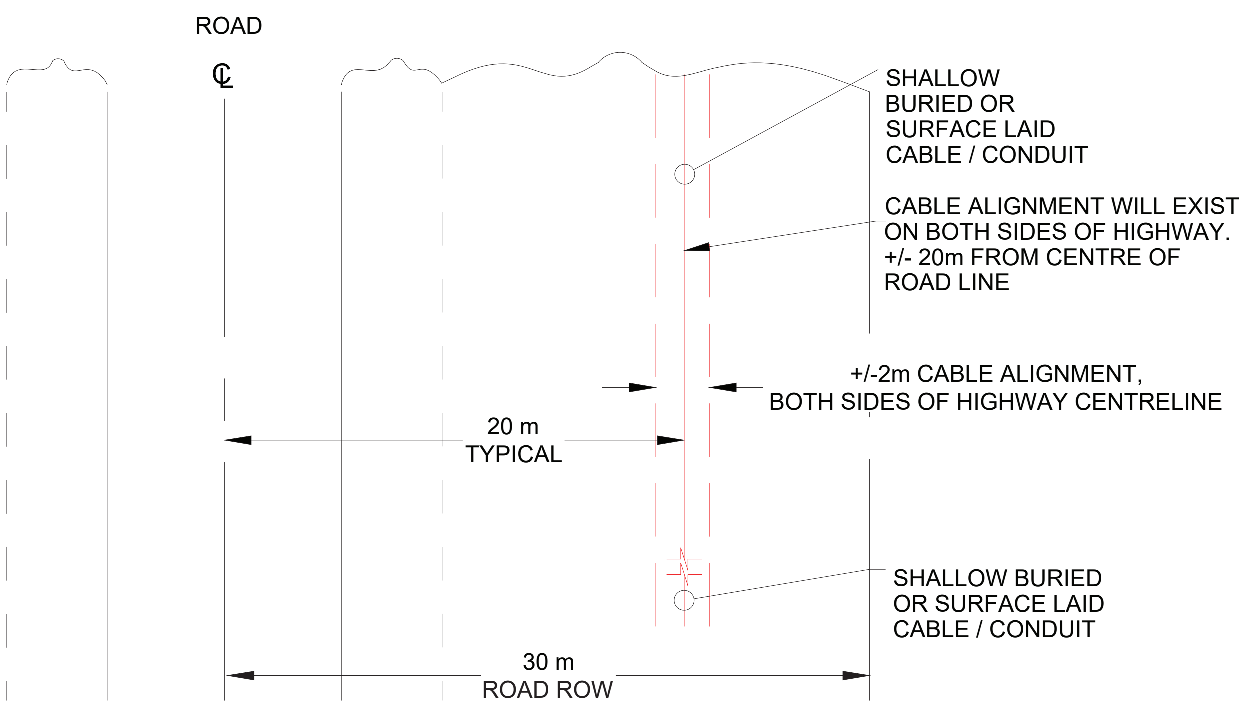
Even with surface-laid cable, we know that disturbance of the vegetation at any level can have negative effects on permafrost warming. Concerns over restoration also surface with installing the cable outside the road prism as there will be a need for some level of clearing even with smaller trenching or plowing machines. Surface-laid cable will have the least long-term impact on the environment. The cable installer must remain diligent in minimizing vegetation and permafrost active layer disruption to avoid heat absorption into the ground resulting in underlying permafrost melt and further loss of vegetation.

To ensure the long-term protection of the cable, the best approach may be to use a small 32 mm conduit in the shallow bury and surface laid areas in order to simplify installation continuity for all the crossings and to also add an additional layer of protection for the cable.

For cable installation outside the road prism, using shallow depth vibratory plows or trenching machines, the construction design will need to consider the following:

- Aggressive construction activities will damage vegetation and disrupt permafrost active layer
- Clearing of the cable alignment and removal of vegetation will increase ambient heat absorption into the ground, elevating the risk of permafrost thaw and ultimately collapse.
- Burial will require cutting a slot or trench, which will tend to become a channel for surface water run-off, especially as the depth of the trench increases. Cutting the trench or slot at an angle then folding the Organic layer back on top after the cable or conduit is placed, may be an approach to effectively minimize and mitigate the surface water run-off concerns.
- Restoration of the trench should include back fill to the surface to reduce future water run-off.
- Where the vegetative mat or surface soils are disturbed, the area of disturbance should be re-contoured and organic material re-distributed as much as possible to ensure proper surface drainage, reduce potential for erosion, and encourage natural re-vegetation.

The following Figure reflects typical shallow bury installations for this project.



TYPICAL BURIED CABLE
PLAN VIEW
N.T.S.

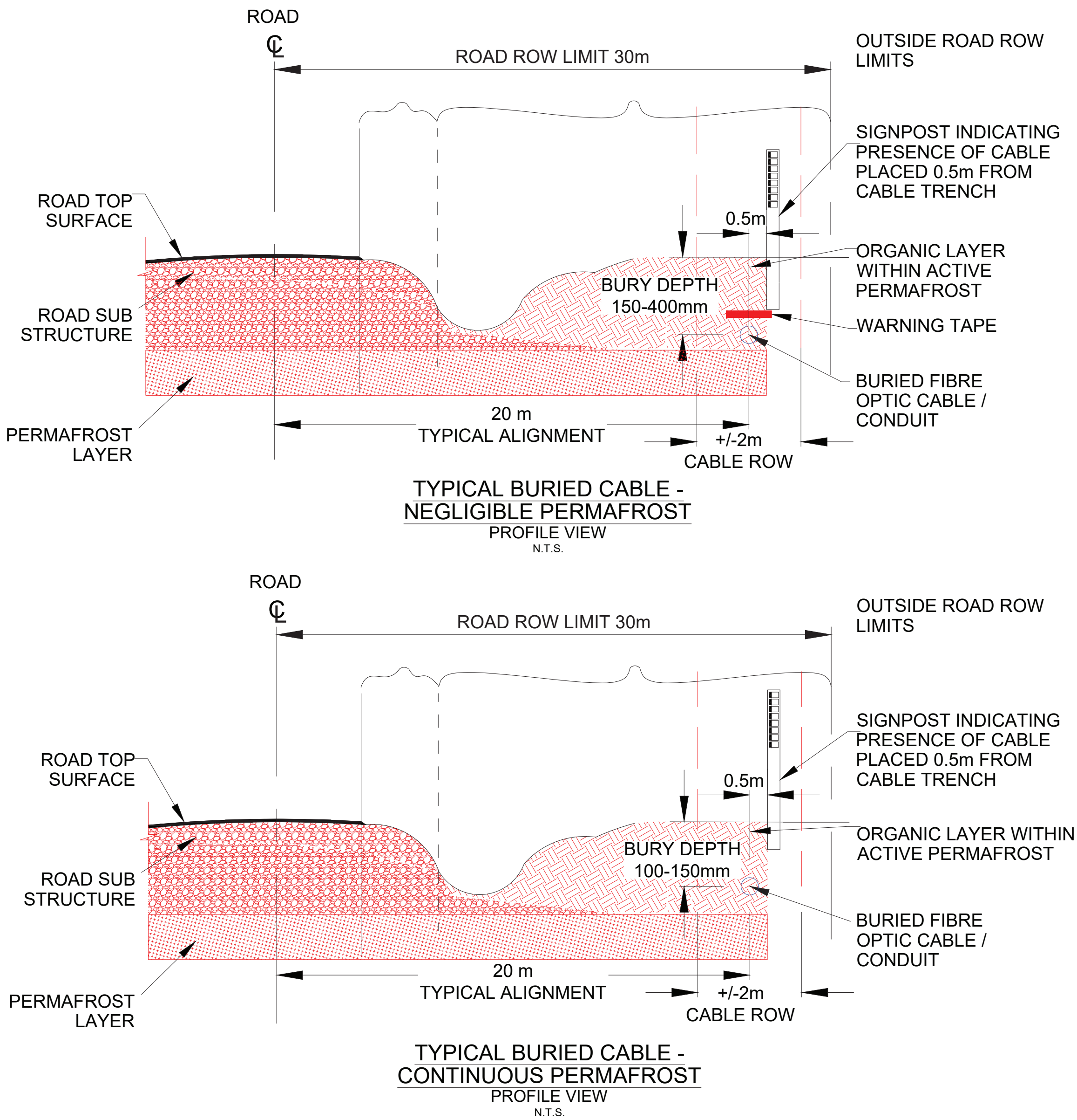


Figure 5 – Typical DFL Shallow Bury Installations

9.6 Horizontal Directional Drilling (HDD)

Horizontal Directional Drilling is a standard industry technique to cross roads, hazards, watercourses, creeks and rivers in the installation of fibre optic cables and pipelines. It is the most expensive construction method and can materially impact a project's feasibility and schedule as it requires considerable set-up time and drills are not always guaranteed to be successful on the 1st attempt. Further as the drill distance increases, the crossings become longer with larger diameter pipes and these will need bigger, more powerful equipment and drilling rigs. As pipe diameter increases, larger volumes of drilling fluids must be pumped, requiring more/larger pumps and mud-cleaning and storage equipment. These factors will increase project costs and impact schedule.

For this DFL application, there will be a large number of HDD crossings depending on final geotechnical requirements and environmental jurisdictional considerations. We anticipate the use of HDD to cross all major rivers without bridges, larger creeks and any watercourses with flowing water and fish habitat. HDD will also be used on all Dempster highway road prism crossings and any highway registered road turnouts or access roads along the route.

The considerations for abandoning HDD and calling for an alternate construction approach will be based on;

- Number of failed drill attempts, normally 3 attempts on smaller simple crossings and 2 attempts on larger more complex crossings,
- The geology encountered under the crossing during the first failed attempt.
- Consideration for size of drill requirement for the crossing, and level of environmental impact on the surrounding terrain
- Practicality of mobilizing a larger diameter drill rig for the crossing which may impact, the highway, and the cable alignment.

HDD requires that for large creek or river crossings, additional information such as a study to identify creek/riverbed geology and/or bed depth, stability (lateral as well as scour), and creek/river width. Typically, pipes are installed to a depth of at least 5m-6m below the expected future creek or river bottom, considering scour. Soil borings for geotechnical investigation are generally conducted to a depth of 10 -12m (up to 40 ft) and for major rivers much deeper than this below the river bottom. In this DFL case, the permafrost layers introduce further complexity to the crossings as it will be important to minimize the disturbance of the permafrost below the creek or riverbeds. Using a small 32 mm conduit for the crossings will meet the minimal disturbance objective.

The larger rivers have greater HDD risk and as such have been geotechnically studied to identify the crossing location and geological profiling of the riverbeds. The Arctic Red river near Tsiigehtchic was not studied formally in the past but will be studied in the summer/fall of 2019. Further, the creeks and flowing watercourses have also not been formally studied geotechnically, therefore additional risk exists in crossing these. The following figure details typical watercourse crossings for this project.

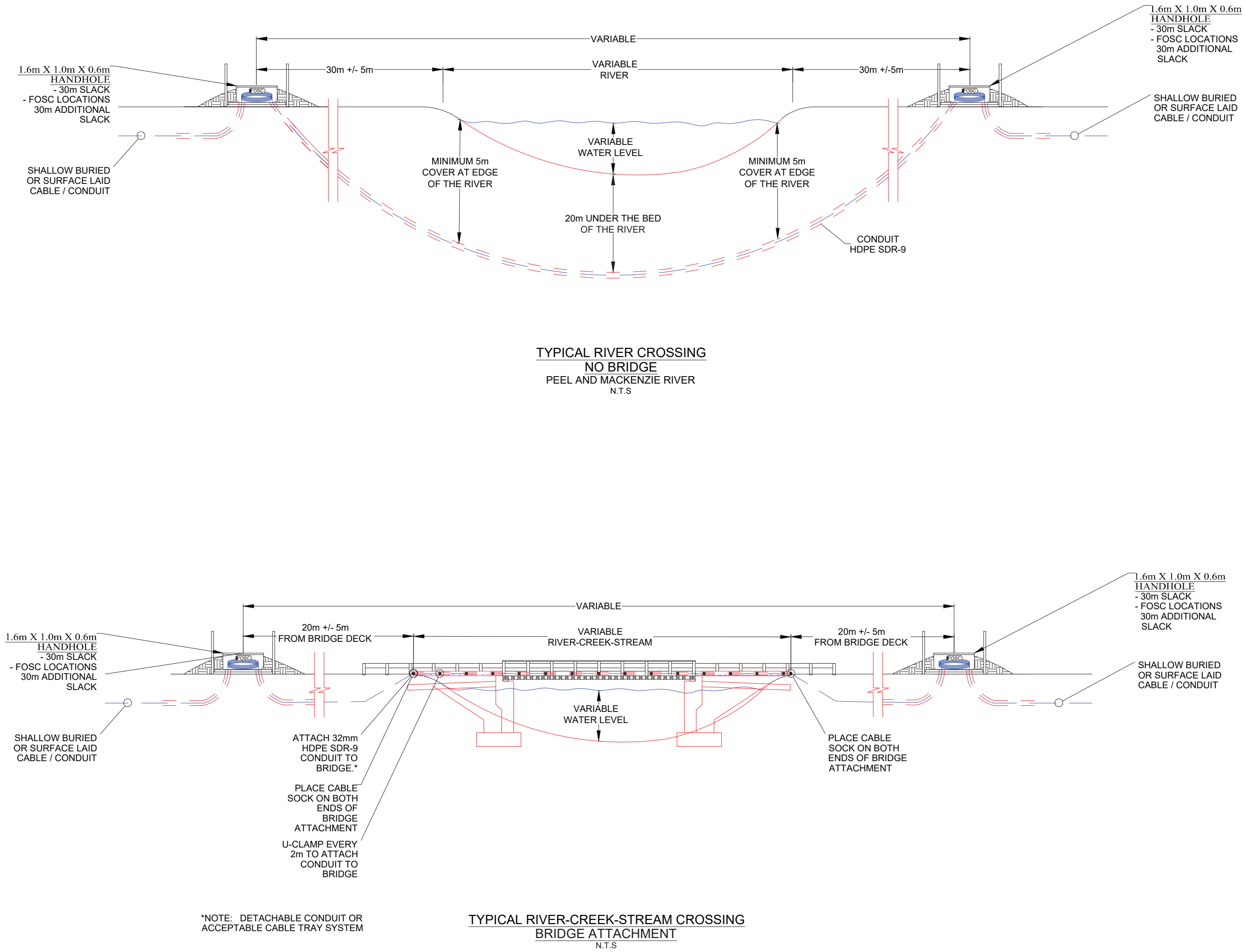


Figure 6 – Typical DFL HDD River-Creek Crossings

The Dempster highway HDD road crossings can be made using crossing angles from 45^0 to 90^0 and 1m-2m below the road prism toe to minimize installation friction and cable bend stresses. This will lengthen the crossings but will simplify the cable installation process and minimize schedule delays. The following Figure details typical road crossings for this project.

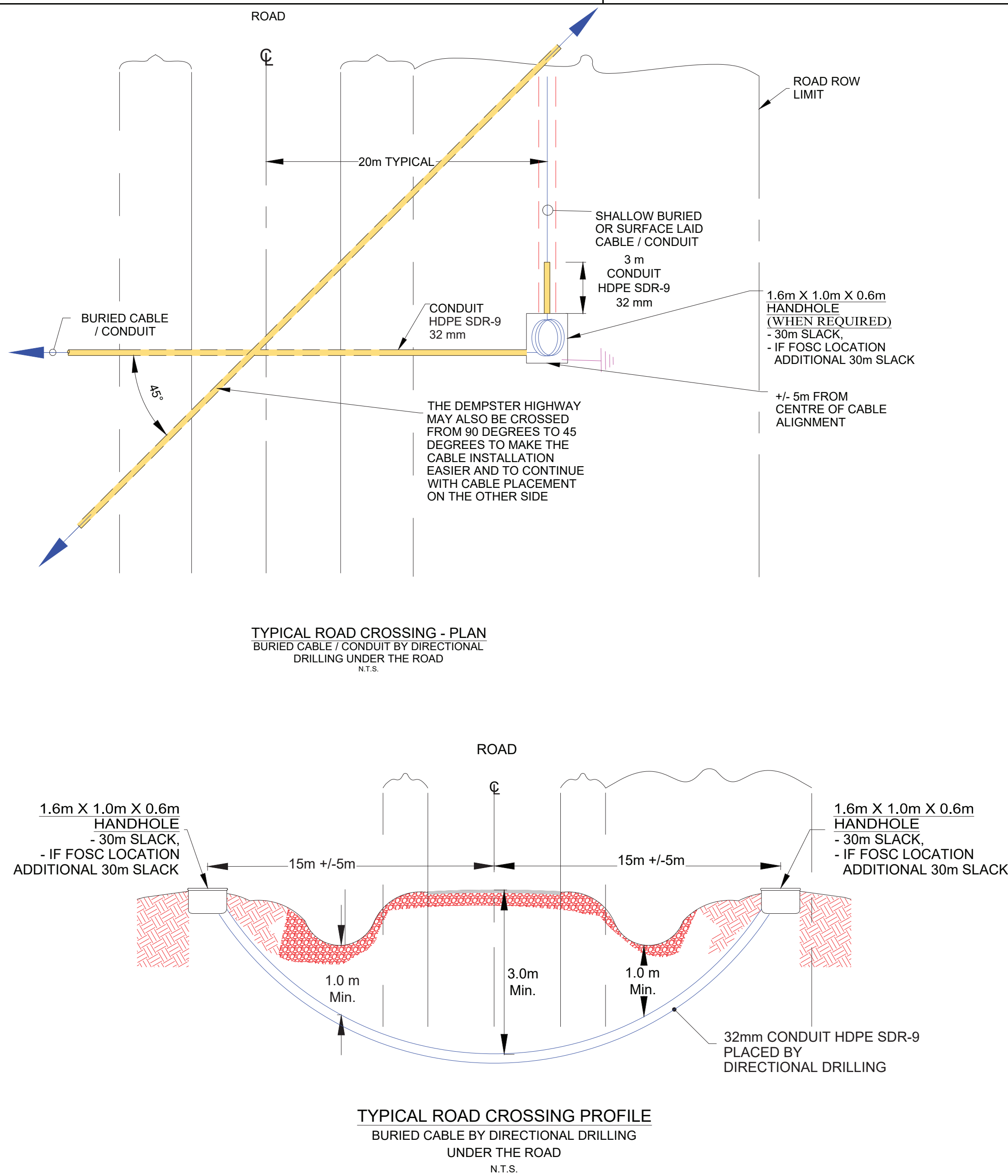
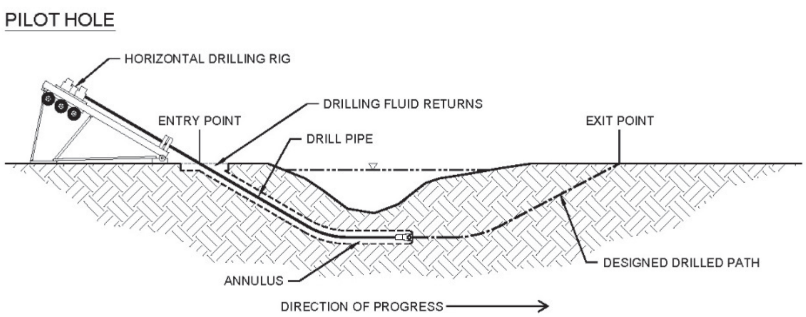
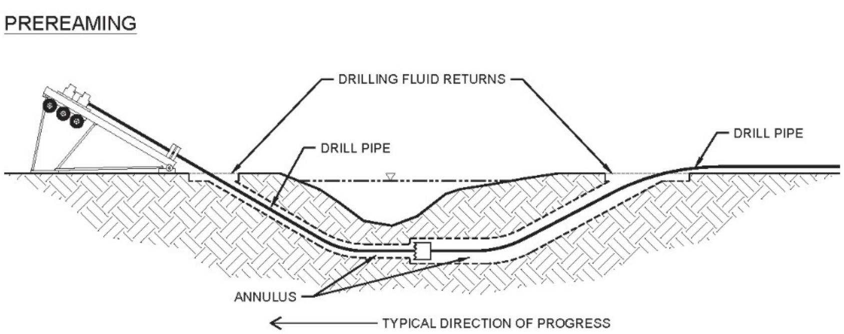


Figure 7 – Typical DFL HDD Roadway Crossings

The design will utilize a small diameter drill size, ideally less than 75mm, in order to minimize disturbance of the soil substructure. In all HDD cases, a conduit will be pulled back and used to create the pathway for the cable. A shadow duct or spare conduit may also be pulled back at the same time to provide a back-up pathway, in the event that the primary conduit is damaged in the HDD process.

To provide some perspective of what is involved in the HDD process, consider the following sketches:





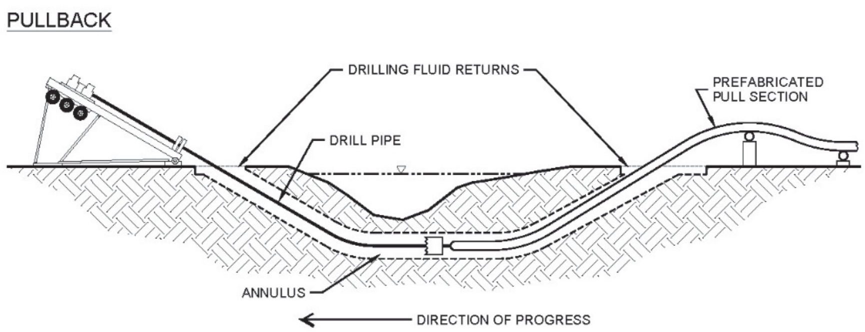


Figure 8 – Typical HDD Crossing Process Components

In summary, HDD installation methods will be considered for the following situations:

- Crossing of flowing watercourses.
- Road crossings (e.g. when changing from one side of the highway to the other, or to cross registered vehicle pull-outs or intersecting access roads).
- Where rock outcrops cannot be avoided by alternative construction means.
- Areas where soil stability and ground conditions indicate significant risk of permafrost damage.
- Where direct-buried or surface-laid options are not practical.

9.7 Surface-Laid Cable

It is evident from discussions thus far with the highway jurisdictions in both the YT and the NT that their requirements are that the fibre cable installation must be kept as far away from the Dempster highway road prism as possible. There is significant evidence to support that road maintenance history has been and will continue to be a challenge along the Dempster highway. The highway is a crucial and critical life-line infrastructure for the communities and Indigenous groups along the route. This essentially requires that the cable be placed as close to the outside edges of the Dempster highway ROW as possible to ensure the integrity of the Dempster highway road prism. The design must still balance this approach with the practical aspects of installing a cable that is far from the contractor's equipment reach, reel trailers and truck booms etc.

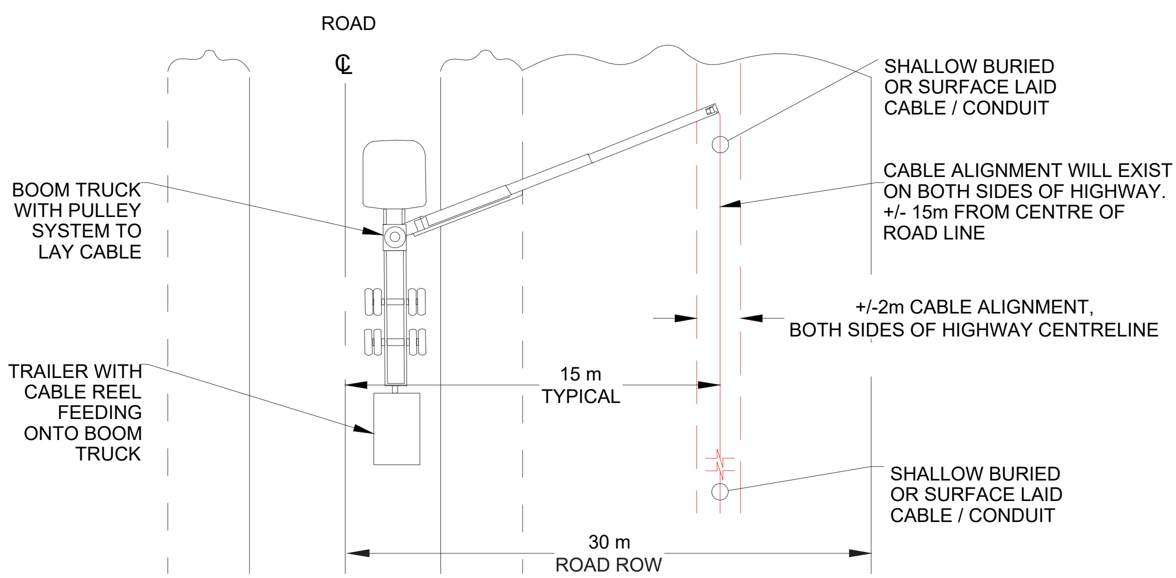
We have discussed several construction methods utilizing conventional plowing and/or trenching at the edges of the highway ROW, but all will require some level of clearing and brushing to allow for the cable installation equipment to efficiently install the cable along the proposed route. Given the environmental consequences of clearing the vegetation and causing damage to the active layer of the permafrost, the least invasive approach would be to shallow bury or surface-lay the cable along the outside edges of the ROW where a smaller swath of alignment clearing will suffice. The use of smaller machines will facilitate keeping the vegetative clearing of the cable alignment to a smaller +/- 2m swath.

Surface-laid cable and/or conduit will have its own challenges, as a surface installation can pose a risk to animals as a tripping hazard but also will draw interest from rodents who may have an appetite for chewing and damaging the outer sheath of the cable or the conduit. Further issues and concerns arise from the potential of cable damage from human sabotage or vandalism efforts who may see the cable as an opportunity to gather copper wire for a quick sale.

Some mitigation strategies have worked well in past projects where surface-laid cables were deployed. Marker posts and public awareness programs can be used successfully to reduce the risk for vandalism, however in our experience, vandalism and sabotage are real issues.

To reduce the animal impact, geotextile saddle sandbags could be used every 20-30m to ensure that the cable stays firm on the ground surface. Vegetation growth over time will also serve to improve the animal tripping or snagging concern, as well it will hold the cable or conduit in place. In all surface lay scenarios, the design will require that an attempt be made to bury the cable/conduit to some level of depth, even if the only cover is minimal surface vegetation.

The project impacts can be considerable as offset plows with extreme boom extensions may be required to either lift the cable/conduit into place or spool off cable/conduit as the surface-laid process travels along the highway. The daily run rates can be quite reasonable; however, specialized equipment mobilization and field personnel costs will be increased. The following Figure details a typical surface laid cable installation which could be used on this project.



TYPICAL BOOM TRUCK PLACEMENT DETAIL
PLAN VIEW
N.T.S.

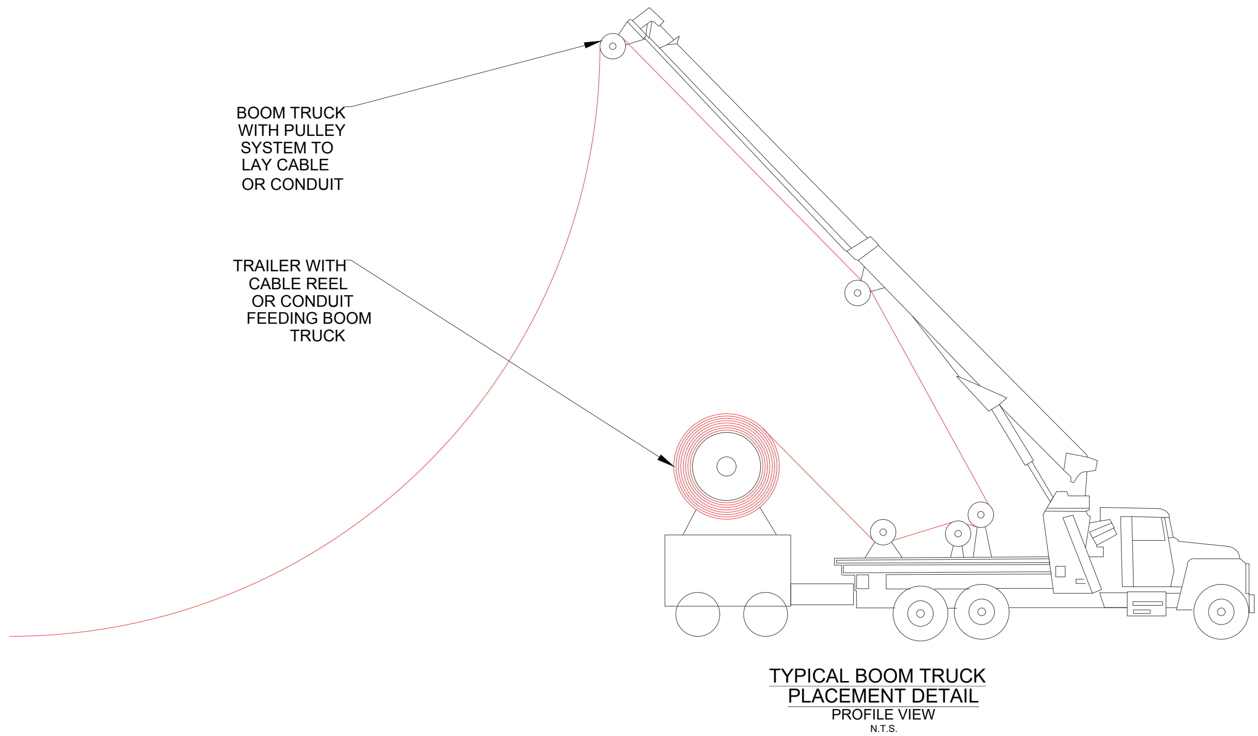
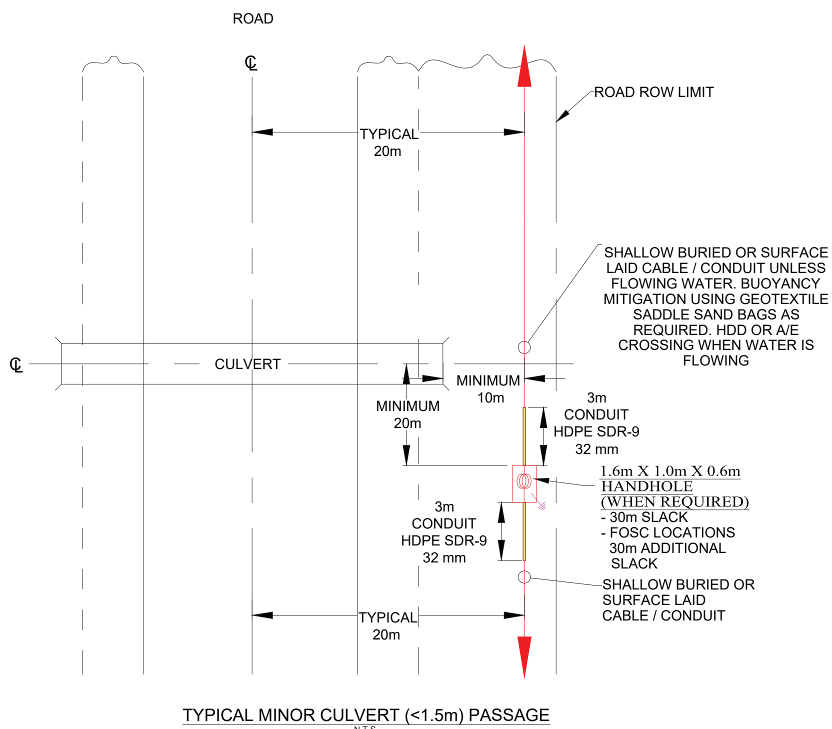


Figure 9 – Typical DFL Surface Laid Cable Installation



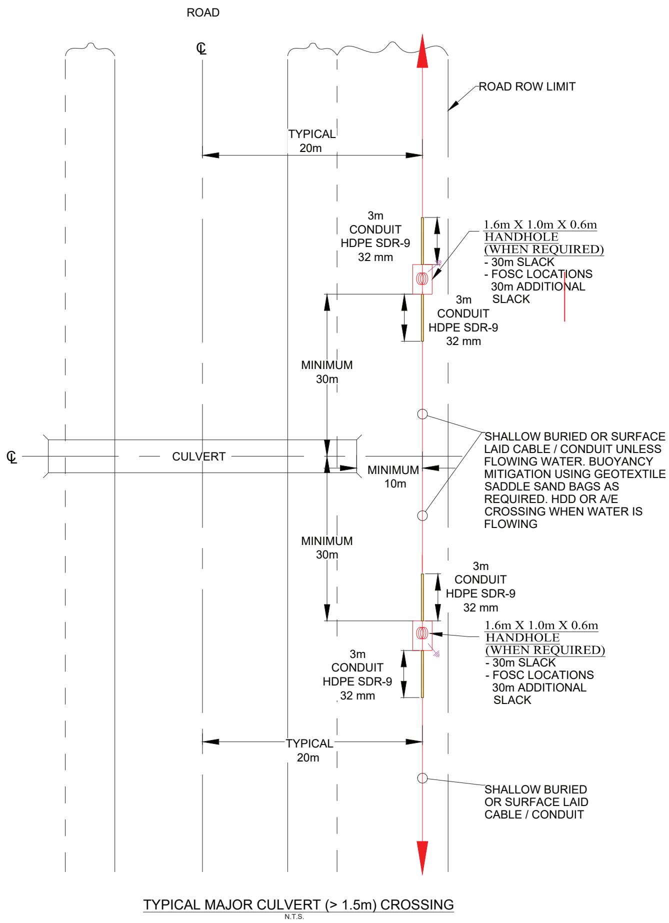


Figure 10 – Typical DFL Culvert Crossings Details

9.8 Considerations for Placing Cable Directly Within or Without Conduit

If a highly robust and resilient fibre cable is used, then the cable will be well protected from the elements and offer long term reliable performance whether directly buried or used in a surface-laid application. Conduits can offer even greater protection to the fibre cable as they can have significant wall thicknesses, but they will add cost and complexity to the installation process.

Small diameter conduits can ease the process of cable installation as the jetting process in more efficient when the cable size and conduit are of similar size. Conduits require a second pass to install the cable after the conduit has been plowed or trenched in. A second pass is required to install the cable after the conduit has been placed and spliced together to form a continuous pathway between handholes.

In this DFL case, where we will have a high number of HDD roadway and hazard crossings, there is significant benefit and efficiency in the construction process by using a conduit and a two (2) pass process. As mentioned in an earlier section, cable installation without conduits will require that the cable be un-spooled upon encountering an HDD crossing, then fed through the crossing conduit to the other side, where the cable will need to be re-spooled back on the reel in order to continue with direct bury construction. This will add considerably to the labour component of the build due to the large number of crossings involved. The only way to avoid the additional labour is to place a FOSC on one side of every HDD crossing which is not recommended as the optical signal loss budgets for the fibre cable would be negatively impacted and the project costs would rise considerably.

Other benefits to the DFL of using a small 32 mm conduit includes reducing the robust mechanical requirements for the cable itself. This facilitates future possibility of using the cable as an acoustic sensing device for permafrost and climatic monitoring applications as well as the tighter bending radius of a less robust cable reduces the size of the handholes required for slack cable and FOSC locations.

Our design contemplates using small diameter heavy walled SDR9, 32 mm conduit along the route for both shallow buried and surface lay areas as well as the shorter HDD crossings and 63.5 mm SDR-9 or Schedule 40/80 HDPE conduits for all the larger HDD crossings, bridge attachments along the route and building entrances to the NWTEL Microwave sites. Using conduits in surface-laid cable areas where there has been landslide history will also be considered, but the optimal crossing approach for landslide areas may simply be aerial poles. Surface-laid conduits tend to lift and twist with seasonality thereby increasing animal hazard risk and network maintenance activities for the system operator. Using geotextile sandbags or cable weights liberally will improve the situation and reduce risk.

9.9 Aerial Pole Line (existing and new installation)

Aerial cable construction is generally far less expensive on a per Km basis than underground cable construction. In this project, there are many considerations and hazard constraints which need to be addressed.

For example, existing aerial pole lines are the best solution if they have existing services attachment capacity on the poles. Traditionally, power pole lines carry the power cables at or near the top of the poles. Other utility attachments are possible as long as there can be sufficient clearance between the existing power cables and the desired utility attachment strand. Keeping in mind that Telecom cables are considered low voltage and therefore the maintenance of those cables is done by low voltage trained and certified personnel. The safety clearances between power cables and/or other attached facilities must meet all provincial and federal; CSA 22.3 No. 1-15 Overhead Systems, AEUC and local Yukon Energy /ATCO and NT Power attachment guidelines and requirements. If clearance issues exist, then the proponent who wishes to attach will need to incur all “Make-Ready” costs in getting the clearances and/or pole line loading into compliance including replacement of any poles. This can be a very expensive and time-consuming process and could render the aerial method as less attractive to underground construction. At this early stage, Stantec have not reviewed the aerial attachment requirements for either Yukon Energy and/or ATCO, or NT Power.

New Installation of poles is proposed along the Dempster highway where shallow bury or surface-laid methods are high risk or not feasible. Also, where the use of HDD is either too risky or impractical due to the length and depth of the crossing required or limitations of the ground geology. An example would be a large ravine or gorge and possibly washout areas, high erosion areas or large standing water crossings. Successful pole spans of 250-300 m can be achieved with properly installed poles and anchors.

The challenges in installing new poles especially in a continuous permafrost environment is to ensure pole stability over time as we know that disturbance of the permafrost layers can result in movement and impact to pole line tensions and sag. It is thought at this conceptual stage, that using small diameter pile technology to create the foundation for the poles or in sensitive permafrost areas, wooden or CSP (corrugated steel pipe) culvert cribbing foundations may be used for the pole bases and guy anchors. These may be acceptable approaches to minimize the long-term pole stability concerns, however there is evidence that standard wooden poles can also be successfully deployed with long term stability. Further investigation is required as the design progresses to ascertain the least risk aerial pole installation strategy for this project.

The following table estimates the total amount of aerial attachments expected on this DFL project.

Table 9-1 Estimate of Aerial Construction Expected on the DFL Deployment

LOCATION	POLE LINE	ESTIMATED LENGTH (Km)
INUVIK (From the edge of town to CO)	EXISTING	2
FORT MCPHERSON (Dempster highway to CO)	EXISTING	2
TSIIGEHTCHIC (In town to CO)	EXISTING	1
KLONDIKE highway TO DAWSON CITY LIMITS	EXISTING	41
DAWSON CITY (From the edge of town to CO)	EXISTING	0.5
ALONG DEMPSTER ROUTE	YT - NEW	16.5
	NT - NEW	7.5
	TOTAL:	**70.5 Km**
NOTE: These are all early estimates. Actual Km will depend on detailed route design		

9.10 Signal Amplification Sites, Breakouts and Central Offices (CO's) Terminations

In order to ensure that a high level of reliability and redundancy at the two NWTEL CO's terminations in Dawson and in Inuvik, consideration should be given to how the DFL cable will enter the building envelope and reach the fibre termination panels.

We expect that in both locations, the fibre cable will traverse the communities on existing aerial poles. Both communities will have other critical cables entering the two CO locations. For example, in Dawson, the NWTEL fibre from Whitehorse and in Inuvik, the MVFL fibre cable.

To ensure that the design does not introduce a single point of failure, there will need to be physical separation within the pole lines getting to the CO's but also in the entrance strategy to the buildings. Further discussions with NWTEL is required to understand how the existing fibre cables enter the two buildings. Stantec recommends that there should be a minimum of 10 m separation between the two entrance strategies. In practice, if one cable enters via an aerial connection, then the second cable should be installed underground or on the opposite side of the building to maintain an appropriate clearance.

With respect to NWTEL's microwave site terminations and signal amplification sites along the Dempster route, Stantec recommends that the East and West fibre cables be installed on either side of the access road to get to the site location, and then enter the equipment buildings via two physically separated pathways. This strategy will increase reliability of the network by eliminating any single points of failure in the network connectivity.

Further discussions with NWTEL and YG are required to determine the reliability requirements for the other breakout sites along the route.

10. High Level Risk Assessment – Cable Placement

This section will address the risks and impacts associated with the different construction and installation methods proposed for the DFL deployment. The objective is to provide perspective on potential impacts of possible construction methods which could be used to address the different cable placement and crossing requirements.

10.1 Dempster Highway Cable Alignment

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	Traditional plowing/trenching away from the road embankment at a depth of 600 mm to 1 m.	Heavy machinery cannot be used in summer season to bury cable. Offset Plow technology has limited reach from the road traffic surface, 3-4 m maximum. Substantial surface damage will occur if construction is completed in summer months. Level of brush or vegetative clearing required places greater risk on permafrost degradation.	Getting the heavy machinery to the plow area will require crossing the shoulder, toe and ditch of the highway prism. It will become a mudhole and can cause significant road damage as well as active permafrost layer degradation issues. Complete construction during Winter Months. Significant impact to the schedule will occur. Not recommended.

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
		A trench depth of 600 mm to 1 m will disturb the top layer of vegetation and the active permafrost layer. Will cause long-term environmental impact.	Removing vegetation will add to the permafrost degradation in the plow zone and will further increase risk and potential instability. Not recommended.
		Heavy machinery in the plow zone will cut a 3-4 m swath in the vegetation. Also, can cause damage to the road prism due to the weight of the machinery.	Removing vegetation will add to the permafrost degradation in the plow zone and will further increase risk and potential instability. Not recommended.
2.0	Shallow bury plowing/trenching away from the road embankment at a depth of 150 mm to 400 mm	Lighter machinery will need to be relocated to the plow zone and this will cause some disturbance to the road prism during summer. A shallow trench depth will only disturb the top layer of vegetation and the active permafrost layer.	Lighter machinery can be used to shallow bury cable in summer months. A smaller machine will require a +/-2 m alignment clearing. Limited to areas that are reasonably flat, moderate to rocky soil conditions with negligible permafrost and a minimum of 200 mm of organic cover. Best suited between YT KM-0 through to Tombstone National Park region at YT Km-80.
3.0	Shallow bury plowing/trenching away from the road embankment at a depth of 100 mm to 150 mm	Lighter machinery will need to be relocated to the plow zone and this will cause some disturbance to the road prism during summer. A shallow trench depth will only disturb the top layer of vegetation and the active permafrost layer.	Lighter machinery can be used to shallow bury cable in summer months. A smaller machine will require a +/-2 m alignment clearing. Limited to areas that are reasonably flat, moderate to rocky soil conditions with continuous permafrost and a minimum of 150 mm of organic cover. Best suited between YT KM-80 through to Inuvik, NT.

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
4.0	Surface-laid Cables and/or Conduit	Brush fires from lightning strikes are of particular concern since there is substantial peat moss and tundra vegetation along the route.	Fires are a problem regardless of construction methodology. Aerial pole lines are also impacted by fires. The only mitigation strategy is to construct the cable with high temperature outer sheath to offer some heat resistance and/or use a heavy walled SDR-9 fire retardant HDPE conduit. The cable construction can also include an inner metal separating tube to further protect and insulate the fibre strands. Fibre strands are made of glass and as such will only melt and distort if extreme sustained high temperatures reach them.
		Movement during summer/winter thaw, transitions	Geotextile sandbags or cable weights could be used at 20 - 30 m intervals or as required along the cable installation to stabilize the surface-laid cable and/or conduit in terrain with offset elevations. Damage to conduits could cause moisture migration and freezing pressures which could impact the cable inside. Use of conduit fusion splice technology is recommended to preserve conduit pathway integrity. Natural vegetation will improve the situation over time. Sandbags could be removed during the maintenance lifecycle if there are any long-term environmental concerns or use of bio-degradable bags.

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
		Animal interaction or contact	Risk of animals in contact with the cable, rodent damage is most probable. The cable can be chemically treated to reduce rodent attraction with moderate success. Animal contact with the cable is unlikely but could cause injury as a snag or trip hazard. Cable weights or sandbags are recommended.
		Subject to Vandalism by the public	Surface-laid cable are very susceptible to human vandalism and damage. A heavy grade conduit will add to further protect the cable but will not prevent vandalism. A level of optical redundancy can be included in the optical platform design to prevent service failures due to cut or damaged cables.
		Potential UV breakdown of protective outer sheath over the project life-cycle	Exposed surface laid cable can breakdown more quickly due to long term exposure to UV and the elements. Over time, vegetation growth will cover the cable and reduce this risk. If conduit is used, then the cable is protected from UV and environmental exposure.
5.0	Place the cable on 6-8 m poles along the difficult sections of the route.	Securing the poles into the permafrost layers could make the pole line unstable longer term. Increases maintenance and operational costs.	It may be appropriate to use a small diameter (75-100 mm) x 4-5 m pile technology to secure metal poles or masts to support the A/E fibre cable. These poles could be mounted closer to the highway prism, @ 20 m +/- 5 m from highway centre line to

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
			minimize damage to vegetation and improve maintenance access. Tourism issues may also arise and need to be considered.
		Maintainability of the pole line will have greater impact to NWTEL Operations	Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above maintenance of the regular fibre infrastructure components.

10.2 Road Prism Crossings

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	HDD all road prism crossings (across highway) between 45^0 and up to 90^0 to minimize angular pulling stress during the cable install. Min depth of 3 m below the road surface or 1 m below the road bottom. Conduit size will be 32 mm SDR-9.	Disturbance to the road prism is possible if size of HDD drill hole is larger than 75-100 mm. Potential Impact to road prism as well depending on where the entrance and exit holes will end up. If top of embankment is at a higher elevation than road surface, then the drill entrance hole will need to be from just outside the embankment closer to the road prism.	Using a small drill size and HDD machine would reduce and/or mitigate any concerns regarding road subsurface disturbance. Total road crossings will be minimized to limit this risk.
2.0	HDD all other road crossings (Access roads long same side of highway) to a minimum depth of 2 m below the road surface or 1 m below the road bottom. Conduit size if required will be 32 mm SDR-9.	Disturbance to access road integrity along the highway is considered to be minimal impact as long as the drill size is small.	The use of a 32 mm SDR-9 conduit to cross access roads along the route will minimize any long-term impact to the road integrity.

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
3.0	Trench/Micro Trench, across small access or turnout road crossings (Along same side of highway) to a min depth of 1m below the road surface. Backfill and compact the trench as otherwise dictated by the Highway Authority. Conduit size will be 32 mm SDR-9 which has sufficient crush resistance to accommodate up to 4.7 m (15 ft) of earth load.	Road integrity concerns especially across heavy truck access roads such as gravel pits and quarries along the Dempster highway.	Disturbance to access roads will be minimal as long as the slot width cut is maintained at ~2" (50 mm) in width and depth is at 600 mm -1.0 m below the road surface. Access roads which support gravel pits, quarries and highway maintenance facilities will be crossed using HDD or alignment moved to opposite side of the highway.

10.3 Minor Culvert Crossings - No Flow, Ephemeral Drainage - Small Diameter Culverts (<1.5m)

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	Surface-laid cables placed at a minimum of 10 m away from edges of culverts.	Movement during summer/winter thaw, transitions. Also, danger of ice flow/movement stressing the cable. Potential to interfere with highway culvert maintenance activities	Handhole on one side with 30 m slack cable will help to mitigate damage from ice flow movement. Resilient submarine grade fibre cable to be used or use of 32 mm heavy walled SDR-9 or better conduit. Ice flow pulling forces could damage the handhole locations. Slack cable and conduit in the handhole would be more able to move with any ice flow.
		Animal interaction or contact	Risk of animals in contact with the cable, rodent damage is most probable. The cable can be chemically treated to reduce rodent attraction with moderate success. Animal contact with

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
			the cable is unlikely but could cause injury as a snag or trip hazard. Cable weights or sandbags are recommended. Use of robust double armoured submarine grade cable for surface laid applications would reduce risk of cable damage by animals chewing or gnawing on cable.
		Subject to Vandalism by the public	Surface-laid cable are very susceptible to human vandalism and damage. A heavy grade conduit will add to further protect the cable but will not prevent vandalism. A level of optical redundancy can be included in the optical platform design to prevent service failures due to cut or damaged cables.
		Potential UV breakdown of protective outer sheath over the project life-cycle	Exposed surface laid cable can breakdown more quickly due to long term exposure to UV and the elements. Over time, vegetation growth will cover the cable and reduce this risk. If conduit is used, then the cable is protected from UV and environmental exposure.
2.0	Place the cable on 6-8 m poles along the difficult sections of the route.	Securing the poles into the permafrost layers could make the pole line unstable longer term. Increases maintenance and operational costs.	It may be appropriate to use a small diameter (75-100 mm) x 4-5 m pile technology to secure metal poles or masts to support the A/E fibre cable. These poles could be mounted closer to the highway prism, @ 20 m +/- 5 m from highway centre line to

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
			minimize damage to vegetation and improve maintenance access. Tourism issues may also arise and need to be considered.
		Maintainability of the pole line will have greater impact to NWTEL Operations	Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above maintenance of the regular fibre infrastructure components.
3.0	HDD all culvert locations, a min of 20 m back from each side.	There are ~1500 culverts along the Dempster highway which makes this a very expensive approach.	HDD would mitigate any surface-laid issues but would be extremely expensive and add considerably to the project schedule.

10.4 Major Culvert Crossings - Large Diameter Culverts (>1.5m)

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	HDD all culvert locations, a min 30 m back from each side.	There are a smaller number of large diameter culvert crossings, but HDD remains the most expensive crossing method. Impact to Construction costs and schedule.	HDD would mitigate any surface-laid issues but would be extremely expensive and add considerably to the project schedule. Aerial crossings of major culverts may be a last resort alternate to HDD.
2.0	Place the cable on 6-8 m poles to cross all the larger diameter (>1.5 m) culverts.	Some of the crossing distances may exceed 100-200m which requires more extensive poles and anchoring of the poles at each side. This crossing approach will add	Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above maintenance of the regular fibre infrastructure

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
		complexity to the crossings and higher maintenance to NWTEL operations.	components. Tourism issues may also arise.
			It may be appropriate to use a small diameter (75-100 mm) x 4-5 m pile technology to secure metal poles or masts to support the A/E fibre cable. These poles could be mounted closer to the highway prism, @ 20 m +/- 5 m from highway centre line to minimize damage to vegetation and improve maintenance access. Tourism issues may also arise and need to be considered.

10.5 Crossings with Bridges

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	Attach conduit or detachable cable raceway to bridge support structure	Risk is that bridge maintenance or future replacement would impact the attached conduit or cable raceway potentially impacting services carried over the fibre link.	Handholes on each side with 50 m slack cable will allow for temporary safe relocation and mitigation while the bridge is being repaired or replaced. The bridge conduit system must be easily removed or detached from the bridge structure. This will have cost and schedule impacts to the attachments but can be achieved.
2.0	Place the cable on 6-8 m poles to cross all the bridges	Some of the crossing distances may exceed 100-200 m which requires more extensive poles and anchoring	Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
		of the poles at each side. This crossing approach will add complexity to the crossings and higher maintenance costs for NWTEL operations.	maintenance of the regular fibre infrastructure components. Tourism issues may also arise. It may be appropriate to use a small diameter (75-100 mm) x 4-5 m pile technology to secure metal poles or masts to support the A/E fibre cable. These poles could be mounted closer to the highway prism, @ 20 m +/- 5 m from highway centre line to minimize damage to vegetation and improve maintenance access. Tourism issues may also arise and need to be considered.
3.0	HDD all bridge crossing locations, a min of 20 m back from each side.	HDD will add construction costs and add schedule impacts to the project. HDD will be required for both the Caribou and Campbell Creek bridge crossings in the NT.	HDD would mitigate any repair or future replacement issues but will have cost and schedule impact to the project.

10.6 Flowing Water, Stream and Creek Watercourse Crossings without Bridges

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	Surface-laid cables/conduits if allowed, to be placed at least 20 m away from road edges of flowing wetlands and watercourse crossings.	Movement during summer/winter thaw, transitions. Also, danger of ice flow/movement stressing the cable. Potential to interfere with highway or ROW maintenance activities	Handhole on one side with 30 m slack cable will help to mitigate damage from ice flow movement. Resilient submarine grade fibre cable to be used or use of 32 mm heavy walled SDR-9 or better conduit. Ice flow pulling forces could damage the

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
		Dempster highways traverses 736 kilometres and crosses 231 streams, lakes and watercourses between the Dempster corner at the Klondike highway junction, Yukon and Inuvik, NWT	handhole locations. Slack cable and conduit in the handhole would be more able to move with any ice flow.
		Animal interaction or contact	Risk of animals in contact with the cable, rodent damage is most probable. The cable can be chemically treated to reduce rodent attraction with moderate success. Animal contact with the cable is unlikely but could cause injury as a snag or trip hazard. Cable weights or sandbags are recommended. Use of robust double armoured submarine grade cable for surface laid applications would reduce risk of cable damage by animals chewing or gnawing on cable.
		Subject to Vandalism by the public	Surface-laid cable are very susceptible to human vandalism and damage. A heavy grade conduit will add to further protect the cable but will not prevent vandalism. A level of optical redundancy can be included in the optical platform design to prevent service failures due to cut or damaged cables.
		Potential UV breakdown of protective outer sheath over the project life-cycle	Exposed surface laid cable can breakdown more quickly due to long term exposure to UV and the elements. Over time, vegetation growth will

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
			cover the cable and reduce this risk. If conduit is used, then the cable is protected from UV and environmental exposure.
2.0	Place the cable on 6-8 m poles to complete all the flowing wetlands and watercourse crossings.	Some of the crossing distances may exceed 100-200 m which requires more extensive poles and anchoring of the poles at each side. This crossing approach will add complexity to the crossings and higher maintenance to NWTEL operations.	Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above maintenance of the regular fibre infrastructure components. Tourism issues may also arise.
			It may be appropriate to use a small diameter (75-100 mm) x 4-5 m pile technology to secure metal poles or masts to support the A/E fibre cable. These poles could be mounted closer to the highway prism, @ 20 m +/- 5 m from highway centre line to minimize damage to vegetation and improve maintenance access. Tourism issues may also arise and need to be considered.
3.0	HDD all flowing wetlands and watercourse crossings 30 m back from edges.	Dempster highways traverses 736 kilometres and crosses 231 streams, lakes and Watercourses between the Dempster corner at the Klondike highway junction, Yukon and Inuvik, NWT HDD is the most expensive crossing approach and will have Construction cost and schedule impact.	HDD would mitigate any surface-laid issues but would be extremely expensive and add considerably to the project schedule.

10.7 Standing Water, Lakes/Ponds, Wetlands

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	Surface-laid Cables placed at least 20 m away from edges of Wetlands and Watercourse areas.	Movement during summer/winter thaw, transitions. Also, danger of ice flow/movement stressing the cable. Potential to interfere with highway or ROW maintenance activities Dempster highways traverses 736 kilometres and crosses 231 streams, lakes and watercourses between the Dempster corner at the Klondike highway junction, Yukon and Inuvik, NWT	Handhole on one side with 30m slack cable will help to mitigate damage from ice flow movement. Resilient submarine grade fibre cable to be used or use of 32 mm heavy walled SDR-9 or better conduit. Ice flow pulling forces could damage the handhole locations. Slack cable and conduit in the handhole would be more able to move with any ice flow.
		Animal interaction or contact	Risk of animals in contact with the cable, rodent damage is most probable. The cable can be chemically treated to reduce rodent attraction with moderate success. Animal contact with the cable is unlikely but could cause injury as a snag or trip hazard. Cable weights or sandbags are recommended. Use of robust double armoured submarine grade cable for surface laid applications would reduce risk of cable damage by animals chewing or gnawing on cable.
		Subject to Vandalism by the public	Surface-laid cable are very susceptible to human vandalism and damage. A heavy grade conduit will add to further protect the cable

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
			but will not prevent vandalism. A level of optical redundancy can be included in the optical platform design to prevent service failures due to cut or damaged cables.
		Potential UV breakdown of protective outer sheath over the project life-cycle	Exposed surface laid cable can breakdown more quickly due to long term exposure to UV and the elements. Over time, vegetation growth will cover the cable and reduce this risk. If conduit is used, then the cable is protected from UV and environmental exposure.
2.0	Place the cable on 6-8 m poles to complete all the flowing wetlands and watercourse crossings.	Some of the crossing distances may exceed 100-200 m which requires more extensive poles and anchoring of the poles at each side. This crossing approach will add complexity to the crossings and higher maintenance to NWTEL operations.	Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above maintenance of the regular fibre infrastructure components. Tourism issues may also arise.
			It may be appropriate to use a small diameter (75-100 mm) x 4-5 m pile technology to secure metal poles or masts to support the A/E fibre cable. These poles could be mounted closer to the highway prism, @ 20 m +/- 5 m from highway centre line to minimize damage to vegetation and improve maintenance access. Tourism issues may also arise and need to be considered.

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
3.0	HDD all Wetlands and Watercourses areas 30 m back from road.	HDD all flowing wetlands and watercourse crossings 20 m back from edges.	Dempster highways traverses 736 kilometres and crosses 231 streams, lakes and Watercourses between the Dempster corner at the Klondike highway junction, Yukon and Inuvik, NWT HDD is the most expensive crossing approach and will have Construction cost and schedule impact.

10.8 **Major Rivers – without Bridges**

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	HDD all Major Rivers, 20-30 m back from edges of riverbed or as required depending on crossing depth determined by Geotechnical studies.	There are three (3) major rivers to cross. Specifically, the Arctic Red, the Mackenzie and the Peel River. The Arctic Red river has not been studied geotechnically and would increase risk.	HDD would mitigate any A/E crossing issues but would be significantly more costly and add moderately to the project schedule. Arctic Red River study to be conducted in late summer/fall of 2019
2.0	Place the cable on 10 m Aerial poles to cross the Arctic Red River or locate a crossing position where the river embankment could be leveraged.	Crossing distance approaches 400m which will require more extensive anchoring of the poles at each side of the crossing. Tourism issues may also arise. Cable is less than 25 mm in diameter, so it is hardly noticeable from any distance. Aviation markers may be required. Increased risk to birds is also present.	Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above maintenance of the regular fibre infrastructure components. It may be appropriate to use a larger diameter (100-150 mm) x 8-10 m pile technology to secure the poles or masts for this crossing. Use of ADSS lighter aerial cable for this

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
			crossing is recommended. 5/16" (8 mm) Strand is recommended for this application. Tourism issues may also arise. Risk to birds is not easily mitigated.

10.9 **Washout Areas, Sink Holes and Loose Rock Crossings**

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	Sink Holes - Place the cable on 6-8 m poles to cross all sink hole and geo movement areas. These are difficult to pin-point, therefore there could be estimate errors in identifying the specific locations.	Some of the crossing distances may exceed 100-200 m which requires more extensive poles and anchoring of the poles at each side. Fifty-four (54) mass movement geohazards and One-hundred and two (102) meander-highway encroachment sites with the potential for future highway impact were identified along the Dempster highway. Selection of which side of the highway the pole line should be installed on also has risk components. There may need to be consideration to move outside of the Dempster ROW if the washout or geo movement areas are extensive and high risk.	Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above maintenance of the regular fibre infrastructure components. Tourism issues may also arise. It may be appropriate to use a small diameter (75-100 mm) x 4-5 m pile technology to secure metal poles or masts to support the A/E fibre cable. These poles could be mounted further from the highway prism and hazard area to reduce risk to the cable. Use of ADSS lighter aerial cable for these crossings is recommended.
2.0	Landslide Areas - Place the cable on 6-8 m poles to cross all identified Landslide and geo movement areas. These are difficult to pin-point, therefore	Some of the crossing distances may exceed 100-200 m which requires more extensive poles and anchoring of the poles at each side. Fifty-four (54) mass movement	Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above maintenance of the regular fibre infrastructure

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
	there could be estimate errors in identifying the locations.	geohazards and One-hundred and two (102) meander-highway encroachment sites with the potential for future highway impact were identified along the Dempster highway. Selection of which side of the highway the pole line should be installed on also has risk components. There may need to be consideration to move outside of the Dempster ROW if the washout or geo movement areas are extensive and high risk.	components. Tourism issues may also arise. It may be appropriate to use a small diameter (75-100 mm) x 4-5 m pile technology to secure metal poles or masts to support the A/E fibre cable. These poles could be mounted further from the highway prism and hazard area to reduce risk to the cable. Use of ADSS lighter aerial cable for these crossings is recommended.
3.0	Bedrock and extremely rocky soil areas - Place the cable on 6-8 m poles to cross	Some of the crossing distances may exceed 100-200 m which requires more extensive poles and anchoring of the poles at each side. Selection of which side of the highway the pole line should be installed on also has risk components. There may need to be consideration to move outside of the Dempster ROW if the washout or geo movement areas are extensive and high risk. Drilling and installing poles in bedrock is extremely expensive and could cause schedule impacts	Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above maintenance of the regular fibre infrastructure components. Tourism issues may also arise. It may be appropriate to use a small diameter (75-100 mm) x 4-5 m pile technology to secure metal poles or masts to support the A/E fibre cable. These poles could be mounted further from the highway prism and hazard area to reduce risk to the cable. Use of ADSS lighter aerial cable for these crossings is recommended.
4.0	Meander encroachments along the route - Place the cable on 6-8 m poles to cross all encroachment areas.	Water is encroaching towards the highway in many cases starting to washout the road prism. Some of the crossing distances may exceed 100-200 m which requires more	Locate the fibre cable on the opposite side of the highway and as far as possible form the road prism and the encroachment. The road may need to be relocated slightly

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
		extensive poles and anchoring of the poles at each side. Selection of which side of the highway the pole line should be installed on also has risk components. There may need to be consideration to move outside of the Dempster ROW if the washout or geo movement areas are extensive and high risk.	in the future or shored up with significant levels of riprap. Aerial pole line would require some level of maintenance over the project lifecycle. This would be over and above maintenance of the regular fibre infrastructure components. Tourism issues may also arise.

10.10 Steep Cable Installation Grades

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	Shallow bury plowing/trenching away from the road embankment at a depth of 150 mm to 400 mm	Lighter machinery will need to be relocated to the plow zone and this will cause some disturbance to the road prism during summer. Organic layer within active permafrost layer would be disturbed.	Lighter machinery can be used to shallow bury cable in summer months. A smaller machine will require a +/-2 m alignment clearing. Limited to areas that are reasonably flat, moderate to rocky soil conditions with negligible permafrost and a minimum of 200 mm of organic cover. Best suited between YT KM-0 through to Tombstone National Park region at YT Km-80.
	Shallow bury plowing/trenching away from the road embankment at a depth of 100 mm to 150 mm	Lighter machinery will need to be relocated to the plow zone and this will cause some disturbance to the road prism during summer.	Lighter machinery can be used to shallow bury cable in summer months. A smaller machine will require a +/-2 m alignment clearing. Limited to areas that are reasonably flat, moderate to

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
		Organic layer within active permafrost layer would be minimally disturbed.	rocky soil conditions with continuous permafrost and a minimum of 150 mm of organic cover. Best suited between YT KM-80 through to Inuvik, NT.
2.0	Surface-laid Cables	Movement during Summer/Winter thaw, transitions	Sandbags or Cable weights could be used at 10–20 m intervals to stabilize the surface-laid cable/conduit. Damage to conduit if used, could cause moisture migration and freezing pressures which could impact the cable inside. Natural vegetation will improve the situation over time. Sandbags could eventually be removed during the maintenance lifecycle if there is environmental concern. Small diameter pile technology could be installed on the high side of the steep grade near the handhole to secure the cable against downward pulling forces.
		Animal interaction or contact	Risk of animals in contact with the cable, rodent damage is most probable. The cable can be chemically treated to reduce rodent attraction with moderate success. Animal contact with the cable is unlikely but could cause injury as a snag or trip hazard. Cable weights or sandbags are recommended. Use of robust double armoured submarine grade cable for surface laid applications would reduce

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
			risk of cable damage by animals chewing or gnawing on cable.
		Subject to vandalism by the public	Surface-laid cable are very susceptible to human vandalism and damage. A level of electronic redundancy can be included in the optical platform design to prevent service failures due to cut or damaged cables.
		Potential UV breakdown of protective outer sheath over the project lifecycle.	Exposed cable can breakdown more quickly due to long term exposure to UV and the elements. Over time, vegetation growth will cover the cable and reduce this risk.

10.11 **Active Geohazard Crossings**

In areas of known or potential geohazards, previous washouts or the potential for washouts the first approach to be employed will be to avoid such areas by installing the cable on the most secure side of the highway. Careful route selection based on the 2017 detailed field survey will help to inform decisions regarding the preferred routing of the cable through such higher risk areas. If the entire ROW was known to be previously impacted by a known washout (or geohazard), the area will be crossed using either HDD or as a last resort, using aerial poles if the span can be met with significant margin.

10.12 **Surface Vegetation, Peat, Grass, Trees, etc.**

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
1.0	Removal or clearing of any vegetation will cause ground temperatures to increase resulting	Permafrost melt can impact the integrity of the Dempster highway road prism over time. There is substantial risk of	Surface vegetation along the highway should not be disturbed in a significant way unless necessary and

Item No:	Risk Element	Risk and Impact Description	Potential Mitigation
	in long term permafrost degradation	water pooling along the highway. This encroachment will increase highway maintenance costs.	unavoidable in certain smaller sections. Utilizing a surface cable installation approach will minimize this disturbance. Shallow bury and surface-lay methods will require smaller machines for the cable trenching/plowing, thus reducing the clearing requirements for the cable alignment. A +/- 2 m alignment should be sufficient to provide the needed working space. Also establishing the cable alignment 15-20 m away from the highway centerline will significantly reduce risk to the road structure.

10.13 **Frozen or Non-Frozen Conditions and Construction Timing**

Item No:	Construction Timing	Activity
1.0	Summer Work	Perform HDD activities on all road prism crossings along the route.
		Perform HDD activities on all flowing water crossings
		Complete all large river crossings
		Where the terrain does not allow the cable to be placed outside the road prism, for example, due to river on one side and high rock slope on the other, plough or trench 32 mm conduit in the road prism embankment to 0.4m -1.0 m depth or as ground conditions allow. To be determined during detailed design.
		Plough/trench shallow-buried cable/conduit into organic layer using lightweight equipment.

Item No:	Construction Timing	Activity
		Install all bridge raceways and/or detachable conduits
		Install all handholes.
		Install all pile technology pole foundations, all anchors, poles and pole line hardware
		Install all aerial ADSS cable
		Pre-Test all fibre reels prior to installation
		Perform fibre splicing and testing after installation
2.0	Winter Work	Perform some horizontal directional drilling where ground conditions preclude summer work and where surface-laid, shallow-buried cable/conduit or conventional cable ploughing methods are impractical.
		To minimize potential impacts leading to erosion and sedimentation, complete most of the necessary ROW clearing and HDD stream crossing activities in the frozen ground conditions.
		Using small equipment, clear a narrow strip of vegetation (3-4 m maximum) along the ROW for the cable alignment, just wide enough to allow lightweight equipment for shallow ploughing of the cable/conduit where required.
		Complete clearing of narrow strip (2-3 m) along the surface-laid alignment to allow for cable placement
		For equalization culverts in wetland areas, the cable/conduit can be surface-laid in frozen conditions, so that it submerges into the wetland during the freshet. This also allows for buoyancy control using strategically fastened saddle sandbags or cable weights along the crossing.

11. Construction Decision Matrix

We have developed a construction decision matrix similar to the one presented in the previous work completed by others. The purpose is to consolidate and tabulate the different construction methods to be used to mitigate the various hazards and crossings encountered along the proposed Dempster highway fibre route.

In the matrix, each construction route challenge reflects the preferred method or techniques to be used to overcome that challenge. A "1" is used to indicate that option as the preferred method, a "2" is used to indicate the 2nd preferred method and so on. Less preferred options are chosen as required due to site specific constraints such as environmental or constructability issues.

The matrix has been subdivided between YT and NT to account for the construction differences between the two jurisdictions.

The matrix was populated based on the risk assessment work presented in earlier sections of this document.

CONSTRUCTION DECISION MATRIX - YT

Proposed Methodology Vs. Construction Environment	Rivers Flowing - Water Crossings	Bridges	Culverts	Highway Road Crossings	Registered Access Road Crossings	Pullouts, Minor Access Roads	Standing water - Lakes, Ponds, Wetlands	Washout Areas	Mass Movements/Slope Instability Risk (L-M-H)	Surficial Geology: Bedrock at Surface	Surficial Geology: Loose Rock	Surficial Geology: Granular Sand and Gravel	Surficial Geology: Fine Grained Silt and Clay	Permafrost: Negligible Permafrost	Permafrost: Discontinuous Permafrost (Low or High Ground Ice)	Permafrost: Continuous Permafrost (Low or High Ground Ice)	Exposed Exposure (Disturbed or Undisturbed - Native Mineral Soil or Organic Cover)	Surface Vegetation – Peat, Grasses, Willows, Trees	Installation Grades: Grades (0 to 5%)	Installation Grades: Grades (6-10%)	Installation Grades: Grades (> 10%)	Existing Pole Line	Other Site Specific (Identify)
HDD (Horizontal Directional Drilling	1	2	3	1	2	2	3	2	2														4
Aerial Construction	2	3	4			4	4	3	3	2												1	
Conventional Ploughed Cable/Conduit												2	2		Bury if low ice, surface lay if high ice				1	1	1	2	
Trenching (Conventional or Cutting)					1	1					2	3							3	3	3		
Shallow Burial (in Conduit)										1	1	1	1	1	1	2	1	2	2	2	2	3	3
Surface-Laid Cable Only			1											3	3	3	3	3	4		4		2
Surface-Laid Cable (in Conduit)			2				2			3	3	4	3	2	2	1	2	1					1
Attach to existing Bridge/Structure		1																					
Move to Opposite Side of Highway						3	1	1	1														

Updated: July 12, 2019

CONSTRUCTION DECISION MATRIX - NT

Proposed Methodology Vs. Construction Environment	Rivers Flowing - Water Crossings	Bridges	Culverts	Highway Road Crossings	Registered Access Road Crossings	Pullouts, Minor Access Roads	Standing water - Lakes, Ponds, Wetlands	Washout Areas	Mass Movements/Slope Instability Risk (L-M-H)	Surficial Geology: Bedrock at Surface	Surficial Geology: Loose Rock	Surficial Geology: Granular Sand and Gravel	Surficial Geology: Fine Grained Silt and Clay	Permafrost: Negligible Permafrost	Permafrost: Discontinuous Permafrost (Low or High Ground Ice)	Permafrost: Continuous Permafrost (Low or High Ground Ice)	Exposed Exposure (Disturbed or Undisturbed - Native Mineral Soil or Organic Cover)	Surface Vegetation – Peat, Grasses, Willows, Trees	Installation Grades: Grades (0 to 5%)	Installation Grades: Grades (6-10%)	Installation Grades: Grades (> 10%)	Existing Pole Line	Other Site Specific (Identify)
HDD (Horizontal Directional Drilling	1	2	3	1	2	2	4	2	2														
Aerial Construction	2	3	4			4	5	3	3	2												1	
Conventional Ploughed Cable/Conduit												2	2		Bury if low ice, surface lay if high ice				1	1	1	2	
Trenching (Conventional or Cutting)					1	1					2	3	3						3	3	3		
Shallow Burial (in Conduit)										1	1	1	1	1	1	2	2	2	2	2	2	3	
Surface-Laid Cable Only			1				2							2	2	1	1	1	4		4		2
Surface-Laid Cable (in Conduit)			2				3			3	3	4	4	3	3	3	3	3					1
Attach to existing Bridge/Structure		1																					
Move to Opposite Side of Highway						3	1	1	1														

Updated: July 12, 2019

Figure 11 – Construction Decision Matrix for YT and NT

12. Outside Plant Components

The following section provides a high-level perspective of the preferred materials and methods for the key OSP infrastructure components.

12.1 FOCI System Component Considerations

The DFL network once operational will be maintained by NWTEL field operations through an operational term lease. It is important to note, that the material and installation specifications should closely align with NWTEL OSP standards for reasons of efficiency and productivity but also to minimize the learning curve for the field operations personnel. Stantec will ensure that alignment occurs through detailed discussions with NWTEL Engineering before finalizing detailed design.

12.2 Conduits and Raceways

Conduit is an enclosed circular channel designed for holding and protecting electrical wires or telecommunication cabling. High Density Polyethylene (HDPE) conduit will be used in this DFL outside plant application; it is readily available on reels and comes in various sizes and wall thickness, has good tensile strength, high crush resistance, corrosion resistance, and is easily installed.

The advantages of underground conduit in comparison to direct buried cable include:

- Allowing for future cabling maintenance considerations, repairs, removal or replacement.
- Ease and efficiency of the installation for the contractor
- Provides additional physical and environmental protection.
- Reduced Material costs as a robust direct buried submarine grade cable is far more expensive than a single armoured cable installed in an SDR-9 heavy walled conduit
- Provides for the use of a more compatible acoustic sensing (DTS) application cable for environmental monitoring of Northern permafrost degradation
- In the DFL design, conduits will be used for;
    - Shallow buried and surface-laid construction areas in both YT and NT jurisdictions
    - HDD crossings in both YT and NT and for major river crossings in the NT
    - Bridge attachments on the YT side of the fibre route.

Specifically, in any sections of the deployment under the Dempster highway road prism, standing water wetlands and watercourses and on the major river crossings in the NT portion of the build. Conduits may also be used in the entrance to NWTEL Microwave sites and at the CO locations at both Dawson and Inuvik.

Given some of the difficult terrain conditions and route challenges, the fibre cables may require additional protection through the use of a heavy walled conduit or protection carrier conduit. At this early stage of design, we are proposing 32 mm HDPE, ASTM D3350/F 2160 Terra Cotta color conduit in certain surface-laid applications and black in color for all crossings. Conduits should include SDR-9, Schedule 40 and Schedule 80 pipe grade. For building entrance applications, a 63.5 mm conduit is recommended. Small detachable 63.5 mm conduits or raceways will also be considered for bridge attachments on the YT portion of the Dempster and on the Klondike Bridge on highway #2.

12.3 Handholes

Handholes are essentially pedestals installed in the ground or above ground used to contain either slack cable sections or Fibre Optic Splice Closures (FOSC) for breakouts or to join contiguous fibre cable lengths along the route.

Handholes will be placed along the cable route at strategic intervals with additional temporary assist points which are required to support slack cable for crossings and to mitigate hazard areas. The spacing of the assist points will be influenced by the terrain, number of bends and cable type. Typically, permanent handholes are placed at 4-5 Km intervals, to accommodate minimizing cable splices, but to also facilitate cable management and slack storage, repairs and maintenance, and to allow for cable break-outs to serve customers along the way.

It is proposed to use 6-8 Km cable reels on this project, so handholes will be placed at end-of-reel splice locations, plus other locations as outlined above. On average the separation between handholes will be between 3-4Km apart.

Handholes will not be placed in the road prism, to avoid damage from, or interference to, highway maintenance operations. Therefore, handholes will be placed away from the road prism above the road embankment. The handholes should be located on high ground elevation, where the terrain is flat, to the extent possible so that they can be accessed easily from the road and drainage concerns are alleviated. In some areas where the roadbed is built up for several Km, it may be unavoidable to install handholes either in the road prism, or at the base of high roadbeds in these cases. All efforts should be made to avoid placing handholes in lower elevations from the roadbed.

In continuous permafrost regions, the handholes will be placed at grade, not buried to any depth. This is to minimize disturbance of the organics and the active permafrost. The handholes will have fill placed around them with a slope of 2:1 to offer protection against movement and to minimize water pooling inside. Handholes will be used rather than pedestals, to reduce the risk of damage due to human intervention such as gunshots or possible damage from snowmobiles or ATV equipment.

To allow for future tie-ins, handholes with FOSC's or slack cable storage will be placed at the entrances of all highway's maintenance yards and at the relevant NWTEL microwave sites, as well as future customer tie-in locations specified by NWTEL and YG. For this Conceptual Design phase, specifically at;

- Selected NorthwesTel sites and YT and NT Government highway camps
- Locations specified by YG (informed by discussion with First Nations, GNWT, and NWTel)
- Tombstone Visitor Centre, YT
- Klondike Highway Camp, YT
- Ogilvie Maintenance Camp, YT

- Eagle Plains CO
- Sites identified by TH, - Arctic Circle rest stop located @ Km 405.6, YT, R-22A @ Km 8, NT and S-202B @ Km 132, NT
- Highway Maintenance Camp @ Km 28.8, NT
- Fort McPherson CO, NT
- Tsiigehtchic CO, NT

The handholes will be approximately 1.6m long x 1.04m wide x 0.6m high (Pencell PEM-360H or equivalent, or PEM 3048 or equivalent) depending on the fibre cable selected. The level or armour and outer jacket protection will govern the bending radius of the cable, therefore the handhole sizing will need to accommodate the static bending radius of the cable without any stress.

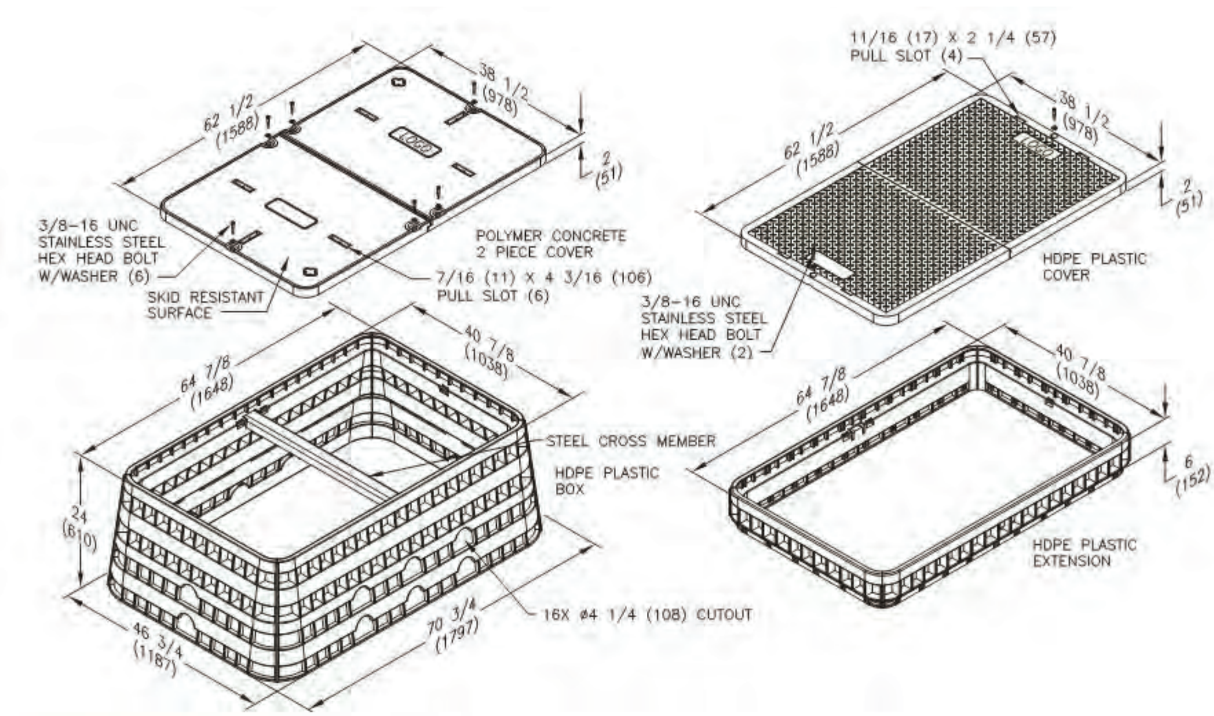


Figure 12 – Typical handhole to be used in the DFL deployment

A typical handhole installation with a FOSC is provided in the following detail (provided by Tetra Tech);

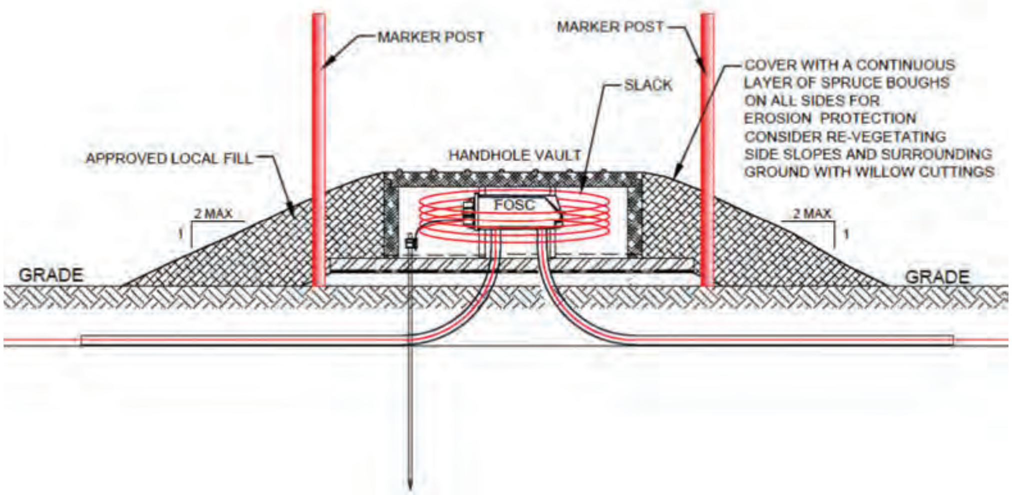


Figure 13 – Typical handhole installation for the DFL deployment

The above configuration will be installed on top of a supporting frame of pressure treated, wood planks and will be accompanied by protective rodent screen and geotextile fabric. When applicable, installation specifications will conform to local and municipal design requirements. Each handhole will be locked and/or secured to prevent vandalism. To decrease the likelihood of collisions with potential snow mobiles and/or ATVs, each site will be accompanied with adequate signage and site-specific slope grading of its walls.

The cable is installed into the handhole from the underside of the fiberglass box as illustrated in Figure 13 above. The ancillary requirement is critical for overall maintenance of the cable line as it allows for repairs and/or replacements at manageable length intervals along the route.

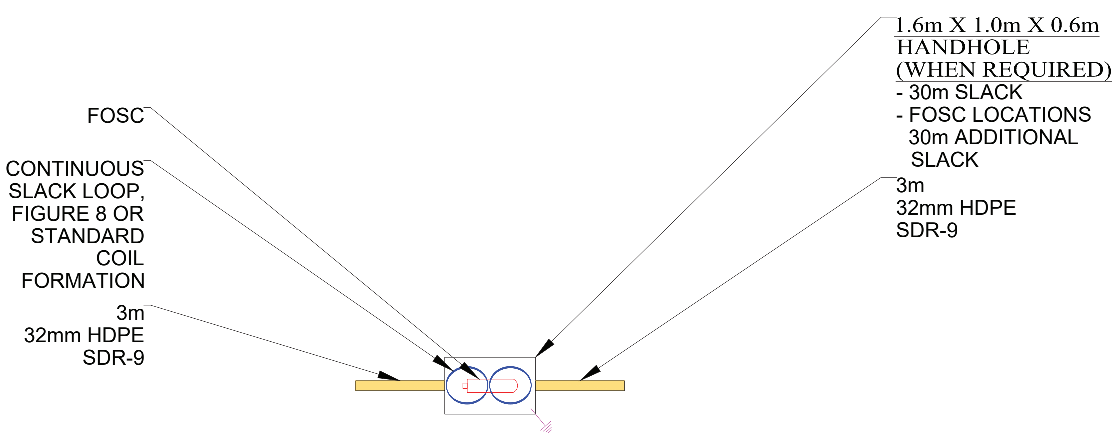
Handholes will be grounded by means of ground rods. The maximum permissible ground resistance will be 25Ω (ohms). It is assumed that this can be achieved by means of a single 3m ground rod at each handhole location. However, if any handholes are placed in the winter, ground plates or ground rods laid horizontally in the cable trench will be considered. Ideally, all handholes should be placed in summer to avoid using ground plates. Further, it is important to ensure that grounding at the handhole locations containing FOSC's be completed in accordance with requirements for the fibre cable monitoring system.

12.4 Slack Cable Requirements

The slack cable is intended to provide a level of mitigation in the event that a hazard causes a need to repair or temporarily relocate the cable until the hazard condition has been resolved. At this stage of design, we are suggesting the following:

- At locations where the cable appears to be at high risk of damage or major road maintenance is anticipated, then 50m lengths of cable slack on each side of the high-risk area is recommended to suit the specific circumstances. If a FOSC is present add an additional 30m to the FOSC handhole.
- At bridge crossings, 30m lengths on each side of the bridge is suggested. If a FOSC is present add an additional 30m to the FOSC handhole.
- At major culvert crossings, 30m of slack cable on each side is suggested. If a FOSC is present add an additional 30m to the FOSC handhole.
- At minor culvert crossings, no slack cable is required. If a FOSC is present add an additional 30m to the FOSC handhole.
- At road prism crossings, 30m of slack cable on one side is suggested. If a FOSC is present add an additional 30m to the FOSC handhole.
- At major river crossings, 30m slack cable is required as greater lengths would not provide any meaningful benefits. Handholes required with splice closures on both sides.
- At all watercourse crossings, 50m of slack cable on one side is suggested. If a FOSC is present add an additional 30m to the FOSC handhole.
- At all other handhole locations, the standard will be 30m of slack cable.

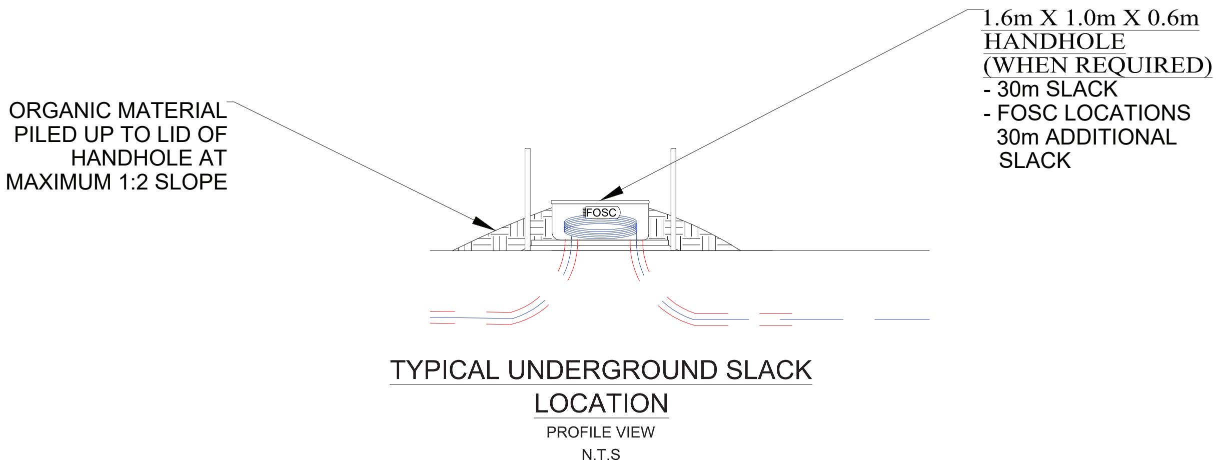
Due to the rigidity of the armoured cable, the cable lay configuration within the handhole should simply be either a single circular or oval coil or depending on the selected cable, the configuration could be figure eight (8). A typical slack cable handhole configuration is below;



TYPICAL UNDERGROUND SLACK LOCATION

PLAN VIEW

N.T.S



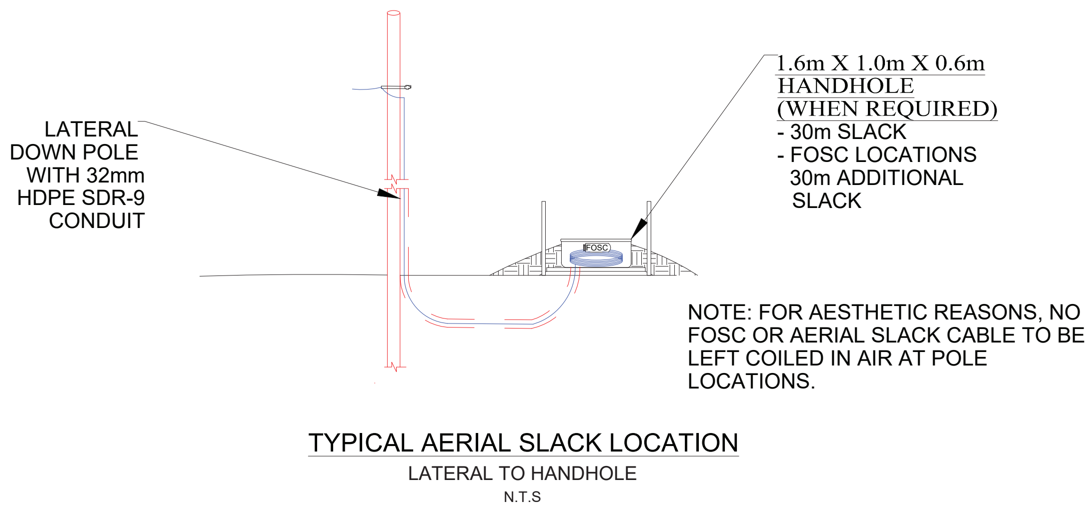


Figure 14 – Typical Slack Cable handhole configurations for the DFL deployment

12.5 **Fibre Optic Splicing**

Fibre Optic splicing is to be completed using fusing splicing techniques according to the FOSC manufacturer installation and splicing process guidelines and in alignment with NWTEL's splicing standards. Each handhole containing a FOSC will have sufficient cable slack to allow splicing to be done in a splicing vehicle parked along the shoulder of the highway.

Within the CO locations, fibre termination panels will be used to facilitate splicing. Ad-hoc splices or terminations will not be permitted. Termination of fibre optic strands on patch panels shall be via fusion splicing to factory assembled pigtail modules. Mechanical splices are not acceptable as splice losses must be minimized in this long-haul network design. Selection of fibre connectors will meet all NWTEL termination requirements at each relevant Microwave site.

12.6 Fibre Cable Monitoring

A fibre cable monitoring system is highly recommended for this critical fibre network. The system will need to align with NWTEL's overall cable monitoring system and at this point, confirmation of the required system has not been received.

Essentially, cable monitoring systems apply a reference voltage to the cable metallic armour and ground. In the event of any cable damage or cut to the outer cable sheath, the cable armour will open or short-circuit to ground and the monitoring equipment at the end of the cable will detect the fault.

Other technologies include real time Optical Time Domain Reflectometry (OTDR) which can also monitor the fibre network for not only damage and cuts but also for optical performance along the route. Design of the Cable Monitoring system is the responsibility of NWTEL and will be identified in detailed design.

12.7 Grounding and Bonding of the Fibre Cable

Grounding of the fibre cables is required at all handhole, Aerial to Underground transitions and on all aerial installations with a target earth impedance of 25 ohms or less. Clay and silts and soils with high moisture content usually provide excellent grounds. Soils consisting mainly of well drained sand and gravel will normally be poor grounding sites. The use of 3m ground rods may be sufficient to provide adequate grounding, however since Ice has a thermal conductivity of 2.22 W/mK at 0 °C, this suggests that unless the ground rod penetrates beyond the Permafrost layer, achieving a maximum resistance to ground of 25 ohms may be a challenge. Grounding work must not be done on grounding systems or cables during electrical storms.

The aerial ADSS cable is an all dielectric cable and therefore cannot be grounded effectively. The metallic aerial strand that supports the ADSS cable will need to be grounded properly through a 3m ground rod at the base of each pole attachment.

12.8 Warning Signs and Marker Posts

Metallic warning tape shall be placed within the plow trench installed midway between the cable/conduit and the ground surface or from 100-150 mm above shallow (150-400 mm) direct buried cable to provide an early warning mechanism for any excavation that may occur near the cable. If the shallow bury of the cable is 100-150 mm then there is no benefit to include marker tape.

In conventional plow where the depth exceeds 0.4m, metallic warning tape shall be placed within the trench installed midway between the conduit/cable and the ground surface or located from 200-250 mm above the direct buried cable/conduit. The text on the marker tape shall be identified during detailed design.

Marker posts are important for support of the ongoing maintenance of the DFL by the operator but also to raise awareness for the public to identify and warn that buried fibre facilities are existing near and along the marker posts. They shall be installed to indicate the presence of buried or surface laid conduit and/or cable and should be spaced from 100-200 m apart and also at both sides of all crossing locations. The color of the post is normally a bright orange to ensure high visibility, however other more subdued colors are available should a balance between aesthetics and visibility be required. The marker consists of a high-impact post, 1.8 m (6 ft.) long with an anchor fin at the bottom. The marker shall include a warning decal sign on each side warning of the presence of a cable and provide suitable information as to whom to contact before digging or driving stakes. Cable route marker posts shall be set at a depth of approximately 450 mm (18 in.) into the ground ideally, first using a pilot hole pounder, then installing marker post plumbed to vertical. Marker post configuration and materials will be coordinated with NWTEL OSP standards.

Appendix A
Geotechnical Design Brief FINAL

TETRA TECH

July 12, 2019

ISSUED FOR USE
ENG.WARC03598-01
Via Email: Warren.McLeod@stantec.com

Stantec Consulting Ltd.
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Attention: Warren McLeod, P.Eng.

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Subject: Dempster Fibre Link (DFL)
Geotechnical Design Brief

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SCHEDULE SECTIONS

SCHEDULES

1.0 INTRODUCTION

The Dempster Fibre Link (DFL) Project will provide fibre optic communication connectivity along the Dempster Highway between Dawson, YT and Inuvik, NT, a distance of approximately 775 km.

The initial design proposed to plow a conduit into the shoulder of the road for the entire route and jet the fibre cable through the conduit. However, based on concerns from the YT and NT highway authorities about impacts to highway operations and maintenance, the design and construction approach has changed and the cable will not be installed within the road prism (embankment) where possible except in select situations where there is no other practical alternative.

The present design basis is to install the fibre optic cable infrastructure within the highway ROW but away from the existing highway embankment. In some places the only practical way to install the cable will be to install it within the existing road prism, in which case the design will aim to minimize the risk to the highway structure while taking constructability into consideration. All proposed installations through the road embankment will be approved by the respective highway authorities prior to finalizing design.

This Geotechnical Design Brief (DB) describes an updated design basis including considerations, assumptions, standards and methodologies covering the identified geotechnical design and construction elements. The DB describes cable installation within the ROW and predominantly towards the edge of the brushed road for the entire route, although this will be adjusted to minimize the amount of vegetation clearing required (to mitigate thermal disturbances to the permafrost terrain), and as otherwise constrained by localized site conditions.

This DB is an evolving design document that is Issued for Use at this time but will be advanced and refined through detailed design and subsequent field reconnaissance planned for July 15-20, 2019.

To successfully complete the DFL Project, it will be necessary that the design team, Yukon Government, the selected Ccontractor, and other stakeholders work collaboratively and in an adaptive manner that will involve using alternative construction methods (as required) to mitigate conditions encountered in the field. Furthermore, it will be imperative that the construction and installation techniques be adaptable to address the range of terrain and permafrost conditions that will be encountered.

1.1 Definitions

The following permafrost terminology is used:

- Active Layer – The top layer of ground in which temperature fluctuates above and below 0˚C during the year. This layer is also known as the seasonally frozen ground, seasonal frost, and annually thawed layer.
- Permafrost - is a permanently frozen layer below the Earth's surface. It consists of soil, gravel, and sand, usually bound together by ice. Permafrost usually remains at or below 0C (32F) for at least two consecutive years.
- Continuous Permafrost – where the average yearly temperature is below -5˚C and is underlying 90-100% of the landscape.
- Discontinuous Permafrost – where the average yearly temperature is below -2˚C and is underlying 50-90% of the landscape.

- Sporadic Permafrost – where the average yearly temperature is always above -2˚C and is underlying 0-50% of the landscape.

Additional select terminology related to permafrost regions are listed in Schedule B.

2.0 PHYSIOGRAPHY/GEOLOGY/PERMAFROST/GEOHAZARDS

The information presented in this section largely drawn from Yukon Geological Survey Miscellaneous Report 17 prepared by McKillop et al (2016), a Tetra Tech EBA (2015) climate change vulnerability assessment prepared for the Government of the Northwest Territories, and available bedrock and surficial geology mapping by the Geological Survey of Canada (http://geoscan.nrcan.gc.ca), and is intended to establish an understanding of the terrain, geology, and permafrost conditions along the route.

2.1 Terrain

An elevation profile of the Dempster Highway is presented in Figure 1 (Refer to Tetra Tech EBA 2015). As can be seen from this information, there is a significant amount of relief along the highway that affects air temperature, precipitation, and ground temperature. The nature of the slopes, soil type and permafrost conditions are all climate related and vary substantially in response to the terrain elements. As shown on Figure 1, the elevation of the Dempster Highway ranges from just above sea level to over 1200 m at its highest point in the Yukon.

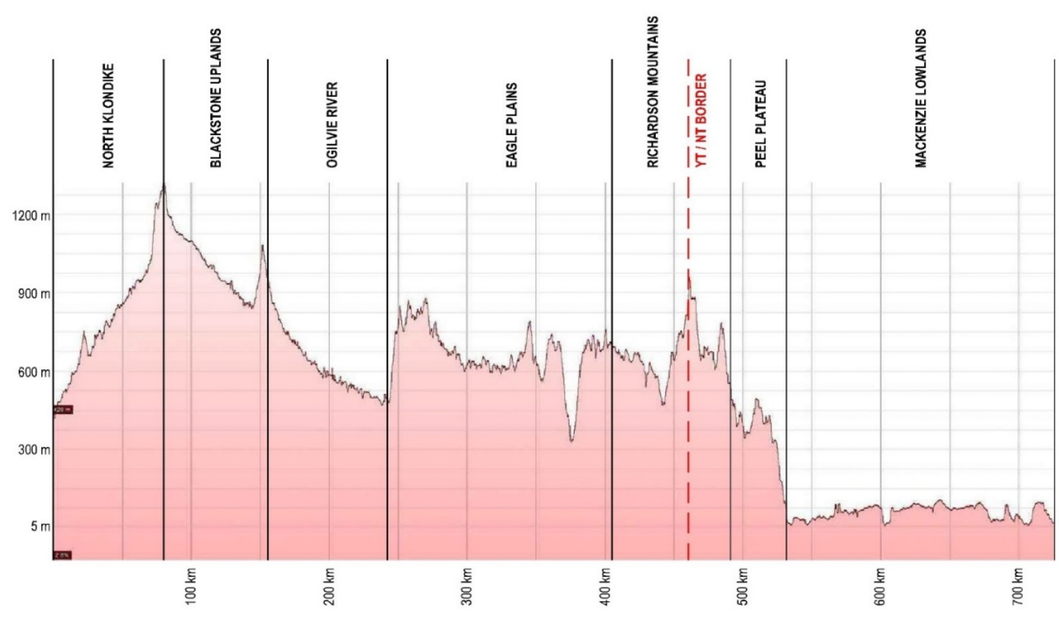

Figure 1. Elevation Profile of the DFL corridor along the Dempster Highway (Tetra Tech EBA, 2015).

2.2 Bedrock Geology

From Hwy 5 km 0 to km 240, the highway crosses Proterozoic to Paleozoic clastic to carbonaceous rocks, including chert, sandstone, shale, conglomerate, limestone and quartzite, with minor amounts of volcanics, phyllite and felsic intrusives. The rocks from Hwy 5 km 240 to km 344 are dominantly Cretaceous fine-grained clastic rocks, such as mudstone, shale, and sandstone. The rest of the highway in the Yukon, from Hwy 5 km 344 to km 465, crosses Silurian to Carboniferous shale, sandstone, siltstone, and limestone.

The bedrock in the NT portion of the Cordillera are comprised of uplifted ocean floor deposits. The rocks are sedimentary sandstones, shales and limestones, covered by blankets and veneers of glacial and colluvial deposits. The limestones have weathered mechanically to boulder size, while the sandstones and shales have been broken into finer-grained soils (Richardson and Sauer 1975).

The Richardson Mountains are the largest extent of unglaciated mountain ranges in Canada. The Richardson Mountains are composed of dark shale and sandstone deposited about 450 million years ago. Exposed bedrock and thin colluvial deposits dominate the unglaciated areas in the Richardson Mountains, whereas the glaciated region is covered by till (Duk-Rodkin and Hughes 1992). The Richardson mountains form a narrow line between north-trending faults. East-directed tectonic forces caused the sedimentary rocks to buckle and uplift between these faults; a mountain range formed during the last 50 million years. The Richardson Mountains are unique because, during the last ice age, the climate was too dry for glacial formation. The Laurentide ice sheet was stopped by this mountain range, marking the eastern edge of the unglaciated area.

The corridor leaves the Richardson Mountains descending to the Peel plateau. The Peel Plateau is underlain by Upper Devonian rocks. Shales, sandstones and conglomerates underlie most of the Peel Plateau and Plain (Douglas and MacLean 1963).

The Mackenzie lowlands are underlain by sedimentary shales, dolomites and sandstones. The bedrock is typically deep, but near Inuvik there are shale, dolomite and sandstone outcrops (Mackay and Dyke 1990), and shale and sandstone outcrops are present near the community of Tsiigehtchic, NT.

2.3 Surficial Geology

Parts of YT were repeatedly glaciated during the past ~2.6 million years (McKillop et al. 2016). These events have left a wide range of surficial materials of varying ages across the region crossed by the Klondike and Dempster Highway corridors. The wide range in ages of the glacial and non-glacial surficial materials in YT results in a difference in the weathering depth of soils across the region crossed by the highway as shown on Figure 2.

The entire area of the Dempster Highway corridor is covered by surficial geology mapping at scales ranging from 1:50,000 to 1:125,000 (Lipovsky and Bond 2014). The highway traverses large areas mapped as fluvial deposits, surrounded by slopes comprising colluvium mantling exposed bedrock. Isolated areas of thick till deposits are scattered throughout regions surrounding the North Klondike and Blackstone Rivers. North of the maximum glacial limit, where the highway enters the Engineer Creek valley, surficial materials comprise a similar distribution of broad fluvial areas surrounded by colluvial materials, with sporadic bedrock outcrops. The long, rounded ridge complexes in the Eagle Plains area are dominated by weathered bedrock, locally veneered by fine-textured colluvium. Colluvial and periglacial processes are widespread throughout the area (McKillop et al 2016).

To the east of the Richardson Mountains the landscape is scoured by the great Laurentide Ice sheet. At its maximum the ice sheet joined the Cordilleran glaciers. Ground moraine covered the bedrock during advance of the Laurentide glacier. During its retreat granular material was deposited in the form or morainal ridges, terraces and eskers in association with the development of glacio-fluvial channels (Lawrence et al. 1972). The area is almost entirely underlain by permafrost (Heginbottom et al. 1995).

The Peel Plateau consists of rolling terrain incised by steep-sided valleys draining eastward toward the Peel River. The terrain in the Mackenzie Lowlands comprises fine-grained and ice-rich glacial tills and glacio-fluvial deposits. The region is characterized as a low-elevation complex of gently undulating and hummocky glacial till and peatland, with lesser amounts of glacio-fluvial and glacio-lacustrine deposits. Moraines typically include till, which is a matrix mixture of clay, silt, sand, cobbles, and boulders. Pockets of poorly sorted gravelly to sandy material can also be present in the till matrix. These predominantly fine-grained deposits overlie Lower Cretaceous marine shale and siltstone bedrock (Norris 1984). The sediments on Peel Plateau are characteristically ice-rich, and massive ice is commonly present at depth (Lacelle et al. 2015). These predominately ice-rich and fine-grained sediments are notoriously susceptible to physical and thermal degradation when disturbed and when the organic vegetation covering these soils is removed or disturbed.

Within the Peel Plateau and Mackenzie Lowlands, hummocky and gently undulating till ground moraine is the common surficial landform. From the Peel River to Inuvik, NT, the terrain is remarkably flat and low elevation. The main mineral surficial deposits in the Mackenzie Lowlands are fine-textured gently inclined and undulating till plains with minor components of glacio-fluvial, glacio-lacustrine, alluvial deposits. Alluvial floodplains confined within steep-walled but shallowly incised meandering river channels occupy less than ten percent of the region but contrast strongly with the surrounding landscapes. Organic veneers from a few centimetres to less than a metre thick are widespread on mineral soils; thicker peatlands occur over nearly half of the area.

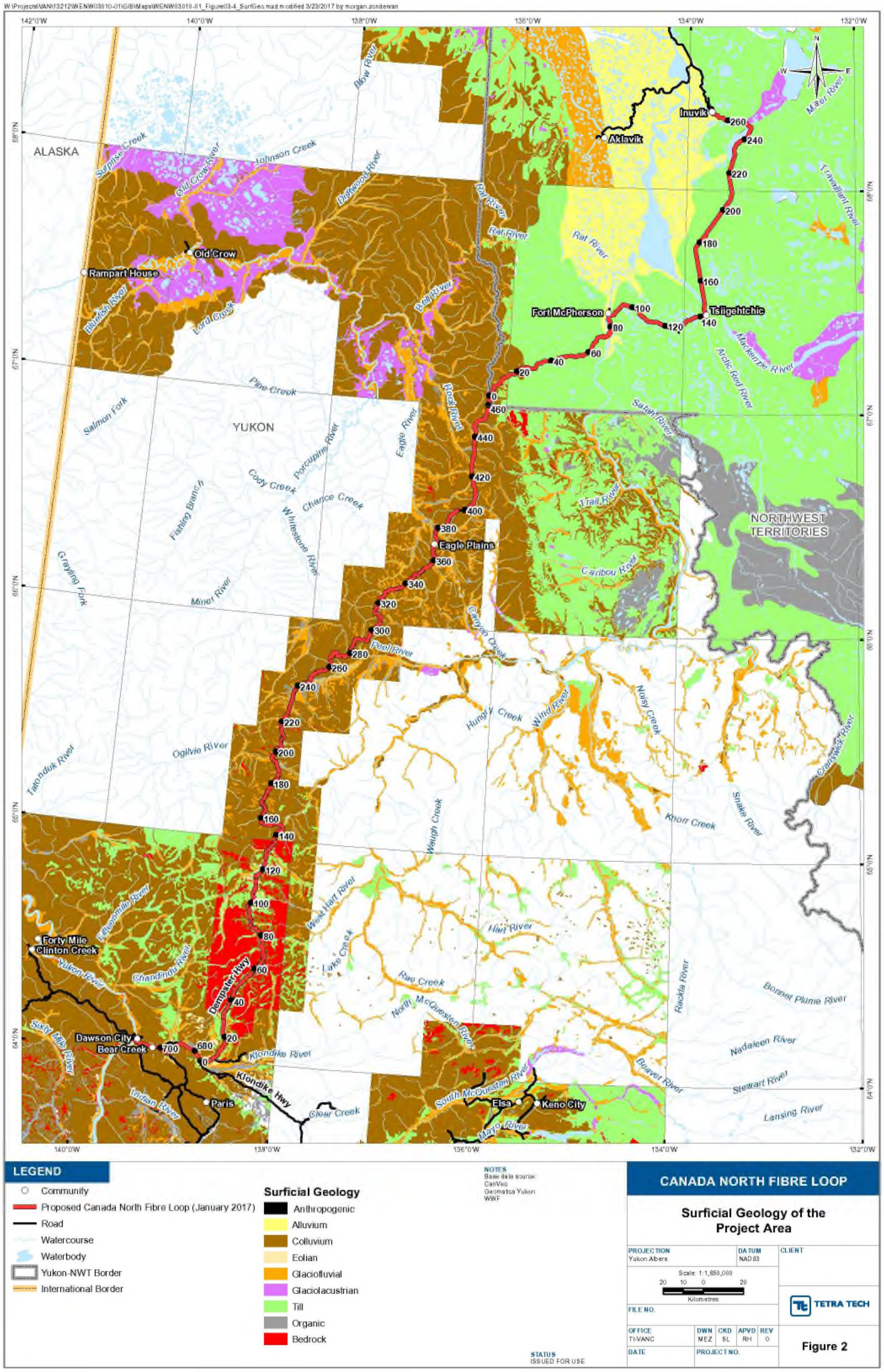

Figure 2. Surficial Geology of the Project Area

2.4 Permafrost

Permafrost is a thermal state of the ground (soil or rock) that is defined as ground that remains at or below 0°C for at least two consecutive years (National Research Council Canada 1988). Permafrost is defined as a ground thermal condition without consideration of the presence of ground ice. However, it is the amount of ground ice in the frozen ground that determines its physical-mechanical properties and the resulting stability of these foundation soils. Excess ground ice may not always be present, as may be in the case of nonporous bedrock, but it frequently occurs in mineral soils and often exceeds the hydraulic saturation of the ground material.

As reported by McKillop et al. (2016) the distribution of permafrost along the Dempster Highway corridor relates to latitude and elevation, at a regional scale, and to a variety of factors including aspect, surficial material, micro-topography, and vegetation, at a local scale (Williams and Burn 1996; Bonnaventure et al. 2012; McKillop et al. 2013). The highway transitions from a region of extensive discontinuous permafrost (50-90% areal coverage) as it ascends the North Klondike River valley through North Fork Pass, to a region of continuous permafrost (90-100% areal coverage) north of the Ogilvie Mountains and continuing beyond Eagle Plains on into the Richardson Mountains (Heginbottom et al. 1995). The Peel Plateau and Mackenzie Lowlands continue to be a region of continuous permafrost (90-100% areal coverage) as the highway routes towards Inuvik. Permafrost, identified based on the presence of visible ground ice, was encountered at all sites in the Eagle Lowland that were examined for granular material in association with construction and maintenance of the Dempster Highway (EBA 1990). The thermal state of permafrost is influenced by many factors most notably climate, vegetation, and snow cover.

The active layer is the upper layer of ground that freezes and thaws seasonally above the permafrost table. It may be restricted to overburden soils and unconsolidated and consolidated surficial materials, or it may extend into underlying, weathered or intact bedrock. The active layer extends to the depth where the annual maximum temperature is 0 °C. The active layer varies spatially at regional and local scales. For the same air temperature, variation in the active layer thickness is influenced by vegetation types, organic layer thickness, soil moisture, and fluctuations in distribution and depth of snow. At a local scale, its thickness primarily depends on elevation, aspect, soil texture, drainage, snow pack, vegetation cover, and wildfire history (Williams and Burn, 1996; Bonnaventure et al. 2012; McKillop et al. 2013). Along the DFL corridor the active layer is generally 1 to 2 m thick, typically becoming thinner to the north. Active layer thicknesses can be much less than 1 m in areas of thick, mossy organic cover terrain, and active layer thicknesses of about 3 m occur in areas severely impacted by anthropogenic or natural disturbances. Well-drained, coarse-textured soils tend to have thicker active layers than poorly drained and fine-textured areas.

Each year active layer thickness increases following spring snowmelt and typically peaks in late summer/early autumn. During the 2 to 3 months when the active layer is un-frozen, snowmelt and rainfall can infiltrate the ground until water reaches the permafrost table. Groundwater perched on the permafrost table moves slowly through the active layer, in some cases entering streams, until the active layer re-freezes in the autumn and groundwater flow ceases. Active layers thicken appreciably following wildfire, which burns most or all the insulating surface organic mat, reduces interception of snow by trees (where present), lowers the surface albedo, increases exposure to solar radiation and decreases evapotranspiration (e.g., Burn 1998).

The permafrost responds immediately by thickening its active layer, commonly by up to several times its original thickness (Burn 1998; Smith et al. 2015). Yoshikawa et al. (2003) estimate natural wildfire recurrence of 50 to 300 years in the boreal forest of interior Alaska. Smith et al. (2015) documented stabilization of post-fire active layer thickening within approximately 5 years in an area of extensive discontinuous permafrost in the central Mackenzie Valley.

Permafrost may or may not contain ice, depending primarily on the material within which it exists and its hydro-geomorphic setting (McKillop et al 2016). The ground can consist of many substrate materials, including bedrock, granular and fine-grained sediment, organic matter, water or ice. Ground ice is not always present in material, as may be the case with nonporous bedrock. Most commonly, ice is restricted to the pores within unconsolidated surficial materials or the voids and fractures within weathered bedrock. These conditions are widespread in areas of exposed or shallow bedrock, along ridges of residual soils and weathered bedrock, and on well-drained colluvial slopes. Permafrost soils with no excess ice are generally stable when thawed. However, high ice content soils with ice contents more than the material's natural moisture content will become unstable when thawed.

In their 1:1,000,000-scale mapping of permafrost and ground ice conditions in northwestern Canada, Heginbottom and Redburn (1992) indicate volumetric ice contents range from "nil to low" to "low to moderate" along a broad corridor encompassing the DFL corridor. Local experience has demonstrated that ice contents are generally highest in valley bottoms and within fine-grained soils. In wetlands, across broad floodplains and on gentle slopes blanketed in fine-textured colluvium, permafrost is often ice-rich, containing seams, lenses or massive bodies of ice. Ice wedges, which can be several metres thick and more than a metre wide, occur in some areas alongside the DFL corridor. On well-drained, southerly aspects with convex slopes, permafrost (if present) is generally ice-poor.

Determining areas with ice-rich permafrost is important for planning sustainable infrastructure and predicting which landscapes are most sensitive to change if the permafrost thaws but is not easily done due to the natural variability of ground ice. Often soil types and terrain conditions are extrapolated to identify sensitive ice-rich permafrost conditions. Thawing of ice-rich permafrost can results in loss of soil strength, settlement, thaw slumping, landsliding, and associated negative impacts.

Ground temperatures have been collected along the highway ROW from several sources: The Temperature Cable monitoring program; NorthwesTel's microwave repeater stations; investigations sponsored by the NT Cumulative Impacts Monitoring Program (CIMP) (Burn et al. 2015); and the published literature. These data span most of the highway route. In addition, since 2005, significant research on ground ice conditions along the route has been published (e.g., Lacelle et al. 2007; Kokelj et al. 2013; Lacelle et al. 2015).

2.5 Seismicity

Seismic activity potentially affecting the DFL route has origins in the northern Cordillera. Seismic activity is more intense in pockets in the Richardson Mountains, northern YT and in the Mackenzie Mountains (Adams and Basham 2001). The Project corridor is in areas of high seismicity, where it passes through the Ogilvie and Richardson mountains. Approximately 130 fault zones have been identified in data from Geomatics Yukon that intersect the study corridor, the majority of which are generally west-east or northwest-southeast trending, unnamed, defined thrust, reverse or normal faults (McKillop et al. 2016).

The southern half of the route is intersected by the east-west trending Tombstone, North Fork, Dawson and Soldier thrust faults; the northwest-southeast trending dextral Tintina Fault; and the northeast-southwest trending Robert Service thrust fault. Only unnamed faults intersect the northern half of the route, north of the Ogilvie River, and the vast majority of these are defined normal or reverse faults.

The Peak Ground Acceleration (PGA) contours for Canada, including the Project area, based on the Natural Resources Canada 2015 Seismic Hazard map of Canada (NRC 2015). PGA is one of the parameters that indicate earthquake intensity. Stronger earthquakes result in higher PGA values. Other earthquake intensity parameters include Magnitude, Peak Ground Velocity, Arias Intensity, etc.

The published PGA ranges for the DFL corridor based on NRC (2015). These PGA values correspond to a return period of 2,475 years (or 2% probability of exceedance in 50 years). This return period is currently being used in the 2015 National Building Code of Canada and the 2014 Canadian Highway Bridge Design Code for seismic design of buildings and bridges. Lower return periods (e.g., 475 years) with lower PGA values may be adopted for design of the DFL Project depending on the consequences of failure and project risk assessment framework.

2.6 Geohazards

Geohazards, including in particular mass movements, involve the downslope transport of material, such as soil and/or rock, under the influence of gravity (McKillop et al (2016). Mass movements may or may not be associated with water, snow or ice. Along the DFL corridor, landslides, whether rapid or slow, are the dominant mode of mass movement. Landslide terminology used by McKillop et al (2016) follows the standards defined by Hungr et al. (2014), a recent update to the classic classifications established by Varnes (1978) and Cruden and Varnes (1996), which describe the process as well as the type of material involved in mass movement.

The terminology used by McKillop et al (2016) also aligns with the classification system outlined in the guidance document entitled: Geohazards and Risk: A Proponent's Guide to Linear Infrastructure (Guthrie and Cuervo 2015). Where two modes of failure contribute to movement, the landslide type is assigned based on the apparent dominant mode.

Where more accurate representation of the role of permafrost is required, refinements to standardized landslide terminology were made by McKillop et al (2016), based on the Multi-language glossary of permafrost and related ground-ice terms (van Everdingen 2005), which is consistent with the approach applied in the regional characterization of landslides along Yukon's Alaska Highway corridor (Huscroft et al. 2004). "Active-layer failures" (referred to herein as active layer detachments, for consistency with local nomenclature) describe flows and/or slides of material in which failure occurs at the interface of a frozen substrate, and "retrogressive thaw slumps" describe mass movements that enlarge upslope through the repeated fall, slide or flow of material from a steep, thawing headscarp (Figure 3-7).

Rock glaciers were excluded by McKillop et al (2016), from this inventory, despite their local presence alongside the highway and their inclusion in Blais-Stevens (2010) landslide inventory along the Alaska Highway corridor, because their snouts are inactive and do not pose a risk to the highway. The prevalence of highway instability caused by erosion along the outer banks of migrating stream meanders, also warranted separately identifying sites exposed to mass movement failures due to meander migration of streams paralleling the DFL corridor.

Understanding the type and distribution of mass movements along the DFL corridor requires an appreciation for the physiographic, geological and permafrost-related factors that govern instability, each of which were characterized by McKillop et al (2016). Within its Yukon extent, the DFL corridor traverses major valleys, mountain passes and subarctic plains. In addition to differences in topography, differences in the weathering (glaciated vs. unglaciated) and permafrost conditions south of, within and north of the Ogilvie Mountains impart important differences in the occurrence, characteristics and detection of ground instability (McKillop et al 2016).

Most mass movements along the DFL corridor are influenced, either directly or indirectly, by permafrost or related periglacial processes (McKillop et al 2016). Climatic warming is contributing to the degradation (thaw) of permafrost, especially on southerly aspects and in broad valley bottoms exposed to prolonged sunlight during the summer. Permafrost degradation results in an increase in active layer thickness, which increases the volume (mass) of surficial material available for downslope transport and degree of soil saturation provided by the release of water from thawing ground ice.

Shallow landsliding (e.g., active layer detachment) occurs once the shear stress exceeds the shear strength of the material. Thermokarst subsidence and gullying may occur in gentler terrain. Deep-seated failures within thick overburden or weathered bedrock occur in response to failures of weak layers or thawing of ice bodies at depth.

Deep-seated permafrost failures may result from movement of groundwater within un-frozen zones (taliks) in or beneath permafrost (McKillop et al 2016).

The most common triggers for both shallow and deep-seated failures are extreme rainfall or heat events (i.e., intense or prolonged) and wildfires (McKillop et al 2016). Seasons of increased geohazard activity include the period from late July to early September, when active layers are deepest, permafrost is warmest, and rainfall is greatest, as well as late May or early June, when erosion during snowmelt freshet freshly exposes permafrost to fluvio-thermal erosion and slumping. Slopes underlain by permafrost that have not experienced recent wildfires are more prone to active layer detachments immediately following a fire (McKillop et al 2016).

Thermokarst is the process by which characteristic landforms result from the thawing of ice-rich permafrost (NRC 1988). Thermokarst processes occur naturally in the Peel Plateau, the Peel Lowlands and the Mackenzie Lowlands physiographic regions.

Meander migration is one of the principal factors contributing to mass movements alongside sections of the highway corridor that parallels (or cross) rivers within major valleys along the DFL corridor. Commonly, the progressive encroachment of a meander alongside the highway through sequential bank undercutting and collapse leads to exposure and accelerated thaw of ice-rich permafrost, and over-steepening of slopes adjacent to the highway embankment (McKillop et al 2016).

3.0 GEOTECHNICAL DESIGN BASIS

3.1 Design Approach

The design approach is to install a fibre cable alongside the Klondike and Dempster Highways within the existing established highway ROW (20 m offset either side of centerline), away from the highway road embankment whenever feasible, and always minimizing ground disturbance. As far as practical, the cable will be located at the edge of the brushed area, away from the road embankment. This will reduce the likelihood of damage to the surface-laid or shallow buried cable due to highway maintenance activities.

3.2 Design Basis

For the DFL Project, the Designers have received the following directions from the YT and NT Highway authorities:

- Install the cable outside the road structure whenever possible. The risk to both the proposed fibre cable and the road structure were deemed excessive by installing the cable in the road prism (embankment), so it was decided to reroute the proposed cable away from the road structure to the extent practical.
- Minimize interaction between cable and road embankment.
- Minimize crossing road embankment.
- Utilize HDD crossing technique as required.
- Utilize existing poles to go aerial, where suitable.
- Install new poles where required due to high ground risk conditions.

In many conventional environments, greater burial depth usually translates into less risk of damage to the cable. However, in a permafrost environment with sensitive fine-grained and ice rich soil conditions and the risk of thermal and physical degradation of the permafrost and its impact to the cable and potentially the highway, a surface-laid or shallow buried cable is the recommended construction method in areas where permafrost ground conditions are present.

It is proposed to use a combination of shallow buried plowing (i.e. less than 150 mm, generally within the organic layer, to avoid penetrating the active layer or permafrost) where it is practical to use small equipment for plowing, or surface-laid cable in conduit where it is not possible for small plow equipment to operate (e.g. through trees and thick vegetation or along steep slopes).

For practical purposes, shallow burial implies that the cable needs to be buried just enough that it is not exposed. In general, this will be less than 150 mm deep, or shallower (subject to ensuring that the cable memory does not cause the cable to spring out of the ground) as required to minimize disturbing mineral soil. Sandbag weight may be needed to prevent the cable from springing above ground. Also, such areas of shallow burial may require additional casing protection.

The general design philosophy is as follows:

- Minimize any disturbance of vegetation or peat in permafrost areas.
- Utilize existing poles to go aerial, where suitable aerial plant already exists.
- Attach conduit to bridge structures where possible, in favor of HDD crossing or aerial pole crossing. This approach is only applicable to YT section and attaching to bridge crossing will not be authorized on the NT side.
- Install cable outside the road structure, where possible, but recognizing that doing so introduces environmental risks by impacting the sensitive permafrost environment.
- Recognize that construction activities beyond the road embankment will inevitably increase impact/damage to vegetation and increase the risk by negatively impacting the permafrost.

A combination of winter and summer construction activities is proposed, to perform the work in such a way as to minimize disturbances and the effects on the environment.

Previous experience has identified that the disturbance of the active layer in permafrost regions has adverse environmental consequences that can be significant. Thus, the design basis proposes shallow burial (less than 150 mm cover) or surface-laid cable, and where it is practical to install the cable in peat or through wetlands.

As for the discontinuous permafrost region along the lower section of the Dempster Hwy 5 km 0-80 (North Klondike Segment) the design basis proposes shallow burial (100-150mm and 150-400mm) and surface-laid cable.

For bridge crossings, YT will allow for cable attachment to most of the bridges along the YT section and the NT is not going to allow any attachment to any of the bridges along the NT section.

The following Guidelines and Reference documents were used for development of the geotechnical design approach:

- Transportation Association of Canada (TAC), 2010. Guidelines for Development and Management of Transportation Infrastructure in Permafrost Regions.
- CSA, 2010. Technical Guide: Infrastructure in Permafrost: A guideline for Climate Change Adaptation, Canadian Standards Association. PLUS 4011-10.

- INAC Northern Land Use Guidelines for Pits and Quarries and Access Roads and Trails / Northern Affairs Program (Canada). Lands Program Ottawa: Indian and Northern Affairs Canada, 2011.
- Government of the Northwest Territories, Department of Transportation, 2013. Erosion and Sediment Control Manual.

It is recognized that any construction activities outside the road prism but within the ROW can impact the natural vegetation and potentially negatively impact the permafrost.

3.3 Reference Documents

The YT and NT authorities have provided reference documents for the DFL Project that have been reviewed at a high level and continue to be referred to by the team through development of the design. The Design Team have also had telecom discussions with both authorities. The list of reference documents has been summarized separately.

Industry Standard

In a traditional long-haul telecommunications construction project, the target cable burial depth is typically 1.0 m, to protect the cable from damage due to excavation. Typical cable systems are installed in urban or suburban areas, or along main roads, where construction work unrelated to the cable takes place on a regular basis. The 1 m burial depth is justified in these areas and is the basis for the industry-wide 1.0 m burial depth standard. However, the standards do not take into consideration the unique environment and different risks associated with the Arctic environment.

NorthwesTel Standards

NorthwesTel has advised that their standard burial depth for communications cable is 1.0 m, with a depth of 1.5 m where the conduit is beneath a road surface. However, given the unique environment in which the proposed DFL cable will be installed, NorthwesTel has agreed to the concept of shallow burial and surface-laid cable for this project.

CSA Standards

The Canadian Standards Association (CSA) standard document that covers underground cable and duct installations is C22.3 No. 7-15 – Underground Systems. The recommendations for cable burial depth are covered in Sections 5 and 7. The general consideration for burial depth is given by paragraph 5.1.1:

> *Communication and supply cables shall be buried at a sufficient depth below the surface of the earth or the bottom of ditches to minimize the probability of damage.*
>
> *Note: When deciding the depth of burial, the following factors should be considered:*
> *a) the possibility of deep digging;*
> *b) deep frost-line conditions;*
> *c) special soil conditions;*
> *d) vibration from heavy traffic; and*
> *e) impact of depth of burial on cable ampacity.*
>
> *In response to any of these conditions, greater depths than those indicated in Clause 5.1 or mechanical protection might be necessary*

The standard calls for a minimum burial depth for telecommunications cable and conduit under roadways of 600 mm.

Paragraph 5.1.5 of the standard describes measures to be taken when the depths stated are not practical, as follows:

> *In some instances, the depths stated in Clauses 5.1.2 to 5.1.4 are not practical. In such cases, reduced burial depths may be used where adequate mechanical protection over the cable is installed, in accordance with Clause 7.3.2 (Table 7.3.2.2 Examples of Mechanical Cable Protection (h) metallic armour on cables).*
>
> *Notes:*
>
> 1) *Reduced depth of burial can be subject to the requirements of local authorities.*
> 2) *See also Clause 16.2.2 regarding marking for reduced depth of burial.*

CSA standards are generally considered to be the minimum requirements to follow, and companies sometimes impose their own more stringent standards. However, CSA standards do not address impact on permafrost, and consequent damage to cables due to ground collapse. Also, the CSA standards are not entirely appropriate for a remote northern project location such as the DFL.

3.4 Surficial Geology and Terrain

The DFL design uses existing terrain information prepared by others to guide routing within the corridor; however, the route is largely defined by default as the DFL is to follow the existing highway and stay within the established ROW.

3.5 Permafrost Conditions and Considerations

The DFL will be within the existing established highway ROW which crosses extensive discontinuous permafrost to continuous permafrost terrain from south to north (Heginbottom, et al. 1995, Permafrost Map of Canada, 5th Edition).

Permafrost conditions vary with latitude and elevation from sporadic discontinuous at the Klondike Highway to continuous at Inuvik. Permafrost conditions are more present in undisturbed areas where the natural vegetative cover is undisturbed, in thick peat deposits, and in fine-grained soils overlain by an insulating peat layer. In areas where the natural cover has been removed or disturbed, and in well drained granular soils, and shallow bedrock, the seasonal thaw is greater and little to no shallow permafrost is anticipated in these terrain types.

The design approach follows best practices for constructing roads on permafrost terrain by minimizing construction related disturbances, including but are not limited to, the following:

- Installing cable on favorable terrain available whenever possible.
- Protecting the organic insulating layer along permafrost sections of the route.

- Limiting ground disturbances and clearing trees and vegetation to areas only where it is necessary.

Since the cable will follow and be installed within the existing highway ROW, many routing options and considerations have been eliminated. The design exercise is to optimize the location of the cable with respect to its location adjacent to the highway and in the most favorable soil conditions.

An increase in average air temperatures due to climate change is expected to result in the permafrost thawing over time, thus the design approach is to avoid known and suspected ice-rich areas, where possible, and to engineer solutions to cross them, if required.

To mitigate ground disturbances and avoid permafrost thermal or physical erosion concerns, the approach must be to employ installation methods that reduce the likelihood of disturbing or exposing thaw-sensitive permafrost mineral soils. The selected contractor will need to employ low impact construction methodologies along the route especially in areas where the permafrost is known to be sensitive to ground disturbances.

3.6 Permafrost Preservation

Permafrost in the region is marginally stable or degrading because of climate warming that has occurred to-date. Long-term climate predictions agree on a continued increase in air temperature over time, which consequently will result in continued natural permafrost degradation. The following design practices are being used:

- It is not smart to attempt to engineer against this natural process, when the ultimate outcome will be a more stable subgrade;
- Engineer with the natural process; and
- Manage the change.

Permafrost degradation will be mitigated by:

- Protecting the organic insulating layer along permafrost sections of the route;
- Limiting ground disturbances and clearing trees and vegetation to areas only where it is necessary; and
- Maintaining existing surface water drainage patterns to mitigate water ponding.

Given the generally warm permafrost temperatures that exist along much of the Klondike and sections of the Dempster Highway alignments, it is considered not reasonable to expect that permafrost will remain unchanged under prevailing climatic conditions, or the long-term future warming that is likely to occur.

In areas of warm, discontinuous permafrost, it is generally impractical to prevent natural permafrost degradation over time. Continuous permafrost conditions are more widespread in thick peat deposits, and in fine-grained soils which are overlain by a layer of peat that insulates the underlying soil.

The DFL cable installation alignment will be optimized to traverse the most favorable terrain available within the existing highway ROW and minimize crossing unfavorable terrain.

3.7 Stability of Terrain, Embankment and Cut Slopes

The terrain that the DFL crosses is largely established since the cable will follow the existing highway. The transportation authorities have records of their respective highways showing sections of their roads that have experienced various forms of slope instability.

The design intent is to minimize potential slope instability and failures utilizing the following measures:

- Avoid making excavations or disturbances in non–granular materials, where possible.
- Non-granular terrain types typically have lower shear strength and are more prone to slope instability on than granular soil types.
- Avoid recontouring natural drainage patterns.
- Avoid or minimize ground disturbances were possible.

Stability issues associated with the highway embankment are expected to occur in the future although their exact locations cannot be completely predicted. To minimize the risk associated with embankment failures, the cable will be installed outside the road embankment wherever possible.

Cut slopes created for the highway exist along the alignment. Cut slopes in high or medium sensitive permafrost can be expected to be unstable and at minimum pose a higher risk to the cable. Where possible, the cable will not be installed at the crest of cut slopes. If a cable is needed to be installed at the toe of a cut slope and cannot be rerouted, then it will be installed within a conduit and slack will be provided in anticipation of future movement.

3.8 Frozen versus Non-Frozen Construction Seasons

The most economical way to install the conduit or cable into mineral soil is to use a conventional cable plow. However, it is not easy to plow through a frozen saturated active layer or underlying permafrost because it is typically too hard. If the plow can penetrate the frozen ground, then the ground is likely to break up in large frozen pieces, rather than slice through. Other options for burying a cable into frozen mineral soils are directional drilling or saw-cutting.

Directional drilling will always be more expensive than plowing (up to 10 times more expensive, depending on the location, ground conditions, traffic control requirements and amount of work required to set up the drill pad). Directional drilling often requires geotechnical investigations to determine if the subsurface soil conditions are suitable for directional drilling methods.

Saw-cutting is typically less expensive than directional drilling (but more expensive than plowing), However, outside of the road embankment it would need to be done in the winter because in the summer the saturated active layer above the permafrost becomes too soft to support the weight of the saw-cutting equipment, and ground disturbances are too significant.

3.9 Erosion and Sedimentation Control

Several construction activities associated with cable installation have the potential to contribute to erosion and the introduction of sediments into local watercourses. To minimize potential erosion and sedimentation issues during construction, the contractor will implement appropriate best management practices for permafrost protection and erosion and sediment control.

Surface erosion techniques are important to absorb precipitation and runoff impacts, reduce runoff velocity, improve infiltration and bind the soil particles with roots. To minimize potential impacts leading to erosion and sedimentation, Tetra Tech suggests completing most of the necessary ROW clearing and HDD stream crossing activities in frozen ground conditions.

For erosion-prone activities to be undertaken during non-frozen conditions, it is recommended to implement various temporary and permanent surface protection techniques based on site-specific surfaces and slopes including:

- Shallow plowing to avoid permafrost exposure and disturbance;
- Surface lay cable were required;
- Hand clearing of riparian areas:
- Mulching during clearing;
- Maintaining root-wads;
- Restoration of riparian areas if necessary using willow cuttings and other native plantings.

Slope protection techniques are typically determined by the type of material and slope grade. If erosion and sediment control measures are required during along slopes during construction, the Contractor will employ appropriate control measures such as:

- Applying applicable surface erosion protection;
- Maintaining vegetative strips (where appropriate);
- Installing wattles, straw bales, silt fences, etc.

To avoid erosion concerns related to permafrost, the contractor shall employ installation methods that reduce the likelihood of disturbing or exposing permafrost and thaw-sensitive mineral soils. The contractor will coordinate with the design team to confirm such sensitive areas along the alignment.

3.10 Geotechnical Considerations for Drainage and Erosion

Drainage and erosion control are important in the design basis. Poor drainage conditions along a road may cause surface water ponding, thermal erosion, thermokarst and/or formation of icings, and ditch erosion can cause potentially serious gullying.

Water can create physical and thermal erosion issues whether in fine-grained or coarse-grained soils, within the seasonal active later or the underlying permafrost. Flowing water in the form of permanent and intermittent streams or sheet flow has a warming effect on the underlying permafrost and results in accelerated thawing of frozen sediments over which it passes. Particles of the thawed soil are detached by the moving water, transported and deposited downstream. This is a dynamic process of thermal erosion which has both hydraulic (mechanical) and thermal (melting of ground ice) components. The finer-grained the soil and the more ice present, results in faster and more destructive process of thermal erosion.

Previous project experiences and lessons learned has clearly demonstrated that the best way to protect against thermal and physical erosion issues is to mitigate, or minimize, all ground disturbances and damage to natural insulating surface vegetation. Overland water flows should not be altered from their natural flow patterns and water should not be permitted to channel, unless along an engineer channel.

Many drainage and erosion control documents have been prepared by local jurisdictions and are available to a Contractor. An example is the Government of the Northwest Territories Erosion and Sediment Control Manual.

https://www.inf.gov.nt.ca/en/resources?search_api_views_fulltext=erosion&sort_by=field_resource_publication_date&sort_order=DESC&=Apply

3.11 Settlement Considerations

The cable is not heavy enough to apply a load resulting in excessive settlement; however, ground disturbances can result in significant physical and thermal erosion causing the greatest settlements the cable will experience. Such disturbances are associated with changes to native ground conditions due to slope instability, geohazard and, hydrologic events, and thermal or physical erosion due to permafrost degradation.

When the cable is placed on thick peat deposits it will settle into the organic mat but not excessively to cause damage. Should the peat deposit move a few metres due to a larger mass movement then the cable across that impacted section will likely be damaged.

3.12 Major River Crossings

The three major rivers (i.e. Mackenzie River, Peel River and Arctic Red River) will be crossed by means of Horizontal Directional Drilling. Geotechnical investigations were undertaken at the Peel and Mackenzie river crossings, but no subsurface data was collected at the Arctic Red River because a crossing location was not established, and it had not been determined whether the community of Tsiigehtchic, NT would be serviced, by an HDD or an aerial crossing.

A decision to service the community has since been made and the fibre routing will need to terminate in the NWTEL Central Office within the community. As such, the Arctic Red river is scheduled to be studied in the summer/fall of 2019

3.13 Culvert Crossings

For this document, a culvert is generally defined as a structure that allows water to flow under a road (Highway or access road), or similar obstruction from one side to the other. When referring to culvert crossings, in general this refers to crossing of the watercourse or waterbody associated with the culvert structure underneath the highway. For the DFL Project, the general design basis is that the cable or conduit system will not be installed in the road structure, so instances where culvert structures will need to be crossed (over/under) will be rare.

Culverts fall into several categories, and the crossing method to be implemented will depend on the category of the culvert and local terrain considerations. Major culverts have been installed where the highway crosses large rivers or deep, steep ravines. The primary crossing option for these features will be HDD and should HDD not be practical an aerial crossing method will be pursued.

Intermediate culverts refer to those provided for perennial small streams or rivers on fairly level terrain. In general, these will be crossed by means of HDD. If soil or terrain conditions are unfavorable for HDD, aerial crossing method will be pursued.

Minor culverts refer to those provided for precipitation run-off, snow melt or other ephemeral water flows, or equalization culverts to allow standing water in wetlands on either side of the road to drain. For ephemeral flow culverts providing there is no flow, the default approach will be to install the cable by means of shallow plow. For equalization culverts in wetland areas, the cable will be surface-laid in frozen conditions, so that it submerges into the wetland during the freshet.

Based on the topography and map data, many of the culverts along the DFL alignment appear to be for seasonal ephemeral flows to allow the passage of rainwater and snowmelt, or to equalize water levels on either side of the road.

From an environmental and longevity perspective, the design allows for HDD under flowing perennial watercourses. Consideration is also given to aerial or surface-laid applications for perennial watercourses; however, the alternative options, such as HDD need, to be evaluated based on site-specific conditions and the following considerations:

- Aesthetic (depending on local vistas and how intrusive an aerial cable would be on the views).
- Ground conditions (where ground is rock or gravel, then it will provide good support for pole foundations but be difficult to drill, whereas in permafrost, it is unadvisable to excavate for the pole bases and in general the ground is easier to drill).
- Site access (for placing of poles and cable, versus setting up HDD rigs).
- Practicality of installation

In general, aerial/surface-laid installations for stream crossings are likely to be more feasible in the section south of Tombstone Park, due to the ground conditions.

It is unlikely that HDD will be used to cross ephemeral drainages for practical reasons, except for exceptional circumstances where burial and aerial options are not possible. Burial is less expensive than new aerial installations and generally requires lower maintenance in the long term.

3.14 Side of Road Embankment Installation

The design and construction approach will be to locate the cable on whichever side of the road appears to pose less risk to it of physical damage, subject to constructability constraints. In general, this will be as follows:

- Where the road runs along a side-slope, install the cable on the upslope side of the road.
- Where a river runs along one side of the road, locate the cable on the other side.
- Near human settlements, locate the cable where it is least likely to be exposed to damage from human activities.

The above mentioned considerations should be treated as a guideline rather than a firm rule. There is a cost, and practical considerations associated with crossing from one side of the road to the other (in terms of directional drilling, added material and labour for conduit and cable, but also in terms of being able to jet the cable, since the bends associated with the road crossing will reduce the jetting distance that can be achieved). Thus, the alignment will not change sides of the road unless the benefits outweigh the practical constraints. For road crossings 45 degree crossings are being considered to reduce the frictional resistance to maximize jetting distances through the conduit.

3.15 Granular Material Requirements

Any granular materials required for construction of the DFL will be sourced from existing material sources (borrow pits) along the highway. No new pits or quarries will be developed.

3.16 Climate Change Effects on Permafrost

Accounting for the relatively warm (-2.5°C to 0°C) permafrost temperatures measured along the Project and the predicted climate warming trends, the permafrost regime is expected to continue to degrade naturally over time, most likely to a large degree during the life of the project. Given that the future impacts of climate change carry a level of uncertainty, managing from a perspective of identification of hazards and reducing risk is the key to success of the project.

3.17 Managing Risk Associated with Climate Change

The DFL design considers a risk-based approach for incorporating climate change into design and operation. The challenge for design and construction is to balance the capital cost of installing the cable against the performance and long-term maintenance, therefore considering cost, functionality and risk, the following approach is adopted:

- Cable will be attached to existing bridges when feasible and acceptable to the authority.
- Cable will be installed in conduit using HDD drilling techniques under the three main river crossings, Peel, Mackenzie and Arctic Red Rivers. However, an aerial option is under consideration for the Arctic Red River crossing.
- HDD drilling will be used at other perennial stream crossings where there is no bridge to attach the cable to. In some smaller perennial stream crossings, and where the topography of the crossing requires a difficult and expensive HDD program, then aerial poles will be used.
- Shallow and conventional bury installation under flowing conditions, and surface-lay installation under no-flow conditions will be applied to ephemeral crossings. The cable will be installed 5.0 to 10.0 m away from all culvert locations or HDD drilled under the crossing regardless of whether the stream is ephemeral or perennial.

4.0 GENERALIZED DESCRIPTION OF CONDITIONS ALONG DFL ROUTE

For this geotechnical design brief, the route from Dawson to Inuvik is divided into 8 geography based sections:

In general, the terrain along the Klondike and Dempster Highways is relatively distinctive in the various geographic regions through which the road traverses. However, within each region there are subsections with their own unique characteristics. The general characteristics of each section are outlined below, but it should be recognized that there are typically areas within each section that deviate from the descriptions provided.

A common theme for large sections the route is the amount of surface water. In low-lying and flat areas this presented itself as ponds, lakes and marshland, often with dense vegetation. Through more mountainous terrain it was apparent as water seeping out of the ground and flowing or standing in ditches beside the road. In many of these areas the road follows river valleys, so it is common to have a river on one side of the road and steep embankments rising on the other.

4.1 Klondike Highway - Dawson to Dempster Highway (Hwy 2 km 0-41)

This segment follows the Klondike Highway (Hwy 2) from Dawson to the Dempster Highway and for this section along Hwy 2 the surface vegetation suggests that there are areas of discontinuous permafrost.

There is an existing NorthwesTel fibre optic cable that utilizes existing YEC High Voltage Transmission (HVT) lines that run aerially for approximately 17 kms from Dawson Central Office to Hunker Creek Road and then utilize existing YEC Low Voltage Distribution (LVD) lines that run from Hunker Creek Road to Henderson Corner (Hwy 2 km 690). For the remainder of the route to the Dempster Highway the cable was installed with shallow burial techniques. NorthwesTel has provided high level installation details for their existing fibre optic line alignment, but there is an outstanding question regarding the potential use of a second pole line which runs parallel to the LVD lines and could potentially be used for the entire 41 km run.

To achieve redundancy the proposed cable installation could run approximately 24 kms aerially along the YEC High Voltage Transmission (HVT) line from the Dempster Highway to junction of Hunker Creek Road and Hwy 2.

4.2 North Klondike Segment (Hwy 5 km 0-80)

This section follows the North Klondike River Valley and is predominantly granular alluvial valley deposits with minor (if any) permafrost features on the route. There are numerous culvert crossings along this section, but no significant erosion or stability issues are identified in review of provided data.

4.3 Blackstone Uplands Segment (Hwy 5 km 80-156)

This is generally an unglaciated (i.e. not in the most recent period of continental glaciation) ice-rich permafrost area characterized by broad valleys and numerous areas of both ice-wedge polygons and thermokarst lakes; however, the highway crosses a short section of glaciated terrain near Hwy 5 km 109 that has deposited steep sided moraine on both sides of the highway (Tetra Tech EBA 2015).

Natural undulations in the terrain adjacent to the highway are about 2.0 m and are indicative of thaw of ice-wedge polygons. Several large thermokarst lakes are also present adjacent to this section of highway – the largest being Chapman Lake and Two Moose Lake. These lakes have increased in size since the highway was constructed and are now adjacent to and potentially encroaching on the highway embankment.

The short glaciated area that the highway passes through is centered on about Hwy 5 km 109 – the moraine in this area is ice-rich and has recently started to exhibit minor slope instabilities (surface flow slides) related to increased active layer thickness, and possibly increased rainfall (Tetra Tech EBA 2015).

Erosion from the Blackstone River has affected the highway at about Hwy 5 km 122, necessitating a realignment. The highway was moved away from the river, but reconstruction included a minor cut section that has created ongoing permafrost thaw-settlement issues and initiated progressive instability that requires regular maintenance (Tetra Tech EBA 2015).

4.4 Ogilvie River Segment (Hwy 5 km 156-250)

The highway in this area generally follows Engineer Creek to its junction with the Ogilvie River, and from there follows the Ogilvie River valley until it starts to climb up to the Eagle Plain. The southern section is underlain by permafrost, but after crossing the Ogilvie River the highway is generally founded on unfrozen alluvial deposits adjacent to steep valley sideslopes underlain by permafrost (Tetra Tech EBA 2015).

The highway in this segment crosses Engineer Creek twice, and increased flows and winter icing have continued to cause maintenance issues at those crossings. Increased flows in Engineer Creek combined with extreme rain events have caused erosion of the Engineer Creek at the bridge, exposing the abutment foundation piles and creating the potential for undermining of the abutment and increasing risk of local collapse (Tetra Tech EBA 2015).

The cable will be installed on opposite side of road to Engineer Creek and Ogilvie River, and anywhere along the alignment opposite the side of ponding water adjacent to the embankment.

4.5 Eagle Plains Segment (Hwy 5 km 250 – 406)

The highway climbs out of the Ogilvie River Valley just before Hwy 5 km 250, and above this, minimal maintenance issues were observed as the road essentially follows bedrock cored ridges to the Richardson Mountains (Tetra Tech EBA 2015)

4.6 Richardson Mountains Segment (Hwy 5 km 406 – Hwy 8 km 27)

The Richardson Mountains are a range of the Canadian Rocky Mountains that parallels the northernmost part of the boundary of the YT and Northwest Territories. Trending northwest-southeast, the Richardson Mountains are the northern extremity of the Rockies.

Increased rainfall and possibly undersized culverts have created road instabilities through washouts adjacent to culverts in some sections of the highway (Tetra Tech EBA).

The thaw of ice-wedges in the permafrost has affected the Dempster Highway (Hwy 8) on the NT side near Hwy 8 km 8.5 since about 1984 when there was a fatal accident at this location in 1985 caused by road collapse into a thawed ice-wedge void. There continues to be some distress to both sides of the highway embankment at this location caused by thaw near the toe of the fill (Tetra Tech EBA 2015).

4.7 Peel Plateau Segment (Hwy 8 km 27 – 74)

The landscape in this segment is almost entirely shaped as result of the most recent (Laurentide) glaciation, along with subsequent post glacial fluvial and other geomorphological processes. Continuous thick permafrost is present throughout to a depth close to 300 m (Geological Survey of Canada, unpublished data). Retrogressive thaw-flow slides are common where ground ice has been exposed in glaciolacustrine deposits by forest fires, debris flows and regressive erosion. These thaw slumps are one of the most active geomorphic features within this segment and they are all situated within the maximum westward extent of the Laurentide Ice Sheet.

The Peel Plateau is particularly susceptible to the effects of a warming climate as it contains a significant amount of ice-rich permafrost. Instability at Hwy 8 km 27 related to thaw of ice-rich near surface soils on both banks of a surface drainage course has affected the toe of the highway embankment.

4.8 Mackenzie Lowlands (Hwy 8 km 74 – 272)

This section of highway from the Peel River to Inuvik is generally flat and contains significant areas of standing water (swamps) connected by small drainage courses. In general, the swamps are shallow and freeze to the bottom every winter, preserving the permafrost. In some sections of the highway, ponded water combined with significant embankment settlement has created deep water that probably doesn’t freeze every winter. This has created ongoing permafrost thaw and resulting culvert and highway distress.

5.0 CABLE INSTALLATION TECHNIQUES

5.1 Geotechnical Considerations

The following describes the methods and techniques to be utilized for the DFL Project both away from the road embankment within the ROW and within the road embankment where necessary. The present design basis for the DFL Project is to install the fibre optic cable infrastructure within the ROW at about 20m offset either side of the highway centerline. However, in some places (road crossing) the only practical way to install the cable will be to install it within the existing road embankment, in which cases the design will aim to minimize the risk to the highway structure while taking constructability into consideration as well as life cycle maintainability of the fibre optic cable.

To successfully complete this Project, the design team recommends that the contractor adopt an adaptive construction approach using alternative construction methods (as required) to mitigate uncertainties encountered in the field that consist of, but are not limited to, the following proposed construction techniques:

- Shallow direct-buried cable (typically 150 mm depth).
- Surface-laid cable.
- Horizontal Directional Drilling (HDD).
- Aerial cable installation (along YEC HVT and LVD lines).
- Aerial Cable installation (within the communities of Dawson, YT, and Fort McPherson, Tsiigehtchic, and Inuvik, NT).
- Any changes and adaptations to field installation will need to be reviewed by the Engineers and approved in advance of implementation. The Contractor does not have unilateral decision authority to choose installation technique.

5.2 Conventional Plow

Conventional plowing involves the use of heavy equipment (static plows) or light equipment (vibratory plows) that are specifically designed and rated for pulling and laying fibre optic cable (The cable spools off the reels as it is plowed into the ground). Generally, the plow slot closes behind the plow, so backfilling requirements for the slot are minimal, depending on the soil, terrain, and season the cable is plowed. For this project the terrain and permafrost conditions will dictate the use of light equipment conventional plow and perhaps vibratory plow in areas where advantageous to use.

5.3 Conventional Trench

In some areas, when ground conditions are unsuitable for plowing or HDD, and the environment requires that the cable be installed at depth for protection, then a conventional trench approach may be appropriate. This applies in some sections along the Dempster Highway, where there are steep slopes on one side of the road and a river on the other, and the ground appears to comprise rock (fractured shale), and a surface-laid cable is not appropriate.

5.4 Shallow Burial

In permafrost areas, the ground is covered with a layer of peat and moss. This layer insulates and preserves the permafrost. In these areas, the plan is to install the cable within the moss and above the mineral soil. This option would protect the cable from forest fires and being an animal hazard. The cable would be susceptible to peat fires, in the event the peat dried out. However, the risk of cable and environmental damage due to permafrost degradation would be significantly reduced compared with trenching the active layer.

5.5 Surface-Laid Cable

Surface-laid cable will be utilized in areas otherwise unsuitable for HDD, plow, shallow-bury plow or aerial Installation, e.g., areas of ice rich permafrost, unsuitable terrain (steep slopes) or unsuitable ground conditions (rock). This method is also proposed for sections where terrain is not accessible by equipment and the highway road embankment is not to be disturbed.

The potential advantages of surface-laid cable are minimal environmental impact and generally lower construction cost.

Risks associated with surface-laying the cable are as follows:

- Cable theft by people who think it may contain copper.
- Animals chewing on cable.
- Deer getting antlers snagged in it.
- Wildfire.
- Peat fire.
- Damage from highway accidents.
- UV degradation of the sheath.
- Risk to hunters on snowmobiles tracking off the road.

These risks (except for peat fire) can be mitigated by shallow burial, or to a lesser extent by installing the cable in conduit. By placing the cable towards the edge of the ROW, risks associated with human activity will be reduced.

5.6 Road Embankment Installation

In some circumstances the only economically practical installation method is to install the cable within the existing road embankment. This is typically recommended in cases where the Project corridor is bounded by a river on one side and steep mountain slope on the other and will be limited to some southern portions of the Project in YT.

When cable installation is required within the road embankment, it will be installed in a conduit which will be placed in a trench, backfilled and compacted (or as otherwise dictated by the Highway Authority). The cable will then be jetted through the conduit. In instances that pose a high risk of erosion of the road base such as the presence of an adjacent river, the cable will be installed on the upslope side of the road.

5.7 Horizontal Directional Drill (HDD)

The major rivers (i.e. Mackenzie, Peel and Arctic Red) will be crossed by means of Horizontal Directional Drilling (HDD).

From an environmental and longevity perspective, the design allows for HDD under flowing perennial watercourses.

HDD installation methods will be considered for:

- Crossing of flowing watercourses where aerial crossings are unsuitable.
- Road crossings (e.g. when changing from one side to the other, or to cross vehicle pull-outs or intersecting roads).
- Where rock outcrops cannot be avoided by alternative construction means.
- Areas where soil stability and ground conditions indicate significant risk of permafrost damage.
- Where direct-buried or surface-laid options are not practical.

Peel River

The 2016 Fall Geotechnical Program factual report (Paladin 2016), presented the results of Paladin's field investigations conducted at the Mackenzie and Peel Rivers near Tsiigehtchic and Fort McPherson, Northwest Territories (NT). Site investigation work was conducted between October 12·25, 2016, which encompassed geotechnical drilling, logging and sampling. The 2016 Fall Geotechnical Program included additional geophysical work near the proposed crossings. Aurora Geosciences completed the geophysical work that consisted of sub-bottom profiling and electric a resistivity tomography (ERT) survey. The results of this work were presented under separate cover.

The geotechnical program consisted of drilling two boreholes to depths of 58.5 m and 55.2 m, about 120 m from each shoreline. There were no boreholes drilled along the ferry crossing alignment through the river bottom sediments. The subsurface soil conditions at each borehole consisted of clay and silt and no ice or frozen soils were noted throughout the borehole. No bedrock was encountered in each of the boreholes.

The geophysical work concluded that near the boreholes and the shorelines on both the west and east sides there were multiple subsurface layers that are interpreted to be sediments with varying degrees of moisture or frost. The findings from the boreholes and the proximity of the shoreline locations near the river's edge, it is unlikely the soil is in a permafrost condition. Sub-bottom profiling was not completed for the Peel River.

The subsurface conditions encountered at the proposed Peel River crossing appear suitable for an HDD crossing.

Mackenzie River

The 2016 Fall Geotechnical Program factual report (Paladin 2016), presented the results of Paladin's field investigations conducted at the Mackenzie and Peel Rivers near Tsiigehtchic and Fort McPherson, Northwest Territories (NT). Site investigation work was conducted between October 12·25, 2016, which encompassed geotechnical drilling, logging and sampling. The 2016 Fall Geotechnical Program included additional geophysical work near the proposed crossings. Aurora Geosciences completed the geophysical work that consisted of sub-bottom profiling and electric a resistivity tomography (ERT) survey. The results of this work were presented under separate cover.

The geotechnical program consisted of drilling two boreholes to depths of 80.5 m and 80.0 m, one about 120 m from south shoreline and the other near the north ramp to the ferry. There were no boreholes drilled along the ferry crossing alignment through the river bottom sediments. The subsurface soil conditions at each borehole consisted of sand, silty sand and silt. Frozen soils (Permafrost) were encountered throughout each borehole to maximum depths of 29 m and 40 m. No bedrock was encountered in each of the boreholes.

The geophysical work concluded that near the boreholes and the shorelines on both the south and north sides there were multiple subsurface layers that are interpreted to be sediments with varying degrees of moisture or frost. The north ERT line identified a possible bedrock interface at a depth of 30 m on the eastern half that seemed to be associated with a nearby cliff with outcropping bedrock.

The subsurface conditions encountered at the proposed Mackenzie River crossing appear suitable for an HDD crossing.

Arctic Red River

No subsurface geotechnical information has been sourced by the Design Team or has been made available to the Design Team. The nearest useful data is the geotechnical information collected from the Mackenzie River crossing by Paladin, 2016 Fall Geotechnical Program (Paladin, 2016).

The Yukon Government will be contracting a geophysical survey across the Arctic Red river to collect data in support of an HDD crossing.

5.8 Considerations for Placing Surface-Laid Cable Within or Without Conduit

Installation of the cable inside an HDPE conduit will provide a trade-off in mitigating the above risks. On the one hand, the conduit will offer a measure of physical protection, but on the other, the conduit will be more prone to suspension across hummocks due to the increased diameter and rigidity. The conduit will also tend to float where installed in wetland.

The use of surface-laid cable will be limited to areas where burial would either be prohibitively expensive, create conditions likely to promote permafrost damage and associated problems, or through wetlands.

5.9 Aerial Pole Line (existing and new installation)

There is a limited amount of aerial cable that can be utilized on the proposed DFL, as follows on Table 1:

Table 1 – Summary of Potential Aerial Route Opportunities

LOCATION	POLE LINE	ESTIMATED LENGTH (Km)
INUVIK (From the edge of town to CO)	EXISTING	2
FORT MCPHERSON (Dempster highway to CO)	EXISTING	2
TSIIGEHTCHIC (In town to CO)	EXISTING	1
KLONDIKE highway TO DAWSON CITY LIMITS	EXISTING	41
DAWSON CITY (From the edge of town to CO)	EXISTING	0.5
ALONG DEMPSTER ROUTE	YT - NEW	16.5
	NT - NEW	7.5
	TOTAL:	**70.5 Km**
NOTE: These are all early estimates. Actual Km will depend on detailed route design.		

In general, installation of new aerial cable along the Dempster Highway might occur at some of the bridge crossings where it is not practical or permissible to attach conduit to the bridge structures (only YT section), aerial crossings of the rivers may also be considered as a practical alternative to HDD crossing is certain conditions. It is therefore proposed to use aerial cable to cross rivers at bridges where the highway authorities do not grant permission to attach to the bridges. In such cases, the area will be cleared of brush to reduce the risk of damage from wildfires and timber poles with a protective paint finish will be used. Aerial crossing will also be considered across drainages that cannot be crossed by direct bury or HDD.

At present, it appears that the Klondike Highway section from Dawson to the Dempster Hwy is viable to use the existing aerial infrastructure (YEC HVT and LVD lines). However, it is understood the single set of HVT poles currently have NorthwestTel fibre on them from Hunker Creek Road to Dawson Central Office.

Aerial will only be used in the NT when other preferred methods, such as HDD are unsuccessful.

6.0 GEOTECHNICAL APPROACH AND RISKS TO CABLE INSTALLATION

6.1 Flowing Water Crossings without Bridges

The DFL Project will employ best management practices for crossing watercourses that mitigate negative interactions between the cable and construction equipment with water or fish habitat by employing the following crossing methods:

- HDD of most fish-bearing streams, rivers and other waterbodies;
- Surface lay through wetland areas; and
- Aerial crossings.

HDD will be the preferred method for crossing the large rivers that have no bridges and uses ferries to cross in the summer and ice bridges for winter crossings. These are the Mackenzie, Arctic Red and Peel Rivers. There is still some consideration for crossing the Arctic Red River by aerial method.

In general, HDD will also be the primary method for crossing streams and drainage channels along the DFL alignment that the highways use existing bridges and culverts provide that:

- Ground conditions are suitable (i.e. no excessive rock or cobble);
- Terrain is suitable (not too steep) for setting up HDD rig (various HDD rigs require different size set up areas); and
- Crossing is not excessively deep or long.

If all the above conditions are not met, then consideration will be given to crossing aerially. Each potential aerial crossing will be assessed individually during the detailed field pick-up and design phase, and the decision whether to cross by means of HDD or aerial will be made based on the merits of each situation.

6.2 Flowing water Crossings with Bridges

River crossings where there are highway bridges in place will be crossed based on the following preferences. These bridge crossing methods have been discussed and agreed with the appropriate highway authority. In instances where bridges are present, the preferred (and most economical) crossing method is to attach conduit or a detachable raceway to the structure and pull cable through it. However, some bridge structures along the route are not suitable for attaching conduit due to their physical state or projected plans for local authorities to upgrade the structure in the future, or because of the design of the approaches. As such, the preferred installation method in these cases would be aerial. Site-specific conditions will determine cable spans, pole lengths and number of poles required for each installation.

6.3 Culvert Crossings

A culvert is generally defined as a structure that allows water to flow under a road, or similar obstruction. When referring to culvert crossings, in general this refers to crossing of the watercourse or waterbody associated with the culvert structure underneath the highway. The general intent is that the proposed cable system will not be installed in the road structure, so instances where culvert structures need to be crossed will be rare.

Major culverts have been installed where the highway crosses large rivers or deep, steep ravines. The primary crossing option for these features will be HDD and should HDD not be practical an alternate installation method will be pursued, such as aerial pole.

Intermediate culverts refer to those provided for small streams or rivers in relatively flat terrain. In general, these will be crossed by means of Aerial Pole or HDD based on terrain and soil conditions and practical constraints.

Minor (equalization) culverts refer to those provided for precipitation run-off, snow melt or other ephemeral water flows, or equalization culverts to allow standing water in wetlands on either side of the road to drain. For ephemeral flow culverts providing there is no flow, the default approach will be to install the cable by means of shallow plow or surface-lay methods. For equalization culverts in wetland areas, the cable will be surface-laid in frozen conditions, so that it submerges into the wetland during the freshet. This also allows for buoyancy control using strategically placed saddle sand bags along the crossing.

6.4 Standing Water, Lakes/Ponds, Wetlands

Cable will be installed through lakes, ponds and wetlands by surface-laying the cable. In the case of ponds and lakes, the cable will be routed towards the edge of the water body so typically it will not be submerged at a depth of more than a couple of metres. If local conditions suggest that the cable will be at risk of damage due to surface-laying the cable/conduit through standing water, then HDD may be considered. Consideration will be given for the use of conduits in this surface lay application, to reduce the risk of ice compression on the cable.

In areas where wetland crossings cannot be avoided, the cable will be pre-placed in the winter months by laying it out over frozen ground and wetlands along the route alignment, providing a generous amount of cable slack. When the ice melts upon spring break-up the cable will sink to the bottom of the water features and over time naturally settle itself into the soils due to its weight.

To minimize potential environmental effects on wetlands, field personnel will physically enter the wetland during the summer to make any adjustments to the final placement of the cable including pressing the cable down by hand or foot or dislodging any portions that are hung up on soil or vegetation mounds.

6.5 Road Embankment Crossings, Pullouts and Access Roads

In places where the cable needs to cross from one side of the highway to the other, the crossing will typically be by means of HDD.

There are several vehicle pull-outs and minor access roads along the route. In general, minor access roads and clearly-defined vehicle pull-outs (i.e. those that appear to be used regularly) will be crossed by means of HDD, or if HDD access is restricted, then plowing or trenching of conduit and subsequent pulling of cable will be used. In locations where the pull-outs appear to be used infrequently, then trenching of conduit will be used. If an aerial crossing of a ravine coincides with an access road crossing, then the aerial cable will be extended across the access road, taking care to ensure adequate clearances for local traffic. No aerial crossings will be made to cross the Dempster highway.

6.6 Existing Pole Lines

Existing pole lines along sections of the route alignment have been identified in the following areas:

- Dawson, YT.
- YEC HVT line along Klondike Highway from Stewart Crossing into Dawson and across the Australia Hill.
- Fort McPherson, NT.
- Tsiigehtchic, NT
- Inuvik, NT.

From a constructability perspective, aerial cable is desirable, and will be used in Dawson and the YEC LVD line wherever possible. For the section of the YEC LVD line into Dawson, the existing Klondike fibre cable is attached to poles so these spans will not be utilized in order to maintain redundancy. There are some joint-use poles in downtown Dawson that will be considered for use during the detailed route design.

Similarly, there is an existing aerial pole line running into Inuvik that will not be utilized for DFL to maintain diversity from Mackenzie Valley Fibre Optic Line. However, there is an aerial lead in the downtown area of Inuvik, which may be utilized to the extent practical.

Authorization to attach to existing poles will be sought from the respective utility owners. YEC has already agreed in principle to the use of their poles for the proposed DFL cable.

The use of aerial installation is proposed for certain circumstances on the DFL Project, which will include new and existing installation aerial segments. Existing aerial installation will be utilized near Dawson, YT and Inuvik, NT along existing pole lines and along the highway where challenging physical conditions exist. Constraints including access (equipment and personnel), sensitive terrain and difficult drilling conditions. These constraints will be evaluated when determining the most suitable areas to be considered for aerial installation.

At this time, the longest aerial construction stretch on the Project is an approx. 41 km run along the YEC HVT and LVD lines utilizing existing poles to the extent possible, along the Klondike Highway. Due to the long spans and high voltage of the YEC HVT line, ADSS cable will be used for this section. For the remaining aerial installation areas, the cable will be lashed to the messenger strand along the existing pole lines.

Aerial cable install may be utilized at the larger river crossings with existing bridges if a cable cannot be installed to the bridge structure and HDD is considered impractical. For these crossings, two to four new poles (depending on the total aerial length required to cross the river and other constructability constraints) will be placed at each crossing with two poles on each side. The reasoning for the utilization of aerial at these locations is the reduction in risk compared to performing HDD shots at these larger, more challenging river crossings.

In other areas along the route, where it is impractical to surface-lay or shallow-bury the cable, the ground conditions preclude the use of HDD (e.g., hard rock or cobble), or the terrain does not provide suitable locations for setting up an HDD drill rig, may be feasible to install new aerial structures for cable installation. While the design will work to limit the number of additional aerial sections, this option may have to be used for areas where other methods are technically prohibitive. However, decisions respecting the final construction methodology and cable placement option to be implemented will be determined through consultation and the detailed design field pickup.

When required, new aerial construction typically includes installing wooden or steel poles for cable attachment. In most mineral soils, they can be augered in place. In sensitive permafrost areas, wooden or CSP (corrugated steel pipe) culvert cribbing foundations may be required for the pole bases and guy anchors. These structures are built up from a framework of timber, metal or fiberglass members or a section of large CSP culvert end up, placed on a layer of aggregate covering the natural ground and filled with stone. Additional design considerations include ice and wind loading and collision risk placement. Small diameter pile technology will also be investigated as a possible pole foundation and anchoring strategy.

6.7 Steep Grades

Where the cable alignment crosses or follows steep grades or areas where the risk of erosion appears to be particularly high, then the construction method will be assessed to minimize the erosion risk while still providing protection to the cable. Preference will be given to shallow burial of the cable, and potentially importing approved native fill and compacting the cable slot, as well as installing erosion control measures.

In some areas, the cable will need to be installed in steep side-slopes that cannot support plow equipment. In these cases, consideration will be given to trenching or surface-laying the conduit and jetting or pulling cable through it.

6.8 Washout Areas and Loose Rock Crossings

In areas of known or potential geohazards, previous washouts or the potential for washouts the first approach to be employed will be to avoid such areas by installing the cable on the most secure side of the highway. Careful route selection based on the 2017 detailed field survey will help to inform a decision regarding the preferred routing of the cable through such higher risk areas. If the entire ROW is known to have been previously impacted by a washout (or geohazard), the area will be crossed using HDD or aerial pole line depending on span considerations. A different alignment outside the ROW may have to be considered to avoid an active geohazard.

Where loose rock is present on slopes where it is likely to move, or in areas that are inaccessible to shallow plow equipment, then the cable will be installed on aerial poles. In areas where the rock is not impermeable to shallow plow equipment, and the terrain is accessible to the shallow plow, then shallow plowing of the cable directly into loose rock may be used. A different alignment outside the ROW may have to be considered to avoid a potential geohazard.

6.9 Surface Vegetation, Peat, Grasses, Trees

Surface vegetation, grass and peat will be present in many of the areas discussed in the previous subsections. The presence of surface vegetation, grass and/or peat will be a primary consideration in determining the construction method to be implemented in a specific area. The preferred method for installing cable in such areas is shallow burial. However, if the terrain precludes construction equipment from running along the route alignment in summer to plow the cable into the ground, then the cable will be surface-laid.

6.10 Route Clearing

Route clearing along the ROW is proposed for the 2019 and 2020 seasons and will utilize two primary techniques including mulching and hand slashing. Mulching involves cutting tall grass and shrubs or small trees using rotating blades mounted on a mechanized vehicle and hand slashing refers to cutting trees, branches or brush with hand-held tools. Project-specific requirements that dictate the use of a certain technique will depend on the location, ground suitability, environmental sensitivity, installation methodology and project scheduling.

Hand slashing will be utilized in sensitive environments and in riparian zones. These zones will be identified by a qualified environmental professional during the detailed design field pick up and indicated on the construction drawings. Where route clearing is required during the summer season, a bird nest sweep will be completed by a qualified professional (as required) in advance of the work.

The amount of vegetation clearing to be performed during construction of the project will be minimized in several ways, including:

- During the desktop design, followed by verification during the field pick-up, the cable alignment will be chosen to follow the least heavily vegetated areas along the ROW (subject to other constraints such as highway infrastructure or topographical features such as rock outcrops).
- During construction, the width of vegetation cleared will be no more than what is required for temporary access and operation of the cable installation equipment.
- Construction techniques and equipment will be chosen to minimize the width of the clearing and the environmental footprint.

Areas to be cleared for the DFL Project include, the cable alignment and temporary access trails. Temporary staging areas and temporary access trails may be required to allow access for personnel and equipment within the ROW. Design and construction will need flexibility during construction for these ancillary features, so the exact locations will be determined as needed in the field. Direction has been provided by the Yukon Government that temporary staging and camps during construction can be located at existing quarries along the YT section.

6.11 Permafrost Degradation (Thermal or Physical Erosion)

Water can create erosion issues whether in fine grained soils or permafrost. Flowing water in the form of permanent and intermittent streams or sheet flow has a warming effect on the underlying permafrost and results in accelerated thawing of frozen sediments over which it passes. Particles of the thawed soil are detached by the moving water, transported and deposited downstream. This is a dynamic process of thermal erosion which has both hydraulic (mechanical) and thermal (melting of ground ice) components. The finer-grained the soil and the more ice present, the faster and more destructive the process of thermal erosion is.

7.0 GEOTECHNICAL RISKS ASSOCIATED WITH ENVIRONMENT

The following information on geotechnical risks associated with the project environment is included for your review and inclusion in the risk matrix being prepared by Stantec.

7.1 Climate Change

As would be expected for the region, average temperatures have been increasing annually. Annual precipitation has also been increasing with the exception of Inuvik, where there has been a slight general decrease in mean annual precipitation since 1958. Due to the uncertainty of climate change however, it is no longer an accepted procedure to only adopt historic trends as design parameters, particularly in regions of permafrost (TAC 2010). General circulation models (GCM) in combination with various population and economic growth scenarios provide simulations of future climate change. Modelled scenarios retrieved from the Pacific Climate Impacts Consortium (PCIC) offer historical and predictive outputs from various Intergovernmental Panel on Planetary Change (IPCC)-approved GCMs for all of Canada for the time period 1950-2100. The selected time period for describing climate change effects is fifty years into the future, described by the 30-year period 2051-2080.

The global climate models predict warming and increased precipitation for the region. Warming is predicted to be of slightly greater magnitude towards the northern part of the highway (Inuvik). The greatest precipitation increase is predicted to occur near the midway point of the Dempster Highway, however general increased precipitation (10% to 30%) is predicted through the region. Changes in mean annual temperature have been found to affect the distribution of permafrost and thermokarst processes in the region (Lawford 1989). A general warming and a snow cover of shorter duration would disrupt the thermal stability of the permafrost, which is sensitive to minor changes in heat transfer at the ground surface, initiating thaw and decreasing the overall stability of the ground (EBA 2010). The current climate warming trends may also lead to increased active layer thickness, diminished permafrost thickness and result in ground ice melting, thermokarst, water ponding, a decrease in terrain stability, and potentially a future increase in mass movements on slopes along the DFL route.

Mitigation measures to address the effects of future climate change on terrain, landforms, permafrost and soils have been described earlier in this report.

7.2 Geohazards

The most recent investigative work conducted by McKillop et al (2016) on behalf of the YT Department of Highways and Public Works – Transportation Engineering Branch aimed at identifying sections of the Dempster Highway corridor that are susceptible to soil and rock mass movements with the potential to impact the highway. The objective of this work was to prioritize high-risk sites for more detailed investigation, guide planning decisions for future remediation works, and ultimately design and implement measures to mitigate risk to the highway.

The desktop analyses and field reconnaissance investigations undertaken by McKillop et al. (2016) culminated in the identification, delineation and characterization of 54 mass movement geohazards with the potential to impact the highway, mostly within the Ogilvie highway maintenance section. The inventoried geohazards, from most to least common, include active layer detachments, retrogressive thaw slumps, rockfall, thermokarst subsidence, debris flows, thermokarst gullies and debris slides.

McKillop et al (2016) estimated that about fifty percent of the 54 mass movement geohazards posed only low or very low risks to the highway, due to their modest possibility for only temporary (<1 day) and/or partial (single-lane) closure for maintenance. Thirteen percent represent high or very high risks to the highway, including some rockfall slopes and retrogressive thaw slumps, due to their relatively high likelihood of impact necessitating localized road reconstruction. Key site and mass movement characteristic statistics have been summarized graphically to support any future predictive terrain stability mapping along the highway corridor and are available in the YUKON GEOLOGICAL SURVEY Miscellaneous Report 17 prepared by Mckillop et al. (2016). Along these high-risk sections, the cable will be buried deeper to get under the mass movement, or the cable will route around the instability, or the instability may be traversed aerially. Detailed plans will be developed for installation of the DFL cable in all the areas of known geohazard risk. However, it should be noted that in general, the buried cable is expected to be less vulnerable to potential damage from geohazards such as rock falls and debris slides that could impact the highway.

To further minimize potential damage to or exposure of the DFL cable, steep slopes, known geohazards and thaw sensitive terrain, will be avoided to the extent practical. Where such terrain cannot be avoided, alternative crossing methods such as installation within the footprint of the highway (subject to authorization), aerial construction or surface lay will be implemented as appropriate. Careful route selection based on future field terrain reconnaissance and geotechnical surveys will assist the design team in decisions regarding the preferred routing of the cable through such areas.

7.3 Flooding and Erosion

Flooding and erosion events are a common annual occurrence along certain sections of the Dempster Highway that also pose a risk to the DFL Project. The most common cause of flooding in YT is the spring snowmelt freshet or a combination of snowmelt and rainfall (Environment & Climate Change Canada 2017).

The annual freshet generally occurs in late-May or early June. Ice jam flooding also occurs primarily in May, during spring break-up, and in winter during freeze-up. In addition, intense summer rainfall events occur annually throughout the Territory. Their most notable impact is on highway stream and river crossings, occasionally necessitating road closures (Environment & Climate Change Canada 2017).

Recent major seasonal flooding events resulting in temporary Dempster Highway closures in YT and the NT were experienced in August 2016, and July 2012 (CBC 2016; Yukon News 2012). In August 2016, officials reported five washed-out sections of the road between the Tombstone Mountains and the NT border and subsequently confirmed several more (CBC 2016a). Excessively high waters also forced the temporary closure of the ferry crossing at the

Peel River on the NT side of the Dempster Highway and caused damage to one of the ferry landings (CBC 2016b). In July 2012, flooding washed out the highway in two places south of Eagle Plains and the Peel River ferry was again closed for several days due to high water levels and floating debris (Yukon News 2012).

Mckillop et al (2016) reported that meander migration is one of the principal factors contributing to mass movements alongside sections of the highway that parallels (or cross) rivers within major valleys along the DFL corridor. Commonly, the progressive encroachment of a meander alongside the highway through sequential bank undercutting and collapse can lead to exposure and accelerated thaw of ice-rich permafrost, and over-steepening of slopes adjacent to the highway embankment.

The most common triggers for both shallow and deep-seated failures are extreme rainfall or heat events (i.e., intense or prolonged) and wildfires (McKillop et al 2016). Seasons of increased geohazard activity include the period from late July to early September, when active layers are deepest, permafrost is warmest and rainfall is greatest, as well as late May or early June, when erosion during snowmelt freshet freshly exposes permafrost to fluvio-thermal erosion and slumping.

To minimize potential damage to or exposure of the DFL cable due to flooding or erosion, the design intent is to avoid installing the cable on the erosion-prone side of the Dempster Highway ROW. Careful route selection based on future field terrain and stream erosion reconnaissance will assist decision making regarding the preferred routing of the cable through areas prone to flooding and erosion. As the DFL cable will be buried and is flexible, it will generally be less vulnerable to flood and erosion damage than the highway.

As previously noted, existing highway bridges might be used to cross the Klondike, Ogilvie and Eagle Rivers in YT and major HDD programs will be undertaken to cross the Peel, Mackenzie and Arctic Red Rivers in the NT. In addition, winter HDD techniques will be employed to cross all perennial and ephemeral streams. Appropriate site-specific mitigation measures are to be deployed

7.4 Seismic Events

Seismic activity potentially affecting the DFL route has its origins in the northern Cordillera. Seismic activity is more intense in pockets in the Richardson Mountains, northern YT and in the Mackenzie Mountains (Adams and Basham 2001). The Dempster Highway and consequentially the DFL project is in areas of high seismicity, where it passes through the Ogilvie and Richardson Mountains.

Seismic events could result in ground surface displacements, changes in soil strength resulting in liquefaction and drainage changes, and these events could expose, damaged or break. To mitigate potential effects related to seismic events, the required cable strength and flexibility have been considered in the selection of the cable material.

7.5 Wildfires

Wildfires in northern Canada can affect the permafrost layer by burning the insulating protection provided by the organic layer, without which the rate of permafrost melting increases. The thawing of permafrost can contribute to thaw settlement and the loss of soil structural integrity.

The primary cause of wildfires is from lightning strikes, or due to human causes.

To mitigate the threat of wildfire, particularly vulnerable sections of exposed cable, the preferred installation will be shallow burial. Some exposed cable sections will exist at aerial crossing sites and overland portions of surface-laid cable. These isolated sections are at greater risk of a temporary loss of connectivity

7.6 Unforeseen Subsurface Conditions with HDD Crossings

There is always a risk that unforeseen subsurface conditions are encountered during and HDD program that can create delays in completing the crossing, added costs, or potential result in an unsuccessful completion.

It is imperative that the construction technique be adaptable to address the terrain and permafrost conditions that are encountered:

7.7 Exceptionally Challenging Conditions

Exceptionally challenging conditions beyond those described herein could be encountered when the actual installation of the DFL occurs. These inherent risks exist, and cannot all be predicted, identified in advance or necessarily mitigated against. The approach for this type of occurrence is to be adaptable to the conditions encountered and adjust or redesign the construction approach accordingly in problematic sections to the most appropriate technique. Adequate contractor field supervision, oversight and near real time issue response will be required for a successful deployment.

8.0 LIMITATIONS

This report and its contents are intended for the sole use of Stantec and the Government of Yukon and their agents. Tetra Tech Canada Inc. (operating as Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Stantec and the Government of Yukon, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Schedule A or Contractual Terms and Conditions executed by both parties.

9.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully Submitted,
Tetra Tech Canada Inc.

PROFESSIONAL ENGINEER
YUKON TERRITORY
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PERMIT TO PRACTICE
TETRA TECH CANADA INC.
SIGNATURE ______
Date July 12/19
PERMIT NUMBER PP003
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Engineers of Yukon

10.0 REFERENCES

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SCHEDULE A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL – CLIENT AND END-CLIENT (YUKON GOVERNMENT)

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the use of TETRA TECH's Client and End-Client (Yukon Government), their respective officers, employees, agents, representatives, successors and assigns (collectively the "CLIENT") as specifically identified in the contracts with both the Client and End-Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the CLIENT, unless authorized in writing by TETRA TECH.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems, as per agreed project deliverable formats. TETRA TECH makes no representation about the compatibility of these files with the CLIENT's future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document.

If any error or omission is detected by the CLIENT or an Authorized Party, the error or omission must be brought to the attention of TETRA TECH within a reasonable time.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The CLIENT acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the CLIENT.

While TETRA TECH endeavours to verify the accuracy of such information, and subject to the standard of care herein, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the CLIENT or an Authorized Party loss or damage, except where TETRA TECH has subcontracted for such information.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The CLIENT, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to make, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the CLIENT.

1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the CLIENT agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

1.8 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.9 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.10 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.11 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.12 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.13 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.14 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.15 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.16 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.17 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.18 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the CLIENT's expense upon written request, otherwise samples will be discarded.

1.19 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

SCHEDULE B

SELECT PERMAFROST TERMINOLOGY

Active Layer - The top layer of ground in which temperature fluctuates above and below 0˚C during the year. This layer is also known as the seasonally frozen ground, seasonal frost, and annually thawed layer.

Excess ice - the volume of ice in the ground that exceeds the total volume that the ground would have under natural unfrozen conditions.

Ice lens(es) - a predominantly horizontal, lens-shaped body of ice of any dimension.

Ice-rich permafrost - permafrost containing excess ice.

Icing - applies to a surface ice mass formed by a freezing of successive sheets of water that originate from drainage flows; as one layer of water freezes, another flows over it and the icing builds layer by layer to a point where it could completely block a culvert, or other drainage conveyance feature.

Karst - a terrane, generally underlain by limestone or dolomite, in which the topography is chiefly formed by the dissolving of rock, and which may be characterized by sinkholes, sinking streams, closed depressions, subterranean drainage, and caves.

Lacustrine - pertaining to lakes.

Non-frost-susceptible (NFS) - ground that is not subject to ice lens formation and frost heave during freezing, and/or to settlement during thawing.

Permafrost — ground (soil or rock and included ice and organic material) that remains at or below a temperature of 0 °C for two or more years.

> Continuous permafrost — permafrost that occurs beneath more than 90 % of the exposed land surface.
>
> Discontinuous permafrost — permafrost occurring in some areas beneath the exposed land surface in a region where other areas are permafrost-free. Widespread discontinuous permafrost underlies 90 – 50 % of the exposed land surface. Sporadic discontinuous permafrost underlies 50 – 10 % of the land surface. Where less than 10 % of the exposed land surface is underlain by permafrost is in isolated patches.

Notes:

1) Cold permafrost is generally considered to have a ground temperature at or below -5 °C. Warm temperature is generally considered to have a ground temperature at or above -2 °C. The ground temperature refers to that measured at a depth where it is constant year around.

Silt - soil particles with a diameter of 0.002 to 0.05 mm.

Sporadic permafrost - permafrost occurring in isolated patches or islands near the southern boundary of discontinuous permafrost.

Talik - a layer or body of unfrozen ground within a permafrost area.

Thaw consolidation - time-dependant compression resulting from thawing of frozen ground and subsequent drainage of pore water.

Thaw settlement - downward movement of the ground causing a lowering of the ground surface resulting from the melting of ground ice in excess of pore fillings. Ground settlement will occur if thawing of ice-rich permafrost takes place. It also occurs annually during the summer when excess ice melts during thawing of the active layer.

Thaw stable permafrost - perennially frozen ground that will not experience either significant thaw settlement or loss of strength upon thawing.

Thaw unstable permafrost - perennially frozen ground that will experience either significant thaw settlement or loss of strength upon thawing.

Thermokarst - land-surface configuration that results from the melting of ground ice in areas underlain by permafrost. In areas that have appreciable amounts of ice, small pits, ponds, valleys, and hummocks are formed when the ice melts and the ground settles unevenly.

Appendix B
Linear Design Schematic

DFL PRELIMINARY ROUTE DESIGN GUIDE - Segment #1 (Dawson CO to Dempster YT Km 80.2)

AERIAL PLANT | KLONDIKE - 1 BRIDGE 61.3 | AERIAL PLANT | U/G PLANT | KLONDIKE - 2 BRIDGE 110 | UNDERGOUND PLANT

NWTEL DAWSON CO | DAWSON | Klondike Highway 2 | Dempster Highway #5

START ---> | 50m | 50m | 50m | 50m | 50m | 50m | RESET @ 0.3m | 60m | 50m | 50m

160
3
23
15.8
2
171.3

GEOHAZARDS

CHAINAGE (km)	0.0	?	1.4		3.0	3.1	?	40.6	0.0	0.03	0.3	0.3	11.8	14.5	15.8	END KM
LOCATION ELEMENT	**NWTEL DAWSON CO** 64° 3'40.35"N ; 139°25'54.10"W	Seventh Ave - Queen (Dawson City)	Edge of Town	Road Crossing 64° 3'7.65"N; 139°26'7.76"W	Klondike Bridge (Dawson)	Klondike Bridge (Dawson)	Road Crossing 64° 1'57.77"N; 139°12'20.95"W	Road Crossing 64° 3'40.20"N; 139° 4'36.17"W	Road Crossing 63°59'26.42"N; 138°45'6.31"W	A/E to U/G Transition 63°59'26.17"N; 138°45'2.73"W	Klondike Bridge (Dempster Hwy)	Klondike Bridge (Dempster Hwy)	Road Crossing 64° 2'26.13"N; 138°34'3.79"W	Road Crossing 64° 3'40.51"N; 138°32'15.52"W	Road Crossing 64° 4'19.22"N; 138°31'32.71"W	
FN IMPACT		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		TBD	TBD	TBD	TBD	TBD	
GEOGRAPHIC SEGMENT		**Klondike Hwy from Dawson City (estimate for now km 0-27)**							**North Klondike Segment (km 0-80)**							
TERRAIN and GEOHAZARDS		This segment follows the Klondike Highway from Dawson City to the Dempster Highway and for the section along the Klondike Highway the surface vegetation suggests that there are areas of discontinuous permafrost. There is an existing fibre optics cable that utilizes existing YEC poles to run aerially for approximately 17 km from Dawson City limits to Henderson Corner (km 690). For the remainder of the route to the Dempster Highway the cable was installed with shallow burial techniques. The proposed installation will run parallel to the existing fibre optics cable and will be installed in a similar fashion to the existing fibre optics cable that runs from Whitehorse to Dawson City. We have learned that there is a parallel YEC High Voltage Transmission (HVT) pole line which goes from the Dempster Highway turn-off on Highway #2 to the power sub-station in Dawson. The design at this conceptual stage will assume that the DFL can use the full 41km or aerial pole line to get to Dawson.							This section follows the North Klondike River Valley and is predominantly granular alluvial valley deposits with minor (if any) permafrost features on the route. There are numerous culvert crossings along this section, but no significant erosion or stability issues are identified in review of provided data.							
PERMAFROST CONDITION		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A	Negligible, sporadic and Discontinuous Permafrost ; North Fork River Valley (km 0 to km 85) – This section of highway corridor gradually ascends the broad North Fork River valley, which was at least partly carved by glaciers draining the southern Ogilvie Mountains and then filled by outwash deposited by deglacial meltwater. Along much of its length, particularly in the south, the highway is constructed on remnant outwash terraces comprising sand and gravel. As the valley narrows toward North Fork Pass, the highway traverses lower slopes of the adjacent mountains and crosses numerous, large alluvial fans. Permafrost is discontinuous, but extensive, along this section of the highway corridor. It is interpreted to shallowly underlie nearly all poorly drained terrain where insulated by a thick organic cover. It is either absent or below a depth of relevance to fibre optic line installation within the outwash terraces and gravelly alluvial fans. Permafrost may be locally ice-rich, where present, but likely only near the base of the active layer in the form of pore and segregated ice. Evidence of thermokarst is isolated and rare. (Hemmera Report)			
MASS MOVEMENT AREAS		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
SURFICIAL GEOLOGY		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
WASHOUT AREAS		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
LAND SLIDE AREAS		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
SINK HOLES		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
INSTALLATION GRADE (0-5%, 6-10%, >10%)		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
OTHER RISKS		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
GROUND/SOIL CONDITIONS		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
VEGETATION		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
WILDLIFE SPECIES AT RISK		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
CABLE/CONDUIT ALIGNMENT																
ROAD PRISM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A				
PREFERED CONSTRUCTION TECHNIQUE	Existing Entrance Conduits	Aerial on Existing Poles	Aerial on Existing Poles	Aerial on Existing Poles	Aerial on Existing Poles	Attach 63mm Conduit to Bridge	Aerial on Existing Poles	Aerial on Existing Poles	Aerial on Existing Poles	Aerial on Existing Poles	Aerial on Existing Poles	Attach 63mm Conduit to Bridge	Shallow bury cable using smaller plowing machines. Direct bury cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ 150-400mm Plow Depth			
CONSTRUCTION TIMING	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
BRIDGE CROSSINGS	N/A	N/A	N/A	N/A	N/A	Handholes each Side with 30M Slack Cable	N/A	N/A	N/A	N/A	N/A	Handholes each Side with 30M Slack Cable	N/A	N/A	N/A	
MAJOR RIVER CROSSINGS	N/A						N/A						N/A			
AERIAL CROSSINGS	Entrance to Building	A/E Plant on Pole Line				A/E Plant on Pole line							N/A			
ROAD CROSSINGS	Aerial	Aerial	HDD or Trenching	Aerial or HDD	Attach to Bridge	Handholes each Side with 30M Slack Cable	HDD or Trenching	HDD or Trenching	Aerial or HDD	Aerial or HDD	HDD or Trenching	Handholes each Side with 30M Slack Cable, Splice Location East Side of Bridge	HDD or Trenching Cross @45 Deg, Handhole c/w 30m slack cable on one side	HDD or Trenching Cross	HDD or Trenching Cross @45 Deg, Handhole c/w 30m slack cable on one side	
CULVERTS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.			
HIGHWAY SIDE	N/A	East Side	Pole Side - South	South Side	South Side	South Side	North Side	South Side	North Side	North Side	North Side	North Side of Bridge	North Side/West Side	West Side/West Side	West Side/West Side	
CLEARING and GRUBBING	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TBD	TBD	TBD	
CULVERTTS QTY	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TBD	52	5	57
CABLE TYPE		ADSS SM28e	ADSS SM28e	ADSS SM28e	ADSS SM28e	ADSS SM28e	ADSS SM28e	ADSS SM28e	ADSS SM28e	ADSS SM28e	ADSS SM28e	ADSS SM28e	TBD	TBD	TBD	
CONDUITS	Existing	N/A	N/A	N/A	N/A	SDR-9, 63.5mm	N/A	N/A	N/A	N/A	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	
FOSC Size	TBD	TBD	TBD	TBD	N/A		TBD	TBD	TBD	TBD	N/A		TBD	TBD	TBD	
HANDHOLES	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	30
NOTES					PEM-3660H/360H Handhole at each side of Bridge crossing	Attach Conduit + Spare per Transportation Requirements			Dempster Highway Turn-off		PEM-3660H/360H Handhole at each side of Bridge crossing	Attach Conduit + Spare per Transportation Requirements				

DFL PRELIMINARY ROUTE DESIGN GUIDE - Segment #1 (Dawson CO to Dempster YT Km 80.2)

UNDERGOUND PLANT | UNDERGOUND PLANT | UNDERGOUND PLANT | UNDERGOUND PLANT

U/G PLANT | NWTEL SITE

Dempster Highway #5 | 0.6 km | Dempster Highway #5 | TOMBSTONE CAMPGROUND

625
12
0
64.4
0
0

GEOHAZARDS

	START --->		75m	50m	50m	50m			50m		50m	50m	50m	50m		50m	50m	
CHAINAGE (km)	15.8	16.2	23.2	30.7	33.0	53.5	0.6		58.7		70.8	71.4	72.8	74.7	79.4		80.2	END KM
LOCATION ELEMENT		Road Crossing 64° 4'31.25"N; 138°31'19.66"W	Road Crossing 64° 8'0.46"N; 138°33'9.88"W	Road Crossing 64°11'53.66"N; 138°33'41.75"W	Road Crossing 64°13'2.78"N; 138°33'15.92"W	Road Crossing 64°22'38.39"N; 138°22'6.72"W	**NWTEL SITE - North Klondike River** 64°22'32.54"N; 138°22'44.75"W		Road Crossing 64°24'46.16"N; 138°18'8.71"W		Road Crossing 64°29'59.86"N; 138°13'3.46"W	Road Crossing 64°30'22.09"N; 138°13'11.45"W	Road Crossing 64°30'58.51"N; 138°13'22.75"W	Road Crossing 64°31'32.48"N; 138°14'31.90"W	Road Crossing 64°34'1.85"N; 138°14'42.60"W		Road Crossing 64°34'30.55"N; 138°15'4.00"W	
FN IMPACT		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		TBD	TBD	TBD	TBD	TBD		TBD	
GEOGRAPHIC SEGMENT		**North Klondike Segment (km 0-80)**																
TERRAIN and GEOHAZARDS		This section follows the North Klondike River Valley and is predominantly granular alluvial valley deposits with minor (if any) permafrost features on the route. There are numerous culvert crossings along this section, but no significant erosion or stability issues are identified in review of provided data.																
PERMAFROST CONDITION		Negligible, sporadic and Discontinuous Permafrost; North Fork River Valley (km 0 to km 85) – This section of highway corridor gradually ascends the broad North Fork River valley, which was at least partly carved by glaciers draining the southern Ogilvie Mountains and then filled by outwash deposited by deglacial meltwater. Along much of its length, particularly in the south, the highway is constructed on remnant outwash terraces comprising sand and gravel. As the valley narrows toward North Fork Pass, the highway traverses lower slopes of the adjacent mountains and crosses numerous, large alluvial fans. Permafrost is discontinuous, but extensive, along this section of the highway corridor. It is interpreted to shallowly underlie nearly all poorly drained terrain where insulated by a thick organic cover. It is either absent or below a depth of relevance to fibre optic line installation within the outwash terraces and gravelly alluvial fans. Permafrost may be locally ice-rich, where present, but likely only near the base of the active layer in the form of pore and segregated ice. Evidence of thermokarst is isolated and rare. (Hemmera Report)																
MASS MOVEMENT AREAS																		
SURFICIAL GEOLOGY																		
WASHOUT AREAS																		
LAND SLIDE AREAS																		
SINK HOLES																		
INSTALLATION GRADE (0-5%, 6-10%, >10%)																		
OTHER RISKS																		
GROUND/SOIL CONDITIONS																		
VEGETATION																		
WILDLIFE SPECIES AT RISK																		
CABLE/CONDUIT ALIGNMENT																		
ROAD PRISM																		
PREFERED CONSTRUCTION TECHNIQUE	Shallow bury cable using smaller plowing machines. Direct bury cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ 150-400mm Plow Depth						Shallow Bury 100-150mm in organic layer if possible, otherwise Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize impact to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement. Cable placement on both Sides of Access Road. EAST cable A/E on one side and WEST cable U/G on the other side of road if possible. Maintain a Min 10m separation.		Shallow bury cable using smaller plowing machines. Direct bury cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ 150-400mm Plow Depth									
CONSTRUCTION TIMING	TBD	TBD	TBD	TBD	TBD	TBD			TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
BRIDGE CROSSINGS	N/A								N/A									
MAJOR RIVER CROSSINGS	N/A								N/A									
AERIAL CROSSINGS	TBD	TBD	TBD	TBD	TBD	TBD			TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
ROAD CROSSINGS		HDD, Handhole one side with 30m Slack	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching		HDD or Trenching Cross @45 Deg		HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg		HDD or Trenching Cross @45 Deg	
CULVERTS	Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.								Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.									
HIGHWAY SIDE		West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	South West, Cable-A	North West, Cable-B	West Side/West Side		West Side/East Side	East Side/East Side	East Side/East Side	East Side/East Side	East Side/East Side		East Side/East Side	
CLEARING and GRUBBING		TBD	TBD	TBD	TBD	TBD	N/A	N/A	TBD		TBD	TBD	TBD	TBD	TBD		TBD	
CULVERTTS QTY		0	12	26	8	44	N/A	N/A	0		48	3	1	6	16		0	164
CABLE TYPE		TBD	TBD	TBD	TBD	TBD	TBD		TBD		TBD	TBD	TBD	TBD	TBD		TBD	
CONDUITS		SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 63.5mm		SDR-9, 32.0mm		SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm		SDR-9, 32.0mm	
FOSC Size		TBD	TBD	TBD	TBD	TBD	2X96 FTP		TBD		TBD	TBD	TBD	TBD	TBD		TBD	
HANDHOLES		2	2	2	2	2	TBD		2		2	2	2	2	2		2	24
NOTES		Mountain Side	Mountain Side	Mountain Side	Mountain Side	North Side of Access Road			Mountain Side		Mountain Side	Tombstone Mountain Campsite	Mountain Side	Mountain Side	Mountain Side		Mountain Side	

DFL PRELIMINARY ROUTE DESIGN GUIDE - Segment #2 (YT Km 80.2 - Km 403)

	UNDERGOUND PLANT						UNDERGOUND PLANT		UNDERGOUND PLANT		
	Dempster Highway #5						U/G PLANT	NWTEL SITE	Dempster Highway #5		
START --->	80.19	50m	50m	50m	50m	50m	1.4 km			50m	50m
CHAINAGE (km)	80.2	80.6	89.9	94.6	94.7	97.8	1.4		97.9	102.4	102.6
LOCATION ELEMENT	Road Crossing 64°34'32.55"N; 138°15'7.25"W	Road Crossing 64°34'41.50"N; 138°15'36.82"W	Road Crossing 64°38'22.03"N; 138°22'37.27"W	Road Crossing 64°40'19.49"N; 138°23'41.64"W	Road Crossing 64°40'23.96"N; 138°23'44.01"W	Road Crossing (+ Handhole) 64°41'59.63"N; 138°24'45.24"W	**NWTEL SITE - North Fork Pass** 64°41'50.00"N; 138°26'11.00"W		Road Crossing (+ Handhole) 64°41'59.67"N; 138°24'44.77"W	Road Crossing 64°43'58.01"N; 138°21'47.90"W	Road Crossing 64°44'3.35"N; 138°21'35.12"W
FN IMPACT	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		
GEOGRAPHIC SEGMENT	**Blackstone Uplands Segment (km 80-156)**										
TERRAIN and GEOHAZARDS	This is generally an unglaciated (i.e. not in the most recent period of continental glaciation) ice-rich permafrost area characterized by broad valleys and numerous areas of both ice-wedge polygons and thermokarst lakes; however, the highway crosses a short section of glaciated terrain near km 109 that has deposited steep sided moraine on both sides of the highway (Tetra Tech EBA 2015). Natural undulations in the terrain adjacent to the highway are about 2.0 m and are indicative of thaw of ice-wedge polygons. Several large thermokarst lakes are also present adjacent to this section of highway – the largest being Chapman Lake and Two Moose Lake. These lakes have increased in size since the highway was constructed and are now adjacent to and potentially encroaching on the highway embankment. The short glaciated area that the highway passes through is centered on about km 109 – the moraine in this area is ice-rich, and has recently started to exhibit minor slope instabilities (surface flow slides) related to increased active layer thickness, and possibly increased rainfall (Tetra Tech EBA 2015). Erosion from the Blackstone River has affected the highway at about km 122, necessitating a realignment. The highway was moved away from the river, but reconstruction included a minor cut section that has created ongoing permafrost thaw-settlement issues and initiated progressive instability that requires regular maintenance (Tetra Tech EBA 2015).										
PERMAFROST CONDITION	Negligible Discontinuous Permafrost ; North Fork River Valley (km 0 to km 85) – This section of highway corridor gradually ascends the broad North Fork River valley, which was at least partly carved by glaciers draining the southern Ogilvie Mountains and then filled by outwash deposited by deglacial meltwater. Along much of its length, particularly in the south, the highway is constructed on remnant outwash terraces comprising sand and gravel. As the valley narrows toward North Fork Pass, the highway traverses lower slopes of the adjacent mountains and crosses numerous, large alluvial fans. Permafrost is discontinuous, but extensive, along this section of the highway corridor. It is interpreted to shallowly underlie nearly all poorly drained terrain where insulated by a thick organic cover. It is either absent or below a depth of relevance to fibre optic line installation within the outwash terraces and gravelly alluvial fans. Permafrost may be locally ice-rich, where present, but likely only near the base of the active layer in the form of pore and segregated ice. Evidence of thermokarst is isolated and rare. (Hemmera Report)			Discontinous Permafrost; Southern Ogilvie Mountains (km 85 to km 130) – This section of highway corridor descends till-mantled ground from its crest at North Fork Pass to the Chapman Lake area, which is characterized by its broad, pond-punctuated valley bottom underlain by fine-grained, morainal material and ice-contact stratified drift deposited at the margin of southward-retreating and stagnating glacial ice during the late Pleistocene. Buried glacial ice is interpreted to be preserved in the Chapman Lake area. Ice-wedge polygons are widespread on level ground. Chapman Lake and some surrounding ponds may have originated as kettles, during deglaciation, but have enlarged considerably over the Holocene through thermokarst subsidence and retrogressive thaw slumping. Ice-rich permafrost underlying the Chapman Lake area is actively degrading, in response to climatic warming and effects of highway construction (e.g. km 124, Idrees et al. 2015), and is particularly sensitive to disturbance. (Hemmera Report)							
MASS MOVEMENT AREAS											
SURFICIAL GEOLOGY											
WASHOUT AREAS											
LAND SLIDE AREAS											
SINK HOLES		Sink Holes at KM-82, ~400m across on East Side of Highway. East Blackstone River, Km 95 - 96, four sinkholes; observed ground movement and degraded ice-wedges									
INSTALLATION GRADE (0-5%, 6-10%, >10%)											
OTHER RISKS											
GROUND/SOIL CONDITIONS											
VEGETATION											
WILDLIFE SPECIES AT RISK											
CABLE/CONDUIT ALIGNMENT											
ROAD PRISM							60m ROW, Same elevation as Dempster Highway				
PREFERED CONSTRUCTION TECHNIQUE	Shallow bury cable using smaller plowing machines. Direct bury cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ 150-400mm Plow Depth. Shallow bury cable using smaller plowing machines. Direct bury cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ 150-400mm Plow Depth. If not possible due to levels of permafrost, then Surface Lay the cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize imapct to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement.						Shallow Bury 100-150mm in organic layer if possible, otherwise Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize impact to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement. Cable placement on both Sides of Access Road. EAST cable A/E on one side and WEST cable U/G on the other side of road if possible. Maintain a Min 10m separation.		Shallow bury cable using smaller plowing machines. Direct bury cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ 150-400mm Plow Depth. If not possible due to levels of permafrost, then Surface Lay the cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize imapct to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement.		
CONSTRUCTION TIMING	TBD	TBD	TBD	TBD	TBD	TBD			TBD	TBD	TBD
BRIDGE CROSSINGS	N/A	N/A	N/A	N/A	N/A	N/A			N/A	N/A	N/A
MAJOR RIVER CROSSINGS	N/A	N/A	N/A	N/A	N/A	N/A			N/A	N/A	N/A
AERIAL CROSSINGS	TBD	TBD	TBD	TBD	TBD	TBD			TBD	TBD	TBD
ROAD CROSSINGS	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching Cross @45 Deg	HDD or Trenching		HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching
CULVERTS	Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.								Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.		
HIGHWAY SIDE	East Side/East Side	East Side/East Side	East Side/East Side	East Side/East Side	West Side/West Side	West Side/South Access	South Side, Cable-A	North Side, Cable-B	North Access /West Side	West Side/East Side	East Side/East Side
CLEARING and GRUBBING	TBD	TBD	TBD	TBD	TBD	TBD	N/A	N/A	TBD	TBD	TBD
CULVERTTS QTY	0	4	27	15	0	14	N/A	N/A	0	17	1
CABLE TYPE	TBD	TBD	TBD	TBD	TBD	TBD	TBD		TBD	TBD	TBD
CONDUITS	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 63.5mm		SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm
FOSC Size	TBD	TBD	TBD	TBD	TBD	TBD	2X96 FTP		TBD	TBD	TBD
HANDHOLES	2	2	2	2	2	2	TBD		2	2	2
NOTES											

			Lower Blackstone BRIDGE 37.8	UNDERGOUND PLANT					UNDERGOUND PLANT		Engineer Creek BRIDGE 38.4
				Dempster Highway #5					Dempster Highway #5		
START --->	50m	50m		50m	50m	50m	50m	50m	50m	50m	50m
CHAINAGE (km)	102.8	115.1	114.8	119.6	121.1	122.7	135.2	153.1	167.5	194.5	194.6
LOCATION ELEMENT	Road Crossing 64°44'15.00"N; 138°21'41.02"W	Road Crossing 64°50'17.17"N; 138°21'38.72"W	Lower Blackstone Bridge (Dempster Hwy)	Road Crossing 64°51'49.27"N; 138°17'49.41"W	Road Crossing 64°52'38.60"N; 138°17'16.23"W	Road Crossing 64°53'27.48"N; 138°16'47.34"W	Road Crossing 64°59'12.61"N; 138°11'52.32"W	Road Crossing 65° 3'48.63"N; 138°16'5.55"W	Road Crossing 65° 9'41.97"N; 138°22'22.42"W	Road Crossing 65°21'25.72"N; 138°17'35.32"W	Engineer Creek Bridge (Dempster Hwy)
FN IMPACT		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
GEOGRAPHIC SEGMENT									**Ogilvie River Segment (km 156-250)**		
TERRAIN and GEOHAZARDS									The highway in this area generally follows Engineer Creek to its junction with the Ogilvie River, and from there follows the Ogilvie River valley until it starts to climb up to the Eagle Plain. The southern section is underlain by permafrost, but after crossing the Ogilvie River the highway is generally founded on unfrozen alluvial deposits adjacent to steep valley sideslopes underlain by permafrost (Tetra Tech EBA 2015). The highway in this segment crosses Engineer Creek twice, and increased flows and winter icing have continued to cause maintenance issues at those crossings. Increased flows in Engineer Creek combined with extreme rain events have caused erosion of the Engineer Creek at the bridge, exposing the abutment foundation piles and creating the potential for undermining of the abutment and increasing risk of local collapse (Tetra Tech EBA 2015).		
PERMAFROST CONDITION							Discontinuos Permafrost; Northern Ogilvie Mountains (km 130 to km 220) – This section of highway corridor parallels meandering creeks and rivers, locally confined by steep mountainsides, and crosses windswept mountain passes. The region is unglaciated. Permafrost is absent or at depth within sand and gravel recently deposited by fluvial processes, but present and shallow within inactive areas of floodplains and on terraces. Meanders are particularly dynamic along Engineer Creek, which drains steep, sparsely vegetated mountains mantled in colluvium and weathered bedrock, and have locally exposed ice-rich permafrost beneath the highway embankment. Ice-rich permafrost is likely relatively thin, where present, and restricted to the boundary with the active layer.				
MASS MOVEMENT AREAS		Km-109.6, Debris Flow on RHS	N/A	Km-116.5, Lost off ground, the enbankment was moved							N/A
SURFICIAL GEOLOGY			N/A		Km-121.5, water level higher at LHS, culvert doies not seem flowing. Blockage?	Km 123.8, Depression Channel forming, repairs crossing airstrip, longitundinal depression mimicking ice wedge. Km-124, Ice wedge degrading in field at LHS. Km-125, an enbankment is built up, road becoming narrower. Km-129, Cracking, RHS at culvert, thick enbankment, (high grade).			Km-166, Road is sinking, berm at both sides, peat deposit at LHS. NCE	Km-192, Road is sinking, presenc eof a hole in the middle of the road. NCE	N/A
WASHOUT AREAS	Km-103, Sagging where two mooseLake touches the enbankment. Km-103.5, A thermokarst Lake located at RHS is expanding Northward.		N/A	Km-119.5, Lake touching the enbankment at RHS			Km-135 - Washout area, repaired, debris flow? NCE				N/A
LAND SLIDE AREAS	The river is eroding enbankment at RHS. East Blackstone River, Km 108.8, YG High Priority Site: shoulder failure along river. Km-109.4, Slide at LHS on hill slope, new from this year.		N/A								N/A
SINK HOLES	Km-102.5, Ice wedge field degrading at LHS, Lakes at RHS. km-104.5, Chapman Lake, Km 115.4 - 116.7; Large thermokarst lake encroaching highway; multiple retrogressive the way slumps in shallow ice-rich permafrost, 1 debris slid - active layer detachment		N/A			Km-126, Sink Hole location, deep excavation, dd not Find Ice, NCE			Engineer Creek, Km 170.9; Recent meander migration anticipated to impact highway within 6 years or less. Engineer Creek Km 175.2; Multiple tension cracks (critical site), meander encroachment site. Engineer Creek, Km 176.5; Estimated 400m wide highway section below rockfall initiating in ice-poor, highly weathered bedrock. Engineer Creek, Km 180.7 - 181.5; two meander migration hard sites; embankment sloughs flooded areas. Engineer Creek, 182 - 182.1; YG High Priority Site: shoulder failure along river (thawing permafrost); meander encroachment. Engineer Creek, 183.9; YG High Priority Site; destroyed culvert. Engineer Creek 185.9; Meander encroachment. Engineer Creek 188.5 - 188.7; YG High Priority Site: erosion, shoulder failure along river (shallow permafrost), meander encroachment washout.		
INSTALLATION GRADE (0-5%, 6-10%, >10%)			N/A								N/A
OTHER RISKS			N/A								N/A
GROUND/SOIL CONDITIONS			N/A								N/A
VEGETATION			N/A								N/A
WILDLIFE SPECIES AT RISK			N/A								N/A
CABLE/CONDUIT ALIGNMENT			N/A								N/A
ROAD PRISM			N/A								N/A
PREFERED CONSTRUCTION TECHNIQUE			Attach 63mm Conduit to Bridge	Shallow bury cable using smaller plowing machines. Direct bury cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ 150-400mm Plow Depth. If not possible due to levels of permafrost, then Surface Lay the cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize imapct to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement.							A/E Crossing of bridge span + Creek Banks
CONSTRUCTION TIMING	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
BRIDGE CROSSINGS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MAJOR RIVER CROSSINGS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AERIAL CROSSINGS	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
ROAD CROSSINGS	HDD or Trenching	HDD or Trenching Cross @45 Deg	Handholes each Side with 30M Slack Cable, Splice Location East Side of Bridge	HDD or Trenching Cross @45 Deg	HDD or Trenching	HDD or Trenching Cross @45 Deg	HDD or Trenching	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	Handholes each Side with 30M Slack Cable, Splice Location East Side of Bridge
CULVERTS											
HIGHWAY SIDE	East Side/East Side	East Side/West Side	East Side Crossing	West Side/East Side	East Side /East Side	East Side/West Side	West Side/West Side	West Side/North Side	North Side/West Side	West Side/East Side	A/E on East side of Bridge
CLEARING and GRUBBING	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CULVERTTS QTY	1	33	N/A	10	4	3	30	35	20	66	N/A
CABLE TYPE	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CONDUITS	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	3 Poles required @ 50m separation
FOSC Size	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
HANDHOLES	2	2	2	2	2	2	2	2	2	2	2
NOTES			PEM-3660H Handhole at each side of Bridge crossing								PEM-3660H Handhole at each side of Bridge crossing

END KM

900
18
2
76.2
280
40

GEOHAZARDS

DFL PRELIMINARY ROUTE DESIGN GUIDE - Segment #2 (YT Km 80.2 - Km 403)

Ogilvie Bridge 110.8 | UNDERGOUND PLANT | U/G PLANT SITE | UNDERGOUND PLANT | U/G PLANT SITE | UNDERGOUND PLANT | EAGLE PLAINS | Eagle River 91.3 | UNDERGOUND PLANT | 750 15

START ---> 194.6 | Dempster Highway #5 50m | 1.0 km | 50m Dempster Highway #5 50m 50m 50m 50m 50m 50m | 1.0 km | 50m 50m 50m Dempster Highway #5 50m 50m | km 377.8 | Local Airport Strip 50m | Dempster Highway #5 | 2 202.1

CHAINAGE (km)	196.0	195.2	253.1	1.0		271.7	313.2	325.0	333.4	341.4	343.2	347.2	1.0		352.9	365.6	369.0	372.6	377.5	377.8	389.8	403.0 END KM
LOCATION ELEMENT	Road Crossing 65°22'4.96"N; 138°18'17.02"W	Ogilvie Bridge (Dempster Hwy)	Road Crossing 65°45'55.59"N; 137°53'40.69"W	**NWTEL SITE - Scriver Creek** 65°50'30.33"N; 137°42'6.14"W		Road Crossing (NWTEL Access Road) 65°50'30.07"N; 137°41'59.99"W	Road Crossing 66° 2'43.21"N; 137°19'29.72"W	Road Crossing 66° 7'16.78"N; 137°14'37.60"W	Road Crossing 66° 9'38.42"N; 137° 6'39.66"W	Road Crossing 66°12'1.25"N; 136°59'1.80"W	Road Crossing 66°12'31.13"N; 136°57'24.83"W	Road Crossing 66°13'57.58"N; 136°54'13.71"W	**NWTEL SITE - Ehnjuu Choo** 66°14'5.31"N; 136°53'23.32"W		Road Crossing 66°15'34.72"N; 136°48'43.44"W	Road Crossing 66°20'40.14"N ; 136°43'47.20"W	**Eagle Plains -FOSC** 66°22'14.56"N; 136°43'12.88"W	Road Crossing 66°23'56.63"N; 136°42'11.30"W	Road Crossing 66°26'27.78"N; 136°42'41.11"W	Eagle River Bridge (Dempster Hwy)	Road Crossing 66°29'40.36"N; 136°34'22.61"W	Road Crossing 66°33'0.58"N; 136°20'46.18"W
FN IMPACT	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD				TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
GEOGRAPHIC SEGMENT	**Ogilvie River Segment (km 156-250)**					**Eagle Plains Segment (km 250 – 406)**																
GEOHAZARDS: TERRAIN and GEOHAZARDS	The highway in this area generally follows Engineer Creek to its junction with the Ogilvie River, and from there follows the Ogilvie River valley until it starts to climb up to the Eagle Plain. The southern section is underlain by permafrost, but after crossing the Ogilvie River the highway is generally founded on unfrozen alluvial deposits adjacent to steep valley sideslopes underlain by permafrost (Tetra Tech EBA 2015). The highway in this segment crosses Engineer Creek twice, and increased flows and winter icing have continued to cause maintenance issues at those crossings. Increased flows in Engineer Creek combined with extreme rain events have caused erosion of the Engineer Creek at the bridge, exposing the abutment foundation piles and creating the potential for undermining of the abutment and increasing risk of local collapse (Tetra Tech EBA 2015).					The highway climbs out of the Ogilvie River Valley just before km 250, and above this, minimal maintenance issues were observed as the road essentially follows bedrock cored ridges to the Richardson Mountains (Tetra Tech EBA 2015)																
PERMAFROST CONDITION	Discontinuous Permafrost; Eagle Lowland (km 220 to km 410) – This section of highway corridor crosses an unglaciated lowland dissected by millennia of fluvial erosion, colluviation and periglacial processes. The highway commonly follows broad ridges separating the dendritic headwater drainages, except at its crossing of the tortuously meandering Eagle River. The ridge crests comprise thin, fine-grained regolith soils weathered from underlying sedimentary bedrock. The active layer is thin where moisture is retained by fine-grained soils but commonly extends into weathered bedrock on summits and other convex terrain features. Permafrost is likely ice-poor, as a broad generalization, but locally ice-rich based on the expression of ice-wedge polygons on some of the broader ridge shoulders and passes.																					
MASS MOVEMENT AREAS		Ogilvie River Km 212.5 - 212.95; Gullied terrain with multiple mass movement processes; two rockfall sites, two debris slides, one debris flow, and one rockfall/debris flow.																				
SURFICIAL GEOLOGY																					Km-381, recently built and instrumented culvert. NCE	
WASHOUT AREAS																						
LAND SLIDE AREAS		Ogilvie River, Km 209.5 -209.8; three active layer detachment slides, YG High Priority Site: shoulder erosion. Ogilvie River Km 210.9; Rockfall initiating from steep bluff (intense freeze/thaw action). ' Ogilvie River, Km 221.5 - 221.9; two rockfall sites, two retrogressive thaw slumps, one debris slide/rockfall, YG High Priority Site: erosion and shoulder failure (increased due to recent maintenance), poor riprap placement; actively eroding and continued failing of embankment material.																Km-375, Thermakarst ponds - slide, thermakarst ponds forming at both sides of the road. NCE				
SINK HOLES		Ogilvie River, Km 224.7; rockfall (intense freeze/thaw action); debris runout on highway and ditch blockage. Eagle Plains - Ogilvie River, Km 243.8 - 243.9; meander encroachment (previously placed reporap accelerated longitudinal migration), YG High Priority Site: progressive shoulder failure and tension cracks; increased embankment erosion and shoulder failures				Km-264, sink hole present, Cones at RHS, water ponding, water disappearing in holes at LHS. NCE																
INSTALLATION GRADE (0-5%, 6-10%, >10%)																						
OTHER RISKS																						
GROUND/SOIL CONDITIONS	Rocky Soil from Bridge to Km -198																			Wet ditches, heavy vegetation		
VEGETATION	Low vegetation levels, rocky soil to Km-225																					
WILDLIFE SPECIES AT RISK																						
CABLE/CONDUIT ALIGNMENT																						
ROAD PRISM				60m ROW, Same elevation as Dempster Highway									60m ROW, Same elevation as Dempster Highway									
PREFERED CONSTRUCTION TECHNIQUE	Surface lay the cable in the still water wetlands. Flowing water wetlands will either be drilled or Poles placed for an Aerial crossing. Handhole with slack cable on one side. Otherwise, directionally drill underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve. If Surface laid cable is the preferred approach, cable placement should be done in winter on the frozen water and appropriate saddle sand bags strategically attached for boyancy control. The cable will sink intot he waterbody the next summer.			Shallow Bury 100-150mm in organic layer if possible, otherwise Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize impact to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement. Cable placement on both Sides of Access Road. EAST cable A/E on one side and WEST cable U/G on the other side of road if possible. Maintain a Min 10m separation.		Surface lay the cable in the still water wetlands. Flowing water wetlands will either be drilled or Poles placed for an Aerial crossing. Handhole with slack cable on one side. Otherwise, directionally drill underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve. If Surface laid cable is the preferred approach, cable placement should be done in winter on the frozen water and appropriate saddle sand bags strategically attached for boyancy control. The cable will sink intot he waterbody the next summer.							Conventional Plowing. Direct bury Cable between Sub-Grade and Toe of Road Prism. 0.400m - 0.600m Plow Depth. Cable placement on both Sides of Access Road. EAST cable on one side and WEST cable on the other side. Min separation 10m.		Surface lay the cable in the still water wetlands. Flowing water wetlands will either be drilled or Poles placed for an Aerial crossing. Handhole with slack cable on one side. Otherwise, directionally drill underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve. If Surface laid cable is the preferred approach, cable placement should be done in winter on the frozen water and appropriate saddle sand bags strategically attached for boyancy control. The cable will sink intot he waterbody the next summer.							
CONSTRUCTION TIMING	TBD	TBD	TBD			TBD	TBD	TBD	TBD	TBD	TBD	TBD			TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
BRIDGE CROSSINGS	N/A	Attach 63mm Conduit to Bridge	N/A			N/A	N/A	N/A	N/A	N/A	N/A	N/A			N/A	N/A	N/A	N/A	N/A	Attach 63mm Conduit to Bridge	N/A	N/A
MAJOR RIVER CROSSINGS	N/A		N/A			N/A	N/A	N/A	N/A	N/A	N/A	N/A			N/A	N/A	N/A	N/A	N/A		N/A	N/A
AERIAL CROSSINGS	TBD	TBD	TBD			TBD	TBD	TBD	TBD	TBD	TBD	TBD			TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
ROAD CROSSINGS	HDD or Trenching Cross @45 Deg	Handholes each Side with 30M Slack Cable, Splice Location East Side of Bridge	HDD or Trenching	HDD or Trenching		HDD or Trenching Cross @45 Deg	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching		HDD or Trenching	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching	HDD or Trenching Cross @45 Deg	Handholes each Side with 30M Slack Cable, Splice Location East Side of Bridge	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg
CULVERTS	Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.			N/A		Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.									Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.							
HIGHWAY SIDE	North Side/West Side	North Side of Bridge	West Side/West Side	North Side, Cable-A	South Side, Cable-B	North Side/North Side	South Side/South Side	West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	North West Side/North West Side	West Side, Cable-A	East Side, Cable B	North West Side/North West Side	East Side/West Side	West Side/East Side	East Side/East Side	East Side/West Side	West Side	West/East Side	East Side/East Side
CLEARING and GRUBBING	TBD	TBD	TBD	N/A	N/A	TBD	TBD	TBD	TBD	TBD	TBD	TBD	N/A	N/A	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CULVERTS QTY	1	N/A	135	N/A	N/A	TBD	92	9	15	9	4	4	N/A	N/A	21	5	3	9	10	N/A	27	26 370
CABLE TYPE	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CONDUITS	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 63.5mm		SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 63.5mm		SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm
FOSC Size	TBD	TBD	TBD	2X96 FTP		TBD	TBD	TBD	TBD	TBD	TBD	TBD	2X96 FTP		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
HANDHOLES	2	2	2	TBD		2	2	2	2	2	2	2	TBD	TBD	2	2	2	2	2	2	2	2 36
NOTES		PEM-3660H Handhole at each side of Bridge crossing																		PEM-3660H Handhole at each side of Bridge crossing		

DFL PRELIMINARY ROUTE DESIGN GUIDE - Segment #3 (YT Km 403 - NT Km 73)

UNDERGOUND PLANT | UNDERGOUND PLANT | UNDERGOUND PLANT

720
12

	Dempster Highway #5					Dempster Highway #5				Dempster Highway #5				NWT - YT BORDER	
START --->	403.0	50m	100m	35m	65m	35m	65m	45m	75m	45m	65m	65m	85m	35m	
CHAINAGE (km)	403.0	405.5	410.8	411.1	414.9	416.4	422.1	426.2	432.9	445.0	445.8	446.2	446.5	454.3	0.0 END KM
LOCATION ELEMENT		Road Crossing 66°33'52.30"N; 136°18'31.35"W	Watercourse Crossing 66°36'36.55"N; 136°17'41.19"W	Watercourse Crossing 66°36'46.05"N; 136°17'46.10"W	Watercourse Crossing 66°38'40.42"N; 136°19'28.87"W	Watercouse Crossing 66°39'29.44"N; 136°19'45.63"W	Watercourse Crossing 66°42'24.82"N; 136°21'30.62"W	Watercouse Crossing 66°44'34.92"N; 136°21'19.98"W	Watercouse Crossing - **Sheep Creek** 66°48'4.36"N; 136°20'16.41"W	Watercouse Crossing 66°54'22.55"N; 136°21'52.50"W	Roadway Crossing 66°54'41.97"N ; 136°21'20.96"W	Roadway Crossing 66°54'48.33"N; 136°20'52.35"W Camping Ground	Watercouse Crossing 66°54'55.34"N; 136°20'40.61"W	Watercouse Crossing 66°57'35.55"N; 136°13'40.57"W	**NWT - YT BORDER** 67° 2'50.23"N; 136°12'30.46"W
FN IMPACT	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
GEOGRAPHIC SEGMENT	**Richardson Mountains Segment (km 406 (YT) – 27 (NT)**														
TERRAIN	The landscape in this segment is almost entirely shaped as result of the most recent (Laurentide) glaciation, along with subsequent post glacial fluvial and other geomorphological processes. Continuous thick permafrost is present throughout to a depth close to 300 m (Geological Survey of Canada, unpublished data). Retrogressive thaw-flow slides are common where ground ice has been exposed in glaciolacustrine deposits by forest fires, debris flows and regressive erosion. These thaw slumps are one of the most active geomorphic features within this segment and they are all situated within the maximum westward extent of the Laurentide Ice Sheet. The Peel Plateau is particularly susceptible to the effects of a warming climate as it contains a significant amount of ice-rich permafrost. Instability at km 27 related to thaw of ice-rich near surface soils on both banks of a surface drainage course has affected the toe of the highway embankment.														
PERMAFROST CONDITION			Continuous Permafrost; Richardson Mountains (km 410 to km 465) – This section of highway corridor gradually ascends the base of the western foothills of the Richardson Mountains toward the border with the Northwest Territories. The region is unglaciated. The highway crosses an apron of fine-grained alluvial and colluvial material formed by the coalescence of fans draining the Richardson Mountains. Underlying bedrock is exposed where the highway crosses incised streams and gullies. Permafrost is continuous and shallow within the fine-grained apron, as demonstrated by the prevalence of slopewash runnels ('water tracks') and extensive ponding along the upslope side of the highway embankment. A proliferation of shrubs alongside the highway reflects active layer thickening caused by snow plowing (inhibits cold penetration in winter and delays thaw in spring), disruption of surface and near-surface drainage (warms underlying permafrost), and fertilization by road dust (e.g. km 421, Idrees et al. 2015). Surface expressions of ice-wedge polygons and incipient retrogressive thaw slumps alongside the highway indicate permafrost is at least locally ice-rich and sensitive to disturbance. (Hemmera Report)												
MASS MOVEMENT AREAS															
SURFICIAL GEOLOGY									Km-438, Degradation - Degradation in the field, 500m at RHS. Km-442, Subsistance - Located in field at RHS. NCE				Km-454, Thaw Lake Subsistance, Ice Wedge degradation in field. NCE		
WASHOUT AREAS							Km-421, Thermakarst ponds at both sides, ice wedges degrading. NCE								
LAND SLIDE AREAS							km-424, Slope movementThermal erosion, Water ponding at RHS, sign of thermal erosion on LHS. NCE								
SINK HOLES											Km-447, Sinkhole - Material keeps disappearing. Km-458, Sinkhole Thaw Lake Subsistance, Water disappears at RHS, depression at LHS, snow patch at LHS shoulder.				
INSTALLATION GRADE (0-5%, 6-10%, >10%)															
OTHER RISKS															
GROUND/SOIL CONDITIONS		Wet Soil, Wet ditches, Standing Water													
VEGETATION		Light vegetation													
WILDLIFE SPECIES AT RISK															
CABLE/CONDUIT ALIGNMENT															
ROAD PRISM		High 2-3m Road Bed to Toe													
PREFERED CONSTRUCTION TECHNIQUE		Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize imapct to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement.													
CONSTRUCTION TIMING		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		TBD
BRIDGE CROSSINGS	N/A														
MAJOR RIVER CROSSINGS	N/A														
AERIAL CROSSINGS															
ROAD CROSSINGS		HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD, Handholes Each Side with 30M Slack Cable,	HDD, Handholes Each Side with 30M Slack Cable,	HDD, Handholes Each Side with 30M Slack Cable,	HDD, Handholes Each Side with 30M Slack Cable,	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD, Handholes Each Side with 30M Slack Cable,
CULVERTS		Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.													
HIGHWAY SIDE		East Side/West Side	South Side/North - West Side	West Side/East Side	East Side/East Side	East Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side
CLEARING and GRUBBING		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CULVERTS QTY		3	12	0	24	5	28	15	30	38	3	5	0	18	56 237
CABLE TYPE		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CONDUITS		SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm
FOSC Size		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
HANDHOLES		2	2	2	2	2	2	2	2	2	3	2	2	2	27
NOTES															

GEOHAZARDS

DFL PRELIMINARY ROUTE DESIGN GUIDE - Segment #3 (YT Km 403 - NT Km 73)

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UNDERGOUND PLANT (U/G PLANT 0.51 km; SITE) | AERIAL PLANT (Dempster Highway #8) | UNDERGOUND PLANT | AERIAL PLANT | UNDERGOUND PLANT (Dempster Highway #8) | AERIAL PLANT (Dempster Highway #8)

	START --->			150m	60m	60m	300m	60m	60m	60m		50m	50m		
CHAINAGE (km)	0.0		0.5	18.5	20.4	27.5	27.6	28.2	29.0	29.3		37.2	53.9	72.8	73.0 END KM
LOCATION ELEMENT	Road Crossing 67° 3'6.57"N; 136°12'7.81"W	**NWTEL SITE - North Vittrekwa** 67° 3'21.00"N; 136°12'17.26"W		**Major Creek Crossing** 67° 8'59.66"N; 135°55'17.73"W	Road Crossing 67° 9'51.77"N; 135°53'58.56"W	Road Crossing 67°10'40.54"N; 135°45'24.25"W	**Ravine Crossing** 67°10'39.69"N; 135°45'9.28"W	Road Crossing 67°10'36.89"N; 135°44'26.10"W	Road Crossing 67°10'36.04"N; 135°43'15.36"W	Road Crossing 67°10'36.84"N; 135°42'53.54"W	Road Crossing 67°10'39.47"N; 135°42'31.51"W	Road Crossing 67°12'51.35"N; 135°34'56.52"W	Road Crossing 67°14'32.34"N; 135°12'55.68"W	**Major Water Crossing** 67°19'53.63"N; 134°54'55.88"W	**Major Water Crossing** 67° 8'59.66"N; 135°55'17.73"W
FN IMPACT	TBD	TBD	TBD	TBD	TBD	TBD	TBD		TBD	TBD		TBD	TBD	TBD	TBD
GEOGRAPHIC SEGMENT	**Richardson Mountains Segment (km 406 (YT) – 27 (NT))**						**Peel Plateau Segment (NT km 27 – 74)**								
GEOHAZARDS															
TERRAIN	The Richardson Mountains are a range of the Canadian Rocky Mountains that parallels the northernmost part of the boundary of the YT and Northwest Territories. Trending northwest-southeast, the Richardson Mountains are the northern extremity of the Rockies. Increased rainfall and possibly undersized culverts have created road instabilities through washouts adjacent to culverts in some sections of the highway (Tetra Tech EBA). The thaw of ice-wedges in the permafrost has affected the highway on the NT side in the vicinity of km 8.5 since about 1984 when there was a fatal accident at this location in 1985 caused by road collapse into a thawed ice-wedge void. There continues to be some distress to both sides of the highway embankment at this location caused by thaw near the toe of the fill (Tetra Tech EBA 2015).						The landscape in this segment is almost entirely shaped as result of the most recent (Laurentide) glaciation, along with subsequent post glacial fluvial and other geomorphological processes. Continuous thick permafrost is present throughout to a depth close to 300 m (Geological Survey of Canada, unpublished data). Retrogressive thaw-flow slides are common where ground ice has been exposed in glaciolacustrine deposits by forest fires, debris flows and regressive erosion. These thaw slumps are one of the most active geomorphic features within this segment and they are all situated within the maximum westward extent of the Laurentide Ice Sheet. The Peel Plateau is particularly susceptible to the effects of a warming climate as it contains a significant amount of ice-rich permafrost. Instability at km 27 related to thaw of ice-rich near surface soils on both banks of a surface drainage course has affected the toe of the highway embankment. (Tetra Tech EBA)								
PERMAFROST CONDITION	Continuous Permafrost														
MASS MOVEMENT AREAS															
SURFICIAL GEOLOGY															
WASHOUT AREAS															
LAND SLIDE AREAS															
SINK HOLES															
INSTALLATION GRADE (0-5%, 6-10%, >10%)															
OTHER RISKS															
GROUND/SOIL CONDITIONS															
VEGETATION															
WILDLIFE SPECIES AT RISK															
ROAD PRISM		60m ROW, Same elevation as Dempster Highway													
CABLE/CONDUIT ALIGNMENT															
PREFERED CONSTRUCTION TECHNIQUE	HDD or Trenching Cross @45 Deg	Shallow Bury 100-150mm in organic layer if possible, otherwise Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize impact to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement. Cable placement on both Sides of Access Road. EAST cable A/E on one side and WEST cable U/G on the other side of road if possible. Maintain a Min 10m separation.		A/E Crossing preferred as the creek is 10 meters below road surface.	Surface lay cable in alignment		A/E Crossing is preferred as ravine is 10-20 meters below road surface.	Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize imapct to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement.							A/E or HDD
CONSTRUCTION TIMING				TBD	TBD	TBD	TBD	TBD	TBD	TBD		TBD	TBD	TBD	TBD
BRIDGE CROSSINGS															
MAJOR RIVER CROSSINGS	N/A			N/A											
AERIAL CROSSINGS	N/A														
ROAD CROSSINGS	HDD or Trenching	HDD or Trenching Cross @45 Deg		N/A	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	N/A	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg		HDD or Trenching	HDD or Trenching	N/A	N/A
CULVERTS	N/A	N/A		Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.											
HIGHWAY SIDE	West Side/West Side	South West, Cable-A	North East, Cable-B	West Side/West Side	West Side/West Side	North SIde/South Side	South Side	South Side/North Side	North Side/North Side	North Side/North Side	North Side/North Side	North Side/North Side	North Side/North Side	North Side/North Side	North Side/North Side
CLEARING and GRUBBING	TBD	N/A	N/A	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	N/A	N/A
CULVERTS QTY	TBD	N/A	N/A	11		3	TBD	TBD	TBD	4	TBD	TBD	1	TBD	TBD 19
CABLE TYPE	TBD	TBD		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CONDUITS	SDR-9, 32.0mm	SDR-9, 63.5mm		SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	N/A	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	N/A	N/A
FOSC Size	TBD	2X96 FTP		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
HANDHOLES	2	TBD		2	2	2	2	2	2	2	2	2	2	2	2 24
NOTES										Gravel Pit - Quarry					

DFL PRELIMINARY ROUTE DESIGN GUIDE - Segment #4 (NT Km 73 - Km 143.9)

	U/G PLANT	AERIAL PLANT			UNDERGOUND PLANT			HORIZONTAL DIRECTIONAL DRILLED			UNDERGOUND PLANT				470 10
		Dempster Highway #8			Dempster Highway #8			PEEL RIVER CROSSING			Dempster Highway #8		FORT MCPHERSON		
START --->	73.0	100m	100m	100m	35m	30m	30m		450m		60m	50m	50m	50m	
CHAINAGE (km)	73.0	?	?	?	74.2	74.3	74.3	74.4	?	74.9	76.3	83.6	85.9	89.7	END KM
LOCATION ELEMENT		Major Watercouse Crossing 67°19'53.63"N; 134°54'55.88"W	Watercourse Crossing 67°19'56.52"N; 134°54'32.54"W	Watercourse Crossing 67°19'58.77"N; 134°54'13.88"W	Roadway Crossing 67°20'9.51"N; 134°53'6.84"W	Roadway Crossing 67°20'11.83"N; 134°53'1.41"W	Roadway Crossing 67°20'12.55"N; 134°52'58.94"W	Peel River - West Side - HDD Pilot/ENTRY Hole 67°20'13.90"N, 134°52'54.80"W	**PEEL RIVER CROSSING**	Peel River - East Side - HDD EXIT Hole 67°20'23.40"N; 134°52'21.90"W	Roadway Crossing 67°20'59.15"N; 134°51'37.28"W	Roadway Crossing 67°24'33.79"N; 134°52'25.30"W	Roadway Crossing 67°25'41.29"N; 134°51'57.30"W	Roadway Crossing 67°26'41.59"N ; 134°48'0.88"W	
PERMIT IMPACT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT				GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	
FN IMPACT	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
GEOGRAPHIC SEGMENT	**Mackenzie Lowlands (km 74 – 272)**														
GEOHAZARDS: TERRAIN	This section of highway from the Peel River to Inuvik is generally flat and contains significant areas of standing water (swamps) connected by small drainage courses. In general, the swamps are shallow and freeze to the bottom every winter, preserving the permafrost. In some sections of the highway, ponded water combined with significant embankment settlement has created deep water that probably doesn't freeze every winter. This has created ongoing permafrost thaw and resulting culvert and highway distress.														
PERMAFROST CONDITION	Continuous Permafrost														
MASS MOVEMENT AREAS								N/A							
SURFICIAL GEOLOGY								N/A							
WASHOUT AREAS								N/A							
LAND SLIDE AREAS								N/A							
SINK HOLES								N/A							
INSTALLATION GRADE (0-5%, 6-10%, >10%)								N/A							
OTHER RISKS								N/A							
GROUND/SOIL CONDITIONS		Rocky Soil, Dry ditches,						N/A							
VEGETATION		Light vegetation						N/A							
WILDLIFE SPECIES AT RISK								N/A							
CABLE/CONDUIT ALIGNMENT								N/A							
ROAD PRISM		High 2-3m Road Bed to Toe						N/A							
PREFERED CONSTRUCTION TECHNIQUE		Aerial construction on new Poles or Surface Laid Cable in the Watercourse. Geotextile Saddle sand bags may be used for boyancy control.			Shallow Bury 100-150mm in organic layer if possible, otherwise Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize imapct to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement.										
CONSTRUCTION TIMING		TBD	TBD	TBD	TBD	TBD	TBD	TBD			TBD	TBD	TBD	TBD	
BRIDGE CROSSINGS		N/A									N/A				
MAJOR RIVER CROSSINGS		N/A						Peel River crossing will be completed using HDD			N/A				
AERIAL CROSSINGS		ADSS Cable on Pole Line			N/A						N/A				
ROAD CROSSINGS		HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg					HDD or Trenching	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	
CULVERTS		Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.													
HIGHWAY SIDE		North Side/North Side	North Side/North Side	North Side/North Side	North Side/North Side	North Side/North Side	North Side/North Side	N/A			North Side/South Side	East Side/East Side	South Side/North Side	North Side/South Side	
CLEARING and GRUBBING		TBD	TBD	TBD	TBD	TBD	TBD	N/A			TBD	TBD	TBD	TBD	
CULVERTS QTY		3	0	0	0	0	0	N/A			0	0	1	0	4
CABLE TYPE		TBD	TBD	TBD	TBD	TBD	TBD	TBD			TBD	TBD	TBD	TBD	
CONDUITS		N/A	N/A	N/A	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	Schedule 40/80, 75mm			SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	
FOSC Size		TBD	TBD	TBD	TBD	TBD	TBD	TBD			TBD	TBD	TBD	TBD	
HANDHOLES		2	2	2	2	2	2	2			2	2	2	2	22
NOTES								PEM-3660H Handhole at each side of Bridge crossing							

DFL PRELIMINARY ROUTE DESIGN GUIDE - Segment #4 (NT Km 73 - Km 143.9)

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A/E PLANT | UNDERGOUND PLANT | UNDERGOUND PLANT | UNDERGOUND PLANT | HORIZONTAL DIRECTIONAL DRILLED

U/G PLANT | SITE

0.51 km | Dempster Highway #8 | NWTEL Site - Deepwater Lake | MACKENZIE RIVER CROSSING

GEOHAZARDS

	START --->			50m	50m	50m	50m	50m	50m	50m	50m	50m	1250m		
CHAINAGE (km)	89.7		0.5	90.1	94.3	100.7	107.0	111.0	118.9	122.9	126.1	126.3	142.7		143.9 END KM
LOCATION ELEMENT	A/E Lateral to Poles on North East side of Roadway @ Km 85.9	**NWTEL SITE - Fort McPherson CO** 67°26'11.67"N; 134°52'34.91"W		Roadway Crossing 67°26'52.42"N ; 134°47'31.14"W	Roadway Crossing 67°28'28.78"N ; 134°43'30.64"W	Roadway Crossing 67°28'2.78"N ; 134°35'9.85"W	Roadway Crossing 67°25'48.65"N ; 134°29'11.07"W	Roadway Crossing 67°24'28.86"N ; 134°24'51.39"W	Roadway Crossing 67°23'34.72"N ; 134°14'22.99"W	Roadway Crossing 67°23'5.04"N ; 134° 8'59.44"W	Roadway Crossing 67°22'57.60"N; 134° 4'44.86"W	Roadway Crossing 67°22'58.61"N; 134° 4'25.84"W	Mackenzie River - South Side - HDD Pilot/ENTRY Hole 67°26'45.0"N; 133°45'31.4"W	**PEEL RIVER CROSSING**	Mackenzie River - North Side - HDD EXIT Hole 67°27'24.1"N; 133°45'27.1"W
PERMIT IMPACT	GNWT DOT	NWTEL	NWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT
FN IMPACT	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
TERRAIN															
PERMAFROST CONDITION	Continuous Permafrost														
MASS MOVEMENT AREAS													N/A		
SURFICIAL GEOLOGY													N/A		
WASHOUT AREAS													N/A		
LAND SLIDE AREAS													N/A		
SINK HOLES													N/A		
INSTALLATION GRADE (0-5%, 6-10%, >10%)													N/A		
OTHER RISKS													N/A		
GROUND/SOIL CONDITIONS													N/A		
VEGETATION													N/A		
WILDLIFE SPECIES AT RISK													N/A		
ROAD PRISM		60m ROW, Same elevation as Dempster Highway											N/A		
CABLE/CONDUIT ALIGNMENT													N/A		
PREFERED CONSTRUCTION TECHNIQUE	Aerial Section, then Shallow Trench to McPherson CO	Shallow Bury 100-150mm in organic layer if possible, otherwise Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize impact to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement. Cable placement on both Sides of Access Road. EAST cable A/E on one side and WEST cable U/G on the other side of road if possible. Maintain a Min 10m separation.		Shallow Bury 100-150mm in organic layer if possible, otherwise Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize imapct to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement.									N/A		
CONSTRUCTION TIMING	TBD			TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		
BRIDGE CROSSINGS				N/A											
MAJOR RIVER CROSSINGS	N/A			N/A									Mackenzie River crossing will be completed using HDD		
AERIAL CROSSINGS		N/A	N/A	N/A											
ROAD CROSSINGS	HDD or Trenching	HDD or Trenching Cross @45 Deg		HDD or Trenching Cross @45 Deg	HDD or Trenching	HDD or Trenching	HDD or Trenching Cross @45 Deg	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	N/A		
CULVERTS	N/A	N/A		Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.									N/A		
HIGHWAY SIDE	North Side/North Side	Cable A - A/E	Cable B - U/G	South Side/North Side	North Side/North Side	North Side/North Side	North Side/South Side	South Side/South Side	South Side/South Side	South Side/South Side	South Side/South Side	South Side/South Side	West Side of Highway		
CLEARING and GRUBBING	TBD	N/A	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	N/A		
CULVERTS QTY	0	N/A	N/A	0	0	0	0	0	0	1	0	0	N/A		1
CABLE TYPE	TBD	TBD		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		
CONDUITS	SDR-9, 32.0mm	SDR-9, 63.5mm		SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	Schedule 40/80, 75mm		
FOSC Size		2X96 FTP		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		
HANDHOLES	2	TBD		2	2	2	2	2	2	2	2	2	2		22
NOTES													PEM-3660H Handhole at each side of Bridge crossing		

DFL PRELIMINARY ROUTE DESIGN GUIDE - Segment #5 (NT Km 143.9 - Km 272)

UNDERGOUND PLANT — UNDERGOUND PLANT — Caribou Creek BRIDGE 37.8 — UNDERGOUND PLANT — 680 14 1 37.8

GEOHAZARDS

		Dempster Highway #8			Dempster Highway #8		RANGLENG RIVER - NWTEL SITE	Dempster Highway #8					Dempster Highway #8			
START --->	143.9	50m	35m	35m	35m	150m	30m	35m	35m	40m	60m		50m	35m	50m	
CHAINAGE (km)	143.9	143.9	166.6	166.7	174.2	178.2	183.8	193.9	211.5	215.9	220.9	221.2	221.9	225.8	230.2	END KM
LOCATION ELEMENT		Roadway Crossing 67°27'26.90"N; 133°45'27.81"W	Roadway Crossing 67°39'16.35"N; 133°50'39.96"W	Roadway Crossing 67°39'19.18"N; 133°50'41.26"W	Roadway Crossing 67°43'14.71"N; 133°52'43.37"W	**Major Watercourse Crossing** 67°45'13.19"N; 133°51'38.87"W	Roadway Crossing 67°47'34.30"N; 133°46'41.75"W (NWTEL Site - Rengleng River)	Roadway Crossing 67°52'2.06"N; 133°39'2.18"W	Roadway Crossing 68° 0'12.95"N; 133°28'16.88"W	Roadway Crossing 68° 2'31.50"N; 133°29'24.97"W	Roadway Crossing 68° 5'10.30"N; 133°29'35.51"W	Caribou Creek Bridge (Dempster Hwy)	Roadway Crossing 68° 5'42.47"N; 133°29'32.36"W	Roadway Crossing 68° 7'39.45"N; 133°27'49.20"W	Roadway Crossing 68° 9'55.62"N; 133°26'16.42"W	
PERMIT IMPACT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT		GNWT DOT	GNWT DOT	GNWT DOT	GNWT DOT	
FN IMPACT	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		TBD	TBD	TBD	TBD	
GEOGRAPHIC SEGMENT	**Mackenzie Lowlands (km 74 – 272)**															
TERRAIN	This section of highway from the Peel River to Inuvik is generally flat and contains significant areas of standing water (swamps) connected by small drainage courses. In general, the swamps are shallow and freeze to the bottom every winter, preserving the permafrost. In some sections of the highway, ponded water combined with significant embankment settlement has created deep water that probably doesn't freeze every winter. This has created ongoing permafrost thaw and resulting culvert and highway distress.															
PERMAFROST CONDITION	Continuous Permafrost															
MASS MOVEMENT AREAS																
SURFICIAL GEOLOGY																
WASHOUT AREAS																
LAND SLIDE AREAS																
SINK HOLES		Sink Hole @ Km-147.1														
INSTALLATION GRADE (0-5%, 6-10%, >10%)																
OTHER RISKS																
GROUND/SOIL CONDITIONS		Wet Soil, Wet ditches, Standing Water						Dry Ditches, Shallow Organic Layer								
VEGETATION																
WILDLIFE SPECIES AT RISK																
CABLE/CONDUIT ALIGNMENT																
ROAD PRISM																
PREFERED CONSTRUCTION TECHNIQUE	Shallow Bury 100-150mm in organic layer if possible, otherwise Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable/conduit on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize imapct to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement.											HDD Under Creek	Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize imapct to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement.			
CONSTRUCTION TIMING		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
BRIDGE CROSSINGS		N/A											N/A			
MAJOR RIVER CROSSINGS		N/A										Handholes each Side with 30M Slack Cable, Splice Location East Side of Bridge	N/A			
AERIAL CROSSINGS		N/A											N/A			
ROAD CROSSINGS		HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching	N/A	HDD or Trenching Cross @45 Deg	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD or Trenching Cross @45 Deg	HDD Under Creek	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	HDD or Trenching Cross @45 Deg	
CULVERTS		Preferred method is to surface lay the cable in the still water wetlands. This should be done in winter when the water is frozen so that the best alignmet can be planned. Strategically place geotextile saddle sand bags and secure to the cable. The cable will sink when summer returns and fine alignment adjustments can then be made. Running water wetlands will either be drilled or poles placed for an aerial crossing. Locate handhole with slack cable on one side. Directionally drill the conduit underneath the culvert. Crossing at 45 deg, underneath the culvert/road may also be easier to achieve depending on the terrain profile.														
HIGHWAY SIDE		West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	West Side/West Side	West Side/East Side	East Side/East Side	East Side/East Side	East Side/East Side	East Side/West Side	West Side of Bridge	West Side/East Side	East Side/East Side	East Side/West Side	
CLEARING and GRUBBING		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
CULVERTS QTY		0	1	0	0	4	1	2	4	0	0	0	0	0	0	12
CABLE TYPE		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
CONDUITS		SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm				SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	
FOSC Size		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
HANDHOLES																

DFL PRELIMINARY ROUTE DESIGN GUIDE - Segment #5 (NT Km 143.9 - Km 272)

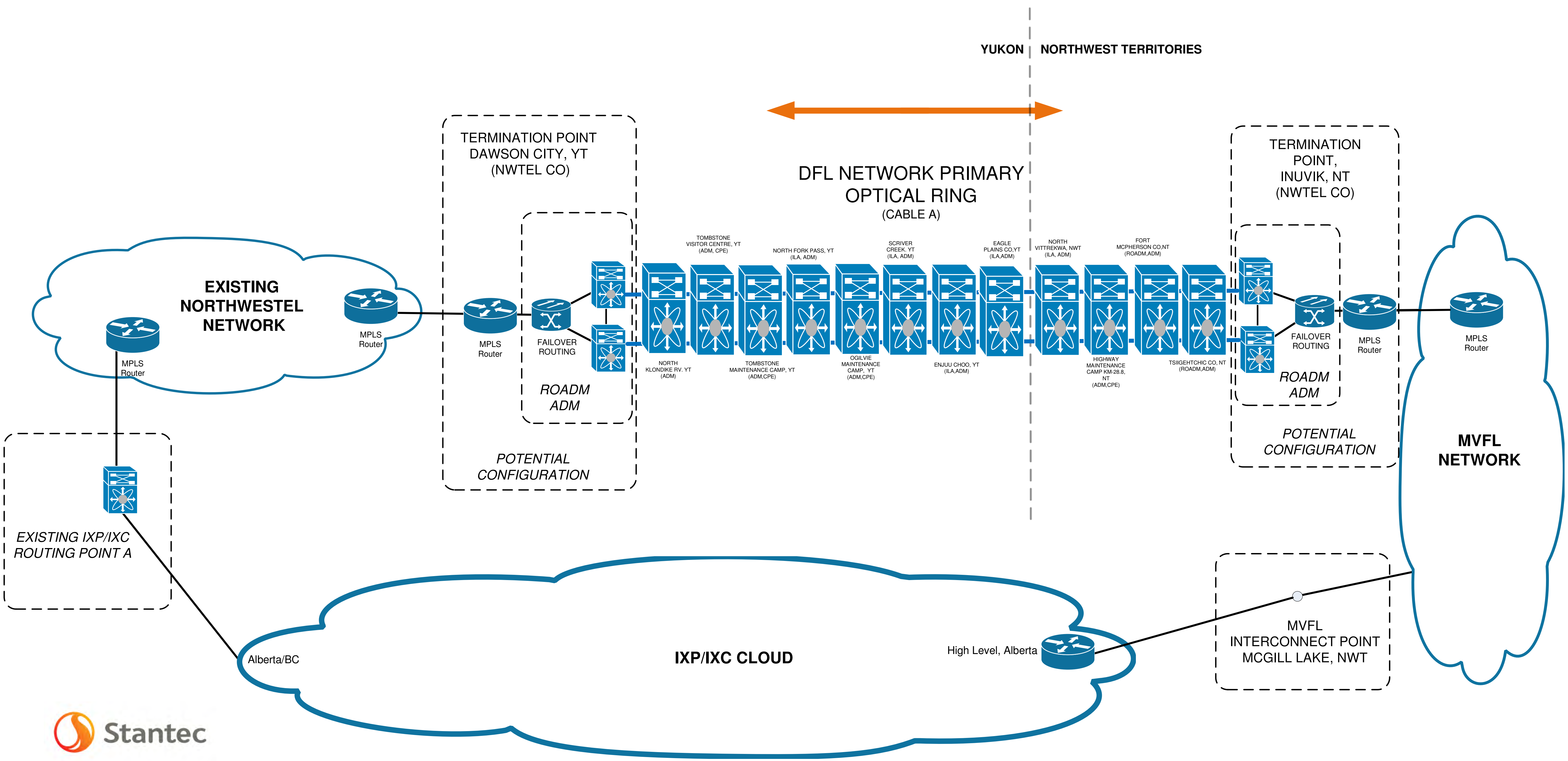
770
14
UNDERGOUND PLANT — UNDERGOUND PLANT — Campbell Creek (BRIDGE) 35 — UNDERGOUND PLANT — A/E PLANT — A/E PLANT
1
35
Dempster Highway #8 — Dempster Highway #8 — Dempster Highway #8 — INUVIK TOWN EDGE — NWTEL - INUVIK CO

	START --->	50m	50m	50m	60m	50m	60m	50m	60m	60m	60m	50m	50m	80m	1.55km
CHAINAGE (km)	231.8	235.6	240.9	242.6	244.6	247.4	247.5	248.7	251.3	254.1	258.3	258.9	259.8	270.3	271.9 END KM
LOCATION ELEMENT	Roadway Crossing 68°10'42.81"N ; 133°26'54.25"W	Roadway Crossing 68°12'34.60"N; 133°24'35.11"W	Roadway Crossing 68°14'5.28"N; 133°18'27.35"W	Roadway Crossing 68°14'46.37"N ; 133°16'54.56"W	**Stream Crossing** 68°15'41.22"N ; 133°15'52.61"W	Roadway Crossing 68°17'9.28"N ; 133°14'52.55"W	Campbell Creek Bridge (Dempster Hwy)	Roadway Crossing 68°17'18.07"N ; 133°16'2.69"W	Roadway Crossing 68°18'23.51"N ; 133°19'14.19"W	Roadway Crossing 68°18'53.11"N; 133°23'3.09"W	Roadway Crossing 68°18'51.92"N ; 133°28'55.64"W	Roadway Crossing 68°18'50.48"N ; 133°29'54.21"W	Roadway Crossing 68°18'44.74"N ; 133°31'7.16"W	Roadway Crossing 68°21'34.98"N ; 133°42'11.88"W	**NWTEL INUVIK CO** 68°21'37.69"N ; 133°43'54.78"W
FN IMPACT	TBD	TBD	TBD	TBD	TBD	TBD						TBD	TBD	TBD	TBD
GEOGRAPHIC SEGMENT															
TERRAIN															
GEOHAZARDS: PERMAFROST CONDITION				Continuous Permafrost											
GEOHAZARDS: MASS MOVEMENT AREAS															
GEOHAZARDS: SURFICIAL GEOLOGY															
GEOHAZARDS: WASHOUT AREAS															
GEOHAZARDS: LAND SLIDE AREAS															
GEOHAZARDS: SINK HOLES															
GEOHAZARDS: INSTALLATION GRADE (0-5%, 6-10%, >10%)															
GEOHAZARDS: OTHER RISKS															
GEOHAZARDS: GROUND/SOIL CONDITIONS															
GEOHAZARDS: VEGETATION															
WILDLIFE SPECIES AT RISK															
ROAD PRISM															
CABLE/CONDUIT ALIGNMENT															
PREFERED CONSTRUCTION TECHNIQUE					HDD under Stream										
BRIDGE CROSSINGS	N/A							N/A							
MAJOR RIVER CROSSINGS	N/A														
AERIAL CROSSINGS	N/A														A/E Plant into Town, ~10.5 Km
ROAD CROSSINGS	HDD or Trenching Cross @45 Deg	HDD or Trenching	HDD or Trenching	HDD or Trenching	HDD	HDD or Trenching	HDD	HDD or Trenching	HDD or Trenching Cross @45 Deg	HDD or Trenching	HDD or Trenching	HDD or Trenching Cross @45 Deg	HDD or Trenching	A/E Crossing	
CULVERTS	Shallow Bury 100-150mm in organic layer if possible, otherwise Surface-Laid cable in alignment near outside edges of the highway ROW (15-20m from road centre) away from the road prism @ surface. Use geotextile saddle sand bags as required to maintain and secure cable/conduit on the ground in areas with varyings terrain levels. Clearing of the alignment will need to be done in winter months with smaller machines to minimize imapct to permafrost active layer. Vegetation growth over time will cover and further secure the cable from minor movement.														N/A
HIGHWAY SIDE	West Side/East Side	East Side/East Side	East Side/East Side	East Side/East Side	East Side/East Side	East Side/East Side	East Side od Bridge	East Side/West Side	West Side/East Side	North Side/South Side	South Side/North Side	North Side/South Side	North Side/North Side	North East/South West	North East/South West
CLEARING and GRUBBING	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CULVERTS QTY	0	0	1	0	0	4	N/A	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD 5
CABLE TYPE	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CONDUITS	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm	SDR-9, 32.0mm		
FOSC Size															
HANDHOLES	TBD	2	2	2	2	2	2	2	2	2	2	2	2		24
NOTES															

Appendix C
Network Logic Diagram

DFL PRELIMINARY NETWORK DIAGRAM (DAWSON TO INUVIK)

REV. 2.0 7/12/19



Stantec

Appendix D
Construction Level Drawing Sample

DEMPSTER FIBRE LINE
KLONDIKE DEMPSTER JUNCTION (DWG SET A)
YUKON, CA

JUNE 2019

PROJECT NUMBER: 1449 02824

DRAWING SHEET INDEX	
SHEET	DESCRIPTION
A1	COVER PAGE
A2	LEGEND
A3	KEYPLAN
A4	DETAILS
A5	DETAILED DESIGN

SURFACE FEATURES

WATERCOURSES

WATERBODIES

OPEN CONIFEROUS AREA

SHRUB AREA

ROADS

ROAD CENTRE LINE

ROAD RIGHT OF WAY

ROAD SURFACE

HWY DISTANCE MARKER

DRAINAGE

CULVERT

LARGE CULVERT (>1.5m)

CONTOURS

ELEV= #

MAJOR CONTOUR

TELECOM

PROPOSED FIBRE ALIGNMENT

PROPOSED MICROWAVE SITE

DIP POLE

JOINT USE POLE

POWER POLE

ANCHOR

TELEPHONE PULLBOX

TELEPHONE MANHOLE

CONSTRUCTION NOTES:

1. CONTRACTOR SHALL CONTACT APPROPRIATE AUTHORITIES TO ARRANGE MARKING OF THE LOCATION OF ALL EXISTING UNDERGROUND STRUCTURES AND UTILITIES. UTILITIES SHALL BE PERMANENTLY MARKED USING SUITABLE PAINT OR FLAGGING TO FACILITATE CONFLICT IDENTIFICATION PRIOR TO ALIGNMENT CONFIRMATION
2. CONTRACTOR SHALL BE RESPONSIBLE FOR CONTACTING ALL IMPACTED BUSINESS AND MUNICIPAL DEPARTMENTS PRIOR TO CONSTRUCTION.
3. ALL PERMANENT RESTORATION WILL BE COMPLETED IN ACCORDANCE WITH, TERRITORIAL, MUNICIPAL AND / OR PROVINCIAL REGULATIONS AND SPECIFICATIONS.
4. CONTRACTOR ASSUMES ALL RESPONSABILITY FOR ANY DAMAGE TO PUBLIC AND PRIVATE PROPERTY, UNDERGROUND UTILITIES, ROAD / SIDEWALK SURFACES, ABOVE AND BELOW GROUND STRUCTURES, RESULTING FROM CONSTRUCTION OF THE PROJECT.
5. WORKING SCHEDULE SHALL BE RESEARCHED BY THE CONTRACTOR TO IDENTIFY LOCAL CONSIDERATIONS FOR SPECIAL EVENTS, SPORTING FUNCTIONS, PARADES, FESTIVALS OR OTHER CONSIDERATIONS WHICH MAY IMPACT PROGRESS, IN ADVANCE OF FINALIZING THE SCHEDULE
6. A MINIMUM 1000mm HORIZONTAL SEPARATION AND 300mm VERTICAL SEPARATION TO EXISTING UTILITIES WILL BE MAINTAINED, OR AS SPECIFIED ON THE DETAILED CONSTRUCTION DRAWING.
7. ALL REFERENCES AND DIMENSIONING TO EXISTING ROADWAY WERE COMPILED TO THE BEST OF THE INFORMATION AVAILABLE TO THE DESIGNER. CONTRACTOR TO VERIFY ACTUAL LOCATIONS AND DIMENSIONING PRIOR TO CONSTRUCTION.
8. ALL CABLES TO BE TAGGED AND IDENTIFIED AT TIME OF PLACING AND SPLICING
9. CONTRACTOR WILL BE RESPONSIBLE FOR ALL TRAFFIC CONTROL REQUIREMENTS INCLUDING BUT NOT LIMITED TO COORDINATION WITH MUNICIPAL TRAFFIC CONTROL, RAILWAY AUTHORITIES, YUKON AND NORTHWEST TERRITORIES TRANSPORTATION AND PRIVATE LANDOWNERS AS APPLICABLE.
10. ALL CONSTRUCTION, MATERIALS AND ACTIVITIES WILL CONFORM TO DFL SPECIFICATIONS AND REGULATIONS.

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REAL PROPERTY SERVICES
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Région de l'ouest

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NOT FOR CONSTRUCTION

Yukon

Stantec

Revision	Description	Date
5		
4		
3		
2		
1	DRAWING SET CONTINUATION CLARITY	2019/07/09
0	Design Completion	2019/06/13

Client / client

Government of Yukon
Highways and Public Works

PO Box 2703, Whitehorse, Yukon

Project title / Projet

Dawson City, YK - Inuvik, NWT
Dempster Highway

DFL - Dempster Fibre Line

Designed by / Conçu par: B. BROSDA

Drawn by / Dessiné par: B. BROSDA

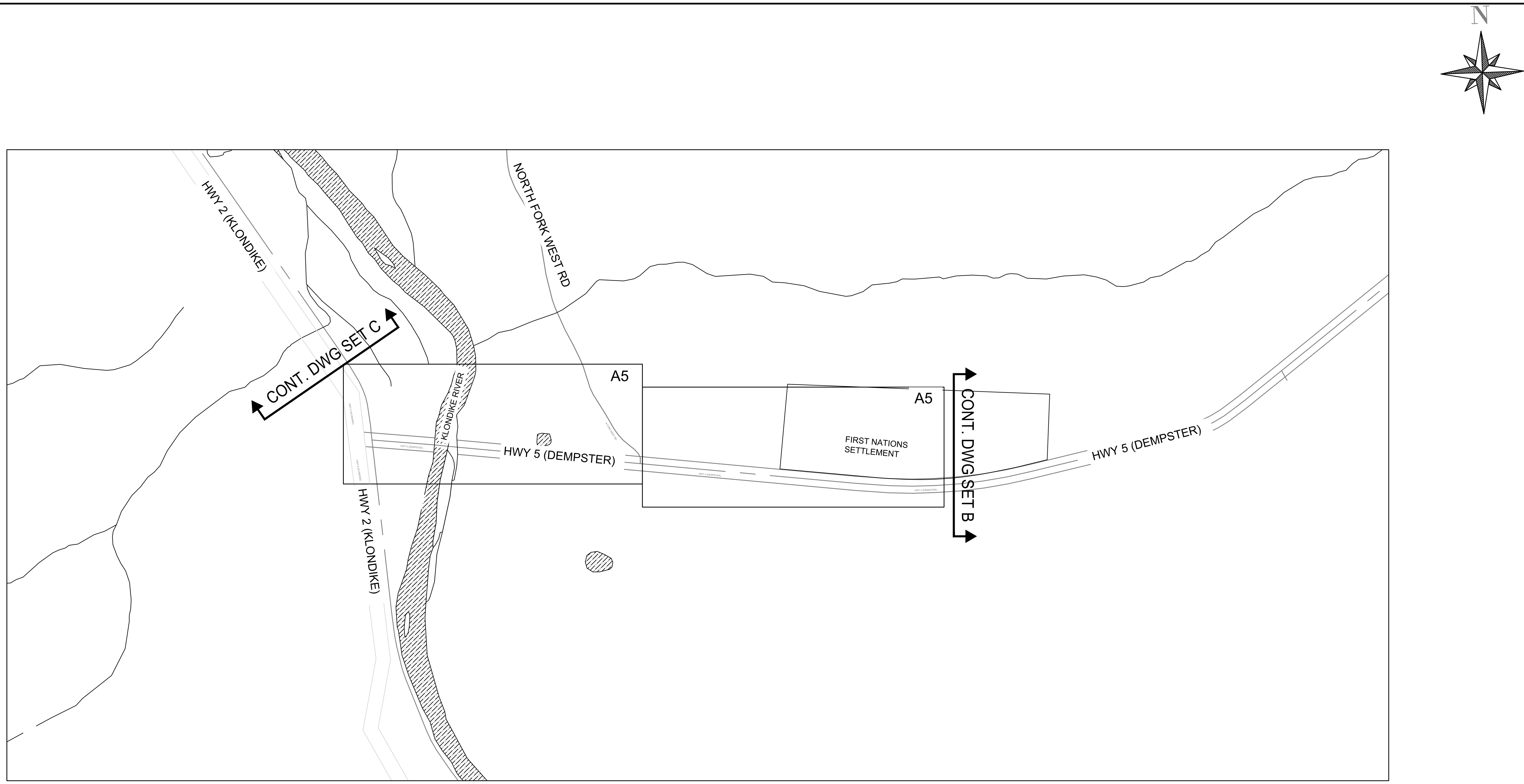
Approved by / Approuvé par: J. MARION

PWGSC Project Manager / Administrateur de Projets TPSGC

Drawing title / Titre du dessin

DETAILED DESIGN
KLONDIKE - DEMPSTER JUNCTION
SAMPLE DRAWING
LEGEND

Project no./No. du projet	Drawing no./No. du dessin	Revision no.
144902824	A2 OF 05	0



PLAN SCALE-1:10000

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REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

PRELIMINARY
NOT FOR CONSTRUCTION

Yukon

Stantec

Revision	Description	Date
5		
4		
3		
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1	DRAWING SET CONTINUATION CLARITY	2019/07/09
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J. MARION

PWGSC Project Manager / Administrateur de Projets TPSGC

Drawing title / Titre du dessin

DETAILED DESIGN
KLONDIKE - DEMPSTER JUNCTION
SAMPLE DRAWING
KEYPLAN

Project no./No. du projet	Drawing no./No. du dessin	Revision no.
144902824	A3 OF 05	0

PSPC – A1 – 841X594

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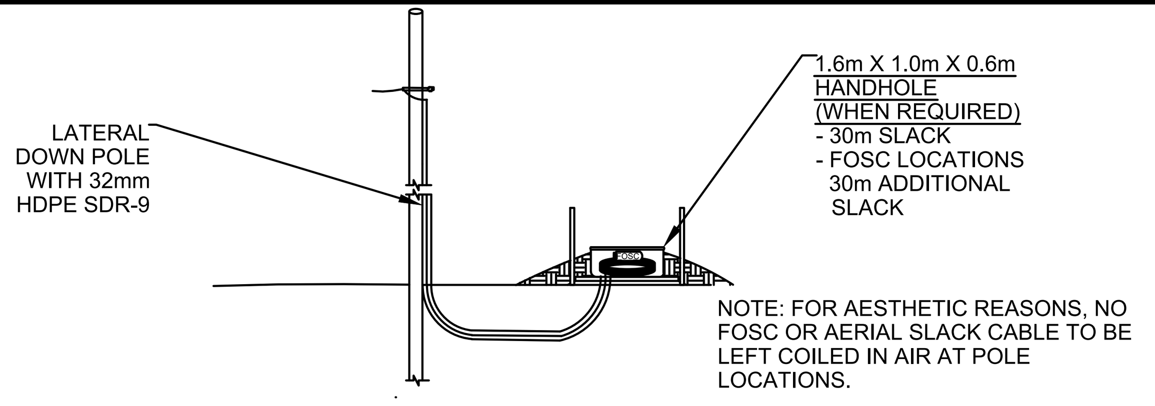
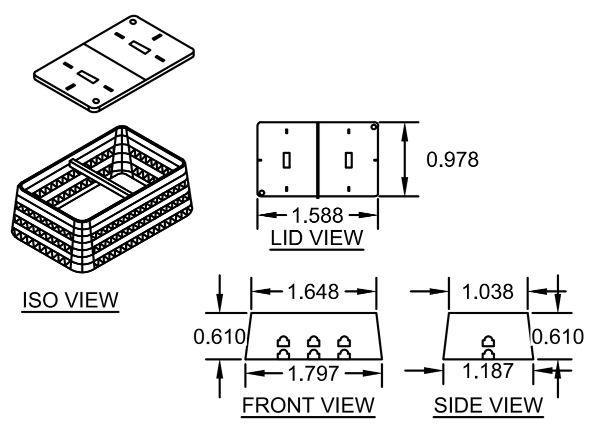
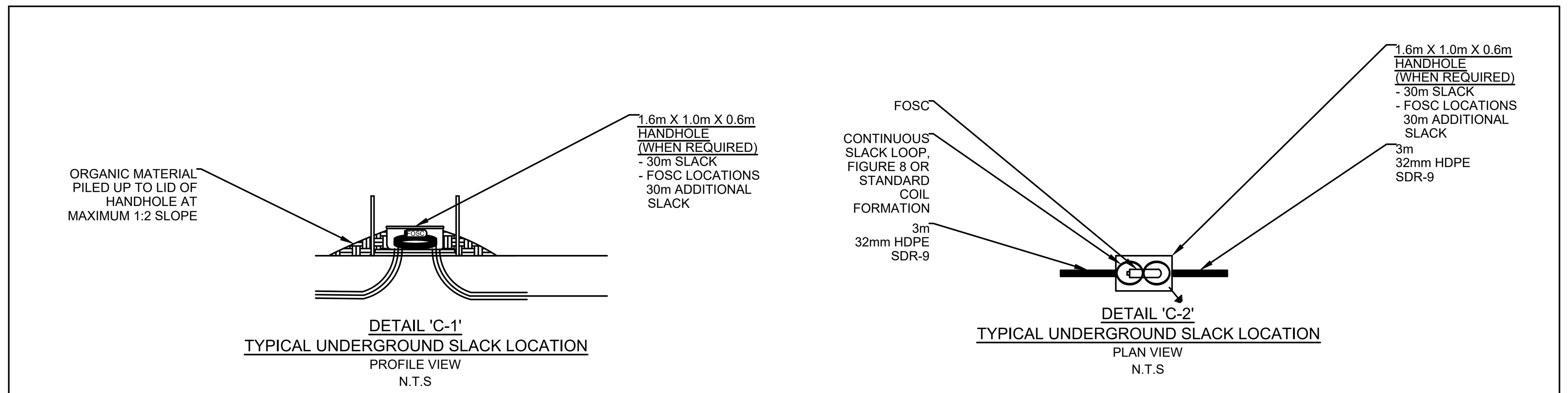
A000



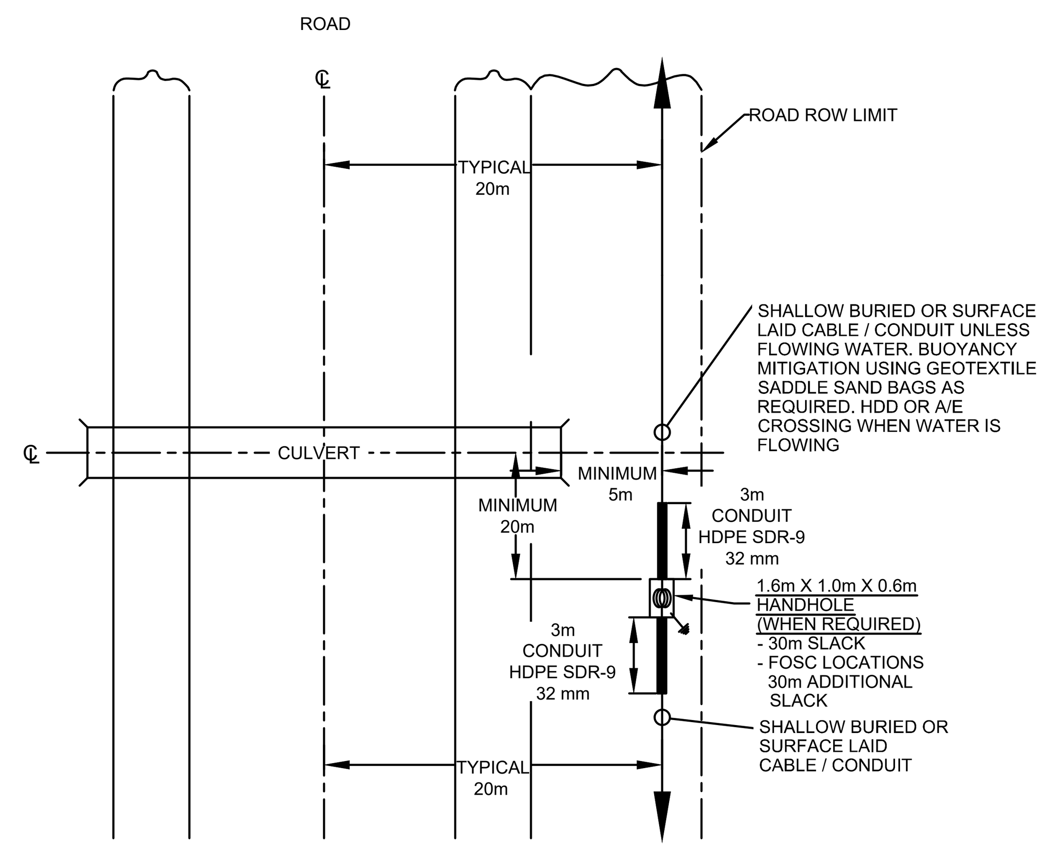
DETAIL 'A'
TYPICAL AERIAL SLACK LOCATION
LATERAL TO HANDHOLE
N.T.S



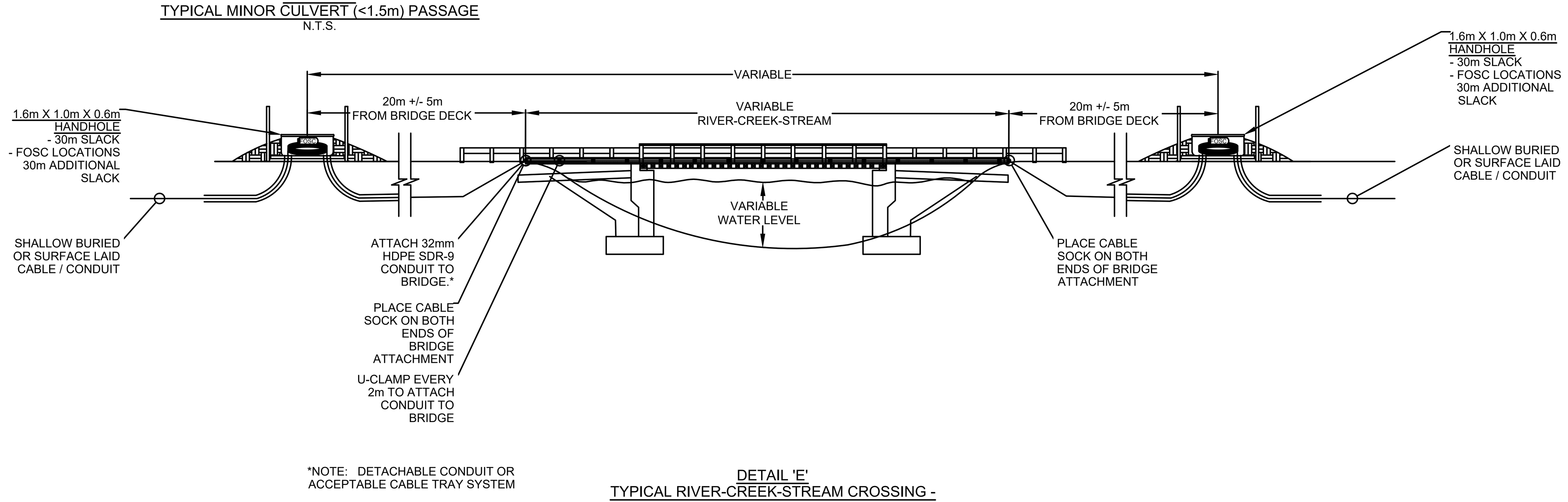
DETAIL 'B'
1.6m x 1.0m x 0.6m TYPICAL HANDHOLE
N.T.S.



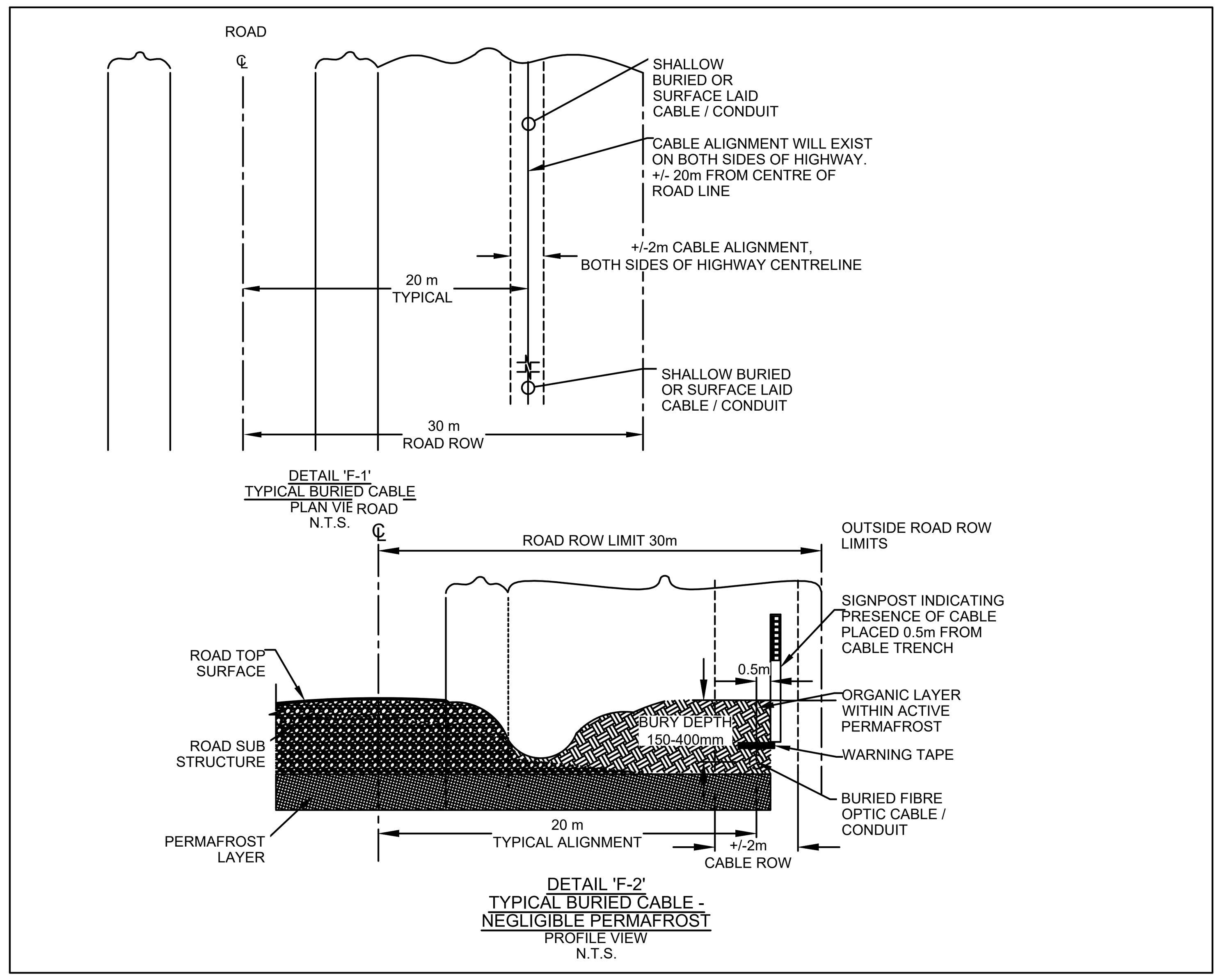
DETAIL 'C'
TYPICAL UNDERGROUND SLACK LOCATION



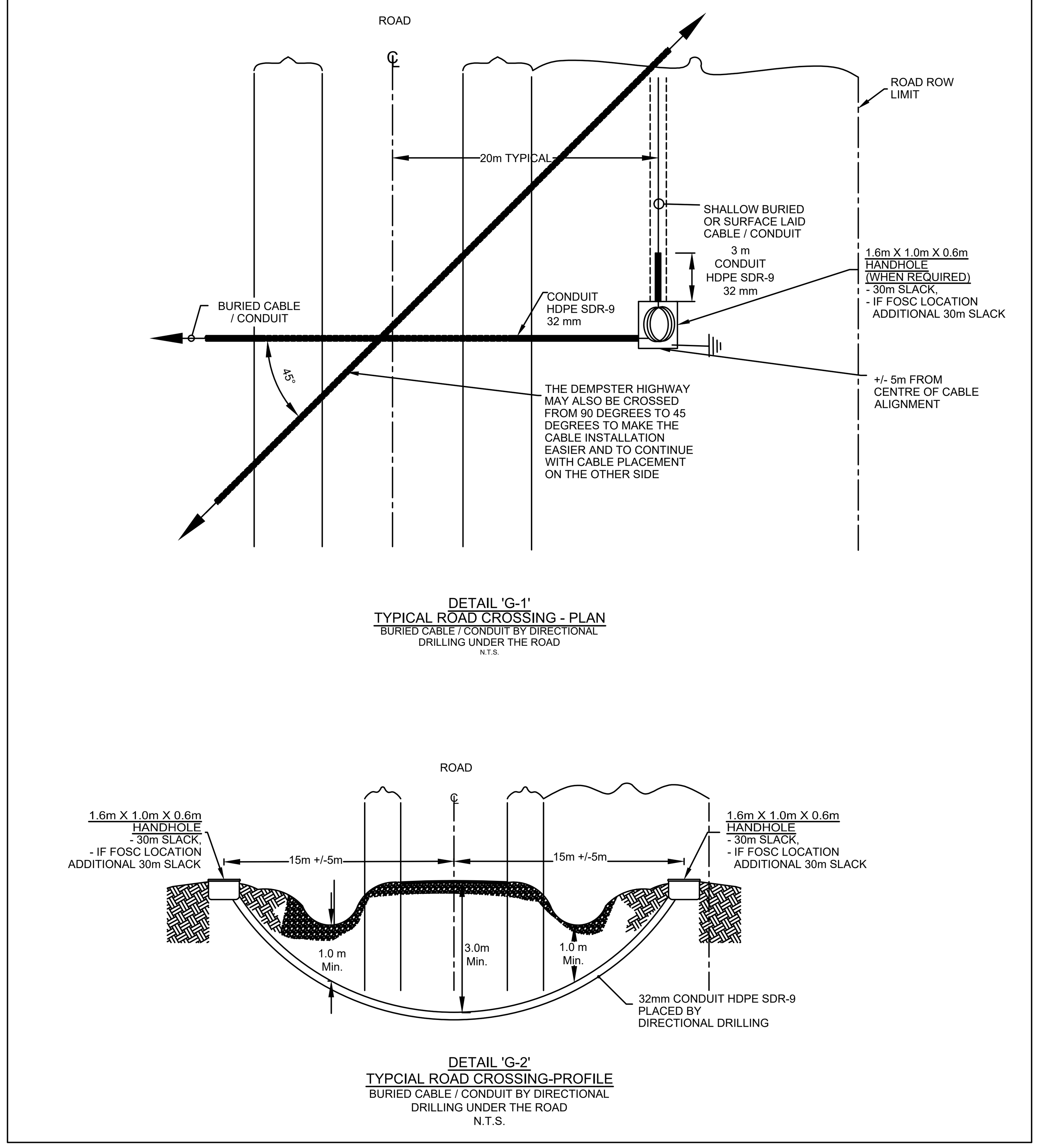
DETAIL 'D'
TYPICAL MINOR CULVERT (<1.5m) PASSAGE
N.T.S.



DETAIL 'E'
TYPICAL RIVER-CREEK-STREAM CROSSING - BRIDGE ATTACHMENT
N.T.S



DETAIL 'F'
TYPICAL BURIED CABLE



DETAIL 'G'
TYPICAL ROAD CROSSING

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REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

PRELIMINARY
NOT FOR CONSTRUCTION

Yukon
Stantec

REFERENCE DOCUMENTS

1	DFL-ELE-STAN-DBS-103001-Rev-A
2	NORTHWESTEL OSP-ENG STANDARD DOC
3	
4	
5	
6	
7	
8	
9	

Revision	Description	Date
5		
4		
3		
2		
1	DRAWING SET CONTINUATION CLARITY	2019/07/09
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PWGSC Project Manager / Administrateur de Projets TPSGC

Drawing title / Titre du dessin

KLONDIKE - DEMPSTER JUNCTION
SAMPLE DRAWING
DETAILS

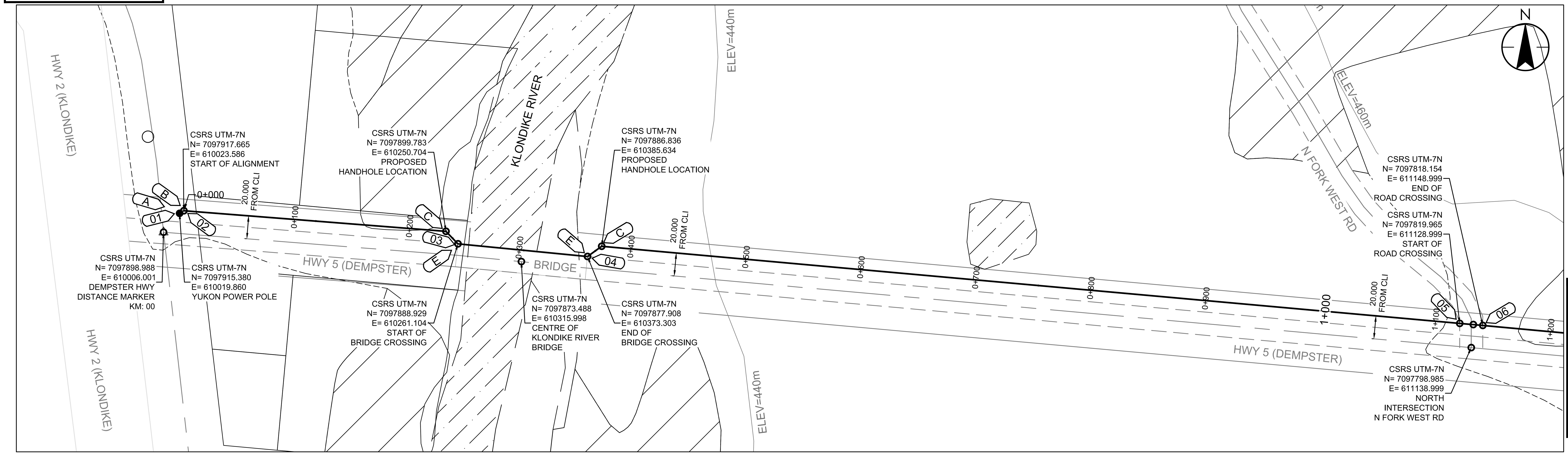
Project no./No. du projet	Drawing no./No. du dessin	Revision no.
144902824	A4 OF 05	0

PSPC – A1 – 841X594

0 10 20 30 40 50 60 70 80 90 100mm

A000

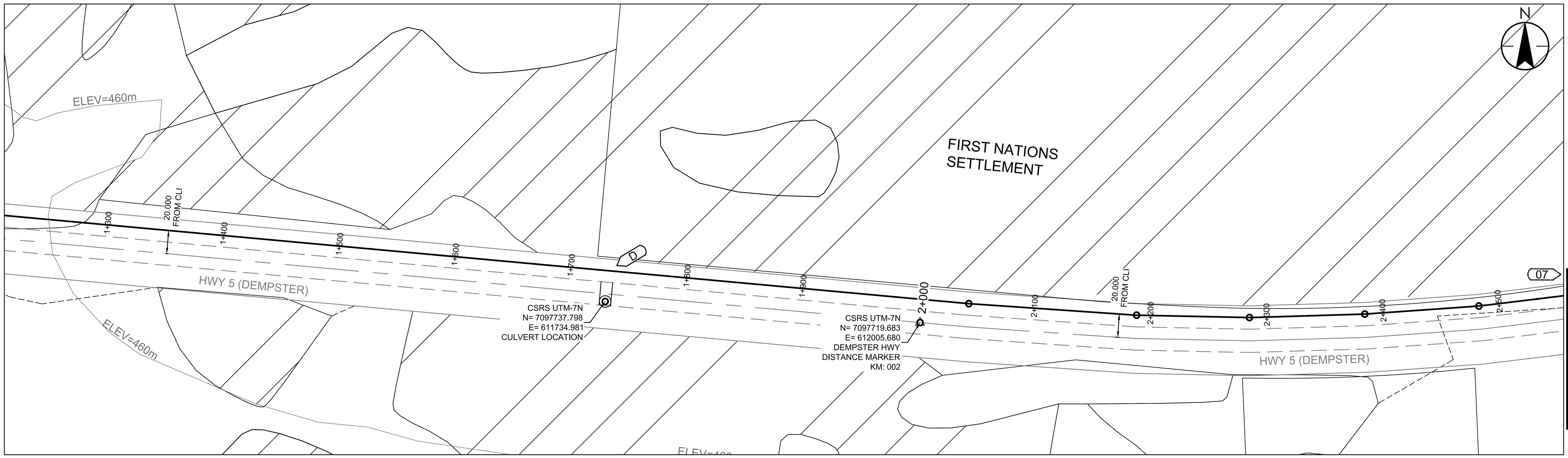
SEE SHEET C1



SEE LOWER LEFT

PLAN SCALE-1:2000

SEE UPPER RIGHT



SEE SHEET B1

PLAN SCALE-1:2000

CONSTRUCTION NOTES

- 01 – 02: LATERAL OFF YUKON ENERGY POLE INTO PROPOSED HANDHOLE
- 02 – 03: SHALLOW BURY 72 FOC AT 150-400mm DEPTH (SEE TYP. BURIED DETAIL 'F' ON SHEET A4)
- 03 – 04: ATTACH 32mm SDR-9 CONDUIT TO BRIDGE, PULL 72 FOC THROUGH CONDUIT (SEE TYPICAL BRIDGE ATTACHMENT DETAIL 'E' ON SHEET A4)
- 04 – 05: SHALLOW BURY 72 FOC AT 150-400mm DEPTH (SEE TYP. BURIED DETAIL 'F' ON SHEET A4)
- 05 – 06: HDD 72 FOC UNDER ROAD CROSSING (SEE TYP. ROAD CROSSING DETAIL 'G' ON SHEET A4)
- 06 – 07: SHALLOW BURY 72 FOC AT 150-400mm DEPTH (SEE TYP. BURIED DETAIL 'F' ON SHEET A4)
- A: LATERAL DOWN YUKON ENERGY POLE (SEE AERIAL SLACK DETAIL 'A' ON DETAIL SHEET A4)
- B: PLACE 1.6m x 1.0m x 0.6m TYPICAL HANDHOLE & FOSC (SEE HANDHOLE DETAIL 'B' ON DETAIL SHEET A4)
- C: PLACE 1.6m x 1.0m x 0.6m TYPICAL HANDHOLE & COIL 30m SLACK CABLE (SEE UNDERGROUND SLACK DETAIL 'C' ON DETAIL SHEET A4)
- D: MINOR CULVERT CROSSING (SEE MINOR CULVERT CROSSING DETAIL 'D' ON SHEET A4)

Public Services and Procurement Canada / Services publics et Approvisionnement Canada

REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

PRELIMINARY
NOT FOR CONSTRUCTION

Yukon
Stantec

REFERENCE DOCUMENTS

1	DFL-ELE-STAN-DBS-103001-Rev-A
2	NORTHWESTEL OSP-ENG STANDARD DOC
3	
4	
5	
6	
7	
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9	

Revision	Description	Date
5		
4		
3		
2		
1	DRAWING SET CONTINUATION CLARITY	2019/07/09
0	Design Completion	2019/06/13

Client / client

Government of Yukon
Highways and Public Works

PO Box 2703, Whitehorse, Yukon

Project title / Projet

Dawson City, YK - Inuvik, NWT
Dempster Highway

DFL - Dempster Fibre Line

Designed by / Conçu par: B. BROSDA

Drawn by / Dessiné par: B. BROSDA

Approved by / Approuvé par: J. MARION

PWGSC Project Manager / Administrateur de Projets TPSGC

Drawing title / Titre du dessin

KLONDIKE - DEMPSTER JUNCTION
SAMPLE DRAWING
DETAILED DESIGN

Project no./No. du projet	Drawing no./No. du dessin	Revision no.
144902824	A5 OF 05	0

APPENDIX E
Waste Management Plan

Dempster Fibre Project
Waste Management Plan

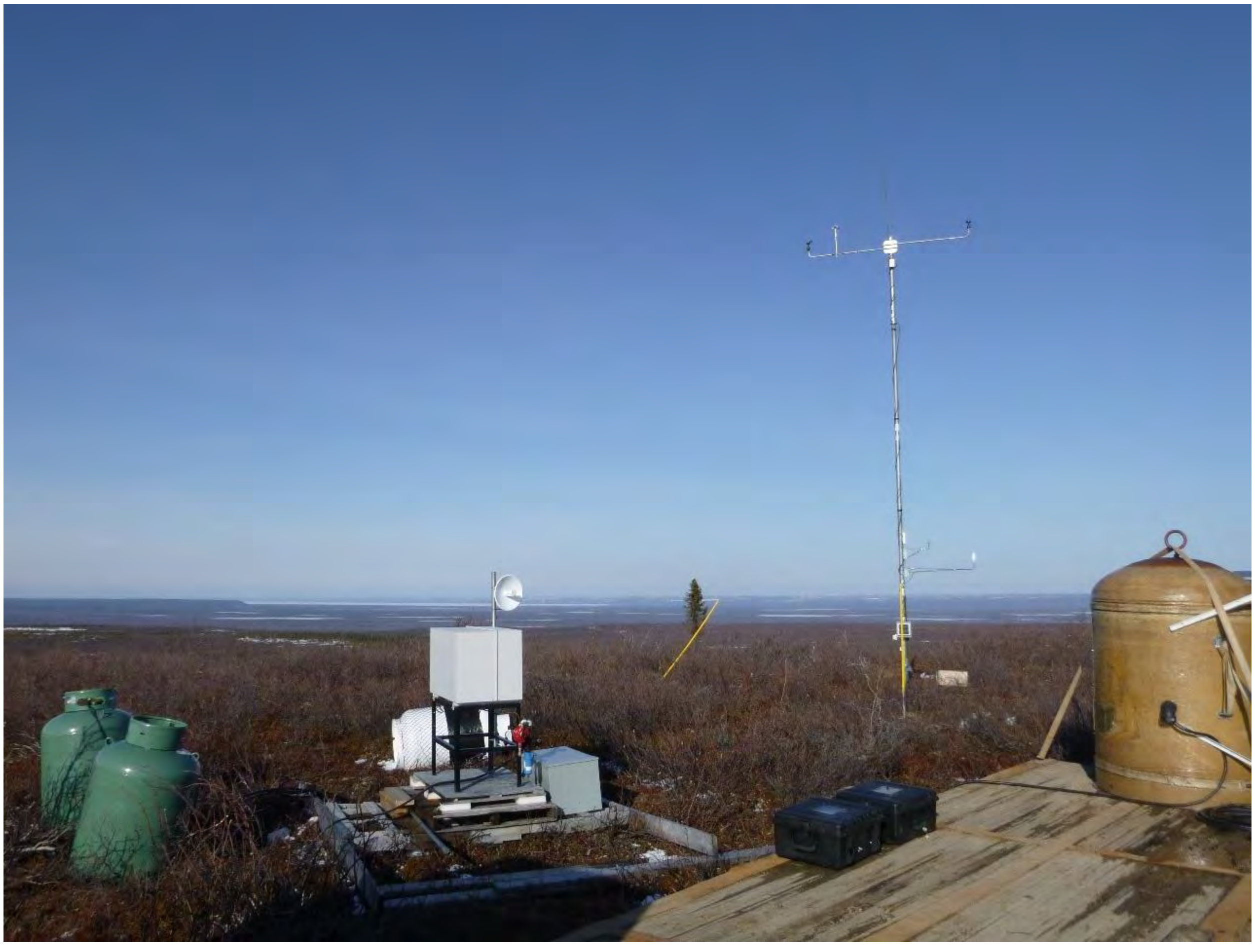

Photo Credit: Devon Yacura, 2018

Submitted to:

Yukon Environmental and Socio-Economic Assessment Board, Dawson City Designated Office
Bag 6050
Dawson City, Y0B 1L0

Submitted by:

Government of Yukon
Department of Highways and Public Works
Property Management Division
9010 Quartz Rd.
Whitehorse, YT Y1A 2C6

Prepared by:

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Whitehorse, YT Y1A 0K7
T: 867.456.4865
F: 604.669.0430
hemmera.com

Project No. 103469-01

July 9, 2019

TABLE OF CONTENTS

1.0 PROJECT BACKGROUND

The proposed Dempster Fibre Project (DFP) is a Yukon Government-driven project intended to provide a redundancy loop, known as a fibre ring, for 39 terrestrial-served and 36 satellite-served northern communities in BC, Yukon, NWT, and Nunavut. This loop will be completed by running an 800 km length of fibre cable along the Klondike Highway from Dawson City, YT, to the Dempster Highway junction, then north up the Dempster Highway to Inuvik, NWT. The fibre cable will connect to the recently constructed Mackenzie Valley Fibre Link (MVFL) at Inuvik. Once complete, 78% of northern communities will benefit from the redundant loop created by this Project.

The Dempster Highway extends for 735 km from the Dempster Highway junction, 40 km east of Dawson City, to Inuvik, NWT. Other than Inuvik, there are two communities along the Dempster Highway: Fort McPherson and Tsiigehtchic, both located in the NWT. There are two river crossings along the highway at the Peel and Mackenzie Rivers that require ferry crossings during the summer and ice road crossings during the winter. The Peel River is located at Fort McPherson and the Mackenzie River at Tsiigehtchic. The highway is located within a legally defined 60 m-wide right-of-way (ROW). Both the Yukon Government – Department of Highways and Public Works and the Government of Northwest Territories – Department of Transportation exercise authority over the operation and maintenance of the Dempster Highway in Yukon and the Northwest Territories, respectively.

To the extent practical, the design specifications for construction of the fibre optic cable and conduit will be installed within the highway ROW but away from the existing highway structure. In some instances, the cable will be required to be installed within the existing highway structure (prism). When this occurs, the design will aim to minimize the risk to the highway structure while taking constructability into consideration, as well as life cycle cost and maintainability of the cable.

Due to the variability of conditions encountered along the Dempster Highway, a variety of construction and installation techniques will be employed to successfully install the fibre optic cable including the following:

- Conventional buried cable using heavy equipment to install the conduit and cable at a depth between 600 mm – 1,000 mm below ground.
- Shallow direct-buried cable using cable plowing techniques
- Surface-laid cable in sensitive terrain and wetland areas in non-frozen and frozen conditions.
- Horizontal Directional Drilling (HDD) of fish-bearing streams, rivers, other waterbodies and challenging sections.
- Aerial cable installation in selected sensitive or challenging construction areas.
- Aerial cable installation along Yukon Energy Transmission Line poles for approximately 28 km adjacent to the Klondike Highway and over Australia Hill.

1.1 Company Name, Location and Mailing Address

Yukon Government
Highways and Public Works
9010 Quartz Road
Whitehorse, YT Y1A 2C6
Main Contact: Darryl Froese – Project Manager
Phone: (867) 667-3089
Email: Darryl.froese@gov.yk.ca

1.2 Effective Date of Waste Management Plan

The Waste Management Plan will be in effect for the duration of the Project for all phases including construction, operation and maintenance. The plan will be in effect from the date of issue of the permit and will expire on the date that the permit is closed.

1.3 Purpose and Scope

The purpose of this plan is to minimize the amount of waste generated by the DFP, and where possible, reuse and recycle material that would otherwise be directed to the landfill. Minimizing, reusing and recycling materials and packaging can reduce waste disposal and material costs, especially in a northern setting, where disposal and transportation costs are increased. Waste reduction will be achieved through best management practices and recycling or reuse efforts.

Adequate training of staff and contractors will be paramount to minimizing the amount of waste generated and maximizing the volume of waste that is recycled or reused for another purpose. Government of Yukon Department of Highways and Public Works (HPW) and its contractor(s) will be required to follow this Plan for the disposition of the waste generated by their activities. This Plan applies to the construction, operation and maintenance of the DFP.

1.4 Distribution List

This plan and the most recent revisions will be distributed to all staff and contractors working on the Project. The Plan will be presented and reviewed during a tailgate meeting prior to the start of construction. The Waste Management Plan will be included as part of new staff orientation activities.

1.5 Additional Copies

Several copies of the plan are to be kept on site at all times. A copy is also to be held at the HPW office in Whitehorse and with the Yukon Environmental and Socio-Economic Assessment Board (YESAB). Additional copies of the plan can be obtained by contacting HPW directly at the phone number or email presented in **Section 1.1**.

1.6 List of Revisions

Any revisions to the plan will be submitted to YESAB for approval prior to implementing any changes.

1.7 Licences, Permits and Fees

All non-hazardous and hazardous wastes related to the construction, operation and maintenance of the DFP will be handled, stored and disposed of in accordance with this Plan, and all applicable federal, territorial, and municipal laws and regulations. HPW and its contractor(s) will be responsible for any required fees, licences, and permits.

2.0 WASTE PRODUCTION SUMMARY

Waste will inevitably be produced during construction, operations, and maintenance of the DFP. The following sections discuss the various sources of waste that are expected to be produced and the potential methods of disposal.

2.1 Non-hazardous Construction Waste

The majority of waste generated for the DFP will be produced during the construction phase. During construction, the Project will generate municipal solid waste and construction waste. Types of construction waste may include:

- Packaging for material and supplies such as plastics, cardboard and scrap metal,
- Waste wood such as pallets, framework or other sources of scrap lumber,
- Drilling fluids and cuttings,
- Waste water from drilling,
- Human and household waste produced by on-site personnel at camp facilities and,
- Cleared vegetation.

2.2 Non-hazardous Operations and Maintenance Waste

During operations and maintenance, the Project will generate small volumes of construction waste, including packaging for material and supplies such as plastics, paper and cardboard products, and scrap metal. A small volume of wood waste and domestic refuse may also be produced.

2.3 Hazardous Waste

HPW anticipates that small amounts of hazardous waste may be generated during construction, operations, and maintenance of the DFP. Hazardous materials that may be generated include automotive fluids, fuel, or any materials contaminated by hydrocarbons. Contractors will maintain an inventory of all hazardous materials that are stored on site and will limit the quantities of hazardous materials brought on-site to minimize the amount of hazardous waste generated.

3.0 WASTE MANAGEMENT FACILITIES

The following is a list of approved waste management facilities located along the Dempster Highway, including locations in the Northwest Territories:

Inuvik

- Inuvik Solid Waste Disposal Facility
  - Location: Airport Road, beside Inuvik golf course
  - Phone: 867-777-8615

- Inuvik Recycling Depot (Caps Off Recycling)
  - Location: 4 Carn Road
  - Phone: 867-777-2434
  - Accepts beverage containers and electronics

- Inuvik Sewage Lagoon
  - Location: North of town, Tank Farm Road
  - Phone: 867-777-5936

Dawson

- Quigley Landfill
  - Location: Molison Drive, approx. 9 km from downtown Dawson
  - Phone: 867-993-7400

- Dawson Recycling Depot (Conservation Klondike Society)
  - Location: 1067 2nd Avenue
  - Phone: 867-993-6666
  - Accepts beverage containers and electronics

Fort McPherson

- Fort McPherson Solid Waste Disposal Facility
  - Location: Approximately 6 km northwest of community center.
  - Phone: 867-952-2428

Tsiigehtchic

- Tsiigehtchic Solid Waste Disposal Facility
  - Location: Approximately 1.7 km east of community center.
  - Phone: 867-953-3302

4.0 MATERIAL STORAGE AND DISPOSAL

All waste will be stored within bear-proof designated temporary waste collection areas until it is collected for transport to an approved facility. These waste collection areas will be designed to minimize attractants to reduce wildlife conflicts. Materials that can be recycled will be stored separately from garbage. Used oil will not be mixed with other solid or hazardous waste and will be stored separately within appropriate secondary containment in accordance with all applicable rules and regulations.

4.1 Hazardous Waste

Hazardous wastes generated during the construction will include waste oils, lubricants, fuels, filters, etc. Hazardous wastes will be temporarily stored at the mobile camp/motorhomes in clearly marked containers with lids (i.e., drums). The materials will be removed on a regular basis for transportation to the nearest approved hazardous waste management facility in Yukon or the NWT for treatment/disposal. If other contaminated materials require disposal (i.e. spill pads), these will be disposed of through a licensed facility (e.g. KBL Environmental Ltd. in Whitehorse). All hazardous waste shipments will be manifested and records retained for future reporting to the appropriate regulatory agencies in Yukon and the NWT.

4.2 Non-hazardous Waste

All non-hazardous waste will be disposed according to the Waste Management Principles described in Section 4.3.

4.3 Waste Management Principles

4.3.1 Waste Segregation

Segregation of all waste streams by type or category will avoid potentially undesirable combined effects and will facilitate the reuse, recycling, recovery and/or disposal of the various wastes. To the extent practicable, sorting will take place at the source and the sorted waste will be stored at the site. Contractors at the site are required to manage the waste generated from their activities in a manner compatible with this Waste Management Plan.

4.3.2 Brush and Timber

Mulching activities within the proposed corridor will generate clippings, timber and other vegetation, requiring management. Timber felling will be avoided as much as practical, however, some felling including the removal of danger trees is anticipated.

When practical, trees will be felled into the corridor and work space, away from waterbodies and adjacent stands. Larger trees (greater than 10 cm in diameter) will be bucked into manageable pieces and left in place. Felled trees will not be left leaning and danger trees that pose a potential risk to field crews will be removed. Care will be taken to not obstruct known or visually obvious, watercourses, wetlands, trails (hunting or trapping) and wildlife trails.

During mulching activities in the winter months, residual debris including snow and ice is anticipated. When practical, this material will be left in place. In higher brush areas, where management is required, the material will be pushed aside into consolidated piles along the route. Care will be taken not to obstruct known or visually obvious, watercourses, wetlands, trails (hunting or trapping), and wildlife trails.

4.3.3 Solid Wastes

All solid wastes generated by the mobile camp and motorhome operations will be temporarily stored on site prior to biweekly or weekly transport and disposal in the nearest municipal solid waste facilities mentioned above in Section 3.0. As required, solid wastes will be stored in secure containers to prevent access by wildlife.

Agreements will be made with waste facilities prior to any work beginning in a given area. All solid wastes will be transported and disposed of in municipal facilities as per agreements negotiated between contractors and the communities. No solid wastes will be left or disposed of on the land.

4.3.4 Sewage

As a primary operation, sewage generated by the DFP will be temporarily and securely stored at camp locations and in the motorhomes and transported regularly for disposal in municipal sewage disposal facilities along the route. If required, porta-johns and/or pacto toilet systems will be utilized. Prior to construction, agreements will be made with municipalities to allow disposal of sewage in their facilities as required.

4.3.5 Greywater

All camp greywater generated by the DFP will be temporarily and securely stored at camp locations and motorhomes and transported regularly for disposal in municipal sewage disposal facilities along the route. Agreements will be negotiated with municipalities to allow disposal of sewage in their facilities.

If this becomes impractical, due to distance or other reasons, greywater will be treated and discharged to a sump or natural depression located at least 100 m from the ordinary high-water mark of any waterbody and in compliance with all applicable legislation.

Treated greywater from any camp will be discharged to the surface in such a way as to limit pooling and erosion and sumps will be monitored regularly to reduce animal interactions. When required, the sump will be covered appropriately with local material and left to settle naturally.

4.3.6 Drill Mud

Directional drilling will require the use of drilling fluids to aid in drilling and cutting retrieval. Drilling fluids consist of water with an inert bentonite additive to maintain the drill bore and to aid in cooling, cuttings retrieval and stabilization of the hole. Drill cuttings and fluids will initially be contained and stored in mud tanks at the respective drilling locations. For minor HDD, the drill mud and cuttings will generally be contained within the drill pits. Depending on the sensitivity of the local environment and proximity to potentially fish-bearing water bodies, the drill cuttings and associated drilling fluids will be disposed of in nearby natural depressions, transported for disposal in existing Dempster Highway borrow pits (subject to landowner permission) or, subject to community approval, in the nearest municipal solid waste facilities located along the highway.

4.3.7 Recycling

Recyclable materials may include paper, aluminum cans, corrugated cardboard, glass, aerosol cans, wood, plastic, and metals. As of October 2018, the Inuvik Recycling Depot only accepts beverage containers (cartons, bottles, cans, etc.) and electronics. The Town of Inuvik is understood to be developing additional recycling options. To the extent that local programs are available and can be implemented, these materials will be recycled. If no feasible recycling options can be identified, the recyclable materials will be disposed of as refuse.

4.3.8 Salvage and Reuse

Salvage is the recovery of materials for on-site reuse, off-site sale, or donation to a third party. Reuse is making use of a material without altering its form. Materials can be reused on-site or reused on other projects off-site. To the extent practicable, materials will be salvaged and/or reused to divert them from the community landfills. Options for the salvage and reuse of wood pallets or other wood products in particular will be discussed with the community prior to disposal.

5.0 WASTE MINIMIZATION

HPW and their contractor(s) will minimize the amount of construction waste and debris disposed of in the community landfills to the extent possible. HPW and their contractor(s) will be responsible for communication and training of field personnel and subcontractors regarding waste management.

5.1 Packaging

All vendors and their suppliers will be encouraged to minimize the packaging for materials and equipment and to identify opportunities for the return of packaging materials for reuse. Packaging materials will be evaluated, and their selection will take into consideration opportunities for reuse and recycling.

5.2 Materials Storage

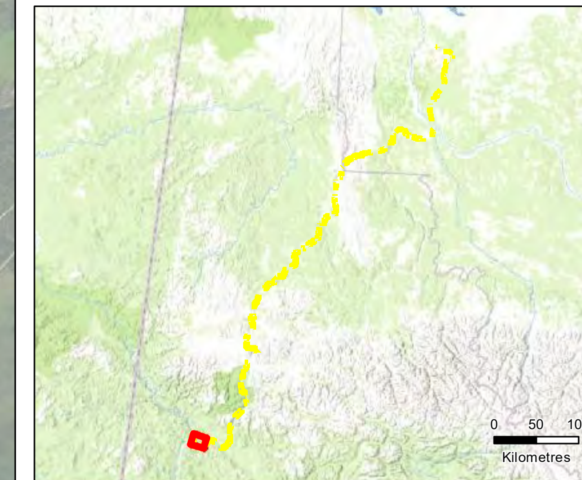
All materials will be stored in a manner to prevent contamination, expiration and deterioration. This ensures that the material will meet the specified requirements and that unused or outside-specification products will not become waste. Inventory control procedures will be implemented by HPW and its contractor(s) to ensure that excess materials are not brought on site.

APPENDIX F
Mapbook: Preferred Construction Technique by Segment

DISCLAIMER: This mapbook is not intended to be a stand-alone document, but a visual aid of the information contained within the Conceptual Design Brief (Stantec 2019). It is intended to be used in conjunction with the scope of services and limitations described therein. Preferred construction techniques are illustrated but methods may change based on geotechnical information collected during construction.

Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

- Stream Crossing

PREFERRED CONSTRUCTION TECHNIQUE

- Aerial construction
- Attach 63mm Conduit to Bridge
- Existing Entrance Conduits

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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An Ausenco Company

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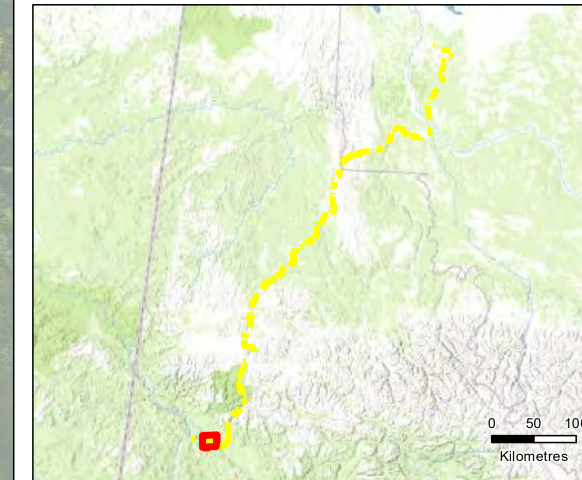
Dempster Fibre Project

Preferred Construction Technique Mapbook



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PREFERRED CONSTRUCTION TECHNIQUE

Aerial construction

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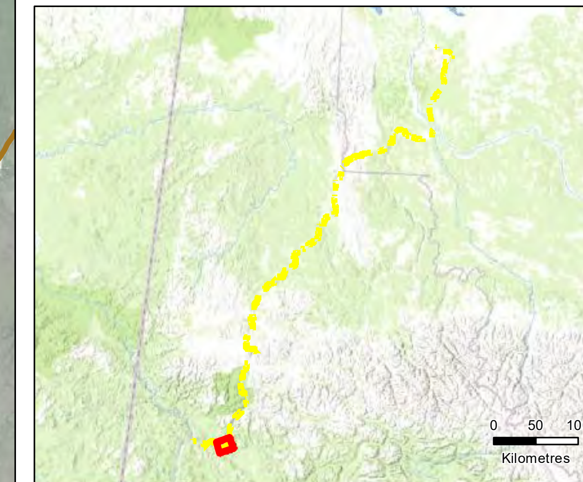
Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

- Stream Crossing

PREFERRED CONSTRUCTION TECHNIQUE

- Aerial construction
- Attach 63mm Conduit to Bridge
- Shallow Burial

Notes

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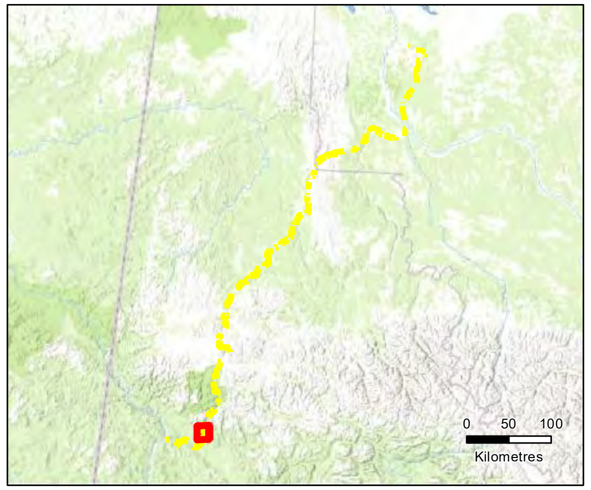
Dempster Fibre Project

Preferred Construction Technique Mapbook



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PREFERRED CONSTRUCTION TECHNIQUE

Shallow Burial

Notes

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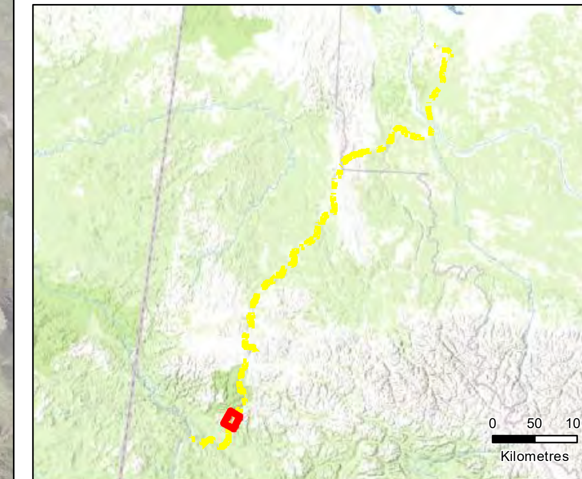
Dempster Fibre Project

Preferred Construction Technique Mapbook



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PREFERRED CONSTRUCTION TECHNIQUE

Shallow Burial

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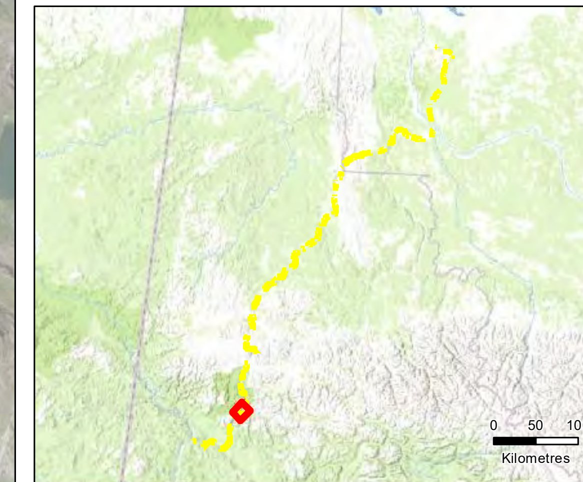
DRAFT
PREFERRED CONSTRUCTION TECHNIQUE
For Discussion Purposes Only

Dempster Fibre Project

Preferred Construction Technique Mapbook



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PREFERRED CONSTRUCTION TECHNIQUE

Shallow Burial

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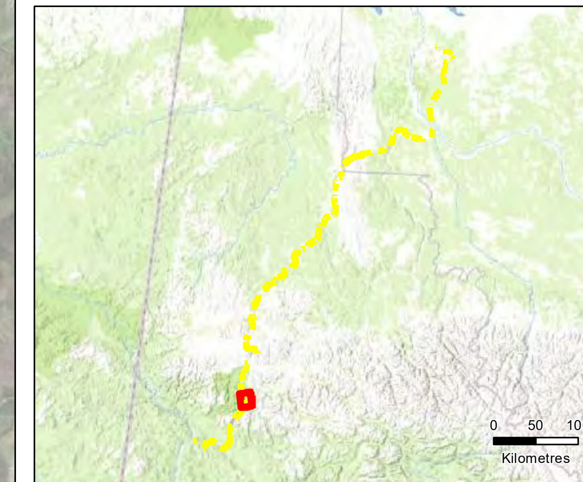
Dempster Fibre Project

Preferred Construction Technique Mapbook



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PREFERRED CONSTRUCTION TECHNIQUE

Shallow Burial

Notes

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103469-01	Production Date: Aug 14, 2019	Figure 7 of 28

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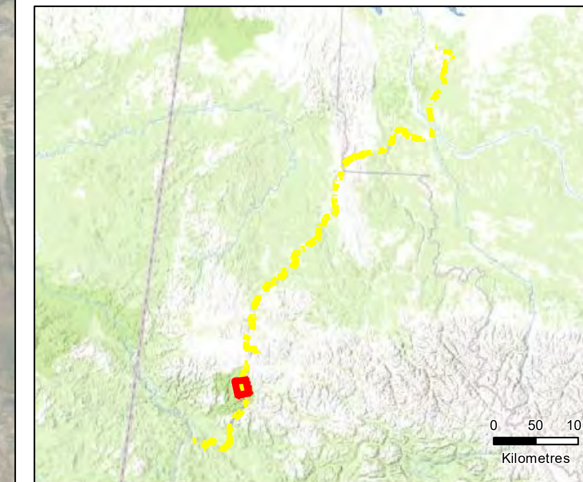
Dempster Fibre Project

Preferred Construction Technique Mapbook



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PREFERRED CONSTRUCTION TECHNIQUE

Shallow Burial

Notes

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An Ausenco Company

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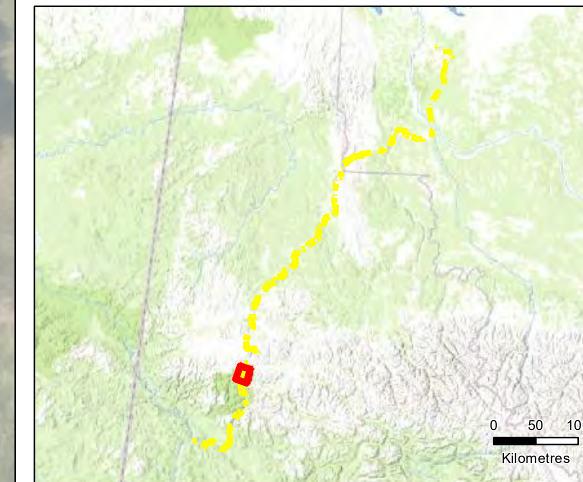
Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

- Stream Crossing

PREFERRED CONSTRUCTION TECHNIQUE

- Attach 63mm Conduit to Bridge
- Shallow Burial
- To Be Determined

Notes

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Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 Yukon Albers

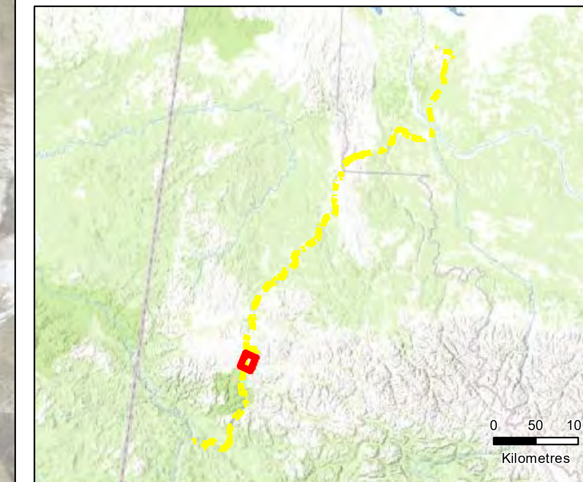
Page Size: 11" x 17"

103469-01	Production Date: Aug 14, 2019	Figure 9 of 28

Hemmera
An Ausenco Company

Dempster Fibre Project

Preferred Construction Technique Mapbook



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PREFERRED CONSTRUCTION TECHNIQUE

Shallow Burial

Notes

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103469-01	Production Date: Aug 14, 2019	Figure 10 of 28

Hemmera
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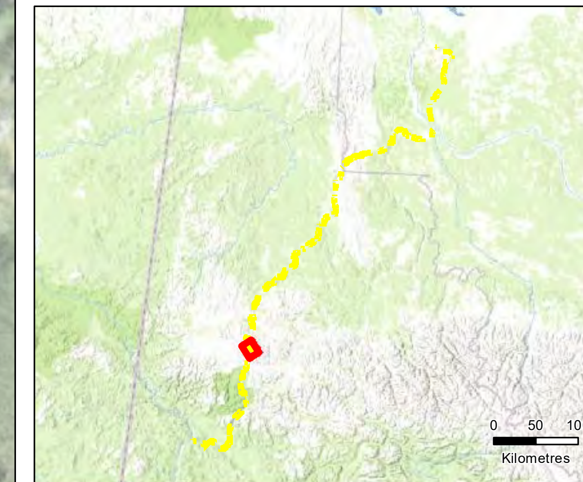
Dempster Fibre Project

Preferred Construction Technique Mapbook



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PREFERRED CONSTRUCTION TECHNIQUE

Shallow Burial

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103469-01	Production Date: Aug 14, 2019	Figure 11 of 28

Hemmera
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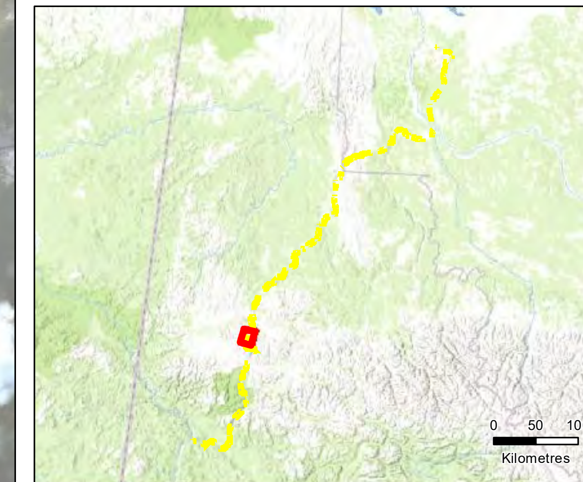
Dempster Fibre Project

Preferred Construction Technique Mapbook



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PREFERRED CONSTRUCTION TECHNIQUE

Shallow Burial

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103469-01	Production Date: Aug 14, 2019	Figure 12 of 28

Hemmera
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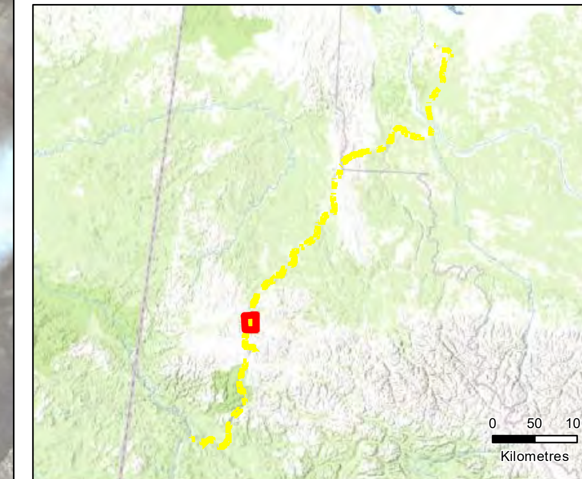
Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

- Stream Crossing

PREFERRED CONSTRUCTION TECHNIQUE

- A/E Crossing
- Shallow Burial
- Surface-Laid Cable

Notes

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103469-01	Production Date: Aug 14, 2019	Figure 13 of 28

Hemmera
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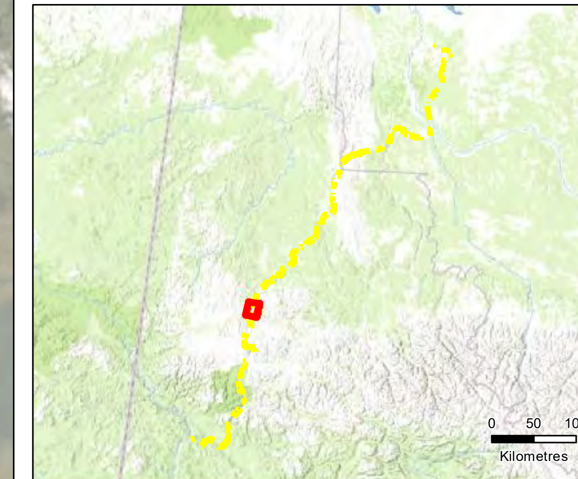
Dempster Fibre Project

Preferred Construction Technique Mapbook



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PREFERRED CONSTRUCTION TECHNIQUE

Surface-Laid Cable

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103469-01	Production Date: Aug 14, 2019	Figure 14 of 28

Hemmera
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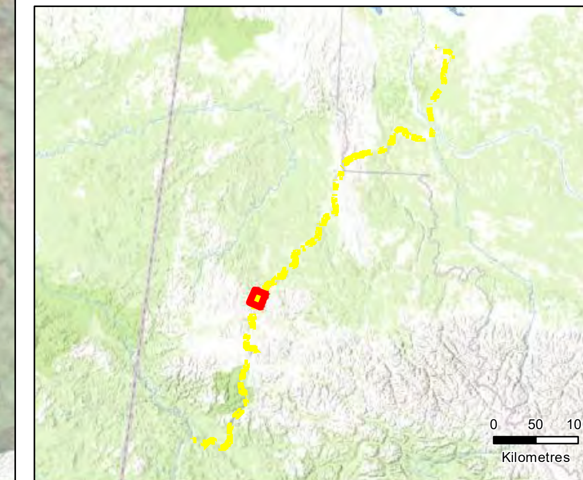

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PREFERRED CONSTRUCTION TECHNIQUE

Surface-Laid Cable

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103469-01	Production Date: Aug 14, 2019	Figure 15 of 28

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PREFERRED CONSTRUCTION TECHNIQUE
For Discussion Purposes Only

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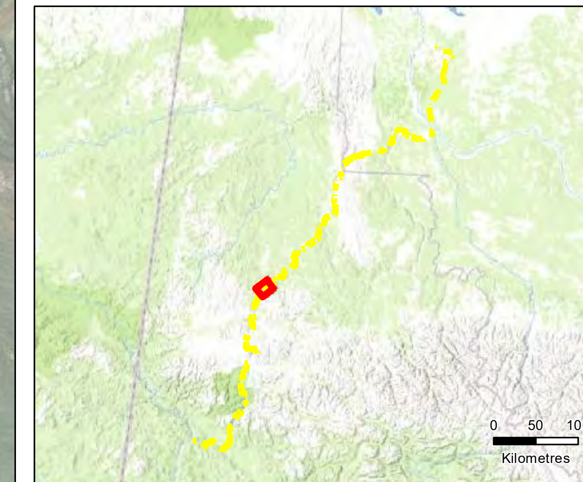
Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

PREFERRED CONSTRUCTION TECHNIQUE

- Shallow Burial
- Surface-Laid Cable

Notes

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NAD 1983 Yukon Albers

Page Size: 11" x 17"

103469-01	Production Date: Aug 14, 2019	Figure 16 of 28

Hemmera
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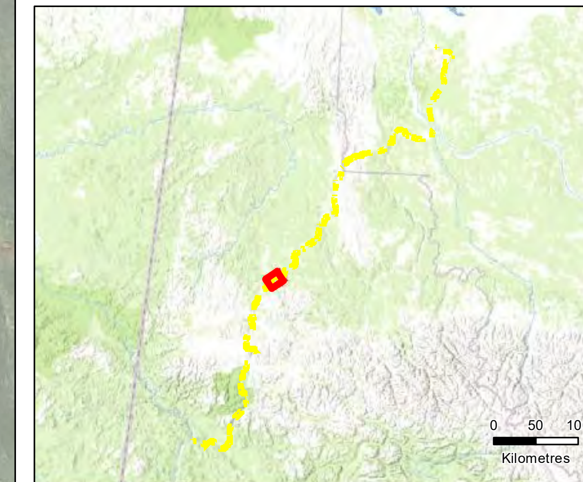
Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

PREFERRED CONSTRUCTION TECHNIQUE

- Shallow Burial
- Surface-Laid Cable

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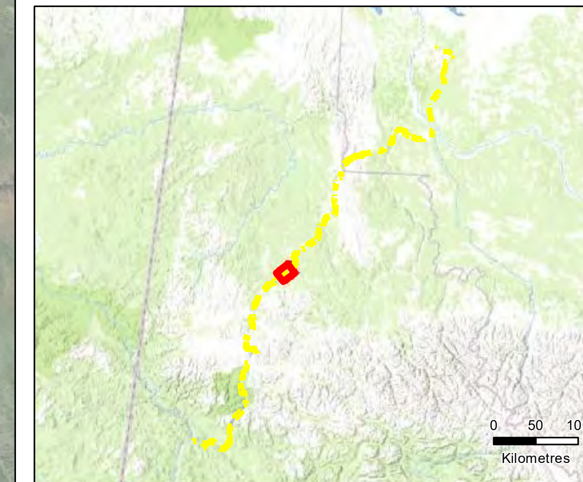
103469-01	Production Date: Aug 14, 2019	Figure 17 of 28

Hemmera
An Ausenco Company

Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

PREFERRED CONSTRUCTION TECHNIQUE

Surface-Laid Cable

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103469-01	Production Date: Aug 14, 2019	Figure 18 of 28

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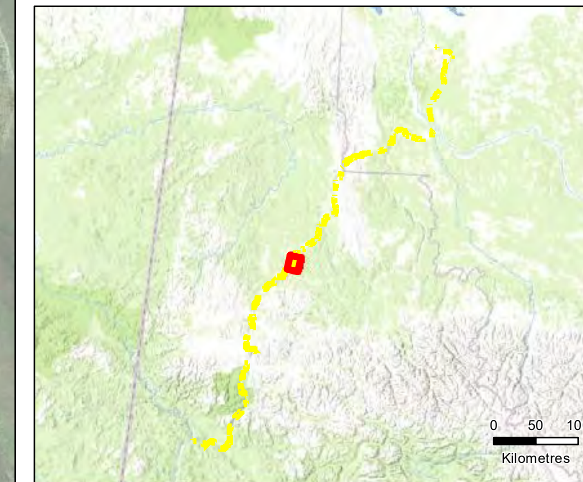
Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

PREFERRED CONSTRUCTION TECHNIQUE

- Surface-Laid Cable

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103469-01	Production Date: Aug 14, 2019	Figure 19 of 28

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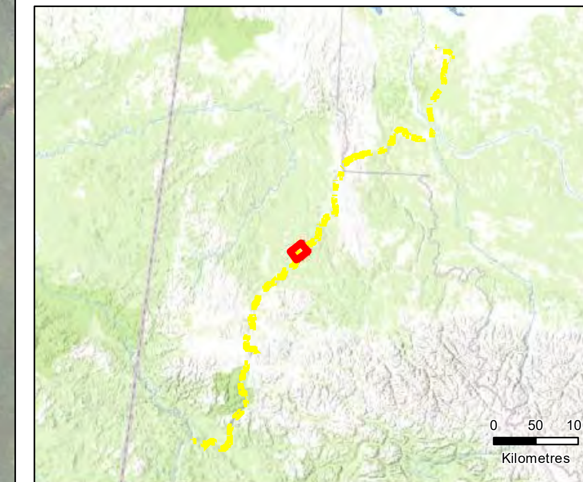
Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

PREFERRED CONSTRUCTION TECHNIQUE

- Surface-Laid Cable

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NAD 1983 Yukon Albers

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103469-01	Production Date: Aug 14, 2019	Figure 20 of 28

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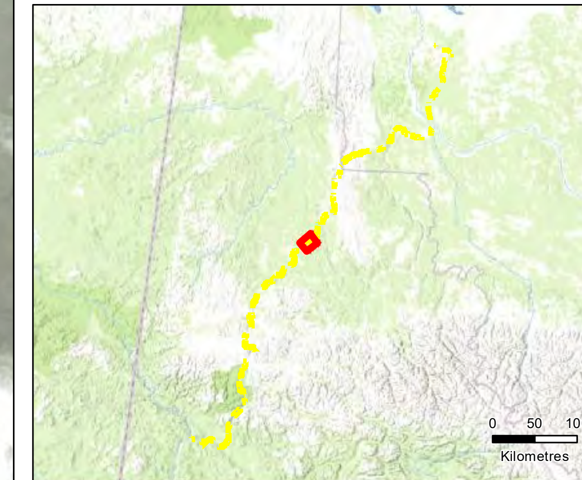
Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

PREFERRED CONSTRUCTION TECHNIQUE

Surface-Laid Cable

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Metres

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103469-01	Production Date: Aug 14, 2019	Figure 21 of 28

Hemmera
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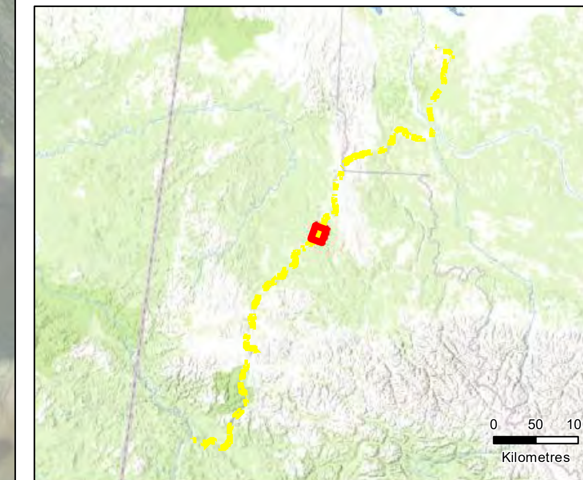
Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

PREFERRED CONSTRUCTION TECHNIQUE

Surface-Laid Cable

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103469-01	Production Date: Aug 14, 2019	Figure 22 of 28

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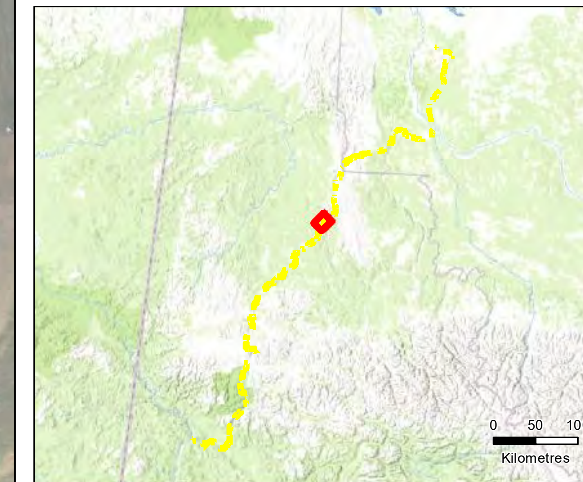
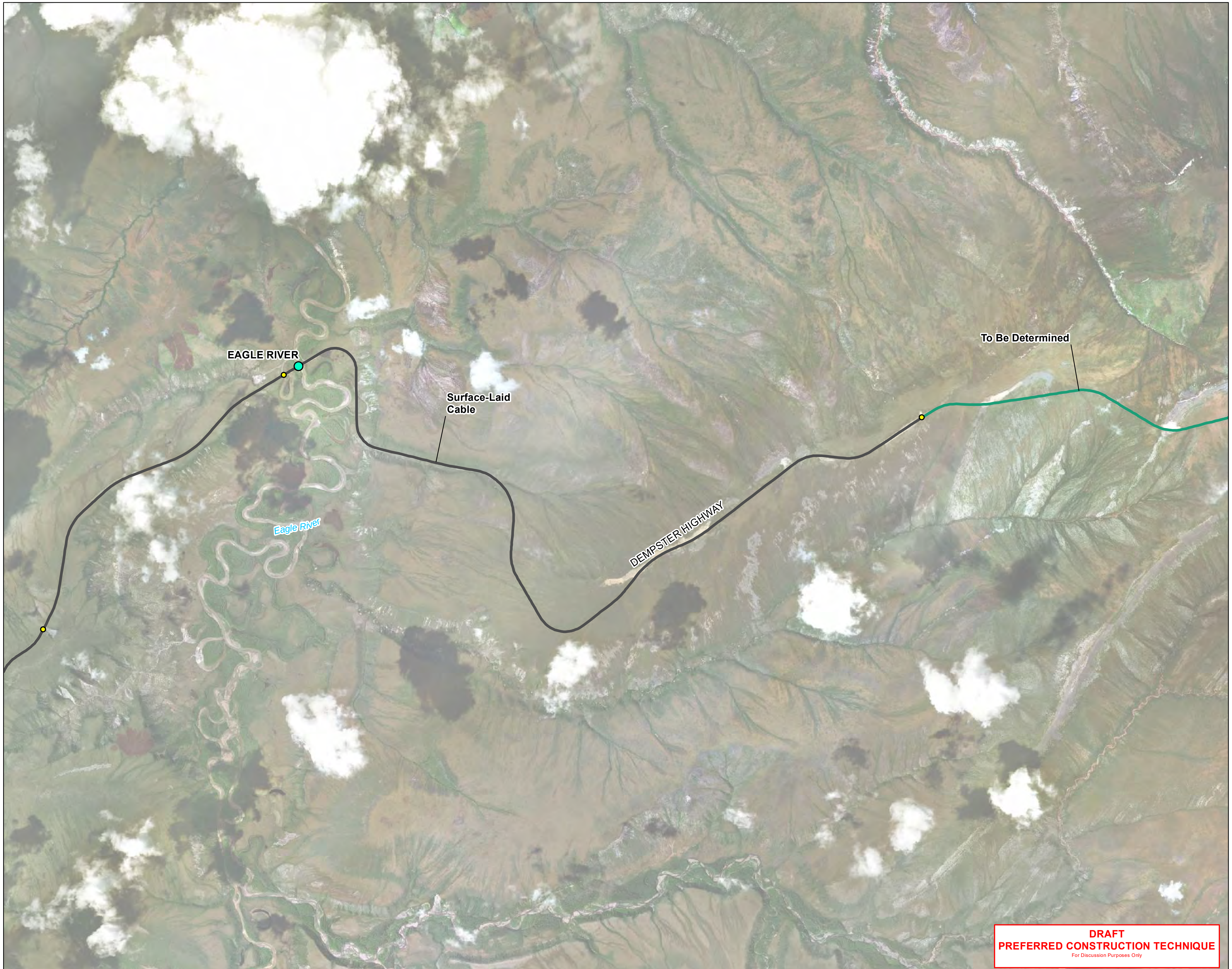
Dempster Fibre Project

Preferred Construction Technique Mapbook





Legend

Stream Crossing

PREFERRED CONSTRUCTION TECHNIQUE

Surface-Laid Cable

To Be Determined

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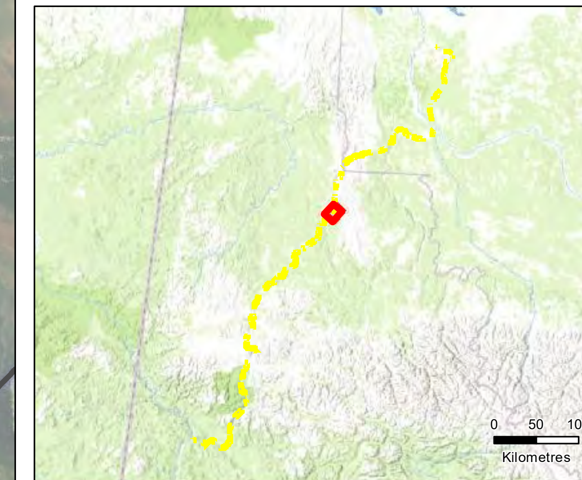
Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

Stream Crossing

PREFERRED CONSTRUCTION TECHNIQUE

Surface-Laid Cable

To Be Determined

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103469-01	Production Date: Aug 14, 2019	Figure 24 of 28

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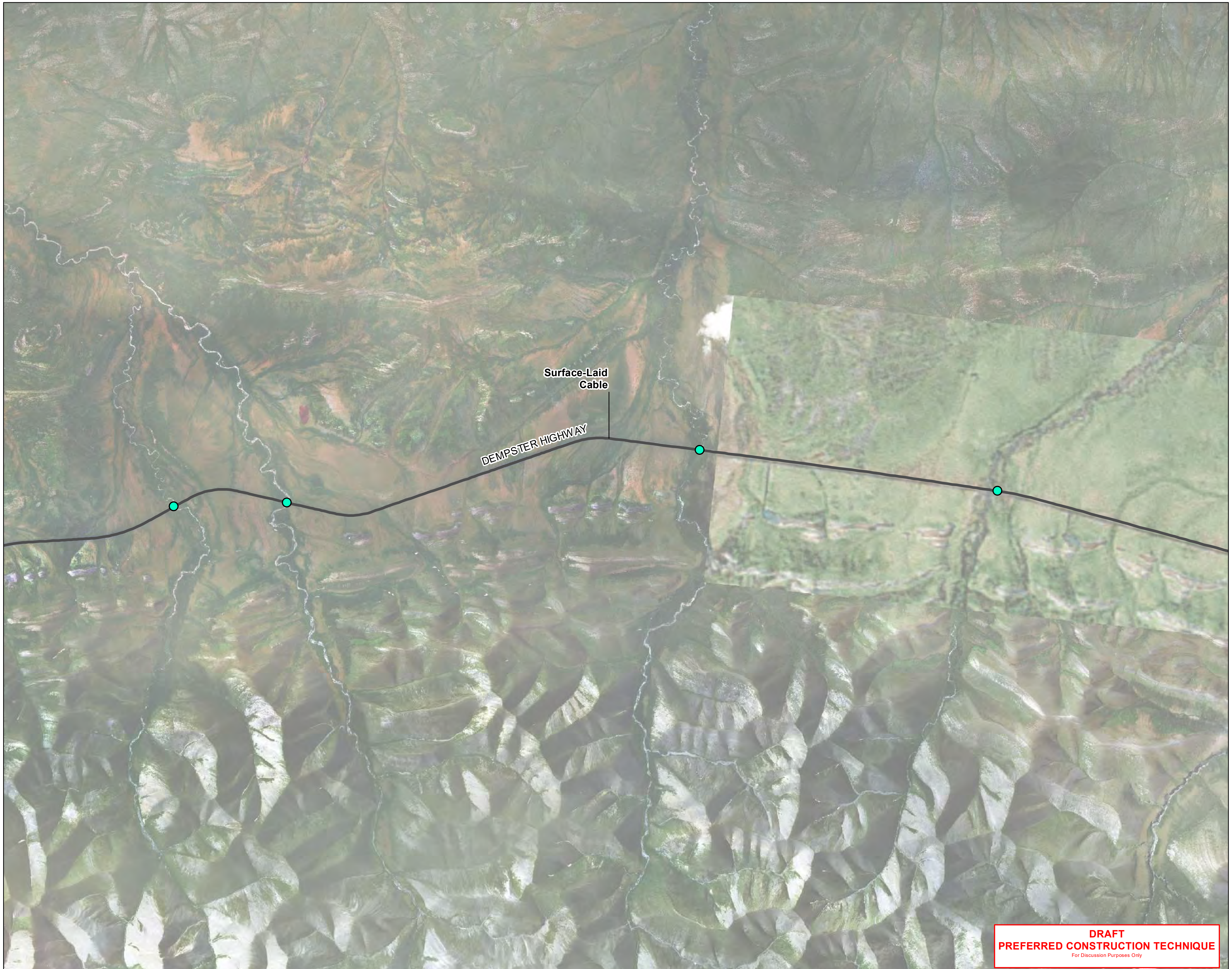
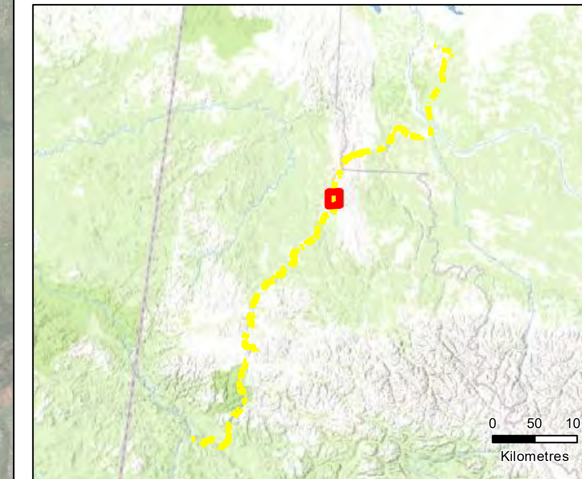


Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

Stream Crossing

PREFERRED CONSTRUCTION TECHNIQUE

Surface-Laid Cable

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103469-01	Production Date: Aug 14, 2019	Figure 25 of 28

Hemmera
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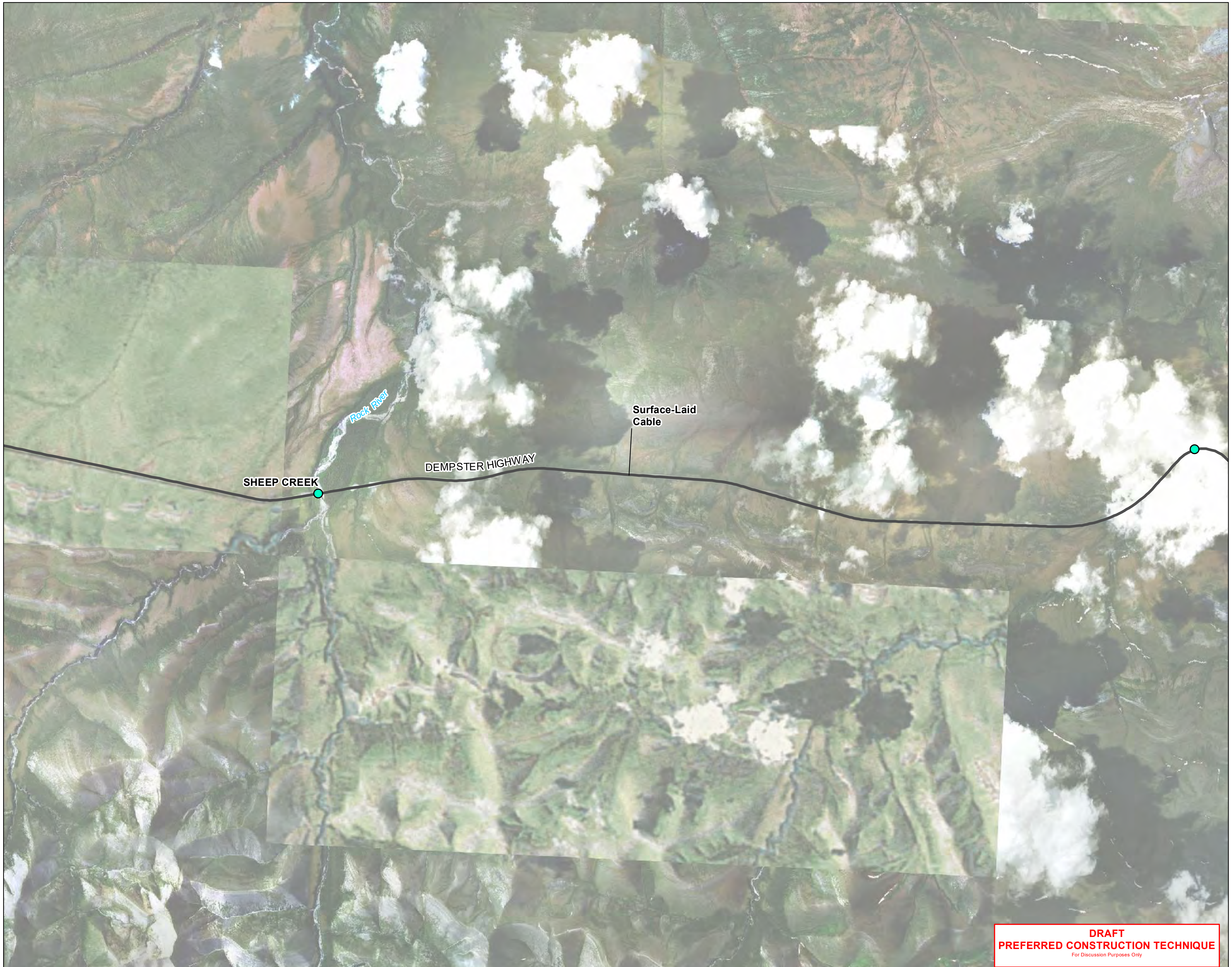
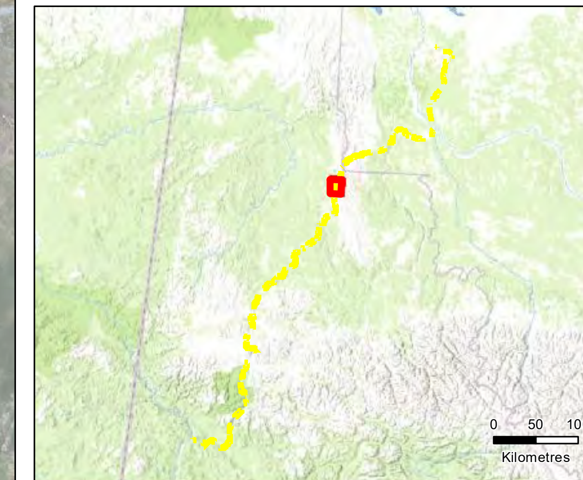


Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

Stream Crossing

PREFERRED CONSTRUCTION TECHNIQUE

Surface-Laid Cable

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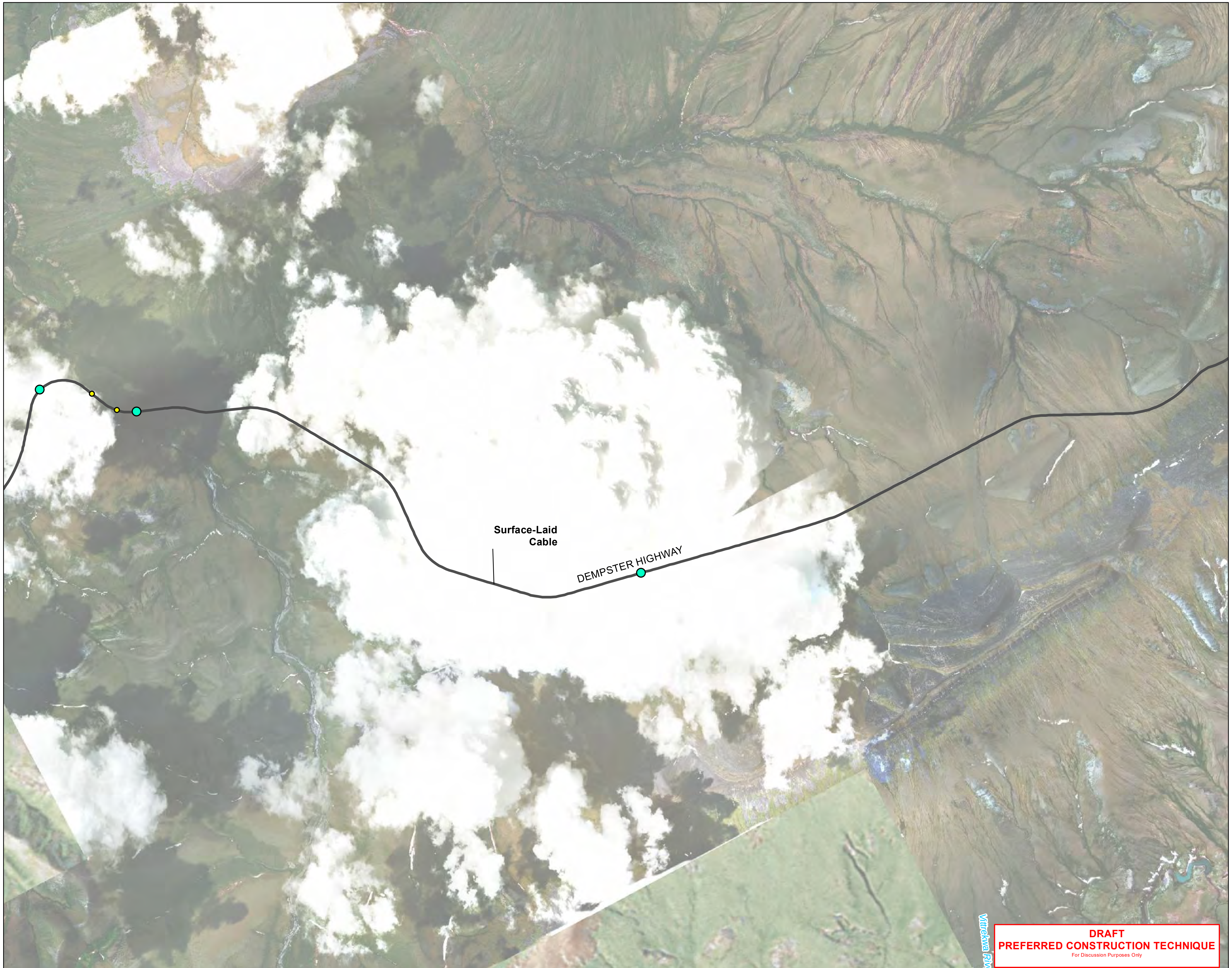
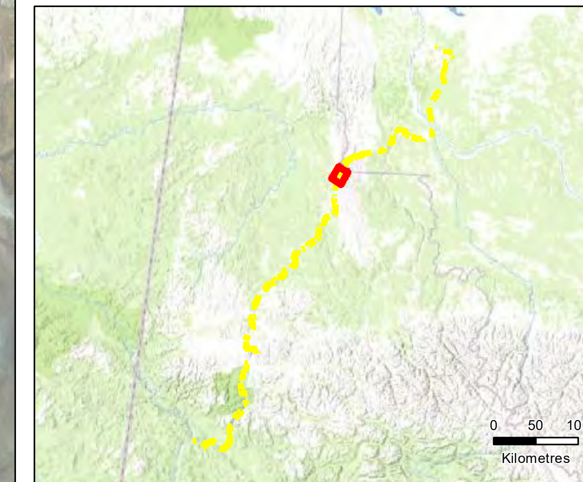


Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

Stream Crossing

PREFERRED CONSTRUCTION TECHNIQUE

Surface-Laid Cable

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NAD 1983 Yukon Albers

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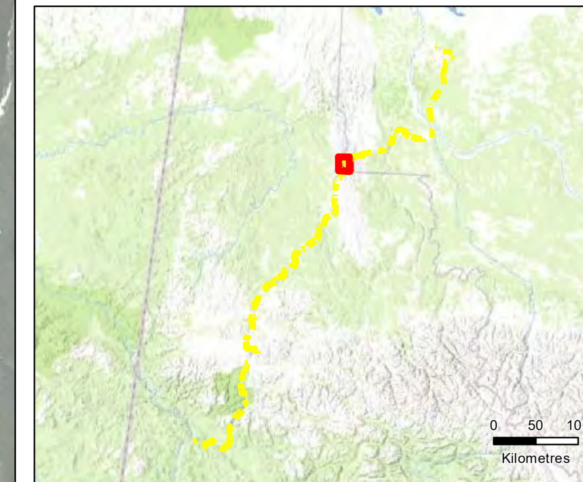
103469-01	Production Date: Aug 14, 2019	Figure 27 of 28

Hemmera
An Ausenco Company

Dempster Fibre Project

Preferred Construction Technique Mapbook



Legend

PREFERRED CONSTRUCTION TECHNIQUE

- A/E Crossing
- HDD
- Surface-Laid Cable

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NAD 1983 Yukon Albers

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103469-01	Production Date: Aug 14, 2019	Figure 28 of 28

Hemmera
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APPENDIX G
Sample Inspection Form

XX SAMPLE- Notice of Routine Maintenance Completion

Environmental – Fibre Route

Frequency: Bi- Annual

Date: ________/______/______mm/dd/yy

Technician: ____

Location: One form submitted for each location. This form for (check box):

o Segment 1	o Segment 2	o Segment 3
o Segment 4	o Segment 5	o Segment 6

Maintenance Action	Initial Completed	Comment On Condition Found	Further Action Taken or Required
Fibre Route Inspection			
1. Debris: o Check for debris not natural to the location. o Remove fallen trees if within 10' of any hand hole.			
2. Erosion: o Check for and document any exposed cable for reporting and subsequent remediation purpose for the following scenarios: § Wash outs § Erosion § Deep ruts § Check for blocked culverts and look for signs of water runoff and document/report potential hazards/concerns § Check condition of remediation solutions § Document and report on undermining of trees and local vegetation			

Maintenance Action	Initial Completed	Comment On Condition Found	Further Action Taken or Required
3. Brush: o Check growth of natural vegetation – Brushing on sites where applicable (e.g. handhold locations, existing cleared sites for repair equipment staging) o Allow natural vegetation to re-establish in accordance with Closure and Reclamation Plan			
4. Fire Tolerance: o Check for exposed fibreglass of the tub in hand holes to ensure coverage o Ensure lids are closed o Check to ensure no fallen trees or local vegetation within 10' of plant facilities that increase chance of fire damage			
5. At bridge structures, check condition of: o Cable route markers (at maximum distance of 50m between each marker at all bridges; check for clear visibility of markers) o Fibre tags on conduit on bridges o Attachments for physical damage o Photograph visible structures o Check integrity of steel conduit running on the ground			
6. Splice Enclosures, Hand holes & Poles and Anchors: o Check condition of each splicing chamber: o Ensure they are closed properly and sealed o For Hand holes, ensure splice enclosures are sealed properly and check for moisture o Visual inspection of facilities to report on any physical damage (where applicable) o Report any pole damage, brushing requirements etc. to pole owners			

Maintenance Action	Initial Completed	Comment On Condition Found	Further Action Taken or Required
7. Water Crossings: o Remove obstacles, branches and fallen trees o Check for exposed cables in creek bed as part of visual inspections o Locate and record depth for comparison purposes with construction specs			
8. Video/Photo Record: o Check for quality of video/photo recorded o Compare critical sites year over year			

Attach scanned / photographed copy to vFire ticket upon completion of this inspection.

APPENDIX H
Consultation Plan

DRAFT Consultation Plan

Name of Proponent: Department of Highways and Public Works

Name of Affected Party:

When will you be engaging?	What is the purpose for engaging?	Who will be engaged at each of these stages?	How will you engage?
What is the trigger for engagement?	*In relation to the trigger, what will you be discussing (e.g. updates to design or plans etc.)?*	*The people engaged at each stage may vary depending on what is being discussed*	*Which engagement methods will be used?*
At any time, the affected party may initiate additional engagement activities via written communication (letter, email, fax) to HPW.			
Completion of regulatory processes	• Project updates	• Indigenous organizations	• Written communication (letter or email)
Initiation of procurement activities	• Project updates • Project related training and employment opportunities	• Indigenous organizations • Community	• Meetings • Open houses
Initiation of construction activities	• Project updates	• Indigenous organizations	• Written communication (letter or email)
Monitoring reports	• Reports from environmental monitors	• Indigenous organizations	• Written communication (letter or email)
Bi-annually after the winter and summer construction seasons	• Project updates • Potential issues arising during construction	• Indigenous organizations	• Written communication (letter or email signalling an interest in meeting) • Meetings (if requested)
Completion of construction	• Project updates	• Indigenous organizations	• Written communication (letter or email)
Annually post-construction	• Potential issues arising during operation and maintenance	• Indigenous organizations	• Written communication (letter or email signalling an interest in meeting) • Meetings (if requested)
Permit Reporting Requirements	• Project updates • Potential issues	• Indigenous organizations	• Written communication (letter or email signalling an interest in meeting) • Meetings (if requested)

APPENDIX I
Spill Contingency Plan

DEMPSTER FIBRE PROJECT

Spill Contingency Plan

Photo Credit: Devon Yacura, 2018

Submitted to:

Yukon Environmental and Socio-Economic Assessment Board, Dawson City Designated Office
Bag 6050
Dawson City, Y0B 1G0

Submitted by:

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Project No. 103469-01

July 9, 2019

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1.0 PROJECT BACKGROUND

The proposed Dempster Fibre Project (DFP) is a Yukon Government-driven project intended to provide a redundancy loop, known as a fibre ring, for 39 terrestrial-served and 36 satellite-served northern communities in BC, Yukon, NWT, and Nunavut. This loop will be completed by running an 800 km length of fibre cable along the Klondike Highway from Dawson City, YT, to the Dempster Highway junction, then north up the Dempster Highway to Inuvik, NWT. The fibre cable will connect to the recently constructed Mackenzie Valley Fibre Link (MVFL) at Inuvik. Once complete, 78% of northern communities will benefit from the redundant loop created by this Project.

The Dempster Highway extends for 735 km from the Dempster Highway junction, 40 km east of Dawson City, to Inuvik, NWT. Other than Inuvik, there are two communities along the Dempster Highway: Fort McPherson and Tsiigehtchic, both located in the NWT. There are two river crossings along the highway at the Peel and Mackenzie Rivers that require ferry crossings during the summer and ice road crossings during the winter. The Peel River is located at Fort McPherson and the Mackenzie River at Tsiigehtchic. The highway is located within a legally defined 60 m-wide right-of-way (ROW). Both the Yukon Government – Department of Highways and Public Works and the Government of Northwest Territories – Department of Infrastructure exercise authority over the operation and maintenance of the Dempster Highway in Yukon and the Northwest Territories, respectively.

To the extent practical, the design specifications for construction of the fibre optic cable and conduit will be installed within the highway ROW but away from the existing highway structure. In some instances, the cable may be required to be installed within the existing highway structure (prism). When this occurs, the design will aim to minimize the risk to the highway structure while taking constructability into consideration as well as life cycle cost and maintainability of the cable.

Due to the variability of conditions encountered along the Dempster Highway, a variety of construction and installation techniques will be employed to successfully install the fibre optic cable including the following:

- Conventional buried cable using heavy equipment to install the conduit and cable at a depth of between 600 mm – 1,000 mm below ground.
- Shallow direct-buried cable using cable plowing techniques in non-frozen conditions.
- Surface-laid cable in sensitive terrain and wetland areas in non-frozen and frozen conditions.
- Horizontal Directional Drilling (HDD) of fish-bearing streams, rivers, other waterbodies and challenging sections.
- Aerial cable installation in selected sensitive or challenging construction areas.
- Aerial cable installation along Yukon Energy Transmission Line poles for approximately 28 km adjacent to the Klondike Highway and over Australia Hill.

1.1 Company Name, Location and Mailing Address

Yukon Government
Highways and Public Works
P.O. Box 2703 (W-5)
Whitehorse, YT Y1A 2C6
Main Contact: Darryl Froese – Project Manager
Phone: (867) 667-3089
Email: Darryl.froese@gov.yk.ca

1.2 Effective Date of Spill Contingency Plan

The Spill Contingency Plan will be in effect for the duration of the Project for all phases including construction, operation and maintenance. The plan will be in effect from the date of issue of the permit and will expire on the date that the permit is closed.

1.3 Purpose and Scope

The purpose of this plan is to outline response actions for potential spills of any size, including a worst-case scenario for Yukon Government (YG) and their contractor(s) at the work site. The plan identifies key response personnel and their roles and responsibilities in the event of a spill, as well as the equipment and other resources available to respond to a spill. The plan also details spill response procedures that will minimize potential health and safety hazards, environmental damage, and clean-up efforts. The plan has been prepared to ensure quick access to all the information required in responding to a spill.

1.4 Distribution List

This plan and the most recent revisions will be distributed to all staff and contractors working on the Project. The Plan will be presented and reviewed during a tailgate meeting prior to the start of construction. The Spill Contingency Plan will be included as part of new staff orientation activities.

1.5 Additional Copies

Several copies of the plan are to be kept on site at all times. A copy is also to be held at the YG office in Whitehorse and with the Yukon Environmental and Socio-Economic Assessment Board (YESAB). Additional copies of the plan can be obtained by contacting YG directly at the phone number or email presented in Section 1.1.

1.6 List of Revisions

Any revisions to the plan will be submitted to YESAB for approval and regulating agencies prior to implementing any changes.

1.7 Licences, Permits and Fees

All fuels and hazardous wastes related to the construction, operation and maintenance of the DFP will be handled, stored and disposed of in accordance with this Plan and all applicable federal, territorial, and municipal laws and regulations. YG and its contractor(s) will be responsible for any required fees, licences, and permits.

1.8 Hazardous Materials Stored On-Site

The construction phase will require the use of diesel and gasoline fuel for mobile equipment and camp facilities. All fuel needed for the Project will be supplied by standard fuel trucks and distributed as needed with pick-up trucks equipped with tidy tanks. Estimated fuel type and storage locations are shows in **Table 1**. A final list of fuel and storage requirements can be provided once the contractor is hired and prior to construction.

Diesel will be used for the majority of fueling. Gasoline will be used to fuel pick-up trucks and potentially for generators at the camps. Propane will be used for heating at the camps.

Table 1 Estimated Fuel and Fuel Storage Requirements

Fuel Type and Location	Containment Requirements (L)	Containment Type	Amount	Secondary Containment
Diesel p-50 (ULSDF): at staging areas	3,400	Double-walled fuel tank	2	Secondary tank and/or external secondary containment area
Diesel p-50 (ULSDF) at staging areas:	2,250	Double-walled fuel tank	2	Double-walled and/or external secondary containment
Diesel drums on trucks	235	Double-walled fuel tank	4	Secondary tank and/or external secondary containment area
Diesel drums at staging areas	235	New steel drums	20	Steel or polyurethane tub designed to hold 110% of the total volume and/or secondary containment area.
Gasoline (mid-grade) at staging areas	235	New steel drums	4	Steel or polyurethane tub designed to hold 110% of the total volume and/or secondary containment area.
Oils and Grease at staging areas	22	Polyurethane pail	20	Steel or polyurethane tub designed to hold 110% of the total volume stored.
Propane at camps	375	Propane Cylinder	10	n/a

1.9 Preventive Measures

Along with the preventative measures outlined below, adequate training of all staff and contractors is paramount. Site specific spill prevention and spill response measures are to be discussed as part of the health and safety meetings to be held at the beginning of each field day.

Spill kits will be located wherever fuel is stored or used on-site. See **Section 4** for details on spill kit contents. Portable drip trays and appropriately sized fuel transfer hoses with pumps are to be used when refueling vehicles and equipment to avoid any leaks/drips onto the land. In order to prevent spill occurrences, the following spill prevention measures and general precautions are to be employed at the various installation sites:

- Truck and equipment inspections should be performed on a regular basis (i.e., daily);
- Leak checks should be performed for motorized vehicles and other equipment on a regular basis throughout the term of the installation activities;
- Spill containment equipment should be inspected prior to use and regularly thereafter;
- Secondary containment measures should be in place at required locations;
- Personal protective equipment (PPE) should be worn at all times when handling hazardous materials;
- SDS should be readily available for all hazardous materials present on-site;
- Spill kits should be readily available for fuel/oil spills; and
- Inspection checklists should be prepared and followed by appropriate personnel.

2.0 RESPONSE ORGANIZATION

The flow chart depicted in **Figure 1** below identifies the response organization, and when applicable, their alternates, as well as the chain of command for responding to a spill or release. The duties of various response personnel are summarized, contact information is provided in **Section 4.2** (including 24-hour phone numbers).

An immediately reportable spill is defined as a release of a substance that is likely to be an imminent environmental or human health hazard or meets or exceeds the volumes outlined in **Attachment 1**. It will be reported to the YT 24-Hour Spill Report Line at (867) 667-7244. Any spills less than these quantities do not need to be reported immediately to the spill reporting line. Rather, these minor spills will be tracked and documented by YG and their contractor(s) and submitted to the appropriate authority either immediately upon request or at a pre-determined reporting interval. If there is any doubt that the quantity spilled exceeds reportable levels, the spill will be reported to the YT 24-Hour Spill Report Line.

In the event of a spill involving danger to human life, satellite phones or cell phones will be used to contact emergency response personnel in Inuvik, Dawson City or Whitehorse. The spill will be immediately reported by personnel to YG, and the NT 24-hour Spill Report Line.

Reportable quantities for hazardous spills are provided in **Attachment 1** and defined in Schedule A of the Yukon Environment Act Spill Regulations: http://www.gov.yk.ca/legislation/regs/oic1996_193.pdf.

2.1 Flow Chart of Response Organization

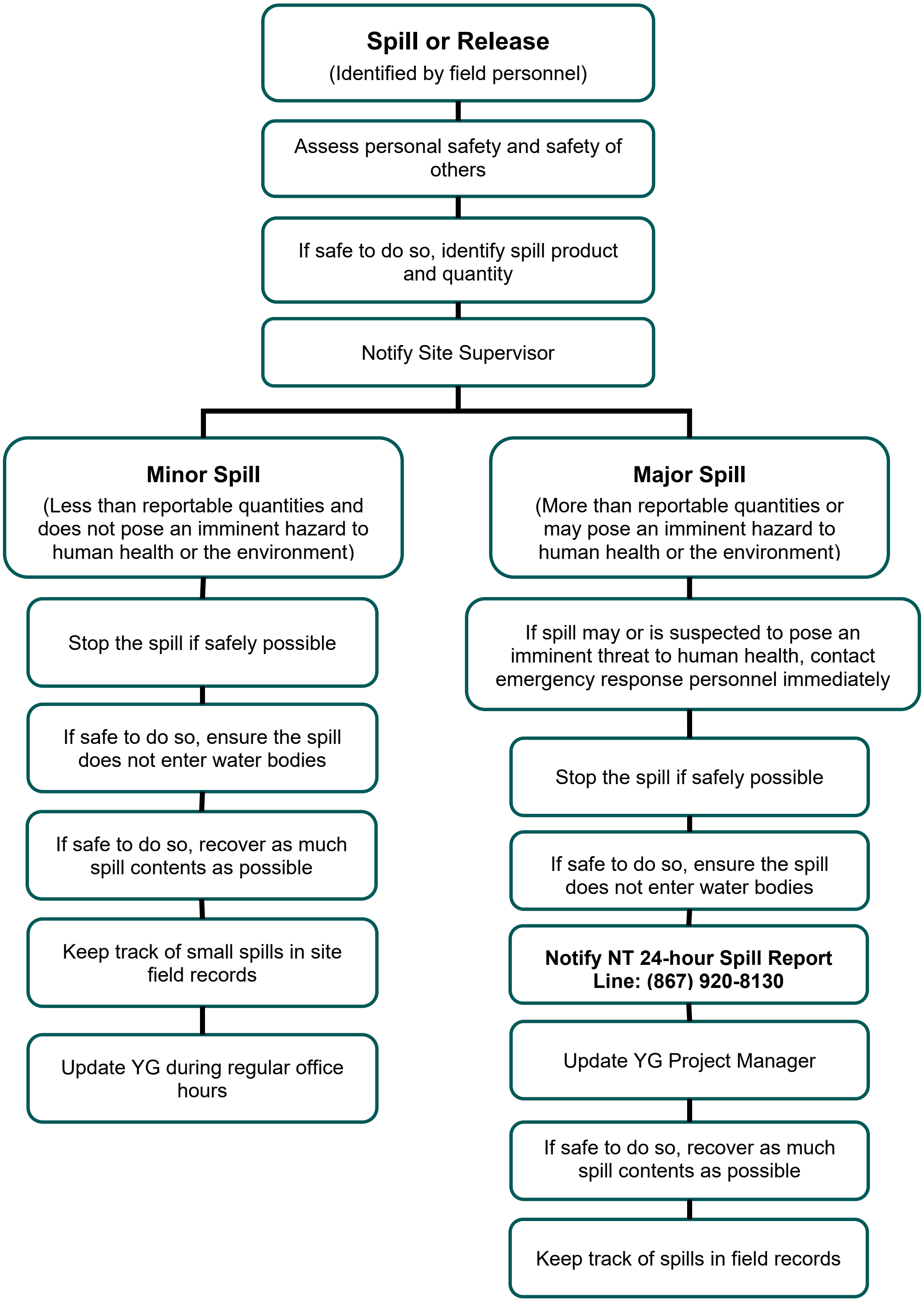

Figure 1 Flow Chart of Response Organization in the Event of a Spill

3.0 ACTION PLAN

3.1 Potential Spill Sizes and Sources for Hazardous Material On-Site

In **Table 2**, a list of potential discharge events, with associated discharge volumes and directions is presented for the primary hazardous materials stored on site. The most likely discharge volume is indicated and the spill clean up procedures will focus on spills of this quantity. A worst-case scenario is also presented. Specific discharge rates are not indicated for each fuel type as these would vary from a few minutes to several hours, based on the source of leak or puncture.

Table 2 List of Hazardous Materials, Potential Discharge Events, Potential Discharge Volumes (worst case scenarios in brackets) and Direction of Potential Discharge

Material (sources)	Potential Discharge Event	Discharge Volume (worst case)	Direction of Potential Discharge
Diesel Fuel (trucks, equipment)	1) Over pumping of fuel from fuel truck into equipment 2) Leaking from equipment 3) Fuel service truck accident	Likely under 1 L (Maximum 43,000 L, assuming the largest available fuel service truck)	Based on local topography, it is likely that petroleum hydrocarbons discharged into the environment would pool in low lying areas in the vicinity of the refueling truck.
Gasoline (trucks, ATVs, snow machines)	1) Leaking from equipment	Likely under 1 L (Maximum 75 L)	Based on local topography, it is likely that petroleum hydrocarbons discharged into the environment would pool in low lying areas in the vicinity of the refueling truck.
Propane (storage container)	1) Leaking from storage container	Likely under 1 L (Maximum 375 L)	It is likely that propane will discharge into the air and should dissipate immediately.
Engine Oil (trucks and equipment)	1) Overfilling vehicle storage tanks. 2) Leaking from vehicles.	Likely under 1 L (Maximum 4 L)	Based on local topography, it is likely that engine oil discharged into the environment would pool in low lying areas in the vicinity of the vehicle where it leaked from.

3.2 Potential Environmental Impacts of Spill

For all hazardous materials discussed below, impacts are lower during winter as snow is a natural sorbent and ice forms a barrier limiting or eliminating soil or water contamination. Spills can be more readily recovered when identified and reported.

3.2.1 Diesel Fuel

Environmental impacts: Diesel may be harmful to wildlife and aquatic life. It is not readily biodegradable and has the potential for bioaccumulation in the environment. Diesel burns slowly and thus risk to the environment is reduced during recovery as burn can be more readily contained compared with volatile fuels. Runoff into water bodies must be avoided.

Worst case scenario: All fuel drums were punctured or open simultaneously and contents seeped into surrounding soil and water bodies. This could cause illness or death to aquatic life and indirectly affect wildlife feeding from the land and water.

3.2.2 Gasoline

Environmental impacts: Gasoline may be harmful to wildlife and aquatic life. It is not readily biodegradable and has the potential for bioaccumulation in the environment. Gasoline is quick to volatize. Runoff into water bodies must be avoided.

Worst case scenario: All fuel drums were punctured or open simultaneously and contents seeped into surrounding soil and water bodies. This could cause illness or death to aquatic life and indirectly affect wildlife feeding from the land and water.

3.2.3 Propane

Environmental impacts: None

3.2.4 Waste Oil and Miscellaneous Oil/Grease

Environmental impacts: Waste oils may be harmful to wildlife and aquatic life. It is not readily biodegradable and has the potential for bioaccumulation in the environment. Runoff into water bodies must be avoided.

Worst case scenario: All storage drums were punctured or open simultaneously and contents seeped into surrounding soil and water bodies. This could cause illness or death to aquatic life and indirectly affect wildlife feeding from the land and water.

3.3 Procedures for Initial Action

1. Be alert and consider your personal safety first.
2. Assess the hazard to persons in the vicinity of the spill and where possible, take action to control danger to human life (ensure safety for everyone).
3. Assess the situations and make arrangements for first aid and removal of injured personnel.

3.4 Procedures for Containing and Controlling the Spill (e.g., on land, water, snow, etc.)

If safe to do so, follow these steps:

1. Initiate spill containment by first determining what will be affected by the spill.
2. Assess speed and direction of spill and cause of movement (water, wind and slope).
3. Determine best location for containing spill, avoiding any waterbodies.
4. Have a contingency plan ready in case spill worsens beyond control or if the weather or topography impedes containment.

3.4.1.1 Containment of Spills on Land

Spills on land include spills on rock, gravel, soil and/or vegetation. It is important to note that soil is a natural sorbent; thus, spills on soil are generally less serious than spills on water as contaminated soil can be more easily recovered. Generally, spills on land occur during the late spring, summer or fall when snow cover is at a minimum. It is important that all measures be undertaken to avoid spills reaching open water bodies.

1. In the event of a spill, any person who found it should report this to the Site Supervisor.
2. The Site Supervisor should, upon notification, determine the source, the extent and size of the spill. The Site Supervisor is responsible to take the appropriate action and alert the necessary people.
3. Use the reporting procedures to notify the proper authorities.
4. If the area in which the spill occurred is accessible to the public or domestic pets, the contaminated area must be clearly marked or cordoned off to restrict access. Keep children and interested bystanders away from cleanup activities.
5. Protective clothing (at a minimum, rubber or latex gloves, safety goggles and rubber boots) should be worn when cleaning up a spill. (Dispose of gloves and wash rubber boots and safety goggles when leaving spill site)
6. Assess speed and direction of spill.
7. Determine best location for containing spill.
8. In all cases of liquid spills, the initial containment step is to prevent further dispersion. This is done with cut-off ditches and dyking with soil as needed around the spill utilizing mobile heavy equipment. If necessary, absorbents (e.g., Zorbal, Hazorb Pillows, peat moss, sawdust) or gelling agents (e.g., Chemgel) should be spread to prevent further spread or seepage.
9. Dykes can be created using soil surrounding a spill on land. These dykes are constructed around the perimeter or down slope of the spilled fuel. A dyke needs to be built up to a size that will ensure containment of the maximum quantity of fuel that may reach it. Fuels that pool up can be removed with sorbent materials or by pump (be sure to use a proper hose and pump rated for the specific contaminant) into barrels. If the spill is migrating very slowly a dyke may not be necessary and sorbents can be used to soak up fuels before they migrate away from the source of the spill.
10. If you cannot build a dyke, trenches can be dug out to contain spills as long as the top layer of soil is thawed. Shovels, pick axes or a loader can be used depending on the size of trench required. It is recommended that the trench be dug to the bedrock or permafrost, which will then provide containment layer for the spilled fuel. Fuel can then be recovered using a pump (be sure to use a proper hose and pump rated for the specific contaminant) or sorbent materials. Once the soil has been removed, it should be replaced with clean soil to avoid slumping.

3.4.1.2 Containment of Spills on Open Water

Spills on water such as rivers, streams or lakes are the most serious types of spills as they can negatively impact water quality and aquatic life. All measures need to be undertaken to contain spills on open water.

For spills in open water, containment procedures will vary depending on whether the material floats or sinks, and whether the water is flowing or standing.

1. In the event of a spill, any person who found it should report this to the Site Supervisor.
2. The Site Supervisor should, upon notification, determine the source, the extent and size of the spill. Therefore, the Site Supervisor is responsible to take the appropriate action and use the reporting procedures to notify the proper authorities.

3. If the area in which the spill occurred is accessible to the public or domestic pets, the contaminated area must be clearly marked or cordoned off to restrict access. Keep children and interested bystanders away from cleanup activities.
4. Protective clothing (at a minimum, rubber or latex gloves, safety goggles and rubber boots) should be worn when cleaning up a spill. (Dispose of gloves and wash rubber boots and safety goggles when leaving spill site)
5. Assess speed and direction of spill.
6. Determine best location for containing spills.
7. For floating materials, a surface boom shall be deployed. Booms are commonly used to recover fuel floating on the surface of a lake or slow-moving streams. They are released from the shore of a water body to create a circle around the spill. If the spill is away from the shoreline, a boat will need to be used to reach the spill and the boom can be set out. More than one boom may be used at once. Booms may also be used in streams and should be set out at an angle to the current. Booms are designed to float and some have sorbent materials built into them to absorb fuels at the edge of the boom. Fuel contained within the circle of the boom will need to be recovered using sorbent materials or pumps (be sure to use a proper hose and pump rated for the specific type of contaminant) and placed into barrels for disposal. If a boom cannot be installed, weirs may be constructed, especially in shallow areas.
8. Weirs can be used to contain spills in streams and to prevent further migration downstream. Plywood or other materials found on-site can be placed into and across the width of the stream, such that water can still flow under the weir. Spilled fuel will float on the water surface and be contained at the foot of the weir. It can then be removed using sorbents, booms or pumps (be sure to use a proper hose and pump rated for the specific contaminant) and placed into barrels.
9. The Site Supervisor will have to judge whether the impact of the spill will be most reduced by carrying out a containment procedure or by immediately attempting to remove any contaminant from the water. This will depend on the equipment available and how long it will take for additional equipment to arrive. Removed contaminants should be placed on an impermeable contained surface (example poly liner in a depression) or an overpack drum to prevent further seepage.

3.4.1.3 Containment of Spills on Ice

Spills on ice are generally the easiest spills to contain due to the predominantly impermeable nature of the ice. For spills on ice, containment procedures will vary depending on whether the material stays on the ice or sinks into it.

1. In the event of a spill, any person who found it should report this to the Site Supervisor.
2. The Site Supervisor should, upon notification, determine the source, the extent and size of the spill. The Site Supervisor is responsible to take the appropriate action and alert the necessary people.
3. Use the reporting procedures to notify the proper authorities.
4. If the area in which the spill occurred is accessible to the public or domestic pets, the contaminated area must be clearly marked or cordoned off to restrict access. Keep children and interested bystanders away from cleanup activities.
5. Protective clothing (at a minimum, rubber or latex gloves, safety goggles and rubber boots) should be worn when cleaning up a spill. (Dispose of gloves and wash rubber boots and safety goggles when leaving spill site)

6. Assess speed and direction of spill.
7. Determine best location for containing spill.
8. Spills on ice can be affected by the strength of the ice and the floating or sinking characteristics of the materials. The safe bearing capacity of ice must be carefully assessed.
9. If the spill does not penetrate the ice, and the ice is safe to work on, sorbent materials can be used to soak up spilled fuel. Remaining contaminated ice/slush can be scraped and shoveled into a barrel. However, all possible attempts should be made to prevent spills from entering ice covered waters as no easy method exists for containment and recovery of spills if they seep under ice.
10. If the spill penetrates the ice, dykes can be used to contain fuel spills on ice. By collecting surrounding snow, compacting it, mounding it and watering it down to form a dyke down slope of the spill, a barrier is created thus helping to contain the spill. The collected fuel can then be pumped (be sure to use a proper hose and pump rated for the specific contaminant) into barrels or collected with sorbent materials.
11. For significant spills on ice, trenches can be cut into the ice surrounding and/or down slope of the spill such that fuel is allowed to pool in the trench. It can then be removed via pump (be sure to use a proper hose and pump rated for the specific contaminant) into barrels, collected with sorbent materials, or mixed with snow and shoveled into barrels.

3.4.1.4 Containment of Spills on Snow

Snow is a natural sorbent; thus, as with spills on soil, spilled contents can be more easily recovered. Therefore, snow should be used as much as possible when it is available.

1. In the event of a spill, any person who found it should report this to the Site Supervisor.
2. The Site Supervisor should, upon notification, determine the source, the extent and size of the spill. The Site Supervisor is responsible to take the appropriate action and alert the necessary people.
3. Use the reporting procedures to notify the proper authorities.
4. If the area in which the spill occurred is accessible to the public or domestic pets, the contaminated area must be clearly marked or cordoned off to restrict access. Keep children and interested bystanders away from cleanup activities.
5. Protective clothing (at a minimum, rubber or latex gloves, safety goggles and rubber boots) should be worn when cleaning up a spill. (Dispose of gloves and wash rubber boots and safety goggles when leaving spill site)
6. Assess speed and direction of spill.
7. Determine best location for containing spill.
8. Small spills on snow can be easily cleaned up by raking and shoveling the contaminated snow into empty barrels, and storing these at an approved location.
9. Dykes can also be used to contain fuel spills on snow. By compacting snow down slope from the spill, mounding it to form a dyke and watering it down, a barrier is created thus helping to contain the spill. The collected fuel/snow mixture can then be shoveled into barrels, or collected with sorbent materials.

3.4.1.5 Worst Case Scenarios

Dealing with spilled fuel which exceeds the freeboard of a dyke or barrier would present a possible worst-case scenario. To contain the overflow, a trench or collection pit would have to be created downstream of the spill to contain the overflow. Another worst-case scenario would be an excessive spill on water that may be difficult to contain with the booms present at the site. In this case, an emergency response mobile unit would need to be called in to deal with the spill using appropriate equipment.

3.4.1.6 Fire or Explosion

1. In all cases, the first step is to clear people from the surrounding area. Particular care must be taken to prevent inhalation of vapors that are products of combustion.
2. When fire is associated with a spill of hazardous material, the local fire department must be the first responder to fire and explosion occurrence.
3. The fire department will take all the necessary measures to extinguish the fire.
4. If necessary, the fire department will construct dykes down slope from liquid spills, to minimize spreading of fire and contain unburned fluid. Foam, CO_2 or water will then be used as appropriate for the fire.

3.5 Procedures for Transferring, Storing, and Managing Spill-Related Wastes

In most cases, spill cleanups are initiated at the far end of the spill and contained moving toward the source of the spill. Sorbent socks and pads are generally used for small spill clean up. A pump with attached fuel transfer hose can suction spills from leaking containers or large accumulations on land or ice and direct these larger quantities into empty drums. Be sure to use a proper hose and pump rated for the specific fuel/contaminant. Hand tools such as cans, shovels, and rakes are also very effective for small spills or hard to reach areas. Heavy equipment can be used if deemed necessary, and given space and time constraints.

Used sorbent materials are to be placed in barrels for future disposal. All materials mentioned in this section are to be available in the spill kits that will be located at each site. Following clean up, any tools or equipment used will be properly washed and decontaminated, or replaced if this is not possible.

For most of the containment procedures outlined in **Section 3.4**, spilled petroleum products and materials used for containment will be placed into containers such as empty waste oil/fuel containers and sealed for proper disposal at an approved disposal facility.

3.6 Procedures for Restoring Affected Areas, Providing Regulators with Status Updates and Clean-up Completion

Once a spill of reportable size has been contained, YG will consult with the appropriate regulatory authorities to determine the level of clean-up required. The regulator may require a site-specific study to ensure appropriate clean up levels are met. Criteria that may be considered include natural biodegradation of oil, replacement of soil, and re-vegetation.

4.0 RESOURCE INVENTORY

4.1 On-Site Resources

Spill kits are to be available at site. The proposed content of the spill kit is described below.

Proposed Content of Spill Kit

- 30 socks/booms (3" X 4")
- 30 pillows (2 L)
- 24 dispersal bags
- 4 pairs gloves
- 2 boxes of disposable gloves (latex ornitrile)
- 2 pairs goggles
- 2 pairs Tyvek coveralls
- 4 shovels
- 2 spill signs
- 1 waste containment drum

This response kit should be designed to contain and collect up to 200 L of spilled fuel. If larger volumes need to be accommodated, additional spill response personnel will be contacted.

4.2 Off-Site Resources

Table 3 Off-Site Resource Information

Organization	Location/Contact	Number
YT – 24 Hour Spill Report Line	Environment Yukon Spill Report Centre	(867) 667-7244
Yukon Government	Darryl Froese	(867) 667-3089
RCMP	Emergency Number	(867) 777-1111

* 24-hour phone line

5.0 TRAINING PROGRAM

Orientation sessions will be held prior to beginning work at each site. These sessions will review:

- The location of the Spill Contingency Plan
- An overview of the Spill Contingency Plan
- The hazards of the materials stored-on site
- The location of spill kits on site, spill kit contents, and their use
- Procedure for containing spills
- Muster points
- Off-site resources

ATTACHMENT 1
Reportable Quantities for YT Spills

SCHEDULE A

ITEM	COLUMN 1 - SUBSTANCE SPILLED	COLUMN 2 - SPECIFIED AMOUNT
1.	Explosives of Class 1 as defined in section 3.9 of the Federal Regulations	any amount
2.	Flammable gases, of Division 1 of Class 2 as defined in section 3.11(a) of the Federal Regulations	Any amount of gas from a container larger than 100L, or where the spill results from equipment failure, error or deliberate action or inaction
3.	Non-flammable gases of Division 2 of Class 2 as defined in section 3.11(d) of the Federal Regulations	Any amount of gas from a container larger than 100L, or where the spill results from equipment failure, error or deliberate action or inaction
4.	Poisonous gases of Division 3 of Class 2 as defined in section 3.11(b) of the Federal Regulations	any amount
5.	Corrosive gases of Division 4 of Class 2 as defined in section 3.11(c) of the Federal Regulations	any amount
6.	Flammable liquids of Class 3 as defined in section 3.12 of the Federal Regulations	200 L
7.	Flammable solids of Class 4 as defined in section 3.15 of the Federal Regulations	25 kg
8.	Products or substances that are oxidizing substances of Division 1 of Class 5 as defined in sections 3.17(a) and 3.18(a) of the Federal Regulations	50 kg or 50 L
9.	Products or substances that are organic compounds that contain the bivalent "-0-0-" structure of Division 2 of Class 5 as defined in sections 3.17(b) and 3.18(b) of the Federal Regulations	1 kg or 1 L
10.	Products or substances that are poisons of Division 1 of Class 6 as defined in sections 3.19(a) to (e) and 3.20(a) of the Federal Regulations	5 kg or 5 L
11.	Organisms that are infectious or that are reasonably believed to be infectious and the toxins of these organisms as defined in sections 3.19(f) and 3.20(b) of the Federal Regulations	any amount
12.	Radioactive materials of Class 7 as defined by section 3.24 of the Federal Regulations	any discharge or a radiation level exceeding 10 mSv/h at the package surface and 200 mSv/h at 1 m from the package surface
13.	Products or substances of Class 8 as defined by section 3.24 of the Federal Regulations	5 kg or 5 L

ITEM	COLUMN 1 - SUBSTANCE SPILLED	COLUMN 2 - SPECIFIED AMOUNT
14.	Miscellaneous products or substances of Division 1 of Class 9 as defined by sections 3.27(1) and 2(a) of the Federal Regulations	50 kg or 50 L
15.	Miscellaneous products or substances of Division 2 of Class 9 as defined in section 3.27(1) and 2(b) of the Federal Regulations	1 kg or 1 L
16.	Miscellaneous products or substances of Division 3 of Class 9 as defined in section 3.27(1) and 2(c) of the Federal Regulations	5 kg or 5 L
17.	Special waste as defined in section 1 of the Special Waste Regulations	amounts specified in s. 3(1)(b) of Special Waste Regulations
18.	A pesticide as defined in section 2 of the *Environment Act*, but not including those pesticides and fertilizers listed in Schedule 4 of the Pesticide Regulations	5 kg or 5L
19.	Pesticides and fertilizers listed in Schedule 4 of the Pesticide Regulations	any amount

APPENDIX J
List of Bird Species

Appendix G: List of Bird Species

Common Name	*Scientific Name*	Expected Presence	Common Name	*Scientific Name*	Expected Presence
Red-throated Loon	*Gavia stellata*	Uncommon; Breeder	Bonaparte's Gull	*Chroicocephalus philadelphia*	Uncommon; Breeder
Pacific Loon	*Gavia pacifica*	Uncommon; Breeder	Mew Gull	*Larus canus*	Common; Breeder
Common Loon	*Gavia immer*	Uncommon; Breeder	Herring Gull	*Larus argentatus*	Uncommon; Breeder
Horned Grebe	*Podiceps auritus*	Uncommon; Breeder	Arctic Tern	*Sterna paradisaea*	Uncommon; Breeder
Red-necked Grebe	*Podiceps grisegena*	Uncommon; Breeder	Great Horned Owl	*Bubo virginianus*	Uncommon; Year-Round
Greater White-fronted Goose	*Anser albifrons*	Rare; Migrant	Northern Hawk Owl	*Surnia ulula*	Uncommon; Year-Round
Snow Goose	*Chen caerulescens*	Rare; Migrant	Great Gray Owl	*Strix nebulosa*	Rare; Year-Round
Canada Goose	*Branta canadensis*	Uncommon; Breeder	Short-eared Owl	*Asio flammeus*	Uncommon; Year-Round
Brant	*Branta bernicla*	Rare; Migrant	Boreal Owl	*Aegolius funereus*	Rare; Year-Round
Trumpeter Swan	*Cygnus buccinator*	Uncommon; Breeder	Common Nighthawk	*Chordeiles minor*	Rare; Breeder
Tundra Swan	*Cygnus columbianus*	Rare; Migrant	Belted Kingfisher	*Megaceryle alcyon*	Uncommon; Breeder
American Wigeon	*Anas americana*	Common; Breeder	Yellow-bellied Sapsucker	*Sphyrapicus varius*	Rare; Breeder
Mallard	*Anas platyrhynchos*	Common; Breeder	Hairy Woodpecker	*Picoides villosus*	Rare; Year-Round
Blue-winged Teal	*Anas discors*	Rare; Breeder	American Three-toed Woodpecker	*Picoides dorsalis*	Uncommon; Year-Round
Northern Shoveler	*Anas clypeata*	Uncommon; Breeder	Northern Flicker	*Colaptes auratus*	Common; Breeder
Northern Pintail	*Anas acuta*	Common; Breeder	Olive-sided Flycatcher	*Contopus cooperi*	Uncommon; Breeder
Green-winged Teal	*Anas crecca*	Common; Breeder	Western Wood-Pewee	*Contopus sordidulus*	Common; Breeder
Canvasback	*Aythya valisineria*	Uncommon; Breeder	Alder Flycatcher	*Empidonax alnorum*	Common; Breeder
Ring-necked Duck	*Aythya collans*	Uncommon; Breeder	Hammond's Flycatcher	*Empidonax hammondii*	Uncommon; Breeder
Greater Scaup	*Aythya marila*	Uncommon; Breeder	Say's Phoebe	*Sayornis saya*	Uncommon; Breeder
Lesser Scaup	*Aythya affinis*	Common; Breeder	Northern Shrike	*Lanius excubitor*	Uncommon; Breeder
Harlequin Duck	*Histrionicus histrionicus*	Uncommon; Breeder	Gray Jay	*Perisoreus canadensis*	Common; Year-Round
Surf Scoter	*Melanitta perspicillata*	Uncommon; Migrant	Common Raven	*Corvus corax*	Uncommon; Year-Round
White-winged Scoter	*Melanitta fusca*	Uncommon; Breeder	Horned Lark	*Eremophila alpestris*	Uncommon; Breeder
Long-tailed Duck	*Clangula hyemalis*	Common; Breeder	Tree Swallow	*Tachycineta bicolor*	Uncommon; Breeder
Bufflehead	*Bucephala albeola*	Common; Breeder	Violet-green Swallow	*Tachycineta thalassina*	Common; Breeder
Common Goldeneye	*Bucephala clangula*	Uncommon; Breeder	Bank Swallow	*Riparia riparia*	Uncommon; Breeder
Barrow's Goldeneye	*Bucephala islandica*	Uncommon; Breeder	Cliff Swallow	*Petrochelidon pyrrhonota*	Common; Breeder
Common Merganser	*Mergus merganser*	Uncommon; Breeder	Black-capped Chickadee	*Poecile atricapilla*	Rare; Year-Round

Appendix G: List of Bird Species

Common Name	*Scientific Name*	Expected Presence	Common Name	*Scientific Name*	Expected Presence
Red-breasted Merganser	*Mergus serrator*	Uncommon; Breeder	Boreal Chickadee	*Poecile hudsonica*	Common; Year-Round
Osprey	*Pandion haliaetus*	Rare; Breeder	American Dipper	*Cinclus mexicanus*	Rare; Year-Round
Bald Eagle	*Haliaeetus leucocephalus*	Uncommon; Breeder	Ruby-crowned Kinglet	*Regulus calendula*	Common; Breeder
Northern Harrier	*Circus cyaneus*	Uncommon; Breeder	Northern Wheatear	*Oenanthe oenanthe*	Rare; Breeder
Sharp-shinned Hawk	*Accipiter striatus*	Uncommon; Breeder	Townsend's Solitaire	*Myadestes townsendi*	Uncommon; Breeder
Northern Goshawk	*Accipiter gentilis*	Uncommon; Year-Round	Gray-cheeked Thrush	*Catharus minimus*	Uncommon; Breeder
Swainson's Hawk	*Buteo swainsoni*	Rare; Breeder	Swainson's Thrush	*Catharus ustulatus*	Common; Breeder
Red-tailed Hawk	*Buteo jamaicensis*	Uncommon; Breeder	Hermit Thrush	*Catharus guttatus*	Uncommon; Breeder
Rough-legged Hawk	*Buteo lagopus*	Rare; Breeder	American Robin	*Turdus migratorius*	Common; Breeder
Golden Eagle	*Aquila chrysaetos*	Common; Breeder	Varied Thrush	*Ixoreus naevius*	Common; Breeder
American Kestrel	*Falco sparverius*	Uncommon; Breeder	American Pipit	*Anthus rubescens*	Common; Breeder
Merlin	*Falco columbarius*	Rare; Breeder	Bohemian Waxwing	*Bombycilla garrulus*	Uncommon; Breeder
Gyrfalcon	*Falco rusticolus*	Uncommon; Year-Round	Orange-crowned Warbler	*Oreothlypis celata*	Common; Breeder
Peregrine Falcon	*Falco peregrinus*	Uncommon; Breeder	Yellow Warbler	*Setophaga petechia*	Common; Breeder
Ruffed Grouse	*Bonasa umbellus*	Uncommon; Year-Round	Yellow-rumped Warbler	*Setophaga coronata*	Common; Breeder
Spruce Grouse	*Falcipennis canadensis*	Uncommon; Year-Round	Townsend's Warbler	*Setophaga townsendi*	Rare; Breeder
Willow Ptarmigan	*Lagopus lagopus*	Common; Year-Round	Blackpoll Warbler	*Setophaga striata*	Uncommon; Breeder
Rock Ptarmigan	*Lagopus muta*	Common; Year-Round	Northern Waterthrush	*Parkesia noveboracensis*	Uncommon; Breeder
White-tailed Ptarmigan	*Lagopus leucura*	Rare; Year-Round	Wilson's Warbler	*Cardellina pusilla*	Common; Breeder
Blue Grouse	*Dendragapus obscurus*	Rare; Year-Round	American Tree Sparrow	*Spizella arborea*	Common; Breeder
Sharp-tailed Grouse	*Tympanuchus phasianellus*	Uncommon; Year-Round	Chipping Sparrow	*Spizella passerina*	Uncommon; Breeder
Sandhill Crane	*Grus canadensis*	Rare; Migrant	Savannah Sparrow	*Passerculus sandwichensis*	Common; Breeder
American Golden-Plover	*Pluvialis dominica*	Common; Breeder	Fox Sparrow	*Passerella iliaca*	Common; Breeder
Semipalmated Plover	*Charadrius semipalmatus*	Common; Breeder	Lincoln's Sparrow	*Melospiza lincolnii*	Common; Breeder
Lesser Yellowlegs	*Tringa flavipes*	Common; Breeder	White-crowned Sparrow	*Zonotrichia leucophrys*	Common; Breeder
Solitary Sandpiper	*Tringa solitaria*	Uncommon; Breeder	Golden-crowned Sparrow	*Zonotrichia atricapilla*	Uncommon; Breeder
Wandering Tattler	*Heteroscelus incanus*	Uncommon; Breeder	Dark-eyed Junco	*Junco hyemalis*	Common; Breeder
Spotted Sandpiper	*Actitis macularius*	Common; Breeder	Lapland Longspur	*Calcarius lapponicus*	Uncommon; Migrant
Upland Sandpiper	*Bartramia longicauda*	Common; Breeder	Smith's Longspur	*Calcarius pictus*	Uncommon; Breeder

Appendix G: List of Bird Species

Common Name	*Scientific Name*	Expected Presence	Common Name	*Scientific Name*	Expected Presence
Whimbrel	*Numenius phaeopus*	Uncommon; Breeder	Snow Bunting	*Plectrophenax nivalis*	Rare; Migrant
Semipalmated Sandpiper	*Calidris pusilla*	Rare; Migrant	Red-winged Blackbird	*Agelaius phoeniceus*	Rare; Breeder
Least Sandpiper	*Calidris minutilla*	Uncommon; Breeder	Rusty Blackbird	*Euphagus carolinus*	Uncommon; Breeder
Baird's Sandpiper	*Calidris bairdii*	Rare; Breeder	Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*	Uncommon; Breeder
Pectoral Sandpiper	*Calidris melanotos*	Uncommon; Migrant	Pine Grosbeak	*Pinicola enucleator*	Uncommon; Breeder
Long-billed Dowitcher	*Limnodromus scolopaceus*	Rare; Migrant	White-winged Crossbill	*Loxia leucoptera*	Uncommon; Breeder
Wilson's Snipe	*Gallinago delicata*	Common; Breeder	Common Redpoll	*Acanthis flammea*	Common; Breeder
Red-necked Phalarope	*Phalaropus lobatus*	Uncommon; Breeder	Hoary Redpoll	*Acanthis hornemanni*	Rare; Migrant
Long-tailed Jaeger	*Stercorarius longicaudus*	Common; Breeder	Pine Siskin	*Carduelis pinus*	Uncommon; Breeder

APPENDIX C
Wildlife Sightings Log Data Sheet

Dempster Fibre Project - Wildlife Observation Log

Date	Species	# Observed	Location	Age	Behaviour	Other Comments

Dempster Fiber Optic Project Wildlife Observation Log

Date	Time (24hr)	Observer	Location	Weather (sky conditions, temperature)	Animal type	# of Adult Male(s)	# of Adult Female(s)	# of Adult Unknown(s)	# of Adolescent-not born this year	# of Young-born this year	Total # of animal(s)	Distance from personnel	Direction of movement	Description of encounter including, describing animal activity	Behaviour, circle what applies	Did you take steps to deter or drive off the animal/animals?
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No
															Curious Cautious Disinterested Calm Aggressive Other	Yes No

APPENDIX D
Wildlife Incident Investigation Form

WILDLIFE INCIDENT REPORT

Location of Incident (e.g., GPS, KM, worksite name):

Date:	Time:	Incident Report No.:

Name(s) of Individual(s) Involved:
Company(s):
Contact Number(s):

Nature of Wildlife Incident (check all that apply):

- ☐ Property Damage
- ☐ Aggressive Animal Encounter
- ☐ Wildlife Has, or Potentially Has, Accessed an Attractant
- ☐ Human-wildlife interactions that present a risk to either people or animals (e.g., dangerous animal in camp)
- ☐ Deterrent Used (complete box below)
- ☐ Other:____
- ☐ Wildlife Mortality/Injury
- ☐ Destruction of Wildlife Residence OR Residence Found While Clearing

Species:

# of Animals Involved:

Animal Behaviour: ☐ Aggressive* ☐ Flees ☐ Curious ☐ Indifferent ☐ Foraging ☐ Resting ☐ Traveling ☐ Other:_____________

* Explain the aggressive behaviour(s) in Details of Incident

Details of Incident (e.g., age and sex of animal, the animal's direction of travel, aggressive behaviour, weather conditions, reason for attraction to site, estimate how long the animal was dead, any other animals seen in the area, photographs):

Reason(s) for Deterrent Use (if applicable):

- ☐ On or near Camp
- ☐ On or near Active Worksite at km:_____________
- ☐ Endangering Human Safety
- ☐ Gained Access to a Food Reward
- ☐ Destroying Equipment / Property
- ☐ Other (Specify):

Deterrent(s) Used	Successful (Provide more info on back)	
☐ Air Horn / Whistle	☐ Yes	☐ No
☐ Bangers	☐ Yes	☐ No
☐ Bear Spray	☐ Yes	☐ No

Damage by Wildlife*

- ☐ Human Injury
- ☐ Equipment/Supplies:
  Damage $_______
- ☐ Other:______________________________

*Describe the damage using the Details of Incident and Additional Comments sections

WILDLIFE INCIDENT REPORT

Report to a regulator anytime an animal is injured, diseased, found dead, damaged property, deterred from camp, involved in a human-wildlife conflict, when nest/den accidentally destroyed, or there is a potential for disturbing an active nest/den. Report to a regulator within 24 hours.

YG-ENV Regional Biologist:(867) 996-2162 or (867) 993-6461; Inuvik Wildlife Sighting and Emergency: 867-678-0289
GNWT Big Game Collision Reporting: 866-629-6438.

Date & Time Spoke to Regulator:______________________

Regulator Contact:________________________________

Contact #:______________________________________

Date & Time Spoke to Regulator:_____________

Regulator Contact:___________________________

Contact #:______________________________________

Report Completed by:

____

Report Submitted to:

☐ Regulator:________ on Date:_________

☐ Regulator:________ on Date:_________

Report Submitted by:__________________

Additional Comments (type of deterrent, carcass disposal, removal of attractant)

Direction Provided by Regulator(s) (type of deterrent, carcass disposal, removal of attractant, reporting, etc.):

Additional Follow up Actions or Reviews (identify responsible parties and timelines/reporting requirements)

APPENDIX E
YESAB Decision Document

Yukon

Infrastructure Canada

Yukon Environmental and Socio-economic Assessment Act

Consolidated Decision Document

This document meets the decision bodies' requirements as set out in the *Yukon Environmental & Socio-economic Assessment Act*.

Decision Bodies for this Project

Government of Yukon
Infrastructure Canada
Tr'ondëk Hwëch'in

Project

Project Name Dempster Fibre Optics Project **YESAB File Number** 2019-0140

Proponent Name Darryl Froese

Company Name Highways and Public Works

Project Description
Project Scope - Summary
The complete project scope and activities list are the same as indicated in the Evaluation Report and are appended to this decision document
The Project is the construction of an 800 km fibre optic line from Dawson City, Yukon to Yukon/ Northwest Territories border. The fibre optic line will start at the NorthwesTel (NWTel) terminal facility in Dawson City and follow the Klondike and Dempster Highways to Yukon/Northwest Territories border, primarily within the highway right-of-way (ROW). The Project is located within the Traditional Territories of Tr'ondëk Hwëch'in, Vuntut Gwitchin First Nation, the First Nation of Na-Cho Nyak Dun and the Tetlit Gwich'in Council Secondary Use Area. Project activities are proposed to occur on Tr'ondëk Hwëch'in Settlement Land parcels S-113B1, S-165B and S-166B1.
Construction activities will commence during the winter of 2020 and will occur year-round for five years. The Project will continue to operate as long as the fibre optic line remains functional. The temporal scope of the assessment is 25 years, which includes the construction and operation of the Project. Decommissioning and reclamation activities are not proposed as part of the Project.

Decision Bodies for this Project

Consolidated Decision Document Yes

Decision Body Consultation
Per section 78 of YESAA, the decision bodies for the project have consulted one another and have agreed to issue this consolidated decision document.

Tr'ondëk Hwëch'in Infrastructure Canada

First Nations Consultation

A. Consultation under YESAA section 74(2) Not Applicable

B. First Nations Consultation - General

Consultation was initially done by the project proponent (i.e., Yukon government Highways & Public Works) with affected First Nations in Yukon and Northwest Territories to prepare the project proposal. Mitigation measures were put in place through the pre-submission consultation and Yukon Environmental & Socio-economic Assessment Act process.

Yukon government's Land Management Branch has reviewed Yukon government Highways & Public Works' consultation and engagement report and is taking into account the issues raised by affected First Nations during that portion of the consultation. Yukon government's Land Management Branch is consulting the four affected First Nations in Yukon (i.e., Tr'ondëk Hwëch'in (TH), First Nation of Na-Cho Nyäk Dun, Vuntut Gwitchin First Nation, Tetlit Gwich'in Council / Gwich'in Tribal Council) during the issuance of the Decision Document. The affected First Nations are consulted on a draft consolidated decision document written by the three Decision-Bodies. This consultation entails an exchange of letters and, where required, video conferencing is undertaken to discuss issues raised by the affected First Nations in more details.; their comments and concerns, in particular where this project may have adverse effects on these First Nations' treaty rights, are taken into account and terms and conditions are adapted to address these.

YESAB Recommendation

Under s. 56(1)(b) of the *Yukon Environmental and Socio-economic Assessment Act*, the Dawson City Designated Office recommends to the Decision Bodies that the Project be allowed to proceed, subject to specified terms and conditions. The Designated Office determined that the Project will have significant adverse environmental and socio-economic effects in or outside Yukon that can be mitigated by those terms and conditions.

Decision

Pursuant to section 75 and 80, the Yukon government and Infrastructure Canada, Tr'ondëk Hwëch'in have considered the assessment of this project and:

- ○ Accept the recommendation and the terms and conditions as follows:
- ○ Reject the recommendation and the terms and conditions as follows for the reason(s) specified:
- ◉ Vary the recommendation and the terms and conditions as follows for the reason(s) specified:

Rationale for Decision

After giving full and fair consideration to the Evaluation Report and supporting information, including the scientific information, traditional knowledge and other information provided with the recommendation contained in the Evaluation Report, the Decision Body varies the recommendation and terms and conditions of the Dawson District Office.

Term	Term & condition	Status	Reason
1	YESAB: The Proponent shall engage in a dialogue annually with the Porcupine Caribou Management Board, the Dawson Regional Biologist and affected First Nations to communicate planned project activities and solicit advice for project activities occurring in identified caribou Wildlife Key Areas. NEW Term: The Proponent shall contact the Regional Biologist (867-993-6461) weekly between October 1 and November 30 and between February 1 and April 30 to obtain fall and spring migration updates on the relevant caribou herds. Additionally, when conducting project activities North of the Eagle River, the Proponent shall consult the Porcupine Caribou Management board website (www.PCMB.ca/herd) weekly and contact the Regional Biologist if the herd location overlaps the area of active construction. If the Regional Biologist anticipates caribou to migrate through the project area, the Regional Biologist shall provide written guidance to the Proponent through the Government of Yukon, Highways and Public Works, Property Management Division to enable advanced planning of project activities.	Change	As written, the term bundles together the roles of groups with very different responsibilities in managing caribou. Also, TH feels the requirement for only annual communication does not provide adequate or useful protection to caribou as it does not facilitate or require the proponent to access the most up to date information around migration. TH also requests that updated information be provided as the project progresses through the Traditional Territory.
2	YESAB: The Proponent shall avoid activities within 1 km of the mineral lick at km 158 of the Dempster highway from May 15 to June 30.	Agree	--
3	YESAB: The Proponent shall not establish a temporary camp within 5 km of km 158 of the Dempster highway from May 15 to June 30.	Agree	--
4	YESAB: Project activities shall be avoided within 500 m of known lek (DH001) from April 1 - April 20 between 5 am - 10 am, and within 2 km of leks during the peak attendance period, from 5 am – 10 am between April 20 and May 4. The Proponent shall contact the Dawson Regional Biologist (867-332-4273) to obtain information on known lek locations as this information is confidential.	Agree	--
5	YESAB: If the Proponent identifies additional leks, activities shall be avoided within 500 m of the lek from April 1 - April 20 between 5 am – 10 am, and within 2 km of leks during the peak attendance period, from 5 am-10 am between April 20 and May 4. The Proponent shall notify the Dawson Regional Biologist (867-332-4273) of any newly identified lek locations.	Agree	--
6	YESAB: If a sharp-tailed grouse nesting site is identified and active, the Proponent shall avoid stripping and clearing activities within 2 km of the nest location during the sharp-tailed grouse nesting period (May 7 to June 8).	Agree	--

Term	Term & condition	Status	Reason
7	YESAB: The Proponent shall ensure that the third-party design engineer (the engineer) hired to monitor the installation of the fibre optic line is a permafrost specialist with experience working in northern environments including tundra. The engineer shall, at a minimum, provide annual updates to Government of Yukon and affected First Nations on permafrost conditions, types of permafrost issues that are being encountered and the construction schedule.	Agree	--
8	YESAB: The Proponent shall collaborate with affected First Nations to develop an adaptive management protocol to address unanticipated impacts from permafrost degradation. NEW Term: The Proponent shall provide a draft adaptive management protocol to affected First Nations for consideration and collaboration to further develop, with the end objective of addressing unanticipated impacts from permafrost degradation.	Change	TH has capacity better able to respond to a draft document before a final document.
9	YESAB: The timing of ground disturbance shall be planned to be undertaken prior to seed set of invasive plant species in areas where these species are known to occur.	Agree	--
10	YESAB: If ground disturbance must occur in an area containing invasive species during late flowering or seed set, invasive species should be removed from the area to be disturbed and disposed of safely as per guidance from the Yukon Invasive Species Council for the encountered species to minimize the potential for seeds to spread during construction.	Agree	--
11	YESAB: In addition to cleaning large equipment in designated areas before moving between work sites, the Proponent shall ensure that all employees are cleaning footwear, hand tools, and other items that may have come into contact with soil or plant propagules in areas with invasive species presence.	Agree	--
12	YESAB: Prior to undertaking project activities during snow-free conditions, the Proponent shall undertake an invasive species survey to identify where invasive species are present along the Dempster highway. NEW Term: On an annual basis prior to undertaking project activities during snow-free conditions, the Proponent shall undertake invasive species observations to identify the presence of invasive species along the Dempster highway at project activity locations. If invasive species are found, a removal program shall be undertaken until the invasive species are eradicated from the project activity location.	Change	Combine Term and Condition 12 and Term and Condition 13 for the purpose of clear implementation.

Term	Term & condition	Status	Reason
13	YESAB: An invasive species survey shall be undertaken along the Dempster highway annually. If invasive species are found, a removal program shall be undertaken until the invasive species are eradicated from the project location. NEW Term: On an annual basis prior to undertaking project activities during snow-free conditions, the Proponent shall undertake invasive species observations to identify the presence of invasive species along the Dempster highway at project activity locations. If invasive species are found, a removal program shall be undertaken until the invasive species are eradicated from the project activity location.	Change	Combine Term and Condition 12 and Term and Condition 13 for the purpose of clear implementation.
14	YESAB: The Proponent shall obtain maps from Government of Yukon, Department of TourismHeritage indicating the areas with elevated potential for the presence of archaeological or historic sites. Areas with elevated potential for the presence of archaeological or historic sites shall be avoided until such time as a heritage resources impact assessment can be completed. NEW Term: The proponent shall obtain maps indicating the areas with elevated potential for the presence of archaeological or historic sites. Areas with elevated potential for the presence of archaeological or historic sites shall be avoided until such time as a heritage resources impact assessment can be completed.	Change	To clarify that the proponent is responsible for obtaining maps (from a consultant not Government of Yukon) indicating the areas with elevated potential for the presence of archaeological or historic sites.
15	YESAB: A heritage resources impact assessment shall be completed in advance of ground disturbing activities in areas with elevated potential for the presence of archaeological or historic sites.	Agree	--
16	YESAB: A copy of Tr'ondëk Hwëch'in's Chance Finds protocol shall be shared will all individuals working on the Project, including all contractors and their staff.	Agree	--
17	YESAB: The Proponent's Heritage Resource Protection Plan shall specify that all on-site workers are required to complete mandatory heritage identification training specific to the types of artefacts that may be uncovered in this region.	Agree	--
18	YESAB: On-site workers shall not explore any cabin or campsites (including sites that appear abandoned or derelict), and may not cause damage or remove any objects from these locations.	Agree	--

Term	Term & condition	Status	Reason
19	YESAB: If archaeological or heritage materials are encountered during the development within the Tetlit Gwich'in Council Secondary Use Area, all work shall cease immediately, and the Department of Culture and Heritage (DCH) and the Prince of Wales Northern Heritage Centre in Yellowknife must then be contacted. NEW Term: If archaeological or heritage materials are encountered during the development within the Traditional Territory of an affected Yukon First Nation or the Tetlit Gwich'in Council Secondary Use Area, all work shall cease immediately, and the Department of Heritage of the affected Yukon First Nations or the Department of Culture and Heritage (DCH) and the Prince of Wales Northern Heritage Centre in Yellowknife if in the Tetlit Gwich'in Council Secondary Use Area must then be contacted.	Change	To include all affected First Nations.
20	YESAB: The Proponent shall and affected First Nations shall collaboratively develop a document describing hunting and trapping practices and rights recognized in the Final Agreements and the Gwich'in Comprehensive Land Claim Agreement to be shared with the Contractor and all employees. NEW Term: The Proponent shall and affected First Nations shall collaboratively develop a document describing hunting and trapping practices, seasonal traditional and culturally significant harvesting activities and rights recognized in the Final Agreements and the Gwich'in Comprehensive Land Claim Agreement to be shared with the Contractor and all employees.	Change	To broaden the term to include additional seasonal and culturally significant harvesting and gathering activities.
21	YESAB: The Proponent shall not block access to Settlement Land.	Agree	--
22	YESAB: The Proponent shall finalize the fibre line marker design in collaboration with affected First Nations.	Agree	--
23	YESAB: The Proponent shall ensure that the occupational health and safety plan includes guidelines for the use of personal protective equipment and reporting procedures for accidents and malfunctions.	Agree	--

Term	Term & condition	Status	Reason
24	YESAB: The Proponent shall develop a Drug and Alcohol Policy that outlines a drug and alcohol screening program. This policy should also include the development and delivery of education programs and describe available counselling and treatment resources. NEW Term: The Proponent shall develop a Drug and Alcohol Policy that outlines a drug and alcohol screening program. This policy should also include the development and delivery of education programs and describe available counselling and treatment resources. The proponent is required to include crime prevention as part of the training program in the field season preceding September 2021 or until such time as the 2020 amendments to the Occupational Health and Safety Regulations come into force.	Change	To include training regarding violent and abusive acts.
25	YESAB: The Proponent shall develop and deliver a mandatory, regular harassment prevention training program in consultation with a qualified expert, to be delivered to all project employees, Contractors and consultants working at the site. The training program shall include training specific to employees in a supervisory role, teaching preventative approaches and providing tools to address issues that may arise. In addition, all employees should be educated on the appropriate policies and be empowered with tools to address any harassment or abusive behaviours which may take place around them or towards them. NEW Term: The Proponent shall develop and deliver a mandatory, regular harassment prevention training program in consultation with a qualified expert, to be delivered to all project employees, Contractors and consultants working at the site. The proponent is required to include Sexually Transmitted Disease prevention as part of the training program. The training program shall include training specific to employees in a supervisory role, teaching preventative approaches and providing tools to address issues that may arise. In addition, all employees should be educated on the appropriate policies and be empowered with tools to address any harassment or abusive behavior which may take place around them or towards them.	Change	To include mandatory training for all employees regarding Sexually Transmitted Disease prevention.
26	YESAB: The Proponent shall develop, with a qualified expert, an Anti-Harassment and Bullying Policy that outlines specific processes and actions to address any harassment or bullying which may take place within the Project's scope.	Agree	--
27	YESAB: The Proponent shall develop, with a qualified expert, a gender appropriate and gender- and sexuality-specific policies and processes, which promote a safe, respectful and inclusive environment for women and sexual minorities.	Agree	--

Term	Term & condition	Status	Reason
28	NEW Term: A Heritage Resources Management Plan (HRMP) shall be produced for the project area prior to the development of this project; this plan shall be referred to during the entirety of this project. This plan and the scope of the plan shall be created in collaboration with the proponent, Cultural Services Branch, Government of Yukon, and all affected First Nations.	Add	A heritage resource management plan (HRMP), among other purposes, addresses gaps in the baseline information and provides guidance on mitigation requirements so that potential effects to heritage can be mitigated. Without the proposed term and condition of a HRMP for the proposed project it is not possible to mitigate adverse effects to heritage resources. Additionally, this term has been changed to include all affected First Nations.
29	NEW Term: Copies of the Stop Work Policy (referred to as "All work activities will cease if any caribou are observed within a 1 km radius of a work site, until caribou have moved beyond the 1 km buffer." As per the Project Scope - Activities appended to this Decision Document) shall be provided to all contractors and their staff to ensure this occurs. The Proponent shall provide all affected First Nations with an update if the Stop-Work Policy is implemented in sensitive caribou locations.	Add	This term has been changed to ensure mitigation is implemented and to keep all affected First Nations informed if the Stop-Work Policy is implemented in sensitive caribou locations.
30	NEW Term: The Proponent shall require a Construction Environmental Protection Plan from the contractor, third-party overview during construction by a design engineer (independent of the contractor), and a qualified environmental monitor to ensure wetland identification and the most suitable construction method to use in wetlands. The proponent shall continue monitoring revegetation success and related potential effects (e.g., erosion, sedimentation), until the monitoring demonstrates that the stated revegetation goal has been achieved.	Add	These commitments are important to include as part of the wetland and revegetation mitigation.
31	NEW Term: The Proponent (or their contractors) shall provide updates monthly, or more frequently if activities progress rapidly, to the Department of Natural Resources of the affected First Nation government to communicate planned project activities within their Traditional Territory, observations from the on-site Wildlife Monitor, and solicit advice for project activities occurring in identified caribou Wildlife Key Areas.	Add	Reason is the same as the original Term 1 recommended in the Evaluation Report. This term derives from the original Term 1. Additionally, this term has been changed to include all affected First Nations.
32	NEW Term: The Proponent shall engage in a dialogue annually with the Porcupine Caribou Management Board and affected First Nations to communicate planned project activities and solicit advice for project activities occurring in identified caribou Wildlife Key Areas.	Add	Reason is the same as the original Term 1 recommended in the Evaluation Report. This term derives the original Term 1.

Yukon Environmental and Socio-economic Assessment Act

Consolidated Decision Document

Date

Project Recommendation Issued 2020-09-25

Recommendation Received From

Designated Office - Dawson City

Authority

By signing below, the Yukon government has exercised its authority as per YESAA section 75 to issue a decision document on this project.

Name ~~Matt Ball~~ Susan Antpoehler

Position Acting Director, Land Management Branch

Phone 667-5215

Email Matt.Ball@gov.yk.ca

Redacted

Signature

Original signed by EMR-LMB-Land Client Services

Date December 22, 2020

By signing below, Infrastructure Canada has exercised its authority as per YESAA section 75 to issue a decision document on this project.

Name Erin Stratton

Position Acting Manager

Phone 613-614-8316

Email Erin.stratton@canada.ca

Redacted

Signature

Original signed by Infrastructure Canada

Date January 13, 2021

By signing below, Tr'ondëk Hwëch'in has exercised its authority as per YESAA section 75 to issue a decision document on this project.

Name ~~Darren Taylor~~ Charles Pugh

Position Executive Director ~~Director of Natural Resources~~

Phone 867-993-7100 ext. 14

Email Darren.Taylor@trondek.ca

Redacted

Signature

Original signed by Tr'ondëk Hwëch'in

Date Dec. 24 / 2020

Distribution

Project Proponent	Yes
Other Decision Bodies	No
Major Projects Yukon, Executive Council	Yes
YESAB Designated Office	Yes
YESAB Executive Committee	No
Yukon Surface Rights Board	No
Yukon Water Board	No
Land Use Planning Commission	
Independent Regulatory Agency	
Other Body/Person as Required	