The Mackenzie Valley Alternate Highway Route Alignment

A Study on Physical Viability

Prepared for: Wrigley Community, Chief and Council

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1. Executive Summary

Pehdzeh Ki First Nation Council has requested an independent review of the alignment options for the Mackenzie Valley All Weather Road. To date, the design work has been focused on following the winter road alignment and intersecting the existing bridges along the winter road route. Pehdzeh Ki First Nation Council wished to explore alignment options that may result in a better end product that accesses less sensitive traditional land use areas. The report identifies the importance of protecting natural resources that are critical to the historic and traditional lifestyles of the local indigenous population and are used to exercise their treaty rights. Pehdzeh Ki First Nation Council contracted Maskwa Engineering to explore alignment options.

Maskwa Engineering evaluated the terrain, reviewed historical information, interviewed individuals with local knowledge, reviewed lidar data from Enbridge and consulted with the Chief and Council for Pehdzeh Ki First Nation Council. Maskwa Engineering has identified a route that will result in higher embankment stability, ease of accessing construction material, less impact to traditional lands and lower risk of sediment and erosion concerns. The route follows the Enbridge Pipeline route and follows higher ground away from the Mackenzie River. The recommendation in this report is that the alternate route selected should be considered as a viable option to the alignment that follows the Winter Road route.

The report findings suggested that;

- ✓ Higher Ground is less susceptible to permafrost and ice lenses.
- ✓ Higher ground is easier to manage surface water.
- ✓ Highway development follows areas that have lower traditional land use.
- ✓ Erosion risk reduction by crossing waterways in areas of lower peak flows.
- ✓ Alignment follows alpine terrain with less dense vegetation.
- ✓ Higher ground will result in better borrow material as the silts/clays are generally on the valley low country and higher ground has more granular deposits.
- ✓ Alignment terrain allows for cut/fill embankment construction reducing costs and reducing quarry frequency.
- ✓ Water course crossings are in locations of lower historic land use.

2. History

Informational history was provided to Maskwa by the Pehdzeh Ki First Nation Council. The existing winter road along the Mackenzie River was constructed in the 1960s to provide winter access to communities along the river and to serve as a supply line to Tulita and Norman Wells. The route was chosen to optimize the ease of winter road construction, adhering to lower, flat terrain close to the Mackenzie Valley River system. This alignment necessitated numerous creek and river crossings, leading to the construction of temporary bridges to facilitate transport across these waterways. These bridges were constructed without consultation of the Pehdzeh Ki First Nation Council. Over time, the temporary bridges have been upgraded along the winter highway alignment.

During the 1960s construction period, there was no consultation or involvement with the local Pehdzeh Ki First Nation Council. Consequently, many of the bridge locations were selected and constructed without consideration of the impacts on historical land use and water bodies, archaeological sites, spiritual lands, and areas of special interest. The route was selected for ease of constructing a winter road, and therefore did not account for future permanent all-season road considerations.

The proposed all-season road aims to follow the existing winter highway alignment and make use of the pre-existing bridges. The recommended new highway alignment has been designed with a comprehensive approach, integrating feedback from the Pehdzeh Ki First Nation Council and data from Enbridge Inc., to ensure that the route respects the cultural, historical, and environmental significance of the land. The recommended new highway alignment attempts to follow a pre-existing pipeline alignment, a surveyed route that was chosen for its all-season suitability.

The recommended new highway alignment is designed to provide a more reliable and sustainable transportation corridor while maintaining the existing winter road as an uninterrupted supply line north of Wrigley during construction. That is, the project will allow for the use of existing infrastructure, such as bridges and road networks along the winter highway alignment to facilitate construction of the alternate all-season highway. By leveraging the established infrastructure of the winter road, the project aims to balance engineering requirements with the preservation of important cultural and historical lands.

Figure 1: Existing Winter Road Alignment

3. Background

The Pehdzeh Ki First Nation Council has expressed concerns regarding the construction of an all-season highway along the existing winter highway alignment since the proposal of the Design Report Criteria in 2012. These concerns highlight issues such as public access to spiritual lands, a lack of consultation on the route, and improper ground stability.

In response to the Government not looking into alternate alignments that consider the best option for the community and longevity of the all-season road, Maskwa was retained by the Pehdzeh Ki First Nation Council, to investigate alternate options for an all-season highway alignment. Maskwa assembled a team of engineers and scientists to collaborate with the Pehdzeh Ki First Nation Council to ground truth and evaluate the viability of alternative all-season road alignments. The engineers reviewed the design criteria outlined in the 2012 project briefing report, which proposed an embankment fill-only design approach for the all-season route along the winter road. For the proposed all-season highway alignment, the design parameters aimed to maximize cut/fill design options and reduce the number of borrow sources needed, by utilizing excavated rocky material for roadway embankment fill.

Maskwa Engineers collected contour maps and proposed three separate alignments. Route 1 followed an existing pipeline alignment along the west side of Cap Mountains. Routes 2 and 3 traveled on the east side of Cap Mountains and accessed LOCATION . However, the community rejected Routes 2 and 3, stating that access to LOCATION would not be permitted.

4. Chief and Council Community Meeting

A meeting was held between the Maskwa Engineering Project Team and the Chief and Council on July 8, 2024, in Wrigley NT at 10:30 am. Community concerns were raised and discussed in order to develop an understanding of the items listed in the table below. The following comments were presented to the design team:

	Topic	Comments
1	Traditional Land Use areas need to be avoided	The winter route follows the east edge of the Mackenzie River which is a high use area historically and currently. PRIVILEGED

		The areas that the bridges currently occupy have been used by residents for thousands of years. The areas near the bridges have the most archeological sites and need to be protected. Moving the alignment away from the bridges will protect high use, spiritually significant and archaeologically sensitive areas.
2	Proposed Routes presented by Maskwa	Any routes providing access to LOCATION were removed by Chief and Council as options since they do not want access to LOCATION . Routes 2 and 3 options were removed from consideration.
3	Alignment only through Lands Impacted by Wrigley	The Chief and Council requested that the alternate alignment only consider routes that attempt to avoid the Mackenzie River, Blackwater Lake and Mount Gaudet.
4	Bridge Locations	All bridges to be relocated farther east and away from the Mackenzie River. Special consideration must be given to the Blackwater bridge as this bridge location should be moved as far inland as possible. CONFIDENTIAL
5	Ground Conditions near the Mackenzie River	Many concerns were voiced about ground stability near the Mackenzie River. Concerns included slope stability of drainage systems as there are deeper erosion channels, permafrost degradation, swampy areas and access to wildlife habitat. The community expressed concerns about building over permafrost and referenced the highway between Yellowknife and Behchokǫ̀, where permafrost is degrading the roadway and creating unsafe roadway conditions.
6	Winter Road accesses swampy areas that are moose habitat	The moose travel along the river and live in the swamps located near the river. The winter road route accesses the traditional hunting areas that the community relies on for their food source. Access by permanent roads into these areas will result in outside hunting pressure and impacts on the moose population that the community rely upon. Alignments with higher elevation will have a lesser impact on moose habitat and result in protection of the local animal population.
7	Mount Gaudet	There shall be no development or work completed on Mount Gaudet.

8	Third Party Access	Concerns voiced about people accessing sensitive areas and disrespecting the land, water, fish and animals. Overfishing and access to spawning areas will be a concern with all locations where water systems enter the Mackenzie River system.
9	Bridge Site Reclamation	The community will want all existing bridge sites remediated and returned to the original conditions from before the bridges were built.
10	Economic Benefits	The community wants to see benefits from the highway development with training, employment and economic stimulus from contracting opportunities. Long term maintenance of the road should include contracting opportunities for the community of Wrigley
11	Alignment near Wrigley	The community supports the alignment starting where the existing winter highway starts but that the route should bend to the east and access higher country near the base of Cap Mountains. There are suitable borrow sources along Cap Mountain, and less historical and cultural significance, as identified by the Pehdzeh Ki First Nation Council.
12	Limit access to Land	The design needs to consider the access to lands and limiting access. Borrow sites need to be minimized with restricted access to limit third party access.
13	Access to Borrow	There are no limits to borrow locations along the Cap Mountains as this area has less land use and historical significance.

5. Field Observations

The Design Team conducted a field investigation using a fixed-wing aircraft to observe ground conditions, tree cover, drainage, and the feasibility of the proposed all-season highway, located near the base of the Cap Mountains and following the Enbridge Pipeline Route. The recommended new highway alignment is expected to cross the Enbridge Pipeline a total of two times and is reflected in the cost estimates section of this report. INDIVIDUAL NAME supported the field investigation, providing valuable local knowledge of the land and water. Due to the unavailability of a rotary aircraft, a 206 Cessna fixed-wing plane was utilized for the investigation. The team flew over the proposed all-season highway alignment and the existing winter road twice to gather necessary observations.

Observations and records were documented and presented below;

5.1. Existing Winter Road Comparison to the Alternate All-Season Highway

	Topic	Winter Road Alignment	The Alternate All-Season Highway Alignment
1	Topography	Most of the winter road alignment is on the first bench up from the Mackenzie River resulting in lowest profile.	Higher elevation along entire route of Proposed Alignment
2	Tree Cover	Heavily Treed with birch, poplar and evergreen	Alpine Meadows with no tree cover over 40% of route and sparse tree cover over 30% and heavily treed over 30%.
3	Drainage	Deep Erosion scars along route that need to be crossed	High ground presents less runoff and lower erosion scars – less severe water crossings.
4	Wildlife	Swamps and low country result in excellent moose habitat	Higher alpine areas are less suitable for moose habitat.
5	Access to Borrow	Low country near Mount Gaudet has borrow sources that are assumed to be fine grained/frost susceptible soils.	High ground with access to rock outcrops and talus deposits available.
6	Permafrost	Higher tree cover and more access to water suggests higher permafrost density. Presence of water and swamps suggest potential for ice lenses in permafrost. Clearing trees and construction activities may impact ice lenses and speed permafrost degradation. No cut/fill allowed to protect permafrost, fill only design.	Higher ground and talus deposits suggest less permafrost and ice lenses. Cut/Fill design is an option along this route.
7	Views	Views along the existing winter roads are limited and primarily available near the bridge crossings	Higher alpine access allows vistas of the Mackenzie River and valley.
8	Borrow requirements	Fill only design requires borrow sources for all fill material along alignment. Main Access to hard granular borrow is Mount Gaudet which is a no access permitted area by the Chief and Council.	Cut/Fill design will reduce demand and development of borrow sources. Suitable access to hard rock borrow material along the Cap Mountains and pre-existing borrow areas near Blackwater River Crossing
9	Cultural Significance	Alignment crosses areas of high archeological use, areas of cultural significance and wildlife habitat along the Mackenzie River System.	Higher ground away from the Mackenzie River results in lower land use, lower cultural significance and lower wildlife occupancy.

7. Design Parameters

The alternate highway alignment is selected to;

1	Avoid permafrost.
2	Reduce environmental footprint.
3	Avoid traditional land use areas.
4	Reduce erosion susceptibility.
5	Maintain positive drainage.

The alignment for the alternate all-season highway project was selected based on feedback from the Pehdzeh Ki First Nation Council. The project involves year-round construction of embankments and bridges, with considerations for dual lane bridges and ensuring uninhibited traffic flow at a design speed of 100 km/hr. The route was chosen for its more suitable ground conditions to reduce maintenance costs, with materials sourced from borrow areas for chip seal, base course, and general borrow. The new road's centerline height will be compared to the existing winter road alignment, and uninterrupted operation of the winter road north of Wrigley will be maintained. Before opening, the new alignment will receive a chip seal layer.

A cut and fill highway design consists of two primary components. These are the extraction of the cut and placement of the fill sections. This design would allow construction teams to remove borrowed material from the slope and use that material to produce a highway surface on the downslope. As a result, there would be less need for borrow sources throughout the length of the highway, as excavated rock could be reused for construction. Alternatively, a fill only highway design consists of transporting material from designated borrow sites and placing material above the original ground to create the highway's surface. This design would produce a longer construction phase when compared to a cut and fill design, and a larger environmental footprint, by necessitating the need for extended mass hauls of material and extensive borrow sources along the length of the highway.

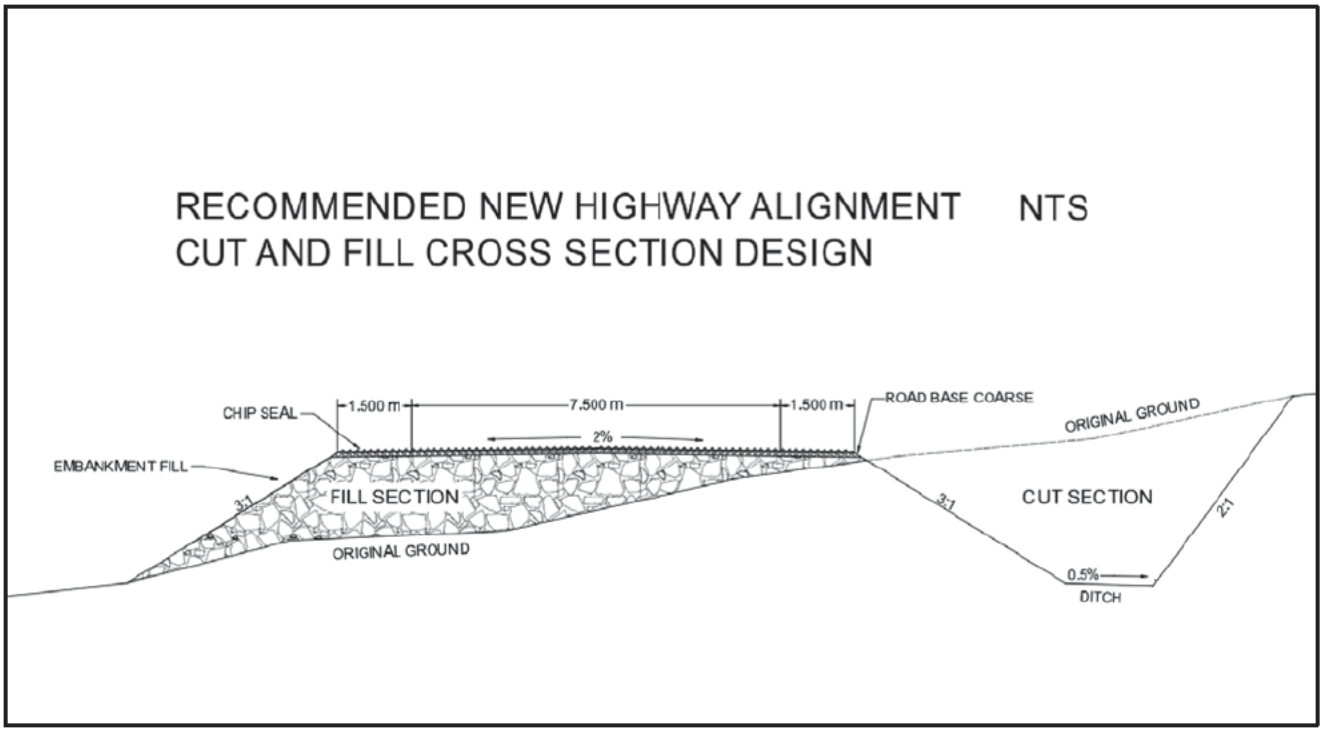


Figure 3: Typical Cross Section Detail for Cut/Fill Road Design.

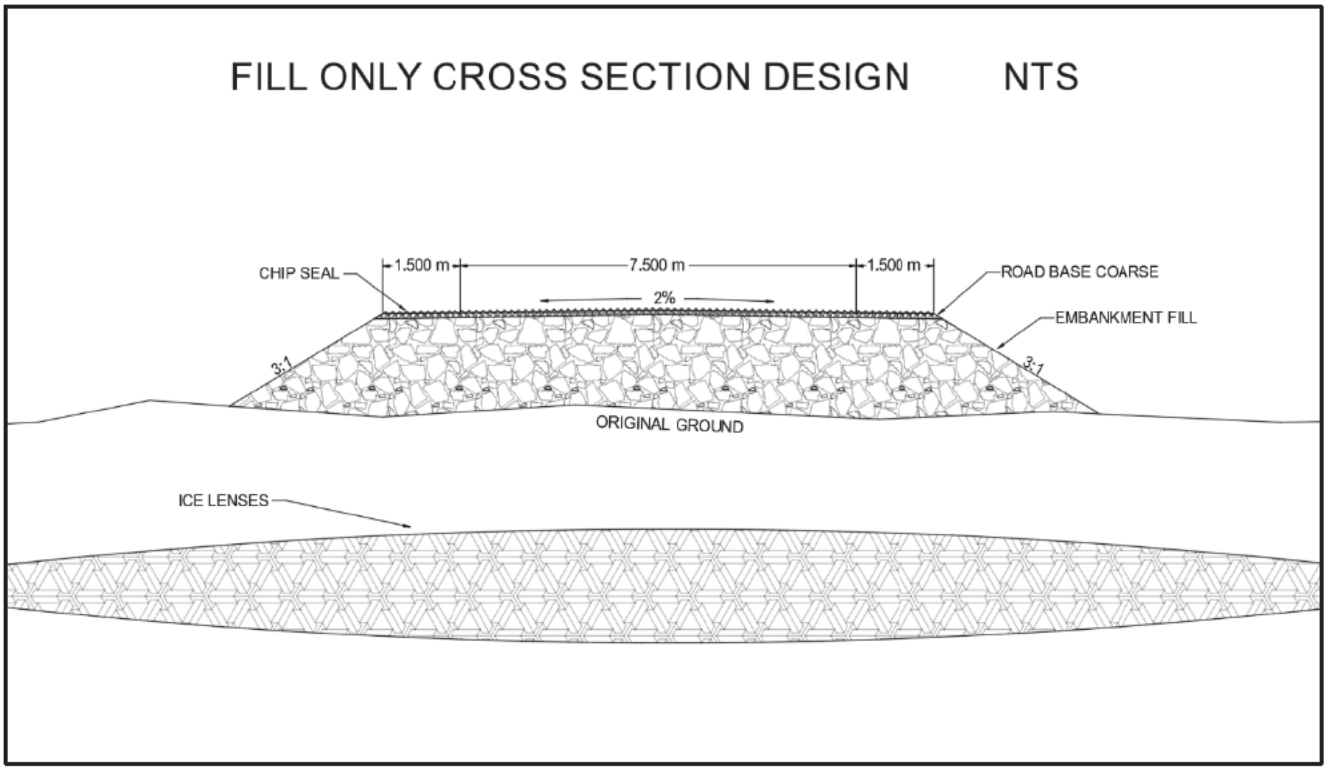


Figure 4: Typical Cross Section Detail for Fill Only Road Design.

8. Design

The alternate all-season highway spans a stretch of 110 kilometers. The estimated quantity of material that will be needed to construct the road is equal to roughly 1.87 million cubic meters. In total, 8 bridges were used in the all-season highway design, with an average length of 67 meters. The table below summarizes the bridge crossing lengths:

Location	Length (m)
Crossing #1	15
Hodgson Creek	50
Ochre River	55
White Sand #1	25
White Sand #2	120
Dam Creek	20
Blackwater River #1	110
Blackwater River #2	110

The recommended new highway alignment attempted to cross drainage networks where peak flow rates are less severe. Peak flow rates are less severe towards drainage sources, which typically come in the form of shallow gullies. This design consideration was implemented to facilitate the need to reduce construction costs and erosion susceptibility. As a result, the recommended new highway alignment attempts to follow elevated terrain near the base of the Mackenzie mountains, as seen in figure 5. By avoiding major tributaries along the Mackenzie River, the recommended new highway alignment aims to reduce future engineering, construction, and maintenance costs. This would be achieved by allowing for proper drainage, reducing the magnitude of annual erosion, and requiring shorter, less expensive bridges.

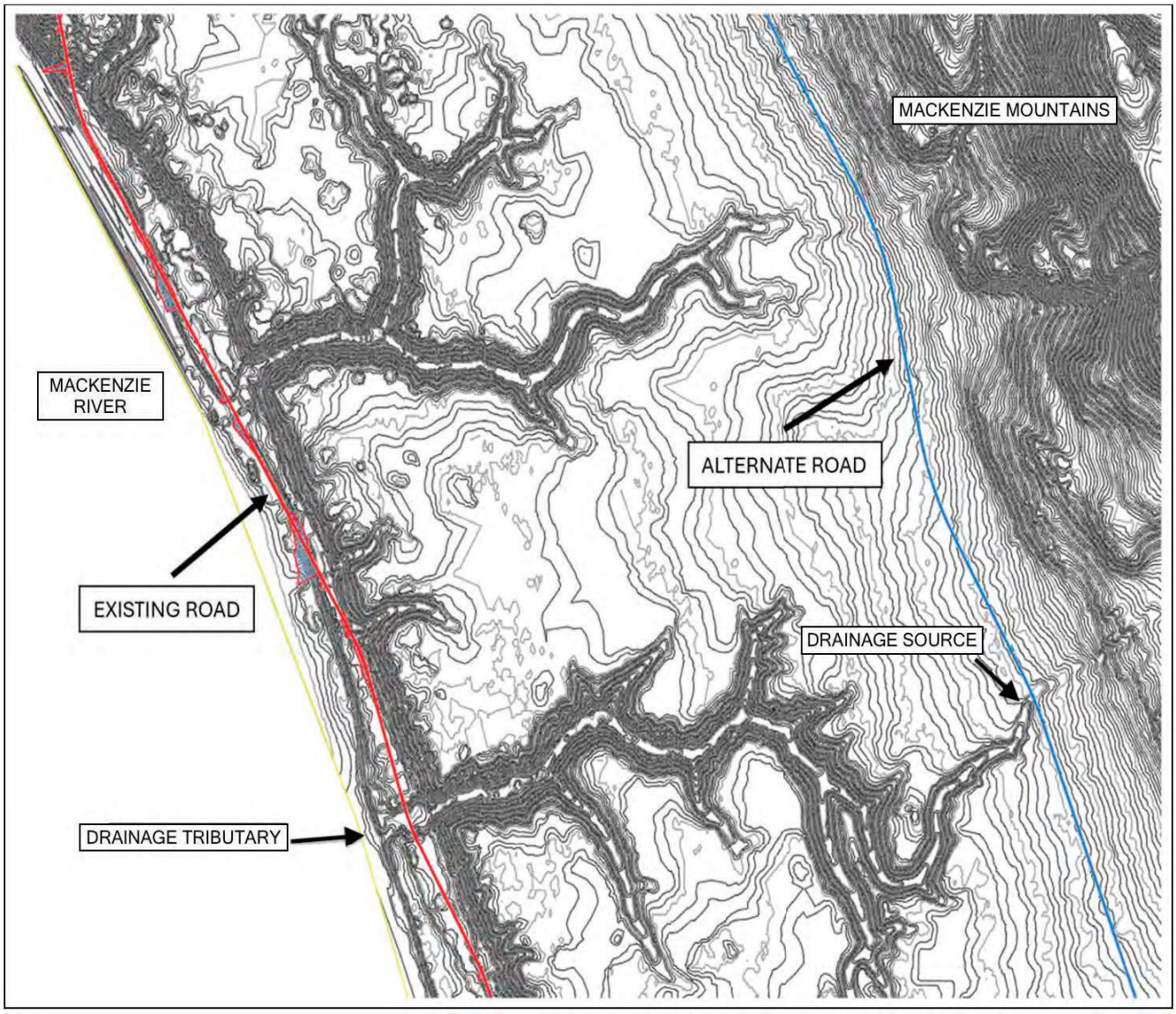


Figure 5: Valley Crossing Magnitude of Winter Route and All-Season Highway Alignments.

9. Proposed Borrow Sources

Maskwa understands that the location of borrow sources are to be exclusively limited to higher elevation terrain. Under no circumstances shall borrow source material be extracted from Mount Gaudet. INDIVIDUAL NAME conveyed to Maskwa representatives that Cap Mountain would be an appropriate source for borrow material. It should be noted that a cut/fill cross section design will allow for the use of minimal borrow sources along the proposed all season highway. For proposed borrow source locations, refer to Appendix A: All-Season Road Alignment.

10. Impacts of Existing Winter Road

Maskwa recognizes the importance of avoiding culturally significant areas identified by the Pehdzeh Ki First Nation Council in the proposed all-season road design. To address these concerns, the decision was made to align the road through higher terrain after carefully comparing topographical data with the culturally significant areas, including traditional lands and archeological sites, as identified by the Wrigley community. The current winter road alignment crosses areas of cultural importance, including THREE LOCATIONS . Existing bridge crossings have been identified as having an impact on the local Wrigley community. In response to the preferences expressed by the Pehdzeh Ki First Nation Council, these structures are expected to be removed from all culturally significant sites to ensure the preservation of the community's heritage and respect for their traditional lands.

11. Major River Valley Crossings

Maskwa has determined that the construction of the proposed all-season highway alignment will require 3 major river valley crossings, and 5 minor valley crossings.

12. Pros for Recommended New and Winter Highway Alignments

	Pros for Recommended New Alignment	**Pros for Winter Highway Alignment**
1	The Recommended New Highway Alignment recognizes sensitive traditional areas. The route selection attempted to minimize the impact on these traditional land use areas.	Ability to intersect existing bridge locations.
3	The Recommended New Highway Alignment follows higher ground with more suitable drainage patterns. The alignment recognizes that higher ground intersects drainage patterns where the peak flow rates are less severe.	Already in an impacted area.
4	There is a lower probability of ice lenses being present underneath the Recommended New Highway Alignment.	
5	The grade alignment selected is more suitable for implementing a cut and fill cross section design.	

6	The Recommended New Highway Alignment follows terrain that is less susceptible to weathering, such as erosion.	

13. Cons for Recommended New and Winter Highway Alignments

	Cons for Recommended New Alignment	**Cons for Winter Highway Alignment**
1	A new development area.	Ice lenses present along the Winter Highway Alignment.
2		The Winter Highway Alignment travels through areas of poor drainage in low lying terrain.
3		The Winter Highway Alignment would infringe on the PKFN communities treaty rights by allowing outsiders to harvest their natural resources.
4		The Winter Highway Alignment interacts with historical land use areas.
5		Higher susceptibility to erosion.

A key consideration is the construction philosophies between the recommended new highway alignment and existing winter highway alignment. The recommended new highway alignment has been designed to specifically serve as an all-season highway whereas the winter highway alignment was designed to be a temporary winter road. Typically, temporary winter roads are routed through low-lying terrain, as permafrost conditions are not a critical concern during the construction phase. This equates to a fill only design, with extended material hauls from designated quarrying sites. On the other hand, an all-season highway necessitates the ability to produce adequate drainage, with minimal permafrost being present, and the ability to implement a cut and fill design to reduce the need to haul material longer distances.

The objective of this study was to evaluate a viable alignment for the proposed all season highway north of Wrigley, NT. After thorough investigations, it is concluded that an alternate all season highway alignment is viable north of Wrigley and will be discussed in more detail throughout this report.

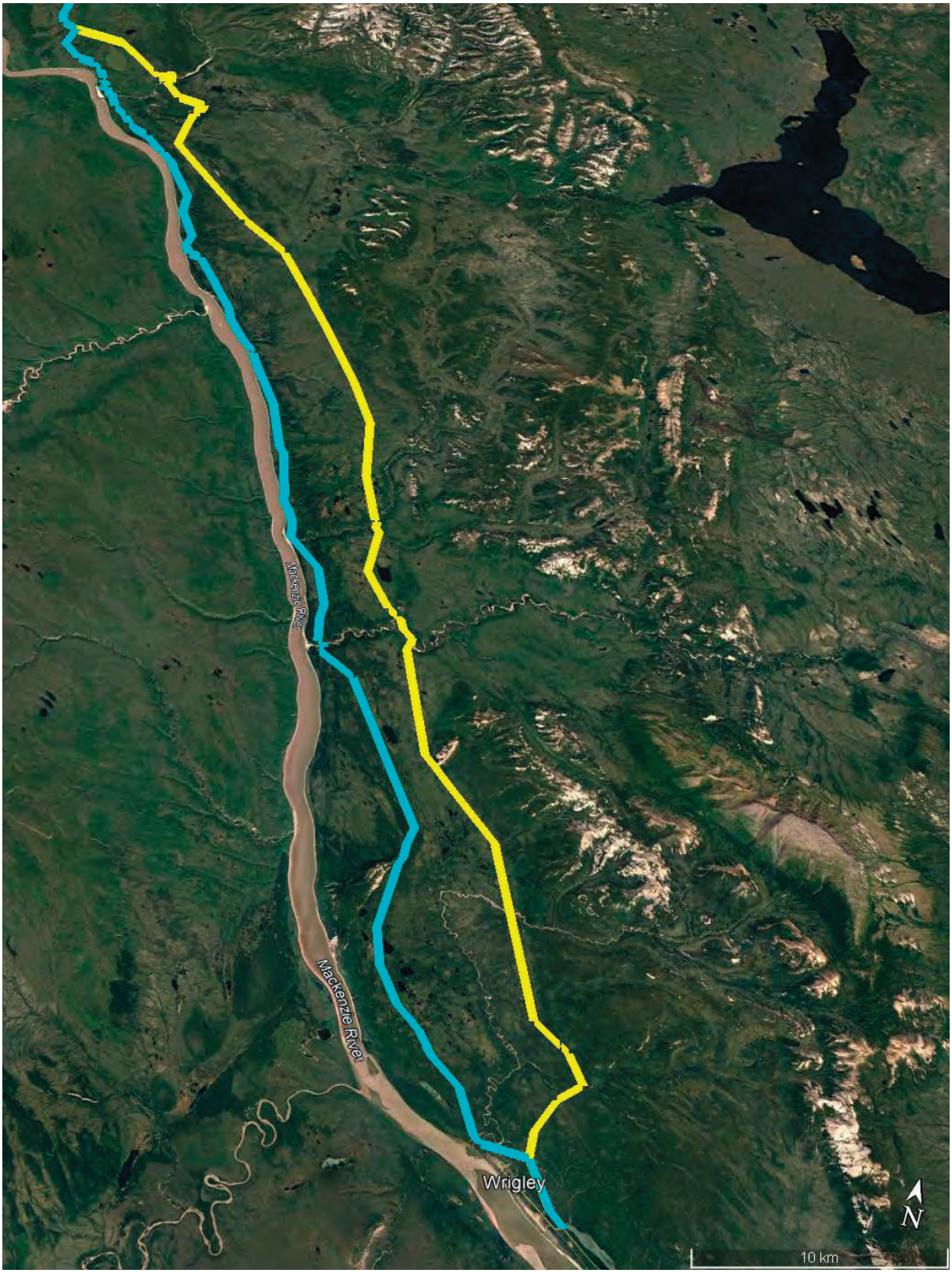


Figure 6: Existing Winter Road (Cyan) and Proposed All Season Road Alignment (Yellow)

14. Cost Estimate

The assumptions that were used to estimate the cost for the overall roadway and bridge construction are summarized below:

- The centerline will have a total centerline length of 110 kilometers.
- 1 500 millimeter culvert every 1 kilometer.
- 1 1000 millimeter culvert every 1 kilometer.
- Culvert lengths of 20 meters.
- 10-meter-wide chip seal surface.
- 10.5-meter-wide roadway surface.
- 1.2-meter-high average embankment.
- 60 meter wide right of way.
- 25-meter-wide stripping road footprint.

14.1. Highway Construction Cost Estimate

The cost estimates for the all-season road are summarized in the tables below:

Mackenzie Valley Highway Construction					
Highway Construction Cost Estimate					
	Description	Unit	Quantity	Unit Rate	Cost
1	Clearing ROW	m^2	6600000	$ 2.00	$ 13,200,000.00
2	Stripping m^2	m^2	2750000	$ 5.00	$ 13,750,000.00
3	Cut/Fill Volume m^3	m^3	2100000	$ 25.00	$ 52,500,000.00
4	Roadway Blast Rock m^3	m^3	50000	$ 200.00	$ 10,000,000.00
5	Aggregate production/placement m^3	m^3	340000	$ 175.00	$ 59,500,000.00
6	500mm diameter culverts lin. M	lin.m.	2200	$ 1,750.00	$ 3,850,000.00
7	1000mm diameter culverts	lin.m.	2200	$ 2,500.00	$ 5,500,000.00
8	Enbridge Pipe Line Crossings	each	2	$150,000.00	$ 300,000.00
9	Chipseal production/application	m^2	1100000	$ 25.00	$ 27,500,000.00
10	Line Painting	LS	1	$ 50,000.00	$ 50,000.00
11	Signage	LS	1	$ 50,000.00	$ 50,000.00
	Sub-Total				$186,200,000.00
	Engineering/Construction Management 18%				$ 33,516,000.00
	Total				$219,716,000.00

14.2. Bridge Construction Cost Estimate

The bridge estimates for the all-season road are summarized in the table below:

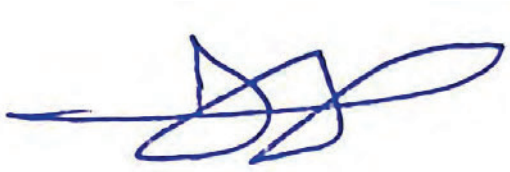
Bridge Construction Cost Estimate					
1	Bridges over 100 meter	lin.m.	3	$ 60,000,000.00	$ 180,000,000.00
2	Bridges at 50 meters	lin.m.	2	$ 30,000,000.00	$ 60,000,000.00
3	Bridges under 30 meters	lin.m.	3	$ 2,000,000.00	$ 6,000,000.00
	Sub-Total				$ 246,000,000.00
	Engineering/Construction Management 18%				$ 44,280,000.00
	Total				$ 290,280,000.00

15. Closure

This investigation was carried out in accordance with generally accepted practice of Geotechnical Engineering. It should be understood that this report is a preliminary investigation and requires further information that includes but is not limited to LiDAR data, subsurface ground conditions, and borrow source locations. We trust that the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

MASKWA ENGINEERING LTD.,

Prepared by:



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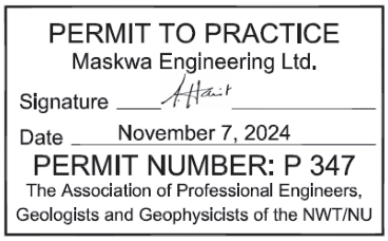
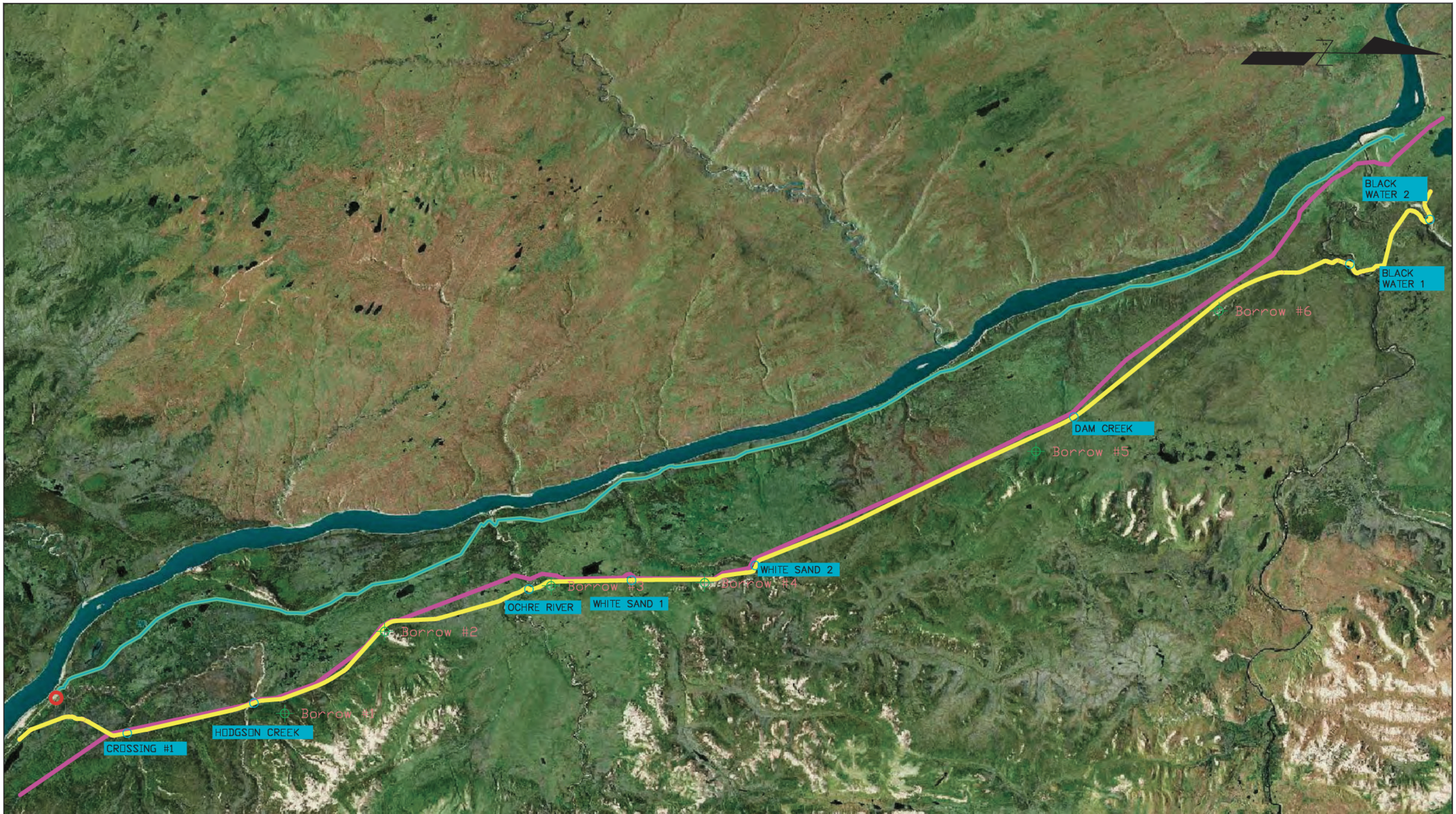


16. Third Party Disclaimer

This report has been prepared by Maskwa engineering Ltd. (Maskwa) For the benefit of the client to whom it is addressed. The information and data contained herein represent Maskwa's best professional judgment in light of the knowledge and information available to Maskwa at the time of preparation. Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by the Client, its officers, and employees. Maskwa denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss, or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents without the express written consent of Maskwa and the Client.

17. Appendices

Appendix A: All Season Road Alignment



MASKWA ENGINEERING LTD

Project No.: N/A	DRAWING TITLE: PROPOSED ROAD ALIGNMENT	CLIENT: Pehdzeh Ki First Nation	DRAWN BY: CJC
Dwg No.: 1			CHECKED BY:
Revision 0	PROJECT: WRIGLEY COMMUNITY CONSULTATION FOR ALL SEASON ROAD	MASKWA JOB No.: 24–070	DATE: July 2024

ALL SEASON ROAD
EMBRIDGE PIPELINE
WINTER ROAD
WRIGLEY NT
BRIDGE CROSSING
POTENTIAL BORROW SOURCE

0 5 10 Kilometers

Date	Description	Chkd
07–20–24	PROPOSED ALIGNMENT	

Appendix B: Reconnaissance Photos

Photo 1: Pipeline/Road Alignment Vegetation

Photo 2: Dam Creek and Pipeline

Photo 3: Hodgson Creek Facing East

Photo 4: Ochre River Facing East

Photo 5: Ochre River facing West

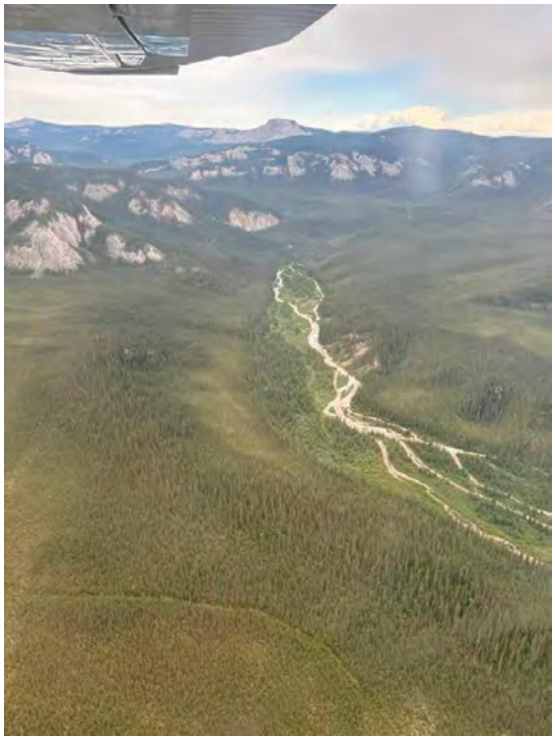


Photo 6: White Sand #2 Facing East

Photo 7: Dam Creek Facing East

Photo 8: Black Water River Facing East

Photo 9: Typical Vegetation of Proposed Alignment

Photo 10: Mackenzie River and Typical Vegetation of Winter Road Alignment