Northwest Territories

MACKENZIE HIGHWAY EXTENSION
WRIGLEY TO THE DEMPSTER HIGHWAY

1999 Engineering Update

NORTHWEST TERRITORIES
TRANSPORTATION

MACKENZIE HIGHWAY EXTENSION
WRIGLEY TO THE DEMPSTER HIGHWAY

1999 Engineering Update

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Department of Transportation

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INTRODUCTION

The primary purpose of this study was to update or develop cost estimates for the extension of the Mackenzie Highway from Wrigley to the Dempster Highway and for an access road from Deline to the Mackenzie Highway near Tulita, as shown on Figure 1.

This study is only one of a number of studies undertaken by the Department of Transportation for the completion of the Mackenzie Highway. Other studies which were undertaken include Environmental Scoping and a Benefit/Cost Analysis. The studies will be used for further planning and decision making with respect to the Department's overall Transportation Strategy.

PREVIOUS WORK

The original plan by Public Works Canada was to complete the construction of the Mackenzie Highway from Fort Simpson to the Dempster Highway in a four year period from 1972 to 1976. Although construction did not proceed past a point south of Wrigley, a tremendous amount of engineering and environmental work was done over the entire length of the highway. Pre-engineering and design was basically completed to the "ready to go to tender stage" for most of the highway.

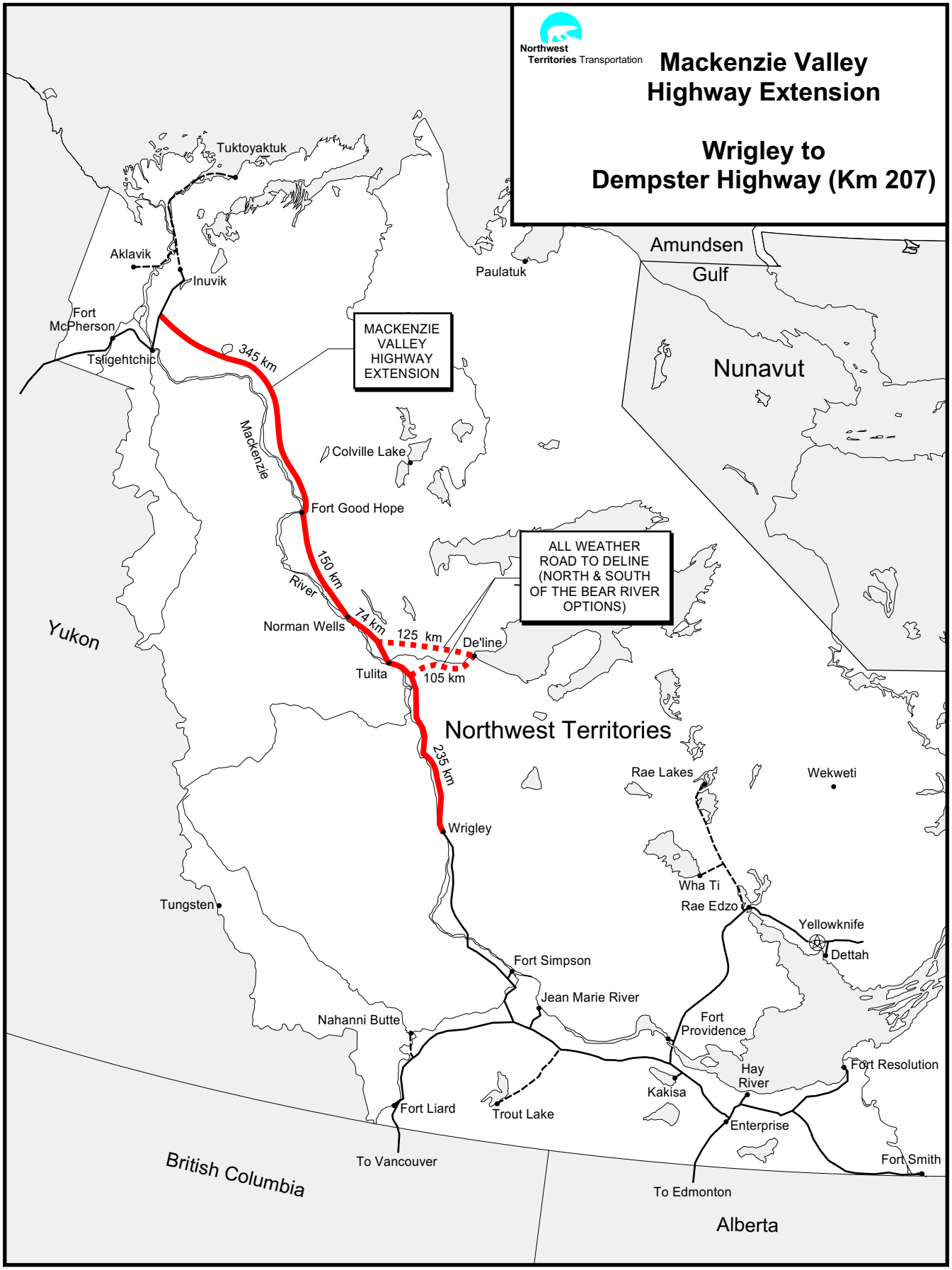
More background and a summary of the Public Works Canada work, along with "updated cost estimates" was presented in a brief 1989 report by the Department of Transportation entitled *Mackenzie Highway, Wrigley to Inuvik Extension***.** This report is included in its entirety, with the exception of the pocket map, as Appendix B of this study.

DESIGN STANDARDS

For this study, design standards and resultant cost estimates were developed for two types of all-weather highways; a 60 kilometres per hour highway and an 80 kilometres per hour highway. The design parameters and the design cross sections that were selected for the two types of highway are shown in Table 1.

Calling one a 60 kilometres per hour highway is a bit of a misnomer. In reality, the allowable speed limit would be 80 - 90 kilometres per hour over approximately 95% of the highway with 60 kilometres per hour speed zones through sections of high local relief where the requirements for the vertical alignment and appropriate sight distances have different design parameters..

The main difference in the two designs is the roadtop width. With the 10.0 metre roadtop, the 80 kilometres per hour highway could accommodate the additional granular base required for an asphalt surface without further embankment widening, while the 60 kilometres per hour highway with a roadtop width of 8.4 metre would require widening in order to upgrade to an asphalt surface.

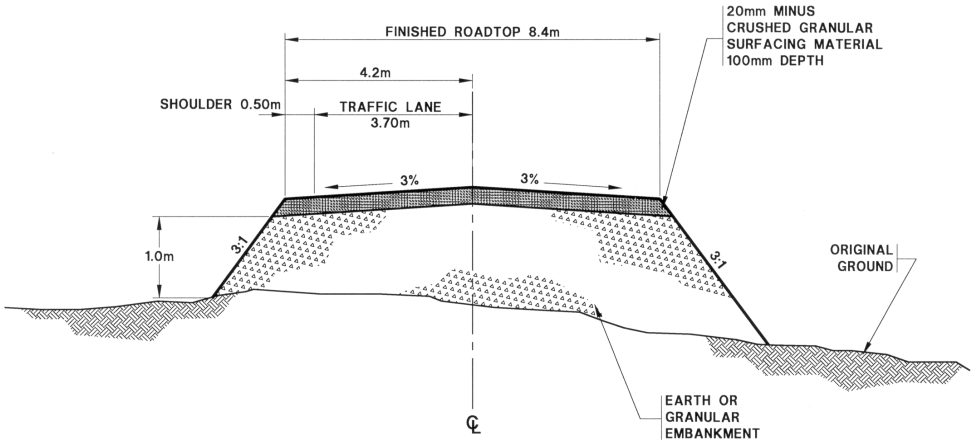

Northwest Territories Transportation
Mackenzie Valley Highway Extension
Wrigley to Dempster Highway (Km 207)
Tuktoyaktuk
Aklavik
Inuvik
Paulatuk
Amundsen Gulf
Fort McPherson
Tsiigehtchic
345 km
MACKENZIE VALLEY HIGHWAY EXTENSION
Nunavut
Mackenzie
Colville Lake
Fort Good Hope
150 km
River
ALL WEATHER ROAD TO DELINE (NORTH & SOUTH OF THE BEAR RIVER OPTIONS)
Yukon
Norman Wells
74 km
125 km
De'line
Tulita
105 km
Northwest Territories
235 km
Rae Lakes
Wekweti
Wrigley
Wha Ti
Rae Edzo
Tungsten
Yellowknife
Dettah
Fort Simpson
Jean Marie River
Nahanni Butte
Fort Providence
Hay River
Fort Resolution
Kakisa
Fort Liard
Trout Lake
Enterprise
Fort Smith
To Vancouver
To Edmonton
British Columbia
Alberta

With the possible exception of the Great Bear River at Tulita, single lane, timber or steel deck bridges are proposed for all stream or creek crossings. These would be similar to the existing bridges on the highway between Fort Simpson and Wrigley.

TABLE 1
DESIGN PARAMETERS AND PRELIMINARY CROSS SECTION

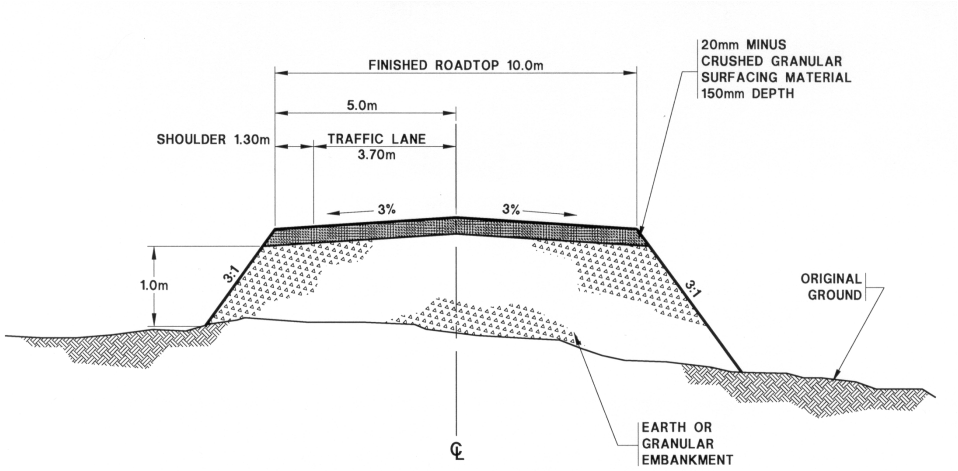
Design Standard	60Km/hr	80Km/hr
Horizontal Alignment		
Min. Radius (m)	120	230
Min. Stopping Sight Distance (m)	85	140
Vertical Alignment		
Sag 'K' Value	20	30
Crest 'K' Value	20	40
Maximum Gradient (%)	10	8
Cross Section		
Roadtop Width (m)	8.4	10.0
Granular Base Course/Surfacing(mm)	100	150
Subgrade Width (m)	9.0	10.9
Minimum Embankment Fill (m)	1.0	1.0
Side Slope Ratio	3 to 1	3 to 1

Figure 2 - TYPICAL DESIGN CROSS SECTION (60 km/hr Design)



60km/hr DESIGN CROSS-SECTION

Figure 3 - TYPICAL DESIGN CROSS SECTION (80 km/hr Design)



80km/hr DESIGN CROSS-SECTION

BASIS OF COST ESTIMATES

The unit cost estimates (per kilometre costs, bridge and culvert costs and engineering costs) which are used in this report were derived, as much as possible, from average costs associated with similar recent highway projects undertaken by the GNWT. These projects include the reconstruction of the Yellowknife Highway (No.3) to Yellowknife, completion of the Mackenzie Highway (No.1) to Wrigley and reconstruction work on the Dempster Highway (No.8). The cost estimates are based on preliminary quantity estimates developed from the Table 1 design parameters and probable construction costs for a project through this area over an eight (8) to ten (10) year construction period based on standard GNWT contracting policies.

These cost estimates do not include any royalties or land acquisition costs that may be payable to First Nation Land Claimant groups. The highway alignment traverses three First Nation Settlement Land areas and any royalty costs for borrow material (if payable) would add substantial costs to the project for this borrow material (general embankment fill and base granular materials).

Embankment Construction Cost Estimates

The estimated per kilometre embankment construction costs provided below for each of the highway sections take into account the variations in accessibility, borrow availability, availability of granular material for surfacing and general topography and terrain types encountered within the sections linking the communities. Embankment construction costs include embankment construction, minor drainage structures (small diameter culverts) and ditching and granular (gravel) surfacing.

Embankment Construction Section	60 km/hr	80 km/hr
• Wrigley to Tulita	$325,000/km	$400,000/km
• Tulita to Norman Wells	$300,000/km	$375,000/km
• Norman Wells to Fort Good Hope	$325,000/km	$400,000/km
• Fort Good Hope to the Dempster	$400,000/km	$500,000/km
• Deline Access (north side of Great Bear River)	$325,000/km	$400,000/km
• Deline Access (south side of Great Bear River)	$275,000/km	$350,000/km

Structures (Bridges/Culverts) Cost Estimates

The following bridge and culvert costs were used for estimating the cost of the structures required for each section of highway.

Bridge/Drainage Structure	Costs
• Single Span, single lane bridges up to 70 m	$14,000 /m
• Single Span, single lane bridges 71m to 100m	$17,000 /m
• Double span, single lane bridges up to 200 m	$6,000,000 /ea
• Great Bear River bridge at Tulita	$12,000,000
• Culverts 1.5 m to 2.4 m diameter	$150,000 /ea
• Culverts 2.5 m to 4.5 m diameter	$300,000 /ea

The above costs do not include design and other associated engineering costs.

Engineering Cost Estimates

Engineering costs for highway construction include all costs associated with geotechnical investigations, preliminary/topographic surveys, highway design, bridge design, contract preparation and construction supervision and administration. Experience in the Northwest Territories and other jurisdictions has shown that these combined costs typically amount to 8 - 12 percent of the project capital costs. In this study, a figure of 10% has been used for the 60 kilometres per hour design and 9% for the 80 kilometres per hour design.

ESTIMATED CONSTRUCTION COSTS

This section provides the estimated construction costs for each of the inter-community sections of highway and a brief description of some of the factors that affect the construction costs in each section.

Wrigley to Tulita

From the existing Hodgson Creek bridge at Wrigley, the alignment closely follows the Mackenzie River all the way to Tulita for a length of 235 kilometres.

A total of about 13 bridges (in addition to the three bridges already installed under the Winter Road Improvement Program) will be required on this section of highway linking Wrigley to Tulita. The longest bridge would be across the Blackwater River with a required length of approximately 200 metres. This would be similar to the existing bridge across the Willowlake River south of Wrigley. Up to 20 large diameter (>1.5 metres) culverts may also be required at minor stream crossings along this section of highway.

Because of the large number of creek and river crossings, a number of barge landing sites may have to be utilized for summer access to construction zones both for embankment construction and bridge construction.

Borrow sources for this section of highway vary from clay to granular material with some of it coming from right of way cuts (roadway excavation). Minor amounts of shale and sandstone could also be utilized between the Saline River and Big Smith Creek.

Winter construction of the embankment will be required between Big Smith Creek and Tulita, a distance of approximately 60 kilometres, due to the high moisture content of the available borrow material. This section will also require capping with higher quality granular borrow after embankment settlement occurs.

The estimated cost of construction for this 235 kilometre section is as follows:

Construction Activity	60 km/hr	80 km/hr
• Embankment Construction	$76,375,000	$94,000,000
• Bridge and Culverts	$27,000,000	$27,000,000
• Engineering	$10,335,000	$10,890,000
TOTAL:	**$113,710,000**	**$131,890,000**
Average Cost per Kilometre:	**$484,000**	**$561,000**

Tulita to Norman Wells

This is the shortest of the inter-community links with a distance of only 74 kilometres between Tulita and Norman Wells. The alignment is fairly direct between the communities and is approximately 10 kilometres away from the Mackenzie River at the farthest point.

On this section, the embankment would be constructed from a combination of limestone, shale and clay borrow. In order to access the Tulita end of the section during the summer, a three kilometre access road would have to be constructed from a barge landing site

about 1.5 kilometres north of the mouth of Great Bear River. The north end could be accessed from the existing road to the limestone quarry near Norman Wells.

Four or five bridges and an equal number of large diameter culverts are required at creek crossings between Tulita and Norman Wells. One of the bridges (Vermillion Creek) was completed in early 1999 and a second bridge will be completed at Canyon Creek in early 2000 as part of the on going Winter Road Improvement Program. Not included in the above is the major crossing required at the Great Bear River near Tulita.

A bridge across the Great Bear River would need to be approximately 400m long and it is doubtful if a single lane bridge would be suitable for such a length in such close proximity to the community. At the very least, it is expected that a separate pedestrian walkway with adequate guardrails would be required. Further engineering studies and community consultation will be required to determine the appropriate bridge design for this location.

The estimated cost of construction for this section is as follows:

Construction Activity	60 km/hr	80 km/hr
• Embankment Construction	$22,200,000	$27,750,000
• Bridge and Culverts	$6,000,000	$6,000,000
• Great Bear River Bridge	$12,000,000	$12,000,000
• Engineering	$4,020,000	$4,120,000
TOTAL:	**$44,220,000**	**$44,870,000**
Average Cost per Kilometre:	**$598,000**	**$674,000**

An alternative option, which must be assessed in more detail, is that of establishing ferry crossing facilities for the Great Bear River. Ferry crossing facilities at the Great Bear River would reduce the capital cost by approximately $7,000,000, however, the trade off would be seasonal road closures in the spring and fall and an approximate additional $500,000 in annual operating costs.

Norman Wells to Fort Good Hope

The alignment distance between Norman Wells and Fort Good Hope is 150 kilometres. The route follows along the Mackenzie River from Norman Wells until the river veers to the west at about the halfway point. From that point, the alignment stays at approximately 25 kilometres east of the Mackenzie River until they converge again near Fort Good Hope.

Available borrow material for this section consists of sand, gravel and limestone with some clay north of Norman Wells and gravel, shale, clay and limestone south from Fort Good Hope. The alignment can be accessed from the existing roads at Norman Wells, but at

Fort Good Hope, construction would have to start with building the 3 kilometre access road from the community to the highway alignment.

Nine or ten bridges are required between Norman Wells and Fort Good Hope in addition to the existing bridge at Bosworth Creek, just north of Norman Wells. The largest one would be approximately 100 metres long over the Donnelly River which is 55 kilometres south of Fort Good Hope.

The estimated cost of construction for the total of 153 kilometres of road required for this section is as follows:

Construction Activity	60 km/hr	80 km/hr
• Embankment Construction	$49,725,000	$61,200,000
• Bridge and Culverts	$8,000,000	$8,000,000
• Engineering	$5,775,000	$6,230,000
TOTAL:	**$63,500,000**	**$75,430,000**
Average Cost per Kilometre:	**$415,000**	**$493,000**

Fort Good Hope to the Dempster Highway

From Fort Good Hope, it is 345 kilometres to the proposed junction with the Dempster Highway 65 kilometres south of Inuvik. The alignment parallels the Mackenzie River for about two thirds of the way and then continues on to the Dempster Highway as the river turns and flows in a westerly direction towards Tsiigehtchic.

The north half of this section would be constructed almost entirely of shale borrow and the south half would be constructed from a combination of granular, shale and clay borrow materials. Access for construction would be from the Dempster Highway, Fort Good Hope and a potential central barge landing site on the Mackenzie River which would require construction of a 1.0 - 1.5 kilometre access road to the highway alignment.

Only five bridges and a few large diameter culverts are required over the 345 kilometre distance between Fort Good Hope and the Dempster Highway. The Hare Indian River near Fort Good Hope is the largest water crossing and will require a bridge in the order of 150 - 200 metres long.

The estimated cost of construction for this section of highway is as follows:

Construction Activity	60 km/hr	80 km/hr
• Embankment Construction	$138,000,000	$160,000,000
• Bridge and Culverts	$8,500,000	$8,500,000
• Engineering	$14,650,000	$15,165,000
TOTAL:	**$161,150,000**	**$15,165,000**
Average Cost per Kilometre:	**$467,000**	**$532,000**

Deline Access to the Mackenzie Highway

An access road from Deline to the Mackenzie Highway would be 125 kilometres long, if it were located entirely on the north side of the Great Bear River, or, only 105 kilometres long if it was located on the south side of the Great Bear River. Locating the road on the north side would avoid the need to cross the Great Bear River near Deline, where it flows out of Great Bear Lake. However, the shorter distance and lower per kilometre construction costs associated with the south side route appear to more than offset the additional cost of constructing a bridge across the river near Deline.

Cost estimates are provided below for both routes:

North Side (125 kilometres)

Construction Activity	60 km/hr	80 km/hr
• Embankment Construction	$40,625,000	$50,000,000
• Bridge and Culverts	$3,000,000	$3,000,000
• Engineering	$4,365,000	$4,770,000
TOTAL:	**$47,990,000**	**$57,770,000**
Average Cost per Kilometre:	**$384,000**	**$462,000**

South Side (105 kilometres)

Construction Activity	60 km/hr	80 km/hr
• Embankment Construction	$28,875,000	$36,750,000
• Bridge and Culverts	$3,000,000	$3,000,000
• Great Bear River Bridge (200m)	$6,000,000	$6,000,000
• Engineering	$3,790,000	$4,120,000
TOTAL:	**$41,665,000**	**$49,870,000**
Average Cost per Kilometre:	**$397,000**	**$475,000**

SUMMARY OF CONSTRUCTION COST ESTIMATES

The estimated construction costs for all of the sections are summarized below:

Road Section	60 km/hr	80 km/hr
• Wrigley to Tulita	$113,710,000	$131,890,000
• Tulita to Norman Wells	$44,220,000	$49,890,000
• Norman Wells to Fort Good Hope	$63,500,000	75.430,000
• Fort Good Hope to the Dempster	$161,150,000	$183,665,000
• Deline Access (South Side)	$41,665,000	$49,870,000
TOTAL:	**$424,245,000**	**$490,725,000**
Average Cost per Kilometre:	**$465,000**	**$538,000**

Depending on the design selection, the total cost for construction of the Mackenzie Highway extension and access road from Deline would be somewhere between 400 and 500 million dollars. It should be pointed out that the 60 kilometres per hour design could be changed to an 80 kilometres per hour design with an 8.4 metre roadtop for an additional cost of only about five percent. Such a road would still require widening if it were to be upgraded (changes to speed limits) and asphalt surfaced in the future.

OPERATION AND MAINTENANCE COSTS

The estimated annual maintenance costs for the Mackenzie Highway extension and Deline access road are somewhat dependant on the selected highway design. It will cost more to maintain a 10.0 metre wide roadtop than it will to maintain an 8.4 metre roadtop. Based on maintenance costs for various sections of the existing NWT Highway System, the basic annual highway maintenance costs (excluding bridges and large diameter culverts) for this study are estimated to be $9,000 per kilometre for the 8.4 metre roadtop and $9,500 per kilometre for the 10.0 metre roadtop. The annual maintenance costs for bridges and large diameter culverts are estimated to be an additional one percent of the initial capital cost of the structures.

The total annual estimated maintenance costs for the sections of highway are as follows:

Highway Section	60 km/hr	80 km/hr
• Wrigley to Tulita	$2,385,000	$2,502,000
• Tulita to Norman Wells	$846,000	$883,000
• Norman Wells to Fort Good Hope	$1,457,000	$1,534,000
• Fort Good Hope to the Dempster	$3,190,000	$3,363,000
• Deline Access (South side)	$1,035,000	$1,087,000
ANNUAL TOTAL:	**$8,913,000**	**$9,369,000**
Overall Average Annual Cost per Kilometre:	**$9,773**	**$10,273**

IMPLEMENTATION AND SCHEDULING

As mentioned previously, the cost estimates developed for this study were based on standard GNWT contracting policies and an eight (8) to ten (10) year construction period. This is considered to be the optimum time period for the efficient distribution of work and utilization of available resources.

However, in order to maximize local and northern economic benefits, a longer construction period may be more appropriate. In a 1992 report entitled *Implementation Plan for the Mackenzie Highway Extension*, the department recommended a 20 year construction period as the optimum time frame for maximizing economic benefits.

A discussion on a Community Based Construction Approach to improve the winter roads within the Sahtu Region is included as Appendix ‘A’. Under this approach, the emphasis would be entirely on providing long term local economic/business opportunities and employment and training through a low level of annual funding distributed between the four Sahtu communities, Wrigley and communities in the Inuvik Region (Fort McPherson, Tsiigehtchic and Inuvik) and not on completing the road within a reasonable time frame.

The end objective would be to, firstly , extend the winter road operation period then complete a low standard all-weather road that would link the Sahtu communities to the Deh Cho Region and beyond.

Should the GNWT elect to proceed with construction of this highway extension project using the standard GNWT Public Tendering process, the first most probable area of construction activity would be on the Wrigley to Tulita section. The same approach, as mentioned in the Community Based Construction options, of extending the winter road operation period into the Sahtu Region would be employed. This will involve constructing bridges and culvert installations at major river and stream crossings. Once this river and stream work has been completed, the all-weather road embankment construction activities could then be distributed between the communities of Wrigley, Tulita and Norman Wells. The first priority would be to provide an all-weather road link from Wrigley to Norman Wells. A winter road from Fort Good Hope to the Dempster Highway could also be opened up during the same period of this construction activity. Once the all-weather road reaches Norman Wells, all-weather road embankment construction activity could be distributed between the communities of Norman Wells, Fort Good Hope and the Inuvik Region (Fort McPherson, Tsiigehtchic and Inuvik). The last area for construction would be the access road from the community of Deline, which will be dependant on the community's desire to have an all-weather road into their community.

Regardless of the selected construction time frame or construction approach, which will likely be more dependant on available funding than anything else, a minimum of one year of lead time would be required for pre-engineering and design and preparation of contract documents for the first construction location.

APPENDIX A

Community Based Construction Approach
Sahtu Winter Roads (May 1999)

Mackenzie Highway Winter Road Improvements *(August 1996)*

MACKENZIE HIGHWAY EXTENSION
COMMUNITY BASED CONSTRUCTION APPROACH
SAHTU WINTER ROADS

Purpose

The purpose of this proposed Community Based Construction Approach is the provide long term local employment and economic opportunities by improving the existing Sahtu winter roads, through a low-level funding arrangement, that would lead to the extension of the winter road operation period with the eventual end objective of completing an all-weather road that would link the Sahtu communities to the Deh Cho Region and beyond.

Background

The Sahtu winter roads provides essential transportation links, serving the communities of Tulita, Deline, Norman Wells, and Fort Good Hope with connections to the communities in the Deh Cho Region and beyond. The winter road also serves the Norman Wells petroleum complex (Esso) and the Mackenzie Valley Pipeline. Oil and gas exploration activities continue to increase each winter with the potential for further oil and gas development.

In the past, the Sahtu winter roads has operated for approximately two and a half to three months each year. Over the past three years, the operation window has been reduced to approximately two months. The decreased level of service can, in part, be attributed to changes in climatic conditions (i.e. warmer temperatures and less snow accumulation), and to the tighter regulatory controls and construction practices applied to ensure protection of the environment, fish and wildlife and their habitat.

Employment opportunities in the Sahtu Region are scarce in the heavy construction field. Some petroleum industry activities have provided short term seasonal work. Major airport projects at Fort Good Hope and Deline are complete. Minor projects for winter road improvements and operations also provide some limited seasonal employment and business opportunities for local heavy equipment operators and companies. Overall, the region has a very high unemployment rate.

Project Proposal

Long term improvement of the Sahtu winter roads is proposed to meet the following key objectives:

- Extend the period of winter road operation;
- Address environmental concerns;
- Provide employment and economic opportunities for Sahtu residents and businesses; and
- Work towards an all-weather road.

Technical

Bridge improvements at many crossings are already underway on the Sahtu winter roads. A proposed annual budget of $700,000 is planned for an ongoing bridge installation program at stream and creek crossings. This program will address the majority of the current environmental concerns along the existing winter road. It is also expected to provide a longer winter road operating season.

A larger earthworks project would complement the improvements to the water crossings with the addition of embankment construction and drainage works directed towards completion of an all-weather road. Road work would progress on the existing winter road alignment. Designs already prepared for new highway construction would not be applied, Instead, technical information would be utilized and design and construction of a low standard all-weather road would be directed to include:

- Minimum embankment fill;
- Ten metre (10m) wide road surface;
- Minimum drainage work; and
- Minimum granular surfacing (travel surface).

The low standard all-weather road means less construction work at a reduced cost per kilometre. But it also means accepting deficiencies and increased risk of roadway distress and failure. For example, the minimum embankment fill height would include severe vertical/horizontal curve geometry and grades. The lack of a proper drainage design would limit the number of drainage pipes (culverts) and the extent of drainage ditch construction. The sub-standard road base would increase the potential for wet conditions, areas having low structural strength or carrying capacity and the probability that heavy truck loads will cause roadbed failures. In each case, the problems would involve additional maintenance attention and effort and possible road closures. Over the long term, reconstruction or, at the very least, rehabilitation will be necessary.

All requirements to protect fish and wildlife and their habitat, the environment and to ensure the traveling public's safety would be applied.

Construction Plan

The project would proceed simultaneously with the two main components:

- Stream/Creek crossing (bridge) work; and
- Embankment Construction work.

The stream/creek crossing (bridge) plan is reflected in the existing multi-year plan already underway (copy attached). Embankment construction activities would also proceed at the stream/creek crossing (bridge) sites, by improving approaches and grades adjacent to the bridge.

The remaining, and a more intensive, road embankment construction work would be divided into the following five sections (section lengths shown are approximate only):

- Fort Good Hope to Norman Wells (150 kilometres);
- Norman Wells to Tulita (74 kilometres);
- Deline to Tulita (105 kilometres);
- Tulita to Saline River (105 kilometres); and
- Wrigley to Saline River (130 kilometres).

Construction will consist of work zones within each section. The equipment fleet and support infrastructure would be scaled to match the workforce and equipment availability from the local communities. A typical Construction/Workforce Plan is included with this report.

Under the Community Construction Approach, major construction contracts would not be used. Instead, the successfully demonstrated approach of a community based construction program would be employed. This program would include:

Department of Transportation technical and project management support;
Department of Transportation own-forces equipment;
Local company equipment rental;
Employment Services Contracts with local community agencies; and
Certified training program for Heavy Equipment Operators and Mechanics.

Construction could proceed with very little lead time and would proceed mainly in the summer and fall starting once the ground is thawed and dry. Winter work activities may include drainage work, gravel hauls, and clearing where required.

Construction Costs

Total embankment construction costs for this project are estimated as follows:

Section 1	Fort Good Hope to Norman Wells (150 km)	$ 16,000,000
Section 2	Norman Wells to Tulita (74 km)	$ 8,500,000
Section 3	Deline to Tulita (105 km)	$ 13,000,000
Section 4	Tulita to Saline River (105 km)	$ 15,000,000
Section 5	Wrigley to Saline River (130 km)	$ 17,000,000
	TOTAL COST	**$ 69,500,000**
	(Average cost per Kilometre)	**($ 123,000)**

Major cost estimating assumptions:

- Class “D” Estimates;
- Construction Plan as proposed;
- Historic environmental regulatory processes/requirements;
- No granular or Land use/procurement royalty/acquisition costs;
- No major construction contracts; and
- Direct training costs funded by others.

Funding Plan

- Embankment Construction ($ 1,000,000 per section) — $ 5,000,000/year
- Stream/Creek Crossings (Bridges) (various locations) — $ 700,000/year

Employment Outputs

Surveys conducted in 1996 clearly indicate adequate workforce potential from the communities for each construction section. The Department of Education, Culture and Employment states that the statistics for 1997 and 1998 have not changed substantively.

Labour Force - 1996 Community Statistics

Community	Persons 15 Years +	Labour Force	Employed	Un-Employed
Fort Good Hope	410	260	215	45
Norman Wells	560	505	475	35
Tulita	285	195	155	45
Deline	395	240	180	60
Wrigley	115	75	50	20

The Community Based Construction Approach will consider worker rotation and shutdown periods respecting local, cultural, traditional and seasonal activities.

Business Opportunities

Local businesses will have the opportunity to provide construction or support services directly to the project (i.e. Employment Services, Equipment Rental, Petroleum Products, Accommodations and Catering, Miscellaneous Materials and Supplies, etc.). Sahtu based businesses currently involved in heavy construction activities include:

- Fossil Lake Enterprises Ltd. (Fort Good Hope);
- Fort Good Hope Services (Fort Good Hope);
- Island Valley Oil Ltd. (Norman Wells);
- Flint Construction Ltd. (Norman Wells);
- Sahtu Contractors Ltd. (Norman Wells);
- Red Dog Mountain Contracting Ltd. (Tulita);
- Deline Development Corporation (Deline);
- Deline Construction Ltd. (Deline); and
- Pehdzeh Ki First Nation (Wrigley).

Project Title: **1999/00 Winter Road Improvement, Mackenzie HWY.**

BUDGET: $ 700,000

1. Scope of Work

1. Hodgson Creek Bridge, km 691.

   - Installation of four (4) corner bin walls to retain the side slopes to prevent erosions.
   - Estimated cost $ 60,000
   - Expected construction period June 1999

2. Canyon Creek Bridge, km 1009.3

   - Construction of binwall abutments, bridge assembly, launchng & decking, construction of approaches, rip rap protection & ditch blocks.
   - Estimated cost $ 250,000
   - Expected construction period November/December '99

3. Orchre River Bridge, km 722.4

   - Completion of detail survey, preparation of conceptual design, preparation of structural steel drawings, tender & award of steel superstructure, fabrication of the steel super structure.
   - Estimated cost $ 340,000
     - Survey work June/July '99
     - Conceptual design/drawing July'99
     - Steel drawings & tender August'99
     - Fabrication September/March 2000

4. Grade Improvement, Various locations

   - Road alignment improvements at various locations to improve sight distances, removing sharp curves, and improve the overall safety and ride quality of the winter road.
   - Estimated cost $ 50,000
   - Expected construction period July/October'99

2. Rationale for the change in scope of work from what is identified in the Project Substantiation:

- Canyon Creek land exchange process was settled last year and as a result the construction, which was put on hold was started last fiscal year. This year is the final year of this project.

- Hodgson Creek Bridge was damaged due to ice last spring. Immediate repair work was undertaken last year to open the bridge for the winter season. Minor side slope protection work is required to fix the erosion control problem.

- Orchre River crossing was identified by the Highway maintenance crew as one of the crossings, which delays the opening of the winter road from Wrigley by between two (2) to three (3) weeks.

- Overflow Creek at km 1108 was identified as a priority since this crossing has overflow problems. This bridge crossing is within the Sahtu settlement land and would require some time to complete the land exchange process. As a result this crossing is slotted in the next two to three years to complete.

- The need for the Donnelly River Bridge at km 1118 was discussed with Regional Office and the contractor who maintain this section of the Winter Road. During the last few years of winter road operation, there were no problems with this crossing and as a result is considered a lower priority.

Ranjit Tharmalingam
Head, Structures Section
Highways & Engineering

Mackenzie Highway Winter Road Improvements

PROPOSAL

Highways and Engineering Division
Department of Transportation
Government of the Northwest Territories

August 1996

Department of Transportation
Government of the Northwest Territories

Mackenzie Winter Road Improvements Proposal

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Department of Transportation
Government of the Northwest Territories

SECTION A
Mackenzie Winter Road Improvements Proposal

INTRODUCTION

This proposal presents a five (5) year program for improvement of selected stream crossings on the Mackenzie Winter road system between Wrigley, km 690.0 and Fort Good Hope, km 1172.2 and one (1) bridge crossing on the Trout Lake Winter Road.

Capital funding for the program is $700,000 per fiscal year.

With the input and comments from the Department's Regional Offices and Highway Operations, details of the program are described below including the background, site selection, bridge design, schedule and cost estimates.

Two (2) types of crossings were selected for improvement as follows:

- Permanent bridges on binwall abutments are proposed for small and medium size streams. Estimated cost for each of these bridges is below $1,000,000.00. Presently, snow fill approaches are built on these locations every year and removable bridges or culverts are installed to handle the overflow.

- Light 18 m long portable bridges are proposed for major river crossings. These structures will be installed every year on snow fill embankments and removed prior to break up. Permanent structures on these locations costing more than $1,000,000.00 each are not considered at present time.

SITE SELECTION

A total of twelve (12) steam crossings selected by the regional offices are proposed for improvement. Our office completed site inspections and conducted site survey of each crossing (except Steep Creek and Donnelly River).

They are as follows:

1.	Hodgson Creek, km 691.4	24.0 meter long existing bridge (vertical clearance to be increased)
2.	Whitesand Creek, km 731.0	18.0 meter long portable bridge (new bridge)
3.	Vermillion Creek (South), km 750.1	18.0 meter long portable bridge (replacing existing 24.0 meter portable)
4.	Steep Creek, km 815.8	50.0 meter long permanent bridge (new bridge, further engineering required)
5.	Saline River, km 832.4	18.0 meter long portable bridge (using existing bridge from Vermillion Creek north)
6.	Gotcha Creek (South), km 913.7	24.0 meter permanent bridge (using existing bridge from Vermillion Creek south)
7.	No Name Creek, km 944.0	24.0 meter permanent bridge (using existing bridge from Saline River)
8.	Vermillion Creek (North), km 984.4	42.0 meter long permanent bridge (using existing bridge from Porcupine Creek)
9.	Prohibition Creek, km 995.3	42.0 meter long permanent bridge
10.	Canyon Creek, km 1009.3	30.0 meter long permanent bridge
11.	Donnelly River, km 1118.4	60.0 meter long permanent bridge
12.	Trout Lake Winter Road	18.0 meter long portable bridge

1. FY 1996/97 Program

Hodgson Creek Bridge, km 691.4 (complete)	Bridge Upgrade	$ 60,000
Vermillion Creek (south) Bridge, km 750.1 (fabrication and delivery, complete)	18.0 Portable Bridge	$ 60,000
Gotcha Creek (south) Bridge, km 913.7 (complete)	24.0 m Permanent Bridge	$125,000
No Name Creek, km 944.0 (binwall supply & deliver gravel supply, haul and stockpile)	24.0 m Permanent Bridge	$ 60,000
Vermillion Creek (north) Bridge, km 984.4 (binwall supply & deliver, gravel supply, haul and stockpile)	42.0 m Permanent Bridge	$220,000
Canyon Creek Bridge, km 1009.3 (binwall supply & deliver, gravel supply, haul & stockpile)	30.0 m Permanent Bridge	$100,000
Trout Lake Winter Road (complete)	18.0 m Portable Bridge	$ 60,000
Steep Creek Bridge, km 815.8	18.0 m Portable Bridge	$ 60,000

TOTAL FOR WINTER ROAD BRIDGES $745,000

Grade Improvement Costs $ 50,000

2. FY 1997/98 Program

Whitesand Creek Bridge, km 731.0 (complete)	18.0 m Portable Bridge	$ 60,000
Saline River, km 832.4 (complete)	18.0 m Portable Bridge	$ 10,000
No Name Creek, km 944.0 (bridge relocate and launch, complete)	24.0 m Permanent Bridge	$ 65,000
Vermillion Creek (north) Bridge, km 984.4 (binwall and bridge relocate, assembly/launching, complete)	42.0 m Permanent Bridge	$180,000
Canyon Creek Bridge, km 1009.3 (fabricate and deliver new bridge, binwall and bridge assembly/launching, complete)	30.0 m Permanent Bridge	$335,000
Grade Improvement Costs		$ 50,000
TOTAL FY 1997/98		**$700,000**

3. FY 1998/99 Program

Prohibition Creek Bridge, km 995.3 (fabricate and deliver new bridge, binwall supply & deliver, gravel supply, haul and stockpile)	42.0 m Permanent Bridge	$310,000
Donnelly River Bridge, km 1118.4	60.0 m Permanent Bridge	$340,000
Grade Improvement Costs		$ 50,000
TOTAL FY 1998/99		**$700,000**

4. FY 1999/2000 Program

Steep Creek Bridge, km 815.8 (supply, deliver binwall on site)	50.0 m Permanent Bridge	$ 80,000
Prohibition Creek Bridge, km 995.3 (binwall and bridge assembly/launching complete)	42.0 m Permanent Bridge	$210,000
Donnelly River Bridge, km 1118.4 (complete)	60.0 m Permanent Bridge	$380,000
Grade Improvement Costs		$ 30,000
TOTAL FY 1999/2000		**$700,000**

5. FY 2000/2001 Program

Steep Creek Bridge, km 815.8 (complete)	50.0 m Permanent Bridge	$520,000
Grade Improvement Costs		$180,000
TOTAL FY 2000/2001		**$700,000**

CLOSING

The program has been arranged to consider seasonal deliveries and construction works to occur during the winter and summer months. This includes activities such as follows:

1. Supply and deliver a total of 5,000 m^3 of free draining gravel as structural fill for the three (3) sites near Tulita. The material would be hauled during on the winter road and stockpiled accordingly at each site.

2. At the sites with new portable bridges, the equipment delivering the new structures would be used to relocate four (4) existing portable bridges on their new locations.

3. This proposed winter road program is flexible to reprioritization of the stream crossings based on operational considerations.

SECTION B
PERMANENT BRIDGES

Mackenzie Winter Road

PERMANENT BRIDGE (no engineering drawing)
STEEP CREEK
Mackenzie Highway Winter Road, km 815.8

Bridge Features: The site requires further engineering and survey before the bridge configuration can be selected. Tentatively, a 50.0 meter long span with 4.0 meter wide timber deck could be located on the main highway alignment. The substructure will consist of gravel filled binwall abutments and gabion basket approach fills.

The bridge freeboard to be determined.

Embankment Features: An engineering survey will be carried out during the 1996/97 Winter Road season. Details will be finalized at that time.

Environmental Issues: The following regulatory agencies would be contacted in connection with this work:

- Department of Indian and Northern Affairs, Land Use Permit, Quarry Permit
- Department of Fisheries and Oceans
- NWT Water Board, Water License

Cost Estimate: (Approximate)	**1999/00**	**2000/01**
Fiscal Year Total	**$80,000**	**$520,000**
Steep Creek Total		**$600,000**

PERMANENT BRIDGE
GOTCHA CREEK (SOUTH) BRIDGE
Mackenzie Highway Winter Road, km 913.7, NT

Bridge Features: The permanent bridge crossing will consist of a 24.0 meter span located on the main alignment of the winter road. An existing 24.0 meter long portable bridge from the crossing at Vermillion Creek (South), km 750.1 will be relocated to the Gotcha Creek site. The bridge consists of two (2) 750mm deep steel plate box girders with a 4.0 meter wide timber deck. The substructure will consist of gravel filled binwall abutments and gabion basket approach fills.

The new crossing will have 3.5 meter freeboard above the stream ice level.

Embankment Features: The approaches to the bridge require 2,000 m^3 of material from the surrounding earth embankment to provide a 25.0 meter long level grade each side of the crossing before matching the 10% embankment grade.

The structural fill for the abutments will require 1,250 m^3 of well graded free draining gravel to the area. The nearest source for this material is at Little Bear River across from the community of Tulita. The gravel source is accessible only during the winter months by constructing a road across the Mackenzie River to the site.

Environmental Issues: The following regulatory agencies would be contacted in connection with this work:

- Department of Indian and Northem Affairs, Land Use Permit, Quarry Permit
- Department of Fisheries and Oceans
- NWT Water Board, Water License

		Cost Estimate:	**1996/97**
1.	Binwall supply and delivery		$ 20,000
2.	Gravel supply, haul and stockpile		$ 60,000
3.	Binwall abutment assembly		$ 10,000
4.	Embankment/approach construction 2,000 m^3		$ 15,000
5.	Bridge relocation and launching		$ 10,000
6.	Engineering		$ 10,000
		Gotcha Creek South Total	**$125,000**

PERMANENT BRIDGE

NO NAME CREEK

Mackenzie Highway Winter Road, km 944.0, NT

Bridge Features: The permanent bridge crossing will consist of a 24.0 meter span located on the main alignment of the winter road. An existing 24.0 meter long portable bridge from the crossing at Saline River, km 832.4 will be relocated to the No Name Creek site. The bridge consists of two (2) 750mm deep steel plate box girders with a 4.0 meter wide timber deck. The substructure will consist of gravel filled binwall abutments and gabion basket approach fills.

The new crossing will have 3.5 meter freeboard above the stream ice level.

Embankment Features: The approaches to the bridge require 1,000 m^3 of material from the surrounding earth embankment to provide a 25.0 meter long level grade each side of the crossing before matching the 10% embankment grade. The structural fill for the abutments will require 1,250 m^3 of well graded free draining gravel to the area. The nearest source for this material is at Little Bear River across from the community of Tulita. The gravel source is accessible only during the winter months by constructing a road across the Mackenzie River to the site.

Environmental Issues: The following regulatory agencies would be contacted in connection with this work:

- Department of Indian and Northern Affairs, Land Use Permit, Quarry Permit
- Department of Fisheries and Oceans
- NWT Water Board, Water License

Cost Estimate:		**1996/97**	**1997/98**
1.	Binwall supply and delivery	$ 20,000	
2.	Gravel supply, haul and stockpile, 1250 m^3	$ 55,000	
3.	Binwall abutment assembly		$ 10,000
4.	Embankment/approach construction 1,000 m^3		$ 15,000
5.	Bridge relocation and launching		$ 10,000
6.	Engineering		$ 10,000
	Fiscal Year Total	**$ 75,000**	**$ 45,000**
	No Name Creek Total		**$120,000**

PERMANENT BRIDGE
VERMILLION CREEK (NORTH) BRIDGE
Mackenzie Highway Winter Road, km 984.4, NT

Bridge Features: The permanent bridge crossing will consist of a 42.0 meter span located on the main alignment of the winter road. An existing 42.0 meter long bridge from the crossing at Porcupine River, km 81.0, Deline Winter Road will be relocated to the Vermillion Creek site. The bridge consists of two (2) 1600mm deep steel plate box girders with a 4.0 meter wide timber deck. The substructure will consist of gravel filled binwall abutments and gabion basket approach fills.

The new crossing will have 4.2 meter freeboard above the stream ice level.

Embankment Features: The approaches to the bridge require 12,000 m^3 of material from the surrounding earth embankments to cross the Vermillion River for a 60.0 meter long level grade on the Tulita side and over 160 meters of grade on the Norman Wells side before matching the 10% embankment grade.

The structural fill for the abutments will require 3,000 m^3 of well graded free draining gravel to the area. The nearest source for this material is Norman Wells and would require hauling the material during the annual winter road operation.

Environmental Issues: The following regulatory agencies would be contacted in connection with this work:

- Department of Indian and Northern Affairs, Land Use Permit, Quarry Permit
- Department of Fisheries and Oceans
- NWT Water Board, Water License

Cost Estimate:		**1996/97**	**1997/98**
1.	Binwall supply and delivery	$ 60,000	
2.	Gravel supply, haul and stockpile 3,000 m^3	$150,000	
3.	Binwall abutment assembly	$ 70,000	
4.	Embankment/approach construction 12,000 m^3		$ 25,000
5.	Bridge relocation and launching		$ 50,000
6.	Engineering	$ 10,000	$ 35,000
	Fiscal Year Total	**$290,000**	**$110,000**
		Vermillion Creek North Total	**$400,000**

PERMANENT BRIDGE
PROHIBITION CREEK BRIDGE
Mackenzie Highway Winter Road, km 995.3, NT

Bridge Features: The permanent bridge crossing will consist of a new 42.0 meter span located on the main alignment of the winter road. The bridge consists of two (2) 1600mm deep steel plate box girders with a 4.0 meter wide timber deck. The substructure will consist of gravel filled binwall abutments and gabion basket approach fills.

The new crossing will have 4.5 meter freeboard above the stream ice level.

Embankment Features: The approaches to the bridge require 16,000 m^3 of material from the surrounding earth embankments to cross Prohibition Creek for a 50.0 meter long level grade on the Tulita side and over 160 meters of grade on the Norman Wells side before matching the 10% embankment grade.

The structural fill for the abutments will require 3,000 m^3 of well graded free draining gravel to the area. The nearest source for this material is Norman Wells and would require hauling the material during the annual winter road operation.

Environmental Issues: The following regulatory agencies would be contacted in connection with this work:

- Department of Indian and Northern Affairs, Land Use Permit
- Department of Fisheries and Oceans
- NWT Water Board, Water License

Cost Estimate:		**1998/99**	**1999/00**
1.	Binwall supply and delivery	$ 65,000	
2.	Gravel supply, haul and stockpile 3,000 m^3	$ 75,000	
3.	Fabricate and deliver new 42.0 m bridge, 55t	$150,000	
4.	Binwall abutment assembly		$ 75,000
5.	Bridge assembly and launching, 55t		$ 35,000
6.	Embankment/approach construction, 16,000 m^3		$ 60,000
7.	Engineering	$ 20,000	$ 40,000
	Fiscal Year Total	**$310,000**	**$210,000**
		Prohibition Creek Total	**$520,000**

PERMANENT BRIDGE
CANYON CREEK BRIDGE
Mackenzie Highway Winter Road, km 1009.3, NT

Bridge Features: The permanent bridge crossing will consist of a new 30.0 meter span located on the main alignment of the winter road. The bridge consists of two (2)1200mm deep steel plate box girders with a 4.0 meter wide timber deck. The substructure will consist of gravel filled binwall abutments and gabion basket approach fills.

The new crossing will have 4.5 meter freeboard above the stream ice level.

Embankment Features: The approaches to the bridge require 12,000 m^3 of material from the surrounding earth embankments to cross the flood plain at Canyon Creek for a 180.0 meter long level grade on the Tulita side and 30 meters of grade on the Norman Wells side before matching the 10% embankment grade.

The structural fill for the abutments will require 3,000 m^3 of well graded free draining gravel to the area. The nearest source for this material is at Norman Wells. The gravel would require hauling the material during the annual winter road operation.

Environmental Issues: The following regulatory agencies would be contacted in connection with this work:

- Department of Indian and Northern Affairs, Land Use Permit
- Department of Fisheries and Oceans
- NWT Water Board, Water License

Cost	**Estimate:**	**1996/97**	**1997/98**
1.	Binwall supply and deliver	$ 65,000	
2.	Gravel supply, haul and stockpile 3,000 m^3	$ 75,000	
3.	Fabricate and deliver new 30.0 m bridge, Sit		$120,000
4.	Binwall abutment assembly		$ 60,000
5.	Bridge assembly and launching, Sit		$ 15,000
6.	Embankment/approach construction, 12,000 m^3		$ 30,000
7.	Engineering	$ 5,000	$ 50,000
	Fiscal Year Total	**$145,000**	**$275,000**
		Canyon Creek Total	**$420,000**

PERMANENT BRIDGE (no engineering drawing)
DONNELLY RIVER
Mackenzie Highway Winter Road, km 1118.4

Bridge Features: The site requires further engineering and survey before the bridge configuration can be selected. Tentatively, a 60.0 meter long span with 4.0 meter wide timber deck could be located on the main highway alignment. The substructure will consist of gravel filled binwall abutments and gabion basket approach fills.

The bridge freeboard to be determined.

Embankment Features: An engineering survey will be carried out during the 1996/97 Winter Road season and Summer 1997. Details will be finalized at that time.

Environmental Issues: The following regulatory agencies would be contacted in connection with this work:

- Department of Indian and Northern Affairs, Land Use Permit, Quarry Permit
- Department of Fisheries and Oceans
- NWT Water Board, Water License

Cost Estimate: (Approximate)	**1998 /99**	**1999/00**
Fiscal Year Total	**$340,000**	**$380,000**
Donnelly River Total		**$720,000**

SECTION C
PORTABLE BRIDGES

Mackenzie Winter Road

PORTABLE BRIDGES

Bridge Features: The portable bridges will each consist of an 18.0 meter span, placed at stream crossings with repeated winter road overflow problems. Each bridge consists of two (2) 680mm deep steel plate box girders with a 4.0 meter wide Umber deck. The substructure will consist of snow/ice abutments at each winter road season. The length of the portable bridges is designed such that the bridge may be easily hauled using local available equipment in these areas.

The freeboard at each bridge will vary depending on site conditions.

Environmental Issues: The following regulatory agencies would be contacted in connection with this work:

- Department of Fisheries and Oceans

Cost Estimate (per bridge):		**1996197**	**1997/98**
1.	VERMILLION CREEK (South), Mackenzie Highway No.1, Winter Road, km 750.1	$ 60,000	
2.	TROUT LAKE, Trout Lake Winter Road	$ 60,000	
3.	WHITESAND CREEK, Mackenzie Highway No.1, Winter Road, km 731.0		$ 50,000
4.	SALINE RIVER, Mackenzie Highway No.1, Winter Road, km 832.4 (relocated from Vermillion Creek (North) km 984.4)		$ 5,000
	Fiscal Year Total	**$120,000**	**$ 55,000**
	Portable Bridge Total		**$175,000**

SECTION D
BRIDGE UPGRADING

Mackenzie Winter Road

BRIDGE UPGRADING
HODGSON CREEK BRIDGE
Mackenzie Highway Winter Road, km 691.4, NT

Bridge Features: The existing 24.4 meter long crossing is subject to high water conditions during spring runoff. To improve the site against further flooding, the freeboard under the bridge will be increased an additional 1.6 meters for a total clearance of 4.5 meters above stream level. Improvements will also include replacing the cross bracing with full depth steel diaphragms at each bearing end.

The substructure will consist of additional steel binwall abutments placed on to of the existing binwalls.

The structural fill for the new abutments will require 1,000 m^3 of well graded free draining gravel to the area. The nearest source for this material is at Wrigley and is available all year.

Environmental Issues: The following regulatory agencies would be contacted in connection with this work:

- Department of Indian and Northem Affairs, Land Use Permit
- Department of Fisheries and Oceans
- NWT Water Board, Water License

Cost Estimate:		**1996/97**
1.	Gravel supply, haul and place 2,000 m^3	$32,000
2.	Binwall abutment assembly	$10,000
3.	Bridge removal and re-launching, 34t	$13,000
4.	Engineering	$5,000
	Hodgson Creek Total	**$60,000**

SECTION E
DRAWINGS

Mackenzie Winter Road

THE REMAINING PAGES WERE INTENTIONALLY OMITTED FROM THIS DOCUMENT

APPENDIX B

1989 Report
Mackenzie Highway, Wrigley to Inuvik Extension

MACKENZIE HIGHWAY

WRIGLEY TO INUVIK EXTENSION

prepared by

TRANSPORTATION ENGINEERING DIVISION

Department of Transportation
Government of the Northwest Territories
Yellowknife, Northwest Territories

September, 1989

SYNOPSIS

This report briefly summarizes the status of the Mackenzie Highway extension from Fort Simpson to Inuvik and provides a current cost estimate for completion of the extension as well as preliminary cost estimates for paving from the junction of the Yellowknife Highway to Inuvik. Discussions are also presented on design standards, project scheduling and further work required prior to construction.

With the exception of ferry crossing facilities for the Mackenzie River at Camsell Bend and a bridge at Willowlake River, the Mackenzie Highway is basically complete as an all weather gravel surfaced highway to km 702 near Wrigley. Bridge and ferry crossing facilities to complete the section are estimated to cost $10 million (1989 dollars).

This leaves 804 km of highway to be constructed from Wrigley to km 1506; the junction with the Dempster Highway 60 km south of Inuvik. The estimated cost to construct this portion of the extension to a gravel surface standard is $417 million (1989 dollars). Risk factors due to quantity and market variance could increase this amount to $500 million.

Paving from the junction of the Yellowknife Highway to Inuvik is estimated to cost $422 million (1989 dollars).

Total capital costs and additional operation and maintenance costs for both a gravel surfaced highway and a paved highway are summarized below:

Mackenzie Highway Junction Hwy. #3 to Inuvik (1379km)	**Total Additional Capital Cost**	**Annual Additional Operation and Maintenance Cost**
Gravel Surface	$427,000,000	$8,573,000
Asphalt Surface	$849,000,000	$8,158,000

If a decision was made to proceed with the extension, a minimum of one year of lead time would be required before construction could begin. The actual construction could reasonably be completed over an eight year period as proposed by Public Works Canada. Paving of the Mackenzie Highway could add three to four years to the total construction period.

Prior to construction all contract plans and specifications would have to be reviewed and revised, detailed bridge designs and specifications developed and some additional geotechnical work would need to be completed. Public consultation and briefing would also be required prior to construction.

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1. INTRODUCTION

This report presents a current cost estimate for construction of the Mackenzie Highway from Wrigley to a connection with the Dempster Highway approximately 60 km south of Inuvik. The surveyed alignment for the extension is illustrated on the map in the pocket of this report. Design standards and further work required to bring the project to the construction stage are also discussed.

The study was undertaken as part of an overall Transportation Strategy being developed for the Northwest Territories.

2. BACKGROUND

The federal government announced in the spring of 1972 that the Mackenzie Highway would be extended from Fort Simpson to the Dempster Highway, which was then under construction. Initial planning proposed that the pre engineering, design, and construction would all be completed in a four year period. This did not prove to be forthcoming.

Extensive survey work, geotechnical investigations by four consulting companies, environmental studies and bridge and culvert design studies were carried out over a four year period ending in 1976.

At the same time, final highway designs were prepared for various portions of the route as the field data became available. The design packages were thoroughly reviewed by the Technical Working Group and the Environmental Working Group of the Mackenzie Highway Committee, which was formed to direct and monitor the project. These groups were made up of representatives from various federal departments with expertise in a wide range of environmental and engineering concerns involved with the construction of northern roads.

The scope and thoroughness of the pre engineering and design and environmental studies which were conducted for the Mackenzie Highway extension is best illustrated by the Public Works Canada reference list included as Appendix A of this report.

Actual construction of the highway extension, which ceased in the summer of 1977, was limited to 210 km of highway from Fort Simpson to km 684, south of Wrigley. In the early 80,s the highway grade was completed to Wrigley (km 702), and remedial work and some granular surfacing was done by the GNWT in 1988. Still required to complete all weather access to Wrigley are the Willowlake River Bridge at km 630 and the Camsell Bend Ferry facilities for the Mackenzie River at km 553.

Winter road access along the proposed alignment has been extended as far north as Fort Good Hope at km 1161.

In 1977 all of the design work for the remainder of the extension was consolidated into a volume of Provisional Contract Packages, which could be used in the future if the project was reactivated.

3. PROVISIONAL CONTRACT PACKAGES

The volume of Provisional Contract Packages prepared by Public Works Canada contains detailed plans and specifications for 23 grading contracts to complete the Mackenzie Highway extension from Wrigley to a connection with the Dempster Highway, south of Inuvik. Grading contracts could be tendered for any of the sections with probably only minor changes to the specifications after they are reviewed. The plans and specifications for the grading contracts should be changed from imperial to metric, however, before going to tender.

A well thought out construction schedule is presented in the volume. The proposed schedule is based on a minimum time of eight years and takes into account the construction resources

of western and northern Canada as well as the most economical use of barge landing sites. The results of a full investigation of the potential barge landing sites and access are included in the report.

Conceptual bridge designs and suggested contract packages are presented in the report but detailed working drawings and contract specifications for bridges were not developed by Public Works Canada.

4. ENVIRONMENTAL CONCERNS

Environmental data pertaining to surficial geology, vegetation, wildlife, fish, archaeology, landscape architecture and construction has been summarized and is presented on strip mosaics in an Appendix of the Public Works Canada report. Recommended construction constraints and environmental assessments are also shown on the strip mosaics. The final highway design and alignment are based on the extensive environmental studies, which are listed in Appendix A of this report.

5. DESIGN STANDARDS

The Mackenzie Highway extension has been designed by Public Works Canada as an all weather gravel surfaced road to a Development Collector Road - 60 mph classification. The road was designed for a total subgrade width of lO.4m, a maximum curvature of 6 degrees, maximum grade of 8 percent, a crown slope of 4 percent and a maximum of 6 percent for super elevation on curves. The side slopes are generally 3 to 1. This exceeds the current NWT Rural Collector Road - 90 kmph classification.

Most of the highway was located and designed as an overlay embankment to avoid cuts in frozen, high ice content, fine grained soils, and materials where the moisture content is well above optimum, and therefore is thaw unstable. A minimum height of fill of 1.4 m was chosen for the embankment with the majority of material designated to come from borrow pits. An embankment height of l.4m was considered adequate to avoid undue thermal degradation of the subsoils. Cut and fill sections were designed in areas in which the geotechnical data indicated good materials with low moisture content.

The conceptual bridge designs provided by Public Works Canada are for the construction of double lane bridges

with steel girder superstructures, cast in place concrete decks and concrete substructures founded on piles where required. These structures are of the same style as those on the Liard Highway.

A design alternative proposed by GNWT is the construction of single lane bridges with pre fabricated steel girder superstructures, timber decks, timber crib or binwall substructures, and concrete piers founded on steel piles where required. This style of bridge has been constructed at Poplar River on the Liard Highway in place of two failed multiplate culverts and at Hodgson Creek near Wrigley. Similar bridges will be installed at Bosworth Creek near Norman Wells and at Martin River and Shale Creek between Fort Simpson and Camsell Bend later this year. The cost estimate for bridges presented in Table 1 is for this type of structure, considered adequate for the loading and traffic volumes that are anticipated.

A median alternative would be the construction of double lane bridges where single spans are feasible and single lane bridges where more costly multispans are required.

Summer ferry crossings with winter ice bridges are

proposed for the Mackenzie River at Camsell Bend and the Great Bear River near Fort Norman.

6. CURRENT CONSTRUCTION COST ESTIMATES

The current cost estimate (1989 dollars) for construction of the 804 km of highway from Wrigley (km 702) to the junction with the Dempster Highway (km 1506) is $417 million; an average of about $519,000/km. Risk due to quantity estimating and market rates could increase the total estimate to about $500 million. With the exception of bridges, the cost estimate is based on the design standards and takes off quantities contained in Public Works Canada's Provisional Contract Packages. As discussed elsewhere, the proposed bridge standard has been reduced from two lane concrete deck bridges to single lane timber deck bridges.

The construction of a bridge at Willowlake River and ferry crossing facilities at Camsell Bend, which are required to complete the highway to Wrigley, is estimated to cost $10 million. This cost is already included in existing GNWT programs.

Unit prices and other costs used to prepare the estimate are based on actual 1989 figures, where available, and best estimates of current anticipated prices where data is not available. The prices used are indicative of the prevailing economic conditions in western and northern Canada. No attempt has been made to assess the effects other major projects, such as a Mackenzie Valley pipeline, may have on the estimate if construction schedules were to coincide. It could be substantial. The magnitude and scheduling of the highway extension project itself could also affect the price.

In comparison, cost figures for 208 km of the Liard Highway built during the period from 1979 to 1983 show an average cost of approximately $285,000/km. Most of these dollars would have been spent in 1980 and 1981 and if inflation is taken into consideration there is reasonable correspondence with the 1989 cost estimate.

Table 1 summarizes the quantities and costs used for the current estimate.

TABLE 1

QUANITY AND CONSTRUCTION COST ESTIMATE

	Description	Quantity	Rate	Cost
1.	Clearing	2880 ha	$3,000.00	$ 8,640,000
2.	Excavation Common	12,548,600 m3	5.00	62,743,000
3.	Excavation Rock	718,700 m3	12.00	8,624,400
4.	Excavation Useable	14,956,000 m3	6.50	97,214,000
5.	Excavation Waste	3,093,700 m3	4.00	12,374,800
6.	Channel Excavation	8,300 m3	10.00	83,000
7.	Compaction	49,500 hours	various	5,296,000
8.	Drying Equipment	2,440 hours	200.00	488,000
9.	Overhual	47,068,800 m3-km	0.75	35,301,600
10.	Pitrun Gravel	727,750 tonnes	4.00	2,911,000
11.	Gravel Haul	13,460,500 tonne-km	0.20	2,692,100
12.	Water for Compaction	67,200 m3	22.00	1,478,400
13.	Rip Rap	32,1 50 m3	200.00	6,430,000
14.	Ditch Lining	17,510 m3	10.00	175,100
15.	Haul Ditch Lining	41,600 nil-km	0.75	31,200
16.	Snow and Ice Removal	11,060 hours	140.00	1,548,400
17.	Engineers' Camp	23	100,000	2,300,000
18.	Engineers' Board	73,440 man-days	50.00	3,672,000
19.	Mobilization	23	500,000	11,500,000
20.	Deliver C.S.P. Culverts	3,278,860 kg	0.35	1,147,600
21.	Install C.S.P. Culverts	47,310 m	various	8,945,000
22.	Deliver C.S.P.P. Culverts	3,005,715 kg	0.35	1,052,000
23.	Install C.S.P.P. Culverts	7,830 m	various	10,894,000
24.	Install temporary bridges	13	200,000.	2,600,000
25.	Supply Culverts	55,140 m	various	9,920,000
26.	Grading Supervision			26,762,000
27.	Surfacing Contracts Plus Supervision			28,943,000
28.	Bridge Contracts Plus Supervision			47,302,500
29.	Ferry Crossing (Great Bear River)			6,000,000
30.	Additional Pre Engineering and Design			10,000,000
			TOTAL	**$417,069,100**

Preliminary estimates for paving the Mackenzie Highway From the junction with the Yellowknife Highway (Hwy #3) at km 187 to the Dempster Highway and on to Inuvik total $422 million.

The estimates are based on a pavement structure with a 300mm subbase, 200mm base course and 100mm of asphalt concrete. It isassumed that known granular deposits could supply the required quantities of aggregate. The preliminary cost estimates, considered accurate to within 20 percent, for paving the various sections of highway are presented in Table 2.

TABLE 2

PAVEMENT COST ESTIMATE

Highway Section	Length	Cost per km	Section Cost
1. Junction Hwy. #3 to Fort Simpson	285 km	$260,800	$74,328,000
2. Fort Simpson to Wrigley	230 km	304,600	70,058.000
3. Wrigley to Dempster Highway	804 km	322,750	259,491,000
4. Dempster Hwy. to Inuvik Airport	50 km	357,140	17,857,000
TOTAL	1369 km		**$421,734,000**

7. OPERATION AND MAINTENANCE COSTS

Estimated annual operation and maintenance costs for the Mackenzie and Dempster Highways from the junction with the Yellowknife Highway to Inuvik are presented in Table 3. There is very little difference in costs between a gravel surfaced highway and the asphaltic concrete option. Total annual operation and maintenance costs for either would be in the order of $13 $14 million. Of this amount the new or additional operation and maintenance costs associated with completion of the Mackenzie Highway to Inuvik would be $8 $9 million.

TABLE 3

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE

		Operation and Maintenance Costs	
Highway Section	**Length**	**Gravel Surface**	**Asphalt Surface**
1. Jct. Hwy #3 to Fort Simpson	285 km	$3,180,000	$2,898,000
2. Fort Simpson to Wrigley	230 km	2,790,000	2,800,000
3. Wrigley to Dempster Highway	804 km	7,623,000	7,478,000
4. Dempster Highway to Inuvik	60 km	498,000	498,000
TOTAL	**1379 km**	**$14,091,OOO**	**$13,676,000**

8. PROJECT SCHEDULING

The contract scheduling proposed in the Public Works Canada report for construction of the remainder of the Mackenzie Highway extension is based on an eight year program to complete the grading, bridges and surfacing contracts. Grading would be completed in year seven. Bridge construction would commence in year one with completion in year seven and surfacing would commence in year six and be completed in year eight. Public Works Canada considered the eight year program to be the minimum time period for proper distribution of work and utilization of available resources. For comparison, approximately 210 km of the Liard Highway was constructed and surfaced, at a slower pace, in a 5 year period from 1979 to 1983.

The schedule proposed by Public Works Canada contains a number of short one year grading contracts near the communities. These could be handled by local contractors. Other grading contracts are of 2 year duration and up to 70 km in length. It is possible that the schedule could be reduced by one or two years by increasing the number of contracts under way at one time or by including the shorter contracts with other sections.

If a decision were made to proceed with construction of the Wrigley to Inuvik extension, a minimum of one year of lead time would be required for additional pre-engineering and design, review and preparation of tender plans and specifications. This lead-time requirement could be even longer if major design changes were to be incorporated into the contracts.

Paving of the Mackenzie and Dempster Highways could increase the total time required for completion by up to 4 years.

9. FURTHER WORK

Further pre-engineering and design work which would be required prior to beginning construction of the Mackenzie Highway extension has been identified in the Public Works Canada report.

All of the grading contract plans and specifications would need to be converted from imperial units to metric units. This was done to one of the grading contracts by Public Works Canada as a sample to determine the problems which may be encountered with such a conversion. Although no special problems were encountered, even with the aid of computers it was a time consuming project which required an average of two man days of work per kilometer of contract conversion.

Detailed bridge designs with contract construction drawings and specifications need to be developed for each of the 30 to 40 stream or river crossings, which will require bridges. The exact number of bridge crossings will depend on the results of a detailed review of all large structural plate pipe culvert designs. It may be desirable to change some of the larger culverts contained in the provisional contract packages to short span bridges. Contract drawings and specifications also need to be developed for the two proposed ferry crossing facilities.

Contract packages for gravel surfacing need to be prepared but as recommended by Public Works Canada these are best developed after the completion of respective grading contracts as the grading construction operation may discover additional sources of granular surfacing materials.

Additional geotechnical information involving field test drilling and sampling will be required at many locations along the proposed route to investigate alternative alignments, better define borrow sources, and fill in areas where information was not obtained during previous investigations. Some of this information would be required before various grading contracts could go to tender and other information could be gathered during grade construction.

An additional concern involves land use and the impact of the proposed Dene Metis land claim on the highway alignment and access to construction materials. This would have to be resolved as well as the need for public consultation and briefings in each of the communities.

APPENDIX A

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