HIGHWAY
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GOVERNMENT OF THE NORTHWEST TERRITORIES

TRANSPORTATION DEPARTMENT

PRELIMINARY ENGINEERING ASSESSMENT OF 22 STREAM CROSSINGS MACKENZIE VALLEY WINTER ROAD WRIGLEY TO FORT GOOD HOPE

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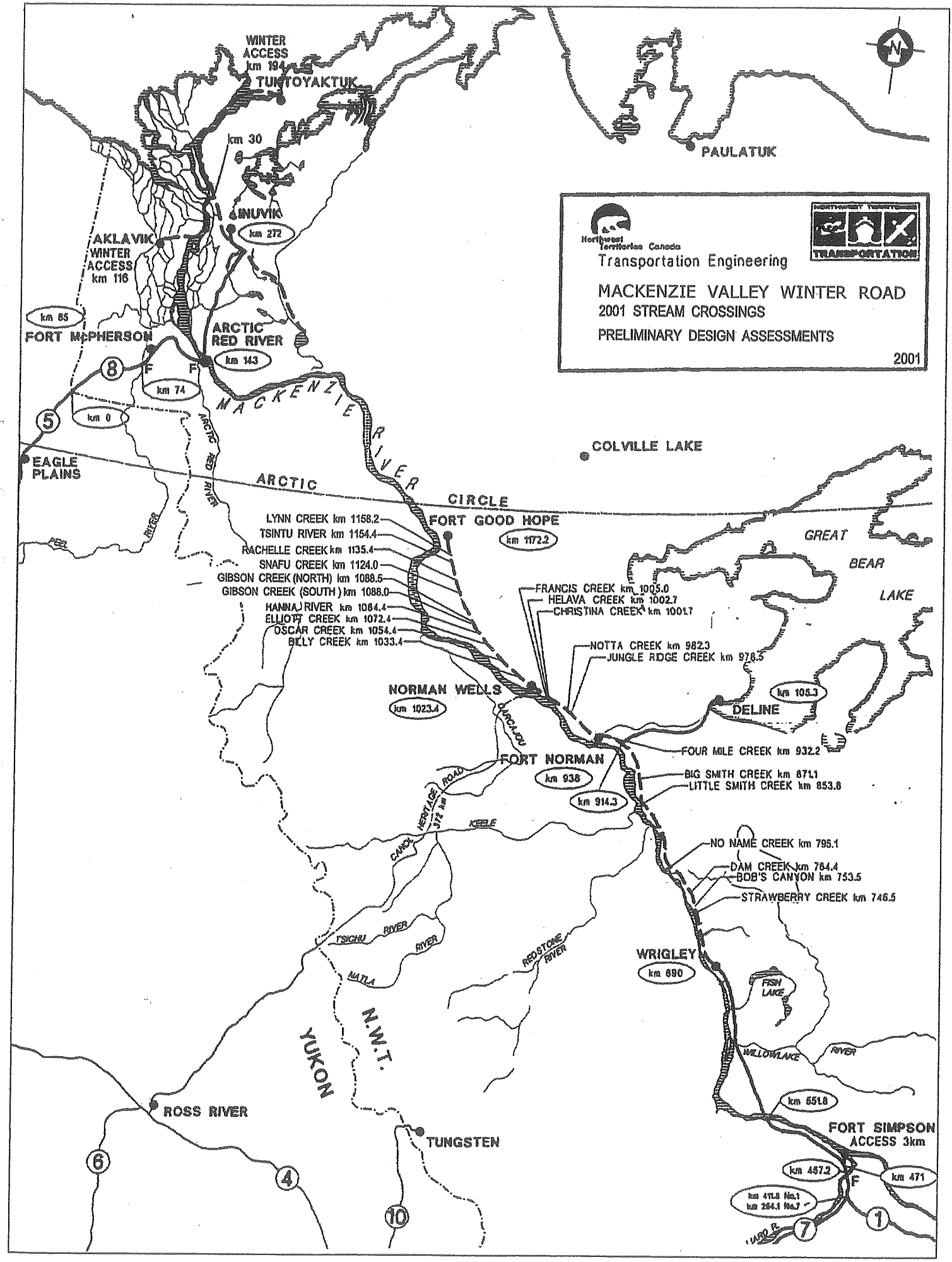
WINTER ACCESS km 194
TUKTOYAKTUK
km 30
INUVIK
km 272
AKLAVIK WINTER ACCESS km 116
km 85
FORT McPHERSON
ARCTIC RED RIVER
km 143
km 74
km 0
EAGLE PLAINS
MACKENZIE RIVER
ARCTIC RED RIVER
ARCTIC CIRCLE
PAULATUK
COLVILLE LAKE
Northwest Territories Canada
Transportation Engineering
MACKENZIE VALLEY WINTER ROAD
2001 STREAM CROSSINGS
PRELIMINARY DESIGN ASSESSMENTS
2001
TRANSPORTATION
LYNN CREEK km 1158.2
TSINTU RIVER km 1154.4
RACHELLE CREEK km 1135.4
SNAFU CREEK km 1124.0
GIBSON CREEK (NORTH) km 1088.5
GIBSON CREEK (SOUTH) km 1088.0
HANNAJ RIVER km 1084.4
ELLIOTT CREEK km 1072.4
OSCAR CREEK km 1054.4
BELLY CREEK km 1033.4
FORT GOOD HOPE
km 1172.2
FRANCIS CREEK km 1005.0
HELAVA CREEK km 1002.7
CHRISTINA CREEK km 1001.7
GREAT BEAR LAKE
NOTTA CREEK km 982.3
JUNGLE RIDGE CREEK km 978.5
NORMAN WELLS
km 1023.4
DELINE
km 105.3
FOUR MILE CREEK km 932.2
FORT NORMAN
km 938
BIG SMITH CREEK km 871.1
LITTLE SMITH CREEK km 853.8
km 914.3
HERITAGE ROAD
378 km
KEELE
CANOL
NO NAME CREEK km 795.1
DAM CREEK km 764.4
BOB'S CANYON km 753.5
STRAWBERRY CREEK km 746.5
TSICHU RIVER
NAHANNI RIVER
REDSTONE RIVER
WRIGLEY
km 690
FISH LAKE
YELLOWKNIFE RIVER
km 551.8
FORT SIMPSON ACCESS 3km
km 457.2
km 471
km 471.8 No.1
km 264.1 No.7
HARE R.
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YUKON
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Preliminary Engineering Assessment of 20 Stream Crossings Mackenzie Valley Winter Road Wrigley to Fort Good Hope

1. INTRODUCTION

The Mackenzie Valley winter road normally opens to light vehicle traffic in early January and to heavy traffic several weeks later. The main limitations to earlier openings are the numerous stream crossings along the route. Typically the northern portion of the road is accessible to traffic several weeks before the southern section is ready.

The GNWT Transportation Department commissioned Camillus Engineering Consultants Ltd. and BP-TEC Engineering Group Ltd. to conduct preliminary engineering assessments of 20 stream crossings along the route. Civil, structural and hydrotechnical assessments were done at each site. Trillium Engineering and Hydrographics were retained by BP-TEC to provide the hydrotechnical assessments.

Site assessments of the crossings were done between August 23 to August 29, 2001. Mr. Tom Williams and Ms. Rhonda Batchelor of GNWT Transportation, Mr. Stuart Smith of BP-TEC and Mr. Gary Van Der Vinne of Trillium conducted the field investigations. The assistance of Carl Yakelaya was greatly appreciated in providing the survey of the sites. The cooperation of Sahtu Helicopters was also greatly appreciated.

During the site inspections, two additional crossings were assessed and are included in this report. As a result, a total of 22 sites were assessed along the Mackenzie Valley winter road.

1.1 Report Organization

The report provides detailed assessments and recommendation for each of the 22 sites. Assessments included alignment issues, hydrotechnical issues, environmental concerns, alternatives and recommendations. The hydrotechnical analysis by Trillium is included for each site.

Each crossing report has the following sections.

• General	Describes site inspection and site coordination.
• Existing Information	Outline of any previous work at the crossing.
• Hydrotechnical	Report prepared by Trillium.
• Environmental	Assessment of fish habitat, etc.
• Alternatives	Description of alternative structures considered feasible.
• Cost Estimates	Estimates of construction costs for each alternative.
• Recommendation	Gives recommended structure and alignment.
• Summary	Brief summary of recommendation.

1.2 Summary Chart

The following summary chart outlines the recommended structure for each site, the estimated cost for construction and the recommended location.

CROSSING SUMMARY CHART				* FA means Federal Alignment * WR means Winter Road
	Crossing	Recommended Structure	Estimated Cost	Recommended Location
4.1	Strawberry Creek	2.0 m Radius Concrete Arch x 30.0 m Long	$ 247,000	FA 150 m upstream of WR crossing.
4.2	Bob's Canyon	2.0 m Radius Concrete Arch x 30.0 m Long	$ 231,700	WR location preferred.
4.3	Dam Creek	31.0 m Single Span Bridge	$ 443,300	WR location preferred.
4.4	No Name Creek	2.0 m Radius Concrete Arch x 18.0 Long	$ 130,890	WR location same as FA.
4.5	Little Smith Creek	66.0 m Single Span Bridge	$ 845,140	WR crossing, 30 m of FA.
4.6	Big Smith Creek	58.0 m Single Span Bridge	$ 1,072,050	50 m upstream of WR crossing.
4.7	Four Mile Creek	2.0 m Radius Concrete Arch Culvert X 18.0 m Long	$ 223,400	Straight WR alignment.
4.8	Jungle Ridge Creek	18.288 m Single Span Bridge	$ 343,780	FA 100 m upstream of WR crossing.
4.9	Nota Creek	22.555 m Single Span Bridge	$ 275,560	WR location same as FA.
4.10	Christina Creek	17.068 m Single Span Bridge	$ 243,925	WR location, 400 m downstream of FA.
4.11	Helava Creek	21.946 m Single Span Bridge	$ 265,985	WR location same as FA.
4.12	Frances Creek	18.288 m Single Span Bridge	$ 251,080	30 m downstream of WR location.
4.13	Billy Creek	32.918 m Single Span Bridge	$ 545,890	WR location.
4.14	Oscar Creek	56.083 m Single Span Bridge	$ 963,300	WR location.
4.15	Elliot Creek	20.726 m Single Span Bridge	$ 319,540	Straight WR alignment, 350 m downstream of existing crossing.
4.16	Hanna River	29.87 m Single Span Bridge	$ 234,090	WR location same as FA.
4.17	Gibson Creek (South)	23.165 m Single Span Bridge	$ 415,590	WR location.
4.18	Gibson Creek (North)	25.908 m Single Span Bridge	$ 454,190	WR location.
4.19	Snafu Creek	21.336 m Single Span Bridge	$ 344,985	FA 100 m upstream of WR crossing.
4.20	Rachelle Creek	23.774 m Single Span Bridge	$ 554,640	WR location, 400 m downstream of FA.
4.21	Tsintu River	30.48 m Single Span Bridge	$ 645,535	50 m downstream of WR location.
4.22	Lynn Creek	18.898 m Single Span Bridge	$ 392,580	60 m to 150 m upstream of WR crossing.

2. SCOPE OF WORK

The scope of work includes the following activities:

- Review of existing files provided by the Department of Transportation.
- Visits to the sites to determine existing conditions.
- Preliminary centreline survey of the existing winter road crossing at each site.
- Assessment of road alignments including comparison to the Federal alignment determined in the 1970's.
- Hydrotechnical assessment including determination of stream flows, predicted high water and ice elevations and minimum openings.
- Cursory geotechnical assessment at each site based on visual observations on the ground surface.
- Environmental constraints based on previous environmental assessments by others.
- Assessment of alternate structures, span arrangements and alignments for each crossing.
- Preparation of drawings for each site incorporating the survey information, hydrotechnical and bridge structure alternatives.
- Cost estimates for each crossing including associated approach embankment fills or cuts and road realignment if recommended.

2.1 Reference Documents

The following documents were reviewed as part of the preliminary engineering assessments.

- Mackenzie Valley Winter Road Operational and Environmental Management Plan, Saline River km 832.4 to Norman Wells km 1023.4 by Department of Transportation, GNWT, May 1997.
- Mackenzie Valley Winter Road Operational and Environmental Management Plan, Norman Wells km 1023.4 to Gibson Gap km 1093.9 by Department of Transportation, GNWT, August 1997.
- Mackenzie Valley and Deline Winter Roads Fish Habitat Assessment by Ferguson Simek Clark, October 1997.
- Basic Environmental Data, Mile 346 to 366, Mile 366 to 395, and Mile 446 to 450 by Department of Public Works, January 1975.

- Basic Environmental Data, Mile 335 to 346, Mile 415 to 448, and Mile 500 to 550 by Department of Public Works, December 1972.

- Technical Report: An Environmental Information Update for Selected Stream Crossings Along the Mackenzie Valley Winter Road by Geonorth and Golder Associates Ltd., March 2000.

- Winter Road Survey - 2000, NWT Highway 1, Mackenzie Highway, Wrigley to Fort Good Hope by Highways and Engineering Division, Hay River.

- Hydrology Study of Bridge Crossings, Mile 297 to Mile 550, Mackenzie Highway by Bolter Parish Trimble, January 1973.

- Mackenzie Valley Winter Road Operational and Environmental Management Plan, Hodgson Creek km 691.4 to Saline River km 832.4 by Department of Transportation, GNWT, May 1997.

- Report on 1973 Program Archeological Impact Study Mackenzie Highway System, DPW 1985.

- Mackenzie Valley Winter Road Operational and Environmental Management Plan, Gibson Gap km 1093.4 to Fort Good Hope km 1172.2 by Department of Transportation, GNWT, August 1997.

- Stream Crossing Survey Mackenzie Highway No. 1, NWT, km 690 to 1023 Wrigley to Norman Wells (Winter Road) by Department of Transportation, Planning, 1973.

- Provisional Bridge Contract packages, Miles 394.8 to 935.9, Public Works Canada Western Region, March 1977.

3. COMMON ITEMS FOR ALL SITES

There are a number of common items applicable to each crossing with respect to construction and use.

1. Access to Sites

Accessibility to the sites is a major restriction to the size and type of structure that can be economically built. Girder lengths are limited to multiples of approximately 20 metres due to sharp curves and abrupt grade changes on the winter road which restrict the length of the trucks transporting the girders. Weight limits are also a factor.

2. Deck Construction

Deck construction must take into account the winter conditions. Using cast-in-place concrete is very expensive as all material must hauled in, heated and hoarded to prevent freezing or stored during the winter and placed in the summer. Modular construction has proved to be very workable for these sites.

3. Road Embankment Construction

Road embankment construction is also done in winter and difficulties occur with monitoring for frozen material. Based on observations of recent fills, significant settlements of the fills can be expected in the first few seasons after construction.

4. Precast Concrete Girders

Precast concrete girders, although capable of spans of 20 to 25 m, require longitudinal concrete grout keys. To install the grout would require heating and hoarding or returning in the summer to do the grouting. Concrete girders are also much heavier for transporting.

5. Maintenance

Low maintenance structures are required due to the remote locations and limit to access. Precast concrete decks are considered to offer the least maintenance concerns. Timber decks, which are used extensively by the oil industry, require replacement of the timber periodically and present more ongoing maintenance requirements.

At several sites, the use of timber decks was considered to be the most effective solution. There are sites where shorter span bridges, 24 m or less are recommended, and the typical oilfield timber deck could be used initially. The bridge girders could be designed to accommodate the precast decks in the future by the addition of welded studs. In some cases, the bridge might be relocated to another location when the road is upgraded and it would be easier to move the bridge without the concrete deck.

6. Culverts

Several of the stream crossings could be crossed using culverts. Culverts, however, present difficulties for construction in the cold winter weather. Culverts are able to support high fills and vehicle loads using an interaction between the compacted fill and the steel structures. Obtaining suitable compaction of fill is difficult in winter and problems could arise including such things as washouts and excessive settlement. Culverts also require disruption of the streambed during installation which may pose problems in the environmental approvals.

7. Arches

An alternate to culverts could be the use of arches supported on driven piles. Northern contractors have expertise in driving piles as has been proven on previous bridge projects. Arches still depend to some extent on a soil-steel interaction so obtaining good fill is still important. An option to steel would be precast concrete arches. Northern contractors would have the ability to cast concrete arches. Design of the concrete arches could be done to include the effects of poor fill compaction.

Construction of the arches would also have less disturbance in the stream and would be considered more environmentally friendly.

8. Driven Piling

Northern contractors have experience driving steel piles and have the equipment to do the work. On several recent projects, driven piles were used and a dynamic pile analysis method used to confirm the pile capacity. Without extensive geotechnical investigation this procedure would seem to be the most suitable.

Standard pile sizes could be utilized in the designs and contractors could stock these sizes only without having to order varying sizes. Two pile sizes that are considered suitable are 610 mm diameter pipe piles or HP 310 x 94 steel H-piles.

3.1 Cost Estimates

Cost estimates for the recommended structure and the alternative structure were developed. Quantities were estimated for such items as approach fills, riprap and pile lengths. A table is attached to each section which gives a breakdown of the estimated quantities and unit costs. Contingency costs of 15% were added plus engineering costs (department and consulting) of 7% were also added.

Cost estimates for realignment of the winter road, if a different crossing location is recommended, have also been included.

Mobilization costs are included for each site to allow for moving in campsites and construction equipment such as cranes for girder erection. The mobilization costs developed

in this assessment are based on doing two or three close sites at one time. If sites are done singly, the mobilization costs should be reassessed as they will likely be higher.

3.2 Additional Information Required

Prior to the final design for each site, a detailed survey of each site will be required to confirm the preliminary data. At many of the crossings, the stream is skewed to the road and some adjustment in the bridge length may be necessary.

At some sites, the survey would also be used to determine the elevation of the bridge site with respect to the Mackenzie River to allow assessment of the impact of high water and ice jam effects.

Geotechnical investigations are recommended for the sites, especially for longer spans and locations where pier structures could be used.

4. STREAM CROSSING SITES

4.1 Strawberry Creek

4.1.1 General

The Strawberry Creek winter road crossing is located at km 746.6 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 63° 39' 35.7" N and Long. 123° 49' 07.3" W.

A field investigation of the site was done on August 24, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking north on the winter road. The present winter road crossing is located within approximately 150 m of the Mackenzie River and 180 m downstream of the federal alignment done in the 1970's.

The approach from the north is on a straight long gentle slope, while the southern approach curves approximately 70 m from the stream.

Stream banks are well vegetated and appear to be stable. The creek bed is composed on small rocks ranging up to 350 mm in size. The stream was 3.0 m wide and 0.5 m deep at the time of the site inspection.

Two test holes were drilled using a hand auger. Both holes ended in gravel at approximately 0.5 m and 1.0 m below ground level.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment, and the recommended structure.

4.1.2 Existing Information

Existing information included an environmental assessment of the winter road operation, a preliminary site survey done by DOT in 1996, and an environmental information update report by GeoNorth and Golder Associates in 2000.

4.1.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information for the Strawberry Creek crossing consisted of topographic maps and air photos of the site as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. A drainage area of 45.6 km^2 was obtained from the federal alignment study. The present winter road crossing is about 180 m downstream of the proposed federal alignment crossing. The drainage area at the present crossing is 45.8 km^2. The slope of the channel near these sites obtained from a 1:50,000 scale topographic map is 0.025. The maximum elevation in the basin obtained from the topographic maps is 610 m. Air photos taken in 1945, 1973 and 1981 were obtained for analysis. The 1950 photographs at 1:20,000 are the earliest available, the 1973 photographs at 1:12,000 are the largest scale available and the 1988 photographs at 1:50,000 are the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 37 m^3/s. The 50-year breakup discharge is also estimated to be about 37 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the present winter road crossing.

On the day of the survey the water was 0.5 m deep and 2.7 m wide at the winter road crossing. Upstream and downstream of the crossing the water was shallower as it flowed over cobbles and boulders. The survey found the channel had a slope of 0.016 over a 30 m length of channel.

A high water mark was found on the downstream side of the winter road crossing on the left bank 2.0 m above the water level. At the cross section location this highwater mark would have an elevation of 100.6 m relative to the local benchmark. No ice scars were evident at the crossing site but a possible ice scar from the Mackenzie was found south of the crossing at the top of the creek valley on the river side of the tree line. This scar was not tied into the cross-section survey due to its distance from the channel but it was above the maximum surveyed elevation of 102.9 m.

Both banks were well vegetated with grass and trees. The bed material was sampled using a line sample technique in the shallow flow at the winter road crossing. The median diameter (D_{50}) of the bed material is 150 mm while the largest stones (D_{90}) are about 340 mm in diameter.

3. River Engineering Analysis

The design high water level based on local flow conditions for the site was calculated to be 101.7 m, which is 3.1 m above the surveyed water level and 3.6 m above the bed. This level is the estimated 50-year ice jam elevation at this site. This level is 1.1 m higher than the highest observed high water mark. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 102.7 m or greater.

Analysis of potential Mackenzie River ice jams near the mouth of Strawberry Creek indicate that high water levels from a Mackenzie River ice jam may occur at the site. The 1:50,000 map contours indicate that the water level at the site is only about 3.2 m above the Mackenzie River, presumably at low flow. However, geodetic water levels on the Mackenzie River indicate that the site may be as much as 6.8 m above the low flow Mackenzie River level. The 50-year ice jam could raise the level in the Mackenzie River as much as 15.0 m at the mouth, so water levels at the crossing site may be as high as 110.4 m. This elevation is 8.7 m higher than the design high water level based on the local hydraulics. The topographic map contours indicate that the federal alignment crossing is about 4.4 m higher than winter road crossing. This added elevation will reduce the effects of a Mackenzie River ice jam at this site. The map elevations are coarse, therefore, a survey is required to determine the actual differential elevation between the low flow open water elevation of the Mackenzie River and the benchmark at the crossing site.

Analysis of air photos of the site indicates that the channel is stable. No channel movement is evident between 1945 and 1981. Both the winter road crossing and the federal alignment site have been stable over the 38 year period. No changes in channel position were apparent in the 2001 air photos as well.

The federal alignment (or even farther upstream) is the preferred crossing location. The channel is stable and relatively straight at both sites but the federal alignment site is farther from the Mackenzie River and is in-line with the main winter road alignment. Both sites may be affected by high water levels from Mackenzie River ice jams but the federal crossing is not likely to be affected by the Mackenzie ice floes themselves whereas the present winter road crossing may be affected by these ice floes. The federal crossing is also 4.4 m higher than the present winter road crossing so the Mackenzie River ice jam water levels will not be as high relative to the local design water level.

The existing channel at the cross section location is 2.7 m wide. The minimum bottom width of the channel should be 3 m to preserve the existing channel. The design open water elevation of 100.9 m would produce a mean velocity of about 2.2 m/s through an opening with an 3 m bottom width and 2:1 side slopes. Alternatively, this creek could be spanned using a culvert. A 3.66 m diameter culvert would be adequate to pass the flow without over-topping the road if the culvert is buried to 20% of its diameter (relative to the downstream bed level of 98.6 m) to provide a natural creek bottom.

4.1.4 Environmental Considerations

The environmental assessment indicates the stream has suitable fish habitat for rearing and feeding, however, it considers the spawning habitat suitability low.

The crossing is located on a stable section of the stream and erosion does not appear to be an issue. Effects of ice jams from the Mackenzie River would likely occur and need to be considered in the design of the crossing.

4.1.5 Alternatives

The site is well suited to a culvert or a short span bridge structure. Based on the hydrotechnical review, a 3.66 m diameter culvert would be suitable. An arch structure is also considered to be very suitable.

The federal alignment would be a suitable location for the bridge crossing, as it is further upstream and at a higher elevation and would be less susceptible to the Mackenzie River ice jam levels.

Bridge alternatives considered were for the two high water/ice conditions due to the possibility of ice jam effects from the Mackenzie River which could lead to a difference of 8.7 m in the predicted high water levels.

Based on a review of the 2001 air photos, the stream crosses the federal alignment on a 25° LHF skew, therefore, two alternate spans were considered. A skewed alternate and a square crossing alternate were considered for the lower high water level case.

The first alternative considered the lower high water level and resulted in a span of 23.774 m for the skewed case and 27.432 m for the square crossing. The second alternative used the estimated possible Mackenzie River ice jam effect and resulted in a three span 20 m - 22 m - 20 m structure with a deck elevation of 112.4 m.

Driven piles were considered to be the most suitable foundation type. A geotechnical investigation would be necessary to determine pile capacities and lengths.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for the site. Preliminary sizing of the bridge girders indicates the bridge structure would consist of two welded wide flange girders.

The attached drawings show the alternative structures that were considered suitable.

4.1.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table. The estimated costs for construction are as follows:

2.0 m radius x 30 m long concrete arch.	$247,000
3.66 m diameter x 37.19 m long culvert.	$315,508
24.732 m single span bridge (on square) (lower high ice).	$339,800
23.774 m single span bridge (on skew).	$313,350
3 span (20.0 - 22.0 - 20.0 m) bridge (Mackenzie Ice).	$1,799,840

4.1.7 Recommendations

The federal alignment would be recommended for this site as it is further away from the Mackenzie River and on a straighter road alignment.

A 2.0 m radius precast concrete arch with an overall length of 30.0 m supported on driven steel piles is recommended for this site. Road fills would be constructed to provide 1.5 m cover over the arch. No disturbance of the streambed would be required.

A 3.66 m diameter culvert with an overall length of 37.15 m could also be recommended for this site. Road fills would be constructed to provide 1.5 m cover over the culvert. Sideslopes of 3H to 1V were assumed in determining the culvert length. To provide for a natural creek bottom, the culvert invert would be placed 0.7 m below the existing streambed.

Verification of the high water level due to the possibility of Mackenzie River ice jam effects is recommended. This could be done by a survey to determine the elevation difference between the low flow open water elevation of the Mackenzie River and the temporary site benchmark.

The attached drawings indicate the preliminary site survey, the hydrotechnical assessments, the alternative structures, and the recommended structure.

4.1.8 Summary

A 2.0 m radius precast concrete arch culvert by 30.0 m long is recommended on the federal alignment for the Strawberry Creek winter road crossing. A detailed survey to determine the elevation of the site relative to the Mackenzie River is required to determine the impact of high water from ice jams.

Site	Strawberry Creek			Pg 1 of 2
	Recommended Structure -2.0m Radius Arch			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	1350	40,500
Backfill - granular	cu.m.	35	800	28,000
Riprap - haul and place	cu.m.	28	50	1,400
New Jersey Concrete Barriers	each	500	16	8,000
Arch Panels				
supply and install	m	900	30	27,000
Driven Piling	each	2500	20	50,000
		Sub-Total		202,400
		Contingency(15%)		30,400
		Engineering(7%)		14,200
		Total		247,000

Alternative - 3.66m dia Culvert

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	1500	45,000
Backfill - granular	cu.m.	35	1000	35,000
Riprap - haul and place	cu.m.	28	80	2,240
New Jersey Concrete Barriers	each	500	16	8,000
Culverts				
supply and install	m	1500	37.19	55,785
earthworks	m	1750	37.19	65,083
		Sub-Total		258,608
		Contingency(15%)		38,800
		Engineering(7%)		18,100
		Total		315,508

Alternative - 27.432m Single Span Bridge on Square (lower ice level)

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	45000	1	45,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	1	25,000
Approaches - common fill	cu.m.	30	1090	32,700
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	50	1,400
Deck Panels				
fabricate and deliver	each	3400	9	30,600
Steel Girders				
fabricate and deliver	kg	1.15	18000	20,700
Steel and Deck Panel Erection	m	1500	27.4	41,100
Bridgerail	m	100	55	5,500
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		278,500
		Contingency(15%)		41,800
		Engineering(7%)		19,500
		Total		339,800

Site	Strawberry Creek			Pg 2 of 2
	Alternative - 23.774m Single Span on Skew (lower ice level)			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Driven Steel Piling	each	10000	4	40000
Precast Concrete Pile Caps	each	7000	2	14,000
Road Realignment	km	25000	1	25,000
Approaches - common fill	cu.m.	30	1090	32,700
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	50	1,400
Deck Panels				
fabricate and deliver	each	3400	8	27,200
Steel Girders				
fabricate and deliver	kg	1.15	12000	13,800
Steel and Deck Panel Erection	m	1500	23.7	35,550
Bridgerail	m	100	47	4,700
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		256,850
		Contingency(15%)		38,500
		Engineering(7%)		18,000
		Total		313,350

Alternative - Mackenzie River Ice Jam Effect

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	150000	1	150,000
Driven Steel Piling - Abutment	each	10000	12	120,000
Driven Steel Piling - Pier	each	20000	5	100,000
Precast Concrete Pile Caps	each	4500	4	18,000
Pier Diaphragms	each	10000	2	20,000
Road Realignment	km	25000	1	25,000
Approaches - common fill	cu.m.	30	26000	780,000
Backfill - granular	cu.m.	35	600	21,000
Riprap - haul and place	cu.m.	28	200	5,600
Deck Panels				
fabricate and deliver	each	3400	21	71,400
Steel Girders				
fabricate and deliver	kg	1.15	25600	29,440
Steel and Deck Panel Erection	m	1500	62	93,000
Bridgerail	m	100	128	12,800
New Jersey Concrete Barriers	each	500	40	20,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		1,475,240
		Contingency(15%)		221,300
		Engineering(7%)		103,300
		Total		1,799,840

Photo 1 - Looking North on Winter Road (Stream Flow to Left)

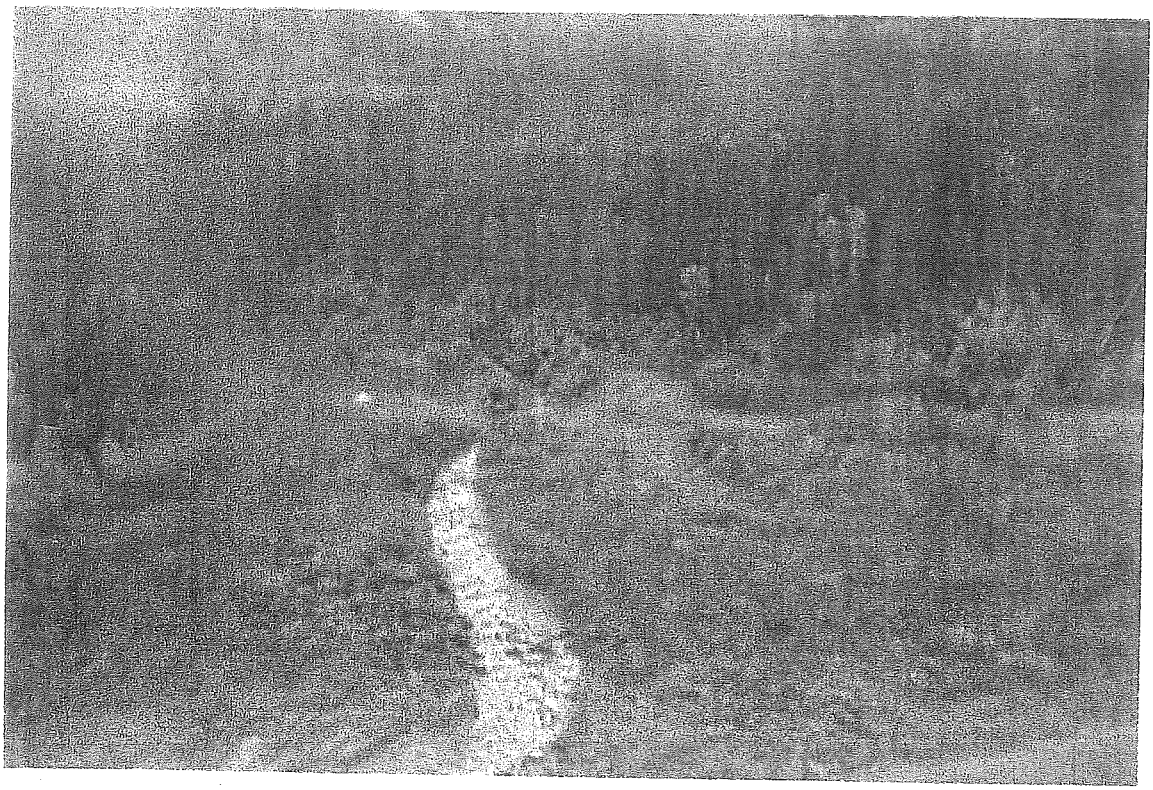


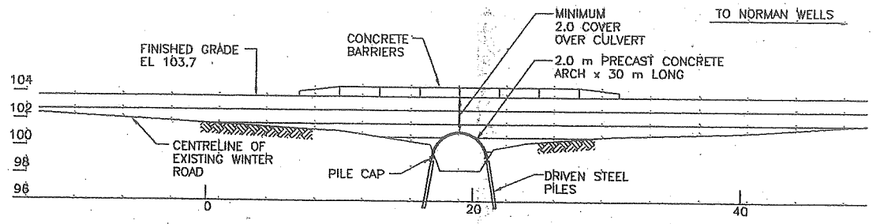
Photo 2 - Looking Upstream

Photo No. 3 - Looking North on Winter Road (Stream Flow to Left)

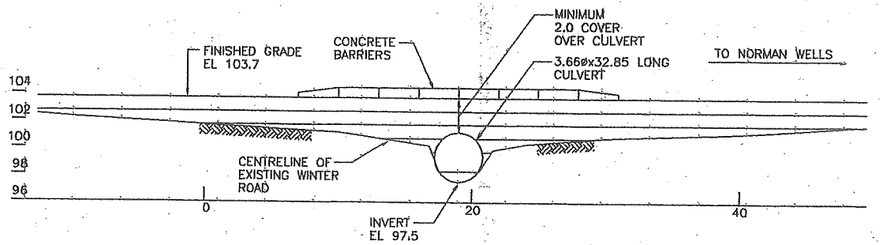
Photo 4 - Looking South on Winter Road

Photo 5 - Looking Upstream

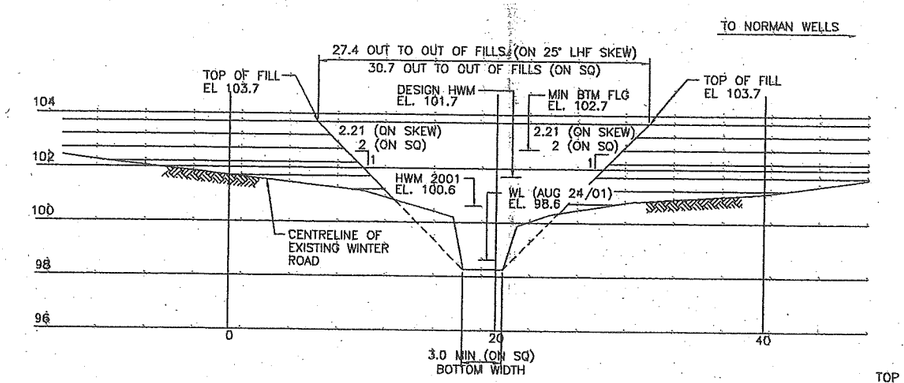
Photo 6 - Looking Downstream



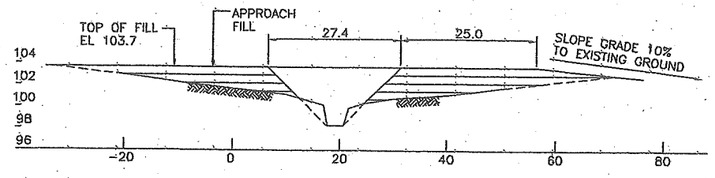
ARCH OPTION ELEVATION – NATURAL SCALE
1:200



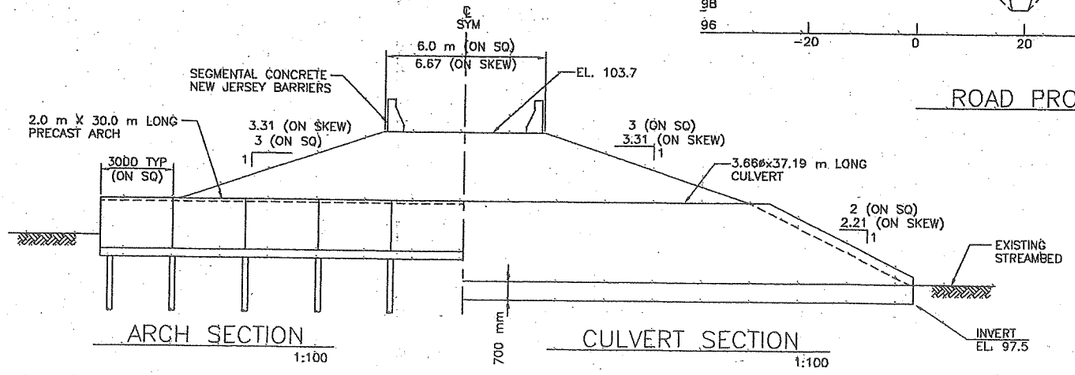
CULVERT OPTION ELEVATION – NATURAL SCALE
1:200



ELEVATION
H – 1:200
V – 1:100

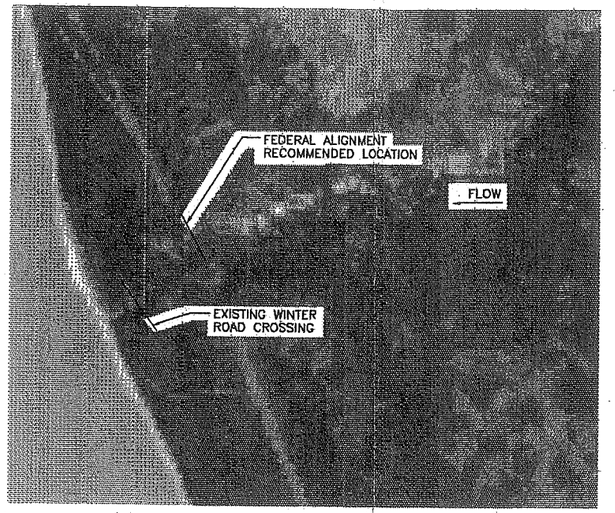


ROAD PROFILE
H – 1:500
V – 1:250

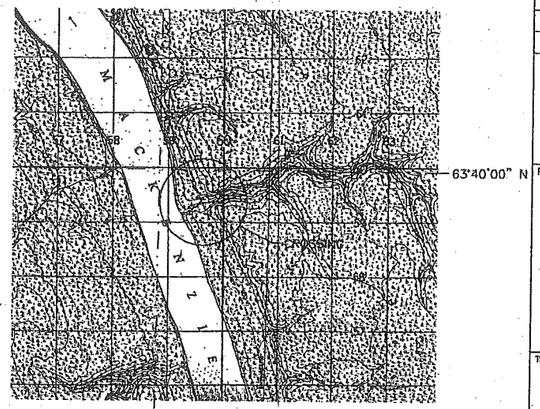


ARCH SECTION
1:100

CULVERT SECTION
1:100



AERIAL PHOTOGRAPH
1:10 000



SITE MAP
1:50 000

SITE INFORMATION

SITE 1
TEMPORARY BENCH MARK ELEV. 100.000 m
NAIL IN WILLOW APPROX. 40 m WEST OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 24, 2001
WINTER ROAD km 747.6
COORDINATES LAT 63°39'35.7" N
LONG 123°49'07.3" W
SITE MAP REFERENCE 95-O/12

HYDROTECHNICAL DATA

- DRAINAGE AREA = 45.8 sq. km
- DESIGN DISCHARGE = 37 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.016 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 2.2 m/s
- ICE DESIGN ELEV. 101.7 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA-S6-00
- POSSIBLE MACKENZIE RIVER ICE JAM EFFECT-MAXIMUM ELEV 110.4 (REQUIRES VERIFICATION BY SURVEY)

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

Northwest Territories Transportation

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EDMONTON, AB
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PH. (780)436-5376

Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

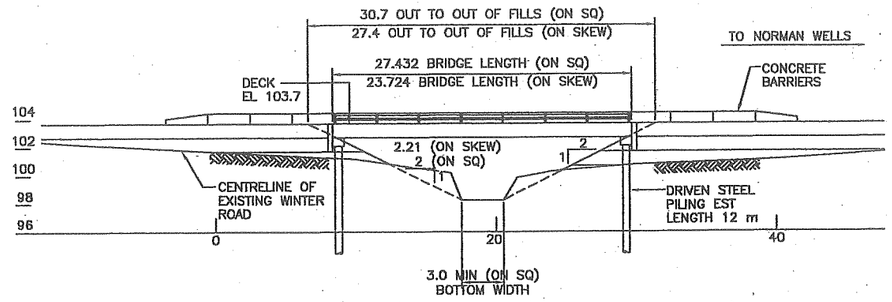
Title

STRAWBERRY CREEK
km 747.6
PRELIMINARY DESIGN
INFORMATION
SHEET 1

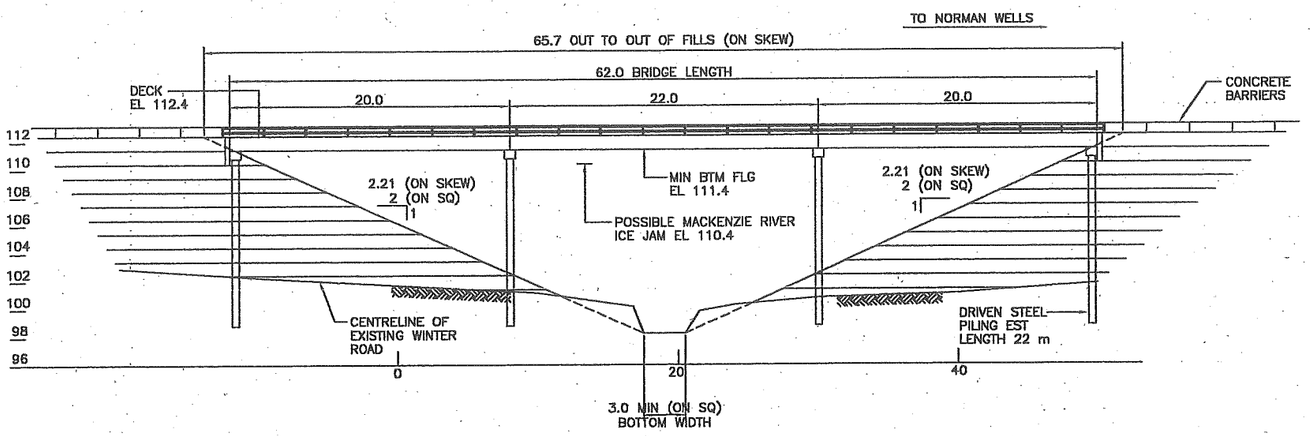
Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Insignia
Signature
Date
Signature
Date
Approved by
Project No.
Page 1 of 22
Drawing No. 608-9-1

FILE NAME: 608-9

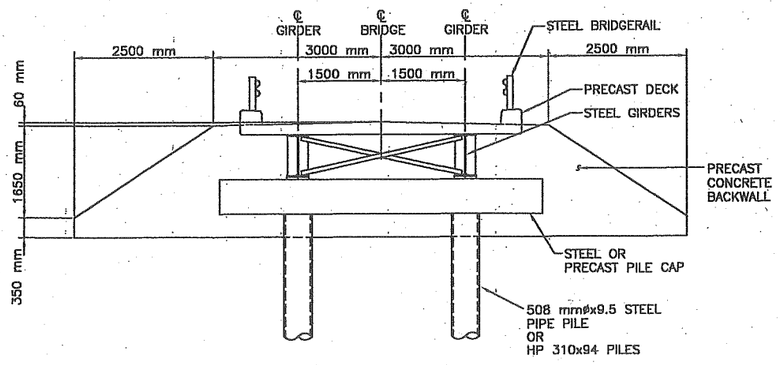
TITLE:



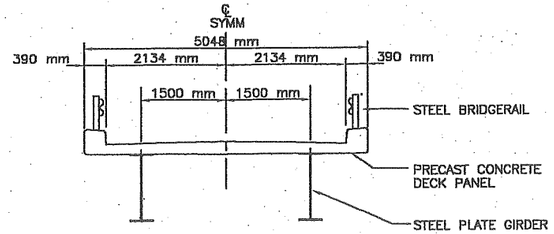
BRIDGE OPTION ELEVATION – NATURAL SCALE
1:200



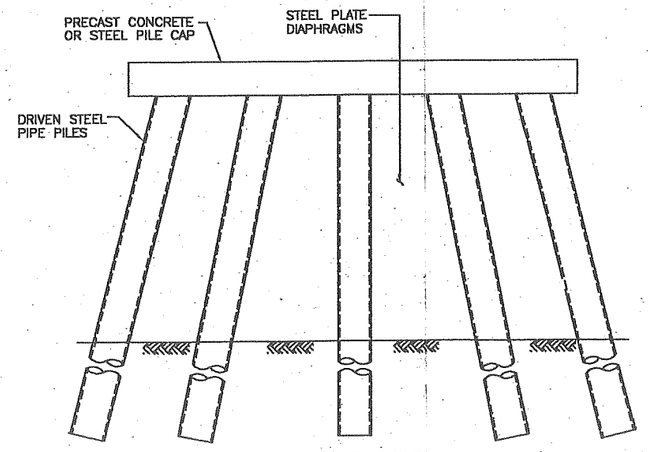
ALTERNATIVE SPAN (FOR MACKENZIE ICE EFFECT)
1:200



ABUTMENT ELEVATION
1:50



DECK SECTION
1:50



PIER ELEVATION
1:50

Northwest Territories Transportation

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

STRAWBERRY CREEK
km 747.6
PRELIMINARY DESIGN
INFORMATION
SHEET 2

Scale	AS NOTED
Surveyed by	
Drawn by	MAP
Designed by	SDS
Checked by	SDS
Insignia	Insignia
Signature / Date	Signature / Date
Approved by	
Project No.	Page 1A of 22
Drawing No.	608-S-1A

4.2 Bob's Canyon Creek

4.2.1 General

The Bob's Canyon Creek winter road crossing is located at km 753.5 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 63° 43' 02.5" N and Long. 123° 52' 10.1" W.

A field investigation of the site was done on August 24, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking north on the winter road. Photos 2 and 3 show the existing crossing looking north and south on the winter road respectively.

The winter road alignment curves as it approaches the crossing from each direction and crosses at a 45° RHF skew to the stream. At the time of the site inspection, the creek was 1 m wide and 0.1 m deep.

Stream banks were well vegetated and appear to be stable. The streambed was composed of small and large rocks. Soil conditions appear to be good as no muskeg was observed.

Mature trees were found along the valley. There appears to be good sources for fill material available from the approach roads.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment and the recommended structure.

4.2.2 Existing Information

Existing information was limited to air photos of the site and photos taken of the winter road. A 400 mm diameter culvert is used in the stream for the winter crossing.

4.2.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The drainage area at the winter road crossing site is 9 km^2. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.042. The maximum

elevation in the basin obtained from the topographic maps is 180 m. Air photos taken in 1946, 1973, and 1981 were obtained for analysis. The 1946 photographs at 1:28,000 are the earliest available, the 1981 photographs at 1:50,000 are the most recent and the 1973 photographs at 1:12,000 are at the largest available scale. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. Based on this method the 50-year design discharge would be 13 m^3/s. The 50-year breakup discharge is also estimated to be about 13 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size.

On the day of the survey there was approximately 0.1 m of water in a 0.9 m deep channel. Channel width at water level was 1.7 m and at top of bank the width was 3.1 m. The slope was surveyed and found to be 0.0036 over a 16.7 m length at the present winter road crossing. However, downstream of the crossing, the channel dropped an additional 1.5 m over a short distance.

High water marks were found on both banks downstream of the winter road crossing. These high water marks were 2.1 and 1.4 m above the water level respectively. Relative to the local benchmark, the high water marks would have elevations of 98.7 and 98.0 m at the winter road crossing. No ice scars were found.

Both banks are well vegetated with grass. Upstream and downstream of the crossing the banks are lined with willow, small deciduous trees, and mature spruce. The bed is composed of cobbles and boulders. Downstream of the winter road crossing there are large boulders with diameters of 0.5 to 1.0 m where the channel drops 1.5 m in height.

3. River Engineering Analysis

A design high water level for the site was calculated to be 98.9 m. This elevation is 2.2 m above the bed level and is 0.2 m above the high water mark observed at the site. The channel elevation appears to be well above the Mackenzie River ice jam level even though the mouth of the creek is only 800 m from the river. The minimum flange elevation of a bridge should provide 1.0 m of freeboard to allow debris to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 99.9 m or greater.

The minimum bottom width of the channel is 1.7 m. This bottom width preserves the natural low water channel. The mean velocity through a bridge opening of this width with 2:1 headslopes is about 0.9 m/s. Alternatively, this creek could be spanned using a culvert. A 3.05 m diameter culvert would be adequate to pass the flow without over-

topping the road if the culvert is only buried to 10% of its diameter. This burial depth is sufficient to preserve the width of the low water channel.

Air photos of the site indicate that the channel has remained fairly stable between 1946 and 1973. No changes in channel position were apparent in the 2001 air photos as well. At the winter road crossing the creek lies in a confined reach and appears laterally stable. However, since the winter road parallels the creek upstream of the crossing the creek may erode the north approach road. The federal alignment crossing, which is 600 m downstream, appears to be in a less confined reach and is quite skewed. The winter road crossing is the preferred site.

4.2.4 Environmental Considerations

No environmental assessment was available for this crossing; however, it would likely be capable of providing some fish habitat. Erosion was not apparent at the crossing and the channel appears to be stable. The skewed crossing could be of concern to erosion of any approach fills.

4.2.5 Alternatives

The site is well suited to a culvert structure. Based on the hydrotechnical review, a 3.05 m diameter culvert would be required. The culvert would be placed along the stream and be skewed approximately 45° right hand forward (RHF) to the road. A length of 42.7 m would be required.

Alternatively, a 2.0 m radius precast concrete arch culvert supported on driven piling is suitable for this site. Road fills would be constructed to provide a minimum 1.75 m cover over the arch. Sideslopes of 3H to 1V were used in determining the arch length. No disturbance of the streambed would be required.

Alternatively, a single span bridge structure could be constructed, either skewed with the stream or built square to the road. Using a skewed bridge, an overall length of 23.774 m would be required. Using a square bridge, an overall length of 28.042 m would be required. The attached drawing indicates the alternatives considered.

The existing location is considered to be suitable for the winter road crossing. The federal alignment location, which is 600 m downstream, appears to be in a less stable section of the stream and is also highly skewed to the road.

4.2.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table. The estimated costs for construction are as follows:

2.0 m radius precast concrete arch x 30.0 m long	$231,700
3.06 m diameter x 42.7 m long culvert.	$301,050
28.042 m single span bridge (on square).	$375,740
23.774 m single span bridge (on skew).	$393,860

4.2.7 Recommendations

The existing crossing location is suitable and no change in alignment need be considered. A 2.0 m radius precast concrete arch with an overall length of 30.0 m supported on driven steel piles is recommended for this site. A 3.05 m diameter culvert with an overall length of 42.7 m could also be recommended for this site. Road fills would be constructed to provide a minimum 1.5 m cover over the culvert. Side slopes of 3H to 1V were assumed in determining the overall culvert length.

To provide for a natural creek bottom, the culvert invert should be placed 0.3 m below the existing streambed.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment, the alternate structure and the recommended culvert structure.

4.2.8 Summary

A 2.0 radius precast concrete arch by 30.0 m long is recommended on the existing alignment for the Bob's Canyon Creek winter road crossing.

Site	Bob's Canyon Creek			Pg 1 of 2
	Recommended Structure -2.0m Radius Arch			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Approaches - common fill	cu.m.	30	1350	40,500
Backfill - granular	cu.m.	35	800	28,000
Riprap - haul and place	cu.m.	28	50	1,400
New Jersey Concrete Barriers	each	500	16	8,000
Arch Panels				
supply and install	m	900	30	27,000
Driven Piling	each	2500	20	50,000
		Sub-Total		189,900
		Contingency(15%)		28,500
		Engineering(7%)		13,300
		Total		231,700
	Alternative - 3.06m dia Culvert			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Approaches - common fill	cu.m.	30	1600	48,000
Backfill - granular	cu.m.	35	750	26,250
Riprap - haul and place	cu.m.	28	50	1,400
New Jersey Concrete Barriers	each	500	16	8,000
Culverts				
supply and install	m	1250	42.7	53,375
earthworks	m	1750	42.7	74,725
		Sub-Total		246,750
		Contingency(15%)		37,000
		Engineering(7%)		17,300
		Total		301,050

Site: Bob's Canyon Creek

Alternative - 28.042m Single Span Bridge (on Square)

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	50000	1	50,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Approaches - common fill	cu.m.	30	1200	36,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	9	30,600
Steel Girders fabricate and deliver	kg	1.15	20000	23,000
Steel and Deck Panel Erection	m	1500	56	84,000
Bridgerail	m	100	56	5,600
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		307,940
		Contingency(15%)		46,200
		Engineering(7%)		21,600
		Total		375,740

Alternative - 23.774m Single Span Bridge (on Skew)

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	50000	1	50,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Approaches - common fill	cu.m.	30	1200	36,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	120	3,360
Deck Panels fabricate and deliver	each	3400	8	27,200
Steel Girders fabricate and deliver	kg	1.15	14000	16,100
Steel and Deck Panel Erection	m	1500	46	69,000
Bridgerail	m	100	47	4,700
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		322,860
		Contingency(15%)		48,400
		Engineering(7%)		22,600
		Total		393,860

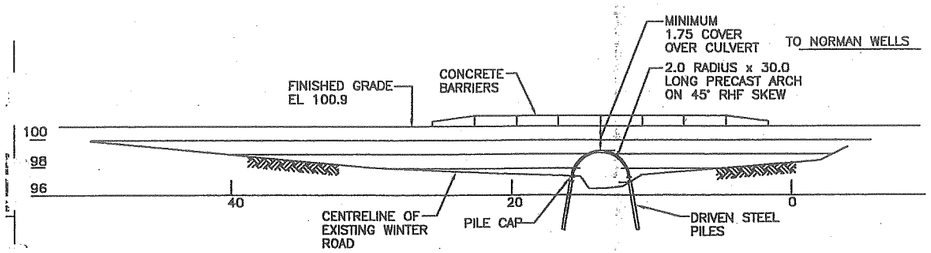
Photo 1 - Looking North on Winter Road (Stream Flow to Left)

Photo 2 - Looking North on Winter Road (Flow to Left)

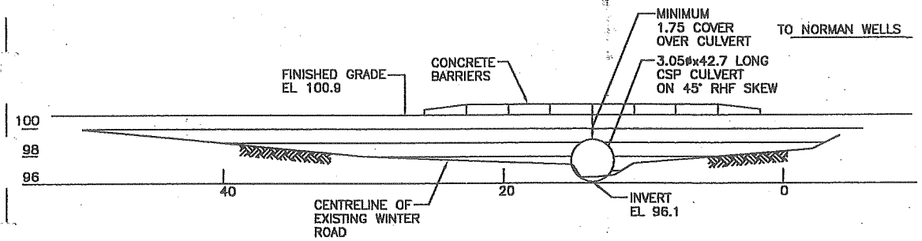
Photo No. 3 - Looking South on Winter Road

Photo 4 - Looking Upstream

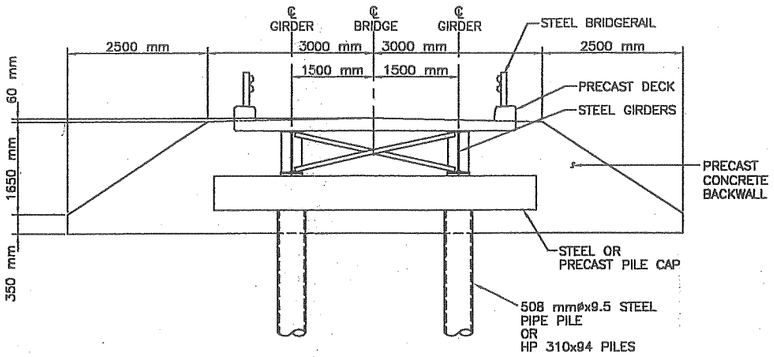
Photo 5- Looking Downstream



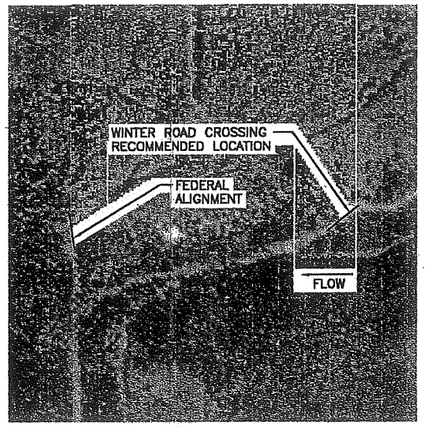
ARCH OPTION ELEVATION – NATURAL SCALE
1:200



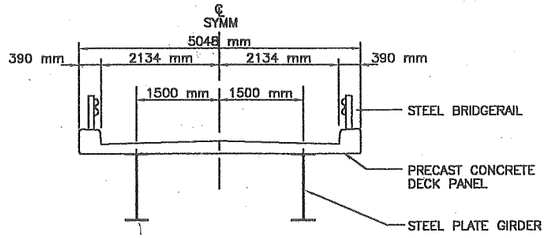
CULVERT OPTION ELEVATION – NATURAL SCALE
1:200



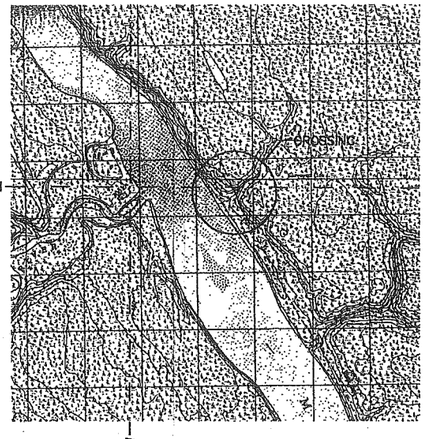
ABUTMENT ELEVATION
1:50



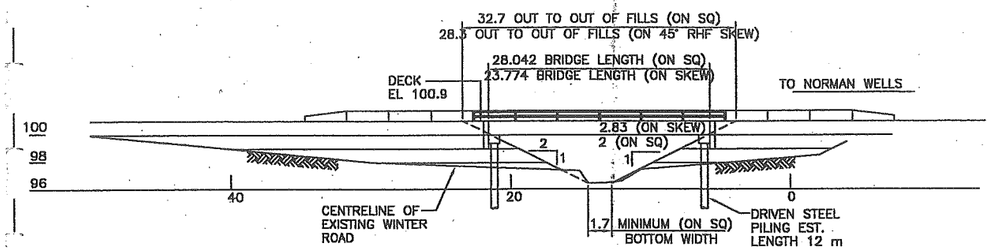
AERIAL PHOTOGRAPH
1:6000



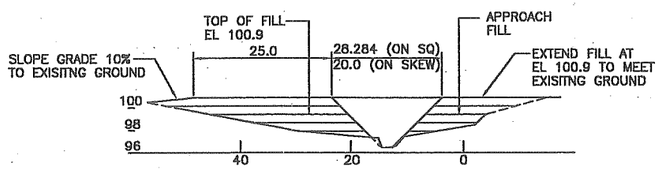
DECK SECTION
1:50



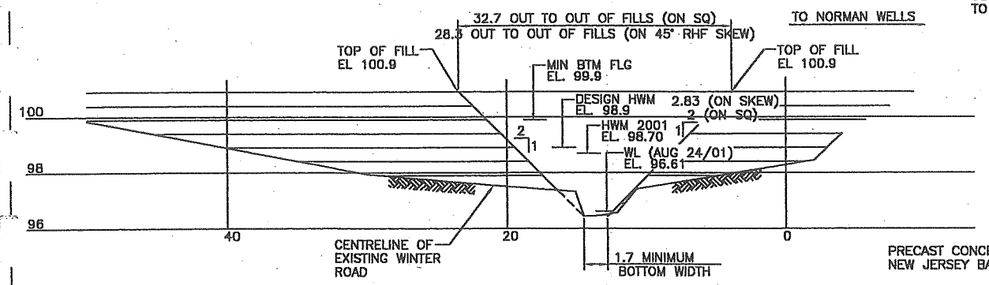
SITE MAP
1:50 000



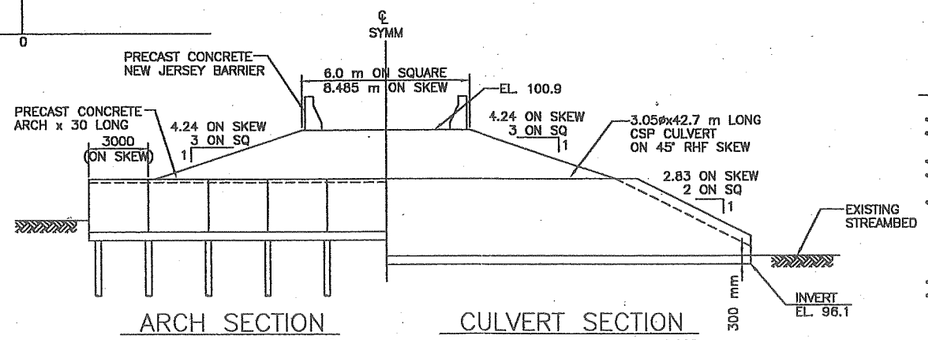
BRIDGE OPTION ELEVATION – NATURAL SCALE
1:200



ROAD PROFILE
H – 1:500
V – 1:250



ELEVATION
H – 1:200
V – 1:100



ARCH SECTION
1:100

CULVERT SECTION
1:100

SITE INFORMATION

SITE 2
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE APPROX. 30 m NW OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 24, 2001
WINTER ROAD km 753.5
COORDINATES LAT 63°43'02.5" N
LONG 123°52'10.1" W
SITE MAP REFERENCE 95-O/12

HYDROTECHNICAL DATA

- DRAINAGE AREA = 9 sq. km
- DESIGN DISCHARGE = 13 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0036 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 0.9 m/s
- ICE – NO ICE SCARS FOUND. ICE IS NOT A CONCERN

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

Northwest Territories Transportation

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

BOB'S CANYON
km 753.5
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 2 of 22
Drawing No. 608-9-2

4.3 Dam Creek

4.3.1 General

The Dam Creek winter road crossing is located at km 764.4 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 63° 47' 27.4" N and Long. 123° 57' 42.1" W.

A field investigation of the site was done on August 25, 2001. A preliminary survey of the centreline of the existing road was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking north on the winter road.

The winter road makes an abrupt turn on each side of the stream and crosses perpendicular to the stream. The federal alignment crosses the creek approximately 50 m upstream and is on a bend of the creek.

The streambed was rocky with stones ranging from 100 mm to 400 mm diameter, and a few boulders up to 1.0 m were found also. On the day of the site inspection, the stream was 8.0 m wide and 0.4 m deep. There appears to be good sources for approach fills available along the winter road near the site.

The existing crossing is located on a straight section of the stream that appears to be fairly stable. There is a bend upstream of the crossing that may be moving downstream towards the crossing.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment, and the recommended structure.

4.3.2 Existing Information

Existing information consisted of an environmental assessment of the winter road operation, a preliminary site survey by DOT in 1996, and an environmental information update report by GeoNorth and Golder Associates in 2000.

No information was available on the structure for the federal alignment done in the 1970's by DPW.

4.3.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The drainage area from the federal alignment study is 122 km^2. The present winter road crossing is in the same location as the federal alignment. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.013. The maximum elevation in the basin obtained from the topographic maps is 780 m. Air photos taken in 1945, 1973, and 1981 were obtained for analysis. The 1945 photographs at 1:27,000 are the earliest available, the 1981 photographs at 1:50,000 are the most recent and the 1973 photographs at 1:12,000 are at the largest available scale. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. Based on this method the 50-year design discharge would be 88 m^3/s. The 50-year breakup discharge is estimated to be about 73 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size.

On the day of the survey the water in the channel was fast flowing and was approximately 0.4 m deep. The width of the channel at the water's surface was 9.7 m and at top of bank it was 11.6 m. The slope was surveyed and found to be 0.0073 over a 29 m length of channel.

A high water mark was found downstream of the winter road crossing. This high water mark was approximately 1.0 m above the water level and relative to the local benchmark it would have an elevation of 99.0 m at the winter road crossing. Ice scars were found upstream and downstream of the crossing. The ice scars ranged from 0.6 to 1.3 m above the water level. Relative to the local benchmark these ice scars would have elevations of 98.8 to 99.2 m.

Both banks are well vegetated with grass and small willows. Upstream and downstream of the crossing the banks are lined with small deciduous trees and mature spruce. The bed is composed of gravel, cobbles and boulders. A line sampling technique showed that the median (D_{50}) grain size is 130 mm while the largest stones (D_{90}) are about 375 mm in diameter.

3. River Engineering Analysis

The design high water level for the site was calculated to be 100.7 m . This elevation is 3.1 m above the bed level and 1.5 m above the highest observed ice scar. The minimum flange elevation of a bridge should provide 1.0 m of freeboard to allow debris to pass

safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 101.7 m or greater.

A minimum bottom width of the channel of 9.0 m will preserve the natural channel top of bank width. The mean velocity through a bridge opening of this width with 2:1 headslopes is about 3.3 m/s.

Analysis of potential Mackenzie River ice jams near the mouth of Dam Creek indicate that high water levels from a Mackenzie River ice jam may occur at the site. The 1:50,000 map contours indicate that the water level at the site is about 10.3 m above the Mackenzie River, presumably at low flow. Furthermore, geodetic water levels on the Mackenzie River indicate that the site may be as much as 16.9 m above the low flow Mackenzie River level. The 50-year ice jam could raise the level in the Mackenzie River as much as 15 m at the mouth so water levels at the crossing site may be affected. However, the crossing is too far from the mouth to be affected by the Mackenzie ice floes themselves. The above elevations indicate that the 50-year ice jam level is between -1.9 to +4.7 m above the local low water level. That is, the water level may be as high as 102.7 m relative to the local bench mark. The map elevations are coarse, therefore, a survey is required to determine the actual differential elevation between the low flow open water elevation of the Mackenzie River and the benchmark at the crossing site.

Air photos of the site indicate that the channel has remained fairly stable between 1945 and 1981. However, between 1945 and 1973 some of the sharp meander bends just downstream of the crossing appear to have migrated downstream about 10 m. The 1981 photos are at too small of a scale to detect any further movement in these bends. No changes in channel position were apparent in the 2001 air photos, however some parts of the channel were indistinct in the historical photos so minor changes could not be detected. The short straight reach at the present winter road crossing appears suitable if the upstream bend does not migrate downstream.

4.3.4 Environmental Considerations

The environmental assessments indicate that the stream is fish bearing and provides habitat for arctic grayling, longnose sucker, lake chub and slimy sculpin. The stream habitat is considered Class 1 by DFO.

The stream banks are well vegetated and appear stable. Erosion does not appear to be a concern at the site.

4.3.5 Alternatives

The site is well suited to a single span bridge structure using driven steel piles for the foundations. A geotechnical investigation has not been done for the existing crossing.

Based on the hydrotechnical review and environmental assessment, culverts are not considered suitable for this crossing.

The existing crossing, although located on a straight reach of the creek, requires abrupt turns in the winter road approaches. Realigning the road to eliminate the abrupt turns to the existing crossing was considered since to follow the federal alignment means crossing the stream in the middle of a sharp bend. The stream would cross the proposed alignment on a 25° LHF skew.

The ice jam effect from the Mackenzie River may affect the high water levels at the crossing and a survey to determine the elevation differential of the Mackenzie River to the crossing would be required.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for the site.

Alternatives considered were two different single span structures corresponding to the two possible high water levels. The first alternative used the lower high water level and resulted in a span of 25.0 m with a deck elevation of 102.7 m. The second alternative used the estimated Mackenzie River ice jam effect and resulted in a 32.9 m span with a deck elevation of 105.2 m.

Each bridge option considered a square and a skew structure. The skewed bridge results in a slightly shorter span as the fills are brought up perpendicular to the stream. For the square structure, it was assumed the fill headslope was 2H to 1V in line with the road, therefore, the toe of the slopes were positioned slightly further apart to stay out of the stream.

The square option allows the use of standard precast panels only, while the skew option uses several special panels, at the bridge ends. The additional girder length cost is partially offset by reduced precast panel costs.

The attached drawing shows the alternative structures that were considered suitable.

4.3.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table. The estimated costs for construction are as follows:

31.0 m single span bridge (on square) (lower ice level).	$443,300
28.047 m single span bridge (on skew) (lower ice level).	$431,140
37.0 m single span bridge (Mackenzie River ice effect).	$732,745

4.3.7 Recommendations

The recommended structure consists of a 31.0 m single span bridge with a minimum bottom flange elevation of 101.7 m. A minimum undisturbed bottom width of 9.0 m is

recommended. Headslopes of 2H to 1V were used resulting an out to out of fills of 35.9 m at elevation 102.7.

Verification of the high water level due to the Mackenzie River ice jam effects is recommended.

The existing crossing location would be the preferred location, however, the winter road alignment should be adjusted to eliminate abrupt curves at the bridge approaches.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessments, the alternative structures, and the recommended structure.

4.3.8 Summary

A single span bridge with an overall length of 31.0 m is recommended on the existing alignment for the Dam Creek winter road crossing. Realignment of the winter road to eliminate abrupt curves is also recommended. A detailed survey to determine the elevation of the site in relation to the Mackenzie River is required to determine if the bridge needs to be raised and lengthened due to high water from ice jams.

Site Dam Creek

Recommended Structure - 31.0m Single Span Bridge (on Square)

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	55000	1	55,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	2200	66,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	50	1,400
Deck Panels				
fabricate and deliver	each	3400	10	34,000
Steel Girders				
fabricate and deliver	kg	1.15	22000	25,300
Steel and Deck Panel Erection	m	1500	31	46,500
Bridgerail	m	100	62	6,200
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		363,400
		Contingency(15%)		54,500
		Engineering(7%)		25,400
		Total		443,300

Site Dam Creek

Alternative - 28.042m Single Span Bridge (on Skew)

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	55000	1	55,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	2200	66,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	9	30,600
Steel Girders fabricate and deliver	kg	1.15	20000	23,000
Steel and Deck Panel Erection	m	1500	28	42,000
Bridgerail	m	100	56	5,600
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		353,440
		Contingency(15%)		53,000
		Engineering(7%)		24,700
		Total		431,140

Alternative - Mackenzie River Ice Jam Effect - 37m Span

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	90000	1	90,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	7500	225,000
Backfill - granular	cu.m.	35	500	17,500
Riprap - haul and place	cu.m.	28	50	1,400
Deck Panels fabricate and deliver	each	3400	12	40,800
Steel Girders fabricate and deliver	kg	1.15	28300	32,545
Steel and Deck Panel Erection	m	1500	37	55,500
Bridgerail	m	100	74	7,400
New Jersey Concrete Barriers	each	500	40	20,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		600,645
		Contingency(15%)		90,100
		Engineering(7%)		42,000
		Total		732,745

Photo 1 - Looking North on Winter Road (Stream Flow to North)

Photo 2 - Looking North on Winter Road (Flow to Left)

Photo No. 3 - Looking South on Winter Road

Photo 4 - Looking Upstream

Photo 5 - Looking Downstream

Photo 6 - Looking North on Winter Road (Beyond Curve at Crossing)

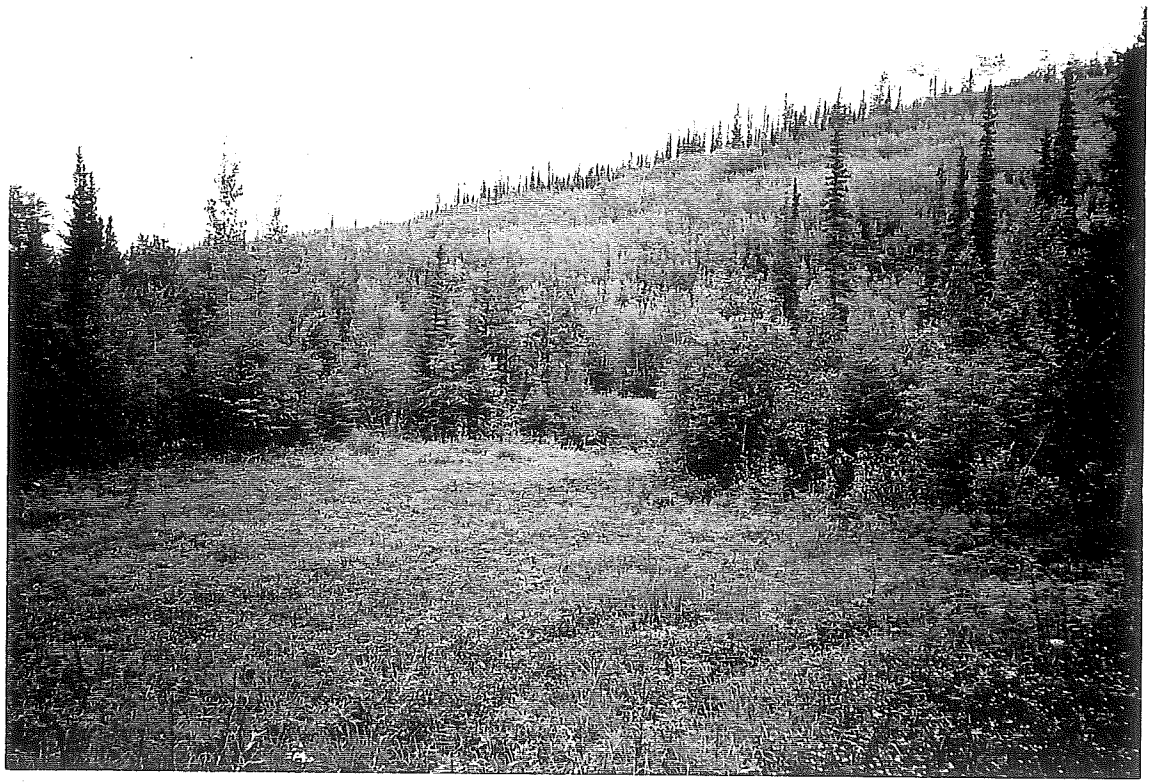
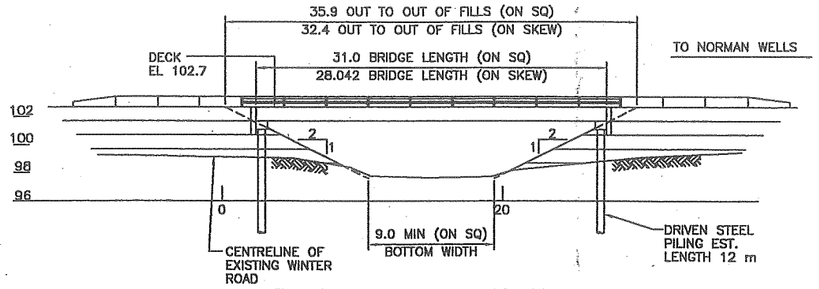
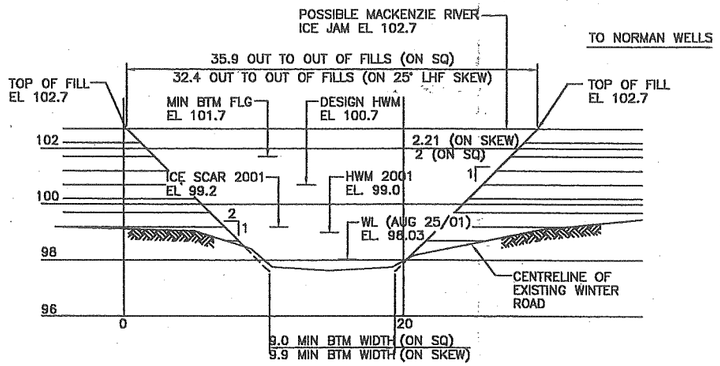


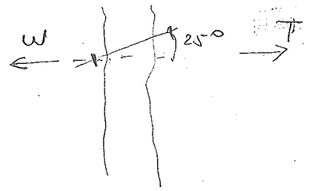
Photo 7 - Looking North on Winter Road (Sharp Curve to Crossing)

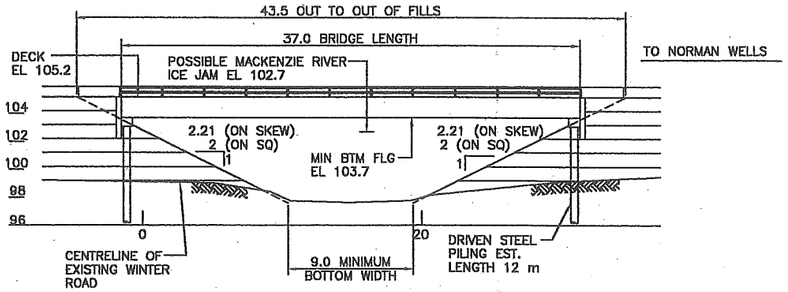


ELEVATION – NATURAL SCALE
1:200

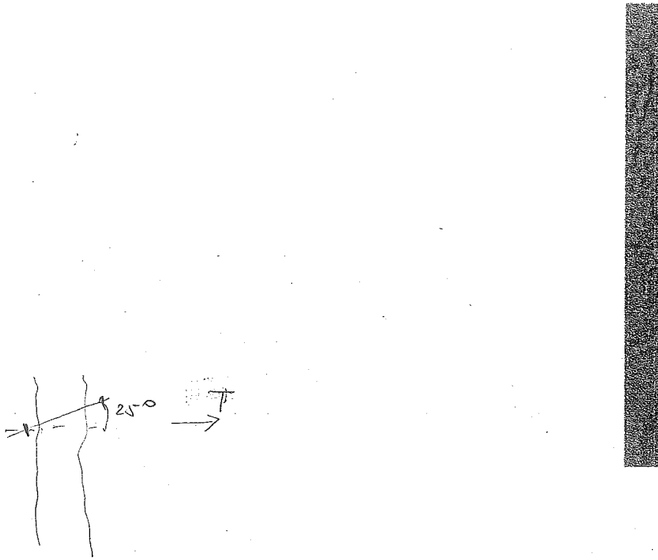


ELEVATION
H – 1:200
V – 1:100

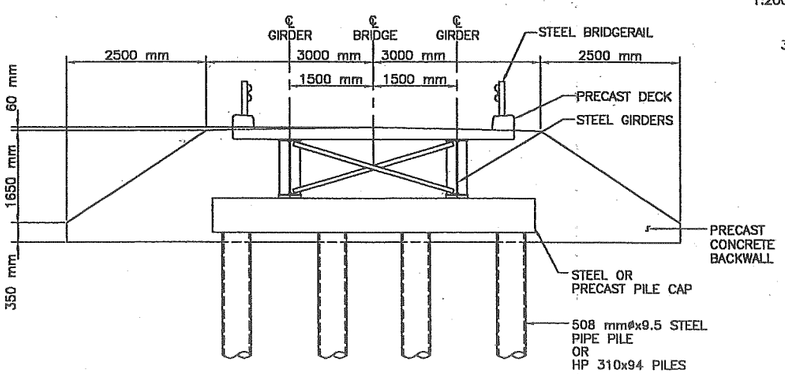




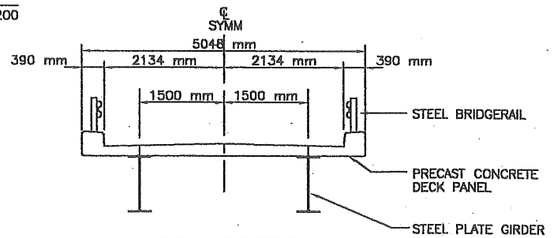
ALTERNATIVE SPAN (FOR MACKENZIE ICE EFFECT)
1:200



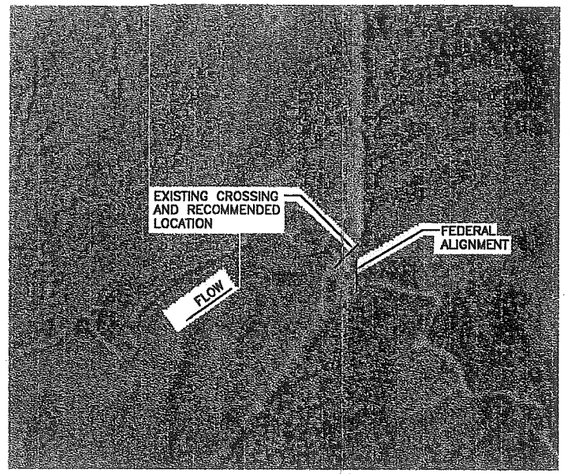
ROAD PROFILE
H – 1:500
V – 1:250



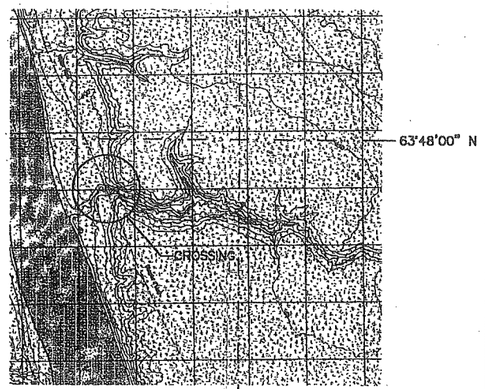
ABUTMENT ELEVATION
1:50



DECK SECTION
1:50



AERIAL PHOTOGRAPH
1:6000



SITE MAP
1:50 000

SITE INFORMATION

SITE 3
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE APPROX. 20 m SOUTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 25, 2001
WINTER ROAD km 764.4
COORDINATES LAT 63°47'27.4" N
LONG 123°57'42.1" W
SITE MAP REFERENCE 95–O/13

HYDROTECHNICAL DATA

- DRAINAGE AREA = 122 sq. km
- DESIGN DISCHARGE = 88 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0073 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 3.3 m/s
- ICE DESIGN ELEV. 100.7 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA–S6–00
- POSSIBLE MACKENZIE RIVER ICE JAM EFFECT–MAXIMUM ELEV 102.7 (REQUIRES VERIFICATION BY SURVEY)

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

Northwest Territories Transportation

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Rev.	Date	Description	Chkd

A = detail number
B = location drawing number
C = drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

DAM CREEK
km 764.4
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Insignia
Signature
Date
Signature
Date
Approved by
Project No.
Page 3 of 22
Drawing No. 608–6–3

4.4 No Name Creek

4.4.1 General

The No Name Creek winter road crossing is located at km 795.1 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 64° 01' 23.1" N and Long. 124° 16' 13.5" W.

A field investigation of the site was done on August 25, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary bench mark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking southeast on the winter road. Photos 3 and 4 show the existing crossing looking north and south on the winter road respectively.

The winter road crosses No Name Creek in the same location as the federal alignment of the 1970's. The channel is small, only 0.7 m wide and 0.4 m deep.

At the time of the site visit there was no flowing water in the stream. Banks are well vegetated and appear to be stable.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.4.2 Existing Information

Previous information was limited to air photos. No information on work done by DPW in the 1970's was available.

4.4.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

   Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The drainage area upstream of the crossing site of 1.3 km^2 was obtained from the federal alignment study. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.032. The maximum elevation in the basin obtained from the topographic maps is 180 m. Air photos taken in 1945, 1973, and 1998 were obtained for analysis. The 1945 photographs at 1:28,000 are the earliest available, the 1998 photographs at 1:20,000 are the most recent and the 1973 photographs at 1:12,000 are at the largest available scale. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 3.6 m^3/s. The 50-year breakup discharge is estimated to be about 2.4 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size.

On the day of the survey there was no flowing water in the channel. The slope was surveyed and found to be 0.16 over a 36.5 m length at the present winter road crossing.

A high water mark was found downstream of the crossing on the left or south bank. This high water mark was 1.0 m above the water level. This high water mark would have an elevation of 96.4 m at the winter road crossing relative to the local benchmark. No ice scars were found.

Both banks are well vegetated with grass and willows. There was some standing water 0.15 m deep but no flowing water. The bed is composed of silt with grass and moss growing on it. The channel is small, only 0.7 m wide and 0.4 m deep.

3. River Engineering Analysis

The design high water level for the site was calculated to be 96.4 m. This level was obtained for the design discharge of 3.6 m^3/s and adopting the map slope of 0.0075 and a roughness of 0.10. This elevation, 1.0 m above the bed level, is the same as the high water mark observed at the site. The minimum flange elevation of a bridge should provide 1.0 m of freeboard to allow debris to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 97.4 m or greater.

Ice does not appear to be of concern at this location. There were no ice scars evident at the site and the channel was dry. The channel likely only flows during the snowmelt runoff period and after large rainfall events. Any ice which did form would be frozen to the soil and vegetation and would melt in place.

The minimum undisturbed width of the channel is 1.0 m. The mean velocity through a bridge opening with 2:1 headslopes is about 2.1 m/s. Alternatively, this creek could be spanned using a culvert. A 1.83 m diameter culvert would be adequate to pass the flow without over-topping the road. However, a 2.44 m diameter culvert would be required if the culvert is buried to 20% of its diameter to provide a natural creek bottom.

Air photos of the site indicate that the channel has remained stable between 1945 and 1998. No changes in channel position were apparent in the 2001 air photos as well. The present winter road alignment crosses the stream in the same location as the original federal alignment. This site appears to be suitable.

4.4.4 Environmental Considerations

Based on the site observations and the size of the drainage basin associated with the crossing, it is unlikely that fish are present at this site. The site has not been identified as a concern for the winter road operation.

4.4.5 Alternatives

The site is well suited to a culvert or a short span bridge. Based on the hydrotechnical review a 2.44 m diameter culvert would be suitable. An arch culvert would also be suitable. The road alignment is good and shifting of the crossing is not required. Alternatively a single span bridge with a length of 9.144 m (30 ft) could be used.

4.4.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table. The estimated costs for construction are as follows:

2.0 m radius x 18 m long concrete arch.	$130,890
2.44 m diameter x 22.02 m long culvert.	$151,780
9.144 m single span steel girder bridge with timber deck.	$211,560
9.144 m single span steel girder bridge with precast deck.	$228,860
9.144 m single span precast girder bridge.	$392,540

4.4.7 Recommendations

The existing crossing location is very suitable and no change in alignment need be considered. A 2.0 m radius concrete arch with an overall length of 18.0 m is recommended for this site. Road fills would be constructed to provide 1.5 m cover over the arch. Side slopes of 3H to 1V were assumed in determining the overall culvert length.

The attached drawing indicates the preliminary site survey, hydrotechnical assessment, the alternate structure, and the recommended structure.

4.4.8 Summary

A 2.0 m radius concrete arch x 18.0 m long is recommended on the existing alignment for the No Name Creek winter road crossing.

Site No Name Creek

Recommended Structure - 2.0m Radius Arch

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	20000	1	20,000
Approaches - common fill	cu.m.	30	900	27,000
Backfill - granular	cu.m.	35	150	5,250
Riprap - haul and place	cu.m.	28	30	840
New Jersey Concrete Barriers	each	500	16	8,000
Arch Panels				
supply and install	m	900	18	16,200
Driven Piling	each	2500	12	30,000
		Sub-Total		107,290
		Contingency(15%)		16,100
		Engineering(7%)		7,500
		Total		130,890

Alternative Structure - 2.44m dia Culvert

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	20000	1	20,000
Approaches - common fill	cu.m.	30	900	27,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	60	1,680
New Jersey Concrete Barriers	each	500	16	8,000
Culverts				
supply and install	m	850	22	18,700
earthworks	m	1750	22	38,500
		Sub-Total		124,380
		Contingency(15%)		18,700
		Engineering(7%)		8,700
		Total		151,780

Alternative Bridge Structure - Steel Girders -9.144m Span - Timber Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	25000	1	25,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Approaches - common fill	cu.m.	30	500	15,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Timber Decking	sq.m.	100	45	4,500
Steel Girders				
fabricate and deliver	kg	1.15	2800	3,220
Bridge Erection	lump sum	5000	1	5,000
Bridgerail	m	100	20	2,000
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		173,460
		Contingency(15%)		26,000
		Engineering(7%)		12,100
		Total		211,560

Site No Name Creek

Alternative Bridge Structure - Steel Girders -9.144m Span - Concrete Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	25000	1	25,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Approaches - common fill	cu.m.	30	500	15,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels				
fabricate and deliver	each	3400	3	10,200
Steel Girders				
fabricate and deliver	kg	1.15	2800	3,220
Steel and Deck Panel Erection	m	1500	9	13,500
Bridgerail	m	100	20	2,000
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		187,660
		Contingency(15%)		28,100
		Engineering(7%)		13,100
		Total		228,860

Alternative Bridge Structure - Precast Girders

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	25000	1	25,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Approaches - common fill	cu.m.	30	500	15,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Bridgerail	m	100	20	2,000
New Jersey Concrete Barriers	each	500	16	8,000
Precast Concrete Girders				
supply and deliver	m	3000	46	138,000
erect	m	500	46	23,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		321,740
		Contingency(15%)		48,300
		Engineering(7%)		22,500
		Total		392,540

Photo 1 - Looking Southeast on Winter Road (Stream Flow to Right)

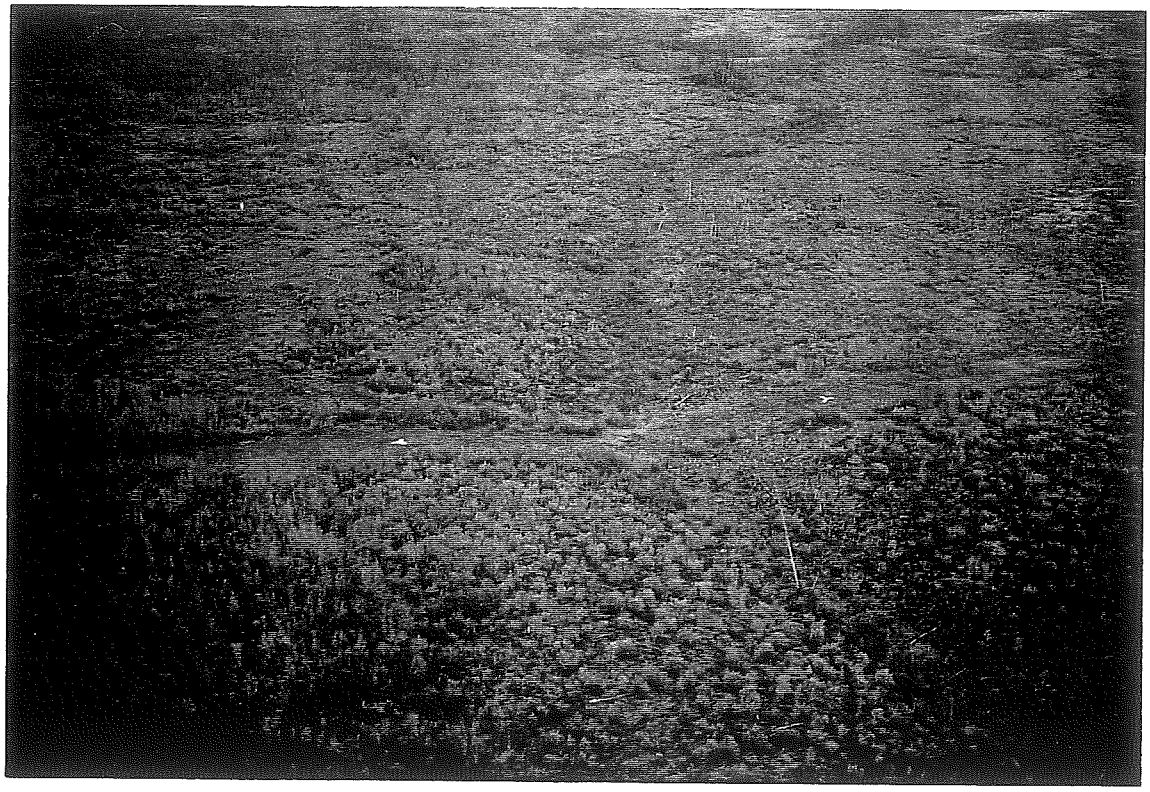


Photo 2 - Looking Upstream (East)

Photo 3 - Looking North on Winter Road (Flow to Left)

Photo 4- Looking South on Winter Road

Photo 5 - Looking Upstream

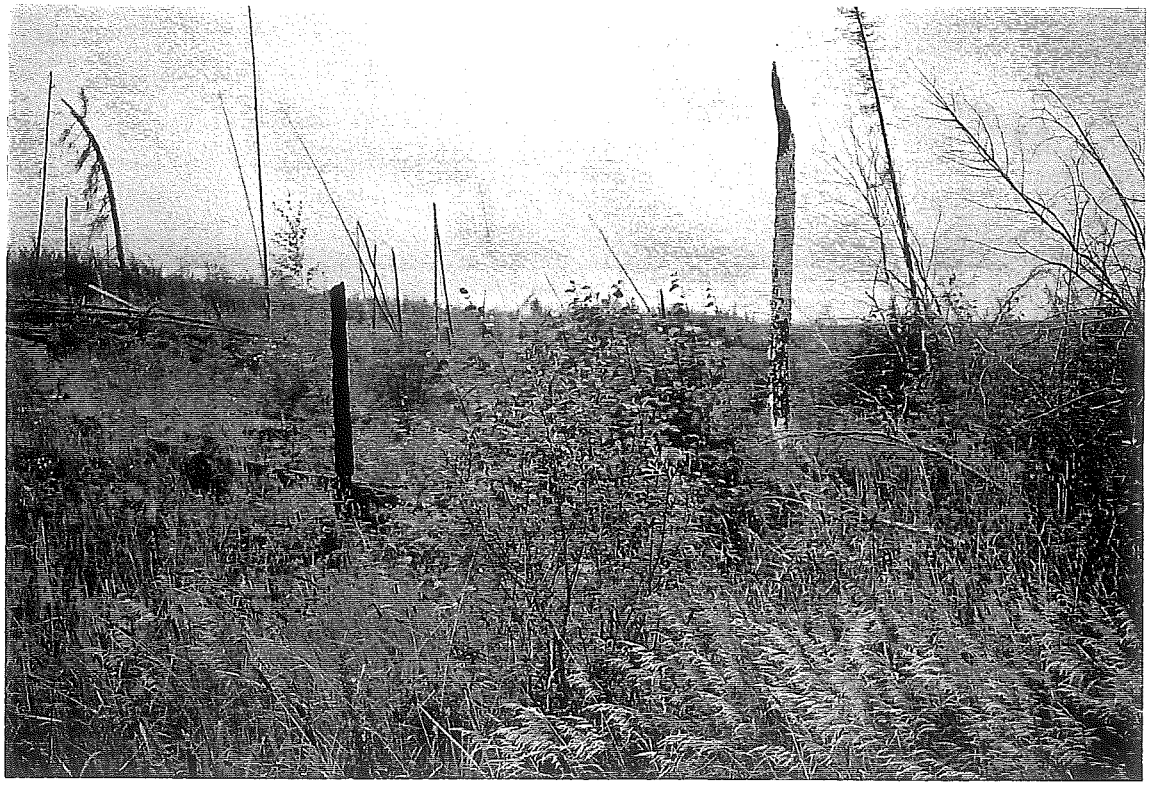
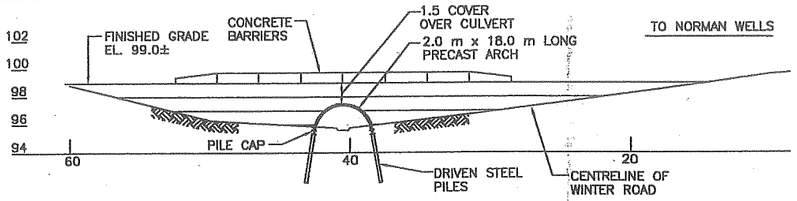
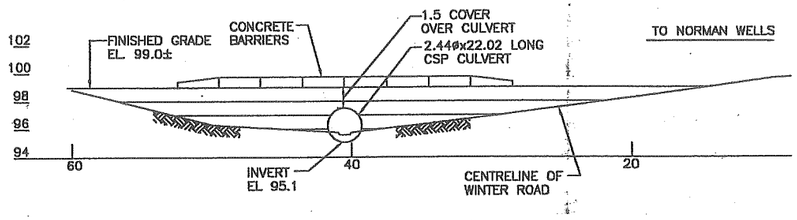


Photo 6 - Looking Downstream



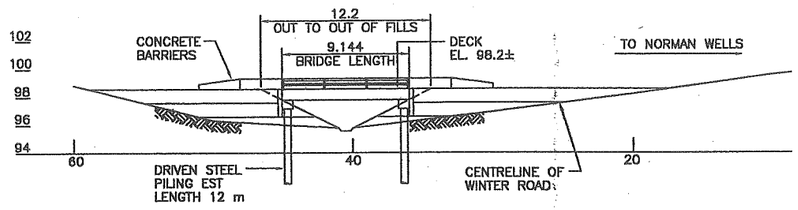
ARCH OPTION ELEVATION — NATURAL SCALE

(LOOKING D/S) 1:200



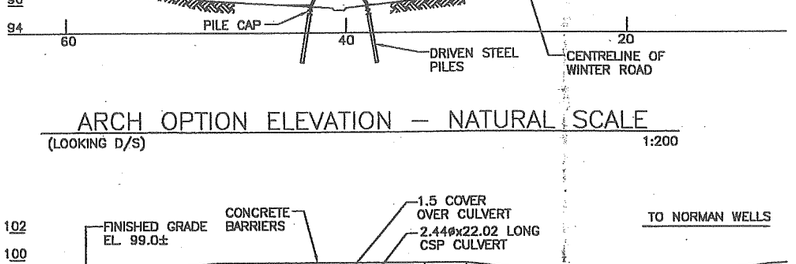
CULVERT OPTION ELEVATION — NATURAL SCALE

(LOOKING D/S) 1:200



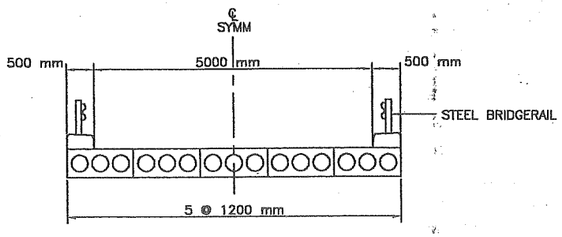
BRIDGE OPTION ELEVATION — NATURAL SCALE

(LOOKING D/S) 1:200



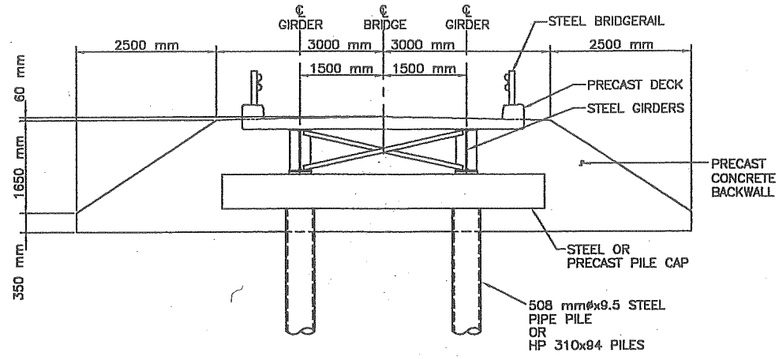
ELEVATION

(LOOKING D/S) H — 1:200
V — 1:100



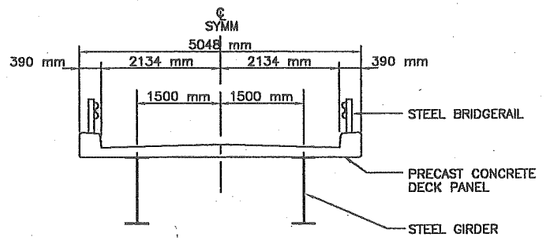
ALTERNATE PRECAST GIRDER

1:50



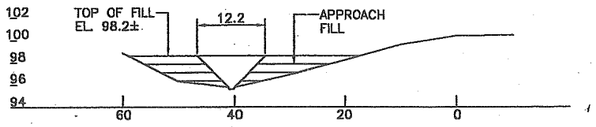
ABUTMENT ELEVATION

1:50



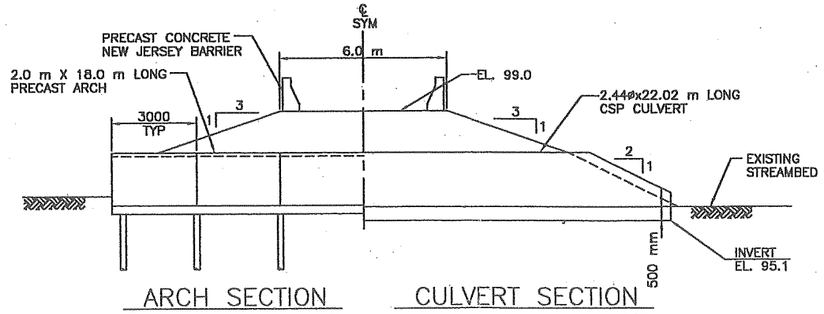
DECK SECTION

1:50



ROAD PROFILE

H — 1:500
V — 1:250

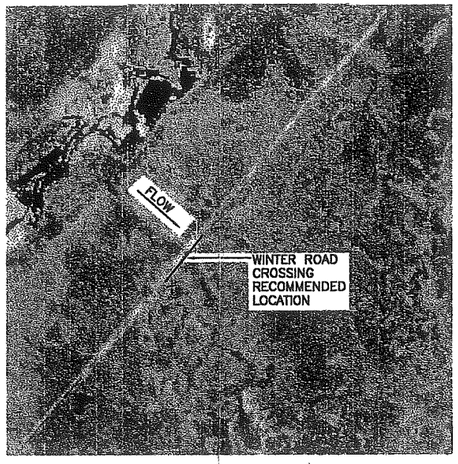


ARCH SECTION

1:100

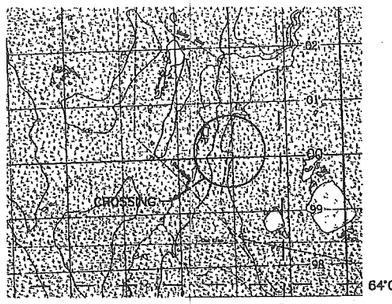
CULVERT SECTION

1:100



AERIAL PHOTOGRAPH

1:10 000



SITE MAP

1:50 000

SITE INFORMATION

SITE 4
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE APPROX. 30 m SOUTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 25, 2001
WINTER ROAD km 795.1
COORDINATES LAT 64°01'23.1" N
LONG 124°16'13.5" W
SITE MAP REFERENCE 96-C/1

HYDROTECHNICAL DATA

- DRAINAGE AREA = 1.3 sq. km
- DESIGN DISCHARGE = 3.8 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0025 m/m AT CROSSING
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = m/s
- ICE — NO ICE SCARS FOUND. ICE IS NOT A CONCERN

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

Northwest Territories Transportation

BPTEC
ENGINEERING GROUP LTD.
6810-104 STREET
EDMONTON, AB
FAX (780)435-4843
PH. (780)436-5378

Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

NO NAME CREEK
km 795.1
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 4 of 22
Drawing No. 608-3-4

4.5 Little Smith Creek

4.5.1 General

The Little Smith Creek winter road crossing is located at km 853.8 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 64° 26' 05.8" N and Long. 124° 44' 31.2"W.

A field investigation of the site was done on August 25, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking south on the winter road.

The existing winter road crossing is located approximately 30 m downstream of the federal alignment done in the 1970's. On the day of the site visit, the stream was 34 m wide and 0.2 m deep. This is a wide crossing having a rocky streambed with stones varying from 25 mm to 150 mm in diameter.

A small island is located 30 m upstream of the crossing. Flow was only going around the north side of the island during the site visit.

A large gravel bar extends downstream of the crossing. Stream banks were shallow and well vegetated. Some bank erosion was noted downstream.

The north approach is flat and firm, extending over 200 m to a rise. On the south approach, the ground is soft and boggy. It appears the winter road follows an old streambed on the south approach as the banks on each side of the approach are 3 m to 4 m high. Some water was flowing along the south approach.

A pipeline crosses the river approximately 100 m downstream, indicated by the marker in Photo 6.

A significant amount of debris (trees, etc.) was found along the streambanks and on shore.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.5.2 Existing Information

Little Smith Creek had a provisional contract package developed by Public Works Canada in 1973. The alignment was approximately 30 m upstream of the existing winter road crossing. The recommended structure consisted of a two span (36.58 m - 40.23 m) span utilizing a single pier in the river. Geotechnical information consisted of two boreholes indicating clay till material below the upper cobbles. Driven steel piles were indicated for the foundation.

The bottom flange of the structure was set at approximately 5.4 m above streambed and 1.8 m above design high water.

Additional information consisted of an environmental report of the winter road operation and an environmental information update report by GeoNorth and Golder Associates, dated March 2000.

4.5.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information for the Little Smith River crossing consisted of topographic maps and air photos of the site as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. A drainage area of 964 km^2 was obtained from the federal alignment study. The present winter road crossing is about 30 m downstream of the proposed federal alignment crossing. The slope of the channel obtained from the federal alignment study is 0.0050 and the slope obtained from a 1:50,000 scale topographic map is 0.0054. The maximum elevation in the basin obtained from the topographic maps is 1460 m. Air photos taken in 1945, 1972 and 1994 were obtained for analysis. The 1945 photographs at 1:18,000 are the earliest available, the 1972 photographs at 1:13,000 are the largest scale available and the 1994 photographs at 1:30,000 are the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

The previous hydrotechnical study for the federal alignment also provided additional hydrotechnical information. A high water mark was observed 2.2 m above the bed. This previous study estimated the design discharge to be 294 m^3/s.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin.The 50-year design discharge estimated for this site is 403 m^3/s. The 50-year breakup discharge is estimated to be about 130 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the present winter road crossing.

On the day of the survey the water was 0.2 m deep and 34 m wide at the winter road crossing. The survey found the water surface slope had a slope of 0.0049 over a 130 m

length of channel. The cross section was surveyed just downstream of a small island. The water was flowing over a riffle on the downstream end of the island.

Four high water marks were found in the vicinity of the winter road crossing. One high water mark on the island upstream of the crossing was 1.2 m above the water surface. The other high water marks ranging from 1.1 to 2.1 m above the water surface were found on the both banks on the downstream side of the winter road. At the cross section location these highwater marks would have elevations from 99.5 to 100.4 m relative to the local benchmark. Four ice scars were found downstream of the crossing on the both the right and left banks. The ice scars were between 1.7 and 2.5 m above the water level. These ice scars would be at elevations of between 99.7 and 100.5 m at the cross section location.

Both banks were well vegetated with grass and trees, however, the downstream right bank appeared to have been recently eroded. The bed material was sampled using a line sample technique on an exposed portion of the bed at the winter road crossing. The median diameter (D_{50}) of the bed material is 85 mm while the largest stones (D_{90}) are about 160 mm in diameter.

3. River Engineering Analysis

The design high water level based on local flow conditions for the site was calculated to be 101.5 m, which is 3.2 m above the surveyed water level and 3.8 m above the bed. This level is the estimated 50-year ice jam elevation at this site. This level is 1.0 m higher than the highest observed ice scars. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 102.5 m or greater.

Analysis of potential Mackenzie River ice jams near the mouth of the Little Smith River indicate that high water levels from a Mackenzie River ice jam may be occur at the site as well. The 1:50,000 map contours indicate that the water level at the site is about 12.3 m above the Mackenzie River, presumably at low flow. However, geodetic water levels on the Mackenzie River indicate that the site may be as much as 19.7 m above the low flow Mackenzie River level. The 50-year ice jam could raise the level in the Mackenzie River as much as 18.1 m at the mouth so water levels at the crossing site could be anywhere from 0 to 5.8 m above the low flow water level. Thus, the design water level may be as high as 104.1 m due to the effects of the Mackenzie River. This level is 2.6 m above the local design high water level and is based on crude data, therefore, a survey is required to determine the actual differential elevation between the low flow open water elevation of the Mackenzie River and the benchmark at the crossing site.

Air photos of the site show numerous abandoned meander loops both upstream and downstream of the crossing which indicate significant channel movement in the past. No new meander cutoffs have occurred between 1945 and 1994 so it appears that these cutoffs do not occur frequently, however, some of the channel banks have shifted as

much as 50 m over this period. The reach at the winter road crossing appears to be relatively stable, however some movement of the left bank has occurred. The upstream left bank has shifted left about 30 m between 1945 and 1972 and the downstream left bank has shifted left about 20 m between 1972 and 1994. Between 1994 and 2001, the downstream bend has eroded about 10 m along parts of the left bank but the crossing site has remained stable.

The present winter road alignment appears to be the most suitable location for the bridge crossing because it is located in a straight stable reach of the river. This location is only 30 m downstream of the proposed federal alignment crossing.

The existing channel at the cross section location is 34 m wide at the water level and 60 m at top of bank. The minimum bottom width of the channel should be 50 m which will limit the impact on the low water channel and will not constrict the channel enough to impede the ice floes during breakup. The channel is as narrow as 40 m in some locations upstream and downstream of the site but the presence of the island just upstream of the bridge makes it difficult to constrict the channel to 40 m at the crossing site. The design open water elevation of 100.4 m would produce a mean velocity of about 3.4 m/s through an opening with a 50 m bottom width and 2:1 side slopes.

4.5.4 Environmental Considerations

The environmental update indicates the stream has moderate potential for spawning and rearing in the vicinity of the crossing. The river is indicated as important to grayling, longnose sucker and chub.

The banks are shallow and well vegetated, although the environmental assessment indicated some concern with bank erosion as the downstream bank has experienced recent erosion.

4.5.5 Alternatives

Alternatives considered were a single span bridge and a three span bridge structure. The hydrotechnical review indicated a possibility of ice jam effects at the site from the Mackenzie River, which could lead to a 2.6 m elevation difference in the design high water level.

The single span structure assumed a lower high water level and resulted in a span of 68.0 m with a deck elevation of 105 m. The three span structure assumed the higher water level and an arrangement of three 25 m spans was considered as a suitable structure with a deck elevation of 106.1 m. Foundations considered were driven steel piles for both abutment and pier structures. Piers would utilize welded steel plate diaphragms between piles to assist in resisting ice forces. A geotechnical investigation would be necessary to determine pile capacities for both compression and tension (uplift) forces.

The existing winter road crossing is located on a stable reach of the river and would be a suitable location.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for this site. Preliminary sizing of the bridge girders indicates the bridge structure would consist of two welded wide flange girders.

The attached drawings show the alternate structures that were considered suitable.

4.5.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table. The estimated costs for construction are as follows:

66.0 m single span bridge (lower ice level).	$845,140
3 span (25 m - 25 m - 25 m) bridge (Mackenzie ice).	$1,190,965

4.5.7 Recommendations

The recommended structure consists of a 66.0 single span bridge with a minimum bottom flange elevation of 102.5 m. A minimum undisturbed bottom width of 50 m is recommended. Headslopes of 2H to 1V was were used resulting in an out to out of fills of 76.0 m at elevation 103.5 m. Verification of the high water/ice level is recommended.

The existing winter road crossing would be recommended for the structure location.

The attached drawings indicate the preliminary site survey, the hydrotechnical assessment, the alternative structure, and the recommended structure.

4.5.8 Summary

A single span bridge with an overall length of 66.0 m is recommended on the existing alignment for the Little Smith Creek winter road crossing. A detailed survey to determine the elevation of the site in relation to the Mackenzie River is required to determine if the bridge needs to be raised and lengthened due to high water from ice jams.

Site	Little Smith Creek			
	Recommended Structure - 66.0m Bridge			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	100000	1	100,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Approaches - common fill	cu.m.	30	5500	165,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	22	74,800
Steel Girders fabricate and deliver	kg	1.15	100000	115,000
Steel and Deck Panel Erection	m	1500	66	99,000
Bridgerail	m	100	132	13,200
New Jersey Concrete Barriers	each	500	24	12,000
Precast Backwall Panels supply and deliver	each	6000	2	12,000
		Sub-Total		692,740
		Contingency(15%)		103,900
		Engineering(7%)		48,500
		Total		845,140

	Alternative Structure - 3 Span 25-25-25m			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	100000	1	100,000
Driven Steel Piling - Abutment	each	10000	8	80,000
Driven Steel Piling - Pier	each	15000	12	180,000
Precast Concrete Pile Caps	each	4500	4	18,000
Pier Diaphragms	each	10000	2	20,000
Approaches - common fill	cu.m.	30	9400	282,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	25	85,000
Steel Girders fabricate and deliver	kg	1.15	43500	50,025
Steel and Deck Panel Erection	m	1500	75	112,500
Bridgerail	m	100	150	15,000
New Jersey Concrete Barriers	each	500	24	12,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		976,265
		Contingency(15%)		146,400
		Engineering(7%)		68,300
		Total		1,190,965

Photo 1 - Looking South on Winter Road (Stream Flow to Right)

Photo 2 - Looking North on Winter Road Approach (200 m South of Crossing)

Photo 3 - Looking North on Winter Road (Flow to Left)

Photo 4 - Looking South on Winter Road

Photo No.5 - Looking Upstream (On Main Channel, Island to Right)

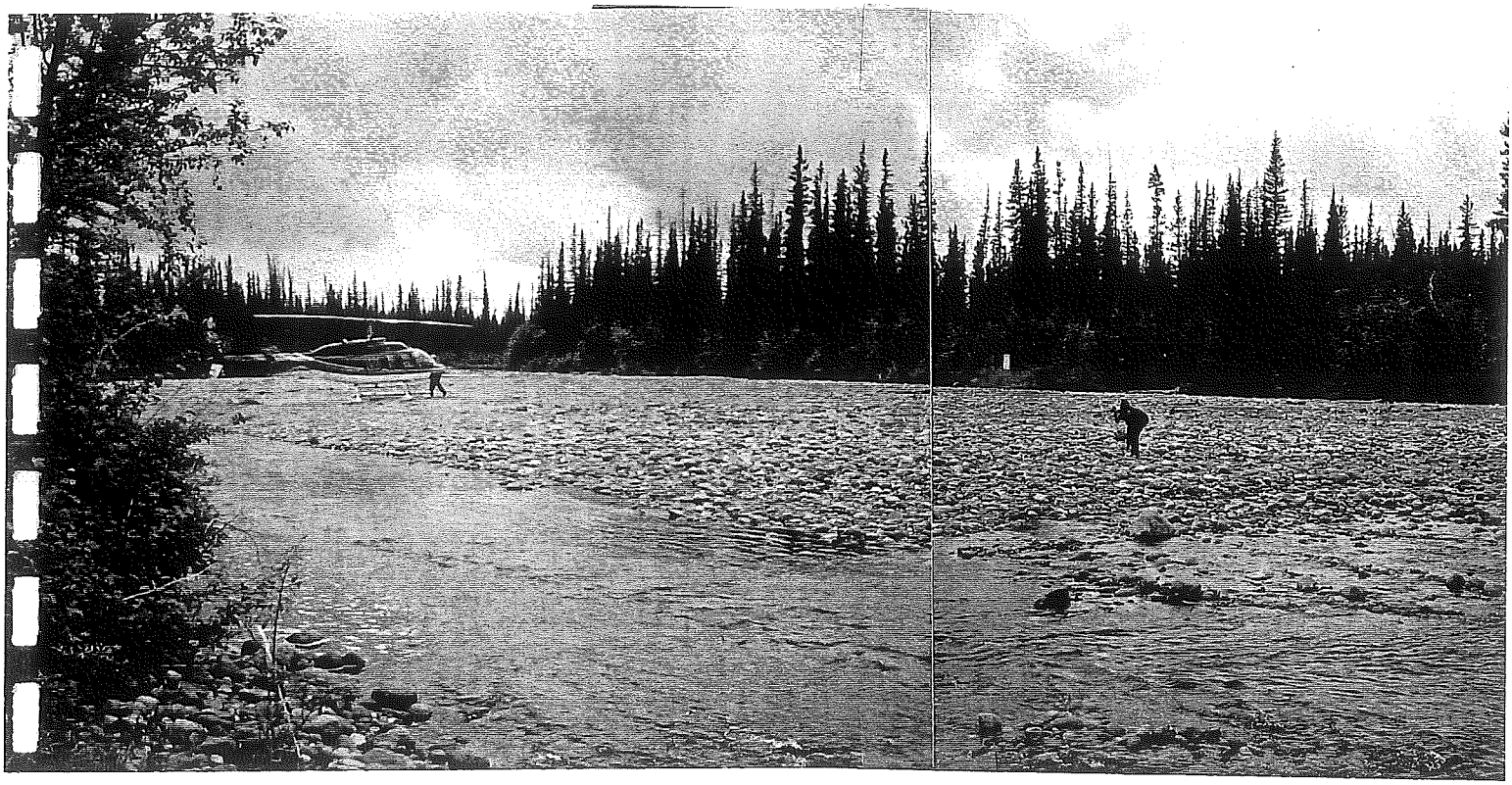
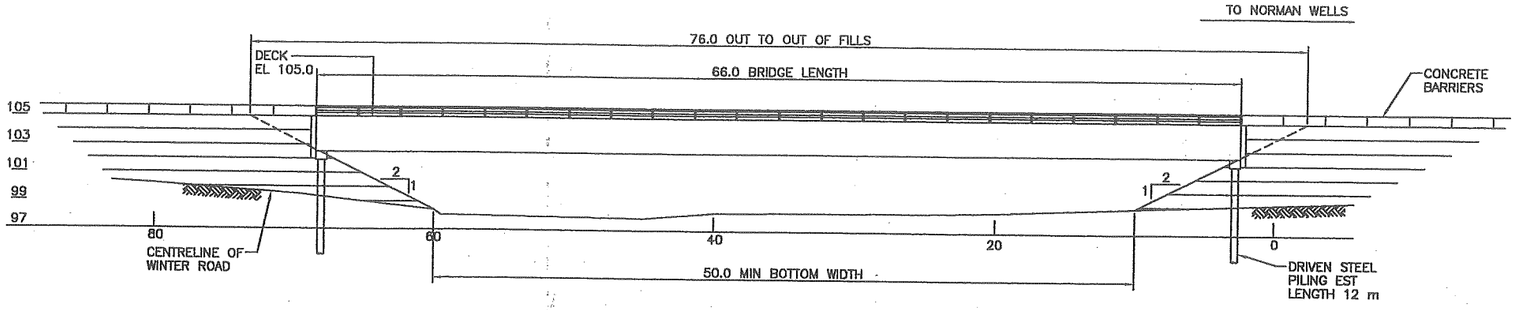
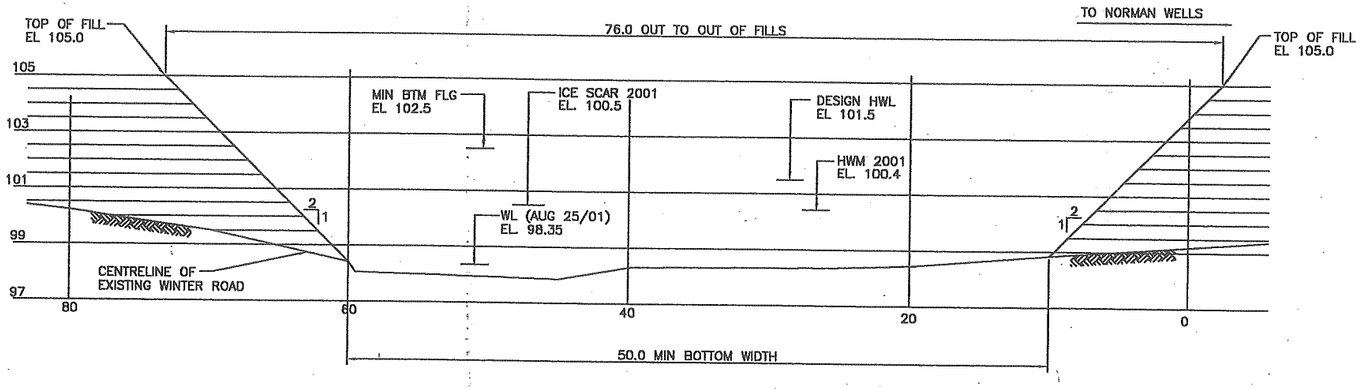


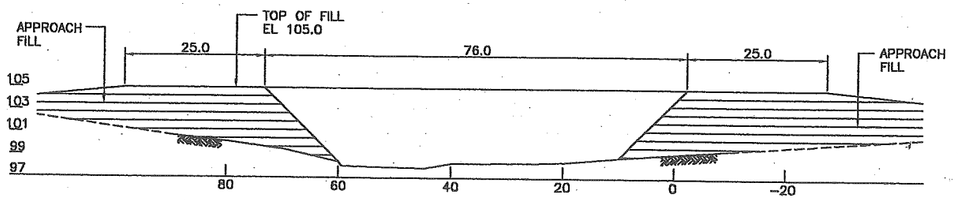
Photo 6 - Looking Downstream



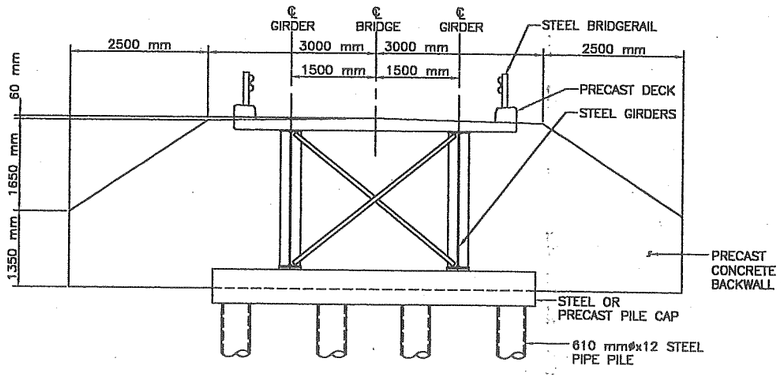
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



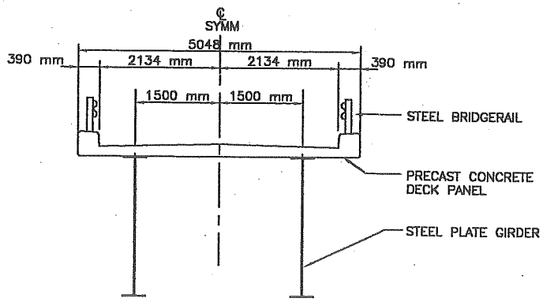
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



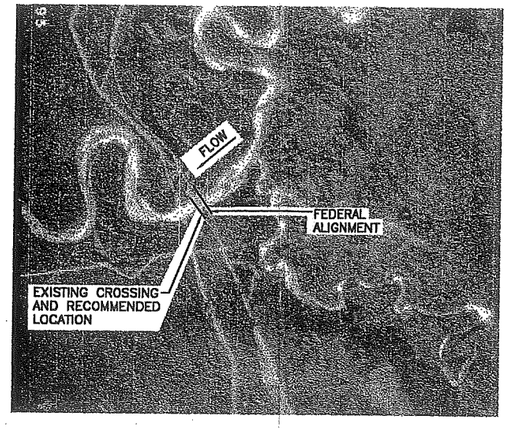
ROAD PROFILE
H – 1:500
V – 1:250



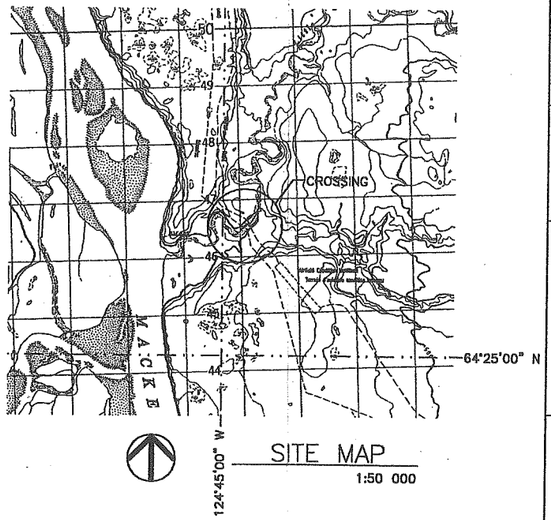
ABUTMENT ELEVATION
1:50



DECK SECTION
1:50



AERIAL PHOTOGRAPH
1:15 000



SITE MAP
1:50 000

SITE INFORMATION

SITE 5
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE APPROX. 20 m NORTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 25, 2001
WINTER ROAD km 853.8
COORDINATES LAT 64°26'05.8" N
LONG 124°44'31.2" W
SITE MAP REFERENCE 96–C/7

HYDROTECHNICAL DATA

- DRAINAGE AREA = 964 sq. km
- DESIGN DISCHARGE = 130 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0049 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 3.4 m/s
- ICE DESIGN ELEV. 101.5 m. ICE DESIGN THICKNESS 1.0 m
- ICE CLASS 'c' 700 kPa TO CAN/CSA–S6–00
- POSSIBLE MACKENZIE RIVER ICE JAM EFFECT–MAXIMUM ELEV. 104.1 (REQUIRES VERIFICATION BY SURVEY)

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

Northwest Territories Transportation

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

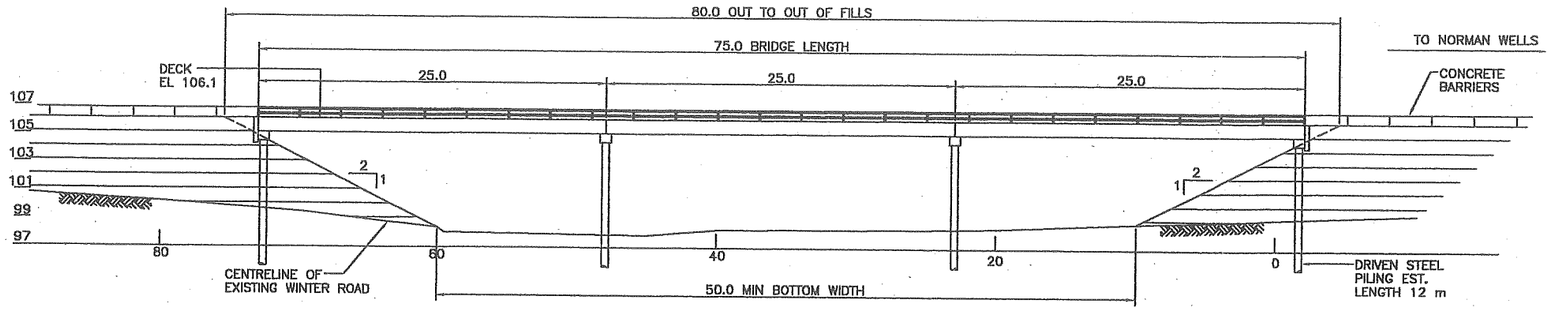
Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

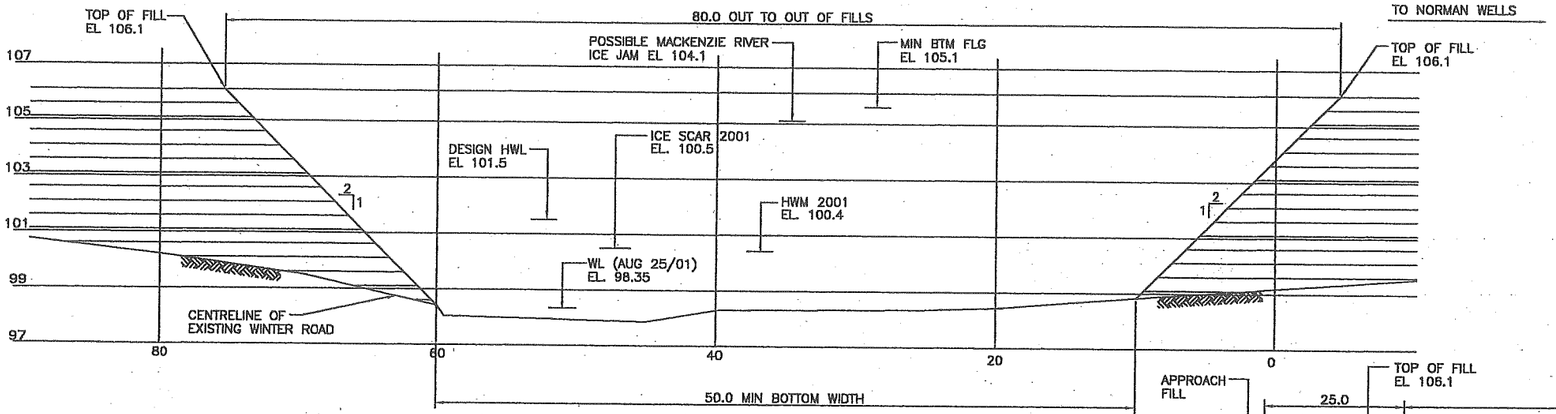
Title

LITTLE SMITH CREEK
km 853.8
PRELIMINARY DESIGN
INFORMATION
SHEET 1

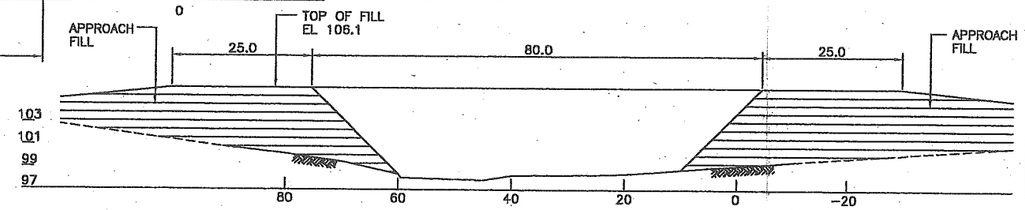
Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 5 of 22
Drawing No.



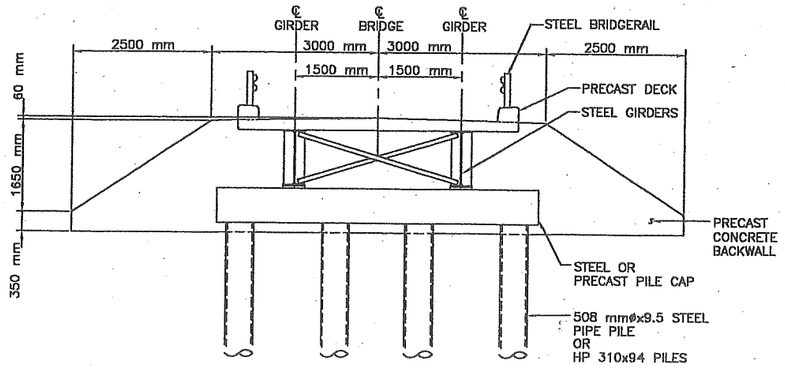
ELEVATION — NATURAL SCALE
(LOOKING D/S) 1:200



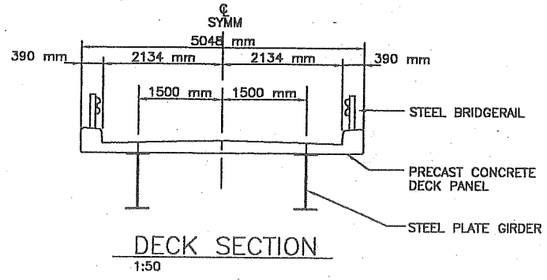
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



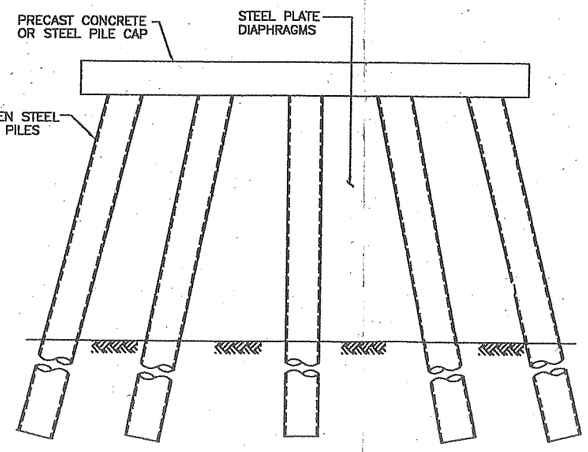
ROAD PROFILE
H – 1:500
V – 1:250



ABUTMENT ELEVATION
1:50



DECK SECTION
1:50



PIER ELEVATION
1:50

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Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

LITTLE SMITH CREEK
km 853.8
PRELIMINARY DESIGN
INFORMATION
SHEET 2

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
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Insignia
Signature
Date
Signature
Date
Approved by
Project No.
Page 5A of 22
Drawing No. 608–9–5A

4.6 Big Smith Creek

4.6.1 General

The Big Smith Creek winter road crossing is located at km 871.1 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 64° 35' 24.2" N and Long. 124° 48' 40.0 W.

A field investigation of the site was done on August 26, 2001. A preliminary survey of the centerline of the existing winter road crossing was done and a benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking north on the winter road. Photo 2 is an aerial view looking upstream. Photos 3 and 4 show the existing crossing looking north and south respectively on the winter road.

The present crossing is located approximately 85 m downstream of the federal alignment done by DPW in the 1970's. An old winter road crossing is approximately 50 m upstream also. A pipeline crosses the river approximately 25 m upstream of the present winter road crossing.

The stream was 38 m wide and 0.3 m deep at the time of the inspection,. Downstream of the crossing there is a rock outcrop, and further downstream there is a waterfall. The rock outcrop was composed of layered bedrock.

The winter road crosses the stream in a bend while the federal alignment crosses upstream of the bend and on a straight reach of the stream. The winter road curves as it approaches the river on each side.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment and the recommended structure.

4.6.2 Existing Information

Big Smith Creek had a preliminary bridge design done by Public Works Canada in 1973. The structure consisted of a three span continuous bridge with span lengths of 21.3 m - 46.3 m - 21.3 m. Test holes were done on an alignment that appears to correspond to the existing winter road crossing. Bedrock was encountered at depths ranging from 3.6 m to 9.1 m. The foundations were indicated as driven steel piles. The bottom flange of the girder was set at a minimum of 7.62 m (25') above the streambed. Class 11 heavy rock riprap was used to provide approach fill bank protection.

Additional information included air photos, an environmental assessment of the winter road operation for the crossing and an environmental information update report by GeoNorth and Golder Associates dated March 2000.

4.6.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information for the Big Smith River crossing consisted of topographic maps and air photos of the site as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The site was also the location of a Water Survey of Canada gauge from 1974 to 1994. A drainage area of 964 km^2 was obtained from the Water Survey of Canada gauge records. The present winter road crossing is about 85 m downstream of the proposed federal alignment crossing. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.0006. The maximum elevation in the basin obtained from the topographic maps is 760 m. Air photos taken in 1945, 1972 and 1994 were obtained for analysis. The 1945 photographs at 1:18,900 are the earliest available, the 1972 photographs at 1:13,000 are the largest scale available and the 1994 photographs at 1:30,000 are the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

The previous hydrotechnical study for the federal alignment also provided additional hydrotechnical information. A high water mark was observed 3.2 m above the bed. This previous study estimated the design discharge to be 510 m^3/s with a design water level 3.8 m above the bed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. This regional analysis included the discharge records for the Water Survey of Canada gauge at this site. An frequency analysis of these discharge records indicate that the 50-year discharge is 209 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the present winter road crossing.

On the day of the survey the water was 0.3 m deep and 38 m wide at the federal alignment crossing. The survey found the water surface slope had a slope of 0.0027 over a 56 m length of channel, however, this length included a portion of the steep reach downstream of the crossing.

One high water mark was found on the left bank upstream of the winter road crossing. This high water mark was 1.2 m above the water surface. At the cross section location

this highwater mark would have an elevation of 98.0 m relative to the local benchmark. Three ice scars were found downstream of the crossing on the right bank. The ice scars were between 2.0 and 3.2 m above the water level. These ice scars would be at elevations of between 98.7 and 100.0 m at the cross section location.

Both banks were well vegetated with grass and trees and appeared to be stable. A large bedrock outcrop is located just downstream of the crossing. The outcrop appears to control the slope of the channel upstream. Downstream of the outcrop, the channel plunges through a series of rapids and falls. The bed material was sampled using a line sample technique on an exposed portion of the bed at the winter road crossing. The median diameter (D_{50}) of the bed material is 55 mm while the largest stones (D_{90}) are about 110 mm in diameter.

3. River Engineering Analysis

The design high water level for the site was calculated to be 100.3 m, which is 3.5 m above the surveyed water level and 3.8 m above the bed. This level is the estimated 50-year ice jam elevation at this site. This level is 0.3 m higher than the highest observed ice scars and 0.6 m higher than the 1973 high water mark and the maximum recorded gauge height. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 101.3 m or greater.

Air photos of the site show numerous oxbow lakes upstream of the crossing but no new oxbows have formed from meander cutoffs between 1945 and 1994. Some of the upstream bends have migrated outward as much as 40 m over this period. No changes have occurred in the reach in the vicinity of the crossing. No changes in channel position were apparent in the 2001 air photos as well.

The federal alignment appears to be the most suitable location for the bridge crossing because it is located upstream of the bend in a straight stable reach of the river. The present winter road crossing also appears to be stable but it is located in a bend which may produce more severe erosion and scour during high flows. The old winter road crossing about 50 m upstream of the present crossing is more suitable than the present crossing because it is farther upstream in the bend and the channel is narrower at this location.

The existing channel at the cross section location is 38 m wide at the water level and 75 m at top of bank. The minimum bottom width of the channel should be 40 m which will limit the impact on the low water channel and will not constrict the channel enough to impede the ice floes during breakup. The design open water elevation of 99.5 m would produce a mean velocity of about 2.0 m/s through this opening with 2:1 side slopes.

4.6.4 Environmental Considerations

Big Smith Creek has been identified as being a fish rearing stream with spawning potential at the crossing. Grayling are found above and below the waterfall.

The existing banks are well vegetated and appear to be stable. Some bank erosion was noted upstream of the crossing but none is occurring at the winter road crossing.

4.6.5 Alternatives

Alternatives considered were a single span bridge and a three span bridge structure. The single span structure had an overall length of 58.0 m with a girder depth of 2.4 m. The three span arrangement consisting of 18 m - 25 m - 18 m spans had a structure depth of 1.5 m and uses two piers located symmetrically in the channel. Driven steel pipe piles were considered to be the most feasible foundation type. Piers would have welded steel plate diaphragms to assist in resisting ice forces. A geotechnical investigation would be necessary to determine pile capacities for both compression and tension (uplift) forces.

The federal alignment is located on a straight stable reach of the river and would be the preferred location. However, the old winter road crossing located approximately 50 m upstream on the present location is also considered suitable. The present crossing is located in a bend of the river that could be more susceptible to scour and erosion.

Steel girders with timber or composite concrete decks were assessed and are considered to be very suitable for this site.

The attached drawings show the alternative structures that are considered suitable.

4.6.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table. The estimated costs for construction are as follows:

58.0 m single span bridge.	$1,072,050
3 span (18 m - 25 m - 18 m) bridge.	$867,170

4.6.7 Recommendations

The bridge crossing should be located upstream at least 50 m to reduce the impact of the bend in the river.

The recommended structure consists of a 58.0 m single span bridge with a minimum bottom flange elevation of 101.3 m. A minimum undisturbed bottom stream width of 40.0 m is recommended. Headslopes of 2H to 1V were used resulting in out to out of fills of 68.0 m

at elevation 103.8 m. This structure is recommended as it provides the least disturbance to the stream.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment, the alternative structure, and the recommended structure.

4.6.8 Summary

A single span bridge with an overall length of 58.0 m is recommended on an alignment 50 m to 85 m upstream of the existing winter road crossing for the Big Smith Creek winter road crossing.

Site	Big Smith Creek			
	Recommended Structure - 58.0m Bridge			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	125000	1	125,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.2	5,000
Approaches - common fill	cu.m.	30	12400	372,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	20	68,000
Steel Girders fabricate and deliver	kg	1.15	73400	84,410
Steel and Deck Panel Erection	m	1500	58	87,000
Bridgerail	m	100	116	11,600
New Jersey Concrete Barriers	each	500	24	12,000
Precast Backwall Panels supply and deliver	each	6000	2	12,000
		Sub-Total		878,750
		Contingency(15%)		131,800
		Engineering(7%)		61,500
		Total		1,072,050

Alternative Structure - 3 span -18-25-18m				
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	125000	1	125,000
Driven Steel Piling - Abutment	each	10000	8	80,000
Driven Steel Piling - Pier	each	15000	8	120,000
Precast Concrete Pile Caps	each	4500	4	18,000
Pier Diaphragms	each	10000	2	20,000
Road Realignment	km	25000	0.2	5,000
Approaches - common fill	cu.m.	30	10800	324,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	20	68,000
Steel Girders fabricate and deliver	kg	1.15	30200	34,730
Steel and Deck Panel Erection	m	1500	61	91,500
Bridgerail	m	100	122	12,200
New Jersey Concrete Barriers	each	500	24	12,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		727,170
		Contingency(15%)		109,100
		Engineering(7%)		50,900
		Total		887,170

Photo 1 - Looking North on Winter Road (Stream Flow to Left)

Photo 2 - Looking Upstream

Photo No. 3 - Looking North on Winter Road (Flow to Left)

Photo 4 - Looking South on Winter Road

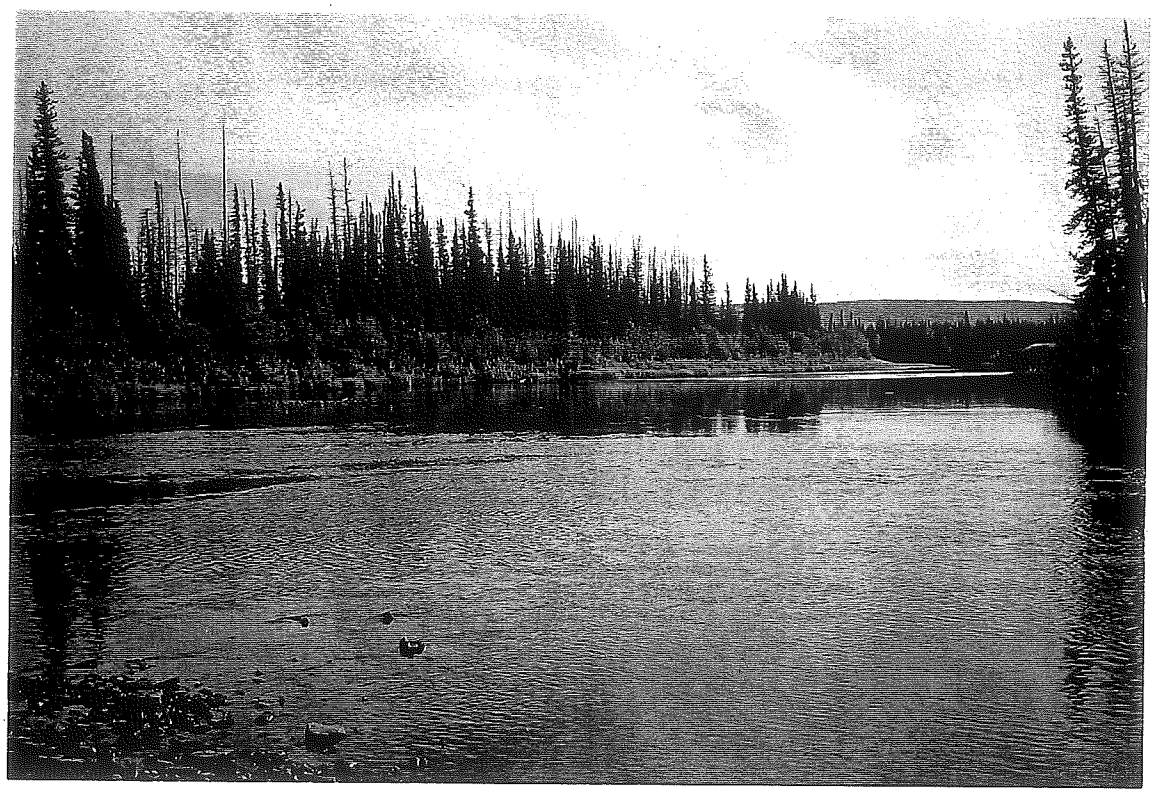


Photo 5 - Looking Upstream

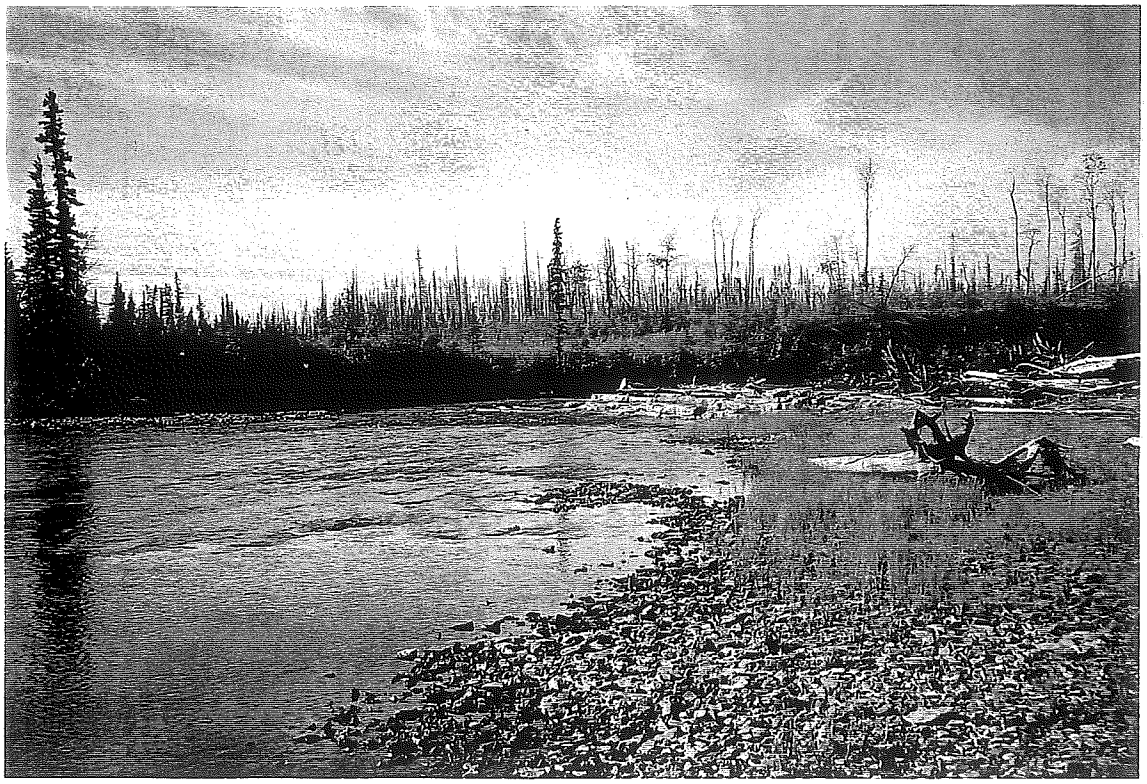
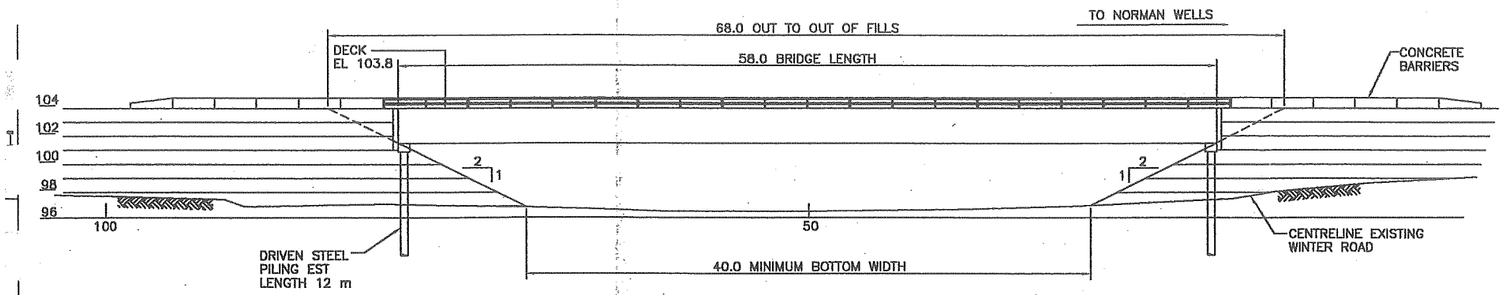
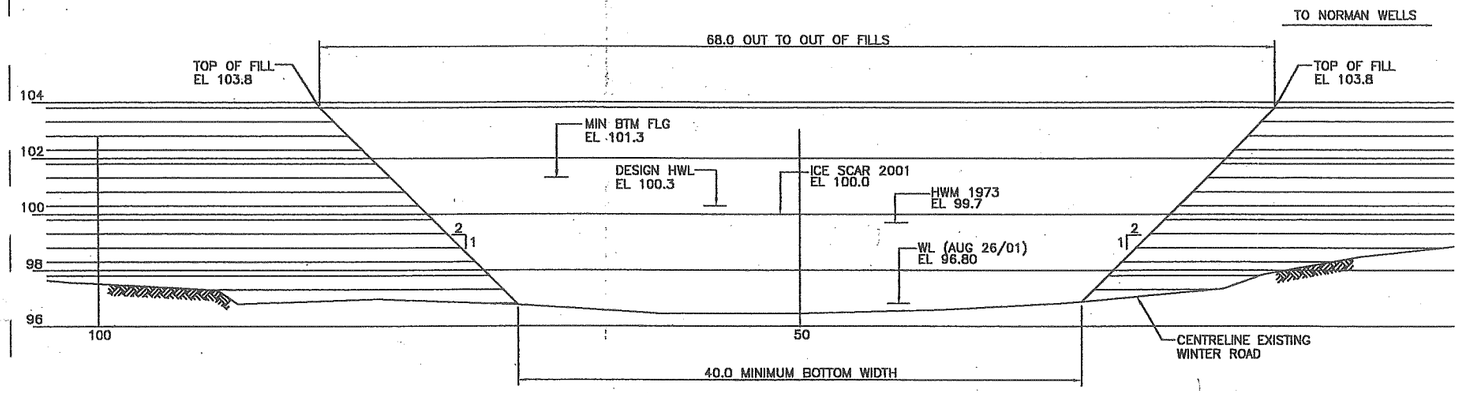


Photo 6 - Looking Downstream



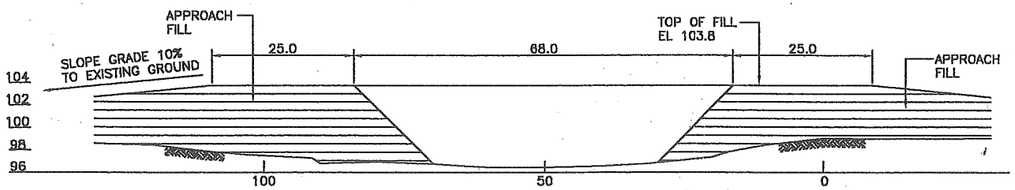
ELEVATION – NATURAL SCALE

(LOOKING D/S) 1:200



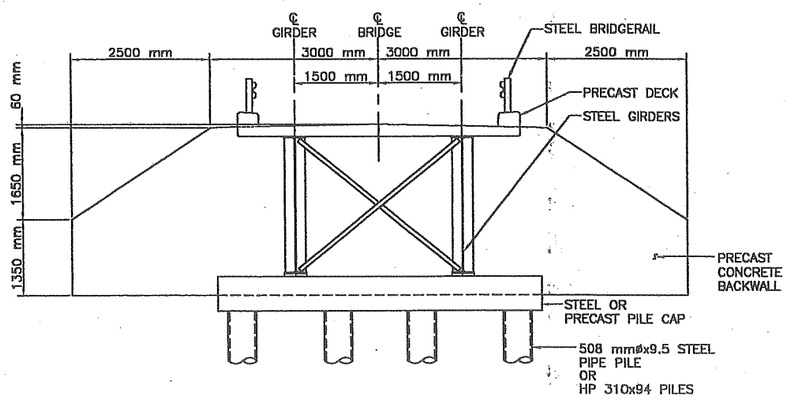
ELEVATION

(LOOKING D/S) H – 1:200
V – 1:100



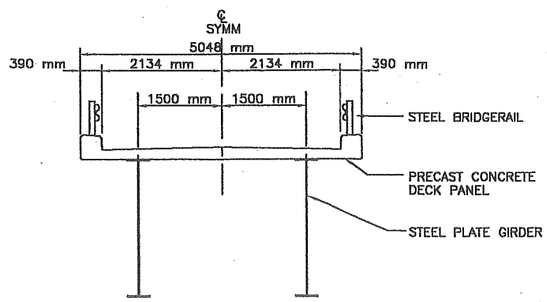
ROAD PROFILE

(LOOKING D/S) H – 1:500
V – 1:250



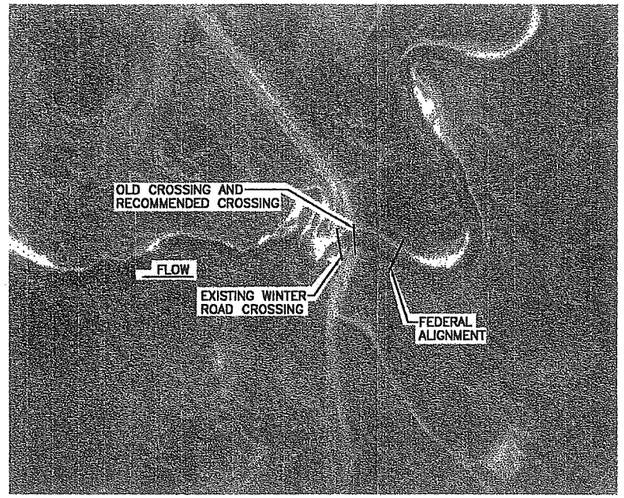
ABUTMENT ELEVATION

1:50



DECK SECTION

1:50



AERIAL PHOTOGRAPHY

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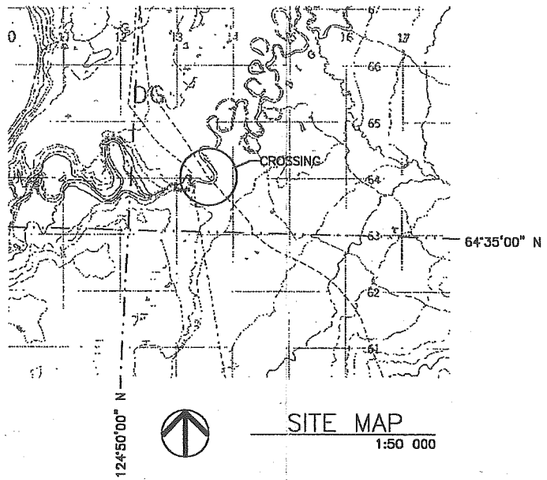

SITE MAP

1:50 000

SITE INFORMATION

SITE 6
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE APPROX. 10 m NORTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 26, 2001
WINTER ROAD km 871.1
COORDINATES LAT 64°35'24.2" N
LONG 124°48'40.0" W
SITE MAP REFERENCE 96–C/10

HYDROTECHNICAL DATA

- DRAINAGE AREA = 964 sq. km
- DESIGN DISCHARGE = 209 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0027 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 2.0 m/s
- ICE DESIGN ELEV. 100.3 m. ICE DESIGN THICKNESS 1.0 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA–S6–00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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B. location drawing number
C. drawing number

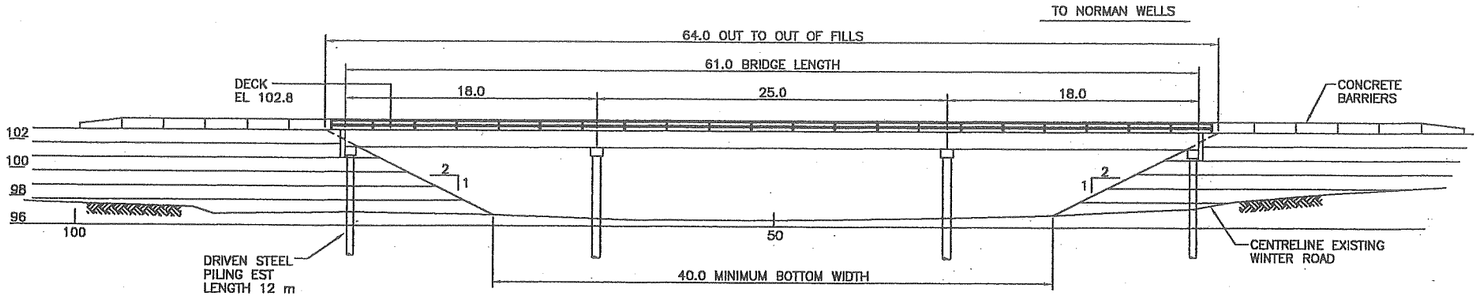
Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

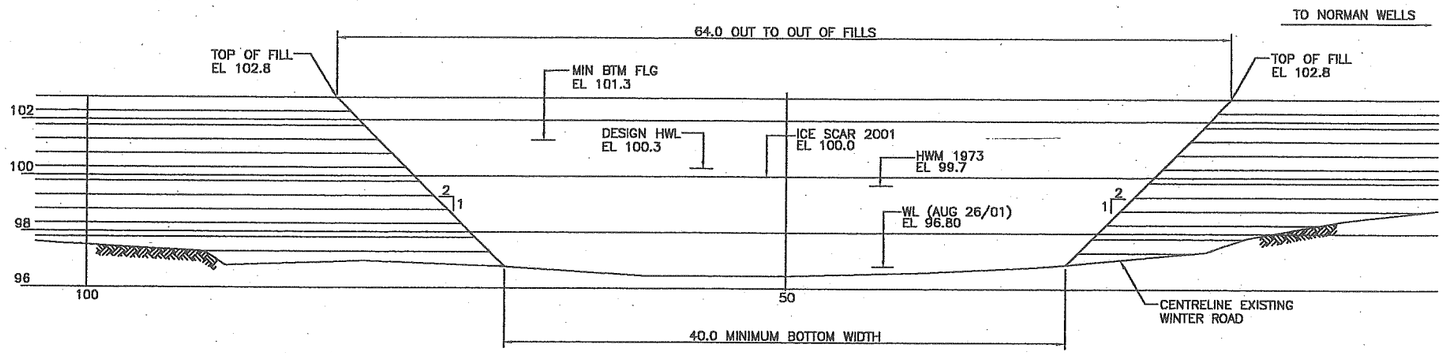
Title

BIG SMITH CREEK
km 871.1
PRELIMINARY DESIGN
INFORMATION
SHEET 1

Scale AS NOTED	
Surveyed by	
Drawn by MAP	
Designed by SDS	Checked by SDS
Insignia	Insignia
Signature / Date	Signature / Date
Approved by	
Project No.	Page 6 of 22
Drawing No. 608–9–6	

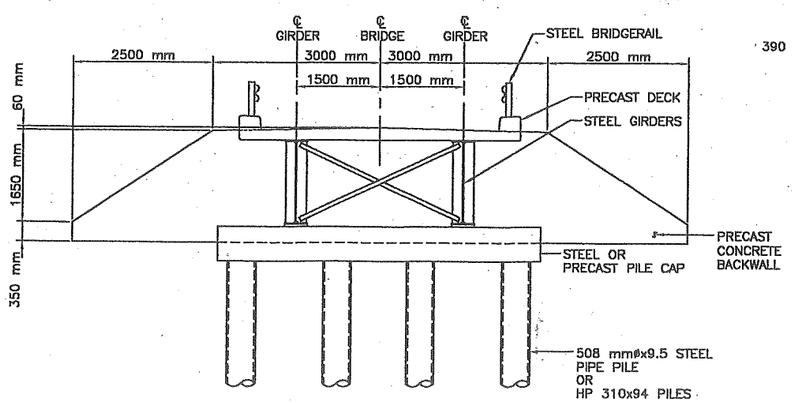


ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200

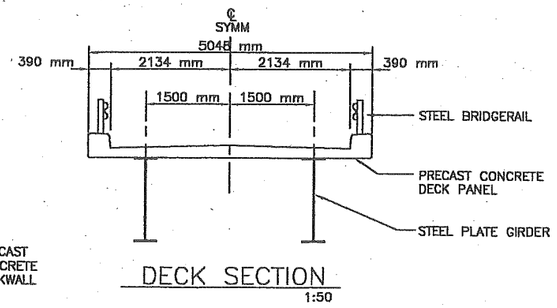


ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100

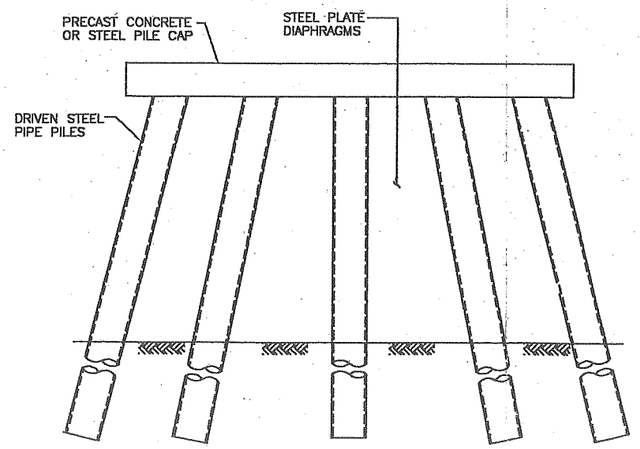
ROAD PROFILE
(LOOKING D/S) H – 1:500
V – 1:250



ABUTMENT ELEVATION
1:50



DECK SECTION
1:50



PIER ELEVATION
1:50

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Project

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WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

BIG SMITH CREEK
km 871.1
PRELIMINARY DESIGN
INFORMATION
SHEET 2

Scale	AS NOTED
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Checked by	SDS
Insignia	Insignia
Signature / Date	Signature / Date
Approved by	
Project No.	Page 6A of 22
Drawing No.	608-9-6A

4.7 Four Mile Creek

4.7.1 General

The Four Mile Creek winter road crossing is located at km 932.2 on the Mackenzie valley winter road. GPS coordinates of the site are Lat. 64° 54' 38.7" N and Long. 125° 28' 27.2" W.

A field investigation of the site was done on August 26, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

The winter road alignment diverges from a straight alignment as it approaches the stream. A straight alignment was used previously to cross the stream, but required very steep slopes, particularly on the south approach.

A pipeline crossing is located approximately 100 m upstream. The approach embankments appear to be sandy soils. Water was running down the north approach road between two ridges. The area north of the stream crossing is low and boggy between the stream valley walls.

On the day of the site investigation, the stream was approximately 1.5 m wide and 0.3 m deep. Banks are well vegetated and appear to be stable. The streambed was fine sand material. This crossing is located within the area burned in a large forest fire in 1995.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment, and the recommended structure.

4.7.2 Existing Information

Existing information was limited to air photos of the site and an environmental assessment of the winter road operation. No information on the fishery resources of the stream was available.

The federal alignment is approximately 400 m downstream of the existing winter road crossing.

4.7.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information for the Four Mile Creek crossing consisted of topographic maps and air photos of the site. A drainage area of 38 km^2 was obtained from the federal alignment study. The present winter road crossing is about 400 m upstream of the federal alignment crossing measured along the channel. There is no significant difference in the drainage area between the sites. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.014. The maximum elevation in the basin obtained from the topographic maps is 110 m. Air photos taken in 1945, 1972, and 1993 were obtained for analysis. The 1945 photographs at 1:28,000 are the earliest available, the 1972 photographs at 1:13,000 are the largest scale available and the 1993 photographs at 1:15,000 are the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site based on this method was found to be significantly less than the design discharges for similar sized basins in the region, due to the low elevation of the basin. Therefore, a design discharge of 31 m^3/s was adopted which is equivalent to the discharge for a basin with a 600 m maximum elevation. The 50-year breakup discharge is also estimated to be about 31 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the winter road crossing.

On the day of the survey the water was approximately 0.2 m deep and 2.1 m wide at the winter road crossing. The survey found that the water surface had a slope of 0.014 over a 11 m length of channel.

Three high water marks were found near the winter road crossing, one on the upstream left bank and two on the right bank just downstream of the crossing. These high water marks were 0.9 and 1.8 m above the local bed and would be at elevations between 95.6 and 96.5 m at the cross section location relative to the local benchmark. No ice scars were found.

Both banks were well vegetated with grass and willow and appeared to be stable. There was some debris in the channel on the downstream side of the winter road crossing. A visual inspection indicated that the bed was mostly fine sand.

3. River Engineering Analysis

The design high water level for the site was calculated to be 96.7 m, which is 2.0 m above the surveyed water level and 2.2 m above the bed. This level is the estimated 50 year ice jam elevation at this site. This level is 0.2 m higher than the 2001 high water mark. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 97.7 m or greater.

Air photos of the site show that it is situated on a terrace above the MacKenzie River. Upstream of the crossing there are a series of small lakes. Downstream of the crossing the creek becomes entrenched as it cuts through the terrace to join the MacKenzie River. There were no significant changes in the location of the creek between 1945 and 1993. No changes in channel position were apparent in the 2001 air photos as well.

Both the federal alignment and the winter road crossing are located in straight reaches of the creek. The winter road crossing is situated in the level portion of the terrace, while the federal alignment is located on the edge of the terrace. Both sites are suitable, however, the federal alignment could be in a steeper reach which may have scour problems due to higher velocities. At the winter road crossing the steeper, direct approach to the creek is preferable to the present winter road crossing because this direct crossing is less skewed.

The existing channel at the cross section on the winter road crossing is 2.1 m wide at the water level and 2.6 m at top of bank. The minimum bottom width of the channel should maintain the 2.1 m bottom width of the existing channel. The design open water elevation of 96.3 m would produce a mean velocity of about 3.7 m/s through this opening. Alternatively, this creek could be spanned using a culvert. A 3.66 m diameter culvert would be required if the culvert is buried to 20% of its diameter to provide a natural creek bottom.

4.7.4 Environmental Considerations

The site is located within the area burnt by the 1995 fire and there is potential for stream erosion. Fishery concerns appear to be minimal due to the size and slope of the channel.

4.7.5 Alternatives

The site is well suited to a culvert or a short span bridge structure. Based on the hydrotechnical review, a 3.66 m diameter culvert would be suitable. An arch structure is also considered to be suitable.

A straight alignment on the winter road was considered to be suitable for the crossing as it would cross the stream square and be located in the level portion of a terrace above the Mackenzie River.

A short span bridge structure would also be suitable for this crossing. Steel girders with timber or composite concrete decks were assessed and are considered very suitable for this site. A bridge length of 15.24 m is recommended. Preliminary sizing of the bridge girders indicates the bridge structure would consist of either two rolled or welded wide flange girders.

4.7.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table.

The estimated costs for construction are as follows:

2.0 m radius precast concrete arch x 18 m long.	$223,400
3.66 m diameter x 25.58 m long culvert.	$264,995
15.24 m single span bridge.	$293,995

4.7.7 Recommendations

The straight winter road alignment would be recommended for this site. A 2.0 radius precast concrete arch with an overall length of 18.0 m supported on driven steel piles is recommended for this site. Road fills would be constructed to provide 1.5 m cover over the culvert. Sideslopes of 3H to 1V were assumed in determining the culvert length. A 3.66 m diameter culvert with an overall length of 25.58 m could also be recommended. To provide for a natural creek bottom, the culvert invert should be placed 0.7 m below the existing streambed.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment, the alternative structure, and the recommended structure.

4.7.8 Summary

A 2.0 m radius precast concrete arch by 18 m long is recommended on the straight winter road alignment for the Four Mile Creek winter road crossing.

Site: Four Mile Creek

Recommended Structure 2.0m Radius Arch

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	30000	1	30,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	1900	57,000
Backfill - granular	cu.m.	35	800	28,000
Riprap - haul and place	cu.m.	28	50	1,400
New Jersey Concrete Barriers	each	500	16	8,000
Arch Panels				
supply and install	m	900	18	16,200
Driven Piling	each	2500	12	30,000
		Sub-Total		183,100
		Contingency(15%)		27,500
		Engineering(7%)		12,800
		Total		223,400

Alternative -3.66 m dia. Culvert

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	25000	1	25,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	1900	57,000
Backfill - granular	cu.m.	35	800	28,000
Riprap - haul and place	cu.m.	28	50	1,400
New Jersey Concrete Barriers	each	500	16	8,000
Culverts				
supply and install	m	1500	26	39,000
earthworks	m	1750	26	45,500
		Sub-Total		216,400
		Contingency(15%)		32,500
		Engineering(7%)		15,100
		Total		264,000

Alternative Bridge Structure - 15.24m Bridge

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	2300	69,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	50	1,400
Deck Panels				
fabricate and deliver	each	3400	5	17,000
Steel Girders				
fabricate and deliver	kg	1.15	5300	6,095
Steel and Deck Panel Erection	m	1500	15	22,500
Bridgerail	m	100	30	3,000
New Jersey Concrete Barriers	each	500	12	6,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		240,995
		Contingency(15%)		36,100
		Engineering(7%)		16,900
		Total		293,995

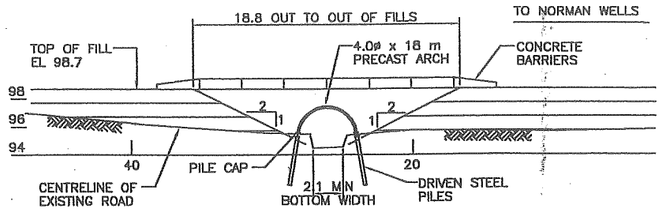
Photo 1 - Looking South on Winter Road (Stream Flow to Right)

Photo 2 - Looking North on Winter Road (Flow to Left)

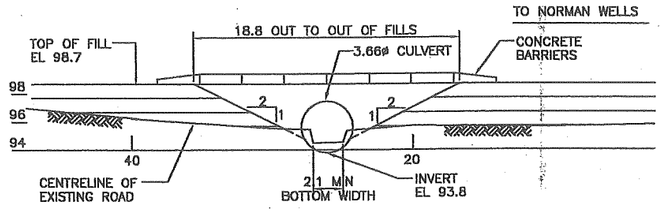
Photo No. 3 - Looking South on Winter Road

Photo 4 - Looking Downstream

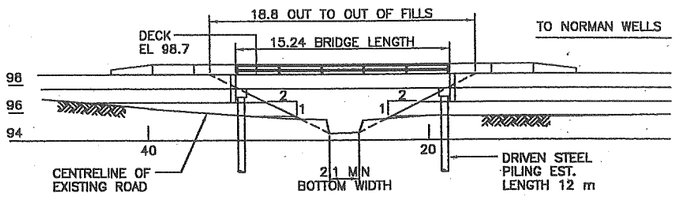
Photo 5 - Looking South at Straight (Preferred) Approach



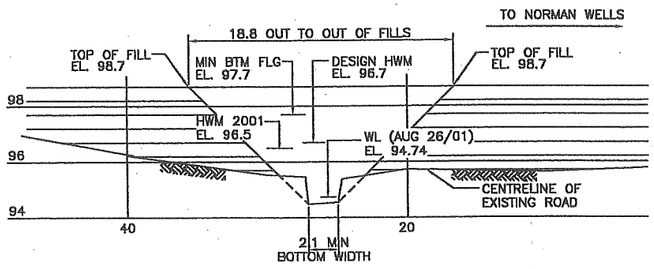
ARCH OPTION ELEVATION – NATURAL SCALE
1:200



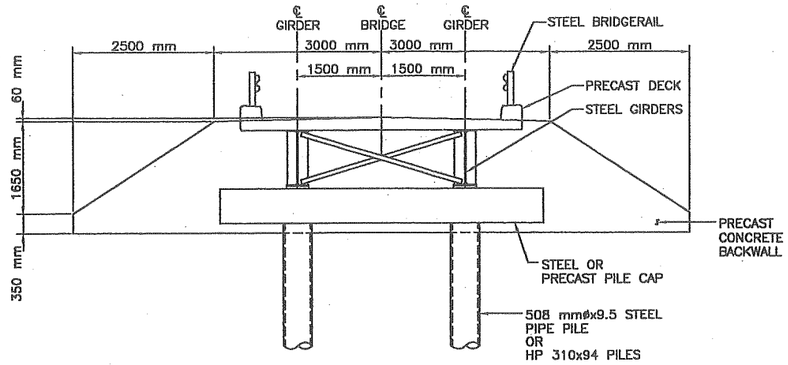
CULVERT OPTION ELEVATION – NATURAL SCALE
1:200



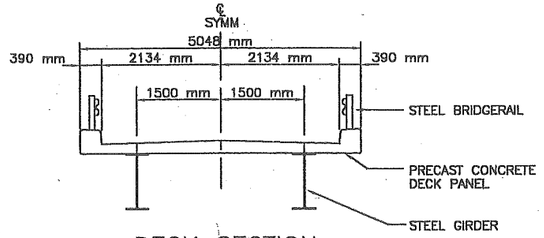
BRIDGE OPTION ELEVATION – NATURAL SCALE
1:200



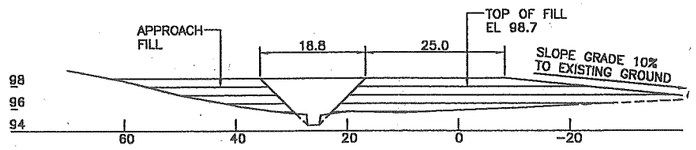
ELEVATION
H – 1:200
V – 1:100



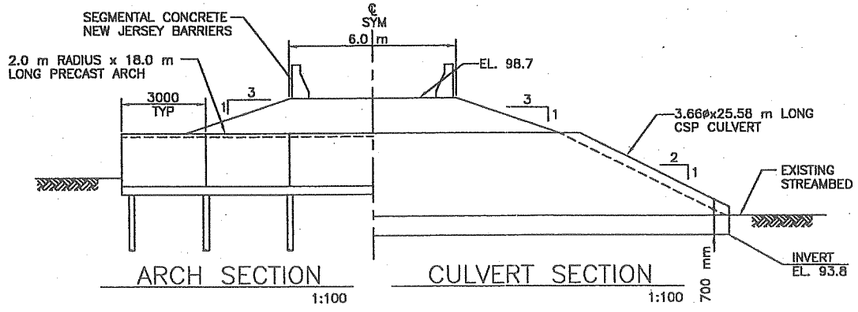
ABUTMENT ELEVATION
1:50



DECK SECTION
1:50

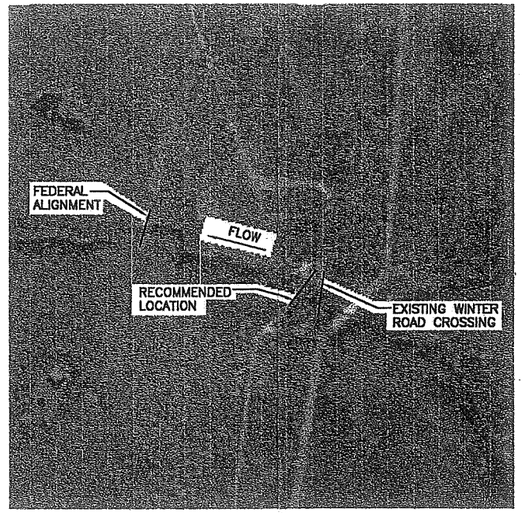


ROAD PROFILE
H – 1:500
V – 1:250

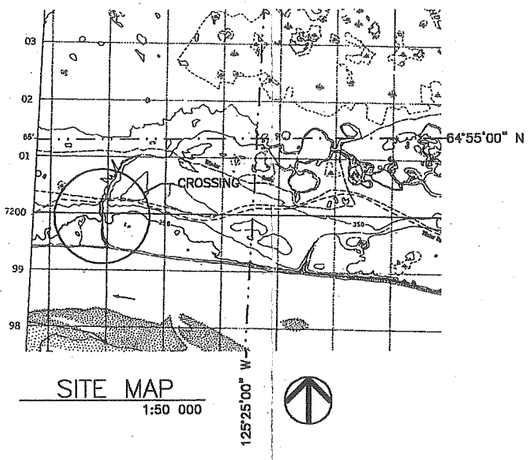


ARCH SECTION
1:100

CULVERT SECTION
1:100



AERIAL PHOTOGRAPHY
1:7500



SITE MAP
1:50 000

SITE INFORMATION

SITE 7
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE APPROX. 30 m SOUTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 26, 2001
WINTER ROAD km 932.2
COORDINATES LAT 64°54'38.7" N
LONG 125°28'27.2" W
SITE MAP REFERENCE 96–C/14

HYDROTECHNICAL DATA

- DRAINAGE AREA = 38 sq. km
- DESIGN DISCHARGE = 31 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.014 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 3.7 m/s
- ICE DESIGN ELEV. 98.7 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA–S6–00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

Northwest Territories Transportation

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ENGINEERING GROUP LTD.
8616–104 STREET
EDMONTON, AB
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PH. (780)438–5376

Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

FOUR MILE CREEK
km 932.2
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 7 of 22
Drawing No. 608–9–7

4.8 Jungle Ridge Creek

4.8.1 General

The Jungle Ridge Creek winter road crossing is located at km 978.5 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 03' 43.0" N and Long. 126° 03' 29.0 W.

A field investigation of the site was done on August 23, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking north on the winter road. Photo 2 shows the existing crossing looking north (stream flow to the right).

The present crossing is located approximately 100 m downstream of the straight federal alignment, indicated on the attached drawing. The winter road takes a sharp bend as it approaches the crossing and crosses the stream approximately at 90 degrees and then returns to the federal alignment. The stream has relatively shallow and stable banks. The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment, and the recommended structure.

4.8.2 Existing Information

Jungle Ridge Creek had a preliminary design done by Public Works Canada in 1974. The present winter road alignment takes a sharp turn to cross the stream at a relatively flat area and avoids steeper banks on the federal alignment. The structure recommended at that time was a 95 foot (28.95 m) span with the bottom flange approximately 4.5 m above the existing banks. The design high water and high ice was approximately 4.0 m above stream bed. Foundations consisted of driven steel piles with massive cast-in-place concrete abutment seats. Class 1 riprap was proposed to armour the approach fill headslopes.

4.8.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

   Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The drainage area upstream of the crossing site of 47 km^2 was obtained from the federal alignment study. This study also reported a surveyed stream slope of 0.0039. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.0047. The maximum elevation in the basin obtained from the topographic maps is 370 m. Air photos taken in 1950, 1973, and 1987 were obtained for analysis. The 1950

photographs at 1:40,000 are the earliest available, the 1987 photographs at 1:10,000 are the most recent and the 1973 photographs at 1:12,000 are from an intermediate year at a large scale. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

The previous hydrotechnical study for the federal alignment also provided additional hydrotechnical information. A high water mark was observed 3.2 m above the bed level. This study estimated the design discharge to be 51 m^3/s with a design water level 4.0 m above the bed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 37 m^3/s. This is somewhat less that the design discharge specified in the federal alignment study. The 50-year breakup discharge is also estimated to be about 37 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size.

On the day of the survey the water was 0.55 m deep and 3.5 m wide with a velocity of about 0.5 m/s. The slope was surveyed and found to be 0.0016 over a 59 m length at the present winter road crossing.

A high water mark found on the upstream right bank was 0.8 above the water level at an elevation of 98.7 m relative to the local benchmark. An ice scar found nearby was 2.2 m above the water level at an elevation of 99.5 m.

No erosion was evident at or near the crossing. Both banks are well vegetated with grass, willows and large trees. The banks are vertical and composed of fine material. The bed material was sampled using a line sample technique. The median diameter (D_{50}) of the bed material is 88 mm while the largest stones (D_{90}) are about 130 mm in diameter. The larger stones are cobble sizes while the finer material is gravel.

3. River Engineering Analysis

The design high water level for the site was calculated to be 101.1 m which is 3.8 m above the bed level. At this water level, the design flow of 34 m^3/s can flow down the main channel (adopting the surveyed slope of 0.0016 and a roughness of 0.050). This elevation is 0.5 m higher than the highest high water mark observed at the site. The minimum flange elevation should still provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge, to allow for some uncertainty in the hydraulic analysis and to allow for the effects of downstream flow blockages such as beaver dams. The minimum flange elevation should be 102.1 m or greater.

Ice affected breakup water levels are not expected to exceed 100.5 m, 1.0 m above the observed ice scar level. The breakup ice thickness is likely limited by the autumn water depth of about 0.55 m.

The minimum undisturbed width of the channel is 6.5 m. Assuming a 2:1 slope on the headslopes, the mean velocity through the opening is about 2.0 m/s.

Air photos of the site indicate that the channel has remained stable between 1950 and 1987. No changes in channel position were apparent in the 2001 air photos as well. The present winter road alignment diverges from the original federal alignment to cross the channel just downstream of a small tributary. If the bridge is built on the winter road alignment, the tributary may cause problems with runoff in the spring. The original straight alignment avoids this tributary and is situated in a straight reach of the creek. The original straight alignment is preferable as the site of the bridge crossing, however, the 2001 air photos indicate that a drainage channel on the north side of the channel may be affected by the original alignment. This channel should be diverted in the main channel upstream of the crossing.

4.8.4 Environmental Considerations

An environmental assessment of the winter road operation indicates the recommended environmental sensitivity is considered medium as to the impact on fish habitat. It is noted that the stream is an important grayling, slimy sculpin, and sucker spawning rearing and summer feeding area.

The area was completely burned in 1995 and could be subject to increased debris (trees, etc.) during high flow events.

4.8.5 Alternatives

The stream is well suited to a single span steel girder bridge structure requiring simple foundations to support the superstructure. Alternate span arrangements or structural types were not considered feasible for this site. A geotechnical investigation has not been done at this time, however, driven pile foundations are considered to be the most likely type. Based on the site observations, there did not appear to be any rock near the surface or large boulders that would restrict pile driving.

The hydrotechnical review indicated that culverts were not suitable for this site due to the size of the stream. Large culvert structures rely on the soil steel interaction achieved by proper compaction of the fills. This can be difficult to achieve in isolated locations, and in winter conditions, and as such, large span culverts are not recommended.

A source of fill material for the approach embankments is available to the north of the crossing along the federal alignment.

A straight alignment following the federal alignment which is approximately 100 m upstream was considered as a suitable alternative. This eliminates sharp bends in the winter road approaches and avoids a small tributary stream.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for this site. A bridge length of 18.288 m (60 ft.) is very typical of the bridges used by the oil and gas industry for similar crossings.

Preliminary sizing of girders indicates that the bridge structure would consist of two welded wide flange girders. The attached drawing indicates the recommended structure.

4.8.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the structure is provided in the following table.

The estimated costs for construction are as follows:

18.288 m single span steel girder bridge with timber deck. $343,780

18.288 m single span steel girder bridge with precast deck. $371,980

4.8.7 Recommendation

Consideration of using the federal alignment is recommended to eliminate the sharp bends in the existing winter road alignment. The recommended location is approximately 100 m upstream of the existing winter road crossing, as shown on the air photo. As noted in the hydrotechnical analysis, the original straight alignment avoids a small tributary stream and crosses on a straight reach of the Jungle Ridge Creek.

The recommended structure consists of an 18.288 m single span bridge with a minimum bottom flange elevation of 102.0 m. A minimum undisturbed stream width of 6.5 m is recommended. Headslopes of 2H to 1V were used resulting in an out to out of fills of 22.4 m at elevation 103.3 m.

Driven steel piles are recommended for the foundations. Steel girders with timber decking or with composite precast deck panels are recommended for the superstructure.

Detailed survey information along the federal alignment would be required for final design of the structure, and the approach fills or cuts.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment, and the recommended structure.

4.8.8 Summary

The original federal alignment is preferred for this crossing. A single span bridge with an overall length of 18.288 m using either the timber deck or precast deck system is recommended on the straight federal alignment for the Jungle Ridge Creek winter road crossing.

Site Jungle Ridge Creek

Recommended Structure -18.288m Bridge -Timber Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	40000	1	40,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	3800	114,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Timber Decking	sq.m.	100	92	9,200
Steel Girders				
fabricate and deliver	kg	1.15	7600	8,740
Bridge Erection	lump sum	15000	1	15,000
Bridgerail	m	100	36	3,600
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		281,780
		Contingency(15%)		42,300
		Engineering(7%)		19,700
		Total		343,780

Alternative Structure -18.288m Bridge -Precast Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	40000	1	40,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	3800	114,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels				
fabricate and deliver	each	3400	6	20,400
Steel Girders				
fabricate and deliver	kg	1.15	7600	8,740
Steel and Deck Panel Erection	m	1500	18	27,000
Bridgerail	m	100	36	3,600
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		304,980
		Contingency(15%)		45,700
		Engineering(7%)		21,300
		Total		371,980

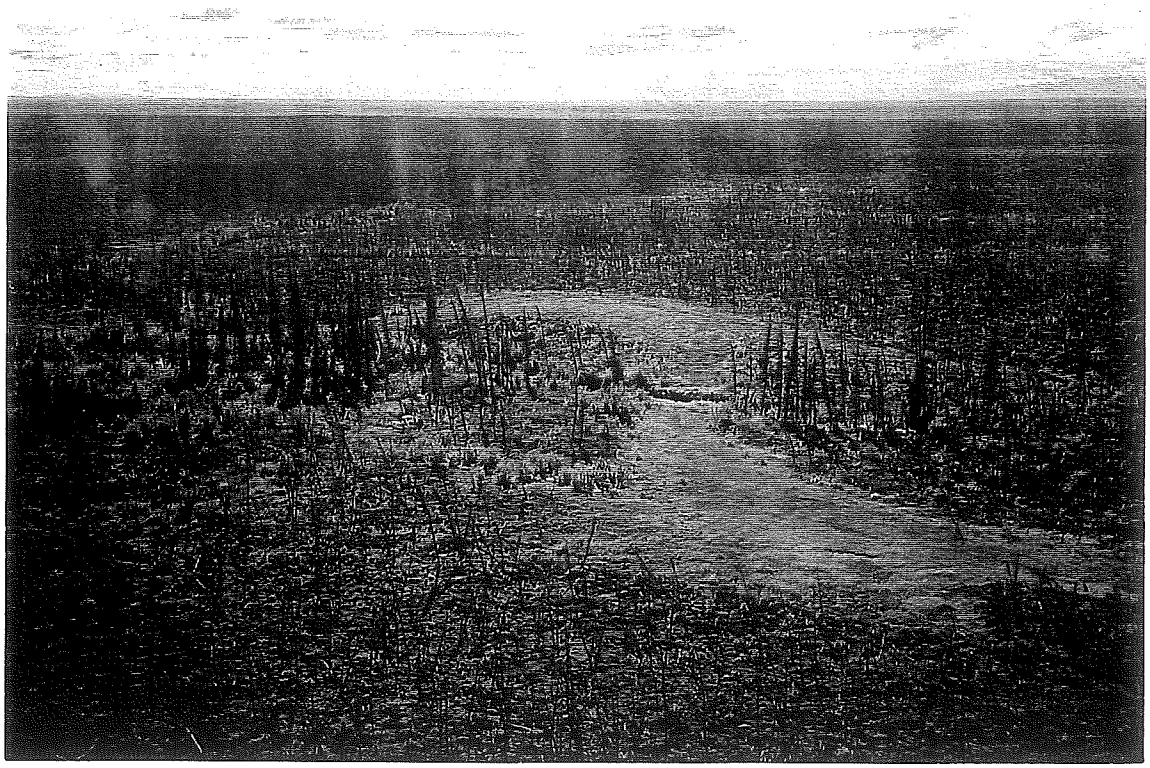
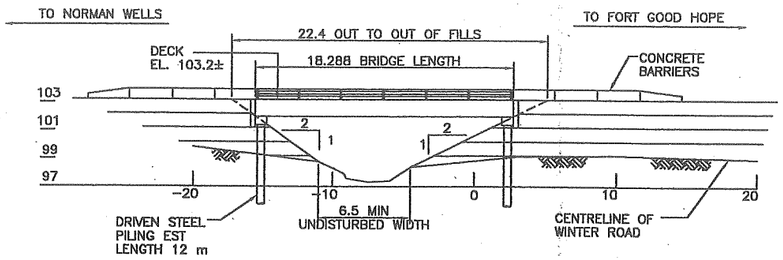


Photo 1 - Looking South on Winter Road (Stream Flow to Right)

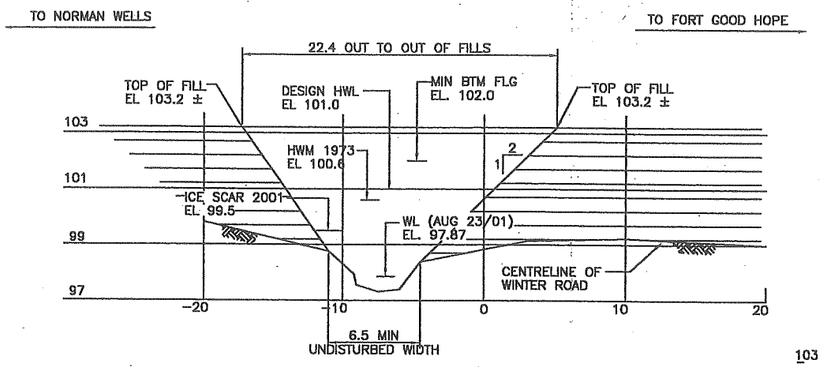
Photo 2 - Looking North on Winter Road

Photo No. 3 - Looking Upstream

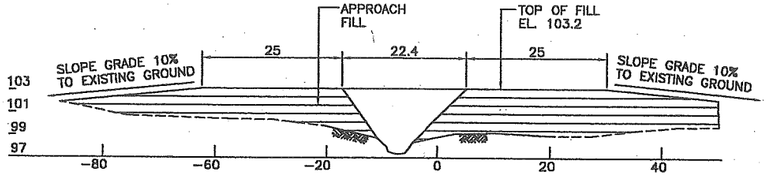
Photo 4 - Looking Downstream



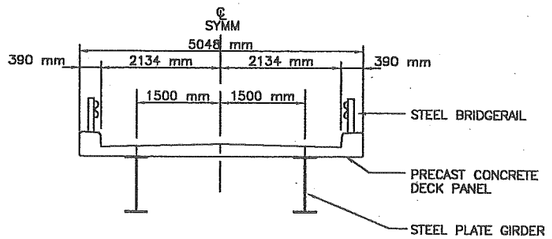
ELEVATION — NATURAL SCALE
(LOOKING D/S) 1:200



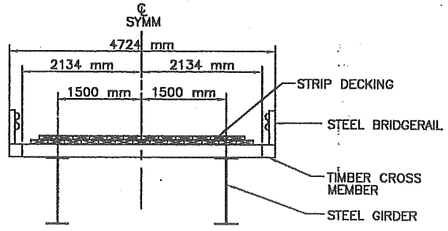
ELEVATION
(LOOKING D/S) H — 1:200
V — 1:100



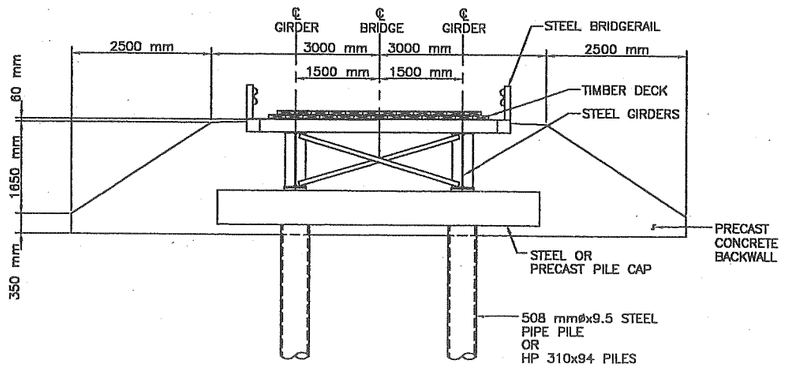
ROAD PROFILE
H — 1:500
V — 1:250



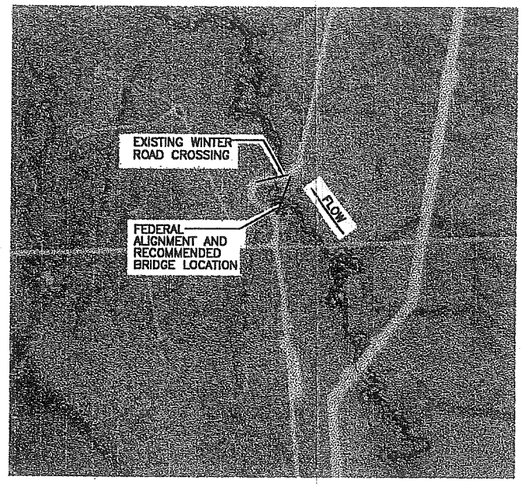
DECK SECTION — PRECAST
1:50



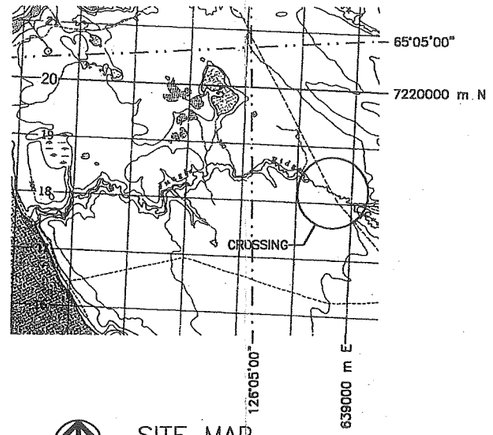
DECK SECTION — TIMBER
1:50



ABUTMENT ELEVATION
1:50



AERIAL PHOTOGRAPH
1:5000



SITE MAP
1:50 000

SITE INFORMATION

SITE 8
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN STUMP APPROX. 70 m NORTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 23, 2001
WINTER ROAD km 978.5
COORDINATES LAT 65°03'43.0" N
LONG 126°03'29.0" W
SITE MAP REFERENCE 96-E/1

HYDROTECHNICAL DATA

- DRAINAGE AREA = 47 sq. km
- DESIGN DISCHARGE = 37 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0016 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 2.0 m/s
- ICE DESIGN ELEV. 99.9 m. ICE DESIGN THICKNESS 0.55 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA-S6-00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A — A. detail number
C — B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

JUNGLE RIDGE CREEK
km 978.5
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Insignia
Signature
Date
Signature
Date
Approved by
Project No.
Page 8 of 22
Drawing No. 608-9-8

4.9 Nota Creek

4.9.1 General

The Nota Creek winter road crossing is located at km 982.3 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 05' 25.5" N and Long. 126° 05' 37.0" W.

A field investigation of the site was done on August 26, 2001. A preliminary survey of the centerline of the existing crossing was done and a temporary bench mark established as a reference to a future detailed survey.

Photo No. 1 shows an aerial view of the site looking north on the winter road with stream flow to the left. Photos 2 and 3 show the existing crossing looking north and south respectively on the winter road alignment.

The existing winter road alignment appears to coincide with the federal alignment of the 1970s. The road crosses on a straight section of the stream. Rocks up to 300 mm diameter were observed in the stream bed. The right bank is steep and approximately 3m high while the left bank is only 1 m high.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.9.2 Existing Information

Existing information included air photos of the site, an environmental report of the winter road operation, and an environmental information update report by GeoNorth and Golder Associates. A preliminary site survey profile done in 1996 by DOT was also provided.

There did not appear to have been any work done by DPW in the 1970's for this crossing.

4.9.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

   Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The drainage area upstream of the crossing site of 96 km^2 was obtained from the federal alignment study. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.0089. The maximum elevation in the basin obtained from the topographic maps is 670 m. Air photos taken in 1950, 1973, and 1986 were obtained for analysis. The 1950 photographs at 1:40,000 are the earliest available, the

1986 photographs at 1:10,000 are the most recent and the 1973 photographs at 1:12,000 are from an intermediate year at a large scale. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 65 m^3/s. The 50-year breakup discharge is also estimated to be about 65 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size.

On the day of the survey the water was 0.5 m deep and 7 m wide. The slope was surveyed and found to be 0.0075 over a 24 m length at the present winter road crossing.

High water marks were found on both banks just downstream of the winter road crossing. These high water marks were 1.2 and 1.4 above the water level. The higher high water mark would have an elevation of 98.0 m at the winter road crossing relative to the local benchmark. Two ice scars were found on the downstream right bank, also 1.2 and 1.4 m above the water level. The higher ice scar would have an elevation of 98.0 m at the winter road crossing.

Both banks are well vegetated with grass, willows and small trees. Large trees are also evident but these have been burnt in a previous forest fire. The right bank at the winter road crossing has a steep bare slope indicating recent erosion along this bank.

The bed material was sampled using a line sample technique. The median diameter (D_{50}) of the bed material is 80 mm while the largest stones (D_{90}) are about 190 mm in diameter. The larger stones are cobble sizes while the finer material is gravel.

3. River Engineering Analysis

The design high water level for the site was calculated to be 98.5 m which is 2.4 m above the bed level. At this water level, the design flow of 65 m^3/s can flow down the main channel (adopting the surveyed slope of 0.0075 and a roughness of 0.050). This elevation is 0.5 m higher than the highest high water mark observed at the site. Ice affected breakup water levels are not expected to exceed 99.4 m, 1.4 m above the observed ice scar level. The breakup ice thickness is likely limited by the autumn water depth of about 0.5 m. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge, to allow for some uncertainty in the hydraulic analysis and to allow for the effects of downstream flow blockages such as beaver dams. The minimum flange elevation should be 100.4 m or greater.

The minimum undisturbed width of the channel is 10.5 m. Assuming a 2:1 slope on the headslopes, the mean velocity through the opening is about 2.9 m/s.

Air photos of the site indicate that the channel has remained stable between 1973 and 1987. No changes in channel position were apparent in the 2001 air photos as well. The present winter road alignment is the same the original federal alignment This alignment has some erosion on the right bank but the channel is relatively straight so the erosion is not expected to progress rapidly. The present alignment is suitable as the site of the bridge crossing.

4.9.4 Environmental Considerations

An environmental assessment of the winter road crossing by the GNWT indicates the environmental sensitivity is high and the area is considered an important grayling spawning site. The environmental update report by GeoNorth and Golder Associates also noted the stream is fish bearing. Bank stability was identified as a concern.

Some erosion on the right bank is occurring at the winter road crossing. The site is within the burnt area of the 1995 forest fire.

4.9.5 Alternatives

The site is well suited to a single span steel girder bridge structure. Alternate span arrangements or structural types are not considered for this site. Some difficulty could be * experienced in driving steel piles due to the presence of the large size rocks in the stream bed. A geotechnical investigation would be useful in assessing the most suitable foundation.

Based on the hydrotechnical review a culvert structure is not considered suitable for this site.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for this site. A bridge length of 22.555 m (74 ft.) is recommended as a suitable span for this site. The bridge structure would consist of two welded wide flange girders as shown on the attached drawing.

Driven steel piles were considered suitable. However, reinforced tips would be required due * to the rocky streambed observed.

The existing alignment of the winter road was considered very suitable and no other alternative location was considered. This alignment also coincides with the federal alignment.

4.9.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the structure is provided in the following table.

The estimated cost for construction of the structure considered is $275,560.

4.9.7 Recommendations

The recommended crossing consists of a 22.555 m single span bridge with a minimum bottom flange elevation of 100.4 m. A minimum undisturbed stream width of 10.5 m is recommended. Headslopes of 2H to IV were used, resulting in an out to out width of fills of 27.6 m at elevation 101.9 m.

Driven steel piles are recommended for the foundation. Steel girders with timber decking or with composite precast deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.9.8 Summary

A single span bridge with an overall length of 22.555 m using either the timber deck or precast deck system is recommended on the existing alignment for the Nota Creek winter road crossing.

Site	Nota Creek			
	Recommended Structure - 22.555m Bridge			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35,000	1	35,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Approaches - common fill	cu.m.	30	1900	57,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels				
fabricate and deliver	each	3400	8	27,200
Steel Girders				
fabricate and deliver	kg	1.15	10800	12,420
Steel and Deck Panel Erection	m	1500	8	12,000
Bridgerail	m	100	45	4,500
New Jersey Concrete Barriers	each	500	14	7,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		225,860
		Contingency(15%)		33,900
		Engineering(7%)		15,800
		Total		275,560

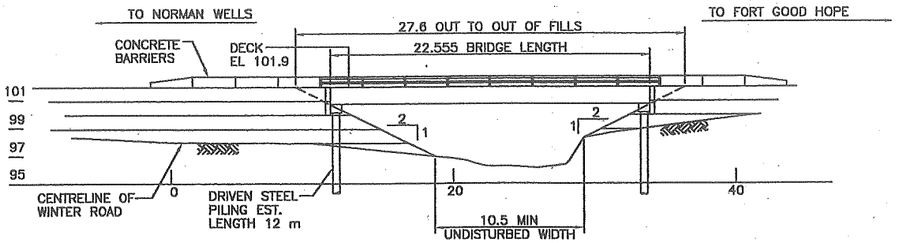
Photo 1 - Looking North on Winter Road (Stream Flow to Left)

Photo 2 - Looking North on Winter Road

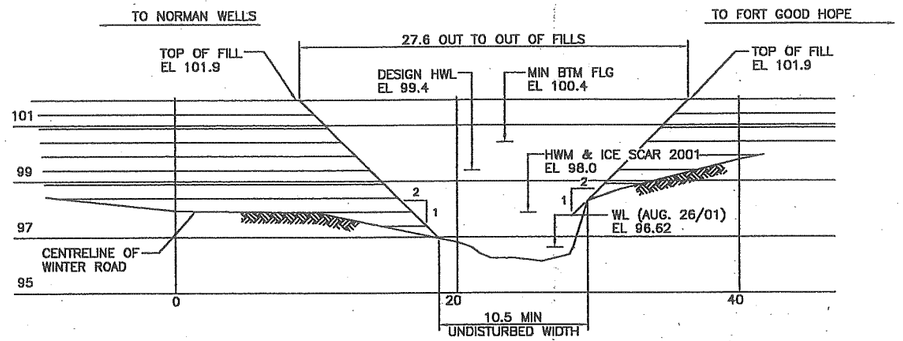
Photo No. 3 - Looking South on Winter Road

Photo 4 - Looking Upstream

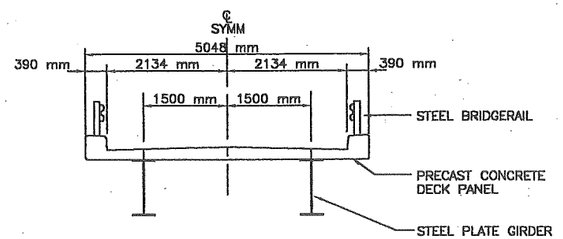
Photo 5 - Looking Downstream



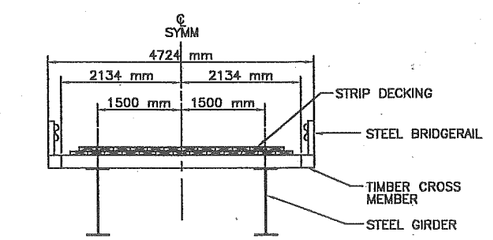
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



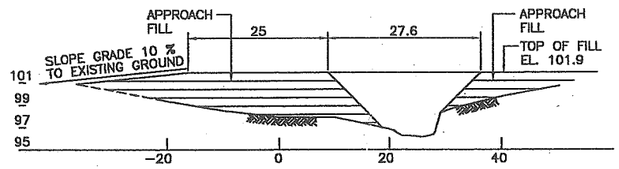
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



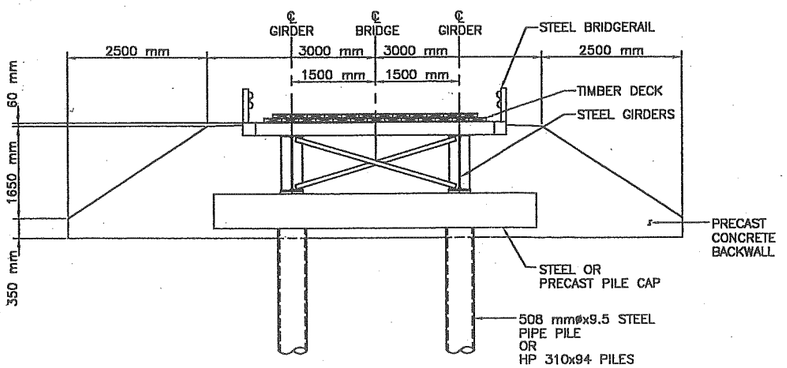
DECK SECTION – PRECAST
1:50



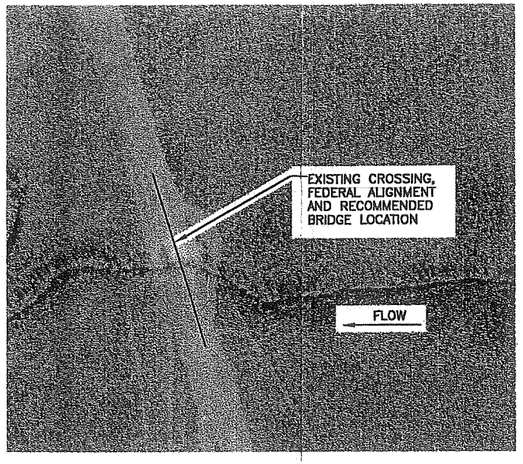
DECK SECTION – TIMBER
1:50



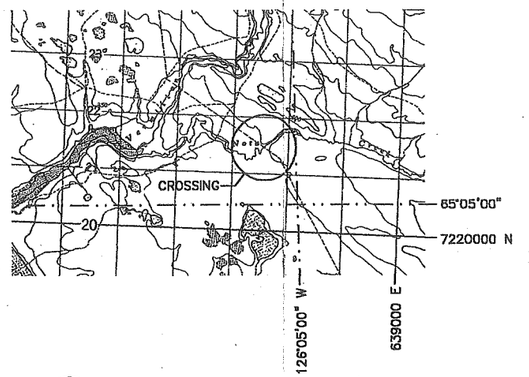
ROAD PROFILE
H – 1:500
V – 1:250



ABUTMENT ELEVATION
1:50



AERIAL PHOTOGRAPH
1:5000



SITE MAP
1:50 000

SITE INFORMATION

SITE 9
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE APPROX. 15 m NORTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 26, 2001
WINTER ROAD km 982.3
COORDINATES LAT 65°05'25.5" N
LONG 126°05'37.0" W
SITE MAP REFERENCE 96 E/1

HYDROTECHNICAL DATA

- DRAINAGE AREA = 96 sq. km
- DESIGN DISCHARGE = 65 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0025 m/m AT CROSSING
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 2.9 m/s
- ICE DESIGN ELEV. 98.2 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA-S6-00.

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

NOTA CREEK
km 982.3
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 9 of 22
Drawing No. 608-9-9

4.10 Christina Creek

4.10.1 General

The Christina Creek winter road crossing is located at km 1001.7 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 11' 12.3" N and Long. 126° 24' 01.0" W.

A field investigation of the site was done on August 26, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking north on the winter road. Photos 2 and 3 show the existing crossing looking north and south on the winter road.

The winter road alignment diverges from a straight alignment slightly (approximately 20 m west) and crosses on a relatively straight reach of the stream. Christina Creek flows parallel to the winter road and then crosses at right angles to the right of way. Stream banks are relatively shallow and appear to be stable.

The attached drawing indicates the preliminary site survey done, hydrotechnical assessments, and the recommended structure.

4.10.2 Existing Information

Existing information included air photos, an environmental operation report for the winter road and a preliminary survey profile done by DOT in 1996.

There was indication of work done by DPW in the 1970's, possibly including a bridge design, but detailed records were not available at this time.

4.10.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The drainage area upstream of the crossing site of 20 km^2 was obtained by adding 1.0 km^2 to the drainage area of 19 km^2 obtained from the federal alignment study. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.016. The maximum elevation in the basin obtained from the topographic maps is 975 m. Air photos taken in 1950, 1974, and 1993 were obtained for analysis. The 1950

photographs at 1:40,000 are the earliest available, the 1987 photographs at 1:15,000 are the most recent and the 1974 photographs at 1:10,000 are at the largest available scale. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 35 m^3/s. The 50-year breakup discharge is estimated to be about 20 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size.

On the day of the survey the water was 0.1 m deep and 7 m wide. The slope was surveyed and found to be 0.014 over a 60 m length at the present winter road crossing.

High water marks were found upstream and downstream of the crossing on both sides of the channel. These high water marks were between 0.8 and 1.6 m above the water level. The highest high water mark would have an elevation of 99.8 m at the winter road crossing relative to the local benchmark. An ice scar was found upstream of the island, 0.4 m above the water level. This ice scar would have an elevation of 98.8 at the winter road crossing.

Both banks are well vegetated with grass and willows with some larger trees. The left bank at the winter road crossing is being under-cut by the flow but the erosion appears to be minor. The banks are composed of alluvial material. The bed material was sampled using a line sample technique. The median diameter (D_{50}) of the bed material is 38 mm while the largest stones (D_{90}) are about 85 mm in diameter. The largest stones are cobbles but most of the bed material is gravel.

3. River Engineering Analysis

The design high water level for the site was calculated to be 99.8 m which is 1.5 m above the bed level. At this water level, the design flow of 35 m^3/s can flow down the main channel (adopting the surveyed slope of 0.014 and a roughness of 0.050). This elevation is the same as the highest high water mark observed at the site. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge, to allow for some uncertainty in the hydraulic analysis and to allow for the effects of downstream flow blockages such as beaver dams. The minimum flange elevation should be 100.8 m or greater.

Ice affected breakup water levels are not expected to exceed 99.8 m, 1.0 m above the observed ice scar level. The breakup ice thickness is likely limited by the autumn water depth which is only about 0.1 m.

The minimum undisturbed width of the channel is 10 m. Assuming a 2:1 slope on the headslopes, the mean velocity through the opening is about 2.3 m/s.

Air photos of the site indicate that the channel has remained relatively stable between 1950 and 1993 and between 1993 and 2001 only minor changes have occurred. Between 1993 and 2001, the upstream bend has migrated about 2 m toward the south approach. The present winter road alignment crosses the stream about 400 m downstream of the original federal alignment. The road crosses the channel in a bend just downstream of a small island. At present, the stream is attacking the upstream side of the winter road before it turns to cross the right-of-way. The position of the channel may lead to erosion problems along the south embankment if the bridge is built on the present winter road alignment. Instead, the bridge crossing should be moved 10 to 30 m downstream to avoid this upstream bend and to cross the channel in a straighter reach.

4.10.4 Environmental Considerations

An environmental assessment of the winter road operation indicates the environmental sensitivity should be assumed as high. No detailed information was available on fishery resources, but the stream should be expected to support fish.

4.10.5 Alternatives

The site is well suited to a single span steel girder bridge structure using driven steel piles for the foundations. Alternate span arrangements or structural types are not considered feasible for this site. A geotechnical investigation has not been done at this time, however, driven piles appear to be most suitable.

The hydrotechnical review indicated that culverts were not suitable for this site due to the size of the stream.

If the existing crossing alignment were utilized, bank protection would be required to prevent erosion of the upstream fills. This could be accomplished with bank armouring of rock riprap. The recommended alternative would be to relocate the alignment 10 to 30 m downstream to cross the stream on a straight reach and avoid the upstream bend.

Steel girders with timber decks or composite concrete decks were assessed and are considered very suitable for this site. A bridge length of 17.068 m (56 ft.) is recommended as a suitable span for this site. Preliminary sizing of girders indicates the bridge structure would consist of two welded wide flange girders, as shown on the attached drawing.

4.10.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the structure is provided in the following table.

The estimated costs for construction are as follows:

17.068 m single span steel girder bridge with timber deck. $243,925

17.068 m single span steel girder bridge with precast deck. $260,025

4.10.7 Recommendation

The bridge crossing should be located 10 to 30 m downstream of the existing location to avoid an upstream bend. The recommended structure consists of an 17.068 m single span bridge with a minimum bottom flange elevation of 100.8 m. A minimum undisturbed stream width of 10 m is recommended. Headslopes of 2H to 1V were used resulting in an out to out of fills of 21.4 m at elevation 101.8 m.

Driven steel piles are recommended for the foundations. Steel girders with timber decking or with composite precast deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, hydrotechnical assessment and the recommended structure.

4.10.8 Summary

A single span bridge with an overall length of 17.068 m with either the timber deck or precast deck system is recommended on an alignment 10 to 30 m downstream of the existing crossing for the Christina Creek winter road crossing.

Site Christina Creek

Recommended Structure - 17.068m Bridge - Timber Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.4	10,000
Approaches - common fill	cu.m.	30	1400	42,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	150	4,200
Timber Decking	sq.m.	100	92	9,200
Steel Girders fabricate and deliver	kg	1.15	7500	8,625
Bridge Erection	lump sum	10000	1	10,000
Bridgerail	m	100	34	3,400
New Jersey Concrete Barriers	each	500	12	6,000
Precast Backwall Panels supply and deliver	each	6000	2	12,000
		Sub-Total		199,925
		Contingency(15%)		30,000
		Engineering(7%)		14,000
		Total		243,925

Alternative Structure - 17.068m Bridge - Precast Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	6000	2	12,000
Road Realignment	km	25000	0.4	10,000
Approaches - common fill	cu.m.	30	1400	42,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	150	4,200
Deck Panels fabricate and deliver	each	3400	6	20,400
Steel Girders fabricate and deliver	kg	1.15	7500	8,625
Steel and Deck Panel Erection	m	1500	6	9,000
Bridgerail	m	100	34	3,400
New Jersey Concrete Barriers	each	500	12	6,000
Precast Backwall Panels supply and deliver	each	6000	2	12,000
		Sub-Total		213,125
		Contingency(15%)		32,000
		Engineering(7%)		14,900
		Total		260,025

Photo 1 - Looking North on Winter Road (Stream Flow to Left)

Photo 2 - Looking North on Winter Road ←

Photo No. 3 - Looking South on Winter Road →

Photo 4 - Looking Upstream →

Photo 5 - Looking Downstream ↑

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May 31, 2003

RECEIVED BY THE
Secretary/Administration
Clerk
JUN 1 1 2003
of Highways Division (DOT)

John Bowen
Tom Williams
Structures Section
Highways Division
DOT, GNWT
Yellowknife, NT

Dear Sirs:

CT03 – 3058 Blackwater River Bridge Crossing
Environmental Concerns and Construction Techniques

I am enclosing one (1) original copy of the Environmental Assessment for the above proposed bridge crossing prepared by our subsidiary company, Bryant Environmental Consultants Ltd.

If you have any questions or concerns with the report, please give Wayne Bryant or myself a call at 920-7501. Thank you.

Sincerely,

CAMILLUS ENGINEERING CONSULTANTS LTD.

Cam Marianayagam, PEng.
President

c.c. Wayne Bryant, BECL
Stuart Smith, BP-TEC

ENVIRONMENTAL ASSESSMENT OVERVIEW OF BRIDGE CROSSING AT BLACKWATER RIVER, NT

DEPARTMENT OF TRANSPORTATION, GNWT YELLOWKNIFE, NT

PROJECT NO. 23-018

Prepared for:

Structures Section
Department of Transportation, GNWT
Yellowknife, NT

Prepared by:

Bryant Environmental Consultants Ltd.
A subsidary of Camillus Engineering Consultants Ltd.

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May 9, 2003

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Executive Summary

This Report provides an environmental assessment overview of the proposed bridge crossing at the Blackwater River, located at mile 492 on the Mackenzie Valley winter road in the Northwest Territories. The construction of bridges along the winter road will extend the amount of time it can remain in operation each year thereby providing benefits to both residents and industry in the area.

The Blackwater Ecosystem, located within the Taiga Cordillera is rich with vegetation, wildlife and fish species. Various cultural and archeological sites are located within close proximity to the proposed bridge-crossing site. It is important that during both the construction and operation phases of the bridge measures are followed that will ensure that the area is preserved as best possible. This report suggests possible environmental impacts that may arise through the construction of the bridge while suggesting mitigative measures that may reduce these impacts.

As this is not the only project in the area, cumulative effects relating to industries that are either present or in the exploration/planning stage are examined, such as the proposed Mackenzie Valley Gas Pipeline.

1.0 Introduction

move 350 m → east

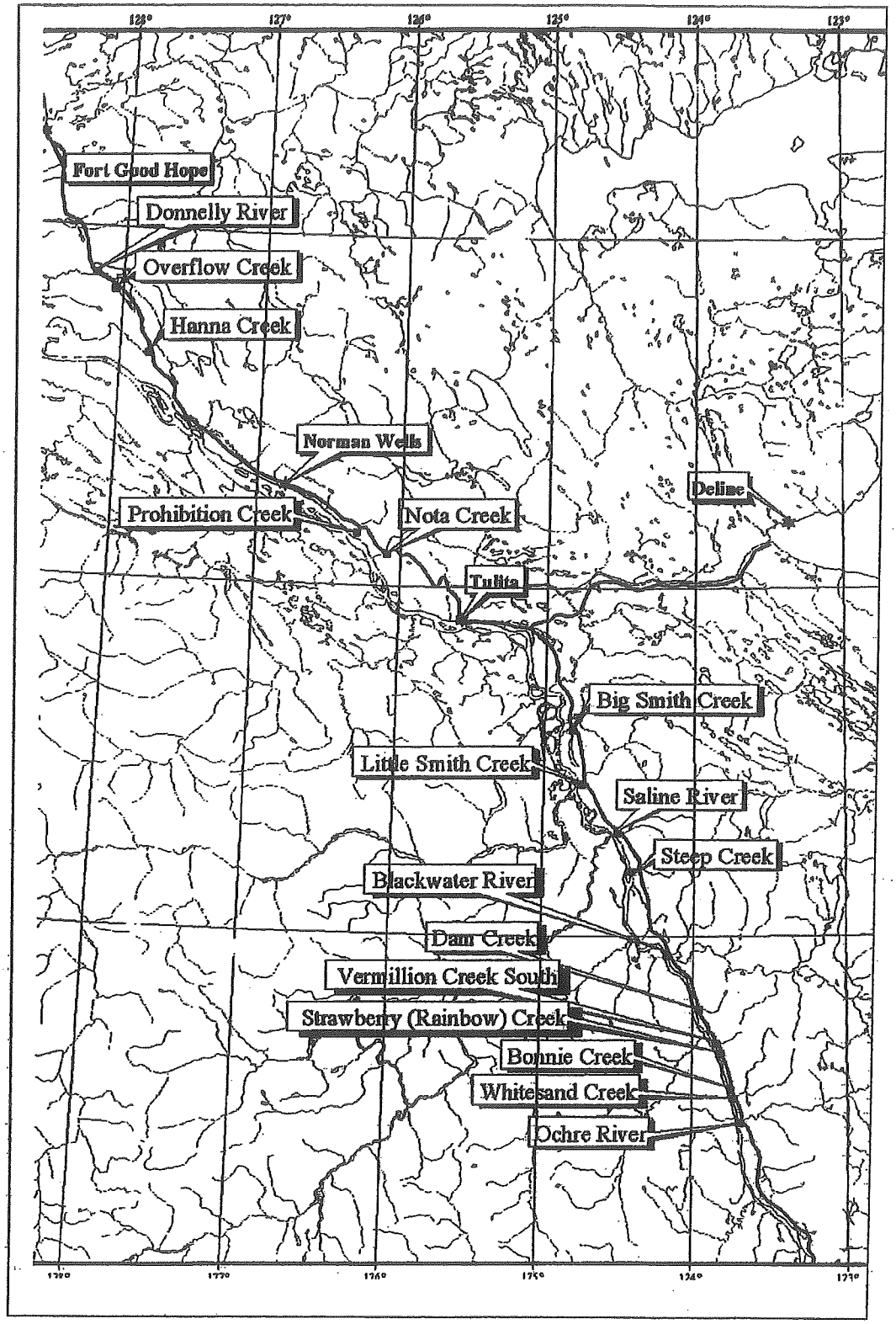
In 1973 and 1974, Slaney & Company Ltd. prepared two brief environmental reports for Public Works Canada concerning a proposed Blackwater River Bridge. These reports provide a summary of the environmental data that was known back in the 1970s. Since then, a great deal more environmental information has been collected on the Blackwater ecosystem. With a number of reports been prepared about this area. This document serves as an Environmental Assessment Overview for the project. In order to achieve this, relevant environmental information about the Blackwater River crossing site was compiled, assessed and analyzed to identify current environmental issues.

2.0 Description of Project Area

The Blackwater River crossing site is located at Mile 492 along the Mackenzie Valley winter road (see Map 1). It lies in the Taiga Cordillera ecoregion. The Blackwater River flows through a stream cut valley, the Blackwater Valley, and then through the Mackenzie Valley where it meets the Mackenzie River (Brooks 1996).

The Blackwater River at the proposed crossing site is approximately 100 m wide (DOT 1997). A gravel bar separates the channel from a narrow (30 m) dry channel on the right downstream section of the crossing (see Photos 1 & 2). Back-flooding and ice jams from the Mackenzie River are common in the spring. Flooding could be a concern if the winter road is routed along an old channel for the Mackenzie River that is on the right downstream bank of the Blackwater River (Golder & GeoNorth 2000).

The lower reach of the river is characterized by short sections of riffle habitat. A short section of riffle at the crossing is estimated to be 0.5-0.9 m deep. Pool habitat was not observed at the crossing but is common along the length of the river (Hatfield et al. 1972; DOT 1997). At the crossing location, gravel, cobble and boulders dominate the riverbed. Water in the river appears tea-stained (Golder & GeoNorth 2000).



Map 1. Stream and River Crossings on the Mackenzie Valley Highway
Map from Golder Associates Ltd. & GeoNorth Ltd. 2000 report

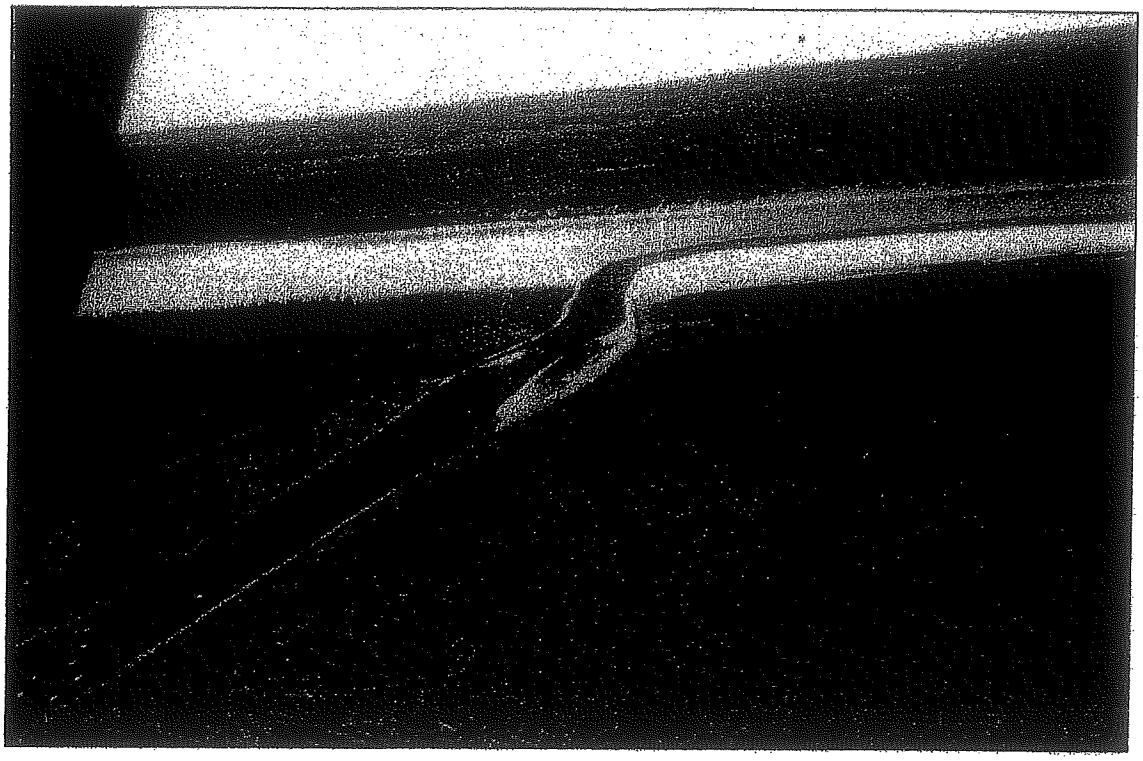


Photo 1. Blackwater River aerial view of crossing and river entering Mackenzie River.
Photo from Golder Associates Ltd. & GeoNorth Ltd. 2000 report

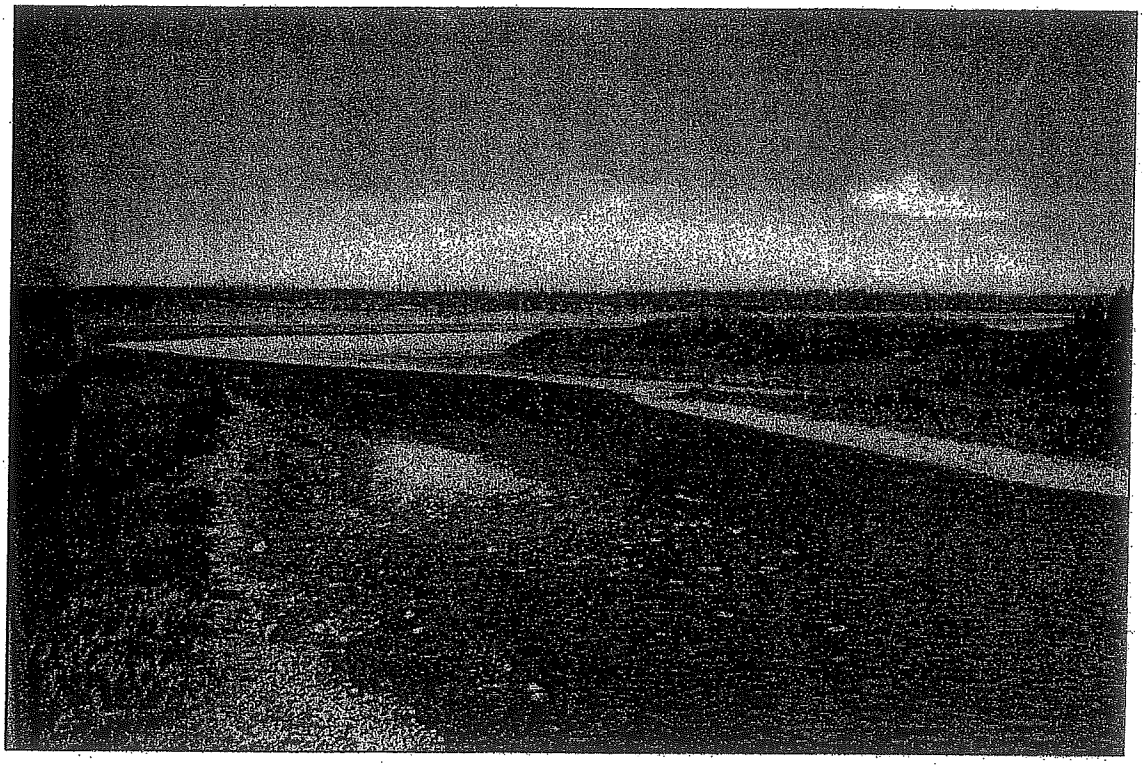


Photo 2. Blackwater River downstream view of crossing.
Note: winter road crossing in centre. Photo from Golder Associates Ltd. & GeoNorth Ltd. 2000 report

2.1 Vegetation

Vegetation in the Taiga Cordillera is characterized by alpine tundra at higher elevations and sub-alpine open woodland vegetation at lower elevations. The sub-alpine vegetation includes stunted white spruce and occasional alpine fir, also included are willow, dwarf birch and Labrador tea (Environment Canada website).

A survey of the Blackwater River crossing conducted by Golder Associates Ltd. and GeoNorth Ltd. in 1999, found that the area within the vicinity of the crossing is comprised of mixed deciduous and white spruce forests with varying dominance between spruce and balsam poplar. Balsam poplar, white spruce forests, shrublands and sparse open meadows dominate the lower slopes, the river terrace and the floodplain areas. The areas cleared for the winter road and snow collection have open meadow vegetation communities as well as a trace cover of grasses. A right of way meadow that was surveyed comprised low shrubs such as the prickly rose, raspberry, grey-leaved and yellow willows, dogwood and balsam poplar saplings. Grasses found include the Canada wormwood, tall goldenrod, common and many flowered yarrow, northern bedstraw, wheatgrasses, bluejoint and brome grass (Golder & GeoNorth, 2000). According to the Government of the NWT Wildlife Division, none of the vegetation found during the 1999 investigation is listed as sensitive or at risk (NWT Wildlife & Fisheries website).

2.2 Climate

Cold winters with average temperatures between -19.5 and -22 °C are typical in the Taiga Cordillera. Summers in the region are short with an average temperature around 8 °C. Snow stays on the ground for six to eight months of the year and precipitation is variable, between 250 to 600 mm depending on the location within the Taiga Cordillera. The mountains of the region tend to block much of the precipitation that would otherwise be received (Environment Canada website, Canadian Biodiversity website).

3.0 Biophysical Resources in the Project Area

3.1 Aquatic Resources

The Department of the Environment, Fisheries Services (now the Department of Fisheries and Oceans & Environment Canada) surveyed 48 kilometers of the Blackwater River in 1972. The survey began at the mouth and extended to Blackwater Lake. The river was described as having excellent spawning potential over the length surveyed. Cold, clear and fast running water with intermittent rocky and sandy areas was reported, with pools and long stretches of deep water being common (see Map 2). It was estimated that approximately 1,579,000 m^3 of the surveyed area could be used for spawning (Hartfield et al. 1972).

As part of the investigation, fish were caught on three separate dates; June 27th, July 29th, and September 6th - *year not mentioned in report* (see Table 1). The locations of these sampling events can be seen on Map 2.

Location Data			Temp. (°C)	Fish Data			
Location # Date	*Bottom Type*	*Colour*	*Air Water*	*Catch Method*	*Species*	*#*	*Maturity*
#1 June 27	Boulders	Clear	14 7	An.	-	-	-
#1 July 29	Boulders	Light Rust	21 17	-	-	-	-
#1 Sept. 6	Gravel & Sand	Light Rust	14 11	S.	Grayling	4	Yearling
				S.	Longnose Sucker	2	Yearling
#2 June 27	Coarse Gravel	Clear	15 5	An.	Grayling	2	Mature
#2 July 29	Fine Gravel	Light Rust	18 13	S.	-	-	-
				An.	Grayling	6	Mature
#2 Sept. 6	Fine Gravel	Light Rust	11 11	An.	Grayling	1	Mature

Legend: An.: Angling
S.: Seine

Table 1. Sample Location Data

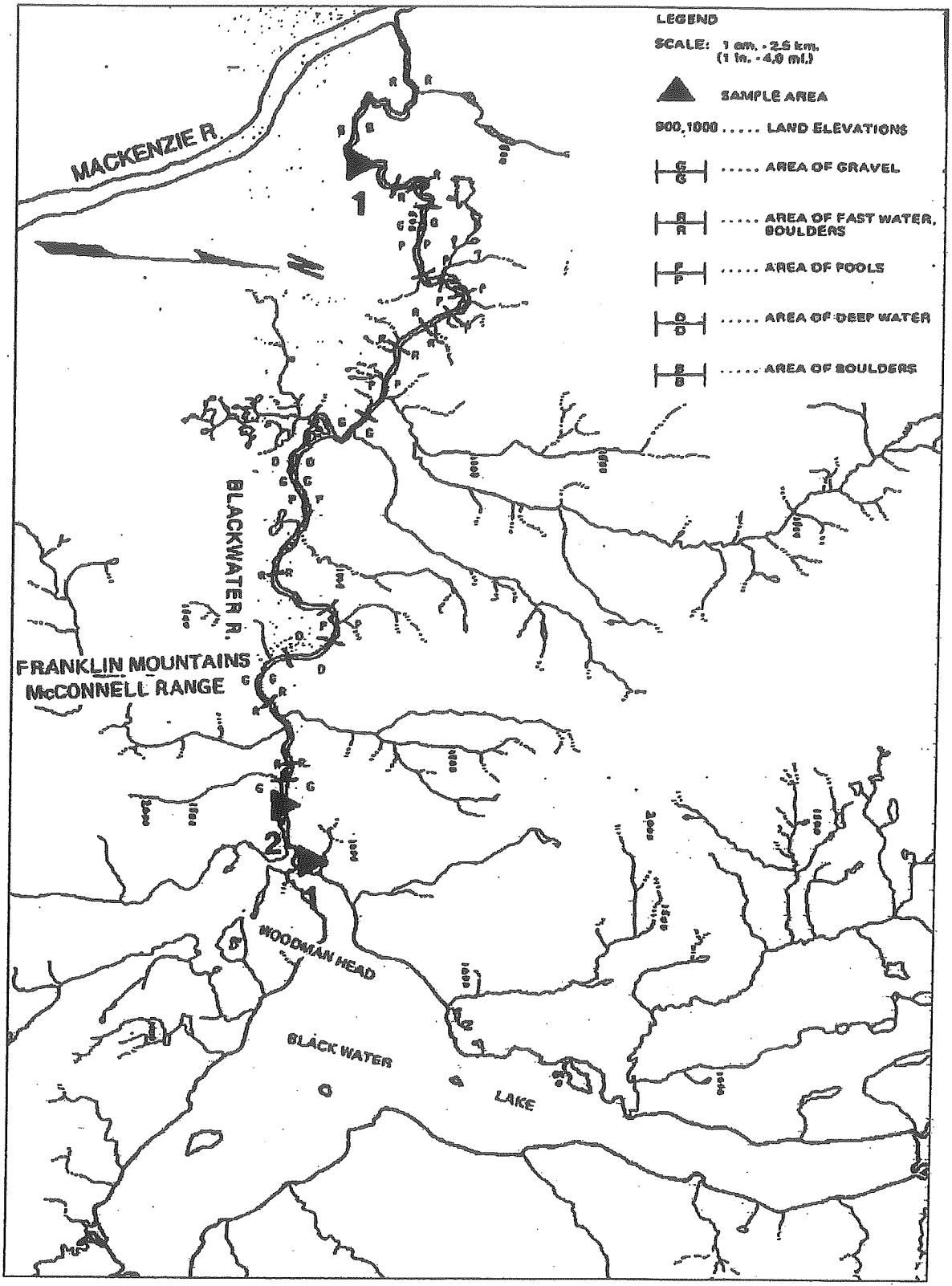
A sample location was also set up at the outlet of the Blackwater Lake (the location can be seen on Map 2). Here, gill netting was conducted during each survey period (see Table 2).

	Fish Data	
Date	*Species*	#
June 27	Pike	4
	Longnose Sucker	1
	Humpback Whitefish	2
July 29	Pike	3
Sept. 6	Pike	2
	Longnose Sucker	1
	Humpback Whitefish	6

Table 2. Data from Blackwater Lake sampling station.

The investigation in 1999 by Golder Associates Ltd. and GeoNorth Ltd characterized the river as fish-bearing. Arctic grayling, longnose sucker, slimy sculpin and round whitefish (Hartfield et al. 1972) have been captured in the river. Due to the proximity of the proposed crossing site to the Mackenzie River, additional species may migrate upstream to utilize the lower reaches of the Blackwater River as nursery areas (rearing) in periods of high sediment in the Mackenzie River. Little is known about the presence of fall-spawning fish or over-wintering species in the Blackwater River (McCart 1982; DOT 1997). Although there is a significant flow rate, the depth of the riffle at the crossing in August (estimated 0.5 – 0.9 m) may provide only limited over-wintering habitat. The over-wintering potential at the crossing is therefore considered low. However, the over-wintering potential upstream of the crossing in pool areas is high (Golder & GeoNorth 2000).

The fish habitat potential for the spawning, rearing, and migration at the crossing is high. Gravel and cobble in the riverbed provide suitable habitat for spawning and rearing, particularly for species such as Arctic grayling. The dark colour of the water, the depth of the water and the cobble on the riverbed provide in-steam cover, which may provide cover for adult fish who are feeding. No overhanging cover was observed, except in the limited reaches of the stream that contact vegetated banks (Golder & GeoNorth 2000)



Map 2. Blackwater River-bed materials,
and sampling locations used by Environment Canada in 1972
Map from Hartfield et al. 1972 report

3.2 Hydrology

A water station (ID 3633) on the Blackwater River at the mouth was used for collecting data from June 1983 through to December 1985 (see Table 3). This station was then moved along the Blackwater River to the outlet of the Blackwater Lake (ID 3634). Data was obtained from this station from June 1986 through to December 1993 (see Table 4). Through discussions with Environment Canada it was discovered that this station burnt down and has never been rebuilt, the collection of water flow data in this area has ceased.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983						179.00	62.40	24.60	14.10	8.47	3.00	1.00
1984	1.00	1.00	0.00	5.00	85.80	45.40	78.80	127.00	162.00	83.30	34.00	15.00
1985	7.00	4.00	3.00	3.00	213.00	216.00	83.20	42.60	38.40	23.80	6.00	4.00

Table 3. Flow data obtained at station ID 3633. (*units: m^3/s*)
Data obtained from the R-ArcticNet website

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986						252.00	93.60	69.70	73.30	43.30	18.00	7.00
1987	5.00	3.00	3.00	3.00	105.00	69.60	31.80	14.10	6.95	6.89	4.00	3.00
1988	2.00	2.00	2.00	2.00	84.40	133.00	300.00	76.20	124.00	72.20	22.00	14.00
1989	6.00	4.00	4.00	8.00	236.00	206.00	93.00	37.30	18.70	15.30	10.00	7.00
1990	2.00	1.00	1.00	2.00	89.40	110.00	63.70	24.60	20.10	22.50	10.00	6.00
1991	3.00	2.00	2.00	2.00	217.00	149.00	42.30	72.10	41.80	44.30	21.00	11.00
1992	6.00	4.00	4.00	4.00	128.00	344.00	80.70	33.30	13.50	7.23	4.00	2.00
1993	1.00	0.00	1.00	3.00	270.00	158.00	44.00	21.40	13.30	8.23	3.00	1.00

Table 4. Flow data obtained at station ID 3634. (*units: m^3/s*)
Data obtained from the R-ArcticNet website

Through interpretation of this data, it is shown that water flow is significantly reduced during the winter months, specifically January through April when the river would be covered with the greatest amount of ice and snow. The values are high for May and June with some years seeing the high values extending into July. These values correspond with the melting of the ice and snow on the river as well as on the ground and in the mountains around it. The values begin to decrease through the following months as the river flows through the summer and then starts to freeze during the fall and early winter months.

Over the last 40 years, the boulders on the riverbed and insignificant lateral channel change suggest that although the suspended sediment load is not monitored, the bed-material transport rates are relatively low (Brooks 1996).

The waters in the Blackwater River are stained brown by organic acids originating from extensive wetlands within the drainage basin. It is believed that the river's name refers to this staining. Blackwater Lake acts as a major sediment trap within this drainage basin and thereby limits the suspended sediment load at the river mouth, the reason that clear water is observed in the River on many occasions. The dark clear waters of the Blackwater River form an obvious plume in the Mackenzie River where they meet (Brooks 1996).

3.3 Channel Characteristics

A 4-kilometer study area was evaluated in the preparation of the Geological Survey of Canada Bulletin 493. This study area extended downstream from the Mackenzie River to an unnamed stream. Along the area of study, the Blackwater River is a single channel stream with a gravel bed consisting primarily of boulders. It is an un-vegetated channel that ranges in width from 75 to 175 meters wide and is relatively straight when compared to the rest of the Blackwater River. After the unnamed stream, the river begins to meander irregularly; the reason for change in channel characteristics is unknown.

Through the study area a number of point and sidebars incorporate some sinuosity. These bars are low-angled and slope gently from the floodplain to the channel. Mid-channel bars cause the channel to split in some places; most have a low relief above the water surface (<1m). A bar 500 m from the river mouth is approximately 2 to 3 meters above the river surface and likely represents a dissected floodplain. These bars consist of mainly gravel (boulders and cobbles).

Major lateral migration of the Blackwater River along the study reach between 1945 and 1987 has been insignificant. The lateral channel stability of the river is likely contributed to by the coarse nature of the channel materials along with the lack of extreme discharges, which could cause erosion of the riverbanks.

Backwater does not appear to have an effect on the river except during relatively high Mackenzie River stages. This is most likely the result of its relatively steep gradient and swift flow. Evidence of backwater is shown in the presence of finer gravel and sand on the river bars and floodplain in the lower 500 m of the river (Brooks 1996).

3.4 Permafrost and Soil Characteristics

The permafrost in the NWT portion of the Taiga Cordillera ecoregion is characterized as extensive but discontinuous with variable ice content (Environment Canada website).

Golder Associates Ltd. and GeoNorth Ltd surveyed soils east of the winter road on the north side of the river during the 1999 investigation. The soil pit was located on the lower slope in a white spruce and balsam poplar forest. The soil pit shows intermittently deposited silt, sand and loam parent materials. Distinct C-horizons are distinguished by the differences in texture and colour between them. There was no organic layer at the surface or buried in the pit. The soil is well drained with a mesic moisture regime and a rich nutrient regime. Cumulic Regosol (SCWG 1998) is the soil classification given to this soil; this is a Regosol with multiple flood deposited layers. Flooding events have resulted in a good intermixing of organic materials in the upper mineral horizons; this results in humus called Hydromull (Golder & GeoNorth 2000).

3.5 Wildlife Resources and Sensitive Habitat Areas

The Taiga Cordillera ecoregion is home to a variety of wildlife species. Different locations within the ecoregion, for example alpine regions, lowland forests and wetlands all have characteristic species (Canadian Biodiversity website).

August 2nd, 1999 during the survey by Golder Associates Ltd. and GeoNorth Ltd. incidental observations were made at the river-crossing site that included moose, black bear, and wolf tracks. There were sightings of a black bear, a duck species, a shorebird and a hawk species. As part of this survey, wildlife habitat was assessed for a combination of field information such as browse availability, food resources, shelter and security resources, and suitable denning or nesting structures. Mapping of community types was also carried out. Through this work, the following species' habitat ranked high: moose, bears, red squirrel, snowshoe hare, owls and hawks, woodpeckers, grouse, and songbirds. Moderate habitat was available for beaver and muskrat, waterfowl, cranes and herons and shorebirds. Caribou and amphibians had low habitat rankings (Golder & GeoNorth 2000).

3.6 Designated Sensitive and Protected Areas

The community of Wrigley has identified an area called Pehdzeh Ki Deh that includes Blackwater Lake and River. This area is considered an "Area of Interest" through the Northwest Territories Protected Areas Strategy (NWT PAS). The Community is working on a formal proposal for the area that would make it a "Candidate Area" (Personal Comm. David Purchase, GNWT NWT PAS).

According to the NWT PAS website: one of the first steps to deeming an area as an "Area of Interest" is for community members to identify and map "special natural areas and sites of cultural value, such as unique or significant wildlife habitats, traditional harvesting areas and unusual landforms or features, as well as potential sites for core representative areas." The community members, regional organizations and/or land claim bodies then need to "document, using scientific and traditional knowledge methods, the known ecological, cultural and economic values of each initial area of interest."

This information is used to prepare a proposal for consideration as a candidate protected area. Government institutions review the proposal "with respect to factors such as ecoregion representativeness, known resource development interests, land dispositions, fiscal implications, and socio-economic benefits." If the proposal is formally accepted the area becomes a "Candidate Area", if the proposal is rejected, it is returned to those who submitted it for revision.

Upon becoming a "Candidate Area", the communities, regional organizations and/or land claim bodies can move towards making the area a "Protected Area." Once becoming a "Protected Area", the stakeholders undertake public education efforts concerning the maintenance of the protected areas values, and government institutions define management objectives, boundaries and appropriate designation.

3.7 Traditional Knowledge

There is no harvesting or habitat information from the Indian Affairs and Northern Development Mapping Project 1990 for the vicinity of the Blackwater River winter road stream crossing. There are a number of traditional trails that have been used as travel routes and for the use of land water resources that were identified as passing through the stream crossing. As well, a number of cabins are located on the banks of the Mackenzie River both north and west of the crossing (Golder & GeoNorth 2000).

3.8 Cultural and Archeological Sites

In 1974, F.F. Slaney & Company completed an Environmental Assessment of the Blackwater River Bridge. Through their work they concluded that archaeological surveys of the area showed fairly heavy prehistoric and historic utilization. They noted that this potentially high impact area would require particularly careful surveillance during the clearing operation and throughout the construction of a bridge. When deciding on the location of any associated construction camps and storage areas, archaeological potentials should be considered (F.F. Slaney & Company 1974).

Between 1976 and 1980, Robert R. Janes of the Prince of Wales Northern Heritage Centre visited the Blackwater River crossing area and annotated a 1972 map of the Mackenzie Highway Mile 297-550 Section A & B with his findings. This map shows two cabins on the north bank of the Blackwater River near the Mackenzie River. Janes noted that the cabins indicated on the map were still standing when he visited the area. Janes also noted the possibility of an archeological site on the north bank with a question mark next to its location. Across the Mackenzie River and to the north is BM 307 near more cabins. The line for the proposed NWT Highway on this map is east of all these sites.

Robert R. Janes annotated a second map, also produced in 1972, entitled Mackenzie Valley Road Project Bridge Site #5 Mile 492 Blackwater River Crossing between 1976 & 1980. On this map, a footpath is reported which extends from the cabins on the north bank of the Blackwater River (noted on the previous map) west to a platform cache *(which is probably the archeological site with the question mark noted in the previous map)* and continues. This map also shows the suggested crossing site by the consultant as well as the alignment made in the field.

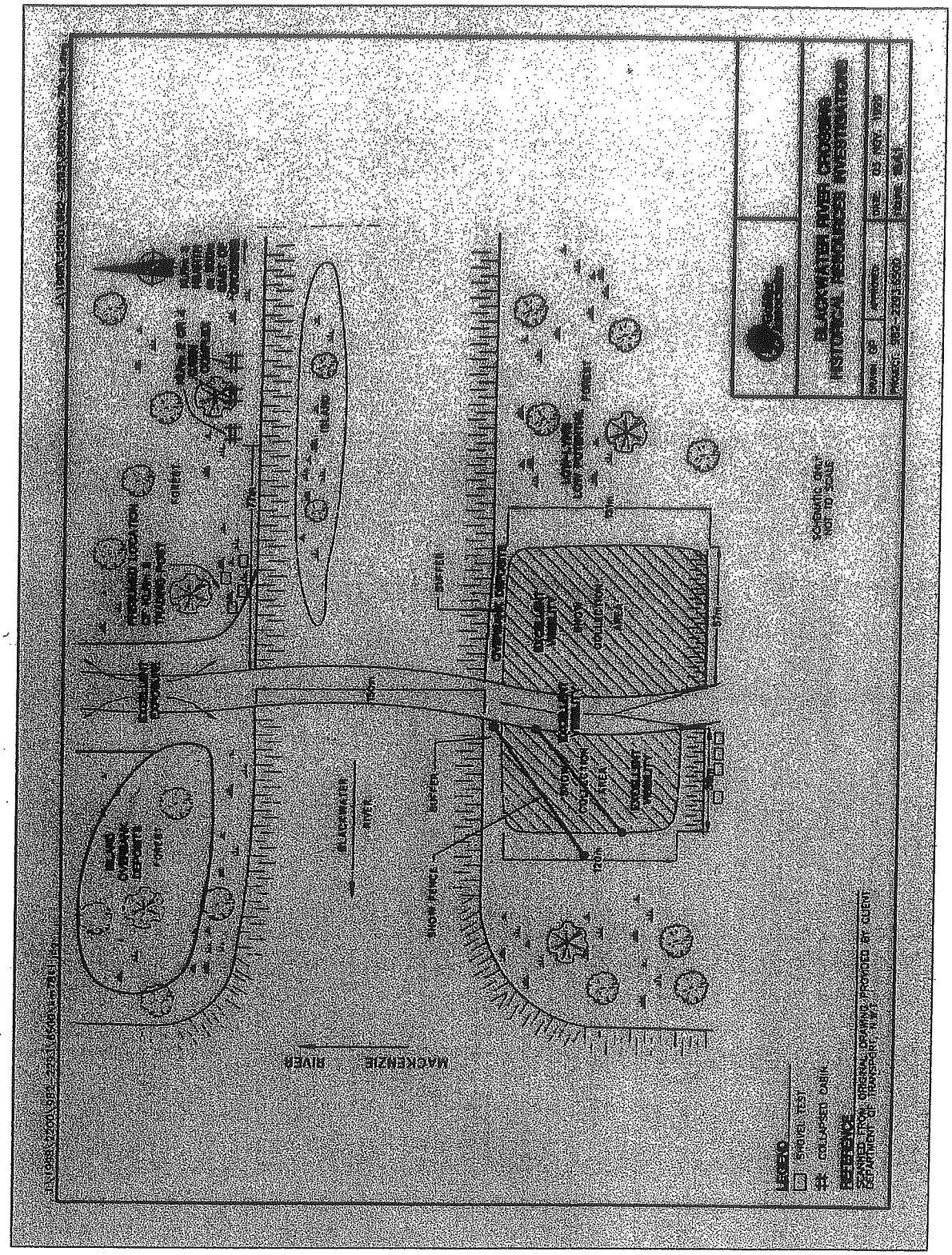
Observations made by Golder Associates Ltd. and GeoNorth Ltd. in 1999 are summarized in Table 5, locations are shown in Map 3.

Site	Type	Relationship to Winter Road Crossing
K1Rm 1	Cabin	2.4 km east of the crossing on the north bank of Blackwater River
K1Rm 2	Cabin	100 m east of the crossing on the north bank of Blackwater River
K1Rm 3	Hearth	200 m east of the crossing on the north bank of the Blackwater River
K1Rm 4	Cabin	East of CNT line – assume within current road alignment
K1Rm 5	Cache	40 m west of CNT line – assume within current road alignment
K1Rm 6	Cache	200 m east of the crossing on north bank Blackwater River
K1Rm 7	Historic shelter	30 m west of CNT line assume within current road alignment
K1Rm 8	Hearth – prehistoric	Uncertain – mapped more than 1 km east of crossing
K1Rm 9	Trading post	North bank of the Blackwater River – Possibly destroyed by road construction but may be same as K1Rm 2
K1Rm 10	Cabin	Ca 670 m east of K1Rm 9
K1Rm 13	Prehistoric scatter	Ca 570 m east of K1Rm 9

Table 5. Cultural and Archaeological sites observed in 1999

Photo 3. Blackwater River Crossing. View from the air east.
K1R 2, 4 or 9 are situated in the trees directly above (north) the gravel bar (see arrow).

Photo obtained from Golder Associates Ltd. & GeoNorth Ltd. 2000 report



Map 3. Historical Resources Investigations carried out by Golder Associates Ltd. & GeoNorth Ltd. in 1999

The sites listed in Table 5 were identified though a prefield site file search at the Archaeological Survey of Canada prior to the 1999 program. All the sites that are reported were found on the north bank of the Blackwater River. Many of the sites have location information related to the previously in place Canadian North Telecommunications (CNT) line. This facility no longer exists in a recognizable form and the Mackenzie Valley Winter Road now appears to occupy the right of way for this line (Golder & GeoNorth 2000).

In summary, despite the presence of significant historic period structural remains east of the road on the north side of the crossing, it would appear that no historical resource concerns are present in association with this proposed bridge installation project (Golder & GeoNorth 2000).

4.0 Potential Environmental Impacts and Mitigative Measures

Following is an examination of the possible environmental impacts that may result during the construction and operation of a bridge crossing at the Blackwater River. Mitigative measures that may reduce impacts are suggested.

4.1 Water

The bridge abutments, ramps, and approaches may affect the water flow and water level, as well as the stream's flow pattern.

Water quality may be affected by spills. In order to mitigate this, an Oil and Fuel Spill Contingency Plan should be prepared and appropriate equipment should be available. A plan should also be developed which includes how and where fuel will be stored on site, as well as how refueling will take place.

Water quality may also be affected by an introduction of sediment into the River; in an effort to counter-act these effects, the introduction of silt screens may be useful.

4.2 Land & Vegetation

The land around the crossing site may be affected by spills. As discussed previously, a mitigation measure would be to have an Oil and Fuel Spill Contingency Plan prepared and appropriate equipment available.

Heavy machinery may result in the compaction of soil around the crossing site. It will be necessary to ensure that operators understand the importance of staying on the designated areas such as the existing winter road.

Material for the bridge should be brought to site using the existing winter road in an effort to reduce disturbance to the area. Primary construction should begin during this time of low water levels to reduce silt generation and the impact on the surrounding area.

The construction of the bridge may cause localized changes in the vegetation. Permafrost may be exposed through activities such as clearing the vegetation. In an effort to diminish the changes that will be occurring, erosion control should be implemented, and reseeding should take place that encourages the growth of species natural to the area.

4.3 Wildlife & Fish

Fish populations may be affected should a fuel spill occur in or near the River; this would be addressed in an Oil and Fuel Spill Contingency Plan. An increase in sediment to the River may also have adverse effects; the use of silt screens may help reduce the amount of silt introduced to the River as a whole.

With a permanent bridge structure, the distribution and areas occupied by wildlife may be affected. Their migration routes may be changed by the ease with which they can cross the River; this could also affect predator-prey dynamics.

4.4 Cultural & Archaeological Sites

Cultural and archaeological sites have been identified near the proposed Blackwater River crossing site, primarily on the north bank of the river. During both the construction and operation of the river crossing it is important to ensure that these sites are both avoided and protected from any possible disturbance. Careful mapping of the sites should take place and any traditional knowledge related to these areas should be documented.

4.5 Socio-Economic

The installation of permanent bridges over river crossings will lengthen the amount of time the winter road will be open. This will affect the commercial operations that depend on the road. It may allow for increased flexibility for land use operations in the future and provide benefits to the residents of the communities it serves.

5.0 Cumulative Effects

The Mackenzie Valley is presently being explored for various developments including the Mackenzie Valley Highway. This section examines some of the possible activities that may be carried out in the area in the near future.

5.1 Natural Gas Pipeline

The Mackenzie Valley has been at the centre of much discussion about the use of this corridor for transporting natural gas from the Inuvik region as well as Prudhoe Bay in Alaska. If a pipeline is constructed, the possibility exists that it would follow much of the same path as the Mackenzie Valley Highway. A consequence of this would be that the pipeline would cross the streams and rivers near the highway, and in the case of the Blackwater River near the proposed bridge site. According to the Geological Survey of Canada Bulletin 493, the current Norman Wells pipeline (Enbridge Oil Pipeline) crosses the Blackwater River approximately 1500 m from the mouth of the river while the winter road crosses approximately 600 m from the mouth (GSC Bulletin 493). As illustrated on Map 4, the Northern Pipelines Project website states that should a pipeline be constructed by the Mackenzie Delta gas producers or Arctic Resource Ltd., its path would go south down the Mackenzie Valley from Inuvik to Norman Wells along the east side of the Mackenzie River and then at Norman Wells would begin to follow the Enbridge Oil Pipeline right of way (Northern Pipelines Project website).

5.1.1 Possible Effects

Cumulative effects that may result from the construction of a pipeline through the Mackenzie Valley will likely be the most visible during the construction phase. During this phase is when traffic loads on the highway will be increased as well as the amount of heavy equipment and number of people occupying the area. Should the pipeline and the bridge crossing at the Blackwater River be approved, an investigation into the cumulative effects from these two projects should be examined.

5.2 Diamond exploration

Patrician Diamonds Inc. began summer exploration on its Blackwater Lake property in 2002. The property is located 160 km southeast of Norman Wells in the Mackenzie River Valley. The property consists of 33 stated claims and forms two distinct blocks that total 26,800 ha. It is within reach of the winter road to Norman Wells and the Mackenzie Valley pipeline. The Blackwater Lake property covers an area that was previously explored by DeBeers Canada Inc. and others in the mid 1970s and early 1980s that was shown to be prospective for diamonds. In September 2002, Patrician Diamonds Inc. announced that the conditional agreement between Diamonds North Resources Inc. and Patrician on the Washburn and Wellington properties, Victoria Island, Nunavut, had been terminated in an effort to concentrate on the promising initial results at Blackwater (Patrician Diamonds website).

5.2.1 Possible Effects

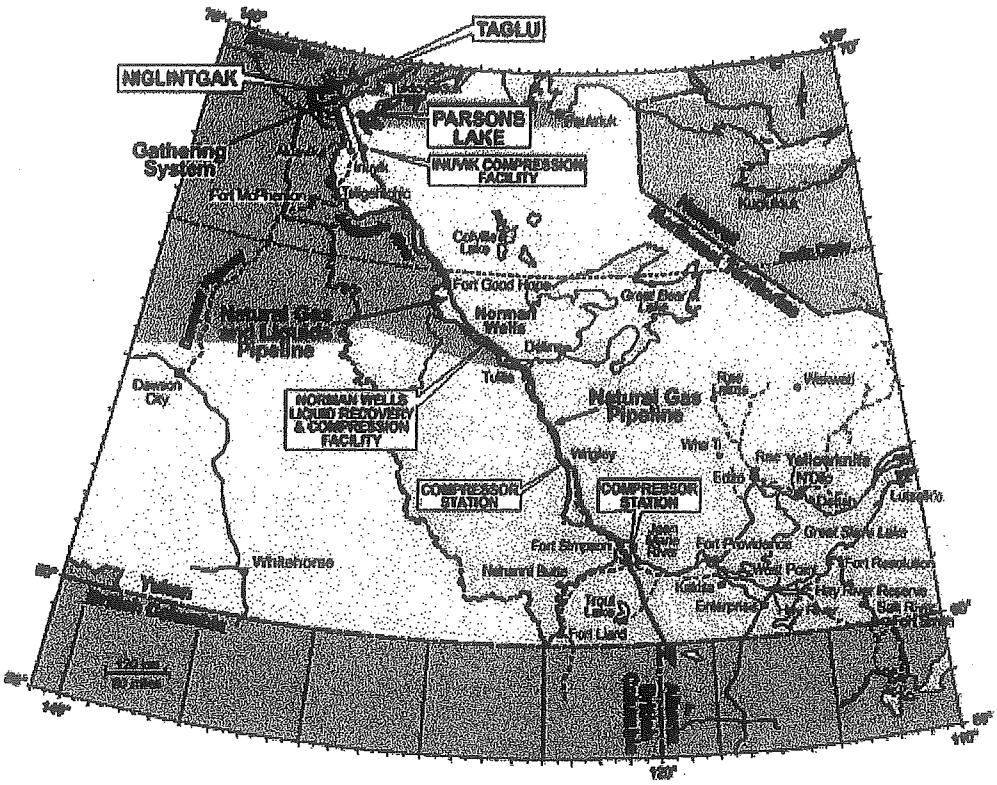
Although the construction of a diamond mine at Blackwater Lake would not be in close proximity to a bridge crossing over the Blackwater River, cumulative effects resulting from the combination of the two projects may result. Possible effects may be an increased usage of the area, for the bridge this would be most evident during the construction phase and any time repairs to the bridge are required. An increase in traffic on the highway may also result, as the length of time the highway would be open could be increased.
A winter road open for an extended period of time would be beneficial to the mine especially during the construction phase, as it would increase the amount of supplies that could be brought up over the highway, a cheaper alternative to bring supplies in via air. The use of heavy trucks over the winter road and bridge crossings would have to be monitored as they are more likely to do damage than smaller personal vehicles.

5.3 Tour Companies

A variety of tour companies operate up the Mackenzie River. One in particular, Denendeh Eco-Adventures operates a tour up the Mackenzie River during which there is an overnight at the Blackwater River.

5.3.1 Possible Effects

The cumulative effects that would result from a bridge crossing over the Blackwater River and the use of the area by tour companies are very limited. The tour companies would likely operate during the summer months for travel up the river and the bridge would be used during the winter months.



Map 4. Anticipated pipeline route through the Mackenzie Valley
Map obtained from Arctic Gas Pipeline website

6.0 Conclusion

This report provides an environmental assessment overview of the proposed bridge crossing at Blackwater River along the Mackenzie Valley Highway in the Northwest Territories. A bridge crossing over this river would lengthen the amount of time that this winter highway could be open and could be beneficial in providing lower-cost alternatives to transportation and shipping in the area for both residents and industry.

A variety of possible environmental impacts have been address and mitigative measures have been suggested. Should the approval and subsequent construction of this bridge crossing take place, it will be important to carry out the work ensuring minimal disturbance to the Blackwater and Mackenzie Valley ecosystems.

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Reviewed by:

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Chief Environmental Engineer

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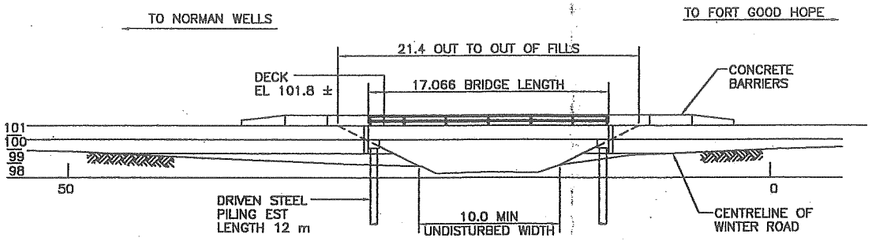
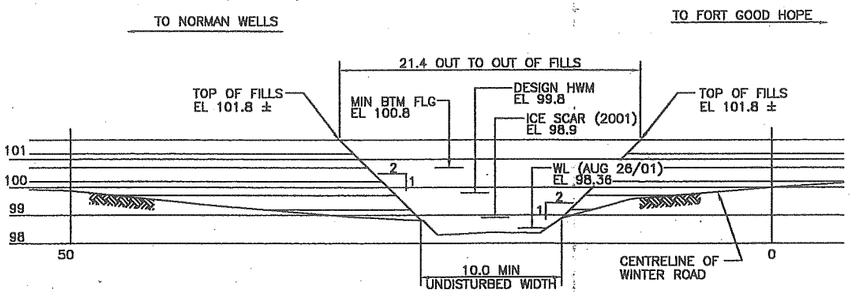
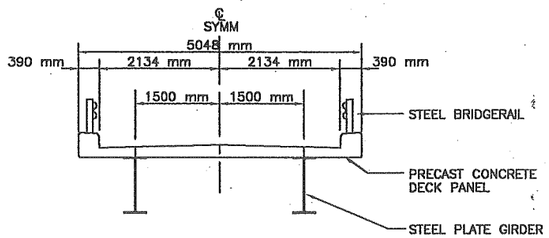


ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



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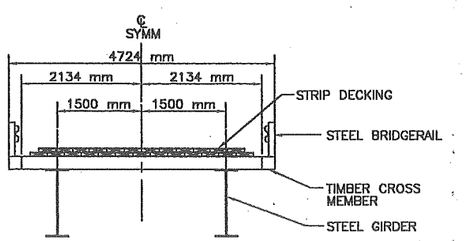
1:50



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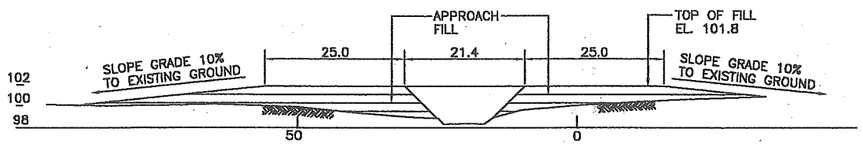
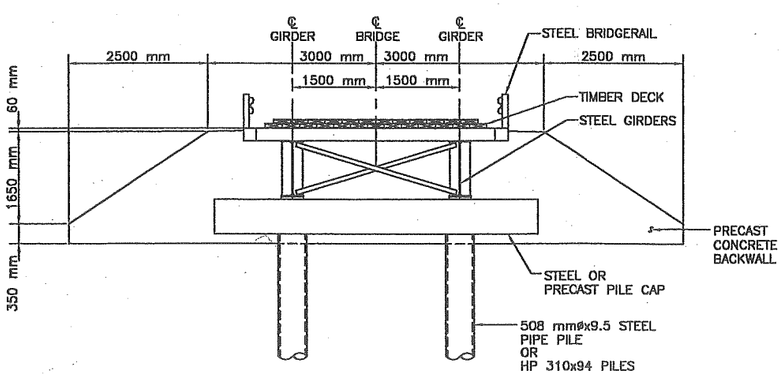
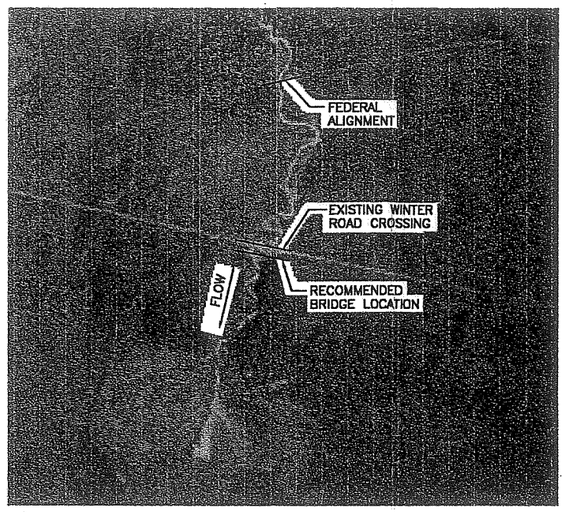


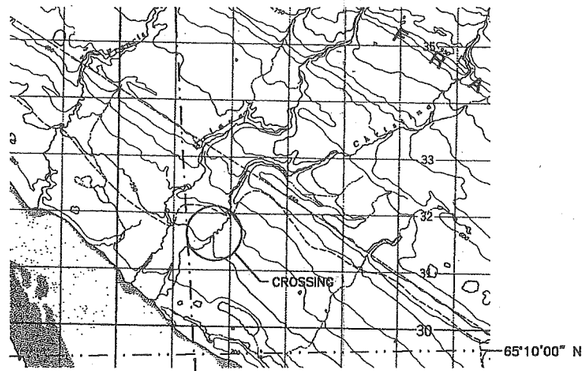
ROAD PROFILE
H – 1:500
V – 1:250



ABUTMENT ELEVATION
1:50



AERIAL PHOTOGRAPH
1:7500



SITE MAP
1:50 000

SITE INFORMATION

SITE 10
TEMPORARY BENCH MARK ELEV 100.000 m
SPIKE IN TREE APPROX. 20 m NORTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 26, 2001
WINTER ROAD km 1001.7
COORDINATES LAT 65°11'12.3" N
LONG 126°24'01.0" W
SITE MAP REFERENCE 96 E/1

HYDROTECHNICAL DATA

- DRAINAGE AREA = 20 sq. km
- DESIGN DISCHARGE = 35 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.014 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 2.3 m/s
- ICE DESIGN ELEV 98.9 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA-S6-00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

Northwest Territories Transportation

BPTEC
ENGINEERING GROUP LTD.
9810–104 STREET
EDMONTON, AB
FAX (780)435–4843
PH. (780)436–6376

Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

CHRISTINA CREEK
km 1001.7
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 10 of 22
Drawing No. 608-9-10

4.11 Helava Creek

4.11.1 General

The Helava Creek winter road crossing is located at km 1002.7 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 11' 32.7" N and Long. 126° 25' 02.2" W.

A field investigation of the site was done on August 28, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking south on the winter road. Photos 2 and 3 show the existing crossing looking north and south respectively.

The winter road crosses Helava Creek on the same alignment as the federal alignment of the 1970's. There appears to have been a previous winter road crossing approximately 30 m downstream.

The stream banks are shallow with small amounts of slumping observed. The stream crosses the road alignment on a skew of approximately 20° LHF. Approaches drop 2 to 3 m into the stream valley at 20 to 30 m from the stream. There appears to be good granular material available for approach fills.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment and the recommended structure.

4.11.2 Existing Information

Existing information included air photos, an environmental report for the winter road operation and a preliminary survey profile done by the GNWT in 1996.

There was indication of work done by DPW in the 1970's possibly including a bridge design, but detailed records were not available at this time.

4.11.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

   Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The drainage area upstream of the crossing site of 22 km^2 was

obtained from the federal alignment study. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.017. The maximum elevation in the basin obtained from the topographic maps is 975 m. Air photos taken in 1950, 1974, and 1993 were obtained for analysis. The 1950 photographs at 1:40,000 are the earliest available, the 1987 photographs at 1:15,000 are the most recent and the 1974 photographs at 1:10,000 are at the largest available scale. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 36 m^3/s. The 50-year breakup discharge is estimated to be about 21 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size.

On the day of the survey the water was 0.1 m deep and 2.3 m wide. The slope was surveyed and found to be 0.011 over a 100 m length at the present winter road crossing.

High water marks were found upstream and downstream of the crossing. These high water marks were between 0.5 and 0.7 m above the water level. The highest high water mark would have an elevation of 97.5 m at the winter road crossing relative to the local benchmark. Ice scars were also found upstream and downstream of the crossing. These ice scars were between 0.3 and 1.5 m above the water level. The highest ice scar would have an elevation of 98.2 m at the winter road crossing. This scar is near the edge of the winter road so it may be machine made rather than an ice scar.

Both banks are well vegetated with grass, willows and large trees. The downstream right bank appear to be slumping and there is some minor under-cutting of the left bank at the winter road crossing. The bed material was sampled using a line sample technique. The median diameter (D_{50}) of the bed material is 39 mm while the largest stones (D_{90}) are about 70 mm in diameter. This size of material is gravel.

3. River Engineering Analysis

The design high water level for the site was calculated to be 97.7 m which is 1.1 m above the bed level. At this water level, the design flow of 36 m^3/s can flow down the main channel (adopting the surveyed slope of 0.014 and a roughness of 0.050). This elevation is 0.2 m above the highest high water mark observed at the site.

Ice affected breakup water levels are not expected to exceed 98.0 m. This elevation is higher than the two lower ice scars at 97.0 and 97.3 m but the highest scar at 98.2 m is 0.2 m above the predicted maximum level. This scar is at the edge of the right-of-way and thus may be machine damage from equipment working on the winter road rather

than an ice scar. If the ice does reach this elevation during an extreme event it will still be 0.8 m below the minimum flange elevation of 99.0 m.

The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge, to allow for some uncertainty in the hydraulic analysis and to allow for the effects of downstream flow blockages such as beaver dams. The minimum flange elevation should be 99.0 m or greater.

The minimum undisturbed width of the channel is 10.2 m. Assuming a 2:1 slope on the headslopes, the mean velocity through the opening is about 3.0 m/s for the design open water conditions.

Air photos of the site indicate that the channel has remained relatively stable between 1950 and 1993. However, the 2001 air photos indicated some minor changes had occurred since 1993. The channel at the present crossing appears to have shifted 1 to 2 m to the right. The present winter road alignment crosses the stream in the same location as the original federal alignment. The road crosses the channel in a bend. The bridge crossing should be located 10 or 20 m downstream of the present alignment to reduce the probability of the south embankment being attacked by the stream in the future.

4.11.4 Environmental Considerations

An environmental assessment of the winter road crossing indicates the recommended environmental sensitivity is considered medium as to the impact on potential habitat for fish. Significant fish resources are considered at this location.

The road crosses the stream in a bend and there is potential for erosion problems with fills unless the alignment is shifted downstream slightly.

4.11.5 Alternatives

The site is well suited to a single span steel girder bridge structure using driven piles for the foundations. Alternate span arrangements or structural types are not considered feasible for this crossing. Based on the hydrotechnical review, culverts were not considered suitable for this site. A bridge structure would have less impact as it does not require work in the stream.

Utilizing the existing crossing location could result in the potential for erosion of the upstream fill and bank armouring would be required. The alternative is to shift the crossing downstream 10 to 20 m to reduce the potential for erosion.

The stream crosses the road alignment on a 20° LHF skew, therefore, two alternate spans were considered. A skewed bridge with an overall length of 18.288 and a square bridge with an overall length of 21.946 m were considered.

Steel girders with timber decks or composite concrete decks were assessed and are considered very suitable for this site. Preliminary sizing of girders indicates that the bridge structure would consist of two welded wide flange girders as shown on the attached drawing.

4.11.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the structure is provided in the following table.

The estimated cost for construction of the structures considered are as follows:

21.946 m single span bridge (on square) with timber deck.	$265,985
21.946 m single span bridge (on square) with precast deck.	$307,090
18.288 m single span bridge (on skew).	$273,200

4.11.7 Recommendations

The bridge crossing should be located 10 to 20 m downstream of the present winter road crossing to reduce upstream erosion potential. The present alignment corresponds to the federal alignment.

The recommended structures consists of an 21.946 m single span bridge with a minimum bottom flange elevation of 98.8 m. A minimum undisturbed creek width of 10.2 m is recommended. Headslopes of 2H to 1V were used resulting in an out to out of fills of 27.4 m at elevation 99.9 m.

Driven steel piles are recommended for the foundations. Steel girders with timber decking or with composite precast deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, hydrotechnical assessment and the recommended structure

4.11.8 Summary

A single span bridge with an overall length of 21.946 m with either the timber deck or precast deck system is recommended on an alignment 10 to 20 m downstream of the existing crossing for the Helava Creek winter road crossing

Site Helava Creek

Recommended Structure -21.946m Bridge (on Square)- Timber Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35,000	1	35,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.4	10,000
Approaches - common fill	cu.m.	30	1700	51,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Timber Decking	sq.m.	100	110	11,000
Steel Girders fabricate and deliver	kg	1.15	10300	11,845
Bridge Erection	lump sum	15000	1	15,000
Bridgerail	m	100	44	4,400
New Jersey Concrete Barriers	each	500	12	6,000
Precast Backwall Panels supply and deliver	each	6000	2	12,000
		Sub-Total		217,985
		Contingency(15%)		32,700
		Engineering(7%)		15,300
		Total		265,985

Alternative Structure -21.946m Bridge (on Square) - Precast Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.4	10,000
Approaches - common fill	cu.m.	30	1700	51,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	4000	7	28,000
Steel Girders fabricate and deliver	kg	3.5	10300	36,050
Steel and Deck Panel Erection	m	1500	7	10,500
Bridgerail	m	100	44	4,400
New Jersey Concrete Barriers	each	500	12	6,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		251,690
		Contingency(15%)		37,800
		Engineering(7%)		17,600
		Total		307,090

Site	Helava Creek			Pg 2 of 2
	Alternative Structure - 18.288m Bridge (on Skew)			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.4	10,000
Approaches - common fill	cu.m.	30	1700	51,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	120	3,360
Deck Panels				
fabricate and deliver	each	3400	8	27,200
Steel Girders				
fabricate and deliver	kg	1.15	7600	8,740
Steel and Deck Panel Erection	m	1500	7	10,500
Bridgerail	m	100	36	3,600
New Jersey Concrete Barriers	each	500	12	6,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		223,900
		Contingency(15%)		33,600
		Engineering(7%)		15,700
		Total		273,200

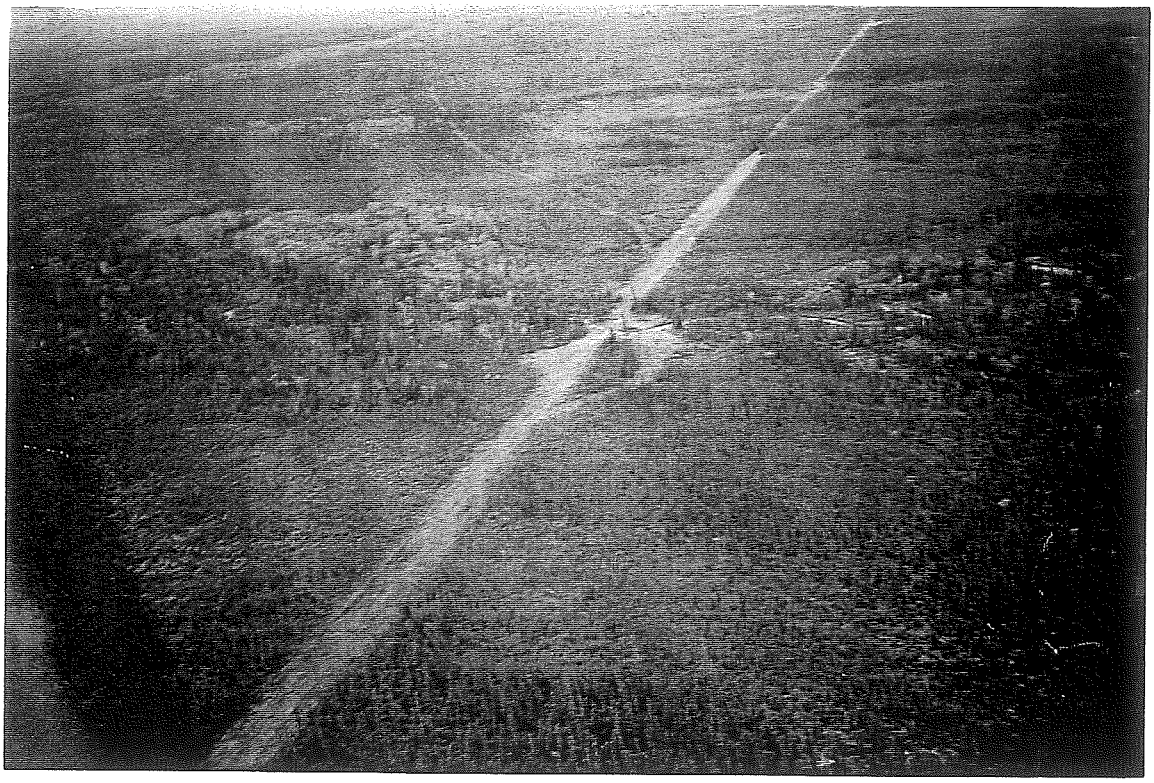


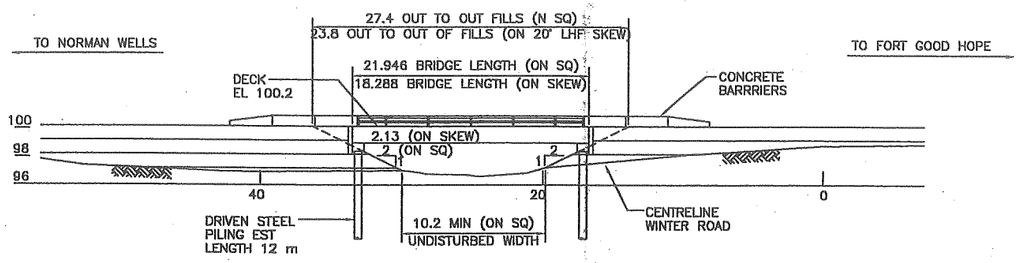
Photo 1 - Looking South on Winter Road (Stream Flow to Right)

Photo 2 - Looking North on Winter Road (Flow to Left)

Photo No. 3 - Looking South on Winter Road

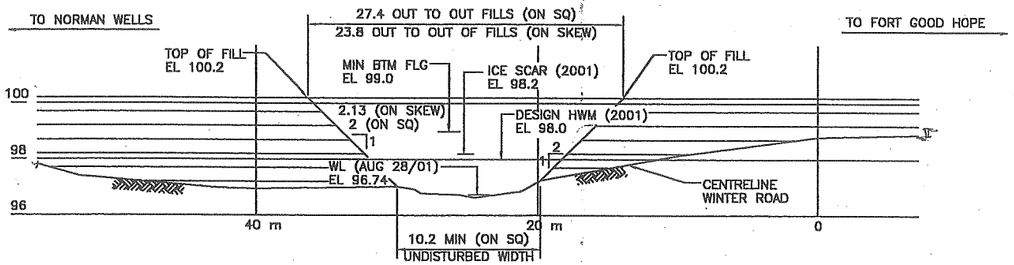
Photo 4 - Looking Upstream

Photo 5 - Looking Downstream



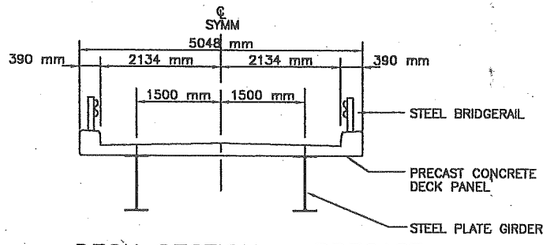
ELEVATION — NATURAL SCALE

(LOOKING D/S) 1:200



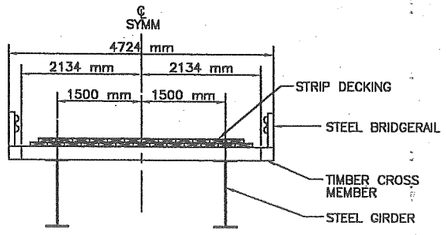
ELEVATION

(LOOKING D/S) H — 1:200
V — 1:100



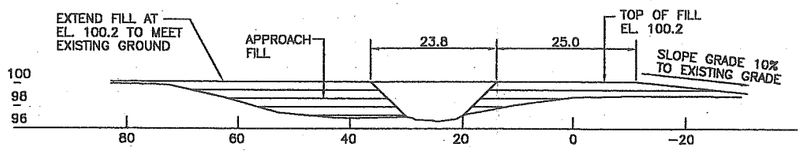
DECK SECTION — PRECAST

1:50



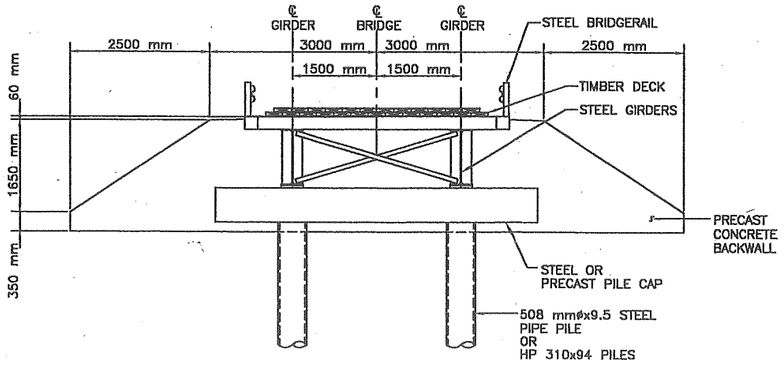
DECK SECTION — TIMBER

1:50



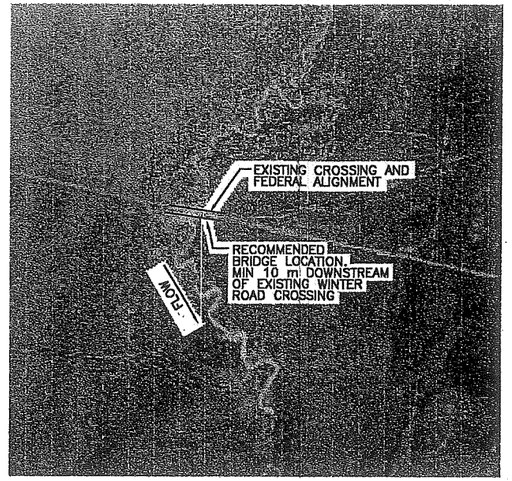
ROAD PROFILE

H — 1:500
V — 1:250



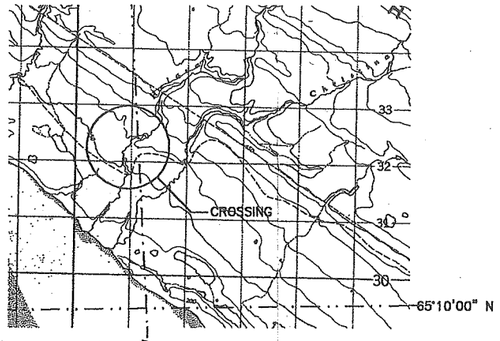
ABUTMENT ELEVATION

1:50



AERIAL PHOTOGRAPH

1:7500



SITE MAP

1:50 000

SITE INFORMATION

SITE 11
TEMPORARY BENCH MARK ELEV 100.000 m
SPIKE IN TREE APPROX. 20 m NORTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 28, 2001
WINTER ROAD km 1002.7
COORDINATES LAT 65°11'32.7" N
LONG 126°25'02.2" W
SITE MAP REFERENCE 96—E/1

HYDROTECHNICAL DATA

- DRAINAGE AREA = 22 sq. km
- DESIGN DISCHARGE = 36 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.011 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 3.0 m/s
- ICE DESIGN ELEV 97.3 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA—S6—00.

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A — A. detail number
C — B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

HELAVA CREEK
km 1002.7
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 11 of 22
Drawing No. 608—9—11

4.12 Francis Creek

4.12.1 General

The Francis Creek winter road crossing is located at km 1005.0 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 12' 17.8" N and Long. 126° 27' 19.4" W.

A field investigation of the site was done on August 28, 2001. A preliminary survey of the centerline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking south on the winter road.

The winter road alignment is on a long straight tangent at the crossing and is located approximately 200 m downstream of the federal alignment done in the 1970's. The road crosses the channel downstream of a sharp bend in the stream. At the crossing, the overall width of the stream was 18 m wide, including a side channel and gravel bar. The main channel section was 5 m wide and 0.3 deep at the time of the inspection.

The streambed was composed of gravel with stones varying from 25 mm to 100 mm in diameter. Streambanks were well vegetated. Some bank erosion is occurring along the upstream side of the winter road. There appears to be a small spring on the northeast side of the crossing that would pose icing concerns.

The north approach appears to have been cut down through the bank.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment and the recommended structure.

4.12.2 Existing Information

Existing information included air photos, a preliminary site survey by DPW in 1996 and a winter road operation description.

There does not appear to have been any work done by DPW for the federal alignment crossing.

4.12.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The drainage area at the crossing site obtained from the federal alignment study is 26 km^2. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.022. The maximum elevation in the basin obtained from the topographic maps is 1040 m. Air photos taken in 1950, 1972, 1993, and 2001 were obtained for analysis. The 1950 photographs at 1:40,000 are the earliest available, the 2001 photographs at 1:3,000 are the most recent and are at the largest available scale.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 43 m^3/s. The 50-year breakup discharge is also estimated to be about 23 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size.

On the day of the survey the water had a maximum depth of 0.3 m and a width of 5 m. The top of the bank width at the crossing was 22 m. The slope was surveyed and found to be 0.016 over a 61 m length at the present winter road crossing.

High water marks were found upstream and downstream of the crossing on both sides of the channel. These high water marks were between 0.3 and 0.9 m above the water level. The highest high water mark would have an elevation of 97.4 m at the winter road crossing relative to the local benchmark. An ice scar was found a bend upstream of the crossing, 0.3 m above the water level. This ice scar would have an elevation of 96.8 at the winter road crossing.

Both banks are well vegetated with grass and willows with some larger trees. Some of the bank is being under-cut by the flow but the erosion appears to be minor. There are several bars in the vicinity of the crossing. The larger bars are vegetated with grass and shrubs. The bed material was sampled using a line sample technique. The median diameter (D_{50}) of the bed material is 22 mm while the largest stones (D_{90}) are about 40 mm in diameter. The bed material is almost entirely gravel.

3. River Engineering Analysis

The design high water level for the site was calculated to be 97.8 m, which is 1.3 m above the surveyed water level and 1.6 m above the bed. This level is 0.4 m higher than the highest observed high water mark. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and

to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 98.8 m or greater.

Air photos of the site indicate that the channel has remained relatively stable between 1972 and 1993. Some minor changes were detected between 1993 and 2001. The present winter road alignment crosses the creek about 200 m downstream of the original federal alignment. The road crosses the channel just downstream of a sharp bend. At present, the creek is eroding the bank on the upstream side of the winter road before it turns to cross the right-of-way. The position of the channel may lead to erosion problems along the south approach if the bridge is built on the present winter road alignment. Instead, the bridge crossing should be moved 30 m downstream to avoid this upstream bend and to cross the channel in a straighter reach. The channel is also narrower at this crossing location and thus the impact on the low flow channel will be minimized.

The minimum bottom width of the channel should be 8 m which will limit the impact on the low flow channel while still providing the conveyance capacity for the design flood. The design open water elevation of 98.8 m would produce a mean velocity of about 3.2 m/s through an opening with a 8 m bottom width and 2:1 side slopes.

4.12.4 Environmental Considerations

The stream banks are well vegetated and appear to be relatively stable. The stream would be suitable for fish habit for spawning arctic grayling.

The upstream bend of the stream is starting to erode the winter road and there is potential for erosion problems with approach fills unless the crossing is shifted downstream slightly. This shift would also reduce the impact of the small spring on the right bank.

4.12.5 Alternatives

The site is well suited to a single span steel girder bridge structure using driven piles for the foundations. Other alternative span arrangements or structural types are not considered feasible for this crossing. Based on the hydrotechnical review, culverts are not considered suitable for this crossing.

Utilizing the existing winter road alignment has the potential for erosion problems on the approach fills and a shift downstream of 20 to 30 m was considered. This would also have the crossing occur on a straighter reach of the stream.

Steel girders with timber or composite concrete deck were assessed and are considered very suitable for this site. A bridge length of 18.288 m is recommended as a suitable span for this crossing. Preliminary sizing of bridge girders indicates the bridge structure would consist of two welded wide flange girders as shown on the attached drawings.

4.12.6 Cost Estimate

The estimated costs for construction, including a 15% contingency plus 7% for department and engineering costs for the structure, is provided in the following table.

The estimated costs for construction are as follows:

18.288 m single span bridge with timber deck.	$251,080
18.288 m single span bridge with precast deck.	$279,580

4.12.7 Recommendation

The bridge crossing should be located approximately 20 to 30 m downstream of the existing winter road crossing to avoid an upstream bend.

The recommended structure consists of a 18.288 m single span bridge with a minimum bottom flange elevation of 98.8 m. A minimum undisturbed stream width of 8.0 m is recommended. Head slopes of 2H to 1V were used resulting in out to out of fills of 21.6 m at elevation 99.8 m.

Driven steel piles are recommended for the foundations. Steel girders with timber decking or with composite precast deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.17.8 Summary

A single span bridge with an overall length of 18.288 m with either the timber deck or precast deck system is recommended on a straight alignment approximately 30 m downstream of the existing winter road crossing for the Francis Creek winter road crossing.

Site Francis Creek

Recommended Structure - 18.288m Bridge = Timber Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35,000	1	35,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9000
Road Realignment	km	25000	0.5	12500
Approaches - common fill	cu.m.	30	1500	45000
Backfill - granular	cu.m.	35	300	10500
Riprap - haul and place	cu.m.	28	80	2240
Timber Decking	sq.m.	100	90	9,000
Steel Girders				
fabricate and deliver	kg	1.15	7600	8740
Bridge Erection	lump sum	15000	1	15,000
Bridgerail	m	100	38	3800
New Jersey Concrete Barriers	each	500	12	6,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9000
		Sub-Total		205,780
		Contingency(15%)		30,900
		Engineering(7%)		14,400
		Total		251,080

Alternative Structure - 18.288m Bridge - Precast Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	35000	1	35,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9000
Road Realignment	km	25000	0.5	12500
Approaches - common fill	cu.m.	30	1500	45000
Backfill - granular	cu.m.	35	300	10500
Riprap - haul and place	cu.m.	28	80	2240
Deck Panels				
fabricate and deliver	each	3400	6	20400
Steel Girders				
fabricate and deliver	kg	1.15	7600	8740
Steel and Deck Panel Erection	m	1500	18	27,000
Bridgerail	m	100	38	3800
New Jersey Concrete Barriers	each	500	12	6,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9000
		Sub-Total		229,180
		Contingency(15%)		34,400
		Engineering(7%)		16,000
		Total		279,580

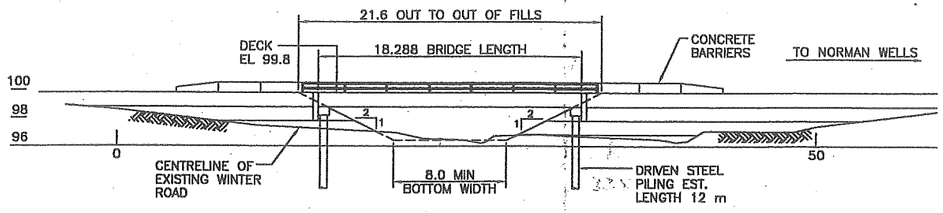
Photo 1 - Looking South on Winter Road (Stream Flow to Right)

Photo 2 - Looking North on Winter Road (flow to left). → E

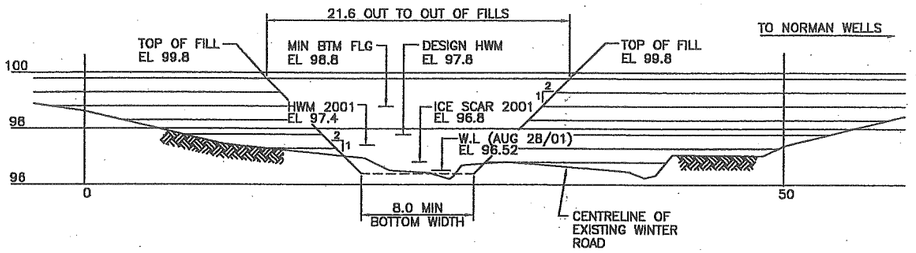
Photo No. 3 - Looking South on Winter Road → W

Photo 4 - Looking Upstream

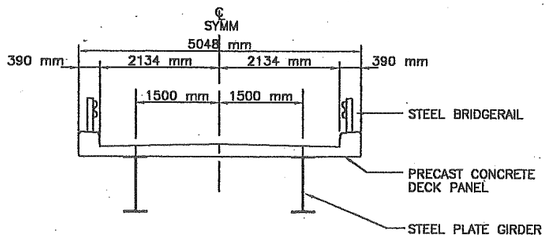
Photo 5 - Looking Downstream



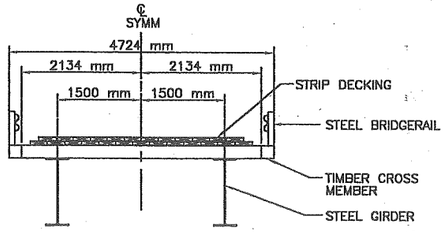
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



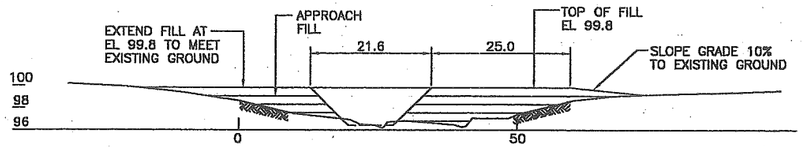
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



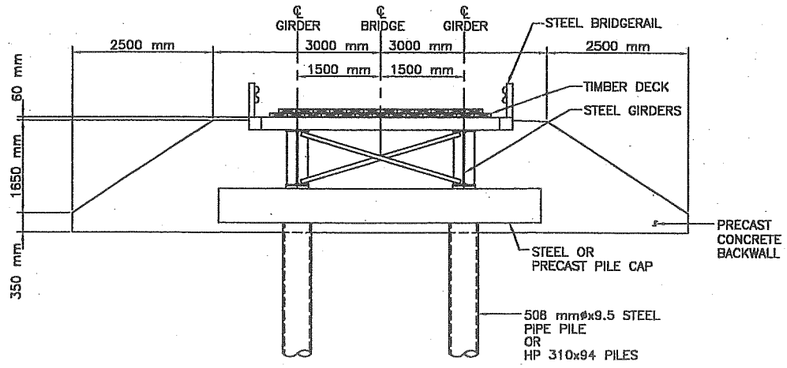
DECK SECTION – PRECAST
1:50



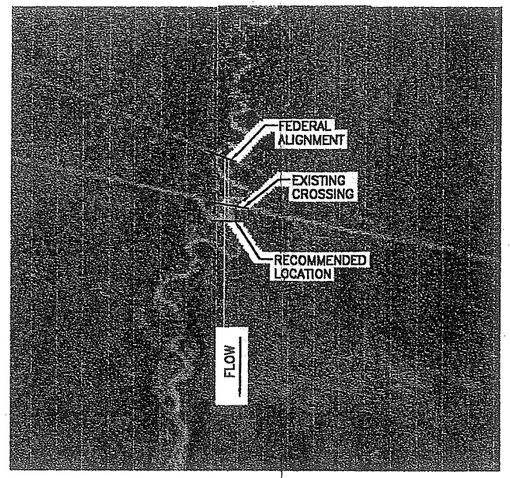
DECK SECTION – TIMBER
1:50



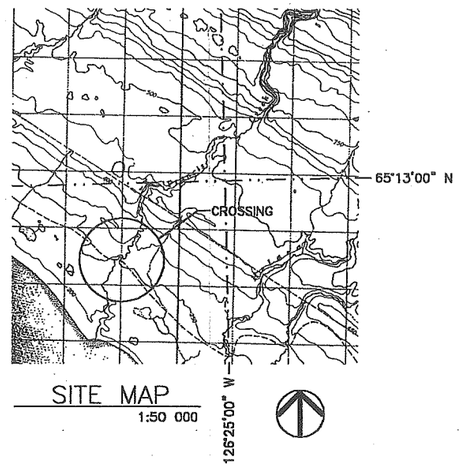
ROAD PROFILE
H – 1:500
V – 1:250



ABUTMENT ELEVATION
1:50



AERIAL PHOTOGRAPH
1:7500



SITE MAP
1:50 000

SITE INFORMATION

SITE 21
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE APPROX. 20 m NORTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 28, 2001
WINTER ROAD km 1005.0
COORDINATES LAT 65°12'17.8" N
LONG 126°27'19.4" W
SITE MAP REFERENCE 96–E/1

HYDROTECHNICAL DATA

- DRAINAGE AREA = 26 sq. km
- DESIGN DISCHARGE = 43 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.016 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 3.2 m/s
- ICE DESIGN ELEV. 97.8 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA–S6–00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

FRANCIS CREEK
km 1005.0
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 12 of 22
Drawing No. 608–2–12

4.13 Billy Creek

4.13.1 General

The Billy Creek winter road crossing is located at km 1033.4 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 20' 27.5" N and Long. 127° 07' 00.5" W.

A field investigation of the site was done on August 28, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking north on the winter road.

The winter road alignment curves at the stream and crosses on the downstream side of a clump of trees as shown on Photos 2 and 3. This shift moves the road away from an upstream bend in the stream.

A beaver dam is located downstream of the crossing and controls the water level at the site. The approaches were generally soft and wet. The stream banks were well vegetated and the banks had mature trees upstream and downstream. The stream was approximately 12 m wide and had 1.2 m high banks. Bed material consisted of cobbles.

The existing winter road crossing is located approximately 4 km downstream of the federal alignment done by DPW in the 1970's. A pipeline is located 700 m downstream of the present crossing.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment, and the recommended structure.

4.13.2 Existing Information

Billy Creek had a provisional contract developed by DPW in 1977. The recommended structure consisted of a 40.8 single span bridge supported on driven piles. Geotechnical information was not available for the site. The bottom flange of the structure was set at approximately 8.5 m above streambed and 2.13 m above the design high water level.

Additional information included an environmental report on the winter road operation and a fish habitat assessment done by FSC in 1997.

4.13.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The drainage area at the winter road crossing site is 141 km^2. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.0041. The maximum elevation in the basin obtained from the topographic maps is 770 m. Air photos taken in 1950, 1973, and 1996 were obtained for analysis. The 1950 photographs at 1:40,000 are the earliest available, the 1996 photographs at 1:30,000 are the most recent and the 1973 photographs at 1:12,000 are at the largest available scale. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. Based on this method the 50-year design discharge would be 96 m^3/s. The 50-year breakup discharge is estimated to be about 81 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size.

On the day of the survey flow in the channel was ponded through the present winter road crossing by a beaver dam downstream. The water level was nearly at the top of bank of the channel and the water depth was approximately 1.1 m. The slope was surveyed and no measurable difference in the water surface elevation was found over a 120 m length of channel upstream of the beaver dam. The water level difference across the beaver dam was approximately 0.5 m.

Two high water marks were found downstream of the winter road crossing. These high water marks were 0.7 and 0.8 m above the water level respectively. Relative to the local benchmark, the high water marks would have elevations of 98.6 and 98.7 m at the winter road crossing. Ice scars were found upstream and downstream of the crossing. The ice scars ranged from 0.4 to 0.7 m above the water level. Relative to the local benchmark these ice scars would have elevations of 98.3 to 98.6 m.

Both banks are well vegetated with grass. Upstream and downstream of the crossing the banks are lined with mature spruce and some small deciduous trees. The bed is composed of cobble.

3. River Engineering Analysis

The design high water level for the site was calculated to be 100.3 m . This elevation is 3.4 m above the bed level and 1.6 m above the observed high water mark. The

minimum flange elevation of a bridge should provide 1.0 m of freeboard to allow debris to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 101.3 m or greater.

A minimum bottom width of the channel of 12.0 m will preserve the natural channel top of bank width. The mean velocity through a bridge opening of this width with 2:1 headslopes is about 2.5 m/s.

Analysis of potential Mackenzie River ice jams near the mouth of Billy Creek indicate that high water levels from a Mackenzie River ice jam are not likely to occur at the site. The 1:50,000 map contours indicate that the water level at the site is about 11.7 m above the Mackenzie River, presumably at low flow. Furthermore, geodetic water levels on the Mackenzie River indicate that the site may be as much as 18.8 m above the low flow Mackenzie River level. The 50-year ice jam could raise the level in the Mackenzie River as much as 12.7 m at the mouth so water levels at the crossing site should not be affected. The above elevations indicate that the 50-year ice jam level is between -6.1 to +1.0 m above the local low water level. The map elevations are coarse, therefore, a survey is required to determine the actual differential elevation between the low flow open water elevation of the Mackenzie River and the benchmark at the crossing site.

Air photos of the site indicate that the channel has remained stable between 1950 and 1996. In the immediate vicinity of the present winter road crossing, and for the majority of the channel there are no discernable changes in the channel platform. Upstream of the winter road crossing there has been some cutoff activity on two of the smaller, tighter bends. Directly upstream of the crossing there is some slumping of the left bank on the inside of the bend along the south approach road. There is a possibility that the bend upstream of the crossing may migrate further southward and cause damage to the south approach road. However, the air photos did not indicate any measurable movement of this bend between 1950 and 1996. No changes in channel position were apparent in the 2001 air photos as well. The present winter road crossing is acceptable for the bridge crossing but may have problems with the south approach road. An alternative crossing location is near the pipeline crossing 700 m downstream. This crossing is in a stable, straight reach of the creek so there should be no erosion problems at this location.

4.13.4 Environmental Considerations

The fish habitat assessment done in 1997 indicates the stream has a very low potential for fishery resources. No fish were found during that assessment. The crossing is considered to be Class 3 by DFO.

The upstream bend may be moving downstream and could potentially affect any approach fills placed on the south side of the stream.

4.13.5 Alternatives

The site is well suited to a single span steel girder bridge structure using driven steel piles for the foundations. Alternate span arrangements or structural types are not considered feasible for this crossing. Geotechnical information is not available for the crossing at this time, but driven piles are considered to be very suitable. Potential sources for approach fills should be available along the winter road.

Based on the hydrotechnical review, culverts are not considered suitable for this crossing.

The existing crossing is considered suitable for the bridge structure; however, there would need to be bank protection works used due to the possibility of erosion from the upstream bend. An alternative location would be near the pipeline crossing which is on a straight reach of the stream, which reduces erosion potential.

Ice jam effects from the Mackenzie River are considered to be unlikely, but elevation differences should be determined by survey to confirm the assumption.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for this site. A bridge length of 32.918 m is recommended as a suitable span for this site. Preliminary sizing of the bridge girders indicates the bridge structure would consist of two welded wide flange girders as shown on the attached drawing.

4.13.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the structure is provided in the following table.

The estimated cost for the construction of the structure considered is $545,890.

4.13.7 Recommendations

The recommended structure consists of a 32.918 m single span bridge with a minimum bottom flange elevation of 101.9 m. A minimum undisturbed creek width of 12.0 m is recommended. Headslopes of 2H to 1V were used, resulting in an out to out of fills of 37.9 m at elevation 103.4 m.

Driven steel piles are recommended for the foundations. Steel girders with timber decking or with composite precast deck panels are recommended for the superstructure.

The existing crossing is considered suitable; however, a realignment of the approach roads would be recommended to ensure straight approaches to the bridge structure. An alternate location would be at the pipeline crossing which is approximately 700 m downstream.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment, and the recommended structure.

4.13.8 Summary

A single span bridge with an overall length of 32.918 m is recommended on the existing crossing alignment for the Billy Creek winter road crossing.

Site	Billy Creek Recommended Structure -32.918m Bridge			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	65,000	1	65,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	4300	129,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	11	37,400
Steel Girders fabricate and deliver	kg	1.15	25000	28,750
Steel and Deck Panel Erection	m	1500	33	49,500
Bridgerail	m	100	66	6,600
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		447,490
		Contingency(15%)		67,100
		Engineering(7%)		31,300
		Total		545,890

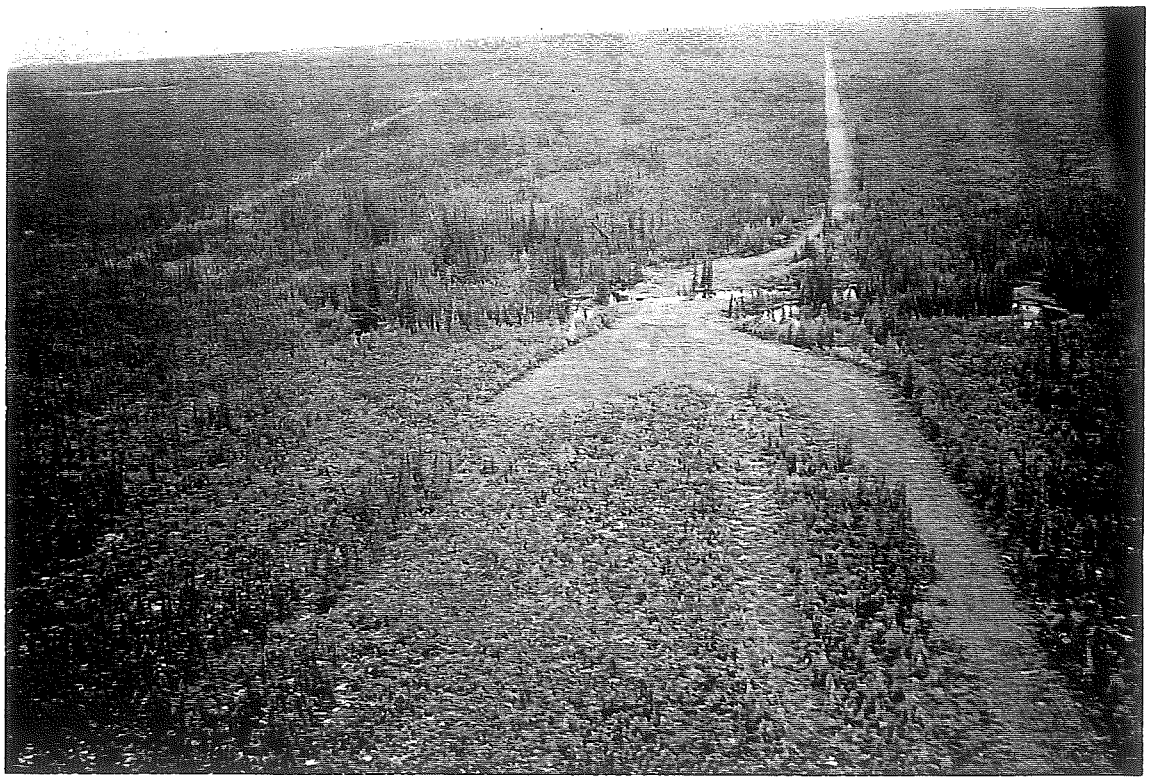


Photo 1 - Looking North on Winter Road (Stream Flow to Left)

Photo 2 - Looking North on Winter Road (Flow to Left)

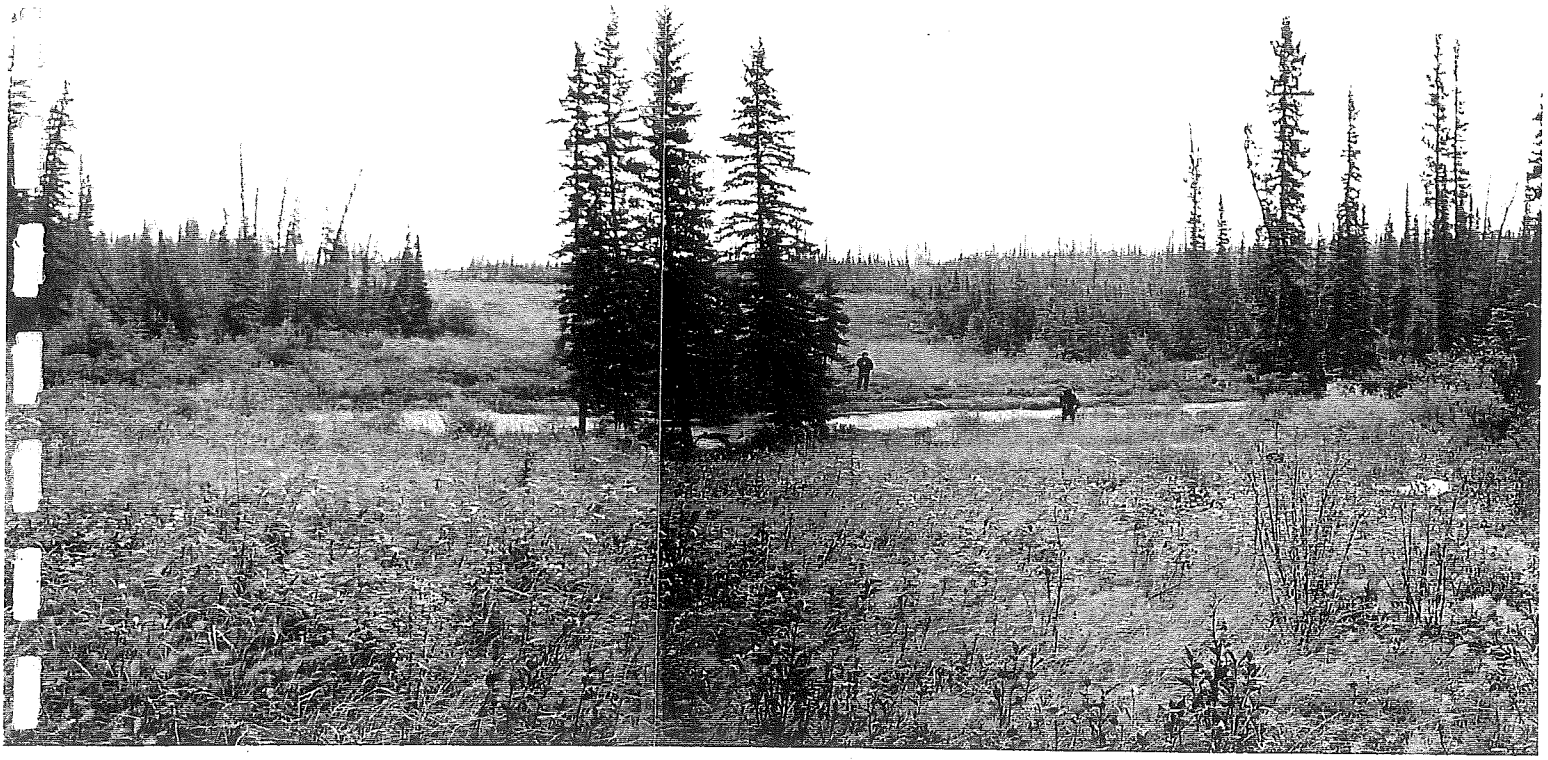
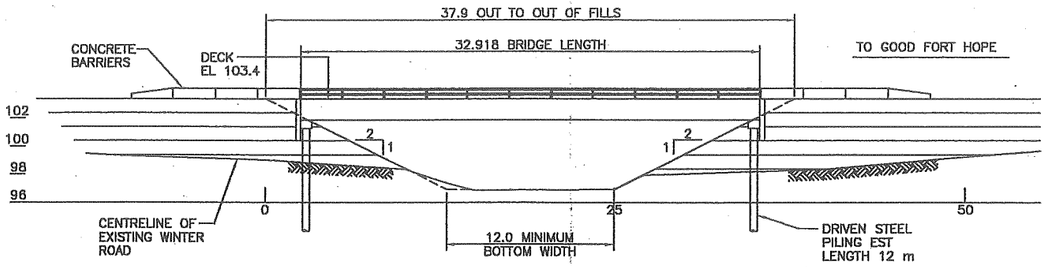


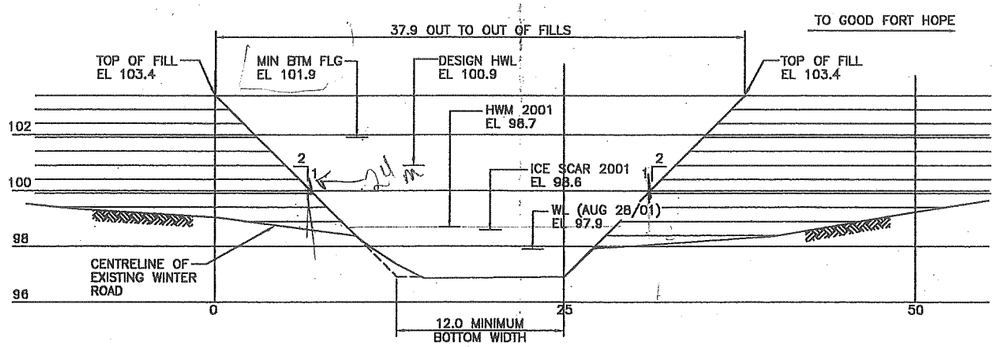
Photo No. 3 - Looking South on Winter Road

Photo 4 - Looking Upstream

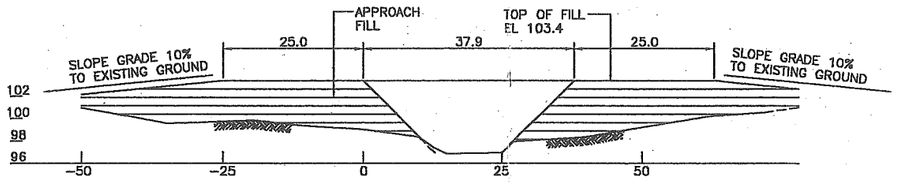
Photo 5 - Looking Downstream



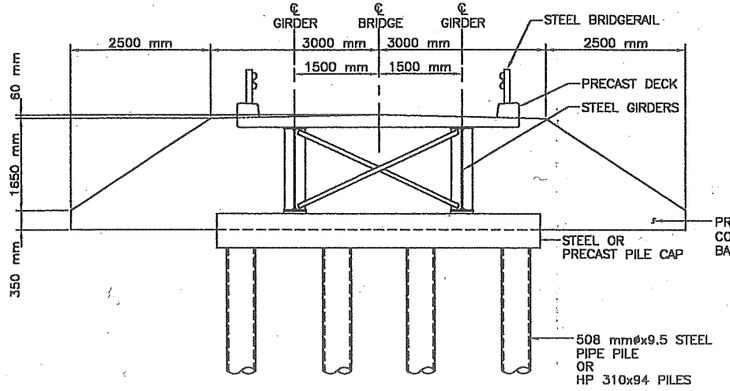
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



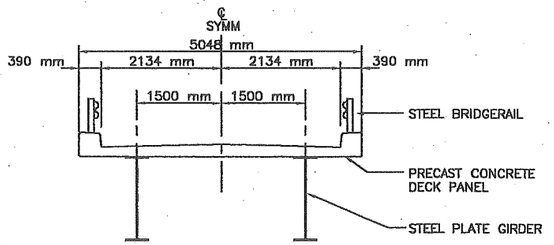
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



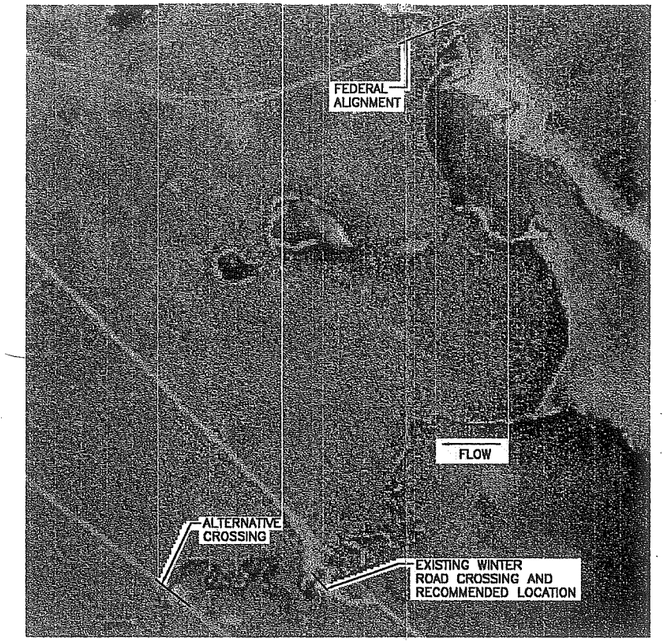
ROAD PROFILE
H – 1:500
V – 1:250



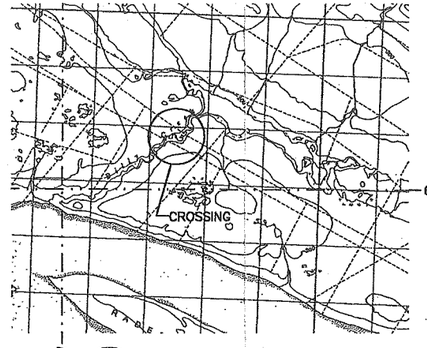
ABUTMENT ELEVATION
1:50



DECK SECTION
1:50



AERIAL PHOTOGRAPH
1:6000



SITE MAP
1:50 000

SITE INFORMATION

SITE 12
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE STUMP APPROX. 10 m SOUTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 28, 2001
WINTER ROAD km 1033.4
COORDINATES LAT 65°20'27.5" N
LONG 127°07'00.5" W
SITE MAP REFERENCE 96-E/6

HYDROTECHNICAL DATA

- DRAINAGE AREA = 141 sq. km
- DESIGN DISCHARGE = 96 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SLOPE OF CHANNEL = 0.0041 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 2.5 m/s
- ICE DESIGN ELEV. 100.9 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA-S6-00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

Northwest Territories Transportation

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

BILLY CREEK
km 1033.4
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 13 of 22
Drawing No. 608-2-13

4.14 Oscar Creek

4.14.1 General

The Oscar Creek winter road crossing is located at km 1054.4 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 26' 23.9" N and Long. 127° 26' 23.2" W.

A field investigation of the site was done on August 28, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary benchmark established as a reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking south on the winter road. Photo 2 shows the proximity of the Mackenzie River to the crossing.

The existing winter road crossing is located approximately 2.9 km downstream of the federal alignment done in the 1970's. On the day of the site visit, the stream was 16 m wide and 0.9 m deep.

The winter road makes sharp turns at approximately 100 m north of the stream and 40 m south of the stream. The crossing is located between two bends on the stream and these bends have been moving laterally; however, the crossing location appears to be relatively stable at this time. Based on the general alignment, the stream crosses the road alignment at a 35° LHF skew.

Stream banks were well vegetated with trees and grasses. Some erosion was occurring in the bank upstream of the crossing, as shown on Photo 3. The streambed was composed of fine gravels less than 30 mm in size.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.14.2 Existing Information

Oscar Creek had a preliminary design done by Public Works Canada in the 1970's for a crossing located approximately 3.9 km upstream of the existing crossing. The recommended structure was a two span bridge (35.05 m - 35.05 m) utilizing a single pier in the river. Driven steel pipe piling was indicated for the foundation. The bottom flange of the structure was set at 3.05 m (10 ft.) above high water level and approximately 9.8 m above streambed.

Additional information consisted of an environmental report of the winter road operation and a fish habitat assessment done by FSC in 1997.

4.14.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information for the Oscar Creek crossing consisted of topographic maps and air photos of the site as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. A drainage area of 638 km^2 was obtained from the federal alignment study. The present winter road crossing is about 3.9 km downstream of the proposed federal alignment crossing. The drainage area at this site is 704 km^2. The slope of the channel obtained from the federal alignment study is 0.0050 and the slope obtained from a 1:50,000 scale topographic map is 0.0020. The maximum elevation in the basin obtained from the topographic maps is 980 m. Air photos taken in 1950, 1973 and 1988 were obtained for analysis. The 1950 photographs at 1:40,000 are the earliest available, the 1973 photographs at 1:12,000 are the largest scale available and the 1988 photographs at 1:15,000 are the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

The previous hydrotechnical study for the federal alignment also provided additional hydrotechnical information. A high water mark was observed 2.6 m above the bed and an ice scar was observed 2.3 m above the bed. This previous study estimated the design discharge to be 430 m^3/s.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 347 m^3/s. The 50-year breakup discharge is also estimated to be about 204 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the present winter road crossing.

On the day of the survey the water was 0.9 m deep and 16.6 m wide at the winter road crossing. The survey found the water surface had a slope of 0.00088 over a 267 m length of channel.

Four high water marks were found in the vicinity of the winter road crossing, one on the upstream left bank 2.2 m above the water level, one on each bank at the crossing

1.9 and 2.5 m above the water level and one on the downstream left bank 2.0 m above the water level. At the cross section location these highwater marks would have elevations between 99.2 and 99.8 m relative to the local benchmark. Four ice scars were also found downstream of the winter road crossing. The ice scars were between 1.0 and 2.2 m above the water level. These ice scars would be at elevations of between 98.4 and 99.6 m at the cross section location.

Both banks were well vegetated with grass and trees. The right bank upstream of the crossing showed evidence of recent erosion. The bed material was sampled using a line sample technique on an exposed portion of the gravel bar upstream of the winter road crossing. The median diameter (D_{50}) of the bed material is 15 mm while the largest stones (D_{90}) are about 30 mm in diameter.

3. River Engineering Analysis

The design high water level based on local flow conditions for the site was calculated to be 101.5 m, which is 4.1 m above the surveyed water level and 5.0 m above the bed. This level is the estimated 50-year ice jam elevation at this site. This level is 1.9 m higher than the highest observed ice scars and 1.7 m above the highest observed high water marks. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 102.5 m or greater.

Analysis of potential Mackenzie River ice jams near the mouth of Oscar Creek indicate that high water levels from a Mackenzie River ice jam may occur at the site. The 1:50,000 map contours indicate that the water level at the site is about 7.1 m above the Mackenzie River, presumably at low flow. However, geodetic water levels on the Mackenzie River indicate that the site may be as much as 15.1 m above the low flow Mackenzie River level. The 50-year ice jam could raise the level in the Mackenzie River as much as 12.7 m at the mouth, so water levels at the crossing site may be as high as 103.0 m. This elevation is 1.5 m higher than the design high water level based on the local hydraulics. The map elevations are coarse, therefore, a survey is required to determine the actual differential elevation between the low flow open water elevation of the Mackenzie River and the benchmark at the crossing site.

Analysis of air photos of the site indicates that the channel is moderately unstable. Numerous abandoned meander loops and oxbows are evident in the air photos but no meander cutoffs occurred between 1950 and 1988. Lateral movement of the channel of up to 50 m has occurred over this period. The bend upstream of the winter road crossing appears to have eroded 50 m toward the road alignment over this time. This bend migrated about 25 m between 1950 and 1973, 25 m between 1973 and 1988 and a further 15 m between 1988 and 2001. The bend may progress to the road alignment in the next ten to twenty years. The actual winter road crossing site appeared to be stable from 1950 to 1988 but has shifted laterally 5 to 10 m between 1988 and 2001. The federal alignment crossing site also appears to be stable from 1950 to 1988 although the bend downstream of the crossing has shifted considerably.

The winter road alignment appears to be a suitable location for the bridge crossing because it is located in a relatively straight stable reach of the river. However, the south approach should be shifted downstream to avoid the upstream bend and reduce the skew of the bridge relative to the channel. The federal alignment crossing location is acceptable as well. This location appears to be above the elevation affected by Mackenzie River ice jams, however, the federal alignment study indicated severe icing at this location.

The existing channel at the cross section location is 16.6 m wide at the water level and 28 m at top of bank. The minimum bottom width of the channel should be 18 m to limit the velocity in the constriction. The design open water elevation of 100.6 m would produce a mean velocity of about 3.4 m/s through an opening with an 18 m bottom width and 2:1 side slopes.

4.14.4 Environmental Considerations

The fish habitat assessment indicates the stream has good fish habitat and supports arctic grayling spawning and rearing. Other species such as lake chub, longnose sucker, northern pike and whitefish species are also present. This stream is considered to be Class 1 fish habitat.

The stream has many meanders and the channel has moved at the bends upstream and downstream over the last 50 years. Erosion of stream banks would be an environmental issue and bank protection work would likely be required.

4.14.5 Alternatives

Alternatives considered were two different single span bridge structures. The hydrotechnical review indicated a possibility of ice jam effects at this site from the Mackenzie River which could lead to a 1.5 m elevation difference in the high water level.

The stream crosses the road alignment on a 35° LHF skew, therefore two alternate spans were considered. A skewed alternate and a square crossing alternate were considered for the lower high water level case.

The first alternative used the lower high water level and resulted in a span of 54.864 m for the skewed case and 56.083 m for the square bridge case with a deck elevation of 104.5 m. The second alternative used the estimated possible Mackenzie River ice jam effect and resulted in a 63.5 m span with a deck elevation of 106.0 m. Due to the possible lateral movement of the stream, a single span structure was considered more suitable as it eliminates erosion and scour concerns with piers.

Driven piles were assumed to be the most suitable foundation type. A geotechnical investigation would be necessary to determine pile capacities and lengths.

The existing alignment at the crossing has sharp curves near the crossing and a revised alignment was assumed. This involves straightening the winter road to provide straight approaches to the bridge fills.

The federal alignment would also be a suitable location for the bridge crossing, but icing could be a concern.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for this site. Preliminary sizing of the bridge girders indicates the bridge structure would consist of two welded wide flange girders.

The attached drawing shows the alternative structures that were considered suitable.

4.14.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table. The estimated costs for construction are as follows:

56.083 m single span bridge (on square)	$963,300
54.864 m single span bridge (on skew)	$958,400
63.5 m single span bridge (Mackenzie River ice effect).	$1,252,790

4.14.7 Recommendations

The recommended structure consists of a 56.083 m single span bridge with a minimum bottom flange elevation of 102.5 m. A minimum undisturbed bottom width of 18.0 m is recommended. Headslopes of 2H to 1V were used resulting in an out to out of fills of 62.2 m at elevation 104.5 m.

Driven steel piles are recommended for the foundations. Steel girders with composite precast concrete deck panels are recommended for the superstructure.

Verification of the high water level due to the possibility of Mackenzie River ice jam effects is recommended.

The existing winter road crossing would be recommended for the structure location. Realignment of the winter road approaches would be required to suit the bridge.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment, the alternative structure and the recommended structure.

4.14.8 Summary

A single span bridge with an overall length of 56.083 m is recommended on the existing alignment for the Oscar Creek winter road crossing. A detailed survey to determine the elevation of the site in relation to the Mackenzie River is required to determine if the bridge needs to be raised and lengthened due to high water from ice jams.

Site	Oscar Creek			Pg 1 of 2
	Recommended Structure -56.083m Bridge(on Square)			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	120000	1	120,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	2	50,000
Approaches - common fill	cu.m.	30	8900	267,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	50	1,400
Deck Panels				
fabricate and deliver	each	3400	18	61,200
Steel Girders				
fabricate and deliver	kg	1.15	62000	71,300
Steel and Deck Panel Erection	m	1500	56	84,000
Bridgerail	m	100	112	11,200
New Jersey Concrete Barriers	each	500	24	12,000
Precast Backwall Panels				
supply and deliver	each	6000	2	12,000
		Sub-Total		789,600
		Contingency(15%)		118,400
		Engineering(7%)		55,300
		Total		963,300

Site Oscar Creek

Alternative Structure -54.864m Bridge(on Skew)

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	120,000	1	120,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	2	50,000
Approaches - common fill	cu.m.	30	8900	267,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	50	1,400
Deck Panels fabricate and deliver	each	3400	18	61,200
Steel Girders fabricate and deliver	kg	1.15	60000	69,000
Steel and Deck Panel Erection	m	1500	55	82,500
Bridgerail	m	100	110	11,000
New Jersey Concrete Barriers	each	500	24	12,000
Precast Backwall Panels supply and deliver	each	6000	2	12,000
		Sub-Total		785,600
		Contingency(15%)		117,800
		Engineering(7%)		55,000
		Total		958,400

Alternative Structure(Mackenzie Ice Effect)

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	150,000	1	150,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	2	50,000
Approaches - common fill	cu.m.	30	13400	402,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	21	71,400
Steel Girders fabricate and deliver	kg	1.15	92000	105,800
Steel and Deck Panel Erection	m	1500	63.5	95,250
Bridgerail	m	100	127	12,700
New Jersey Concrete Barriers	each	500	24	12,000
Precast Backwall Panels supply and deliver	each	13000	2	26,000
		Sub-Total		1,026,890
		Contingency(15%)		154,000
		Engineering(7%)		71,900
		Total		1,252,790

Photo 1 - Looking South on Winter Road (Stream Flow to Right)

Photo 2 - Looking Southerly

Photo No. 3 - Looking North on Winter Road (Flow to Left)

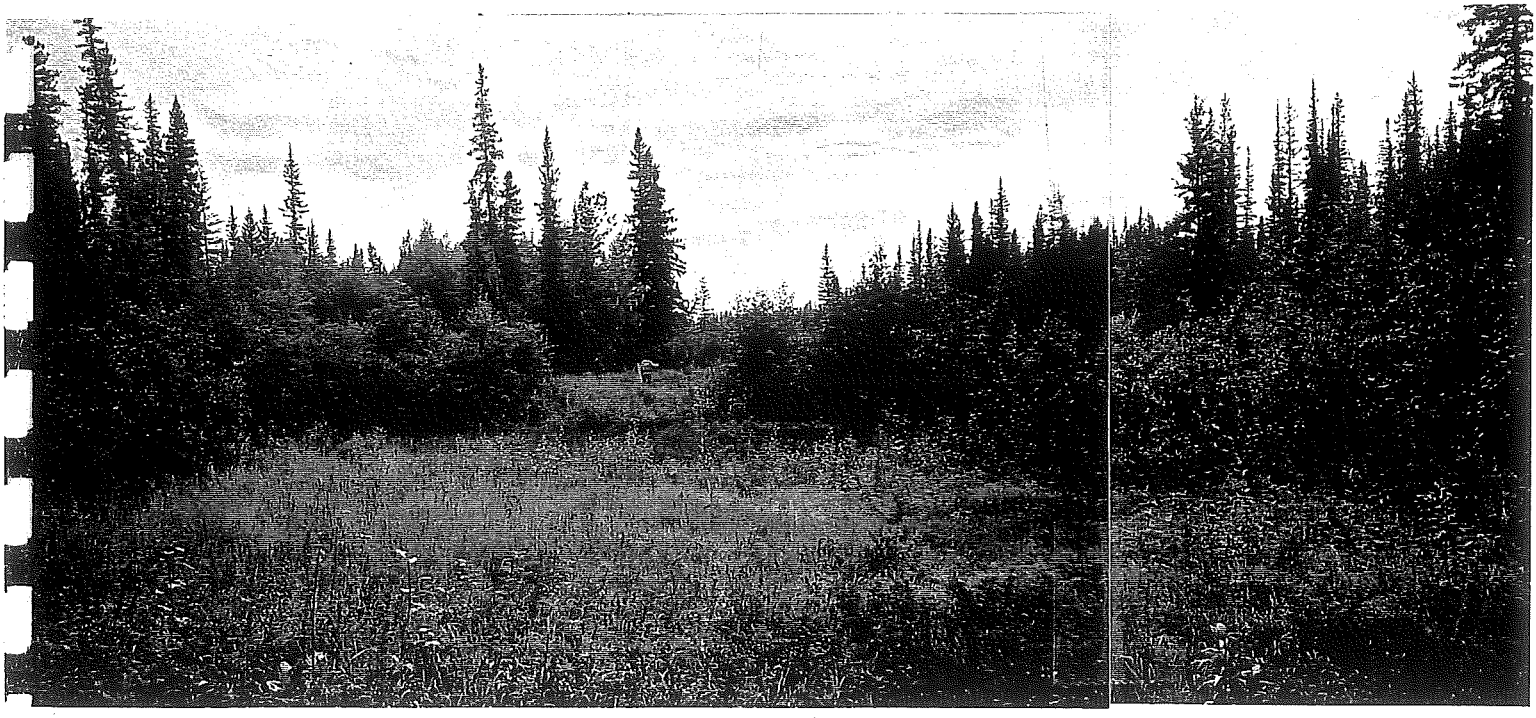
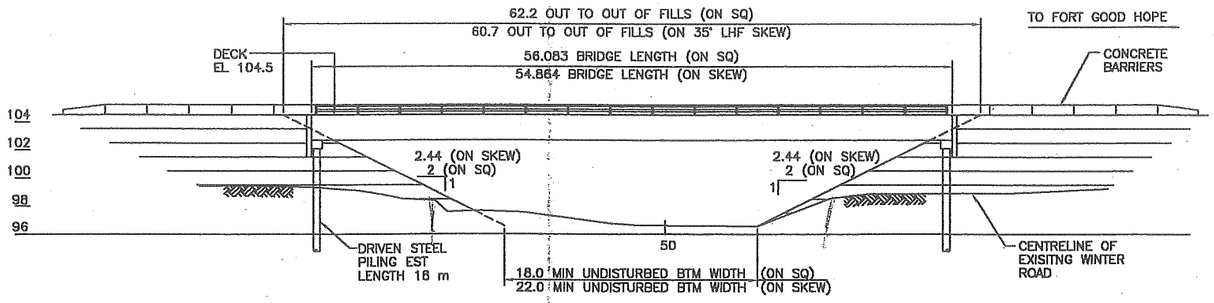


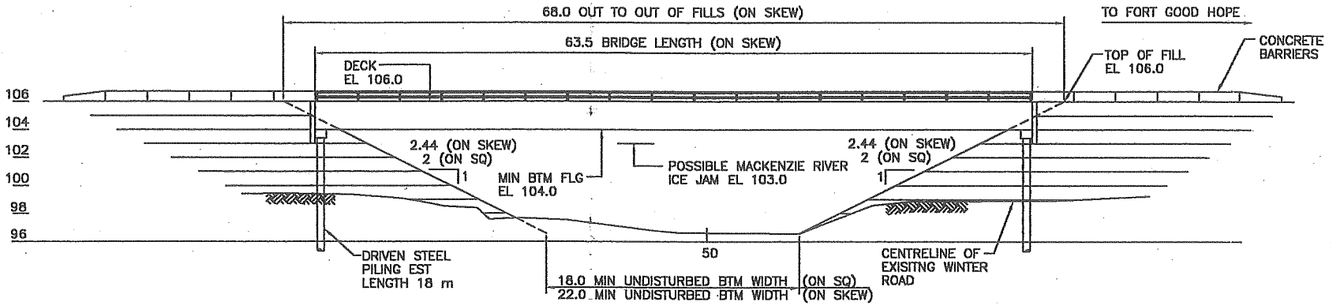
Photo 4 - Looking South

Photo 5 - Looking Upstream

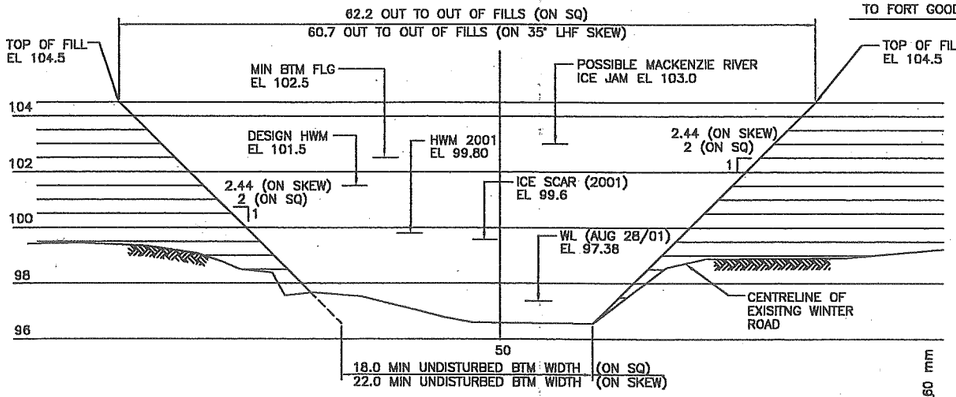
Photo 6 - Looking Downstream



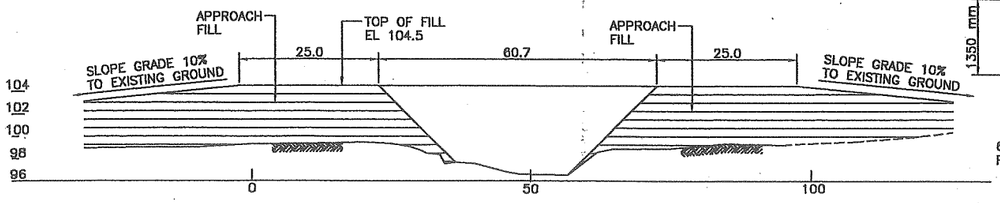
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



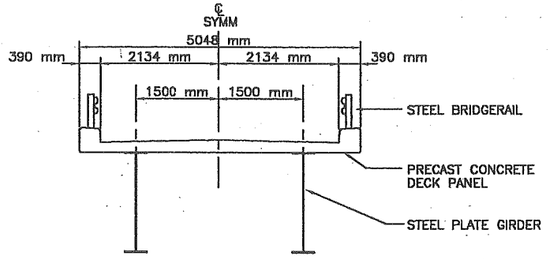
ALTERNATIVE SPAN (FOR MACKENZIE ICE EFFECT)
(LOOKING D/S) 1:200



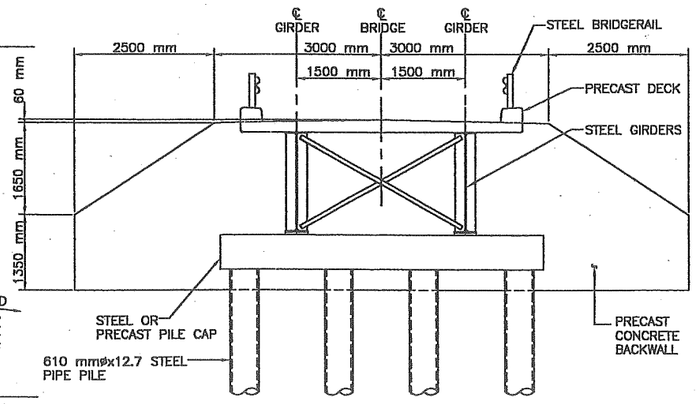
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



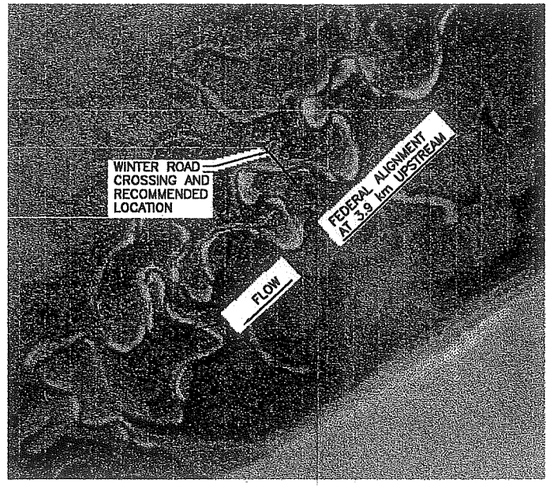
ROAD PROFILE
(LOOKING D/S) H – 1:500
V – 1:250



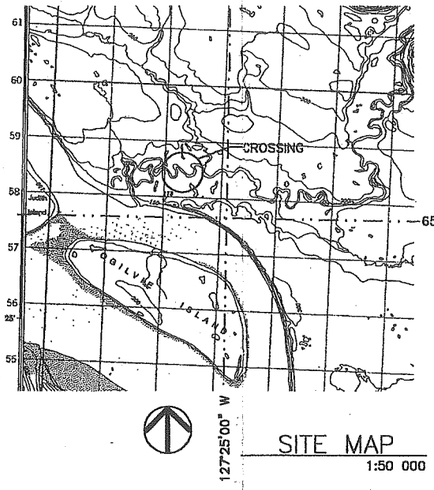
DECK SECTION
1:50



ABUTMENT ELEVATION
1:50



AERIAL PHOTOGRAPH
1:8350



SITE MAP
1:50 000

SITE INFORMATION

SITE 13
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN STUMP APPROX. 10 m SOUTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 28, 2001
WINTER ROAD km 1054.4
COORDINATES LAT 65°26'23.9" N
LONG 127°26'23.2" W
SITE MAP REFERENCE 96–E/6

HYDROTECHNICAL DATA

- DRAINAGE AREA = 704 sq. km
- DESIGN DISCHARGE = 347 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.00088 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 3.4 m/s
- ICE DESIGN ELEV. 101.5 m. ICE DESIGN THICKNESS 1.0 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA-S6-00
- POSSIBLE MACKENZIE RIVER ICE JAM EFFECT – MAX ELEV. 103.0 (REQUIRES VERIFICATION BY SURVEY)

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

OSCAR CREEK
km 1054.4
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 14 of 22
Drawing No. 608-9-14

4.15 Elliot Creek

4.15.1 General

The Elliot Creek winter road crossing is located at km 1072.4 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 31' 20.9" N and Long. 127° 36' 58.5" W.

A field investigation of the site was done on August 29, 2001. A preliminary survey of the centreline of the existing crossing was done and a temporary benchmark established as response to a future detailed survey.

Photo 1 shows an aerial view of the site looking north on the winter road.

The winter road approach from the south is on a long gradual slope, while the north approach is steeper. The road crosses the stream on a straight alignment approximately 900 m downstream of the federal alignment done in the 1970's. To cross the stream, the winter road diverges from a straight alignment to enter the valley.

The streambed was rocky with stones varying from 25 mm to 75 mm in diameter. Banks appeared to be stable and are well vegetated. On the day of the site inspection, the stream was 7.2 m wide and 0.3 m deep. There appears to be good sources for granular fill in the approach areas on each side of the stream.

The existing crossing is located at the downstream end of a bend in the stream, but the location appears stable. The straight alignment of the winter road would cross approximately 350 m downstream and be on a relatively straight reach.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment, and the recommended structure.

4.15.2 Existing Information

Elliot Creek had a provisional contract package design done by Department of Public Works in 1977. The recommended structure at that time was a three span (9.14 m - 18.3 m - 9.14 m) arrangement with the bottom flange located approximately 8.2 m above streambed and over 5.1 m above the design high water and ice elevation. Foundations were indicated as driven pipe piles.

Additional information included air photos, an environmental assessment of the winter road operation, and a fish habitat assessment done by FSC in 1997.

4.15.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river

engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information for the Elliot Creek crossing consisted of topographic maps and air photos of the site as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. A drainage area of 30 km^2 was obtained from the federal alignment study. The present winter road crossing is about 900 m downstream of the proposed federal alignment crossing. The drainage area at this site is 42 km^2. The slope of the channel obtained from the federal alignment study is 0.0089 and the slope obtained from a 1:50,000 scale topographic map is 0.0091. The maximum elevation in the basin obtained from the topographic maps is 520 m. Air photos taken in 1951, 1973 and 1988 were obtained for analysis. The 1951 photographs at 1:40,000 are the earliest available, the 1973 photographs at 1:12,000 are the largest scale available and the 1988 photographs at 1:15,000 are the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

The previous hydrotechnical study for the federal alignment also provided additional hydrotechnical information. A high water mark was observed 2.0 m above the bed. This previous study estimated the design discharge to be 28 m^3/s.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 34 m^3/s. The 50-year breakup discharge is also estimated to be about 34 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the present winter road crossing.

On the day of the survey the water was 0.4 m deep and 7.2 m wide at the winter road crossing. The survey found the water surface slope had a slope of 0.0063 over a 120 m length of channel. The cross section was surveyed just downstream of a mid-channel gravel bar.

A high water mark was found downstream of the winter road crossing on the right bank which was 0.8 m above the water surface. At the cross section location this highwater mark would have an elevation of 96.9 m relative to the local benchmark. Four ice scars were found in the vicinity of the winter road crossing. The ice scars were between 0.5 and 1.4 m above the water level. These ice scars would be at elevations of between 96.6 and 97.5 m at the cross section location. These ice scars

were found on small trees. There were no large trees adjacent to the channel and no scars were apparent on the large trees farther from the channel.

Both banks were well vegetated with grass and small trees, and appear to be stable. The bed material was sampled using a line sample technique on an exposed portion of the gravel bar upstream of the winter road crossing. The median diameter (D_{50}) of the bed material is 20 mm while the largest stones (D_{90}) are about 52 mm in diameter.

3. River Engineering Analysis

The design high water level based on local flow conditions for the site was calculated to be 98.6 m, which is 2.5 m above the surveyed water level and 2.9 m above the bed. This level is the estimated 50-year ice jam elevation at this site. This level is 1.1 m higher than the highest observed ice scars. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 99.6 m or greater.

Analysis of potential Mackenzie River ice jams near the mouth of Elliot Creek indicate that high water levels from a Mackenzie River ice jam are not likely to occur at the site. The 1:50,000 map contours indicate that the water level at the site is about 15.3 m above the Mackenzie River, presumably at low flow. Furthermore, geodetic water levels on the Mackenzie River indicate that the site may be as much as 24.3 m above the low flow Mackenzie River level. The 50-year ice jam could raise the level in the Mackenzie River as much as 12.7 m at the mouth so water levels at the crossing site should not be affected. The ice jam level is as little as 2.6 m below the local low water level and is based on crude data, therefore, a survey is required to determine the actual differential elevation between the low flow open water elevation of the Mackenzie River and the benchmark at the crossing site.

Analysis of air photos of the site indicates that the channel has been relatively stable between 1951 and 1988. Minor lateral movement of the channel of up to 10 m has occurred over this period but this movement is confined within a deep narrow valley. Only in the sharp 180° bend downstream of the winter road crossing does the channel appear to have eroded into the valley wall. Between 1951 and 1973 this bend has migrated laterally about 20 m but has not progressed further since 1973. Some channel movement also occurred between 1988 and 2001. Upstream of the straight alignment of the winter road which would cross the channel about 350 m downstream of the present crossing, the channel has shifted right about 5 m and the sharp 90° bend has moved about 10 m down-valley. This movement is far enough upstream so that it does not affect this crossing site at present. The channel at both the straight winter road alignment and the present winter road crossing appear to be relatively stable, however, the present crossing is located at the downstream end of a bend while the straight alignment would cross the channel in a relatively straight reach.

The straight winter road alignment appears to be the most suitable location for the bridge crossing because it is located in a straight, relatively stable reach of the river.

However, both the present winter road crossing and the federal alignment crossing are acceptable as well.

The existing channel at the cross section location is 7.2 m wide at the water level and 11.5 m at top of bank. The minimum bottom width of the channel should be 6 m which will limit the impact on the low water channel. The design open water elevation of 97.5 m would produce a mean velocity of about 2.2 m/s through an opening with a 6 m bottom width and 2:1 side slopes.

4.15.4 Environmental Considerations

The environmental assessments indicate that the stream provides good fish habitat for adult feeding and has potential for spawning of arctic grayling, lake chub, slimy sculpin and longnose sucker.

4.15.5 Alternatives

The site is well suited to a single span steel girder bridge structure using driven steel piles for the foundations. Alternative span arrangements or structural types are not considered feasible for this crossing. A geotechnical investigation has not been done for the present crossing, but may have been done for the federal alignment located 900 m upstream.

Based on the hydrotechnical review and environmental assessments, culverts are not considered suitable for this crossing.

The existing crossing was considered a suitable location for a bridge structure as were the federal alignment crossing and the straight winter road alignment located approximately 350 m downstream.

The ice jam effect from the Mackenzie River may affect the high water levels at the crossing and a survey to determine the elevation differential of the Mackenzie River to the crossing would be required.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for this site. A bridge length of 20.726 m is recommended as a suitable span for this site. Preliminary sizing of the bridge girders indicates the bridge structure would consist of two welded wide flange girders as shown on the attached drawing.

4.15.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the structure is provided in the following table.

The estimated costs for construction are as follows:

20.725 m single span bridge with timber deck.	$319,540
20.725 m single span bridge with precast deck.	$355,940

4.15.7 Recommendations

The recommended structure consists of a 20.726 m single span bridge with a minimum bottom flange elevation of 99.6 m. A minimum undisturbed creek width of 6.0 m is recommended. Headslopes of 2H to 1V were used resulting in an out to out of fills of 25.4 m at elevation 100.6 m.

Driven steel piles are recommended for the foundations. Steel girders with composite precast concrete deck panels are recommended for the superstructure.

The preferred crossing location would be on the straight alignment of the winter road; however, the existing crossing and federal alignment are both suitable.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessments, and the recommended structure.

4.15.8 Summary

A single span bridge with an overall length of 20.726 m with either the timber deck or precast deck system is recommended on an alignment 350 m downstream of the existing crossing for the Elliot Creek winter road crossing.

A survey would be recommended to determine the actual differential elevation between the low flow open water elevation of the Mackenzie River and the temporary benchmark at the crossing.

Site Elliot Creek

Recommended Structure - 20.726m Bridge - Timber Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	45000	1	45,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	3	75,000
Approaches - common fill	cu.m.	30	800	24,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Timber Decking	sq.m.	100	105	10,500
Steel Girders				
fabricate and deliver	kg	1.15	10000	11,500
Bridge Erection	lump sum	15000	1	15,000
Bridgerail	m	100	42	4,200
New Jersey Concrete Barriers	each	500	12	6,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		261,940
		Contingency(15%)		39,300
		Engineering(7%)		18,300
		Total		319,540

Alternative Structure - 20.726m Bridge - Precast Deck

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	45,000	1	45,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	3	75,000
Approaches - common fill	cu.m.	30	800	24,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels				
fabricate and deliver	each	3400	7	23,800
Steel Girders				
fabricate and deliver	kg	1.15	10000	11,500
Steel and Deck Panel Erection	m	1500	21	31,500
Bridgerail	m	100	42	4,200
New Jersey Concrete Barriers	each	500	12	6,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		291,740
		Contingency(15%)		43,800
		Engineering(7%)		20,400
		Total		355,940

Photo 1 - Looking North on Winter Road (Stream Flow to Left)

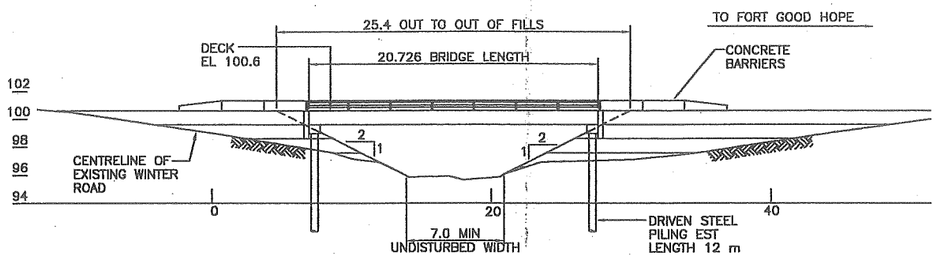
Photo 2 - Looking Northerly on Winter Road

Photo No. 3 - Looking North on Winter Road (Flow to Left)

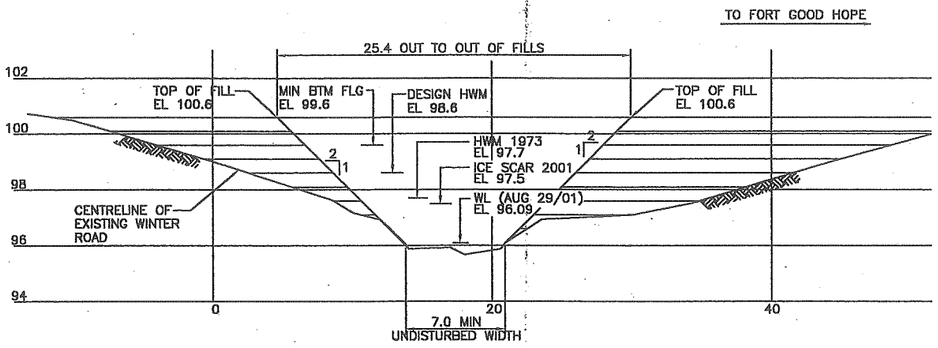
Photo 4 - Looking South on Winter Road

Photo 5 - Looking Upstream

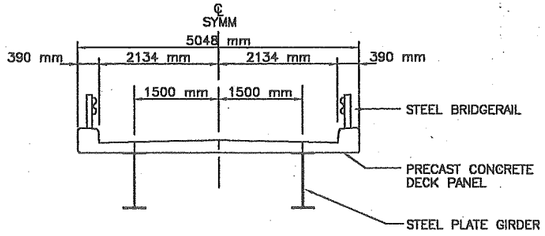
Photo 6 - Looking Downstream



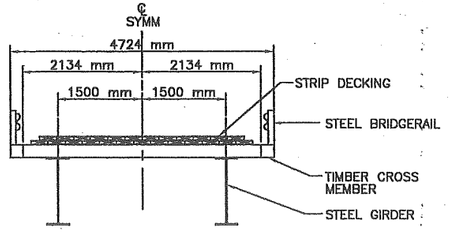
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



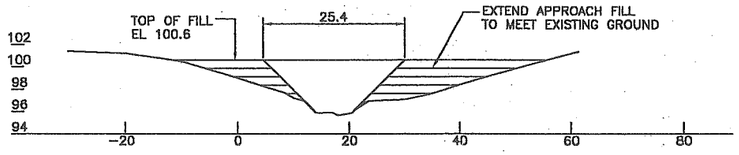
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



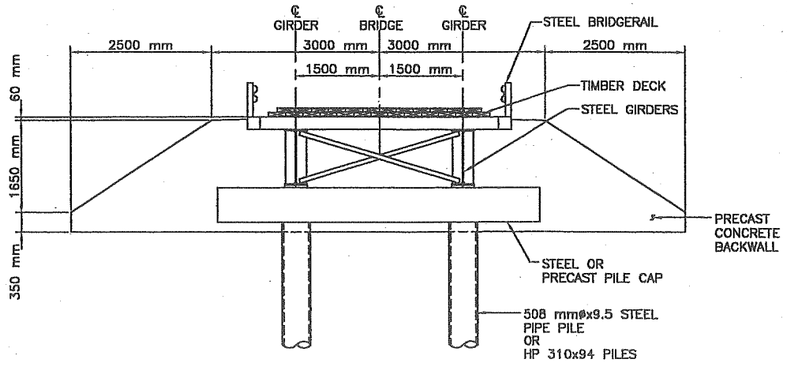
DECK SECTION – PRECAST
1:50



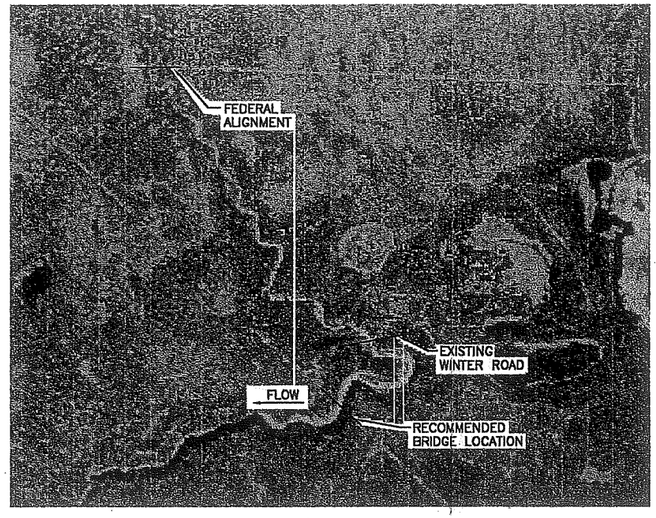
DECK SECTION – TIMBER
1:50



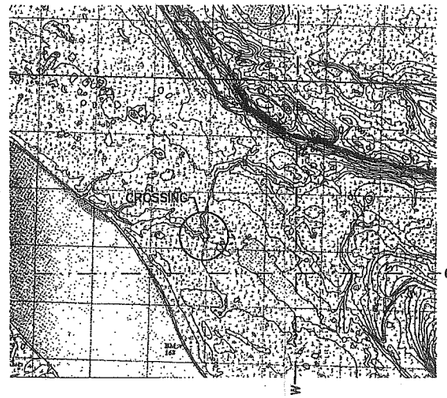
ROAD PROFILE
(LOOKING D/S) H – 1:500
V – 1:250



ABUTMENT ELEVATION
1:50



AERIAL PHOTOGRAPH
1:7500



SITE MAP
1:50 000

SITE INFORMATION

SITE 14
TEMPORARY BENCH MARK ELEV. 100.000 m
NAIL IN TREE APPROX. 15 m SOUTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 29, 2001
WINTER ROAD km 1072.4
COORDINATES LAT 65°31'20.9" N
LONG 127°36'58.5" W
SITE MAP REFERENCE 96–E/12

HYDROTECHNICAL DATA

- DRAINAGE AREA = 42 sq. km
- DESIGN DISCHARGE = 34 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0063 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 2.2 m/s
- ICE DESIGN ELEV. 98.6 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA–S6–00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

Northwest Territories Transportation

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ENGINEERING GROUP LTD.
6810–104 STREET
EDMONTON, AB
FAX (780)438–4843
PH. (780)438–5376

Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

ELLIOT CREEK
km 1072.4
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Insignia
Signature
Date
Signature
Date
Approved by
Project No.
Page 15 of 22
Drawing No. 608–9–15

4.16 Hanna River

4.16.1 General

The Hanna River winter road crossing is located at km 1084.4 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 38' 42.7" N and Long. 127° 48' 04.0" W.

A field investigation of the site was done on August 29, 2001. A preliminary survey of the centerline of the existing winter road crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking south on the winter road. Photos 2 and 3 show the existing crossing looking north and south on the winter road respectively. The surveyed site appears to be the same location as the federal alignment crossing.

The winter road crosses Hanna River on a long, straight stretch of the stream. Both banks were well vegetated and appear to be stable. The north bank is relatively steep with a height of 5 m, while the south bank is much shallower with a height of 2 m. At the time of the inspection, the stream was 11 m wide and over 1.1 m deep at the banks. The streambed appeared to be composed of silty material at the crossing.

The road alignment was found to be good from both approaches. The road curves to the east approximately 200 m south of the crossing.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment and the recommended structure.

4.16.2 Existing Information

Hanna River had a preliminary bridge design done by Public Works Canada in 1974. The recommended structure at that time was a three span arrangement (18.3 m - 35.3 m - 18.3 m) with the bottom flange approximately 9.0 m above high water. One alternative indicated a minimum clearance of 5.18 m to the underside of the structure which incorporated tensioned underslung cables. The design high water was indicated as approximately 4.2 m above streambed. Foundations consisted of driven piles assumed to be 21 m long as the drawing noted that bedrock was not located.

Additional information included air photos, an environmental operation report for the winter road, a fish habitat assessment done 1n 1997, and an environmental information update report by GeoNorth and Golder Associates.

4.16.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river

engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information for the Hanna River crossing consisted of topographic maps and air photos of the site as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. A drainage area of 214 km^2 was obtained from the federal alignment study. The present winter road crossing is about 1300 m upstream of the federal alignment crossing measured along the channel. There is no significant difference in the drainage area between the sites. The federal alignment study reported a surveyed stream slope of about 0.00053. The slope of the channel obtained from a 1:50,000 scale topographic map is between 0.0066 upstream and 0.0010 downstream. The maximum elevation in the basin obtained from the topographic maps is 400 m. Air photos taken in 1950, 1973 and 1981 were obtained for analysis. The 1950 photographs at 1:40,000 are the earliest available, the 1973 photographs at 1:12,000 are the largest scale available and the 1981 photographs at 1:50,000 are the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

The previous hydrotechnical study for the federal alignment also provided additional hydrotechnical information. A high water mark was observed 3.7 m above the bed. This previous study estimated the design discharge to be 170 m^3/s with a design water level 4.3 m above the bed. During breakup in 1974 the velocity was measured at 1.5 m/s when water level was 3.2 m above the bed. Based on these measurements, the discharge is estimated to have been about 58 m^3/s.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site based on this method is 65 m^3/s. This is significantly less that the design discharge specified in the federal alignment study and only slightly higher than the 1974 breakup flow, therefore, a design discharge of 100 m^3/s was adopted which is equivalent to the discharge for a basin with a 600 m maximum elevation. The 50-year breakup discharge is also estimated to be about 100 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the federal alignment. What appears to be the winter road crosses the channel about 1300 m upstream of the survey site.

On the day of the survey the water was 1.1 m deep and 10.9 m wide at the federal alignment crossing. The survey found the water surface slope had no measurable slope over a 27.6 m length of channel.

Three high water marks were found near the winter road crossing, one on the upstream left bank, one on the right bank just downstream and one downstream on the left bank. These high water marks ranged from 1.4 to 1.7 m above the water surface. At the cross section location these highwater marks would have elevations of 97.4 and 97.7 m respectively relative to the local benchmark. Ice scars were also found both upstream and downstream of the crossing. The ice scars were between 1.5 and 2.7 m above the water level. These ice scars would be at elevations of between 97.5 and 98.7 m at the cross section location.

Both banks were well vegetated with grass and trees and appeared to be stable. The water was too deep to obtain bed material samples, however, visual inspection indicated that the bed was mostly silt. However, there are what appears to be gravel bars on the inside of some bends both upstream and downstream of the crossing.

3. River Engineering Analysis

The design high water level for the site was calculated to be 100.2 m, which is 4.2 m above the surveyed water level and 5.3 m above the bed. This level is the estimated 50 year ice jam elevation at this site. This level is 1.5 m higher than the observed ice scars and 1.4 m higher than the 1973 high water mark. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis The minimum flange elevation should be 101.2 m or greater.

Air photos of the site show numerous oxbow lakes but no new oxbows have formed from meander cutoffs between 1950 and 1981. Between 1950 and 1973, the some bends have migrated outward as much as 20 m but no changes have occurred in the reach between the winter road and the federal alignment crossings. No changes were detected between 1973 and 1981. As well, no changes in channel position at the federal alignment were apparent in the 2001 air photos.

The federal alignment appears to be the most suitable location for the bridge crossing because it is located in a long, straight, stable reach of the river. The winter road crossing also appears to be stable but it is located just downstream of a bend which may cause erosion problems in the future. Further survey work is required if the winter road crossing is selected for the bridge location because the both previous surveys were done at the federal alignment crossing site.

The existing channel at the cross section location on the federal alignment is 11 m wide at the water level and 23 m at top of bank. The minimum bottom width of the channel should be 5 m which will limit the channel constriction to 2 m for 2:1 side slopes. The design open water elevation of 99.0 m would produce a mean velocity of about 2.0 m/s through this opening.

4.16.4 Environmental Considerations

An environmental assessment of the winter road crossing dated October 1997 indicates the site has good habitat for spawning, rearing and adult feeding, although the stream had high sediment loads. The site was considered to have good potential for arctic grayling and long nose sucker.

The banks appear to be well vegetated and stable, although the environmental assessment had some concern about future bank erosion due to the relatively fine (silty) materials.

4.16.5 Alternatives

The site is well suited to a single span bridge structure using driven steel piles for the foundations. A geotechnical investigation may have been done for the federal alignment, but information was not available. Culverts are not considered suitable for this site.

A two span arrangement was considered having the pier located 20 m from the north end and using a shorter (12 m) end span on the south. This alternative would require one pier. A single span 29.87 m bridge was considered also. The length would likely require field splicing of the girders due to shipping restrictions.

The existing crossing was considered to be most suitable for a bridge location, as it crosses a long straight reach of the stream.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for this site. A bridge length of 29.87 m is recommended as a suitable span for this site. The bridge structure would consist of two welded wide flange girders as shown on the attached drawing.

4.16.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table. The estimated costs for construction are as follows:

29.87 m single span bridge.	$234,090
2 span (12 m - 20 m) bridge.	$409,960

4.16.7 Recommendations

The bridge should be located at the present winter road crossing which is on a straight apparently stable section of the river.

The recommended structure consists of a 29.87 m single span bridge with a minimum bottom flange elevation of 101.2 m. A minimum stream bottom width of 5.0 m is

recommended. Head slopes of 2H to 1V were used resulting in out to out of fills of 34.5 m at elevation 102.2 m.

Driven steel piles are recommended for the foundations. Steel girders with composite precast concrete deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.16.8 Summary

A single span bridge with an overall length of 29.87 m at the present crossing location is recommended for the Hanna River winter road crossing.

Site Hanna River

Recommended Structure - 29.87m Bridge

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	30,000	1	30,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Approaches - common fill	cu.m.	30	1500	45,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	10	34,000
Steel Girders fabricate and deliver	kg	1.15	21000	24,150
Steel and Deck Panel Erection	m	1500	30	45,000
Bridgerail	m	100	60	6,000
New Jersey Concrete Barriers	each	500	14	7,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		191,890
		Contingency(15%)		28,800
		Engineering(7%)		13,400
		Total		234,090

Alternative - 2 Span(12m - 20m)

Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	30,000	1	30,000
Driven Steel Piling - Abutment	each	10000	4	40,000
Driven Steel Piling - Pier	each	15000	4	60,000
Precast Concrete Pile Caps	each	4500	3	13,500
Pier Diaphragms	each	10000	1	10,000
Approaches - common fill	cu.m.	30	1500	45,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	11	37,400
Steel Girders fabricate and deliver	kg	1.15	14800	17,020
Steel and Deck Panel Erection	m	1500	32	48,000
Bridgerail	m	100	64	6,400
New Jersey Concrete Barriers	each	500	14	7,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		336,060
		Contingency(15%)		50,400
		Engineering(7%)		23,500
		Total		409,960

Photo 1 - Looking South on Winter Road (Stream Flow to Right)

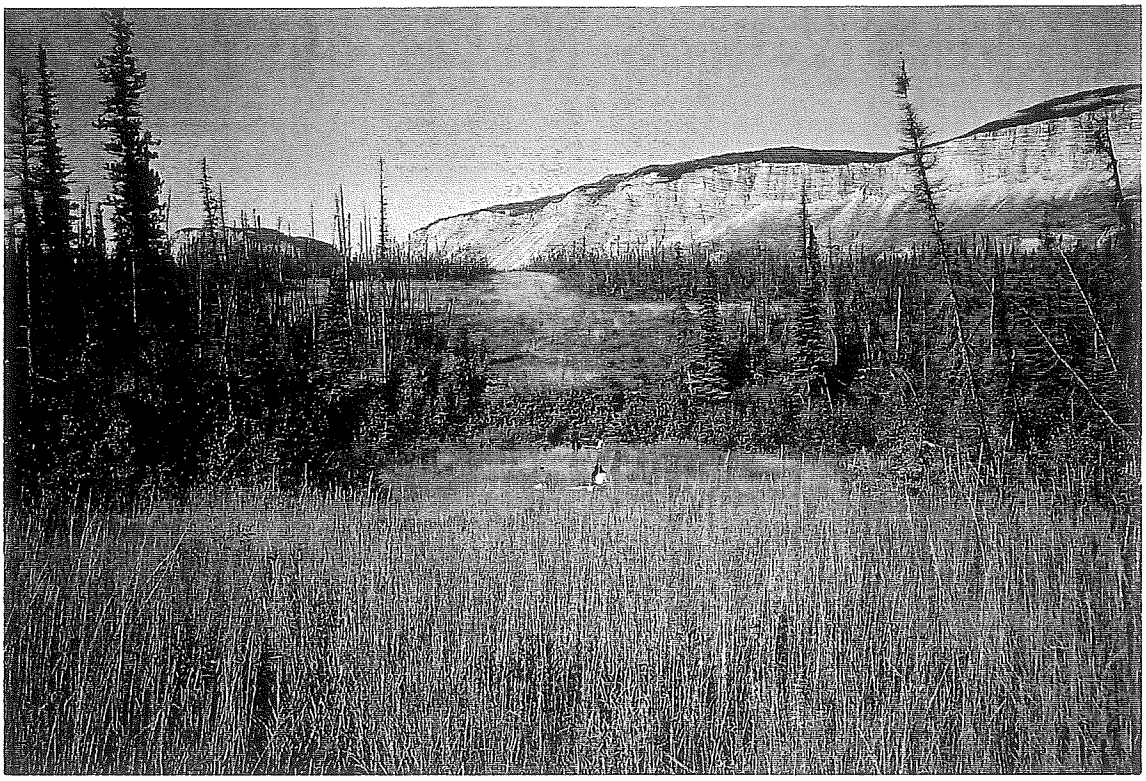


Photo 2 - Looking North on Winter Road (Stream Flow to Left)

Photo No. 3 - Looking South on Winter Road

Photo 4 - Looking Upstream

Photo 5 - Looking Downstream

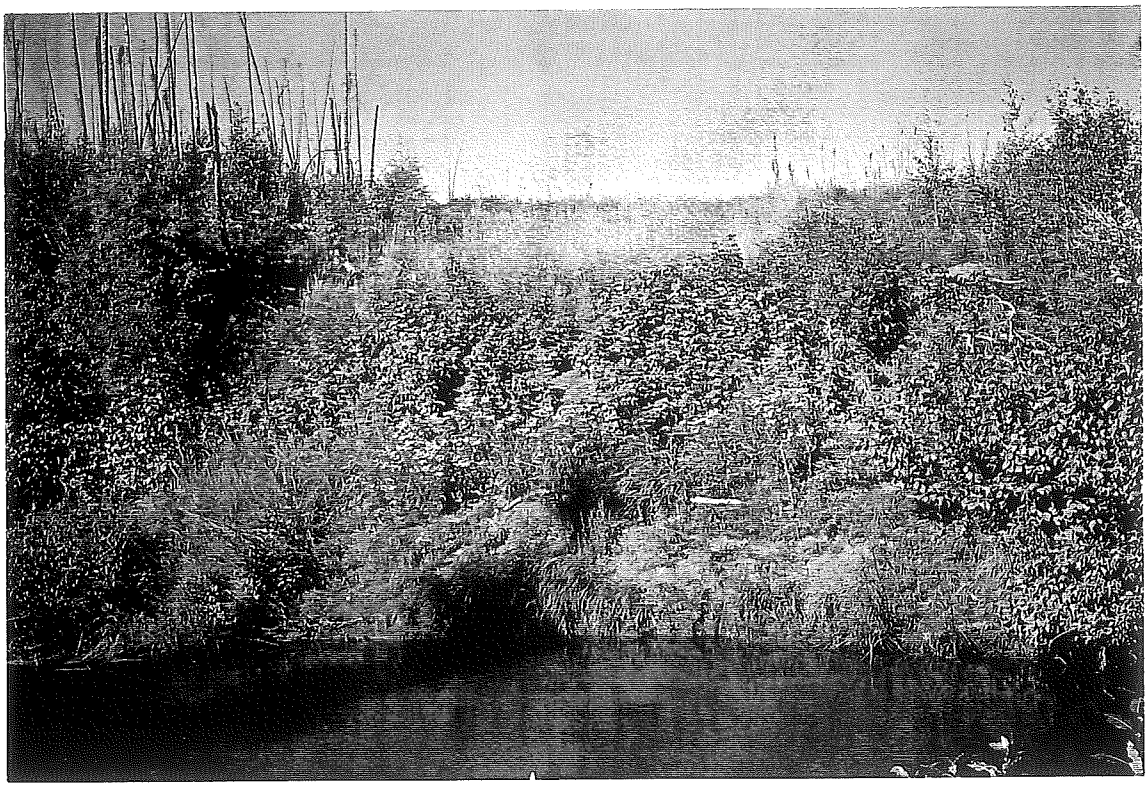


Photo 6 - North Bank

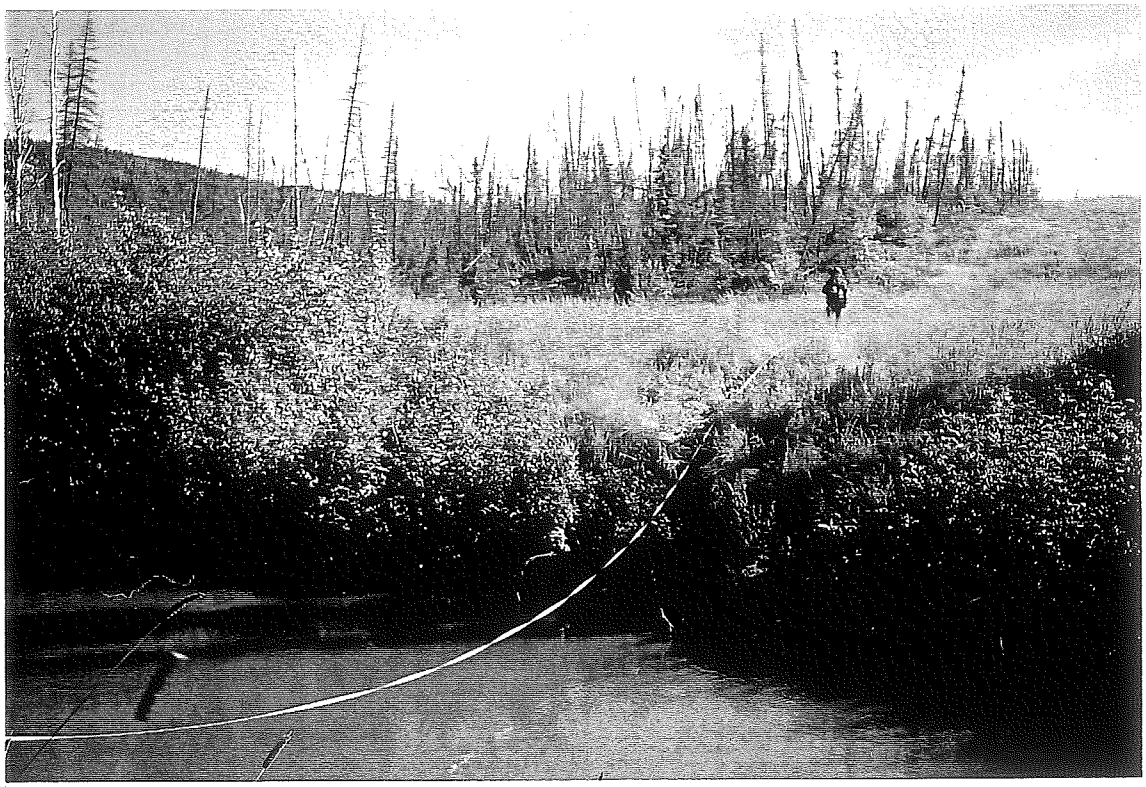
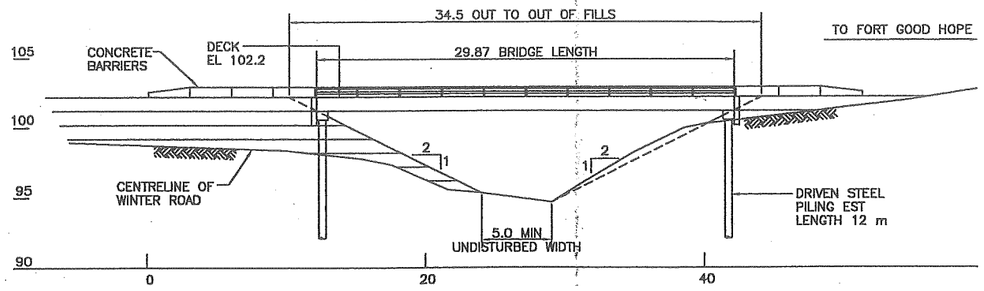
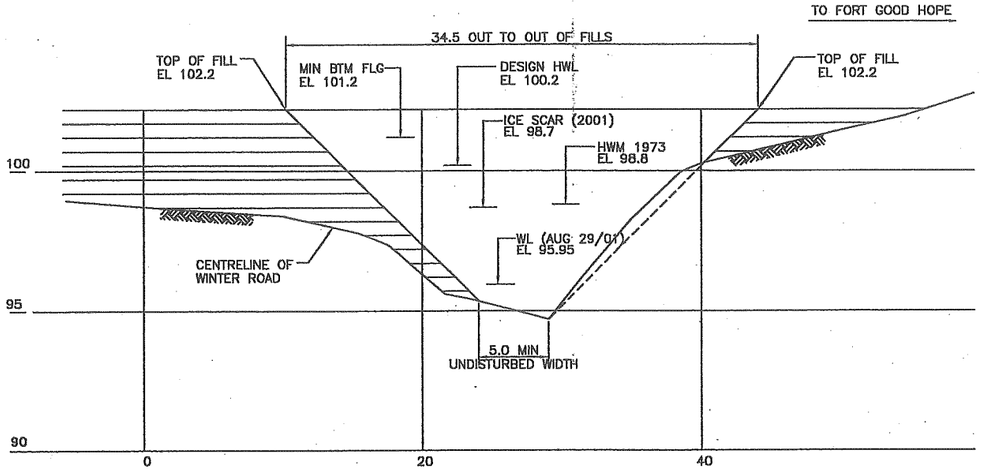


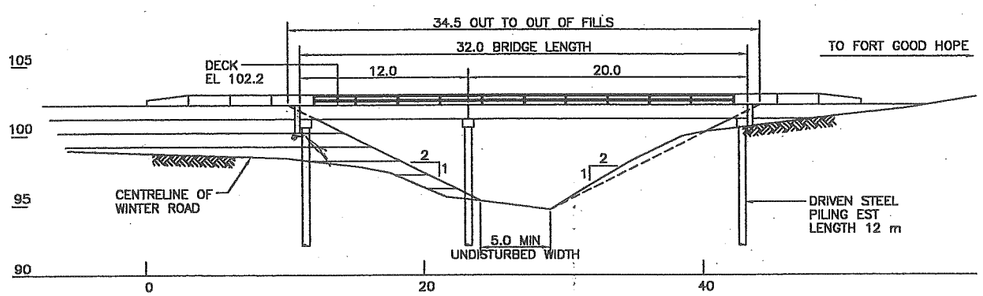
Photo 7 - South Bank



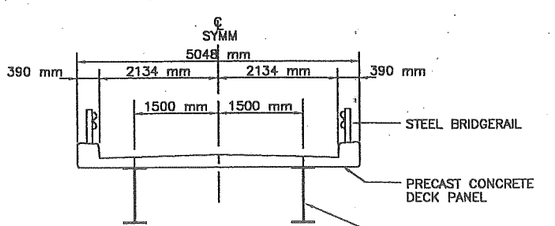
ELEVATION — NATURAL SCALE
(LOOKING D/S) 1:200



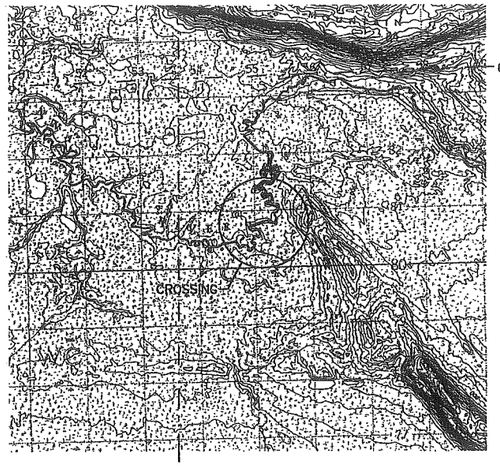
ELEVATION
(LOOKING D/S) H — 1:200
V — 1:100



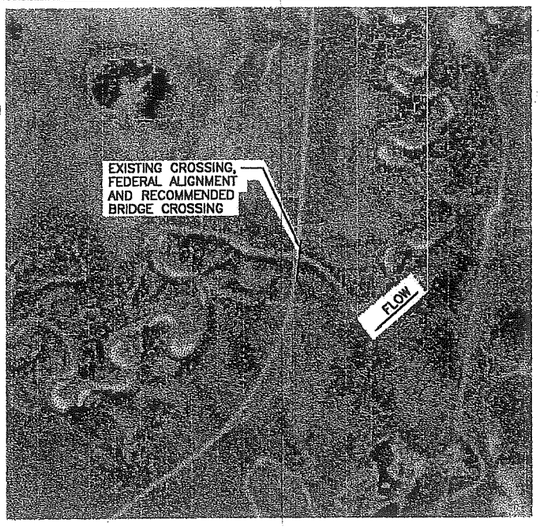
ELEVATION — ALTERNATE SPAN
(LOOKING D/S) 1:200



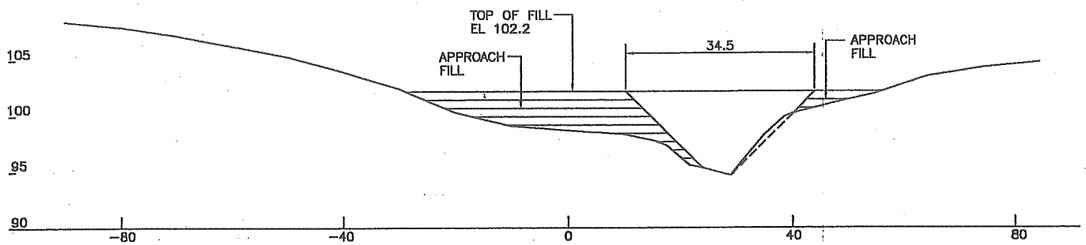
DECK SECTION
1:50



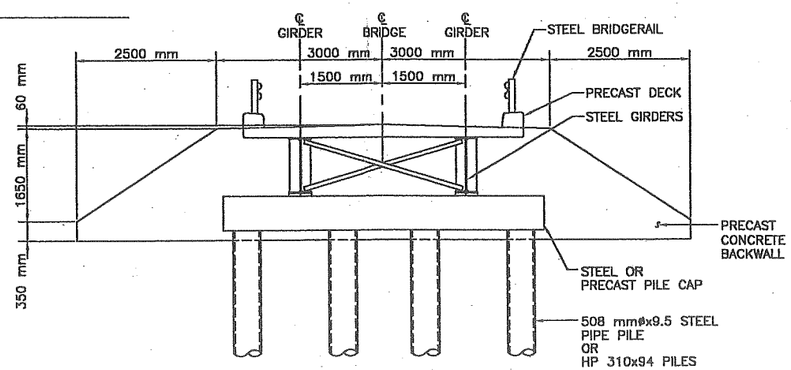
SITE MAP
1:50 000



AERIAL PHOTOGRAPH
1:6000



ROAD PROFILE
(LOOKING D/S) H — 1:500
V — 1:250



ABUTMENT ELEVATION
1:50

SITE INFORMATION

SITE 15
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE APPROX. 20 m SOUTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 29, 2001
WINTER ROAD km 1084.4
COORDINATES LAT 65°38'42.7" N
LONG 127°48'04.0" W
SITE MAP REFERENCE 96-E/12

HYDROTECHNICAL DATA

- DRAINAGE AREA = 214 sq. km
- DESIGN DISCHARGE = 100 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SLOPE OF STREAMBED = 0.00053 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 2.0 m/s
- ICE DESIGN ELEV. 100.2 m. ICE DESIGN THICKNESS 1.0 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA-S6-00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

HANNA RIVER
km 1084.4
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED	
Surveyed by	
Drawn by MAP	
Designed by SDS	Checked by SDS
Insignia	Insignia
Signature / Date	Signature / Date
Approved by	
Project No.	Page 16 of 22
Drawing No. 608-9-16	

4.17 Gibson Creek (South)

4.17.1 General

The Gibson Creek (South) winter road crossing is located at approximately km 1088.1 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 41' 59.2" N and Long. 127° 53' 32.4" W.

A field investigation of the site was done on August 29, 2001. A preliminary survey of the centerline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking south on the winter road. Photos 2 and 3 show the existing crossing looking north and south respectively.

The winter road diverges from a straight alignment to cross the creek. Immediately upstream of the crossing the creek has a bend which could potentially move downstream.

Based on air photos the winter road alignment is about 900 m downstream of the federal alignment of the 1970's.

At the time of the inspection, the stream was 3 m wide and 0.25 m deep. The approach from the south is relatively straight and then the road curves sharply north of the crossing. There appears to be a good source of granular fill from the nearby mountain for approach fill construction. Fill could also be obtained from along the south approach.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment and the recommended structure.

4.17.2 Existing Information

Existing information included air photos, an environmental report for the winter road operation and a fisheries habitat assessment by FSC dated 1997.

There does not appear to have been any work done by DPW for the federal alignment crossing.

4.17.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information for the South Gibson Creek crossing consisted of topographic maps and air photos of the site as well as information from previous hydrotechnical studies for other bridge sites. The present winter road crossing is about 2.0 km downstream of the federal alignment crossing. No data was available for the federal alignment. A drainage area of 19.2 km^2 was obtained from a 1:50,000 scale topographic map. This topographic map did not have detailed enough elevation data to obtain a map slope for the crossing site. The maximum elevation in the basin obtained from the topographic maps is 560 m. Air photos taken in 1950, 1973 and 1981 were obtained for analysis. The 1950 photographs at 1:40,000 are the earliest available, the 1973 photographs at 1:12,000 are the largest scale available and the 1981 photographs at 1:50,000 are the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 20 m^3/s. The 50-year breakup discharge is also estimated to be about 20 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the present winter road crossing.

On the day of the survey the water was 0.5 m deep and 5.8 m wide at the winter road crossing, however, the water was deeper upstream of the riffle. The survey found the water surface slope to be 0.00036 over a 56 m length of channel.

Three high water marks were found near the winter road crossing, one on the upstream left bank and two other either side of the channel downstream of the crossing. The upstream high water mark was 1.1 m above the water level and the downstream high water marks were 1.1 and 1.2 m above the water level. At the cross section location these highwater marks would have elevations of 98.1 and 98.2 m respectively relative to the local benchmark. One ice scar was found in the bend upstream of the crossing. The ice scar was only 0.4 m above the water level which would be at an elevation of 97.4 m at the cross section location.

Both banks were well vegetated with grass and trees and appeared to be stable. The bed material was mostly silt except for some gravel deposited around some debris. There was debris in the channel both upstream and downstream of the winter road crossing.

3. River Engineering Analysis

The design high water level for the site was calculated to be 100.2 m, which is 3.2 m above the surveyed water level and 3.7 m above the bed. This level is the estimated 50 year ice jam elevation at this site. This level is 2.8 m higher than the observed ice scars and 2.0 m higher than the high water mark. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 101.2 m or greater.

Analysis of the air photos of the site indicate that some minor channel movement may have occurred downstream of the crossing between 1950 and 1973, however, the 1:40,00 scale of the 1950 air photos is quite small so that the channel details are not distinct. This is also true for the 1981 air photos. No changes in channel position were apparent in the 2001 air photos.

The present winter road crossing is immediately downstream of a bend. This bend has the potential to migrate downstream and cause erosion if the bridge crossing is placed in this location. It would be preferable to locate the bridge in line with the general road alignment because this crossing location is farther downstream of the bend.

The existing channel at the cross section location on the winter road is 5.8 m wide at the water surface and 10.0 m at the top of bank. The minimum undisturbed width of the channel should be 10.0 m at the top of the banks. This will allow the bottom width of the channel to be 4.0 m even if the vertical banks need to be modified to 2:1 slopes. With any further constriction there is a risk that the ice floes will not pass through the opening and ice jams will occur more frequently. The design open water elevation of 99.0 m would produce a mean velocity of about 0.9 m/s through this opening with 2:1 headslopes.

4.17.4 Environmental Considerations

An environmental assessment of the winter road crossing indicated the stream has a high potential for arctic grayling and longnose sucker spawning and rearing. It is also indicated that the stream has potential for over-wintering habitat.

The stream banks were well vegetated and appear to be stable. The winter road crosses immediately downstream of a bend and there is potential for erosion problem with fills unless the crossing is shifted downstream slightly.

4.17.5 Alternatives

The site is well suited to a single span steel girder bridge structure using driven piles for foundations. Alternative span arrangements or structural types are not considered feasible for this crossing. Based on the hydrotechnical review culverts are not considered suitable for this crossing.

Utilizing the existing winter road crossing has the potential for erosion problems on the approach fills and an alternative crossing using the straight alignment was considered.

Steel girders with timber or composite concrete decks were assessed and are considered to be very suitable for this site. A bridge length of 23.165 m is recommended as a suitable span for this site. Preliminary sizing of bridge girders indicate the bridge structure would consist of two welded wide flange girders as shown on the attached drawing.

4.17.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the structure is provided in the following table.

The estimated cost for construction of the stricture considered is $415,590.

4.17.7 Recommendation

The bridge crossing should be located approximately 20 m downstream of the existing winter road crossing to avoid an upstream bend. This would also result in a straight alignment for the bridge approaches.

The recommended structure consists of a 23.165 m single span bridge with a minimum bottom flange elevation of 101.2 m. A minimum undisturbed stream width of 10.0 m is recommended. Head slopes of 2H to 1V were used resulting in out to out of fills of 28.0 m at elevation 102.2 m.

Driven steel piles are recommended for the foundations. Steel girders with composite precast concrete deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.17.8 Summary

A single span bridge with an overall length of 23.165 m is recommended on a straight alignment approximately 20 m downstream of the existing winter road crossing for the Gibson Creek (South) winter road crossing.

Site	Gibson Creek (South)			
	RecommendedStructure - 23.165m Bridge			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	30000	1	30,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.2	5,000
Approaches - common fill	cu.m.	30	3600	108,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels				
fabricate and deliver	each	3400	8	27,200
Steel Girders				
fabricate and deliver	kg	1.15	11000	12,650
Steel and Deck Panel Erection	m	1500	23	34,500
Bridgerail	m	100	46	4,600
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		340,690
		Contingency(15%)		51,100
		Engineering(7%)		23,800
		Total		415,590

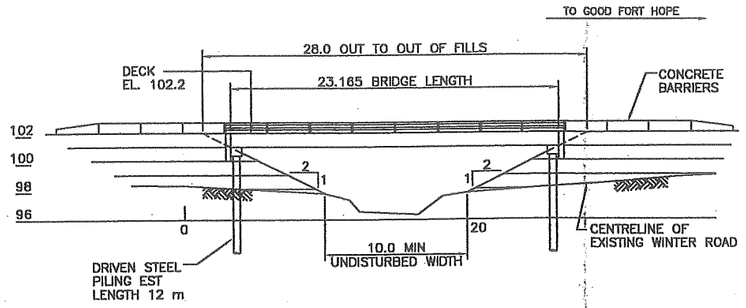
Photo 1 - Looking North on Winter Road (Stream Flow to Left)

Photo 2 - Looking North on Winter Road (Flow to Left)

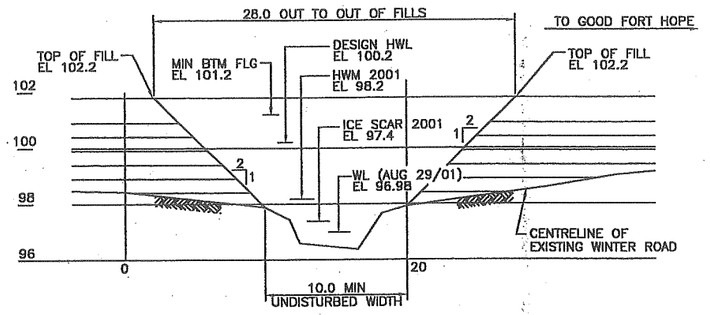
Photo No. 3 - Looking South on Winter Road

Photo 4 - Looking Upstream

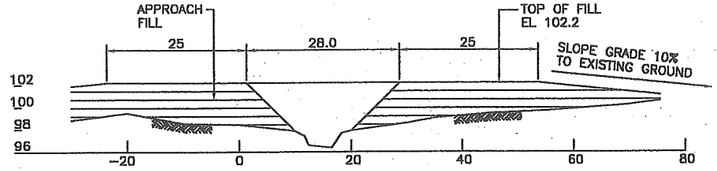
Photo 5 - Looking Downstream



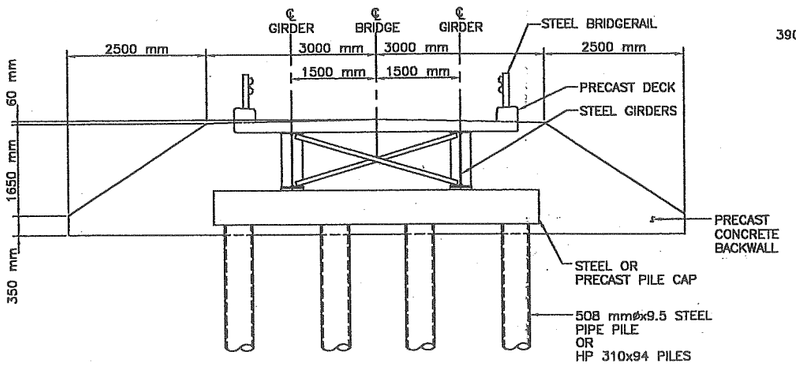
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



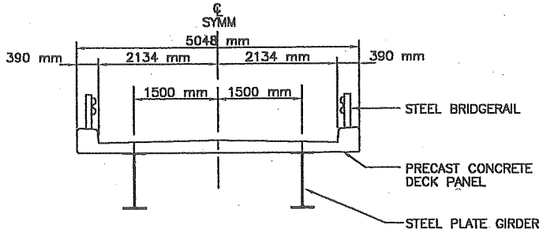
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



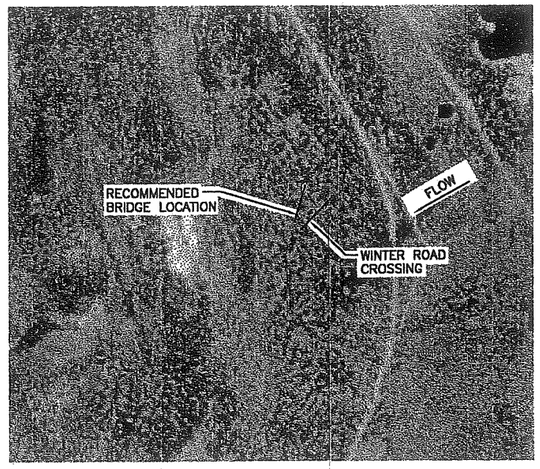
ROAD PROFILE
(LOOKING D/S) H – 1:500
V – 1:250



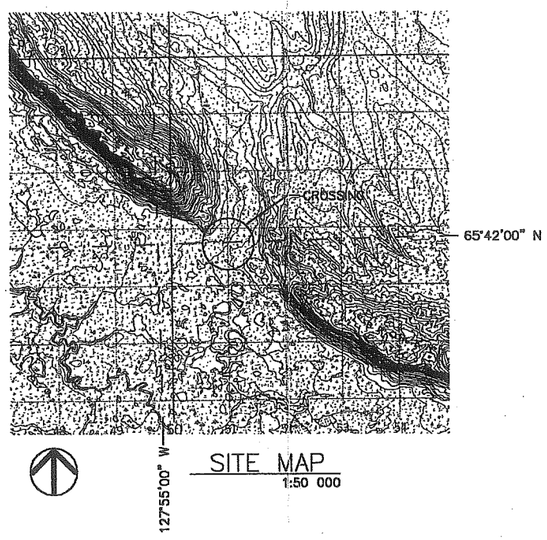
ABUTMENT ELEVATION
1:50



DECK SECTION
1:50



AERIAL PHOTOGRAPH
1:6000



SITE MAP
1:50 000

SITE INFORMATION

SITE 16 SOUTH
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN TREE APPROX. 10 m NORTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 29, 2001
WINTER ROAD km 1088
COORDINATES LAT 65°41'59.2" N
LONG 127°53'32.4" W
SITE MAP REFERENCE 96-E/12

HYDROTECHNICAL DATA

- DRAINAGE AREA = 19.2 sq. km
- DESIGN DISCHARGE = 20 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.00036 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 0.9 m/s
- ICE DESIGN ELEV. 100.2 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA-S6-00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

GIBSON CREEK (SOUTH)
km 1088
PRELIMIARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Insignia
Signature
Date
Approved by
Project No.
Page 17 of 22
Drawing No. 608-9-17A

4.18 Gibson Creek (North)

4.18.1 General

The Gibson Creek (North) winter road crossing is located at approximately km 1088.5 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 42' 28.6" N and Long. 127° 53' 13.1" W.

A field investigation of the site was done on August 29, 2001. A preliminary survey of the centerline of the existing crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking south on the winter road. Photos 2 and 3 show the existing crossing looking north and south respectively.

The winter road curves approximately 100 m before the crossing and crosses the stream on a 35° LHF skew.

Based on air photos the winter road alignment is about 850 m downstream of the federal alignment crossing.

At the time of the inspection, the stream was 4 m wide and 0.8 m deep. Banks are well vegetated and appear to be stable. The approaches on each side have soft, wet material to at least 75 m from the crossing. The streambed material is comprised mainly of silt.

Approach fill material appears to be available from the nearby mountain.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment and the recommended structure.

4.18.2 Existing Information

Existing information included air photos, an environmental report for the winter road operation and a fisheries habitat assessment by FSC dated 1997.

There does not appear to have been any work done by DPW for the federal alignment crossing.

4.18.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information for the North Gibson Creek crossing consisted of topographic maps and air photos of the site as well as information from previous hydrotechnical studies for other bridge sites. The present winter road crossing is about 850 m downstream of the federal alignment crossing. No data was available for the federal alignment. A drainage area of 15.1 km^2 was obtained from a 1:50,000 scale topographic map. This topographic map did not have detailed enough elevation data to obtain a map slope for the crossing site. The maximum elevation in the basin obtained from the topographic maps is 560 m. Air photos taken in 1950, 1973 and 1981 were obtained for analysis. The 1950 photographs at 1:40,000 are the earliest available, the 1973 photographs at 1:12,000 are the largest scale available and the 1981 photographs at 1:50,000 are the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 18 m^3/s. The 50-year breakup discharge is also estimated to be about 18 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the present winter road crossing.

On the day of the survey the water was 0.7 m deep and 4.2 m wide at the winter road crossing. The survey found the water surface slope to be 0.00075 over a 31 m length of channel.

Two high water marks were found near the winter road crossing, one on the upstream left bank and the other on the left bank downstream of the crossing. Both high water marks were 0.9 m above the water level. At the cross section location these highwater marks would have elevations of 99.9 m relative to the local benchmark. One ice scar was found in the bend downstream of the crossing. The ice scar was only 0.5 m above the water level which would be at an elevation of 99.5 m at the cross section location.

Both banks were well vegetated with grass and trees and appeared to be stable. The bed material was mostly silt. There was debris in the channel both downstream and at the winter road crossing.

3. River Engineering Analysis

The design high water level for the site was calculated to be 101.3 m, which is 2.3 m above the surveyed water level and 3.0 m above the bed. This level is 1.8 m higher

than the observed ice scars and 1.4 m higher than the high water mark. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 102.3 m or greater.

Analysis of the air photos of the site indicate that the previous photos of the site were not distinct enough to provide information on channel movement. The present winter road crossing is in a short straight reach which appears suitable for the bridge crossing.

The existing channel at the cross section location on the winter road is 4.2 m wide at the water surface and 5.1 m at the top of bank. The minimum bottom width of the channel in the bridge section should be 3.5 m. This will allow ice and debris the pass unimpeded down the main channel. The design open water elevation of 100.1 m would produce a mean velocity of about 0.9 m/s through this opening with 2:1 headslopes.

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

4.18.4 Environmental Considerations

An environmental assessment of the stream indicated a high potential for arctic grayling and longnose sucker spawning and rearing. It is also indicated that the stream has potential for over-wintering habitat.

The winter road crosses immediately downstream of a bend and there is potential for erosion of approach fills unless the crossing is shifted downstream 20 to 30 m.

4.18.5 Alternatives

The site is well suited to a single span steel girder bridge structure using driven piles for foundations. Other alternative span arrangements or structural types are not considered feasible for this crossing. Based on the hydrotechnical review, culverts are not considered suitable for this crossing.

The stream crosses the road on a 35° LHF skew; therefore, two alternate spans were considered. A skewed bridge with an overall length of 21.336 m and a square bridge with an overall length of 25.908 m were considered.

Steel girders with timber or composite concrete decks were assessed and are considered to be very suitable for this site. A bridge length of 25.908 m is recommended as a suitable span for this crossing. Preliminary sizing of bridge girders indicate the bridge structure would consist of two welded wide flange girders as shown on the attached drawing.

4.18.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table.

The estimated costs for construction are as follows:

25.908 m single span bridge (on square)	$464,190
21.336 m single span bridge (on skew)	$479,860

4.18.7 Recommendation

The recommended structure consists of a 25.908 m single span bridge with a minimum bottom flange elevation of 102.3 m. A minimum undisturbed stream width of 3.5 m at elevation 98.5 m is recommended. Head slopes of 2H to 1V were used resulting in out to out of fills of 23.9 m at elevation 103.3 m.

Driven steel piles are recommended for the foundations. Steel girders with composite precast concrete deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.18.8 Summary

A single span bridge with an overall length of 25.908 m is recommended on the existing alignment for the Gibson Creek (North) winter road crossing.

Site	Gibson Creek (North)			
	Recommended Structure - 25.908m Bridge (on Square)			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	55,000	1	55,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Approaches - common fill	cu.m.	30	3700	111,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels				
fabricate and deliver	each	3400	9	30,600
Steel Girders				
fabricate and deliver	kg	1.15	15000	17,250
Steel and Deck Panel Erection	m	1500	23	34,500
Bridgerail	m	100	52	5,200
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		372,290
		Contingency(15%)		55,800
		Engineering(7%)		26,100
		Total		454,190
	Alternative - 21.336m Bridge on Skew			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	55,000	1	55,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Approaches - common fill	cu.m.	30	3700	111,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	120	3,360
Deck Panels				
fabricate and deliver	each	3400	7	23,800
Steel Girders				
fabricate and deliver	kg	3.75	12000	45,000
Steel and Deck Panel Erection	m	1500	23	34,500
Bridgerail	m	100	42	4,200
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		393,360
		Contingency(15%)		59,000
		Engineering(7%)		27,500
		Total		479,860

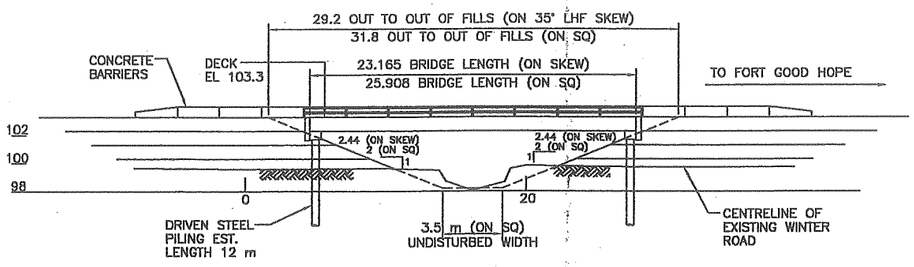
Photo 1 - Looking South on Winter Road (Stream Flow to Left)

Photo 2 - Looking North on winter road. (Stream flow to right).

Photo No. 3 - Looking South on Winter Road

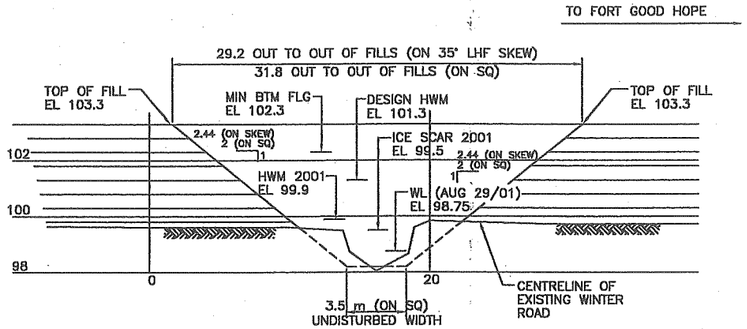
Photo 4 - Looking Upstream

Photo 5 - Looking Downstream



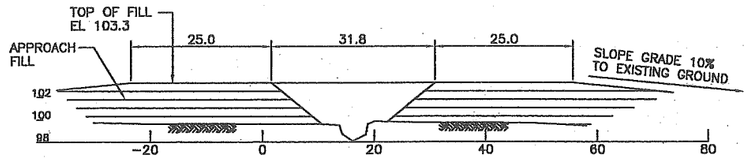
ELEVATION – NATURAL SCALE

(LOOKING U/S) 1:200



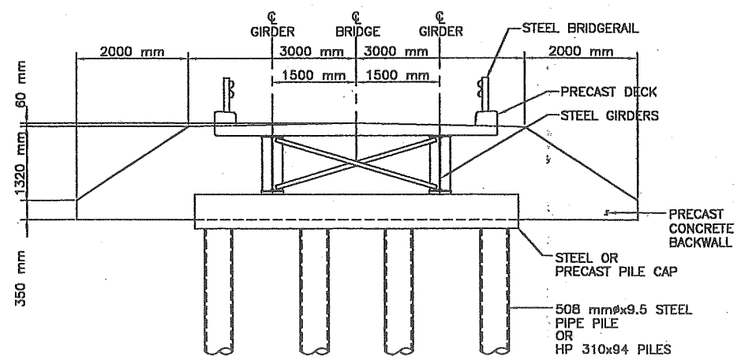
ELEVATION

(LOOKING U/S) H – 1:200 V – 1:100



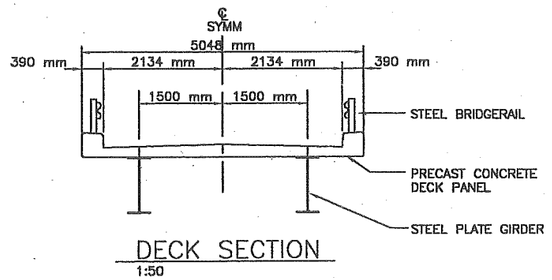
ROAD PROFILE

H – 1:500
V – 1:250



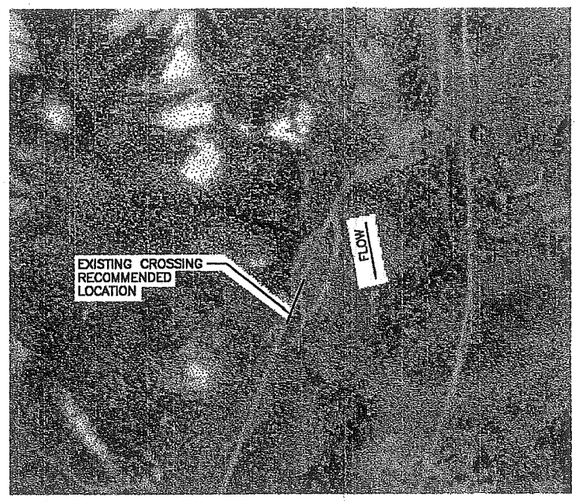
ABUTMENT ELEVATION

1:50



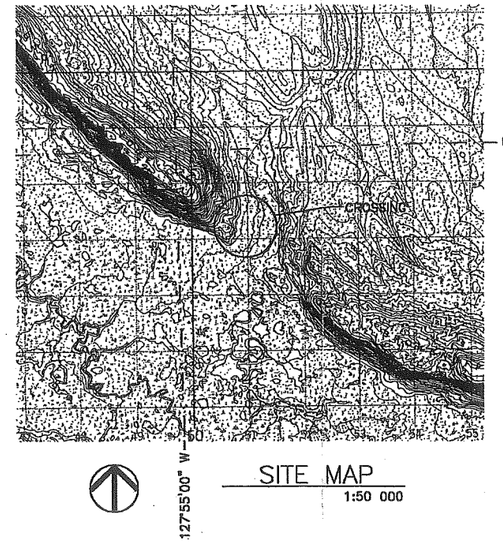
DECK SECTION

1:50



AERIAL PHOTOGRAPHY

1:6000



SITE MAP

1:50 000

SITE INFORMATION

SITE 16A
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN STUMP APPROX. 20 m SOUTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 29, 2001
WINTER ROAD km 1088.5
COORDINATES LAT 65°42'28.6" N
LONG 127°53'13.1" W
SITE MAP REFERENCE 96–E/12

HYDROTECHNICAL DATA

- DRAINAGE AREA = 15.1 sq. km
- DESIGN DISCHARGE = 18 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.00075 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 0.9 m/s
- ICE DESIGN ELEV. 101.3 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA–S6–00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

GIBSON CREEK (NORTH)
km 1088.5
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Insignia
Signature
Date
Signature
Date
Approved by
Project No.
Page 18 of 22
Drawing No. 608–8–17B

4.19 Snafu Creek

4.19.1 General

The Snafu Creek winter road crossing is located at km 1124.0 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 65° 59' 15.9" N and Long. 128° 18' 00.1 W.

A field investigation of the site was done on August 27, 2001. A preliminary survey of the centerline of the existing winter road crossing was done and a temporary benchmark established as reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking south on the winter road. Photos 2 and 3 show the existing crossing looking north and south respectively.

The existing crossing is located approximately 100 m upstream of the federal alignment done by DPW in the 1970's.

The federal alignment crosses the stream on a straight alignment and appears to have stable banks. The winter road crossing is located in the middle of a large meander loop that may be more susceptible to channel migration.

At the present crossing, the banks are well vegetated and appear to be stable. The streambed was cobbled with stone sizes ranging from 25 mm to 100 mm diameter.

The alignment to the present crossing is good from the north. A small curve was noted on the approach from the south.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment and the recommended structure.

4.19.2 Existing Information

South Snafu (Denise Creek) had a preliminary bridge design done by DPW in 1974. A recommended structure at that time was a 32.918 m (108 ft) span with a minimum 2.13 m (7 ft) clearance above the high water level, resulting in the bottom flange being approximately 5 m above streambed.

Additional information included air photos of the site, an environmental assessment of the winter road operation for the crossing, and a fish habitat assessment by FSC in 1997.

4.19.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information consisted of topographic maps and air photos of the site as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. A drainage area of 78 km^2 was obtained from the federal alignment study. The present winter road crossing is about 100 m upstream of the federal alignment crossing. There is no significant difference in the drainage area between the sites. The federal alignment study reported a surveyed stream slope of about 0.0041. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.0040. The maximum elevation in the basin obtained from the topographic maps is 690 m. Air photos taken in 1950 and 1973 were obtained for analysis. The 1950 photographs at 1:40,000 are the earliest available and the 1973 photographs at 1:12,000 are the largest scale available and the most recent.

The previous hydrotechnical study for the federal alignment also provided additional hydrotechnical information. A high water mark was observed 2.9 m above the bed, however, the reference bed level was in a shallow pool 0.4 m deep. The height of the high water mark above the upstream riffle was 2.5 m. This previous study estimated the design discharge to be 79 m^3/s with a design water level 3.2 m above the bed at the upstream riffle.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 58 m^3/s. This is somewhat less that the design discharge specified in the federal alignment study. The 50-year breakup discharge is also estimated to be about 58 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the present winter road crossing.

On the day of the survey the water was 0.1 m deep and 4.8 m wide at the winter road crossing, however, the water was deeper upstream of the riffle. The survey found the water surface slope to be 0.0060 over a 21.8 m length of channel.

Two high water marks were found near the winter road crossing, one on the upstream left bank and the other on the downstream right bank. The upstream high water mark was about 1.25 m above the water level and the downstream high water mark was about 1.8 m above the water level. At the cross section location these highwater marks would have elevations of 97.5 and 98.1 m respectively relative to the local benchmark. Ice scars were also found both upstream and downstream of the crossing. The ice scars were between 1.7 and 2.0 m above the water level. These ice scars would be at elevations of between 98.0 and 98.3 m at the cross section location.

Both banks were well vegetated with grass and trees. The banks appeared to be stable, however, some trees are leaning over the channel on the upstream left bank so there may be some erosion occurring in this area. The bed material was sampled using a line sample technique on an exposed portion of the riffle at the winter road crossing. The median diameter (D_{50}) of the bed material is 40 mm while the largest stones (D_{90}) are about 70 mm in diameter. The material on the riffle is mostly gravel with some cobble and silt. The bed material in the deeper parts of the channel appears to be composed of smaller stones.

3. River Engineering Analysis

The design high water level for the site was calculated to be 99.4 m, which is 3.2 m above the surveyed water level and 3.3 m above the bed. This level is the estimated 50 year ice jam elevation at this site. This level is 1.1 m higher than the observed ice scars and 0.6 m higher than the 1973 high water mark. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis The minimum flange elevation should be 100.4 m or greater.

Air photos of the site indicate that, between 1950 and 1973, the channel has shifted as much as 30 m to the north near the lake downstream of the site. The channel appears to be stable at the federal alignment and at the winter road crossing, however, the scale of the earlier photos is too small to detect movements of less than 10 m. The site observations indicate that some erosion may be occurring on the left bank upstream of the winter road crossing. The upstream side of this bend may be migrating down-valley, however, the recent large scale air photos need to be assessed to determine if any significant bank migration has occurred since 1973.

The federal alignment appears to be a more suitable location for the bridge crossing than the winter road crossing because it crosses in a straight reach that has less potential for channel migration. The straight reach is also likely to require less channel control.

The existing channel at the cross section location on the winter road is 4.8 m wide from bank to bank. The preferred crossing at the federal alignment is wider, approximately 7 m wide. The minimum undisturbed width of the channel should be 7.0 m pass the design discharge without excessive velocity at the winter road or infringing on the channel at the federal alignment. The design open water elevation of 98.2 m would produce a mean velocity of about 3.4 m/s through an opening with a 7 m bottom width and 2:1 headslopes at the winter road crossing.

4.19.4 Alternatives

The site is well suited to a single span steel girder bridge structure using driven steel piles for the foundations. Alternate span arrangements or structural types are not considered feasible for this crossing. A geotechnical investigation has not been done for this site nor for the federal alignment crossing.

Based on the hydrotechnical review culverts are not considered suitable for this crossing.

The federal alignment was considered as a suitable alternative as it crosses the stream on a straight reach having less potential for channel movement. The existing crossing is also considered a suitable alternative, but would likely require more channel control and approach embankment protection works.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for this site. A bridge length of 21.336 m is recommended as a suitable span for this site. Preliminary sizing of bridge girders indicates the structure would consist of two welded wide flange girders as shown on the attached drawing.

4.19.5 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the structure is provided in the following table.

The estimated costs of construction are as follows:

21.336 m single span bridge with timber deck.	$344,965
21.336 m single span bridge with precast deck.	$381,385

4.19.6 Recommendations

The preferred crossing is at the federal alignment location approximately 100 m upstream of the present winter road crossing, however the existing location is also considered suitable.

The recommended structure consists of a 21.336 m single span bridge with a minimum bottom flange elevation of 100.4 m. A minimum undisturbed creek width of 7.0 m is recommended. Head slopes of 2H to 1V were used resulting in out to out of fills of 26.2 m at elevation 101.4 m.

Driven steel piles are recommended for the foundations. Steel girders with composite precast concrete deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.19.7 Summary

A single span bridge with an overall length of 21.336 m with either the timber deck ore precast deck system is recommended on the federal alignment approximately 100 m upstream of the existing crossing for the Snafu Creek winter road crossing.

Site	Snafu Creek			
	Recommended Structure - 21.336m Bridge = Timber Deck			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	45,000	1	45,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	3500	105,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Timber Decking	sq.m.	100	105	10,500
Steel Girders				
fabricate and deliver	kg	1.15	10300	11,845
Bridge Erection	lump sum	15000	1	15,000
Bridgerail	m	100	42	4,200
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		282,785
		Contingency(15%)		42,400
		Engineering(7%)		19,800
		Total		344,985

	Alternative Structure - 21.336m Bridge - Precast Deck			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	45000	1	45,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	3500	105,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels				
fabricate and deliver	each	3400	7	23,800
Steel Girders				
fabricate and deliver	kg	1.15	10300	11,845
Steel and Deck Panel Erection	m	1500	21	31,500
Bridgerail	m	100	42	4,200
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		312,585
		Contingency(15%)		46,900
		Engineering(7%)		21,900
		Total		381,385

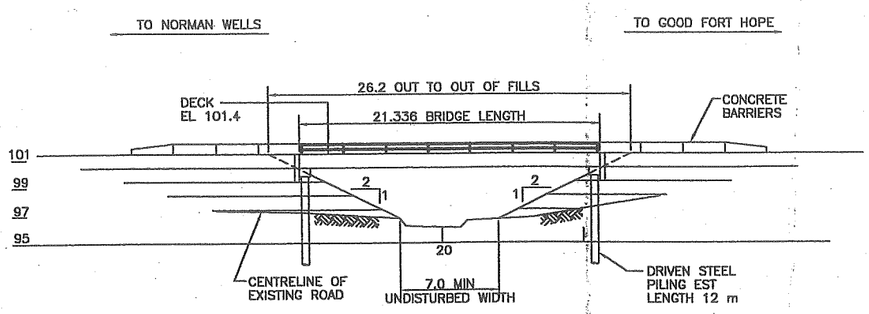
Photo 1 - Looking South on Winter Road (Stream Flow to Right)

Photo 2 - Looking North on Winter Road (Flow to Left)

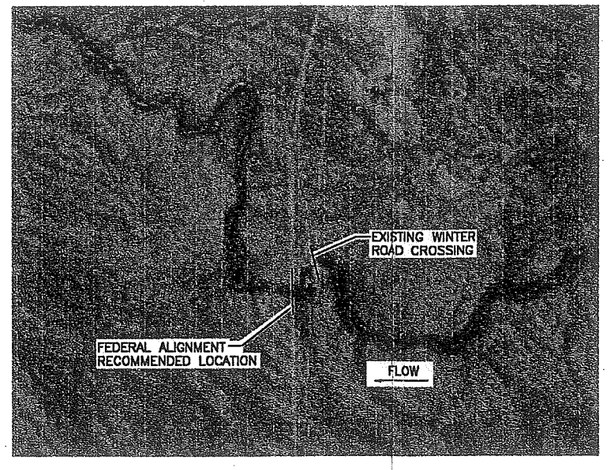
Photo No. 3 - Looking South on Winter Road

Photo 4 - Looking Upstream

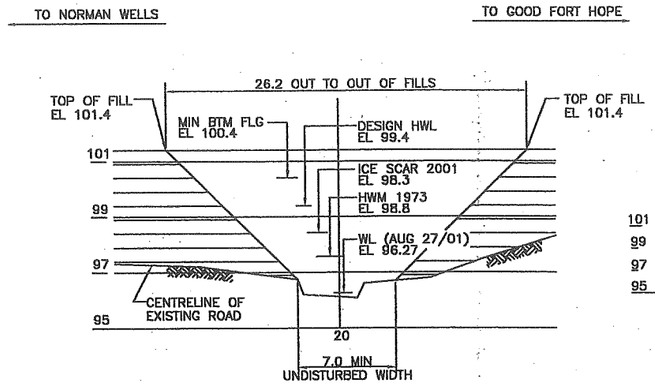
Photo 5 - Looking Downstream



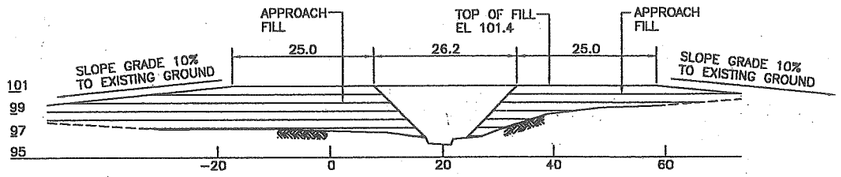
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



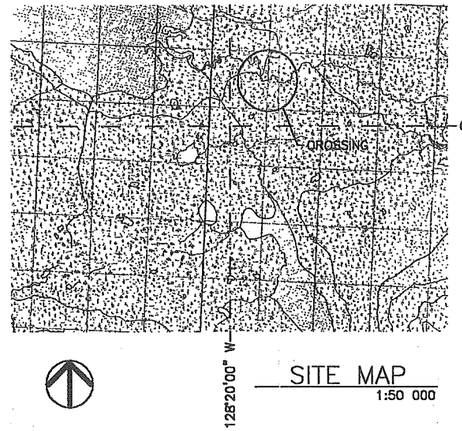
AERIAL PHOTOGRAPH
1:6000



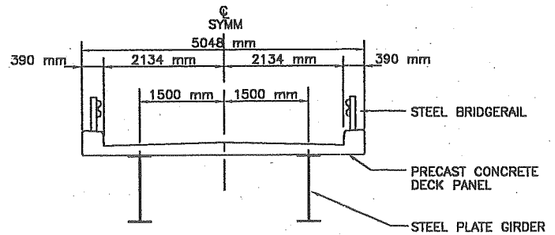
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



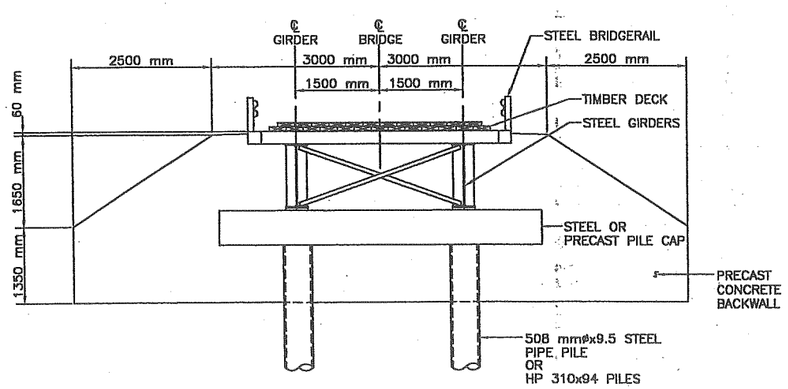
ROAD PROFILE
(LOOKING D/S) H – 1:500
V – 1:250



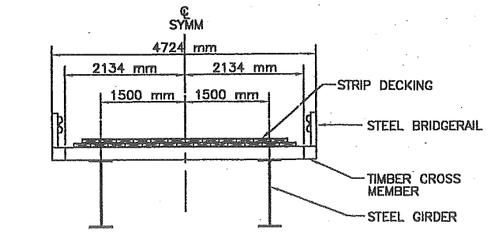
SITE MAP
1:50 000



DECK SECTION – PRECAST
1:50



ABUTMENT ELEVATION
1:50



DECK SECTION – TIMBER
1:50

SITE INFORMATION

SITE 17
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN STUMP APPROX. 20 m NORTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 27, 2001
WINTER ROAD km 1124.0
COORDINATES LAT 65°59'15.9" N
LONG 126°18'00.1" W
SITE MAP REFERENCE 106–H/16

HYDROTECHNICAL DATA

- DRAINAGE AREA = 78 sq. km
- DESIGN DISCHARGE = 58 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0060 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 3.4 m/s
- ICE DESIGN ELEV. 99.4 m. ICE DESIGN THICKNESS 1.0 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA–S6–00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

SNAFU CREEK
km 1124.0
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Insignia
Signature
Date
Approved by
Project No.
Page 19 of 22
Drawing No. 608–9–18

4.20 Rachelle Creek

4.20.1 General

The Rachelle Creek winter road crossing is located at km 1135.5 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 66° 00' 26.8" N and Long. 128° 20' 44.2" W.

A field investigation of the site was done on August 27, 2001. A preliminary survey of the centerline of the existing crossing was done and a temporary benchmark established as a reference to a future detailed survey.

Photo 1 shows an aerial view of the site looking south on the winter road and Photo 2 shows the proximity of the lake downstream. Photo 3 and 4 show the existing crossing looking north and south respectively across the crossing.

The present crossing is located approximately 400 m downstream of the federal alignment and approximately 700 m upstream of the straight winter road alignment. This crossing has likely been moved upstream away from the open lake area where blowing snow would cause visibility problems.

The existing road alignment has sharp bends on each side of the river as shown on the aerial photographs. The stream has stable banks about 2 m high.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment and the recommended structure.

4.20.2 Existing Information

Existing information included air photos and an environmental report on the winter road operation. There was indication of work done by DPW in the 1920's possibly including a bridge design but detailed records were not available at this time.

4.20.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

   Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. A drainage area of 161 km^2 was obtained from the federal alignment study. The present winter road crossing is about 400 m downstream of the federal alignment crossing. There is about 8 km^2 of additional drainage area between

the sites so the drainage area at the winter road crossing is 169 km^2. The slope of the channel is affected by the lake 800 m downstream of the winter road crossing. The federal alignment study reported a surveyed stream slope of about 0.0001. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.0020. The maximum elevation in the basin obtained from the topographic maps is 220 m. Air photos taken in 1950 and 1973 were obtained for analysis. The 1950 photographs at 1:40,000 are the earliest available and the 1973 photographs at 1:12,000 are the largest scale available and the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

The previous hydrotechnical study for the federal alignment also provided additional hydrotechnical information. A high water mark was observed 3.2 m above the bed and 2.0 m above the surveyed water level. This previous study estimated the design discharge to be 88 m^3/s with a design water level 4.4 m above the bed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 84 m^3/s. The 50-year breakup discharge is estimated to be about 84 m^3/s as well.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed at the present winter road crossing.

On the day of the survey the water was 1.5 m deep and 16.6 m wide. The survey found the water surface slope to be essentially horizontal over a 78 m length of channel.

Two high water marks were found near the winter road crossing, one on the upstream left bank and the other on the downstream right bank. Both of these high water marks were about 1.9 m above the water level and would be at an elevation of 99.3 m relative to the local benchmark. Ice scars were also found both upstream and downstream of the crossing. The ice scars were between 1.6 and 2.1 m above the water level. These ice scars would be at elevations of between 99.0 and 99.5 m at the cross section location.

Both banks were well vegetated with grass and trees. The banks appeared to be stable. The bed material was sampled using a line sample technique on an exposed bar downstream of the winter road crossing. The median diameter (D_{50}) of the bed material is 20 mm while the largest stones (D_{90}) are about 42 mm in diameter. The bed material is mostly gravel with some silt and cobble.

2. River Engineering Analysis

The design high water level for the site was calculated to be 100.7 m, which is 3.2 m above the surveyed water level and 4.7 m above the bed. This level is the maximum expected ice jam elevation at this site. It is expected that ice jams will form frequently at this site because the ice in the downstream lake will block the ice transport. This level is 1.2 m higher than the observed ice scars. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge and to allow for some uncertainty in the hydraulic analysis. The minimum flange elevation should be 101.7 m or greater.

Air photos of the site indicate that the channel has remained relatively stable between 1950 and 1973, however, the air photos do show evidence of some meander loops cutoff before 1950. The straight reach near the federal alignment has migrated about 10 m to the right and the center of the tight meander between the federal alignment and the winter road crossing has shifted 20 m downstream. Site observations did not indicate any major changes in the channel position since 1973. No changes in channel position were apparent in the 2001 air photos as well.

Presently, the winter road crosses the channel about 700 m upstream of where the actual straight alignment crosses the channel. The straight alignment would place the crossing very near to the lake. The crossing was likely moved upstream to avoid blowing snow from the lake. Both the present winter road crossing and the federal alignment appear to be suitable from a river engineering respectively.

The minimum undisturbed width of the channel would need to be 17 m to leave the bed of the existing channel at the cross section location undisturbed. The channel in the vicinity of the federal alignment appears to be narrower, about 9 m wide. This narrower bottom width is suitable for the winter road crossing as well since the low slope caused by the lake will result in low velocities through the constriction. A discharge of 84 m^3/s combined with the observed high water mark elevation of 99.3 m would only produce a mean velocity of about 2.2 m/s through an opening with a 9 m bottom width and 2:1 headslopes.

4.20.4 Environmental Considerations

The environmental assessment of the winter road indicates the stream has good habitat for Arctic grayling, longnose sucker spawning and rearing. Northern pike and slimy sculpin would also be present.

4.20.5 Alternatives

The site is well suited to a single span steel girder bridge structure using steel piles for the foundations. Alternative span arrangements or structural types are not considered feasible for this crossing. A geotechnical investigation has not been done at this time, but a previous investigation may have been done for the federal alignment. Culverts are not considered a suitable alternative for this site.

If the existing crossing were utilized, a realignment of the winter road would be required to provide a straight approach to the bridge. Using the straight winter road alignment was not considered suitable due to blowing snow from off the lake.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable be this site. A bridge length of 23.774 m (78 ft) is recommended as a suitable span for this site. Preliminary sizing of the bridge girders indicates the bridge structure would consist of two welded wide flange girders as shown on the attached drawing.

4.20.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the structure is provided in the following table.

The estimated costs for construction are as follows:

23.774 m single span bridge with timber deck.	$554,640
23.774 m single span bridge with precast deck.	$592,740

4.20.7 Recommendation

The bridge crossing would be located at the existing winter road crossing and the winter road alignment should be adjusted to provide straight approaches to the bridge. The recommended structure consists of a 23.774 m single span bridge with a minimum bottom flange elevation of 101.7 m. A minimum undisturbed stream width of 9.0 m is recommended. Head slopes of 2H to 1V were used resulting in an out to out of fills of 34.4 m at elevation 102.7.

Driven steel piles are recommended for the foundations. Steel girders with composite precast concrete deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, hydrotechnical assessment, and the recommended structure.

4.20.8 Summary

A single span bridge with an overall length of 23.774 m with either the timber deck or precast deck system is recommended at the existing crossing and realignment of the winter road to provide straight approaches is also recommended for the Rachelle Creek winter road crossing.

Site	Rachelle Creek			
	Recommended Structure - 23.774m Bridge - Timber Deck			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	65,000	1	65,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	2	50,000
Approaches - common fill	cu.m.	30	5600	168,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Timber Decking	sq.m.	100	120	12,000
Steel Girders fabricate and deliver	kg	1.15	14000	16,100
Bridge Erection	lump sum	20000	1	20,000
Bridgerail	m	100	48	4,800
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		454,640
		Contingency(15%)		68,200
		Engineering(7%)		31,800
		Total		554,640

	Alternative Structure - 23.774m Bridge - Precast Deck			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	65,000	1	65,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	2	50,000
Approaches - common fill	cu.m.	30	5600	168,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels fabricate and deliver	each	3400	8	27,200
Steel Girders fabricate and deliver	kg	1.15	14000	16,100
Steel and Deck Panel Erection	m	1500	24	36,000
Bridgerail	m	100	48	4,800
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels supply and deliver	each	4500	2	9,000
		Sub-Total		485,840
		Contingency(15%)		72,900
		Engineering(7%)		34,000
		Total		592,740

Photo 1 - Looking South on Winter Road (Stream Flow to Right)

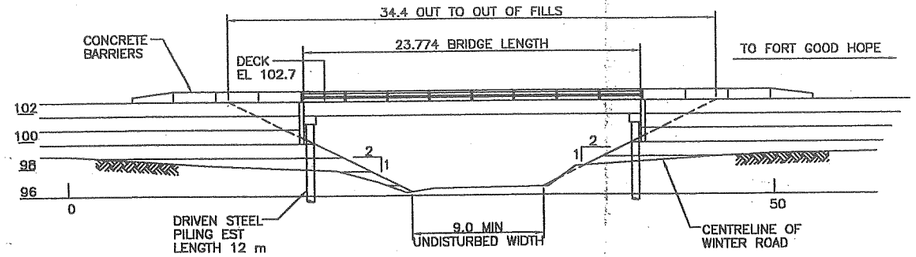
Photo 2 - Looking Downstream toward Lake

Photo No. 3 - Looking North on Winter Road (Flow to Left)

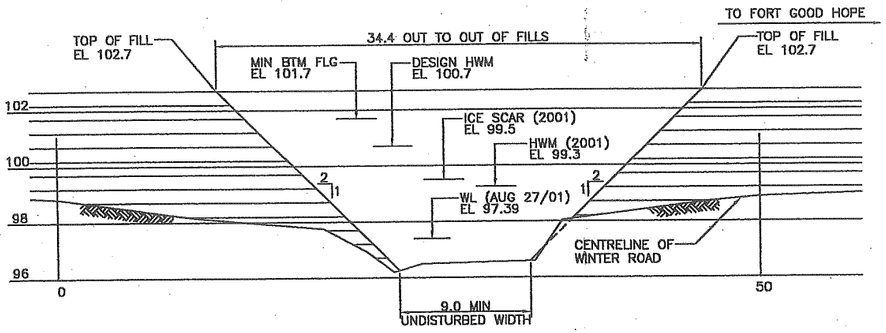
Photo 4 - Looking South on Winter Road

Photo 5 - Looking Upstream

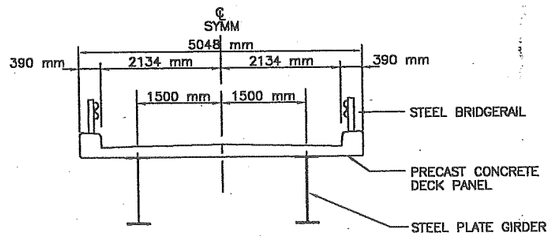
Photo 6- Looking Downstream



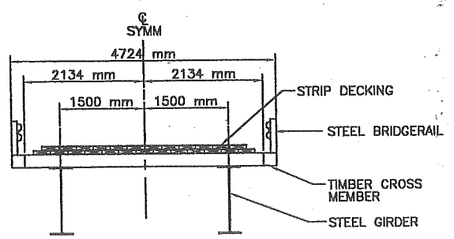
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



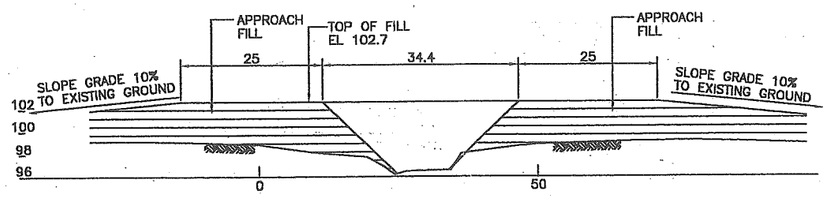
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



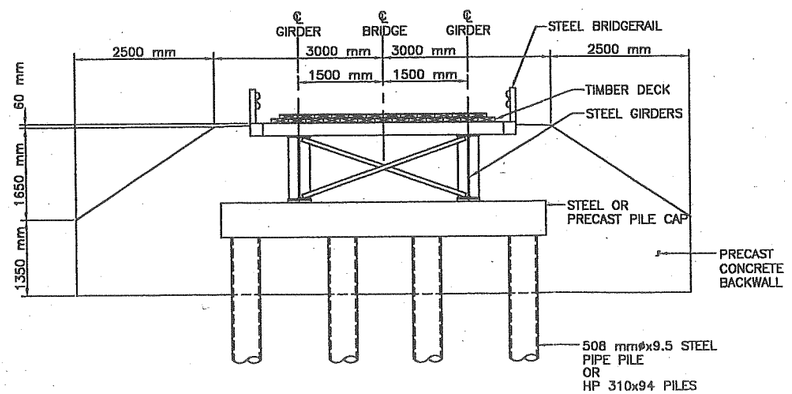
DECK SECTION – PRECAST
1:50



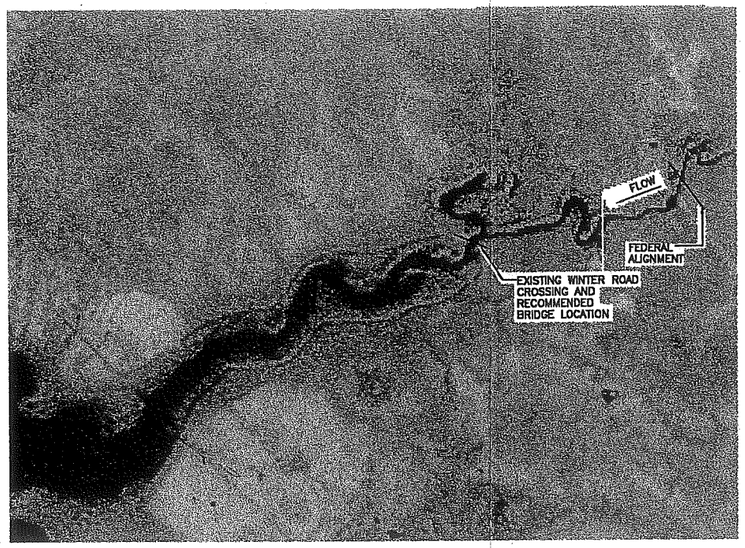
DECK SECTION – TIMBER
1:50



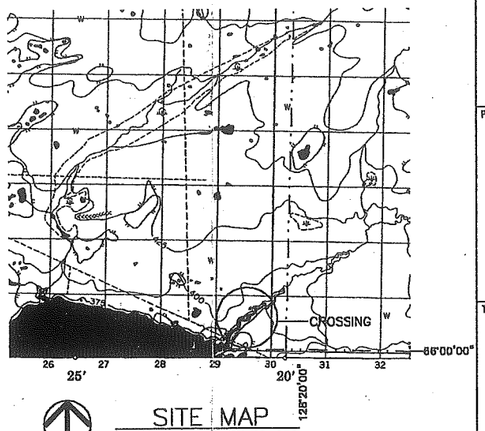
ROAD PROFILE
H – 1:500
V – 1:250



ABUTMENT ELEVATION
1:50



AERIAL PHOTOGRAPH
1:6000



SITE MAP
1:50 000

SITE INFORMATION

SITE 18
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN STUMP APPROX. 10 m SOUTH OF CROSSING
SURVEY ON CENTRELINE OF EXISTING WINTER ROAD CROSSING
SURVEYED AUGUST 27, 2001
WINTER ROAD km 1135.5
COORDINATES LAT 66°00'26.8" N
LONG 128°20'44.2" W
SITE MAP REFERENCE 106–I/1

HYDROTECHNICAL DATA

- DRAINAGE AREA = 169 sq. km
- DESIGN DISCHARGE = 84 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0001 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 2.2 m/s
- ICE DESIGN ELEV. 100.4 m. ICE DESIGN THICKNESS 1.0 m
- ICE CLASS 'b' 700 kPa TO CAN/CSA–S6–00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

Northwest Territories Transportation

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5810–104 STREET
EDMONTON, AB
FAX (780)435–4843
PH. (780)436–5376

Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

RACHELLE CREEK
km 1135.5
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Signature
Date
Approved by
Project No.
Page 20 of 22
Drawing No. 608–9–19

4.21 Tsintu River

4.21.1 General

The Tsintu River winter road crossing is located at km 1154.4 on the Mackenzie Valley winter road. GPS coordinates of the site are Lat. 66° 07' 50.3" N. and Long. 128° 29' 22.9" W.

A field investigation of the site was done on August 27, 2001. A preliminary survey of the centreline of the straight alignment of the winter road was done, and a temporary benchmark established as reference to a future detailed survey. This location is approximately 50 m upstream of the existing crossing.

Photo 1 shows an aerial view of the site looking north on the winter road (stream flow to the left). Presently the winter road crossing is located approximately 50 m downstream of the straight alignment. This location crosses on a straight reach of the stream. See Photo 2. The winter road curves to cross the stream then returns to the straight alignment. The federal alignment is approximately 700 m upstream of the present winter crossing.

The right bank is relatively steep and approximately 3.5 m in height while the left bank is shallower. Some slumping was noted on the right bank.

The attached drawing indicates the preliminary site survey done, the hydrotechnical assessment and the recommended structure.

4.21.2 Existing Information

Tsintu River had a preliminary design done by Public Works Canada in 1974. The recommended structures were a 32.92 m (108 ft) single span or three span arrangements. Geotechnical information was not available for the federal alignment. The bottom flange of the structure was set at 3.05 m (10 ft) above high water level which was approximately 4.5 m above the streambed.

Additional information included an environmental report on the winter road operation and a fish habitat assessment by FSC in 1997.

4.21.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. A drainage area of 353 km^2 was obtained from the federal alignment study. The present winter road crossing is about 700 m downstream of the federal alignment crossing. There is about 1 km^2 of additional drainage area between the sites so the drainage area at the winter road crossing is 354 km^2. The federal alignment study also reported a surveyed stream slope of 0.0027. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.0011. The maximum elevation in the basin obtained from the topographic maps is 350 m. Air photos taken in 1945 and 1973 were obtained for analysis. The 1945 photographs at 1:28,000 are the earliest available and the 1973 photographs at 1:12,000 are the largest scale available and the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

The previous hydrotechnical study for the federal alignment also provided additional hydrotechnical information. An ice scar was observed 3.3 m above the bed. This previous study estimated the design discharge to be 184 m^3/s with a design water level 4.1 m above the bed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 136 m^3/s. This is somewhat less that the design discharge specified in the federal alignment study, however, with low relief and numerous lakes in the basin, this lower value is more appropriate. The 50-year breakup discharge is estimated to be about 136 m^3/s as well.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size. The cross section was surveyed in line with the straight road alignment.

On the day of the survey the water was 1.7 m deep and 16.4 m wide. The survey found the water surface slope over a 50 m length of channel to be 0.0087. The river flows 0.25 m deep over a riffle 2 m wide just downstream of the winter road crossing. The velocity over this riffle was about 0.4 m/s.

A high water mark was found upstream of the winter road crossing on the right side of the channel. This high water mark was 2.0 m above the water level. At the cross section location, this high water mark would be at an elevation of 99.8 m relative to the local benchmark. Ice scars were also found both upstream and downstream of the crossing. The ice scars were between 3.0 and 3.6 m above the water level. An old ice scar just under a recent ice scar on one tree indicates that ice at these elevations is not

a rare occurrence. These ice scars would be at elevations of between 100.4 and 101.0 m at the cross section location.

Both banks were well vegetated with grass, willows and trees. The right bank at the winter road was slumping, likely due to erosion on the outside of the bend. The bed material was sampled using a line sample technique. The median diameter (D_{50}) of the bed material is 60 mm while the largest stones (D_{90}) are about 160 mm in diameter. The larger stones are cobble sizes while the finer material is gravel.

3. River Engineering Analysis

The design high water level for the site was calculated to be 102.2 m, which is 4.4 m above the surveyed water level and 5.9 m above the bed. This level is 1.2 m above the level of the highest observed ice scar. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge, to allow for some uncertainty in the hydraulic analysis and to allow for the effects of downstream flow blockages such as beaver dams. The minimum flange elevation should be 103.2 m or greater.

Air photos of the site indicate that the channel has remained stable between 1945 and 1973, however, the air photos do show evidence of some meander loops cutoff before 1945. Site observations did not indicate any major changes in the channel position since 1973. No changes in channel position were apparent in the 2001 air photos as well.

Presently, the winter road crosses the channel about 50 m downstream of where the actual straight alignment crosses the channel. The straight alignment would place the crossing in a moderately sharp bend to the left. This bend curvature appears to be causing erosion which has produced the observed slumping of the right bank. As well, this location is just downstream of a narrow meander loop which may be cutoff in the future. It would be preferable to place the crossing in the middle of the downstream straight reach near the present winter road crossing or on the original federal alignment. Both of the potential crossings are located in stable, straight reaches where the affects of erosion and meander cutoff would be minimized.

The minimum undisturbed width of the channel would need to be 16.4 m to leave the bed of the existing channel at the cross section location undisturbed. The preferred downstream crossing location appears to be narrower, approximately 10 m wide. The design open water elevation of 101.0 m would produce a mean velocity of about 1.8 m/s through an opening with a 10 m bottom width with 2:1 headslopes.

4.21.4 Environmental Considerations

Tsintu River has been identified as having an abundance of spawning and rearing habitat for such species as yellow walleye, arctic grayling and longnose sucker, etc.

Some erosion was noted on the existing north approach and on the high banks of the straight alignment.

4.21.5 Alternatives

The site is well suited to a single span bridge structure supported on simple piled foundations. A geotechnical investigation has not been done at this time; however, driven piles are considered the most likely type of foundation.

The hydrotechnical review indicated that culverts were not a suitable option due to the size of the stream.

A source for the fill embankments appears to be available to the north of the crossing along the straight winter road alignment.

The straight alignment, although preferable from road geometry considerations, places the structure on a sharp bend of the stream and increases the potential for erosion of the approach fills. A longer span with additional bank protection works (riprap) would be necessary.

The existing winter road crossing is considered to be suitable and requires a shorter span than the straight alignment.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for this site. A bridge length of 30.48 m (100 ft) is recommended for the existing crossing while a bridge length of 33.528 m (110 ft) would be recommended for the straight alignment.

The bridge structure would consist of two welded steel plate girders as shown on the attached drawing.

High abutments using crib walls were considered for this site to reduce the span length to 27.432 m as the shorter girder lengths are preferred for hauling along the winter road.

4.21.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the alternative structures are provided in the following table. The estimated costs for construction are as follows:

30.48 m single span bridge.	$645,535
27.432 bridge (with crib wall abutments).	$660,400

4.21.7 Recommendations

The bridge should be located at the present winter road crossing to cross the stream on a straight reach and avoid the meander loop near the straight alignment.

The recommended structure consists of a 30.48 m single span bridge with a minimum bottom flange elevation of 103.2 m. A minimum undisturbed creek width of 10.0 m is recommended. Headslopes of 2H to IV were used resulting in an out to out of fills of 40.6 m at elevation 104.7 m.

Driven steel piles are recommended for the foundations. Steel girders with composite precast concrete deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.21.8 Summary

A single span bridge with an overall length of 30.48 m is recommended on the existing winter road crossing which is 50 m downstream of the straight road alignment for the Tsintu River winter road crossing.

Site	Tsintu River			
	Recommended Structure - 30.48m Bridge			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	75,000	1	75,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Approaches - common fill	cu.m.	30	7000	210,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	50	1,400
Deck Panels fabricate and deliver	each	3400	10	34,000
Steel Girders fabricate and deliver	kg	1.15	20900	24,035
Steel and Deck Panel Erection	m	1500	31	46,500
Bridgerail	m	100	62	6,200
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels supply and deliver	each	6000	2	12,000
		Sub-Total		529,135
		Contingency(15%)		79,400
		Engineering(7%)		37,000
		Total		645,535
	Alternative Structure (Crib Wall Abutments)			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	75,000	1	75,000
Driven Steel Piling	each	10000	8	80,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	0.5	12,500
Crib Wall Abutments	each	10000	2	20,000
Approaches - common fill	cu.m.	30	7000	210,000
Backfill - granular	cu.m.	35	600	21,000
Riprap - haul and place	cu.m.	28	50	1,400
Deck Panels fabricate and deliver	each	3400	10	34,000
Steel Girders fabricate and deliver	kg	1.15	16000	18,400
Steel and Deck Panel Erection	m	1500	27	40,500
Bridgerail	m	100	55	5,500
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels supply and deliver	each	3000	2	6,000
		Sub-Total		541,300
		Contingency(15%)		81,200
		Engineering(7%)		37,900
		Total		660,400

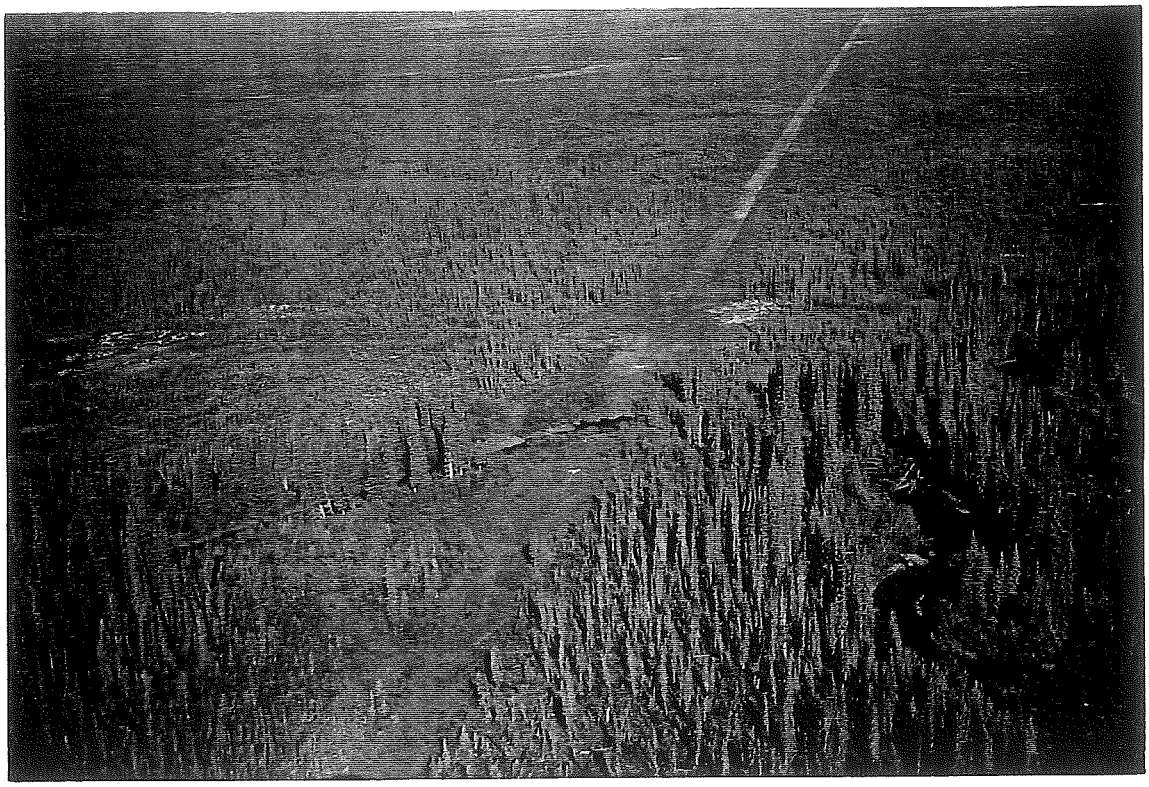


Photo 1 - Looking North on Winter Road (Stream Flow to Left)

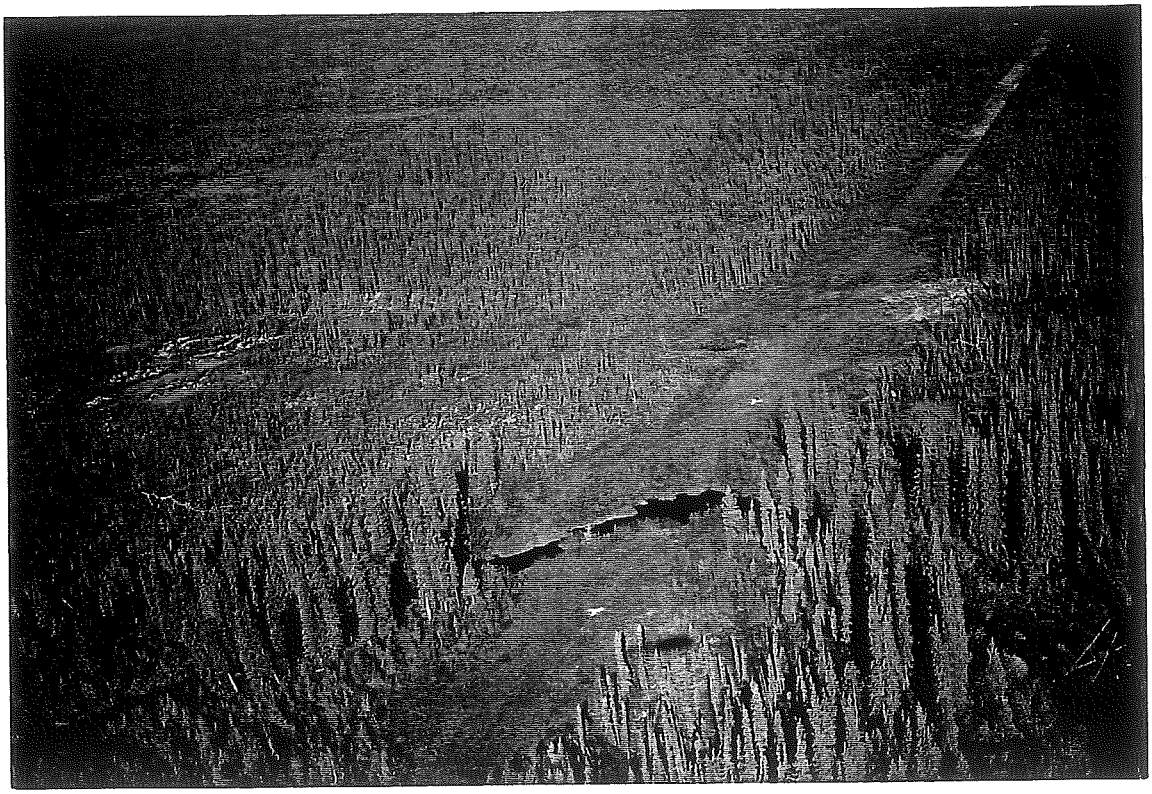


Photo 2 - Looking North - Existing Crossing to Left of Straight Alignment

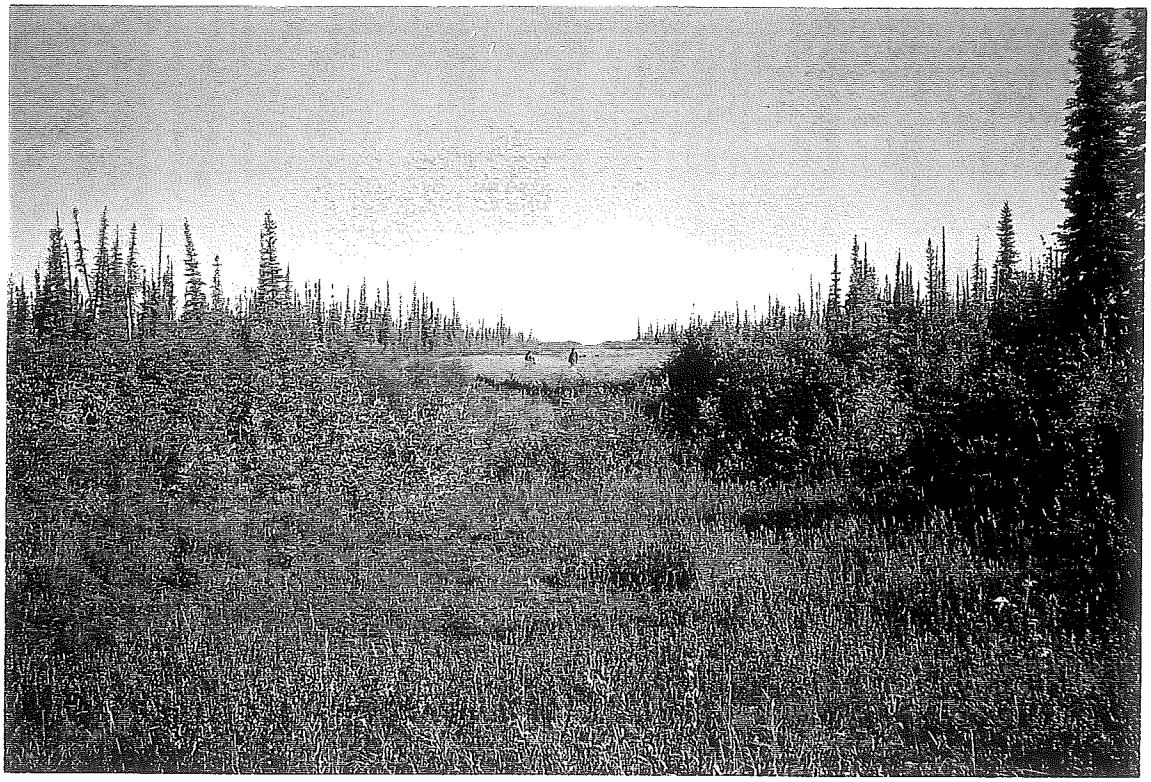


Photo No. 3 - Looking North on Winter Road - On Straight Alignment (Flow to Left)

Photo 4 - Looking South on Winter Road - On Straight Alignment

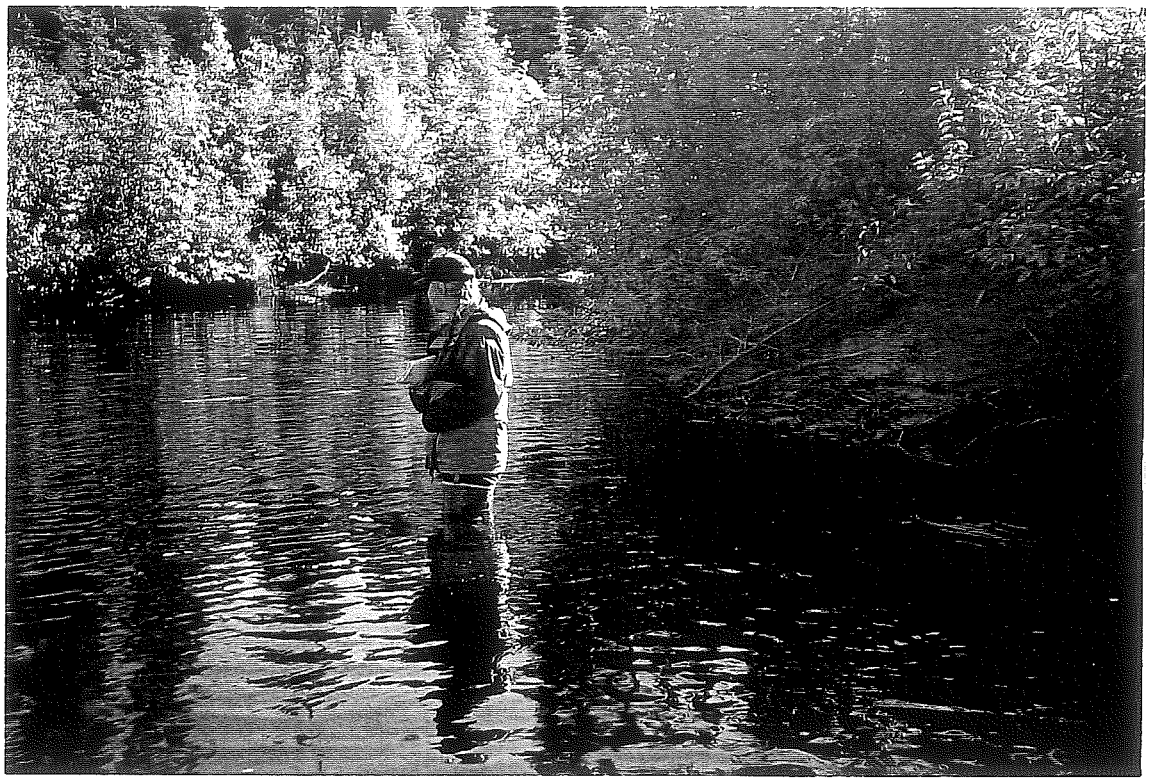
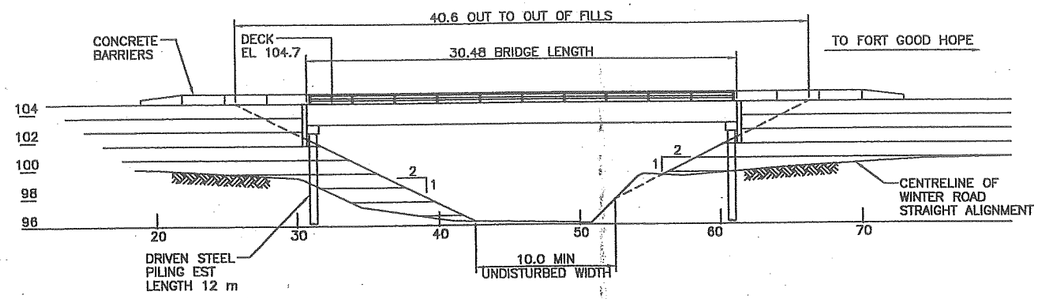
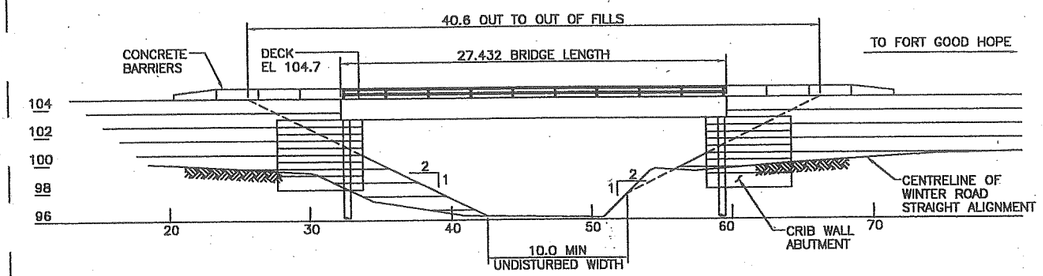


Photo 5 - Looking Upstream

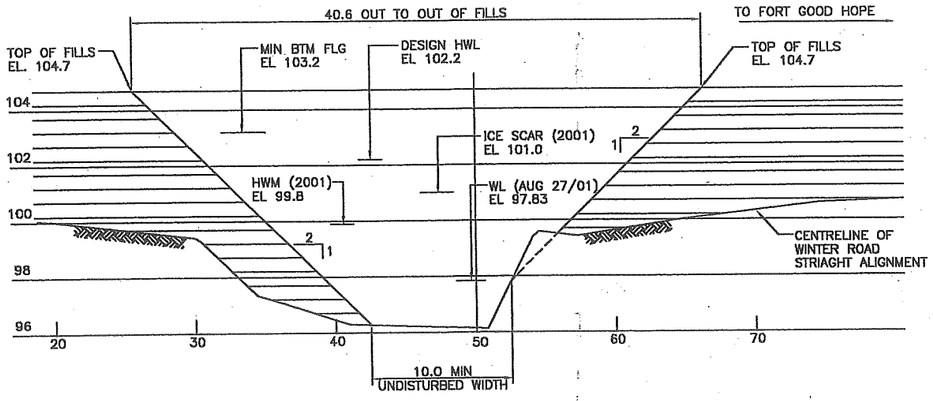
Photo 6- Looking Downstream



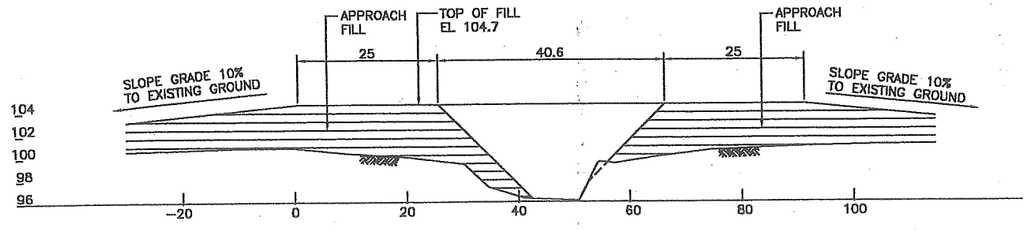
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



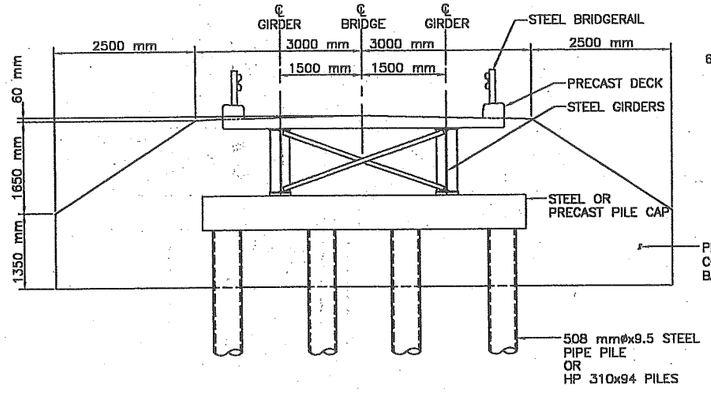
ELEVATION – CRIB WALL ABUTMENTS
(LOOKING D/S) 1:200



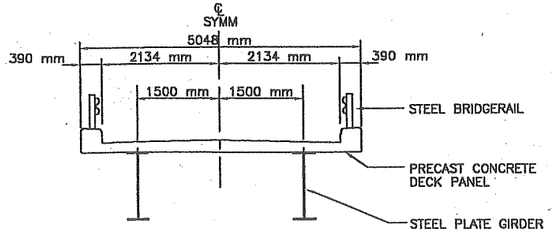
ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



ROAD PROFILE
H – 1:500
V – 1:250



ABUTMENT ELEVATION
1:50



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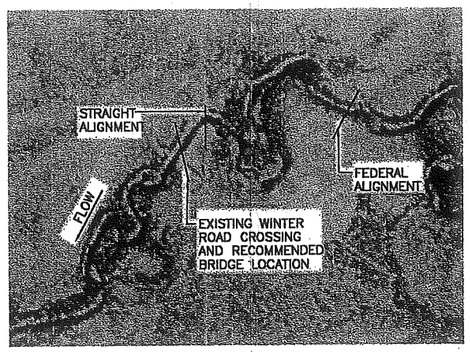
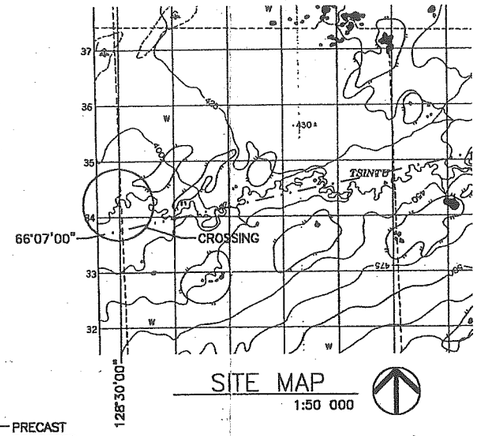
1:50



AERIAL PHOTOGRAPH
1:6000



SITE MAP
1:50 000

SITE INFORMATION

SITE 19
TEMPORARY BENCH MARK ELEV. 100.000 m
SPIKE IN STUMP APPROX. 15 m NORTH OF CROSSING
SURVEY ON CENTRELINE OF STRAIGHT WINTER ROAD ALIGNMENT
SURVEYED AUGUST 27, 2001
WINTER ROAD km 1154.4
COORDINATES LAT 66°07'50.3" N
LONG 128°29'22.9" W
SITE MAP REFERENCE 106–I/1

HYDROTECHNICAL DATA

- DRAINAGE AREA = 353 sq. km
- DESIGN DISCHARGE = 136 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SURVEYED SLOPE OF STREAMBED = 0.0087 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 1.8 m/s
- ICE DESIGN ELEV. 102.2 m. ICE DESIGN THICKNESS 0.5 m (APPROX)
- ICE CLASS 'b' 700 kPa TO CAN/CSA–S6–00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

TSINTU RIVER
km 1154.4
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED	
Surveyed by	
Drawn by MAP	
Designed by SDS	Checked by SDS
Insignia	Insignia
Signature / Date	Signature / Date
Approved by	
Project No.	Page 21 of 22
Drawing No. 608–9–20	

4.22 Lynn Creek

4.22.1 General

The Lynn Creek winter road crossing is located at km 1158.2 on the Mackenzie Valley winter road. GPS coordinates of the rate are Lat. 66° 09' 51.8" N and Long. 128° 29' 29.3" W.

A field investigation of the site was done on August 27, 2001. A preliminary survey of the centerline of the existing crossing was done and a temporary bench mark established as reference to a future detailed survey.

Photo No. 1 shows an aerial view of the site looking south on the winter road, with the stream flow to the right. The present crossing location is approximately 150 m downstream of the original federal alignment.

The existing winter road alignment crosses the stream in the middle of a meander loop. Straighter reaches are located 60 to 150m upstream near the federal alignment of the 1970s.

The existing terrain consists of soft swampy ground. The surrounding area is flat and has little relief.

Stream flow was very slow with water depths of 1 m at the time of the site visit. Beaver dams are likely. No obvious source of fill was evident for embankment construction.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.22.2 Existing Information

Lynn Creek had a preliminary bridge design done by DPW in 1974. The recommended structure at that time was a 91.5 ft (27.88 m) span with the bottom flange located approximately 5.4 m above the existing stream bed. The design high water and ice was approximately 3.0 m above the stream bed. Foundations consisted of a massive concrete backwall and pile cap, supported on driven piles. The crossing is located approximately 150 m upstream of the existing winter road crossing. Class 2 rock riprap was used to armour the approach fills.

Information also included an environmental report of the winter road operation and a preliminary survey profile done by DOT in 1996.

4.22.3 Hydrotechnical

The hydrotechnical analysis consisted of three components. First, existing information was collected and assessed; second, a field investigation was performed; and third, a river

engineering analysis of the information was performed to determine suitable alignments, water levels and opening widths.

1. Existing Information

Existing information consisted of topographic maps and air photos of the sites as well as information from previous hydrotechnical studies for the federal alignment and for other bridge sites. The drainage area upstream of the crossing site of 80 km^2 was obtained from the federal alignment study. This study also reported a surveyed stream slope of 0.0047. The slope of the channel obtained from a 1:50,000 scale topographic map is 0.0037. The maximum elevation in the basin obtained from the topographic maps is 350 m. Air photos taken in 1945, 1973, and 1998 were obtained for analysis. The 1945 photographs at 1:28,000 are the earliest available, the 1973 photographs at 1:12,000 are the largest scale available and the 1998 were the most recent. Additional air photos at 1:3,000 were taken in 2001 after the field investigation was completed.

The previous hydrotechnical study for the federal alignment also provided additional hydrotechnical information. A high water mark was observed 1.5 m above the bed level and an ice scar was observed 1.9 m above the bed. This study estimated the design discharge to be 42 m^3/s with a design water level 2.6 m above the bed.

A regional hydrological analysis done previously by Trillium Engineering indicated that the 50-year design discharge for a stream could be estimated from the drainage area and maximum elevation of the basin. The 50-year design discharge estimated for this site is 52 m^3/s. The 50-year breakup discharge is also estimated to be about 52 m^3/s.

2. Field Investigation

The hydrotechnical component of the field investigation included surveying a cross section and water surface slope, identifying ice scars and high water marks, assessing erosion and evaluating the bed material size.

On the day of the survey the water was 1.1 m deep and 4 m wide with a velocity of about 0.02 m/s. The slope survey found no detectable slope on the water surface over 30 m of channel. These flow conditions indicate that the channel is being backed up due to a blockage such as a beaver dam downstream.

High water marks were found upstream and downstream of the crossing on both sides of the channel. These high water marks were all about 0.8 or 0.9 m above the water level at elevations of 99.8 to 99.9 m relative to the local benchmark. Two ice scars were also found, one upstream and one downstream of the crossing. The ice scars were 0.6 and 0.7 m above the water level at elevations of 99.7 and 99.8 m.

No erosion was evident at or near the crossing. Both banks were well vegetated with grass and small trees. The bed material appeared to be gravel but was not sampled due to the depth of the water.

3. River Engineering Analysis

The design high water level for the site was calculated to be 100.9 m which is 2.9 m above the bed. This elevation is 1.0 m above the highest high water marks observed at the site and is 1.1 m above the observed ice scar level. The minimum flange elevation should provide 1.0 m of freeboard to allow debris and ice to pass safely under the bridge, to allow for some uncertainty in the hydraulic analysis and to allow for the effects of downstream flow blockages such as beaver dams. The minimum flange elevation should be 101.9 m or greater.

The minimum undisturbed width of the channel is 10 m. Assuming a 2:1 slope on the headslopes, the mean velocity through the opening is about 3.4 m/s.

Air photos of the site indicate that the channel has remained relatively stable between 1945 and 1973, however, the meander loop downstream of the winter road crossing appears to have been cutoff during this time. No additional changes in channel position were apparent in the 1998 or 2001 air photos.

The present winter road alignment crosses the channel in the middle of a meander loop. If the bridge is built on the winter road alignment, future migration of this meander will result in erosion problems on the embankments. As well, the curvature of the flow through the bridge opening will result in increased velocity on the outside of the bend increasing the size of riprap required. These concerns are reduced if the crossing is relocated to the straight reach 60 m upstream or to the original federal alignment 150 m upstream.

4.22.4 Environmental Considerations

An environmental assessment of Lynn Creek was not available, but it appears the stream would be capable of supporting fish.

4.22.5 Alternatives

The site is well suited to a single span steel girder bridge structure using driven steel piles for the foundations. Alternate span arrangements or structural types are not considered feasible for this crossing. A geotechnical investigation has not been done at the present location, but may have been done for the Federal alignment located approximately 150 m upstream.

Based on the hydrotechnical review culverts were not considered suitable for this crossing. A bridge structure will have less impact as it does not require work in the stream.

Utilizing the existing winter road crossing in the middle of a meander loop has the potential for erosion problems of the approach fills, and extensive bank armouring would be required. Alternatively the crossing could be relocated upstream to cross Lynn Creek on a straight reach of the stream. This shift would be 60 to 150 m.

Steel girders with timber or composite concrete decks were assessed and are considered very suitable for the site. A bridge length of 18.898 m (40 ft) is recommended as a suitable span for this site. Preliminary sizing of bridge girders indicates that the bridge structure would consist of either two welded or rolled wide flange girders as shown on the attached drawing.

4.22.6 Cost Estimate

The estimated costs of construction, including a 15% contingency plus 7% for department and engineering costs for the structure is provided in the following table.

The estimated costs for construction are as follows:

18.898 m single span bridge with timber deck.	$392,280
18.898 m single span bridge with precast deck.	$418,280

4.22.7 Recommendations

The bridge crossing should be located upstream to cross the stream on a straight reach and avoid the meander loop at the existing winter road crossing.

The recommended structure consists of an 18.898 m single span bridge with a minimum bottom flange elevation of 101.9 m. A minimum undisturbed creek width of 10 m is recommended. Headslopes of 2H to IV were used resulting in an out to out of fills of 24.8 m at elevation 102.9 m.

Driven steel piles are recommended for the foundations. Steel girders with composite precast concrete deck panels are recommended for the superstructure.

The attached drawing indicates the preliminary site survey, the hydrotechnical assessment and the recommended structure.

4.22.8 Summary

A single span bridge with an overall length of 18.898 m with either the timber deck or precast deck system is recommended on an alignment 60 to 150 m upstream of the existing crossing for the Lynn Creek winter road crossing.

Site	Lynn Creek			
	Recommended Structure - 18.898m Bridge - Timber Deck			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	50,000	1	50,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	1	25,000
Approaches - common fill	cu.m.	30	4200	126,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Timber Decking	sq.m.	100	95	9,500
Steel Girders				
fabricate and deliver	kg	1.15	7600	8,740
Bridge Erection	lump sum	20000	1	20,000
Bridgerail	m	100	36	3,600
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		321,580
		Contingency(15%)		48,200
		Engineering(7%)		22,500
		Total		392,280

	Alternative Structure - 18.898m Bridge - Precast Deck			
Item	Unit	Unit Price	Quantity	Estimate
Mobilization	lump sum	50,000	1	50,000
Driven Steel Piling	each	10000	4	40,000
Precast Concrete Pile Caps	each	4500	2	9,000
Road Realignment	km	25000	1	25,000
Approaches - common fill	cu.m.	30	4200	126,000
Backfill - granular	cu.m.	35	300	10,500
Riprap - haul and place	cu.m.	28	80	2,240
Deck Panels				
fabricate and deliver	each	3400	6	20,400
Steel Girders				
fabricate and deliver	kg	1.15	7600	8,740
Steel and Deck Panel Erection	m	1500	19	28,500
Bridgerail	m	100	55	5,500
New Jersey Concrete Barriers	each	500	16	8,000
Precast Backwall Panels				
supply and deliver	each	4500	2	9,000
		Sub-Total		342,880
		Contingency(15%)		51,400
		Engineering(7%)		24,000
		Total		418,280

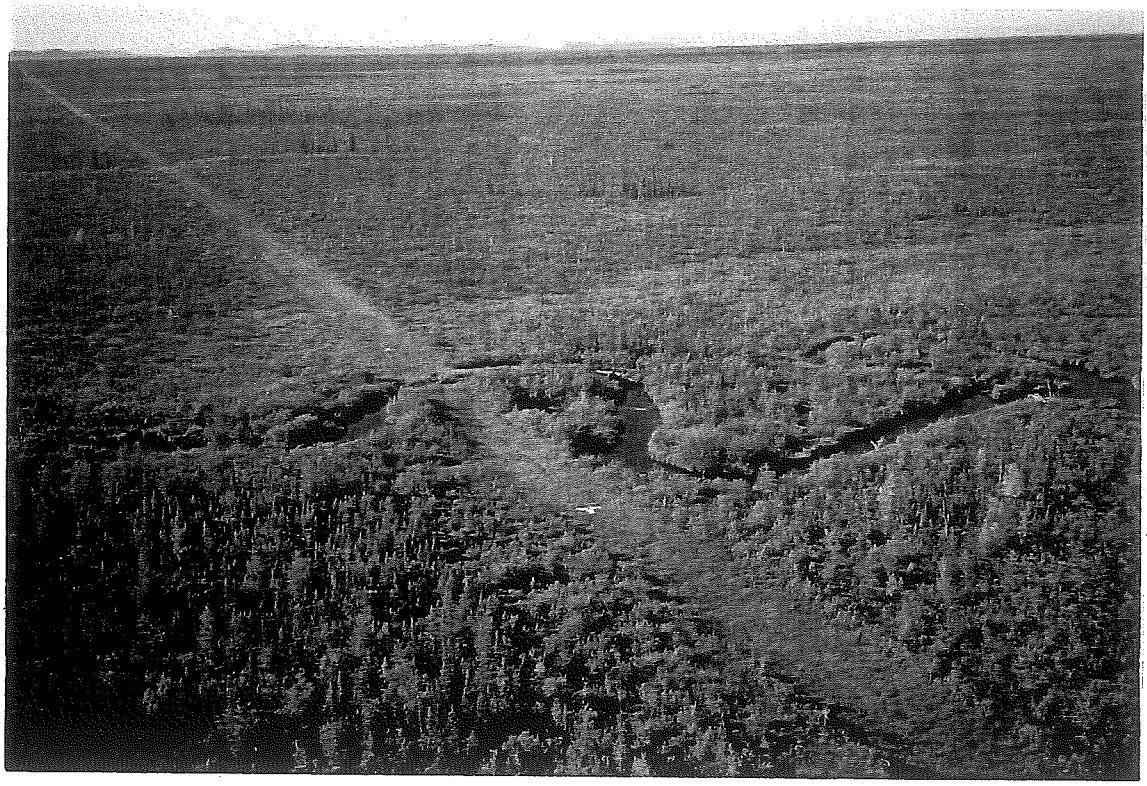


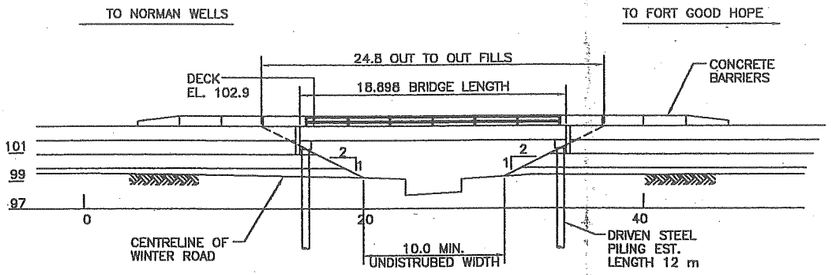
Photo 1 - Looking South on Winter Road (Stream Flow to Right)

Photo 2 - Looking North on Winter Road

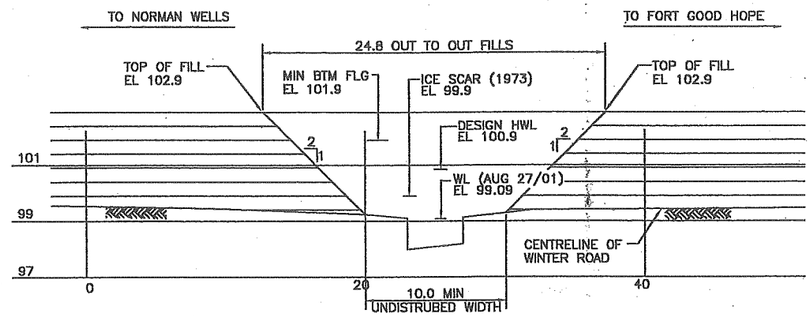
Photo No. 3 - Looking South on Winter Road

Photo 4 - Looking Upstream

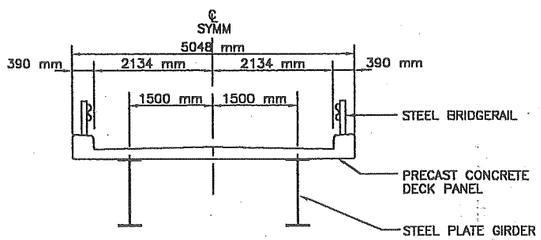
Photo 5 - Looking Downstream



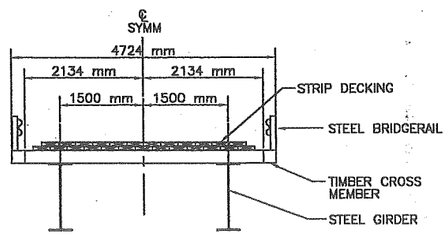
ELEVATION – NATURAL SCALE
(LOOKING D/S) 1:200



ELEVATION
(LOOKING D/S) H – 1:200
V – 1:100



DECK SECTION – PRECAST
1:50



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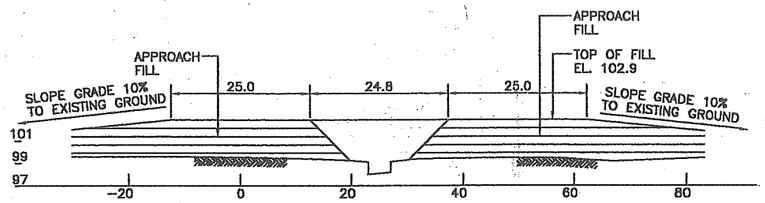
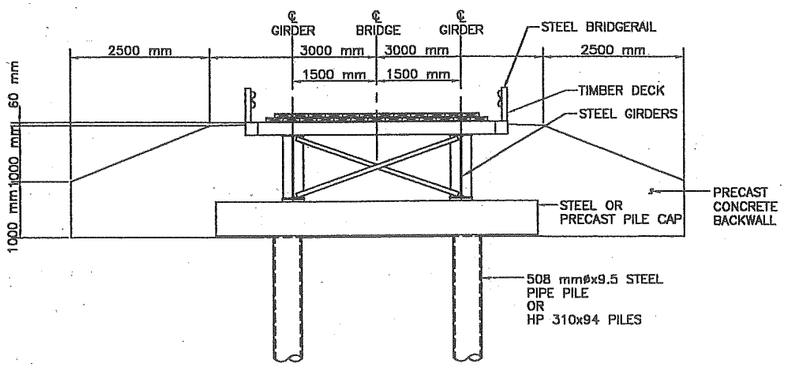
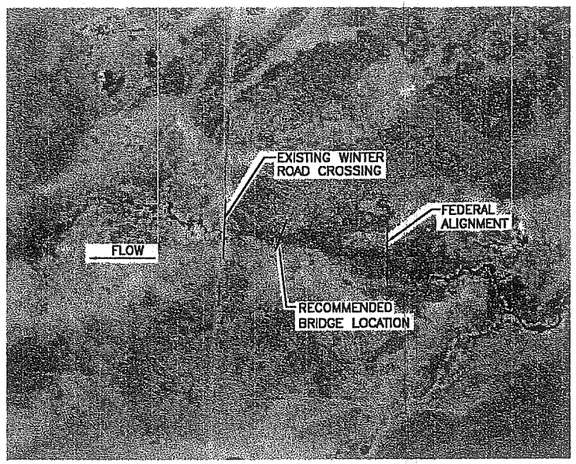
1:50



ROAD PROFILE
H – 1:500
V – 1:250



ABUTMENT ELEVATION
1:50



AERIAL PHOTOGRAPH
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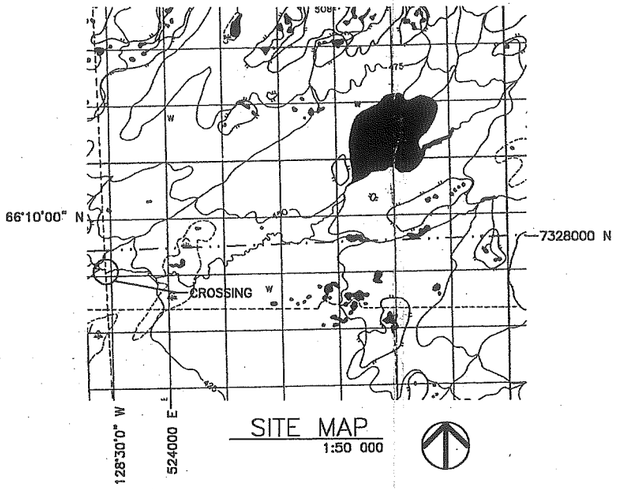

SITE MAP
1:50 000

SITE INFORMATION

SITE 20
TEMPORARY BENCH MARK ELEV 100.000 m
SPIKE IN TREE APPROX 20 m SOUTH OF CROSSING
SURVEY ON CENTRELINE OF EXISITNG WINTER ROAD CROSSING
SURVEYED AUGUST 27, 2001
WINTER ROAD km 1158.2
COORDINATES LAT 66°09'51.8" N
LONG 128°29'29.3" W
SITE MAP REFERENCE 106–I/1

HYDROTECHNICAL DATA

- DRAINAGE AREA = 80 sq. km
- DESIGN DISCHARGE = 52 m^3/s (ESTIMATED 1:50 YEAR INSTANTANEOUS DISCHARGE)
- AVERAGE SLOPE OF STREAMBED = 0.0047 m/m
- MEAN OUTLET VELOCITY AT PROPOSED STRUCTURE FOR DESIGN DISCHARGE = 3.4 m/s
- ICE DESIGN ELEV. 100.2 m. ICE DESIGN THICKNESS 0.5 m
- ICE CLASS 'b' 700kPa TO CAN/CSA–S6–00

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN METRES UNLESS NOTED OTHERWISE
- ELEVATIONS ARE GIVEN IN METRES BASED ON TEMPORARY BENCHMARK

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Rev.	Date	Description	Chkd

A. detail number
B. location drawing number
C. drawing number

Project

MACKENZIE VALLEY WINTER ROAD
WRIGLEY TO FORT GOOD HOPE
BRIDGE PRELIMINARY ENGINEERING

Title

LYNN CREEK
km 1158.2
PRELIMINARY DESIGN
INFORMATION

Scale AS NOTED
Surveyed by
Drawn by MAP
Designed by SDS
Checked by SDS
Insignia
Insignia
Signature
Date
Signature
Date
Approved by
Project No.
Page 22 of 22
Drawing No. 608–9–21

BP-TEC Engineering Group Ltd.
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BLACKWATER RIVER BRIDGE
MACKENZIE VALLEY

REPORT ON CONSTRUCTION TECHNIQUES AND HYDROTECHNICAL REVIEW

1.0 INTRODUCTION

The Mackenzie Valley Winter Road crosses the Blackwater River at Mile 492. Previous work has been done in the 1970's on a bridge crossing of the river as part of a major highway assessment project. This crossing is located approximately 600 m upstream from the existing winter road crossing.

This report provides an updated hydrotechnical review of the bridge crossing and reviews the proposed bridge construction techniques proposed in 1974 and updates the construction techniques to what could be expected to be used at this time .

BP-TEC Engineering Group Ltd. was retained by Camillus Engineering Ltd. to provide engineering services to the Government of the Northwest Territories, Department of Transportation. Trillium Engineering and Hydrographics Inc. was retained as specialist sub consultants to conduct the hydrotechnical review and BP-TEC provided the construction techniques review.

Bryant Environmental Consultants Ltd. provided an environmental assessment overview of the bridge crossing in a separate report dated May, 2003.

2.0 SCOPE

2.1 Hydrotechnical Review

This report presents the results of the hydrotechnical review and provides recommendations for the hydraulic parameters. Trillium reviewed the previous hydrotechnical work done by Bolter Parish Trimble in 1973 and included more recent data collected since that time to develop the hydraulic parameters. Their complete report is attached as Appendix A.

2.2 Construction Technique Review

The construction technique review addresses the structure proposed in a report by Canada North Engineering Ltd. dated August, 1974. This report describes the original proposed structure and assesses the various elements involved in the construction and compares

this construction to techniques that could be employed at this time. Some significant chances can now be utilized due to construction equipment improvements.

Environmental Assessment Review

The environmental assessment review describes the potential impacts of the bridge and bridge construction and suggests mitigative measures that may reduce the impacts.

Cumulative effects of this project together with other projects in the area were examined for their combined impact on the area.

3.0 DESCRIPTION OF ORIGINAL CROSSING STRUCTURE

The Blackwater River bridge crossing is located at Mile 492 on the Mackenzie Valley Winter Road. The winter road crossing is approximately 600 m from the Mackenzie River while the proposed bridge crossing is approximately 1.2 km from the Mackenzie River.

In 1974 the Federal Department of Public Works developed plans for an all weather road along the Mackenzie River Valley. Canada North Engineering Ltd. prepared a report in 1974 for a bridge crossing of the Blackwater River. The crossing location was selected as the Alignment C alternative assessed in the hydrotechnical report done by Bolter Parish Trimble Ltd. For reference purposes, two drawings from Bolter Parish Trimble's report are included in Appendix B.

The proposed bridge crosses the river on an alignment perpendicular to the flow and consists of four spans. Span lengths are 44.2 m (145 ft.) - 59.4 m (195 ft.) - 59.4 m (195 ft.) - 44.2 m (145 ft.). Three piers are required with two being located in the main channel and one near the left bank. For reference purposes, four drawings from the Canada North report are provided in Appendix B.

2 44.2
44.2
59.4
59.4
207.2m.
3 piers

The structure consisted of a four span continuous steel plate girder with a composite cast in place concrete deck. The deck width is 9.45 m (31.0 ft.) overall consisting of two 4.27 m (14' 0") lanes plus curbs. Two welded plate girders were used to support the deck, and had an overall depth of 3.05 m (10 ft.). Weathering steel was indicated for the girders to reduce ongoing maintenance costs such as painting. The abutments consist of cast in place concrete seats, backwalls, and wingwalls supported by driven steel H-piles. The pier consists of massive solid concrete shafts on a large concrete footing (pile cap) supported by driven steel H-piles.

The bridge elevation was set to provide 0.9 m (3 ft.) freeboard above the high water level El. 116.3 m (El. 381.5 ft.) due to Mackenzie River ice jamming. High water flow on the Blackwater River was indicated as El. 112.0 (El. 367.5); therefore the bridge elevation was controlled by the Mackenzie River ice jam elevation.

Design of the superstructure was for two HS25 trucks plus impact. The HS25 truck is a three axle vehicle having axle loads of 44.5 kN - 178 kN - 178 kN. An allowance for an overload HS40 truck with a total load of 640 kN was included in the design.

Concrete for the abutments and pier had a compressive strength of 24 MPa (3500 psi) and the deck slab had a strength of 27.5 MPa (4,000 psi). Steel for the girders was indicated as having a yield strength of 350 MPa (50 ksi).

The foundations consist of steel H piles driven to refusal into the gravel and sand deposits found near the proposed crossing. Test holes wee not done on the recommended alignment, but the material was assumed to be similar to the holes drilled downstream at two other alignment positions.

4.0 ASSESSMENT OF ORIGINAL CROSSING STRUCTURE CONSTRUCTION

The proposed structure consisted of relatively standard construction techniques which are also approaches commonly used at this time..

Substructure construction was to occur during the winter months likely over two winters. Steel erection would be done during the second winter construction season and deck construction would be done during the following summer months. The Canada North report did not discuss the construction of the approach fills, but it is assumed these would be done prior to the bridge construction beginning to allow for settlement.

Pier construction was proposed as utilizing cofferdams set into the gravel and sands of the river bed. Work would be done from the ice eliminating the need for barges or work bridges. Material would be removed from within the cofferdam and the piles driven. A tremie concrete seal estimated as 1.5 m (5 ft.) thick would be placed to seal the cofferdam and allow construction of the pile cap and pier shaft in the dry.

Girder delivery was to come by the winter road and be erected off the ice following the pier construction. The report did not indicate the lengths of each girder segment to be shipped, but lengths of approximately 20 m (66 ft.) are about the maximum that can be delivered by the winter road.

Due to the remote location, it is assumed that an on site concrete batching facility would have been used and all concrete materials (cement, sand, gravel) would be trucked in via the winter road. This material would be stockpiled the previous year to allow construction to begin as early as possible when river access was permitted.

The deck construction would need to be done during the summer months as the costs to provide heating for the concrete slab would be prohibitive. As the piers are relatively massive structures the need for extensive heating would not be required, and winter concrete placing is suitable.

5.0 HYDROTECHNICAL ASSESSMENT

The hydrotechnical review done by Trillium is provided in Appendix A. The review addressed the channel characteristics, the ice characteristics and the bridge hydraulics characteristics. A summary of the hydrotechnical design parameters compares the original design to the present design recommendations.

Most of the updated hydraulic design parameters are similar to the original design values with one significant exception. The predicted high water elevation due to Mackenzie River ice jamming was increased by 1.1 m to elevation 117.4 from elevation 116.3 (381.5 ft.). This increase was based on studies done by Trillium in 2001 while the earlier prediction was based on very limited data.

The minimum bottom flange elevation is recommended to be raised to provide 1.5 m of free board above the predicted high water / ice jam level to allow passage of drift. The new elevation would therefore be elev. 118.9 m as compared to elev. 117.2 m (384.5 ft.) in the original design.

A summary comparing the hydrotechnical design parameter is given in the following table.

Design Parameter		Original Design	Updated Design
Hydrologic Characteristics			
Drainage Area	km^2	10640	10640
Design Discharge	m^3/s	1840	1840
Ice Characteristics			
Thickness	m	1.2	1.2
Strength	kPa	1500	1100
Elevation	m	111.4	111.0
Hydraulic Characteristics			
Open Water Velocity	m/s	2.8	2.8
Open Water Elevation	m	112.0	112.0
Mackenzie Ice Jam Elevation	m	116.3	117.4
Minimum Bridge Elevation	m	117.2	118.9
Minimum Scorer Elevation	m	105.5	106.1
Riprap Median Diameter	m	0.8	0.5

6.0 ENVIRONMENTAL ASSESSMENT

The environmental assessment overview by Bryant addressed the potential impacts of the bridge and bridge construction. These impacts could be significant if not controlled, and Bryant suggested mitigative measures to reduce the potential impacts.

During construction the possibility of fuel spills could occur and controls need to be used for refuelling operations. Construction was recommended during the flow periods to reduce silt generation. Control of silt by the use of silt screens was recommended.

Access to the site was reviewed and it was recommended that the winter road be used only to limit the impact of construction traffic in the area.

Animal passage routes could be affected by the bridge structure by restricting passage along the banks. This could result in a longer bridge being required to allow passage below the bridge. In other bridge projects this has been required by the regulatory authorities.

There has been a significant change in the requirements of the regulatory authorities regarding environmental controls and mitigation since the 1970's. This results in additional costs during construction to control the potential impacts. Monitoring by qualified companies is required.

7.0 UPDATED BRIDGE STRUCTURE DESCRIPTION

The attached drawing S1 in Appendix C indicates the original proposed structure and also shows the updated structure that incorporates the updated hydrotechnical parameters.

The proposed bridge would have two traffic lanes, similar to the original design. The minimum bottom flange elevation is increased by 1.7 m to allow for an increased height of the Mackenzie ice jam and to provide 1.5 m (5 ft.) of freeboard for debris passage.

For design, the live load truck would be the CS600 truck as per the Canadian Highway Bridge Design Code.

The bridge deck is proposed to have precast concrete deck panels instead of cast in place concrete. Following placing of the panels, prestressing cables would be used to longitudinally stress the panels together. Concrete for the panels would have a compressive strength of at least 40 MPa.

The superstructure is proposed to consist of four welded plate steel girders instead of the two girders in the original design. Girder depth and weight are reduced. Weathering steel with yield strength of 350 MPa would be used.

Abutments are proposed to be simplified structures without expansion joints. These are referred to as integral abutments and are now used commonly for short (40 m) span bridges, but longer bridges can be designed for the forces created. Abutments would be supported on driven piles, either H piles or pipe piles. Instead of a cast in place concrete seat, precast concrete could be used for the abutment seat / pile cap.

Piers could consist of large diameter drilled caissons with a solid diaphragm to brace the caissons. The attached sketch Sk-2 indicates a possible pier arrangement. Due to the ice forces a massive pier is required.

As there was no geotechnical testing done at the bridge location it may not be feasible to utilize the large diameter caissons. If that is the case, the piers would be cast in place concrete supported on driven piles.

The bridge riding surface is proposed to be directly on the concrete deck slabs which would include an allowance for wear. An asphalt concrete pavement would be installed in the future when sufficient wear has occurred on the deck slabs.

Geotechnical investigation of the site is required to facilitate design. Detailed survey of the site would be necessary to determine the channel and aid in confirmation of the hydrotechnical design parameters.

8.0 UPDATED BRIDGE STRUCTURE ASSESSMENT OF CONSTRUCTION

The attached drawing S1 in Appendix C indicates the original proposed structure and also shows an updated structure that incorporates the updated hydrotechnical parameters.

The original structure had two traffic lanes, which has also been assumed in this review. As the bridge length is over 220 m and requires three large river piers, the two lane deck is recommended since the cost to widen in the future would be very high.

8.1 Deck

Recently several bridges constructed on the winter road have used precast deck panels which offer several advantages over the cast in place concrete deck, such as ease of erection and quality control. It also eliminates the need to import large amounts of concrete production materials to the site and stockpiling over the winter.

The deck panels would be erected in the winter and then post tensioned and grouted in place the following summer. Panels are easy to erect and save considerable time as compared to cast in place concrete. Due to the cold weather, placing concrete in the winter for the decks would be prohibitive in cost due to the heating and hoarding requirements for concrete curing. Precast panels eliminate this cost.

The precast deck panels could be made to match one half of the deck width resulting in lighter weights and more ease in handling.

8.2 Girders

The original design utilized two steel girders with depths of 3.05 m. These sections would be quite heavy and difficult to transport to the site. As well large cranes would be required for erection. Shipping and erection costs would comprise a large percentage of

2.4m

the steel costs and an alternate approach could result in significant savings. Four girders with depths of 24 m could be used resulting in lighter sections to handle. Equipment and shipping costs would be reduced even though more pieces are required. Girder segments would be shipped in pairs and could be delivered along the Mackenzie River and stored until winter.

8.3 Abutment

Abutment construction techniques would not be substantially changed from the original design. Driven steel piles are considered to be most appropriate. Prefabricated steel or precast concrete pile caps would be more likely to be used now instead of the cast in place concrete in the original design. Consideration of using integral abutments that eliminate expansion assemblies would be recommended. Expansion joints are typically one item that requires rehabilitation on bridge structures. Precast concrete could be used for the abutment backwall / retaining wall instead of cast in place concrete.

8.4 Piers

The piers will likely prove to be one item that involves the most risk during construction. In the original site assessment test holes were not drilled at the eventual recommended alignment, but it was assumed the soils were similar to the test holes results of the previously considered alignments. Soils consisted of sands and gravels to a depth of at least 12 m below stream bed. The sand and gravel deposits were fully saturated, likely to produce settlements under loads, and are not considered suitable for spread footings.

Any pier construction would have to deal with the saturated sands and gravels and either involve sealing off the site with cofferdams or employ another technique such as large caissons. Large diameter caissons have been used on several large rivers in Alberta recently and have proven to be highly successful. The equipment required is not available from northern contractors, however. Sketch Sk 2 in Appendix D indicates a possible pier structure utilizing large diameter caissons. Steel casing would be installed through the sands and gravels using vibratory hammers. The material within the casings would be removed and concrete placed. This approach, although still requiring concrete, involves substantially less material and less time (and risk) in construction. This approach has the potential of requiring only one winter construction season. Caissons would be 3 m diameter or greater in the sands and gravels. Above the water or ice level, the pier shafts could be a combination of precast concrete filled with cast in place concrete.

Verification of the soil stratigraphy would need to be done at the selected crossing site to ensure that the caisson option is viable.

8.5 Erection of Girders

Two methods could be used for the girder erection including erection by cranes from the ice or by launching where the girders are pushed or pulled across the piers. Launching is employed where spans are usually long and ice conditions may not be suitable for

construction traffic. In this case, it is felt that the ice would be suitable for cranes and using lighter sections, cranes would be able to access the site by the winter road.

Launching is considered to be feasible also and the erection method will ultimately be decided by contractor preference. Girders need to be designed for the forces that occur during launching which require the girders to cantilever a full span length. The four girder deck system would be suitable for launching either in pairs or all together.

9.0 CONSTRUCTION ESTIMATE

The following tables provide an estimate of the construction costs to construct the original proposed structure (Table 1) and to construct the updated structure (Table 2). Since there has not been any detailed design, the quantities are approximare and the estimated costs should be considered to be within 25% accuracy. Confirmation of the soils and provision of geotechnical design parameters is necessary to confirm the proposed design of the pier.

T he estimated cost for the abutments is reduced in the proposed structure due to simplified construction techniques and elimination of cast in place concrete.

Pier costs are reduced significantly for the proposed structure due to the use of large diameter caissons which should be easier and less risky to construct than cofferdams.

Superstructure costs are estimated to be slightly reduced primarily to the use of precast slabs for the deck and an overall shortening of the construction time required.
The estimated construction costs are as follows:

Original 1970's Proposed Structure	$9,499,000
Updated Structure	$8,085,000

Additional costs will occur in the project such as environmental monitoring, engineering design and inspection during construction plus project management cost.

10.0 SUMMARY

The hydrotechnical review resulted in an increase in the bridge bottom flange elevation to suit the predicted Mackenzie river ice jam level. Other hydrotechnical design parameters were similar to the original proposed data from the 1970s.

The bridge construction techniques proposed in the 1970s are considered to be suitable at this time, but some changes could be implemented to simplify construction and to be more suitable to the cold weather construction environment.

Blackwater River **Table 2**

Updated Bridge Arrangement

Item	Unit	Quantity	Unit Price	Estimated Cost
Substructure				
Piers				
Cast in Place Concrete	cu.m.	1,500	2,000	3,000,000
Caissons	m.	120	4,000	480,000
Reinforcement	tonnes	90	3,000	270,000
Building Ice	L.S.	1	150,000	150,000
Excavation	cu.m.	900	300	270,000
			Sub-Total	**4,170,000**
Abutments				
Precast Panels	cu.m.	40	2,500	100,000
Precast Pile Caps	cu.m.	30	2,500	75,000
H-Piles	No.	22	500	11,000
	m	1,300	120	156,000
Approach Fills	cu.m.	8,500	30	255,000
Riprap	cu.m.	1,000	200	200,000
			Sub-Total	**797,000**
Superstructure				
Structural Steel	tonnes	320	3,850	1,232,000
Building Ice	L.S.	1	150,000	150,000
Precast Deck Panels	cu.m.	500	2,200	1,100,000
Reinforcement	tonnes	100	3,000	300,000
Handrail	m	420	800	336,000
			Sub-Total	**3,118,000**
			Total	**8,085,000**

Blackwater River **Table 1**

Quantities from 1974 Report
Updated Cost Estimate to 2003 Prices

Item	Unit	Quantity	Unit Price	Estimated Cost
Substructure				
Piers				
Cast in Place Concrete	cu.m.	2,060	1,500	3,090,000
Tremie Seal	cu.m.	700	1,100	770,000
Reinforcement	tonnes	120	3,000	360,000
H-Piles	No.	150	500	75,000
	m	2,700	120	324,000
Excavation	cu.m.	2,700	20	54,000
Riprap	cu.m.	800	200	160,000
Cofferdam	L.S.	3	200,000	600,000
			Sub-Total	**5,433,000**
Abutments				
Cast in Place Concrete	cu.m.	150	1,500	225,000
Reinforcement	tonnes	40	3,000	120,000
H-Piles	No.	22	500	11,000
	m	1,300	120	156,000
Approach Fills	cu.m.	7,600	30	228,000
Slope Protection	L.S.	2	100,000	200,000
			Sub-Total	**940,000**
Superstructure				
Structural Steel	tonnes	320	4,000	1,280,000
Cast in Place Concrete Deck	cu.m.	575	2,000	1,150,000
Reinforcement	tonnes	120	3,000	360,000
Handrail	m	420	800	336,000
			Sub-Total	**3,126,000**
			Total	**9,499,000**

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May 12, 2003

BPTEC Engineering Group Ltd
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Edmonton, AB, T6E 6A1

Attn: Stuart Smith, M.Eng., P.Eng

RE: MACKENZIE HIGHWAY BRIDGES: BLACKWATER RIVER BRIDGE HYDROTECHNICAL REVIEW

INTRODUCTION

A hydrotechnical review was undertaken for a bridge crossing on the Blackwater River near its confluence with the Mackenzie River. This crossing is part of the winter road between Wrigley and Norman Wells (Figure 1). The river is presently being crossed using an ice bridge, however a permanent bridge is being planned for the site to increase the length of time that the crossing can be used each winter. Detailed bridge design work was carried out in 1974 by Canada North Engineering Limited but the bridge was not constructed. Considerable time has passed since this design work was carried out so the original hydrotechnical assessment is being reviewed. This hydrotechnical review will include an evaluation of the basin hydrology to evaluate the design discharge; an analysis the river hydraulics to evaluate the proposed bridge opening and channel stability; and an analysis of ice characteristics to evaluate the design ice values.

HYDROLOGY

The hydrologic review consists of a comparison of the original design discharge to that obtained from a regional hydrologic analysis and a lake routing analysis.

The drainage basin above the crossing site is show in Figure 1. A number of streams including the upper Blackwater River flow into Blackwater Lake, which in turn flows into the lower Blackwater River. The lake collects inflows from the east slopes and low areas east of the Franklin Mountains. Below the lake, tributaries draining the Franklin Mountains flow directly into the lower Blackwater River.

Original Design Discharge

A drainage area of 10,640 km^2 was reported in the original 1973 hydrologic study by Bolter Parish Trimble Ltd. A design discharge of 1840 m^3/s was obtained using a modified rational method with some reduction for the storage effects of Blackwater Lake. The analysis was based

on a modified rational method because only limited discharge data was available in the region at that time.

Historical Stream Flows

Since the time of the original study, data from two Water Survey of Canada (WSC) gauges has been collected on the Blackwater River. The locations of these gauges are shown in Figure 1. The first gauge (10HC005) was located near the mouth about 7.5 km upstream of the bridge site. This gauge was operated from 1983 to 1985. In 1986 a new gauge (10HC006) was located at the outlet of Blackwater Lake. This gauge was operated for nine years from 1986 to 1994. The gauges were not operated concurrently.

The WSC gauge near the mouth had a drainage area of 10,400 km^2, slightly less than that at the bridge site. The WSC gauge at the lake outlet had a drainage area of 7,850 km^2 therefore 75% of the total drainage area flows into the lake.

A frequency analysis of peak flows out of Blackwater Lake is shown in Figure 2. This analysis is of limited accuracy due to the short period of record but does provide an indication of the peak flows coming out of the lake. The mean annual peak flow for the period of record is 350 m^3/s while the projected 50-year peak flow is 780 m^3/s. The maximum peak flow from the three years of record near the mouth was 400 m^3/s. This is not significantly higher than the mean annual peak flow from the lake outlet.

Regional Analysis

A regional analysis of peak flows from gauged streams flowing into the Mackenzie River carried out by Trillium Engineering in 2001 indicated that the peak flows were predominantly a function of drainage area and maximum elevation in the basin. This regional analysis is only applicable to the drainage area of 2,790 km^2 between the lake outlet and the bridge location, where lake storage does not affect the flows. The maximum elevation in the sub-basin was 1200 m which is low compared with the mountain drainages to the west of the Mackenzie River but higher than the lowlands to the east. The regional analysis suggests that the 50-year peak flow from this portion of the basin is about 1040 m^3/s.

The 50-year discharge for the basin below the lake obtained from the regional analysis can be added to the 50-year discharge obtained from the frequency analysis if it is assumed that the same sequence of events causes both discharges to occur at the same time. The lake outflows are relatively steady compared to the river flows so this assumption is not unreasonable. The 50-year discharge obtained from this combined analysis is 1820 m^3/s. This discharge is quite similar to the original design discharge.

Lake Routing Analysis

A spreadsheet based flow routing model of the basin was developed to examine the effect of the combined runoff from a single extreme event. An 80 mm rainfall runoff event occurring over an 18 hr period was superimposed on a typical 100 mm snowmelt event in the upper basin to simulate an extreme runoff event. The increased base-flow from the snowmelt tends to increase the peak flow from the rainfall event. The peak discharge obtained from this event was 750 m^3/s at the lake outlet and 2240 m^3/s at the bridge site.

The lake routing analysis produces a peak discharge about 20% higher than the original design discharge. The lake outflow of 750 m^3/s is similar to the discharge of 780 m^3/s obtained from the frequency analysis but the assumption of an 18 hr rainfall produces a discharge of 1490 m^3/s in the lower basin. This is about 40% greater than the lower basin discharge suggested by the regional analysis. The lake routing technique is the least reliable of the methodologies and does not provide a frequency based discharge but only a potential upper bound to the peak flow. Thus, the original design discharge of 1840 m^3/s appears to be a reasonable design value at the bridge site.

Breakup Discharge

Breakup downstream of a lake such as Blackwater Lake typically begins at the outlet of the lake where warm lake water flowing into the river accelerates the melting of the ice cover. As the open water area at the outlet expands, the resistance to flow caused by the ice is reduced and the lake outflow increases. Breakup will likely progress downstream from the lake outlet as this open water area expands.

The maximum recorded breakup flow at the lake outlet was 139 m^3/s, however this flow may increase considerably before breakup occurs at the mouth. Additional flow will also come from the downstream tributaries as snow melts in the higher elevations. Regional analysis of breakup flows by Trillium Engineering (2001) suggests that the 50-year breakup flow could be as high as 800 m^3/s when lake storage effects are taken into account.

CHANNEL CHARACTERISTICS

The proposed bridge crossing is located in the river reach immediately upstream of the confluence with the Mackenzie River. Three crossing alignment alternatives have been proposed. The locations of these alignments are shown in Figure 3.

Bank Stability

Bank stability at the site was assessed by analysing historical air photos over the period of 49 years. Air photos from 1945, 1983, and 1994 were selected for comparison. The 1994 air photo is shown in Figure 3. The low flow channel has an irregular meander pattern with alternating bars. The high flow channel ranges from 200 to 300 m wide.

The shape and location of the high flow banks has not changed significantly between 1945 and 1994 but some changes in the low flow channel occurred between 1945 and 1983. The vegetated bar on the south bank downstream of alignment C has eroded about 20 m on the upstream end and a channel in the north bar upstream of alignment C is no longer active at low flow. Thus, it appears that there is some bar movement within the channel but the high flow channel remains stable.

Channel Geometry

Channel profiles were surveyed on June 4, 1972 during high flow and on Sept. 19, 1972 during low flow. The high flow slope of 0.0040 is somewhat higher than the low flow and bed slope of

0.0035, likely due to the effects of the Mackenzie River. The high flow slope of 0.0040 was adopted for the hydraulic analysis.

The channel cross-sections used in the original design are shown in Figure 4. These cross-sections have all be adjusted to the survey datum used by Canada North Engineering (1974). The locations of the three alignments are shown in Figure 3. The original hydraulic design was undertaken using river cross-sections estimated from contour map elevations. A survey undertaken in January, 1973 provided more detail but confirmed the basic channel shape at alignment A. The recent air photos indicate that the cross-section at alignment C may have changed considerably since the 1974 study. Thus, it is recommended that, if this alignment is chosen, a detailed survey of the stream crossing be performed at this alignment before proceeding with the bridge design.

The low water channel is about 70 m wide and 3 m deep. A smaller flood channel with a bed elevation 2 m higher than the main channel cuts through the vegetated bar on the south bank. The channel bed is armoured with cobble and some boulders. The material under the armour layer is primarily gravel. The banks are composed of silt, sand and gravel.

ICE CHARACTERISTICS

Ice can affect the bridge design at the crossing location in two ways. Local breakup can produce ice loads on the bridge piers and high water levels. Ice jams from the Mackenzie River can also cause very high water levels at the bridge site.

Local Breakup

Local breakup will produce ice loads on the bridge piers but is not likely to generate higher breakup water levels than those produced by ice jams in the Mackenzie River. However, the elevation of the moving ice from the local breakup, as well as the ice thickness and strength, is required to determine the ice load elevation.

A regional analysis of ice thicknesses was carried out by Trillium Engineering in 2001 for tributaries of the Mackenzie River. This analysis suggested that a design ice thickness of 1.2 m was appropriate for shallow streams such as the Blackwater River.

The relatively wide 70 m low flow width of the Blackwater River makes it likely that breakup will occur at melting temperatures but the ice may move in large pieces and may be internally sound. Thus a design ice strength of 1100 kPa should be used for this crossing site.

The water level elevation of an ice run is not expected to be greater than 111.5 m at alignment C. The elevation of the applied ice load occurs at the center of the ice thickness which is 92% submerged, thus the load would be applied at 111.0 m, 0.5 m below the maximum ice effected water level. The original design specified a slightly higher ice load elevation of 111.4 m.

Mackenzie River Ice Jams

Previous analysis of Mackenzie River ice jams in the vicinity of the Blackwater River (Trillium

Engineering, 2001) indicated that the jams could rise as much as 14.9 m above a low water reference stage. This low water reference stage is about 1.0 m lower than the Mackenzie River water level of 103.5 m surveyed at the mouth of the Blackwater River on Sept. 19, 1972; therefore, the maximum ice jam elevation is about 117.4 m. The original design specified a lower elevation of 116.3 m, however, this was based on only four years of breakup data available at Wrigley.

Ice floes from the Mackenzie River are not expected to travel far enough up the Blackwater channel to impact with the bridge piers at the ice jam elevation. However, the Mackenzie jam may trigger local breakup in the Blackwater River due to the rapidly rising water levels. The velocity of any of these ice floes will be small and the likelihood of the jam occurring when the ice thickness and strength are at a maximum is low. Still, some minor impacts may occur, thus a some nominal ice load should be accommodated in the design. An ice thickness of 0.35 m and an ice strength of 400 kPa will produce an appropriate load to apply at this ice jam elevation.

BRIDGE HYDRAULIC CHARACTERISTICS

The hydraulic characteristics of the bridge depend on the adopted alignment and opening width. Narrow openings may reduce the length of the bridge but will block flood plain flow and increase velocities.

Environmental Effects of Bridge Alignment Alternatives

The locations of three bridge alignment alternatives proposed during the original design process are shown in Figure 3. Alignment A, the most downstream alternative, crosses the river at the middle of a large vegetated bar on the south bank. Alignment B crosses at the upstream end of the bar. Alignment C crosses at the downstream end of the upstream bar on the north bank.

Alignments A and B would block the high flow channel on the south side of the vegetated bar whereas alignment C does not encroach significantly on the main channel. Blocking the high flow channel and bar with the approach embankment will cause increased flow velocities during high flow events which may impede fish movement. Alignment C does not increase the flow velocity significantly at high flows relative to the natural river but both alignment A and B increase the mean velocity by about 15% at high flows.

Alignment A also required that a portion of the bar be excavated to provide a wider low water channel at this crossing location. This disturbance of the channel during construction has the potential to introduce silt in the river, however this can be controlled by using appropriate construction techniques to isolate the disturbance.

Alignment C appears to produce the least environmental effects on the river. The location is in the narrowest part of the high flow channel so the shortest span is required to bridge from bank to bank. These high flow banks also appear to be more stable than the bars within the channel. Alignment C should be adopted unless it has serious shortcomings for other aspects of the design. The following hydraulic analysis will focus on this alignment.

Bridge Hydraulics

The bridge opening proposed in the original design for alignment C consisted of four spans with a total length of 207.2 m. The two central spans were 59.4 m long and the spans on either side were 44.2 m long. The 2:1 headslope on the north bank was set back about 10 m from the bank while the 2:1 headslope on the south bank encroached about 12 m into the channel. A profile of the bridge opening is shown in Figure 5.

The water level of 112.0 m at the design discharge of 1840 m^3/s proposed in the original hydraulic design can be simulated using in a Manning roughness of 0.052. This roughness value is in the range of expected roughness for a cobble bed channel, however it is on the high end of the range. No further flow data is available at the site so it is prudent to maintain this water level as the design open water elevation.

The mean velocity calculated from the design discharge and water level is 2.8 m/s. This velocity would be higher if a lower roughness value were adopted so is recommended that Class II riprap with a median diameter of 0.5 m be used for slope protection.

The hydraulic design values obtained from the above analysis are summarized and compared with the original design values in Table 1. Most of the hydraulic design parameters are similar to the original design values.

Minimum Bridge Elevation

The Mackenzie River ice jam level is much higher than the open water or local breakup elevations. The original bridge design at alignment C specified a minimum bridge elevation of 117.2 m which provided 0.9 m of freeboard above the Mackenzie River ice jam level of 116.3. The present analysis indicates that the Mackenzie River ice jam level may be as high as 117.4 m. As well, freeboard of 1.5 m is recommended on Mackenzie River ice jam levels to allow for uncertainty in the ice jam analysis. The minimum flange elevation of the bridge should be 118.9 m to provide 1.5 m of freeboard above the Mackenzie River ice jam level.

Raising the bridge to accommodate the higher Mackenzie River ice jam level will either require a narrower opening between the headslopes or a longer bridge span. The opening will only be about 8 m narrower which will not increase the mean velocity significantly so the original span length may still be used.

Scour

General scour may cause the bed to lower locally through the bridge section when the flood plain flow is blocked by approach embankments or if the headslopes project into the active channel and restrict the width. A maximum general scour elevation of 105.5 m was given in the original design. The original scour elevation may be conservative for the alignment C because the same amount of scour was specified for alignments A and B where a significant amount of the high flow channel was blocked. At alignment C, the south headslope may project into the channel up to 20 m when the bridge elevation is raised to accommodate the new Mackenzie River ice jam level. As well, about 5% of the flow will be blocked by the north embankment and be diverted through the bridge opening. These factors along with the possible shifting of the thalweg may produce minimum scour elevations of about 106.1 m.

Pier scour should be added to the maximum general scour if the piers are located in the channel. The original design proposed 2.1 m wide piers which would produce up to 4.8 m of pier scour. This pier scour can be reduced if narrower piers are selected.

RECOMMENDATIONS

It appears that, from a hydraulic perspective, alignment C is the preferred alignment, however, the above analysis is based on the existing information at the crossing site. It is recommended that a new detailed survey be carried out at the alignment C crossing to determine the present shape of the channel. The hydraulic analysis should be reviewed again once this additional data is available.

Most of the hydraulic design parameters obtained from the above analysis are similar to the original design values, however the bridge should be raised 1.7 m to better accommodate the high water levels generated by Mackenzie River ice jams. The narrower opening caused by raising the bridge will not increase the mean velocity significantly so the original span lengths may still be used.

If you have any questions or comments about the above analysis call me at 496-7671.

Sincerely,

Gary Van Der Vinne, M.Sc., P.Eng.
Trillium Engineering and Hydrographics Inc.

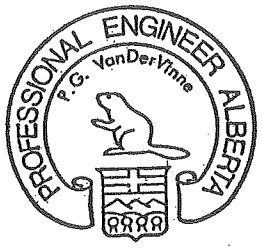

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Table 1 Summary of hydrotechnical design parameters

Design Parameter		Original Design	Present Design
Hydrologic Characteristics			
Drainage Area	(km^2)	10,640	10,640
Design Discharge	(m^3/s)	1840	1840
Ice Characteristics			
Ice Thickness	(m)	1.2	1.2
Ice Strength	(kPa)	1500	1100
Ice Load Elevation	(m)	111.4	111.0
Hydraulic Characteristics			
Open Water Velocity	(m/s)	2.8	2.8
Open Water Elevation	(m)	112.0	112.0
Mackenzie Ice Jam Elevation	(m)	116.3	117.4
Min. Bridge Elevation	(m)	117.2	118.9
Min. Scour Elevation	(m)	105.5	106.1
Riprap Median Diameter	(m)	0.8	0.5

ALTERNATE "C"

ALTERNATE "B"

ALTERNATE "A"

RIP-RAP

RIP-RAP HEADSLOPE EXCAVATE INTO BANK

APPROX. 165'

APPROX. 100'

63m.

D = 4°00'00" R = 1432.69'

D = 3°00'00" R = 1910.08'

D = 2°30'00" R = 2292.08'

D = 2°00'00" R = 2864.93'

D = 1°30'00" R = 3819.72'

D = 2°00'00" R = 2864.93' T = 601.19'

BLACKWATER RIVER

OLD FLOOD CHANNEL

TO FT. SIMPSON

TEST HOLE No. 2715

CNT. LINE

CNT. LINE

MACKENZIE RIVER

500' 0 500'

SCALE

ALIGNMENT
TAKEN FROM D.P.W. CONTOUR PLAN No. 95N16E
SCALE: 1"=200'
CONTOUR INTERVAL: 5'
DATE OF PHOTO: JUNE 4, 1972

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
PERMIT NUMBER P220
BOLTER PARISH TRIMBLE LTD.

NO.	DATE	DESCRIPTION	BY
3	DEC. 6/73	ALTERNATE "C"	C.M.M.
2	DEC. 21/72	ALTERNATE "B"	S.P.K.
1	DEC. 12/72	rip-rap and rip-rap armour.	

REVISIONS

Bolter · Parish · Trimble · Ltd.
CONSULTING ENGINEERS

DATE	FILE	DWN. BY	SCALE

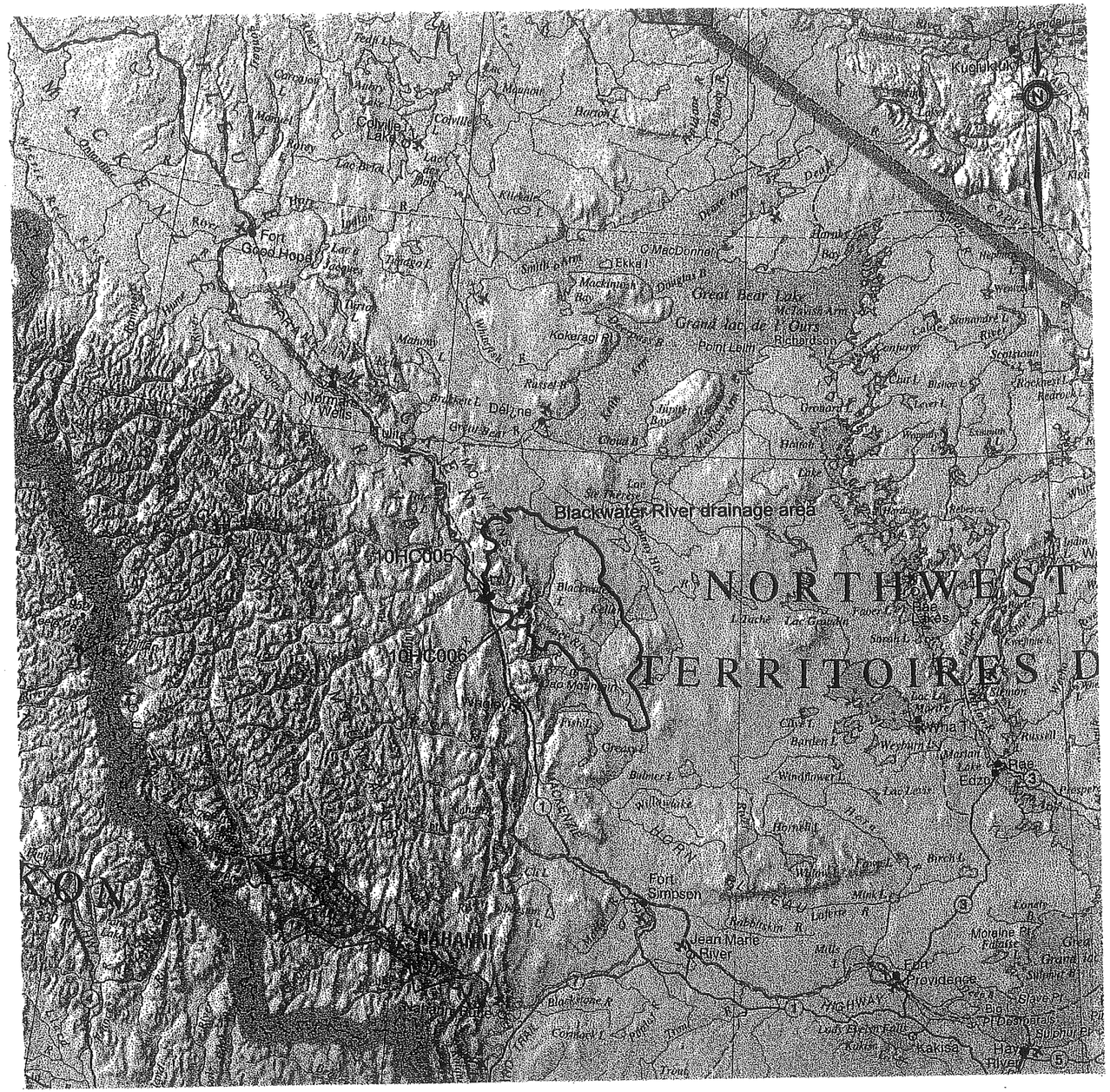
DEPARTMENT OF PUBLIC WORKS
WESTERN REGION

MACKENZIE HIGHWAY

BLACKWATER RIVER Mi. 492
ALIGNMENT

SHEET No. 1 of 2

DWG. No. 115-3-66



Map: MCR 36
Scale: 1:4 000 000

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CLIENT	BPTEC ENGINEERING GROUP
PROJECT	HYDROTECHNICAL ASSESSMENT FOR BLACKWATER RIVER BRIDGE

LOCATION PLAN

TRILLIUM FILE	DATE	FIGURE
03-552	MAY 12, 2003	1