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December 13, 1973

Department of Public Works
10th Floor, One Thornton Court
P.O. Box 488
Edmonton, Alberta
T5J 2K1

Attention Mr. F. E. Kimball
Project Manager NWT Roads
Western Region

Gentlemen:

Mackenzie Highway - Preliminary Engineering Phase 1B
Ochre River Bridge Mile 454.6

We are pleased to present herein our Phase 1B on the Ochre River Bridge which has been prepared in accordance with Mr. Kimball's letter of October 3, 1973.

As instructed, the Report includes a summary of the hydrology and geotechnical reports; impact statements on the temporary and permanent crossings by the environmental consultant; and, a brief description of the proposed structure and alternate systems considered together with preliminary drawings and cost estimates.

The M.H.E.W.G. Assessment Report #2 was received after the Report drawings and text were completed but fortunately the major item i.e. the elimination of guide banks and river training and the lengthening of the structure, has been incorporated into the Phase 1B proposal. The response of the hydrological and geotechnical consultants to specific questions are included in Appendix D.

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We are in agreement with Bolter, Parish & Trimble's comment on clearance above Mackenzie high water level in that the structure can be raised 2-feet without changing the concept of the structure. However, if the decision is made to raise the bridge by 2-feet then the profile should be raised by 9-feet± and not 7-feet± as indicated in the text.

We trust that the content of our Report provides a basis for approval in principle and authorization to proceed with final design.

Yours very truly,



R. C. Aitken, P. Eng.
Manager, Transportation Division

RCA/mm

Enclosures

MACKENZIE HIGHWAY
PRELIMINARY ENGINEERING PHASE 1B
OCHRE RIVER BRIDGE MILE 454.6

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MACKENZIE HIGHWAY
PRELIMINARY ENGINEERING PHASE 1B
OCHRE RIVER BRIDGE MILE 454.6

INTRODUCTION:

The proposed crossing of the Ochre River is in a stable reach of the river immediately downstream from a partially vegetated gravel bar island and approximately 1,000-feet from the Mackenzie River.

At this location, the channel is approximately 250-feet wide at normal water level; the water is clear and fast-flowing; the stream bed consists of gravel and boulders; and, the banks are approximately 25-feet high and well defined. The forest cover, consisting of black and white spruce and aspen up to 60-feet in height, extends to within a few feet of low water except in the immediate vicinity of the proposed crossing where the trees have been cleared for the telegraph line and the existing road.

The drainage area of the Ochre River is approximately 450 square miles and the estimated design discharge is 18,600 c.f.s. at an average velocity of 8-feet per second; flow at all stages will be confined within the existing banks. No general bed scour is anticipated.

The highway grade at the proposed crossing will be controlled not by flow in the Ochre River, but by backwater due to ice jams on the Mackenzie River. Backwater has been estimated on the basis of recorded extremes on the Mackenzie River at Wrigley, approximately 27 miles south of the Ochre River.

Fish access to the Mackenzie River is good and it appears that the fishery potential of the Ochre River is high. The following species have been noted - grayling, trout perch, round white fish, long-nose sucker, white sucker, slimy sculpin and lake chub.

Several archaeological and historic sites have been identified in the vicinity of the proposed crossing; these are shown on the site plan - Dwg. P501. These sites should be clearly identified and fenced off prior to start of construction.

The previous submission dated December, 1972, based on the proposal by the hydrology consultant, provided a bridge of minimum length and cost. However, this proposal required extensive river training, including a guide bank extending 250-feet upstream from the bridge to the existing gravel bar island and, the partial excavation of this island. This proposal is considered to be unacceptable both from the viewpoint of fisheries and future maintenance of the guide banks and therefore an alternate solution

with a considerably longer bridge is now proposed. The proposed bridge shown on Dwg. P501 is now 114-feet longer than the previous proposal but the river training has been deleted and the average velocity at flood stage has been reduced from 11-feet per second to 8-feet per second.

To further reduce the impact of the proposed crossing and to permit more flexible scheduling of construction, the bridge piers have been located so that they are virtually out of the river at normal flow. Comments by F. F. Slaney & Company Limited on the environmental impact of the proposed bridge and the temporary crossing are included in Appendix B.

A minimum clearance of 3-feet from the underside of the bridge superstructure to the estimated high water due to ice jams on the Mackenzie has been used to establish the highway grade. It should be noted that the proposed structure, having a considerably longer center span, will be deeper than the previous submission; as a result, the highway profile has to be raised to a minimum elevation of 326 (top of deck) i.e. 7-feet± higher than the original profile shown on the Interim Report.

The geotechnical investigation, although carried out under adverse conditions, is quite adequate for the design of the bridge piers and abutments. The results of the investigation can be summarized as follows. Permafrost was encountered from 20-feet

below stream bed to 80-feet (the depth of the deepest hole). The stratigraphic sequence below the river consists primarily of coarse/fine to coarse gravel with clay layers in the upper portions. Below the granular deposits, a hard dark blue "shale-like" clay was encountered at a depth of 70-feet± which, it is believed, is bedrock. Coring of this strata was unsuccessful due to caving and loss of a core barrel. Bedrock in the area is believed to consist of cretaceous sedimentary deposits of interbedded shale, silt stones and sandstones. Boring logs are included in Appendix C of this Report.

DESIGN CONSIDERATIONS:Proposed Structure.

The proposed bridge is a three span structure with spans of 72'-260'-72'; the deck is cast-in-place concrete supported by two welded plate girders with composite action in areas of positive moment. Cast-in-place piers and abutments with piled foundations are recommended for the substructure. The proposed layout is shown on Dwg. P501.

It is fair to say that the Ochre River Bridge is now a significant structure and, while we acknowledge that cost is the primary consideration, the appearance of the bridge should not be ignored completely. On this basis, we have proposed that girder soffits be curved rather than straight and that the bridge piers be slightly flared towards the base to create an impression of strength and stability and to break up the large plane surfaces of these relatively massive piers. We have used a shape similar to this on other structures and we consider it to be visually superior to a straight shaft with round nosings, particularly when formwork panels and tieholes are arranged symmetrically and the exposed concrete surfaces sandblasted.

"Spill through" abutments have been shown (Dwg. P502) on the assumption that the approach embankments may not be in place

when the bridge is constructed; if in fact embankments are placed ahead of bridge construction then a more economical "perched abutment" supported by piles driven through the approach fills will be substituted. The unconventional bearing arrangement at the abutments is required by the unbalanced superstructure which produces uplift forces under all loading conditions.

Subsurface conditions are such that piled foundations are recommended both for piers and abutments - (a) to protect piers against local scour and (b) to reduce differential settlement between piers and abutments to a negligible amount - the proposed structure with its short, stiff end spans will be particularly sensitive to differential movements at supports.

For the purposes of this preliminary design and cost estimate H-piles have been assumed although we share the soils consultant's reservations on the feasibility of successfully driving them through the dense gravel layers. There is a distinct possibility that some H-piles will "hang up" and that additional piles will have to be driven since we doubt that pile testing during construction is really practical at these remote sites. Therefore, it would appear that extra H-piles will have to be delivered to each bridge site if lengthy delays during construction are to be avoided. A preliminary investigation indicates that open ended pipe piles drilled to bedrock may be a

more predictable and economical solution at this and other bridge sites along the east bank of the Mackenzie and they will be given further consideration during final design.

In consideration of the fact that many of the bridge sites along this stretch of the highway have similar subsurface conditions we would recommend that a comprehensive program of pile driving and load testing be carried out at one or two representative sites. Such a program would investigate H-piles installed by dynamic and vibrating equipment, open ended pipe piles seated into bedrock and would provide:

- a more rational basis for design;
- valuable information to contractors tendering on the project.

The riverbanks adjacent to the bridge piers will be protected by riprap as indicated on the Drawings - limits of riprap will be determined during the final design phase of the project. It is understood that embankments will be grassed except beneath the structure where slope protection will be provided.

Design Criteria.

Specifications: C.S.A. S6
A.A.S.H.O.
A.W.S. D1.1

Materials: Structural Steel - C.S.A. G40.21 Grade 50A
Deck Concrete - f'c - 4,000 p.s.i.
Substructure Concrete - f'c - 3,000 p.s.i.
Reinforcing Steel - C.S.A. G30.12 60 Grade

Loading: Live Load - H.S. 25 + Impact
Future Wearing Surface - 30 p.s.f.
Ice Pressure - 250 p.s.i.
Ice Thickness - 5'-0"

Piles: 70 Ton Compression (Group I C.S.A. S6)
100 Ton Compression } (Group VIII C.S.A. S6)
30 Ton Tension }

Alternate Systems.

Before selecting the three span structure, four deck systems and a four span structure were evaluated. Deck systems considered were:

- concrete deck, three girders;
- concrete deck, two girders with transverse floor beams;
- concrete deck, two girders without transverse floor beams; and,
- open steel deck, two girders with transverse floor beams.

The concrete deck/two girder system proved to be more economical than the other concrete deck systems and the welded steel deck; in estimating the cost of the open steel deck system, a 6½-inch Armco welded deck was considered. From discussions with the manufacturer, it appears that a steel deck could be installed for around \$12.00/sq. ft.; however, the plate girders and floor beams required to support a steel deck would be in the order of 10 lbs./sq. ft. heavier than the plate girders required to support the concrete deck so that the relative cost of a steel deck would be in the order of \$19.00 - \$20.00/sq. ft. (assuming structural steel at \$0.75/lb.). Therefore deck concrete could cost up to \$500.00/cu. yd. including formwork (but excluding reinforcing steel) before the steel deck would be economically competitive.

From this preliminary investigation it is evident that the steel deck, although structurally adequate, will be

considerably more expensive than a concrete deck and, in addition, the riding qualities of the steel deck will be inferior to those of a concrete deck. The alternate concrete and steel deck two girder systems with floor beams are shown on Dwg. P504.

Under normal conditions one would anticipate that a four span structure would be more economical than a three span structure however, in this instance, it was found that the additional steel required for the longer span was largely offset by the cost of the additional river pier. This pier proved to be relatively expensive because of its size, the high cost of concrete and piling, and the environmental constraints which recommend that construction in the river be carried out during winter. Scheduling of the three span structure will be more flexible and estimating the cost of the structure will be more reliable since the greatest unknown is the risk factor which contractors will apply to concrete and piling unit prices.

TEMPORARY CROSSING:

The proposed location of the temporary crossing is approximately 250-feet downstream from the permanent bridge at the existing winter road crossing.

The proposed structure, a two span Bailey bridge supported by rock filled timber cribs, is shown on Dwg. P503. The temporary bridge is designed to carry a maximum live load of 52 tons (D9G Cat).

The underside of the structure has been set at an elevation 3-feet above the estimated high water level on the Ochre River. At this height, the temporary bridge will have little effect on the river at flood stage and it will not be subjected to damage during ice breakup; however, it should be noted that the structure and the approaches may be inundated for a short period of time by backwater conditions on the Mackenzie River.

The hydrology consultant has advised that there are, at present, no reliable methods of predicting backwater conditions due to ice but there is a possibility inundation of the bridge could occur every spring. However, he further notes that the bridge will be above the ice run on the Ochre and that he would not anticipate damage to the structure because of backwater conditions if the bridge is well anchored against uplift forces.

Alternatively, the bridge can be raised and lengthened but this would of course increase the cost significantly.

Local scour at the timber cribs is anticipated and, since pile driving is impractical, a protective apron of riprap will be required. However, if sufficient rock is not available, a filter fabric protected by triple-twist wire mesh is recommended - the mesh will be attached to the timber cribs and weighted at its extremities by drill stem or other appropriate means.

The elevation of the bridge is such that the approaches can be tied to existing grade or the highway grade depending on whether or not the highway embankment is in place when bridge construction commences.

Consideration was given to building a native timber structure, however the local timbers are such that the clear span would at best be 15-feet. An arrangement of short spans and timber cribs would be quite impractical on this river both from the environmental and hydrological viewpoints. Native timber will be suitable for deck and crib construction.

SCHEDULING:

The following schedule assumes that highway construction will commence in the spring of 1975 and that all bridges on this section of the highway will be completed in the fall of 1976.

Allowing six months for structural steel delivery the tentative schedule will require bridge drawings and contract documents to be completed not later than April, 1975 and possibly sooner depending on the period of time required for approvals.

Schedule.

- Deliver concrete aggregates to Ochre River mouth - Fall 1974 or Summer 1975.
- Construct temporary bridge - Winter 1974-75.
- Start abutment construction - July, 1975.
- Start pier construction - August, 1975.
- Erect structural steelwork - Winter 1975-76.
- Place deck and complete structure - Summer 1976.

It would appear that completion of the four bridges between Mile 411.0 (River Between Two Mountains) and Mile 460 (Whitesand Creek) by late 1976 is impossible unless some of them are designated for winter construction and each phase of

construction is carefully scheduled. We realize that these decisions will be made as part of an overall construction plan which will cover all aspects of the project; to assist the Department in this major undertaking we have prepared a bar chart showing a possible construction schedule for these bridges. This schedule assumes that all bridges will be let as one contract.

COST ESTIMATE:

Estimating costs at this stage of the project has proved to be even more difficult than it was one year ago, when the Interim Report was prepared, because of the unstable prices which are currently being experienced throughout the construction industry.

We have reviewed the unit prices which were developed for the Interim Report and, while some of the units now appear to have been on the low side, they were generally speaking quite realistic at that time. These unit prices have therefore been used as a basis for the present estimate but increased to reflect current prices (December, 1973). A detailed breakdown of the estimate is given on the following page.

OCHRE RIVER BRIDGE MILE 454.6
COST ESTIMATE - DECEMBER, 1973

<u>Item</u>	<u>Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Amount</u>
Excavation & Backfill				
- Rock	--	--	\$ --	\$ --
- Gravel	800	cu.yd.	50.00	40,000
- Riprap	1,100	cu.yd.	25.00	27,500
Piles	3,000	lin.ft.	30.00	90,000
Concrete				
- Foundations	300	cu.yd.	300.00	90,000
- Piers & Abutments	420	cu.yd.	300.00	126,000
- Deck	475	cu.yd.	350.00	166,300
- Approach Slab	45	cu.yd.	300.00	13,500
Reinforcing Steel	300,000	lb.	0.40	120,000
Structural Steel	250	ton	1,500.00	375,000
Handrail	890	lin.ft.	30.00	26,700
Expansion Joint	65	lin.ft.	100.00	6,500
Bearings	8	each	1,500.00	<u>12,000</u>
Sub-Total				\$1,093,500
15% Contingency				\$ 164,000
7% Engineering & Administration				<u>\$ 88,500</u>
TOTAL				<u>\$1,346,000</u>
Temporary Bridge				\$ 200,000