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Design and Construction Resources (Civil)

Structures (Bridges) Section

Mackenzie Highway Northwest Territories

Loon River Bridge

Mile 742.2

Phase 1 Report

June 1975

D003059

REFERENCE COLLECTION
PROTECTION BRANCH

000017

MACKENZIE HIGHWAY

NORTHWEST TERRITORIES

LOON RIVER BRIDGE

MILE 742.2

PHASE 1 REPORT

JUNE, 1975

STRUCTURES (BRIDGES) SECTION

CIVIL ENGINEERING DIVISION

RESOURCES BRANCH

DESIGN AND CONSTRUCTION

PUBLIC WORKS CANADA

OTTAWA

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INTRODUCTION

At the request of the Western Region, Public Works Canada, the Structures (Bridges) Section, Civil Engineering Division, Resources Branch, Headquarters, Public Works of Canada undertook the Phase 1 (Preliminary Engineering) design of Loon River Bridge based on the information and data given by the following consultants.

1. Hydrologist: Foundation of Canada Engineering Corporation Ltd., 9731 51st. Avenue, Edmonton, Alberta

2. Geotechnical: Public Works Canada, Western Region, Edmonton, Alberta

3. Environmental Impact: Schultz International Limited, 325 Howe Street, Vancouver, Canada. V6G 2A1

The Phase 1 Design includes preliminary investigations and recommended type of structures, estimated quantities and costs, environmental concerns, aesthetics, construction schedule, and temporary crossing.

SUMMARY

1. Loon River Bridge crossing is located in Section D, at mile 742.2 of the MacKenzie Highway, about 17 miles north of Fort Good Hope.

2. The recommended superstructure is a 266 foot long, three-span (70', 126', 70') composite construction (steel and concrete). The recommended substructures are two identical abutments supported by steel piles and two identical piers on spread footings.

3. The estimated cost is approximately $900,000 as of April, 1975. The cost of the temporary crossing is not included.

4. The estimated construction time is about two years including shop fabrication but excluding moving out of heavy equipment after completion of construction.

5. A 130 foot long single span Bailey bridge on timber cribs is recommended for the temporary crossing.

6. The hydrological, geotechnical and environmental impact data provided by the consultants is considered sufficient for Phase 2 Design.

7. Sources of concrete aggregates close to the bridge site are uncertain.

HYDROLOGICAL DATA

The data was provided by Foundation of Canada Engineering Corporation Ltd. in their report "Bridge and Culvert Hydraulics, Mackenzie Highway, Fort Good Hope to Dempster Highway", March, 1974. It is sufficient for Phase 2 Design.

1. Drainage area: 1126 sq. miles
2. Design discharge: 12,700 cfs.
3. Mean velocity at design discharge: 7.2 fps.
4. Natural channel width at design discharge: 212 ft.
5. Minimum channel width required without general scour: 202 ft.
6. Design high water level: El. 201.1
7. Low water level: El. 192.23
8. Local scour depth recommended / Pier width

Local scour depth recommended	Pier width
6'	4'
9'	6'
11'	8'

   Based on the above, the local scour depth for a 3' wide pier would be about 4'.
9. Local velocity around pier: 10.8 fps.
   Required rip-rap around pier: 15" diameter stones
10. Ice tends to pile up on shores; high ice level: El. 200.1
11. Flood plain on West side.

GEOTECHNICAL DATA

We received, in June, 1975 the geotechnical information provided by Public Works Canada, Western Region, Special Services Section, Design and Construction Branch in their report "Geotechnical Investigation, Loon River Bridge - Mile 742.2, Mackenzie Highway, Volume XII". The information and recommendations are sufficient for Phase 2 Design.

Abutments are to be supported on steel piles driven to refusal into shale:

A. H-piles: A heavy section - minimum HP 12x53 is recommended. Before driving, the pile should be placed directly on the shale surface. Using a heavy pile driving hammer (Delmag D-12 diesel hammer or equivalent), the pile should penetrate the shale to refusal at 0.25 inch per blow over the last foot of driving. Two or three days after initial refusal, redriving is recommended to permit additional penetration. For piles driven to practical refusal, an allowable capacity of 100 kips per pile may be used.

B. Pipe piles: A closed-end pipe pile, of minimum 10.75" O.D. x 0.365" is recommended. Pre-bore a hole of 85 to 90% of the outside pile diameter 15 feet into the shale. With a high energy hammer (Delmag D-12 or equivalent), drive the pile to refusal at 0.25 to 0.4 inch per blow over the last foot of driving. The allowable capacity of the pile should reach 100 kips at refusal.

For the pier foundations, spread footings on shale should be considered due to the shallow overburden. They should be placed at sufficient depth to prevent local scour or at a minimum of 4 feet below the shale surface. An allowable assumptive bearing capacity of 20 kips per square foot may be employed on undisturbed intack bedrock.

With the long center span and two short end spans, the abutments and the piers would be founded on frozen shale. Construction on frozen shale is not considered detrimental, since the shale has a low moisture (ice) content and there was no evidence of ice-filled joints or cracks during test drilling. Permafrost degradation into the shale is not considered to affect adversely the bearing of the foundations elements whether spread footings or piles.

The stability of the approach fills will not be a problem because the permafrost is likely to rise into these fills. Embankments should be of well-compacted granular or bedrock material. The closest known borrow sources of bedrock are located at mile 732.5 and mile 748.0. Field compaction control is recommended on all backfill associated with piers and abutments.

ENVIRONMENTAL IMPACT DATA

The information below was provided by Schultz International Limited mainly from their "Base Data Report, Section D-MacKenzie Highway, Miles 715 to 936", June, 1974. It is considered sufficient for Phase 2 Design.

SUMMARY

The area at the river crossing is described as being highly sensitive to almost any adverse environmental change. Therefore, it is recommended that precautionary measures be taken by the contractor(s) during the construction of the bridge, temporary crossing, access roads and adjoining highway.

TERRAIN

The highway approaches Loon River along one of its tributary gullies and crosses the river from an alluvial terrace. The flood plain to the west is drumlinized and a large meander scar and old river benches indicate the earlier courses of the river. The till plain with a veneer of organic material and numerous ponds is poorly drained. Both river banks are subject to solifluction.

VEGETATION

The alluvial terrace was burned over some years ago. The area has a large proportion of bogs, with a cover of small scattered black spruce and a sparse shrub layer on sphagnum moss. There are glacial deposits with an improved growth of black and white spruce and some deciduous trees on the better drained slopes. Larch is scattered in the wetter areas and alder close to the water.

In ice-rich permafrost terrains which exist along the whole route, disturbance of the insulating vegetative cover from construction operations can trigger substantial erosion as well as adverse visual impace and loss of wildlife feeding areas.

WILDLIFE

Wildlife is a major resource of the area. It provides an economic and subsistence base to the native people of the area.

Generally, wildlife is highly mobile and can avoid highway construction. However the impact on wildlife can be very high if the highway impinges on areas good for habitat.

The area is part of a broad spring and fall migration route and staging area that is used by several species of waterfowl, a variety of ducks, loons, broods, and dabblers. However, the highway does not cross a prime waterfowl habitat.

Beavers are found all along the highway but especially in well-defined, well-drained areas which does not include Loon River.

Bears and bear dens are scattered along the MacKenzie River and a few were located in the Loon River area close to the mouth of the river.

One raptor nest (Osprey) was located two miles upstream of the crossing on Loon River. Woodland caribou is rare and a few were sighted in the area.

FISHERIES

In Loon River, a high concentration of fish was found: grayling, pike, longnose sucker, ninespine stickleback, slimy sculpin, lake chub, humpback whitefish, broad whitefish, least cisc, arctic cisco. The river bottom was found to be sand and gravel with little bottom vegetation. During the winter of 1973-74 the ice thickness was 2.5 feet with 4 inches of water underneath.

ARCHAEOLOGY

The Loon River was not specifically investigated for actual archaeological resources because study of aerial photographs indicated that this area has not such potential.

VISUAL RESOURCES

Water bodies: scattered, small lakes

Vegetation: even pattern of dense forest

Topographic relief: very little

Potential views: Mackenzie River, Franklin Mountain Ranges

Local elements: river itself.

SELECTION OF BRIDGE STRUCTURE

1. Recommended structure:

   A. Substructure: two identical cast-in-place concrete abutments supported by steel piles.
   two identical cast-in-place concrete piers supported by spread footings on bedrock.

   B. Superstructure: two 70 foot end spans and one 126 foot center span of continuous composite construction consisting of two steel girders and cast-in-place reinforced concrete deck.

2. The major reasons for the above selections:

   A. For the relatively longer crossing the three-span bridge is found to be more suitable. The longer center span permits the piers to be located on higher and drier ground, thus facilitating the construction of the piers, reducing ice forces on the bridge and reducing local scour at the pier base. Also, the wider opening reduces the effect on fish migration.

   B. The adequate clearance above high water permits the use of the twin girder system, which has a relatively deeper section, but requires less steel than the multi-girder system. The clearance is about 12 feet.

3. Other alternative schemes of bridge superstructure:

   A. Precast concrete deck on two steel girders may be used if local sources of aggregates are uncertain. A comparison of the feasibility of a precast concrete deck versus a cast-in-place concrete deck is given in the report "Lynn Creek Bridge, Mile 713.4, Phase I Report", by Structure (Bridges) Section, Resources (Civil), Public Works Canada, March, 1975.

B. Cast-in-place concrete deck on multi steel girders: A comparison of a cast-in-place concrete deck on a twin girder system versus a multi girder system is as follows:

Item	Two Girders	Multi Girders
Steel required	Less	More
Number of bearings required	Less	More
Depth of girder	Deep	Shallow
Formwork	Costly due to long deck span	Less costly
Deck concrete required	More	Less

<u>Note:</u> The multi girder system is not suitable for a precast concrete deck due to uneven girder deflections whereas the twin girder system selected would provide the option of using the precast concrete deck alternative.

STRUCTURAL DATA

1. Specifications: CSA Standard S6-1974

2. Loading:
   A. HS 25 or one HS 40 along centerline of roadway with 125% allowable stress.
   B. 30 psf. on roadway for future surfacing or for concrete overlay.

3. Bridge length:
   A. Overall bridge length: 291'-6
   B. Face to face of backwalls of abutments: 267'-6
   C. Overall superstructure length: 267'-0
   D. Spans bearing to bearing: 70'-0, 126'-0, 70'-0

4. Bridge width:
   A. Overall width: 31'-0
   B. Roadway width: 28'-0

5. Piles for abutments: Use steel HP or pipe piles.

6. Abutments: Two identical cast-in-place concrete (f'_c = 4,000 psi.) abutments with wingwalls and approach slab. Use of precast concrete elements combined with cast-in-place concrete will be investigated in final design. Spread footings will also be investigated.

7. Piers: Two identical cast-in-place concrete (f'_c = 4,000 psi) piers with spread footings. Use of precast concrete elements along with cast-in-place concrete will be investigated in final design.

8. Embankments: 2 to 1 slope

9. Rip-rap: 15" diameter stones

10. Bearings: Any type, such as rocker, Lubritef, which functions well in cold weather.

11. Girders: Two 5'-0 deep steel (CSA G40.21,50A) girders spaced at 18'-0.

12. Cast-in-place concrete deck (f'_c = 4,000 psi): 12" thick (average)

13. Deck expansion joint: Sliding steel plates with gutter or water-tight, non-tension joint.

14. Curbs: Two 1'-6 x 1'-0 (high) cast-in-place concrete curbs (f'_c = 4,000 psi).

15. Railing: Galvanized HSS (CSA G40.21, 50W) posts and rails at 2'-6 above roadway.

16. Elevations: at centerline of roadway

A.	East abutment, face of backwall:	224.94
B.	East pier, center of bearing:	222.94
C.	West Pier, center of bearing:	219.38
D.	West abutment, face of backwall:	217.40
E.	Bottom of girder, West Pier:	213.21
F.	Clearance above design high water level:	12'+

QUANTITY AND COST ESTIMATES (APRIL 1975)

1. Assumptions:
   - A. Total 26 steel H-piles, each 35 feet long.
   - B. Unit cost is all inclusive of work in place.
   - C. Embankment by bridge contractor.

2. Estimated Quantities And Costs:

Item	Unit of Measurement	Estimated Quantity	Unit Cost $	Cost $
Abutments				
Steel piles	ft.	910	140	127,400
Concrete	cu. yd.	143	450	64,350
Reinforcing steel	lb.	10,000	.65	6,500
Embankment	cu. yd.	5,560	6	33,360
Rip-rap	cu. yd.	440	40	17,600
			sub-total	249,210
Piers				
Concrete	cu. yd.	180	450	81,000
Reinforcing steel	lb.	12,600	.65	8,190
Excavation	cu. yd.	160	10	1,600
Backfill	cu. yd.	56	6	336
Rip-rap	cu. yd.	27	40	1,080
			sub-total	92,206
Superstructure				
Structural steel	ton	83	2,400	199,200
Concrete	cu. yd.	340	450	153,000
Reinforcing steel	lb.	68,000	.65	44,200
Railing	ft.	595	60	35,700
Deck joints	ft.	62	100	6,200
Deck drains	each	8	200	1,600
			sub-total	439,900
				781,300
		Plus approx. 15% contingency		118,700
			Total	900,000

3. Average Costs:
   - A. $3,364 per foot of superstructure length.
   - B. $3,087 per foot of overall bridge length.
   - C. $100.00 per square foot of overall bridge dimension.

CONSTRUCTION SCHEDULE

Year	Month		Activity	Activity
1	10	Materials - Fabrication (9 months) begins	Tender call and contract award. Fabricate steel piles, reinforcing steel, steel girders, bearings, deck joints, drains and railings.	
	11			
	12			
2	1			
	2			
	3			
	4			
	5	Logistics (11 months) begins		Ship by barge to Fort Good Hope: heavy construction equipment, concrete aggregates, cement and all fabricated items.
	6	Materials - Fabrication ends		
	7		Advance party and survey crew to site by helicopter.	
	8			
	9			
	10			
	11			
	12			Haul by winter roads, concrete aggregates, fill, and rip-rap materials from local source and all construction equipment and materials from Fort Good Hope to bridge site.
3	1			
	2	Field Construction (8 months) begins	Construct embankments, abutments, piers and rip-rap.	
	3			
	4	Logistics ends		
	5		Erect steel girders and concrete deck formwork.	
	6			
	7		Place reinforcing steel, pour concrete for deck and curbs, and install railings.	
	8			
	9	Field Construction ends		

TEMPORARY CROSSING

A 130 feet long single span Bailey bridge is recommended. Details are listed below:

1. Location: about 100 feet upstream from the proposed permanent bridge.

2. Bridge type: 130 feet long Extra Wide Double Double Reinforced Bailey with timber deck.

3. Bridge capacity including impact:
   - A. Moment: 4910.08 ft.-kips equivalent to HS39.8 or H42.4
   - B. Shear: 132.16 kips equivalent to HS32.7 or H32.7
   - C. Deck: 44.8 kip axles at a minimum spacing of 4 feet.

4. Abutments: Rock filled timber cribs

5. Clearance: Bottom chords at El.203.1 two feet above design high water level at El.201.1

NOTE: The temporary bridge at this site is not essentially required for the construction of the permanent bridge.

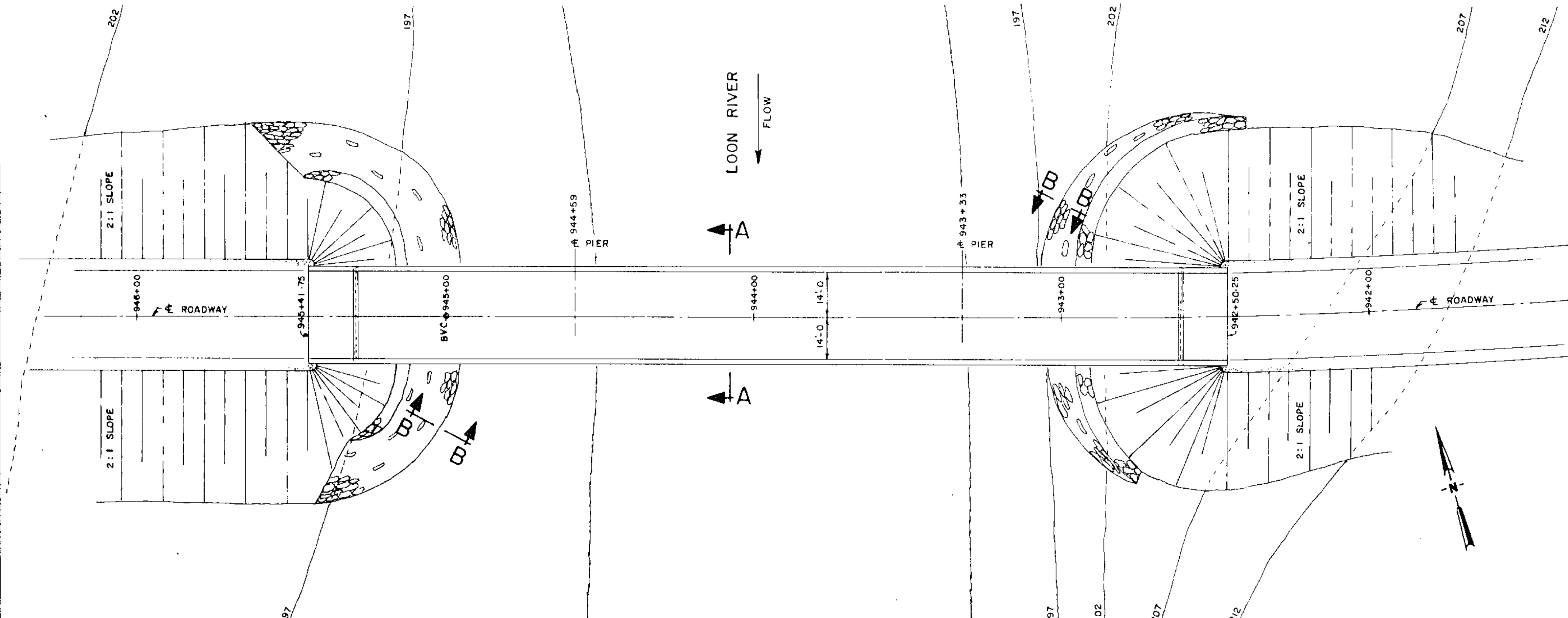
LIST OF DRAWINGS

1. GENERAL LAYOUT

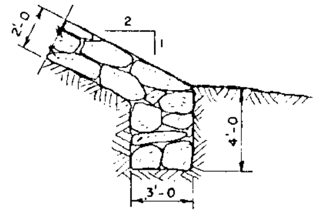
2. SUBSTRUCTURE

3. SUPERSTRUCTURE

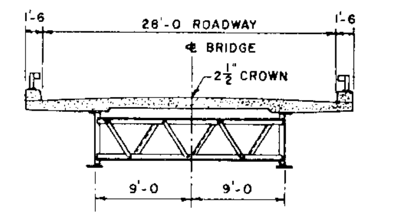
4. TEMPORARY CROSSING



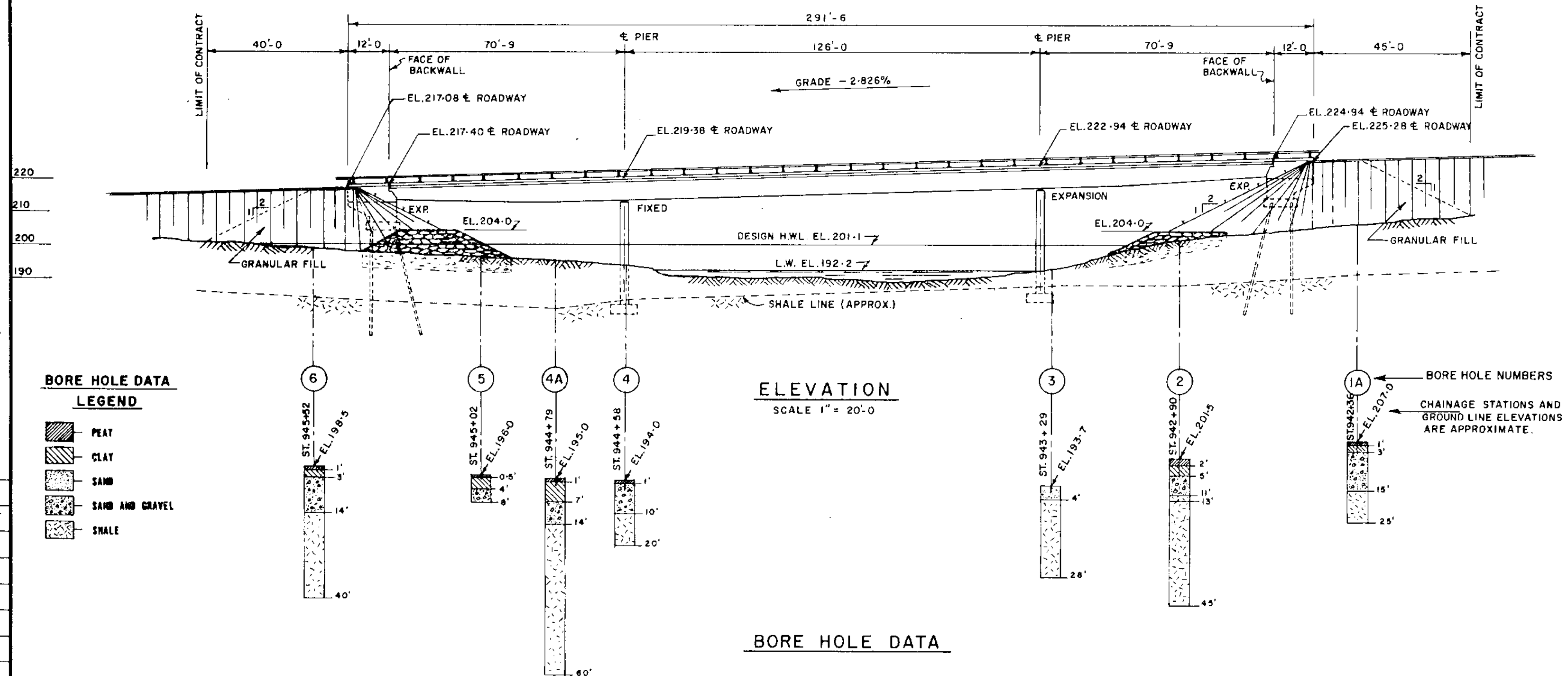
PLAN
SCALE 1" = 20'-0



SECTION B-B
SCALE ¼" = 1'-0



SECTION A-A



ELEVATION
SCALE 1" = 20'-0

BORE HOLE DATA

HYDROLOGICAL DATA

1. DRAINAGE AREA: 1126 SQ. MILES
2. DESIGN DISCHARGE: 12,700 CFS.
3. MEAN VELOCITY AT DESIGN DISCHARGE: 7.2 FPS.
4. NATURAL CHANNEL WIDTH AT DESIGN DISCHARGE: 212 FT.
5. MINIMUM CHANNEL WIDTH REQUIRED WITHOUT GENERAL SCOUR: 202 FT.
6. DESIGN HIGH WATER LEVEL: EL. 201.1
7. LOW WATER LEVEL: EL. 192.23
8. LOCAL SCOUR DEPTH RECOMMENDED — PIER WIDTH

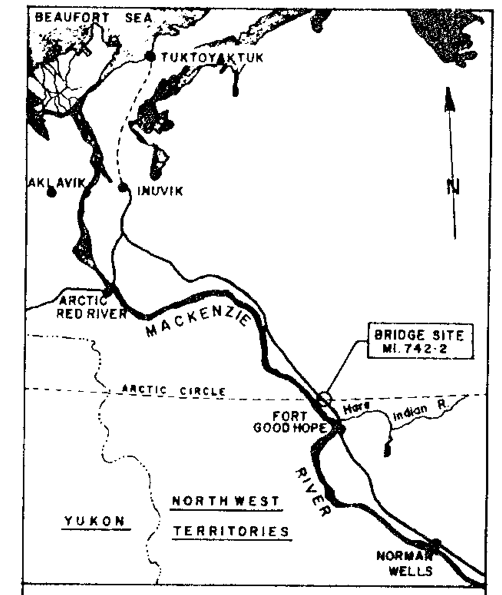
LOCAL SCOUR DEPTH RECOMMENDED	PIER WIDTH
8'	4'
9'	6'
11'	8'

BASED ON THE ABOVE, THE LOCAL SCOUR DEPTH FOR A 3' WIDE PIER WOULD BE ABOUT 4'.

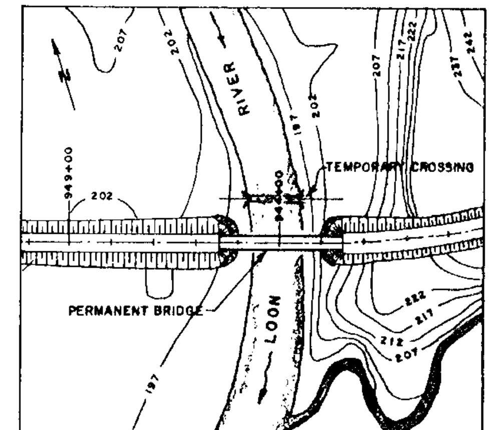
9. LOCAL VELOCITY AROUND PIER: 10.8 FPS.
REQUIRED RIP-RAP AROUND PIER: 15" DIAMETER STONES.
10. ICE TENDS TO PILE UP ON SHORES; HIGH ICE LEVEL: EL. 200.1
11. FLOOD PLAIN ON WEST SIDE.

GENERAL NOTES

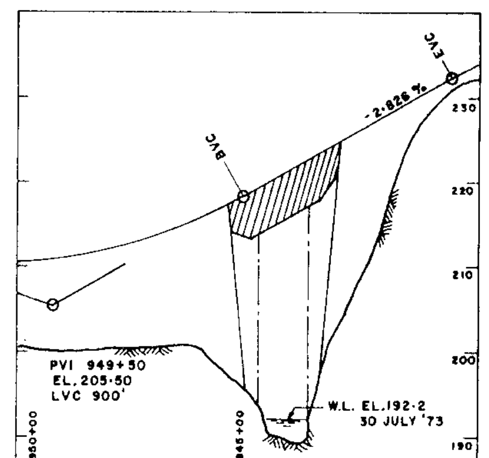
1. DESIGN SPECIFICATIONS = CSA STANDARD S6-1974.
2. LOADING:
   (a) HS 25 OR ONE HS 40 ALONG CENTERLINE OR ROADWAY WITH 125% ALLOWABLE STRESS.
   (b) 30 PSF. ON ROADWAY FOR FUTURE SURFACING.
3. STRUCTURAL STEEL SHALL CONFORM TO CSA G40.21-1973, 50A.
4. CONCRETE SHALL HAVE COMPRESSIVE STRENGTH OF 4,000 PSI AT 28 DAYS.
5. REINFORCING STEEL SHALL CONFORM TO CSA G30.12-1972.



LOCATION PLAN
SCALE 1" = 50 miles



SITE PLAN
SCALE 1" = 200'



HIGHWAY ℄ PROFILE
SCALE HORIZ. 1" = 200' VERT. 1" = 10'

Public Works Canada — Travaux public Canada

Design and Construction
Études et Construction

Resources (civil)
Direction des resources (génie civil)

Structures (Bridges) Section
Section des ouvrages d'art (ponts)

A. detail no. / détail no.
B. location drawing no. / sur dessin no.
C. drawing no. / dessin no.

revisions / revisions

designed by / conçu par	R.H. PION	date
checked by / examiné		date
drawn by / dessiné par	D.A. SYMON	
checked by / examiné		date
recommended by / recommandé par	J.C. BEAUCHAMP, chief bridge engineer / ingénieur en chef (ponts)	date
approved by / approuvé par	assistant director resources (civil) / directeur adjoint ressources (génie civil)	date

project title / titre du projet

LOON RIVER BRIDGE

MACKENZIE HIGHWAY MI. 742.2

N. W. T.

drawing title / titre du dessin

GENERAL LAYOUT

PHASE I

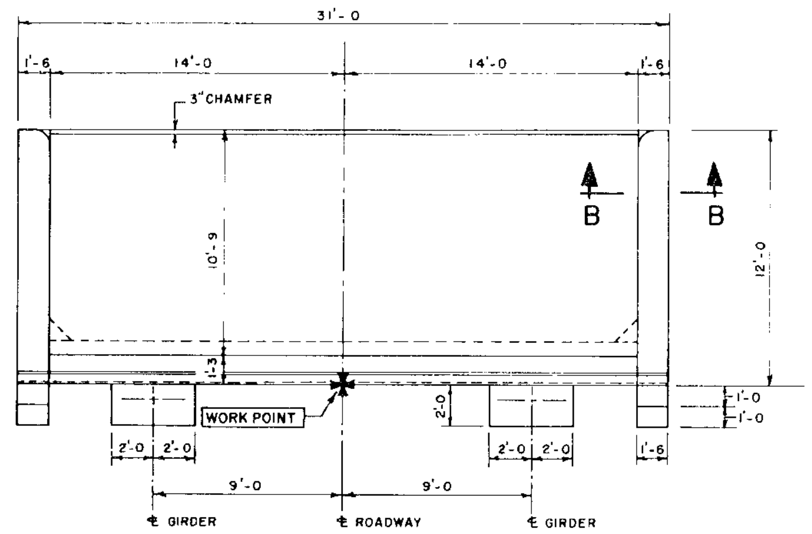
project no. / no. du projet

drawing no. / dessin no. 1 of/de 4

PRELIMINARY

Date 23-6-75

D.P.W. 700 B (revised april 1,1974)



PLAN
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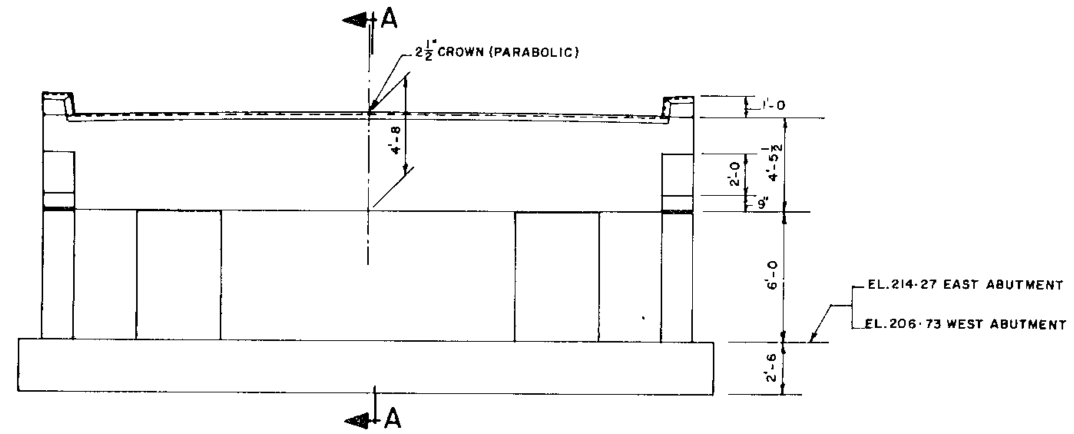
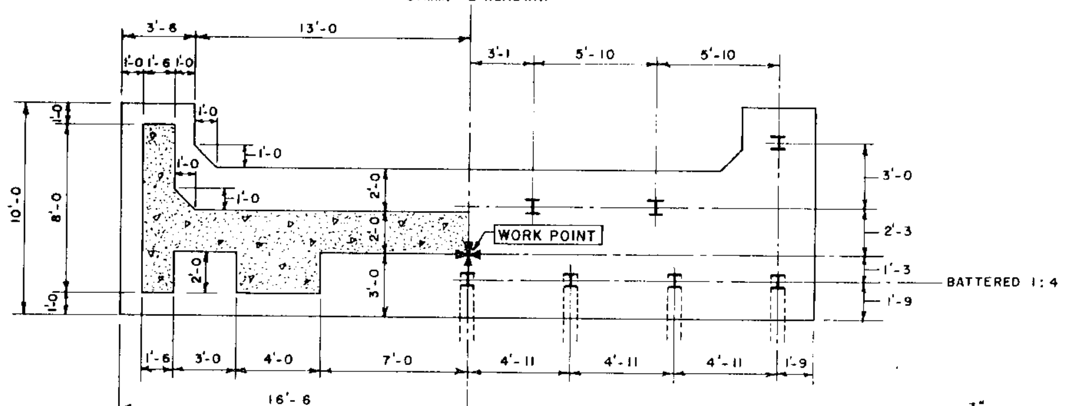
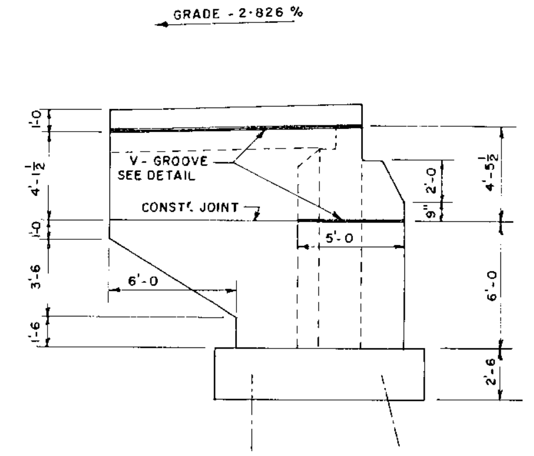


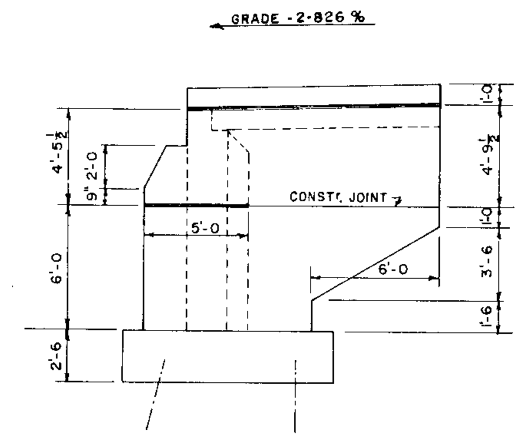
ELEVATION
SCALE 1/4" = 1'-0



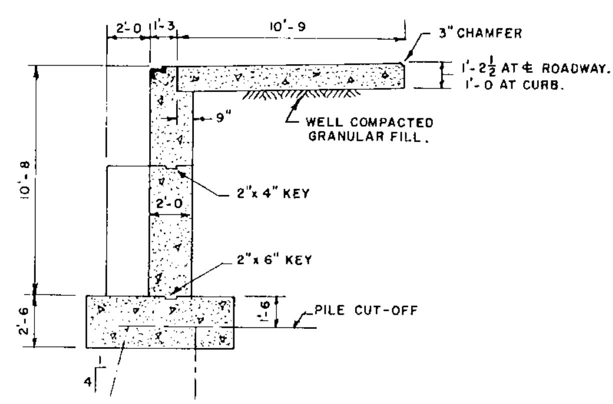
FOUNDATION PLAN
SCALE 1/4" = 1'-0



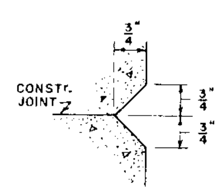
WEST ABUTMENT
SIDE ELEVATION
SCALE 1/4" = 1'-0



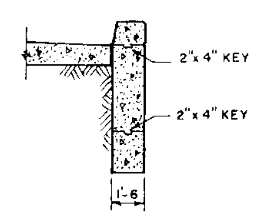
EAST ABUTMENT
SIDE ELEVATION
SCALE 1/4" = 1'-0



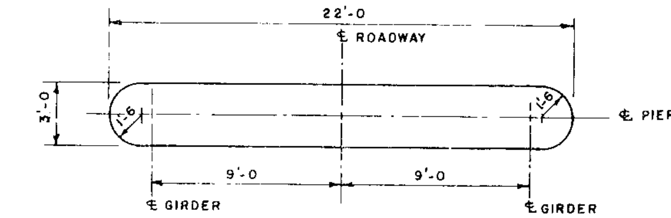
SECTION A-A
SCALE 1/4" = 1'-0



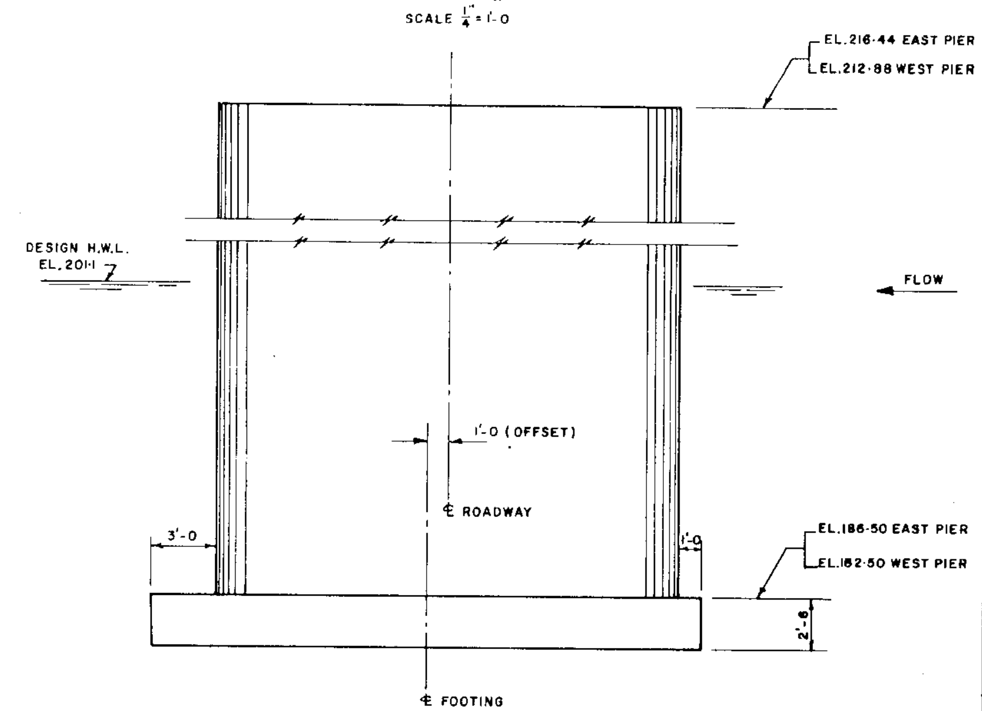
V-GROOVE DETAIL
SCALE 1/2" = 1"



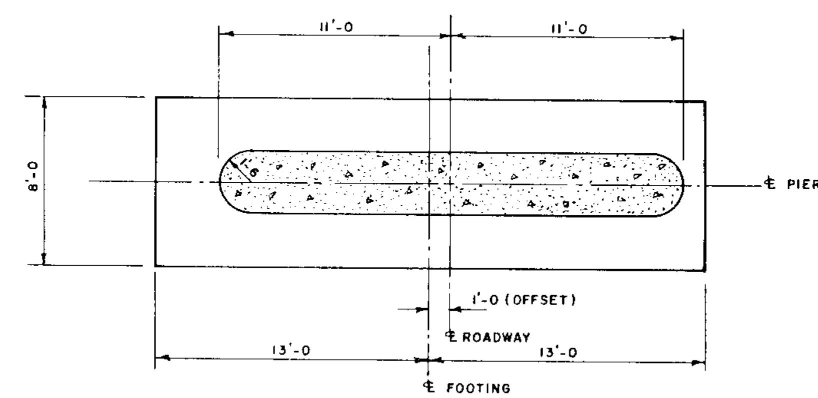
SECTION B-B
SCALE 1/4" = 1'-0



PLAN
SCALE 1/4" = 1'-0



ELEVATION
SCALE 1/4" = 1'-0



FOUNDATION PLAN
SCALE 1/4" = 1'-0

NOTES:

1. PILE DATA
   (i) PILE SIZE (MINIMUM) - HP 12 x 53.
   (ii) NUMBER REQUIRED - 26 (13 PER ABUTMENT).
   (iii) LENGTH - 35'.
   (iv) DESIGN CAPACITY - 100 KIPS.
2. ALLOWABLE BEARING CAPACITY FOR PIER FOOTING - 20 KSF.

PRELIMINARY

Public Works Canada — Travaux public Canada

Design and Construction
Études et Construction

Resources (civil)
Direction des ressources (génie civil)

Structures (Bridges) Section
Section des ouvrages d'art (ponts)

A. detail no. / détail no.
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revisions / revisions

designed by / conçu par	R.H. PION	date
checked by / examiné		date
drawn by / dessiné par	D.A. SYMON	
checked by / examiné		date
recommended by / recommandé par		date
chief bridge engineer / ingénieur en chef (ponts)		
approved by / approuvé par		date
assistant director resources (civil) / directeur adjoint ressources (génie civil)		

project title / titre du projet

LOON RIVER BRIDGE

MACKENZIE HIGHWAY Mi. 742·2

N. W. T.

drawing title / titre du dessin

ABUTMENTS & PIERS

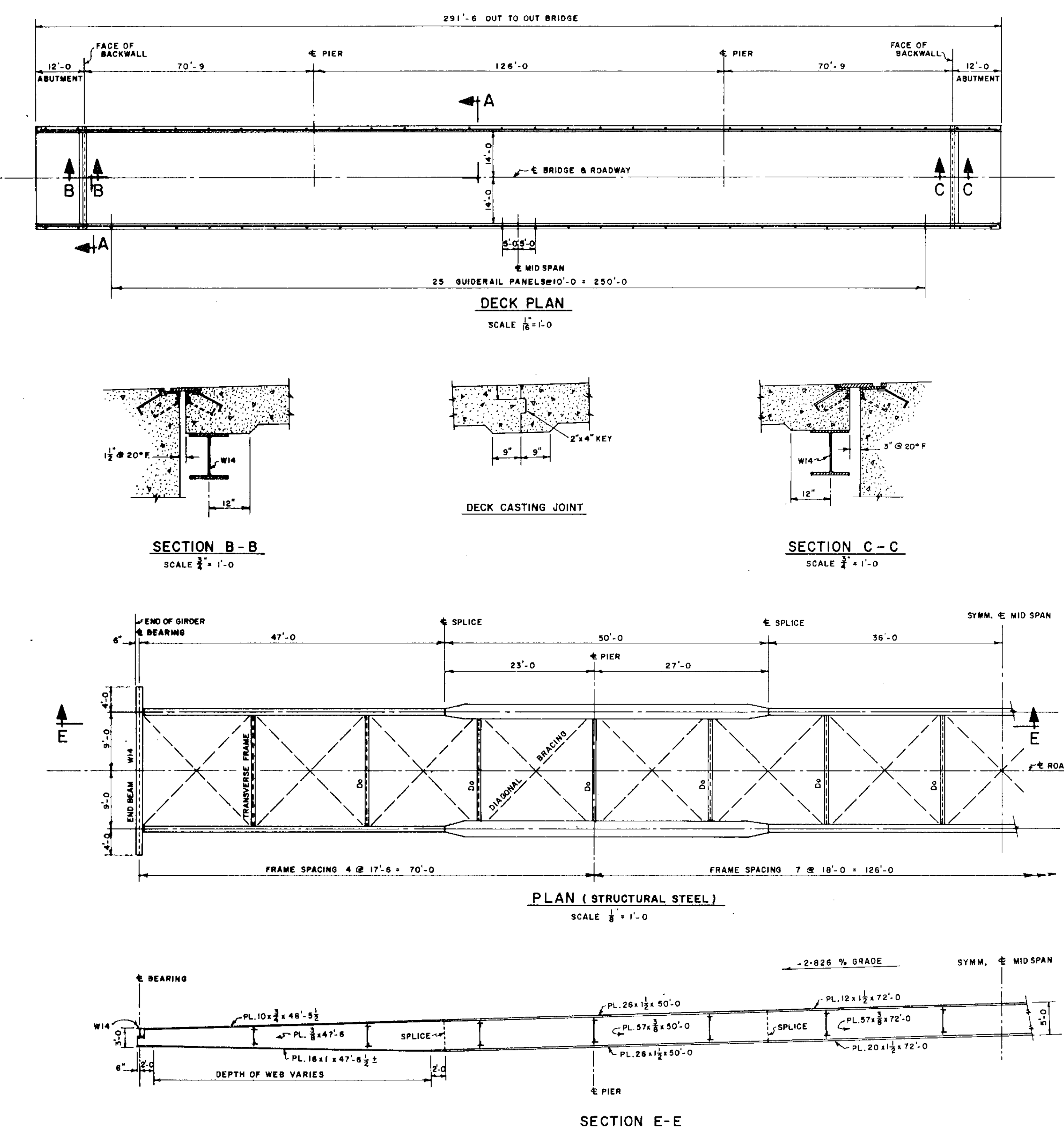
PHASE I

project no. / no. du projet

drawing no. / dessin no. 2 of / de 4

Date 23-6-75

D.P.W. 700 B (revised april 1, 1974)



PRELIMINARY

Public Works Canada / Travaux publics Canada

Design and Construction
Études et Construction

Resources (civil)
Direction des resources (génie civil)

Structures (Bridges) Section
Section des ouvrages d'art (ponts)

A. detail no. / détail no.
B. location drawing no. / sur dessin no.
C. drawing no. / dessin no.

revisions / révisions

designed by / conçu par: R.H. PION — date

checked by / examiné — date

drawn by / dessiné par: D.A. SYMON

checked by / examiné — date

recommended by / recommandé par — date

chief bridge engineer / ingénieur en chef (ponts)

approved by / approuvé par — date

assistant director resources (civil) / directeur adjoint ressources (génie civil)

project title / titre du projet

LOON RIVER BRIDGE

MACKENZIE HIGHWAY MI. 742.2

N.W.T.

drawing title / titre du dessin

SUPERSTRUCTURE

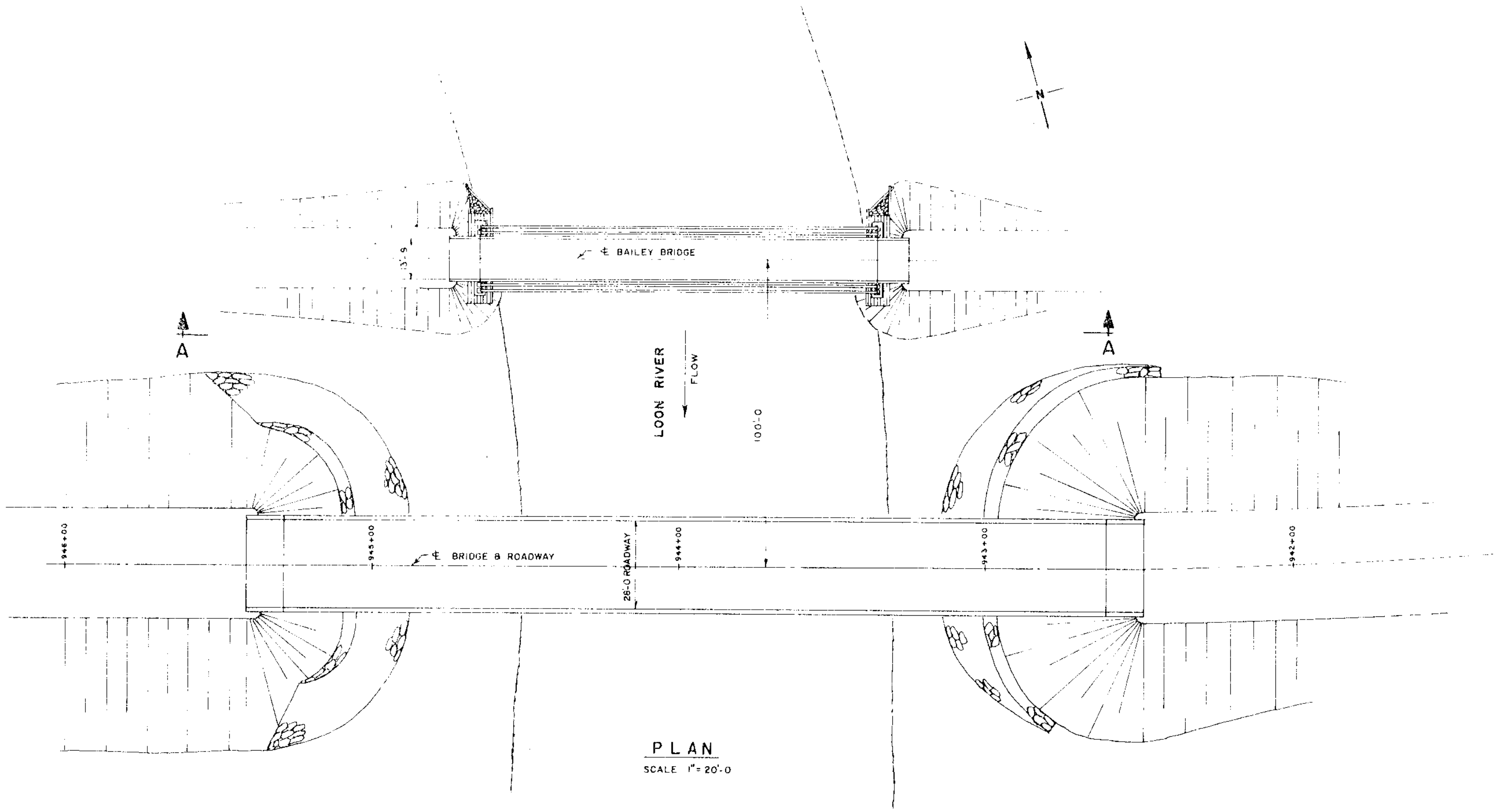
PHASE I

project no. / no. du projet

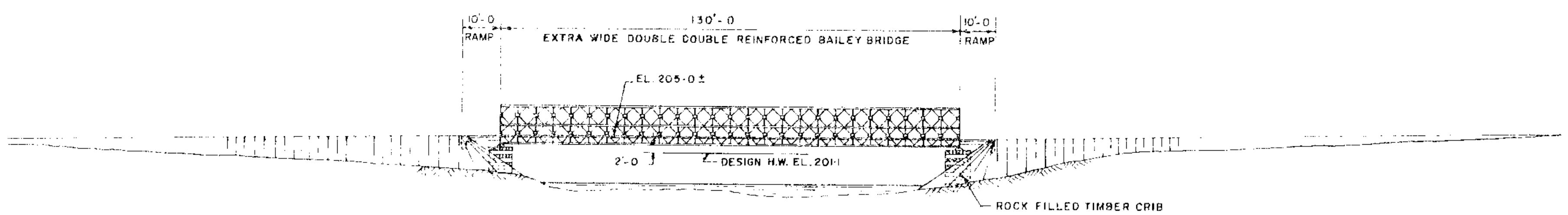
drawing no. / dessin no. 3 of/de 4

Date 23-6-75

D.P.W. 700 B (revised april 1, 1974)



PLAN
SCALE 1" = 20'-0



ELEVATION A–A
SCALE 1" = 20'-0

NOTES:

1. FOR DETAILS OF BAILEY BRIDGE SEE " THE BAILEY AND UNIFLOTE HANDBOOK", FOURTH EDITION, 1971.

PRELIMINARY

Public Works Canada / Travaux public Canada

Design and Construction
Etudes et Construction

Resources (civil)
Direction des resources (genie civil)

Structures (Bridges) Section
Section des ouvrages d'art (ponts)

A detail no. / detail no.
B location drawing no. / sur dessin no.
C drawing no. / dessin no.

revisions
revisions

designed by / conçu par: R. H. PION — date

checked by / examiné — date

drawn by / dessiné par: D. A. SYMON

checked by / examiné — date

recommended by / recommandé par — date

chief bridge engineer / ingénieur en chef (ponts)

approved by / approuvé par — date

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project title / titre du projet

LOON RIVER BRIDGE

MACKENZIE HIGHWAY MI. 742.2

N.W.T.

drawing title / titre du dessin

TEMPORARY CROSSING

PHASE I

project no. / no. du projet

drawing no. / dessin no. 4 of / de 4