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Memo

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Project/File:	26353 Quesnel-Hixon Road Safety Improvements	Date:	October 30, 2024

Reference: Ahbau Creek Bridge Rehabilitation Technical Memo

1 Ahbau Creek Bridge Rehabilitation Technical Memo

1.1 Objective

This memo reviews the Ahbau Creek Bridge in its current context and presents a rationale for its rehabilitation.

Previous assessments have necessarily included the requirement for the bridge to function as part of the Quesnel Hixon Corridor, a requirement which meant its geometric limitations overshadowed the structure's strength and condition benefits. It was thus slated for demolition. The 2024 decision to close the adjacent Cottonwood River Bridge greatly reduces the service demands on Ahbau and a new assessment considers this new context.

1.2 Rehabilitation Target

The goals of the work of this memo are to consider the feasibility and conceptual costs for two options:

- A **Maintenance Level Bridge Rehabilitation** that would provide no strengthening (but rather retain the current 16 tonne load limit) and provide repair and retrofit measures consistent with a remaining 25-year service life.
- A **Bridge Strengthening Rehabilitation** that would increase the load limit to 22 tonnes. This would address concerns regarding the current limit and allow for fully loaded box trucks, larger delivery vehicles, dump trucks, utility trucks, lightly loaded semi-trucks (tractor-trailers), most fully loaded school buses, fire trucks (many models fall under 22

tonnes) and smaller construction vehicles. This effectively removes restrictions for the anticipated users.

2 Background

2.1 Bridge Context

The Ahbau Creek Bridge is a 36.6-metre span timber Howe truss bridge currently open to the travelling public to provide access for 11 occupied properties and the Cottonwood Provincial Park. The park has no active recreational facilities, no maintenance, and, in it, camping is prohibited. The properties and the park are also accessible via Grenley FSR which connects to Highway 97 without crossing the Cottonwood River.

The bridge is posted at a 16-tonne gross vehicle weight (GVW) load limit. It has a 4.48-meter vertical clearance. Its width accommodates single lane traffic (4.88m between wheel guards).

2.2 Bridge History

The Ahbau Creek Bridge was constructed in 1937. Its original configuration featured four timber approach spans for a total elevated length of approximately 55m. The approach spans have since been replaced with an embankment. At 87 years old, it is one of 19 timber Howe truss bridges remaining in the Ministry's inventory (not including Cottonwood which is slated for demolition due to road closure), which range in age from 63 years to 117 years. Recent activity and documentation associated with the bridge includes:

a) The bridge was inspected by Westmar in 2007 and based upon this inspection, Westmar apparently produced a report "Condition Inspection and Evaluation, Feb 18 2008". This report is not currently available.
b) Westmar produced an additional document in February 2008, "Conceptual Design Report Repair Option". This report detailed suggested repairs to the truss top chords, deck, portal frames, transverse bracing, and abutments. While no subsequent documentation is available such as detailed design, recent observations indicate that this work was in fact carried out.
c) The document in (b) references the document in (a) and indicates that the current load posting of 16 tonnes resulted from this evaluation, and that the limiting element capacity was shear in the deck stringers.
d) The Ministry completed a condition inspection in August 2021, which indicated no major issue and showed the bridge superstructure to be in generally good condition.
e) WSP completed an Enhanced Condition Inspection in August 2023, documented in "Enhanced Condition Inspection Report Dec 01 2023". This inspection noted deficiencies

in channel/erosion protection and the substructure but also found the superstructure to be in generally good condition, with a few small deficiencies noted.

f) WSP completed a detailed load evaluation in accordance with CHBDC Section, documented in "Load Evaluation Report June 07 2024". This report confirmed that for Normal Traffic (no permit restrictions), the current load posting of 16 tonnes was appropriate, limited by bending moment capacity in floorbeams, with stringers a close second. Further discussion on the content of this report is include in Section 3.2 below.

2.2.1 Hydraulics

Given that the spans of the original bridge (55m prior to infill) and the recent design (60m) are similar, it is interesting to note that the soffit elevation of the existing bridge (540m) compares favorably to the new WSE calculated and even gives 1.7m of freeboard.

- Earlier hydraulic analysis calculated the 100-year design flow at Ahbau bridge as 157 m^3/s. This includes a 15% increase for climate change. This analysis considered a channel corresponding to a 60m clear span and produced a Water Surface Elevation (WSE) of 538.3m, or roughly 2.1m depth of water.
- The current existing bridge channel width of 36.6m contracts flow through the bridge opening resulting in higher flow velocities, water depths, and water surface elevations from those values calculated for the new design. During flood events these existing hydraulics increase backwatered depths upstream of the bridge, specifically, along the previous approach spans near the tertiary road tie-in west of the bridge and increase scour potential along the toe of the abutment riprap. The existing bridge has likely been exposed to such flood events during its lifespan so current riprap extents may be acceptable but should be reviewed in more detail.
- Current hydraulic reports also indicate large woody debris and aggradation concerns. These concerns led new bridge designers to raise the soffit of their bridge. However, these concerns were not considered in this review as bridge rehabilitation makes these issues no worse than they were in the recent past and the existing bridge has found a way to survive both issues in its current configuration for decades.

3 Assessment

3.1 Foundation Suitability

According to the original design drawings, the structure was founded on timber piles, 22 ft to 26 ft long. It is now supported on steel H-pile bents with steel pile caps, with two rows of H-piles at each abutment. No foundation record is available. Timber ballast walls support bridge approach fills.

No foundation movement or settlement has been identified in the Condition Inspection Report dated August 10, 2021. No differential settlement was observed between the bridge and the approach embankments during site visits by the Geotechnical OE at three different times between 2022 and 2024.

Corrosion on one steel pile at ground level (loss >50% in areas) was noted in the Condition Inspection Report dated August 10, 2021. This appears to occur at the point of pile entry into the ground and was not noted on later inspections. It should be confirmed by subsequent inspections. If interface corrosion is apparent mitigation measures may include coatings and/or passive cathodic protection.

Recent borehole investigation adjacent to the abutments show the subsurface soils consist of mainly sand and gravel with cobbles. In such subsurface conditions, pile capacity does not typically govern, rather the foundation settlement becomes the governing parameter. The bridge and the approach embankments have been in service for several decades and no known settlement concern are apparent. This single-span bridge will accommodate differential settlements, and the gravel surfaced approach embankments can accommodate future settlement by surface grading, so the risk associated with future settlement is minimal.

Notwithstanding the assumption that the axial capacity of the piles is adequate - for the purpose of this exercise some estimates may be useful. Steel H-piles are typically supplied in either 40-foot (12.2 m) or 60-foot (18.3 m) lengths. It is possible the length of the piles used at this site are 12.2 m with an embedment depth in the range of 7 to 10 m. If this range of embedment depth is assumed, an ultimate capacity per pile of 250 kN/pile is generated. Considering the number of piles (nine) sharing the estimated total specified reaction of about 700 kN at each abutment, the piles appear to have residual capacity. If further confidence is desired, the pile lengths could be estimated using Pile Integrity Tests (PIT). The PIT involves attaching strain gauges and accelerometers to the exposed part of the piles and tapping the side of the pile with the hand-held hammer. It is a relatively simple and fast test which has been used for assessing pile lengths of other MOTI bridges in the past. Confirming the pile lengths will also be useful to assess the pile embedment below scour depths.

3.2 Superstructure Suitability

Bridge superstructure assessment for continued use is based upon the observations and conclusions provided in the existing documentation, particularly as described in Sec 2.2 (e) & (f) above. The discussion below relates to the conclusions around Normal Traffic, as this is the category for publicly-posted load limits.

If a decision is reached to retain the bridge, then some additional inspection work should be completed to confirm certain aspects of the bridge condition being relied upon for ongoing

service. This additional inspection work should include dropping selected tension rods for inspection of concealed portions, confirmation of the extent of several areas of found or suspected fungal decay, and additional work to confirm suitable material grades for analysis.

Additionally, if rehabilitation is selected and the load posting is to be increased, engineers experienced in rehabilitation and repair of timber Howe truss bridges should complete further analysis and the detailed design of the modifications. This is a specialized area of design, and there are some nuances within the Howe truss designs that where experience is helpful.

The current condition inspection indicates that the trusses, bracing, and deck elements are in generally good condition, with only local defects that can be addressed. These are discussed in Sec 3.3 below.

For the bridge to have achieved a load rating of 22 tonnes, as suggested, the evaluation by Section 14 would have needed to show minimum Live Load Capacity Factors (LLCFs) equal to 22000kg/63700 kg = 0.35. The current load rating report indicates that the capacity of the bridge is controlled by the deck, specifically bending moment in the floorbeams (LLCF=0.24) and stringers (LLCF=0.28). These values generally confirm the current GVW limit of 16 tonnes.

When Section 14 is used for evaluation, the load factors for individual elements are adjusted to suit system and element behavior and inspection level while maintaining a consistent level of safety. For these floor elements, the dead load factor has been reduced in the evaluation to 1.18 or 1.16 from 1.2, and the live load factor to 1.63 or 1.56 from 1.7, fairly small reductions. In rehabilitation design, the load factors of 1.2 dead and 1.7 live would be used, therefore the increase in the deck capacity needs to be a bit more than 0.35/0.24 = 1.46, say about 1.55, or 55% stronger. This would require some strengthening of the deck support members, or a full deck replacement with a stronger design. This is discussed further in Sec 3.4 below.

For the truss members, the current load rating report indicates that truss capacity is limited by combined moment and tension in the bottom chords (after having reduced the bottom chord capacity to account for some decay detected). The LLCF here is 0.46, greater than the 0.35 required for a 22 tonne load posting. Most other truss members are comfortably above this capacity, leading to the conclusion that rehabilitation to increase the posting to 22 tonnes will require little or no truss strengthening. Note that the system, element and inspection levels assessed for truss member evaluation result in load factors of 1.2 dead and 1.7 live, the same as used in new design.

The tension rods in the Howe truss design are critical members and are also not readily inspectable in the area where they pass through the bottom chords, an area that is also subject to moisture, putting the steel rods at risk of hidden corrosion. The load rating report puts the minimum LLCF for these rods at 0.59, which provides a fair allowance for further corrosion over the needed 0.35, while staying safe. The planned Maintenance Rehabilitation design, however, should include field work to drop and inspect portions of these rods for certainty.

3.3 Maintenance Rehabilitation

To continue the use of the bridge, even without an increase to the posted load limit, some repairs and protective measures should be completed. These are generally as outlined in the Enhanced Condition Inspection Report and include riprap placement, antifungal treatments, deck repairs, and curb replacement.

The cost of the above has not been estimated in detail at this time, but total construction cost would be in the range of $120,000 with assumed a marginally increased extent of riprap at abutments and along one face of infilled embankment as compared to what is currently shown on WSP's July 2024 Hydrotechnical Design Report.

In addition, it is recommended to inspect tension rods as outlined above. There are a total of 28 tension rods in the structure. Six rods were dropped in 1991 (at approx. 2/3 of the bridge's current life) and were all found to be in good condition with minimal corrosion. It is recommended that an initial 25% of the rods (7 rods) be dropped, at select locations, different than 1991. If they are all found to be in good condition, it should not be necessary to drop more. If significant deterioration is found, it will be prudent to drop additional rods for inspection. If between 25% to 50% of rods are dropped, the cost for crew, equipment, and engineering observation is approximately estimated at $25,000 to $40,000.

Note that if any tension rods are found to be excessively deteriorated, they will require replacement, which is readily done with off-the-shelf high strength threadrods. The material cost is not great, and this work would be most efficiently conducted in the same mobilization as the inspection work (ie. have replacement rods on hand).

Altogether, a budget for construction, for this stage would be $170,000.

3.4 Strengthening Rehabilitation

To strengthen the bridge to achieve a load posting of 22 tonnes, the above Maintenance Rehabilitation should be undertaken, plus work on the floor system and deck to increase its capacity.

There may be several options available for upgrading the deck capacity. Since a service life of about 25 years is required, it make sense to replace the decking in any case, which will make access to the underlying elements – stringers and floorbeams – easier. In all cases the marginal increases in dead load are considered in determining the upgraded live load capacity. Some options to increase the deck capacity include:

a. Remove decking and cross-ties. Replace alternate floorbeams with steel W-beam sections of similar height, add supplementary stringers. Replace cross-ties and decking with new.
b. Remove decking, cross-ties, and stringers. Replace alternate floorbeams with steel W-beam sections of similar height, install new, larger stringers. Replace cross-ties and decking with new.
c. Remove decking, cross-ties, stringers, and floorbeams. Install new, larger floorbeams at regular spacing of about 1.0m. Install new decking 140 thick directly upon the floorbeams.
d. Remove decking, cross-ties, stringers, and floorbeams. Install recycled, larger floorbeams at regular spacing of about 1.0m. Abhau Bridge currently has 36 floorbeams that are 190mm x 394 mm. Recycled floorbeams would come from the nearby Cottonwood Bridge, which is set to be dismantled. Cottonwood has 44 floorbeams 305mm x 451mm, likely in good condition, which is enough pieces to provide this configuration. Install new decking 140 thick directly upon the floorbeams. Preliminary calculations indicate that this deck should be suitable for the proposed 22 tonne posting.

It should be noted that several of the other remaining timber Howe truss bridges in B.C. have had their floor systems strengthened to increase load postings, having had similar capacity issues as at Ahbau. These works have included adding floorbeams, adding supplementary stringers or replacing stringers, and replacing some timber floorbeams with steel W-beam sections.

A similar strengthening approach to (a) and (b) was undertaken at Moose Mouth Bridge (timber Howe truss) east of Fort St. John, where alternate timber floorbeams were removed and replaced with steel I-beams which were then shimmed tight under the nail-laminated deck. This bridge has no load posting, allowing full highway traffic.

The deck configuration described in (c) and (d) is similar to that on Tete Jaune Bridge near Valemount (timber Howe truss), where 305mm x 387mm floorbeams regularly spaced at 1.0m supporting a 140 mm thick plank deck. This bridge is posted at 25 tonnes. The configuration is also similar to the deck at Cottonwood Bridge.

Each of the options to increase deck capacity should be feasible. Options (a) and (b) retain a deck of similar overall thickness to the existing. Options (c) and (d) result in a deck of about 300mm less height. To adjust for this, either:

- the roadway and the top of the abutments would have to be lowered, thus providing greater vertical clearance on the bridge, OR
- the trusses would have to be jacked up and shimmed between the timber bearing blocks and the steel pile caps, thus providing greater freeboard under the bridge.

Detailed cost estimates have not been prepared for the above options. Option (d) would likely be the least expensive, provided the floorbeams at Cottonwood can be salvaged and re-used. Otherwise, within the accuracy of a very preliminary estimate, all the options would have similar construction costs. This is estimated as a total in the order of $600,000, including construction and

accounting for some construction inefficiency inherent in maintaining traffic with limited closures (see more discussion on this below).

4 Construction

Approximate construction costs for Maintenance and Strengthening are given for each stage above. These should be considered Class 5 estimates (Options Screening, -50%/+100%). Costs are construction only, and do not include design, owner's cost, PM, traffic control, etc.

More accurate estimates can be readily prepared for each option, given more time and a bit more information. A more accurate estimate for the Strengthening will require preliminary design to be undertaken.

It is understood that it would be desirable to keep the bridge mostly open during construction, with limited closures. The Maintenance Rehabilitation work can be completed with short closures, reopening the bridge after a set amount of time after traffic arrives at it, say 20 minutes to an hour. The deck replacement will require somewhat longer closures, but if carefully planned, can accommodate traffic with closures of a few hours at a time, and potentially with provisions for emergency access as needed. Some years ago, the Ministry completed redecking projects on two narrow bridges in the Lower Mainland, Hatzic Pumps and Forestry #1, with closures of 20 minutes at a time and fast accommodation of emergency traffic, through the use of a temporary portable bridging panel, a similar approach could be used here if closures need to be reduced.

A typical procedure, described for Option (d) as an example, might be as follows. To limit time of closure, the deck replacement work would be completed one panel at a time (there are eight panels at 4.57m long each). Prior to closure, the timber decking would be pre-cut. After closure, the decking would be pulled up, and the cross-ties, stringers and floorbeams removed. This work goes quite quickly as the material can be cut as needed and pulled up with a small excavator. The new floorbeams would then be set and decking partly nailed directly to them. To allow for the normal stagger in deck plank joints, alternating joints will be held back by one floorbeam from the end of the panel. A road plate can be laid over the gaps in the decking to allow for traffic to move. As the traffic volume is very low, nailing of the decking can probably be completed between vehicle passages.

It would be reasonable to expect to do one panel of deck per normal working day, thus requiring a total of eight days of more significant traffic disruptions. Preparation and finishing time will add to this, but with lesser traffic impacts.

Heavy construction equipment necessary for Ahbau rehabilitation and/or Cottonwood Bridge deconstruction can be delivered to site via the Grenley FSR. The FSR may require relatively minor grade and curve modifications in the last 500m before its intersection with Quesnel Hixon Road.

5 Conclusions

5.1 Comparison of Rehab to New Construction

There are many schedule and cost benefits of rehabilitation when compared with a new structure. A rehabilitation stays on the same alignment, it does not require archeological investigations, does not require new foundation elements, temporary detour structures, delivery of girders or concrete. The schedule and cost benefits are significant.

If we assume a new bridge will follow the recommendations in MOTI's Best Practices for Low-Volume Road Structures with parameters, such as:

- Configuration – single lane for an overall bridge width of 6 m.
- Design Loads – reduction in design loads relative to CSA S6 requiring a design exception – Assume CS600 loading for the new bridge.
- Design Flow - a reduced return period, as may be used for LVR Structures, also reduced freeboard clearances, as are available to be pursued. Assume a 55m span will accommodate flows produced.

We could compare the rehabilitation options to a new structure cost, not including design or contingency, based on a bridge area of 55x6=330m^2 of $4.0M.

5.2 Recommended Rehabilitation Option

We recommend the strengthening option. Howe truss strengthening has precedent within the Ministry's inventory. St. Marys Wycliffe, at 93 years old, was rehabilitated in 2010 including new approach spans, a new deck, and truss strengthening to increase the posted load limit.

This would require protection measures that are identified in earlier documents such as rip rap improvement at abutments and along the western approach embankment. It would also require newly identified measures such as additional inspection, pile length confirmation and corrosion investigation and mitigation (if required).

We recommend the current project charter be amended to no longer preclude rehab given the new project status, the low capital cost, and the ability, in this situation, to define a live load capacity that is less than CS625.

Regards,

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Attachments: [Attachment 1: General Plan]

[Attachment 2: Details of Chords]

[Attachment 3: Details of Ironwork

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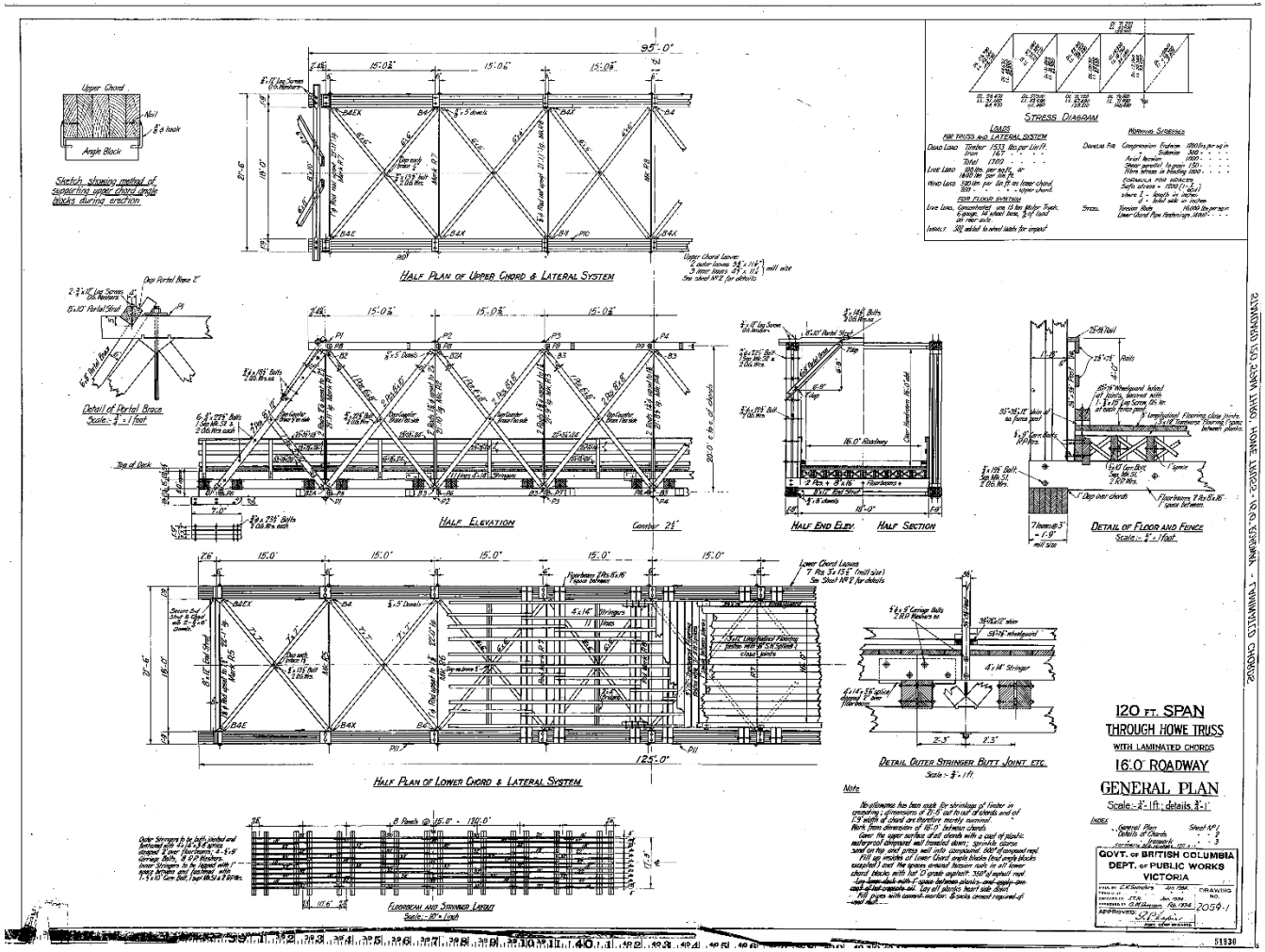
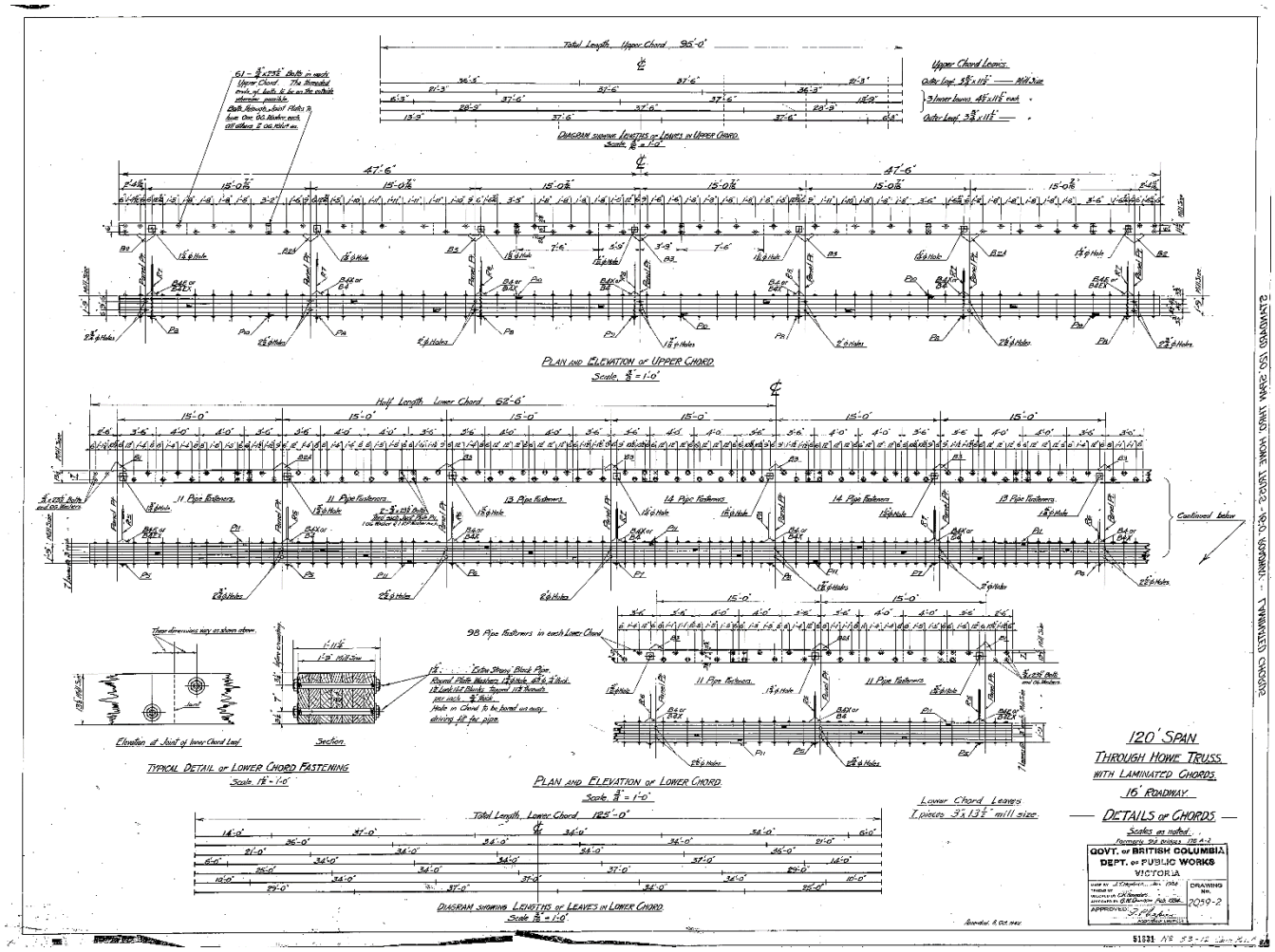
ATTACHMENT 1: 120 FT SPAN THROUGH HOWE TRUSS WITH LAMINATED CHORDS: GENERAL PLAN

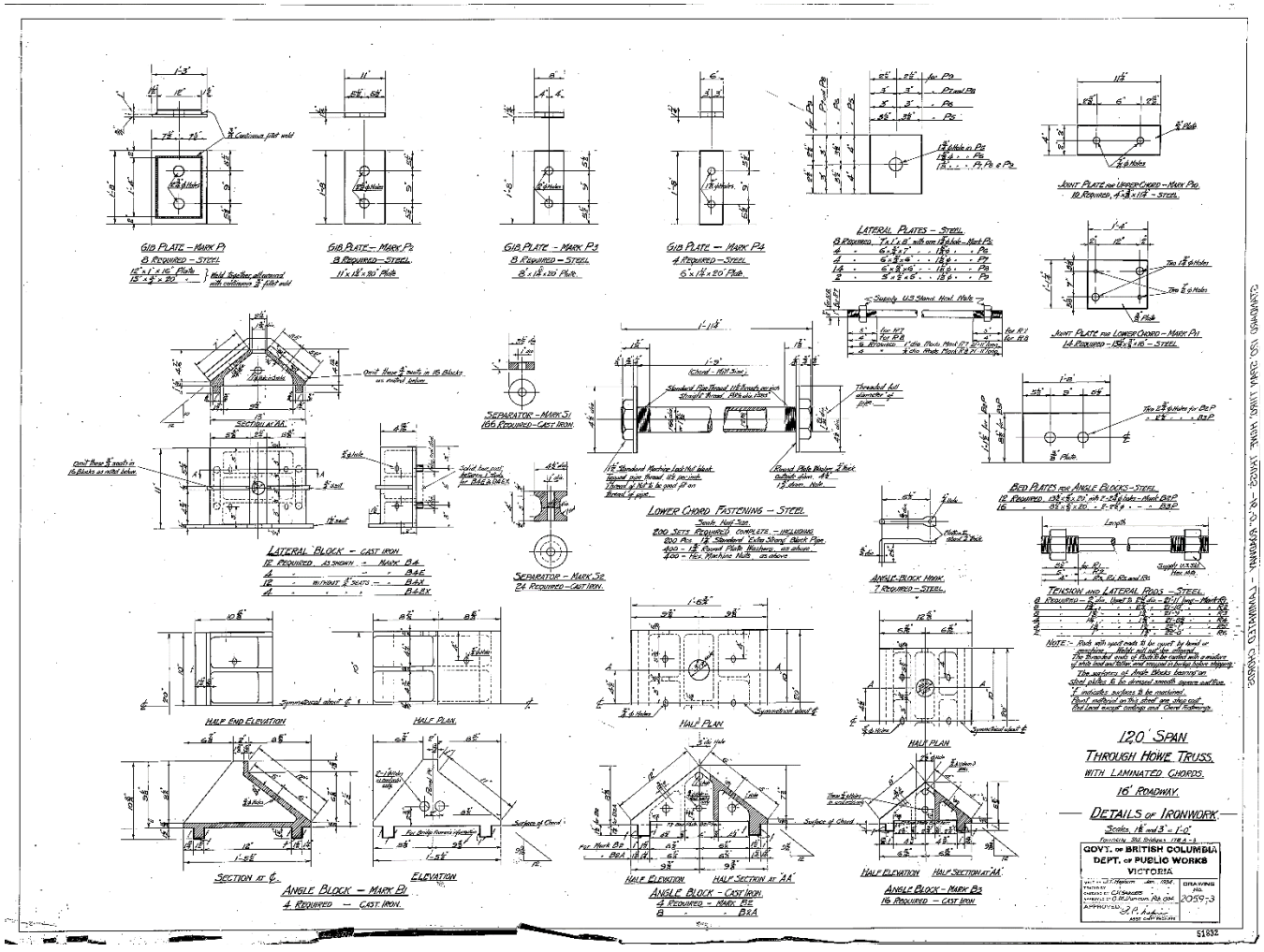
26353 dia cnm-abcrk bridge gen plan.pdf (Version: A)



ATTACHMENT 2: 120 FT SPAN THROUGH HOWE TRUSS WITH LAMINATED CHORDS: DETAILS OF CHORDS

26353 dia cnm-abcrk bridge chords.pdf (Version: A)



ATTACHMENT 3: 120 FT SPAN THROUGH HOWE TRUSS WITH LAMINATED CHORDS: DETAILS OF IRONWORK

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