

Langstaff Bowstring Bridge – Condition Report



Langstaff Bowstring Bridge
Condition Report

PREPARED FOR
Schollen & Company Inc.

JULY 11, 2018
PROJECT NO: 2018-076

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1.0 INTRODUCTION

Brown & Co. Engineering Ltd. (Brown|Co) was retained by Schollen & Company Inc. to review the condition of the existing Langstaff (Old Alignment) Bridge over the East Humber River, and to recommend repair/ replacement options for the existing bridge that will form part of a redesigned pedestrian trail in Vaughan.

The Langstaff Bridge is a 4.6m wide by 20m long single span concrete tied arch bridge. It was originally constructed for vehicle traffic but it currently serves as a decommissioned pedestrian bridge. The bridge is located close to the south entrance to the Boyd Conservation Area accessed from the west end of Langstaff Road.

Brown|Co originally conducted a general condition review report for the Toronto and Region Conservation Authority back in 2008. The 2008 report concluded that the bridge's abutments were reusable, its two main arch ribs were in good to fair condition, and recommended sequential replacement of deck, floor beams and bottom chords only, and with local repair to the arch ribs, vertical and horizontal elements for an estimated cost of refurbishment about \$170,000. The alternative cost for a replacement bridge superstructure of the same size would be about \$120,000.

No rehabilitation work was done on the bridge since 2008, and it has suffered further deterioration in multiple areas ever since.

For this report, Brown|Co revisited the site on the 6th of July 2018 and conducted a visual inspection of the structure with limited sounding of concrete and with no quantitative measurements. The purpose of this report and the recent inspection is to provide an up-to-date overall review of the structure, confirm the overall suitability of the structure for continued use, determine any limitations on loading, identify rehabilitation works that are required and provide cost guidance for the work.

2.0 HISTORY

The Langstaff Bridge was originally constructed in 1923 by Frank Barber of Toronto, Ontario, as a single lane structure as part of the road network in the Vaughan area. The land for the current park was acquired in 1957, with the Langstaff Bridge already in place. The bridge has not been used as an active highway bridge since that time. The construction detailing of the bridge reflects typical concrete bowstring designs between the 1920s and 1930s.



3.0 CURRENT CONDITION

The existing 95 years old bridge is in “poor” condition due to its age and the many years of neglect. This rating is based on the Ontario Structures Inspection Manual (OSIM). In this rating system “Good” signifies components that are fit for service with any likely rehabilitation more than 10 years away. “Fair” indicates components which are fit for service but which are expected to require rehabilitation in 5 to 10 years, “Poor” indicates components which require rehabilitation in 1 to 5 years. There is no OSIM rating inferior to “poor”.

There are multiple components that are deteriorated which reduces the capacity of the load bearing elements of the bridge and these components requires immediate rehabilitation in order to stop the ongoing deterioration. The condition of each of these components is indicated in this section. The need for rehabilitation, and proposed methods will be provided in later sections of the report.

3.1 SOTHERN ARCH RIB

The south-west half of the arch is generally in fair condition, but the **south-east half of the arch is in very poor condition and requires immediate attention and remedial measures.**

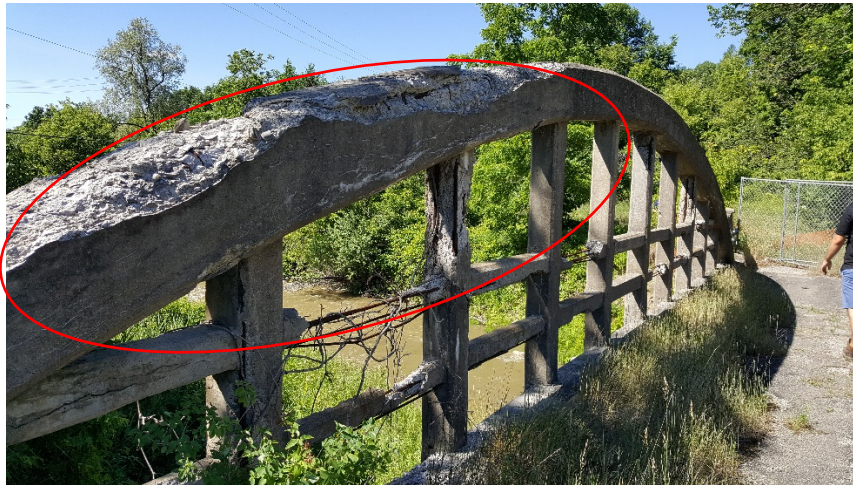
The south-east half of the arch has extensive spalling due to moisture damage from nearby vegetation growth which resulted in the loss of the outer 50mm to 75mm surface concrete on the top and side faces of the arch. The existing arch stirrups and top longitudinal rebars are partially exposed at areas of significant loss of concrete cover. The exact depth of water penetrations below and beyond the visible concrete surface is unknown. The deterioration of the south-east half of arch rib is the most serious distress on the bridge. It is the opinion of the writer that this portion of arch requires immediate remedial action to stop further deterioration and the continues loss of bridge capacity. To stop the on-going deterioration, the concrete surface should be restored with a partial depth concrete replacement coat with mesh reinforcing as soon as possible, before the 2018 winter conditions arrive. This will slow down the deterioration, but to restore the arch capacity, a surgical replacement of the damaged portion of the arch accompanied by construction shoring of the bridge will be necessary.

Total area of deteriorated concrete surface requiring immediate rehabilitation: 5.0 m2

Total volume of deteriorated concrete arch requiring replacement: 1.2 m3



Close-up view of the south-east half of the southern arch, with serious spalling damages along top and side faces of the arch. Stirrups and longitudinal rebars are now partially and/or fully exposed due to the loss of concrete cover.



Long shot view of the south-east half of the southern arch, showing the full length extent of the spalling damage. The damaged area should be parged with concrete coating as soon as possible, and then be surgically replaced if original bridge capacity is to be restored.

The remaining south-west half of the arch has limited chipping damage along the southern top corner of the arch towards the west end. The zone is small relative to the size of the arch, with the apparent depth of damage approximately 50 mm by 2000mm long. The limited depth of the damage zone indicates that this portion of concrete is repairable.

Total area of damage 0.5 m², typically 50 mm deep



South-west half of the southern arch, will spalling along top corner of arch

3.2 NORTHERN ARCH RIB

The northern arch rib is generally in good condition except for frost spalling damage observed on the east end of the arch. This zone with the spalling has some indication of laitance. The zone is small relative to the size of the arch, with the apparent depth of damage approximately 50 mm. No sign of delamination was noted in any part of the northern arch rib including the area with spalling. No reinforcing was exposed in the locations probed, and rust staining was not observed.

Total area of damage 4.0 m², typically 50 mm deep



Northern Arch Rib, east side, spalling near the arch end

3.3 BOTTOM CHORDS

Extensive lengths of the two bottom chords have zones of spalling damage for the full width of underside surface. Vertical hangers and bottom longitudinal rebars are exposed at many locations.

The two bottom chords were previously condemned in the 2008 report. The 2008 report recommended the demolition and reconstruction of these components together with the sequential replacement of the deck substructure. This recommendation remains valid. All deteriorated vertical hanger end plate assemblies should be replaced at the same time given the opportunity.

Total area of damage The full length of the two bottom chords are damaged beyond local repair and must be replaced.



Bottom Chord, frost damage and spalling, with rebars and hangers exposed

3.4 FLOOR BEAMS

The majority of floor beams below deck have zones of spalling damage on the full width of underside surface. The bottom longitudinal rebars are exposed for a large number of floor beams.

The floor beams were already condemned in the 2008 report. The 2008 report recommended the demolition and reconstruction of these components together with the sequential replacement of the deck substructure. This recommendation remains valid.

Total area of damage: All 12 floor beams are damaged beyond repair and must be replaced.



Floor beam with exposed and fully corroded rebars

3.5 DECK

The deck slab was already condemned in the 2008 report. The 2008 report recommended the demolition and reconstruction of this component together with the sequential replacement of the entire deck substructure. This recommendation remains valid.



Large hole in the west end of deck, partially covered with a steel sheet.



Rust stains visible at the underside of deck slab, indicating corrosion of the deck slab mesh reinforcing

3.6 ABUTMENTS

The east abutment is generally in fair condition, with 20% of surface area having some degree of spalled and frost damage. The most developed frost damage is at the south east corner where the damage extends for a 4 m width for the full height, with some increase in width at the base. The north east corner had similar damage indicated. The face of the abutment directly under the bridge had limited vertical cracking but was generally sound. The bearing seat appeared generally fair to good with no repair required. The ballast wall was obscured and could not be evaluated, but is likely to have frost damage because of its location in the structure.

The west abutment is generally in fair condition except for the bottom horizontal strip section of frost damage above the footing of the structure due to frequent exposure to the river water. The face of the abutment is sound as is the bearing seat. It has been assumed there will be frost damage in the ballast wall but it could not be directly observed. Damage to the ballast wall would not be critical to the bridge.



East abutment face
from west

Frost damage



West abutment face
from east

Bearing seat

Frost damage
typical along bottom
portion of abutment
close to the river

3.7 HANGERS

The hangers connect the floor beams to the top chord and are a critical component of the structure. The condition of the reinforcing in the hangers is more directly related to the condition of the structure than the concrete since the hangers are tension structures and the concrete is typically assumed to be cracked and to not contribute to tension capacity. The hangers are generally in fair to poor condition. Concrete surface spalling and vertical crackings are noted but the exposed reinforcing does not have major section loss. These surface cracks be repaired by grouting the cracks. The delamination and spalling noted on the hangers is limited and the vertical reinforcing does not have measureable section loss. Areas where spalls on the hangers are locally limited will be treated as small area spalls to limit the removals to a minimum and to avoid attempting to form the repair on the small element. At where significant concrete cover to the hanger vertical steel have spalled off, the vertical hanger cover will be cast with mesh reinforcing inside enclosed formworks.



Loss of concrete cover to the vertical hanger steel as a result of spalling

Some hangers remain in good shape



Crack and delamination in upper section of a hanger.



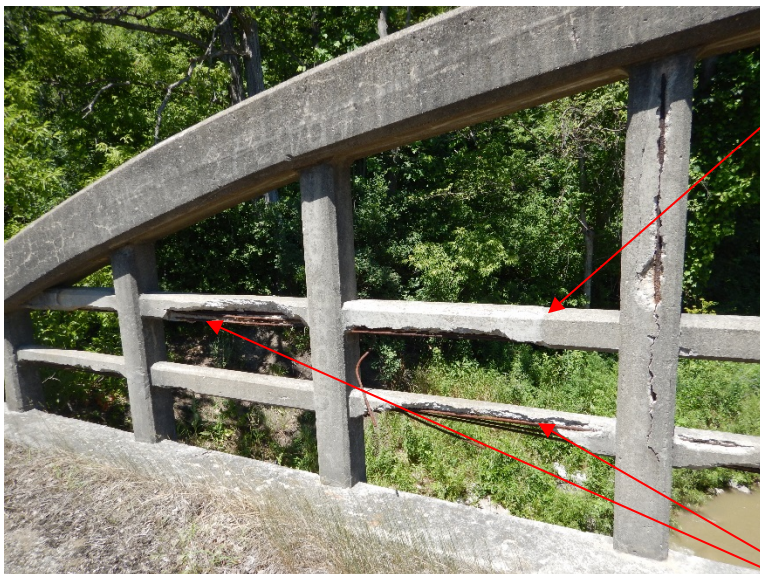
Loss of concrete cover to the vertical hanger steel as a result of spalling

3.8 RAILING

The railing is the component of the structure with the most visible distress. Sections of the railing are severely delaminated and/or spalled, with some sections of railing completely missing. The railing unit is generally not repairable and will need full replacement. It is assumed at this time that the railing will be replaced with a similar unit.

The railing heights are not consistent with current requirements for bicycle guardrails. This is considered acceptable based on the historic context and the presence of the curb and hangers.

Sections of rail to be replaced/repared 38/44



Typical Rail



Failed rail with rail rebar
exposed along South Arch

4.0 RECOMMENDED REHABILITATION OPTIONS

The structure is currently deteriorating quickly. Brown|Co initially reviewed the structure in 2008, and comparison of the components, including the most heavily damaged parts, reveals rapid progression. It is apparent that the structure is in a harsh environment and will likely be unsalvageable within three years if repairs continue to be postponed.

The three basic options for the management of the bridge are 1) demolish the existing bridge and construct a new bridge superstructure while reusing existing abutments, 2) rehabilitation of the existing superstructure for the support of pedestrian loading 3) retain as-is bridge as an “overlook” feature, and provide all necessary permanent shoring under existing bridge (and over the river), construct new bridge crossing at an alternative river location, and restrict public access to the old bridge

For Option 1, if a new structure is planned it would require careful demolition of the existing structure to minimize contamination of the river. The abutments would be reused to minimize in river work since the abutments are still serviceable. It is anticipated that the cost of a replacement bridge superstructure of the same capacity would be about \$200,000.

For Option 2, if the existing bridge would be rehabilitated to its original design and would carry pedestrian loading, the rehabilitation program would retain and locally repair approximately 40% of existing bridge components only. Bridge components that would be retainable include the existing abutments, arch ribs, some of the existing vertical hangers and a small number of existing horizontal railings. All remaining components including the deck slab, the bottom chords and the floor beams will not be salvageable and will require replacement. Throughout the rehabilitation construction period, the bridge must be fully shored above the river.

It is recommended that the frost damaged concrete, spalls and delaminations on the arch ribs, vertical hangers, railings, and abutment walls be carefully chipped off and replaced with sound concrete. The repair should be reinforced with galvanized wire mesh where the repair is more than 50mm thick. Thinner repairs would be left unreinforced to avoid having to build up the section to provide concrete cover. The hangers require chipping and concrete replacement where they are delaminated, and crack injection where the cracks are suitable.

At the completion of the work the bridge would need a cementitious topping to protect the concrete from continued freeze thaw damage and to blend the structure into a uniform unit. Some local remedial work would also be required for the substructure. The cost of Option 2 refurbishment would likely be about \$500,000, with \$150,000 allowed for construction shoring and \$350,000 allowed for the deck reconstruction and local repairs.

To put the Option 2 refurbishment cost into perspective, it is approximately twice the refurbishment cost from the 2008 report. The substantial cost increase is due the need to

provide a construction shoring system over the river that would be capable of supporting and stabilizing the bridge during rehabilitation, and the large increase in the number of localized repairs for the retained bridge components.

For Option 3, stabilizing the as-is bridge with permanent shoring in order to keep it as an overlook feature and constructing a new steel truss bridge crossing with similar span (25m) at an alternative river location will cost about \$500,000, with \$250,000 allowed for the permanent shoring work and stabilizing of existing bridge, and \$250,000 allowed for the new 25m bridge. The cost would increase to about \$600,000 should the new bridge span approach 40m.

One should note that the cost for Option 2 and Option 3 is similar for the following reasons:

1. Both options would require the installation of similar shoring frames under the existing bridge and above the river (See Section 5.0 Appendix A Drawings for conceptual shoring illustrations). The difference is that for Option 2, the construction shoring will be disassembled and scrapped for value at the end of bridge rehabilitation, while for Option 3, the shoring will remain permanently for the support of the overlook feature bridge. The cost of disassembly shoring in Option 2 will be similar to purchasing the shoring steel permanently in Option 3.
2. The restoration cost of the existing bridge will be similar to the cost of building a new bridge with new abutments at a new location (with an increased bridge span which is the typical modern practice to minimize abutment erosion).

From a cost perspective, Option 1 would be the cheapest option, as the existing abutments will be reused for the support of a modern steel truss bridge. Option 1 would also be the only realistic option should critical repairs be postponed by about two years after the issue date of this report, as the bridge would likely be unsalvageable.

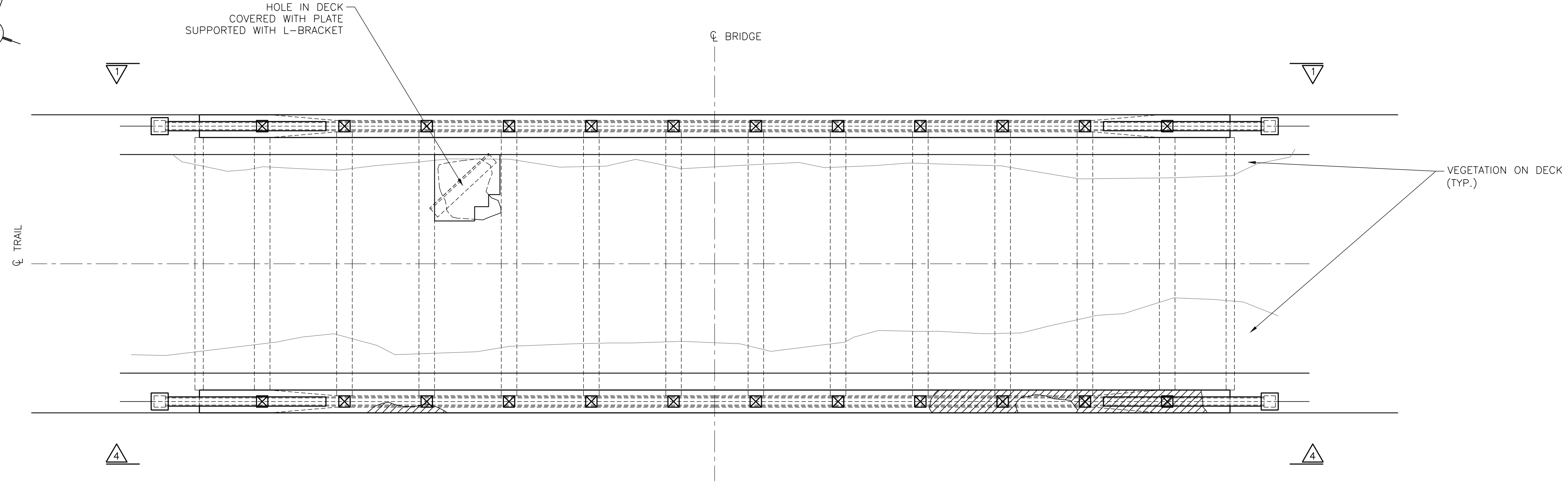
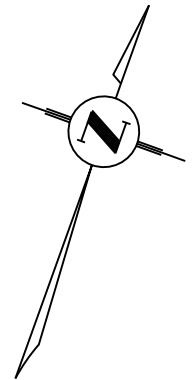
Both Option 2 and Option 3 will preserve the historical bridge context, with Option 3 offering greater flexibility to the owner, as the new bridge at new location can be designed to suit the new trail requirements. If the owner is inclined to pursue Option 2 or Option 3, it is imperative that partial depth concrete replacement repair work to the south arch (described in Section 3.1) be commissioned preferably before the winter of 2018 to slow down the deterioration of the bridge, as this component is a critical load path member.

Respectfully submitted

Andrew Au-Yeung

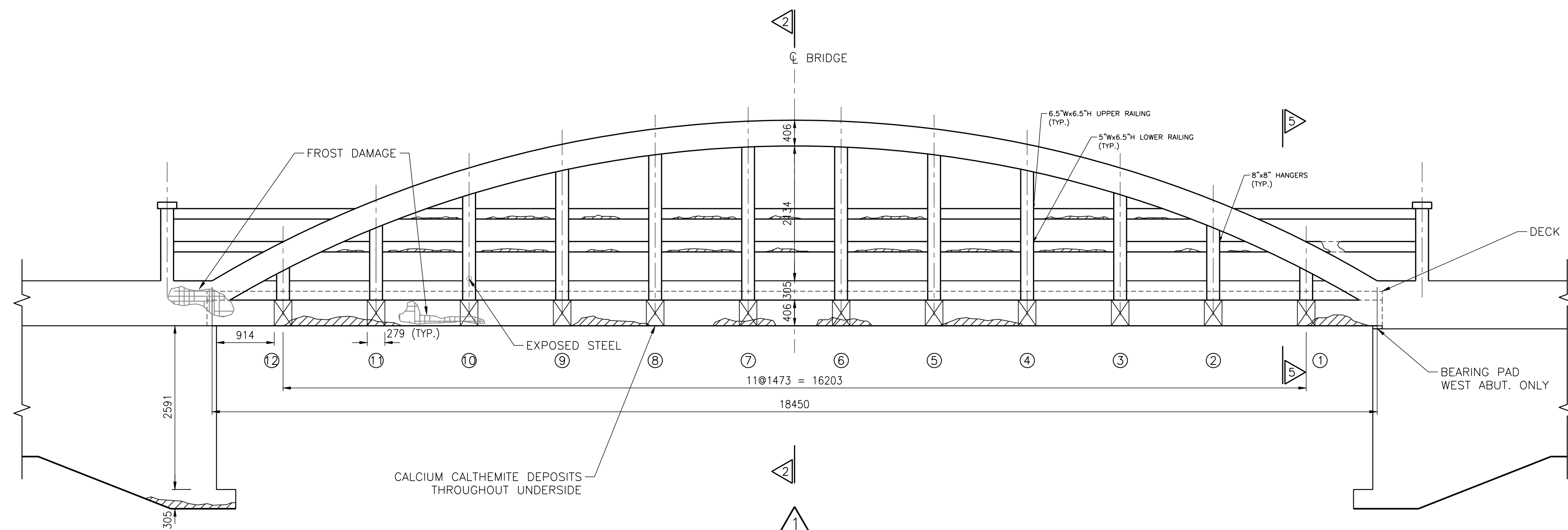
5.0 APPENDIX A, DRAWINGS

NOTE:
ALL DIMENSION SHOWN ARE IN METRES
AND/OR MILLIMETRES UNLESS NOTED
OTHERWISE.

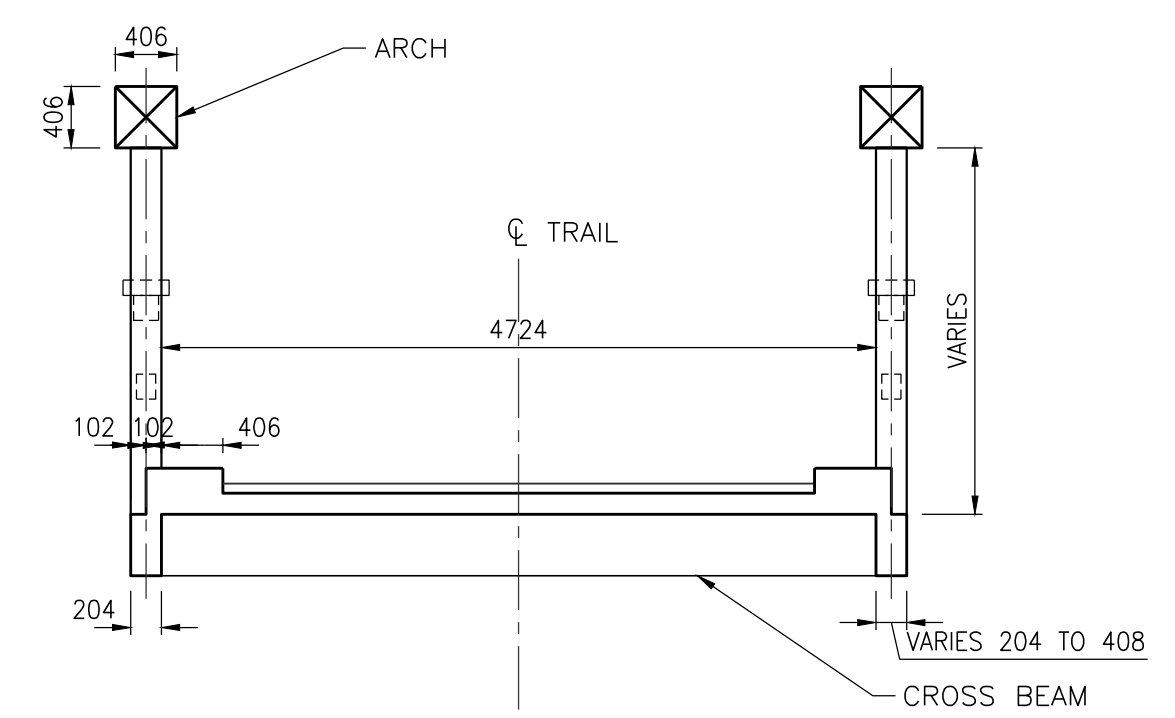


- LEGEND:**
- SPALL
 - FROST DAMAGE
 - CRACK
 - END BEAM MISSING OR SPALLED

PLAN
1:50



NORTH ARCH
1:50



MID SPAN
1:50

REV.	DATE	DESCRIPTION	S.B.	BY
0	JULY2018	ISSUED FOR REVIEW		

CONSULTANT: **BROWN | CO**

PREPARED FOR: **Toronto and Region Conservation for The Living City.**

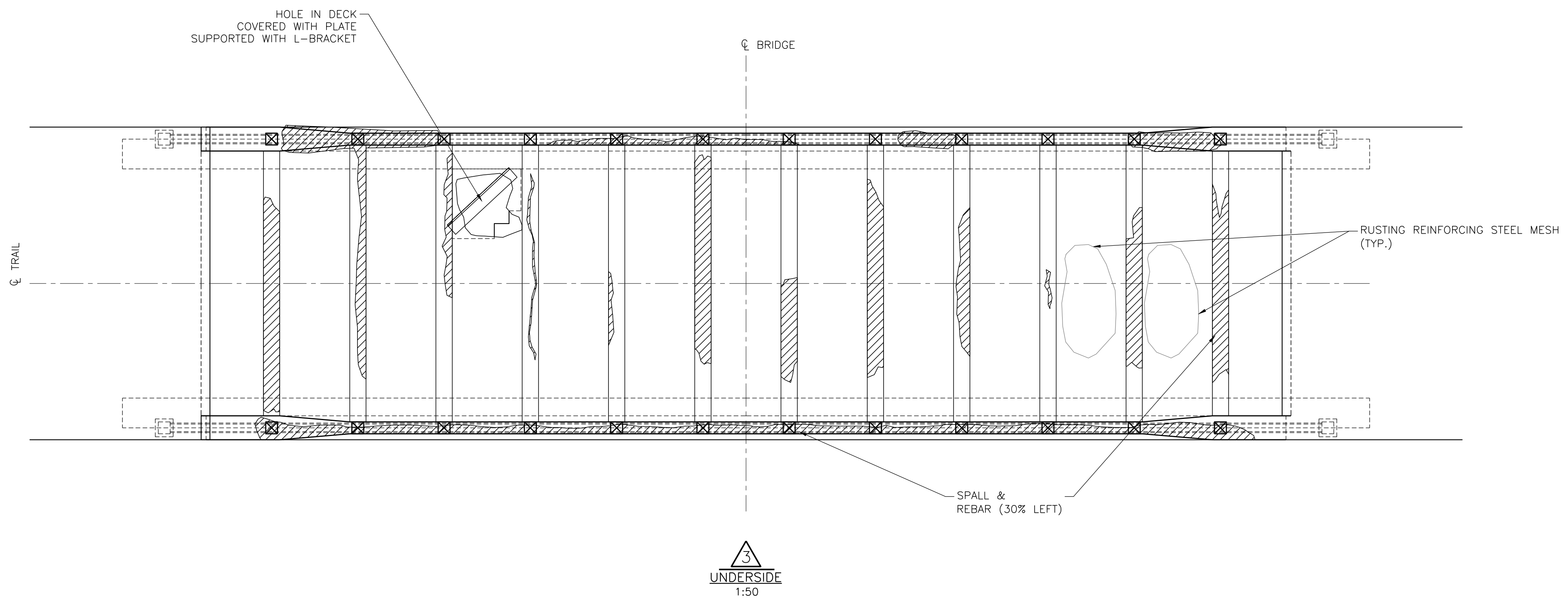
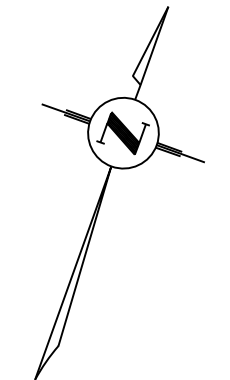
**HUMBER BRIDGE
PLAN AND NORTH ARCH**

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CHK	S.B.	10 JUL2018	SCALE AS INDICATED		

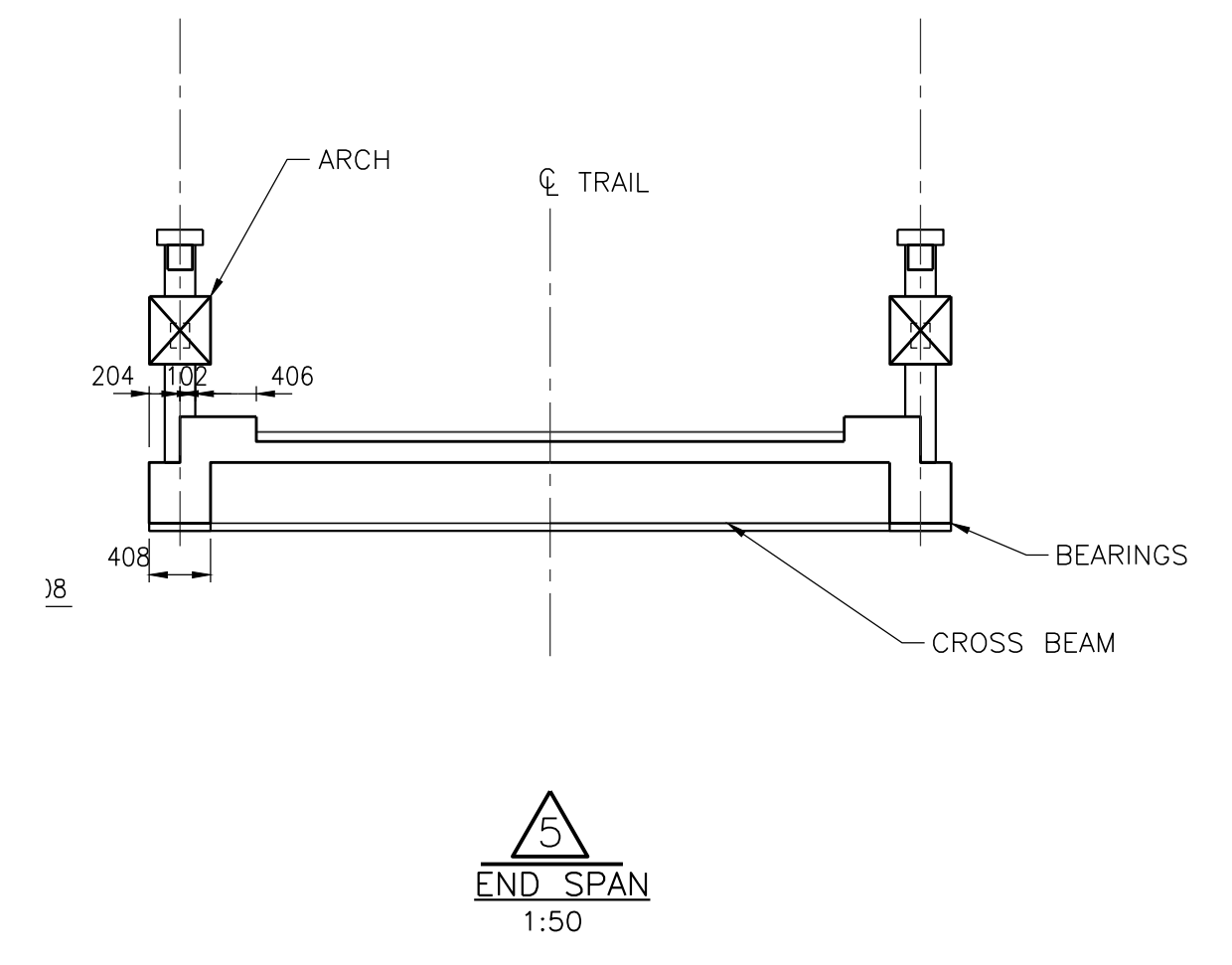
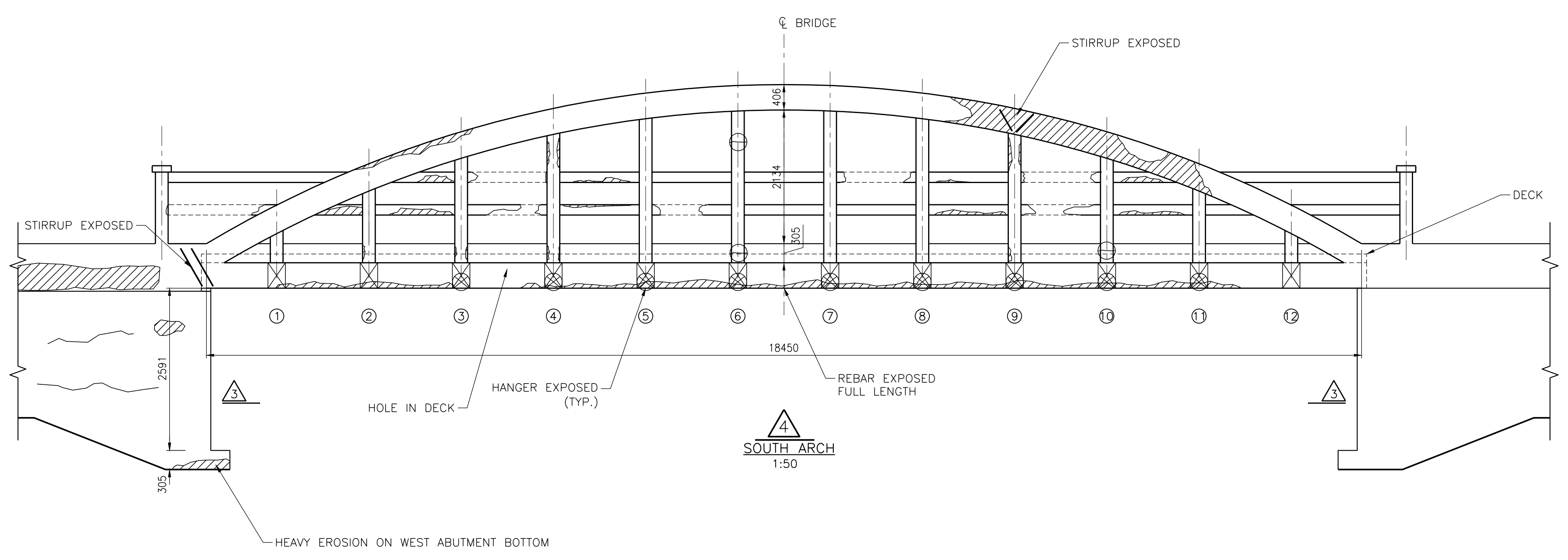


DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

NOTE:
ALL DIMENSION SHOWN ARE IN METRES
AND/OR MILLIMETRES UNLESS NOTED
OTHERWISE.



- LEGEND:
- SPALL
 - FROST DAMAGE
 - CRACK
 - END BEAM MISSING OR SPALLED



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REV.	DATE	DESCRIPTION	S.B.	BY
0	JULY2018	ISSUED FOR REVIEW		

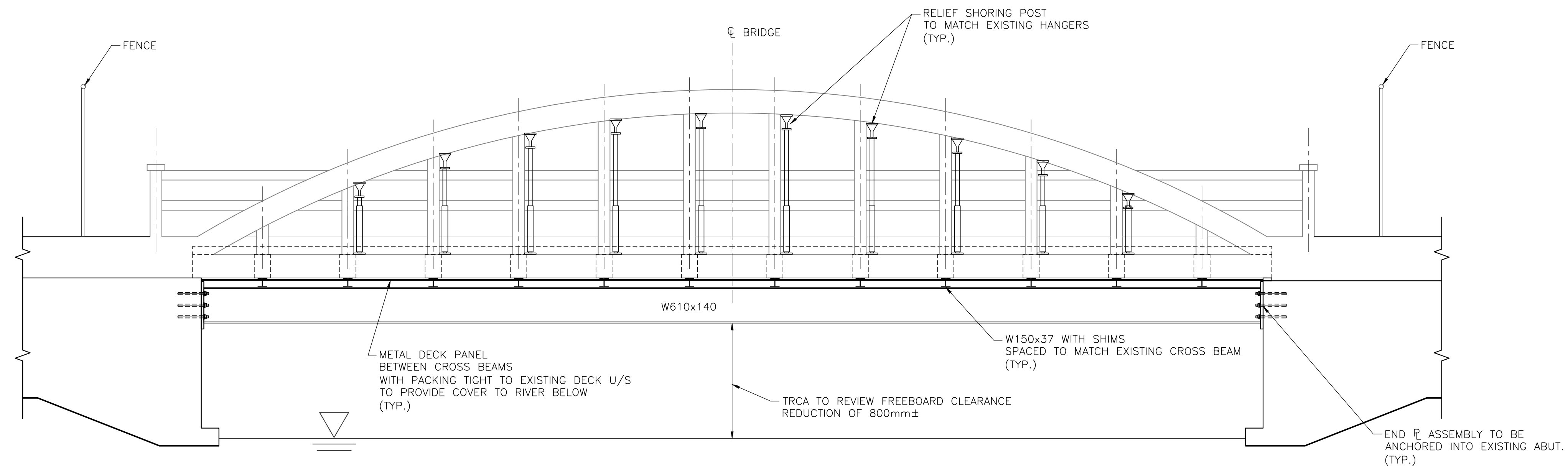
CONSULTANT: **BROWN | CO**

PREPARED FOR: **Toronto and Region Conservation for The Living City.**

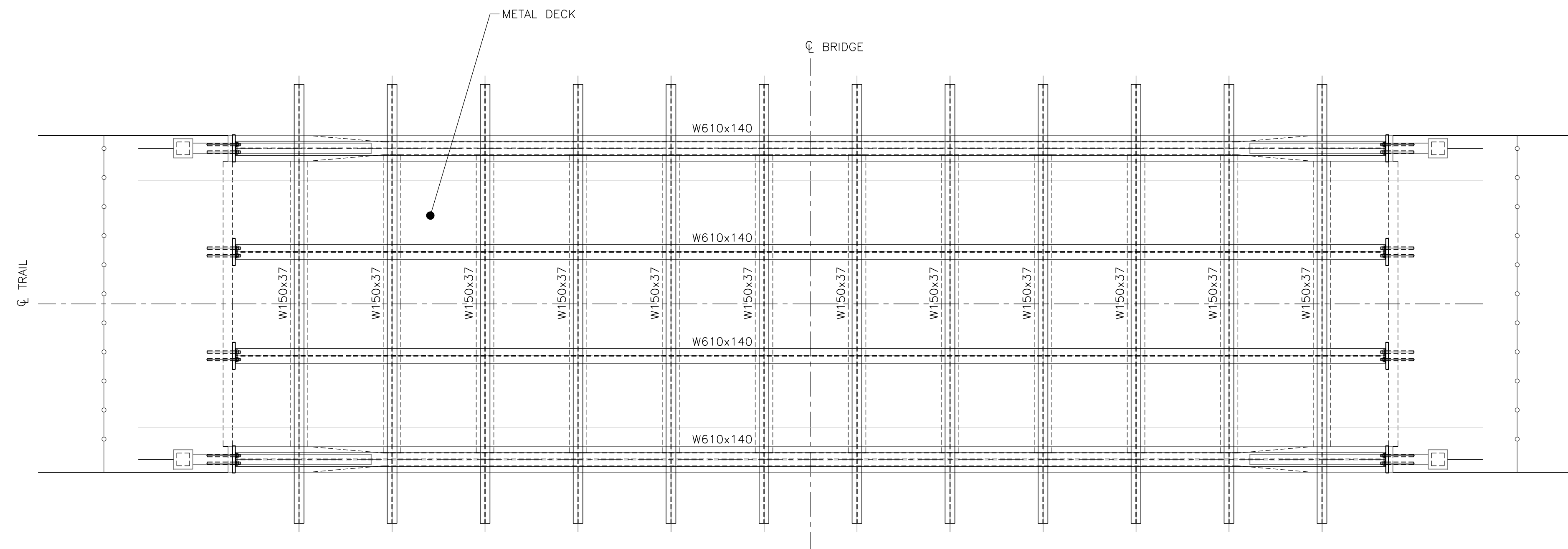
**HUMBER BRIDGE
UNDERSIDE AND SOUTH ARCH**

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NOTE:
ALL DIMENSION SHOWN ARE IN METRES
AND/OR MILLIMETRES UNLESS NOTED
OTHERWISE.



NORTH ARCH ELEVATION
SOUTH ARCH ELEVATION SIMILAR
1:50



PLAN
1:50

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

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CONSULTANT:			
PREPARED FOR:			
HUMBER BRIDGE OPTION 2 AND OPTION 3 CONCEPTUAL SHORING			