PARSONS

LaSalle Causeway Bascule Bridge

Main Trunnion Rehabilitation Study – Detailed Inspection Memorandum (Revision 1)

PSPC Project Number: R.099350.002

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Executive Summary

The LaSalle Causeway opened in 1917 and consists of five interconnecting structures: the West Bridge, West Wharf, Bascule Bridge, East Wharf, and the East Bridge. It carries Highway 2 across the Cataraqui River within the City of Kingston. The Bascule Bridge provides marine access to the inner harbour of Kingston, lifting an average of 900 times per year, and access to the southern entrance of the Rideau Canal. Currently the nearest alternate crossing is via Ontario Highway 401 over the Cataraqui River, a detour of 17 km

Parsons Inc. (Parsons) was retained by PSPC in September 2019 to provide professional engineering services related to the rehabilitation of the main trunnion bearings and adjacent structural steel members and connections of the Bascule Bridge. The mandate includes a detailed close-up inspection, measuring the dynamic amplification of the bridge during opening and closing of the bridge using strain gauges, a structural analysis of the main trunnion assemblies, development of repair and/or replacement concepts, and a traffic impact analysis. This memorandum presents the results of the detailed inspection of the main trunnions and adjacent steel members, which was carried out between October 16 and 17, 2019.

The movable leaf span of the Bascule Bridge rotates about the two main trunnions, which consist of three main elements (the pin, the bearing, and the collar) and a number of gusset plates and diaphragms. Six structural steel truss members frame into the main trunnions: the diagonal end post 13-16, the bottom chord strut 14-15, the bottom chord 14-16 (all through-truss members), the fixed diagonal 15-17 and tie 15-18 (both tower truss members) and the vertical post which supports the main trunnion bearing.

The **through-truss** diagonal end posts typically exhibit localized deterioration at the trunnions. 13N-16N has 75% section loss of the south bottom flange, and 13S-16S has perforations in the bottom batten plate, and severe section loss in the lower flange of the inner channel at 16S. The through-truss bottom chord members (14-16) cross the bottom chord strut members (14-15). At this interface, localized moderate to severe pitting and minor rust jacking is typical on the exterior faces, and severe localized pitting and section loss of the flanges on the interior of 14S-16S. Bottom chord strut member 14S-15S has severe localized section loss and knife-edge corrosion of both bottom flanges near node 14 representing from 50% to 100% loss of the bottom flange thickness. Both 14N-16N and 14S-16S have a perforation in one of the channel webs near the main trunnions. Severe localized section loss of the channel flanges and rivet heads at sidewalk floor beam connections to 14N-16N is typical. Thirteen rivet heads in the outboard (south) channel connection of 14S-16S to 16S have over 75% section loss. The flanges of the south channel of 14S-16S have deformed near the main trunnion at 16S. Although the exact cause is unknown, it does appear that the channel flanges were not straightened prior to the repair and when the bolts/nuts were torqued it probably made the deformation worse. We do not think that an urgent repair is warranted, but it will be necessary to take into account when designing the trunnion repairs. In the meantime, it is recommended that the deformation is monitored.

Water tends to get trapped inside **tower truss** members 15-17 at node 15 and as a result there is severe pitting in the interior of the members and many rivet heads exhibit severe to complete section loss. The standing water has also led to 100% section loss of the stiffening angles at node 15N and the bolt heads from both the trunnion bearings. Members 15-18 have localized section loss of the top flange of the channels at some lattice connections, perforations (with a crack in 15S-18S) in the channel webs, and localized areas of severe section loss of the bottom flange. 15N-18N has moderate to very severe pitting at the base of the web, and 15S-18S has up to 70% section loss of rivet heads.

The visible sections of the short **columns** below 15N and 15S (which are only visible when the bridge is the open position) are in generally good condition. No performance deficiencies were noted.

The inboard vertical plate at **tower truss connection** 15N has localized pitting between 2mm and 7mm deep representing up to 70% loss of cross-section of the plate, four perforations, and 80% loss of a rivet head at roadway level (Photo 17). The inboard gusset plate at node 15S has severe pitting with a perforation below 15S-18S.

Both the main trunnions exhibit areas of deterioration. There is contact between the moving structure and the fixed structure in the vicinity of the main trunnion bearings during operation of the bridge, which is creating a wear step in tower truss members 15-17 and wearing away the heads of the rivets in the line of action. In addition, the outboard sides of the bridge structure contact the outboard sides of the north and south trunnion support steel, with contact at the south side heaviest. There are perforations at the base of the vertical gusset plates between the end of 14N-16N and 14S-16S and the adjacent floor beam (FB16) at 16N and 16S. The perforation in the south plate at 16N has a crack-like initiation at the top. The north plate at 16S has a perforation and crack in the east edge immediately above 14S-16S. Many of the rivet heads at the base of the vertical gusset plates have very severe section loss. The upper sections of the north and south roadside plates adjacent to the trunnion collar have widespread severe pitting. Various degrees of pitting are evident in the vertical gusset plates adjacent to the top flanges of the bottom chord members, with up to 50% localized section loss of the plates at 16S. The triangular members behind FB16 exhibit perforations, although repairs to these areas have been previously carried out.

1.0 Introduction

The LaSalle Causeway (the Causeway), owned and operated by Public Services and Procurement Canada (PSPC), carries Highway 2 across the Cataraqui River within the City of Kingston, providing a critical transportation link between the downtown area on the west side of the river with the Barriefield/CFB Kingston area on the east side of the river. Approximately 25,000 vehicles cross the Causeway daily, with approximately 2% commercial vehicles. The Causeway consists of five (5) interconnecting structures: the West Bridge (including its west approach), the West Wharf, the Bascule Bridge (Photos 1 to 3), the East Wharf, and the East Bridge (including its east approach). The location of the Causeway is shown on the key plan (Figure 1).

The Bascule Bridge provides marine access to the inner harbour of Kingston, lifting an average of 900 times per year, and access to the southern entrance of the Rideau Canal. The number of average openings per year has varied over the life of the structure, and it is estimated that the bridge has opened approximately 193,000 times since construction was completed on April 15, 1917. Currently the nearest alternate crossing is via Ontario Highway 401 over the Cataraqui River, a detour of 17 km.

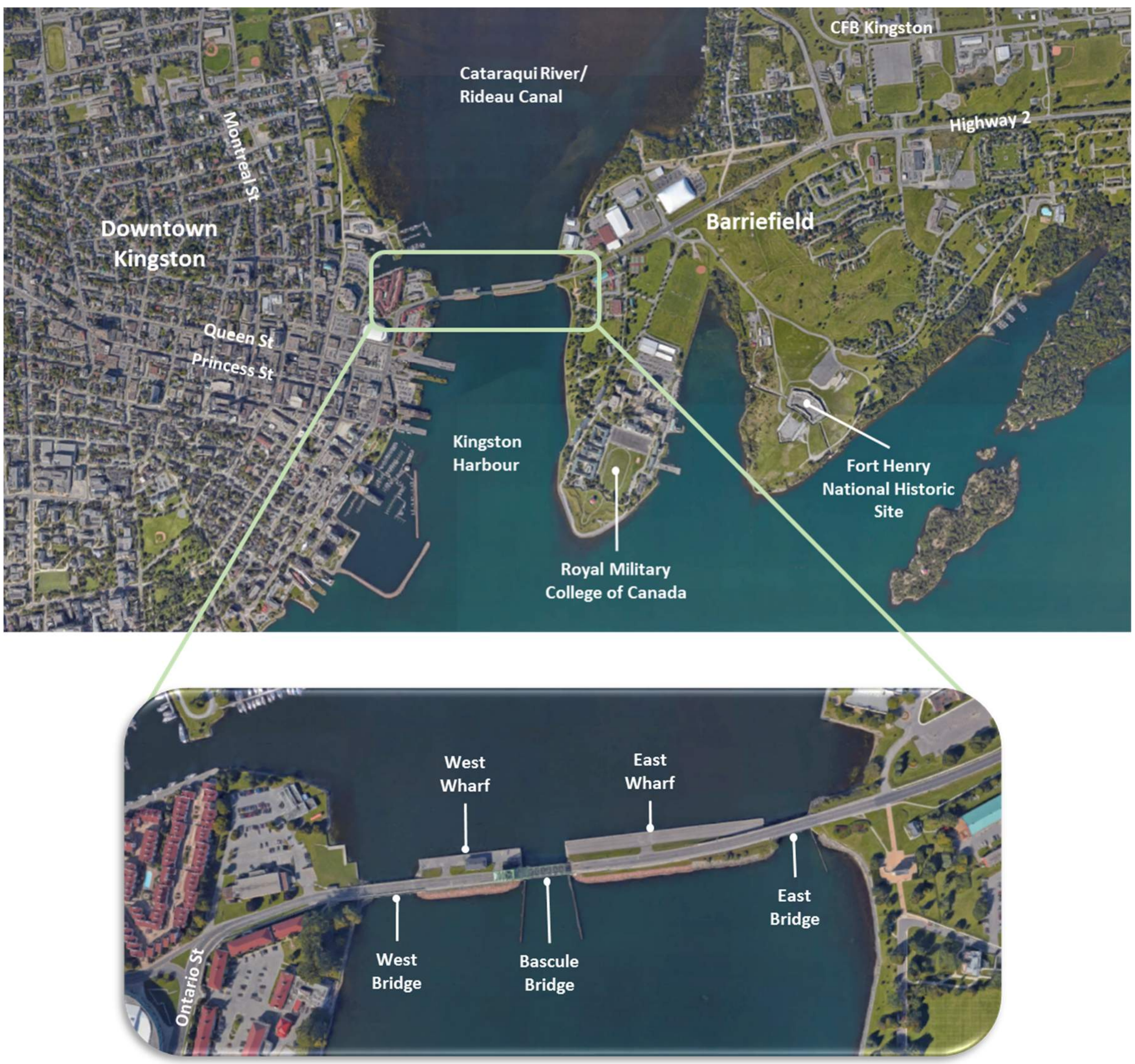


Figure 1: Key Plan (from Google Maps)

In September 2019, Parsons Inc. (Parsons) was retained by PSPC to provide professional engineering services related to the rehabilitation of the main trunnion assemblies of the Bascule Bridge. The mandate includes the following tasks: a detailed close-up inspection (including ultrasonic thickness testing by Brouco NDT) of the main trunnions and adjacent structural steel members and connections; measuring the dynamic amplification of the bridge during opening and closing of the bridge using strain gauges; a structural analysis of the main trunnion assemblies; development of repair and/or replacement concepts; steel coating requirements; construction staging strategies, including Class 'C' cost and working day estimates; and a traffic impact analysis.

This memorandum presents the results of the detailed inspection of the main trunnions and adjacent steel members, and outlines the purpose and methodology of the inspection, provides a summary of the significant findings, and summarizes and presents updated material and performance condition (MCR/PCR) ratings as well as section losses of the main trunnions and each adjacent primary truss member. Deterioration drawings of the main trunnions are included in Appendix A. A copy of Brouco NDT's ultrasonic thickness testing report is included in Appendix B. Selected annotated photographs of the existing condition of deteriorated areas are included in Appendix C. Updated condition ratings are included in Appendix D. Detailed baseline measurements of the deformation of 14S-16S are included in Appendix E.

2.0 Structure Description

The Bascule Bridge is a single-leaf Strauss heel trunnion bascule bridge, designed by The Strauss Bascule Bridge Co. of Chicago (Figures 2 and 3). Construction of the bridge was completed in April 1917. The structure is supported on two concrete abutments (also known as piers) founded on timber piles (based on available original drawings), the front faces of which are protected with steel sheet piling.

The main through (or *leaf*) truss span of the bridge spans between the East Wharf and West Wharf and consists of a Modified Warren through truss with a span length of 48.77 m (160'). The centre-to-centre truss width is 8.23 m (27') and the centre of bottom chord to centre of top chord height varies from the east to the west end from 6.10 m (20') to 7.92 m (26'). The bridge has a posted vertical clearance of 4.2 m and a vertical clearance above the water of approximately 0.6 m.

The roadway width on the bridge is 7.32 m (24') and carries one eastbound and one westbound vehicular traffic lane on an open steel deck grating. The deck grating is supported by a floor system comprised of transverse sills, nine longitudinal stringers, and transverse floor beams located at each panel point. A 1.2 m (4') wide timber plank sidewalk is cantilevered from the exterior of the south truss.

The fixed tower truss supports the counterweight truss and machinery room. The lower members of the north and south trusses are located directly adjacent to the roadway. The counterweight truss above supports the concrete counterweight.

The top chords, bottom chords, verticals, diagonals, cantilevered sidewalk floor beams, sway bracing and struts, top lateral bracing, fixed tower, counterweight link, operating strut, and counterweight truss members consist of built-up sections of plates, channels, angles, and/or lattice. Repairs carried out under previous contracts have strengthened or repaired some deteriorated members and replaced lattices with cut out steel plates on others.

The concrete counterweight weighs approximately 550 tons (1,220,000 lbs.) and is suspended from the counterweight truss. The counterweight has an internal steel truss structure and is reinforced at the exterior faces by steel bars and wire mesh. There are steel plates mounted on the north and south faces which are secured in place by threaded steel rods. Two pockets are provided in both the east and top faces of the counterweight, which can accommodate additional dead load required to balance the bridge.

The machinery room containing the span drive machinery (brakes, motors, open gearing, etc.) is located over the roadway and is supported within the fixed tower truss. Access to the machinery room, top of the counterweight, bearings and pins is provided by various catwalks, stairs, and access ladders. The operator's control house containing the electrical systems for bridge operations is located to the northwest of the structure on the east end of the West Wharf. The building containing the PSPC office and workshop is located on the West Wharf.

Figure 2: South Elevation

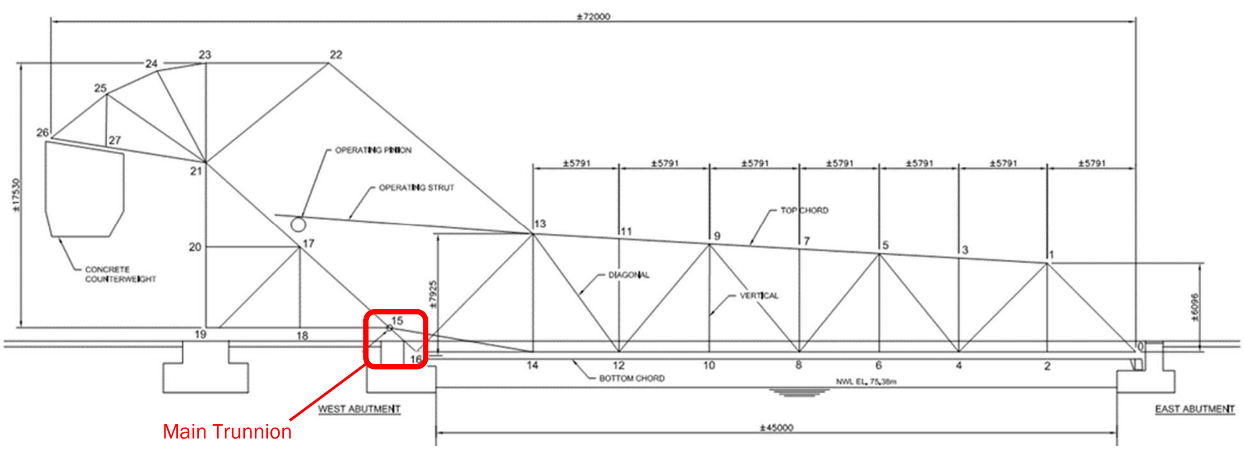


Figure 3: Dimensions and Truss Member Designation

For reference within this report, primary members of the Bascule Bridge, truss nodes and member numbers were adopted from the 1915 original drawings (see Figure 3).

The movable leaf span rotates about the two main trunnions, which consist of three main elements (the pin, the bearing (at Node 15), and the collar) and a number of gusset plates and diaphragms. Six structural steel truss members frame into the main trunnions: the diagonal end post 13-16, the bottom chord strut 14-15, the bottom chord 14-16 (all through-truss members), the fixed diagonal 15-17 and tie 15-18 (both tower truss members) and the vertical post (Photo 4) which supports the main trunnion bearing. The vertical post, trunnion bearing, and tower truss members 15-17 and 15-18 are connected by two vertical plates (referred to herein as the *tower truss connections* 15N and 15S) which are mostly embedded in concrete and therefore only the top section is visible.

Both the main trunnion collar and bearing are fabricated from cast steel, whereas the pin is forged steel. The pin is 317.5mm (12.5") in diameter and has oil grooves and ports to permit lubrication. The bearing has a 19mm (¾") phosphorus bronze bushing in contact with the pin.

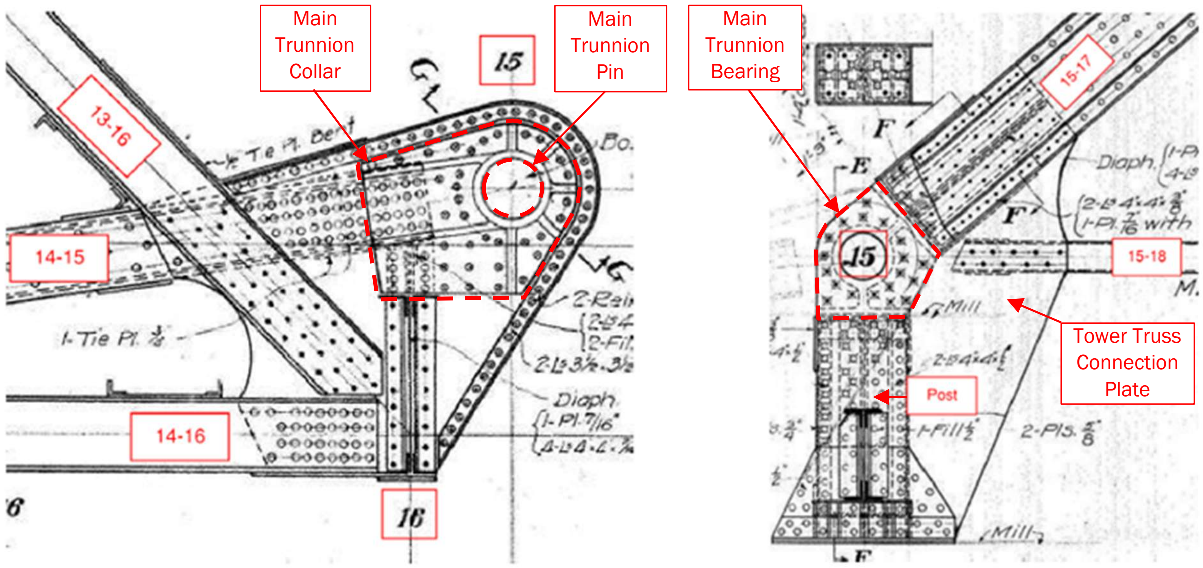


Figure 4: Main Trunnions (a) Left: Moveable part (b) Right: Fixed part

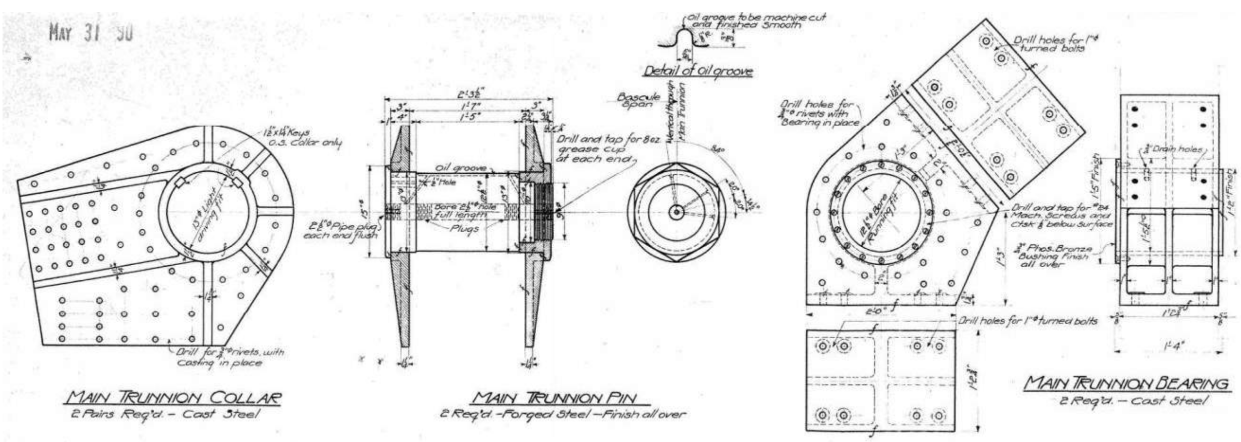


Figure 5: Main Trunnion Components

3.0 Detailed Inspection

3.1 Inspection Methodology

The inspection was carried out between October 16 and 17, 2019 and in accordance with the PSPC *Bridge Inspection Manual* (BIM), the current edition of the Canadian Highway Bridge Design Code (CHBDC) CSA-S6, the Federal Highway Administration (FHWA) *Inspection of Fracture Critical Bridge Members* supplement, and the AASHTO *Moveable Bridge Inspection, Evaluation and Maintenance Manual*. Safety measures were implemented as per the *Occupational Health and Safety Act* (OHSA) and the MTO *Safety Practices for Structure Inspection* manual. Prior to the commencement of the field work, a Traffic Management Plan and a Site-Specific Health & Safety Plan were prepared and submitted to PSPC for review. A copy of the plans was kept on site at all times with the inspection team.

The structural inspection of the main trunnions and adjacent truss members consisted of a close-up, detailed visual inspection of all exposed surfaces by a team comprising a Parsons engineer, and non-destructive testing specialists from Brouco NDT. Above-deck sections were observed from the deck and sidewalk surfaces and embankments, and below-deck sections were inspected from the west abutment. The sections of the main trunnions and truss members that are hidden from view when the bridge is in the closed position were inspected overnight when the bridge was in the open (i.e. raised) position. Detailed section loss measurements of steel components were measured using calipers, pit gauges and an electronic ultrasonic thickness (UT) gauge. Details of the strain gauge testing to measure the dynamic amplification of the bridge during opening and closing of the bridge are provide in the following section. The testing was carried out by BMT Canada Ltd. (BMT).

Traffic control measures for the temporary alternating lane closures (including signage and Traffic Control Persons, i.e. flaggers) required for the inspection and counterweight investigation were implemented in accordance with the requirements of the Ontario Traffic Manual, Book 7, and provided by Beacon Lite. No specialized access equipment was utilized.

Material and Performance Condition Ratings (MCR, PCR) for all elements were assessed using the specified rating criteria outlined in *Part 2 – Inspections* and Appendix A of the BIM and are summarized in Figure 2.2 of the BIM (see Figure 5). Overall section loss of deteriorated sensitive components was calculated using recorded deterioration measurements. Note that the updated MCR and PCR ratings listed in Appendix D are based on measured section loss only and do not take into account the Demand-over-Capacity (D/C) ratios of the members. The January 2020 draft Structural Evaluation Report (submitted separately) contains the Demand-over-Capacity (D/C) ratios based on the measured section losses and applied loading.

3.2 Strain Gauges

The strain gauge testing of the north and south main trunnions and connecting truss members was carried out by BMT Canada in conjunction with Brouco NDT under the supervision of Parsons' engineer and was conducted during several opening and closing cycles of the bridge. The strain measurements allowed the determination of stresses on the trunnion plates and forces on the truss members with two objectives: to rationalize the dynamic load amplification during the operation of the bridge; and to validate structural analysis models.

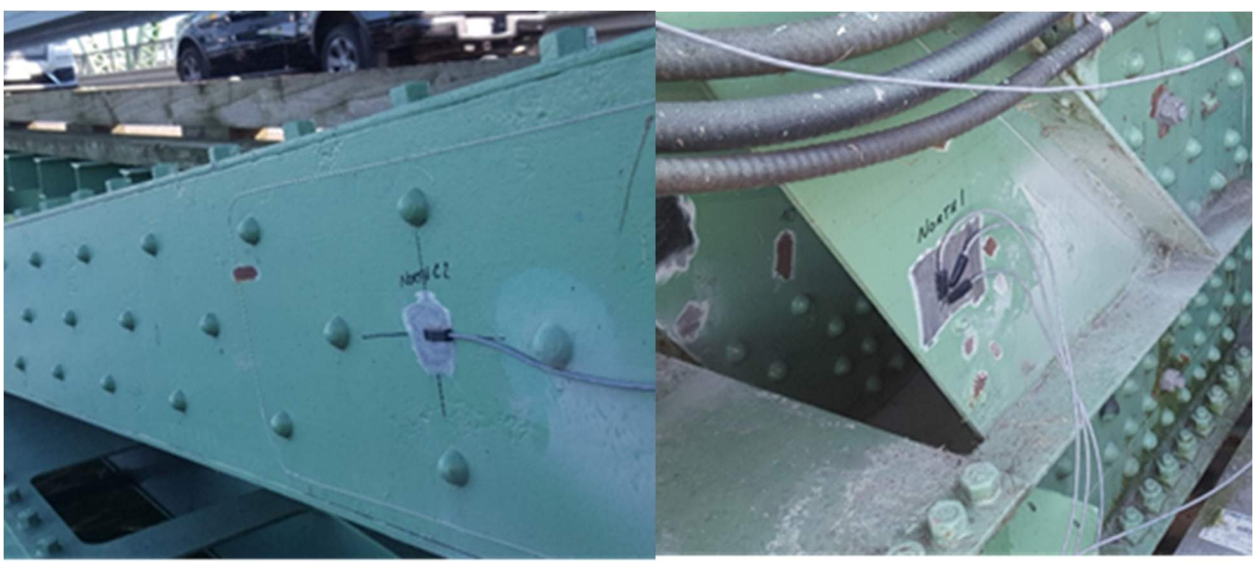


Figure 6: Typical strain gauge configurations. (a) Left: Uni-axial (b) Right: Tri-axial.

The strain gauges were installed by two personnel from BMT in association with one personnel from Brouco NDT. Installation took place during the hours of 9:30 and 15:00 (with single alternating temporary lane closures as necessary) on Tuesday October 15 and Wednesday October 16. Strain gauge installation involved using a grinder to locally remove the coating, then spot welding the strain gauges to the steel elements with a low voltage spot welder. Zinc-rich primer was then applied to the steel members at locations of coating removal. Typical photos of some of the installed strain gauges (prior to the application of the zinc-rich primer) are shown in **Error! Reference source not found.**.

Three-hundred-fifty (350) ohm weldable strain gauges in uni-axial and tri-axial configurations were used during the test and two sixteen-channel data acquisition systems were used to record the strain measurements. A total of sixty-four (64) strain gauges were intended to be installed on the trusses as follows:

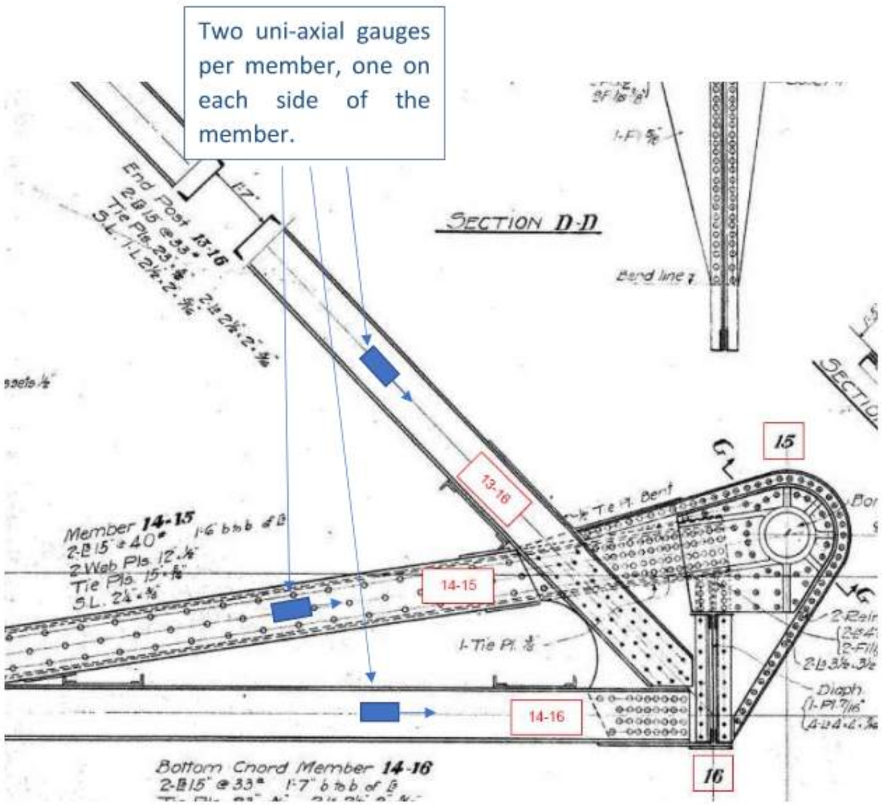


Figure 7: Uni-axial (blue rectangle) gauges on members 14-16, 14-15 and 13-16.

An issue was encountered on site whereby there was not enough space to properly install the tri-axial gauges on the trunnion posts. This was resolved by installing a single uni-axial gauge on the interior of each post. A total of twenty (20) uni-axial gauges were installed on the truss members that are attached to the trunnion (13-16, 14-16, 14-15, 15-18, and 15-17), four (4) uni-axial gauges on the operating struts, two (2) uni-axial gauges on the interior of each trunnion post. Nine (9) tri-axial gauges and one (1) uni-axial gauge in total were installed on the trunnion plates. The locations of the installed strain gauges can be seen in Figures 7 to 10.

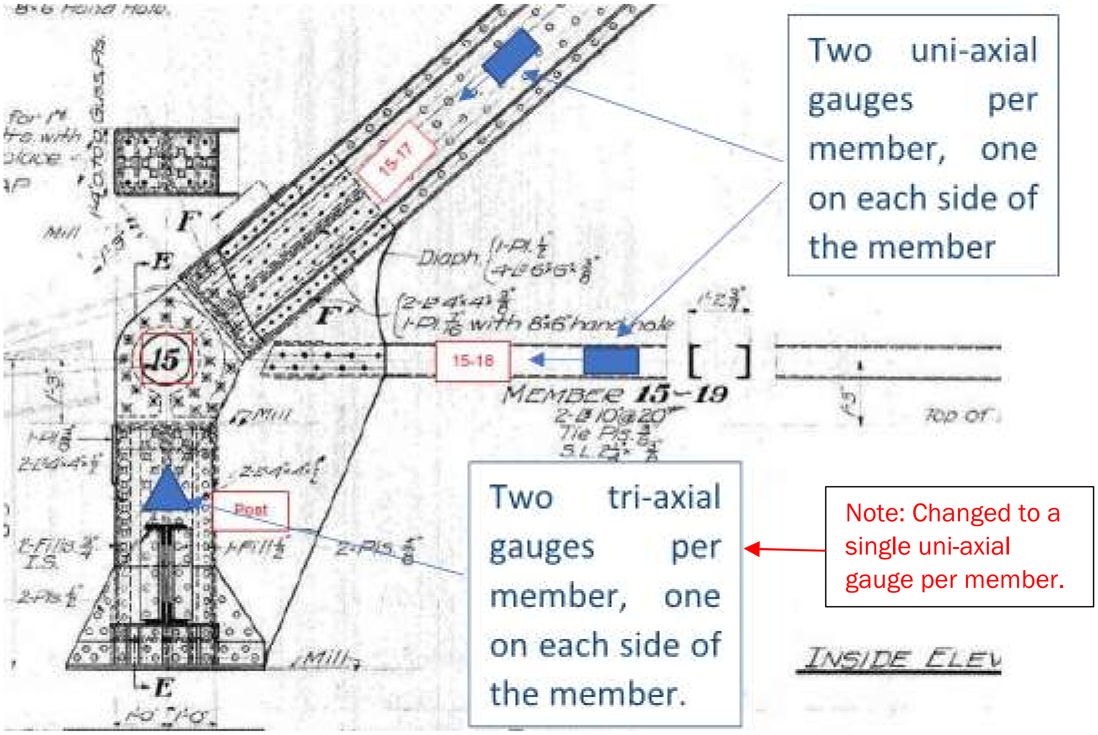


Figure 8: Uni-axial (blue and red rectangle) gauges on post and members 15-18 and 15-17.

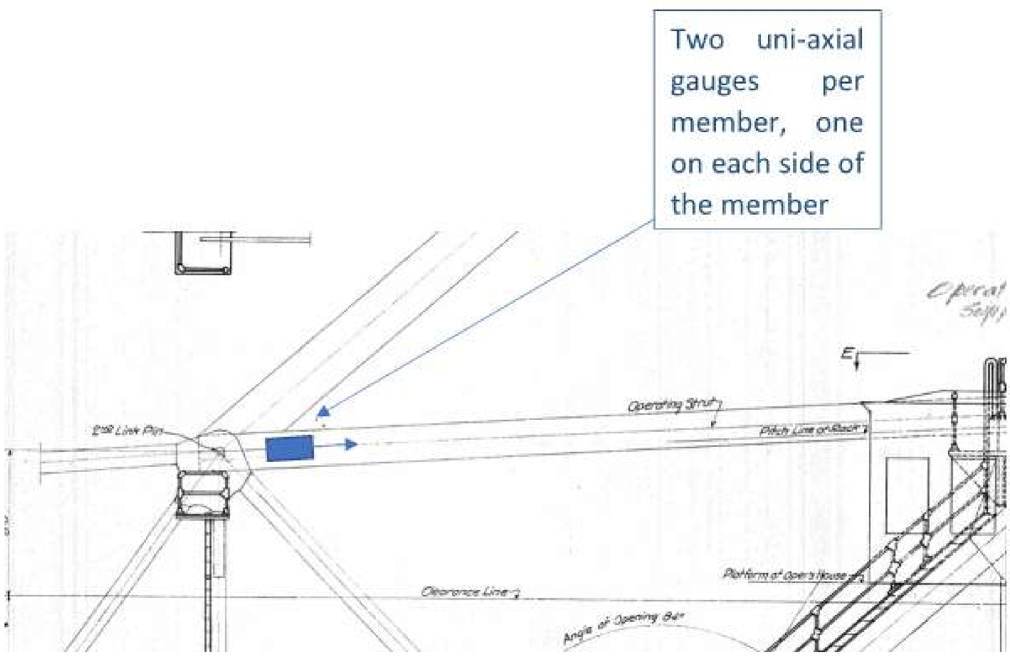


Figure 9: Uni-axial (blue rectangle) gauges on operating struts.

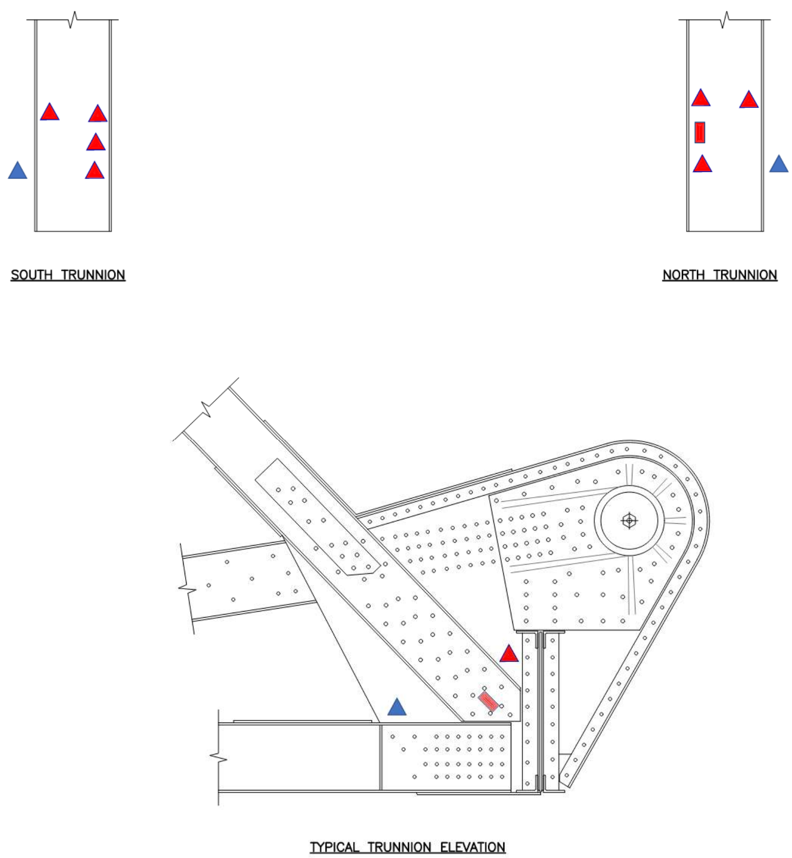


Figure 10: Uni-axial (red rectangle) and tri-axial (blue and red triangles) gauges on trunnion plates.

The testing operations were conducted on October 17, 2019 between 12:00 a.m. and 6:00 a.m. The test operations were conducted twice since the data acquisition system (DAS) available could only record thirty-two (32) channels at a time. For the duration of the entire test, data acquisition frequency was about 1.6 Hz. This value was the largest allowed by the DAS, given the duration of the test.

A total of seven (7) lift scenario operations were defined in order to include different operating speeds as well as regular braking and emergency stops. These scenarios were:

- Lift 1: Opening and closing at regular speed (3) with only one regular (i.e. non-emergency) stop at current maximum permissible opening position (65°);
- Lift 2: Opening and closing at speed 2 with only one regular stop at 65°;
- Lift 3: Opening and closing at speed 2 with regular stops at 5°, 21°, 42°, 60°and 65°;
- Lift 4: Opening and closing at speed 2 with regular stops at 5°, 21°, 42°, 60°and 65°;
- Lift 5: Opening and closing at speed 2 with regular stops at 5°, 21°, 42°, 60°and 65°;
- Lift 6: Opening and closing at speed 2 with emergency stops at 5°, 21°, 42°, 60°and 65°; and
- Lift 7: Opening and closing at speed 3 with regular stops at 5°, 21°, 42°, 60°and 65°.

3.3 Component Condition Ratings

In accordance with Part 2 – Inspections, Section 2.2 of the BIM, each component has been assigned a Condition Rating. Tables detailing specific material and performance related defects may be found in the same section of the BIM General guidelines for percentage reduction based on the severity and extent of material defects and on the reduction in capacity to perform its intended function are as indicated in Figure 2 below.

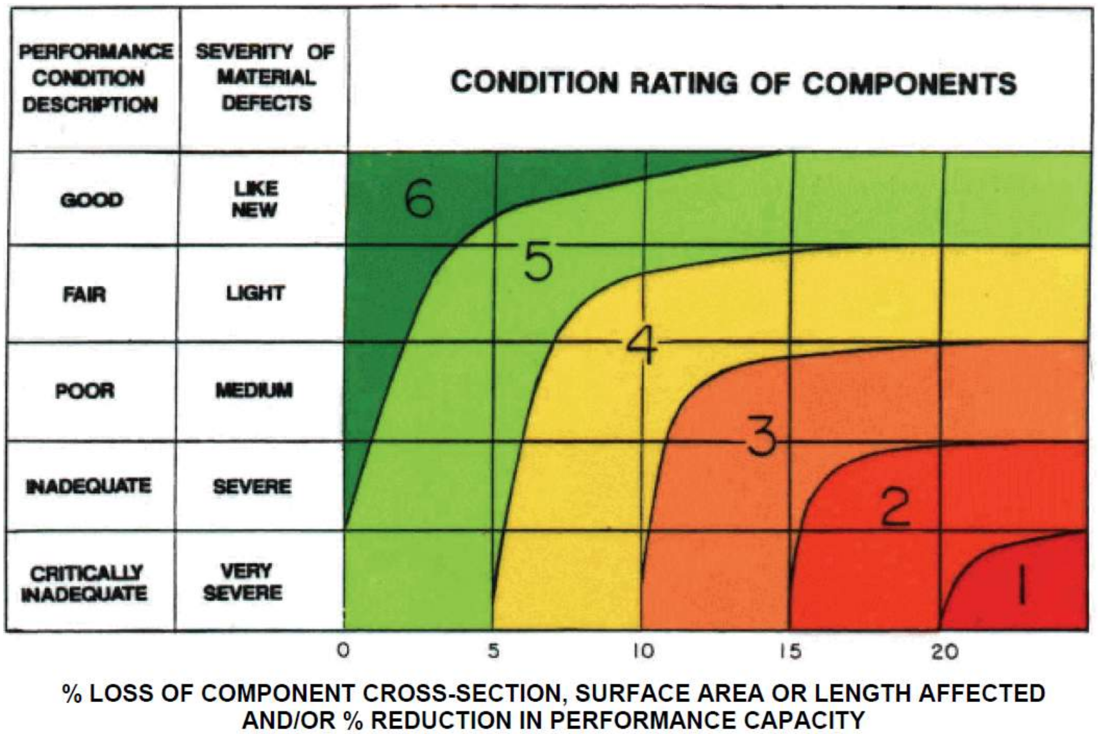


Figure 11: Figure 2.2 of the BIM - Condition Rating of Primary Components

3.4 Inspection Findings

3.4.1 Through Truss Members

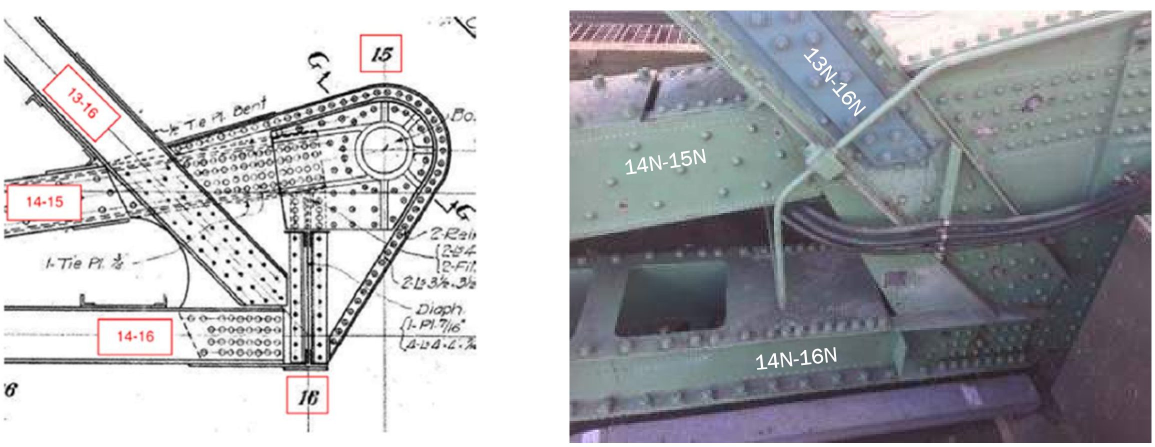


Figure 12: Through Truss Members

13N-16N

The north and south channel webs have been reinforced with a plate at the intersection with members 14-15.

Light pitting around 1mm deep was noted in the channels at the interface between the vertical gusset plates at 16N, and pitting 3mm deep in the top of the north channel flange near 16N. Very severe pitting of the south bottom flange at the connection to the bracing lower gusset plate has resulted in 75% section loss of the flange.

Impact damage to the south bottom flange above deck level was found to have a 3mm long crack (which was later ground out). 5mm deep pitting representing an overall 6% loss of cross-sectional area in the top of the south flange around 2 metres above deck level was also noted. Severe section loss is typical in many lattices above the roadway.

13S-16S

Several small perforations and severe section loss were noted in the bottom batten plate and lower flange of the inner channel at 16S. Both webs of the member are severely corroded, perforated and have been reinforced at the intersection of 13S-16S and 14S-15S.

14N-16N

Severe localized section loss of the channel flanges and rivet heads at sidewalk floor beam connections is typical. There is a perforation in the south channel web near node 16N (Photo 9) and a section of coating is missing over a large section of the outer face of the inner channel at 16N permitting light corrosion to develop. There is moderate to severe localized pitting and minor rust jacking at the interface between members 14N-15N and 14N-16N (Photo 5). The rust-jacking is minor and appears to have been present for a while. Light pitting around 1mm deep was noted in the exterior face of the outer channel web.

14N-15N

Severe localized pitting is evident in the exterior of the south channel web where members 14N-16N and 14N-15N intersect near 14N (Photo 5). Light corrosion was also noted in these areas and along the interior webs. Pack rust and active corrosion between the web plate and channel web were noted and light to moderate pitting in the interior surfaces of web plates.

14S-16S

In 1997, all the top and bottom lattices were replaced with cut-out plates and rivets replaced with bolts, but the drawings we have do not show the addition of the web plate nor the replacement of the lattice near the end of the member; these were likely a change during construction. Rivets have also been replaced with bolts on the inboard vertical gusset plate at 16S.

The flanges of the south channel have deformed upwards at two locations near the main trunnion at 16S. The most pronounced deformation is located around 910mm from 16S and is over a length of approximately 520mm with a maximum upward deflection of 8mm (bottom flange) and 3mm (top flange). The upward deformation at the second location is approximately 4.5mm, around 2100mm from 16S. No deformation of the south channel web or north channel is evident. The same member on the north truss shows no such deformation. Although the exact cause is unknown, it does appear that the channel flanges were not straightened prior to the repair (there are shims between the bottom flange and the new plate) and when the bolts/nuts were torqued it probably made the deformation worse. We do not think that an urgent repair is warranted, but it will be necessary to take into account when designing the trunnion repairs. In the meantime, it is recommended that the deformation is monitored. Detailed baseline measurements of the deformation are included in Appendix E.

The member has a perforation and a 12mm long vertical crack perpendicular to the main stress in the interior (north) channel web towards 16S (Photo 10). Severe localized pitting and section loss of the flanges where 14S-16S and 14S-15S intersect was noted (Photo 7). 13 rivet heads in the outboard (south) channel connection to

16S have over 75% section loss. Light corrosion was noted along the interior face of the north channel and light pitting 1mm deep is typical in horizontal surfaces.

14S-15S

This member has been reinforced and rivets have been replaced with bolts.

A small perforation in the north channel web was noted and two perforations and multiple cracks in the bottom batten plate near node 15S (Photo 8). The cracks range in length from 3mm to 11mm. There is severe localized section loss and knife-edge corrosion of both bottom flanges over 1m near node 14 where members 14S-16S and 14S-15S intersect representing from 50 to 100% loss of the bottom flange thickness (Photo 7). Light to medium active corrosion was also noted in these areas. There is a large area of very severe pitting in the exterior web and the edge of the bottom flange of the channel. Light to moderate pitting was noted over most surfaces, and section loss of rivets evident at 14S.

3.4.2 Tower Truss Members

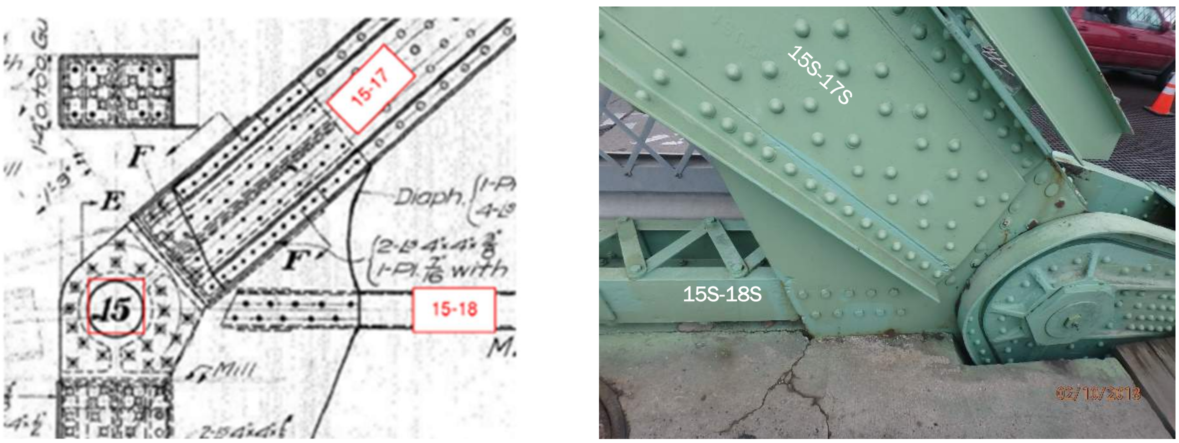


Figure 13: Tower Truss Members

15N-17N

Water tends to get trapped inside 15N-17N at 15N and as a result there is severe pitting in the interior of the member at the connection and 5 rivet heads inboard and 2 rivet heads outboard exhibit severe to complete section loss (Photo 11). The standing water has also led to 100% section loss of the stiffening angles at node 15N and the bolt heads from the trunnion. There is active corrosion between the web plate and northwest angle at the base of the member and rust jacking between the web plates and light corrosion at several locations. A few lower lattices at the base of the member are bent and there is localized severe pitting in the channel flanges at the connections to lattice.

15N-18N

Member 15N-18N has moderate to very severe pitting of the channel flanges at lattice locations and at the base of the web, a perforation in the inner (south) channel at mid-span, and loss of a section of the north bottom flange at 15N (Photo 12). Several areas exhibit localized section loss of the bottom flanges (around 10% of the flange area) and light and localized moderate pitting is visible near 15N.

15S-17S

The lower connection at 15S traps water inside the member causing severe pitting in the interior of the member and many of the rivet heads exhibit severe section loss. There is up to 20% localized section loss of the underside of the bottom flange at lattices near the base of the member and up to 50% localized section loss of the interior of the webs at 15S above the gusset plates. Corrosion jacking was noted on the inner and outer web plates near the base of member and pitting in the interior of the south web plate above the gusset plate at 15S. Several lattices are bent.

15S-18S

There is a 3mm long crack emanating from a perforation in the south channel of 15S-18S and areas of up to 80% localized section loss of the bottom flange thickness and up to 70% section loss of rivet heads were noted. Between 10% to 30% localized section loss of the top flange of the channels was noted at some lattice connections. Localized active corrosion and pitting of the top batten plate was observed at the east end near 15S, as well as medium corrosion on flanges around bolts in the channels (Photo 34). Active rust jacking on reinforcement plates was noted.

3.4.3 Post below Node 15

The visible sections of the short posts/columns below 15N and 15S (which are only visible when the bridge is the open position) are in generally good condition (Photos 13 and 14). The rear (west side) of the posts is never visible and appears to be at least partially encased in concrete.

3.4.4 Tower Truss Connections

The visible (above-ground) sections of the inboard gusset plate behind node 15N has localized pitting between 2mm and 7mm deep representing up to 70% loss of cross-section of the plate, four perforations, and 80% loss of a rivet head at roadway level (Photo 17). Water is trapped inside the connection.

The inboard gusset plate behind node 15S has severe pitting with a perforation below 15S-18S.

3.4.5 Main Trunnions

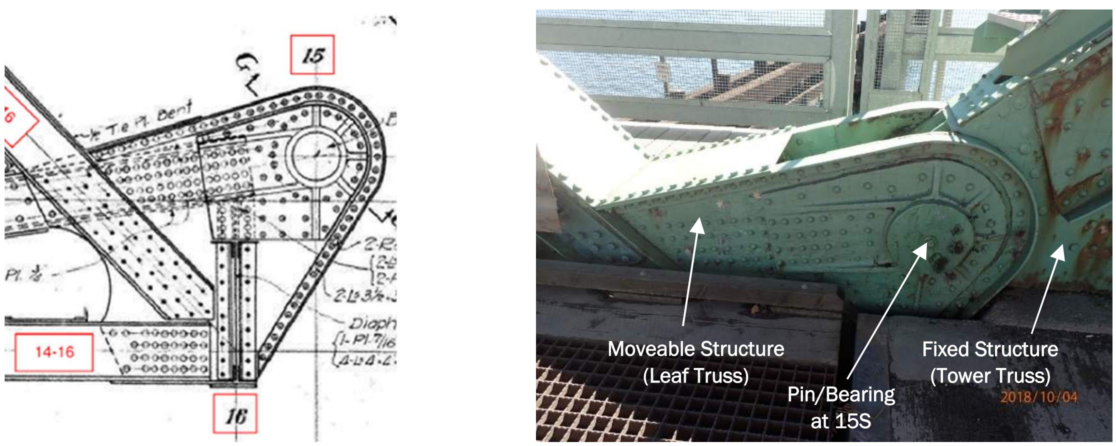


Figure 14: Main Trunnions

There is contact between the moving structure and the fixed structure in the vicinity of the main trunnion bearings during operation of the bridge. The contact is creating a wear step in the tower truss members (15-17) and wearing away the heads of the rivets in the line of action. In addition to the contact near the main trunnion bearings, the outboard sides of the bridge structure contact the outboard sides of the north (Photos 15 and 16) and south trunnion (Photos 19 and 35) support steel. While the contact at the north side is light and appears to be addressed by the applied lubrication, the contact at the south side is heavy and has worn away the paint and the exposed steel is corroded.

The head ends of four of the mounting bolts for the main trunnion bearing have 100% section loss due to corrosion at both the north and south (Photo 36) bearings caused by standing water in the structural cavity covering the head end of the lower two mounting bolts at both locations. In addition, at the north trunnion bearing there is minor fretting corrosion, indicating movement, at the connection interface.

North Main Trunnion (15N/16N)

There is a crack-like initiation propagating from a large perforation at the base of the inside vertical gusset plate between the end of 14N-16N and FB16 at 16N parallel to the shear stress affecting capacity (Photos 20 and 21). The remaining thickness of the 12.7mm plate above the perforation was determined by UT to be as low as 3mm. The south face of the interior vertical gusset plate has 3mm pitting at the interface with the top flange of 14N-16N. Six rivet heads at the base of the interior face of the south vertical gusset plate between the end of 14N-16N and FB16 at 16N have very severe section loss (Photo 22). The interior plate of the south triangular member behind FB16 has three perforations and 10 to 12mm section loss adjacent to the connecting clip angles (Photo 23). Severe pitting was also noted in the clip angles. There is a large perforation (Photo 6) in the west transverse built-up plate (only visible when the bridge is in the open position) between the vertical gusset plates and very severe section loss in the rivet heads and angle at the base of the exterior face of the south plate (Photo 24).

South Main Trunnion (15S/16S)

The north vertical gusset plate has a perforation and a 3mm long crack in the east edge immediately above the north top flange of bottom chord 14S-16S (Photo 25). The north face of the plate has pitting at the interface with 14S-16S with a remaining thickness as low as 5.7mm. There are perforations at the base of the north (Photo 26) and south (Photo 27) vertical gusset plates between the end of 14S-16S and FB16 at 16S. Thirteen rivet heads at the base of the interior face of the south vertical gusset plate at the end of 14S-16S have around 75% section loss, and the base of the gusset plate has severe pitting (Photo 29). The exterior face of the south vertical gusset plate has 6mm pitting (50% section loss) at the interface with the top flange of 14S-16S (Photo 28). The exterior plate of the north triangular member behind FB16 has a large perforation at the base of the original plate (Photo 32). Additional perforations have been repaired by the addition of a welded plate. The upper section of the north (roadside) plate adjacent to the trunnion collar has widespread severe pitting (Photo 18). UT measurements indicate that the remaining thickness is generally between 6.6mm and 9.6mm (the original thickness of the plate was 12.7mm) with one location (at the top of the plate next to the trunnion collar) of 3.3mm (Photos 30 and 31). The rivets at the base of the north vertical gusset plate at the end of 14S-16S at 16S have been replaced with bolts, and there is widespread 2mm pitting in the south face of the plate.

4.0 Condition Ratings of Members

The Material and Performance Condition Ratings (MCR, PCR) for the elements inspected were assessed using the specified rating criteria outlined in *Part 2 – Inspections* and Appendix A of the BIM. Note that the updated MCR and PCR ratings listed in Table 1 are based on measured section loss only and do not take into account the Demand-over-Capacity (D/C) ratios of the members, which can be found in the January 2020 draft Structural Evaluation Report (submitted separately). The overall section loss of deteriorated components was calculated using the recorded deterioration measurements and has been converted to a capacity reduction factor as calculated during the analysis phase of the project.

Table 1: MCR, PCR and Section Loss of Components

Member	Element	2018 MCR	2018 PCR	New MCR	New PCR	Capacity Reduction Factor
Through Truss Members	13N-16N	5	5	4	5	5%
	14N-15N	5	5	4	3	15%
	14N-16N	5	3	2	3	15%
	13S-16S	5	5	5	5	5%
	14S-15S	4	4	2	3	15%
	14S-16S	2	3	2	3	15%
Tower Truss Members	15N-17N	4	3	3	5	5%
	15N-18N	3	4	3	4	5%
	15S-17S	4	3	3	5	5%
	15S-18S	2	4	2	4	5%
Post below Node 15	North	Not Rated	Not Rated	5	5	0%
	South	Not Rated	Not Rated	5	5	0%
Tower Truss Connections	15N	4	2	4	2	N/A
	15S	5	3	4	3	N/A
Main Trunnions	15N/16N	3	4	3	4	N/A
	15S/16S	3	4	3	4	N/A

The significant deterioration of members 13S-16S and 14S-15S that has been mitigated by the addition of steel plates is not taken into account in the new MCR and PCR ratings or capacity reduction factor. The rating of the vertical posts below 15N and 15S is based on the visible sections only. The rear (west side) of the posts is partially encased in concrete and is therefore not visible. No significant material or performance deficiencies were noted. The deterioration in the vertical plates behind node 15 that connects the posts, trunnion bearing, and tower truss members is very localized, and the capacity reduction factor varies greatly depending on the exact location in question. Similarly, the deterioration in the main trunnion components at nodes 15/16 is also very localized and it is difficult to provide an accurate capacity reduction factor for the member as a whole.

5.0 Closure

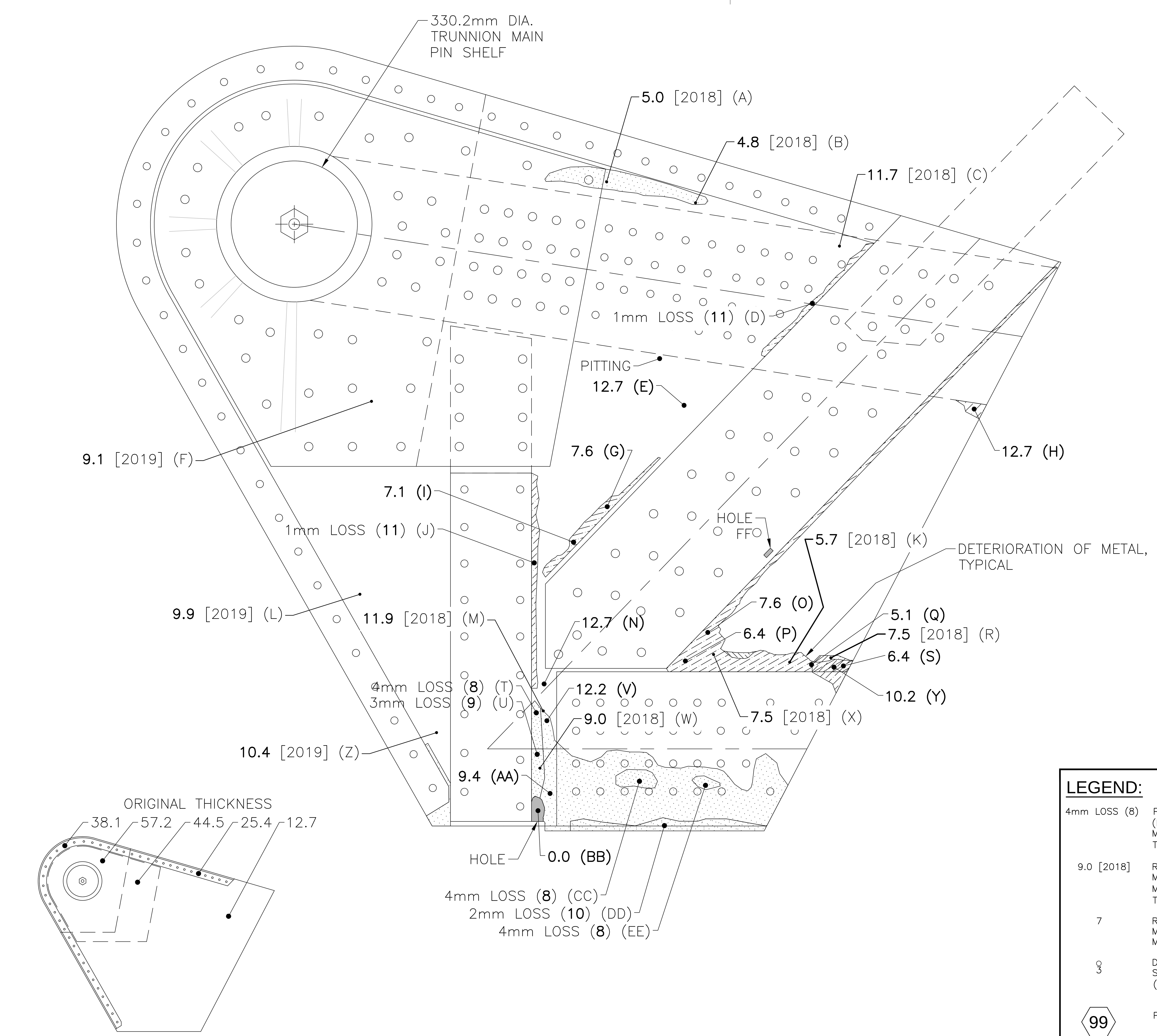
We trust this memorandum is adequate for your present requirements. If you have any comments or questions, please contact the undersigned.

Yours truly,

PARSONS INC.

Peter Harvey, P.Eng
Structural Engineer

Appendix A: Trunnion Plate Deterioration Drawings



MAIN CASTING – CAST STEEL – 11/4" 31.75mm
INTERIOR PLATE – PLATE STEEL – 1/2" 12.7mm
GUSSET – PLATE STEEL – 1/2" 12.7mm

SOUTH TRUNNION EXTERIOR PLATE			
READING	ORIGINAL THICKNESS (mm)	REMAINING THICKNESS (mm)	PERCENT LOSS (%)
A	12.7	5	60.6
B	12.7	4.8	62.2
C	12.7	11.7	7.9
D	12.7	11	13.4
E	12.7	12.7	0.0
F	12.7	9.1	28.3
G	12.7	7.6	40.2
H	12.7	12.7	0.0
I	12.7	7.1	44.1
J	12.7	11	13.4
K	12.7	5.7	55.1
L	12.7	9.9	22.0
M	12.7	11.9	6.3
N	12.7	12.7	0.0
O	12.7	7.6	40.2
P	12.7	6.4	49.6
Q	12.7	5.1	59.8
R	12.7	7.5	40.9
S	12.7	6.4	49.6
T	12.7	8	37.0
U	12.7	9	29.1
V	12.7	12.2	3.9
W	12.7	9	29.1
X	12.7	7.5	40.9
Y	12.7	10.2	19.7
Z	12.7	10.4	18.1
AA	12.7	9.4	26.0
BB	12.7	0	100.0
CC	12.7	8	37.0
DD	12.7	10	21.3
EE	12.7	8	37.0
FF	12.7	0	100.0

LEGEND:

4mm LOSS (8)	PLATE SECTION LOSS (REMAINING THICKNESS IN MILLIMETRES BASED ON 12mm THICKNESS)
9.0 [2018]	REMAINING THICKNESS IN MILLIMETRES BASED ON ULTRASONIC MEASUREMENTS [YEAR MEASUREMENT TAKEN]
7	REMAINING THICKNESS IN MILLIMETRES. BASED ON ULTRASONIC MEASUREMENTS
3	DETERIORATED RIVETS PERCENT SECTION REMAINING DIVIDED BY 10 (i.e. 1=10%, 2=20%, 3=30%, ETC.)
99	PHOTOGRAPH KEY
*	PHOTO FROM 2015 MMM GROUP LIMITED REPORT

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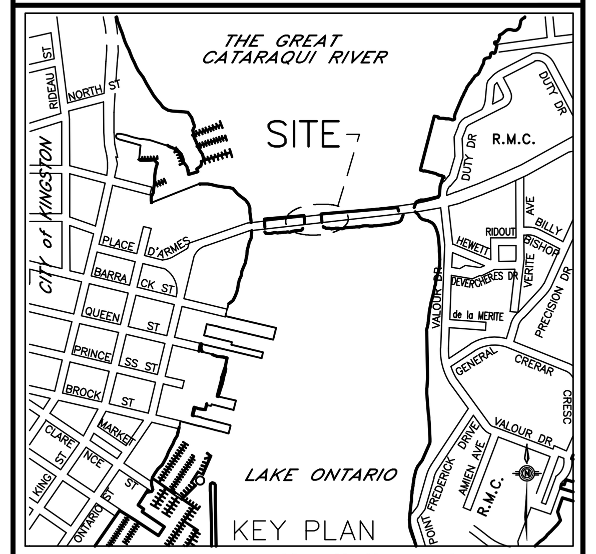

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revisions	description	date

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

project / projet

LASALLE CAUSEWAY
TRUNNION EVALUATION

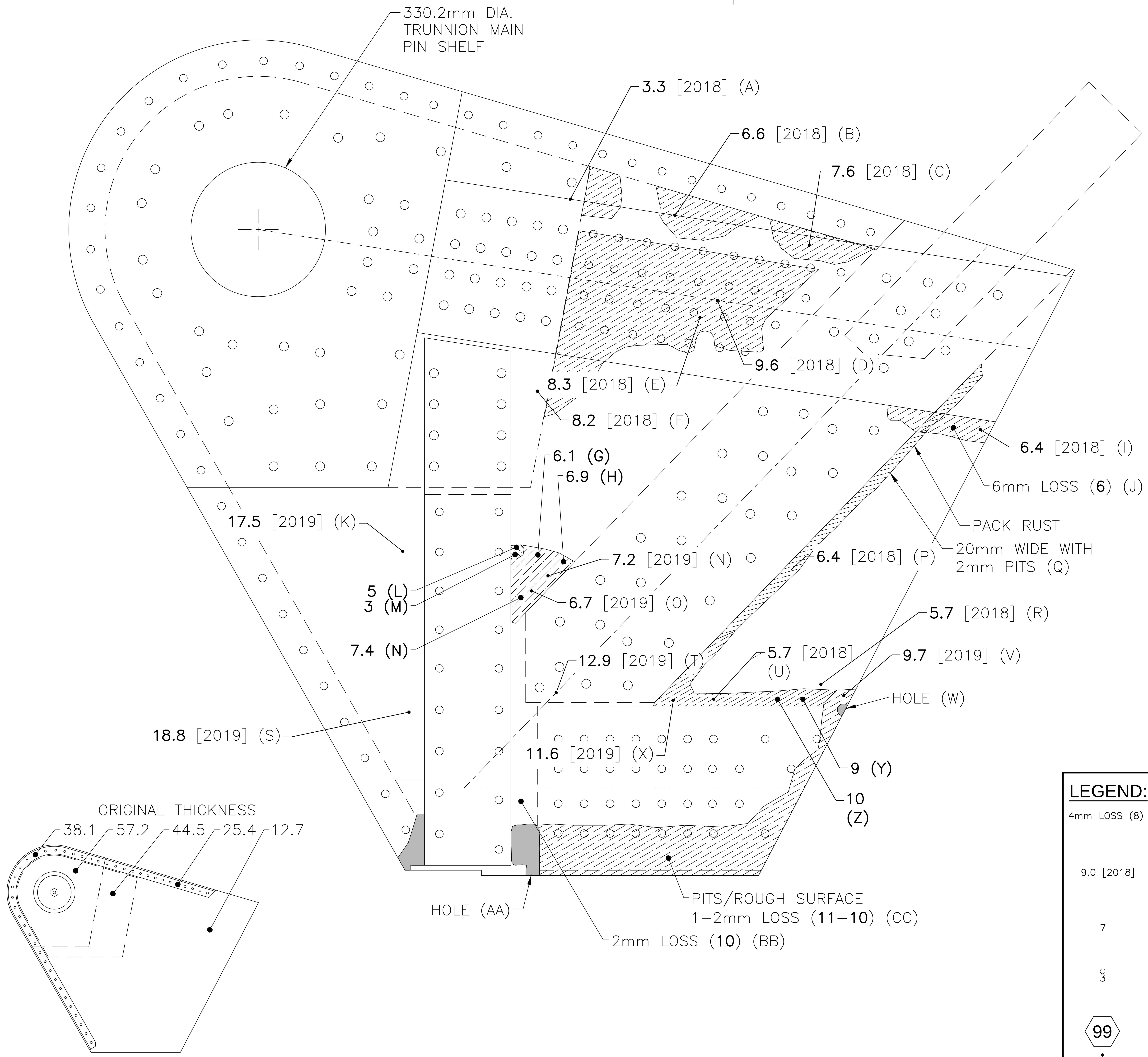
drawing / dessin

SOUTH TRUNNION
FULL EXTERIOR PLATE
DETERIORATION
A B

Designed By		Conçu par
Date		(yyyy/mm/dd)
Drawn By	R.D.	Dessiné par
Date	22 JAN 2020	(yyyy/mm/dd)
Reviewed By	B.R.M.	Examiné par
Date	22 JAN 2020	(yyyy/mm/dd)
Approved By		Approuvé par
Date		(yyyy/mm/dd)
Tender		Soumission
Project Manager		Administrateur de projets

Project no. / No. du projet: R.099350.002

Drawing no. / No. du dessin: 0000-1



MAIN CASTING – CAST STEEL – 11/4" 31.75mm
INTERIOR PLATE – PLATE STEEL – 1/2" 12.7mm
GUSSET – PLATE STEEL – 1/2" 12.7mm

SOUTH TRUNNION INTERIOR PLATE			
READING	ORIGINAL THICKNESS (mm)	REMAINING THICKNESS (mm)	PERCENT LOSS (%)
A	12.7	3.3	74.0
B	12.7	6.6	48.0
C	12.7	7.6	40.2
D	12.7	9.6	24.4
E	12.7	8.3	34.6
F	12.7	8.2	35.4
G	12.7	6.1	52.0
H	12.7	6.9	45.7
I	12.7	6.4	49.6
J	12.7	6.0	52.8
K	23.8	17.5	26.5
L	12.7	5.0	60.6
M	12.7	3.0	76.4
N	12.7	7.4	41.7
O	12.7	6.7	47.2
P	12.7	6.4	49.6
Q	12.7	10.7	15.7
R	12.7	5.7	55.1
S	23.8	18.8	21.0
T	12.7	12.7	0.0
U	12.7	5.7	55.1
V	12.7	9.7	23.6
W	12.7	12.7	0.0
X	12.7	11.6	8.7
Y	12.7	9.0	29.1
Z	12.7	10.0	21.3
AA	12.7	12.7	0.0
BB	12.7	10.0	21.3
CC	12.7	11.0	13.4

LEGEND:

4mm LOSS (8)	PLATE SECTION LOSS (REMAINING THICKNESS IN MILLIMETRES BASED ON 12mm THICKNESS)
9.0 [2018]	REMAINING THICKNESS IN MILLIMETRES BASED ON ULTRASONIC MEASUREMENTS [YEAR MEASUREMENT TAKEN]
7	REMAINING THICKNESS IN MILLIMETRES. BASED ON ULTRASONIC MEASUREMENTS
3	DETERIORATED RIVETS PERCENT SECTION REMAINING DIVIDED BY 10 (i.e. 1=10%, 2=20%, 3=30%, ETC.)
99	PHOTOGRAPH KEY
*	PHOTO FROM 2015 MMM GROUP LIMITED REPORT

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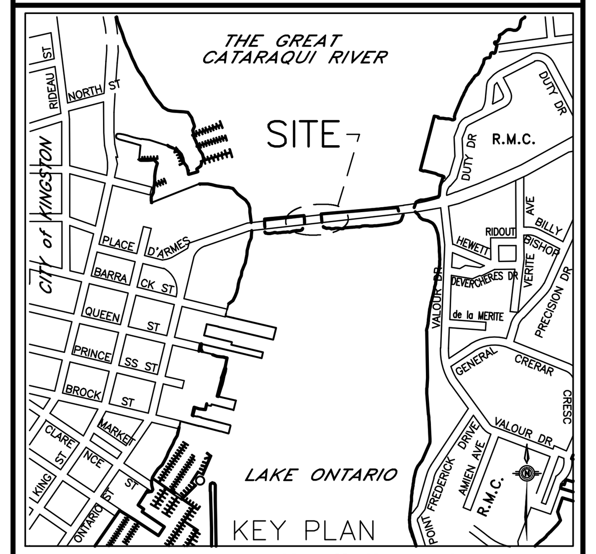

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revisions	description	date

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

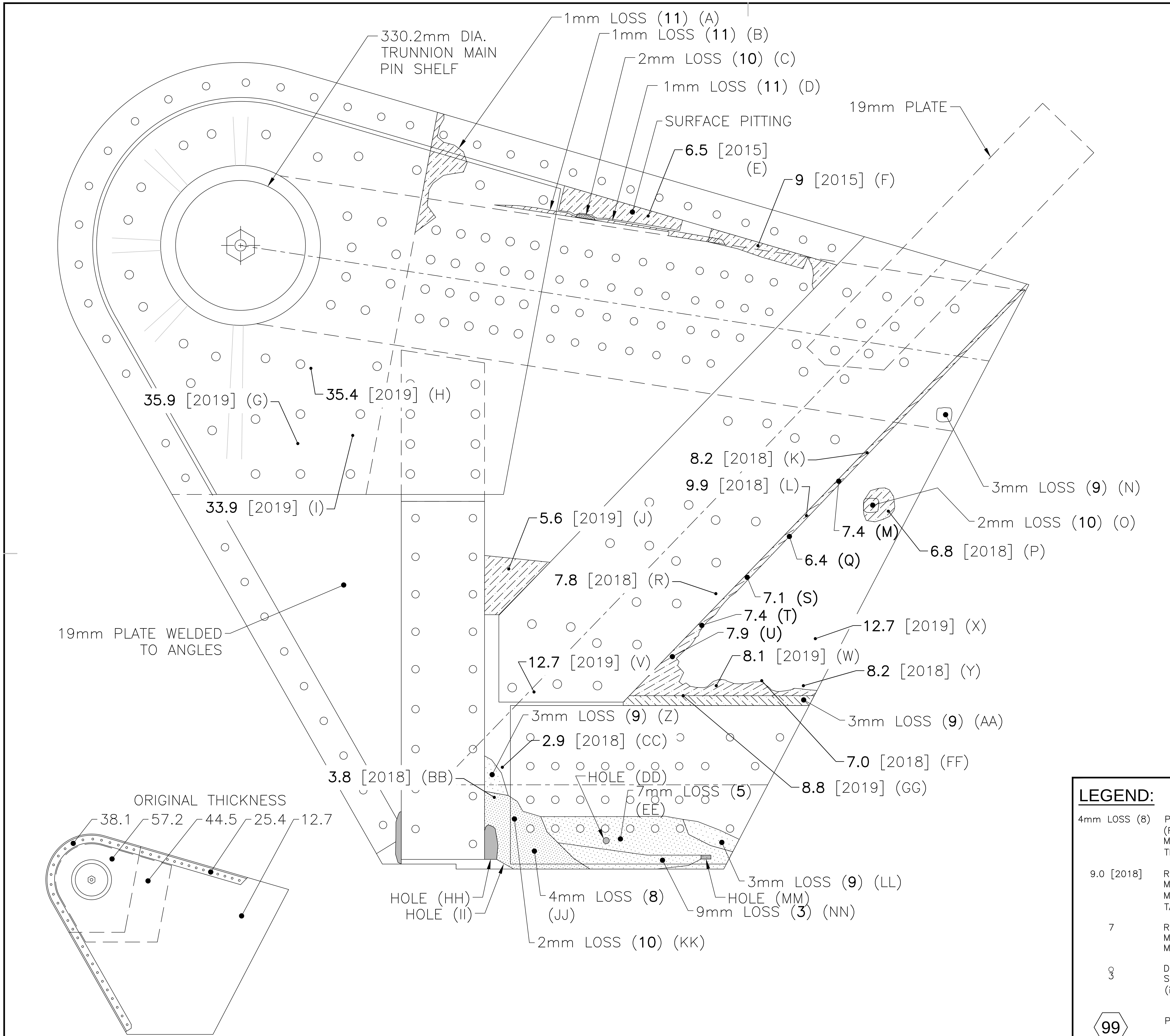
project / projet: LASALLE CAUSEWAY TRUNNION EVALUATION

drawing / dessin: SOUTH TRUNNION FULL INTERIOR PLATE DETERIORATION C D

Designed By / Conçu par	
Date (yyyy/mm/dd)	
Drawn By / Dessiné par	R.D.
Date (yyyy/mm/dd)	22 JAN 2020
Reviewed By / Examiné par	B.R.M.
Date (yyyy/mm/dd)	22 JAN 2020
Approved By / Approuvé par	
Date (yyyy/mm/dd)	
Tender / Soumission	
Project Manager / Administrateur de projets	
Project no. / No. du projet	R.099350.002
Drawing no. / No. du dessin	0000-2

PWGSC A1 (841x594)

0 10 20mm 40 60 80 100 120 140 160 180 200mm



MAIN CASTING – CAST STEEL – 11/4" 31.75mm
INTERIOR PLATE – PLATE STEEL – 1/2" 12.7mm
GUSSET – PLATE STEEL – 1/2" 12.7mm

NORTH TRUNNION INTERIOR PLATE			
READING	ORIGINAL THICKNESS (mm)	REMAINING THICKNESS (mm)	PERCENT LOSS (%)
A	12.7	11.0	13.4
B	12.7	11.0	13.4
C	12.7	10.0	21.3
D	12.7	11.0	13.4
E	12.7	6.5	48.8
F	12.7	9.0	29.1
G	38.1	35.9	5.8
H	38.1	35.4	7.1
I	38.1	33.9	11.0
J	12.7	5.6	55.9
K	12.7	8.2	35.4
L	12.7	9.9	22.0
M	12.7	7.4	41.7
N	12.7	9.0	29.1
O	12.7	10.0	21.3
P	12.7	6.8	46.5
Q	12.7	6.4	49.6
R	12.7	7.8	38.6
S	12.7	7.1	44.1
T	12.7	7.4	41.7
U	12.7	7.9	37.8
V	12.7	12.7	0.0
W	12.7	8.1	36.2
X	12.7	12.7	0.0
Y	12.7	8.2	35.4
Z	12.7	9.0	29.1
AA	12.7	9.0	29.1
BB	12.7	3.8	70.1
CC	12.7	2.9	77.2
DD	12.7	12.7	0.0
EE	12.7	5.0	60.6
FF	12.7	7.0	44.9
GG	12.7	8.8	30.7
HH	12.7	12.7	0.0
II	12.7	12.7	0.0
JJ	12.7	8.0	37.0
KK	12.7	10.0	21.3
LL	12.7	9.0	29.1
MM	12.7	12.7	0.0
NN	12.7	3.0	76.4

LEGEND:

4mm LOSS (8)	PLATE SECTION LOSS (REMAINING THICKNESS IN MILLIMETRES BASED ON 12mm THICKNESS)
9.0 [2018]	REMAINING THICKNESS IN MILLIMETRES BASED ON ULTRASONIC MEASUREMENTS [YEAR MEASUREMENT TAKEN]
7	REMAINING THICKNESS IN MILLIMETRES. BASED ON ULTRASONIC MEASUREMENTS
3	DETERIORATED RIVETS PERCENT SECTION REMAINING DIVIDED BY 10 (i.e. 1=10%, 2=20%, 3=30%, ETC.)
99	PHOTOGRAPH KEY
*	PHOTO FROM 2015 MMM GROUP LIMITED REPORT

C

0 10 20mm 40 60 80 100 120 140 160 180 200mm

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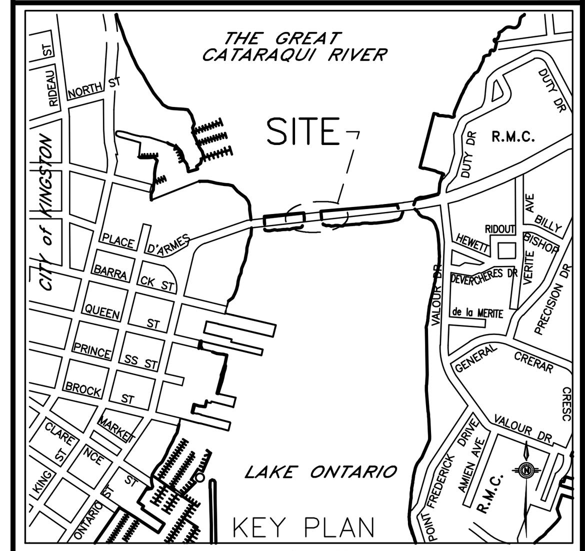

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revisions	description	date

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

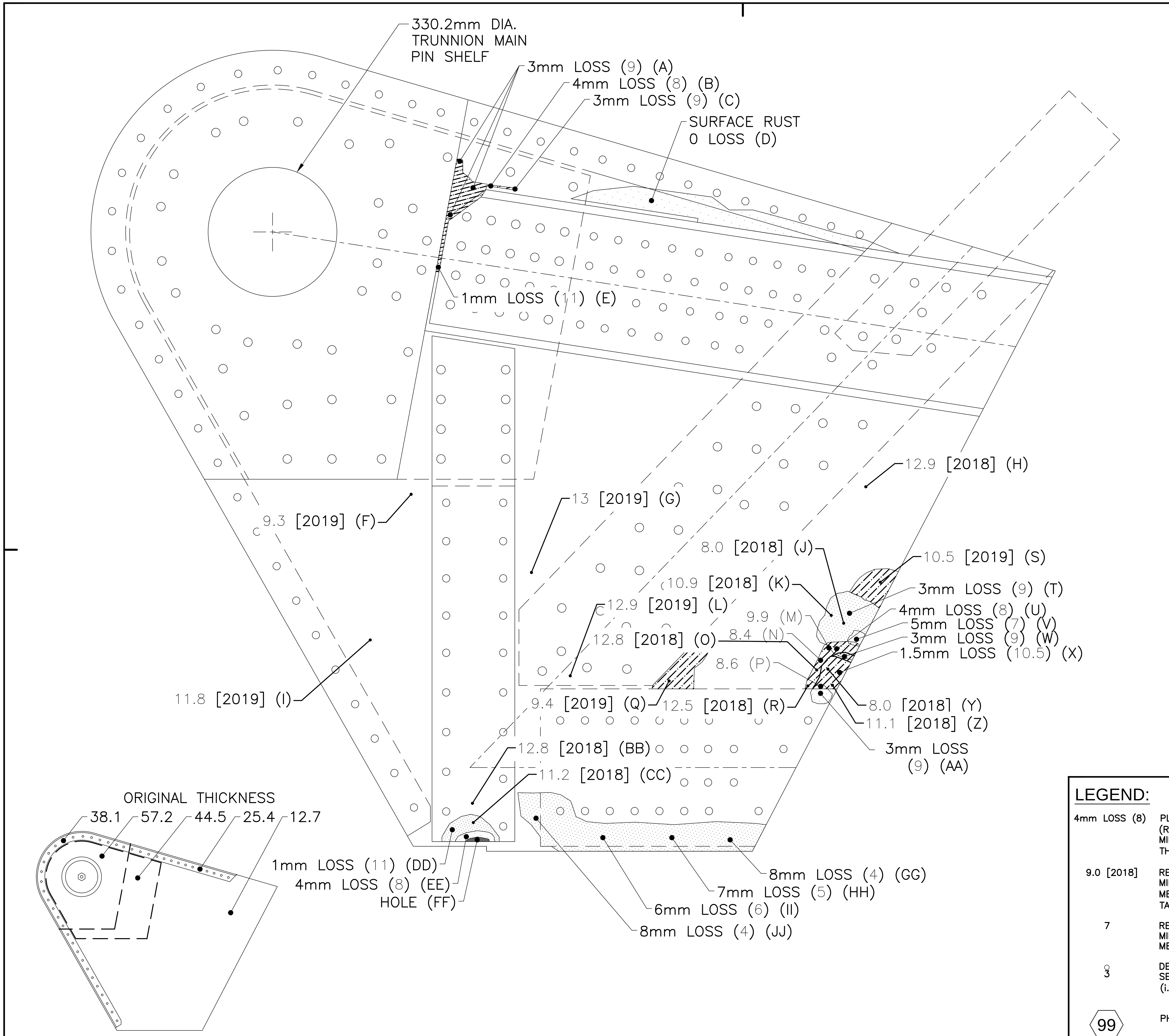
project / projet

LASALLE CAUSEWAY
TRUNNION EVALUATION

drawing / dessin

NORTH TRUNNION
FULL INTERIOR PLATE
DETERIORATION
E F

Designed By		Conçu par
Date		(yyyy/mm/dd)
Drawn By	R.D.	Dessiné par
Date	22 JAN 2020	(yyyy/mm/dd)
Reviewed By	B.R.M.	Examiné par
Date	22 JAN 2020	(yyyy/mm/dd)
Approved By		Approuvé par
Date		(yyyy/mm/dd)
Tender		Soumission
Project Manager		Administrateur de projets
Project no.	R.099350.002	No. du projet
Drawing no.	0000-3	No. du dessin



MAIN CASTING – CAST STEEL – 11/4" 31.75mm
INTERIOR PLATE – PLATE STEEL – 1/2" 12.7mm
GUSSET – PLATE STEEL – 1/2" 12.7mm

NORTH TRUNNION EXTERIOR PLATE			
READING	ORIGINAL THICKNESS (mm)	REMAINING THICKNESS (mm)	PERCENT LOSS (%)
A	12.7	9.0	29.1
B	12.7	8.0	37.0
C	12.7	9.0	29.1
D	12.7	12.7	0.0
E	12.7	11.0	13.4
F	12.7	9.3	26.8
G	12.7	12.7	0.0
H	12.7	12.7	0.0
I	12.7	11.8	7.1
J	12.7	8.0	37.0
K	12.7	10.9	14.2
L	12.7	12.7	0.0
M	12.7	9.9	22.0
N	12.7	8.4	33.9
O	12.7	12.7	0.0
P	12.7	8.6	32.3
Q	12.7	9.4	26.0
R	12.7	12.5	1.6
S	12.7	10.5	17.3
T	12.7	9.0	29.1
U	12.7	8.0	37.0
V	12.7	7.0	44.9
W	12.7	9.0	29.1
X	12.7	10.5	17.3
Y	12.7	8.0	37.0
Z	12.7	11.1	12.6
AA	12.7	9.0	29.1
BB	12.7	12.7	0.0
CC	12.7	11.2	11.8
DD	12.7	11.0	13.4
EE	12.7	8.0	37.0
FF	12.7	12.7	0.0
GG	12.7	4.0	68.5
HH	12.7	5.0	60.6
II	12.7	6.0	52.8
JJ	12.7	4.0	68.5

LEGEND:

4mm LOSS (8)	PLATE SECTION LOSS (REMAINING THICKNESS IN MILLIMETRES BASED ON 12mm THICKNESS)
9.0 [2018]	REMAINING THICKNESS IN MILLIMETRES BASED ON ULTRASONIC MEASUREMENTS [YEAR MEASUREMENT TAKEN]
7	REMAINING THICKNESS IN MILLIMETRES. BASED ON ULTRASONIC MEASUREMENTS
3	DETERIORATED RIVETS PERCENT SECTION REMAINING DIVIDED BY 10 (i.e. 1=10%, 2=20%, 3=30%, ETC.)
99	PHOTOGRAPH KEY
*	PHOTO FROM 2015 MMM GROUP LIMITED REPORT

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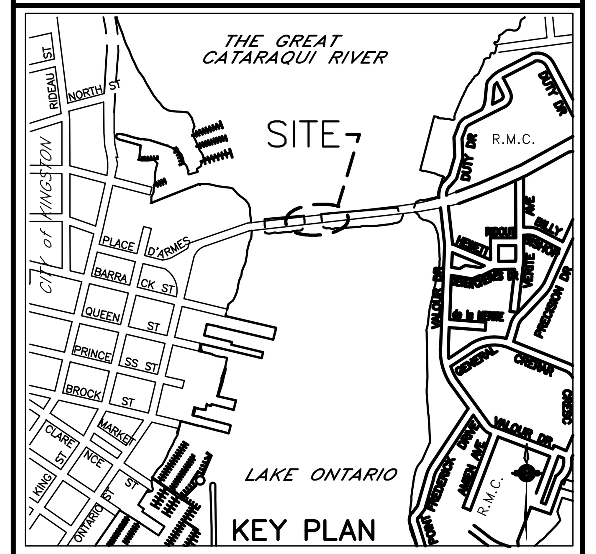

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revisions	description	date

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

project / projet

LASALLE CAUSEWAY
TRUNNION EVALUATION

drawing / dessin

NORTH TRUNNION
FULL EXTERIOR PLATE
DETERIORATION
G H

Designed By / Conçu par
Date (yyyy/mm/dd)
Drawn By / Dessiné par: R.D.
Date: 22 JAN 2020 (yyyy/mm/dd)
Reviewed By / Examiné par: B.R.M.
Date: 22 JAN 2020 (yyyy/mm/dd)
Approved By / Approuvé par
Date (yyyy/mm/dd)
Tender / Soumission
Project Manager / Administrateur de projets
Project no. / No. du projet: R.099350.002
Drawing no. / No. du dessin: 0000-4

PWGSC A1 (841x594)

0 10 20mm 40 60 80 100 120 140 160 180 200mm

Appendix B: UTT Inspection Report (Brouco NDT)

Brouco NDT Inc.	Welding Inspection Report Form 201 Revision: 000 June 6 2011

Customer:	Parsons INC.	Job No:	B-NDT- 3164	Date:	October 27, 2019
Project:	LaSalle Causeway – Bascule Bridge Main Trunnion Bearings Rehabilitation Project		Weather Conditions:		N/A
Subject:	Visual and Ultrasonic Thickness Testing of Main Trunnion Plates		Inspection Date:		October 17 and October 18, 2019
References:	CSA W47.1 Standard, CSA W59-13 Standard, CSA W178.1, CSA W178.2, ASTM E797 – Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method				

As requested by Peter Harvey from Parsons INC., inspector Kent Leclair performed Ultrasonic Thickness Testing (UTT) of the Main Trunnion Plates as part of the LaSalle Causeway Bascule Bridge Main Trunnion Bearings Rehabilitation Project. The purpose of the testing was to update the corrosion mapping drawings for the trunnion plates.

Equipment:

Panametrics – NDT 37DL Plus Serial #041218711, D799 5MHz .312" diameter probe, Serial #1216107
Milwaukee Battery Powered Grinder (wire wheel and flap disk attachments used for surface preparation)
3400W Gas Powered Inverter Generator with built in spill containment for back-up power

Results:

1. Results of UTT Testing at North and South Main Trunnion Locations. Results are as follows:
   a) **Table 1 through Table 48** contain the ultrasonic thickness test measurements of the North and South Exterior and Interior main Trunnion Plates. Three readings were taken at each location and the tables also show the average of the three readings at each test location. **Figure 1 through Figure 16** shows photos of the test locations and **Figure 17 to Figure 21** shown the mapping of the test locations on the Trunnion Drawings.

   b) Additional pit gauge readings were taken on the North Trunnion, Interior Plate Location (Near UTT test locations 18 and 19) as shown in **Figure 18**. Two locations of pitting measured showed localized section loss of 0.277" and 0.138" (access was not possible on the backside of the angle member to perform UTT testing).

   c) Test locations above include readings taken at strain gauge location around and on the main trunnion plates.

Table 1: North Trunnion Exterior Plate Deterioration (At Strain Gauge Location), Test Location #1	
Reading 1	.409
Reading 2	.413
Reading 3	.418
Average:	**.413**

Table 2: North Trunnion Location 14-15N Exterior Web at Strain Gauge Location, Test Location #2	
Reading 1	.522
Reading 2	.520
Reading 3	.528
Average:	**.523**

Table 3: North Trunnion Location 14-16N Exterior Web at Strain Gauge Location, Test Location #3	
Reading 1	.391
Reading 2	.392
Reading 3	.393
Average:	**.392**

Table 4: North Trunnion Plate Interior Plate Deterioration, Test Location #4	
Reading 1	.502
Reading 2	.502
Reading 3	.500
Average:	**.501**

Table 5: North Trunnion Plate Interior Plate Deterioration at Strain Gauge Location, Test Location #5	
Reading 1	.261
Reading 2	.200
Reading 3	.201
Average:	**.221**

Table 6: North Trunnion Plate Interior Plate Deterioration at Strain Gauge Location, Test Location #6	
Reading 1	.499
Reading 2	.500
Reading 3	.502
Average:	**.500**

Table 7: North Trunnion Plate Exterior Plate Deterioration at Strain Gauge Location, Test Location #7	
Reading 1	.509
Reading 2	.511
Reading 3	.510
Average:	**.510**

Table 8: North Trunnion Plate Exterior Plate Deterioration at Strain Gauge Location, Test Location #8	
Reading 1	.507
Reading 2	.508
Reading 3	.510
Average:	**.508**

Table 9: North Trunnion Plate Interior Plate Deterioration, Test Location #9a	
Reading 1	.320
Reading 2	.318
Reading 3	.406
Average:	**.348**

Table 10: North Trunnion Plate Interior Plate Deterioration, Test Location #9b	
Reading 1	.311
Reading 2	.322
Reading 3	.320
Average:	**.318**

Table 11: North Trunnion Plate Exterior Plate Deterioration, Test Location #10	
Reading 1	.364
Reading 2	.373
Reading 3	.370
Average:	**.369**

Table 12: North Trunnion Location 14-16N Interior Web at Strain Gauge Location, Test Location #11	
Reading 1	.395
Reading 2	.394
Reading 3	.398
Average:	**.396**

Table 13: North Trunnion Location 14-15N Interior Web at Strain Gauge Location, Test Location #12	
Reading 1	.513
Reading 2	.512
Reading 3	.513
Average:	**.512**

Table 14: North Trunnion Plate Exterior Plate Deterioration, Test Location #13	
Reading 1	.462
Reading 2	.464
Reading 3	.471
Average:	**.466**

Table 15: North Trunnion Plate Exterior Plate Deterioration, Test Location #14	
Reading 1	.338
Reading 2	.392
Reading 3	.364
Average:	**.365**

Table 16: North Trunnion Plate Interior Plate Deterioration, Test Location #15	
Reading 1	1.348
Reading 2	1.315
Reading 3	1.344
Average:	**1.336**

Table 17: North Trunnion Plate Interior Plate Deterioration, Test Location #16	
Reading 1	1.388
Reading 2	1.369
Reading 3	1.384
Average:	**1.380**

Table 18: North Trunnion Plate Interior Plate Deterioration, Test Location #17	
Reading 1	1.422
Reading 2	1.421
Reading 3	1.402
Average:	**1.415**

Table 19: North Trunnion Plate Interior Plate Deterioration, Test Location #18	
Reading 1	.242
Reading 2	.237
Reading 3	.217
Average:	**.232**

Table 20: North Trunnion Plate Interior Plate Deterioration, Test Location #19	
Reading 1	.363
Reading 2	.353
Reading 3	.357
Average:	**.358**

Table 21: North Trunnion Plate Batten Plate Deterioration, Test Location #20	
Reading 1	.425
Reading 2	.424
Reading 3	.426
Average:	**.425**

Table 22: South Trunnion Plate Interior Plate Deterioration, Test Location #21	
Reading 1	.746
Reading 2	.738
Reading 3	.742
Average:	**.742**

Table 23: South Trunnion Plate Interior Plate Deterioration, Test Location #22a	
Reading 1	.702
Reading 2	.699
Reading 3	.698
Average:	**.700**

Table 24: South Trunnion Plate Interior Plate Deterioration, Test Location #22b	
Reading 1	.689
Reading 2	.687
Reading 3	.688
Average:	**.688**

Table 25: South Trunnion Plate Interior Plate Deterioration, Test Location #23	
Reading 1	.338
Reading 2	.369
Reading 3	.363
Average:	**.357**

Table 26: South Trunnion Plate Exterior Plate Deterioration, Test Location #24	
Reading 1	.404
Reading 2	.411
Reading 3	.409
Average:	**.408**

Table 27: South Trunnion Plate Exterior Plate Deterioration, Test Location #25	
Reading 1	.436
Reading 2	.439
Reading 3	.449
Average:	**.441**

Table 28: South Trunnion Plate Exterior Plate Deterioration, Test Location #26	
Reading 1	.389
Reading 2	.384
Reading 3	.390
Average:	**.388**

Table 29: South Trunnion Plate Exterior Plate Deterioration, Test Location #27	
Reading 1	.327
Reading 2	.302
Reading 3	.292
Average:	**.307**

Table 30: South Trunnion Plate Exterior Plate Deterioration, Test Location #28	
Reading 1	.429
Reading 2	.441
Reading 3	.444
Average:	**.438**

Table 31: South Trunnion Plate Exterior Plate Deterioration, Test Location #29	
Reading 1	.477
Reading 2	.476
Reading 3	.475
Average:	**.476**

Table 32: South Trunnion Plate Interior Plate Deterioration, Test Location #30	
Reading 1	.387
Reading 2	.348
Reading 3	.365
Average:	**.367**

Table 33: South Trunnion Location 14-15N Interior Web at Strain Gauge Location, Test Location #31	
Reading 1	.521
Reading 2	.528
Reading 3	.522
Average:	**.524**

Table 34: South Trunnion Location 14-15N Exterior Web at Strain Gauge Location, Test Location #32	
Reading 1	.479
Reading 2	.481
Reading 3	.480
Average:	**.480**

Table 35: South Trunnion Location 14-16N Exterior Web at Strain Gauge Location, Test Location #33	
Reading 1	.396
Reading 2	.394
Reading 3	.397
Average:	**.396**

Table 36: South Trunnion Location 14-16N Interior Web at Strain Gauge Location, Test Location #34	
Reading 1	.401
Reading 2	.400
Reading 3	.400
Average:	**.400**

Table 37: South Trunnion Plate Exterior Plate Deterioration, Test Location #35	
Reading 1	.491
Reading 2	.492
Reading 3	.491
Average:	**.491**

Table 38: South Trunnion Plate Exterior Plate Deterioration at Strain Gauge Location, Test Location #36a	
Reading 1	.496
Reading 2	.497
Reading 3	.496
Average:	**.496**

Table 39: South Trunnion Plate Exterior Plate Deterioration, Test Location #36b	
Reading 1	.282
Reading 2	.286
Reading 3	.309
Average:	**.292**

Table 40: South Trunnion Plate Interior Plate Deterioration at Strain Gauge Location, Test Location #37a	
Reading 1	.273
Reading 2	.242
Reading 3	.272
Average:	**.262**

Table 41: South Trunnion Plate Interior Plate Deterioration, Test Location #37b	
Reading 1	.315
Reading 2	.271
Reading 3	.266
Average:	**.284**

Table 42: South Trunnion Plate Interior Plate Deterioration at Strain Gauge Location, Test Location #38	
Reading 1	.508
Reading 2	.509
Reading 3	.511
Average:	**.509**

Table 43: South Trunnion Plate Interior Plate Deterioration, Test Location #39	
Reading 1	.394
Reading 2	.363
Reading 3	.382
Average:	**.380**

Table 44: South Trunnion Plate Exterior Plate Deterioration, Test Location #40	
Reading 1	.283
Reading 2	.282
Reading 3	.288
Average:	**.284**

Table 45: South Trunnion Plate Exterior Plate Deterioration, Test Location #41	
Reading 1	.408
Reading 2	.422
Reading 3	.429
Average:	**.420**

Table 46: South Trunnion Plate Interior Plate Deterioration, Test Location #42	
Reading 1	.455
Reading 2	.461
Reading 3	.453
Average:	**.456**

Table 47: South Trunnion Exterior Location Deterioration at Batten Plate, Test Location #43	
Reading 1	.158
Reading 2	.169
Reading 3	.196
Average:	**.174**

Table 48: South Trunnion Plate Exterior Plate Deterioration, Test Location #44	
Reading 1	.387
Reading 2	.386
Reading 3	.376
Average:	**.383**

Figure1: Test Locations 5 and 6 at North Trunnion Plate Interior Plate at Strain Gauge Locations (Readings Taken from Inside surface of Plate)

Figure2: Test Locations 7 and 8 at North Trunnion Plate Exterior Plate at Strain Gauge Locations (Readings Taken from Inside surface of Plate)

Figure3: Test Locations 9a and 9b at North Trunnion Plate Interior Plate (Readings Taken from Inside surface of Plate)

Figure4: Test Location 10 at North Trunnion Plate Exterior Plate (Readings Taken from Inside surface of Plate)

Figure4: Test Locations 15, 16, and 17 at North Trunnion Plate Interior Plate

Figure5: Test Location 20 at North Trunnion Location, Batten Plate

Figure6: Test Locations 21 and 22 at South Trunnion Plate Interior Location (Readings Taken on Exterior Plate Surface)

Figure7: Opposite Side of South Trunnion Plate Interior Location (Inside Plate Surface, see Figure 6 for Exterior Plate Surface)

Figure8: Test Locations 25, 26 and 28 at South Trunnion Plate Exterior Location (Readings Taken from Inside Surface)

Figure9: Test Locations 28 and 29 at South Trunnion Plate Exterior Location (Readings Taken from Inside Surface and Bottom Surface of Angle)

Figure10: Test Locations 23 and 30 at South Trunnion Plate Interior Location (Readings Taken from Inside Bottom Surface of Angle)

Figure11: Test Locations 43 and 44 at South Trunnion Exterior Plate at Interior Batten Plate and Angle

Figure12: Test Locations 43 and 44 at South Trunnion Exterior Plate at Interior Batten Plate and Angle

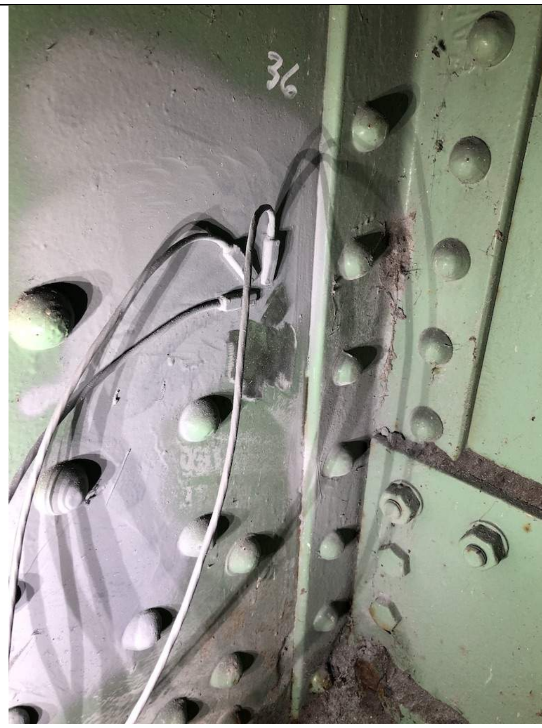


Figure13: Test Location 36 at South Trunnion Exterior Plate Location (Readings Taken on Interior Surface of Plate)

Figure14: Test Locations 37, 38, and 42 at South Trunnion Interior Plate Location (Readings Taken on Interior Surface of Plate)

Figure15: Test Locations 35, and 40 at South Trunnion Exterior Plate Location (Readings Taken on Interior Surface of Plate)

Figure16: Test Location 41 at South Trunnion Exterior Plate Location (Readings Taken on Interior Surface of Plate)

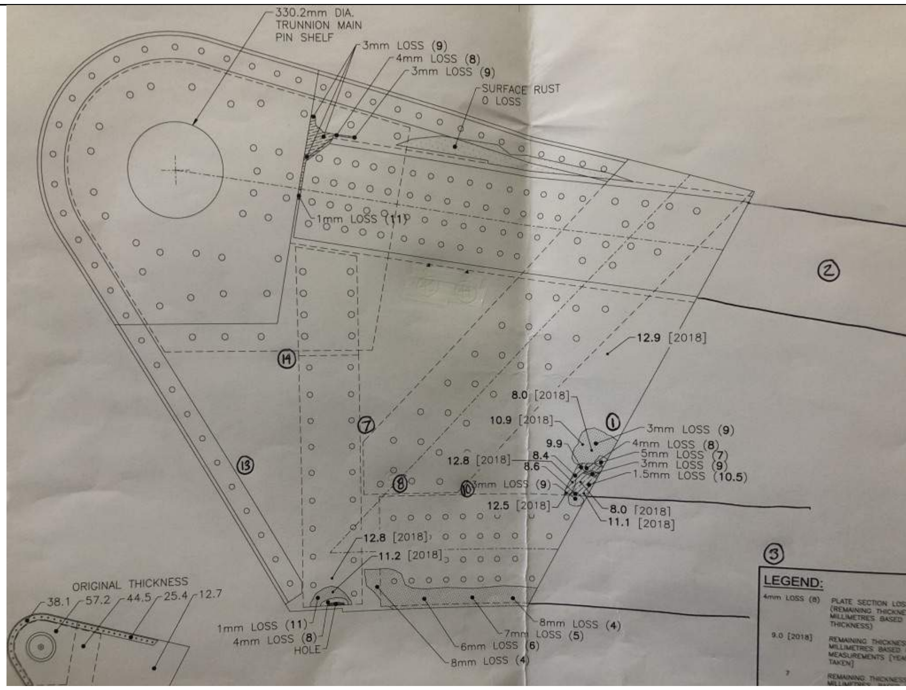


Figure17: North Trunnion Exterior Plate Test Locations

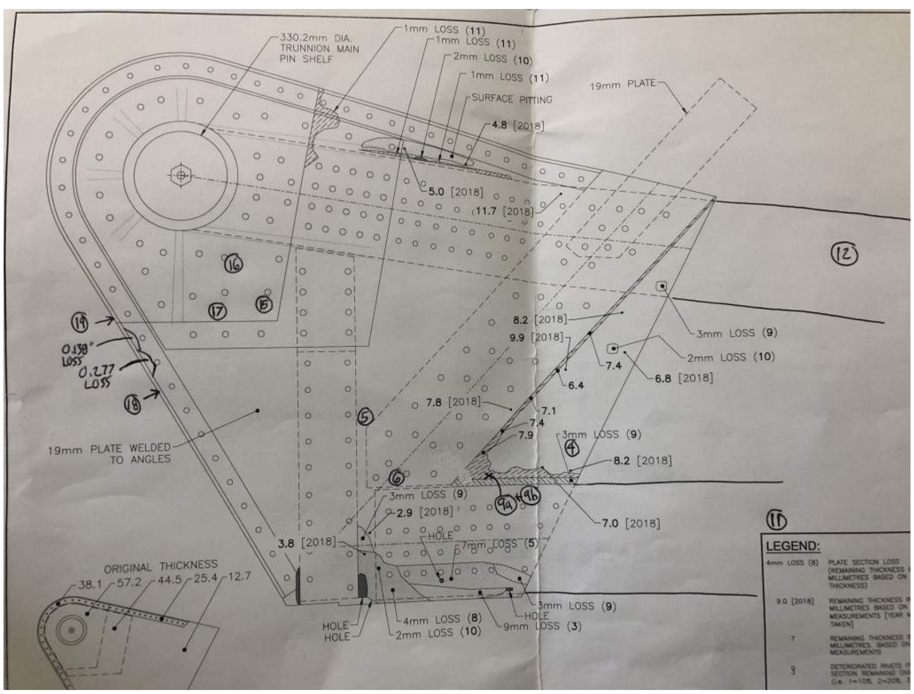


Figure18: North Trunnion Interior Plate Test Locations

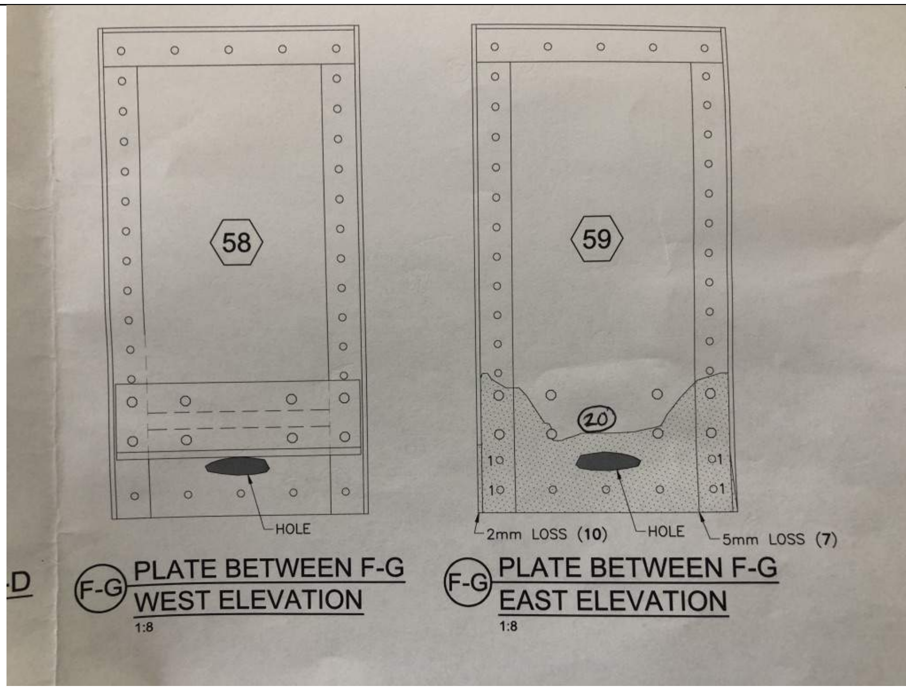


Figure19: North Trunnion Location, Batten Plate Test Location

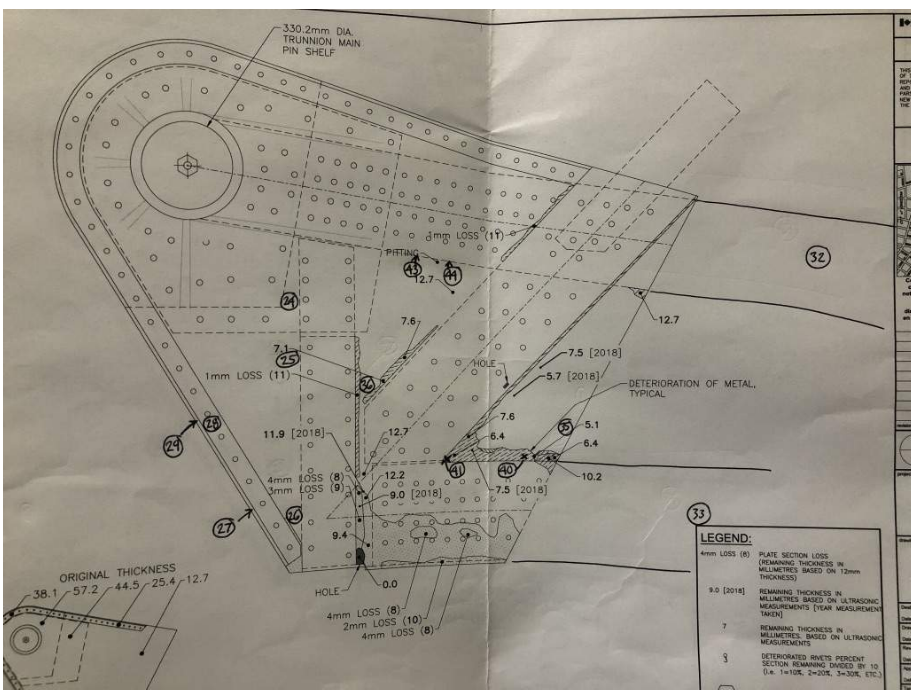


Figure20: South Trunnion Exterior Plate Test Locations

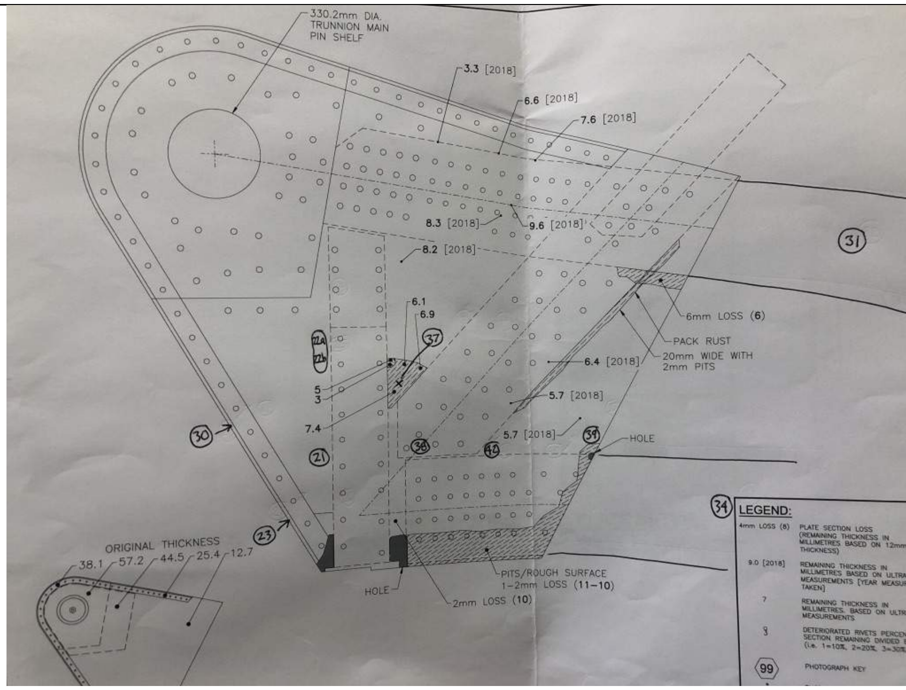


Figure21: South Trunnion Interior Plate Test Locations

Conclusion:

The above test results are for the ultrasonic thickness testing for updating the main trunnion plate corrosion mapping. Test locations were also performed at stain gauge locations as reference. Parsons assisted in selecting the above test locations.

Inspection Date: October 17 and October 18, 2019 **Report Date**: October 27, 2018	**Inspection and Report by**: Kent Leclair CSA W178.2 Level 3 Certified Welding Inspector Reg. #3938 Level II MT CGSB Reg. #16878 **Report Reviewed by**: Kent Leclair CSA W178.2 Level 3 Certified Welding Inspector Reg. #3938 Level II MT CGSB Reg. #16878

Appendix C: Selected Inspection Photographs

Photo 1: South elevation.

Photo 2: North elevation (2017 photo).

Note: All photos are from Parson's 2018 CDI Report unless noted otherwise.

Photo 3: Bridge in open position.

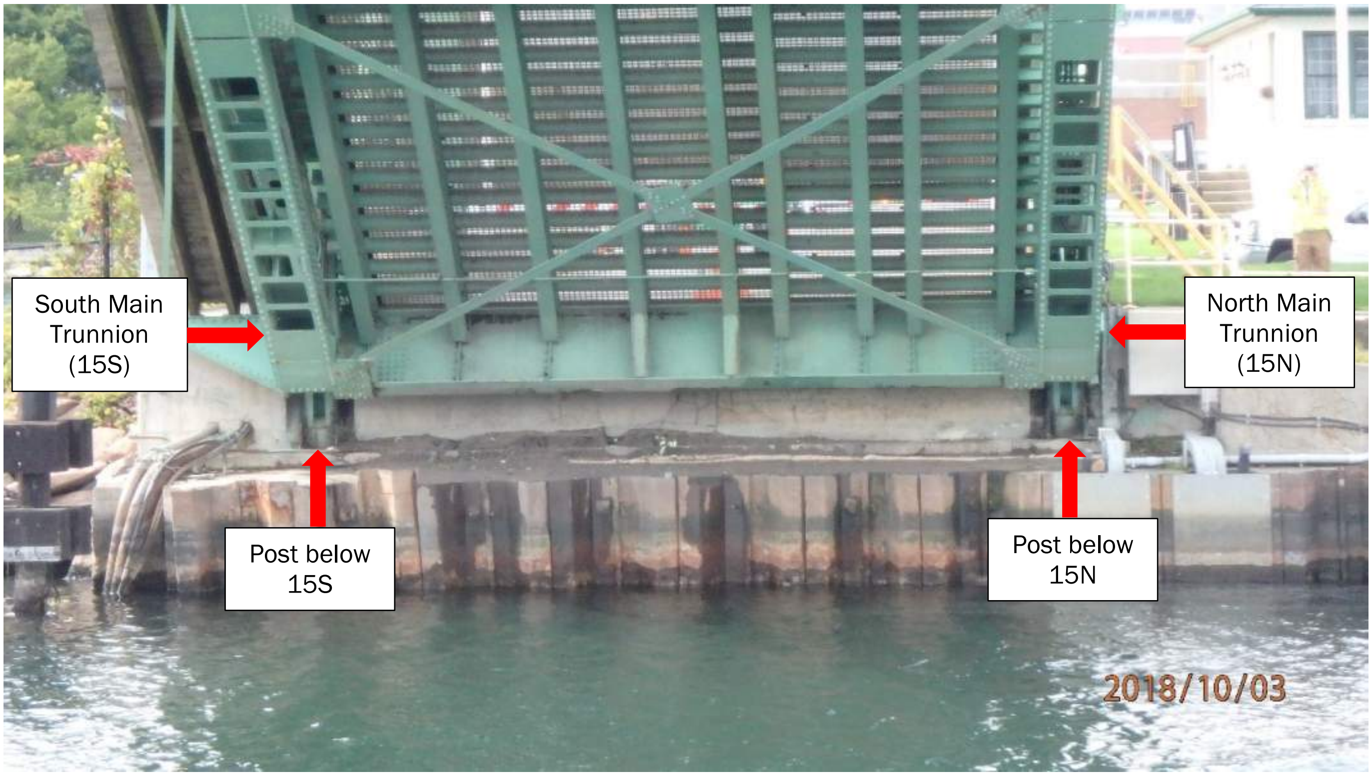


Photo 4: Bridge in open position.

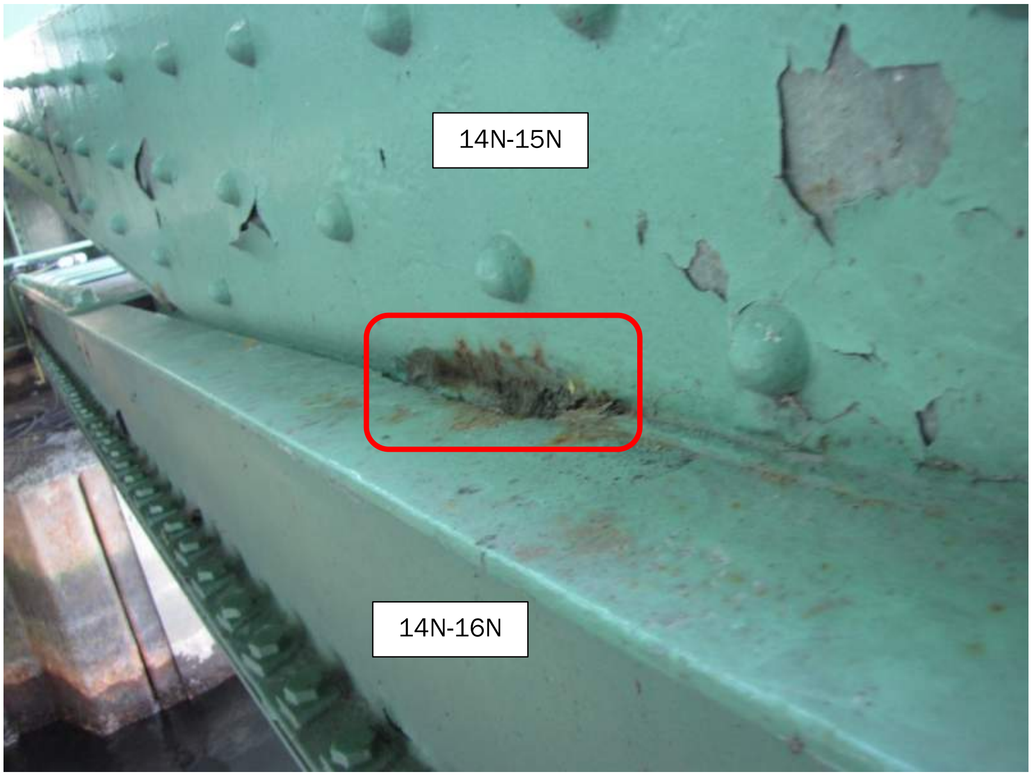


Photo 5: Moderate to severe pitting and minor rust jacking between member 14N-15N and 14N-16N.

Photo 6: Perforation in batten plate of north trunnion (photo by Brouco NDT).

Photo 7: Severe localized pitting and section loss of flanges where 14S-16S and 14S-15S intersect. Several rivet heads have over 75% section loss.

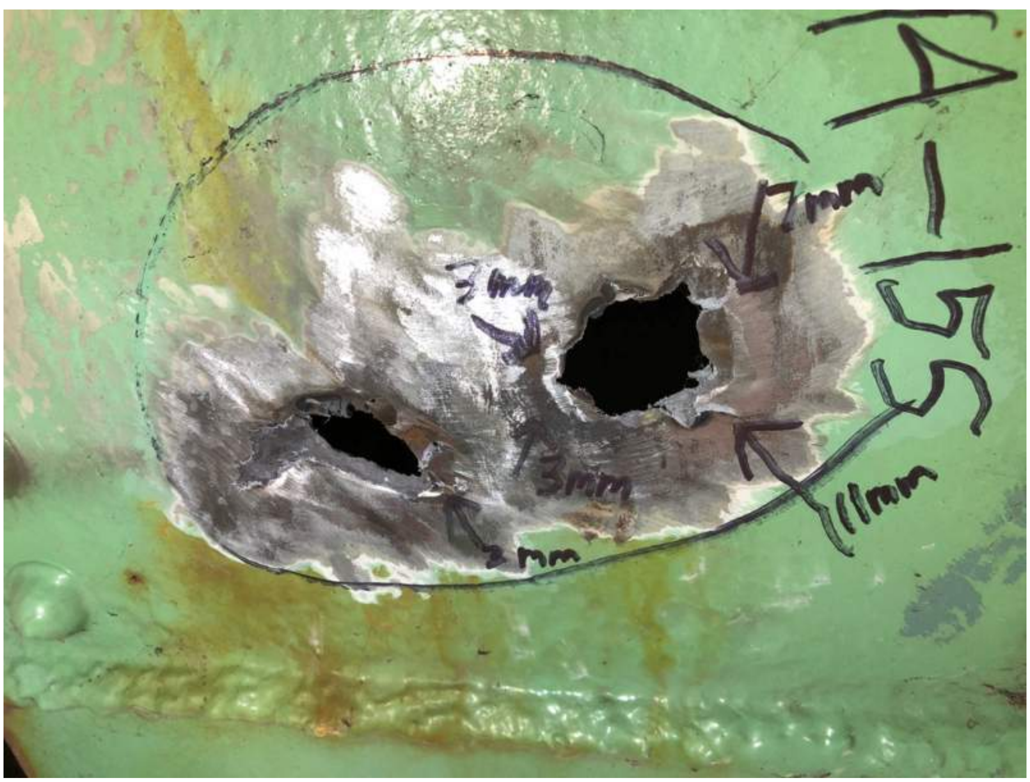


Photo 8: Perforations and cracks in bottom batten plate of bottom chord member 14S–15S near node 15S. The cracks range in length from 3mm to 11mm (photo by Brouco NDT).

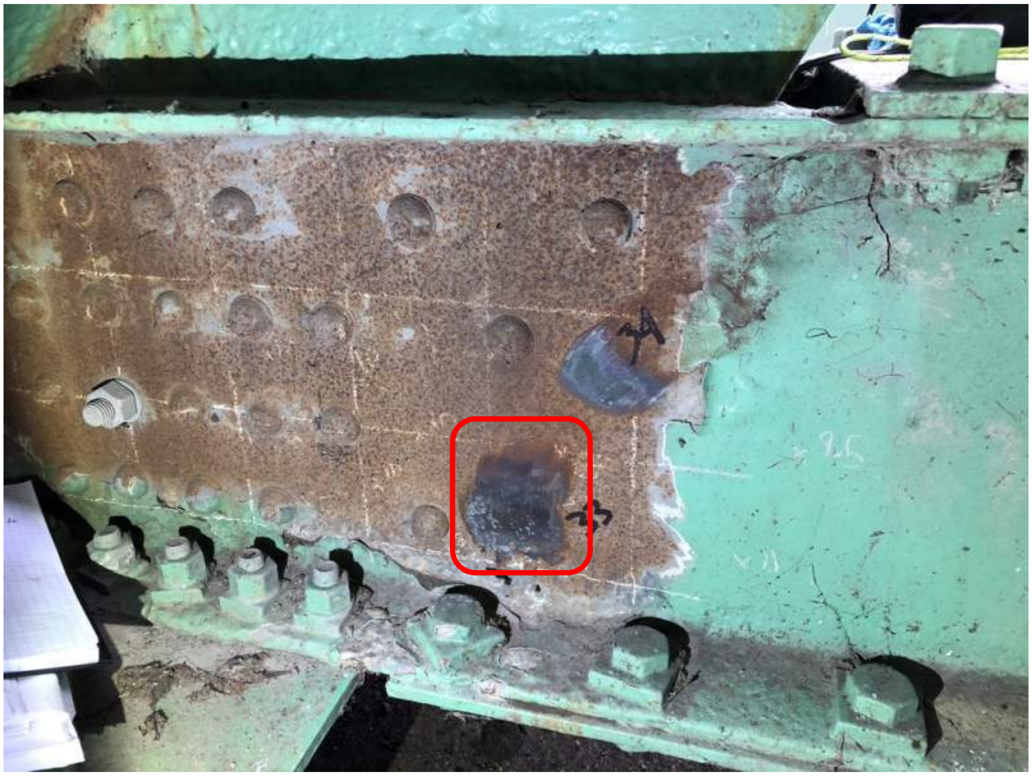


Photo 9: Perforation in the web of bottom chord member 14N–16N near node 16N and generalized light corrosion (photo by Brouco NDT).

Photo 10: Perforation and 12mm long crack in interior channel of bottom chord member 14S–16S (photo by Brouco NDT).

Photo 11: Severe corrosion and section loss of rivet heads at the base of 15N-17N and section loss of the gusset plate at the main trunnion (photo from 2017 inspection).

Photo 12: View of the west side of the north trunnion. Note the loss of the bottom flange of the north channel of tower truss member 15N-18N (photo from 2017 inspection).

Photo 13: The visible / accessible sections of the post below 15N are in relatively good condition.

Photo 14: The visible / accessible sections of the post below 15S are in relatively good condition.

Photo 15: View of the top of the north trunnion (15N).

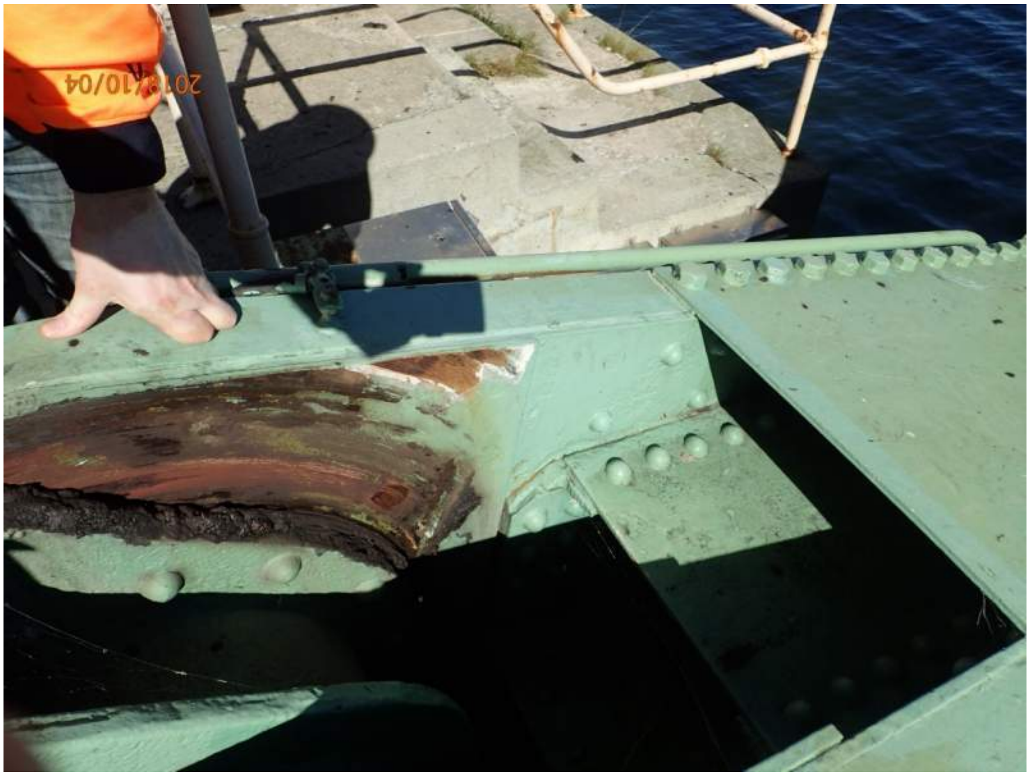


Photo 16: Areas of coating on the interior of the north plate of the north trunnion have been worn away due to contact between the moving structure and the fixed structure.

Photo 17: The vertical gusset plate at node 15N at roadway level exhibits very severe section loss and perforations.

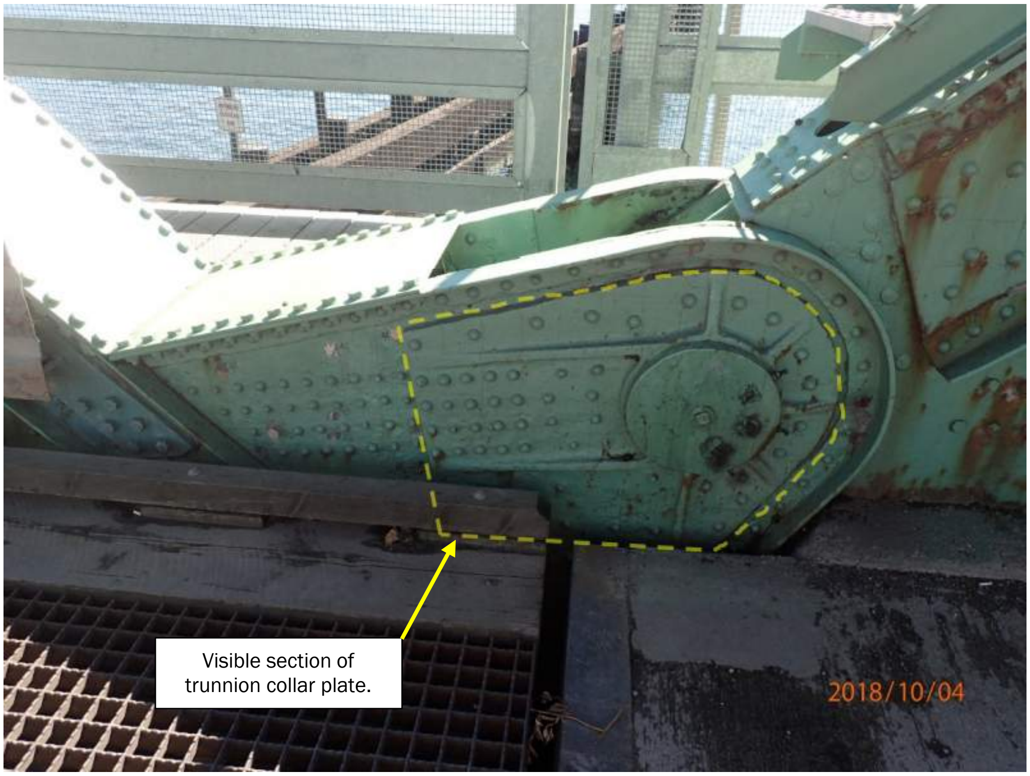


Photo 18: The north (roadway) side of the south trunnion.

Photo 19: View of the top of the south trunnion (15S).

Photo 20: The interior (south) vertical gusset plate at node 16N exhibits severe section loss and a perforation with a crack (viewed from south).

Photo 21: The interior (south) vertical gusset plate at node 16N exhibits severe section loss and a perforation with a crack (viewed from north, 2020 photo).

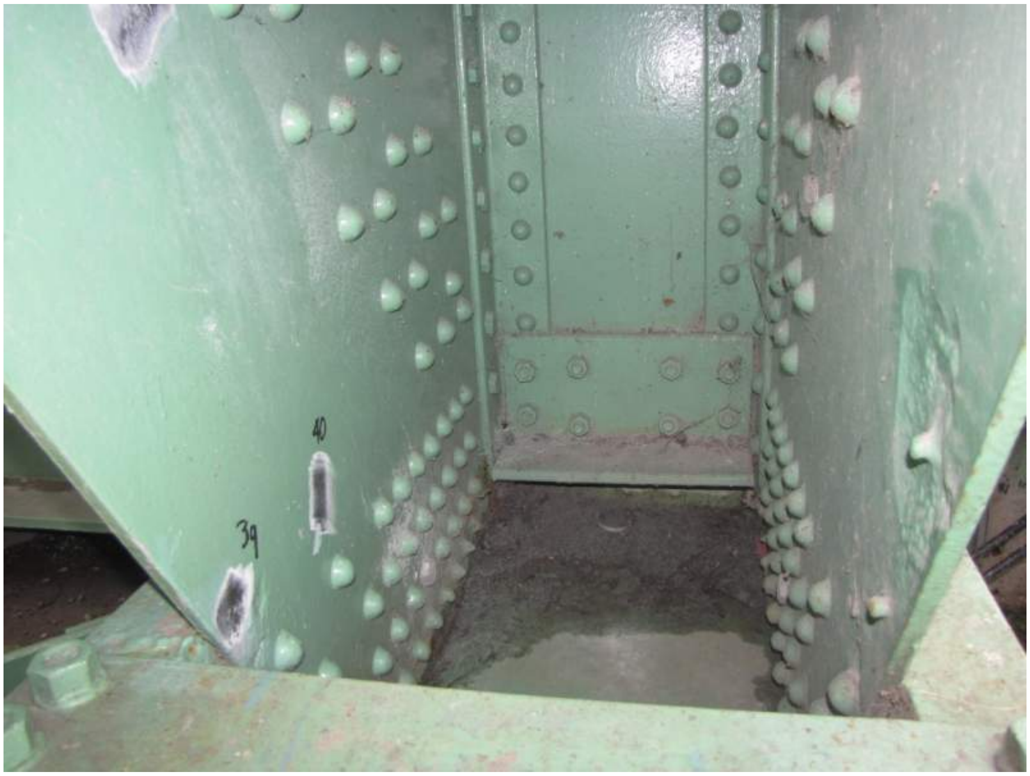


Photo 22: The interior faces of the plates and rivet heads at the base of the north trunnion have localized severe section loss.

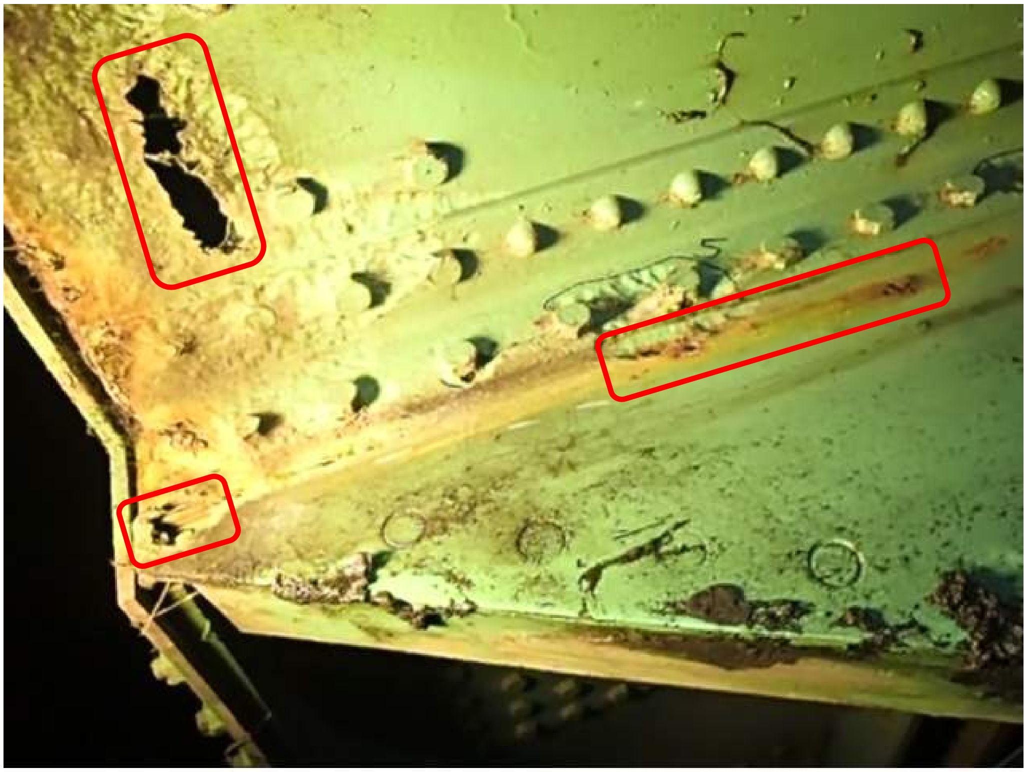


Photo 23: Perforations in the interior face of the south plate and front plate of the north trunnion at 16N.

Photo 24: Very severe section loss in the rivet heads and angle at the base of the exterior face of the south plate of the north trunnion.

Photo 25: View of the interior of the north plate of the south trunnion below deck level. A crack was found at the perforation circled.

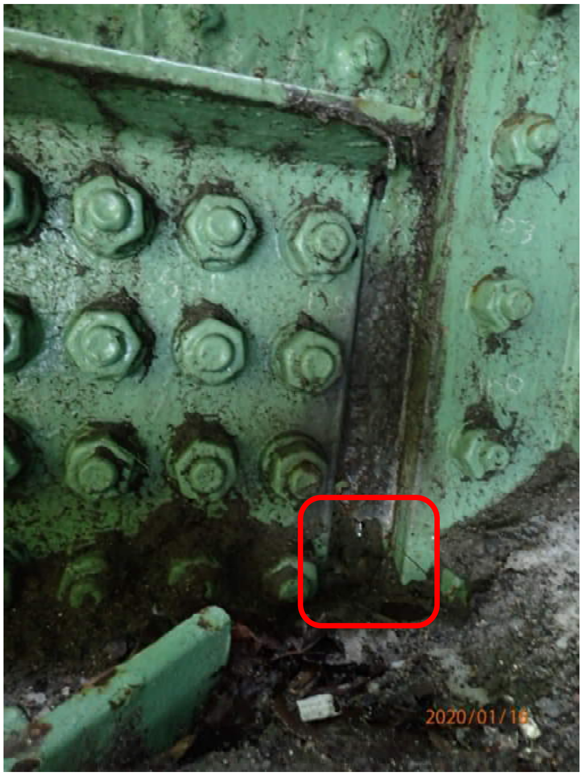


Photo 26: Perforation in the north side of the north gusset plate at the end of 14S-16S (2020 photo).

Photo 27: South side of south plate of south trunnion (photo by Brouco NDT).

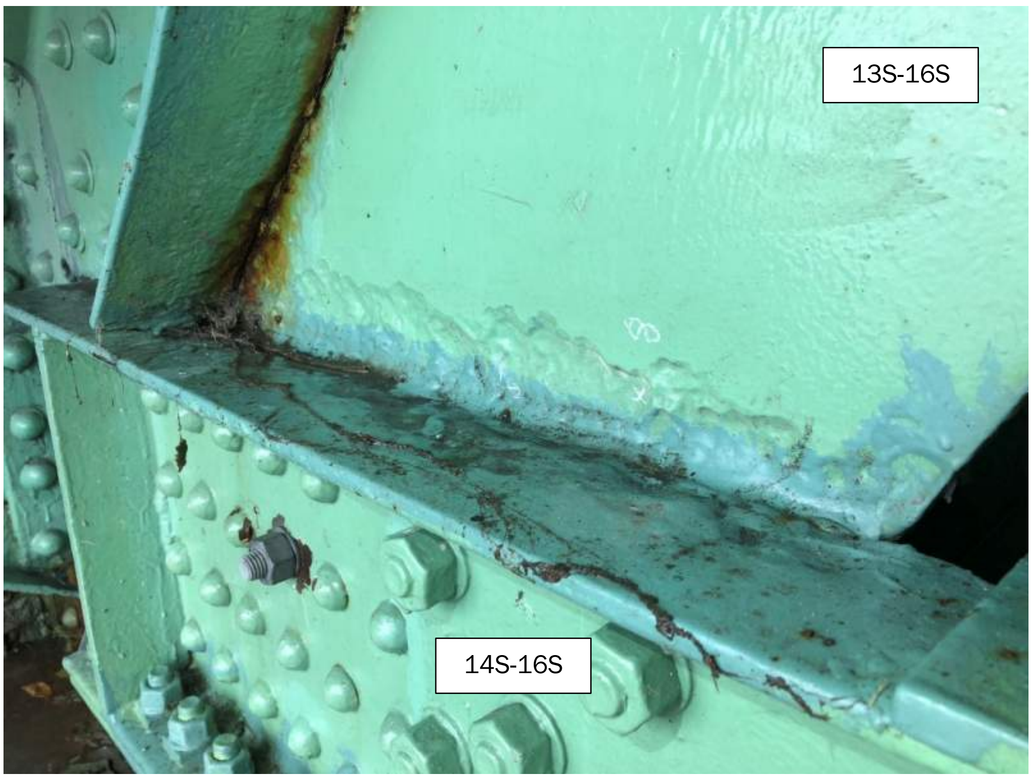


Photo 28: Severe pitting in south exterior gusset plate near 16S (photo by Brouco NDT).

Photo 29: Severe pitting at the base of the interior face and rivet heads of the south plate of the south trunnion.

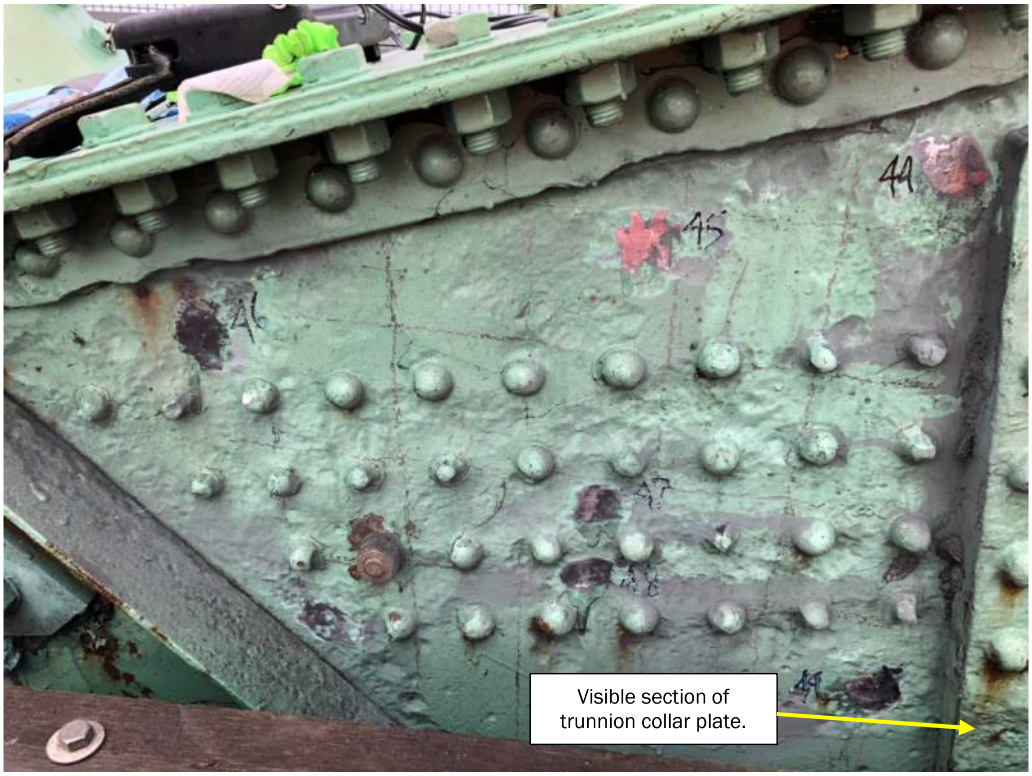


Photo 30: The north (roadway) side of the south trunnion has widespread pitting in the collar plate (right side), connection plate (left side) and some rivet heads (photo by Brouco NDT).

Photo 31: The north (roadway) side of the south trunnion has widespread pitting in the collar plate, connecting plate, and some rivet heads.


Photo 32: Inside face of north plate of south trunnion (photo by Brouco NDT, 2019).

Photo 33: Inside face of south plate of south trunnion (photo by Brouco NDT, 2019).

Photo 34: View of the west side of the south trunnion. Note the severe corrosion of member 15S-18S (photo from 2017 inspection).

Photo 35: South trunnion. Note the evidence of contact between the span structure and the bearing support (photo by Stafford Bandlow).

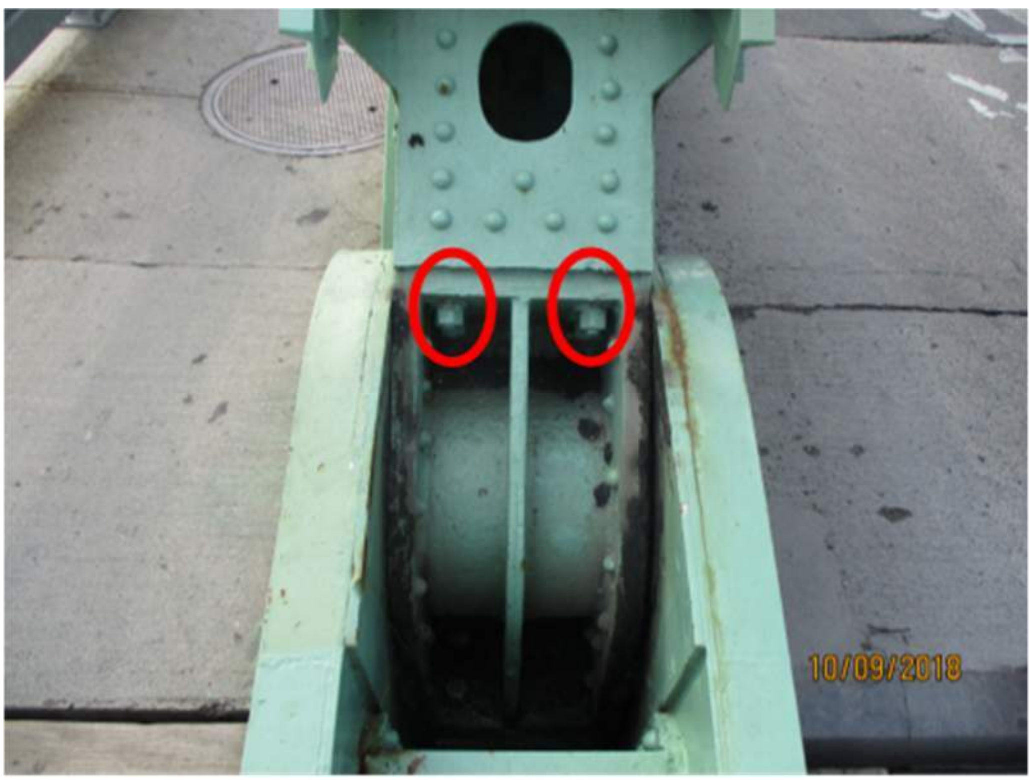


Photo 36: South trunnion. The head end of the four bolts that secure the bearing housing to the structure has 100% section loss due to corrosion. The nut end of these bolts (circled) are pictured (photo by Stafford Bandlow).

Appendix D: MCR, PCR, and Overall Section Loss Forms

PWGSC BRIDGE INSPECTION MANUAL (BIM) MCR/PCR AND OVERALL SECTION LOSS FORMS

Structure: LaSalle Causeway Bascule Bridge
Project Title: Main Trunnion Rehabilitation Study

Member	Element	2018 MCR	2018 PCR	New MCR	New PCR	Capacity Reduction Factor	Notes
Through Truss Members	13N-16N	5	5	4	5	5%	1
	14N-15N	5	5	4	3	15%	
	14N-16N	5	3	2	3	15%	
	13S-16S	5	5	5	5	5%	1
	14S-15S	4	4	2	3	15%	1
	14S-16S	2	3	2	3	15%	
Tower Truss Members	15N-17N	4	3	3	5	5%	1
	15N-18N	3	4	3	4	5%	
	15S-17S	4	3	3	5	5%	1
	15S-18S	2	4	2	4	5%	
Post below Node 15	North	Not Rated	Not Rated	5	5	0%	2
	South	Not Rated	Not Rated	5	5	0%	2
Tower Truss Connections	15N	4	2	4	2	N/A	3
	15S	5	3	4	3	N/A	3
Main Trunnions	15N/16N	3	4	3	4	N/A	3
	15S/16S	3	4	3	4	N/A	3

Notes:

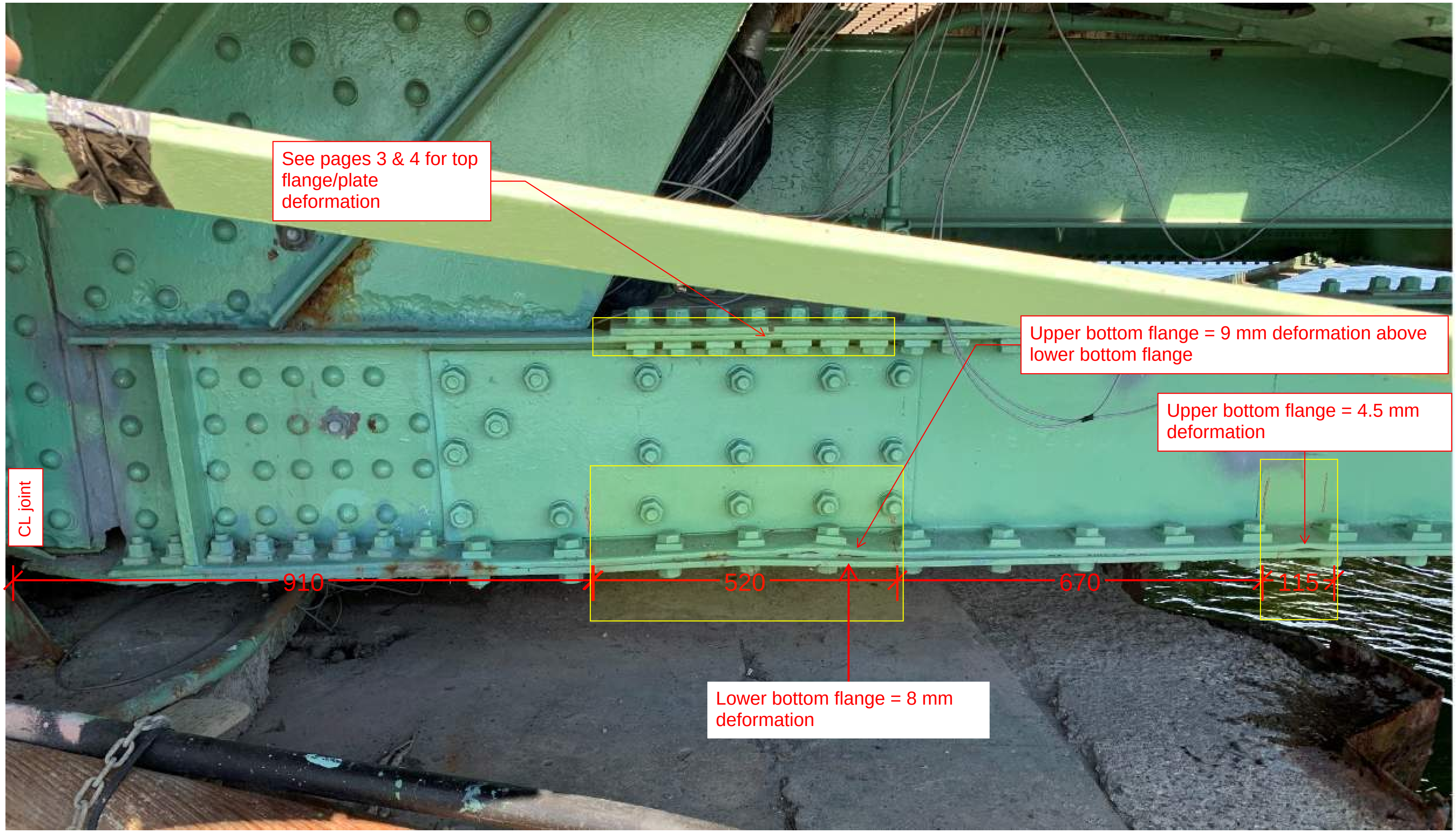
MCR and PCR are based on maximum overall section loss of the member as per the 2010 Bridge Inspection Manual and do not take into account the Demand-over-Capacity (D/C) ratios calculated in the analysis phase.

1. The previous deterioration that has been mitigated by the addition of steel plates is not taken into account.
2. Rating based on visible sections only. The rear (west side) of the posts is partially encased in concrete and is not visible. No performance deficiencies were noted.
3. The members have very localized deterioration therefore the capacity reduction factor varies depending on the exact location in question.

Appendix E: Bottom Chord 14S-16S Deformation – Baseline Measurements

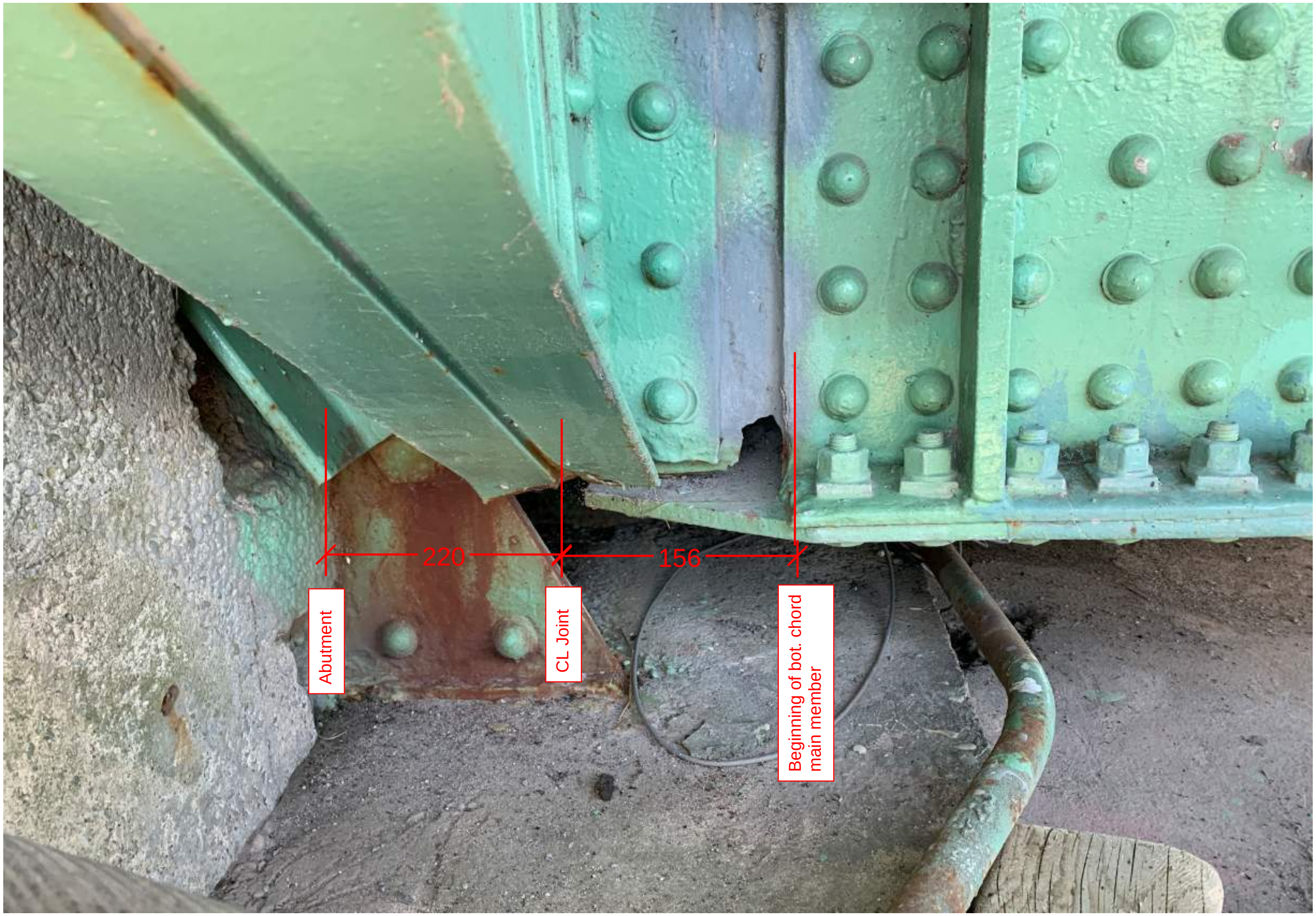
LaSalle Causeway Bascule Bridge
Bottom Chord 14S-16S Deformation - Baseline Measurements

Overall View



Measurements taken by Dennis Voltchek on May 20, 2020.

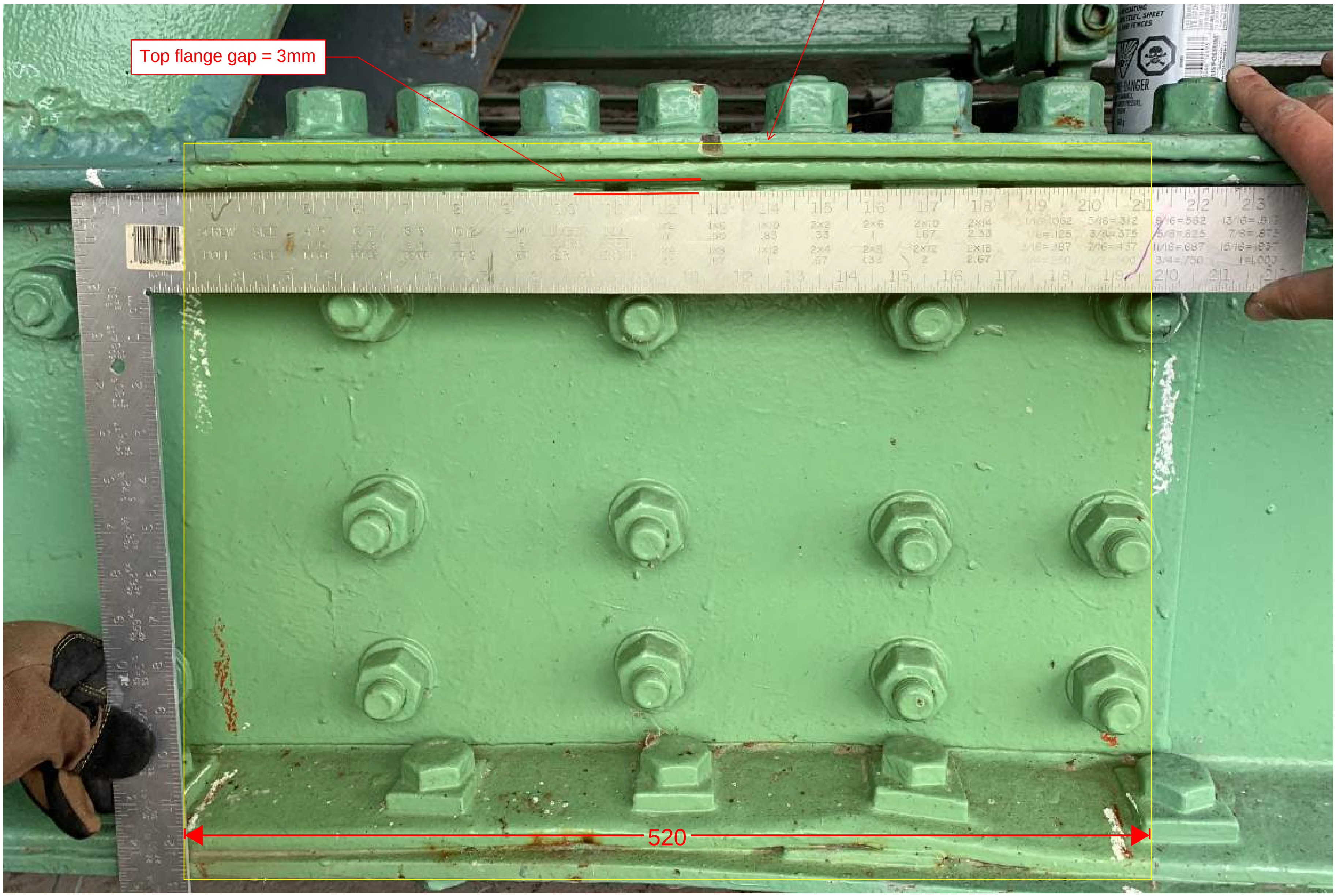
Beginning of Bottom Chord at West Abutment



Measurements taken by Dennis Voltchek on May 20, 2020.

Top Flange Deformation

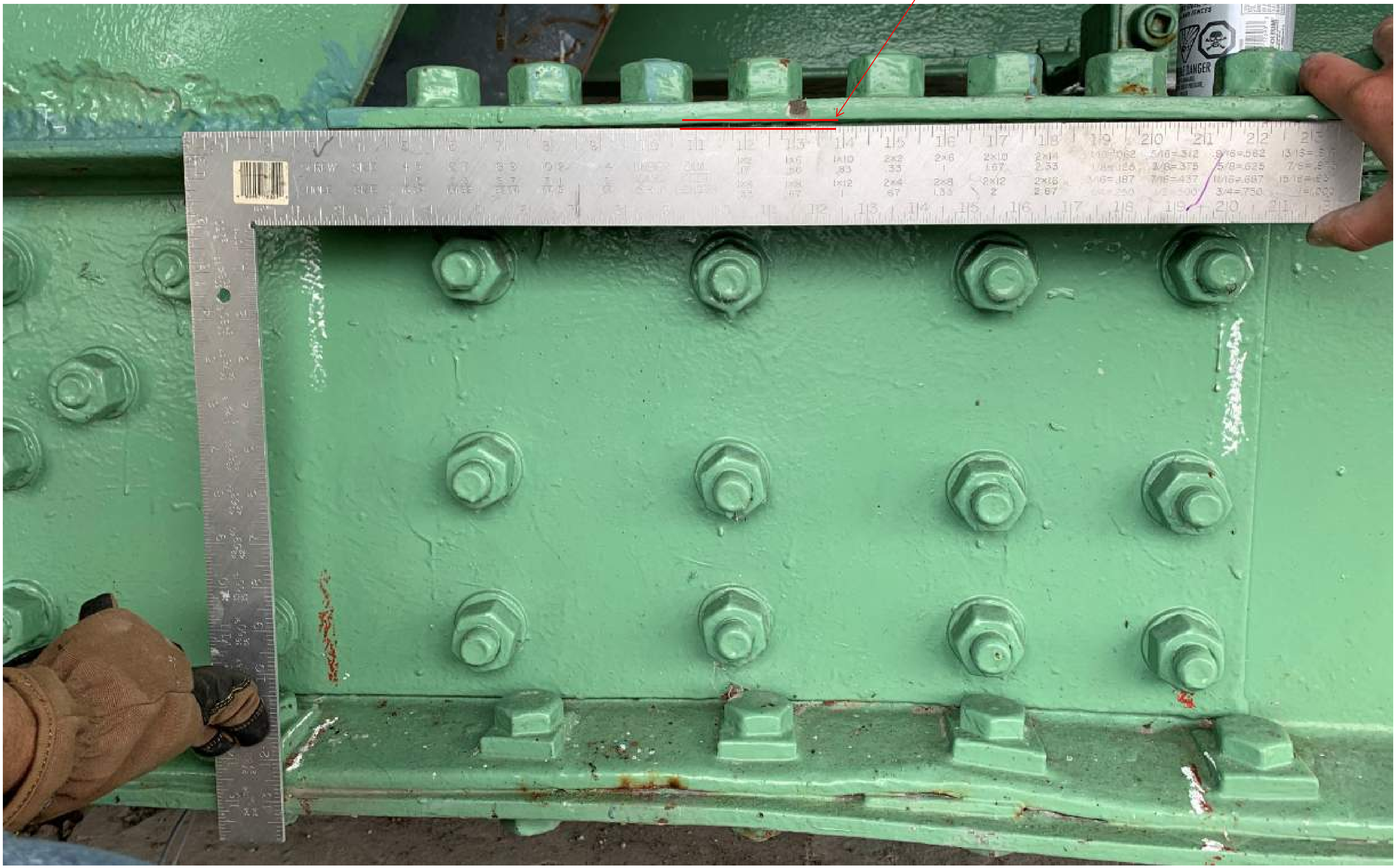
Note that the lengths of deformation for the bottom and top flanges are approximately equal at 520 mm, as illustrated by the highlighted rectangle.



Measurements taken by Dennis Voltchek & Spencer Willows on May 28, 2020.

Top Connection Plate Deformation

Connection plate gap = 3mm



Measurements taken by Dennis Voltchek & Spencer Willows on May 28, 2020.

Bottom Flange Deformation

Measurements taken by Dennis Voltchek on May 20, 2020.

LaSalle Causeway Bascule Bridge

Main Trunnion Rehabilitation Study –
Detailed Inspection Memorandum (Revision 1)

PSPC Project Number: R.099350.002

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