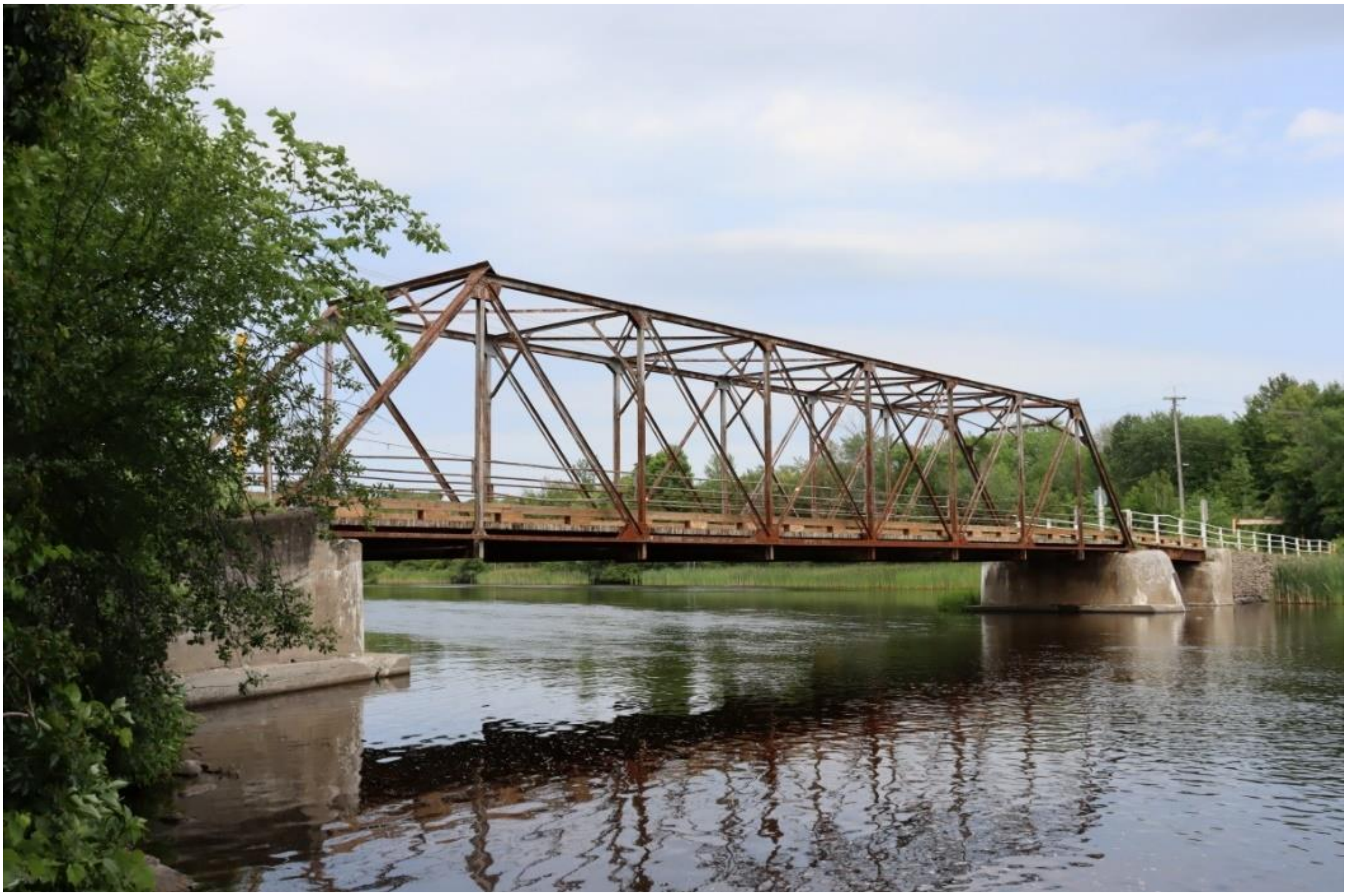

ANDREWSVILLE BRIDGE WADING INSPECTION REPORT- JULY 2021

Lanark County, United Counties Leeds & Grenville

Keystone Bridge Management Corp.
Your Bridge Asset Management Specialist

Introduction

Keystone Bridge Management was retained by the County of Lanark to complete a wading inspection of the underside of the Andrewsville Bridge over the Rideau River downstream of Merrickville, Ontario. This is the third wading inspection of the Andrewsville Bridge by Keystone Bridge Management. Keystone previously provided a wading inspection of the bridge in August 2016 and August 2018. Keystone also has provided biennial (OSIM) inspections of the bridge in 2017 and 2019 and will again this year. This report should be read together with the previous reports.

This inspection was completed on July 5, 2021. Harold Kleywegt, P.Eng., was the principal inspector. He was assisted by engineering student Kyle Davis. Sean Derouin of Lanark County and Jacob Ouellette of United Counties of Leeds & Grenville were on hand to observe the beginning of the inspection.

Access to the underside of the bridge was obtained by setting up a 10' step ladder and 24' extension ladder on the river bottom. The depth of water and uneven bottom prevented ladder access to about half of the plan area of the truss. River flows were modest during the inspection.

The Rideau River is flowing principally north at the Andrewsville Bridge. Accordingly, the east abutment is on the United Counties of Leeds & Grenville side of the bridge and the west abutment is on the Lanark County side.

The bridge has two spans, a 39.0 m long main truss forming the west span and a 9.2 m steel girder section comprising the east span. The truss has 9 lower chord panel points supporting floor beams spaced at 4.88 m. Floor beams are only located at the interior panel points.

Spanning from floor beam to floor beam on the truss are five lines of steel S200 x 27 stringers spaced at nominally 0.9 m. They directly support the 4.9 m-wide laminated timber deck.

The structural steel framing on the east approach span consists of two main girders, a connecting floor beam and five stringers spaced at 914 mm. The S150 x 19 approach span stringers are a lighter section than the truss stringers.

For this report the area between floor beams is referred to as "Bays." There are eight bays comprising the truss floor system. They are numbered from west to east with Bay 1 closest to the west abutment and Bay 8 closest to the pier. The stringers are numbered 1 to 5 from south to north (upstream to downstream). This convention has been followed in captioning the images included with this report.

The Bay 1 stringers were not closely inspected as they were replaced in late 2016. Similarly, the approach span stringers were not closely inspected as they were replaced in late 2018.

The primary purpose of the wading inspection is to provide direct access to the underside of the bridge by standing ladders on the river bottom. During the summer months when the river flow is reduced and the water temperature pleasant, this approach is a highly economical means of access as compared to swing stages or raft access.

Although the principal focus is the underside of the bridge, a thorough inspection of the top side and approaches was also provided.

History

There is some uncertainty as to the actual year of construction of the bridge. A historical photo of a 1904 dam break and flood event shows the east end of the bridge submerged with the east abutment presumably lost to scour. The year of construction of the main truss is most likely close to 1900. It is possible that the east approach span was added after 1904.

It is surmised that that the timber deck of the main truss was last replaced in 2008. Other repairs were completed in 2008 as well. Height-restricting portals on the approaches to the bridge were added in 2013. This followed damage to the bridge from an overload in May 2012.

Five steel stringers at the west end of the bridge were replaced in the fall of 2016. In December 2018, following the first winter closure of the bridge, the east approach span stringers and deck were replaced, and all the timber curbs on the main truss span and approach span were replaced. The stringers were replaced due to severe section loss with perforations.

Inspection Findings

Stringers

The seven bays of the main truss numbered 2 to 8 have stringers that are original equipment to the main truss and are therefore well over 100 years old. Previous inspection of these stringers confirmed generalized corrosion and significant section loss; however, no perforations were present.

During the 2021 wading inspection select areas with heavy slab rust (laminar corrosion) were hammer tapped as in previous inspections. This time, the stringers were found to have perforated webs in two locations. Perforation of a web signifies a 6.9 mm thickness of steel section loss. Generalized web thinning of the stringers and significant section loss of the stringer flanges was also noted. It is estimated that the five stringers acting together as a deck system have lost approximately 50% of their intended strength at this time.

In some locations there was very pronounced section loss of either the top or bottom flange of a stringer. Full section loss was incised horizontally to an estimated depth of 6 mm on the top flange at one inspected location.

All lines of stringers were examined for signs of permanent deformation such as would form under an overload. No evidence of permanent deformation was present.

The stringers were generally plumb; however, stringer 4 of bay 8 is slightly inclined at the bearing. One other stringer end had mild inclination at a floor beam support.

Despite closing the bridge to winter traffic as of 2018, thus minimizing salt corrosion, it is clear that the structural steel of the floor system has continued to experience ongoing corrosion. The corrosion may be from historical salt content chemically bound to the steel. Salts in the preservative of the timber deck may also be contributing to the corrosion. The outlook is continued degradation of the structural capability of the truss floor system.

Floor Beams

The floor beams span transverse to the axis of the truss and are connected to the lower chord panel points of the truss. They support the stringers and help stabilize the trusses. The floor beams' condition has changed very little in the past seven years. The upstream and downstream ends of each of the seven floor beams are generally more heavily corroded than the middle sections. None of the corrosion on the floor beams is of a critical nature. That is, the load capacity of the truss is not governed by the floor beam condition.

A comparison of the floor beam condition change over time was made by careful comparison of 2018 imagery to 2021 imagery. A small increase in paint loss is clear. It was not possible to discern an increase in section loss. A small amount of additional section loss would be expected.

Timber Deck

The timber deck could be visually examined from above and below. The deck on the truss dates to 2008. The deck on the east approach span was replaced in late 2018. The timber is generally sound and competent. The timber is nail-laminated, so that wheel loads are shared by multiple planks acting in unison. Thus, the system is tolerant of limited deterioration such as checking and decay. The timber deck on the main truss has at least five years of estimated remaining service life. The timber curbs on ether side of the deck were replaced in 2018 and are in good condition. The anchor bolts fastening the curbs to the deck have loosened due to drying shrinkage of the curbs and should be tightened. The running boards are in fair-to-good condition with some spot replacement indicated on the main truss.

Concrete

The concrete in the two abutments and pier is lightly reinforced, lacks air entrainment, is of low strength, and is affected by alkali-aggregate reactivity. This is resulting in slow but gradually accelerating disintegration of the concrete. The disintegration is most pronounced on the upstream upper surfaces of the pier, and the upstream side of the east abutment. The disintegration of the east abutment may also be exacerbated by ice scour.

Presently the disintegration front is about to affect the main truss bearing at the upstream east corner. The concrete around the bearing is incompetent, and eventually the concrete under the bearing will also become incompetent.

Repair of the concrete is still possible without having to provide temporary support to the truss. However, the window for easy repair is rapidly closing.

Dry-Stone Retaining Walls

The east approach to the bridge has nominally 35 metres of dry-stone masonry retaining walls forming a causeway to the bridge. The walls are up to about 2.7 m high. The downstream side of the west approach has a similar dry-stone wall. These walls would have been originally constructed with a steep batter. The internal composition of the walls is not known. There is no evidence of iron or steel ties to internally support the walls.

The walls exhibit bulging, displacement, and localized dislodgement of stone. It is remarkable that they are still standing.

Some sections of the wall are partly collapsed. This is most notable on the west approach and at the eastern terminus of the downstream east wall. Erosion from turtle nesting has contributed to the partial collapse.

It is not anticipated that the dry-stone walls make the approaches vulnerable to catastrophic loss. That is to say, the slow deterioration of the walls will not cause a large collapse and full loss of the road platform. However, an extreme flood event or a seismic event could produce large scale failure of the walls and loss of the road. Certainly, a portion of the wall could collapse unexpectedly at any time and compromise the road surface.

Restoration of the walls would require almost complete reconstruction using salvaged material from the walls, most likely augmented by modern practises such as internal ties.

There is considerable risk exposure to the Municipalities arising from the condition of the dry-stone walls.

Railings

The approaches and bridge possess "safety" railings. All the railings are generally in a neglected state of repair, and do not conform to any current codes for guide rail or bridge railings. The deterioration of the dry-stone walls has resulted in settlement and displacement of the footings for the approach railings.

Scour

A nominal 0.5 m deep depression in the embankment in the upstream west corner of the truss was noted for the first time in 2021. The embankment is enclosed at this location by the west abutment and a reinforced concrete retaining wall.

Significant scour in front of the west abutment footing appeared after 2018 spring flooding. It is possible that some embankment material is "leaking" from gaps under the abutment footing or retaining wall footing. This would explain the noted depression in the embankment.

The Rideau River channel under the bridge is "lined" with natural blocky limestone. There is minor scour associated with the pier, and some suspected general scour between the pier and east abutment.

Trusses

There has been no observable deterioration of the trusses above the level of the bridge deck over the past seven years. Similarly, below the deck level, the bottom chords and connection gussets at the panel points show no observable change.

There is no evidence of any recent high or wide load damage to the trusses or upper sway bracing and portals.

Structural Evaluation

A simple structural evaluation was completed to establish some confidence in the residual capacity of the corroded stringers. There is some uncertainty with respect to the actual section properties of the stringers. They are certainly 8" high by 4" flange width Imperial stringers. Reference to historical section properties suggests there were about 10 rolled "S" shaped 8 x 4 beams with weights of 17 to 18.4 pounds per foot. The closest currently available section has a metric designation of S200x27 and an equivalent Imperial designation of S8x18.4. As the properties of the S200x27 section are reliably known, and the other similar sections will have closely similar structural attributes, this section was used as a starting point in the analysis.

The section was artificially weakened by reducing the combined flange area by half. The weakened section has 54% of the bending capacity of the original section.

Assuming a historical yield strength of 210 MPa, the weakened beam is predicted to plastically yield at an unfactored moment of 27 kN.m.

The unfactored weight of the deck and girders requires approximately 15% of the reduced girder capacity. Depending on assumptions around load distribution, a 5-tonne vehicle will require an additional 40% of the reduced capacity of the girders.

The upshot of this simple analysis is that the present 5-tonne load limit on the bridge is realistic but not conservative. Continued corrosion of the stringers will gradually erode the capacity of the bridge to the point that a 5-tonne load limit is no longer valid.

A 5-tonne single truck load limit is the practical lowest load rating for a bridge. Any posting lower than that is effectively a bridge closure according to the Bridge Code.

Synopsis

The Andrewsville Bridge has already greatly exceeded its normal anticipated service life. Despite significant effort to extend the life of the bridge, ongoing corrosion, concrete deterioration, and an aging main timber deck pose ever increasing risk of localized failures. The dry-stone retaining walls that support the bridge approaches are misshapen and are no longer considered reliable. Safety appliances such as bridge railings and approach railings are inadequate.

Restoration

Bridge

The existing bridge cannot be restored to full truck loading. It is conceivable that the bridge can be restored to a 20-tonne single truck load rating. To achieve this the floor beams and stringers together with the deck will need to be replaced. Significant concrete restoration will also be required. To maximize the life of the restoration, the truss should be painted. It may be necessary to dismantle the truss and make shop repairs and complete strengthening ahead of painting the members. The cost of the truss work will greatly exceed $1,000,000.

Approaches

The existing dry-stone retaining walls have heritage value, although this may not have been officially recognized. To reconstruct them with fidelity to the original construction will require highly skilled and exceedingly scarce specialist masons. The cost is expected to be prohibitive.

The alternative to reconstruction would be simple embankment widening with low retaining walls designed to defend against river scour. This would almost double the footprint of the causeway in the river on the east side and would encroach on flood plain and possibly private property on the west side.

Rust in Peace

The bridge can remain open with the current 5-tonne load posting for a few more years. However, every year that the bridge remains open, the risk of localized failure and liability exposure increases. It is the writer's recommendation to plan on fully closing the bridge to traffic within five (5) years. Until such time as the bridge is closed, regular monitoring of the approaches and bridge surface will be required to capture any untoward developments.

An annual comprehensive inspection of the bridge and approaches will be required.

Vehicle Trespass

Despite clearance portals at each approach to the bridge, and advance warning signs, incidents of oversize vehicle and possibly over-weight vehicle trespass is known to be occurring. Such incidents put the security of the bridge in peril and add to the overall risk. Moreover, heavy axle weights could cause a failure of the dry-stone approach walls.

Failure modes

The bridge stringers are presently the weakest component of the deck system. Should a stringer become slightly overloaded, it will permanently bend in the loaded direction or crush where it rests on a floor beam, abutment, or pier. This can result in local overloading of the timber deck, and an obvious "soft spot" will develop in the deck. The above is all premised on a light over-load such as a 7.5 tonne vehicle. It is very possible that a failure such as this will develop in the next five years. Fortunately, a failure such as this will be relatively benign, but would lead to a closure of the bridge, pending local strengthening or permanent closure.

If a loaded triaxle truck attempted to cross the bridge, the failure would be catastrophic and plainly visible to any following traffic. A gross overload such as this would likely not be benign and could result in the complete loss of the bridge.

Failure of the drystone retaining walls is anticipated to be of a relatively slow progressive mode exacerbated by rainfall, traffic and time. There should be some warning of the failure as the road platform narrows. However, under a severe flood, failure could occur suddenly and progress rapidly. A heavy rainfall event with gullying could also result in rapid failure.

Future Inspections

A more thorough inspection, especially of the stringers, is strongly recommended within two years. Several days of field measurement and documentation are recommended to achieve a strong objective understanding of the level of deterioration of the stringers so that their reduced capacity can be more precisely determined. A large stable raft may expedite such an inspection.

A coring and probing survey of the timber deck should also take place concurrently.

Summary Remarks

The Andrewsville Bridge has surpassed its useful life and is rapidly approaching the need to either invest major capital in its rehabilitation or renewal or close it to vehicle traffic. The road approaches to the bridge are failing and represent increasing risk to road users as they continue to degrade.

Several million dollars will be required to meaningfully extend the life of the existing bridge and improve the road approaches. The least costly alternative is to close the bridge, which is expected to be necessary within five years.

An environmental assessment study (EA) is strongly recommended at this time. An EA study will formalize an acceptable approach to dealing with end of useful life considerations for the Andrewsville Bridge, following well established guidelines. Options that will need full consideration include:

- Closure
- Conversion to pedestrian use only
- Rehabilitation
- Replacement

A do-nothing option for the bridge does not merit consideration even though it is typically considered in an EA study.

Signature

Keystone is very pleased to be of continuing service in the monitoring and management of the Andrewsville Bridge. We trust this report will be helpful in determining the future of this structure. Thank you for this opportunity to be of service.

Harold Kleywegt, P.Eng.
Managing Director

Photos

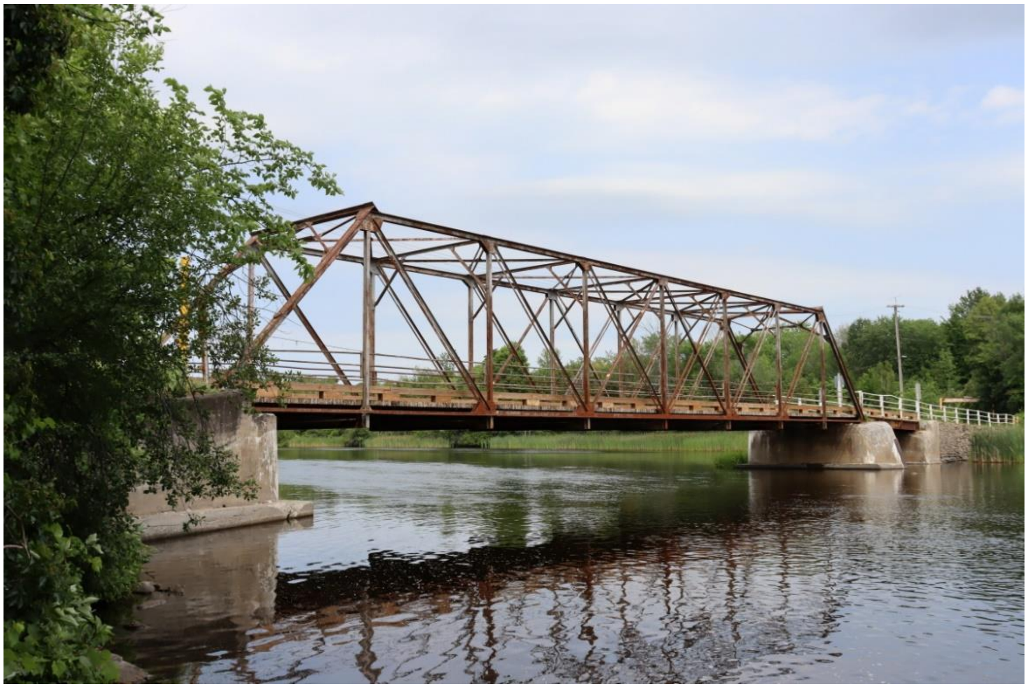

Figure 1: South elevation

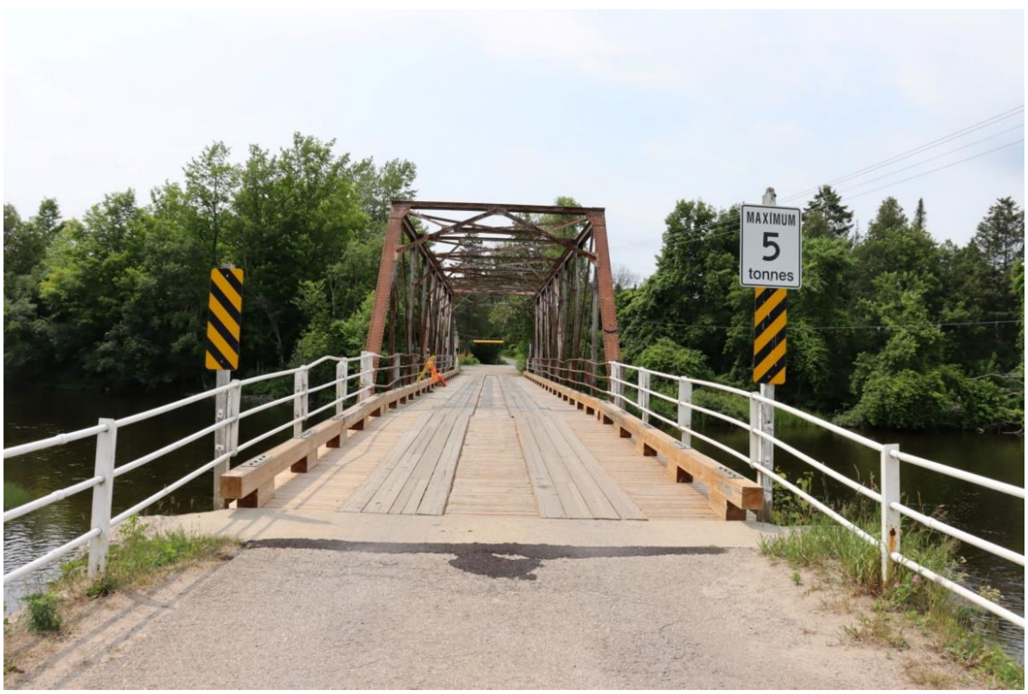

Figure 2: East approach

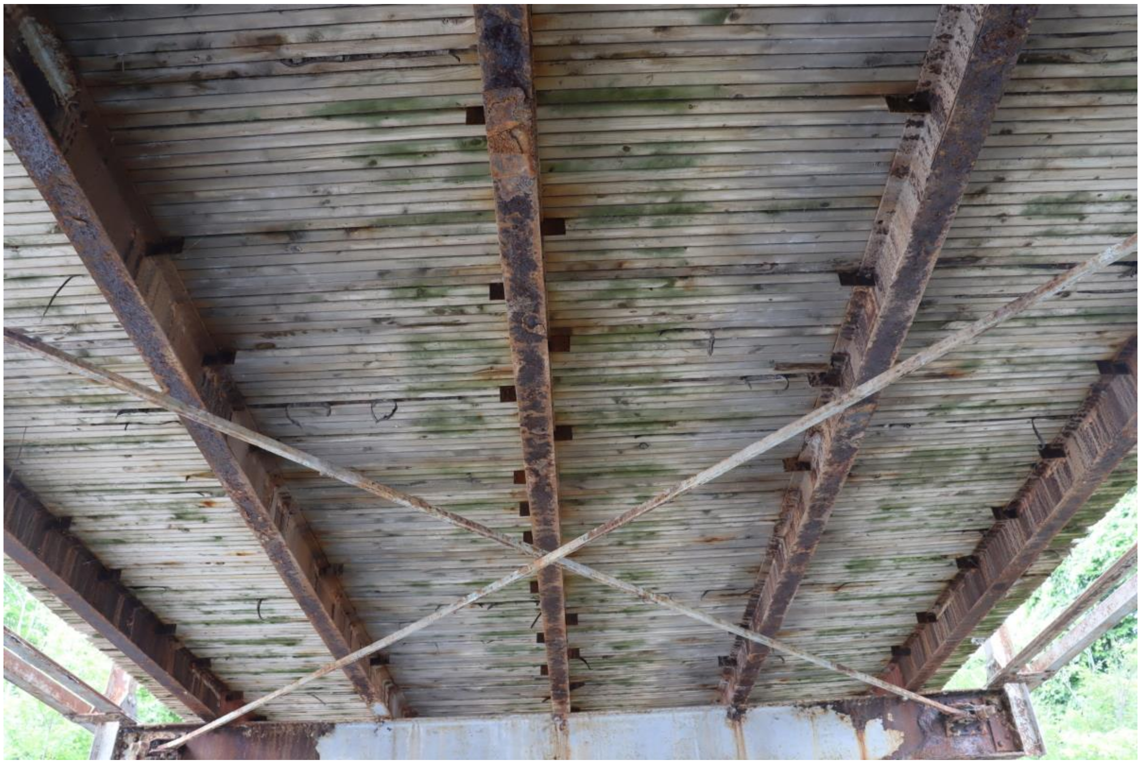

Figure 3: Bay 2 overview

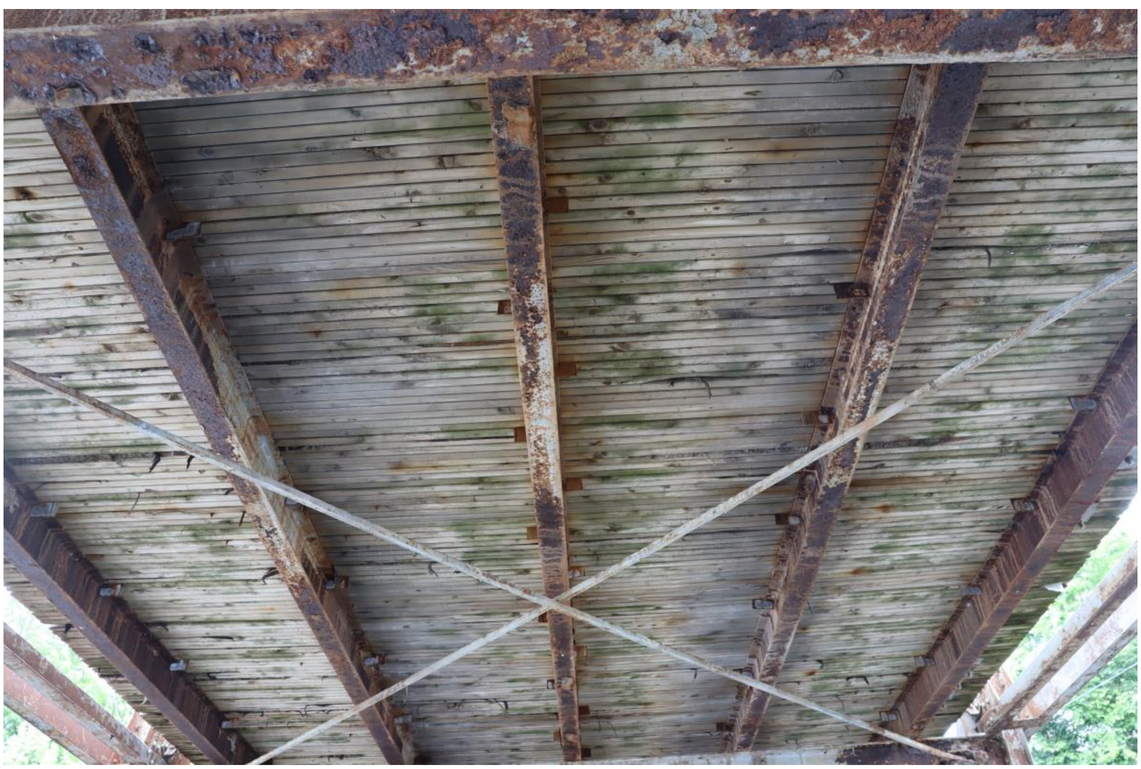

Figure 4: Bay 3 overview

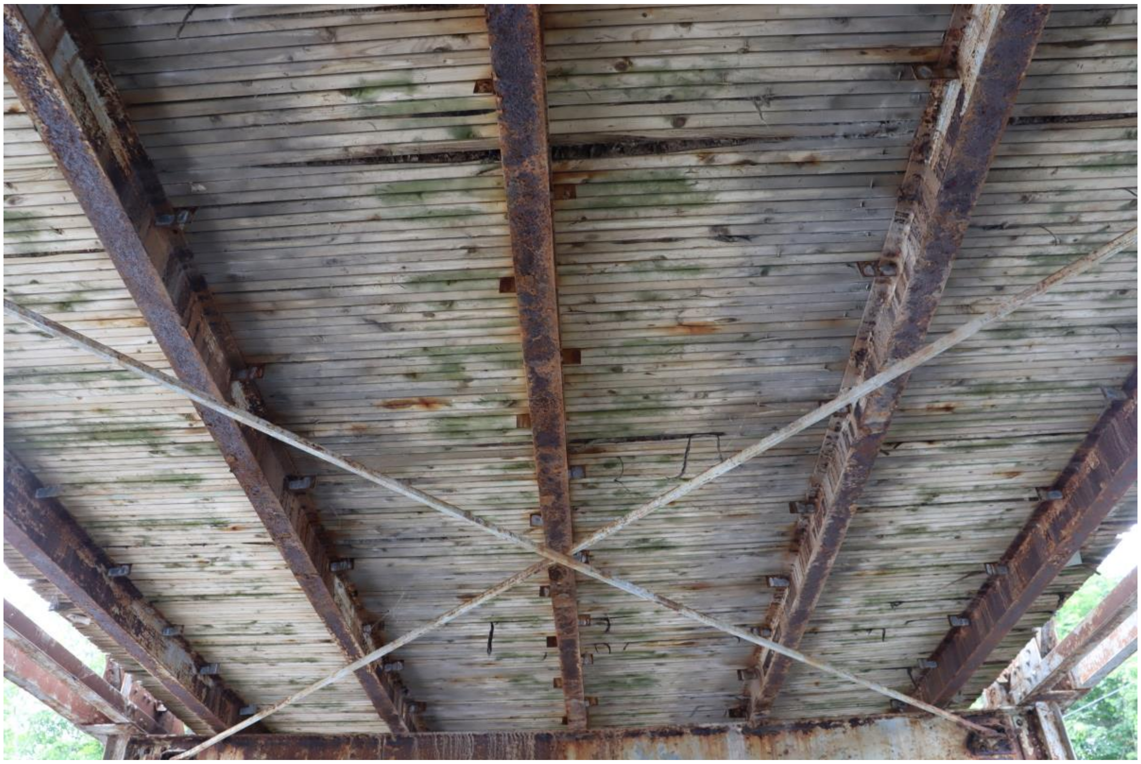

Figure 5: Bay 4 overview

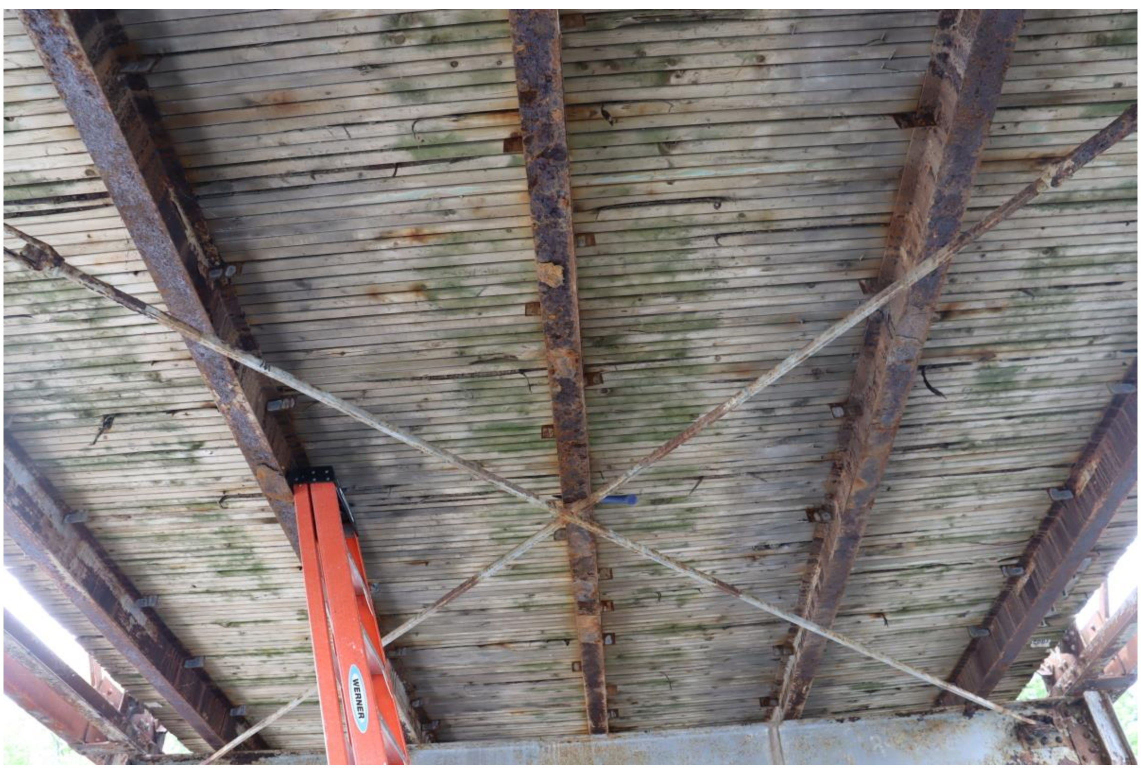

Figure 6: Bay 5 overview

Figure 7: Bay 6 overview

Figure 8: Bay 7 overview

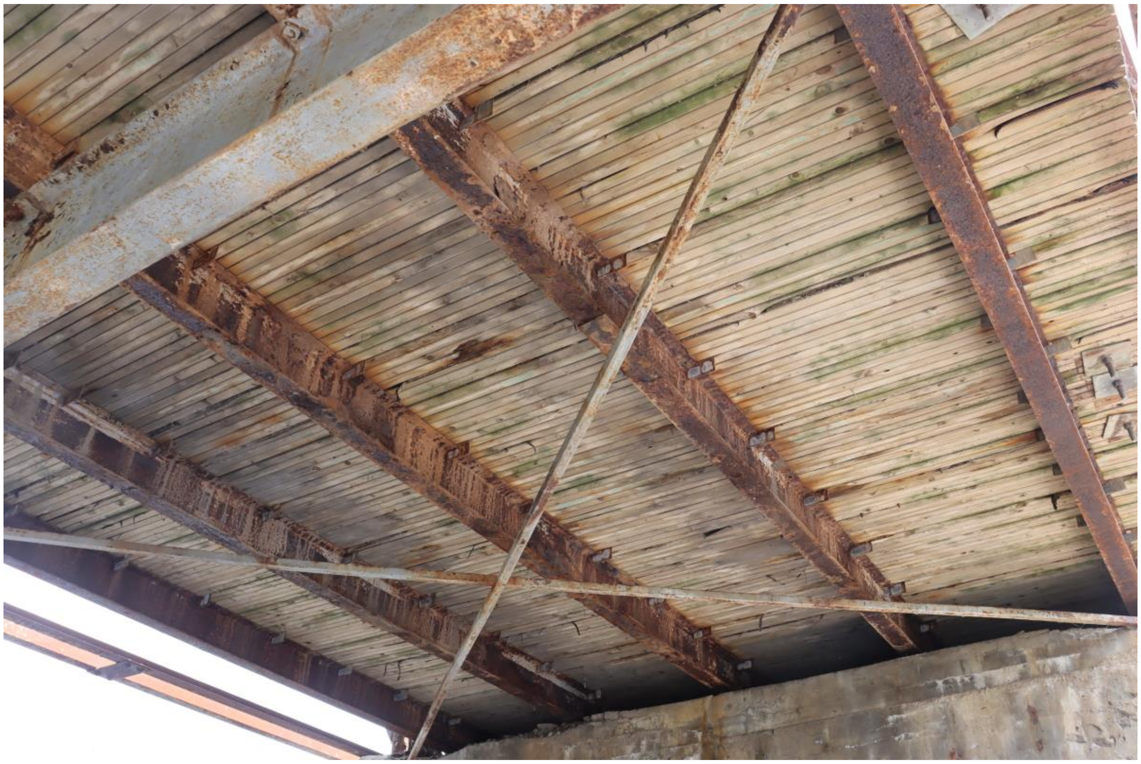

Figure 9: Bay 8 overview

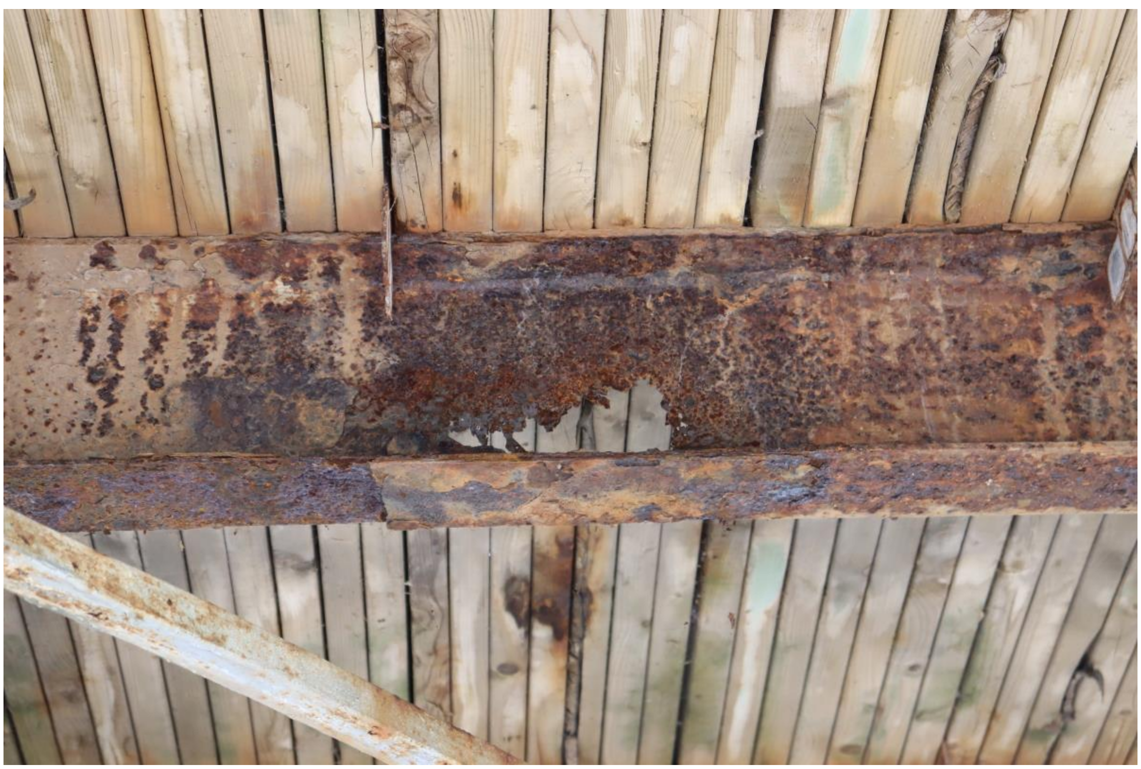

Figure 10: Stringer 2 perforation in bay 8

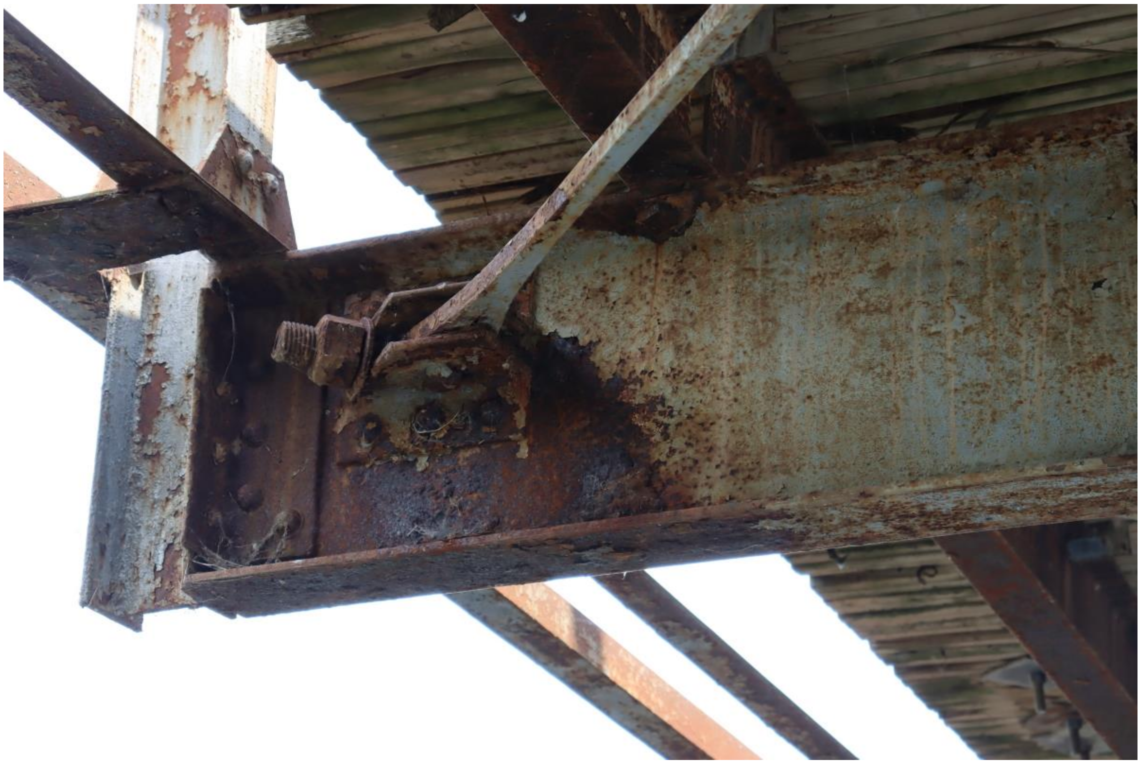

Figure 11: Floor beam 7 north end

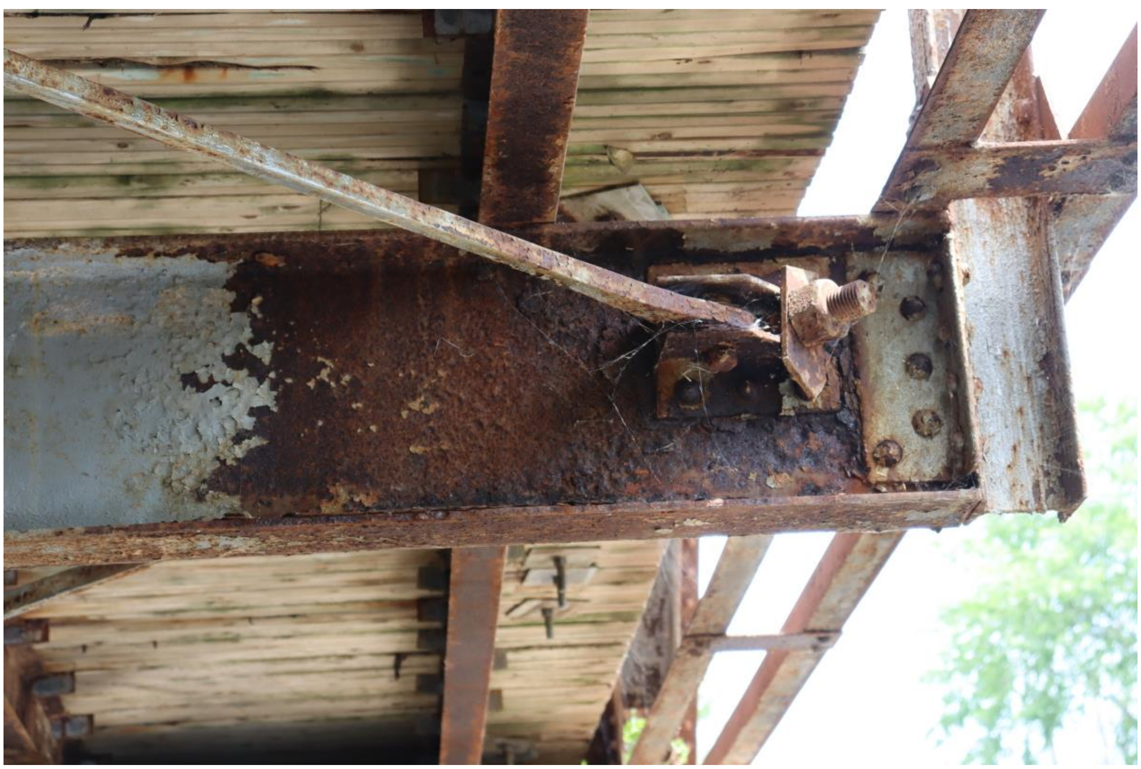

Figure 12: Floor beam 7 south end

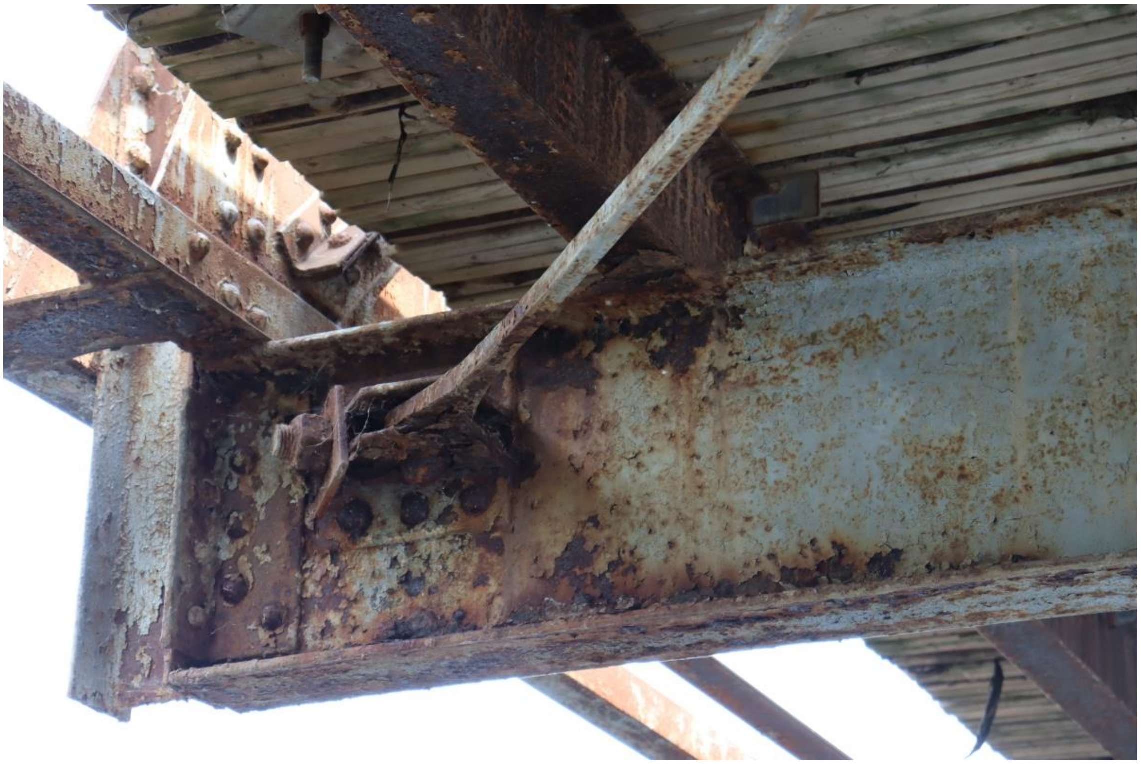

Figure 13: Floor beam 6 north end

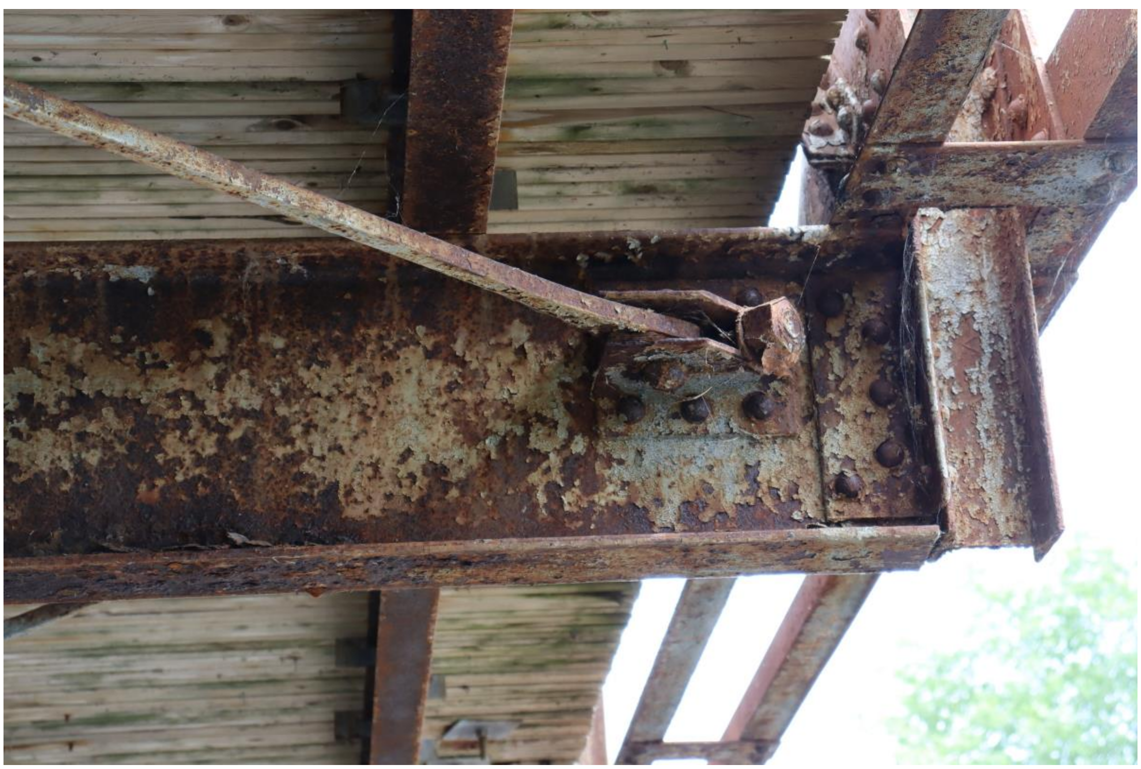

Figure 14: Floor beam 6 south end

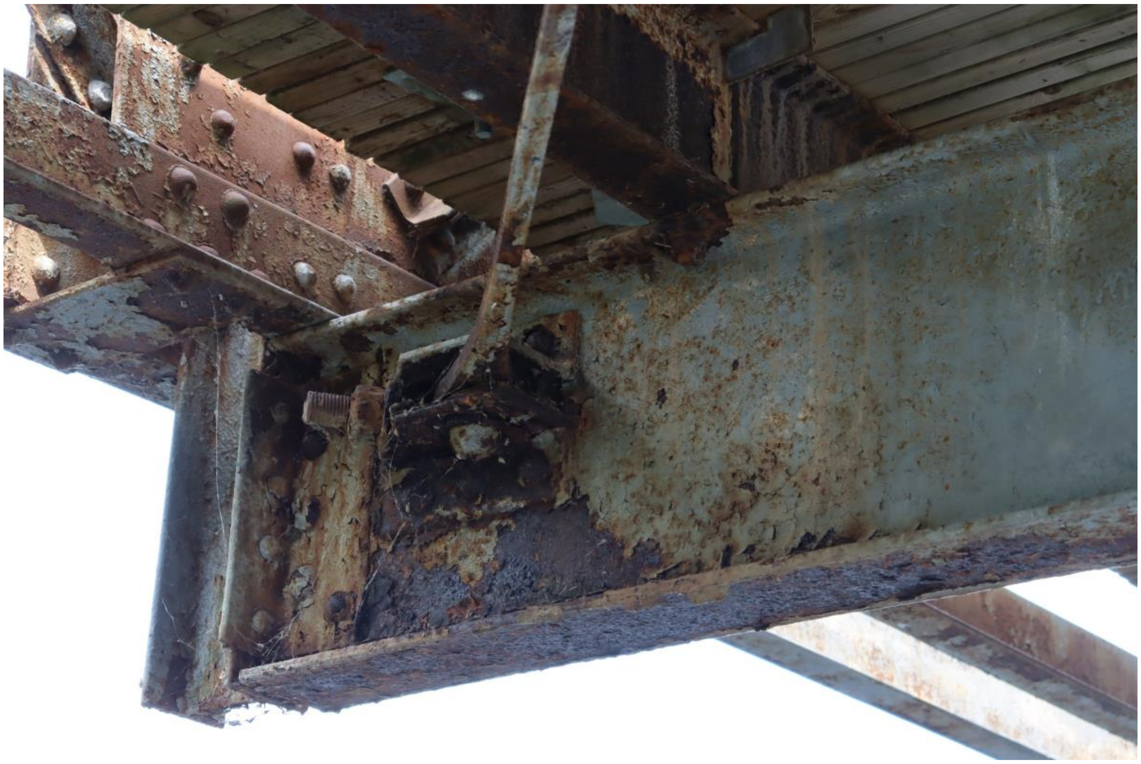

Figure 15: Floor beam 5 north end

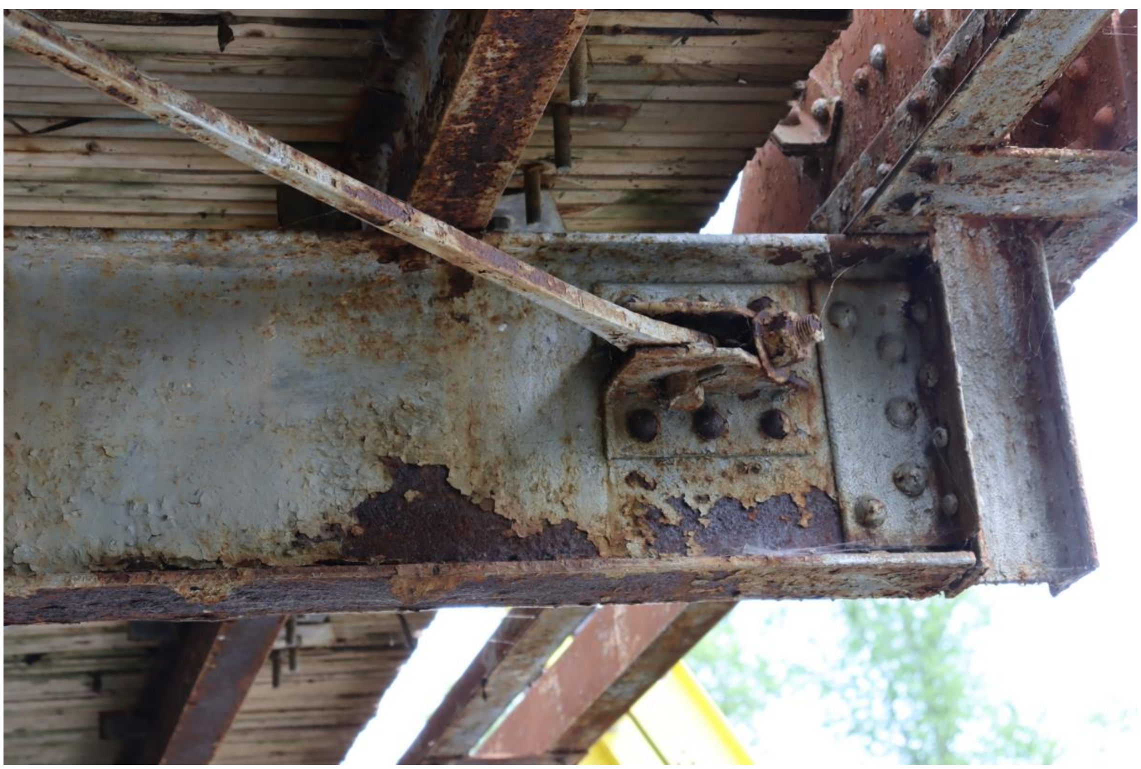

Figure 16: Floor beam 5 south end

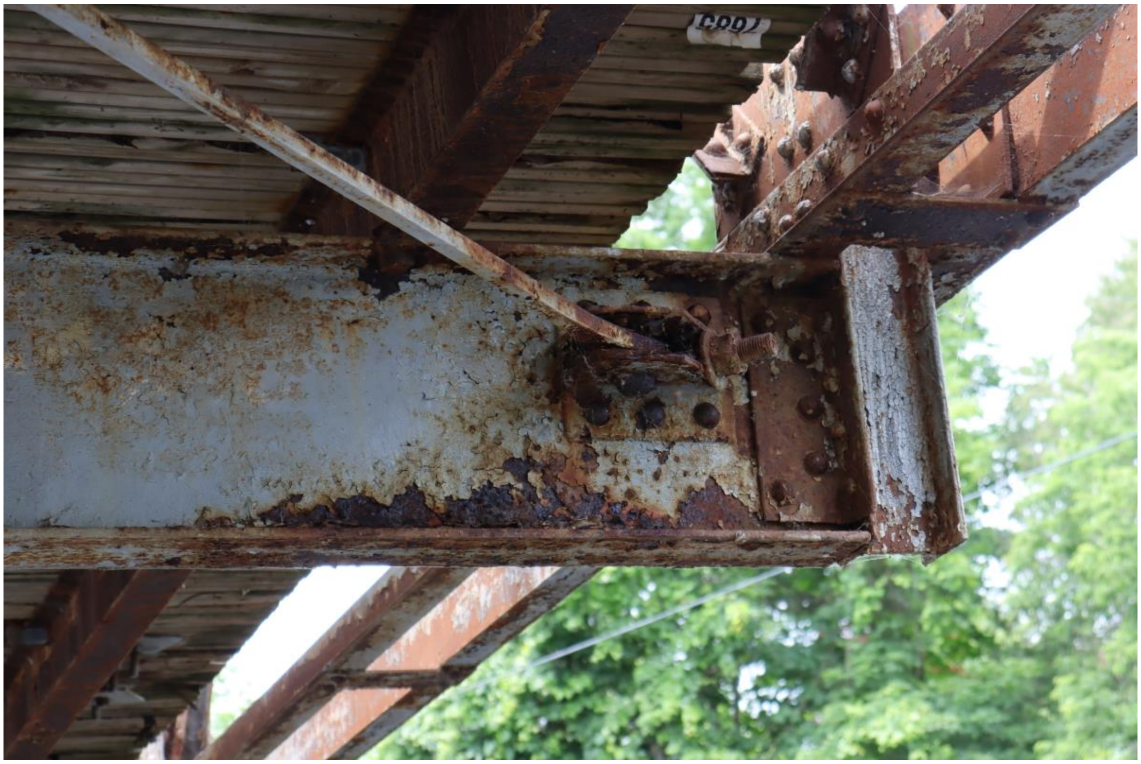

Figure 17: Floor beam 4 north end

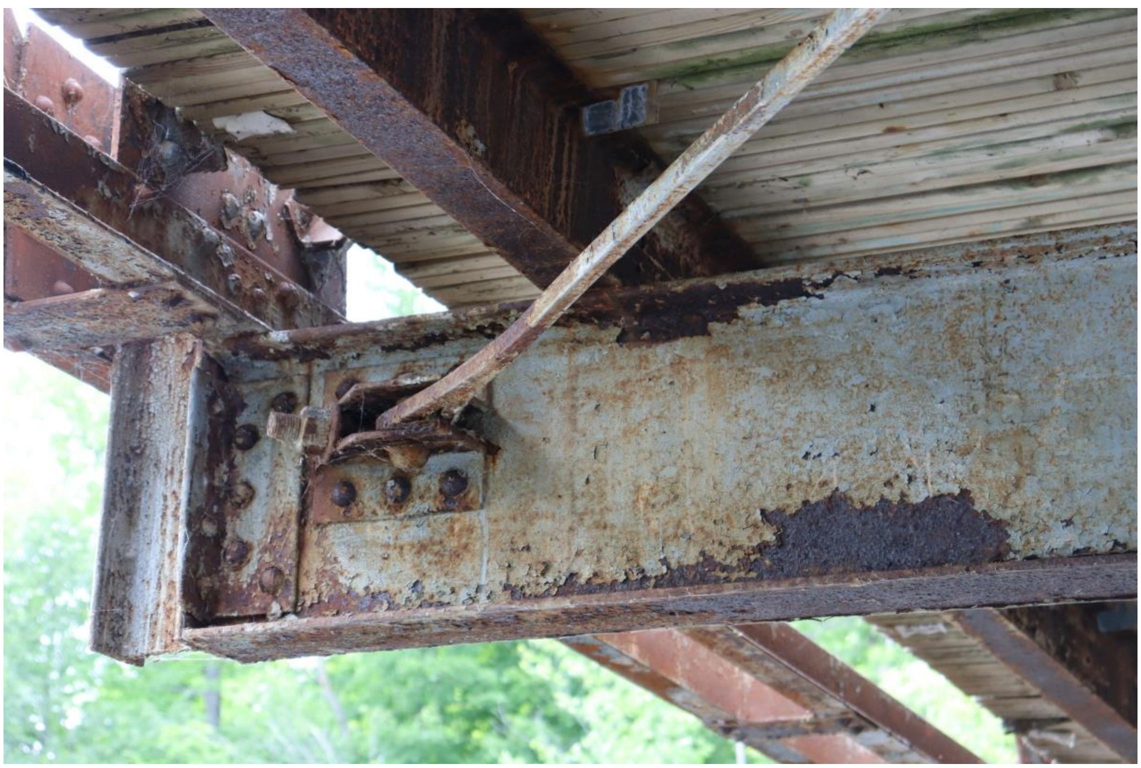

Figure 18: Floor beam 4 south end

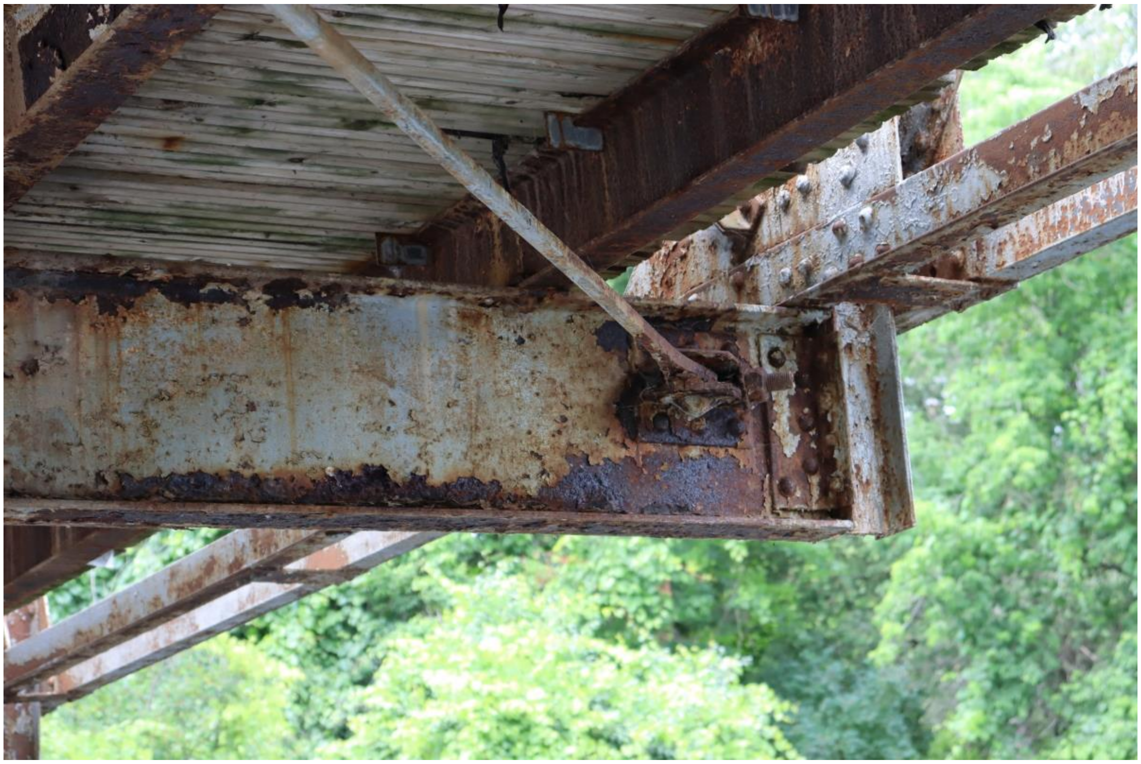

Figure 19: Floor beam 3 north end

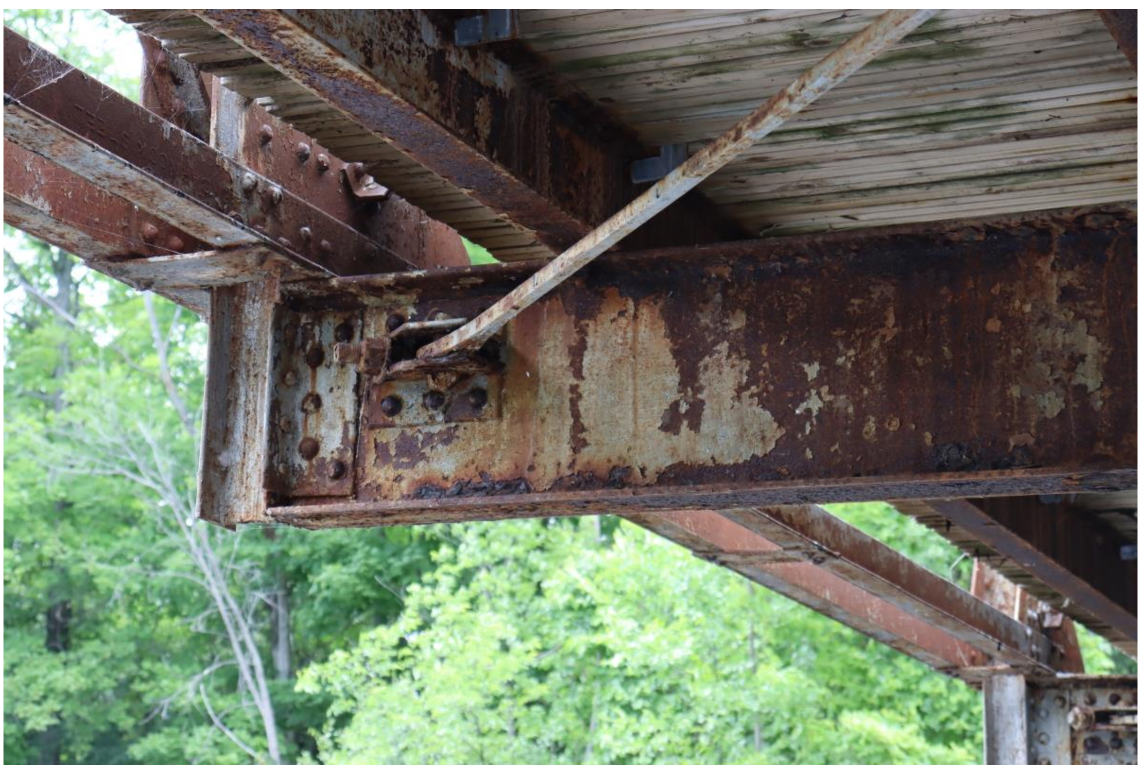

Figure 20: Floor beam 3 south end

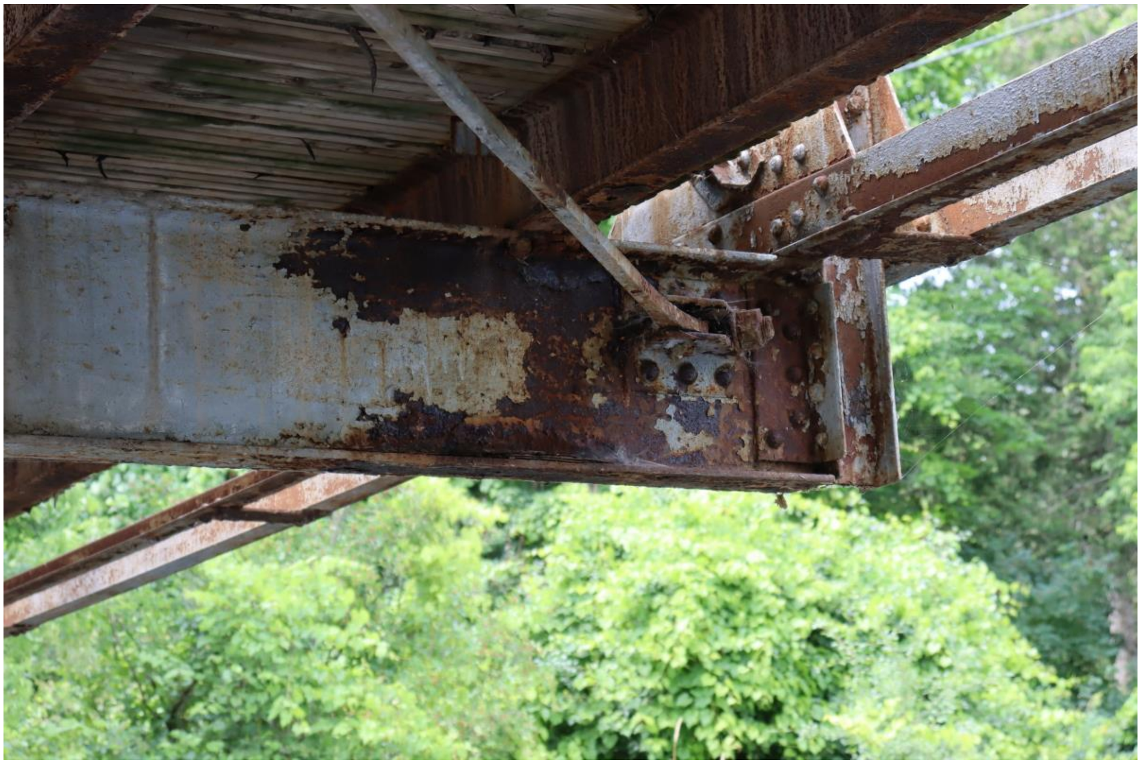

Figure 21: Floor beam 2 north end

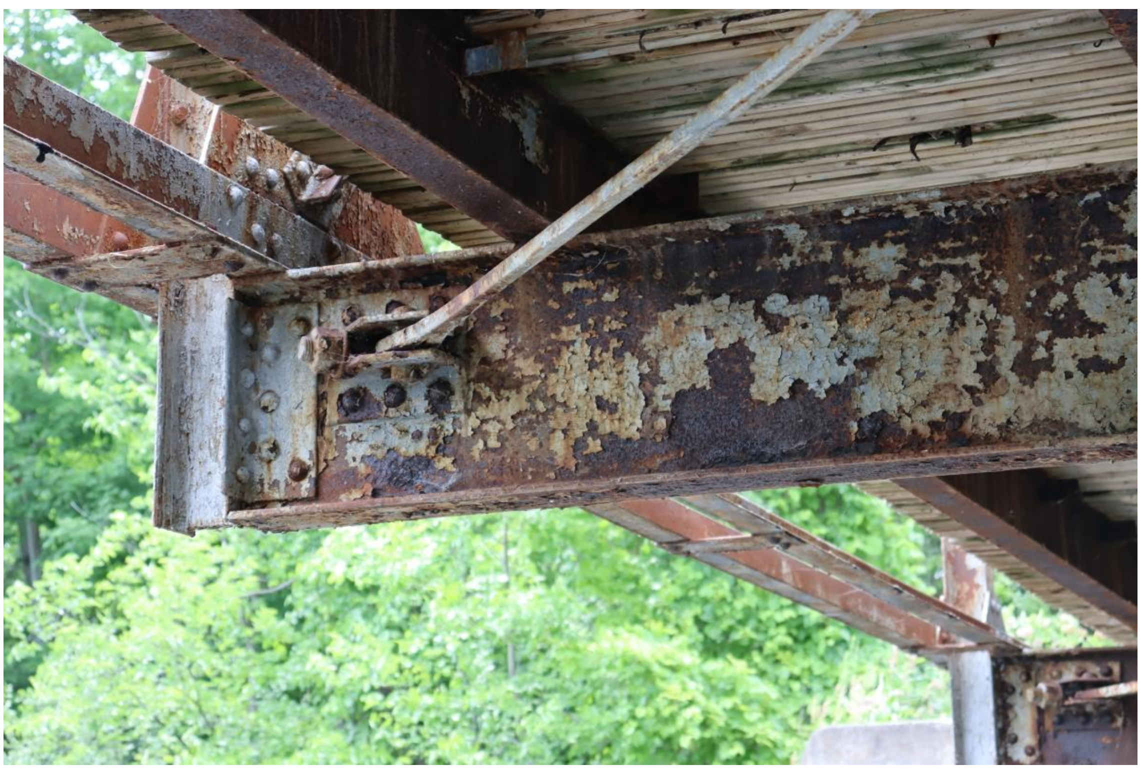

Figure 22: Floor beam 2 south end

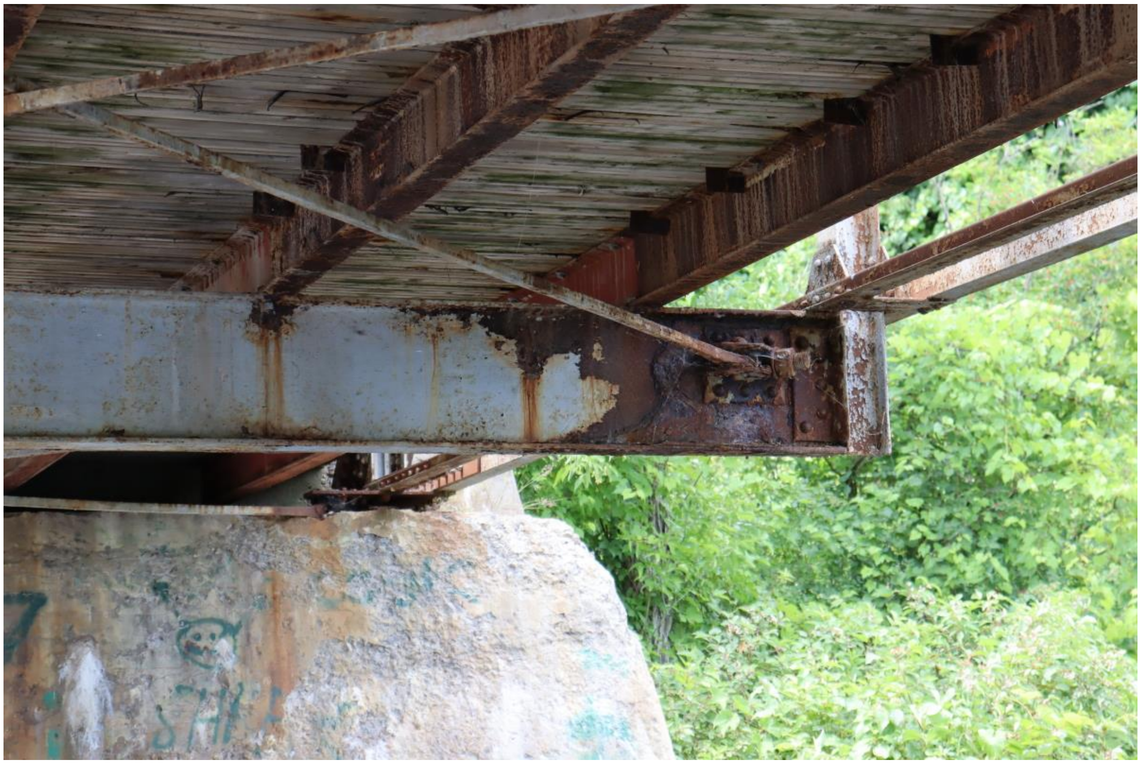

Figure 23: Floor beam 1 north end

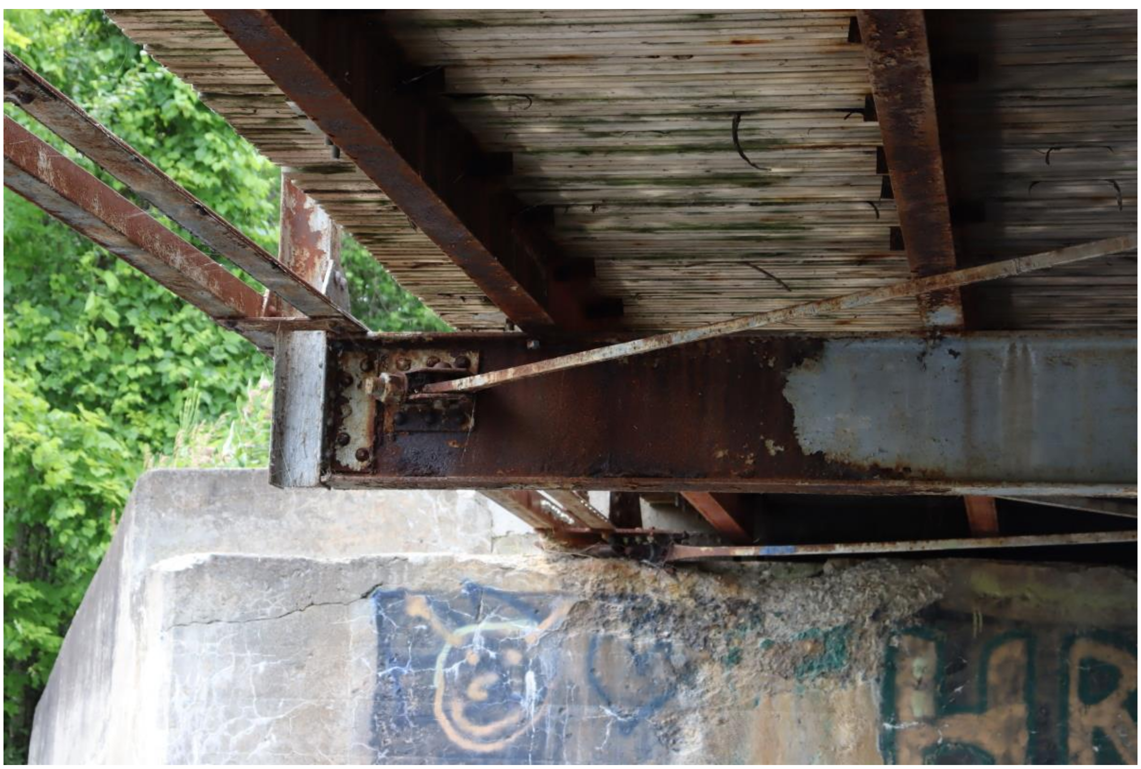

Figure 24: Floor beam 1 south end

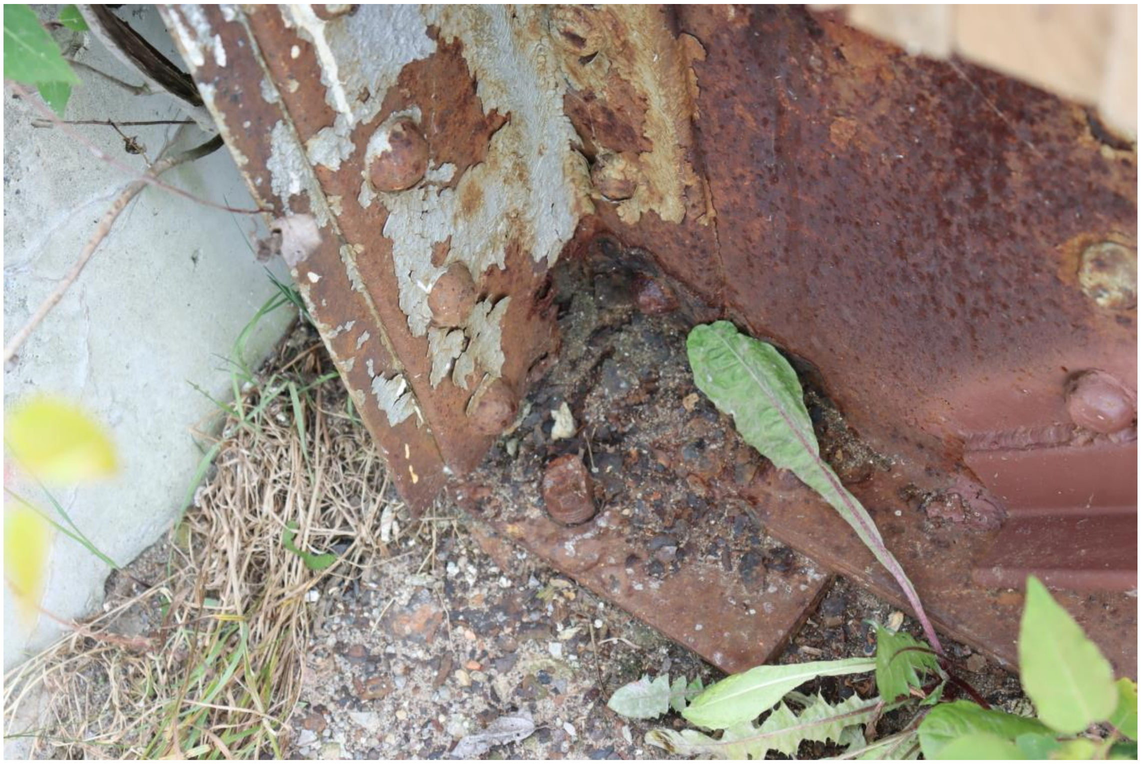

Figure 25: NE bearing

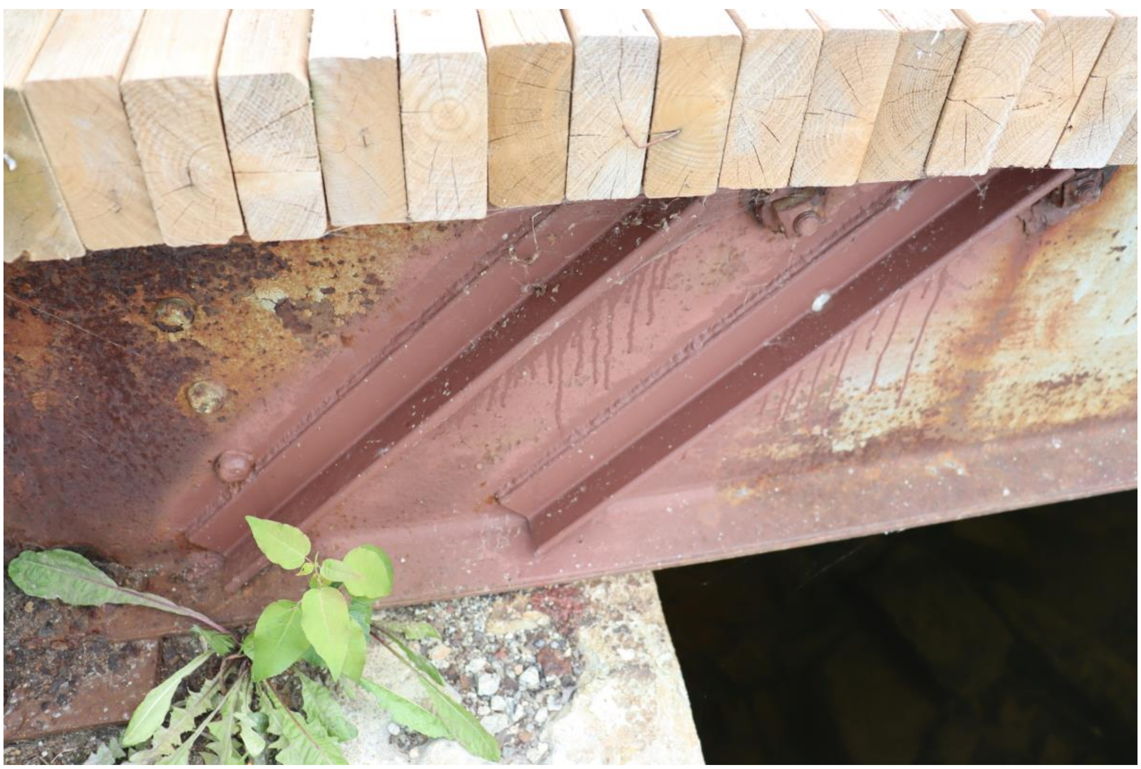

Figure 26: NE girder end web stiffening

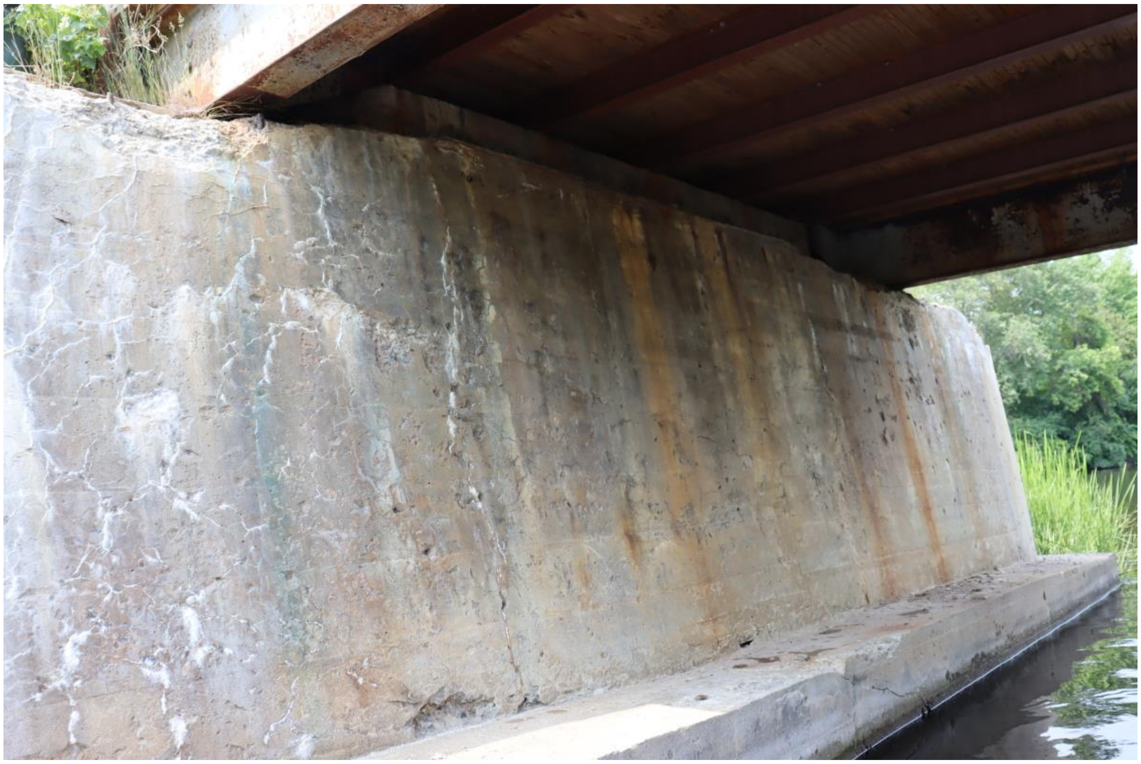

Figure 27: East face of pier

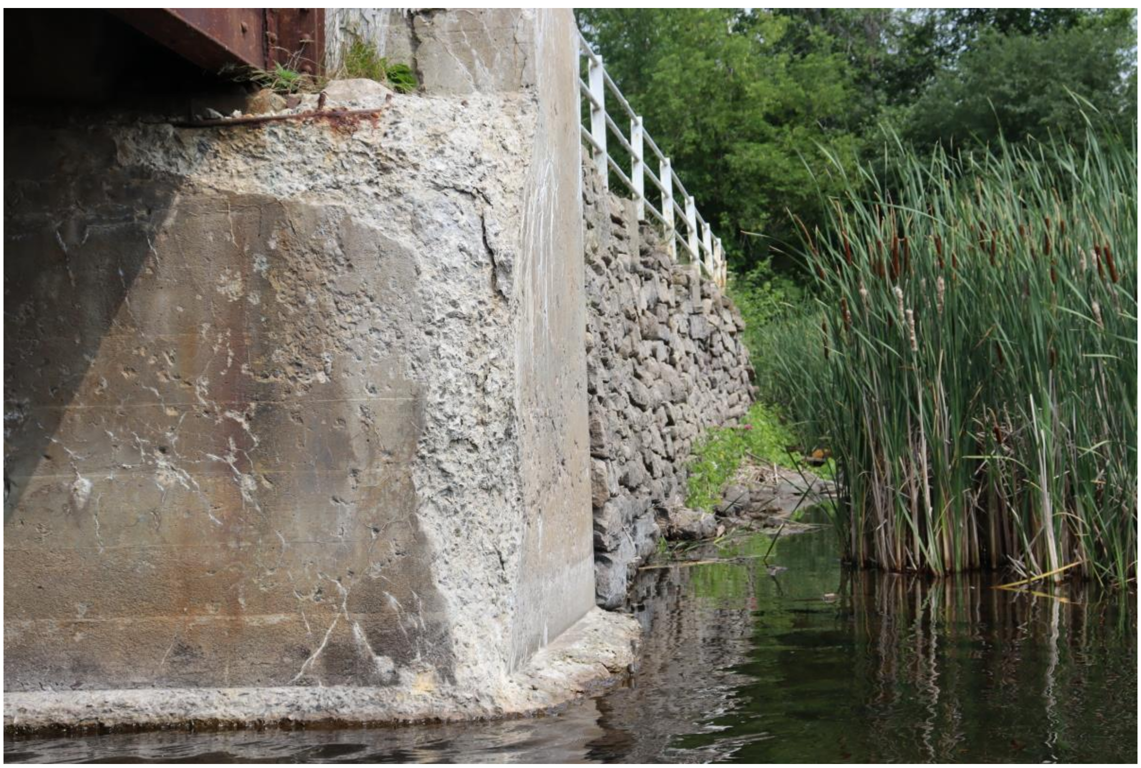

Figure 28: East abutment and causeway from south

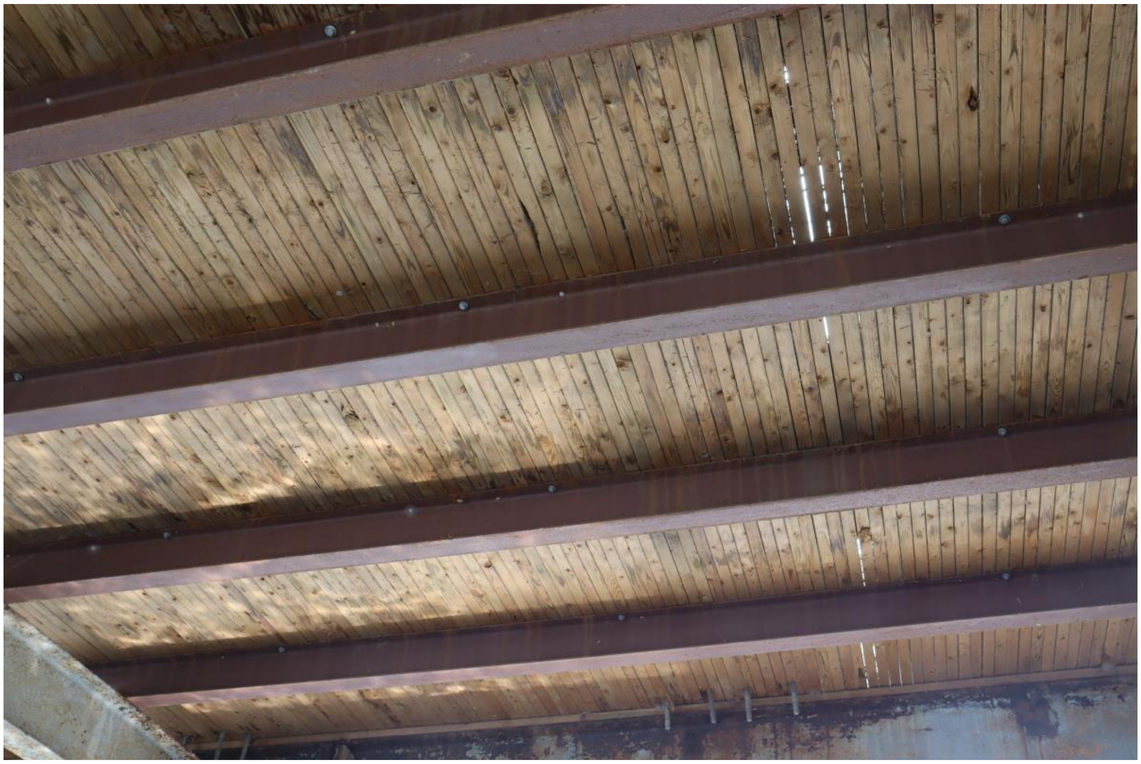

Figure 29: East span west end soffit

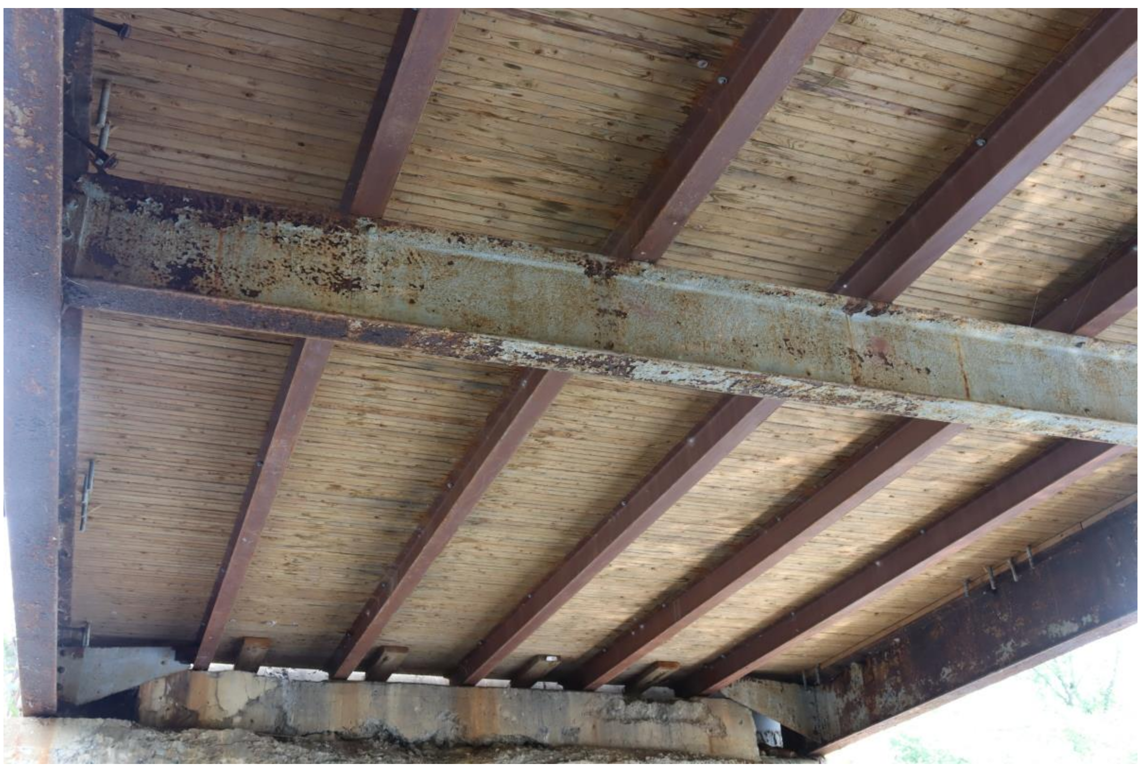

Figure 30: East span east end soffit

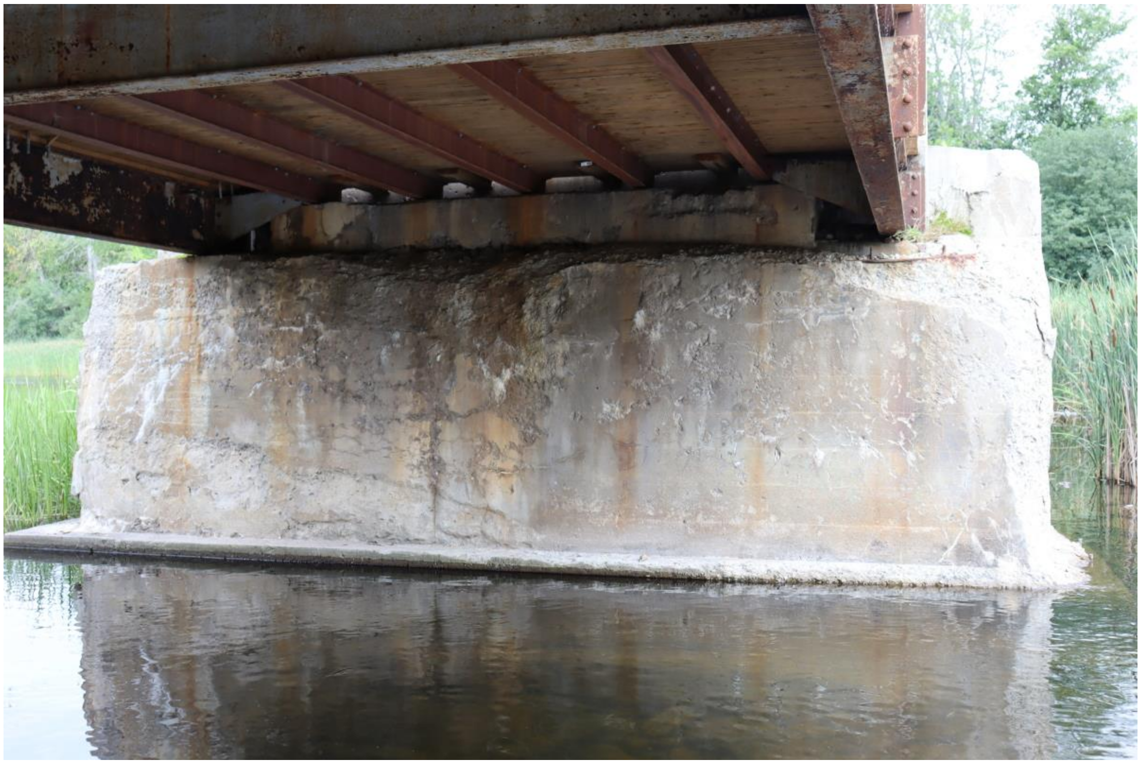

Figure 31: East abutment

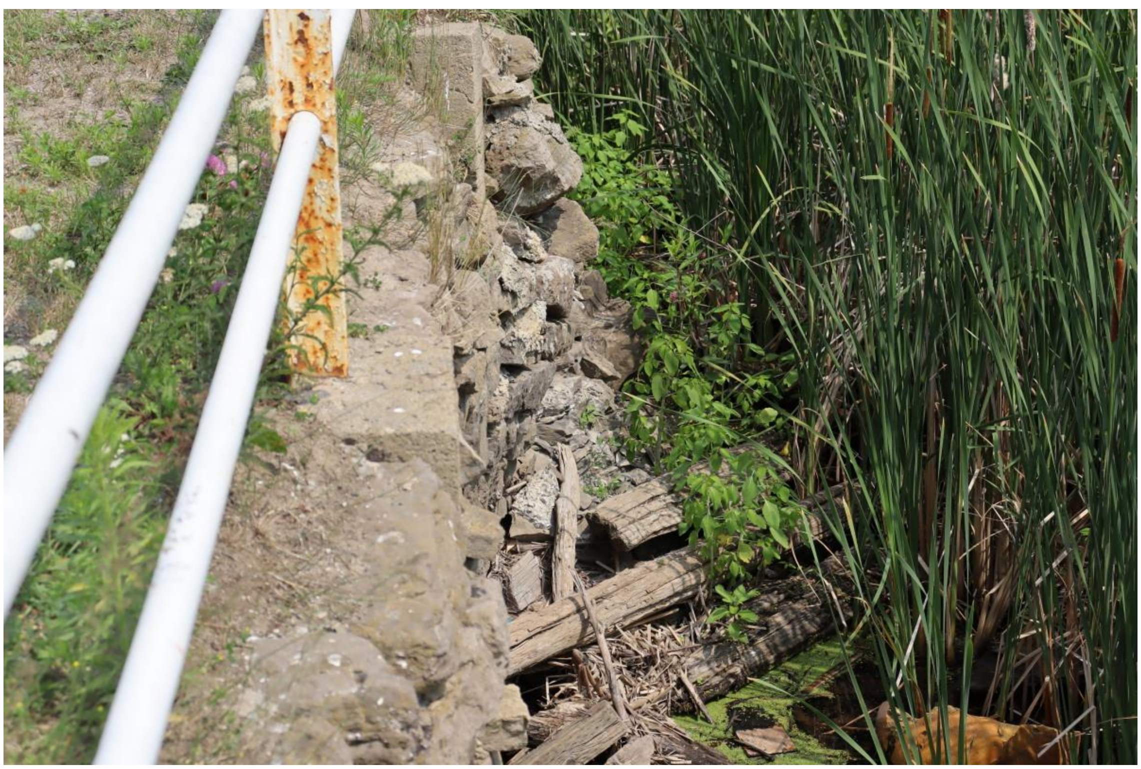

Figure 32: Bulging retaining wall in SE

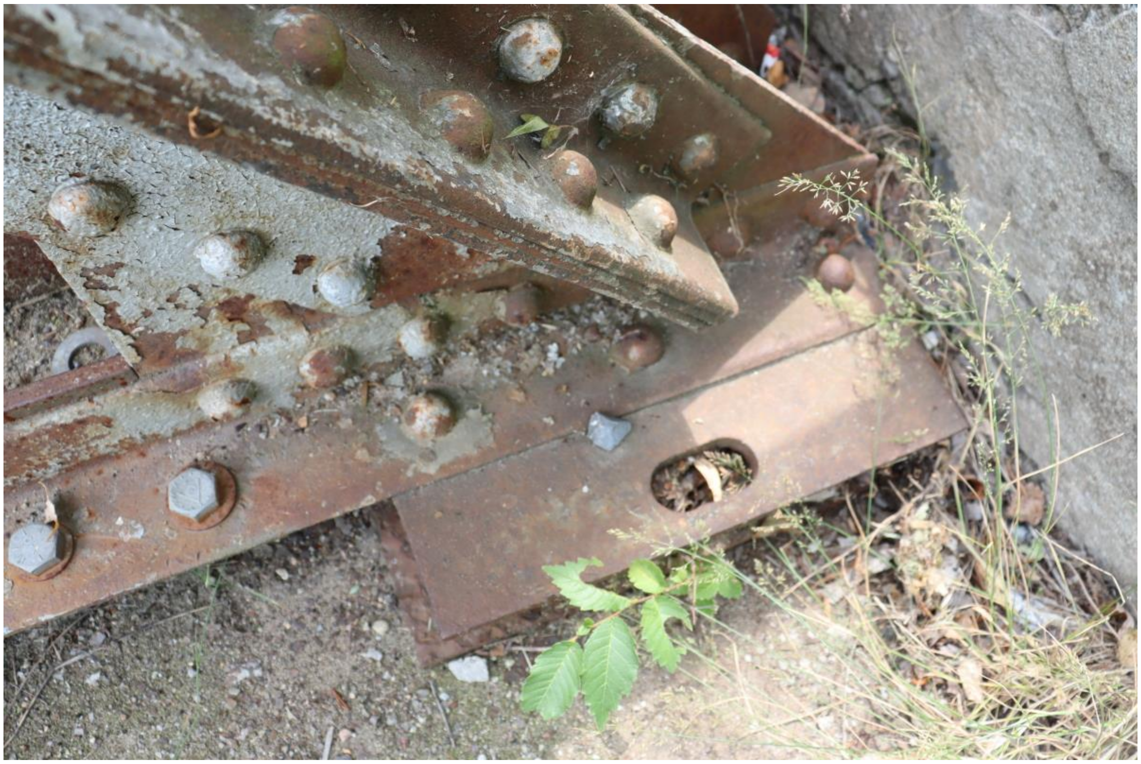

Figure 33: NW truss bearing

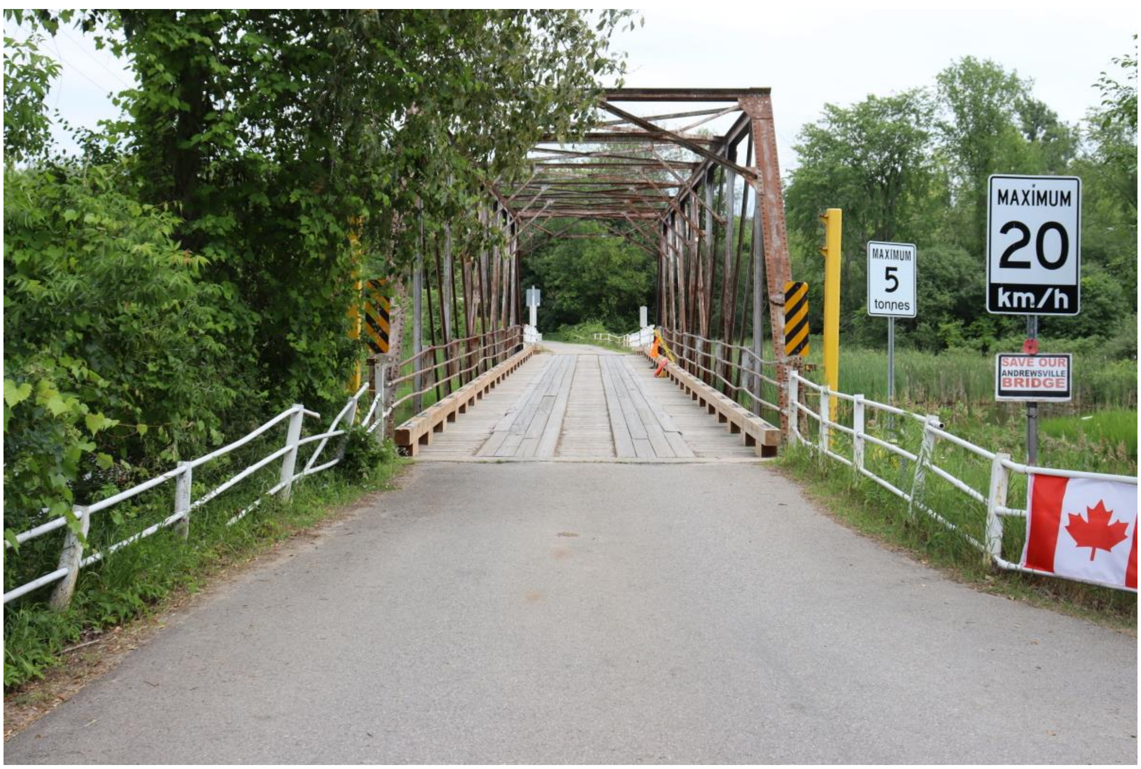

Figure 34: West approach

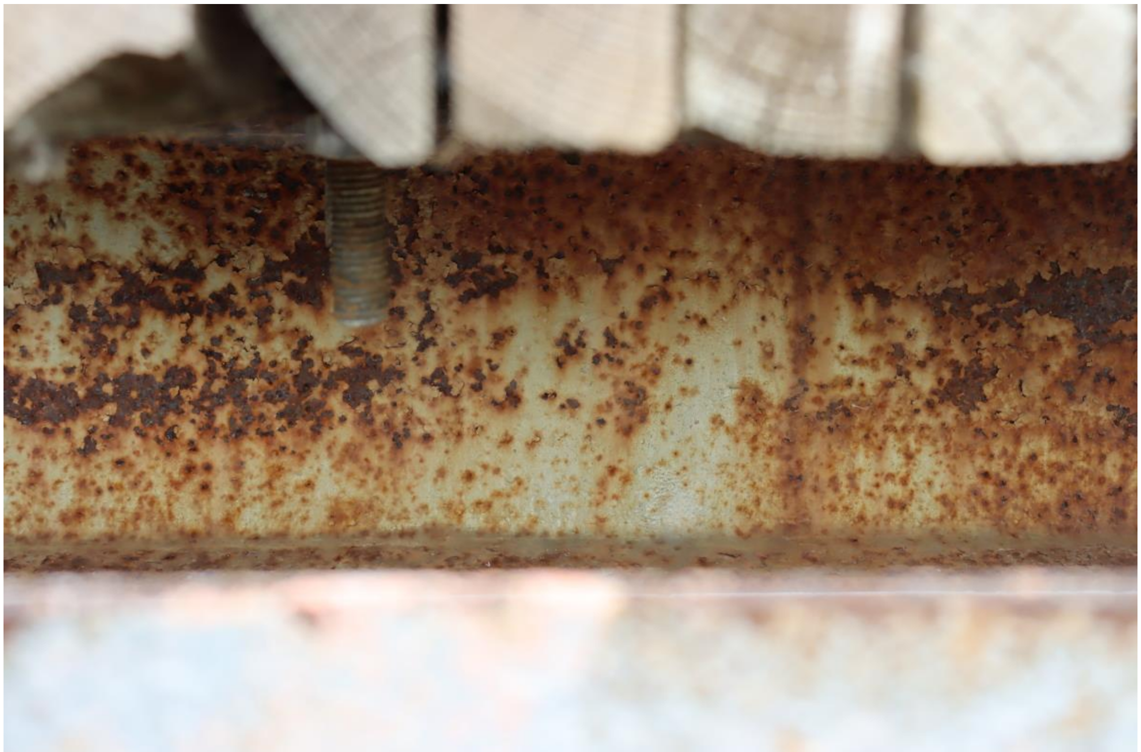

Figure 35: External stringer 1 condition Bay 6

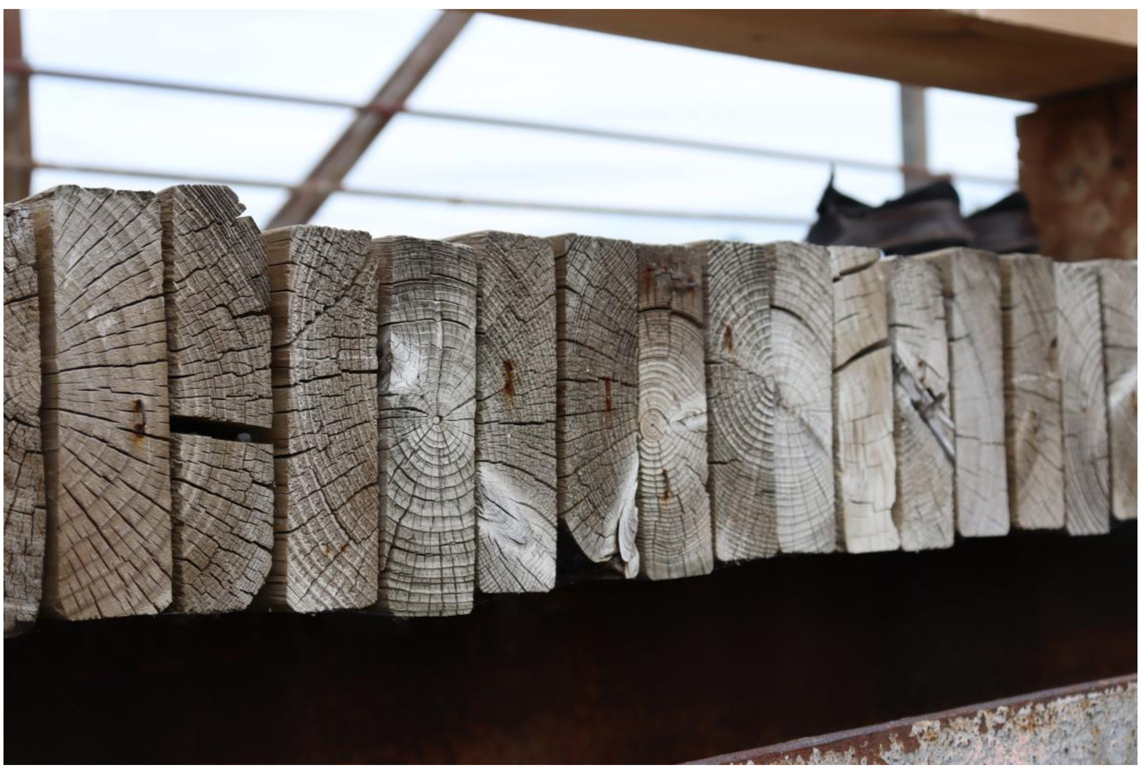

Figure 36: Deck boards end detail

Figure 37: West abutment

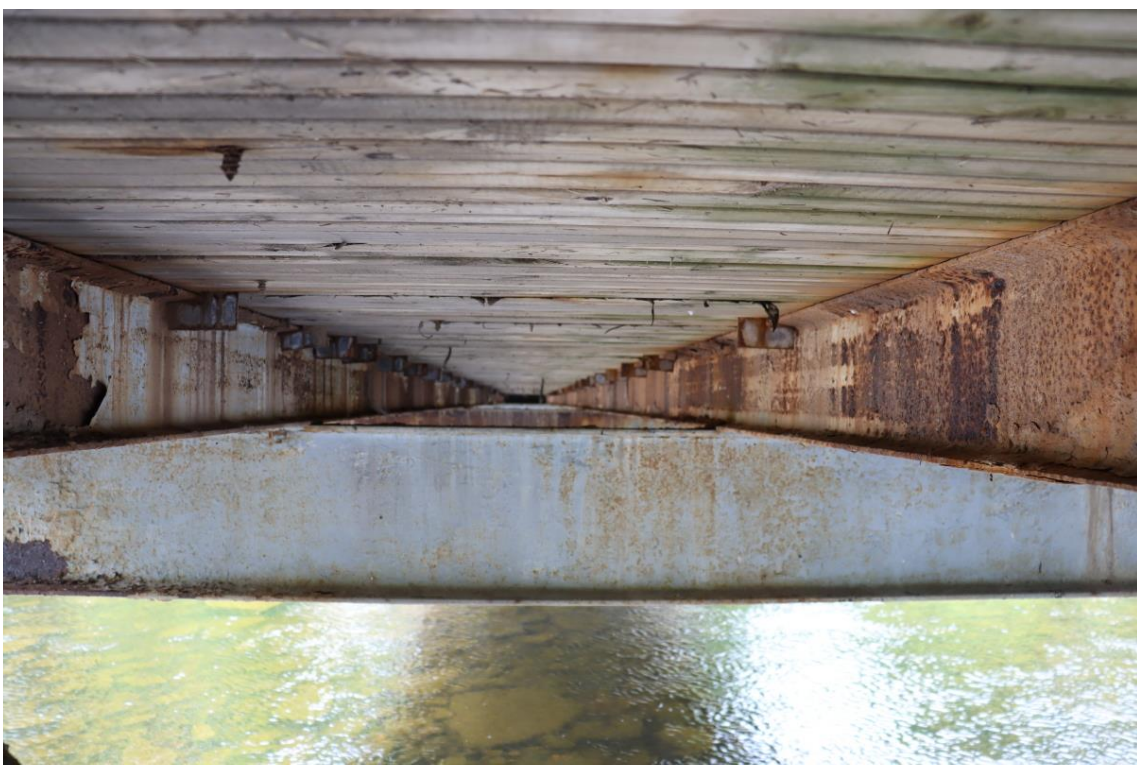

Figure 38: Looking west between stringers 2 and 3

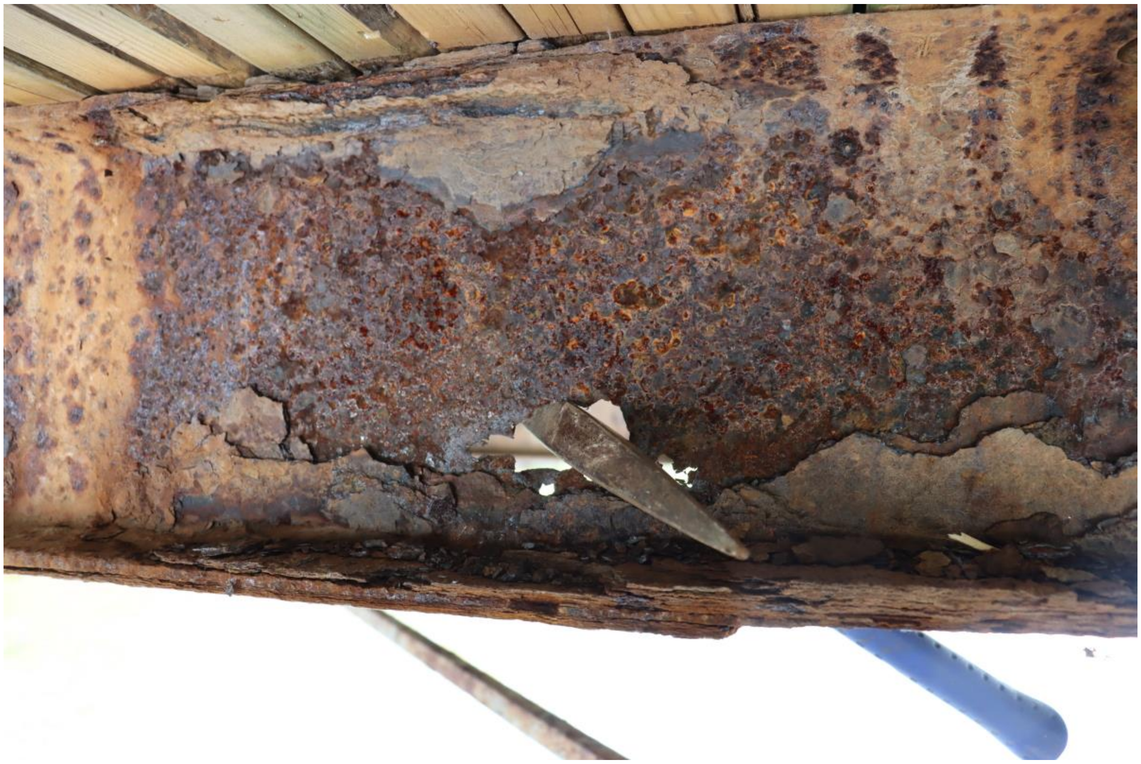

Figure 39: Stringer 3 perforation in bay 5

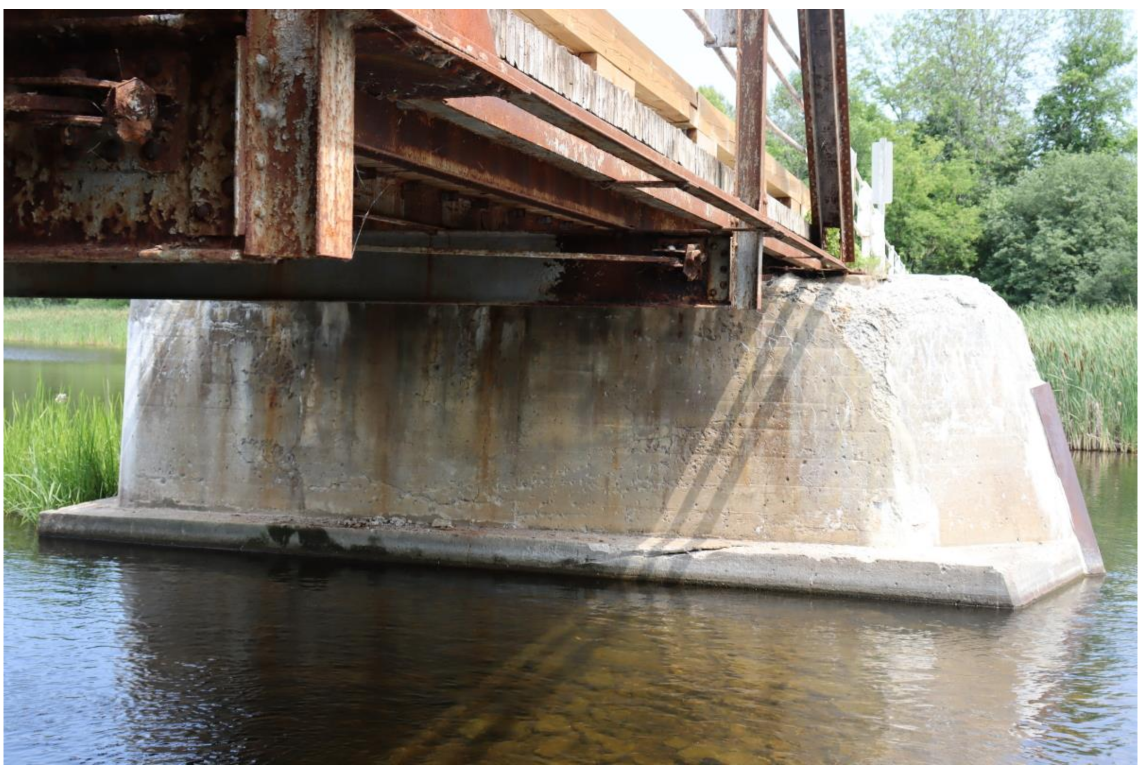

Figure 40: West face of pier

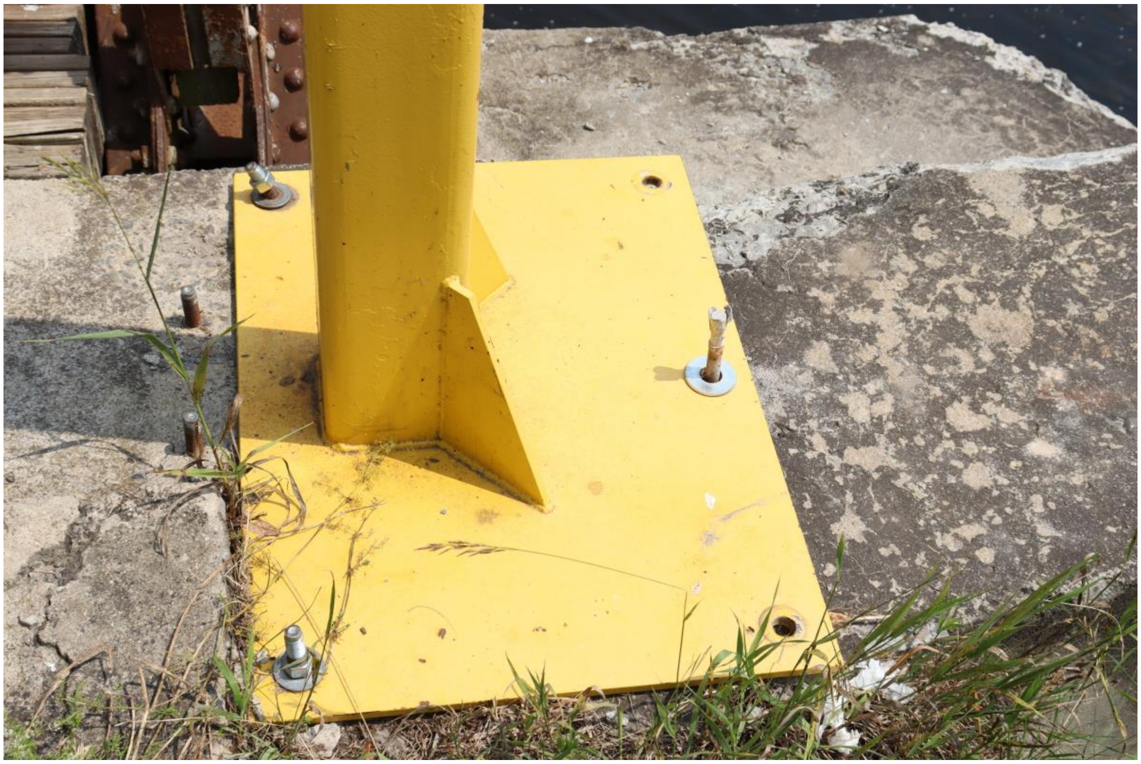

Figure 41: SW portal base

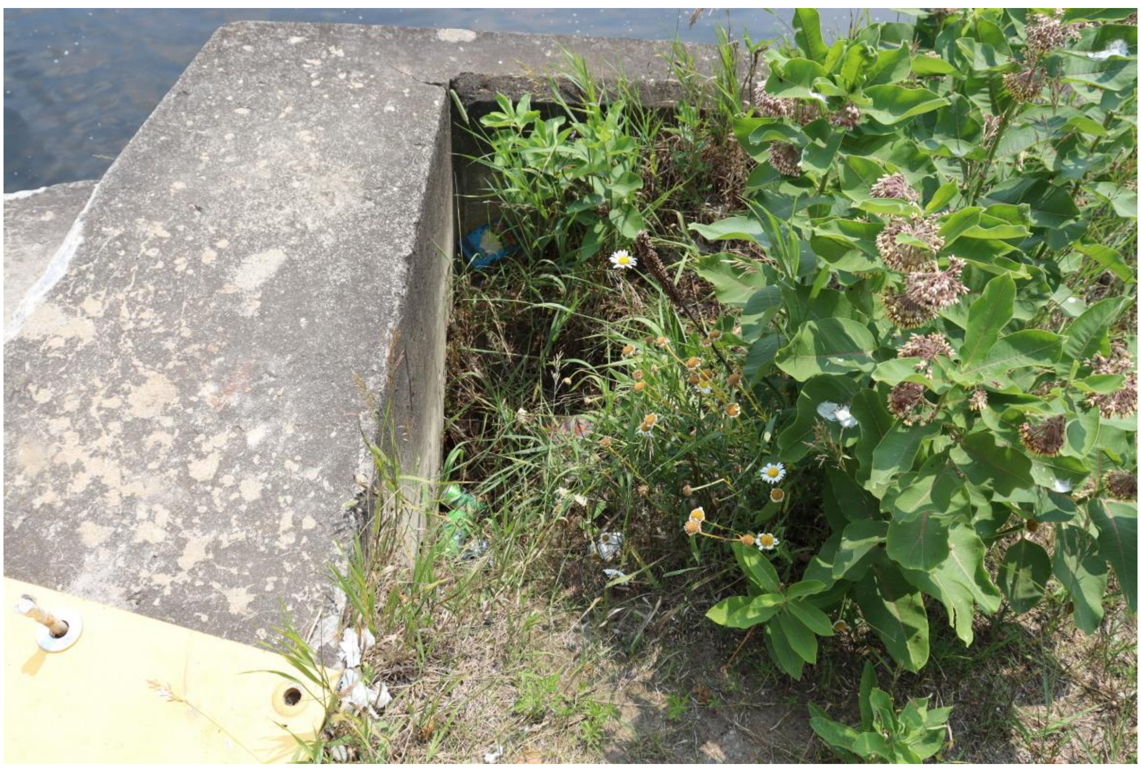

Figure 42: Sinkhole in SW corner

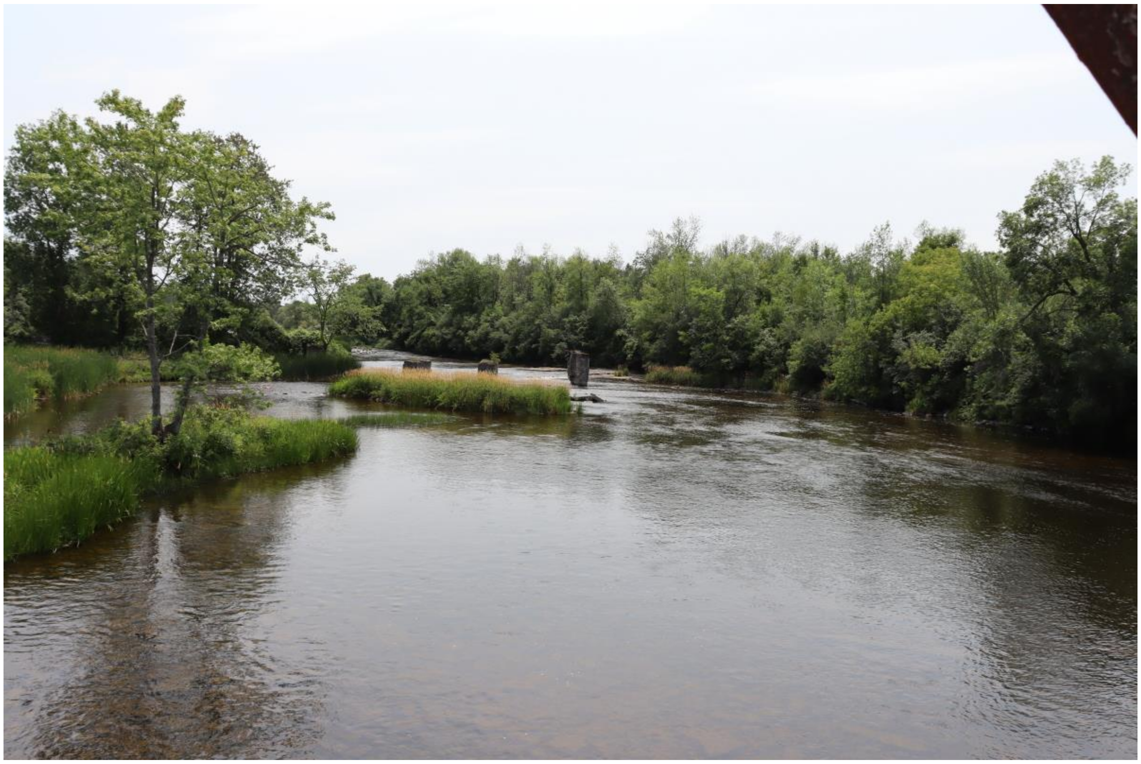

Figure 43: South channel upstream

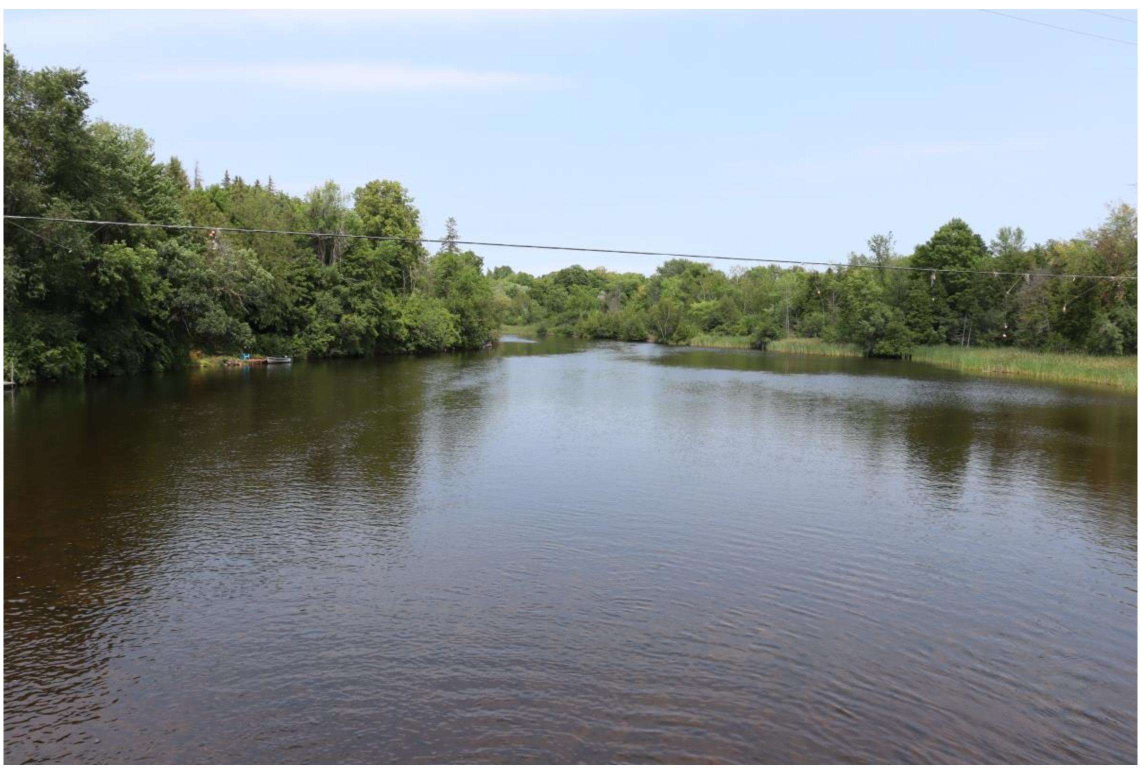

Figure 44: North channel downstream

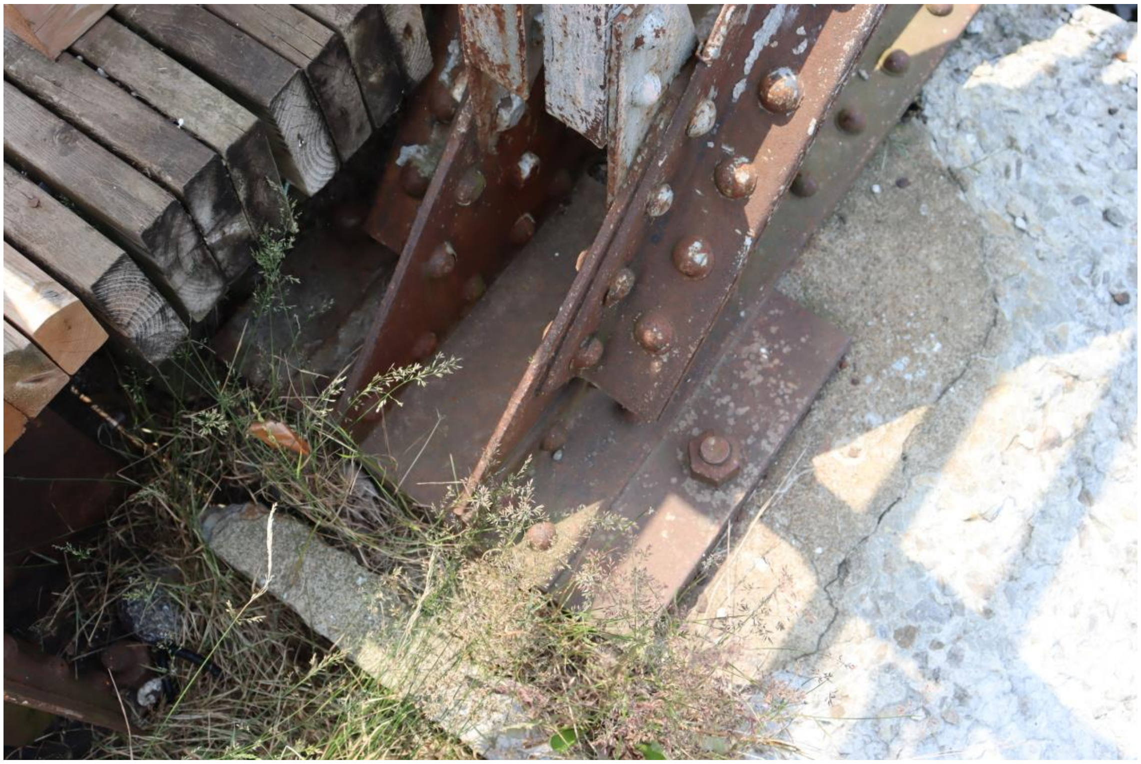

Figure 45: North pier truss bearing

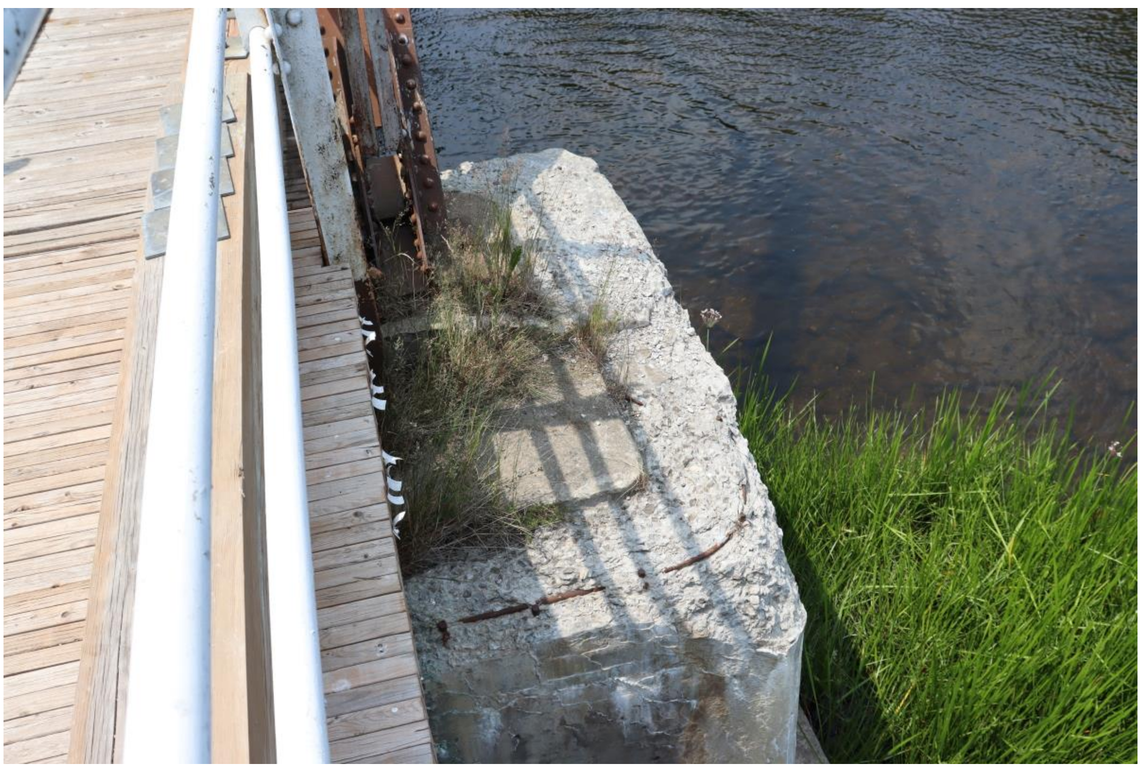

Figure 46: Pier top north end

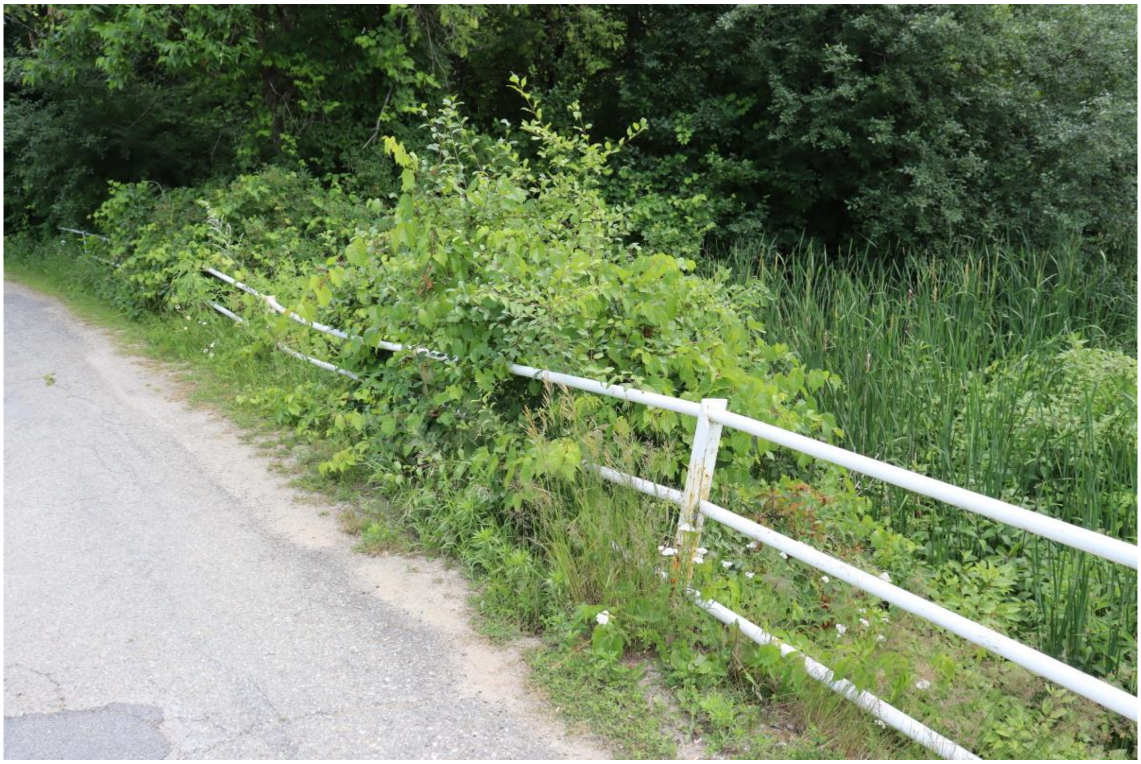

Figure 47: Railing south side of causeway

Figure 48: Bulging retaining wall north-east quadrant

Figure 49: Blocked drainage opening through causeway

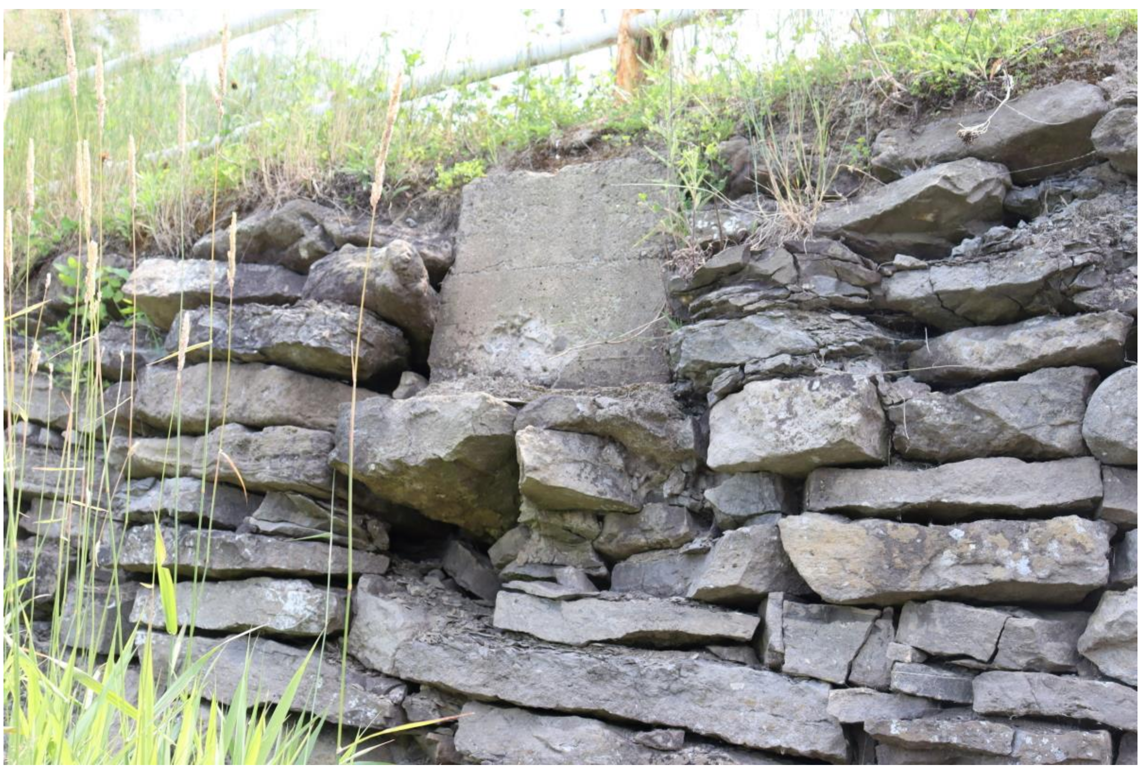

Figure 50: North-east quadrant dry-stone retaining wall

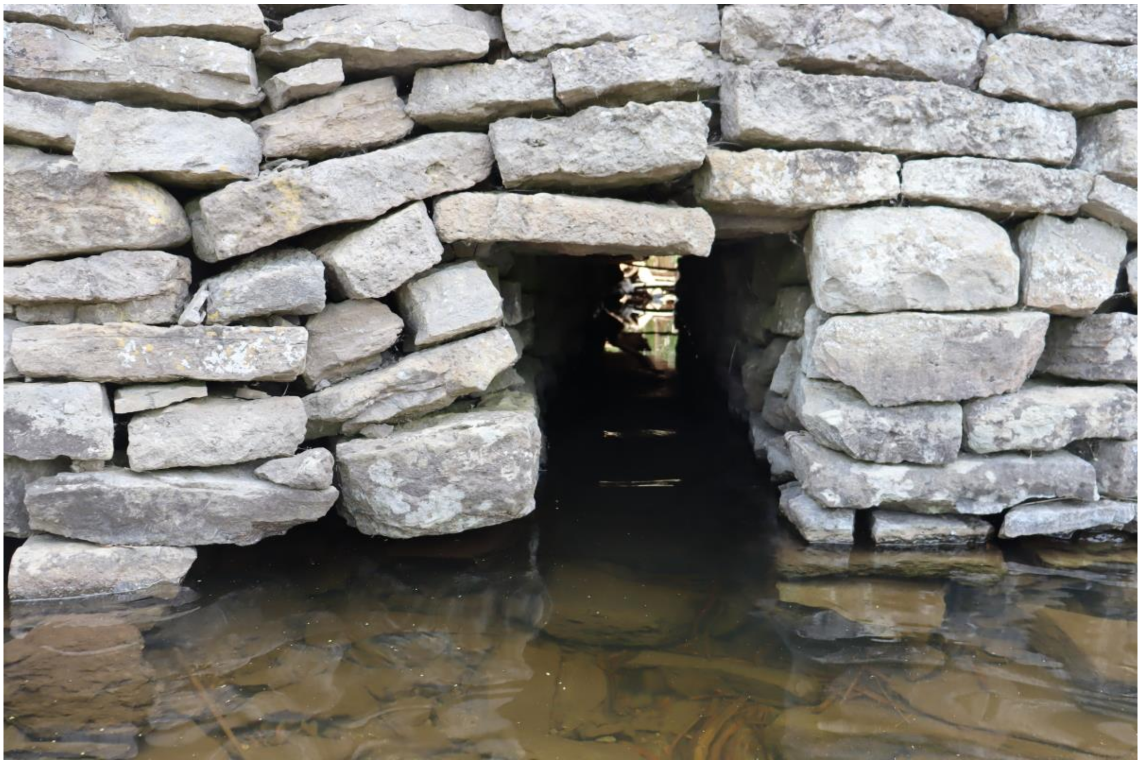

Figure 51: Drainage opening through causeway

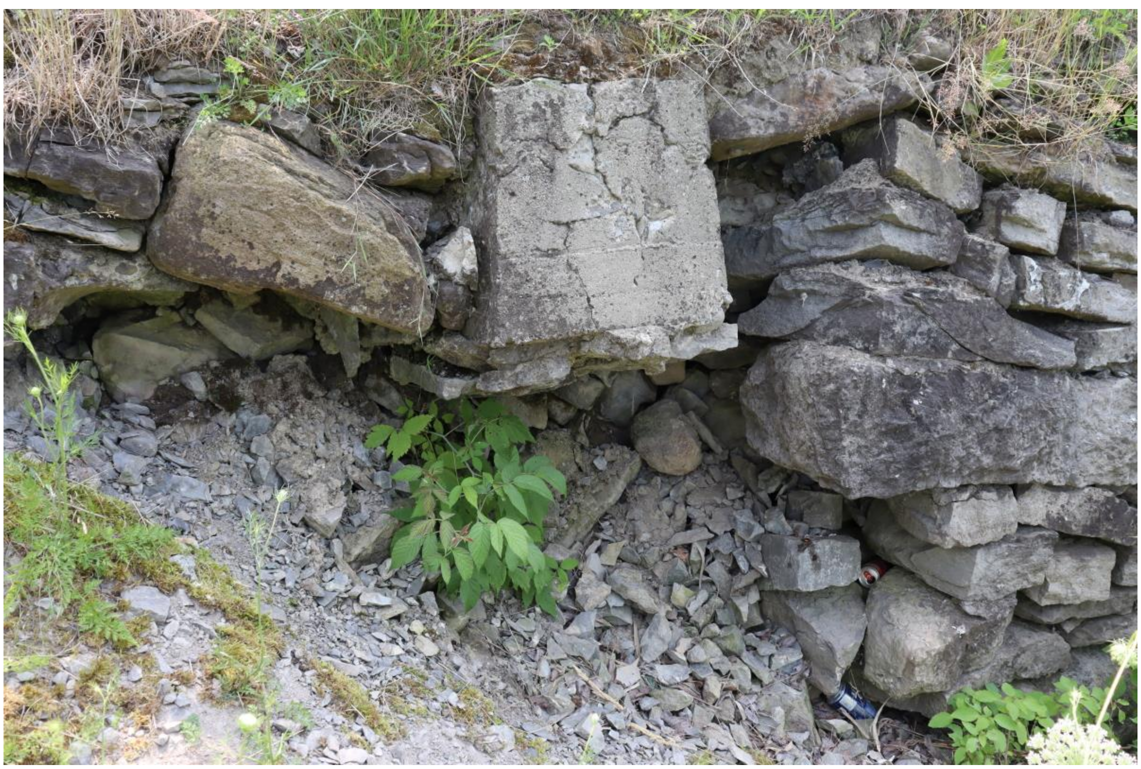

Figure 52: Undercut railing base in north retaining wall east end

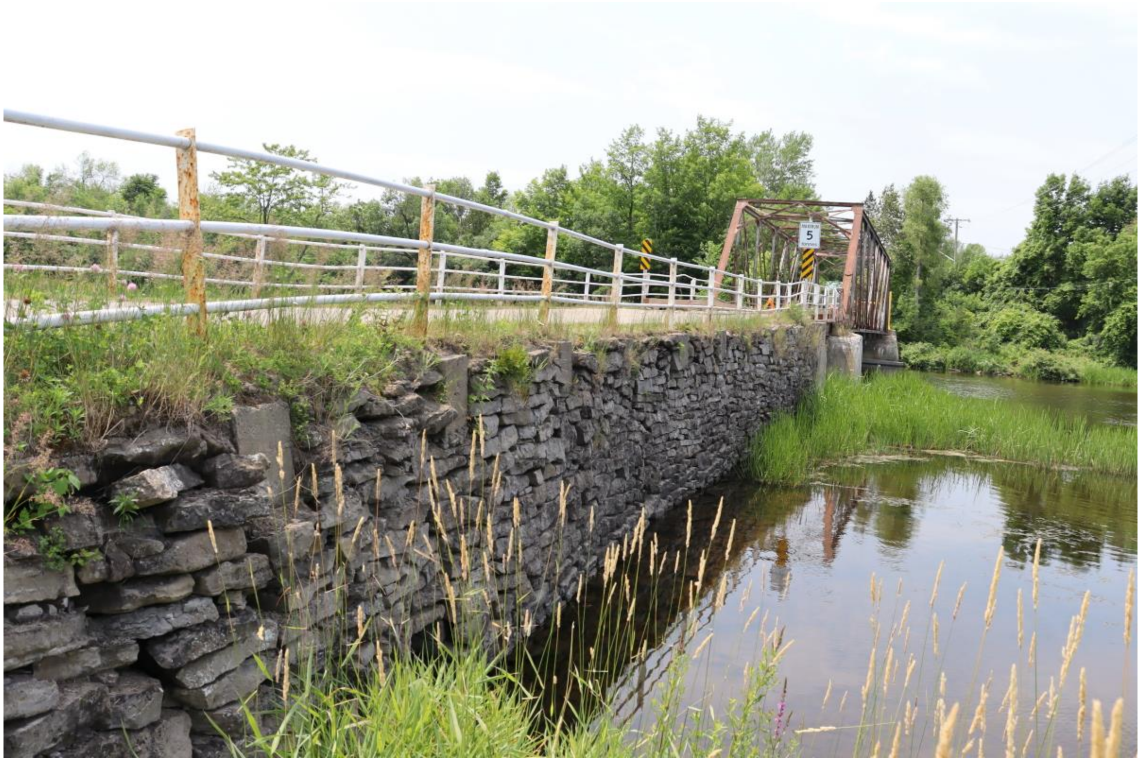

Figure 53: North dry-stone retaining wall east approach

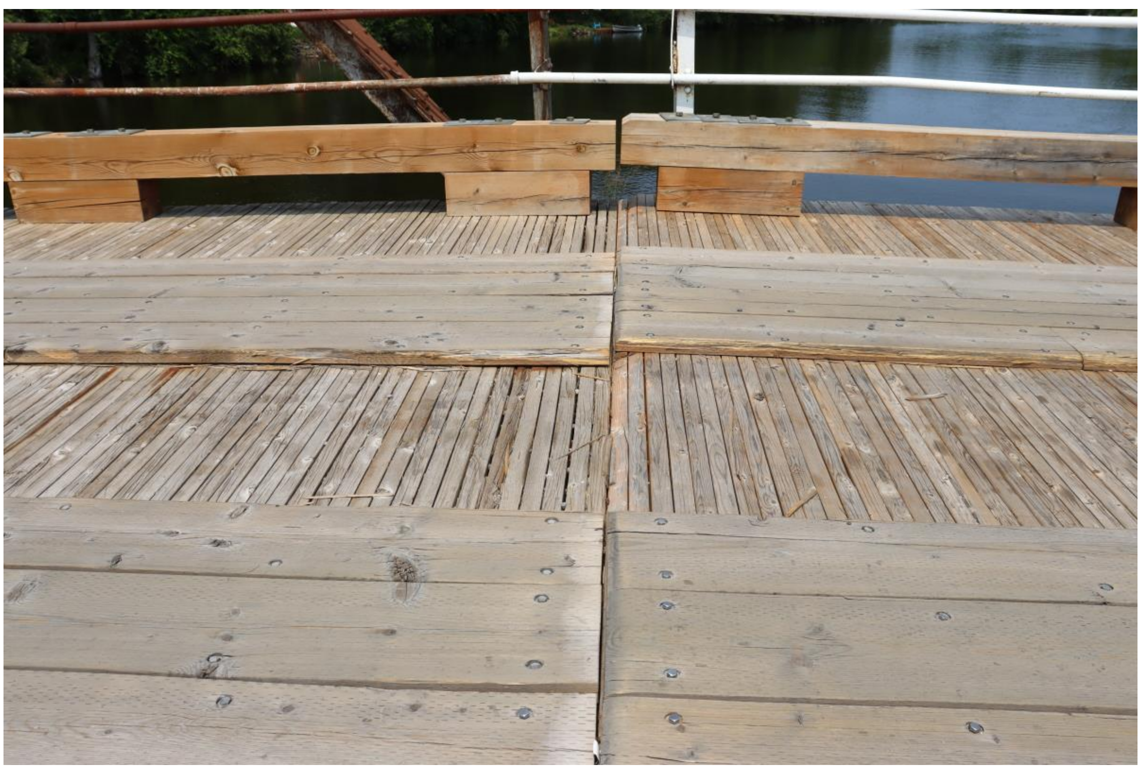

Figure 54: Grade change / bump over pier

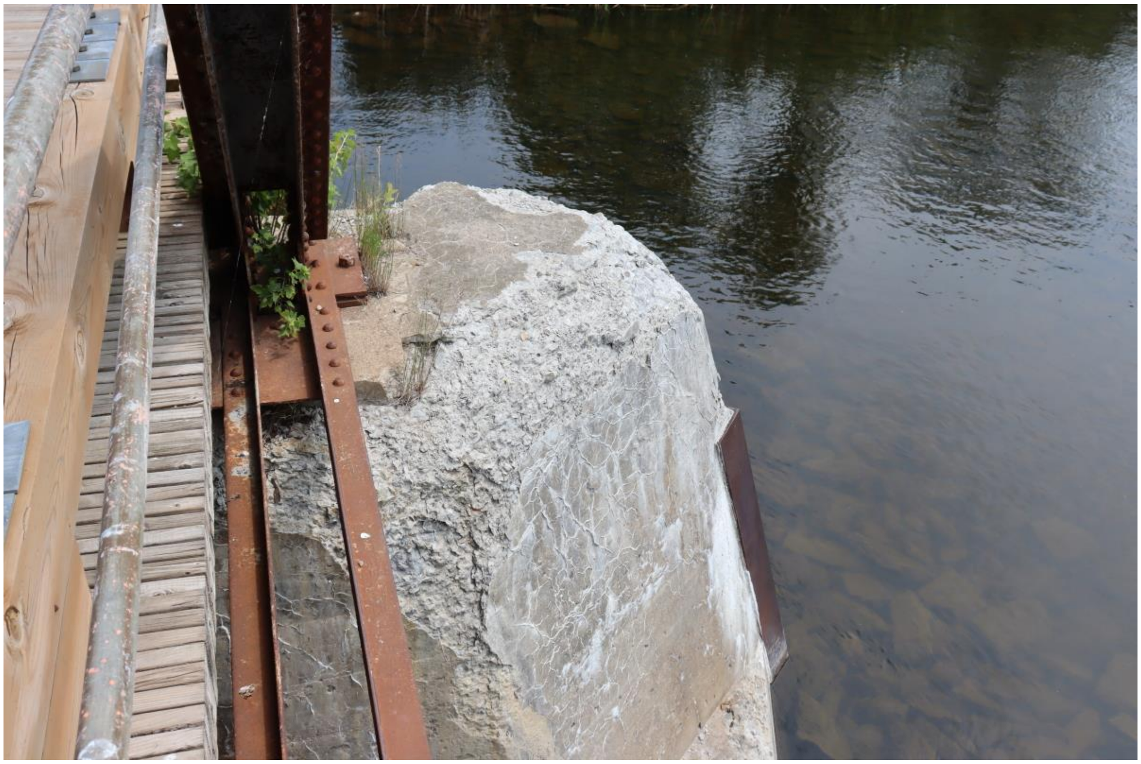

Figure 55: Pier top south side from west

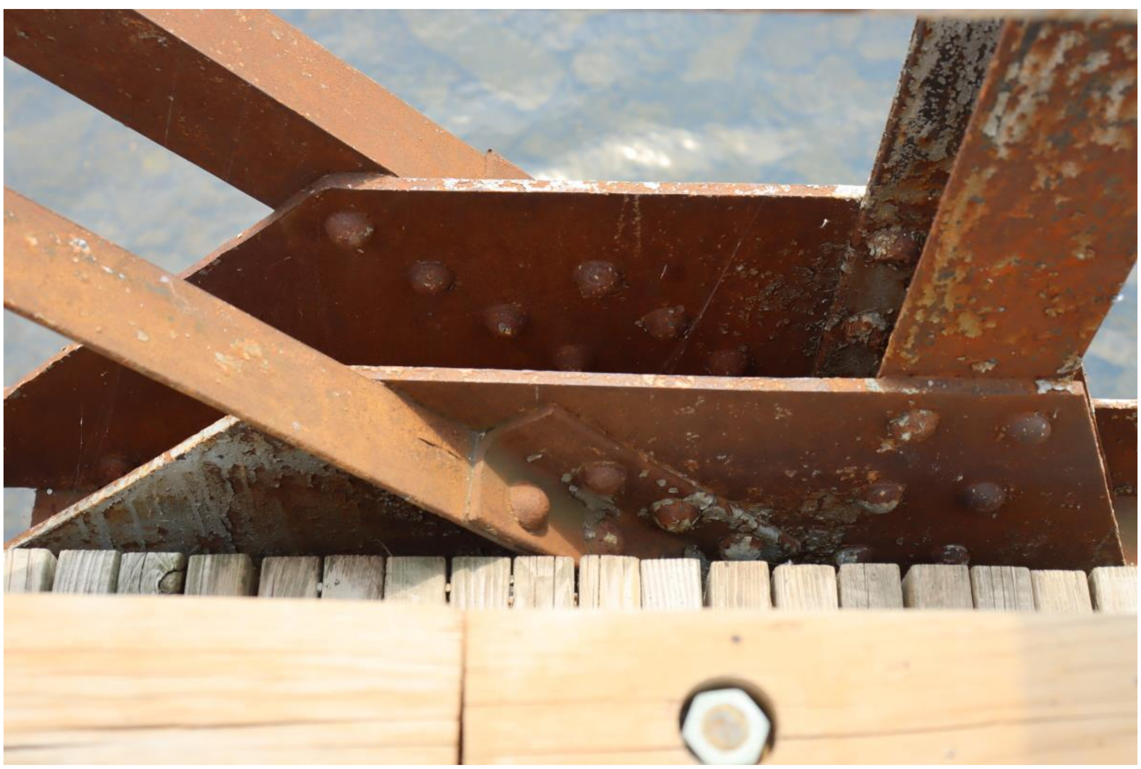

Figure 56: Typical bottom chord connection

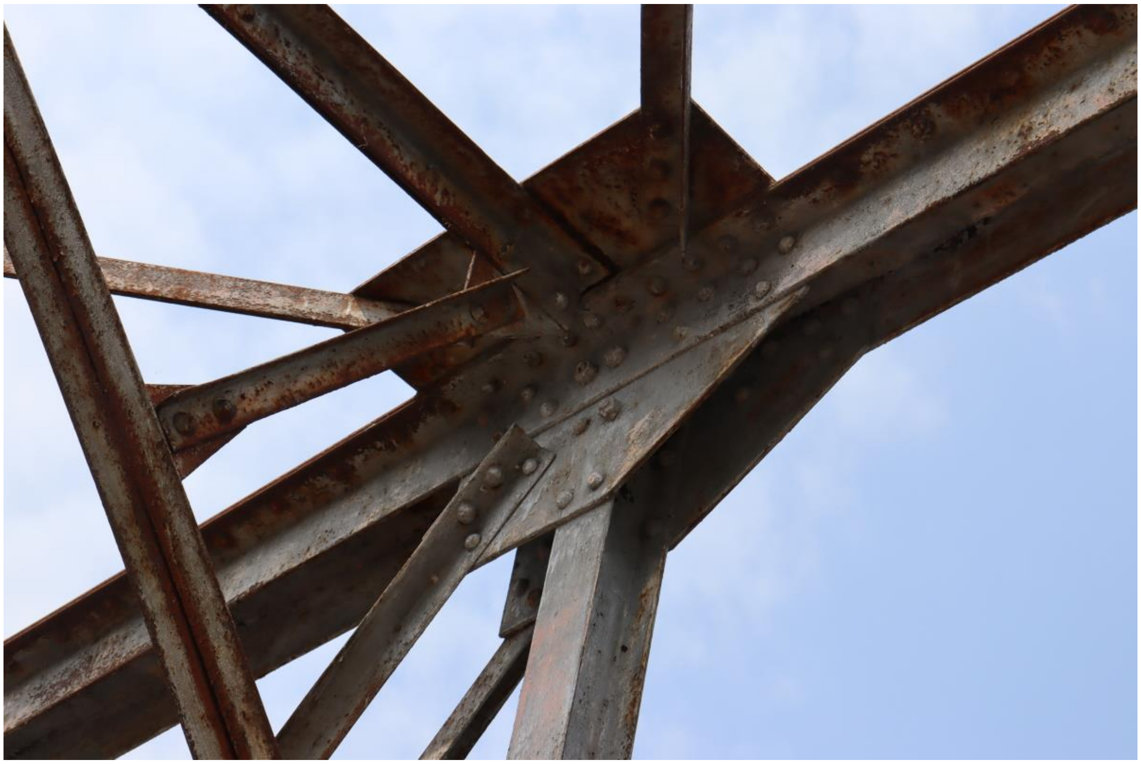

Figure 57: Typical top chord connection

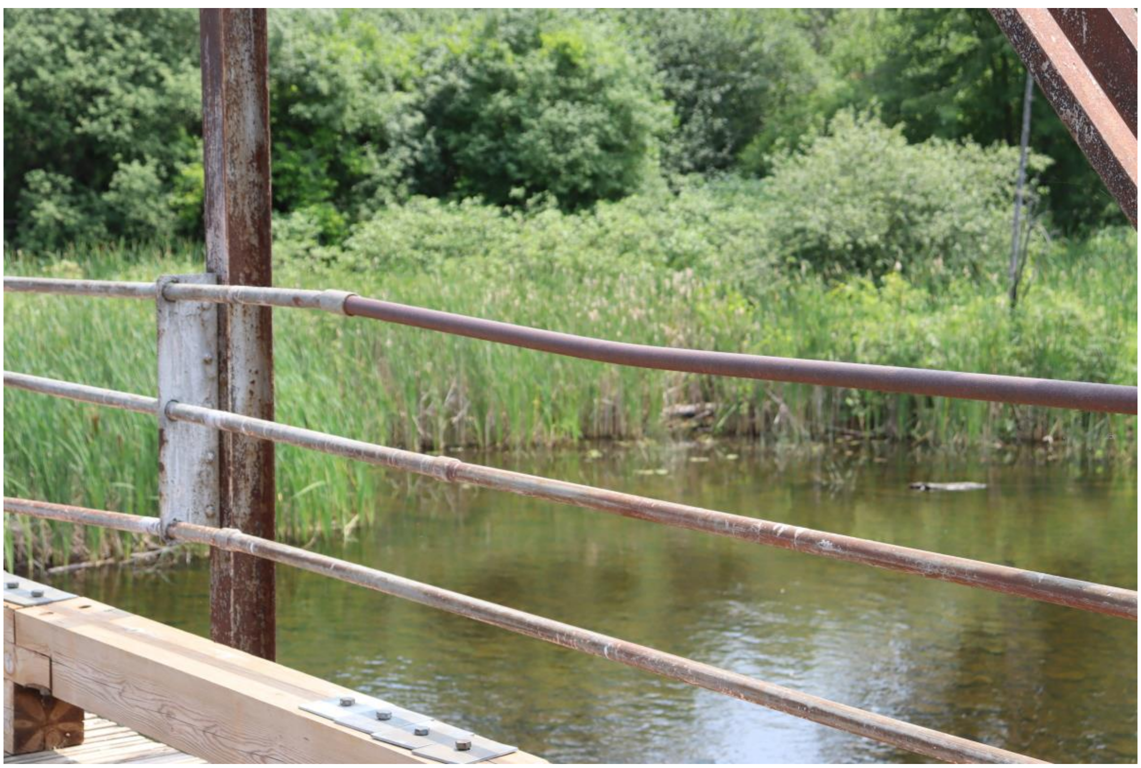

Figure 58: South pipe railing

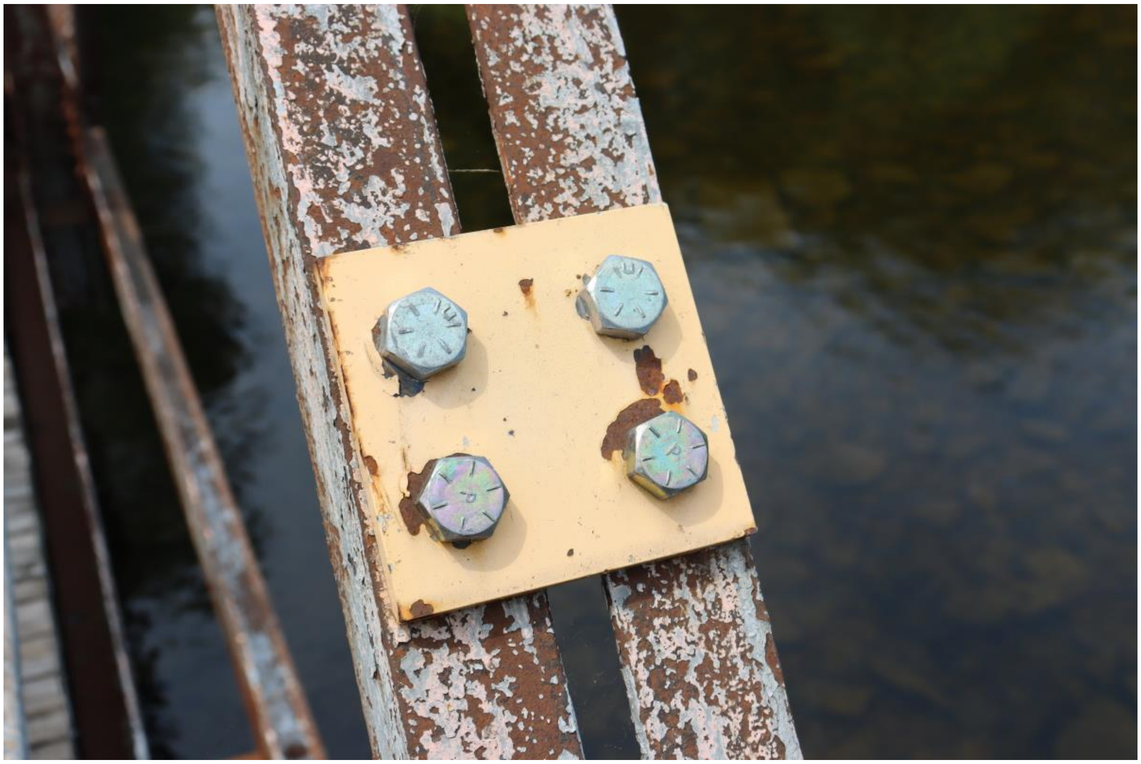

Figure 59: Typical compression diagonal bracing tie plate

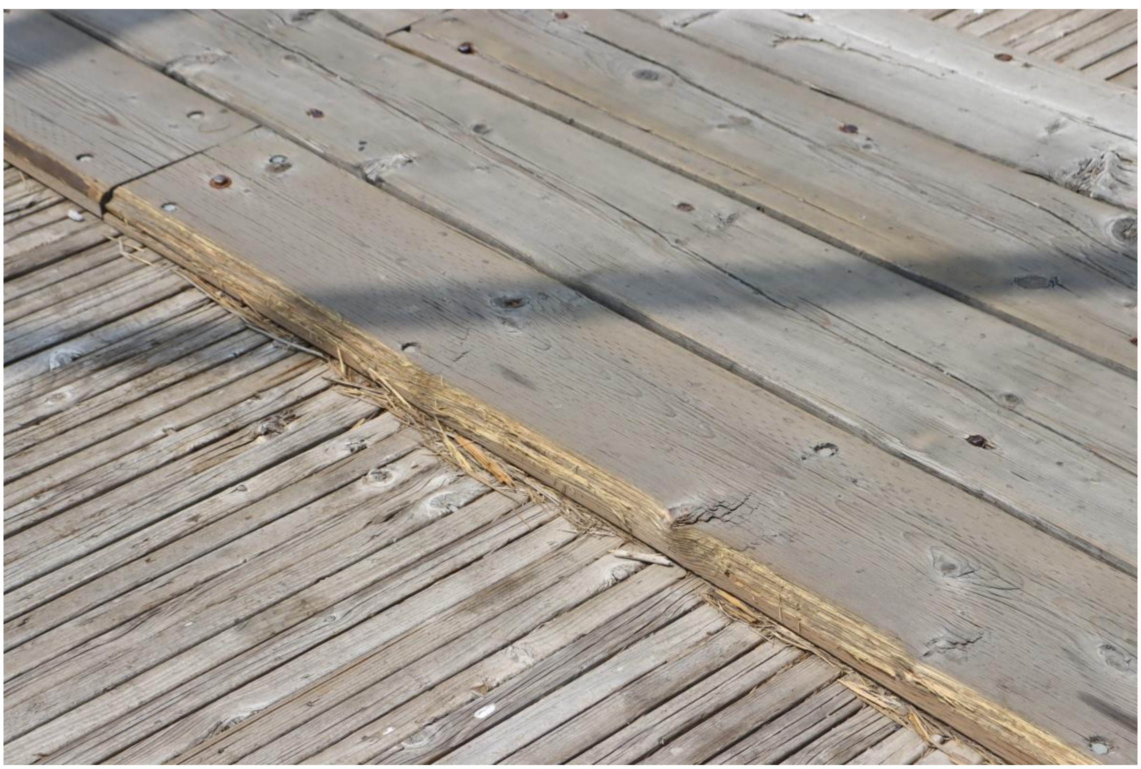

Figure 60: Damaged running boards

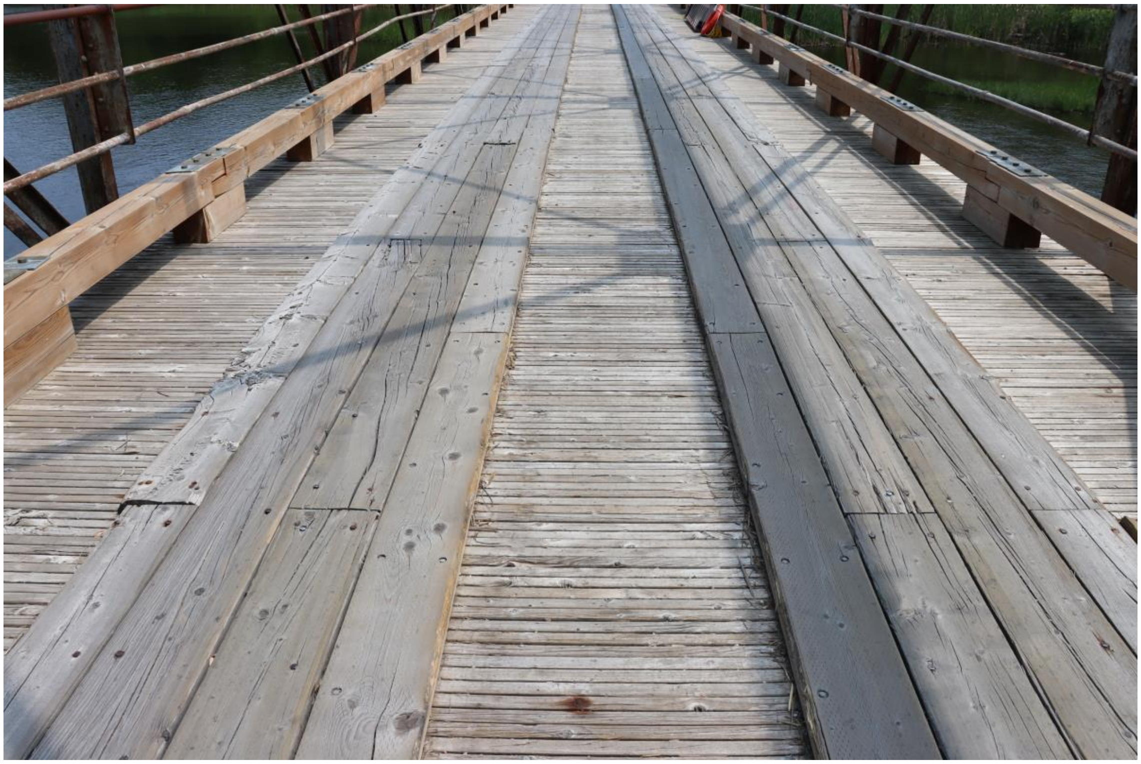

Figure 61: Deck surface looking west

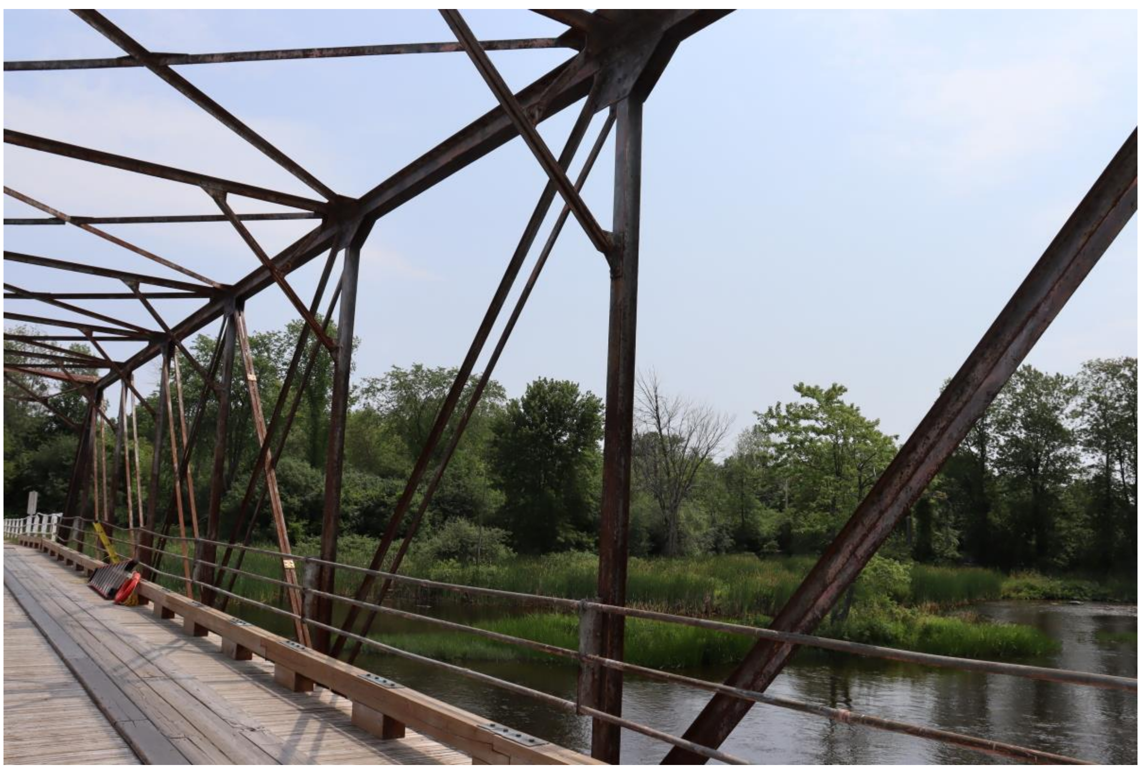

Figure 62: South side truss

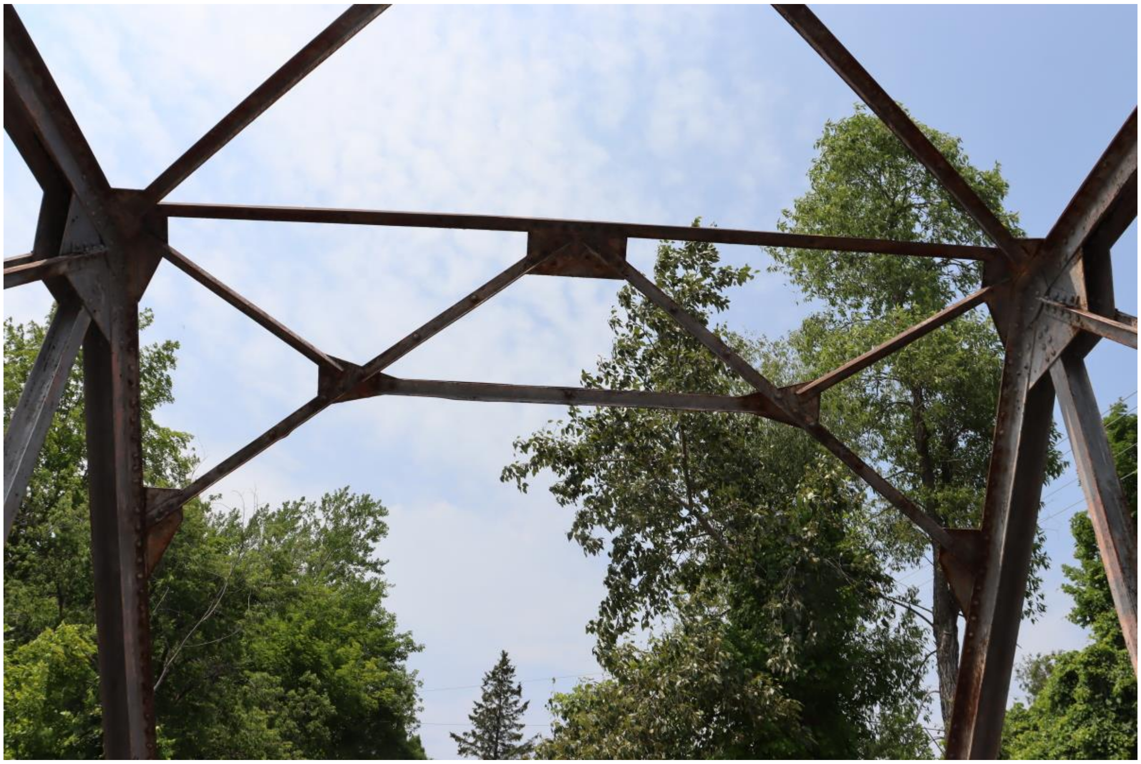

Figure 63: West portal

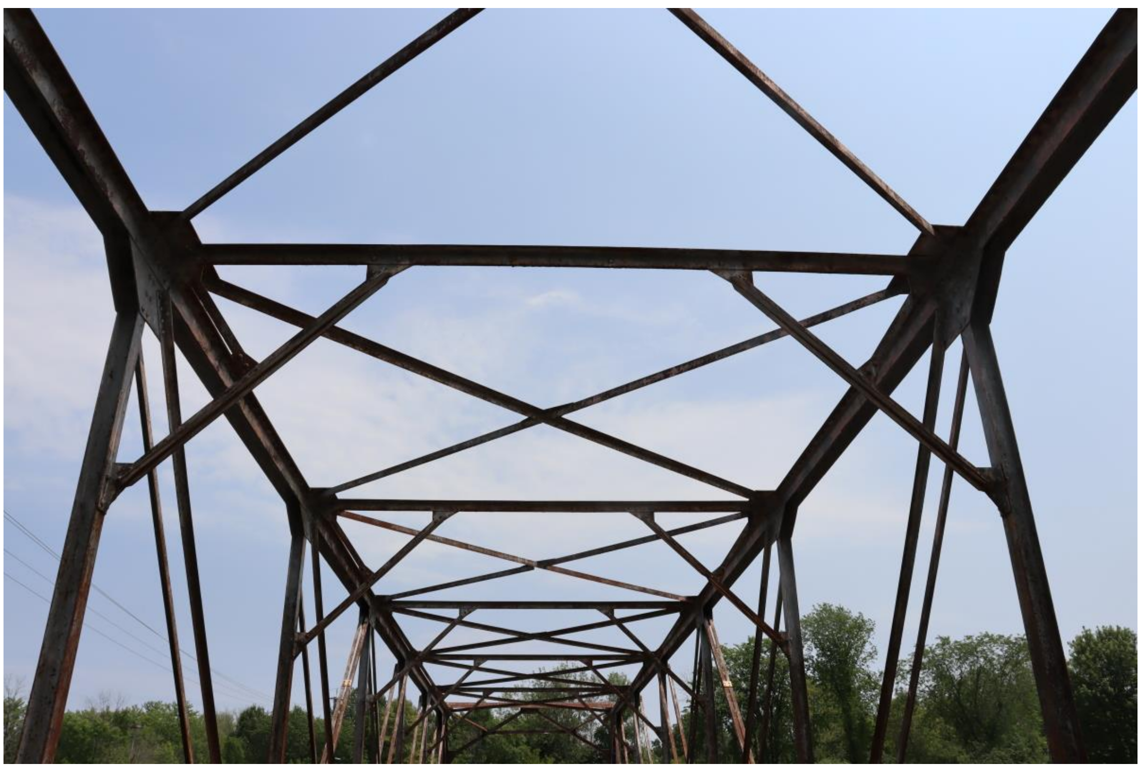

Figure 64: Wind and sway bracing

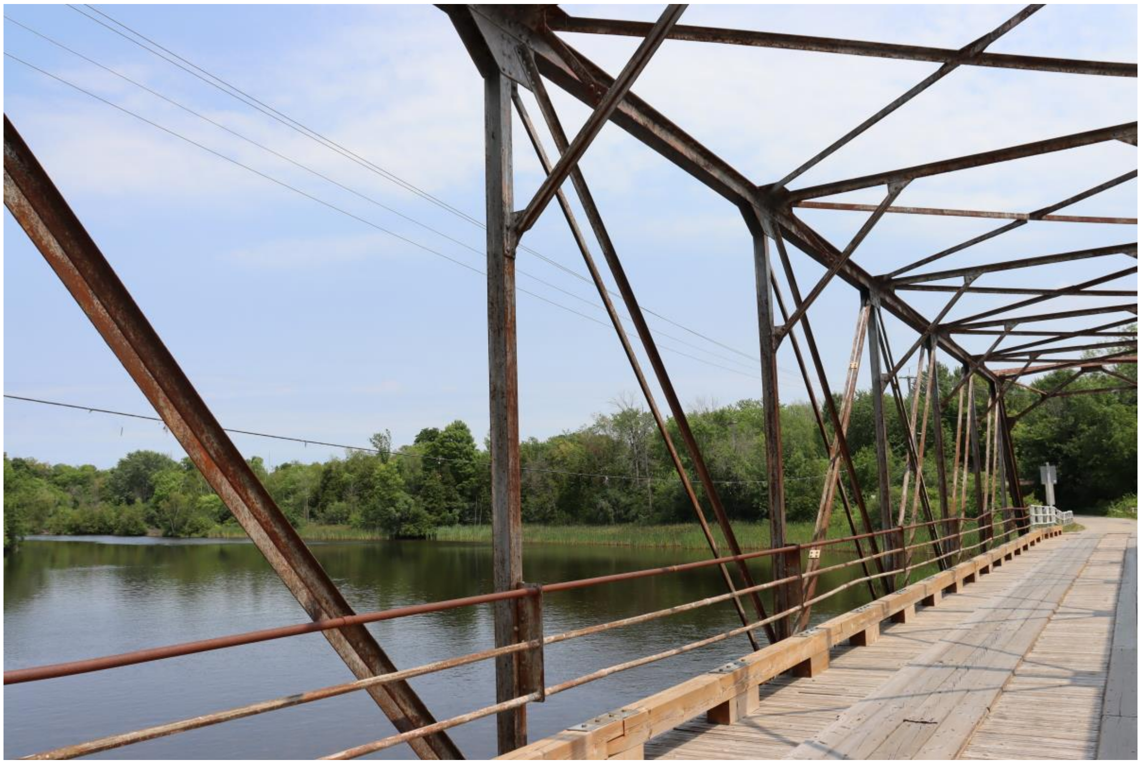

Figure 65: North truss

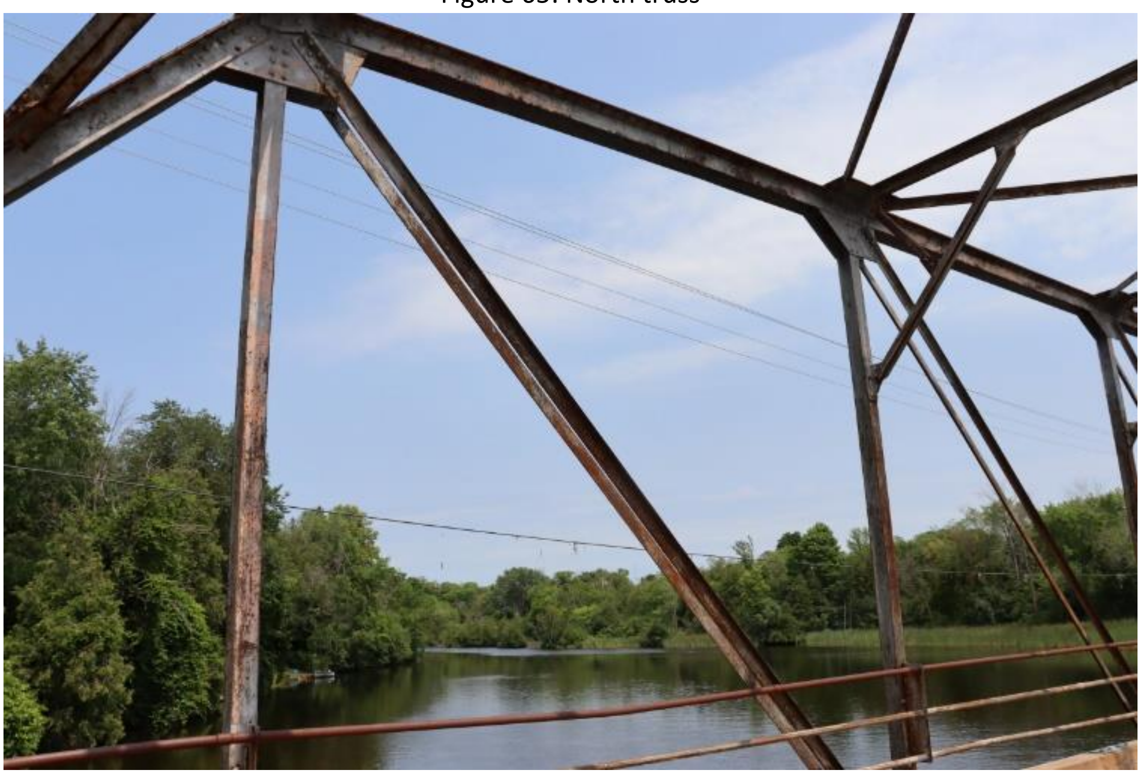

Figure 66: North truss section

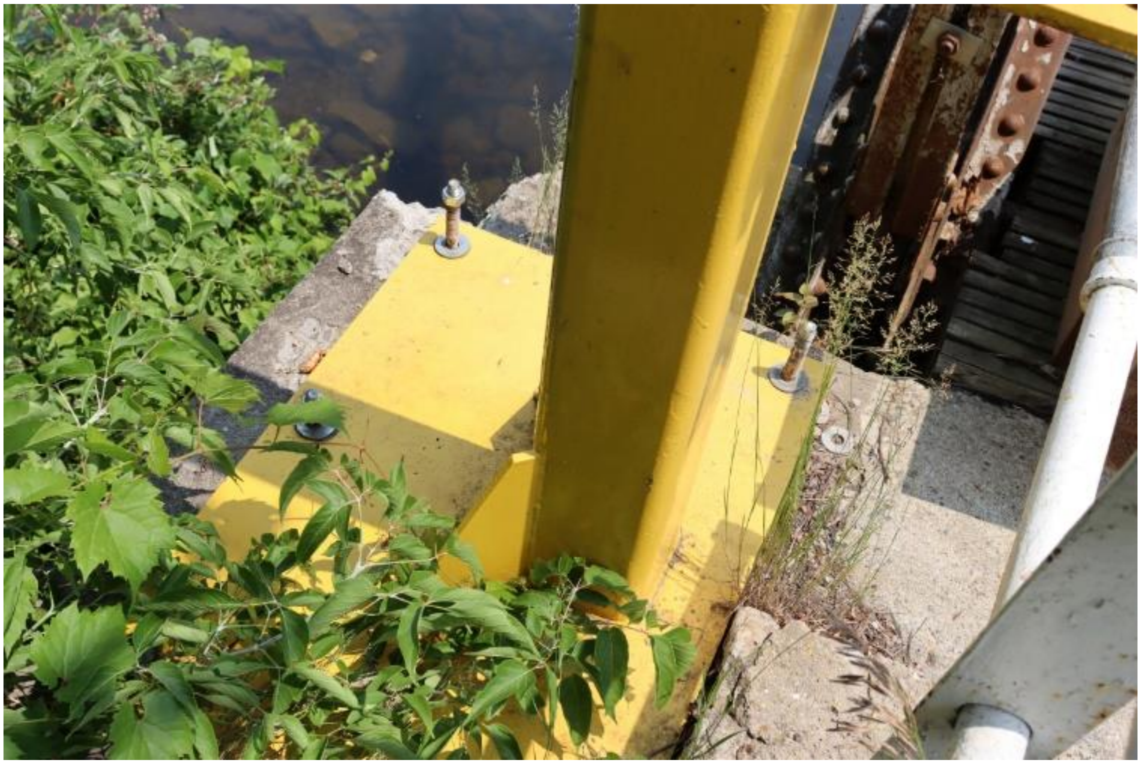

Figure 67: NW portal base

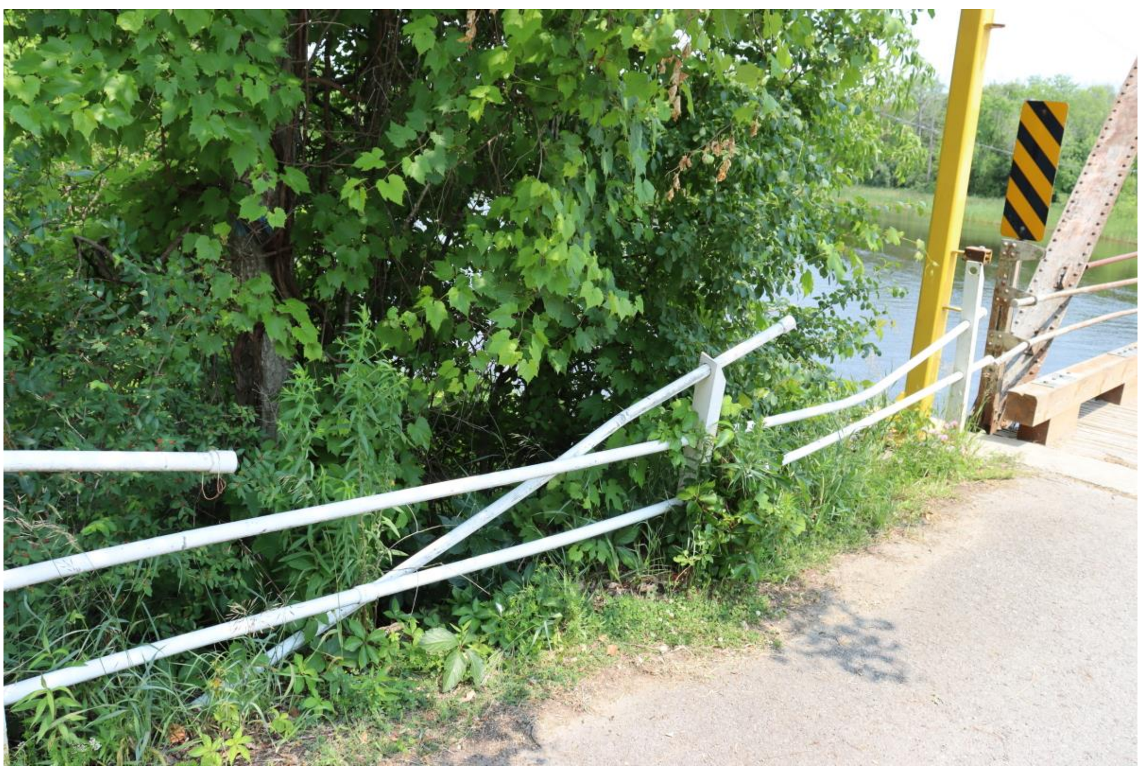

Figure 68: NW damaged approach railing