Inspection Report
8/1/16 – 8/2/16

Frank J. Wood Bridge #2016
over
Androscoggin River

Brunswick - Topsham, Maine

STP-2260(300)
WIN 022603.00

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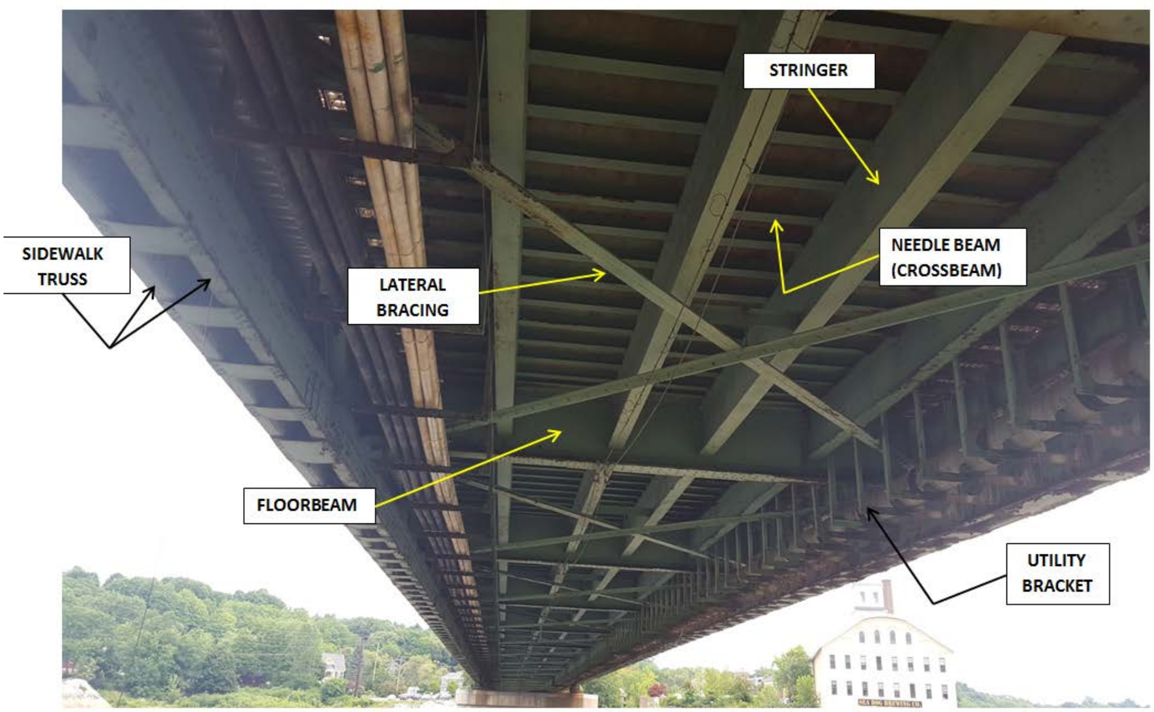
BACKGROUND AND GENERAL NOMENCLATURE

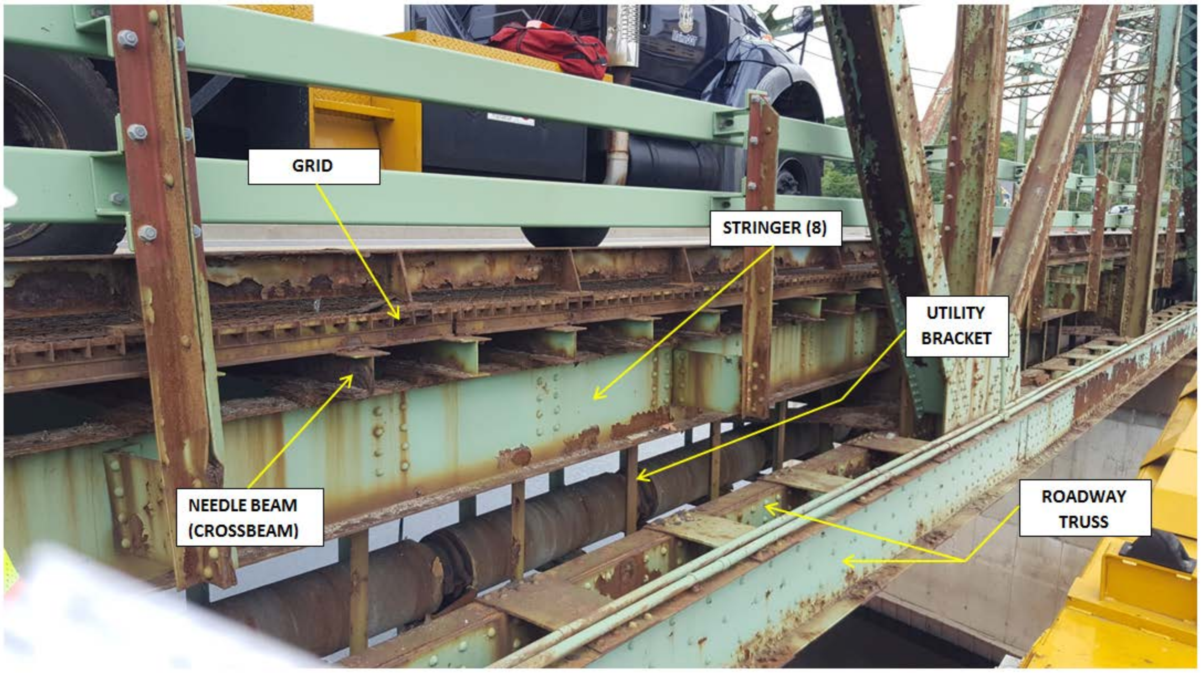
BACKGROUND

A joint field inspection was performed from 8/1/16 to 8/2/16 by representatives from the Bureau of Project Development and Maintenance & Operations, MaineDOT, in an effort to provide additional insight on the condition of Frank J Wood, Bridge #2016. This special inspection was designed to summarize and confirm advanced deterioration, target expected repairs over the next 5 years as well as carefully review issues involving rehabilitation alternatives of 30 - 75 years. Utilizing an earlier results of NBI Bridge Inspection Conducted 6/16/2016 by the Department, Bridge Load Rating results prepared by Parsons Brinckerhoff – March 2013, results of a Routine And Fracture Critical Bridge Inspection Report by Parson Brinkerhoff – 8/20/2012 and interim Department inspections, the team was able to focus on component/attachment conditions of interest effectively. This most recent NBI Bridge Inspection dropped the superstructure rating from 5 to 4 prompting this field work and report.

GENERAL NOMENCLATURE



Typ. nomenclature of Frank J Wood Bridge – looking north from Abut. 1 to Pier 1, in Span 1.



Typical Nomenclature of Frank J Wood Bridge – Looking Northwest midspan of Span 2.

PART A - 5 YEAR REPAIR

EXECUTIVE SUMMARY

Part A of this report focuses on possible repairs within the next 5 years on the MaineDOT Bridge #2016 (Frank J Wood) carrying Routes 201 and 24 over the Androscoggin River in Brunswick and Topsham, Maine. The inspection revealed & confirmed deterioration of this 3 span riveted through truss essentially in Floorbeams, Stringer connections and Truss rivet issues.

- Span 1 – Floorbeam Section Loss in Shear Area, Stringer Connections.
- Span 2 – Floorbeam Cover Plate Distress in Moment Area.
- Span 3 – Stringer Connections, Truss Lower Chord Rivet Deterioration.

There may also be eventual repair work needed in the deck structure (Needle Beam & Grid) as well as utility brackets in order to reach the 5 year mark.

The most significant finding is the loss of section (holes rusted through) in the shear area of 3 Floorbeams (7, 5 & 2). A recalculation of the Load Rating for Floorbeam 7 resulted in a drop from 0.66 to 0.51 or 19% in 4 years. This contributed to the Posting Committee re-evaluating the structure and posting the Frank J Wood Bridge to 25 Tons.

The rate of deterioration is difficult to quantify. This report briefly compares the specific deterioration in Floorbeams 7 & 5 (Span1) using the <u>Routine And Fracture Critical Bridge Inspection Report</u> by Parson Brinkerhoff – 8/20/2012 to the current conditions (4 years later). The result is concerning.

An approximate estimate to repair the listed possible current deterioration within the next 5 years is $805K. Previous successful repair methods on other bridges could be applied to this steel superstructure. There is a possibility not all the listed deteriorated components will reach repair status.

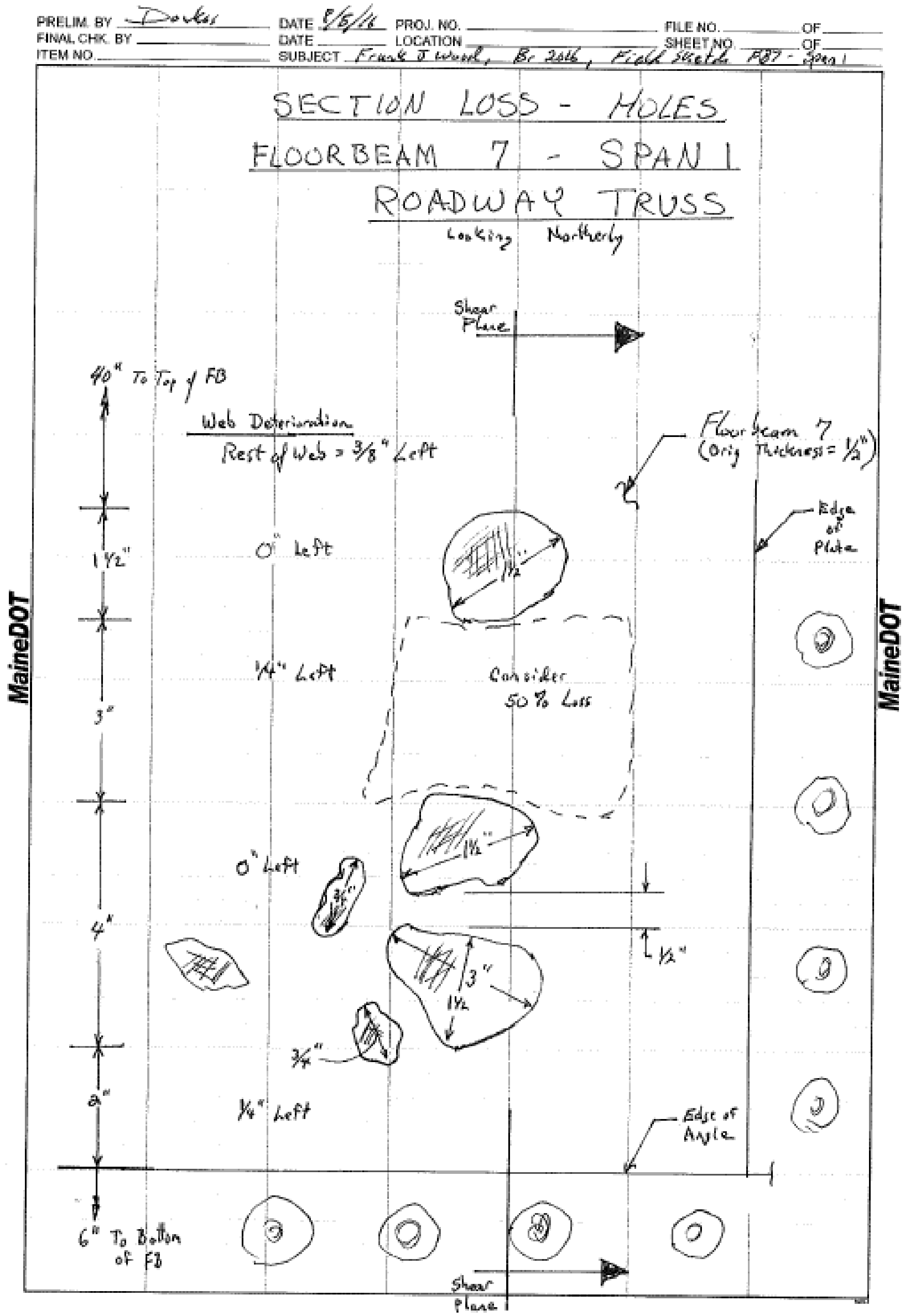
FLOORBEAMS

<u>Span 1</u>

Floorbeams 7, 5 and 2 (in order of most deterioration) had holes representing significant section loss to the web.   See table and photos below.

TABLE 1 – SUMMARY OF FLOORBEAM REPAIR – WITHIN 5 YEARS SPAN 1		
Floorbeam #	**Repair Location**	**Closest Stringer**
FB7	Near Conn to Roadside Truss	S8
FB5	Near Conn to Roadside Truss	S8
FB2	Near Conn to Roadside Truss	S8

Photo A1 – Floorbeam 7, Roadway Truss @ Stringer 8 (Exterior)



Sketch 1 – Section Loss in Floorbeam 7 Shear Plane. See Photo A1.

Photo A2 – Floorbeam 5, Roadway Truss @ Stringer 8 (Exterior)

Photo A3 – Floorbeam 2, Roadway Truss @ Stringer 8 (Exterior)

Floorbeam 2, bottom flange cover plate is exhibiting advanced corrosion, pack rust, significant loss of rivet head section loss reaching enough concern to warrant a repair in the next 5 years.

Photo A4 – Floorbeam 2 coverplate particularly between Stringer 7 & 6 is an area of concern which will be closely monitored.

Span 2

Span 2 of the bridge is exhibiting more concerns with the riveted bottom flange cover plates at Floorbeams 5, 6 and 8. The other Floorbeams have noted corrosion problems as well, but likely may remain adequate over the next 5 years.

TABLE 2 – SUMMARY OF FLOORBEAM REPAIR – WITHIN 5 YEARS SPAN 2		
Floorbeam #	**Repair Location**	**Closest Stringers**
FB5	Cover Plate	S6 – S7
FB6	Cover Plate	S6 – S7
FB8	Cover Plate	S2 – S6

Photo A5 – Floorbeam 5 coverplate has enough deterioration issues to expect a repair within 5 years.

Photo A6 – Floorbeam 6 exhibiting excessive pack rust and rivet deterioration.

Photo A7 – Floorbeam 8 bottom flange midspan plies showing pack rust and deformation which may lead to repair activity within the next 5 years.

Span 3

Span 3 did not appear to have any Floorbeam issues likely to need repair within the next 5 years.

TRUSSES – SIDEWALK & ROADWAY

Spans 1 & 2 - there are no expectations of Truss Repairs within the next 5 years at this time.

Span 3

Span 3 exhibited a rivet deterioration issue which could reach a necessary repair status within the next 5 years. Due to the open grid at the gutter lines of this bridge, a good amount of sand, salts and debris are left covering portions of primary members. The difference of Span 3 and the others is the Sidewalk Truss has continuous rivet head deterioration in the lower tension chord. The panels of Span 3 are 22’ in length. Along the lower chord, from Floorbeam 5 to 8 (3 panels @ 22’ = 66’), the rivets fastening the lower angle to the plate will need to be monitored. Additionally, at least another portion of this same chord had this same condition from Floorbeam 1 to 2. See table and photos below.

TABLE 3 – SUMMARY OF TRUSS REPAIR – WITHIN 5 YEARS - SPAN 3		
Truss	**Repair Location**	**Deteriorated Component**
Sidewalk	FB 5 thru 8 & FB 1 to 2	Rivets fastening bottom inside angle of the lower tension chord.

Photo A8 - View of the inside of Sidewalk Truss's lower angle depicts continuous corroding rivet heads and sand, salts and debris occupying the angle flange.

Using a claw hammer the loose corrosion was pounded away from a typical rivet head just described to reveal what remained. The result was a significantly smaller head size. See Photos A9 and A10. Further investigation and computations may be necessary before determining precise remedial action.

Photo A9 - Typical rivet head condition along Sidewalk Truss Lower Chord of Span 3 for at least 100 ' length of angle to plate connection.

Photo A10 – This is the same rivet as above after briefly pounding loose corrosion away. The rivet head size is significantly smaller than the diameter and height of a new rivet head.

<u>Spans 1 & 2</u>

Although Spans 1 & 2 had noted corrosion and accumulated debris, the trusses did not appear to require an immediate repair or one within 5 years at this time.

Photo A11 – This is the general condition view of the inside lower chord truss member collecting rust and debris on the lacing bars.

STRINGERS

Span 1

At Floorbeam 2, Stringer 8 has a corroded hole in its web close to the bottom flange. See Photo A12. It is likely this will develop into a large enough issue to warrant a reattachment repair for this end of the stringer. At the other end of Stringer 8, the connection at Floorbeam 3 is exhibiting enough deterioration issues to expect a reattachment repair within 5 years as well. See Photo A13. Repair of Stringer 8 connection to Floorbeam 5 is also likely. See Photo-A3. Over the next 5 years – Stringer 8 connection to Floorbeam 6, Stringer 3 connection to Floorbeam 6 and Stringer 3 connection to Floorbeam 7 are likely. In all, Span 1 Stringer connection repairs total 6.

TABLE 4 – SUMMARY OF STRINGER CONNECTION REPAIR – WITHIN 5 YEARS SPAN 1		
Stringer #	**Connection Component**	**Closest Truss**
S8	Floorbeam 2	Roadway
S8	Floorbeam 2	Roadway
S8	Floorbeam 5	Roadway
S8	Floorbeam 6	Roadway
S3	Floorbeam 6	Sidewalk
S3	Floorbeam 7	Sidewalk

Photo A12 – Stringer 8, Roadway Truss @ Floorbeam 2 has section loss revealing a web hole.

Photo A13 – Looking at the condition of north end of Stringer 8 attached to Floorbeam 3.

Photo A14 – Stringer 8 connection to Floorbeam 6, Roadside Truss, may warrant a reattachment repair within 5 years. Similar connection conditions @ Stringer 3 to Floorbeams 6 and 7.

Span 2

There are no expectations of a Stringer Connection Repairs within the next 5 years at this time.

Span 3

In all, there appears to be approximately 10 Stringer to Floorbeam connections that will likely become a repair item.

TABLE 5 – SUMMARY OF STRINGER CONNECTION REPAIR – WITHIN 5 YEARS SPAN 3		
Stringer #	**Connection Component**	**Closest Truss**
S8	Floorbeam 0	Roadway
S8	Floorbeam 1	Roadway
S3	Floorbeam 1	Sidewalk
S8	Floorbeam 2	Roadway
S7	Floorbeam 3	Roadway
S8	Floorbeam 5	Roadway
S3	Floorbeam 5	Sidewalk
S8	Floorbeam 6	Roadway
S3	Floorbeam 6	Sidewalk
S3	Floorbeam 7	Sidewalk

Photo A15 – Stringer 8 connection to Floorbeam 1 showing active corrosion.

Photo A16 – Stringer 8 connection to Floorbeam 2 will likely need repair within 5 years.

Photo A17 – Stringer 8 connection to Floorbeam 5 shows active corrosion.

Photo A18 - Stringer 8 connection to Floorbeam 6. Stringer 3 connection similar condition.

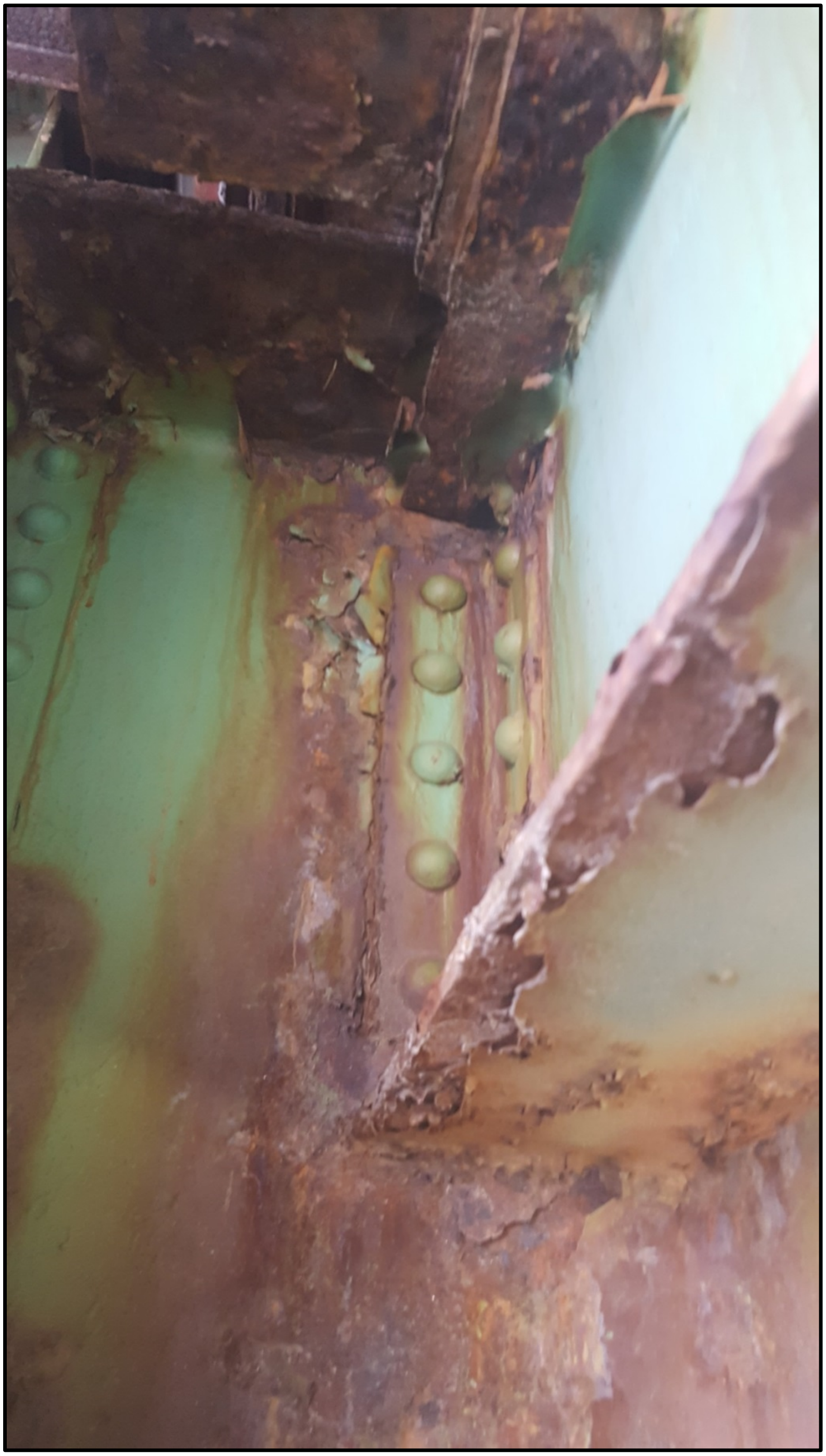


Photo A19 – Stringer 8 connection to Floorbeam 6 will likely require repairs within 5 years.

NEEDLE BEAMS (CROSSBEAMS)

In particularly poor condition are areas in Span 1, Floorbeam 0 to 1 on the Roadway side of the truss and Floorbeams 3 to 4 on the Sidewalk side of the truss. Additionally, areas near Floorbeam 2 at Stringers S7 and S8 are in similar condition. Area between Floorbeams 3 and 4 on the Sidewalk Truss side have multiple Needle Beams with major section loss.

The grid is supported by these needle beams at every 2’, distributing the loads effectively. The grid is adequate condition filled with concrete with the exception of 1 foot gutter area (open). The deterioration of the Needle Beams is widespread to the point where the Department will carefully monitor the deck for distress over the next 5 years. Should there be a compromise of the deck, one repair method would be to cut out area topside, lay in similar grid with a steel plate and then fill with asphalt as a temporary repair until a full deck is replaced or a new bridge is built.

Photo A20 – Deteriorated Needle Beams shown here in Span1, Floorbeam 0 to 1, are evident throughout all 3 spans. These beams are 2’-0” on center supporting a grid deck mostly filled with concrete supporting an 1 ½ “ to 2” asphalt wearing surface.

Photo A21 – View showing Needle Beams between Stringers 7 and 8. Area between stringers 3 and 4 are similar.

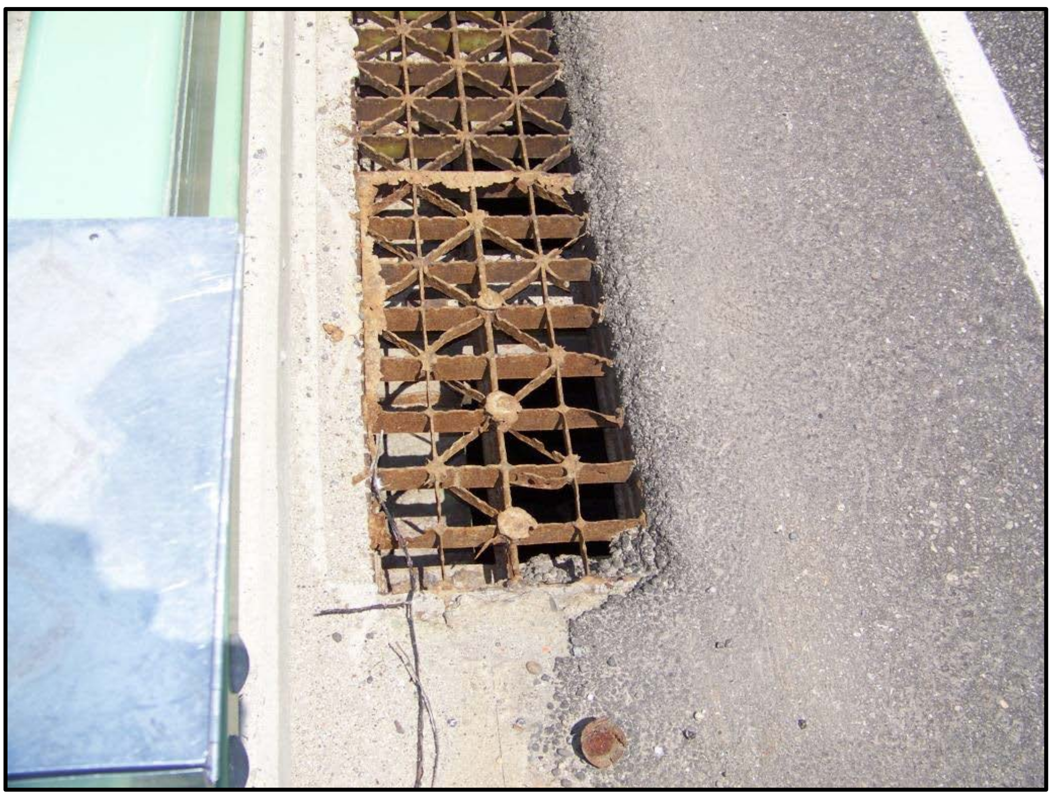


Photo A22 – An open grid approximately 1 foot wide runs parallel to Stringers.

UTILITY BRACKETS

The utility brackets supporting an insulated steel pipe are in generally poor condition. There is a possibility of strengthening a percentage of them within the next 5 years - and will be monitored.

Photo A23 – View of steel insulated utility pipe extending across the bridge on the Roadside Truss side.

Photo A24 – The Utility Brackets are in poor condition with extensive active corrosion.

CANTILEVERED SIDEWALK

The Routine And Fracture Critical Bridge Inspection Report, 8/2012, from Parsons Brinckerhoff considered the top flange of these cantilevered sections to be severely corroded in all 3 spans. It is likely the top flange of the angle was likely removed roughly with a torch when the sidewalk was updgraded/installed. This component can be monitored rather than repaired immediately.

Photo A25 – View of the top half of cantilevered brackets that support the sidewalk.

LATERAL BRACING

Lateral bracing has pack rust issues throughout the structure. Considered essentially for construction forces and loads, these components will be monitored rather than be targeted for repair.

Photo A26 – In general, a good amount of deterioration exists in the lateral bracing system.

RATE OF DETERIORATION

Precisely determining the "rate" of steel bridge deterioration is challenging. NBI ratings provide a good overall consideration. The methodology of comparing earlier recorded conditions to current also shows reasonably good insight. Consider the comparisons below regarding Span 1, Floorbeam 7 conditions changes from 2012 to 2016.

Excerpt from Routine & Fracture Critical Bridge Inspection Report

At Span 1 FB7 below S8 both faces of the web exhibit active corrosion with section loss of 1/8 inch depth over a height of 8 inches and length of 12 inches (Photo 44).

Photo 44 – At Span 1 FB7 below S8 both faces of the web exhibit active corrosion with section loss of 1/8 inch depth over a height of 8 inches and length of 12 inches.

4 YEARS LATER -

Results of Special Bridge Inspection conducted 8/1/2016

Photo A1 – Floorbeam 7, Roadway Truss @ Stringer 8 (Exterior)

12 inches at the bottom of this 42" Floorbeam has nearly 100% section loss.

Excerpt from Routine & Fracture Critical Bridge Inspection Report

Span 1 FB5 has a
zone of significant active corrosion to the top of the bottom flange on the north side of the web between S6 and S7 with up to 1/8 inch section loss to rivet heads in this zone (Photo 43). The ends of the floorbeams below S1 and S8 exhibit paint loss and active

4 YEARS LATER –

Results of Special Bridge Inspection conducted 8/1/2016

Photo A2 – Floorbeam 5, Roadway Truss @ Stringer 8 (Exterior)

This area of 100% section loss was not targeted as a corrosion problem 4 years ago.

LOAD RATINGS

Listed in the Parsons Brinckerhoff Load Rating conducted March of 2013 is the "Breakdown of Truss Bridge Rating" highlighting the various Bridge Component ratings. Of particular interest are several Floorbeam ratings in Spans 1 and 2.

LOAD RATING POINTS OF INTEREST

Bridge Component	HL-93		HL-93 Modified		MaineDOT Truck Configurations							
	Inv	Oper	Inv	Oper	1	2	3	4	5	6	7	8
	72.0 kip	72.0 kip	90.0 kip	90.0 kip	100.0 kip	94.0 kip	88.0 kip	88.0 kip	88.0 kip	75.9 kip	59.0 kip	37.4 kip
Floor Beam Span 1 & 2 Intermediate Shear * At Truss Connection	**0.63**	**0.82**			**0.86**	**0.78**	**0.74**	**0.76**	**0.78**	**0.81**	**0.90**	1.42
Floor Beam Span 1 & 2 Interm. Edge of Effective Length of 18' Cover Plate - Moment **	**0.66**	**0.86**			**0.96**	**0.87**	**0.83**	**0.85**	**0.87**	**0.91**	1.01	1.58

Currently 3 Intermediate Floorbeams in Span 1 have significant section loss in the shear area near the truss connection. The above 2013 table lists 0.63 for HL-93 Inventory Loading. (1.0 is the successful rating target.) In August of 2016 the Department recalculated this Load Rating component with the discovered section loss (Floorbeam 7, see Sketch) resulting in a rating of 0.51. This is a 19% reduction over the past 4 years.

Additional Load Ratings of the Legal Load Configurations were conducted which resulted in a Rating Tonnage of 25 Tons (Configurations 6, 7 &8).

A second area of interest is the pack rust and related rivet stress midspan of 3 Floorbeam Lower Flanges. The 2013 Load Rating above depicts 0.66 for HL-93 Inventory Loading. This portion of the Floorbeam is considered Fracture Critical and is currently targeted for possible repair on 3 Floorbeams within the next 5 years.

There are other load rated components below 1.0 for HL-93 Loading (and scored below 1.0 under the Legal Configurations) in the 2013 Report which our team was alerted to review component current conditions.

LOAD RATING POINTS OF INTEREST

Bridge Component	HL-93		HL-93 Modified		MaineDOT Truck Configurations							
	Inv	Oper	Inv	Oper	1	2	3	4	5	6	7	8
	72.0 kip	72.0 kip	90.0 kip	90.0 kip	100.0 kip	94.0 kip	88.0 kip	88.0 kip	88.0 kip	75.9 kip	59.0 kip	37.4 kip
Floor Beam End Span 1 & 2 Edge of Effective Length of Cover Plate - Moment	**0.87**	1.13			**0.96**	**0.87**	**0.83**	**0.85**	**0.87**	**0.91**	1.01	1.58
Diagonal S2 Sidewalk Axial Compression L2-U3	**0.59**	**0.77**			**0.99**	1.05	1.08	1.07	1.08	**0.93**	1.39	1.88

REPAIR COST ESTIMATES – 5 YEARS

A repair cost estimate was developed for Floorbeam Repairs in Span 1- Floorbeam 7 and 5. The total for both accomplished during the same time frame was $65K. Using this as a template for other repair costs for Floorbeam midspan strengthening and Stringer end Connections are calculated. These are approximate costs accomplished by M & O Forces and do not include public user costs.

Floorbeams

Floorbeam	Repair Location	Cost per Location
7 – Span 1	Shear Section – End of FB	$35K
5 – Span 1	"	$35K
2 – Span 1	"	$35K
5 – Span 2	Midspan Pos Moment	$100K
6 – Span 2	"	$100K
8 – Span 2	"	$100K
Total		**$405K**

Stringers

No. of Stringer Locations	Span Location	Cost per Span
6	1	$75K
10	3	$130K
Total		**$205**

Truss

Sidewalk Truss Rivets	Allowance
Investigation Of Rivet Condition*	$20K
Repair Place Holder*	$100K
Total	**$120K**

Unsure at this time the extent of rivet deterioration and appropriate retrofit.*

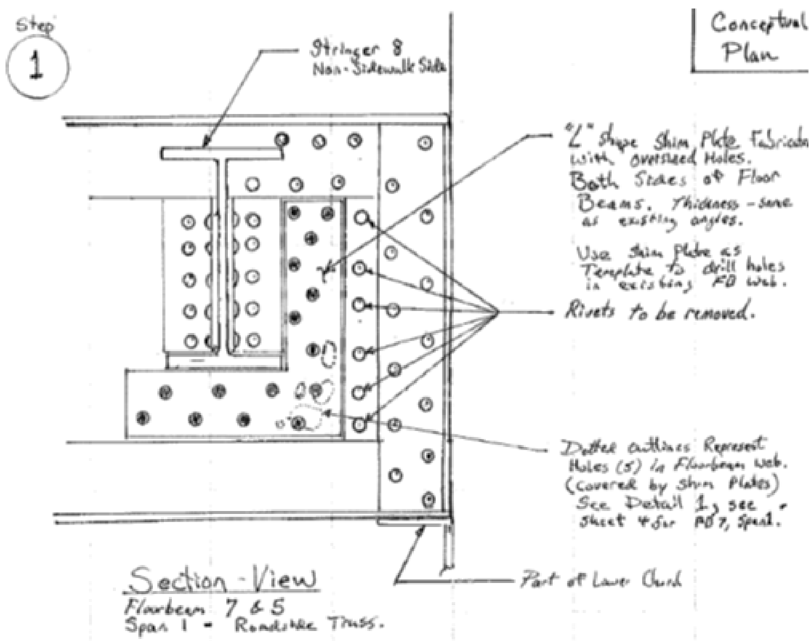
Needle Beams (Crossbeams)/Utility Brackets/Misc

Component	Allowance
Needle Beam (Topside Repair)	$25K
Utility Brackets	$25K
Misc	$25K
Total	**$75K**

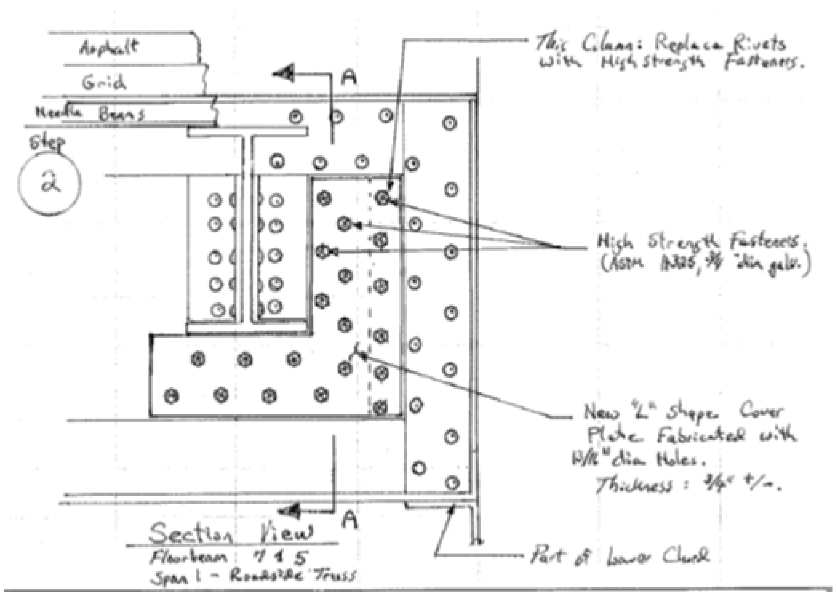
GRAND TOTAL ALL REPAIRS AND ALLOWANCES $805K

REPAIRS

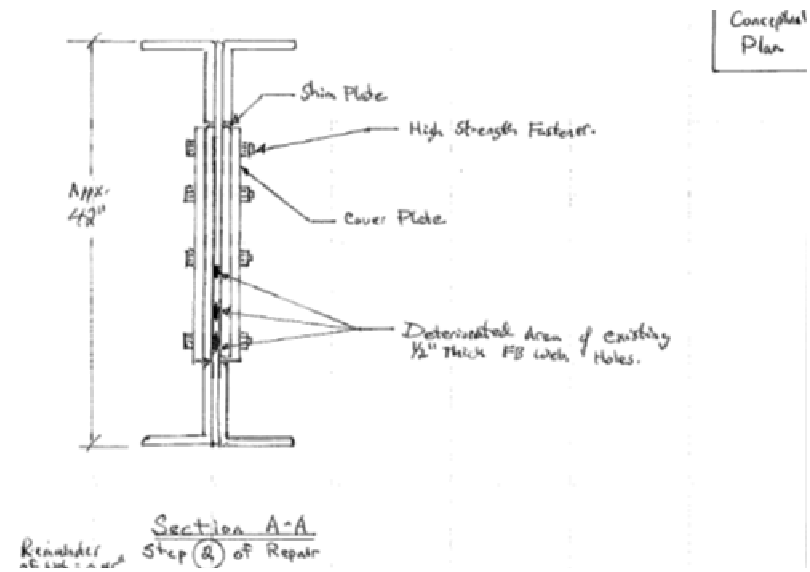
A conceptual design repair was developed for Floorbeam 7 & 5 (and eventually could be applied to Floorbeam 2 and possibly others. Essentially the section loss in the web would be restored by bolting steel plates (shim and cover) on both sides by high strength bolts.



Sketch 2 – Step 1 of Floorbeam Repair.



Sketch 3 – Step 2 of Floorbeam Repair.



Sketch 4 – Step 2, Section View of Floorbeam Repair.

Photo A26 – End result of similar repair to Floorbeam.

Midspan of a distressed Floorbeam caused by pack rust could be temporarily repaired by replacing the rivets with bolts and adding a new steel coverplate. This could possibly be accomplished using a “split coverplate” to accommodate a 2 phase installation rather than removing all of the rivets at one time.

Photo A27 – End result of repair to built-up Floorbeam bottom flange.

The repair method of Stringers vary depending on what deteriorates. Essentially adding steel plates, to both sides of the webs, extending to areas that are in reasonably good condition serves as an acceptable temporary repair. A shim the same thickness of the attaching angle is placed under the cover plate.

Photo A28 – End result of a typical Stringer to Floorbeam connection.

PART B - 30-75 YEAR REHABILITATION

EXECUTIVE SUMMARY

Part B of this report focuses on the rehabilitation necessary to provide an additional 30-75 years of life for MaineDOT Bridge #2016 (Frank J Wood) carrying Routes 201 and 24 over the Androscoggin River in Brunswick and Topsham, Maine. The inspection revealed & confirmed deterioration in all of the critical members of the three (3) span structure. This portion of the report ignores any repairs that may be done as the result of Part A of this report as those are short term fixes that will not last the desired 30-75 year range.

The overall recommendation of this portion of the report is that the entire floor system (roadway deck, floorbeams, stringers, cross (needle) beams, etc.) needs to be replaced, portions of the truss members need to be rehabilitated or replaced, and the entire structure is repainted in order to extend the life of the existing structure 30-75 years. This recommendation is based upon the existing condition and the assumed continued deterioration of the individual elements. The projected rate of deterioration is difficult to quantify, however when comparing the 8/1/16 to 8/2/16 inspection to the Routine And Fracture Critical Bridge Inspection Report by Parson Brinkerhoff from 8/20/2012, the level of deterioration seen in a time span of only 4 years, leads any assumed continued deterioration to result in the failure of multiple critical structural members and connections.

A breakdown of the existing conditions of each element group, as well as an explanation of the rehabilitation recommendations is provided in the following sections.

ELEMENT INSPECTION SUMMARY

FLOORBEAMS (FB)

A total of thirty one (31) floorbeams, eleven (11) in spans 1 & 2 and nine (9) in span 3, make up the transverse supports for the deck and stringers. The floorbeams span between trusses at all vertical members, supporting the six roadway stringers on each side of the floorbeam for a total of twelve (12) stringers supported per floorbeam, with the end floor beams supporting just six (6) stringers. The floorbeams are attached to the trusses by angles that are riveted through the floorbeam web and through the inside gusset plate of the truss. The floorbeams are fracture critical members, as they are not redundant in the transverse direction. The floorbeams were defined as FB0 through FB11 in spans 1 & 2, and as FB0 through FB8 in Span 3.

The floorbeams are in overall poor condition due to the severe corrosion, pack rust and section loss of the beams at their connection to the interior gusset plates and near mid-span.

The ends of every floorbeam, at the connection to the interior truss gusset plates, are exposed to the elements as they are not below the concrete deck. The beam ends are also partially located below the open grid decking in the roadway shoulder, allowing roadway salts and debris to spray and collect on and around the floorbeams. This level of exposure has generally resulted in significant paint failure at the beam ends, with varying degrees of corrosion, pack rust and section loss along the length of the floorbeam, at all floorbeam locations.

Span 1 had the highest level of floorbeam deterioration as several floorbeams have areas of complete section loss. Holes through the web were present in FB2, FB5 & FB7, with the condition of the web on FB7 being significantly worse than the other two. During the 2016 routine inspection mentioned above, the inspector was able to punch holes through the web of FB7 when struck with a hammer on the non-sidewalk truss end of beam. Holes in the web were naturally formed in FB2 & FB5, however the steel near the holes appeared sound when struck during the 8/1/16-8/2/16 inspection. These three floorbeams were the only beams in the structure that had holes through the webs, although the condition of the all of the remaining floorbeams could result in similar section loss in the near future. See Appendix A, photos 12 through 17 for images of the holes through the floor beam webs.

Paint failure and varying degrees of corrosion, pack rust and section loss was present near midspan of all of the floorbeams in all three spans of the bridge. Several floorbeams in span 2 have the worst deterioration, as there is severe corrosion and section loss to the bottom flange and rivets, as well as pack rust between the cover plate and the angles making up the bottom flange of the floorbeams at FB5, FB6 and FB8, (see Appendix A, photos 18 through 20 for images of the midpsan corrosion). These floorbeams had the worst deterioration in the cover plated area of the beams near midspan, however most, if not all of the floorbeams showed corrosion at this location.

The horizontal connection plates, joining the floorbeams and lateral bracing at the floorbeam ends, are overall in poor condition. Roadway salts and debris from the open grid decking in the roadway shoulder collects on these plates resulting in varying degrees of corrosion, section loss and pack rust. The rivets connecting the elements to this plate are in poor condition as a result of the debris collection.

STRINGERS (S1 – S8)

A total of eight (8) stringers make up the longitudinal support of the needle beams and bridge deck. Six (6) stringers are attached to the floorbeams to support the vehicular travel way, while the remaining two (2) attach to the cantilevered sidewalk brackets and support the sidewalk. The stringer connections are comprised of an angle on either side of the stringer web, connected with rivets to both the stringer and their respective supporting members. The stringers are located 3 ½” below the top flange of the floorbeams, and 2” below the top of the sidewalk bracket. The stringers are labeled S1 through S8 starting on the sidewalk side of the structure, with S1 & S2 below the sidewalk and S3 through S8 below the roadway.

The stringers are in overall fair condition based on the current levels of corrosion to the stringers themselves and their connections to their supporting members. The sidewalk stringers (S1 &S2) are in good condition as they are protected by the stay in place formwork used to cast the sidewalk concrete. There are some areas of paint distress and failure, but corrosion is minimal. The roadway stringers (S3-S8) are in overall poor condition, as paint failure with varying degrees of corrosion, pack rust and section loss is present on all roadway stringers, and stringer connection areas.

The exterior roadway stringers in all three spans were consistently in the worst condition due to their location below the open grid decking in the roadway shoulders which allows roadway salts and debris to drop directly onto S3 & S8. As a result, there is varying degrees of corrosion, pack rust and section loss along the length of these stringers and at the stringer to floorbeam connections areas. The worst deterioration was a hole through the web of S8 near its connection to FB2 (see Appendix A, photo 26). Pack rust between the connection angle and the stringer/floorbeam webs has begun to twist the connection angles at several locations. The top and bottom flanges have varying degrees of deterioration, section loss and pack rust.

The interior stringers (S4 to S7) are in better condition than the exterior stringers, however corrosion is still a concern. Generally, most of the interior stringers and stringer connections are in fair condition, however varying degrees of paint failure has occurred at all interior stringer to floorbeam connections, which has resulted in varying degrees of corrosion, pack rust and section loss to the flanges, as well as pack rust between the connection angles and the stringer web.

Please see Appendix A, (photos 23 through 29) for photos of the stringers.

<u>TRUSS MEMEBERS & COMPONENTS</u>

The truss members and components are in overall fair condition, however the general paint failure on the structure has resulted in varying degrees of corrosion, section loss and pack rust. The vertical and overhead members were in good condition, with some collision damage and general corrosion. The horizontal members at the deck level and below are in far worse condition, bringing the overall condition rating down. The bottom chords of both the sidewalk and non-sidewalk trusses are in poor condition with varying degrees of corrosion, pack rust and section loss to the angles, plates and rivets comprising the bottom chords.

The lattice plates connecting the two vertical components of the truss bottom chord are in poor condition as all of the bottom lattice plates have “bowed” due to general corrosion to the plates and pack rust between the connection of the plates and the vertical components. There are multiple top lattice plates that have a lesser degree of “bow” to them, due to general corrosion of the plates and pack rust at the plate to vertical component connection. (See Appendix A, (photos 30 through 34) for images of the “bowed” lattice plates).

The bottom angle of the vertical component of the bottom chord is overall in poor condition. Paint failure has resulted in varying degrees of corrosion, section loss and pack rust to the bottom flange as roadway salts and debris has collected on top of the bottom flange and on the lattice plates. Span 3 has the worst deterioration as a large portion of the bottom chord on the sidewalk truss has severe deterioration, section loss and pack rust to the angles, cover plates and rivets. (See Appendix A, photos 35 through 39 for images of the corroded bottom chord).

The gusset plates are in fair condition, with minimal corrosion and section loss as the paint on the gusset plates has not failed to the levels of other areas of the structure. The largest issue affecting the gusset plates themselves is any pack rust that has formed at the connection between the floorbeams and the interior gusset plates. The condition of a small portion of the rivets through the gusset plates may be suspect, but overall are in fair condition.

The sidewalk brackets that cantilever from the exterior gusset plates to support the sidewalk on the western side of the bridge are in overall good condition. Paint failure is present on all brackets, however the sidewalk has provided protection from weathering, and from roadway salts & debris. The sidewalk is in overall good condition and has experienced far less corrosion than other portions of the structure.

Please see Appendix A, photos 30 through 41 for Truss Members & Component photos

__CROSS BEAMS (NEEDLE BEAMS)__

The W6x15.5 cross beams (needle beams) run the full width of the deck and are supported by six (6) stringers, connected by welds on each side of the stringer top flange. The needle beams were generally in poor condition based on the level of deterioration to the ends of the cross beams over the exterior stringer bays. There was moderate to severe corrosion and section loss to every needle beam in these exterior bays as water, roadway salts & sands drop through the open grid decking above these bays directly onto the cross beams ends. Knifing of the top and bottom flanges is present on essentially every beam. Measurable section loss in the webs is consistently present in the end bays, with complete web section loss present at several locations. The weld between the needle beams and stringers has deteriorated to the point that many have cracked, and at several locations along the bridge, completely failed.

Please see Appendix A for photos of the cross beams (photos 42 through 47).

LATERAL BRACING (LB)

4”x4”x5/8” angles comprise the lateral bracing spanning diagonally between floor beams (FB) in all three spans. The lateral bracing in spans 1 & 2 consist of two (2) of these angles riveted together to form a “T” shape, while the lateral bracing in span 3 is only one (1) angle. The lateral bracing was generally in poor condition in all three spans of the structure due to the level of corrosion and section loss to the angles and rivets. In spans 1 & 2, pack rust has formed between the angles and has distorted and in some cases completely separated the two angles. In all three spans, there are areas of complete section loss to portions of the angles. Collection of debris and salt spray from the roadway above has resulted in heavy corrosion, pack rust and section loss to the ends of the bracing at their connection to the horizontal connection plate near the ends of the floor beams. The amount of corrosion to these members compromises their effectiveness to the overall structure. The location of the lateral bracing will also limit access to several key structural members of the bridge during any rehabilitation efforts.

Please see Appendix A for photos of the lateral bracing members (photos 48 through 55).

UTILITY HANGERS

The utility hangers are in overall poor condition. Paint failure has resulted in varying degrees of corrosion, section loss and pack rust between the angles comprising the brackets and their connection to the stringers. There is severe deterioration to the rivets connecting these angles. Pack rust and section loss to the angle supporting the conduit and water pipe greatly reduces the capacity of each individual hanger.

Please see Appendix A, for photos of the utility hangers (photos 6 through 8).

SUBSTRUCTURE

The substructure units are in overall fair condition and appear sound. The abutment backwalls have areas of spalling and concrete section loss, and minor cracks. The piers are in good condition as they were rehabilitated in 2006. The bearing pedestals were in fair shape, although the non-sidewalk side bearing at pier 2, for span 3 had shoring in place due to the condition of the adjacent bearing pedestal & bearing.

Please see Appendix A for photos of the shoring at pier 2 (photos 57 and 58).

SUMMARY OF INSPECTION & RECOMMENDATIONS

In order to maintain the existing structure for the next 30-75 years, a great deal of rehabilitation work would need to be done. General paint failure across the entire structure has resulted in the varying degrees of deterioration to multiple key structural, and most importantly fracture critical elements. Below is a summary of the rehabilitation work suggested to provide a minimum of 30 years of additional life for the elements mentioned above. As standard practice, all rivets removed for any work done on the structure are to be replaced by high strength bolts and heavy hex nuts.

GENERAL

The following is recommended as general rehabilitation work to be done:

- Replace the existing concrete filled grid deck with a standard 8” composite reinforced concrete deck
- Repaint the all components of the bridge every 25 to 30 years, once as part of a potential rehabilitation now, and at least once more over the next 30-75 years
- Deck replacement of the rehabilitated structure after 50 years

FLOORBEAMS

The floorbeams are the most important fracture critical elements on the bridge and are in overall poor condition due to the areas of severe corrosion, section loss and pack rust as previously described. This deterioration (holes through webs, section loss to flanges (angles), deteriorated rivets, etc) to such a key component of the structure warrants complete replacement of all the floorbeams and their connections.

Recommendation: Replace all floorbeams and floor beam connections

STRINGERS

The overall condition of the stringers as a whole is currently fair, however the existing state of corrosion to all of the stringer ends and connections would not last 30+ years. The majority of the stringer ends have at a minimum, the early stages of corrosion and pack rust at their connection to the floorbeams and are assumed to not last 30+ years due to the continued presence of chlorides in the steel, thus warranting the replacement of the stringer to floorbeam connections. The exterior roadway stringers (S3 & S8) which have areas of severe corrosion, section loss and pack rust along their entire length warrant replacement based on condition. The interior roadway stringers may be able to be blast cleaned and repainted to last 30+ years, however since the recommendation is to replace all of the existing floorbeams, all of the stringers should be replaced as well. Replacing the floorbeams means either having to temporarily support the twelve (12) stringers connected to each interior floorbeam, or remove and reset the stringers to avoid installing expensive and time consuming temporary structural supports. Once the existing stringers have been detached from the floorbeams it is recommended that they are replaced, as reinstalling 80+ year old steel with varying levels of existing corrosion to new floorbeams would not good engineering judgment/practice. Pre-existing corroded beams would need rehabilitation much sooner than any new steel, which would add an additional maintenance operation to the structure life.

Recommendation: Replace all stringers and stringer connections

<u>TRUSS MEMEBERS & COMPONENTS</u>

The general condition of the existing bottom chord does not bode well for lasting 30-75 years based on the conditions described above. The top and bottom lattice plates should be replaced due to the “bow” observed in every plate. These plates are already under distress and should not be counted on as part of any long term rehabilitation. Replace the bottom flanges of the bottom chords for the full length of the bridge as the flanges are already in poor condition with reduced structural capacity.

Recommendation:

- Replace all steel lattice plates (top and bottom) on both trusses
- Replace the bottom flange components on the bottom chord of the truss
- Replace all deteriorated rivets with high strength bolts and hex nuts

<u>CROSS BEAMS (NEEDLE BEAMS)</u>

The overall condition of the needle beams is too poor to warrant any rehabilitation. A proposed 30-75 year rehabilitation to the existing bridge will include a new composite structural concrete deck to replace the existing concrete filled steel grid deck. The concrete filled steel grid deck is welded to the needle beams, so removing the needle beams as part of the deck removal will aid in the constructability of a rehabilitation project. A new deck would be a composite concrete deck, meaning shear studs would be installed on the floorbeams and stringers, so the needle beams will no longer be necessary.

Recommendation: Remove all cross beams (needle beams)

<u>LATERAL BRACING</u>

The overall condition of the lateral bracing is too poor to warrant any rehabilitation. The levels of section loss and pack rust between angles comprising the lateral bracing would require replacing multiple bays of bracing. Once the act of removing and replacing bracing is required for the structure, it should be carried through the remaining bays as the bracing will likely not last 30+ years, and the location of the bracing in the bays limits construction access to more important structural components of the bridge. A new composite concrete deck would provide additional lateral support to the structure, so lateral bracing would not be necessary as part of a rehabilitation.

Recommendation: Remove all lateral bracing members

UTILITY HANGERS

The utility hangers that support the conduit on the western side, and the water pipe on the eastern side of the structure are in overall poor condition. These hangers are extremely redundant, as they appear to be spaced every 3-4' along the structure, however their condition will not last 30-75 years. These hangers are currently supported by the first two (2) roadway stringers on each side of the structure (S3-S4 & 37-S8), and since the recommendation is to replace all of the stringers, the utilities will need to be temporarily supported during the rehabilitation work. This may not be at a direct cost to MaineDOT, but it should still be noted that it will affect the constructability of any rehabilitation project.

Recommendation: Replace all utility hangers

SUBSTRUCTURE

The substructure is in overall fair condition as there was a substructure rehabilitation done in 2006. A 30-75 year fix is going to require a minimum of one (1) or two (2) additional rehabilitations to the substructure units, with the first major rehabilitation likely required roughly 10+ years into the rehabilitated life of the structure. The abutment backwalls should be replaced during a proposed deck replacement, as this will be the best time for construction access and the top 18" will need to be replaced as part of a new joint installation anyways. The bearing and bearing pedestal at pier 2 for span 3 should be rehabilitated such that the shoring is no longer necessary. This will likely require casting a new bearing pedestal as well as removing, refurbishing, and resetting the bearing in question.

Recommendation:

- Reconstruct the abutment backwalls during the deck replacement work
- Replace the bearing pedestal at pier 2 for span 3
- Remove, refurbish and reset (or replace if not able to refurbish) the non-sidewalk truss bearing at pier 2 for span 3.

APPENDIX A

Photographs

General Bridge Photos

Photo #1: General view of the bridge (from the Brunswick looking north) (8/1/16)

Photo #2: General view of the underside of the non-sidewalk side of the bridge (eastern side, Span 1 looking north) (8/1/16)

Photo #3: General view of the underside of the sidewalk side of the bridge (western side, Span 2 looking south) (8/1/16)

Photo #4: General view of the superstructure section (8/1/16)

Photo #5: General view of the Floor Beam, Stringer & Vertical Truss member connection (8/1/16)

Photo #6: General view utility conduit supported by a hanger system attached to the stringers (western side of structure looking south) (8/1/16)

Photo #7: General view of utility pipe supported by a hanger system attached to the stringers (eastern side of structure looking north) (8/1/16)

Photo # 8: General view of paint loss and corrosion to bays below the open grid decking in the travel way shoulders on the non-sidewalk side (eastern) of the bridge (8/1/16)

Photo # 9: General view of paint loss and corrosion to bays below the open grid decking in the travel way shoulders on the sidewalk side (western) of the bridge (8//1/16)

Floor Beams (FB)

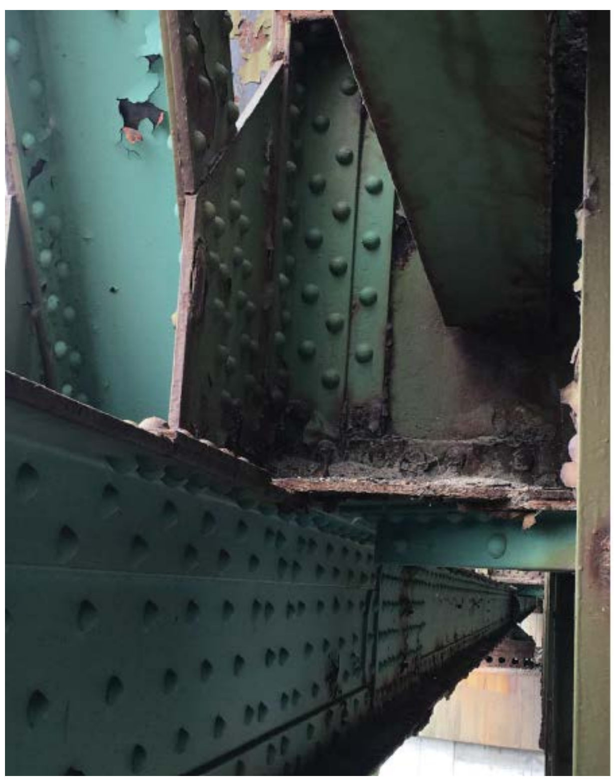


Photo # 10: General view of floor beam to truss gusset plate connection (8/1/16)

Photo # 11: General view of typical paint loss & debris collection at floor beam ends (8/1/16)

Photo # 12: General view of corrosion & hole through the web on the non-sidewalk (eastern) end of FB2 in span 1 (8/1/16)

Photo # 13: Closer image of hole through the web of FB2 in span 1 (8/1/16)

Photo # 14: General view of corrosion and hole through the web of the non-sidewalk (eastern) end of FB5 in span 1 (8/1/16)

Photo # 15: General view of corrosion and holes through the web of non-sidewalk (eastern) end of FB7 in span 1 (8/1/16)

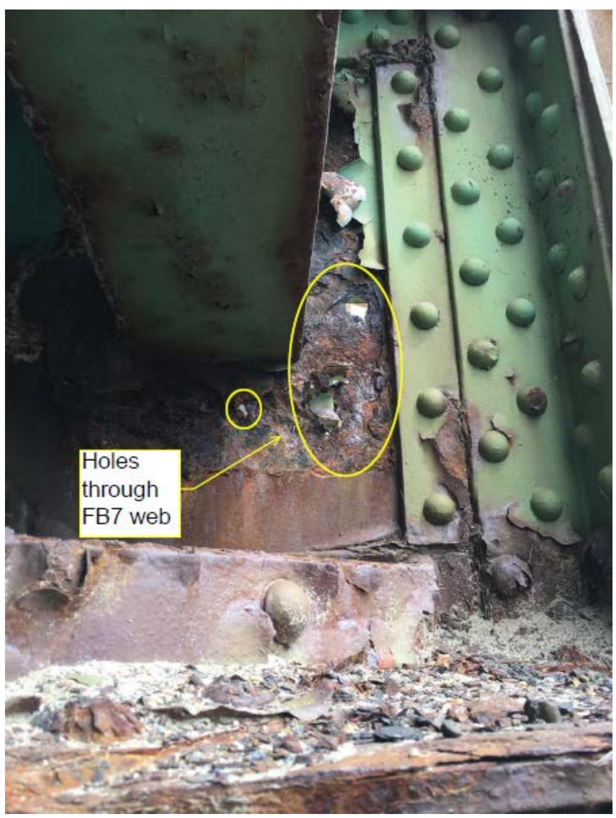


Photo # 16: Closer view of holes through the web of FB7 (8/1/16)

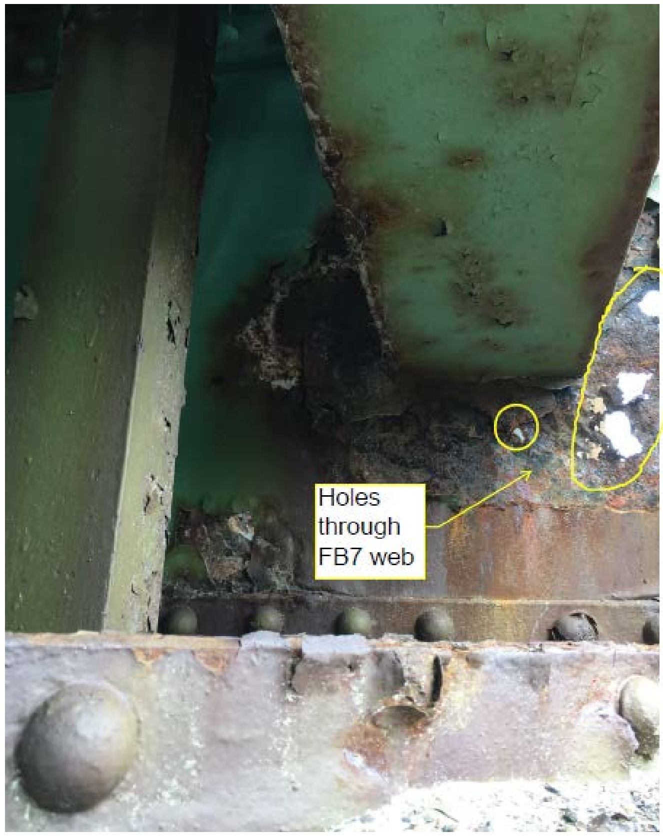


Photo # 17: Closer view of holes through the web of FB7 (8/1/16)

Photo # 18: Severe corrosion & pack rust between the bottom flange of the floor beam and the cover plate near midspan of FB5 in span 2, (span 2 FB4, FB6 & FB7 similar) (8/2/16)

Photo # 19: Severe corrosion to the rivets as well as corrosion & pack rust between the bottom flange of the floor beam and the cover plate near midspan of FB5 in span 2 (span 2 FB4, FB6 & FB7 similar) (8/2/16)

Photo # 20: Advanced deterioration of rivets near midspan of FB7 in span 2 (8/2/16)

Photo # 21: General view of floor beam end in span 3 (8/2/16)

Photo # 22: Top flange corrosion & section loss of FB 5 in span 3 (8/2/16)

Stringers (defined as S1 through S8)

Photo #23: Typical view of the sidewalk stringers (S1 & S2) on the upstream side of the bridge (western side, looking north) (8/1/16)

Photo #24: Typical exterior stringer (S3 & S8) to floor beam connection (Typ. all spans) (8/1/16)

Photo #25: Typical view of bottom flange of S3 & S8 in spans 1 & 2 (8/1/16)

Photo #26: Hole through the web of S8 at FB2 in span 1 (8/1/16)

Photo #27: Moderate corrosion to S3 in span 3 near FB4 (8/2/16)

Photo #28: Moderate corrosion with pack rust between the connection angles and floor beam, at S8 in span 3 near FB5 (8/2/16)

Photo #29: Typical interior stringer (S4 through S7) to floor beam connection (Typ. all spans) (8/1/16)

Truss Members & Components

Photo #30: Typical corrosion of the bottom chord of the truss members, showing “bowing” of the Lattice plates due to pack rust (8/2/12)

Photo #31: Corrosion of lattice plate on bottom chord of non-sidewalk truss in span 1 (8/1/16)

Photo #32: “Bowing” of lattice plates on the bottom chord of the sidewalk truss in span 3 (8/2/16)

Photo #33: “Bowing” of lattice plates on the top of the bottom chords of the sidewalk truss in span 3 (8//16)

Photo #34: Pack rust between lattice plate and bottom angle on the the bottom chord of the sidewalk truss in span 3 (8//16)

Photo #35: Bottom chord of non-sidewalk (eastern) truss, in span 1 near FB 2 (8/1/16)

Photo #36: Corrosion to the bottom flange of the bottom chord of the sidewalk side truss in span 3 (western side of the bridge looking north) (8/2/16)

Photo #37: Pack rust between plates on the bottom chord of the non-sidewalk truss in span 3 (eastern side of the bridge) (8/2/16)

Photo #38: Severely deteriorated rivet heads on the bottom chord of the sidewalk side truss, span 3 (8/2/16)

Photo #39: Remnants of rivet heads along the top of the bottom flange of the bottom chord of the sidewalk truss (western) in span 3 (8/2/16)

Photo #40: “Dent” to the interior member making up the bottom chord on the sidewalk (western) truss, located near midspan of span 1, likely due to impact of debris during extreme high flood waters (8/1/16)

Photo #41: “Dent” to the exterior member making up the bottom chord on the sidewalk (western) truss at the same location of the previous photo (8/1/16)

Cross Beams (Needle Beams)

Photo #42: Typical view of cross beams (needle beams) in the exterior bay between S3 & S4, S7 & S8 similar (8/1/16)

Photo #43: Typical view of cross beams (needle beams) in the first interior bays from S4 through S7 (8/1/16)

Photo #44: Moderate corrosion to cross beams (needle beam) (Typ.) (8/1/16)

Photo #45: Severe corrosion to a cross beam (needle beam) near FB 1 in span 1 of non-sidewalk (eastern) truss (8/1/16)

Photo #46: Severe corrosion to a cross beam (needle beam) on the sidewalk (western) truss (8/1/16)

Photo #47: Failed weld between needle beam and an interior stringer in span 1 (8/1/16)

Lateral Bracing (LB)

Photo #48: General view of lateral bracing spanning between utility supports in span 1 & 2 (8/1/16)

Photo #49: Typical view of lateral bracing connection to bottom horizontal gusset plate in spans 1 & 2 (8/1/16)

Photo #50: Severely corroded lateral bracing member view from top of double angle in spans 1 & 2 (8/1/12)

Photo #51: Severely corroded lateral bracing member, view from the bottom of the double angle connections in Spans 1 & 2 (8/1/12)

Photo #52: General top view of lateral bracing span (inverted) from non-sidewalk truss to sidewalk truss in spans 1 & 2 (8/2/16)

Photo #53: General top view of lateral bracing span from sidewalk truss to non-sidewalk truss in spans 1 & 2 (8/2/16)

Photo #54: Corroded lateral bracing end at its connection to the horizontal plate at FB8 span 2 (8/2/16)

Photo #55: Pack rust and section loss to the lateral bracing near FB6 in span 1 (8/1/16)

Bearings

Photo #56: Typical view of the bearings at pier 1 (8/1/16)

Photo #57: Shoring of non-sidewalk bearing, pier 2, span 3 (looking southwest) (8/2/16)

Photo #58: Shoring of non-sidewalk bearing, pier 2, span 3 (looking south) (8/2/16)