

STATE OF NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION

LOAD RATING REPORT

GENERAL SULLIVAN BRIDGE - DOVER 200/023
OVER THE LITTLE BAY

NEWINGTON-DOVER, 11238S



August 15, 2016



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EXECUTIVE SUMMARY

In the fall of 2013, NHDOT engaged VHB in conjunction with HDR to perform an inspection and load rating of the General Sullivan Bridge. The 2014 inspection report is a separate document. This report presents the results of the load rating, based on the as-inspected condition of the structure in 2014.

The General Sullivan Bridge is 1528 feet long with the primary superstructure consisting of a combination deck truss and partial through-arch truss over Little Bay between the town of Newington and the city of Dover. The bridge is closed to vehicular traffic but open to pedestrians and cyclist.

NHDOT's Bureau of Bridge Design-Existing Bridge Section designates the bridge as Dover 200/023.

The bridge opened to Route 16 traffic in 1934, had southbound traffic only in 1966, was restricted to emergency and maintenance vehicles only in 1984, and closed to vehicles in 1991.

The 9-span bridge is configured as follows, from north to south: 102'-125'-163'-200'-275'-200'-163'-163'-125'. Spans 2 and 3, 4 through 6 and 8 through 9 are continuous and the remaining spans are simple spans.

The steel superstructure in each span consists of riveted built-up truss members with rolled I-shape floorbeams and stringers. There is an 8 1/2" non-composite concrete deck with a 2 1/2" to 5 1/2" asphalt overlay. The bridge is approximately 32' wide (rail to rail) with a 24' roadway and two 4'-0"± sidewalks. There are eight mass concrete piers with granite block fascia and caps and two reinforced concrete abutments.

The Load Rating was performed in accordance with the AASHTO Manual for Bridge Evaluation (MBE), using the Load Factor Rating (LFR) method. As directed by NHDOT, inventory and operating rating factors are provided for pedestrian loads, and HS20 rating factors are provided at the operating level only. Pedestrian loading is 85 psf for all floor system components and 60 psf for truss member analyses. This report provides controlling ratings by member (deck, stringer, floorbeam, truss), location, and by load type (pedestrian or HS20). Some members have zero live load capacity.

Based on discussions between the VHB/HDR inspection and rating team and NHDOT following the inspection the Department is proceeding with fencing the bridge to restrict the pedestrian and cyclists to the middle 15' of the bridge (completed in 2015). This report only presents the results of the as-inspected condition, with fencing limited to Span 7.

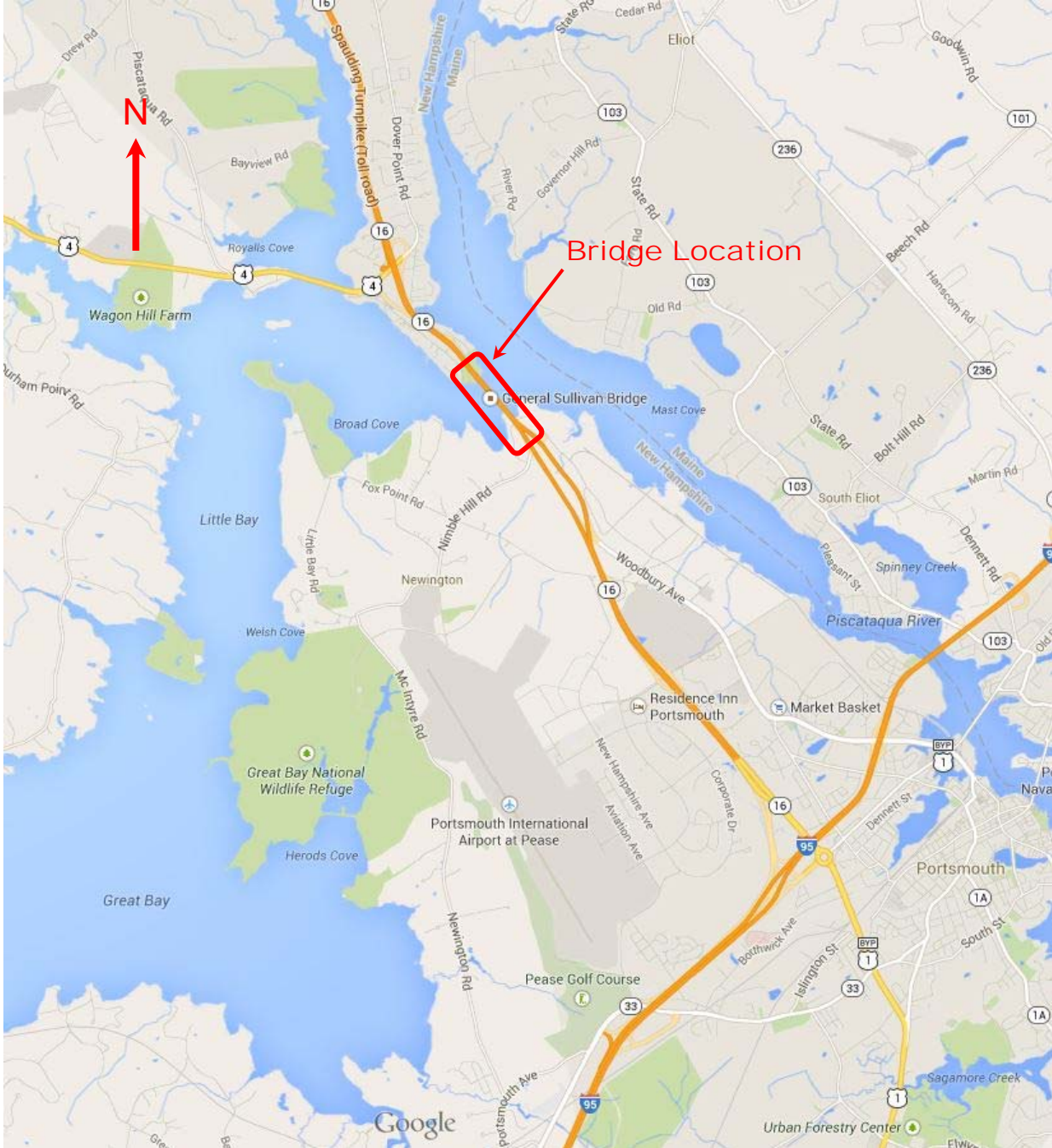
There are multiple stringers in every span, except for Span 2, with pedestrian rating factors <1. However, this is exclusive to the exterior stringers. All of the interior stringer have pedestrian rating factors >1.

Some of the floorbeams in Spans 3, 6, and 7 have operating rating factors <1 at their end sections. However, the midspan portions of the floorbeams supporting interior stringers have an operating rating factor above 1.0.

Only two truss members, L0-L1 (east and west) in Span 7, have rating factors <1. If the pedestrian loading is considered restricted by the current fencing in Span 7 these truss members will have a pedestrian rating factor of 1.0 or greater. All gusset plates have a rating factor of 1.0 or greater.

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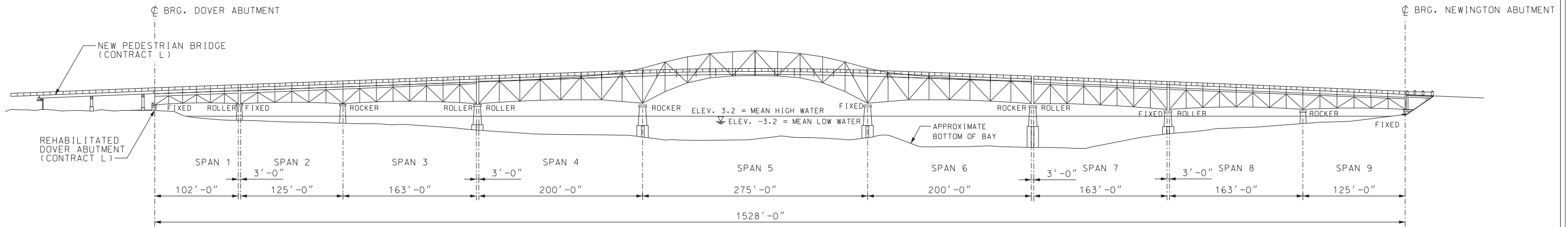
LOCUS MAP



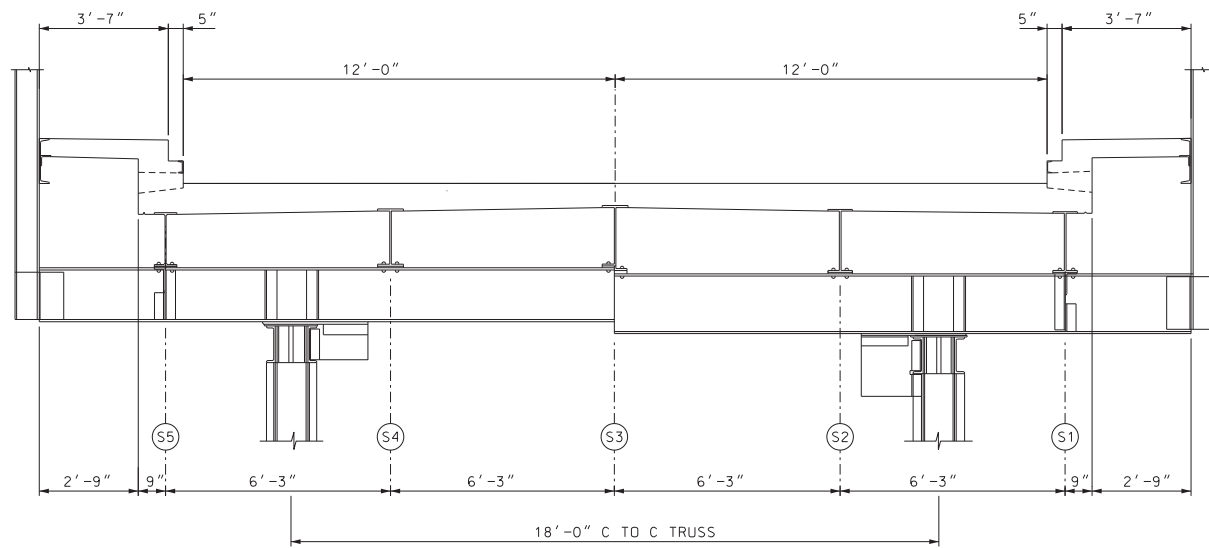
BRIDGE DESCRIPTION

Year Built:	1934
Original Design Loading:	AASHO H-15
Bridge Type:	Deck/Through Arch Truss
Skew:	0°
Bridge Length:	1528'-0" (bearing to bearing)
Spans:	Dover Approach: 1 single span deck truss (Span 1) 1 two-span continuous deck truss (Spans 2 & 3) Main Spans: 1 three span continuous deck/through arch truss (Spans 4, 5, & 6) Newington Approach: 1 single span deck truss (Span 7) 1 two-span continuous deck truss (Spans 8 & 9)
Span Lengths:	Span 1: 102'-0" Spans 2 & 9: 125'-0" Spans 3, 7, & 8: 163'-0" Spans 4 & 6: 200'-0" Span 5: 275'-0"
Width of Bridge Deck:	32'-0" (rail to rail) with a 24'-0" roadway width and two 4'-0" sidewalks (one each side of the bridge). Note – see rating assumptions for loading width used.
Roadway Surface:	Reinforced concrete deck (7" structural deck and 1½" integral concrete wearing surface) with a hot mixed asphalt wearing course (2½"-5½" thick).
Sidewalk Surface:	Reinforced concrete
Bridge Rail:	Double steel bridge rail with steel verticals, attached to double channel posts.
Superstructure:	A three span continuous arch truss consisting of riveted built-up steel members, riveted steel floorbeams, and rolled I-shape stringers. The approach spans consist of riveted built-up members, rolled I-shape floorbeams, and rolled I-shape stringers.
Utilities:	Navigation span lighting conduit Roadway lighting (abandoned) Gas line (abandoned)
Bearings:	10 fixed bearings 12 multi-roller expansion bearings 6 multi-rocker expansion bearings
Substructure:	2 reinforced concrete abutments 8 mass concrete piers with granite block fascia and caps

**GENERAL SULLIVAN BRIDGE
INSPECTION REPORT**



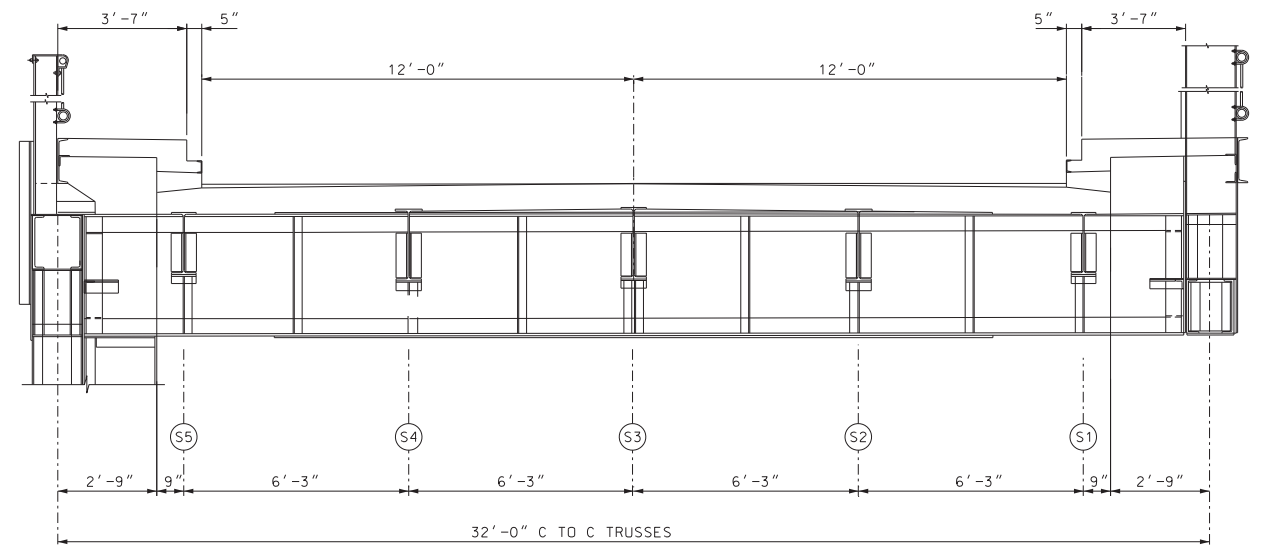
WEST ELEVATION



**HALF SECTION
SPAN 1**

**HALF SECTION
SPANS 2, 3, 7, 8 AND 9**

**TYPICAL SECTION
APPROACH SPANS (1, 2, 3, 7, 8 AND 9)
(LOOKING SOUTH)**



**HALF SECTION
SPANS 4 AND 6**

**HALF SECTION
SPAN 5**

**TYPICAL SECTION
MAIN SPANS (4, 5, AND 6)
(LOOKING SOUTH)**

STATE OF NEW HAMPSHIRE									
DEPARTMENT OF TRANSPORTATION * BUREAU OF BRIDGE DESIGN									
TOWN	NEWINGTON-DOVER	BRIDGE NO.	200/203	STATE PROJECT	11238S				
LOCATION	GENERAL SULLIVAN BRIDGE								
ELEVATION AND TYPICAL SECTIONS									BRIDGE SHEET
REVISIONS AFTER PROPOSAL			BY	DATE	CHECKED	SMH	DATE	OF	
			JGM	1/16	CHECKED	JGM	1/16	FILE NUMBER	
			KDW	1/16	CHECKED	JGM	1/16		
QUANTITIES			CHECKED						
ISSUE DATE	FEDERAL PROJECT NO.			SHEET NO.		TOTAL SHEETS			
REV. DATE									



BACKGROUND INFORMATION

Purpose

NHDOT engaged VHB in conjunction with HDR to perform an in-depth and fracture critical inspection (May 2014) followed by a comprehensive load rating of the General Sullivan Bridge superstructure. The inspection findings are provided in a separate report. This report presents the results of the load rating based on the as-inspected condition of the bridge.

Designation and Status

NHDOT's Bureau of Bridge Design-Existing Bridge Section designates the General Sullivan Bridge as Dover 200/023.

The bridge is closed to vehicular traffic but open to pedestrians and cyclist.

Summary of Use and Function

- 1935: General Sullivan Bridge opens to traffic NB and SB
- 1966: Little Bay Bridge (SB) opens to NB traffic
General Sullivan Bridge changed to SB traffic (both lanes)
- 1984: Little Bay Bridge (NB) opens to NB traffic
Little Bay Bridge (SB) changed to SB traffic.
General Sullivan Bridge use limited to emergency traffic and pedestrians
- 1991: General Sullivan Bridge use limited to pedestrians only
- 2010: General Sullivan Bridge pedestrian access reduced in Span 7 with supplementary fencing
- 2010: New General Sullivan Bridge Pedestrian Ramp and Abutment Modifications, Dover
- 2015: General Sullivan Bridge pedestrian access receded in all spans with supplementary fencing

Reference Documents

- | | |
|--------------------------------------|--|
| 1933: Substructure Design Drawings | 1973: Deck Inspection |
| 1933: Superstructure Design Drawings | 1979: Servi-Lift Inspection |
| 1933: Superstructure Shop Drawings | 1991: Kimball Chase Inspection and Rating |
| 1934: Lighting Plans | 1999: Navigational Lighting Plans |
| 1935: Record Plans | 2004: Hardesty & Hanover Alternatives Study |
| 1936: Gas Line Plans | 2010: Ammann & Whitney Inspection and Rating |
| 1937: Park Approach Plans | |

A review of the existing plans indicates that four diagonal (L8-U9) members in both the East and West Trusses in Spans 3 and 8, were fabricated incorrectly due to an error in the 1933 Superstructure Plans. Channel web cover plates should have been included, but they were omitted from the shop drawings.

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Maintenance History

- 1946: Concrete roadway slabs repaired with sprayed-on gunite layer
- 1950: First major repainting
- Early 1960's: Asphaltic concrete overlay installed over the roadway slabs
- 1962: Sidewalk concrete holes repaired
- 1968: Concrete slab at approach to bridge replaced
- 1970: Eighteen expansion shoes and ten fixed bearings cleaned and repaired. Granite stone facing and capstones repointed. Underwater repairs to the concrete footings at Piers 4 and 6.
- 1971: Repairs to the pier concrete and pointing of stonework
- 1973: Two deck expansion joints repaired
- 1978: Repairs to the piers and pointing of granite stone facing
- 1979-1980: Bridge maintenance replaced sections of concrete sidewalks
- 1983: Shoring placed under the roadway slab
- 1984: Bridge closed to vehicular traffic. Pedestrians and bicycles permitted on the bridge.
- 1989: Sections of concrete sidewalk and roadway slab replaced
- 1999-2002: Sections of concrete sidewalks and roadway slab replaced
- 2010: Fencing installed in Span 7 to channelize pedestrians to middle 12' of the roadway slab
- 2011: Dover Abutment reconstructed to connect with a new Pedestrian Bridge (Bridge No. 196/024)
- 2015: Fencing installed along all spans to channelize pedestrians to the middle 15' of the roadway slab.

There is no record of any major repair of the structural steel.

METHOD AND ASSUMPTIONS

Method

Load ratings are performed in accordance with the American Association of State Highway Transportation Officials (AASHTO) Manual for Bridge Evaluation (MBE), 2nd Edition, with interims through 2014. The Load Factor Rating (LFR) method is used. Where applicable, this load rating is also in accordance with the AASHTO Standard Specification for Highway Bridges, 17th Edition - 2002.

The load rating of the bridge is calculated using the bridge's as-inspected condition, with measured section loss determined during an in-depth inspection performed in May of 2014.

The inventory and operating rating factors are determined based on the AASHTO MBE Equation 6B.4.1-1 as follows:

$$RF_i = \frac{C - 1.3 * D}{2.17 * L * (1 + I)}$$

$$RF_o = \frac{C - 1.3 * D}{1.3 * L * (1 + I)}$$

Where:

RF_i = Rating Factor for Inventory Level

RF_o = Rating Factor for Operating Level

C = Member Capacity

D = Member force due to dead load

L = Member force due to live load (pedestrian or vehicular HS20 loading)

I = Impact Factor per AASHTO 17th Ed. Section 3.8.2. Impact only applies to vehicular loading, and is zero for pedestrian loads.

Live Loads

Inventory and operating rating factors are determined for pedestrian loads, while only operating rating factors are determined for HS20 loading. For floor system members, the applied pedestrian loading is 85 pounds per square foot (psf). For truss elements, pedestrian loading is 60 psf. Pedestrian loading is applied to the entire width of the deck, including sidewalks. The Span 5 deck is considered to be 33'-3 1/2" wide and all other spans are considered to be 31'-6" for pedestrian loading. For floor system elements (deck, stringers, floorbeams), a HS20 truck is applied to the roadway. For truss members and gusset plates a HS20 truck or lane load is applied to produce the maximum effects. The concentrated loads used with a standard (0.64 kip per foot) lane loading are 26 kips for vertical and diagonal truss members, and 18 kips for top and bottom chord members. Two 12' wide vehicular lanes are considered

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loaded for this rating. Loading considerations apply either to pedestrian or vehicular traffic. Simultaneous loading of HS20 trucks and pedestrian loading is not considered.

Deck and Overlay Thickness

During the 2014 inspection, the asphalt deck overlay was drilled in multiple locations to determine its thickness. The asphalt thickness varied from 2 1/2" to 5". The deck is assumed to be 8 1/2" thick. Based on photos and measurements from a 1973 deck inspection provided by NHDOT, top rebar cover is approximately 2" or more, indicating that the 1 1/2" integral wearing surface is likely still intact.

Material Properties

Structural Steel:

- $F_y = 33$ ksi (per testing coupons performed for 1991 load rating)
- $F_u = 66$ ksi
- $E = 29,000$ ksi
- Density = 490 pcf

Rivets (Gusset Plates):

- $F_u = 50$ ksi (per Table L6B.2.6.1-1 (MBE Int. 2014) and Table 6A.6.12.5.1-1 (MBE Int. 2011))

Concrete:

- $f'_c = 2,500$ psi (per MBE Table 6B.5.2.4-1)
- Density = 150 pcf

Reinforcing Steel:

- $F_y = 33,000$ psi per MBE Table 6B.5.3.2

Pavement:

- Density = 150 pcf

Deck Analysis

The deck is rated for its typical as-inspected condition (spalling with section losses on rebar). At locations where exterior stringers are considered failed, the deck is considered to have zero live load capacity. We further analyzed the deck for redistribution of loads to adjacent stringers and to the fascia channels at the bridge railing, as well as two-way redistribution on Spans 4 through 6 and found that the deck is overstressed under both conditions.

Stringer Analysis

Stringers are analyzed for moment and shear, assuming simple beam action. Stringers are analyzed as non-composite and the top flanges are assumed to be continuously braced by the deck. Pedestrian live loading is distributed to stringers using tributary area and the lever rule, and HS20 loading is distributed in accordance with AASHTO 17th Edition section 3.23. Stringers noted in the 2014 inspection report as overstressed with web crippling and buckling are considered to have zero capacity.

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Floorbeam Analysis

Floorbeams are analyzed for moment and shear, assuming simple beam action. Live loads and dead loads are applied as concentrated loads distributed to floorbeams using tributary area and the lever rule. When a stringer with zero capacity is present, the dead and live loads are redistributed to the floorbeams using the adjacent stringers.

Truss Analysis

Truss members are analyzed for axial compression and tension. The trusses for all spans are modelled in two-dimensions using Larsa 4D, Version 7.6. Analyses for both pinned and fixed type member end conditions indicate no significant difference in ratings. Therefore, the trusses are modelled with pinned-type connections. Truss self-weight is based on gross section properties of each member with detail factors applied to account for gussets, lacing bars, batten plates and other miscellaneous member components. Capacity evaluations are based on as-inspected conditions and section losses.

Gusset Plate Analysis

Gusset plates are analyzed in accordance with the 2014 interims of the MBE. Analyses include: capacity of fastener connections, full and partial plane shear, compression and tension at Whitmore sections, and block shear rupture.

Section losses are applied to each analysis section independently. Where section loss is present and adjacent to an analyzed cross-sectional plane, the losses are conservatively applied.

CONTROLLING RATINGS

Deck (All Spans)

Member Type	Location	Pedestrian Loading				HS20 Loading	
		Governing Rating Factor		Governing Rating (psf)		Governing Rating Factor	Governing Rating (Tons)
		Inv.	Op.	Inv.	Op.	Op.	Op.
Reinforced Concrete Deck	At Spalled Locations	3.9	6.5	328	550	0.6	21
	At Failed Stringers †	0	0	0	0	0	0

† Note: Refined analyses and load distribution indicate the deck is overstressed, where stringers are failed. In 2015, fencing was added to limit pedestrians and cyclist to the middle of the roadway and away from the deck at failed stringers.

Span 1

Member Type	Location	Pedestrian Loading				HS20 Loading	
		Governing Rating Factor		Governing Rating (psf)		Governing Rating Factor	Governing Rating (Tons)
		Inv.	Op.	Inv.	Op.	Op.	Op.
• Exterior Stringer	Panel 4-S1	0	0	0	0	0	0
Interior Stringer	Panel 6-S4	7.2	12.0	601	1017	1.9	69
• Floorbeam	FB4	3.3	5.5	281	468	1.1	39
Truss Member	U4-U5 E	2.1	3.6	127	213	2.0	73
Gusset Plate	L0 W	1.8	3.1	110	183	1.7	61

Span 2

Member Type	Location	Pedestrian Loading				HS20 Loading	
		Governing Rating Factor		Governing Rating (psf)		Governing Rating Factor	Governing Rating (Tons)
		Inv.	Op.	Inv.	Op.	Op.	Op.
• Exterior Stringer	Panel 3-S5	3.4	5.7	292	486	1.1	39
Interior Stringer	Multiple	5.8	9.7	494	825	2.1	75
• Floorbeam	FB3	2.2	3.7	186	310	0.8	29
Truss Member	L0-U1 W	1.7	2.9	104	173	1.8	63
Gusset Plate	L4 W	1.3	2.1	77	128	1.4	51

• Note: In 2015 fencing was added to limit pedestrian and cyclist to the middle of the roadway and away from the exterior stringers and the cantilevered portion of the floorbeams.

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Span 3

Member Type	Location	Pedestrian Loading				HS20 Loading	
		Governing Rating Factor		Governing Rating (psf)		Governing Rating Factor	Governing Rating (Tons)
		Inv.	Op.	Inv.	Op.	Op.	Op.
• Exterior Stringer	Multiple	0	0	0	0	0	0
Interior Stringer	Panel 14-S2	3.8	6.4	325	542	0.6	20
• Floorbeam	Multiple †	0	0	0	0	0	0
Truss Member	L8-U9 W	0.9	1.4	52	86	1.2	43
Gusset Plate	L10 W	1.9	3.1	111	186	2.6	95

† Note: There are two locations where the floorbeam end sections have zero live load capacity. The midspan section of the floorbeams supporting interior stringers have a pedestrian operating rating factor > 1.0.

Span 4

Member Type	Location	Pedestrian Loading				HS20 Loading	
		Governing Rating Factor		Governing Rating (psf)		Governing Rating Factor	Governing Rating (Tons)
		Inv.	Op.	Inv.	Op.	Op.	Op.
• Exterior Stringer	Multiple	0	0	0	0	0	0
Interior Stringer	Panel 1-S4	2.5	4.2	213	356	0.9	34
• Floorbeam	FB4	1.0	1.6	81	135	0.8	29
Truss Member	L0-U1 E&W	1.3	2.1	75	126	1.8	63
Gusset Plate	L6 E	1.4	2.3	82	137	2.3	83

Span 5

Member Type	Location	Pedestrian Loading				HS20 Loading	
		Governing Rating Factor		Governing Rating (psf)		Governing Rating Factor	Governing Rating (Tons)
		Inv.	Op.	Inv.	Op.	Op.	Op.
• Exterior Stringer	Multiple	0	0	0	0	0	0
Interior Stringer	Multiple	2.7	4.5	230	384	1.1	38
• Floorbeam	FB9'	1.1	1.8	93	155	0.9	31
Truss Member	U11-U12 E&W	1.4	2.3	81	135	2.3	84
Gusset Plate	L10' E	1.0	1.7	60	100	1.5	55

• Note: In 2015 fencing was added to limit pedestrian and cyclist to the middle of the roadway and away for the exterior stringers and the cantilevered portion of the floorbeams.

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Span 6

Member Type	Location	Pedestrian Loading				HS20 Loading	
		Governing Rating Factor		Governing Rating (psf)		Governing Rating Factor	Governing Rating (Tons)
		Inv.	Op.	Inv.	Op.	Op.	Op.
• Exterior Stringer	Multiple	0	0	0	0	0	0
Interior Stringer	Panel 0'-S4	2.5	4.2	213	356	0.9	34
• Floorbeam	FB2' †	0.3	0.4	21	35	0.2	8
Truss Member	L4'-U5' W	0.7	1.1	41	68	0.9	32
Gusset Plate	L6' E & W	2.2	3.6	130	216	3.8	136

† Note: The end sections of FB2' have very low live load capacity. The midspan section of the FB2' supporting interior stringers have a pedestrian operating rating factor > 1.0.

Span 7

Member Type	Location	Pedestrian Loading				HS20 Loading	
		Governing Rating Factor		Governing Rating (psf)		Governing Rating Factor	Governing Rating (Tons)
		Inv.	Op.	Inv.	Op.	Op.	Op.
• Exterior Stringer	Multiple	0	0	0	0	0	0
Interior Stringer	Panel 1-S4	3.8	6.3	321	536	0.6	19
• Floorbeam	FB8 †	0	0	0	0	0	0
Truss Member	L0-L1 W ††	0.4	0.6	22	37	0.5	19
Gusset Plate	U7 E & W	1.7	2.8	101	168	2.5	90

† Note: The end sections of FB8 have zero live load capacity. The midspan section of the FB8 supporting interior stringers have a pedestrian operating rating factor > 1.0.

†† Note: Truss Members L0-L1, both east and west, have operating rating factors for pedestrian loading <1.0 based on the full width of the bridge loaded. With the current fencing in place in Span 7, restricting the pedestrian loading to 12', the operating rating factors for pedestrian loading will be equal to or greater than 1.0

• Note: In 2015 fencing was added to limit pedestrian and cyclist to the middle of the roadway and away for the exterior stringers and the cantilevered portion of the floorbeams.

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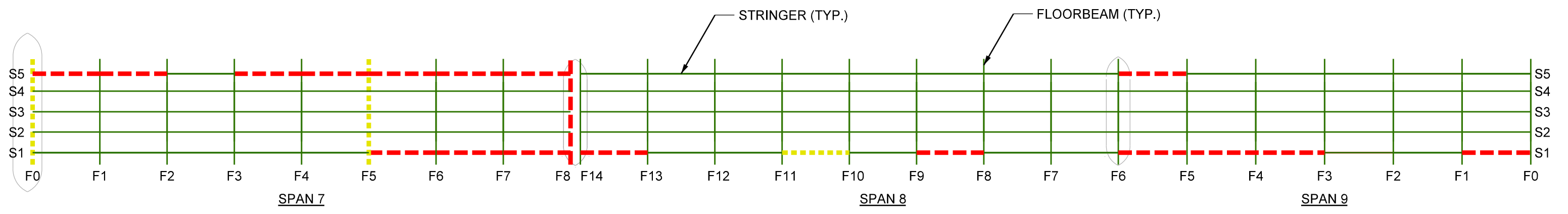
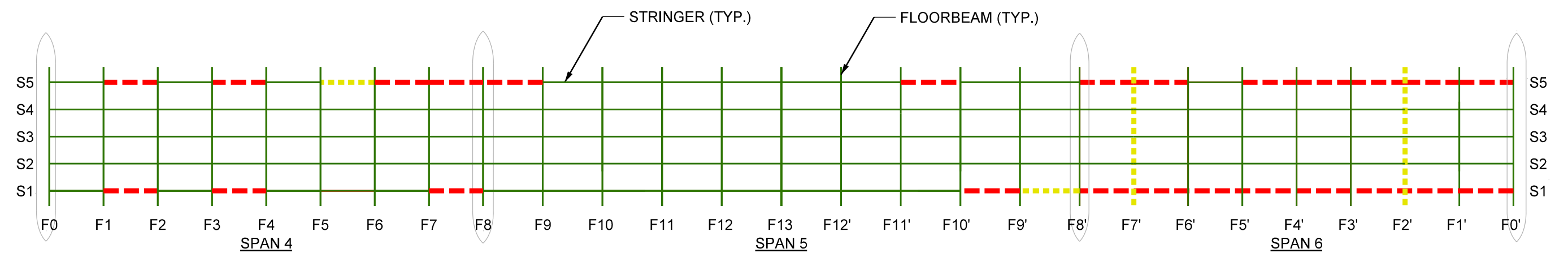
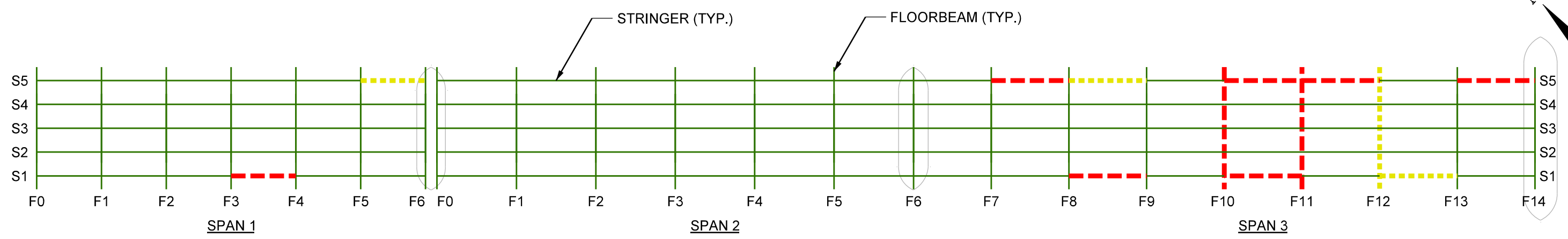
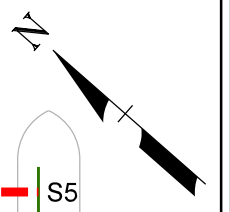
Span 8

Member Type	Location	Pedestrian Loading				HS20 Loading	
		Governing Rating Factor		Governing Rating (psf)		Governing Rating Factor	Governing Rating (Tons)
		Inv.	Op.	Inv.	Op.	Op.	Op.
• Exterior Stringer	Multiple	0	0.	0	0	0	0
Interior Stringer	Typical	6.2	10.3	525	876	2.2	78
• Floorbeam	FB8	2.2	3.7	186	310	1.0	35
Truss Member	L4-U3 W	2.0	3.4	122	204	2.2	80
Gusset Plate	L10 W	1.9	3.1	111	186	2.6	95

Span 9

Member Type	Location	Pedestrian Loading				HS20 Loading	
		Governing Rating Factor		Governing Rating (psf)		Governing Rating Factor	Governing Rating (Tons)
		Inv.	Op.	Inv.	Op.	Op.	Op.
• Exterior Stringer	Multiple	0	0	0	0	0	0
Interior Stringer	Typical	5.9	9.8	497	831	2.1	76
• Floorbeam	FB5	2.2	3.7	187	313	1.3	47
Truss Member	L8-U9 E	0.9	1.6	56	94	1.3	47
Gusset Plate	L4 W	1.3	2.1	77	128	1.4	51

• Note: In 2015 fencing was added to limit pedestrian and cyclist to the middle of the roadway and away for the exterior stringers and the cantilevered portion of the floorbeams.



FLOOR SYSTEM FRAMING PLAN

LOAD RATING RESULTS
LOAD FACTOR RATING (LFR) METHOD
PEDESTRIAN OPERATING LOADING ONLY

- LEGEND**
- - - - - MEMBERS WITH LFR OPERATING RATING FACTOR < 1.0
 - - - - - MEMBER WITH LFR OPERATING RATING FACTOR = 0.0

STATE OF NEW HAMPSHIRE										
DEPARTMENT OF TRANSPORTATION * BUREAU OF BRIDGE DESIGN										
TOWN		NEWINGTON-DOVER		BRIDGE NO.		200/203		STATE PROJECT		11238S
LOCATION GENERAL SULLIVAN BRIDGE										
PEDESTRIAN OPERATING RATING SUMMARY										
REVISIONS AFTER PROPOSAL		BY		DATE		CHECKED		BY		DATE
		JGM		3/16		SMH		3/16		
		KDW		3/16		JGM		3/16		
QUANTITIES		ISSUE DATE		FEDERAL PROJECT NO.		SHEET NO.		TOTAL SHEETS		
						14				
REV. DATE										



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