TECHNICAL RECONSTRUCTION GROUP CHAIRMAN'S FACTUAL REPORT

Bridge Collapse
Mount Vernon, WA; 05/23/2013

HWY-13-MH-012

(32 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C. 20594

A. ACCIDENT

LOCATION:	Interstate 5 at Milepost 228.25 over the Skagit River, in Mount Vernon, Skagit County, Washington.
VEHICLE 1:	2010 Kenworth Truck Tractor and 1997 Aspen Flatbed Trailer, Oversize Load Transport
OPERATOR:	Mullen Trucking LP, Aldersyde, Alberta, Canada
VEHICLE 2:	1997 Dodge Ram Pickup Truck, Piloting the Oversize Load
OPERATOR:	G&T Crawlers, Olympia, Washington
VEHICLE 3:	2000 Kenworth Truck Tractor and 1996 Utility Refrigerated Trailer
OPERATOR:	Motorways Transport LTD, Surrey, British Columbia, Canada
VEHICLE 4:	2010 Dodge Ram Pickup Truck and 2009 Jayco Travel Trailer
OPERATOR:	Private owner
VEHICLE 5:	2013 Subaru VX Crosstrek
OPERATOR:	Private owner
VEHICLE 6:	1995 BMW 525i
OPERATOR:	Private owner
DATE:	May 23, 2013
TIME:	Approximately 7:05 p.m. PDT
FATAL:	0
INJURIED:	3 minor, 5 uninjured
NTSB #:	**HWY13MH012**

B. TECHNICAL RECONSTRUCTION GROUP

Robert Squire — Accident Investigator — Group Chairperson
Office of Highway Safety
National Transportation Safety Board
Washington, DC 20594

Dan Walsh — Highway Factors Investigator
Office of Highway Safety
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Arlington, TX 76011

C. ACCIDENT SUMMARY

For a summary of the accident, please refer to the *Accident Summary* report in the docket for this investigation.

D. DESCRIPTION OF DATA EXAMINED

The Technical Reconstruction Group participated in the documentation of the highway and several of the involved motor vehicles. Primary forensic documentation included photographs, measurements and laser scanning of the bridge deck and overhead structure of the surviving bridge spans, roadway evidence, the tractor and semitrailer combination transporting the oversized load, an exemplar tractor-semitrailer combination transporting an identical load, and the two vehicles that fell with the collapsing bridge span into the Skagit River. This report provides descriptions of significant observations and information regarding the documentation process. Factual reports prepared by other investigative groups should be consulted for additional details.

All photographs were taken in digital format using an SLR camera. Laser scanning was accomplished using the FARO Focus 3D[1] scanner that created multiple linked scans of the object being scanned. The scans were preprocessed and converted to point cloud data files. Select isometric images depicting various perspectives of the subject are presented for illustration. Additional processing permitted the data to be exported for use in various CAD software applications to acquire additional dimensional data and create two-dimensional renderings where needed.

[1] The FARO Focus3D is a high-speed Terrestrial Laser Scanner for 3D measurement and image documentation. The scanner produces dense point cloud scans that can be combined or linked with multiple positions to create a cohesive three-dimensional point cloud rendering an exact measureable copy of the target.

1. Scene Documentation

1.1 Introduction

The subject bridge supported Interstate (highway) 5 (I-5), a north-south highway over the Skagit River between Mount Vernon and Burlington, Washington. The overall length of the bridge was approximately 1111.75 feet with 647.5 feet supported by a through-truss structure. Figure 1 depicts an aerial view of the bridge exhibiting the approaches and truss structure.

Figure 1: Aerial view of bridge as captured by Google Earth in 2011.

The bridge was comprised of 12 spans with the truss structure supporting four equidistant spans each having a length of approximately 160 feet[2]. Construction documents identify the spans by consecutive numbering beginning with number 1 at the south end of the bridge. Spans numbered 5 through 8 were within the truss structure with span number 8 being the one that collapsed into the river. Figure 2 identifies the bridge spans and their approximate lengths as depicted by construction plans.

Span number 8 had collapsed and separated completely from its supporting piers. The bridge deck and truss superstructure were fractured with portions becoming partially submerged in the river following the collapse (see figure 3). Other investigative group reports should be consulted for additional details regarding the collapsed span.

[2] Construction plans indicate approximately 2.5 feet of distance between the spans to accommodate expansion joints.

Figure 2: Bridge span orientation (Google Earth).

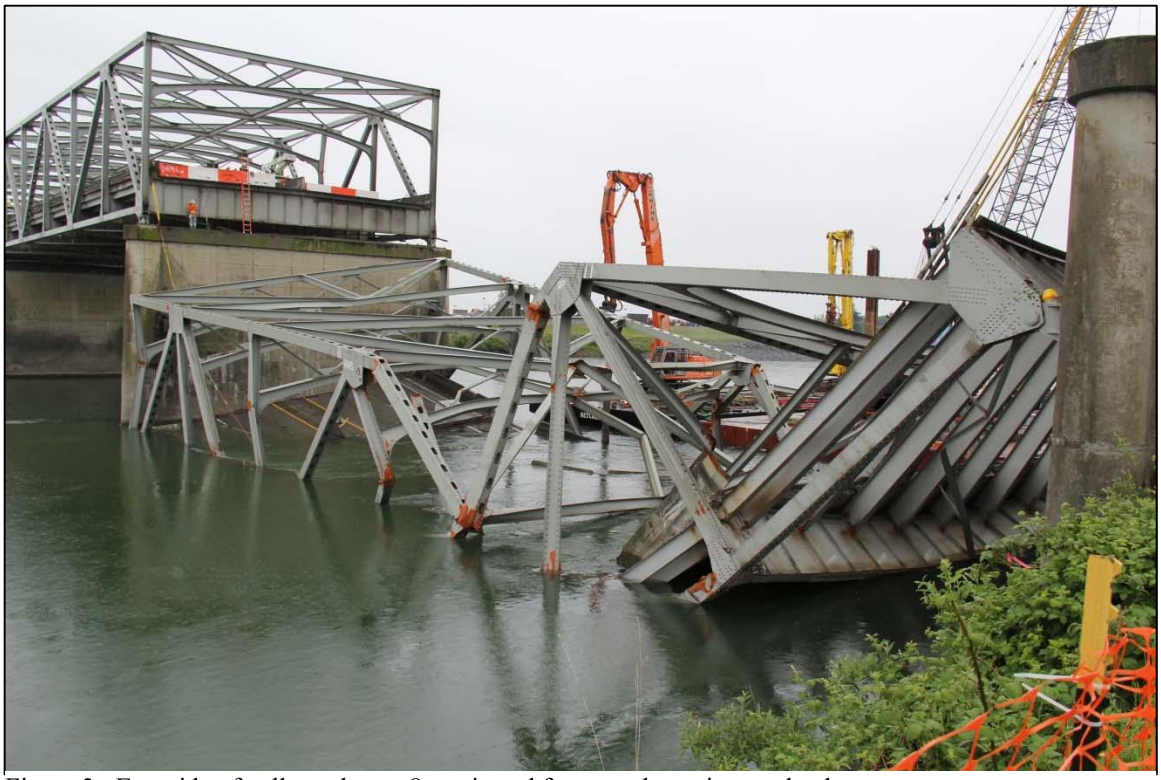


Figure 3: East side of collapsed span 8 as viewed from northern river embankment.

1.2 Vertical Clearance Documentation

The lowest vertical clearance between the highway and overhead through-truss structure was observed at the sway braces (or frames) that laterally traversed the highway. The sway braces are arched components that exhibited lower clearances toward the outside edges of the bridge (east and west sides) and the maximum clearance along the longitudinal centerline of the bridge and above the left highways lanes. The flange at the bottom of each sway brace was parallel to the highway surface. Spans 6 and 7 of the bridge had seven (7) sway braces that were numbered for identification sequentially from zero (0) to six (6) beginning at the south end of each respective span. Span 5 had six (6) sway braces numbered sequentially from one (1) to six (6) also beginning at the south end of the span. Similar to span number 5, span number 8 also had six (6) sway braces, but were numbered sequentially from zero (0) to five (5) in the northward direction. The first brace at both the northern and southern ends of the truss structure were termed portal braces.

The vertical clearance between the highway surface and bottom flange of the sway braces on spans 5 through 7 was measured alomg fourteen (14) locations across the highway (7 locations above both the northbound and southbound roadways), which yielded a total of 280 individual measurements. The measurement locations included – outside barrier face (roadway edge), right lane fog line, center of right lane, lane dividing line, center of left lane, left fog line and left barrier face (roadway edge). The specific measurements along with data summary are presented in table 1. Figures 4 and 5 depict graphical representations of the variations in vertical clearance as exhibited by each sway brace at the points of measurement. The Highway Factors Group report should be consulted for additional details.

Evidence of contact resulting in observable damage to each sway brace was also documented across both the south- and northbound roadways. In addition to documenting the vertical height at which the contact evidence appears, the distance of the contact damage relative to the curb side fog line was also noted[3]. Figure 5 provides a graphical representation of the contact damage position relative to the fog line. Evidence of contact that appeared recent was observed on five of the seven sway braces on span 7. Contact damage that appeared aged was observed to one brace on span 7 (U0), two braces on span 6 and one brace on span 5. Appendix A provides additional detail regarding the documentation of the observed contact damage above the southbound roadway (heading of accident truck).

[3] Generally the southbound right side fog line was approximately XX feet inboard of the western vertical truss supports.

		Southbound Direction								Northbound Direction							
Span	Brace	Outside Barrier	Edge Line - SWL	Mid-Point Outside Lane	Lane Line BWL	Mid-Point Inside Lane	Edge Line - SYL	Inside Barrier	Evidence of Impact	Inside Barrier	Edge Line - SYL	Mid-Point Inside Lane	Lane Line BWL	Mid-Point Outside Lane	Edge Line - SWL	Outside Barrier	Evidence of Impact
5	U1 Portal Brace	14.88	15.80	16.98	17.78	18.02	17.96	17.91		17.93	17.95	17.89	17.65	16.90	15.53	14.85	Yes
	U2 Sway Brace	14.90	15.83	17.09	17.74	18.04	18.04	18.04		18.02	18.05	17.95	17.71	16.93	15.57	14.87	Yes
	U3 Sway Brace	14.83	15.78	17.06	17.73	18.03	18.03	18.02		18.03	18.04	17.97	17.67	16.93	15.61	14.81	Yes
	U4 Sway Brace	14.84	15.78	17.02	17.70	17.99	18.01	18.00		18.00	18.00	17.94	17.67	16.92	15.57	14.76	
	U5 Sway Brace	14.80	15.74	17.01	17.73	18.06	18.07	18.06	Yes	18.04	18.06	18.01	17.69	16.95	15.52	14.67	
	U6 Sway Brace	14.93	15.76	17.04	17.65	18.03	18.04	18.04		18.04	18.07	18.03	17.75	16.96	15.55	14.76	
6	U0 Sway Brace	14.87	15.72	16.99	17.71	17.97	18.02	18.01		18.01	18.02	18.00	17.69	16.90	15.55	14.79	
	U1 Sway Brace	14.86	15.77	17.00	17.82	18.01	18.04	18.04		18.04	18.06	17.97	17.67	16.86	15.49	14.82	
	U2 Sway Brace	14.80	15.69	17.01	17.76	18.07	18.07	18.07	Yes	18.06	18.08	18.03	17.70	16.89	15.46	14.77	
	U3 Sway Brace	14.87	15.75	17.03	17.79	18.03	18.04	18.02		18.03	18.05	18.02	17.73	17.02	15.53	14.87	
	U4 Sway Brace	14.86	15.75	16.96	17.70	18.01	18.03	18.01		18.01	18.03	17.99	17.72	16.88	15.50	14.78	
	U5 Sway Brace	14.75	15.69	17.01	17.75	18.02	18.05	18.04	Yes	18.01	18.05	17.99	17.65	16.86	15.53	14.98	
	U6 Sway Brace	14.83	15.65	16.97	17.71	18.02	18.01	18.01		18.01	18.01	17.95	17.69	16.89	15.51	14.84	
7	U0 Sway Brace	14.83	15.65	16.98	17.71	18.01	18.02	17.99	Yes	17.98	18.00	17.98	17.67	16.93	15.55	14.71	
	U1 Sway Brace	14.84	15.70	16.99	17.72	18.00	18.05	18.04		18.01	18.02	17.96	17.68	16.90	15.57	14.87	
	U2 Sway Brace	14.84	15.71	16.98	17.70	18.03	18.08	18.08	Yes	18.06	18.07	17.98	17.66	16.88	15.56	14.86	
	U3 Sway Brace	14.94	15.66	17.01	17.72	18.06	18.09	18.11	Yes	18.07	18.09	18.00	17.69	16.88	15.55	14.93	
	U4 Sway Brace	14.99	15.88	17.06	17.84	18.10	18.12	18.11	Yes	18.06	18.07	18.00	17.72	16.90	15.56	14.80	
	U5 Sway Brace	15.01	15.75	17.02	17.76	18.06	18.10	18.09	Yes	18.06	18.07	17.98	17.68	16.87	15.55	14.88	
	U6 Sway Brace	15.05	15.79	16.96	17.75	18.13	18.14	18.13	Yes	18.08	18.09	18.03	17.74	16.90	15.54	14.99	
	Minimum	**14.75**	**15.65**	**16.96**	**17.65**	**17.97**	**17.96**	**17.91**		**17.93**	**17.95**	**17.89**	**17.65**	**16.86**	**15.46**	**14.67**	
	Maximum	**15.05**	**15.88**	**17.09**	**17.84**	**18.13**	**18.14**	**18.13**		**18.08**	**18.09**	**18.03**	**17.75**	**17.02**	**15.61**	**14.99**	
	Average (Mean)	**14.88**	**15.74**	**17.01**	**17.74**	**18.03**	**18.05**	**18.04**		**18.03**	**18.04**	**17.98**	**17.69**	**16.91**	**15.54**	**14.83**	
	Range (Min-Max)	**0.30**	**0.23**	**0.13**	**0.19**	**0.16**	**0.18**	**0.22**		**0.15**	**0.14**	**0.14**	**0.10**	**0.16**	**0.15**	**0.32**	
		3.60 inch	**2.76 inch**	**1.56 inch**	**2.28 inch**	**1.92 inch**	**2.16 inch**	**2.64 inch**		**1.80 inch**	**1.68 inch**	**1.68 inch**	**1.20 inch**	**1.92 inch**	**1.80 inch**	**3.84 inch**	
	Median	**14.86**	**15.75**	**17.01**	**17.73**	**18.03**	**18.04**	**18.04**		**18.03**	**18.05**	**17.99**	**17.69**	**16.90**	**15.55**	**14.83**	
	Standard Deviation	**0.07 ft**	**0.06 ft**	**0.03 ft**	**0.04 ft**	**0.04 ft**	**0.04 ft**	**0.05 ft**		**0.03 ft**	**0.03 ft**	**0.03 ft**	**0.03 ft**	**0.04 ft**	**0.03 ft**	**0.08 ft**	

Table 1: Vertical clearance of sway brace above roadway at select positions. Measurements are in feet.

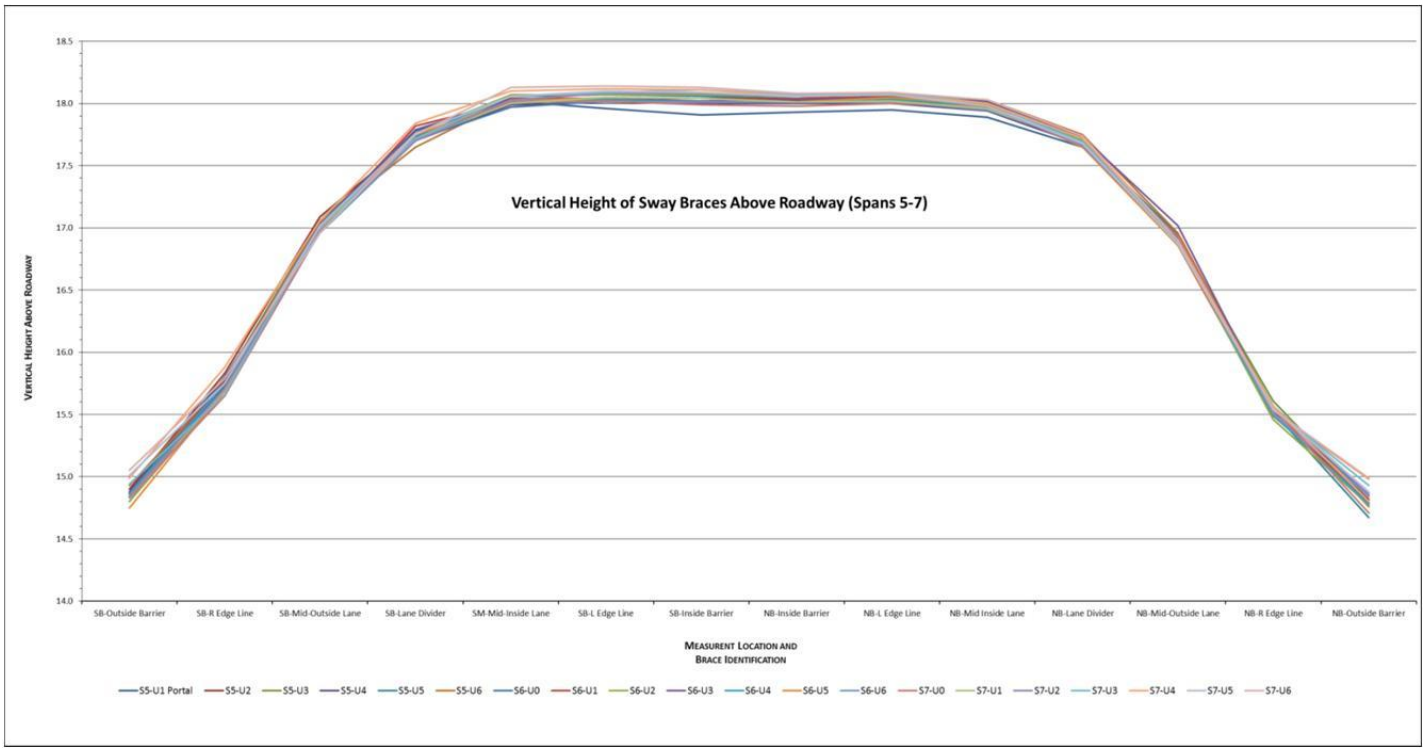


Figure 4: Vertical clearances of sway braces on spans 5 through 7 at select locations.

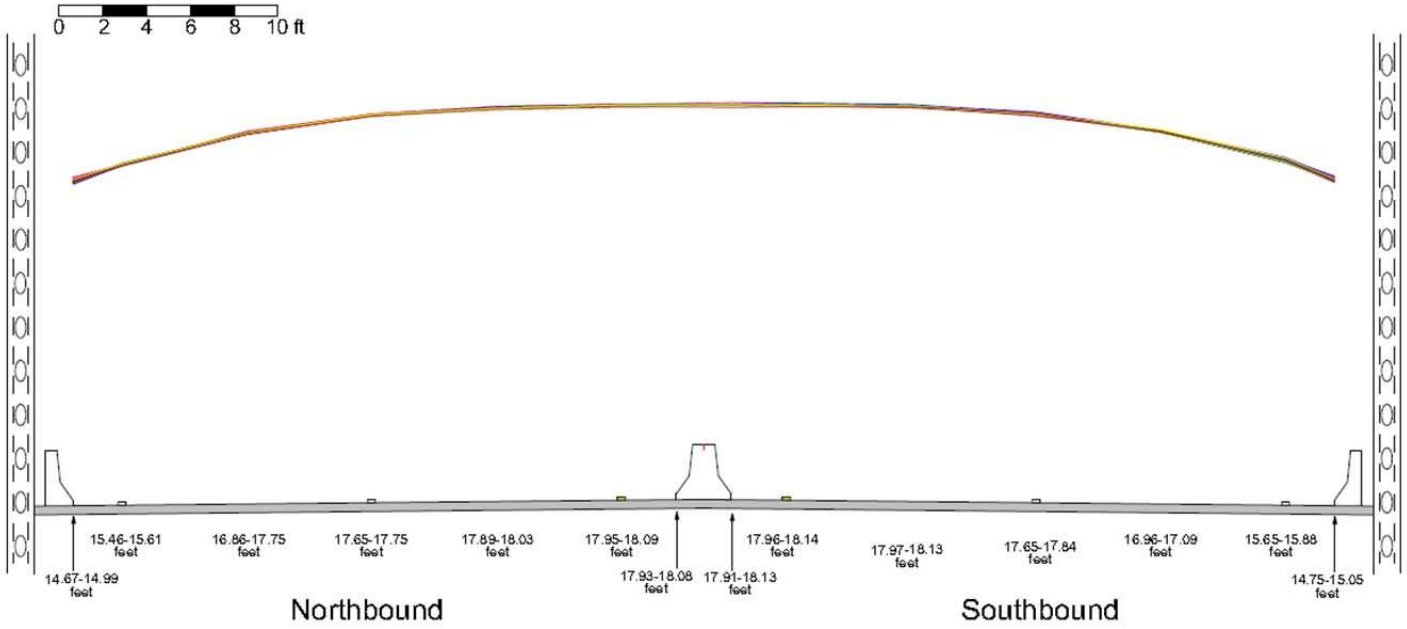


Figure 5: Depiction of vertical clearance of sway braces on spans 5 through 7 relative to roadway surface.

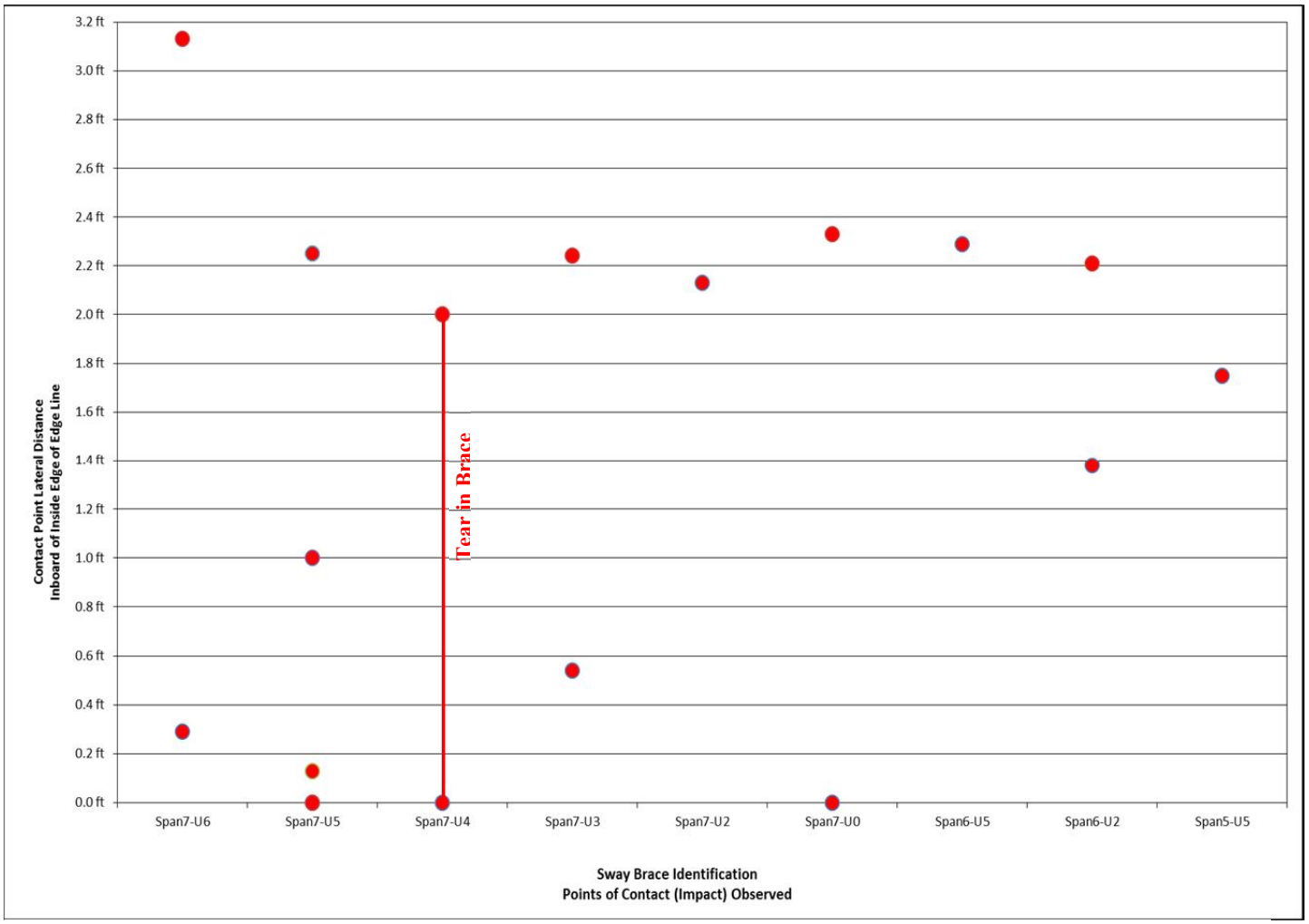


Figure 6: Contact evidence position relative to curb side fog line.

1.3 3D Laser Scanning Documentation

Three-dimensional scanning was completed along the bridge deck between spans 4 through 7, which included the three remaining truss sections. Span number 4 is located on the southern side of the river. The length of the scanned area included approximately 528 feet of the bridge structure and captured the interior of the through-truss superstructure on spans 5 through 7. A total of 24 stations were established to complete the scan.

Figures 6 and 7 depict screen captures[4] of the colorized three-dimensional linked scans of the bridge from the south portal.

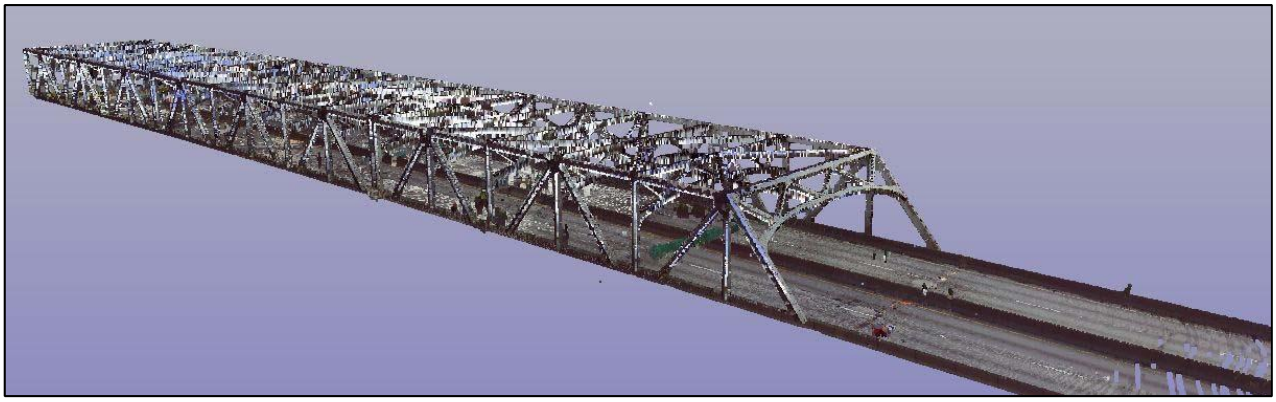


Figure 7: Isometric view of south portal from linked 3D scans.

Figure 8: Linked 3D scans of spans 4 through 7.

[4] Scans are rendered within the FARO software. Since the scanning was performed from inside the truss structure, the image resolution of the exterior surface of the truss superstructure is reduced.

1.4 Roadway Evidence Documentation

Roadway evidence and debris from the impacts between the Kenworth combination and the bridge were observed within the southbound lanes at various locations, specifically along the deck of span 7 and trailing onto span 6. Documentation of the roadway evidence was completed by the Washington Highway Patrol using a totalstation.

Potential evidence located on the roadway consisted of tire friction marks and deposits of dirt debris, blue colored metallic fragments, orange paint chips and a few large steel fasteners (nuts with sheered threaded fasteners). Also observed on the bridge deck were pieces or cargo securement devices including a length of synthetic webbing, a link of steel chain and a securement strap D-ring.

Tire friction marks appeared in single and dual configuration, all of which were located within and parallel to the right southbound lane. The onset of a single narrow mark was located approximately 10.5 feet south of the north end of span 7 and terminated about 34 feet to the south. The friction mark was located approximately 3.5 feet into the lane from (east of) the right fog line. The onset of dual tire friction marks was documented at several locations beginning about 57.5 feet south of the north end of span 7. The onset of these marks was approximately four feet into the right lane. Additional dual tire friction marks appear approximately 102 feet south of the northern end of span 7. The lateral position of these marks ranged from 0.75 to 9.5 feet east of the southbound right fog line. Most of the friction marks terminate within 144 feet south of the north end of span 7, although a pair of dual marks was documented as continuing onto span 6 and terminating about 270 feet south of the north end of span 7.

Approximately 98 feet south of the north end of span 7, deposits of dirt overlapped areas of the tire friction marks. The presence of the dirt deposits terminated about 57 feet south of the initial deposit. Other debris located in the right lane included a link of ½ inch steel chain and a length of 4 inch wide synthetic cargo tie-down webbing. Both were located about 112 feet south of the northern end of span 7 and roughly centered within the right southbound lane.

Several large steel hex nuts with portions of sheered threaded fasteners were located within the southbound roadway atop span 7. Additional debris included a wide scattering of orange-colored paint chips that extended from the northern end of span 7 approximately 194 feet to the south or about one-fifth the overall distance onto span 6. Identical paint chips were also found on the Kenworth combination.

The accident vehicle combination came to a stop off the bridge approximately 188 feet south of span 1 (approximately 905 feet south of the northern end of span 7). The vehicle had been brought to a stop straddling the right edge line.

Figure 8 depicts a diagram of a portion of the scene data collected by the Washington State Patrol on span 7 and part of span 6.

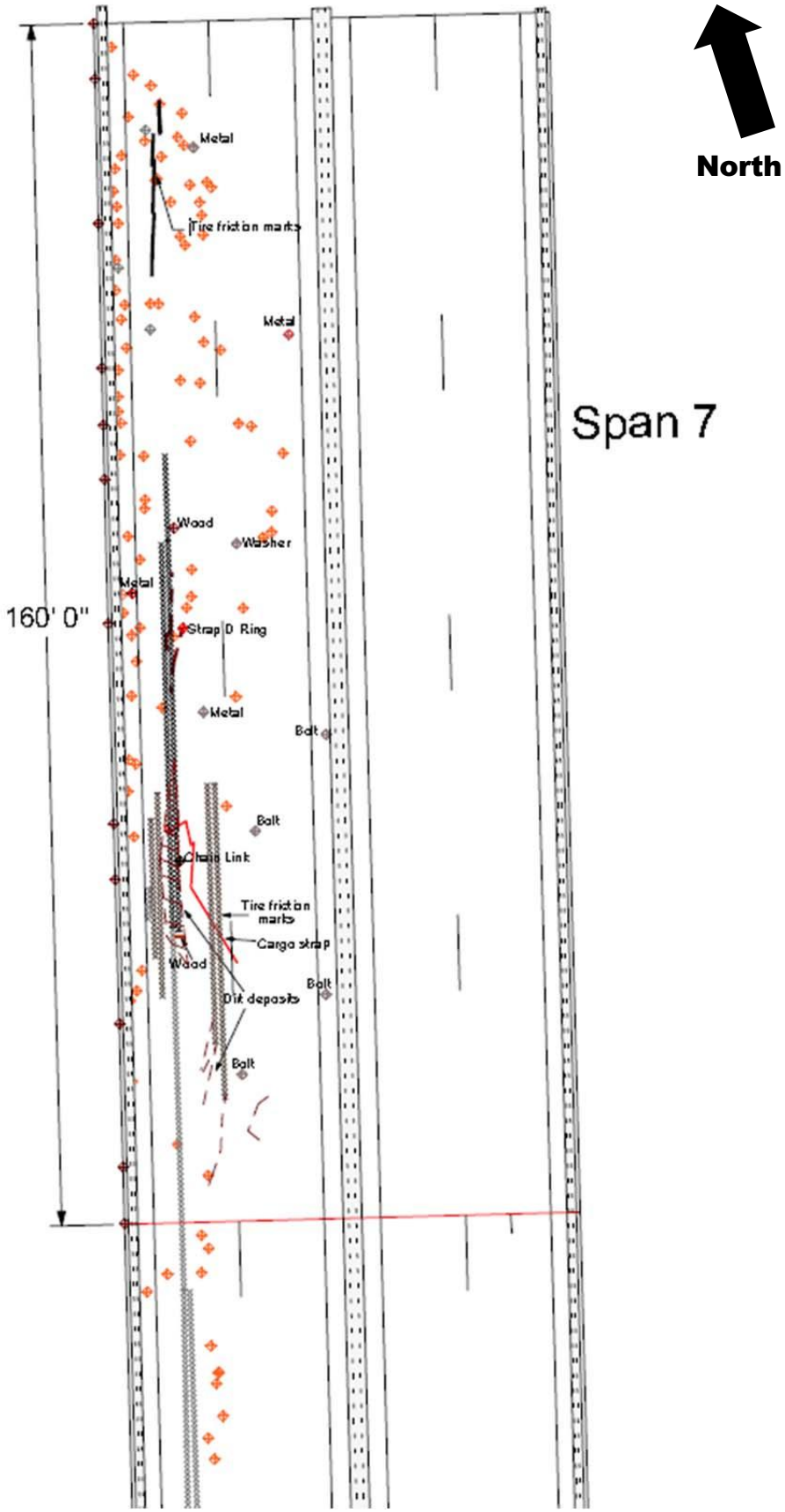


Figure 9: Diagram depicting data captured by Washington State Patrol atop span 7 and a portion of span 6 (numerous orange points represent scattering of paint chips).

2. Vehicle Documentation

2.1 Accident Vehicle and Cargo

The involved commercial motor vehicle was identified as a 2010 Kenworth T800B truck tractor in combination with a 1997 Aspen SD40-3TR tridem extendable step deck semitrailer. At the time of the collision, the vehicle was hauling an open steel structure identified as a casing shed. The casing shed exhibited dimensions[5] of approximately 60 feet in length, 11.5 feet in width, and 12.25 feet in height with an approximate weight of 40,000 pounds. Due to the size of the casing shed, the load was considered oversize by Washington state statute. The overall length and weight of the combination tractor, semitrailer and cargo was approximately 93.58 feet and 88,700 pounds. Post-collision weighing of the combination unit revealed that the trailer axles supported approximately 49% of the gross combination weight while 84% of the gross combination weight was supported by a combination of the trailer and tractor drive axles. See the Vehicle Factors Chairman's Factual Report for additional information.

The combination unit was scanned from a total of 10 stations at two locations that included its post-collision position of rest as well as at a secured storage facility. Scanning captured all exterior surfaces with the exception of the horizontal top and undercarriage of the vehicle. Figure 9 depicts a screen capture of the colorized three-dimensional linked scans of the accident vehicle and cargo.

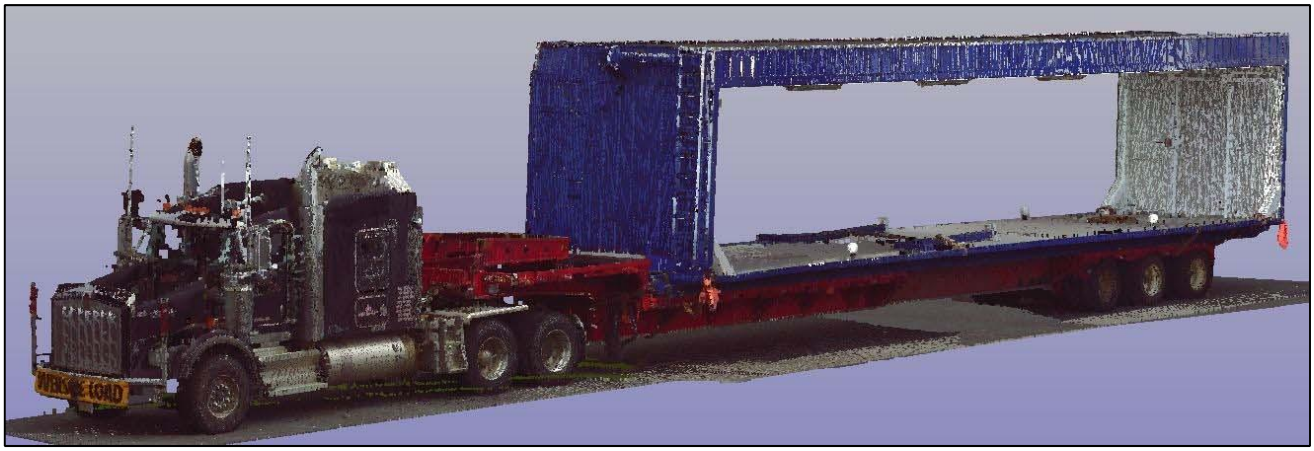


Figure 10: Isometric view of accident vehicle from linked 3D scans.

The 40,000 pound casing shed had been secured to the trailer by four (4) ½ inch, grade 7 steel chains with ratcheting load binders and two (2) four inch wide synthetic straps. The chains were secured each corner of the shed to the trailer. The cargo straps laterally traversed the shed at the front and rear (about seven feet forward of the back wall). The

[5] Dimensions were furnished by the manufacturer, Thunder & Lightning Welding Ltd., Alberta Canada, and confirmed during examination. See Vehicle Factors information report for additional information.

minimum[6] aggregate working load limit (WLL) for all the securement devices was calculated at 29,200 pounds, which was sufficient for compliance with federal regulations[7].

Examination of the load and securement devices revealed that the two synthetic straps and one chain assembly had separated from the cargo during the event. The chain assembly at the right forward corner was found separated from the load binder and hanging from the trailer side rail (see figure 10). The forward cargo strap was unfastened and hanging from the left side forward corner. The casing shed exhibited evidence of a strap having been transversely positioned through the casing shed at the rear. As previously noted, a cargo strap was found in the roadway atop span 7 of the bridge. The trailer deck and load securement chains exhibited evidence of substantial scuffing and blue colored paint transfer.

Figure 11: Broken securement chain at forward right corner of casing shed.

Direct damage sustained by the casing shed as a result of contact with the bridge structure was confined to the forward upper right side corner (relative to truck orientation). The forward wall of the shed was skewed rearward at the top making the shed out of square. The right upper side panel at the roof line exhibited additional minor deformation and

[6] Variations in load binder models exhibited a WLL of 9,200 to 13,000 pounds. Webbing labeled WLL 5,400 lbs.
[7] Federal Motor Carrier Safety Regulations, 49 CFR Part 393.106 specifies that the aggregate WLL of the securement devices must be one –half times the weight of the load.

light scape marks to the painted surface. Paint damage and scrapes was also noted at several points along the horizontal surface of the roof on the right side trailing rearward.

The damaged area at the upper right corner of the casing shed exhibited evidence of multiple points of contact. Distinct areas of contact were located at the roof line, 3½ inches, 7½ inches and 17 inches below the roof line. The individual areas of damage also exhibited an angular or arched pattern. The overall area of damage extended laterally inboard approximately 44 inches from the right side of the shed.

The casing shed also exhibited scrape marks along a portion of the left side upper sidewall. These marks consisted of gouging to the painted surface with some indentation and tearing of the steel at the forward left corner. At the forward end, the contact damage terminated at multiple points with three individual areas being discernible. The areas of damage were longitudinally oriented and extended rearward along the face of the upper sidewall at an apparent uniform spacing. The marks also exhibited a change in vertical height as they progressed longitudinally.

Onset of the longer scrape appeared as a single point toward mid-section of casing shed, about 15 feet aft of shed front. Onset of second scrape appeared further forward approximately 3.2 feet aft of the shed front. The rearward termination points of the scrapes appeared as narrow points but the contact area appeared to widen as the marks progressed forward.

At the forward termination points for this sidewall damage, the upper scrape was approximately 7½ inches downward from the shed roof (15.3 feet above road) and had a maximum contact width of contact of 2.5 inches. The middle area of damage and second longest scrape terminated approximately 12 inches downward from shed roof (14.9 feet above road) and had a maximum contact width of 4 inches. The lower area of contact, which appeared as paint scuffing, was about 22 inches downward from shed roof (14.08 feet above road) and exhibited a width of 1 inch.

Figures 12 through 15 depict the areas of damage on the casing shed.

Figure 12: Accident vehicle at its position of rest on the highway.

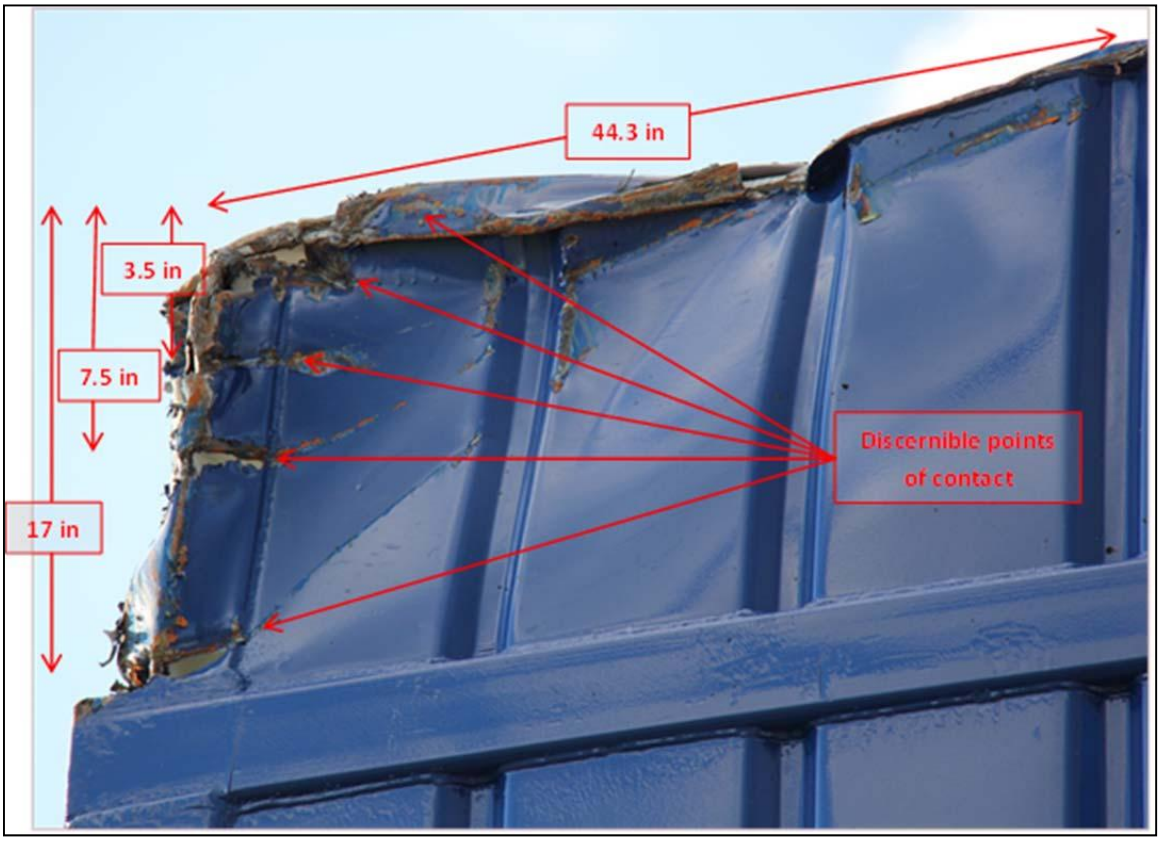


Figure 13: Contact damage at upper right corner of casing shed.

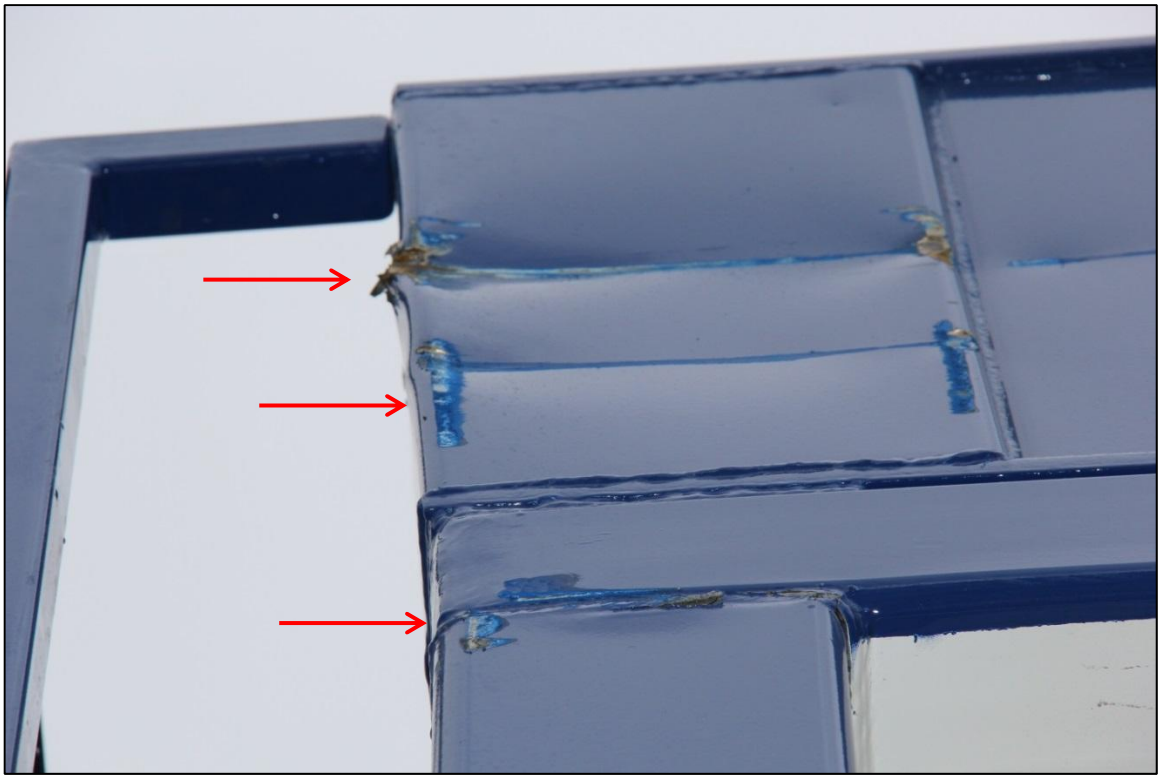


Figure 14: Forward termination of damage at forward left side of casing shed.

Figure 15: Rearward termination point of longest damage on left side of casing shed.

2.2 Exemplar Transport Vehicle and Load

For comparison and documentation of an undamaged load and transport vehicle, an identical casing shed secured atop a sister trailer was coupled to the accident tractor. The exemplar combination was measured, photographed and scanned (using nine stations).

Figure 16 depicts a screen capture of the colorized linked 3D scans of the exemplar combination.

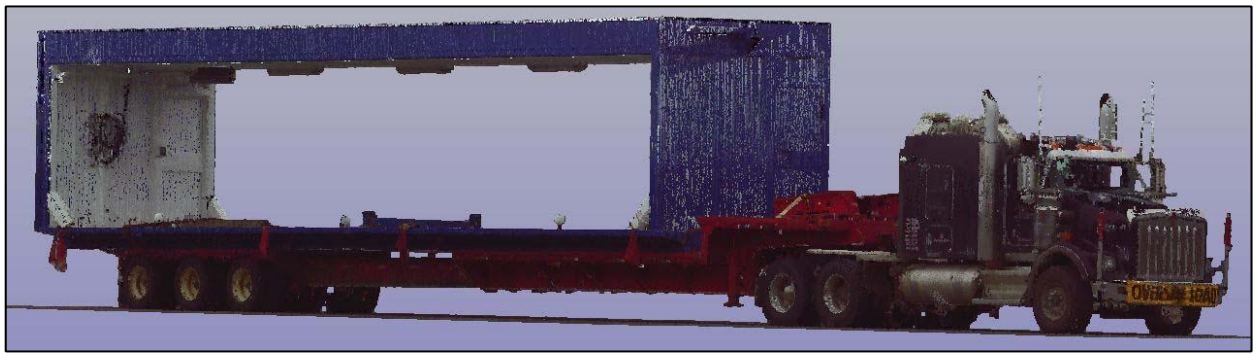


Figure 16: Isometric view of exemplar combination from 3D scanner data.

2.3 2013 Subaru Crosstrek

As the bridge span collapsed, two passenger vehicles that had also been traveling on the bridge fell into the river with the collapsing span. One of the two vehicles was identified as a 2013 Subaru Crosstrek which came to rest upright atop the southern portion of the bridge deck facing northward and partially submerged in the river.

After the vehicle was removed from the river it was documented through photographs and 3D scanning. Figures 17 and 18 depict isometric views of the linked 3D scans.

Figure 17: Isometric view of Subaru from linked 3D scans.

Figure 18: Isometric view of Subaru from linked 3D scans.

2.4 Dodge Pickup Truck

The second vehicle that fell during the collapse of span 8 was identified as a 2010 Ram 1500 pickup truck. The Ram had been towing a 22-foot Jayco travel trailer at the time of the bridge collapse. The Ram came to rest upright atop the southern portion of the bridge deck generally facing southward and partially submerged in the river. The trailer came to rest further north on the collapsed span and was destroyed.

After the vehicle was removed from the river, the pickup was documented through photographs and 3D scanning. Figures 19 and 20 depict isometric views of the linked 3D scans.

Figure 19: Isometric view of Ram from linked 3D scans.

Figure 20: Isometric view of Ram from linked 3D scans.

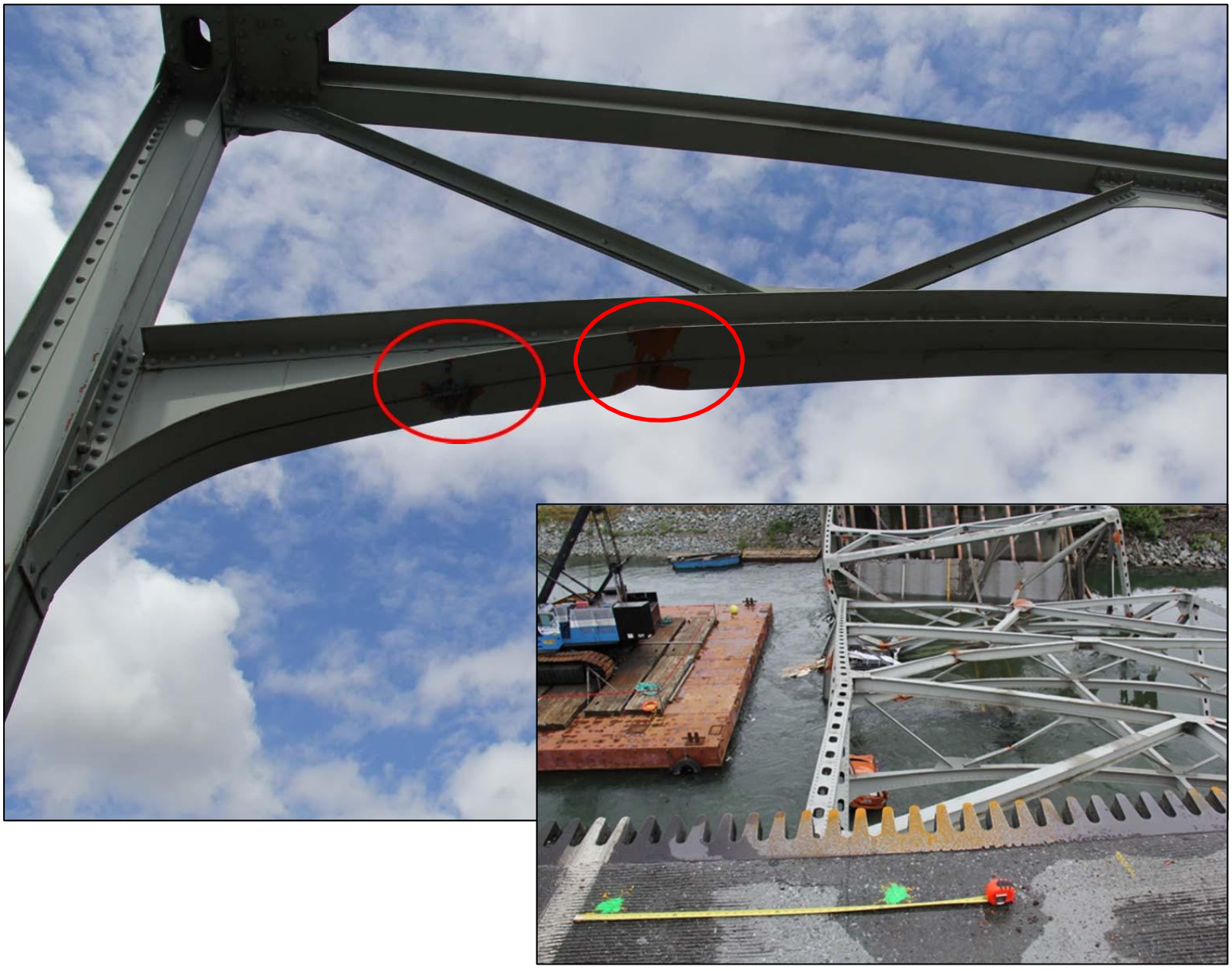
END OF REPORT

Robert Squire
Accident Reconstruction

Appendix A – Documentation of Sway Brace Contact Evidence

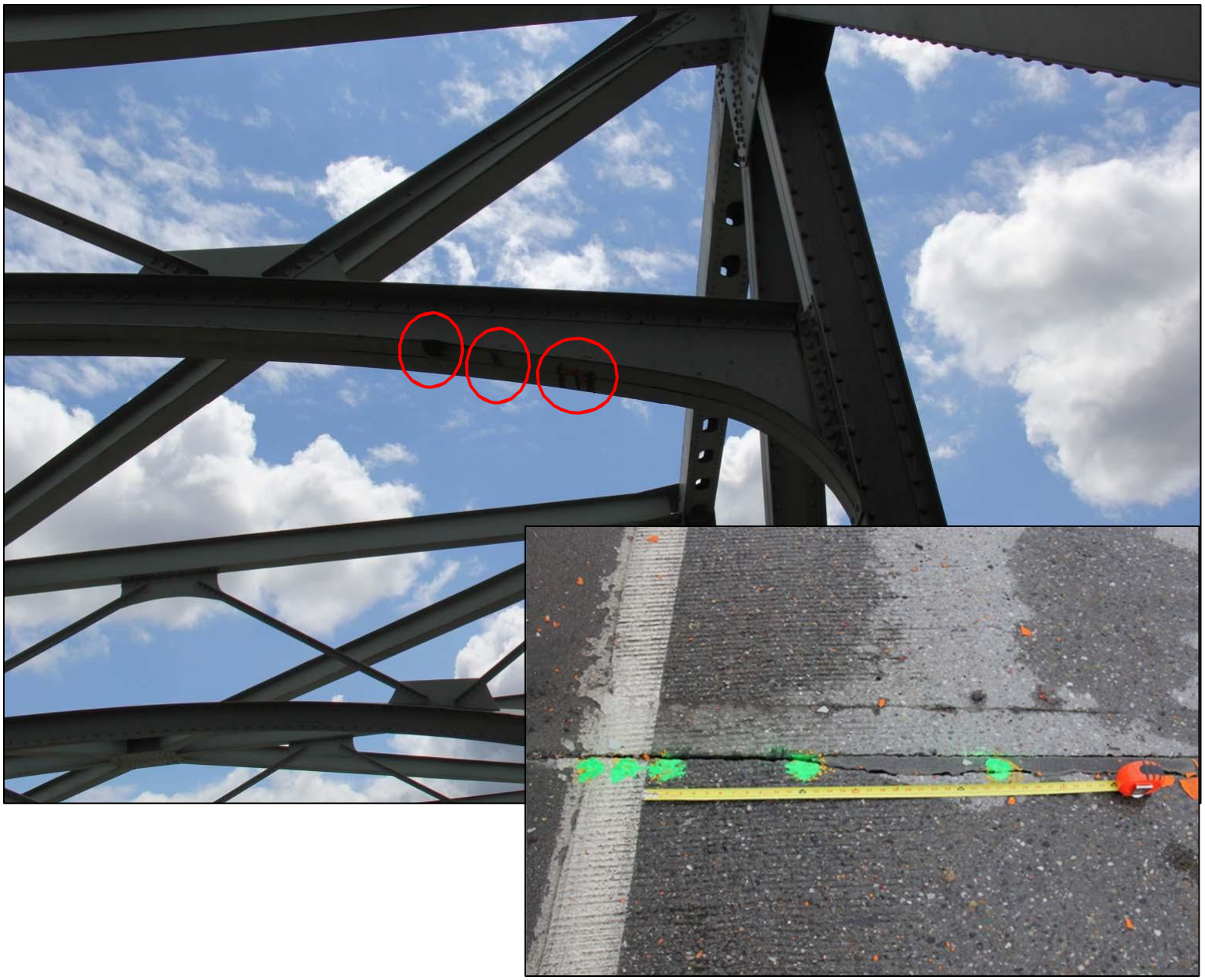
Sway Brace Contact Evidence Documentation – Southbound Lanes, West Side

Span 7 – U6



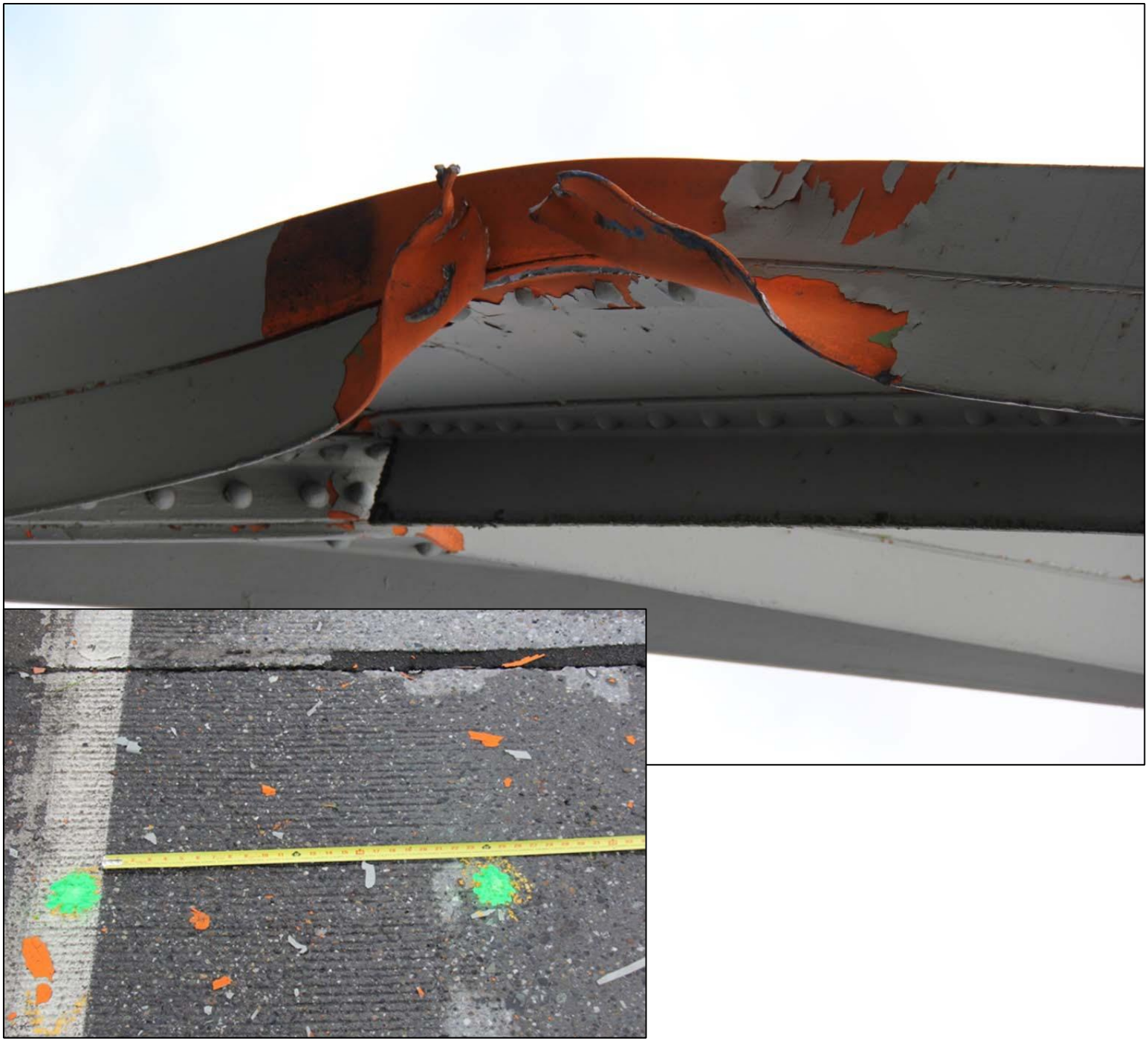
	Point 1	Point 2
Distance inboard of edge line	0.29 ft	3.13 ft
Vertical height	15.95 ft	16.63 ft
	Measurement from inside edge of striping	

Span7 – U5



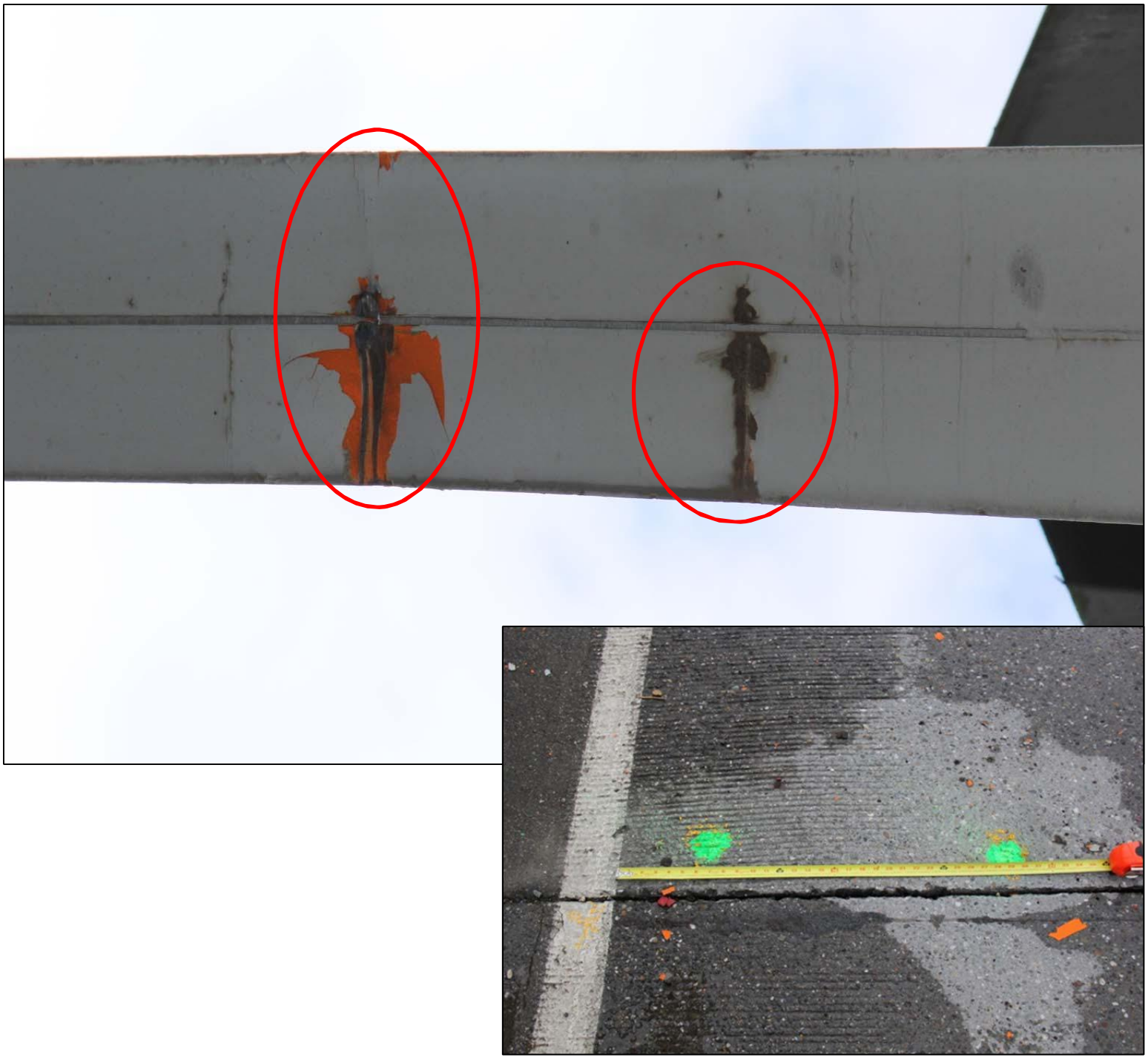
	Point 1	Point 2	Point 3	Point 4	Point 5
Distance inboard of edge line	0.00 ft (-0.37 ft)	0.00 ft (-.17 ft)	0.13 ft	1.00 ft	2.25 ft
Vertical height	15.69 ft	15.75 ft	15.82 ft	16.13 ft	16.40 ft
	Measurement from inside edge of striping				

Span 7 – U4



	Point 1	Point 2
Distance inboard of edge line	0.00 ft (-.16 ft)	2.00 ft
Vertical height	15.24 ft	16.16 ft
	Measurement from inside edge of striping. Measured points define approximate edges of significant deformation.	

Span 7 – U3

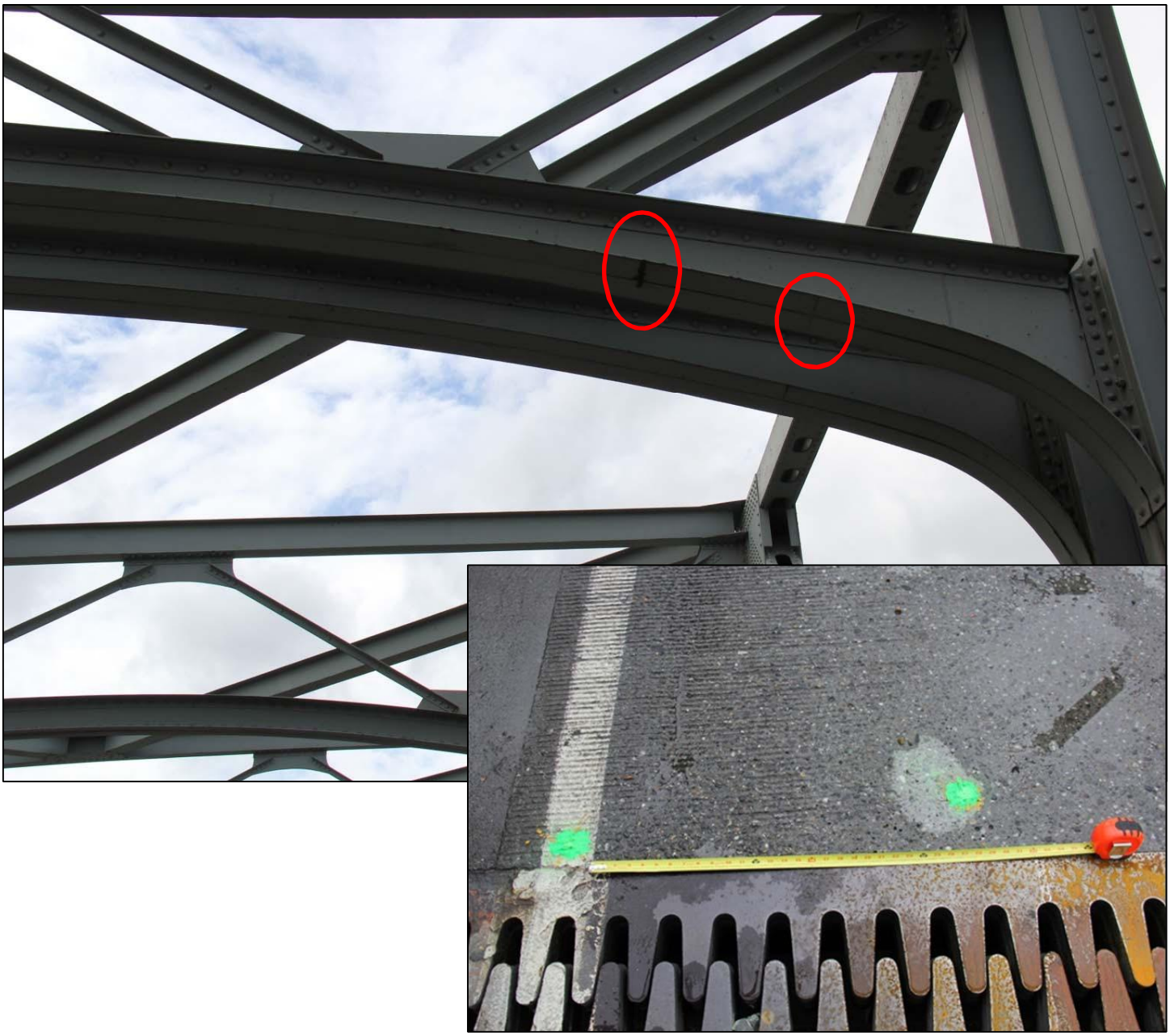


	Point 1	Point 2
Distance inboard of edge line	0.54 ft	2.42 ft
Vertical height	15.98 ft	16.43 ft
	Measurement from inside edge of striping	

Span 7 – U2

	Point 1	
Distance inboard of edge line	2.13 ft	
Vertical height	16.40 ft	

Span 7 – U0



	Point 1	Point 2
Distance inboard of edge line	0.00 ft (-0.17 ft)	2.33 ft
Vertical height	15.65 ft	16.36 ft
	Damage appears aged	Damage appears aged
	Measurement from inside edge of striping	

Span 6 – U5

	Point 1	
Distance inboard of edge line	2.29 ft	
Vertical height	16.33 ft	
	Damage appears aged	

Span 6 – U2

	Point 1	Point 2
Distance inboard of edge line	1.38 ft	2.21 ft
Vertical height	16.17 ft	16.37 ft
	Damage appears aged	Damage appears aged
	Measurement from inside edge of striping	

Span 5 –U5

	Point 1	
Distance inboard of edge line	1.75 ft	
Vertical height	16.34 ft	
	Damage appears aged	

Appendix B – Load Securement Devices, Reference

NATIONAL ASSOCIATION OF CHAIN MANUFACTURERS
Welded Steel Chain Specifications
TABLE III
Grade 70 Transport Chain
(Not to be used in overhead lifting applications)

Nominal Chain Size		Material Diameter		Working Load Limit (Max.)		Proof Test** (Min.)		Minimum Breaking Force**		Inside Length (Max.)		Inside Width (Min.)	
in	mm	in	mm	lbs	kg	lbs	kN	lbs	kN	in	mm	in	mm
1/4	7.0	0.281	7.0	3,150	1,430	6,300	28.0	12,600	56.0	1.24	31.5	0.38	9.8
5/16	8.7	0.343	8.7	4,700	2,130	9,400	41.8	18,800	83.6	1.29	32.8	0.44	11.2
3/8	10.0	0.406	10.3	6,600	2,990	13,200	58.7	26,400	117.4	1.38	35.0	0.55	14.0
7/16	11.9	0.468	11.9	8,750	3,970	17,500	77.8	35,000	155.4	1.64	41.6	0.65	16.6
1/2	13.0	0.531	13.5	11,300	5,130	22,600	100.4	45,200	200.8	1.79	45.5	0.72	18.2
5/8	16.0	0.630	16.0	15,800	7,170	31,600	140.4	63,200	280.8	2.20	56.0	0.79	20.0
3/4	20.0	0.787	20.0	24,700	11,200	49,400	219.6	98,800	439.2	2.76	70.0	0.98	25.0

The Proof Test and Minimum Breaking Force loads **shall not be used as criteria for service or design purposes. See Section 3.0.

Columbus McKinnon Corporation (ratchet load binders)

Ratchet Type Load Binder

- Each ratchet component is forged from pure alloy steel
- Handle is designed loose using self-locking one-way bolts allowing easy removal of unwanted debris such as mud, snow or ice
- Proof tested to 50% of the minimum breaking strength
- Gears are permanently welded to the barrel

Size			Product Code	End Fittings	Working Load Limit	Take Up	Handle Length	Barrel Size O.D. (Dia. x Length)	Screw Diameter	Weight
G30	G43	G70								
Imperial										
in.	in.	in.			lb.	in.	in.	in.	in.	lb.
1/4	1/4	-	48364	Hook / Hook	2,600	4.00	11.00	1-5/16 x 6	3/4 x 6	5.4
-	-	-	48811	Eye / Eye (no hook)	5,400	8.00	12.00	1-5/16 x 6	3/4 x 6	8.6
-	-	-	48363	Eye / Eye (no hook)	13,000	8.00	14.00	1-1/2 x 10	1 x 10	9.8
3/8	3/8	5/16	46565	Body Only	5,400	8.00	-	1-1/2 x 10	1 x 10	11.0
1/2	1/2	3/8	46566	Body Only	9,200	8.00	-	1-1/2 x 10	1 x 10	11.7
-	-	-	46565H	Handle Only	-	-	14.00	-	-	4.3
3/8	3/8	5/16	48810	Hook / Hook	5,400	8.00	12.00	1-5/16 x 6	3/4 x 6	8.6
3/8	3/8	3/8	48360	Hook / Hook	7,100	8.00	14.00	1-1/2 x 10	1 x 10	13.0
3/8	3/8	5/16	48365	Hook / Hook	5,400	8.00	14.00	1-1/2 x 10	1 x 10	12.0
1/2	1/2	3/8	48366	Hook / Hook	9,200	8.00	14.00	1-1/2 x 10	1 x 10	13.0
5/8	5/8	1/2	48367	Hook / Hook	13,000	8.00	14.00	1-1/2 x 10	1 x 10	16.0

Appendix C – Site Diagram Based on Washington State Patrol Totalstation Data