HIGHWAY FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

Collapse of a Bridge Span
Mount Vernon, WA; 05/23/2013

HWY13MH012

(87 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 Semitrailer, Hauling an Oversize Load
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 Semitrailer
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
INJURED:	3 minor, 5 uninjured
NTSB #:	**HWY13MH012**

B. HIGHWAY FACTORS GROUP

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C. ACCIDENT SUMMARY

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

D. DETAILS OF THE HIGHWAY FACTORS INVESTIGATION

The Highway Factors Group Chairman's Factual Report provides the reader with a factual record of the highway conditions that existed at the time of the accident. For a better understanding of the circumstances and facts of the accident, readers are also encouraged to examine all Group Chairman Factual Reports related to the investigation.

The Highway Factors Group Chairman's Factual Report is organized by the following topic areas and page numbers:

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1. Prefatory Data

1.1 Bridge Collapse Location

The bridge collapse occurred on Interstate 5 at Milepost 228.25 over the Skagit River, in Mount Vernon, Skagit County, Washington. **Figure 1** is a location map that illustrates the bridge collapse was located approximately 60 miles north of Seattle, Washington.

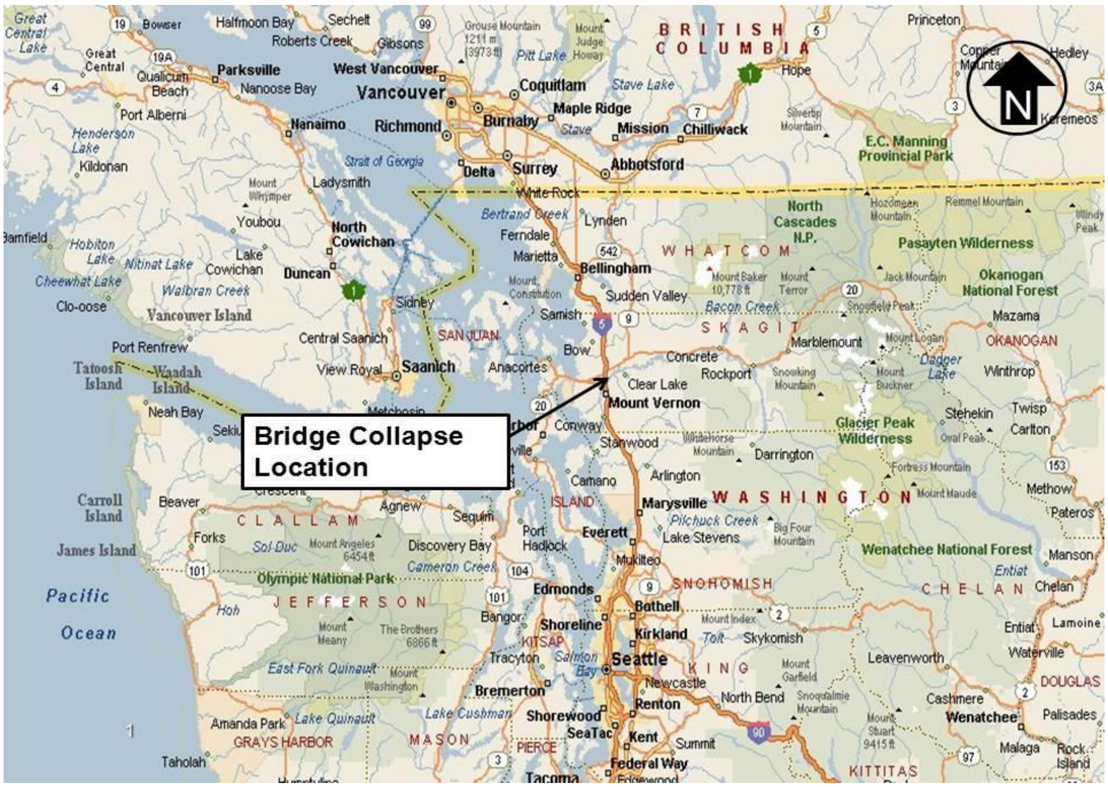


Figure 1 – Location Map

2. Bridge Description

2.1 General Description

The I-5 Bridge over the Skagit River (Bridge #4794A) was built in 1955. **Photograph 1** illustrates the I-5 Bridge over the Skagit River looking to the north when it was originally constructed in 1955. The bridge accommodated two lanes (one lane in each direction) with a wide shoulder. The travel lanes were located under the highest vertical clearance of the bridge and the wide shoulders were located under the lowest vertical clearance of the bridge. A center divider separated the northbound and southbound lane and an ornamental bridge rail with raised curb existed on the outside edges of the bridge structure.

Photograph 1 – I-5 Bridge over the Skagit River looking to the north when it was originally constructed in 1955

Photograph 2 illustrates the I-5 Bridge over the Skagit River looking to the north on May 24, 2013. The pavement markings on the I-5 Bridge were reconfigured to four lanes in August 1956. A research of Washington State Department of Transportation (WSDOT) records indicated that the I-5 Bridge over the Skagit River functioned as a two lane bridge (one lane in each direction) for approximately one to two years before I-5 was widened to a four lane divided highway. I-5 was widened to a four lane divided highway south[1] of the I-5 Bridge in July 1956 and north[2] of the I-5 Bridge in August 1956.

The sway braces of the thru truss structure are an elliptical shape in which the low vertical clearance encroaches over the outside lane, or right lane, in the northbound and southbound direction of travel. The concrete traffic barriers located in the median and outside edges of the bridge structure were constructed in 1975.

[1]Contract #04895 (south of the Skagit River) – contract completion date July 1956.
[2]Contract #04987 (north of the Skagit River) – contract completion date August 1956.

Photograph 2 – I-5 Bridge over the Skagit River looking to the north on May 24, 2013

2.2 Layout of the I-5 Bridge over the Skagit River

Figure 2 illustrates the layout of the I-5 Bridge over the Skagit River. The I-5 Bridge had 13 piers, 12 spans, and a total length of 1,111 feet and 9 inches. The main span type was a thru truss structure. The number of spans in the thru truss structure was four (Spans 5, 6, 7, and 8). Five piers supported the thru truss structure (Piers 5, 6, 7, 8, and 9).

The portion of the bridge that collapsed was Span 8. The length of Span 8 was approximately 160 feet. The total length of the thru truss structure was approximately 652 feet and 6 inches. The number of spans in the south approach spans was four (Spans 1, 2, 3, and 4) and the number of spans in the north approach spans was four (Spans 9, 10, 11, and 12).

Two local roads traversed under the I-5 Bridge at the south and north end of the bridge structure. Stewart Road traversed under the I-5 Bridge at Span 2 and West Whitmarsh Road traversed under the I-5 Bridge at Span 11.

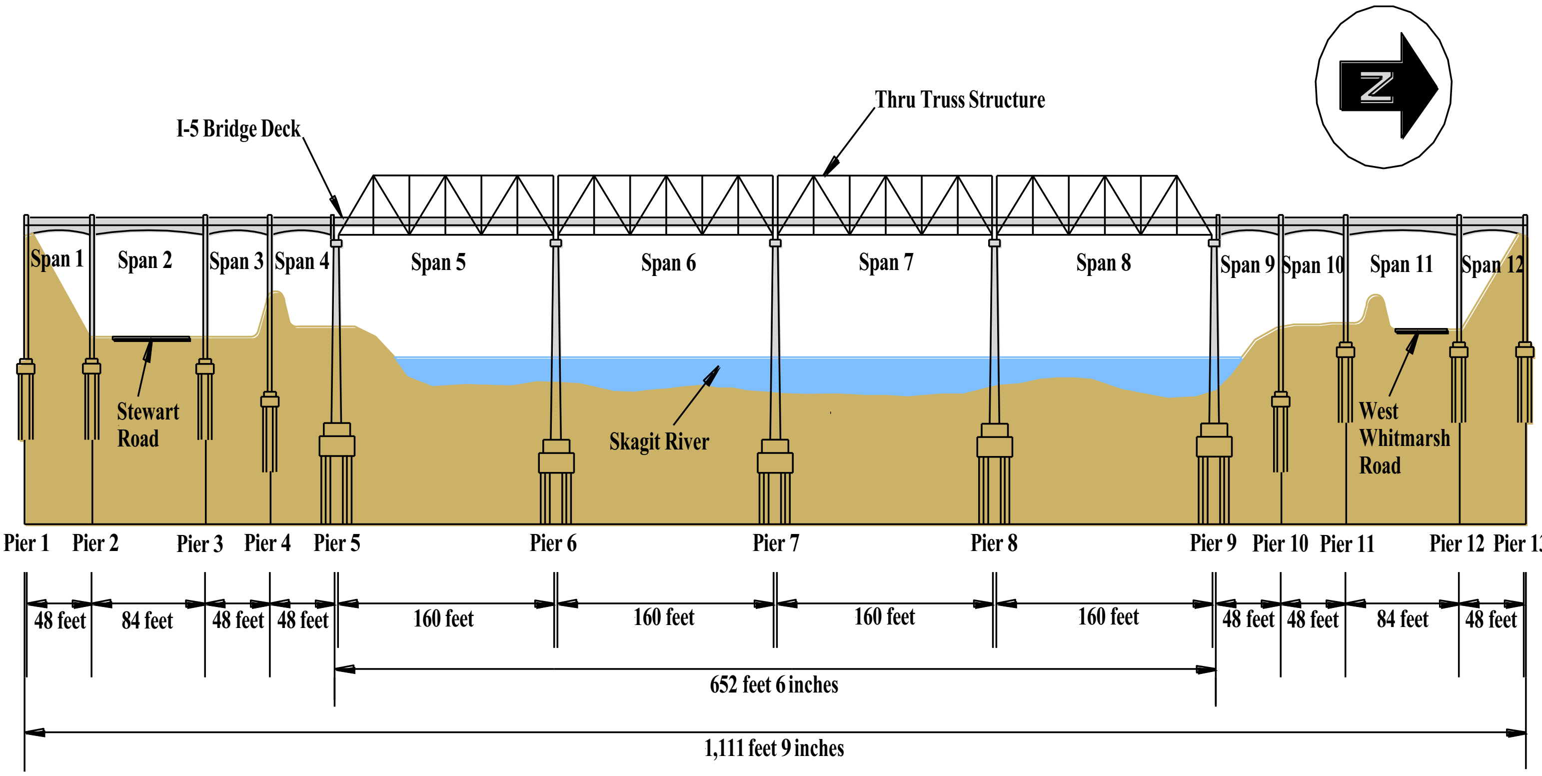


Figure 2 – Layout of the I-5 Bridge over the Skagit River

2.3 Travel Lanes and Shoulder Width

The total number of travel lanes on the bridge deck was four travel lanes, two travel lanes in the northbound direction and two travel lanes in the southbound direction. The measured width of each travel lane was 11-foot and 4-inch[3] wide from the centerline of pavement marking to the centerline of pavement marking. A 2-foot and 2-inch wide paved right shoulder was adjacent to the right lane measured from the centerline of pavement marking to the edge of concrete traffic barrier. A 2-foot and 6-inch wide paved left shoulder was adjacent to the left lane measured from the centerline of pavement marking to the edge of concrete traffic barrier. The concrete traffic barriers located at the outside edges of the bridge deck and in the median were approximately 32 inches in height. The total width of the bridge deck was approximately 60 feet.

[3]The measured width of the travel lane from inside of pavement marking to inside of pavement marking was 11 feet wide.

Figure 3 illustrates a cross section of the I-5 Bridge over the Skagit River.

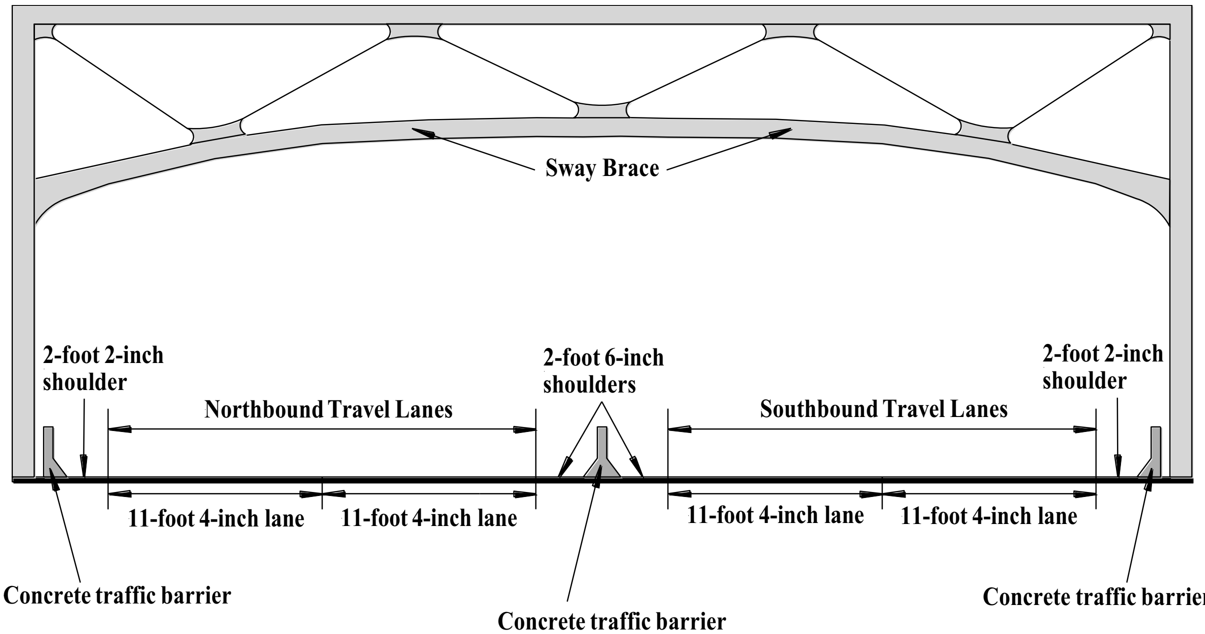


Figure 3 – Cross Section of the I-5 Bridge over the Skagit River

2.4 Travel Lane Pavement Markings

The travel lane pavement markings on the bridge deck consisted of edge lines separating the travel lanes from the shoulder and a broken white line separating the right lane from the left lane. A 4.5-inch wide solid white line separated the right lane from the right shoulder and a 4.5-inch wide solid yellow line separated the left lane from the left shoulder. The right lane and left lane were separated by 4.5-inch wide broken white lines. The 4.5-inch wide broken white lines were each 10 feet long and had 30 foot spaces between them. Both the yellow and white lines were retro-reflective[4] pavement lines.

2.5 Speed Limit

The posted speed limit for I-5 in the vicinity of the bridge collapse was 60 miles per hour (mph). The posted speed limit was reduced from 70 mph to 60 mph in January 2007 for the segment of I-5 from Milepost 228.52 to Milepost 230.50 (Skagit River vicinity to State Route 20 vicinity). The speed limit reduction was needed to match the expansion of the urban growth in Skagit County along this stretch of I-5. The Washington State Department of Transportation, Washington State Patrol, Skagit County, and the City of Burlington concurred with the speed limit reduction. Prior to January 2007, the posted speed limit on I-5 through this segment had

[4]Retro-reflectivity is the property of a surface that allows a large portion of the light coming from a point source to be returned directly back to a point near its origin.

been 70 mph since March 1996. The 70 mph posted speed limit was established following repeal of the National Maximum Speed Limit in 1995.

2.6 85th Percentile Speed Study

Table 1 summarizes the 85th percentile speed study[5] on I-5 in the vicinity of the Skagit River Bridge. The 85th percentile speed study was conducted on June 12, 2007 at two locations along the southbound and northbound lanes of I-5. The 85th percentile speeds varied between 64 mph and 72 mph.

Table 1 – 85th Percentile Speed Study on I-5 in the Vicinity of the Skagit River Bridge

Milepost	Direction	Date	Posted Speed	85th Percentile Speed
228.77	Northbound	6/12/2007	60 mph	68 mph
228.77	Northbound	6/12/2007	60 mph	66 mph
228.77	Southbound	6/12/2007	60 mph	69 mph
228.77	Southbound	6/12/2007	60 mph	64 mph
229.50	Northbound	6/12/2007	60 mph	68 mph
229.50	Northbound	6/12/2007	60 mph	64 mph
229.50	Southbound	6/12/2007	60 mph	72 mph
229.50	Southbound	6/12/2007	60 mph	67 mph

2.7 Average Daily Traffic

Table 2 summarizes the average daily traffic (ADT) on I-5 in the vicinity of the Skagit River Bridge from 2005 through 2012.

Table 2 – Average Daily Traffic on I-5 in the Vicinity of the Skagit River Bridge from 2005 through 2012

Year	Southbound Direction	Northbound Direction	Both Directions
2005	33,268	34,366	67,634
2006	32,871	33,965	66,836
2007	33,317	34,311	67,628
2008	31,822	33,085	64,907
2009	32,828	33,726	66,554
2010	33,701	34,348	68,049
2011	33,201	33,684	66,885
2012	33,105	34,273	67,378

[5]The 85th percentile speed is the speed at which 85% of the vehicle traffic is traveling either at or below that speed or, 15% of the vehicle traffic is traveling above that speed.

2.8 Vehicle Classification Count

Table 3 summarizes the vehicle classification count on I-5 in the vicinity of the Skagit River Bridge from 2010 through 2012.

Table 3 – Vehicle Classification Count on I-5 in the Vicinity of the Skagit River Bridge from 2010 through 2012

Year	Passenger Cars	Single-Unit Trucks and Buses	Semi-Trailer Combination Vehicles	Double-Trailer and Triple-Trailer Combination Vehicles
2010	88.9%	5.4%	5.1%	0.6%
2011	88.8%	5.3%	5.3%	0.6%
2012	88.7%	5.3%	5.4%	0.6%

2.9 Existing Signage on I-5

Table 4 summarizes the existing signage within an approximate 1 mile radius of the I-5 Bridge over the Skagit River in the southbound and northbound direction.

Table 4 – Existing signage within an approximate 1 mile radius of the I-5 Bridge over the Skagit River in the southbound and northbound direction

Milepost	Sign Placement	Message
Southbound Direction		
229.116	Right	EXIT 229 GEORGE HOPPER ROAD
229.01	Right	MILE 229
228.98	Right	EXIT 229
228.915	Right	NO PARKING – TOW AWAY ZONE
228.81	Right	MOUNT VERNON NEXT 2 EXITS
228.775	Left	MERGE
228.598	Right	EXIT 227 STATE ROUTE 538 EAST, COLLEGE WAY 1/2 MILE
228.598	Right	GAS FOOD LODGING
228.598	Right	TRAILER CAMPING SYMBOL
228.535	Right	SPEED LIMIT 60
228.535	Right	PEDESTRIANS AND BICYCLES PROHIBITED
228.525	Right	LATERAL CLEARANCE MARKER
228.48	Right	LATERAL CLEARANCE MARKER
228.474	Right	SKAGIT RIVER SKAGIT VALLEY COLLEGE
228.229	Right	NEXT RIGHT

228.155	Right	ENTERING MT VERNON
228.064	Right	ADOPT-A-HIGHWAY
228.064	Right	ADOPT-A-HIGHWAY NORTH PUGET SOUND
Northbound Direction		
226.997	Right	MILE 227
227.146	Right	SKAGIT VALLEY COLLEGE NEXT RIGHT
227.34	Right	FOOD NEXT RIGHT
227.469	Right	BICYCLES MUST EXIT
227.54	Overhead	EXIT 229 GEORGE HOPPER RD 1 MILE
227.54	Overhead	EXIT 227 STATE ROUTE 538 EAST, COLLEGE WAY
227.596	Right	EXIT 227
227.662	Right	PARK AND RIDE NEXT RIGHT
227.662	Right	GAS FOOD LODGING
227.691	Right	NO PARKING – TOW AWAY ZONE
227.731	Right	COLLEGE WAY
227.77	Right	FOOD EXIT 229/LODGING EXIT 229
227.844	Right	MERGE

2.10 Traffic Accident Summary

Table 5 summarizes the traffic accident summary within a 5 mile radius of the I-5 Bridge over the Skagit River from 2007 through 2012. There were no fatal collisions on I-5 within a 5 mile radius of the I-5 Bridge over the Skagit River in the last six years. One fatality did occur on the southbound off ramp to College Way in 2012 where a pedestrian was struck by a vehicle.

Table 5 – Traffic Accident Summary within a 5 mile radius of the I-5 Bridge over the Skagit River from 2007 through 2012

Traffic Accident Summary by Year							
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**Grand Total**
Total Injuries	80	76	40	78	74	62	**410**

Traffic Accident Summary by Severity	
Evident Injury	42
No Injury	284
Possible Injury	79
Serious Injury	4
Unknown	1
Grand Total	**410**

Traffic Accident Summary by Manner of Collision	
Fixed Object	97
Miscellaneous	10
Opposite Direction	1
Other Object	10
Overturn	10
Parking	4
Pedestrian	2
Rear End	186
Same Direction	20
Sideswipe	70
Grand Total	**410**

Table 6 summarizes the traffic accident summary on the I-5 Bridge over the Skagit River from 2007 through 2012. The fixed object hits reported to the concrete barrier/bridge rail all involved passengers cars and pickup trucks. No police traffic collision reports were filed specifically for high load hits on the I-5 Bridge.

Table 6 – Traffic Accident Summary on the I-5 Bridge over the Skagit River from 2007 through 2012

Traffic Accident Summary by Year							
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	
Injuries	8	9	4	8	1	3	33
Property Damage	10	3	5	8	8	7	41
Grand Total							**74**
Traffic Accident Summary by Vehicle							
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	
Passenger Cars and Pickup Trucks	18	9	8	16	8	10	69
Truck Tractor and Semi-Trailers	0	3	1	0	1	0	5
Grand Total							**74**
Traffic Accident Summary by Manner of Collision							
Passenger Cars and Pickup Trucks							
Fixed Object (Concrete Barrier/Bridge Rail)							10
Other Object							1
Miscellaneous							1
Rear End							46
Same Direction							2
Sideswipe							9
Truck Tractor and Semi-Trailers							
Other Object							1
Rear End							2
Sideswipe							2
Grand Total							**74**

3. National Bridge Inspection Standards (NBIS)

3.1 General Description

The U.S. Department of Transportation Federal Highway Administration (FHWA) had the legislative authority under the Code of Federal Regulations (23 CFR Part 650) to develop a national bridge inspection program. The CFR indicated the following:

> ***"650.301 Purpose.***
> *This subpart sets the national standards for the proper safety inspection and evaluation of all highway bridges in accordance with 23 U.S.C. 151.*
>
> ***650.307 Bridge inspection organization***
> *(a) Each State transportation department must inspect, or cause to be inspected, all highway bridges located on public roads that are fully or partially located within the State's boundaries, except for bridges that are owned by Federal agencies."*

The national bridge inspection program was formed as a direct result from a bridge collapse that occurred in Point Pleasant, West Virginia on December 15, 1967 that killed 46 people. The tragic collapse aroused national interest in the safety inspection and maintenance of bridges when a 2,235-foot section of the Silver Bridge collapsed into the Ohio River.

The national bridge inspection program consists of national bridge inspection standards (NBIS) and a national bridge inventory (NBI). The national bridge inspection standards (NBIS) were first established in 1971 to set national requirements regarding bridge inspection frequency, inspector qualifications, report formats, and inspection and rating procedures. The national bridge inventory (NBI) is the aggregation of structure inventory and appraisal data collected by each state to fulfill the requirements of the program. The structure inventory data consists of fields that include identification of the bridge, structure type and material, age and service, geometric data, navigation data, and classification. The structure appraisal data consists of fields that include condition, load rating and posting, appraisal, proposed improvements, and inspections.

The national bridge inspection standards require bridges be inspected at regular intervals not to exceed 24 months.

> ***"650.311 Inspection frequency***
> *(a) Routine inspections. (1) Inspect each bridge at regular intervals not to exceed twenty-four months."*

Bridge inspectors are required to be trained regarding proper bridge inspection techniques and complete a Federal Highway Administration (FHWA) approved comprehensive bridge inspection training course.

3.2 Bridge Inspection Definitions

Bridges or culverts that carry vehicular traffic and are longer than 20 feet are part of the National Bridge Inventory system. Listed below are standard terms and definitions used in the bridge inspection industry.

General Condition Ratings – general condition ratings describe the current condition of a bridge or culvert. The general condition ratings are an overall assessment of the physical condition of the deck (riding surface), the superstructure (load carrying members such as beams or trusses that support the driving surface), substructure (abutments and piers) or culvert. General condition ratings range from 0 (failed condition) to 9 (excellent).

Structurally Deficient Bridge – bridges are classified as structurally deficient if they have a general condition rating for the deck, superstructure, substructure or culvert as 4 or less or if the road approaches regularly overtop due to flooding. A general condition rating of 4 means that the component rating is described as poor. Examples of poor condition include corrosion that has caused significant section loss of steel support members, movement of substructures, or advanced cracking and deterioration in concrete bridge decks. For bridge owners, the classification structurally deficient is a reminder that the bridge may need further analysis that may result in load posting, maintenance, rehabilitation, replacement or closure.

The fact that a bridge is structurally deficient does not imply that it is unsafe. A structurally deficient bridge typically needs maintenance and repair and eventual rehabilitation or replacement to address deficiencies. To remain open to traffic, structurally deficient bridges can be posted, if required, with reduced weight limits that restrict the gross weight of vehicles using the bridges. If unsafe conditions are identified during a physical inspection, the structure is closed.

Functionally Obsolete Bridge – a functionally obsolete bridge is one that was built to outdated standards that do not meet the current minimum requirements for a new bridge. These bridges are not necessarily rated as structurally deficient, nor are they inherently unsafe. Functionally obsolete bridges include those that have inadequate vehicular capacity or sub-standard geometric features such as narrow lanes, narrow shoulders, poor approach alignment or inadequate vertical or horizontal under clearance.

Fracture Critical Bridge – a fracture critical bridge typically has a steel superstructure with load (tension) carrying members arranged in a manner in which if one fails, the bridge could collapse. Examples of fracture critical bridges are two girder bridges or truss bridges. The classification of fracture critical does not mean the bridge is inherently unsafe. The NBIS defines a fracture critical member as a non-redundant member that is in tension.

3.3 Summary of the Number of Functionally Obsolete and Structurally Deficient Bridges in Washington State and the Nation[6]

Table 7 summarizes the number of functionally obsolete and structurally deficient bridges in Washington State and the Nation. There are a total of 7,840 bridges in Washington State compared to a total of 607,380 bridges in the Nation. **Table 7** illustrates one in four bridges in the nation (or 25%) are either functionally obsolete or structurally deficient. Approximately 22% of the total bridges in Washington State are functionally obsolete compared to a 14% national average. Approximately 5% of the total bridges in Washington State are structurally deficient compared to an 11% national average. There are a total of 158 thru truss bridges in Washington State compared to a total of 9,632 thru truss bridges in the Nation. Approximately 48% of the thru truss bridges in Washington State are functionally obsolete compared to a 21% national average. Approximately 16% of the thru truss bridges in Washington State are structurally deficient compared to a 57% national average.

Table 7 – Number of Functionally Obsolete and Structurally Deficient Bridges in Washington State and the Nation

Description	Washington State	Nation
Total Number of Bridges	7,840	607,380
Number of Bridges that are Functionally Obsolete	1,693 (22%)	84,748 (14%)
Number of Bridges that are Structurally Deficient	366 (5%)	66,749 (11%)
Total Number of Thru Truss Bridges	158	9,632
Number of Thru Truss Bridges that are Functionally Obsolete	76 (48%)	2,067 (21%)
Number of Thru Truss Bridges that are Structurally Deficient	26 (16%)	5,473 (57%)

3.4 Inspection Types and Intervals

U.S. federal regulations define eight types of bridge inspections. Three of these, fracture critical member inspection, routine inspection, and underwater inspection occur at intervals set by regulation. The standard interval for a fracture critical member inspection and routine inspection are 24 months. The standard interval for an underwater inspection is 60 months. The eight types of bridge inspections are described below:

Damage Inspection – An unscheduled inspection to assess structural damage resulting from environmental factors or human actions.

[6] The NBI data set from which these figures were drawn reflect totals from the 2012 NBI data set.

Fracture Critical Member Inspection – A hands-on inspection of a fracture critical member or member components that may include visual and other nondestructive evaluation.

Hands-On Inspection – Inspection within arms length of the component. Inspection uses visual techniques that may be supplemented by non-destructive testing.

In-Depth Inspection – A close-up inspection of one or more members above or below the water level to identify any deficiencies not readily detectable using routine inspection procedures; hands-on inspection may be necessary at some locations.

Initial Inspection – First inspection of a bridge as it becomes a part of the bridge inventory to provide all Structure Inventory and Appraisal data and other relevant data and to determine baseline structural conditions.

Routine Inspection – Regularly scheduled inspection consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from initial or previously recorded conditions, and to ensure that the structure continues to satisfy present service requirements.

Special Inspection – An inspection scheduled at the discretion of the bridge owner, used to monitor a particular known or suspected deficiency.

Underwater Inspection – Inspection of the underwater portion of a bridge substructure and the surrounding channel that cannot be inspected visually at low water by wading or probing, generally requiring diving or other appropriate techniques.

3.5 Condition Ratings for the I-5 Bridge over the Skagit River

The Federal Highway Administration (FHWA) provided the condition ratings and status of the I-5 Bridge over the Skagit River from 1983 through 2013. **Table 8** summarizes the condition ratings and status of the I-5 Bridge over the Skagit River from 1983 through 2013 as recorded on the Structure Inventory and Appraisal (SI&A) sheet.

The I-5 Bridge had been functionally obsolete since 1983, the first year in which the Federal Highway Administration established a national bridge inventory. A functionally obsolete bridge is one that was built to outdated standards that do not meet the current minimum requirements for a new bridge. The I-5 Bridge was functionally obsolete due to its narrow shoulders, vertical clearances, and narrow lanes. The I-5 Bridge was structurally deficient from 1987 to 1992. A structurally deficient bridge is a bridge that has one or more components in poor condition. The I-5 Bridge was structurally deficient from 1987 to 1992 due to its poor condition of the deck. The deck was repaired in 1992 with a modified concrete overlay.

Table 8 – Condition ratings and status of the I-5 Bridge over the Skagit River from 1983 through 2013 as recorded on the Structure Inventory and Appraisal (SI&A) Sheet

Year	Deck Condition Rating	Superstructure Condition Rating	Substructure Condition Rating	Status
1983	7	7	7	Functionally Obsolete
1984	6	7	7	Functionally Obsolete
1985	5	7	7	Not Deficient
1986	5	7	7	Not Deficient
1987	3	7	7	Structurally Deficient
1988	3	7	7	Structurally Deficient
1989	3	7	7	Structurally Deficient
1990	3	7	7	Structurally Deficient
1991	3	4	7	Structurally Deficient
1992	3	7	7	Structurally Deficient
1993	6	7	7	Functionally Obsolete
1994	6	7	7	Functionally Obsolete
1995	6	6	7	Functionally Obsolete
1996	6	6	7	Functionally Obsolete
1997	6	6	7	Functionally Obsolete
1998	6	6	7	Functionally Obsolete
1999	6	6	7	Functionally Obsolete
2000	6	6	7	Functionally Obsolete
2001	6	6	7	Functionally Obsolete
2002	5	5	7	Functionally Obsolete
2003	5	5	7	Functionally Obsolete
2004	5	5	7	Functionally Obsolete
2005	6	5	6	Functionally Obsolete
2006	6	5	6	Functionally Obsolete
2007	6	5	6	Functionally Obsolete
2008	6	5	6	Functionally Obsolete
2009	6	5	6	Functionally Obsolete
2010	6	5	6	Functionally Obsolete
2011	6	5	6	Functionally Obsolete
2012	6	5	6	Functionally Obsolete
2013	6	5	6	Functionally Obsolete

3.6 Description of Condition Rating Guidelines

The description of the condition rating guidelines was contained in the *Washington State Bridge Inspection Manual* dated November 2012. **Table 9** summarizes the condition ratings for primary bridge members of the deck, superstructure, and substructure.

Table 9 – Condition Ratings for Primary Members of the Deck, Superstructure, and Substructure

Code	Description
9	**Not Applicable.**
8	**Very Good Condition.** No problems noted.
7	**Good Condition.** Some minor problems.
6	**Satisfactory Condition.** Structural elements show some minor deterioration.
5	**Fair Condition.** All primary structural elements are sound but may have deficiencies such as minor section loss, deterioration, cracking, spalling, or scour.
4	**Poor Condition.** Advanced deficiencies such as section loss, deterioration, cracking, spalling, or scour.
3	**Serious Condition.** Loss of section, deterioration, spalling, or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete maybe present.
2	**Critical Condition.** Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete maybe present or scour may have removed substructure support. Unless closely monitored, it may be necessary to close the bridge until corrective action is taken.
1	**Imminent Failure Condition.** Major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service.
0	**Failed Condition.** Out of service. Beyond corrective action.

3.7 Bridge Damage Report dated 11/29/2012

The Washington State Department of Transportation (WSDOT) bridge damage report dated 11/29/2012 for the I-5 Bridge over the Skagit River indicated the following:

"Description of Incident

Over height load traveled in the right lane traveling northbound and damaged the first portal in Span 5 and the following two sway braces.

Description of the Facilities Damaged

Span 5 U1 portal, 6 ft. from the inner face of the east vertical (over the right northbound lane), has 16 in. section bent out of plane 3 in. and has a 3 in. tear in the steel. The Span 5 U2 sway brace, 6 ft. from the east vertical, has a 14 in. section pushed up 1.5 in. The Span 5 U3 sway brace, 6 ft. from the east vertical member is gouged.

Description of Recommended Repair(s)

Straighten the damaged angles at U1 portal and splice the tear in the steel. Paint all locations where damage has occurred."

Photograph 3 illustrates the damage to the U1 portal in Span 5 above the right lane in the northbound direction to the I-5 Bridge over the Skagit River as a result of the high load bridge hit on November 29, 2012[7].

Photograph 3 – Damage to the U1 portal in Span 5 above the right lane in the northbound direction to the I-5 Bridge over the Skagit River as a result of the high load bridge hit on November 29, 2012

[7]The date refers to the inspection date and does not coincide with the incident date or the date when reported.

Photograph 4 illustrates the damage to the U2 sway brace in Span 5 above the right lane in the northbound direction to the I-5 Bridge over the Skagit River as a result of the high load bridge hit on November 29, 2012[8].

Photograph 4 – Damage to the U2 sway brace in Span 5 above the right lane in the northbound direction to the I-5 Bridge over the Skagit River as a result of the high load bridge hit on November 29, 2012

3.8 Bridge Inspection Reports Document High Load Hits on the Sways and Portals

The WSDOT routine bridge inspection report dated 8/25/2012 for the I-5 Bridge over the Skagit River indicated the following:

"The following sways and portals have high load hits:

Span 5 U1 portal has a small dent.
Span 6 U2 sway is bent 1" over a 12", see photo #72.
Span 6 U5 sway is bent 1" over 8".
Span 7 U4 sway is bent 2-1/2" over 10".
Span 7 U5 sway is bent 1/2" over 4".
Span 8 U0 sway is bent 1" over 15".
Span 8 U3 sway has two small nicks.
Span 8 U5 portal is bent 1/2" over 4" in two places."

The WSDOT routine bridge inspection reports mention high load hits on the sways and portals on each of the routine bridge inspection reports dating back to 9/14/2003.

[8] The date refers to the inspection date and does not coincide with the incident date or the date when reported.

The WSDOT provided the following information in an email to NTSB investigators dated January 10, 2014 regarding whether any evidence of repairs had been made to the U4W node in Span 8 prior to the May 23, 2013 incident:

> *"WSDOT can confirm that our inspection and maintenance records do not contain any information of a repair to or any work on U4W node in Span 8 prior to the May 23, 2013 incident. We are unaware of the existence of any prior off the record information regarding this node. The Headquarters Bridge Preservation Office and Northwest Region Maintenance are also unaware of any prior repairs to this node other than the 2003 repainting of the entire steel structure."*

3.9 Fracture Critical Member Bridge

Figure 4 illustrates the location of the fracture critical members of the I-5 Bridge over the Skagit River. The fracture critical members are shown in yellow highlight. A fracture critical bridge is a bridge that contains one or more steel members in tension, or with a tension element, and arranged in such a manner that, if one fails, a portion or the entire bridge could collapse. The nomenclature of the truss nodes are broken into the upper chords and lower chords. The upper chords of the truss are numbered sequentially from south to north for each span (U1, U2, U3, and so on). The lower chords of the truss are numbered in a similar fashion (L0, L1, L2, L3, and so on). The fracture critical members are identified from node to node, for example, L0 to L1, U1 to L1, U1 to L2, and so on.

The total number of fracture critical members on the thru truss was 88 members. Each span had 22 fracture critical members or 11 members on each side.

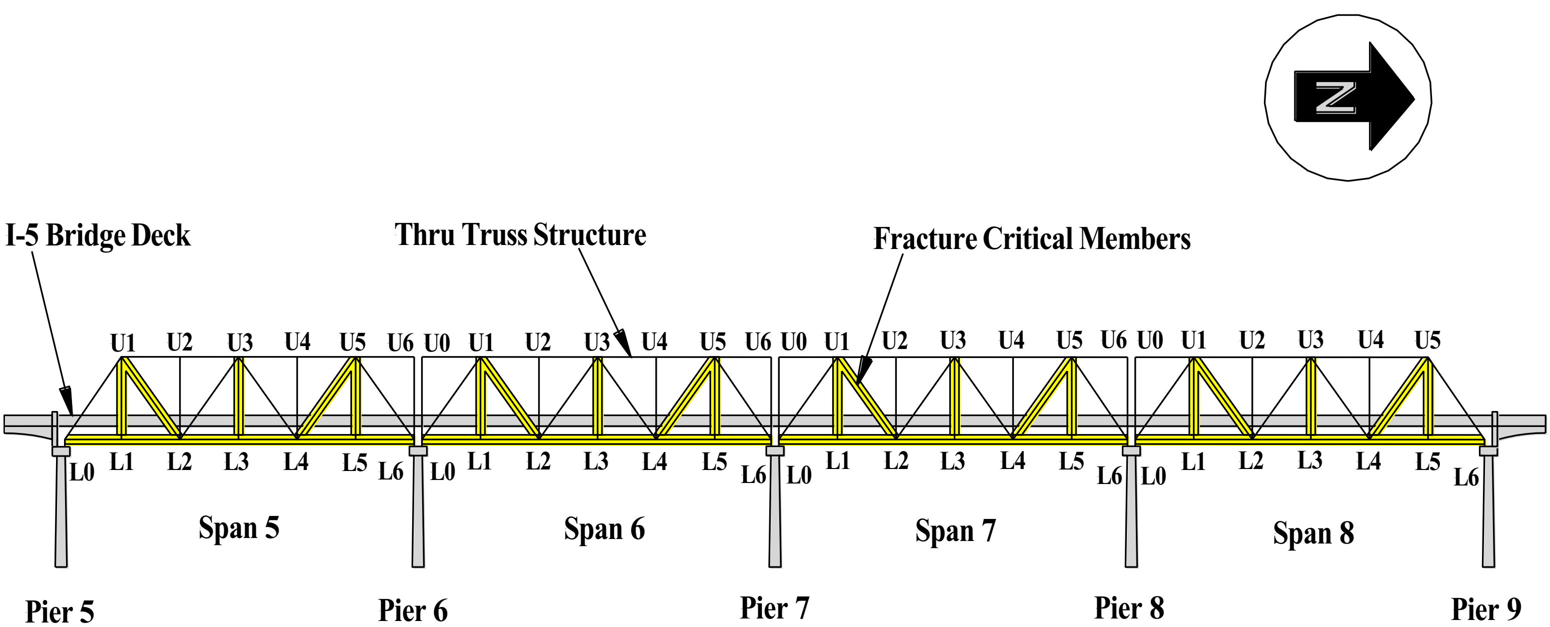


Figure 4 – Location of the Fracture Critical Members of the I-5 Bridge over the Skagit River

3.10 Fracture Critical Inspection Report dated 8/25/2012

Table 10 summarizes the Washington State Department of Transportation (WSDOT) fracture critical inspection report dated 8/25/2012.

Table 10 – Washington State Department of Transportation (WSDOT) Fracture Critical Inspection Report dated 8/25/2012

Span	Truss / Girder	Location	Feature Inspected	Remarks
5	East	L0-L1	Bottom Chord	No defects noted
5	East	L1-L2	Bottom Chord	No defects noted
5	East	L2-L3	Bottom Chord	L3 exterior vertical gusset plate bottom seam has 1/16" pack rust. Interior rivets at L2 have up to 5% section loss.
5	East	L3-L4	Bottom Chord	No defects noted
5	East	L4-L5	Bottom Chord	Seam rust between plates and chord channels.
5	East	L5-L6	Bottom Chord	L5 exterior vertical gusset plate bottom seam has 1/16" pack rust.
5	East	U1-L1	Vertical Member	No defects noted
5	East	U1-L2	Diagonal Member	L2 is full of dirt and vegetation. The connection cannot be inspected.
5	East	U3-L3	Vertical Member	Seam rust on angles at sways
5	East	U5-L4	Diagonal Member	L4 is full of dirt and vegetation. The connection cannot be inspected.
5	East	U5-L5	Vertical Member	Seam rust on angles below sways
5	West	L0-L1	Bottom Chord	Seam rust between plates and chord channels.
5	West	L1-L2	Bottom Chord	Bottom flange is pushed up 1" over 2 ft. at L2.
5	West	L2-L3	Bottom Chord	L2 is full of dirt and vegetation. The connection cannot be inspected.
5	West	L3-L4	Bottom Chord	Seam rust between plates and chord channels.
5	West	L4-L5	Bottom Chord	Laminar rust with < 10% section loss in bottom cover plate.
5	West	L5-L6	Bottom Chord	No defects noted
5	West	U1-L1	Vertical Member	No defects noted
5	West	U1-L2	Diagonal Member	L2 is full of dirt and vegetation. The connection cannot be inspected.
5	West	U3-L3	Vertical Member	6" seam rust between angles at sways.
5	West	U5-L4	Diagonal Member	L4 is full of dirt and vegetation. The connection cannot be inspected.
5	West	U5-L5	Vertical Member	No defects noted
6	East	L0-L1	Bottom Chord	No defects noted
6	East	L1-L2	Bottom Chord	No defects noted

6	East	L2-L3	Bottom Chord	No defects noted
6	East	L3-L4	Bottom Chord	No defects noted
6	East	L4-L5	Bottom Chord	Seam Rust
6	East	L5-L6	Bottom Chord	No defects noted
6	East	U1-L1	Vertical Member	No defects noted
6	East	U1-L2	Diagonal Member	L2 is full of dirt and vegetation. The connection cannot be inspected.
6	East	U3-L3	Vertical Member	No defects noted
6	East	U5-L4	Diagonal Member	L4 is full of dirt and vegetation. The connection cannot be inspected.
6	East	U5-L5	Vertical Member	No defects noted
6	West	L0-L1	Bottom Chord	Seam rust between plates and chord channels.
6	West	L1-L2	Bottom Chord	Seam rust between plates and chord channels.
6	West	L2-L3	Bottom Chord	Seam rust between plates and chord channels.
6	West	L3-L4	Bottom Chord	Pack rust up to 3/16" for 5 ft. along the top west seam near L4.
6	West	L4-L5	Bottom Chord	Pack rust up to 1/4" for 6 ft. along the top west seam near L4.
6	West	L5-L6	Bottom Chord	Seam rust between plates and chord channels.
6	West	U1-L1	Vertical Member	No defects noted
6	West	U1-L2	Diagonal Member	L2 is full of dirt and vegetation. The connection cannot be inspected.
6	West	U3-L3	Vertical Member	No defects noted
6	West	U5-L4	Diagonal Member	L4 is full of dirt and vegetation. The connection cannot be inspected.
6	West	U5-L5	Vertical Member	No defects noted
7	East	L0-L1	Bottom Chord	Seam rust between plates and chord channels.
7	East	L1-L2	Bottom Chord	Seam rust between plates and chord channels.
7	East	L2-L3	Bottom Chord	Seam rust between plates and chord channels.
7	East	L3-L4	Bottom Chord	Seam rust between plates and chord channels.
7	East	L4-L5	Bottom Chord	Seam rust between plates and chord channels.
7	East	L5-L6	Bottom Chord	Seam rust between plates and chord channels.
7	East	U1-L1	Vertical Member	No defects noted
7	East	U1-L2	Diagonal Member	L2 is full of dirt and vegetation. The connection cannot be inspected.
7	East	U3-L3	Vertical Member	No defects noted
7	East	U5-L4	Diagonal Member	L4 is full of dirt and vegetation. The connection cannot be inspected. Bent east top and bottom flange (1/4" over 1 ft).
7	East	U5-L5	Vertical Member	No defects noted
7	West	L0-L1	Bottom Chord	Peeling paint.
7	West	L1-L2	Bottom Chord	L2 exterior vertical gusset plate has seam rust.
7	West	L2-L3	Bottom Chord	L2 exterior vertical gusset plate has seam rust. L3 exterior vertical gusset plate has seam rust.

7	West	L3-L4	Bottom Chord	L3 exterior vertical gusset plate has seam rust. Seam rust at midspan top plate.
7	West	L4-L5	Bottom Chord	L5 exterior vertical gusset plate has seam rust.
7	West	L5-L6	Bottom Chord	L5 exterior vertical gusset plate has seam rust.
7	West	U1-L1	Vertical Member	No defects noted
7	West	U1-L2	Diagonal Member	L2 is full of dirt and vegetation. The connection cannot be inspected.
7	West	U3-L3	Vertical Member	No defects noted
7	West	U5-L4	Diagonal Member	L4 is full of dirt and vegetation. The connection cannot be inspected.
7	West	U5-L5	Vertical Member	No defects noted
8	East	L0-L1	Bottom Chord	No defects noted
8	East	L1-L2	Bottom Chord	No defects noted
8	East	L2-L3	Bottom Chord	No defects noted
8	East	L3-L4	Bottom Chord	No defects noted
8	East	L4-L5	Bottom Chord	No defects noted
8	East	L5-L6	Bottom Chord	No defects noted
8	East	U1-L1	Vertical Member	No defects noted
8	East	U1-L2	Diagonal Member	L2 is full of dirt and vegetation. The connection cannot be inspected.
8	East	U3-L3	Vertical Member	No defects noted
8	East	U5-L4	Diagonal Member	L4 is full of dirt and vegetation. The connection cannot be inspected.
8	East	U5-L5	Vertical Member	No defects noted
8	West	L0-L1	Bottom Chord	L1 west vertical gusset plate has ¼” pack rust.
8	West	L1-L2	Bottom Chord	L1 west vertical gusset plate has ¼” pack rust. L2 west web is pitted 1/16” deep.
8	West	L2-L3	Bottom Chord	L2 west web is pitted 1/16” deep. L3 west vertical gusset plate has 3/16” pack rust.
8	West	L3-L4	Bottom Chord	L3 west vertical gusset plate has 3/16” pack rust. L4 top east seam has 1/32” pack rust.
8	West	L4-L5	Bottom Chord	L4 top west seam has 4 ft. of seam rust.
8	West	L5-L6	Bottom Chord	L5 west web is pitted 1/16” deep.
8	West	U1-L1	Vertical Member	No defects noted
8	West	U1-L2	Diagonal Member	L2 is full of dirt and vegetation. The connection cannot be inspected.
8	West	U3-L3	Vertical Member	No defects noted
8	West	U5-L4	Diagonal Member	L4 is full of dirt and vegetation. The connection cannot be inspected.
8	West	U5-L5	Vertical Member	No defects noted

3.11 High Load Bridge Hit at State Road 16 and Olympic Drive Overpass

A high load bridge hit occurred at State Road 16 and the Olympic Drive Overpass on March 17, 2013[9] in Pierce County, Washington. The minimum vertical clearance over the travel lanes was approximately 15'-8". The oversize vehicle was escorted by a front and rear pilot vehicle. The police accident report indicated the front pilot vehicle advised the oversize vehicle to switch lanes on approach to the bridge from the right lane to the left lane, not knowing the left lane was the minimum vertical clearance under the bridge. No low clearance signs were posted on the Olympic Drive Overpass. The bridge type consisted of a pre-stressed concrete beam bridge. The damage resulted in the entire girder being replaced. A similar high load bridge hit was reported on January 4, 2011.

The Washington State Department of Transportation (WSDOT) bridge damage report dated 3/17/2013 indicated the following:

*"**Description of Incident***

Over height load travelling northbound on SR 16 impacted the northern most girder (Girder 2A) of the bridge. Girder 2A sustained significant impact to the bottom flange 24'-6" east of the connection at Pier 2. This point is above the skip stripe between the two northbound lanes on SR 16. Damage to the load is along the left side indicating the truck was travelling in the right hand lane. Vertical clearances along Girder 2A are 15'-6" at the face of the barrier at Pier 2, 15'-8" at the west fog line, 15'-10" at the west edge of the main bottom flange spall, 15'-11" at the east edge of the main bottom flange spall, 16'-1" at the east fog line, and 16'-4" at the east edge of pavement. Girder 2A is the low point in Span 2. Girder 2B measures 16'-1" at the west fog line and Girder 2I measures 17'-3" at the west fog line.

Description of Recommended Repair(s)

Due to the misalignment of the girder and the loss of prestressing strands in the bottom flange it is recommended that the girder shall be replaced."

The State of Washington Police Traffic Collision Report dated 3/17/2013 indicated the following:

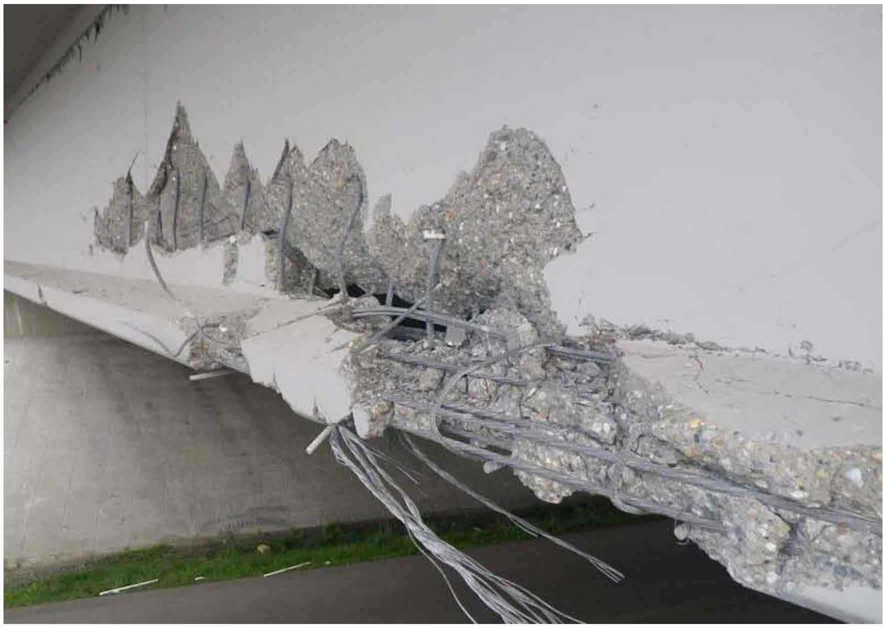
*"**Narrative***

VEH 1 was driving WB on SR 16 in Lane 1. VEH 1 was escorted by a front and rear pilot vehicle. As VEH 1 approached the Olympic Drive Bridge, the front pilot vehicle advised that VEH 1 switch lanes from Lane 1 to Lane 2. As VEH 1 drove under the bridge, the top of the cargo load struck the back portion

[9]The date refers to the inspection date which coincided with the incident date and the date when reported.

underneath the bridge. VEH 2, who was driving in Lane 1, was struck by falling debris from the bridge."

Photograph 5 illustrates the damage to the State Road 16 and the Olympic Drive Overpass as a result of the high load bridge hit on March 17, 2013[10].



Photograph 5 – Damage to the State Road 16 and the Olympic Drive Overpass as a result of the high load bridge hit on March 17, 2013

The Washington State Department of Transportation (WSDOT) bridge damage report dated 1/4/2011 indicated the following:

*"**Description of Incident***

Truck with a forklift on a lowboy trailer travelling northbound on SR 16 in the left lane. The load was too high for the 15'-8" clearance below the affected girder (Girder 2A).

Description of Recommended Repair(s)

Replacement of girder 2A recommended."

[10]The date refers to the inspection date which coincided with the incident date and the date when reported.

Photograph 6 illustrates the damage to the State Road 16 and the Olympic Drive Overpass as a result of the high load bridge hit on January 4, 2011[11].

Photograph 6 – Damage to the State Road 16 and the Olympic Drive Overpass as a result of the high load bridge hit on January 4, 2011

The cost of replacement to the girder that was damaged as a result of the high load bridge hit on 1/4/2011 was the following:

*"**Contract Number:** 008220*
***Contract Title:** SR 16, Olympic Drive NW Bridge Special Repair*
***County:** Pierce*
***Work Description:** Remove/Replace 1 Existing Prestressed Concrete Girder, Reconstruct Bridge Deck Sidewalk*
***Bid Opening:** 10/26/2011*
***Awarded Date:** 10/31/2011*
***Work Started Date:** 2/28/2012*
***Physical Completion Date:** 6/21/2012*
***Completion Date:** 9/7/2012*

***Engineer's Estimate:** $762,019*
***Prime Contractor Bid Amount:** $580,582*
***Authorized Amount:** $629,358"*

[11]The date refers to the inspection date which coincided with the incident date and the date when reported.

3.12 Load Ratings for the I-5 Bridge over the Skagit River

Bridge load rating is a procedure to evaluate the adequacy of various structural components to carry predetermined live loads. The WSDOT Bridge Preservation Office is responsible for the bridge inventory and load rating of existing and new bridges in accordance with the NBIS and the AASHTO *Manual for Bridge Evaluation (MBE)*[12].

Load ratings are required for all new, widened, or rehabilitated bridges in Washington State where the rehabilitation alters the load carrying capacity of the structure. Load ratings shall be done immediately after the design is completed and rating calculations are filed in the WSDOT Bridge Preservation Office. All load rating calculations are stamped, signed, and dated by a registered professional engineer.

The Bridge Preservation Office is responsible for maintaining an updated bridge load rating throughout the life of the bridge based on the current condition of the bridge. Conditions of existing bridges change over time, resulting in the need for reevaluation of the load rating. Such changes may be caused by damage to structural elements, extensive maintenance or rehabilitative work, or any other deterioration identified by the Bridge Preservation Office through their regular inspection program.

Some of the elements included in the WSDOT load rating of a steel truss bridge include chords, diagonals, verticals, end posts, gusset plates, stringers, and floor beams. As a result of the NTSB investigation of the I-35W Bridge Collapse in Minneapolis, MN on August 1, 2007 gusset plates are now included in the load rating for all steel truss bridges.

AASHTO's *Manual for Bridge Evaluation (MBE)* described the three most common load rating methods: *Load and Resistance Factor Method* – a reliability-based design methodology in which force effects caused by factored loads are not permitted to exceed the factored resistance of the components, *Load Factor Method* – in which bridge loadings are factored up individually and compared to capacities based on yield stress of the material, and *Allowable Stress Method* – in which stresses caused by the actual loadings on a structure are compared to allowable stresses.

In Washington State, the *Load and Resistance Factor Method* is used to load rate bridges that have designs completed after October 1, 2010. The *Load Factor Method* or *Load and Resistance Factor Method* are used to load rate bridges that have designs completed prior to October 1, 2010. The *Allowable Stress Method* is used to load rate timber bridges. The I-5 Bridge over the Skagit River was load rated based on the *Load Factor Method*.

AASHTO's *Manual for Bridge Evaluation (MBE)* described the two capacity levels that measure a bridge's load carrying capacity, the *Inventory Rating* and *Operating Rating*. The *Inventory Rating* is the load that a bridge can carry for an indefinite number of loading cycles without detriment to the bridge. The *Operating Rating* is the maximum load that can be carried on an infrequent basis without detriment to the bridge.

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[12] *The Manual for Bridge Evaluation*, American Association of State Highway and Transportation Officials; 2011 2nd Edition.

Posting of a bridge structure shall occur when the *Operating* rating factor for any of the legal loads is less than 1 based on the *Load Factor* or *Allowable Stress Methods* or the rating factor for any of the legal loads is less than 1 based on the *Load and Resistance Factor Method*.

Washington State uses six rating vehicles to check a bridge's load carrying capacity, but only four are mandated. The first three rating vehicles are AASHTO 1, AASHTO 2, and AASHTO 3 that represent actual legal loads. The fourth rating vehicle, NRL, is a national standardized rating vehicle. The NRL rating vehicle is intended to encompass the majority of loads to which a bridge might be subjected. There are also two overload vehicles used by Washington State which are optional, OL-1 and OL-2. The overload vehicles are intended to encompass the typical vehicle which would be allowed to operate under a special overload permit in Washington State. Bridges shall be posted when the *Operating*[13] rating factor for the legal loads is less than 1.

[13]Some states post when the inventory rating factor is less than one, but most use the federal bottom line which is the operating rating factor (ASR and LFR) is less than one or the rating factor (LRFR) is less than one.

Table 11 summarizes the six rating vehicles used by Washington State to check a bridge's load carrying capacity.

Table 11 – Six Rating Vehicles used by Washington State to check a bridge's load carrying capacity

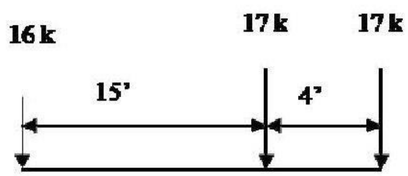
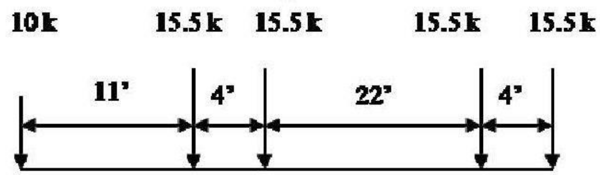
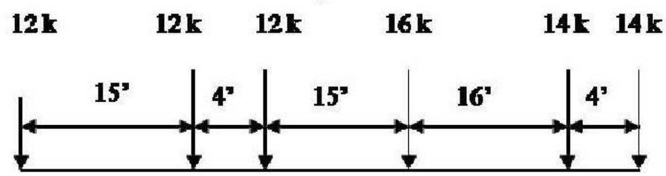
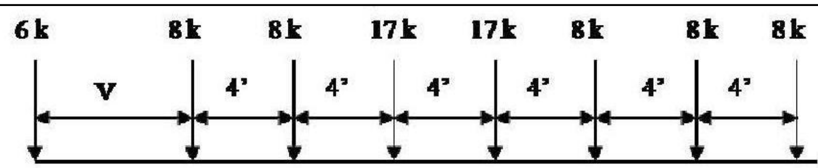
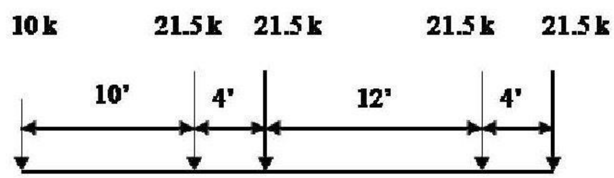
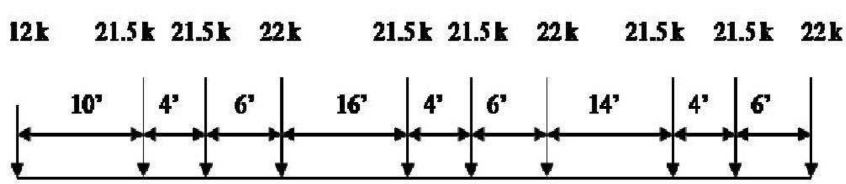
Truck	Designation
	AASHTO 1 (50,000 pounds)
	AASHTO 2 (72,000 pounds)
	AASHTO 3 (80,000 pounds)
	NRL (80,000 pounds)
	OL-1 (96,000 pounds)
	OL-2 (207,000 pounds)

Table 12 summarizes the *Operating* rating factor for the six rating vehicles load rated on the I-5 Bridge over the Skagit River. The posting of the I-5 Bridge over the Skagit River was not required since the *Operating* rating factor for the legal loads was greater than 1. **Table 12** also summarizes the controlling member on the I-5 Bridge over the Skagit River for each of the six rating vehicles.

Table 12 – *Operating* rating factor for the six rating vehicles load rated on the I-5 Bridge over the Skagit River

Truck Designation	*Operating* Rating Factor	Controlling Member of the I-5 bridge
AASHTO 1	1.99	Span 3, Shear, 48 foot span, approach T-Beam
AASHTO 2	1.65	Span 3, Moment, 48 foot span, approach T-Beam
AASHTO 3	1.65	Span 3, Moment, 48 foot span, approach T-Beam
NRL	1.26	Span 3, Moment, 48 foot span, approach T-Beam
OL-1 (Not Legal Load)	1.27	Span 3, Shear, 48 foot span, approach T-Beam
OL-2 (Not Legal Load)	0.84	Span 3, Shear, 48 foot span, approach T-Beam

4. Survey of Vertical Height Clearances on the I-5 Bridge over the Skagit River

NTSB investigators with the assistance of WSDOT personnel conducted a survey on Sunday, May 26, 2013 of the vertical height clearances on the I-5 Bridge over the Skagit River. The survey measured the vertical distance from the bridge deck to the bottom of the sway braces. The survey included a total of 20 sway braces (including the portal brace located at the south end of the bridge). A total of 280 points were included in the survey. Each sway brace was surveyed at specific points on the bridge deck to define the elliptical shape of the sway brace above the northbound and southbound lanes. A total of 14 points were shot for each sway brace (7 points on either side of the concrete median barrier). The survey included the sway braces in Spans 5, 6, and 7. The survey did not include the sway braces in Span 8 since this was the portion of the bridge that collapsed in the Skagit River.

The equipment used in the survey consisted of a Seco Telescopic Prism Pole supplied by the WSDOT. The vertical height clearances were measured to the one-hundredths of a foot. The vial on the prism pole was checked on May 25, 2013 to ensure the prism pole was plumb.

Table 13 summarizes the vertical height clearances on the I-5 Bridge over the Skagit River. The survey also documented whether there was any evidence of high load hits on the sway braces. The nomenclature of the sway braces and orientation of the survey is consistent with the stationing on the I-5 bridge design plans, beginning at the south end of the thru truss structure at Span 5.

Please refer to the Technical Reconstruction Group Chairman's Factual Report for additional figures and correlations between the vertical height clearances relative to the roadway surface.

Table 13 – Survey of Vertical Height Clearances on the I-5 Bridge over the Skagit River

		Southbound Direction								Northbound Direction							
Span	Brace	Outside Concrete Traffic Barrier Edge	Edge Line - Solid White Line	Mid-Point Right Lane	Lane Line Broken White Line	Mid-Point Left Lane	Edge Line - Solid Yellow Line	Median Concrete Traffic Barrier Edge	Evidence of High Load Hits	Median Concrete Traffic Barrier Edge	Edge Line - Solid Yellow Line	Mid-Point Left Lane	Lane Line Broken White Line	Mid-Point Right Lane	Edge Line - Solid White Line	Outside Concrete Traffic Barrier Edge	Evidence of High Load Hits
5	U1 Portal Brace	14.88	15.80	16.98	17.76	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	
	Standard Dev	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	

5. WSDOT Low Clearance Policy

5.1 WSDOT Traffic Manual

The WSDOT Traffic Manual[14] indicated the following regarding low clearance warning signs:

*"**(6) Low Clearance***

LOW CLEARANCE (W12-301) warning signs shall be installed where there is 15'3" or less of vertical clearance between the roadway surface and an overhead obstruction such as an overpass.

The maximum legal vehicle height permitted on state highways is 14 feet (RCW 46.44.020). At the direction of the MUTCD, and through operational experience, a 15-inch buffer (which includes 3 inches for frost heave) has been added to the 14-foot maximum legal height, setting the minimum LOW CLEARANCE signing threshold at 15'3". Appendix 2-10 shows signing details.

Install LOW CLEARANCE signing in the following situations:

*(a) At locations where the clearance is **14 feet or greater but less than 15'3"**, install the following:*

- *The LOW CLEARANCE (W12-301) or the LOW CLEARANCE w/ARROW (W12-302) at the low point on the structure.*
- *The advance LOW CLEARANCE (W12-2) sign on the right shoulder.*
- *Display the clearance height to the nearest inch, but not exceeding the actual clearance.*

*(b) At locations where the clearance on any portion of the structure is **less than 14 feet:***

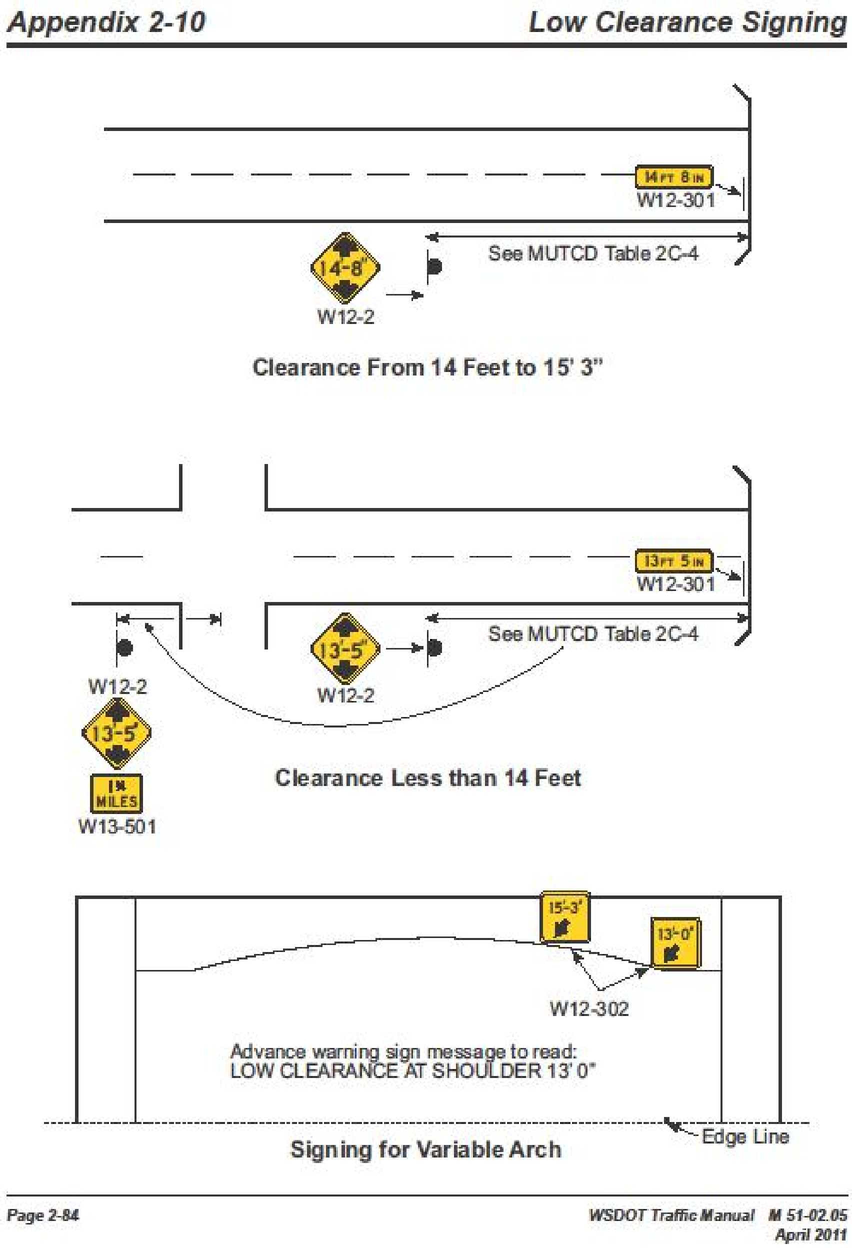
- *Install the LOW CLEARANCE (W12-301) or LOW CLEARANCE w/ARROW (W12-302) sign at the low point on the structure. Where the clearance varies, such as at arched structures or tunnels, additional signs may be used to provide effective clearance information.*
- *Install the LOW CLEARANCE (W12-2) sign in advance of the closest intersecting road that provides a detour around the low clearance obstruction. Supplement with an ADVISORY DISTANCE (W13-501) plaque, showing the distance to the obstruction.*

[14] *Washington State Department of Transportation Traffic Manual*, Washington State Department of Transportation; April 2011; pages 2-20 and 2-21.

- *Install an additional advance LOW CLEARANCE (W12-2) sign before the obstruction, in accordance with MUTCD Table 2C-4 (Advanced Placement of Warning Signs).*
- *Display the clearance height to the nearest inch, but not exceeding the actual clearance.*

Roadway reconstruction or surface overlays can reduce the overhead clearance. When a project is completed, region personnel must measure the revised clearance and change the sign message accordingly.

Vertical clearance for all overhead signs shall be in accordance with Design Manual Chapter 1020."



Appendix 2-10 - WSDOT Traffic Manual – Low Clearance Signing

5.2 Revised Code of Washington (RCW)

The Revised Code of Washington (RCW) is the compilation of all permanent laws now in force in the State of Washington. It is a collection of Session Laws (enacted by the Legislature, and signed by the Governor, or enacted via the initiative process). The RCW indicated the following:

"RCW 46.04.500 Roadway

"Roadway" means that portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the sidewalk or shoulder even though such sidewalk or shoulder is used by persons riding bicycles. In the event a highway includes two or more separated roadways, the term "roadway" shall refer to any such roadway separately but shall not refer to all such roadways collectively.

RCW 46.44.020 Maximum height – Impaired clearance signs

It is unlawful for any vehicle unladen or with load to exceed a height of fourteen feet above the level surface upon which the vehicle stands. This height limitation does not apply to authorized emergency vehicles or repair equipment of a public utility engaged in reasonably necessary operation. The provisions of this section do not relieve the owner or operator of a vehicle or combination of vehicles from the exercise of due care in determining that sufficient vertical clearance is provided upon the public highways where the vehicle or combination of vehicles is being operated; and no liability may attach to the state or to any county, city, town, or other political subdivision by reason of any damage or injury to persons or property by reason of the existence of any structure over or across any public highway where the vertical clearance above the roadway is fourteen feet or more; or, where the vertical clearance is less than fourteen feet, if impaired clearance signs of a design approved by the state department of transportation are erected and maintained on the right side of any such public highway in accordance with the manual of uniform traffic control devices for streets and highways as adopted by the state department of transportation under chapter 47.36 RCW. If any structure over or across any public highway is not owned by the state or by a county, city, town, or other political subdivision, it is the duty of the owner thereof when billed therefor to reimburse the state department of transportation or the county, city, town, or other political subdivision having jurisdiction over the highway for the actual cost of erecting and maintaining the impaired clearance signs, but no liability may attach to the owner by reason of any damage or injury to persons or property caused by impaired vertical clearance above the roadway."

5.3 Washington Administrative Code (WAC)

The Washington Administrative Code (WAC) contained regulations of executive branch agencies issued by authority of statutes. The WAC indicated the following:

> *"**WAC 468-38-070 Maximums and other criteria for special permits***
>
> *(b) **Overheight:** Any move involving height, especially permitted moves exceeding fourteen feet, are governed by the ability to clear overhead obstructions such as bridges, underpasses, wires, overhead signs, and other objects. The issuance of a permit does not insure the route to be free of overhead obstructions. It is the responsibility of the permit applicant to check, or prerun, the proposed route and provide for safe maneuvers around the obstruction or detours as necessary. Structures owned by the state should be reviewed with department field personnel to determine safe navigation of the move, including options for temporary removal of obstructions. Detours off the state route onto county or city roads require authorization from those jurisdictions. A traffic control plan (see WAC 468-38-405 (3)(d)) may be requested for approval by the department before a permit is issued."*

6. WSDOT "Bridge List" Website

The WSDOT "Bridge List" website[15] is available to commercial vehicle drivers to check the vertical clearances along their route. The website indicated the following:

> *"**Forward***
>
> *The Bridge List is usable as a guide for clearances, but because of physical changes to highways and other possible inconsistencies due to new construction, overlays, etc., it cannot be guaranteed. As is stated on all permits, the operator "…shall be responsible and liable for all accidents, damage or injury…and…shall hold blameless…the Washington State Department of Transportation and members thereof…" The operator is also "…responsible to clear overhead obstructions." WAC 468-38-070 states, "It is the responsibility of the permit applicant to check, or prerun, the proposed route and provide for safe maneuvers around the obstruction or detours as necessary.*
>
> ***Instructions for Use***
>
> *It is emphasized here that the Bridge List is only a guide, and WSDOT assumes no responsibility for its completeness or accuracy, or for any damage or injury resulting from its use or misuse.*

[15] http://www.wsdot.wa.gov/Publications/Manuals/M23-09.htm

Consulting this Bridge List does NOT relieve the operator of responsibility to establish a usable route.

To use the clearance list efficiently:

B. Check the "MIN" column relative to the route and direction of the intended trip.

1. *If the height of the load is less than the "MIN" for a bridge, the load should clear in all lanes.*

2. *If the load's height is greater than the "MIN" for any bridge:*

   a. *If the height of the load is less than the "MAX" column, the load should clear the bridge, but the operator must determine the proper lane to travel.*

   b. *If the height of the load is greater than the "MAX" column, the load will not clear, and an alternate route should be determined.*

Interstate 5 (I-5)

			Vertical Clearances			
			NB or EB		***SB or WB***	
Mile Post	***Bridge Number***	***Crossing Name***	***Max***	***Min***	***Max***	***Min***
228.25	***5/712***	***Skagit R***	***17'-3"***	***14'-3"***	***17'-3"***	***14-5"***

7. MUTCD Low Clearance Requirements

The 2009 *Manual on Uniform Traffic Control Devices* (MUTCD)[16] recommended the following on low clearance signs:

*"**Section 2C.27** **<u>Low Clearance Signs (W12-2 and W12-2a)</u>***

Standard: The Low Clearance (W12-2) sign (see Figure 2C-5) shall be used to warn road users of clearances less than 12 inches above the statutory maximum vehicle height.

Guidance: The actual clearance should be displayed on the Low Clearance sign to the nearest 1 inch not exceeding the actual clearance. However, in areas that experience changes in temperature causing frost action, a reduction, not exceeding 3 inches, should be used for this condition.

[16] *Manual on Uniform Traffic Control Devices for Streets and Highways*, U.S. Department of Transportation, Federal Highway Administration; 2009 Edition; page 120.

Where the clearance is less than the legal maximum vehicle height, the W12-2 sign with a supplemental distance plaque should be placed at the nearest intersecting road or wide point in the road at which a vehicle can detour or turn around.

In the case of an arch or other structure under which the clearance varies greatly, two or more signs should be used as necessary on the structure itself to give information as to the clearances over the entire roadway.

Clearances should be evaluated periodically, particularly when resurfacing operations have occurred.

Option: The Low Clearance sign may be installed on or in advance of the structure. If a sign is placed on the structure, it may be a rectangular shape (W12-2a) with the appropriate legend (see Figure 2C-5)."

MUTCD Low Clearance (W12-2) Sign

MUTCD Low Clearance (W12-2a) Sign

MUTCD Supplemental Distance (W16-3P) Plaque

The definition for the term 'roadway' in the MUTCD[17] indicated the following:

*"**Roadway** – that portion of a highway improved, designed, or ordinarily used for vehicular travel and parking lanes, but exclusive of the sidewalk, berm, or shoulder even though such sidewalk, berm, or shoulder is used by persons riding bicycles or other human-powered vehicles. In the event a highway includes two or more separate roadways, the term roadway as used in this Manual shall refer to any such roadway separately, but not to all such roadways collectively."*

8. History of Low Clearance Requirements and Policies – MUTCD and WSDOT

Table 14 summarizes the history of low clearance requirements contained in the MUTCD and low clearance policies received from the WSDOT.

Table 14 – History of Low Clearance Requirements contained in the MUTCD and Low Clearance Policies received from the WSDOT

MUTCD Requirements	WSDOT Policies
1948 Edition – Section 80 "The Low Clearance sign, indicating low overhead clearance and showing the exact amount of clearance at low bridges, underpasses, and other overhead structures, shall be used at all points where clearance is less than 6 inches greater than the maximum height of vehicle and load permitted under the State law, and, in any case, where the clearance is less than 13 feet. The actual clearance shall be shown on the sign, to the nearest inch."	
1961 Edition – Section 1C-35 "The Low Clearance sign, indicating low overhead clearance and showing the exact amount of clearance at low bridges, underpasses, and other overhead structures, shall be used at all points where clearance is less than 12 inches greater than the maximum height of vehicle and load permitted under the State law. The actual clearance shall be shown on the sign to the nearest inch. Additional protection should be provided by markings on the structure itself."	
1971 Edition – Section 2C-35 "The Low Clearance sign is intended for use to warn motorists of clearances less than the maximum	

[17] *Manual on Uniform Traffic Control Devices for Streets and Highways*, U.S. Department of Transportation, Federal Highway Administration; 2009 Edition; page 19.

vehicle height permitted plus 12 inches. It may be erected on or in advance of the structure. If a sign is placed on the structure, it may be a rectangular shape with the legend (12) FT (6) IN. The actual clearance is normally shown on the sign to the nearest inch not exceeding the actual clearance. However, in areas that experience changes in temperature causing frost action, an allowance, not exceeding 3 inches, for this condition is recommended."	
1978 Edition - Section 2C-34 "The Low Clearance sign is intended for use to warn vehicle operators of clearances less than the maximum vehicle height permitted plus 12 inches. The actual clearance is normally shown on the sign to the nearest inch not exceeding the actual clearance. However, in areas that experience changes in temperature causing frost action, an allowance, not exceeding 3 inches, for this condition is recommended."	**1977 -** "In following the guide lines set forth in the MUTCD, it is necessary to warn motorists of clearances less than maximum vehicle height permitted (14'-0") plus 12" (15'-0"). Because of many variables affecting the effective height of a moving vehicle it has been determined signing shall designate the usable clearance which is normally determined by actual field measurement less three inches."
1988 Edition - Section 2C-34 "The Low Clearance sign is intended for use to warn vehicle operators of clearances less than the maximum vehicle height permitted plus 12 inches. The actual clearance is normally shown on the sign to the nearest inch not exceeding the actual clearance. However, in areas that experience changes in temperature causing frost action, an allowance, not exceeding 3 inches, for this condition is recommended."	**1993 -** "For clearances over legal height, signs will be installed in accordance with the MUTCD."
2000 Edition - Section 2C.20 "The Low Clearance (W12-2) sign shall be used to warn road users of clearances less than 300 mm (12 in) above the statutory maximum vehicle height or minimum structure height. The actual clearance should be shown on the Low Clearance sign to the nearest 25 mm (1 in) not exceeding the actual clearance. However, in areas that experience changes in temperature causing frost action, a reduction, not exceeding 75 mm (3 in), should be used for this condition."	**1996 -** "For clearances over legal height, signs will be installed in accordance with the MUTCD."
2003 Edition - Section 2C.22 "The Low Clearance (W12-2) sign (see Figure 2C-3) shall	**2002 -** "The maximum legal vehicle height permitted on a state highway is 14'-0" (RCW

be used to warn road users of clearances less than 300 mm (12 in) above the statutory maximum vehicle height. The actual clearance should be shown on the Low Clearance sign to the nearest 25 mm (1 in) not exceeding the actual clearance. However, in areas that experience changes in temperature causing frost action, a reduction, not exceeding 75 mm (3 in), should be used for this condition."	46.44.020). At the direction of the MUTCD, and through operational experience, a 15" buffer (including 3" for frost heave) has been added to the 14', creating a minimum threshold of 15'-3" for low clearance warning signs."
2009 Edition - Section 2C.27 "The Low Clearance (W12-2) sign (see Figure 2C-5) shall be used to warn road users of clearances less than 12 inches above the statutory maximum vehicle height. The actual clearance should be displayed on the Low Clearance sign to the nearest 1 inch not exceeding the actual clearance. However, in areas that experience changes in temperature causing frost action, a reduction, not exceeding 3 inches, should be used for this condition."	**2011 -** "The maximum legal vehicle height permitted on state highways is 14 feet (RCW 46.44.020). At the direction of the MUTCD, and through operational experience, a 15-inch buffer (which includes 3 inches for frost heave) has been added to the 14-foot maximum legal height, setting the minimum LOW CLEARANCE signing threshold at 15′3″."

9. Survey of States to determine Statutory Maximum Vehicle Height and Low Clearance Signage Requirements

NTSB investigators conducted a survey of the states to determine the statutory maximum vehicle height and low clearance signage requirements. **Table 15** summarizes the statutory maximum vehicle height and low clearance signage requirements in each state.

Table 15 – Statutory Maximum Vehicle Height and Low Clearance Signage Requirements in each State

State	Statutory Maximum Vehicle Height	Low Clearance Signage Requirements
Alabama	13’-6”	Less than 16’-0” – sign on structure
Alaska	15’-0”	17’-0” or less – sign on structure 16’-0” or less – sign on structure and advance warning sign at advance warning distance 14’-6” or less – sign on structure and advance warning sign at advance warning distance and at 1st upstream intersection
Arizona	14’-0”	Less than 16’-0” and above 14’-6” – adjusted low clearance sign on structure 14’-6” or less – sign on structure and low clearance sign installed on both sides of each approaching roadway in

		advance of the exit immediately preceding the structure (on freeways)
Arkansas	13'-6"	15'-0" or less
California	14'-0"	15'-6" or less – sign on structure and two advance low clearance signs shall be installed on the right side of the roadway. The first sign shall be placed in advance of the nearest intersecting street or highway or wide point in the road at which a motorist can detour or safely turn around. The second sign shall be placed in advance of the structure.
Colorado	14'-6"	15'-6" or less
Connecticut	13'-6"	Whenever a restricted clearance of 14'-2" or less is identified, immediate action shall be taken to have signs installed warning motorists of the vertical clearance limitations. Low clearance signs are typically installed in advance of the bridge and on the bridge fascia
Delaware	13'-6"	Less than 14'-6"
District of Columbia[18]	13'-6"	Less than 14'-6"
Florida	13'-6"	14'-6" or less – low clearance sign shall be placed in advance of every bridge or structure 13'-6" or less – low clearance sign or marking shall also be placed on the bridge beam or equivalent of every bridge or structure
Georgia	13'-6"	Less than 14'-6"
Hawaii	14'-0"	Less than 17'-0" (on freeways)
Idaho	14'-0"	16'-0" or less – sign on structure and low clearance sign should be used in advance of low bridges, underpasses, and other overhead structures where the sight distance to the overhead structure is restricted
Illinois	13'-6"	Less than 14'-6" – sign on structure Less than 14'-0" – sign on structure and low clearance sign shall be erected in advance of the structure Less than 13'-6" – sign on structure and advance sign consisting of a __ miles ahead plate mounted beneath the low clearance sign should be provided. This sign should be erected at a junction in advance of the structure that will permit a driver of a critical vehicle to choose an alternate route with a minimum of inconvenience
Indiana	13'-6"	Less than 14'-6" – low clearance warning sign should be provided for each structure
Iowa	13'-6"	14'-9" or less – sign on structure 13'-9" or less – sign on structure and low clearance sign with a supplemental distance plaque shall also be placed at

[18]The District of Columbia is considered a federal district and is the capital of the United States.

		the nearest intersecting road at which a vehicle can detour or turn around
Kansas	14'-0"	Any opening with the lowest vertical under clearance measuring less than 15'-9" – sign on structure as well as advanced warning signs
Kentucky	13'-6"	Less than 14'-6"
Louisiana	13'-6"	Less than 14'-6" – low clearance sign shall be placed on the structure. If this sign cannot be placed on the structure then the low clearance sign shall be placed on the ground in advance of the structure. Low clearance sign with a distance ahead plaque shall be placed at the nearest intersecting road where a vehicle can detour or turn around
Maine	13'-6"	Less than 14'-6"
Maryland	13'-6"	All overpasses less than 14'-6" in height above the roadway surface shall have a sign denoting the height above the roadway. Any structure that has a posted height limitation has a detour route signed in the field so that vehicles exceeding the limit can detour before being confronted with the height limitation
Massachusetts	13'-6"	Less than 14'-6"
Michigan	13'-6"	Low clearance signs are to be present for structures with under clearance of 16'-0" or less
Minnesota	13'-6"	Less than 14'-6"
Mississippi	13'-6"	Less than 14'-6"
Missouri	14'-0"	15'-0" or less but more than 13'-6" – sign on structure and shoulder mounted low clearance sign shall be placed about 750 feet in advance of the structure 13'-6" or less – sign on structure, shoulder mounted low clearance sign shall be placed about 750 feet in advance of the structure, and low clearance sign shall be placed at the nearest intersecting road or wide point in the road at which a vehicle can detour or turn around
Montana	14'-0"	Low clearance signs should be installed along Interstate facilities in advance of and at any structure that has a vertical clearance of 16'-0" or less
Nebraska	14'-6"	Low clearance signs shall be installed on all structures on the state highway system with an overhead clearance of less than 15'-6"
Nevada	14'-0"	Greater than 15'-1" but less than 16'-0" – sign on structure if history of high load hits 14'-1" to 15'-0" – sign on structure 14'-0" and under – sign on structure and advance low clearance sign
New Hampshire	13'-6"	Less than 14'-6"
New Jersey	13'-6"	All owned bridges (which includes interstates) with a minimum vertical distance of less than 14'-9" are required

		to be posted for vertical clearance
New Mexico	14’-0”	A vertical clearance sign denoting the minimum vertical clearance shall be posted for overhead structures with a minimum vertical clearance of less than 16’-0”
New York	13’-6”	Regulatory clearance signs shall be used to indicate legal overhead clearances at bridges and elevated structures when measured overhead clearance is less than 14'-0". Such legal overhead clearance shall be one foot less than the measured clearance (the vertical distance between the traveled portion of the roadway and the overhead structure)
North Carolina	13’-6”	Less than 14’-6” Where the clearance is less than the legal limit, a sign to that effect should be placed at the nearest intersecting road or wide point in the road at which a vehicle can detour or turn around In the case of an arch or other structure under which the clearance varies greatly, two or more signs should be used as necessary on the structure itself, to give information as to the clearance over the entire roadway
North Dakota	14’-0”	Less than 15’-0”
Ohio	13’-6”	The low clearance sign shall be used to warn road users of clearances less than 14’-6”
Oklahoma	13’-6”	All overhead bridge structures on the State Highway system shall have minimum clearance posted on both sides of the structure. In addition, all minimum clearance shall be posted with an advance warning sign bearing the legend LOW CLEARANCE __ FT. __ IN. when the clearance is less than 15’-0”. Where the vertical clearance is 15’-0” or greater to the lowest point of the structure, advance warning signs need not be posted
Oregon	14’-0”	The low clearance sign is intended to warn motorists of clearances less than 15’-0” between the roadway or the shoulder and the structure. The sign shall be mounted on the structure and shall consist of the low clearance dimension and an arrow directed at the low clearance point. This sign shall always be used in conjunction with the “low clearance” sign or the “low clearance on shoulder” x FT x IN sign
Pennsylvania	13’-6”	The low clearance sign may be used on bridges, underpasses and other overhead structures where vertical clearance is less than 14’-6”. When used, the low clearance sign should be mounted overhead, generally directly above the roadway. In the case of an arch or other structure under which the clearance varies greatly, two or more signs should be used as necessary, to give information as to the

		clearance over the entire roadway
Rhode Island	13'-6"	Less than 14'-6"
South Carolina	13'-6"	The use of low clearance signs should be in accordance with Section 2C.27 of the MUTCD
South Dakota	14'-0"	A low clearance sign indicating low overhead clearance and showing the exact amount of clearance, less a 3" buffer, shall be used at low bridges, underpasses, tunnels and other overhead structures where the measured clearance is less than 15'-3"
Tennessee	13'-6"	Less than 14'-6" across the width of the travel lanes
Texas	14'-0"	The ( ) FT ( ) IN clearance sign should be used on or at every structure that spans a State maintained roadway, except overhead sign structures, to show the vertical clearance up to 20'-0". Vertical clearances greater than 20'-0" are not required to be signed. On expressways and freeways the low clearance sign should be erected far enough in advance of an exit ramp in advance of the structure to enable a vehicle or load higher than the signed clearance to detour around the structure if it is less than 20'-0"
Utah	14'-0"	16'-0" or less
Vermont	13'-6"	Less than 14'-9"
Virginia	13'-6"	14'-4" to 14'-5" – sign at structure shall be installed 13'-6" to 14'-3" – sign at structure and sign at least 1500 feet in advance of structure shall be installed; and sign in advance of last alternate route and sign 150 feet past the last alternate route should be installed Less than 13'-6" – sign at structure, sign at least 1500 feet in advance of structure, and sign in advance of last alternate route shall be installed; and sign 150 feet past the last alternate route may be installed
Washington	14'-0"	14'-0" or greater but less than 15'-3" – install the low clearance or the low clearance with arrow at the low point on the structure and the advance low clearance sign on the right shoulder. Less than 14'-0" – install the low clearance or the low clearance with arrow sign at the low point on the structure. Where the clearance varies, such as at arched structures or tunnels, additional signs may be used to provide effective clearance information. Install the low clearance sign in advance of the closest intersecting road that provides a detour around the low clearance obstruction. Supplement with an advisory distance plaque, showing the distance to the obstruction
West Virginia	13'-6"	16'-6" or less
Wisconsin	13'-6"	The low clearance sign shall be used at all points where the

		clearance over any part of the usually traveled portion of the roadway is less than 14'-6". Where the clearance is less than 13'-6" an additional sign to that affect shall be placed at the nearest intersection on which a vehicle can detour onto. The appropriate XXX MILES AHEAD plaque shall be added to the advance sign. On all freeway/expressway interchanges, low clearance signs shall be placed in advance of the exit over height vehicles can use to avoid the low clearance bridge, as well as at the bridge location itself where the bridge clearance is less than 14'-6"
Wyoming	14'-0"	Use bridge clearance signs for structures or overhead objects with 19'-0" of clearance or less over the roadway. On interstates, place a 48 inch bridge clearance height sign 250 feet past the exit gore. Use a median clearance sign when a bridge is 16'-0" or lower in height and place across from the advance exit speed sign
Puerto Rico[19]	14'-0"	Less than 15'-0"

[19]Puerto Rico is considered a United States territory.

Figure 5 illustrates the statutory maximum vehicle height in each state. The statutory maximum vehicle heights varied from a low of 13 feet 6 inches to a high of 15 feet. Thirty-one states and the District of Columbia set the maximum height at 13 feet 6 inches; sixteen states and Puerto Rico set the maximum height at 14 feet; two states set the height at 14 feet 6 inches; and one state (Alaska) sets the height at 15 feet.

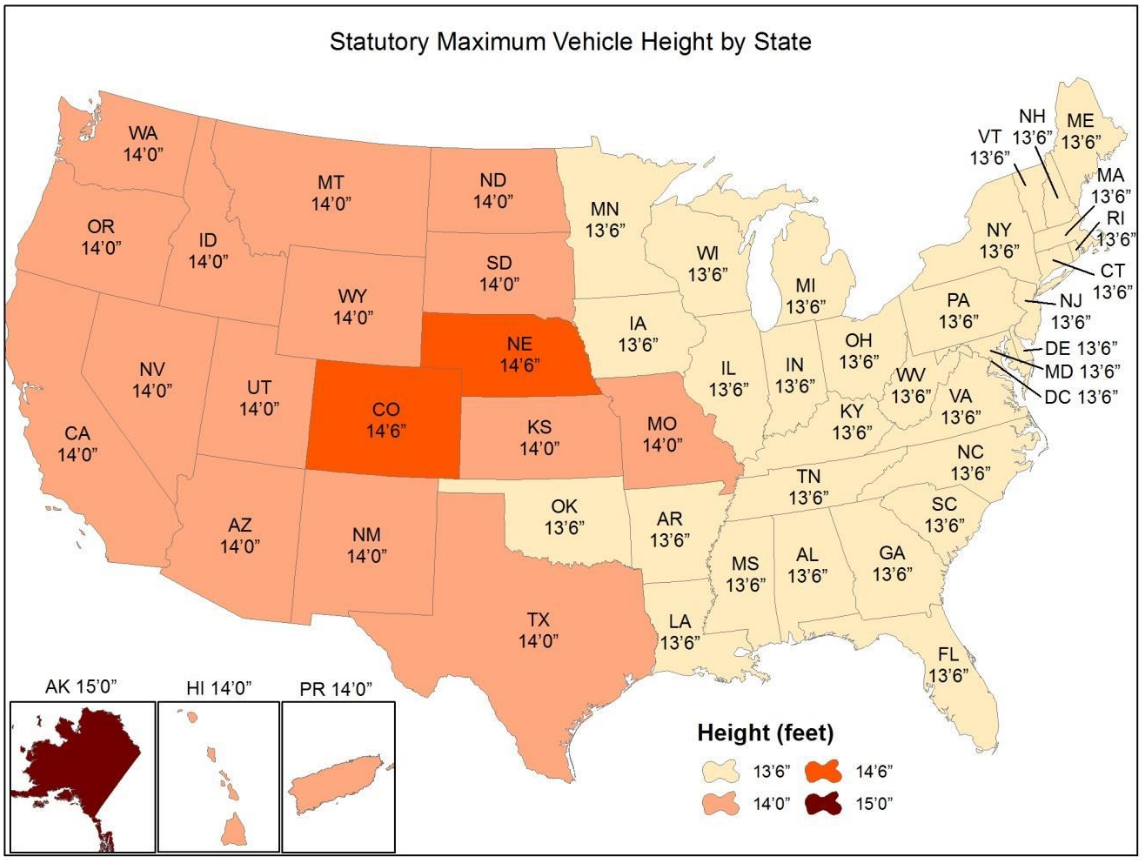


Figure 5 – Statutory maximum vehicle height in each state

Figure 6 illustrates the states that comply with the MUTCD, those that exceed the minimum requirements, and those that do not comply with the minimum requirements. Twenty-six states, and the District of Columbia and Puerto Rico, comply with the MUTCD at a minimum, requiring the posting of low clearance signs for clearances less than 12 inches above the statutory maximum vehicle height. Twenty-two states go further and require the posting of low clearance signs for clearances greater than the 1 foot MUTCD minimum. Two states have low clearance signage requirements that do not comply with the minimum requirements of the MUTCD.

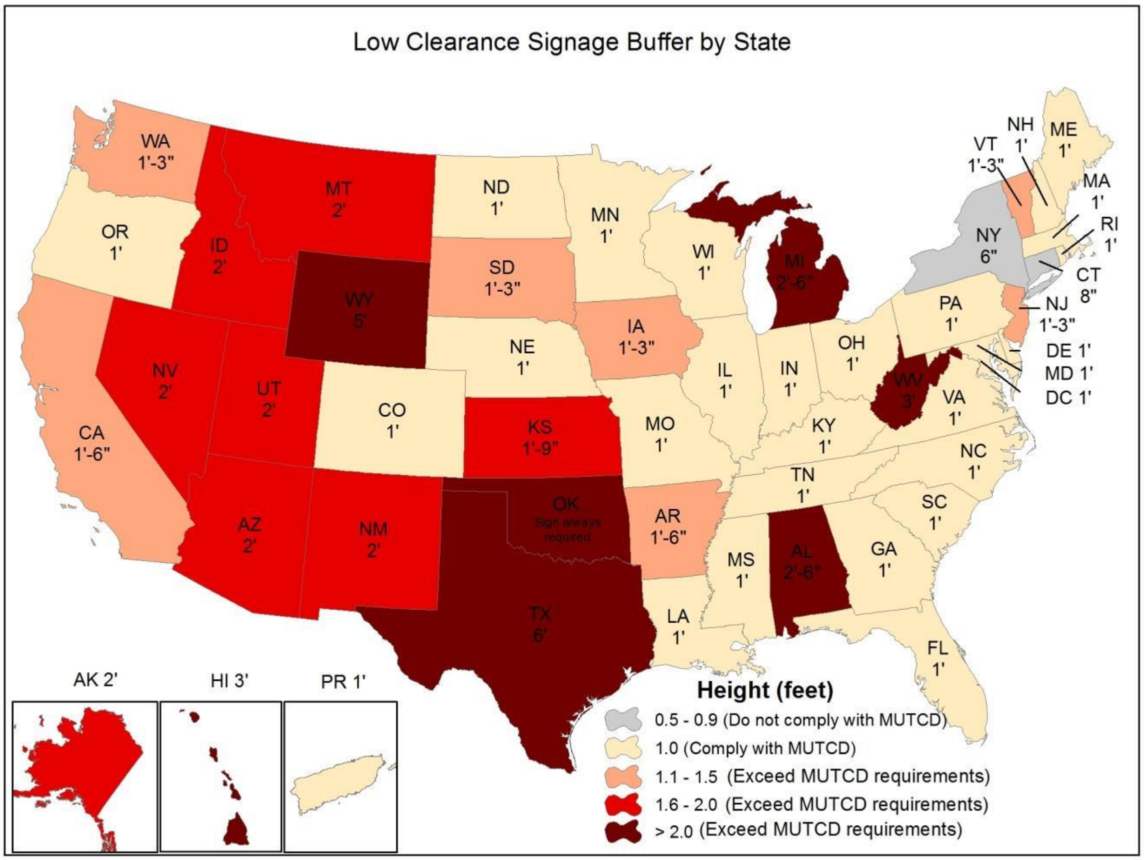


Figure 6 – US state compliance with MUTCD low clearance signage requirements

Figure 7 illustrates the low clearance signage requirements in each state.

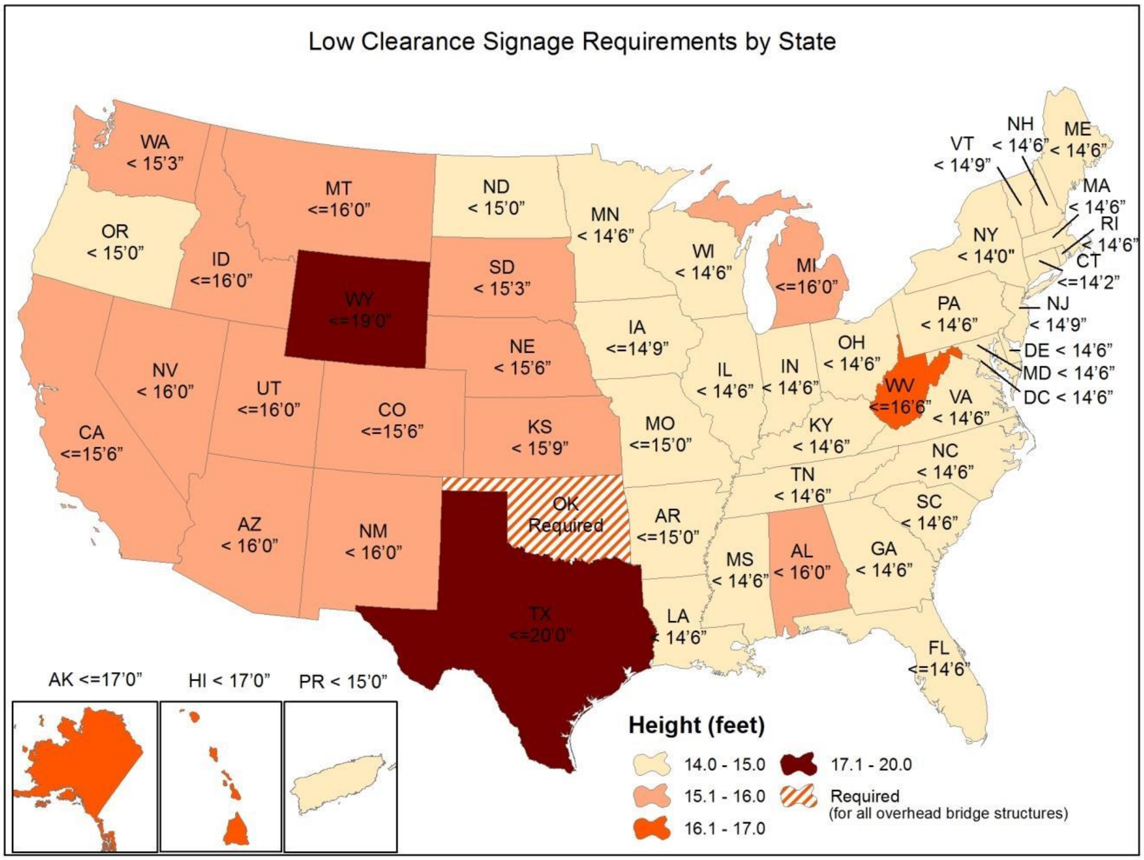


Figure 7 – Low clearance signage requirements in each state

10. AASHTO Guidance on Vertical Clearance of Highway Structures

The American Association of State Highway and Transportation Officials (AASHTO) 2012 *LRFD Bridge Design Specifications*[20] recommended the following regarding vertical clearance of highway structures:

*"**2.3.3.2 – Highway Vertical***

The vertical clearance of highway structures shall be in conformance with the AASHTO publication A Policy on Geometric Design of Highways and Streets for the Functional Classification of the Highway or exceptions thereto shall be justified. Possible reduction of vertical clearance, due to settlement of an

[20] *LRFD Bridge Design Specifications*, American Association of State Highway and Transportation Officials; 2012 6th Edition; page 2-6.

overpass structure, shall be investigated. If the expected settlement exceeds 1.0 in., it shall be added to the specified clearance.

The vertical clearance to sign supports and pedestrian overpasses should be 1.0 ft. greater than the highway structure clearance, ***and the vertical clearance from the roadway to the overhead cross bracing of through-truss structures should not be less than 17.5 ft.****"*

The AASHTO 2011 *A Policy on Geometric Design of Highways and Streets*[21] (or commonly known as the Green Book) recommended the following regarding vertical clearance:

*"**8.2.9 Vertical Clearance***

The vertical clearance to structures passing over freeways should be at least 4.9 m [16 ft] over the entire roadway width, including auxiliary lanes and the usable width of shoulders with consideration for future resurfacing. In highly developed urban areas, where attaining a 4.9 m [16 ft] clearance would be unreasonably costly, a minimum clearance of 4.3 m [14 ft] may be used if there is an alternative freeway facility with a minimum 4.9 m [16 ft] clearance.

Because sign trusses and pedestrian overpasses have lesser resistance to impacts, their vertical clearance should be 5.1 m [17 ft]. On urban routes with less than the 4.9 m [16 ft] clearance, the vertical clearance to sign trusses should be 0.3 m [1 ft] more than the minimum clearance for other structures. ***Similarly, the vertical clearance from the deck to the cross bracing of through-truss structures should also be a minimum of 5.1 m [17 ft].****"*

Table 16 summarizes the history of AASHO[22] and AASHTO guidance on vertical clearance of highway structures.

Table 16 – History of AASHO and AASHTO Guidance on Vertical Clearance of Highway Structures

AASHO and AASHTO Publications
AASHO *A Policy on Geometric Design of Rural Highways* (Blue Book)
1954 Edition (pages 77 and 386) "Considerable variation exists among the States in regard to the maximum permissible heights of motor vehicles. Table II-6 shows that the majority of States limit vehicles to 12.5 foot height, the value recommended by the AASHO. Thirty-five States or 72 percent have upper limits of 12.5 feet for vehicle height, which dimension is considered to be the height of design semitrailer combinations.

[21] *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials; 2011 6th Edition; page 8-4.

[22] The organization was formed in 1914 and, until 1973, was known as the American Association of State Highway Officials (AASHO). Today the organization is known as the American Association of State Highway and Transportation Officials (AASHTO).

Table II-6
Legal Restrictions for Height and Width of Vehicles – 1952

Legal Maximum Permissible Dimension, ft.	Number of States	Percent of States at or below indicated value
HEIGHT		
12.5	35	72
13.0	2	76
13.5	8	92
14.0	2	96
No restriction	2	100
WIDTH		
8	47	96
8.5	2	100

Vertical Clearance

The clear height of all structures should be at least 14 feet over the entire width of traffic lanes, auxiliary lanes and clearances to curbs, including shoulders; see figure IX-5. The adequacy of 14 feet is verified by the State vehicle size restrictions as discussed under Height of Motor Vehicles in Chapter II. To insure continuing adequate vertical clearance of at least 14 feet an additional clearance, say 4 inches or more, should be provided initially to allow for one or two resurfacings."

1965 Edition (pages 81, 86, and 521) "Considerable variation exists among the States in regard to maximum permissible heights of motor vehicles. Table II-4 shows that the majority of States limit vehicle height to 13.5 feet. Thirty-one States or 61 percent have an upper limit of 13.5 feet for vehicle height.

Table II-4
Legal Restrictions for Height and Width of Vehicles – December 1962

Legal Maximum Permissible Dimension, feet	Number of States	Percent of States at or below indicated value
HEIGHT		
12.5	14	27.5
13.0	2	31.4
13.5	31	92.2
14.0	2	96.1
No restriction	2	100.0
WIDTH		
8	48	94.1
8.5	2	98.0
9	1	100.0

Vertical Clearance

The clear height of all structures should be at least 14 feet over the entire width of traffic lanes, auxiliary lanes, and lateral clearance areas to curbs, walls, or piers, including shoulders. See figure IX-5. The adequacy of 14 feet is verified by the State vehicle size restrictions as discussed under Height of Motor Vehicles in Chapter II. To insure continuing adequate vertical clearance of at least 14 feet an additional clearance, say 4 inches or more, should be provided initially to allow for resurfacing.”
AASHO *A Policy on Arterial Highways in Urban Areas* (Red Book)
1957 Edition (page 336) “The clear height of all structures above freeway pavements and shoulders should be at least 14 feet. Normally, an additional clearance of 4 inches or more should be provided initially to allow for future resurfacing. Vertical clearances of 15 feet or more have been suggested to accommodate an occasional high bodied vehicle. This may be justified in sparsely settled rural areas where alternate routes are not nearby, but in urban areas high vertical clearance is not necessary and may be undesirable where adjacent streets are available for the occasional high bodied vehicle.”
AASHO *A Policy on Design of Urban Highways and Arterial Streets* (Red Book)
1973 Edition (page 502) “The clear height of a freeway underpass is a matter of determination for the freeway route as a whole. This in turn may be governed by the standards on the freeway system. The clear height of all structures above freeway pavements and shoulders should be at least 14 feet or at least one foot greater than the legal height load. An additional clearance of 4 or more inches should be provided initially to allow for future resurfacing. Some urban freeways are parts of systems or routes for which a minimum vertical clearance of 16 feet, plus an allowance for future resurfacing has been established. Interstate system standards call for such clearance for one route either passing through or around each urban area, but for other routes a lower vertical clearance is acceptable as a minimum. This dual standard is a practical recognition of the several governing features for an urban freeway. In the urban areas there are alternate parallel routes, not necessarily freeways, for use by the occasional high bodied vehicle.”
AASHTO *A Policy on Geometric Design of Highways and Streets* (Green Book)[23]
1984 First Edition (page 634) “The vertical clearance to structures passing over freeways should be at least 16 ft over the entire roadway width, including auxiliary lanes and the usable width of shoulders. In highly developed urban areas, where attainment of the 16-ft clearance would be unreasonably costly, a minimum clearance of 14 ft may be used if there is a circumferential freeway facility with the minimum 16-ft clearance. Because of their lesser resistance to impacts, the vertical clearance to sign trusses and pedestrian overpasses should be 17 ft. The vertical clearance from the deck to the cross bracing of through-truss structures should also be a minimum of 17 ft. An allowance of 6 in. should be added to all vertical clearances to accommodate future resurfacing.”

[23] The 1965 AASHO A Policy on Geometric Design of Rural Highways (Blue Book) and the 1973 AASHO A Policy on Design of Urban Highways and Arterial Streets (Red Book) were combined into the First Edition of AASHTO’s A Policy on Geometric Design of Highways and Streets (Green Book) published in 1984.

(pages 921 and 922) "Although State laws vary somewhat, most States permit the vehicle height, including load, to be between 13.5 and 14.5 ft. The clear height of all structures above pavements and shoulders should be at least 1 ft greater than the legal height, and allowance should be made for future resurfacing."
1990 Second Edition (pages 585 and 586) "The vertical clearance to structures passing over freeways should be at least 16 ft over the entire roadway width, including auxiliary lanes and the usable width of shoulders. In highly developed urban areas, where attainment of the 16-ft clearance would be unreasonably costly, a minimum clearance of 14 ft may be used if there is an alternate freeway facility with the minimum 16-ft clearance (with allowance for any future resurfacing). Because of their lesser resistance to impacts, the vertical clearance to sign trusses and pedestrian overpasses should be 17 ft. The vertical clearance from the deck to the cross bracing of through-truss structures should also be a minimum of 17 ft. An allowance of 6 in. should be added to all vertical clearances to accommodate future resurfacing." **(page 876)** "Although State laws vary somewhat, most States permit the vehicle height, including load, to be between 13.5 and 14.5 ft. The clear height of all structures above pavements and shoulders should be at least 1 ft greater than the legal height, and allowance should be made for future resurfacing."
1994 Third Edition (page 559) "The vertical clearance to structures passing over freeways should be at least 4.9 m over the entire roadway width, including auxiliary lanes and the usable width of shoulders. In highly developed urban areas, where attainment of the 4.9 m clearance would be unreasonably costly, a minimum clearance of 4.3 m may be used if there is an alternate freeway facility with the minimum 4.9 m clearance (with allowance for any future resurfacing). Because of their lesser resistance to impacts, the vertical clearance to sign trusses and pedestrian overpasses should be 5.1 m. The vertical clearance from the deck to the cross bracing of through-truss structures should also be a minimum of 5.1 m. An allowance of 150 mm should be added to all vertical clearances to accommodate future resurfacing." **(page 828)** "Although State laws vary somewhat, most States permit the vehicle height, including load, to be between 4.1 m and 4.4 m. The clear height of all structures above traveled way and shoulders should be at least 0.3 m greater than the legal height, and allowance should be made for future resurfacing."
2001 Fourth Edition (pages 510 and 511) "The vertical clearance to structures passing over freeways should be at least 4.9 m [16 ft] over the entire roadway width, including auxiliary lanes and the usable width of shoulders (with an allowance for future resurfacing). In highly developed urban areas, where attainment of the 4.9-m [16-ft] clearance would be unreasonably costly, a minimum clearance of 4.3 m [14 ft] may be used if there is an alternate freeway facility with the minimum 4.9-m [16-ft] clearance.

Because of their lesser resistance to impacts, the vertical clearance to sign trusses and pedestrian overpasses should be 5.1 m [17 ft]. Similarly, the vertical clearance from the deck to the cross bracing of through-truss structures should also be a minimum of 5.1 m [17 ft], with an allowance for future resurfacing."

(page 767) "Although State laws vary somewhat, most States permit the vehicle height, including load, to be between 4.1 m [13.5 ft] and 4.4 m [14.5 ft]. The vertical clearance of all structures above the traveled way and shoulders should be at least 0.3 m [1 ft] greater than the legal vehicle height, and allowance should be made for future resurfacing."

2004 Fifth Edition (pages 506 and 507) "The vertical clearance to structures passing over freeways should be at least 4.9 m [16 ft] over the entire roadway width, including auxiliary lanes and the usable width of shoulders (with an allowance for future resurfacing). In highly developed urban areas, where attainment of the 4.9-m [16-ft] clearance would be unreasonably costly, a minimum clearance of 4.3 m [14 ft] may be used if there is an alternate freeway facility with the minimum 4.9-m [16-ft] clearance.

Because of their lesser resistance to impacts, the vertical clearance to sign trusses and pedestrian overpasses should be 5.1 m [17 ft]. On urban routes with less than the 4.9-m [16-ft] clearance, the vertical clearance to sign trusses should be 0.3 m [1 ft] greater than the minimum clearance for other structures. Similarly, the vertical clearance from the deck to the cross bracing of through-truss structures should also be a minimum of 5.1 m [17 ft], with an allowance for future resurfacing."

(page 763) "Although State laws vary somewhat, most States permit the vehicle height, including load, to be between 4.1 m [13.5 ft] and 4.4 m [14.5 ft]. The vertical clearance of all structures above the traveled way and shoulders should be at least 0.3 m [1 ft] greater than the legal vehicle height, and allowance should be made for future resurfacing."

2011 Sixth Edition (page 8-4) "The vertical clearance to structures passing over freeways should be at least 4.9 m [16 ft] over the entire roadway width, including auxiliary lanes and the usable width of shoulders with consideration for future resurfacing. In highly developed urban areas, where attaining a 4.9-m [16-ft] clearance would be unreasonably costly, a minimum clearance of 4.3 m [14 ft] may be used if there is an alternate freeway facility with the minimum 4.9-m [16-ft] clearance.

Because sign trusses and pedestrian overpasses have lesser resistance to impacts, their vertical clearance should be 5.1 m [17 ft]. On urban routes with less than the 4.9-m [16-ft] clearance, the vertical clearance to sign trusses should be 0.3 m [1 ft] more than the minimum clearance for other structures. Similarly, the vertical clearance from the deck to the cross bracing of through-truss structures should also be a minimum of 5.1 m [17 ft]."

(page 10-21) "Although State laws vary somewhat, most States permit the vehicle height, including load, to be between 4.1 m [13.5 ft] and 4.4 m [14.5 ft]. The vertical clearance of all structures above the traveled way and shoulders should be at least 0.3 m [1 ft] greater than the legal vehicle height, and allowance should be made for future resurfacing."

AASHO and AASHTO *Standard Specifications for Highway Bridges*[24]
1969 (10th Edition) through 2002 (17th Edition) "Vertical clearance on state trunk highways and interstate systems in rural areas shall be at least 16 feet over the entire roadway width with an allowance for resurfacing. On state trunk highways and interstate routes through urban areas, a 16-foot clearance shall be provided except in highly developed areas. A 16-foot clearance should be provided in both rural and urban areas where such clearance is not unreasonably costly and where needed for defense requirements. Vertical clearance on all other highways shall be at least 14 feet over the entire roadway width with an allowance for resurfacing."
AASHTO *LRFD Bridge Design Specifications*
1994 (1st Edition) through 2013 Interim Revisions (6th Edition 2012) "The vertical clearance of highway structures shall be in conformance with the AASHTO publication A Policy on Geometric Design of Highways and Streets for the Functional Classification of the Highway or exceptions thereto shall be justified. Possible reduction of vertical clearance, due to settlement of an overpass structure, shall be investigated. If the expected settlement exceeds 1.0 in., it shall be added to the specified clearance. The vertical clearance to sign supports and pedestrian overpasses should be 1.0 ft. greater than the highway structure clearance, and the vertical clearance from the roadway to the overhead cross bracing of through-truss structures should not be less than 17.5 ft."

[24]The last edition (17th Edition) of the AASHTO Standard Specifications for Highway Bridges appeared in 2002. The FHWA and the states established that the AASHTO LRFD Bridge Design Specifications be incorporated in all new bridge designs after 2007.

11. Transition of Lane Configurations on the North End and South End of the I-5 Bridge

Figure 8 illustrates the transition of lane configurations on the north end and south end of the I-5 Bridge. Beyond the north end of the I-5 Bridge, the lane configuration transitioned from three lanes to two lanes because of the on ramp from George Hopper Road to I-5 in the southbound direction and the off ramp from I-5 to George Hopper Road in the northbound direction. Approximately 800 feet north of the I-5 Bridge, the travel lanes on I-5 were approximately 12 feet wide and the paved shoulders were approximately 8 feet wide. Beyond the south end of the I-5 Bridge, the travel lanes on I-5 were approximately 12 feet wide and the paved shoulders were approximately 10 feet wide.

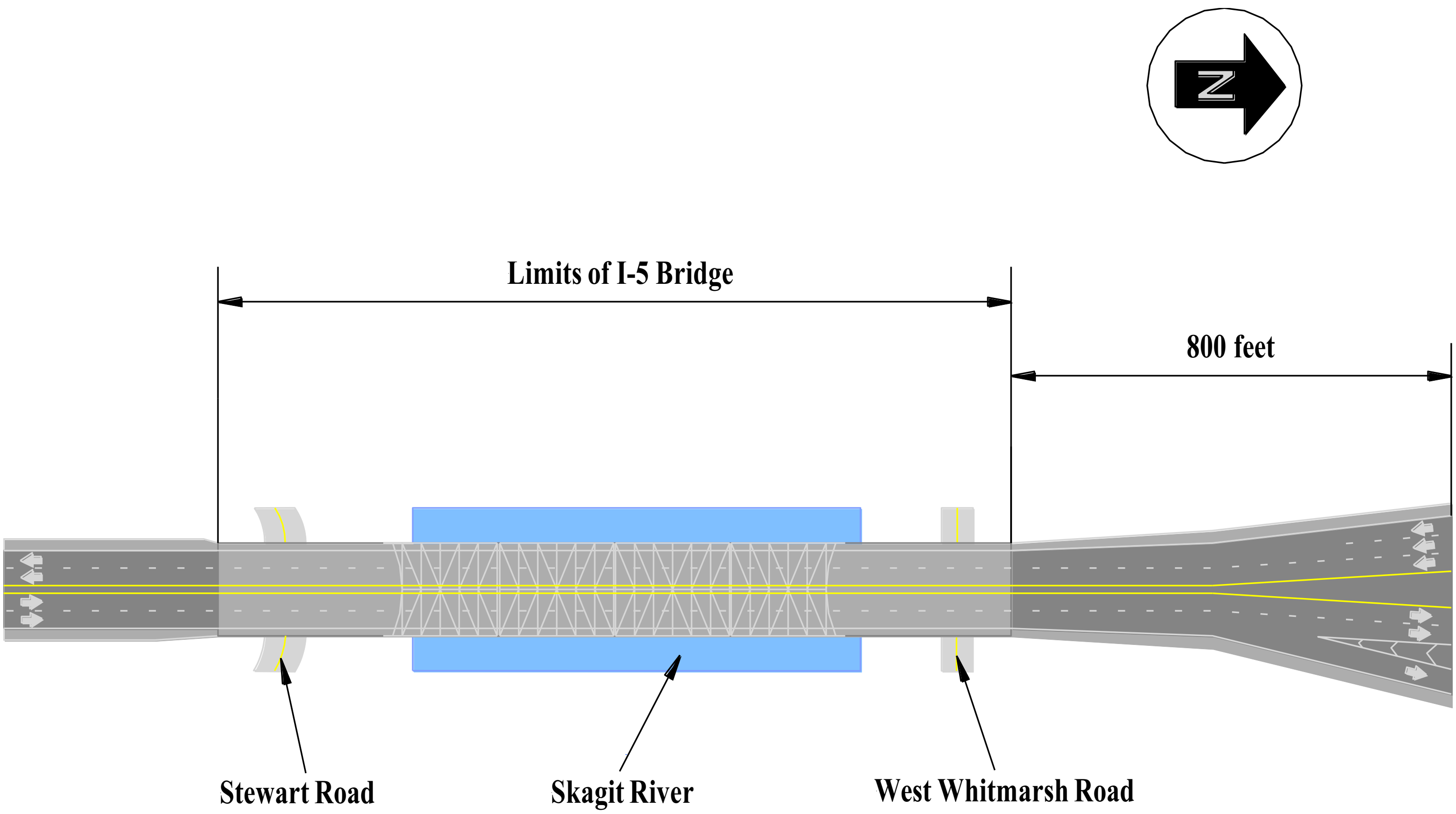


Figure 8 – Transition of Lane Configurations on the North End and South End of the I-5 Bridge

12. AASHTO Guidance on Lane Widths

The AASHTO 2011 *A Policy on Geometric Design of Highways and Streets*[25] (or commonly known as the Green Book) recommended the following regarding lane widths:

> *"4.3 LANE WIDTHS*
>
> ***The lane width of a roadway influences the comfort of driving, operational characteristics, and, in some situations, the likelihood of crashes.*** *Lane widths of 2.7 to 3.6 m [9 to 12 ft] are generally used,* ***with a 3.6 m [12 ft] lane predominant on most high-speed, high-volume highways.*** *The extra cost of providing a 3.6 m [12 ft] lane width, over the cost of providing a 3.0 m [10 ft] lane width is offset to some extent by a reduction in cost of shoulder maintenance and a reduction in surface maintenance due to lessened wheel concentrations at the pavement edges. The wider 3.6 m [12 ft] lane provides desirable clearances between large commercial vehicles traveling in opposite directions on two-lane, two-way rural highways when high traffic volumes and particularly high percentages of commercial vehicles are expected.*
>
> ***Lane widths also affect highway level of service. Narrow lanes force drivers to operate their vehicles closer to each other laterally than they would normally desire. Restricted clearances have a similar effect. In a capacity sense, the effective width of traveled way is reduced by adjacent obstructions such as retaining walls, bridge trusses or headwalls, and parked cars that restrict the lateral clearance.*** *Further information on the effect of lane width on capacity and level of service is presented in the Highway Capacity Manual (HCM).*
>
> ***In urban areas where pedestrian crossings, right-of-way, or existing development become stringent controls on lane widths, the use of 3.3 m [11 ft] lanes may be appropriate.*** *Lanes 3.0 m [10 ft] wide are acceptable on low-speed facilities, and lanes 2.7 m [9 ft] wide may be appropriate on low-volume roads in rural and residential areas. For further information, see NCHRP Report 362, Roadway Widths for Low-Traffic Volume Roads. In some instances, on multilane facilities in urban areas, narrower inside lanes may be utilized to permit wider outside lanes for bicycle use. Reference should be made to the current edition of the AASHTO Guide for the Development of Bicycle Facilities for appropriate lane width dimensions in these situations.*

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[25] *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials; 2011 6th Edition; pages 4-7, 4-8, and 8-2.

8.2.4 Traveled Way and Shoulders

Freeways should have a minimum of two through-traffic lanes for each direction of travel. Through-traffic lanes should be 3.6 m [12 ft] wide."

13. Inventory of Thru Truss Bridges in Washington State

Table 17 provides an inventory of all thru truss bridges in Washington State sorted by Interstate, U.S. Highway, and State Highway. **Table 17** summarizes when each thru truss bridge was built, the minimum vertical clearance over the travel lanes, the minimum vertical clearance over the shoulder, and whether each thru truss bridge was signed for low clearance prior to the accident on May 23, 2013.

Post-accident actions taken by the WSDOT included a review to determine if low clearance signs were installed for thru truss bridges with vertical clearances of 15'-3" or less over the travel lanes. Two (2) thru truss bridges, US-12 over Snake River Clarkston (#2348A) and SH-539 over Nooksack River (#3802B), had vertical clearances less than 15'-3" over the travel lanes and were not signed for low clearance. Six (6) thru truss bridges, US-101 over Sol Duc River (#3372A), US-101 over Sol Duc River #5 (#3372B), SH-109 over Humptulips River (#4874B), SH-203 over Skykomish River (#5294B), SH-410 over White River (#3523A), and SH-536 over Skagit River (#4400A), had vertical clearances of 15'-3" over the travel lanes and were not signed for low clearance. WSDOT has taken the steps to install low clearance signs at these locations.

Five (5) thru truss bridges, US-2 over S FK Skykomish River (#2332A), US-2 over Sultan River (#2580A), US-2 over Wallace River (#2649A), SH-6 over Chehalis River Riverside (#2538B), and SH-18 over Green River (Neeley Bridge), had vertical clearances greater than 15'-3" and were signed for low clearance.

WSDOT provided an explanation of why the five (5) thru truss bridges had vertical clearances greater than 15'-3" and were signed for low clearance in an email to NTSB investigators dated July 13, 2013:

"The remaining five bridges are on two lane roadways, and in each case, the signing has been in place for a significant period of time. I have not been able to determine the specific circumstances relative to each installation.

From a general perspective, we rarely post signs in excess of our operational signing policies, although we do have a few examples. Reasons vary, but are often associated with specific public and political requests, local operational characteristics, and ultimately combined with engineering judgment."

Table 17 – Inventory of all Thru Truss Bridges in Washington State sorted by Interstate, U.S. Highway, and State Highway

Route	Structure ID #	Bridge Name	Year Built	Minimum Vertical Clearance over Travel Lanes	Minimum Vertical Clearance over Shoulder	Signed for Low Clearance (Yes or No)
Interstate						
I-5	4367A	Cowlitz River	1953	15’-7”	15’7”	No
I-5	4367B	Cowlitz River	1953	15’-8”	14’-9”	No
I-5	11757A	Skookumchuck River	1951	15’-5”	14’-8”	No
I-5	11757B	Skookumchuck River	1951	15’-5”	14’-8”	No
I-5	2069A	Nisqually River	1937	16’-0”	16’-0”	No
I-5	8116A	Nisqually River	1967	17’-9”	17’-1”	No
I-5	2473A	E FK Lewis River	1936	16’-11”	15’-0”	No
I-5	8264C	Lewis River	1968	17’-3”	17’-3”	No
I-5	2559A	Lewis River	1940	16’-6”	15’-0”	No
I-5	1652A	Stillaguamish River	1933	16’-8”	16’-8”	No
I-5	4794A	Skagit River	1955	15’-5”	14’-8”	No
I-5	4856A	Nooksack River	1955	15’-4”	14’-10”	No
I-5	8655A	Nooksack River	1971	16’-9”	16’-9”	No
I-82	1583A	Yakima River	1932	16’-3”	16’-3”	No
I-82	6123B	Yakima River	1960	15’-9”	15’-1”	No
I-82	1583B	Naches River	1932	16’-0”	15’-9”	No
I-82	6123C	Naches River	1960	15’-11”	15’-1”	No
I-82	PD	Columbia R Br @ Umatilla	1955	16’-7”	15’-11”	No
I-90	3527A	Cle Elum River	1949	18’-6”	18’-0”	No
I-90	6868B	Cle Elum River	1962	17’-6”	16’-11”	No
I-5	PR	Columbia R Interstate	1916	15’-6”	15’-6”	No
I-5	5216A	Columbia R Interstate	1958	16’-0”	16’-0”	No
U.S. Highway						
US-2	2332A	S FK Skykomish River	1938	15’-5”	14’-8”	Yes
US-2	2001B	Wenatchee River	1900	19’-8”	19’-8”	No
US-2	2580A	Sultan River	1940	15’-7”	14’-7”	Yes
US-2	2649A	Wallace River	1940	15’-6”	14’-7”	Yes

US-2	1667A	S FK Skykomish River	1933	16’-5”	16’-2”	No
US-12	1949A	Wynoochee River	1935	16’-3”	16’-3”	No
US-12	3348A	Cowlitz River Cora	1948	15’-2”	14’-10”	Yes
US-12	5742A	Naches River Nelson	1958	15’-7”	15’-7”	No
US-12	7874A	Naches River Nelson	1966	19’-0”	18’-11”	No
US-12	3762A	Snake River at Burbank	1950	16’-4”	16’-4”	No
US-12	12800A	Snake River at Burbank	1986	18’-4”	18’-4”	No
US-12	1576C	Black River	1932	N/A	N/A	No
US-97	6539A	Biggs Rapids – Sam Hill Br	1962	15’-11”	15’-11”	No
US-101	7666B	Columbia River – Megler (A)	1966	17’-10”	17’-2”	No
US-101	7666D	Columbia River – Megler (C)	1966	17’-10”	17’-2”	No
US-101	8574A	Hoquiam River - Riverside	1970	17’-8”	17’-5”	No
US-101	1084A	Hoquiam River - Simpson	1928	16’-6”	16’-6”	No
US-101	3765B	Humptulips River	1950	15’-0”	14’-10”	Yes
US-101	2060A	Big Quilcene River	1936	17’-3”	17’-3”	No
US-101	2396A	Calawah River	1938	15’-3”	14’-9”	Yes
US-101	5638A	Sol Duc River	1958	17’-8”	17’-8”	No
US-101	2627A	Sol Duc River #2	1941	15’-5”	14’-9”	No
US-101	2627B	Sol Duc River	1941	15’-3”	14’-9”	Yes
US-101	3372A	Sol Duc River	1948	15’-3”	14’-9”	No
US-101	3372B	Sol Duc River #5	1948	15’-3”	14’-9”	No
US-101	1604A	Skokomish River	1932	16’-2”	16’-2”	No
US-12	2311A	Wishkah River Bridge	1925	15’-5”	15’-5”	No
US-12	2348A	Snake River Clarkston	1939	14’-7”	14’-7”	No
US-395	4195A	Pioneer Mem. Bridge	1954	17’-9”	17’-9”	No
US-395	2613A	Columbia River Kettle Falls	1941	15’-1”	14’-10”	Yes
US-97	6835A	Columbia River Beebe	1962	16’-2”	15’-11”	No
State Highway						

SH-4	2331A	Grays River	1938	15’-7”	14’-11”	No
SH-4	4999A	Elochoman River	1955	15’-7”	15’-1”	No
SH-4	3717A	Cowlitz River – P Crawford Bridge	1951	15’-3”	15’-3”	Yes
SH-6	2538B	Chehalis River Riverside	1939	15’-7”	15’-2”	Yes
SH-6	1352A	Willapa River Lilly Wheaton	1929	16’-6”	16’-6”	No
SH-7	4348A	Nisqually River	1953	15’-10”	15’-2”	No
SH-9	5727A	Snohomish River	1959	15’-3”	14’-11”	Yes
SH-9	5773A	Skagit River	1959	15’-7”	15’-1”	No
SH-9	4542A	N FK Nooksack River US	1954	15’-5”	15’-1”	No
SH-10	1403A	Teanaway River	1930	N/A	N/A	No
SH-18	6066B	Green River (Neeley Bridge)	1959	15’-5”	14’-9”	Yes
SH-20	3722A	Methow River	1929	16’-6”	16’-6”	No
SH-21	6282A	Kettle River	1960	15’-10”	15’-4”	No
SH-24	7619A	Columbia River Vernita	1965	16’-3”	16’-3”	No
SH-25	3297A	Columbia River @ Northport	1948	15’-3”	14’-11”	Yes
SH-25	2658A	Spokane River	1941	15’-3”	14’-8”	Yes
SH-104	16525C	Hood Canal West Approach	2007	29’-6”	29’-6”	No
SH-104	16525B	Hood Canal East Approach	2007	29’-6”	29’-6”	No
SH-107	5827A	Chehalis River	1958	15’-9”	15’-4”	No
SH-109	4874B	Humptulips River	1956	15’-3”	15’-0”	No
SH-127	8494A	Elmer C. Huntley Bridge	1969	16’-8”	16’-8”	No
SH-131	8214800	Chilcoat	1949	15’-7”	15’-1”	No
SH-141	2565A	White Salmon River	1940	N/A	N/A	No
SH-153	3704A	Methow River	1950	15’-7”	15’-7”	No
SH-155	JJ	Columbia River Grand Coulee	1935	14’-10”	14’-10”	Yes
SH-167	3960A	Puyallup River	1925	18’-7”	18’-7”	No
SH-197	PC	Columbia River @ The Dalles	1954	15’-8”	15’-8”	No
SH-202	1480A	Snoqualmie River	1931	15’-8”	15’-8”	No
SH-203	5294B	Skykomish River	1957	15’-3”	14’-10”	No
SH-203	10370A	Tolt River	1977	16’-11”	16’-11”	No
SH-207	2657A	Wenatchee River	1940	15’-4”	14’-7”	No
SH-261	8390A	Snake River Lyons	1927	15’-0”	15’-0”	Yes

		Ferry				
SH-305	3573A	Agate Pass	1950	15’-4”	15’-1”	No
SH-409	2377A	Julia Butler Hansen Bridge	1938	16’-4”	16’-4”	No
SH-410	3523A	White River	1949	15’-3”	14’-2”	No
SH-432	9100A	Cowlitz River & NPRR	1973	18’-6”	17’-4”	No
SH-432	6321A	Harry E. Morgan Bridge	1961	16’-0”	16’-0”	No
SH-433	3760A	Columbia River – Lewis & Clark Bridge	1929	18’-11”	18’-11”	No
SH-507	HV	Skookumchuck River	1928	14’-8”	14’-8”	Yes
SH-508	IJ	S FK Newaukum River	1930	N/A	N/A	No
SH-520	6651A	Evergreen Pt. West Approach	1963	17’-3”	16’-10”	No
SH-520	6651B	Evergreen Pt. East Approach	1963	17’-0”	16’-6”	No
SH-529	965A	Snohomish River Bridge	1927	14’-3”	14’-3”	Yes
SH-529	4331A	Snohomish River Bridge	1954	15’-7”	15’-1”	No
SH-529	4373A	Steamboat Slough	1954	15’-8”	15’-8”	No
SH-529	965C	Steamboat Slough	1927	15’-10”	15’-2”	No
SH-530	6038A	Sauk River Bridge	1958	17’-3”	17’-3”	No
SH-536	4400A	Skagit River	1953	15’-3”	15’-0”	No
SH-539	3802B	Nooksack River	1950	14’-11”	14’-10”	No
SH-539	17469C	Nooksack River	2009	27’-0”	27’-0”	No
SH-542	1494A	N FK Nooksack River Warnick	1931	16’-3”	16’-3”	No

14. Inventory of High Load Hits on Thru Truss Bridges and All Bridges in Washington State

Table 18 provides an inventory of high load hits on thru truss bridges in Washington State reported from January 2008 to May 2013. The inventory of high load hits is divided into three categories:

- High load hits resulting in significant structural damage and a Critical Damage Bridge Repair Report (CDBRR) sent to FHWA
- High load hits resulting in structural damage that required site visit by the WSDOT Bridge Preservation Office – significance of structural damage varies but generally requires Priority 1 repair
- High load hits reported by others (Region Maintenance usually) with minor damage, no WSDOT Bridge Preservation Office inspection performed in response to damage

The *Washington State Bridge Inspection Manual* defined a Critical Damage Bridge Repair Report (CDBRR)[26] as the following:

> *"**Critical Damage Bridge Repair Report (CDBRR)** – When a bridge inspection identifies a significant structural problem requiring an emergency load restriction, lane closure, bridge closure, or if a bridge has failed, a Critical Damage Bridge Repair Report (CDBRR) must be completed. The purpose of this option is to provide added visibility and attention to these critical repair recommendations and to ensure all recommendations are acted upon quickly and diligently."*

The *Washington State Bridge Inspection Manual* defined a Priority 1 repair[27] as the following:

> *"**Priority 1** – A Priority 1 repair describes a deficiency to a primary bridge element that could cause a major impact to the bridge such as load restrictions. This type of deficiency may lead to more extensive and costly structural repairs if not completed as soon as possible.*
>
> *Priority 1 is the highest priority assigned to a routine type repair which left uncompleted, could turn into an urgent or emergency repair during the next inspection.*

[26] *Washington State Bridge Inspection Manual*, published jointly by the FHWA Washington Division Bridge Office and the WSDOT Bridge Preservation Office; November 2012; page 6-1.
[27] *Washington State Bridge Inspection Manual*, published jointly by the FHWA Washington Division Bridge Office and the WSDOT Bridge Preservation Office; November 2012; pages 6-10 and 6-11.

These repairs are top priority to ensure:

- *Public Safety*
- *Reliability of the Transportation System*
- *Protection of Public Investments*
- *Maintenance of Legal Federal Mandates*

On occasion, the inspection frequency may need adjustment to ensure that conditions since the previous inspection have not deteriorated to urgent or emergency status, that safety of the traveling public has not become compromised, and that inspectors may verify that repairs have been done in a timely manner. Additionally, the Rating Revision flag may require a "Y" to reexamine the bridge for load carrying capability.

Examples of deficiencies requiring Priority 1 repairs are as follows:

- *Repairing exposure of damaged strands and/or rebar.*
- *Removing or mitigating any existing potential for material falling from the bridge.*
- *Repairing significant joint defects that impact the bridge or create traffic hazards such as 'D' spalls in the header with exposed steel.*
- *Trimming or removal of trees, brush or debris that interferes with inspection procedures or equipment access. List the month and year of the next inspection by which this repair needs to be completed."*

Table 18 – Inventory of High Load Hits on Thru Truss Bridges in Washington State from January 2008 to May 2013

Route	Structure ID #	Bridge Name	Inspection Date[28]	Report Note
1 High Load Hit[29] Resulting in Significant Structural Damage and CDBRR sent to FHWA				
I-5	4794A	Skagit River	5/24/2013	Collapse of Span 8 in Skagit River
12 High Load Hits Resulting in Structural Damage that Required Site Visit by the WSDOT Bridge Preservation Office – Significance of Structural Damage Varies but Generally Requires Priority 1 Repair				
US-97	6539A	Biggs Rapids – Sam Hill Br	1/28/2008	Damage inspection
SH-4	4999A	Elochoman River	6/26/2008	High load damage inspection
US-12	2311A	Wishkah River Bridge	5/7/2009	High load truss hit
SH-25	2658A	Spokane River	5/10/2010	South portal and first interior sway hit
SH-155	JJ	Columbia River Grand Coulee	11/17/2010	High load impact to south portal and first three sway braces
SH-207	2657A	Wenatchee River	4/6/2011	None
US-101	3765B	Humptulips River	5/18/2011	Damage to north portal
SH-4	4999A	Elochoman River	7/8/2011	High load damage inspection
US-101	1084A	Hoquiam River – Simpson	8/11/2011	Bridge hit by logging truck
US-101	1084A	Hoquiam River – Simpson	11/9/2011	High load hit on south portal
US-101	1084A	Hoquiam River – Simpson	8/17/2012	High load hit to the north approach truss
I-5	4794A	Skagit River	11/29/2012	High load hit damage to south portal and the following two sway braces
2 High Load Hits Reported by Others (Region Maintenance Usually) with Minor Damage, No WSDOT Bridge Preservation Office inspection performed in response to damage				
SH-410	3523A	White River	8/25/2009	Damage photos filed
US-101	1084A	Hoquiam River - Simpson	9/9/2011	No inspection by Bridge Preservation Office

[28]The date refers to the inspection date.
[29]For the purposes of this report, a hit is defined as the frequency for which damage was reported.

Table 19 summarizes the high load hit repetition on thru truss bridges in Washington State from January 2008 to May 2013. The US-101 over Hoquiam River – Simpson (#1084A) thru truss bridge was hit 4 times, the SH-4 over Elochoman River (#4999A) and I-5 over Skagit River (#4794A) thru truss bridges were hit twice, and seven (7) thru truss bridges were hit once.

Table 19 – High Load Hit Repetition on Thru Truss Bridges in Washington State from January 2008 to May 2013

Route	Structure ID #	Bridge Name	Inspection Date[30]	Report Note
Thru Truss Bridge Hit[31] 4 Times				
US-101	1084A	Hoquiam River – Simpson	8/11/2011	Bridge hit by logging truck
US-101	1084A	Hoquiam River – Simpson	9/9/2011	No inspection by Bridge Preservation Office
US-101	1084A	Hoquiam River – Simpson	11/9/2011	High load hit on south portal
US-101	1084A	Hoquiam River – Simpson	8/17/2012	High load hit to the north approach truss
Thru Truss Bridges Hit 2 Times				
SH-4	4999A	Elochoman River	6/26/2008	High load damage inspection
SH-4	4999A	Elochoman River	7/8/2011	High load damage inspection
I-5	4794A	Skagit River	11/29/2012	High load hit damage to south portal and the following two sway braces
I-5	4794A	Skagit River	5/24/2013	Collapse of Span 8 in Skagit River
Thru Truss Bridges Hit Once				
US-97	6539A	Biggs Rapids – Sam Hill Br	1/28/2008	Damage inspection
US-12	2311A	Wishkah River Bridge	5/7/2009	High load truss hit
SH-410	3523A	White River	8/25/2009	Damage photos filed
SH-25	2658A	Spokane River	5/10/2010	South portal and first interior sway hit
SH-155	JJ	Columbia River Grand Coulee	11/17/2010	High load impact to south portal and first three sway braces
SH-207	2657A	Wenatchee River	4/6/2011	None
US-101	3765B	Humptulips River	5/18/2011	Damage to north portal

[30]The date refers to the inspection date.
[31]For the purposes of this report, a hit is defined as the frequency for which damage was reported.

Table 20 provides an inventory of high load hits on all bridges in Washington State from January 2008 to May 2013. Ten (10) high load hits resulted in significant structural damage to the bridge, sixty-two (62) high load hits resulted in structural damage that required a site visit by the WSDOT Bridge Preservation Office, and twenty (20) high load hits were reported by others with minor damage. The two (2) high load hits to the Olympic Drive NW over SR 16 (#9245A) concrete beam bridge on 1/4/2011 and 3/17/2013 that resulted in significant structural damage, as previously mentioned in this report, are noted in **Table 20**.

Table 20 – Inventory of High Load Hits on All Bridges in Washington State from January 2008 to May 2013

Structure ID #	Bridge Name	Inspection Date[32]	Report Note
10 High Load Hits[33] Resulting in Significant Structural Damage and CDBRR sent to FHWA			
6011A	SR-11 over I-5	7/10/2008	High load hit on Girder 2F
16597A	24th Street East over SR-167	1/12/2009	Over height load impact to Girders 3N and 3O over right northbound lane
5783D	Danekas Road over I-90	11/17/2010	High load hit above outside eastbound lane to Girders 2A, 2E, and 2F
9245A	Olympic Drive NW over SR-16	1/4/2011	Truck with a forklift on a lowboy trailer struck Girder 2A
7819B	Court Street over US-395	1/15/2011	High load hit to Girder A
8271C	113th Avenue SW over I-5	3/22/2011	Trailered forklift struck Girder 3D
9217C	I-90 over Bandera Road	4/4/2012	None
5668B	Chamber Way over I-5	9/7/2012	High hit on Girder 3F from northbound overloaded log truck
9245A	Olympic Drive NW over SR-16	3/17/2013	Over height load struck Girder 2A
4794A	Skagit River	5/24/2013	Collapse of Span 8 in Skagit River
62 High Load Hits Resulting in Structural Damage that Required Site Visit by the WSDOT Bridge Preservation Office – Significance of Structural Damage Varies but Generally Requires Priority 1 Repair			
6539A	Biggs Rapids – Sam Hill Br	1/28/2008	Damage inspection
8598A	Lieser Road over SR-14	2/6/2008	None
8879B	I-5 over 300th Street NW	3/13/2008	None
5385A	Orting Pedestrian over SR-162	3/17/2008	High load hit in northbound lane. Minor damage to bottom flange and several broken bottom laterals.
8674C	NE 80th Pedestrian over I-405	3/18/2008	Bridge Preservation Office inspected damage to structure at north and south tie beams over southbound lane 1 with

[32]The date refers to the inspection date.
[33]For the purposes of this report, a hit is defined as the frequency for which damage was reported.

			bridge maintenance crew.
7631A	N FK Toutle Road Kid Valley	3/24/2008	Damage to Girders A through C in Span 3.
5783A	Schoessler Road over I-90	4/14/2008	None
4999A	Elochoman River	6/26/2008	High load damage inspection
9808A	Cooper Pt Road over US-101	8/13/2008	None
6926A	I-5 over Portal Way	9/16/2008	None
5453B	Pedestrian Bridge over I-90	9/18/2008	None
9121A	Cloquallum Road over US-101	11/17/2008	High load hit reported in August 2008
5523C	47th Avenue SW over I-5	12/29/2008	Span 2 high hit reported August 2008
5668B	Chamber Way over I-5	2/11/2009	Damage inspection conducted to Span 3 girders over northbound lanes
4495D	Thorne Road over I-5	4/6/2009	Damage inspection for girders over I-5 northbound lanes
10331A	SR-303 over SR-3	5/4/2009	None
2311A	Wishkah River Bridge	5/7/2009	High load truss hit
9144G	I-90 over Deal Road	6/23/2009	None
8598A	Lieser Road over SR-14	8/5/2009	Created damage report from information and photos
8580A	I-5 over Ft Lewis Road	10/21/2009	High load impact to girders
4495D	Thorne Road over I-5	11/12/2009	Damage inspection for girders over I-5 northbound lanes
5783D	Danekas Road over I-90	12/14/2009	Girder 2A was hit at center span
16597A	24th Street East over SR-167	12/15/2009	Girder 3O was hit by a tanker truck that drove up the east embankment
200364	SR-501 over BNRR	3/4/2010	High load damage to Girder 6J
7026B	US-12 over I-5	3/8/2010	Damage inspection from the shoulder
2658A	Spokane River	5/10/2010	South portal and first interior sway hit
4495D	Thorne Road over I-5	8/2/2010	Overheight impact to Span 2 girders
8674C	NE 80th Pedestrian over I-405	10/17/2010	None
JJ	Columbia River Grand Coulee	11/17/2010	High load impact to south portal and first three sway braces
8879B	I-5 over 300th Street NW	4/5/2011	Damage to girders due to a high load hit
2657A	Wenatchee River	4/6/2011	None
9732A	I-90 over SR-18	5/3/2011	High load hit
3765B	Humptulips River	5/18/2011	Damage to north portal
16597A	24th Street East over SR-167	7/6/2011	Girder 3O high load hit above outside northbound lane
4999A	Elochoman River	7/8/2011	High load damage inspection
7026B	US-12 over I-5	7/19/2011	Damage inspection from the shoulder
4136A	US-2 over US-2	8/10/2011	None

1084A	Hoquiam River – Simpson	8/11/2011	Bridge hit by logging truck
5679A	SR-506 over I-5	8/23/2011	Errant vehicle impact to Span 4
8674C	NE 80th Pedestrian over I-405	9/1/2011	Bridge hit by overheight load
5668B	Chamber Way over I-5	10/6/2011	Bridge hit to girders over southbound I-5 inside lane
17610B	US-395 over US-2	10/18/2011	Impact damage to Girder 2A over the pedestrian/bike path
1084A	Hoquiam River – Simpson	11/9/2011	High load hit on south portal
8288A	South Browne Street to WB I-90	11/28/2011	None
8674C	NE 80th Pedestrian over I-405	12/3/2011	Bridge hit by overheight load
8674C	NE 80th Pedestrian over I-405	1/12/2012	Bridge hit by overheight load
6078A	I-5 over SR-18	3/8/2012	Replace bridge mounted sign hardware damaged on east side of bridge over westbound lanes
8446D	SR-526 over Hardeson Road	4/7/2012	None
5641A	Stampede Road over I-90	4/26/2012	None
6078A	I-5 over SR-18	5/8/2012	Replace bridge mounted sign hardware damaged on east side of bridge over westbound lanes
16597A	24th Street East over SR-167	5/15/2012	Girder 3B high load hit above outside northbound lane
1084A	Hoquiam River – Simpson	8/17/2012	High load hit to the north approach truss
8580B	NBCD over Ft Lewis Road	9/10/2012	None
4794A	Skagit River	11/29/2012	High load hit damage to south portal and the following two sway braces
8761A	SR-522 over West Main Street	12/1/2012	High load impact damage to Girder 2F
NQ	Sullivan Road over SR-290	2/20/2013	High load hit to Span 2
5523C	47th Avenue SW over I-5	4/3/2013	None
7818A	Stratford Road over SR-17	4/18/2013	None
3477A	Sen. George Sellar Bridge	4/28/2013	None
5668B	Chamber Way over I-5	5/9/2013	Hit on Girder 3F from northbound over height log truck
5783A	Schoessler Road over I-90	5/9/2013	Prepared damage report and alert for minor damage
5668A	13th Street over I-5	5/22/2013	Girder 3F was damaged
20 High Load Hits Reported by Others (Region Maintenance Usually) with Minor Damage, No WSDOT Bridge Preservation Office inspection performed in response to damage			

6470A	Roanoke Street over I-5	11/12/2009	High load spall over northbound lane 2 reported by third party
6470A	Roanoke Street over I-5	10/1/2009	High load spall with exposed rebar (less than 1 sq. ft.) in Span 3 on south bottom corner over northbound lane 1
JD	Puyallup Road	6/8/2011	Damage occurred on 6/3/2011
3523A	White River	8/25/2009	Damage photos filed
5679A	SR-506 over I-5	3/3/2010	High load damage to Girder 3E
8573H	SR-900 over I-90	3/31/2011	Filled out damage report for impact damage
1084A	Hoquiam River - Simpson	9/9/2011	No inspection by Bridge Preservation Office
12236G	I-182 over Argent Road	9/7/2011	Bridge damage reported
5582A	Bridgeport Way over I-5	10/18/2012	Damage reported by maintenance
8132G	I-5 over Smith Avenue	8/13/2012	Inspection of damage reported by NW Region
12555A	SR-18 over M Street	8/17/2012	High load collision to south bottom flange of Girder J over M Street
8227A	Scott Paper Road over SR-20	3/21/2012	Damage inspection done during routine inspection
5783A	Schoessler Road over I-90	5/1/2013	Prepared damage report and alert for minor damage
5453B	Pedestrian bridge over I-90	4/25/2012	Originally reported by the region as two high load hits, two photos provided show only one spall
5453B	Pedestrian bridge over I-90	6/28/2012	High load collision to west edge of Span 3 over eastbound I-90
3935A	Alaskan Way V Northbound	7/2/2012	Over height load became wedged below Span 15 on Blanchard Street
3935A	Alaskan Way V Northbound	11/5/2012	Damage report entered to document reported over height hit
1589A	SR-99 over North 38th Street	12/24/2012	High load collision to girders in Span 2
1589A	SR-99 over North 38th Street	12/24/2012	High load collision to girders in Span 2
17042A	Kollin Nielson Memorial Bridge	12/27/2012	Damage report for damage reported by others

15. Improvements made to the I-5 Bridge after the Accident

The WSDOT awarded a contract in August 2013 to upgrade the vertical clearance of the I-5 Bridge to 18 feet across all lanes in the remaining 3 thru truss spans (Spans 5, 6 and 7). The contract also included a proposal to retrofit several bridge supports with reinforced steel components to add strength to the bridge in the event it was struck again in the future. The work began on September 9, 2013 and the estimated completion date was late November 2013. **Figure 9** illustrates the vertical clearance upgrade to 18 feet across all lanes. The WSDOT project web page indicated the following:

> *"When crews finish raising and reinforcing the structure by November, the bridge will have an equal 18 foot vertical clearance across all lanes. Several bridge supports will also be retrofitted with reinforced steel components to add strength if the bridge is struck again."*

The WSDOT provided details on the proposal to retrofit several bridge supports with reinforced steel components in an email to NTSB investigators dated January 9, 2014:

> *"The reconstruction of the Skagit River Bridge included the rehabilitation of the remaining trusses to the current functionality standards. The project was to retrofit and reinforce the lateral force resisting system for the truss spans. The truss rehabilitation project consisted of adding portal frames to the existing inclined end posts, and raising the lower chord elements of all the existing sway frames to a minimum vertical clearance of 18.0' to the bridge deck."*

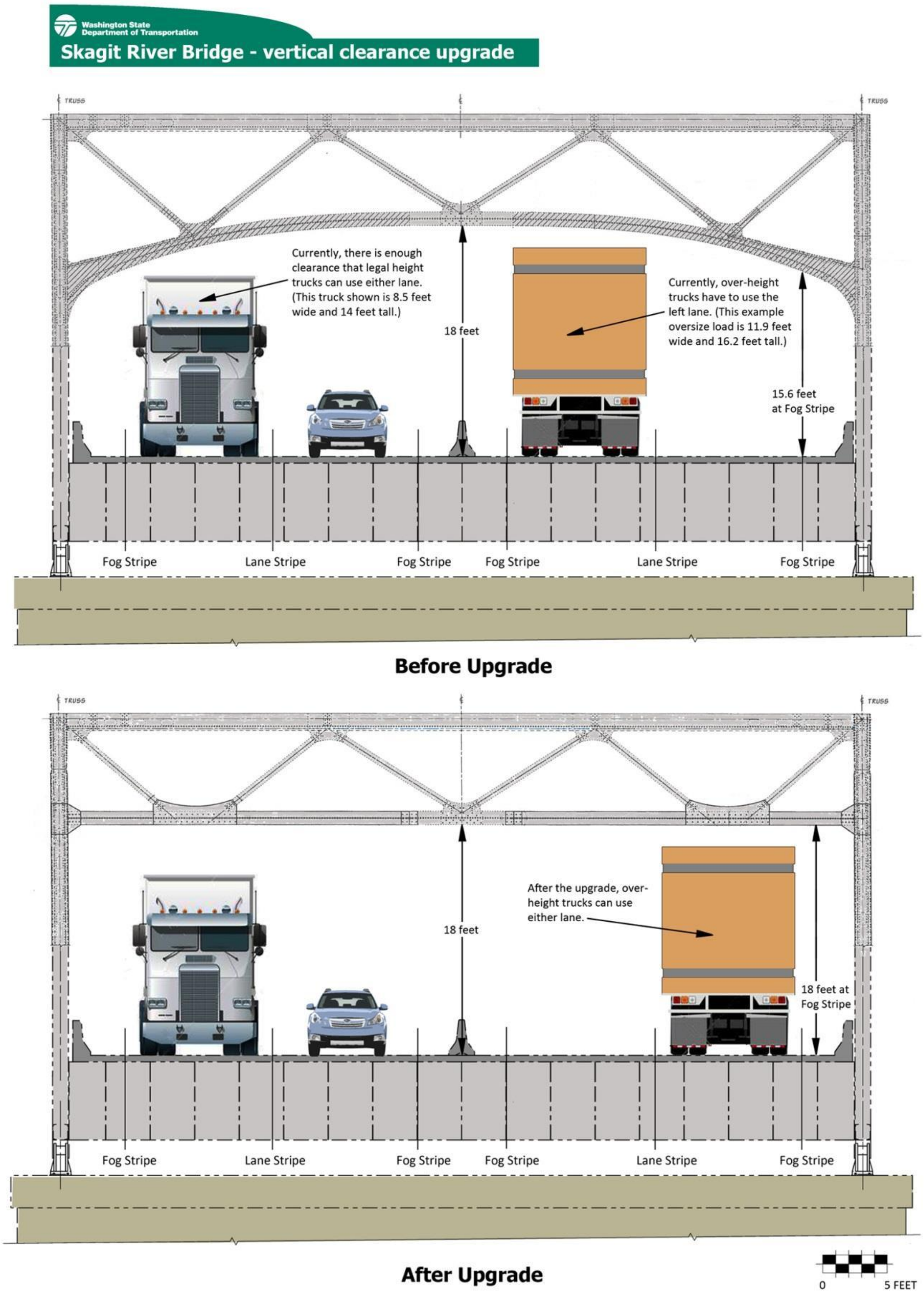

Figure 9 – I-5 Bridge vertical clearance upgrade to 18 feet across all lanes

16. Alexandria Avenue Bridge Overpass Accident; November 14, 2004; Alexandria, Virginia

The NTSB investigated an accident on November 14, 2004 in Alexandria, VA in which a motor coach bus traveling southbound in the right lane of the George Washington Memorial Parkway struck the Alexandria Avenue stone arched bridge overpass colliding with the underside and side of the overpass. Of the 27 student passengers on the motor coach, 10 received minor injuries and 1 sustained serious injuries. The bus driver and chaperone were uninjured. The bus's roof was destroyed.

Photograph 7 illustrates a new low clearance sign developed by the National Park Service after the accident. The new low clearance sign conveys a motor coach bus striking a stone arched bridge overpass in the right lane. The purpose of the sign would be for motor coach buses to stay in the left lane while traveling underneath the overpass. The National Park Service installed the new low clearance sign at four locations on the George Washington Memorial Parkway before the Alexandria Avenue Bridge; two locations before the bridge for southbound motorists and two locations before the bridge for northbound motorists.

Photograph 7 – New low clearance sign developed by the National Park Service as a result of the Alexandria Avenue Bridge Overpass accident on November 14, 2004 in Alexandria, VA

Prior to the accident, among the existing signs posted in the southbound lanes preceding the Alexandria Avenue Bridge were those indicating the vertical clearance of the bridge. MUTCD Low Clearance Signs (W12-2) were placed next to the southbound lanes before the bridge, and mounted MUTCD Low Clearance Signs (W12-2) were placed on the bridge's face over the left and right lanes. **Photographs 8 and 9** illustrate the MUTCD Low Clearance Signs (W12-2) that existed prior to the accident next to the southbound lanes before the bridge and placed on the bridge's face over the left and right lanes.

Photograph 8 – MUTCD low clearance signs (W12-2) that existed prior to the accident next to the southbound lanes before the Alexandria Avenue Bridge Overpass in Alexandria, VA

Photograph 9 – MUTCD low clearance signs (W12-2) that existed prior to the accident placed on the Alexandria Avenue Bridge Overpass face over the left and right lanes in Alexandria, VA

E. ACCIDENT DOCKET MATERIAL

The following attachments and photographs are included in the docket for this investigation:

LIST OF ATTACHMENTS

Highway Factors - Attachment 1, Layout of the I-5 Bridge over the Skagit River showing fracture critical members

Highway Factors - Attachment 2, Speed limit reduction from 70 mph to 60 mph in the vicinity of the I-5 Bridge over the Skagit River

Highway Factors - Attachment 3, 85^{th} percentile speed study in the vicinity of the I-5 Bridge over the Skagit River

Highway Factors - Attachment 4, Existing signage in the vicinity of the I-5 Bridge over the Skagit River

Highway Factors - Attachment 5, Traffic accident summary in the vicinity of the I-5 Bridge over the Skagit River

Highway Factors - Attachment 6, History of National Bridge Inventory (NBI) ratings on the I-5 Bridge over the Skagit River from 1983 to 2013

Highway Factors - Attachment 7, Washington State Department of Transportation (WSDOT) bridge damage report dated 11/29/2012 for the I-5 Bridge over the Skagit River

Highway Factors - Attachment 8, Washington State Department of Transportation (WSDOT) routine bridge and fracture critical member bridge inspection report dated 8/25/2012 for the I-5 Bridge over the Skagit River

Highway Factors - Attachment 9, Washington State Department of Transportation (WSDOT) visual fracture critical inspection report dated 8/25/2012 for the I-5 Bridge over the Skagit River

Highway Factors - Attachment 10, Washington State Department of Transportation (WSDOT) bridge damage report dated 3/17/2013 for the State Road 16 and the Olympic Drive Overpass

Highway Factors - Attachment 11, State of Washington Police Traffic Collision Report dated 3/17/2013 for the State Road 16 and the Olympic Drive Overpass

Highway Factors - Attachment 12, Washington State Department of Transportation (WSDOT) bridge damage report dated 1/4/2011 for the State Road 16 and the Olympic Drive Overpass

Highway Factors - Attachment 13, Cost of replacement to the girder that was damaged as a result of the high load bridge hit to the State Road 16 and the Olympic Drive Overpass on 1/4/2011

Highway Factors - Attachment 14, Bridge rating summary for the I-5 Bridge over the Skagit River

Highway Factors - Attachment 15, Washington State Department of Transportation (WSDOT) Low Clearance Signing Policy

Highway Factors - Attachment 16, Washington State Department of Transportation (WSDOT) "Bridge List" Website containing vertical clearances for the I-5 Bridge over the Skagit River

Highway Factors - Attachment 17, 2009 Manual on Uniform Traffic Control Devices (MUTCD) Low Clearance Sign Requirements

Highway Factors - Attachment 18, Washington State Department of Transportation (WSDOT) Special Motor Vehicle Oversize/Overweight Permit for Accident Vehicle

LIST OF PHOTOGRAPHS

Highway Factors Photo 12 - View of collapsed portion of I-5 Bridge in the Skagit River looking to the west

Highway Factors Photo 13 - View of collapsed portion of I-5 Bridge in the Skagit River looking to the east

Highway Factors Photo 14 - View of collapsed portion of I-5 Bridge and vehicles in the Skagit River looking to the northeast toward Pier 9

Highway Factors Photo 15 - View of collapsed portion of I-5 Bridge and vehicles in the Skagit River looking to the southeast toward Pier 8

Highway Factors Photo 16 - View of collapsed portion of I-5 Bridge and vehicles in the Skagit River looking to the southwest toward Pier 8

Highway Factors Photo 17 - View of damage to the U4 sway brace in Span 7 above the right lane in the southbound direction to the I-5 Bridge over the Skagit River as a result of the high load bridge hit on May 23, 2013

Highway Factors Photo 18 - View of bowing to the vertical member as a result of the high load bridge hit to the U4 sway brace in Span 7 above the right lane in the southbound direction to the I-5 Bridge over the Skagit River on May 23, 2013

Highway Factors Photo 19 - View of damage to the U5 and U6 sway braces in Span 7 above the right lane in the southbound direction to the I-5 Bridge over the Skagit River as a result of the high load bridge hit on May 23, 2013

Highway Factors Photo 20 - View of 2-foot and 2-inch wide paved right shoulder adjacent to the right lane in the southbound direction to the I-5 Bridge over the Skagit River

Highway Factors Photo 21 - View of 2-foot and 6-inch wide paved left shoulders adjacent to the left lanes on the I-5 Bridge over the Skagit River looking to the south

Highway Factors Photo 22 - View of barge and crane equipment used to remove the vehicles and the collapsed portion of the I-5 Bridge in the Skagit River looking to the southwest

Highway Factors Photo 23 - View of high load bridge hit to I-82 Naches River Bridge in August 2006

END OF REPORT

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