WIM System Field Calibration and Validation Summary Report

Virginia SPS-1
SHRP ID – 510100

Validation Date: October 18, 2011
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Table of Contents

List of Figures

List of Tables

1 Executive Summary

A WIM validation was performed on October 18, 2011 at the Virginia SPS-1 site located on route US-29 at milepost 12.8, 5.3 miles north of US 360.

This site was installed on November 04, 2006. The in-road sensors are installed in Portland concrete cement pavement in the southbound driving lane. The site is equipped with bending plate WIM sensors and IRD iSINC WIM controller. The LTPP lane is identified as lane 1 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on March 02, 2011 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

The equipment is in working order. Electronic and electrical checks of the WIM components determined that the the equipment is operating within the manufacturer's tolerances. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, there were no pavement distresses noted that may affect the accuracies of the WIM system. A visual observation of the trucks as they approach, traverse, and leave the sensor area indicated some bouncing in the LTPP lane as they cross the transition from asphalt to concrete pavement surfaces. The trucks appear to stop bouncing prior to the WIM scale sensors. Trucks appear to track down the center of the lane. Further pavement condition discussion is provided in Section 4.

Based on the criteria contained in the LTPP Field Operations Guide for SPS WIM Sites, Version 1.0 (05/09), this site is providing research quality loading data. The summary results of the validation are provided in Table 1-1 below.

Table 1-1 – Validation Results – 18-Oct-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.4 ± 4.6%	Pass
Tandem Axles	±15 percent	0.0 ± 2.9%	Pass
GVW	±10 percent	-0.3 ± 2.2%	Pass
Vehicle Length	±3.0 percent (1.6 ft)	0.2 ± 0.9 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.2 ± 0.1 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was 0.4 ± 1.2 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. However, since the site is measuring axle spacing length with a mean error of 0.2 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

The validation study demonstrated that the site is currently providing high-quality research-type traffic loading data. In addition, the average weight measurement errors are close to zero. For example, the average GVW measurement error was -0.7 percent for the primary truck and +0.1 percent and for the secondary truck. Consequently, considering the uncertainty that can be introduced by even marginal changes to the calibration factors, no calibration changes are recommended and none were made. Since no changes were made to any of the speed or distance compensation factors, a post-validation classification and speed study was not carried out.

This site is not providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 2.6% is greater than the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 4.9% from the 101 truck sample (Class 4 – 13) was due to cross-classification of Class 3, 4, 5, and 8 vehicles.

There were two test trucks used for the validation. They were configured and loaded as follows:

- The *Primary* truck was a Class 9 vehicle with air suspension on the tractor and trailer tandems, and standard (4 feet) tandem spacings. It was loaded with stone.

- The *Secondary* truck was a Class 9 vehicle with air suspension on the tractor tandem, air suspension on the trailer tandem, standard tandem spacing on the tractor and standard tandem on the trailer. The Secondary truck was loaded with stone.

Prior to the validation, the test trucks were weighed and measured, cold tire pressures were taken, and photographs of the trucks, loads and suspensions were obtained (see Section 7). Axle length (AL) was measured from the center hub of the first axle to the center hub of the last axle. Axle spacings were measured from the center hub of the each axle to the center hub of the subsequent axle. Overall length (OL) was measured from the edge of the front bumper to the edge of the rear bumper. The test trucks were re-weighed at the conclusion of the validation. The average validation test truck weights and measurements are provided in Table 1-2.

Table 1-2 – Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.6	10.8	14.6	14.6	17.9	17.9	15.0	4.3	27.9	4.1	51.3	56.3
2	66.1	11.0	13.7	13.7	13.8	13.8	15.0	4.3	23.1	4.1	46.5	51.5

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 45 to 66 mph, a range of 21 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The validation pavement surface temperatures varied from 55.0 to 92.5 degrees Fahrenheit, a range of 37.5 degrees Fahrenheit. The sunny weather conditions provided for the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 25 shows that there are 57 consecutive months of level "E" WIM data for this site. This site requires no additional years of data to meet the minimum of five years of research quality data.

2 WIM System Data Availability and Pre-Visit Data Analysis

To assess the quality of the current traffic data, a pre-visit analysis was conducted by comparing a two-week data sample from July 25, 2011 (Data) to the most recent Comparison Data Set (CDS) from February 28, 2011. The assessments performed prior to the site visits are used to develop reasonable expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 25 shows that there are 5 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2007 to 2011.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2007	332	12
2008	365	12
2009	363	12
2010	361	12
2011	226	9

As shown in the table, this site requires no additional years of data to meet the minimum of five years of research quality data. The data meets the 210-day minimum requirement for a calendar year, for years 2007 through 2011.

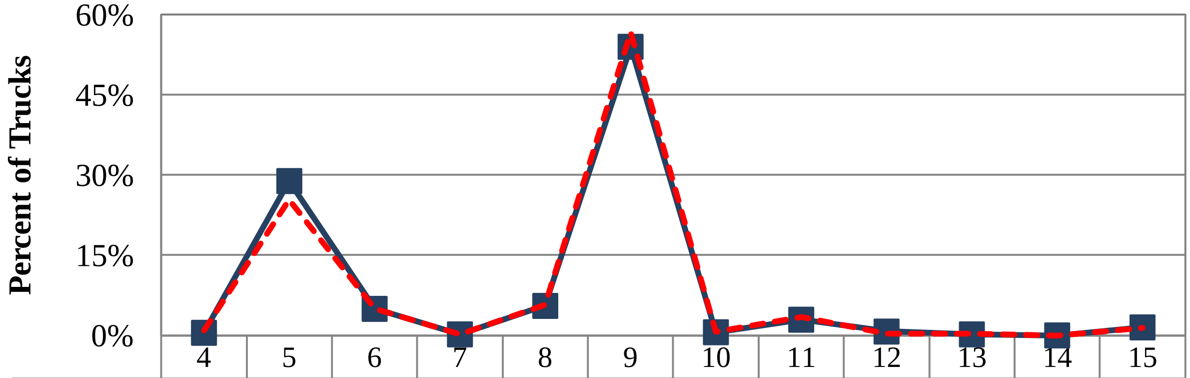
Table 2-2 provides a monthly breakdown of the available data for years 2007 through 2011.

Table 2-2 – LTPP Data Availability by Month

Year	Month												No. of Months
	1	2	3	4	5	6	7	8	9	10	11	12	
2007	27	28	30	15	19	30	31	31	29	31	30	31	12
2008	30	29	31	30	31	30	31	31	30	31	30	31	12
2009	31	28	31	30	31	28	31	31	30	31	30	31	12
2010	30	26	31	30	31	30	30	31	30	31	30	31	12
2011	30	28	31	30	31	25	17	30	4				9

2.2 Classification Data Analysis

The traffic data was analyzed to determine the expected truck distributions. This analysis provides a basis for the classification distribution study that was conducted on site. Figure 2-1 provides a comparison of the truck type distributions for the two datasets.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	0.5%	28.9%	5.0%	0.2%	5.5%	54.0%	0.6%	2.9%	0.7%	0.2%	0.0%	1.5%
CDS	1.0%	25.4%	5.0%	0.2%	5.7%	56.7%	0.6%	3.4%	0.4%	0.3%	0.0%	1.4%

Figure 2-1 – Comparison of Truck Distribution

Table 2-3 provides statistics for the truck distributions at the site for the two periods represented by the two datasets. The table shows that according to the most recent data, the most frequent truck types crossing the WIM scale are Class 9 (54.0%) and Class 5 (28.9%). Table 2-3 also provides data for vehicle Classes 14 and 15. Class 14 vehicles are vehicles that are reported by the WIM equipment as having irregular measurements and cannot be classified properly, such as negative speeds from vehicles passing in the opposite direction of a two-lane road. Class 15 vehicles are unclassified vehicles. The table indicates that 1.5 percent of the vehicles at this site are unclassified.

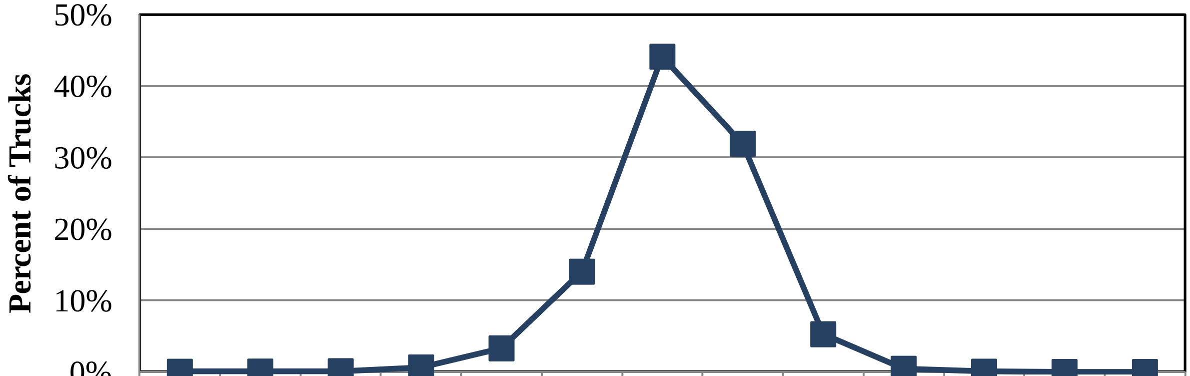
Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	2/28/2011		7/25/2011		
4	157	1.0%	65	0.5%	-0.5%
5	4188	25.4%	3849	28.9%	3.5%
6	828	5.0%	662	5.0%	-0.1%
7	31	0.2%	26	0.2%	0.0%
8	932	5.7%	736	5.5%	-0.1%
9	9348	56.7%	7197	54.0%	-2.7%
10	102	0.6%	79	0.6%	0.0%
11	562	3.4%	392	2.9%	-0.5%
12	58	0.4%	96	0.7%	0.4%
13	46	0.3%	26	0.2%	-0.1%
14	0	0.0%	0	0.0%	0.0%
15	237	1.4%	200	1.5%	0.1%

From the table it can be seen that the number of Class 9 vehicles has decreased by 2.7 percent from February 2011 to July 2011. Changes in the number of heavier trucks may be attributed to seasonal variations in truck distributions. During the same time period, the number of Class 5 trucks increased by 3.5 percent. These differences may be attributed to changes in the use of the roadway for local deliveries, cross-classifications of type 3 and 5 vehicles, as well as natural variations in truck volumes.

2.3 Speed Data Analysis

The traffic data received from the Phase II Contractor was analyzed to determine the expected truck speed distributions. This will provide a basis for determining the speed of the test trucks during validation testing. The CDS distribution of speeds is shown in Figure 2-2.



	35	40	45	50	55	60	65	70	75	80	85	90	95
Data	0.0%	0.1%	0.1%	0.6%	3.3%	14.0%	44.1%	31.9%	5.3%	0.4%	0.0%	0.0%	0.0%

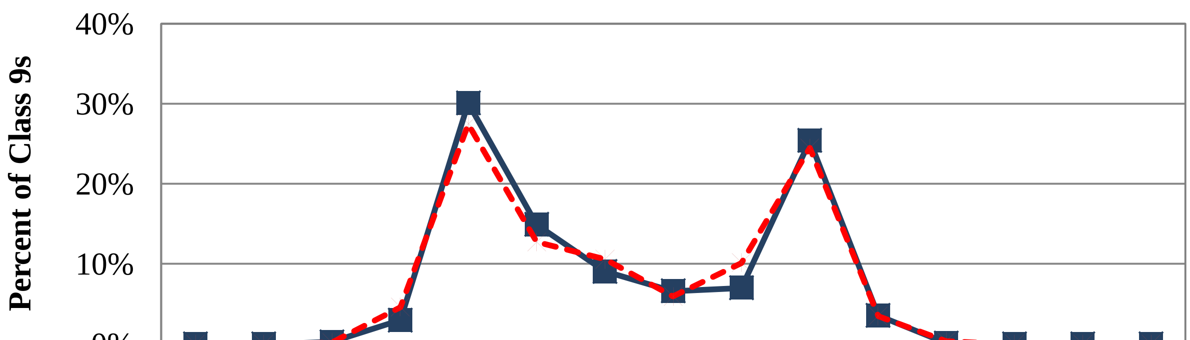
Figure 2-2 – Truck Speed Distribution – 12-Sep-11

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 60 and 70 mph. The posted speed limit at this site is 65 and the 85th percentile speed for trucks at this site is 68 mph. The range of truck speeds for the validation will be 45 to 65 mph.

2.4 GVW Data Analysis

The traffic CDS data received from the Regional Support Contractor was analyzed to determine the expected Class 9 GVW distributions. Figure 2-3 shows a comparison between GVW plots generated using a two-week W-card sample from July 2011 and the Comparison Data Set from February 2011.

As shown in Figure 2-3, there was a slight increase in the percentage of unloaded and loaded trucks between the February 2011 Comparison Data Set (CDS) and the July 2011 two-week sample W-card dataset (Data).



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.3%	3.0%	30.1	14.9	9.0%	6.6%	7.0%	25.4	3.6%	0.1%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.2%	4.6%	27.5	12.7	10.6	5.9%	10.1	24.5	3.5%	0.4%	0.0%	0.0%	0.0%

Figure 2-3 – Comparison of Class 9 GVW Distribution

Table 2-4 is provided to show the statistical comparison for Class 9 GVW between the Comparison Data Set and the current dataset.

Table 2-4 – Class 9 GVW Distribution from W-Card

GVW weight bins (kips)	CDS		Data		Change
	Date				
	2/28/2011		7/25/2011		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	17	0.2%	18	0.3%	0.1%
32	429	4.6%	212	3.0%	-1.7%
40	2552	27.5%	2156	30.1%	2.6%
48	1181	12.7%	1070	14.9%	2.2%
56	982	10.6%	648	9.0%	-1.5%
64	551	5.9%	475	6.6%	0.7%
72	942	10.1%	502	7.0%	-3.1%
80	2273	24.5%	1821	25.4%	0.9%
88	324	3.5%	255	3.6%	0.1%
96	34	0.4%	7	0.1%	-0.3%
104	0	0.0%	0	0.0%	0.0%
112	0	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	54.6 kips		54.2 kips		-0.4 kips

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range increased by 2.6 percent while the number of loaded class 9 trucks in the 72 to 80 kips range increased by 0.9 percent. During this time period the number of overweight trucks decreased by 0.2 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site decreased by 0.7 percent, from 54.6 kips to 54.2 kips kips.

2.5 Class 9 Front Axle Weight Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average front axle weight. This will provide a basis for the evaluation of the quality of the data by comparing the average front axle weight from the current data sample set with the expected average front axle weight average from the Data Comparison Set.

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from July 2011 and the Comparison Data Set from February 2011.

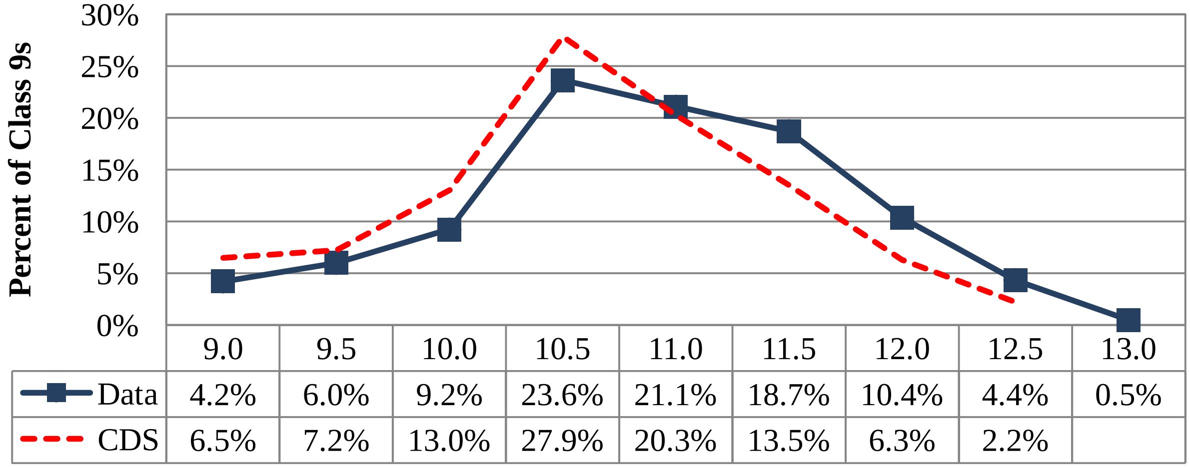


Figure 2-4 – Distribution of Class 9 Front Axle Weights

It can be seen in the figure that the greatest percentage of trucks have front axle weights measuring between 10.5 and 11.0 kips. The percentage of trucks in this range has increased between the February 2011 Comparison Data Set (CDS) and the July 2011 dataset (Data). The plot indicates a drift of heavy axles to the right by approximately 250 pounds.

Table 2-5 provides the Class 9 front axle weight distribution data for the February 2011 Comparison Data Set (CDS) and the July 2011 dataset (Data).

Table 2-5 – Class 9 Front Axle Weight Distribution from W-Card

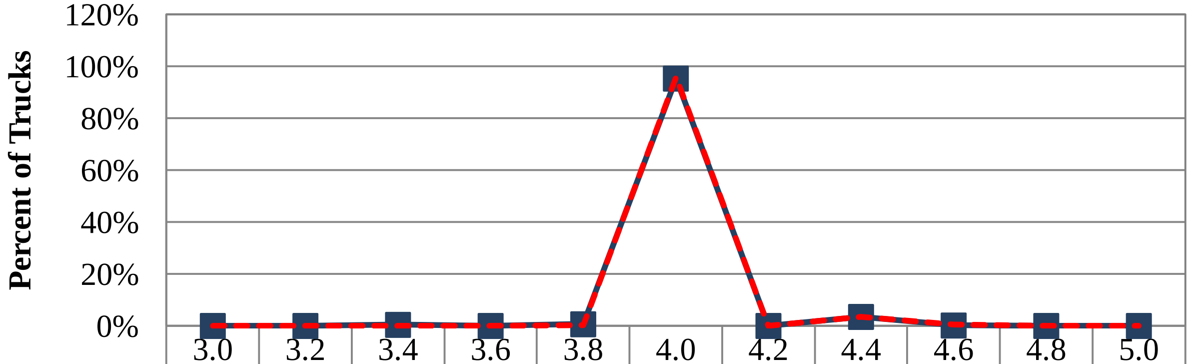
F/A weight bins (kips)	CDS		Data		Change
	Date				
	2/28/2011		7/25/2011		
9.0	252	2.7%	133	1.9%	-0.9%
9.5	600	6.5%	302	4.2%	-2.3%
10.0	670	7.2%	430	6.0%	-1.2%
10.5	1206	13.0%	660	9.2%	-3.8%
11.0	2582	27.9%	1689	23.6%	-4.2%
11.5	1876	20.3%	1508	21.1%	0.8%
12.0	1254	13.5%	1339	18.7%	5.2%
12.5	585	6.3%	741	10.4%	4.1%
13.0	208	2.2%	311	4.4%	2.1%
13.5	31	0.3%	35	0.5%	0.2%
Average =	10.9 kips		11.1 kips		0.2 kips

The table shows that the average front axle weight for Class 9 trucks has increased by 0.2 kips, or 1.8 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 11.1 kips. The percentages of light axles decreased by approximately 2.5% and the percentages of heavy axles increased by approximately 2.5%, indicating possible positive bias (overestimation of loads) in front axle measurement.

2.6 Class 9 Tractor Tandem Spacing Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average tractor tandem spacing. This will provide a basis for the evaluation of the accuracy of the equipment distance and speed measurements by comparing the observed average tractor tandem spacing from the sample data (Data) with the expected average tractor tandem spacing from the comparison data set (CDS).

The class 9 tractor tandem spacing plot in Figure 2-5 is provided to indicate possible shifts in WIM system distance and speed measurement accuracies.



	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
Data	0.0%	0.0%	0.4%	0.0%	0.6%	95.3%	0.0%	3.5%	0.2%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	0.0%	0.3%	95.8%	0.0%	3.4%	0.4%	0.0%	0.0%

Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacings for the February 2011 Comparison Data Set and the July 2011 Data are nearly identical.

Table 2-6 shows the Class 9 axle spacings between the second and third axles.

Table 2-6 – Class 9 Axle 2 to 3 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	2/28/2011		7/25/2011		
3.0	0	0.0%	0	0.0%	0.0%
3.2	0	0.0%	0	0.0%	0.0%
3.4	5	0.1%	30	0.4%	0.4%
3.6	0	0.0%	0	0.0%	0.0%
3.8	32	0.3%	46	0.6%	0.3%
4.0	8895	95.8%	6827	95.3%	-0.5%
4.2	0	0.0%	0	0.0%	0.0%
4.4	313	3.4%	249	3.5%	0.1%
4.6	40	0.4%	12	0.2%	-0.3%
4.8	0	0.0%	0	0.0%	0.0%
5.0	0	0.0%	0	0.0%	0.0%
Average =	4.0 feet		4.0 feet		0.0 feet

From the table it can be seen that the drive tandem spacing of Class 9 trucks at this site is between 3.8 and 4.6 feet. Based on the average Class 9 drive tandem spacing values from the per vehicle records, the average tractor tandem spacing is 4.0 feet, which is identical to the expected average of 4.0 feet from the CDS per vehicle records. Further axle spacing analyses are performed during the validation and validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (February 2011) based on the last calibration with the most recent two-week WIM data sample from the site (July 2011). Comparison of vehicle class distribution data indicates a 2.7 percent decrease in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 0.2 kips and average Class 9 GVW has decreased by 0.7 percent for the July 2011 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical the expected average of 4.0 feet.

The differences between the two data sets are minor and can be attributed to seasonal variation (February 2011 versus July 2011) and natural variation in traffic flows.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on March 02, 2011 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

3.1 Description

This site was installed on November 04, 2006 by International Road Dynamics. It is instrumented with bending plate weighing sensors and an IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

3.2 Physical Inspection

Prior to the validation test truck runs, a physical inspection of all WIM equipment and support services equipment was conducted. No deficiencies were noted. Photographs of all system components were taken and are presented after Section 7.

3.3 Electronic and Electrical Testing

Electronic and electrical checks of all system components were conducted prior to the validation test truck runs. Dynamic and static electronic checks of the in-road sensors were performed. All values for the WIM sensors and inductive loops were within tolerances. Electronic tests of the power and communication devices indicated that they were operating normally. The negative terminal on the battery has excessive corrosion built up.

3.4 Equipment Troubleshooting and Diagnostics

The WIM system appeared to collect, analyze and report vehicle measurements normally. No troubleshooting actions were taken.

3.5 Recommended Equipment Maintenance

No unscheduled equipment maintenance actions are recommended.

4 Pavement Discussion

4.1 Pavement Condition Survey

During a visual distress survey of the pavement conducted from the shoulder, no areas of pavement distress that may affect the accuracy of the WIM sensors were noted.

4.2 Profile and Vehicle Interaction

Profile data was collected on July 13, 2011 by the North Atlantic Regional Support Contractor using a high-speed profiler, where the operator measures the pavement profile over the entire one-thousand foot long WIM Section, beginning 900 feet prior to WIM scales and ending 100 feet after the WIM scales. Each pass collects International Roughness Index (IRI) values in both the left and right wheel paths. For this site, 11 profile passes were made, 5 in the center of the travel lane and 6 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000 foot WIM section and the 400 approach section is 384 in/mi and is located approximately 328 feet prior to the WIM scale. This area of the pavement was closely investigated during the validation visit, and truck dynamics in this area were closely observed. The visual observation of the trucks as they approach, traverse and leave the sensor area did not indicate any visible motion of the trucks that would affect the performance of the WIM scales. Trucks appear to track down the center of the lane.

4.3 LTPP Pavement Profile Data Analysis

The IRI data files are processed using the WIM Smoothness Index software. The indices produced by the software provide an indication of whether or not the pavement roughness may affect the operation of the WIM equipment. The recommended thresholds for WIM Site pavement smoothness are provided in Table 4-1.

Table 4-1 – Recommended WIM Smoothness Index Thresholds

Index	Lower Threshold (m/km)	Upper Threshold (m/km)
Long Range Index (LRI)	0.50	2.1
Short Range Index (SRI)	0.50	2.1
Peak LRI	0.50	2.1
Peak SRI	0.75	2.9

When all values are less than the lower threshold shown in Table 4-1, it is unlikely that pavement conditions will significantly influence sensor output. Values between the threshold values may or may not influence the accuracy of the sensor output, and values above the upper threshold would lead to sensor output that may preclude achieving the research quality loading data.

The profile analysis was based on four different indices: Long Range Index (LRI), which represents the pavement roughness starting 25.8 m prior to the scale and ending 3.2 m after the scale in the direction of travel; Short Range Index (SRI), which represents the pavement roughness beginning 2.74 m prior to the WIM scale and ending 0.46 m after the scale; Peak LRI – the highest value of LRI within 30 m prior to the scale; and Peak SRI – the highest value of SRI between 2.45 m prior to the scale and 1.5 m after the scale. The results from the analysis for each of the indices for the right wheel path (RWP) and left wheel path (LWP) values for the 3 left, 3 right and 5 center profiler runs are presented in Table 4-2.

Table 4-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass 5**	**Avg**
Left	LWP	LRI (m/km)	0.909	0.869	0.964			0.914
		SRI (m/km)	0.714	0.691	0.722			0.709
		Peak LRI (m/km)	0.914	0.882	0.968			0.921
		Peak SRI (m/km)	0.966	0.854	1.042			0.954
	RWP	LRI (m/km)	0.949	1.066	1.084			1.033
		SRI (m/km)	0.951	0.930	0.940			0.940
		Peak LRI (m/km)	0.949	1.066	1.084			1.033
		Peak SRI (m/km)	1.429	1.136	1.376			1.314
Center	LWP	LRI (m/km)	1.295	1.101	1.205	0.738	0.681	1.085
		SRI (m/km)	1.704	0.790	1.049	1.254	0.861	1.199
		Peak LRI (m/km)	1.413	1.332	1.425	0.771	0.814	1.235
		Peak SRI (m/km)	**1.753**	**0.924**	**1.249**	**1.351**	**1.005**	**1.319**
	RWP	LRI (m/km)	0.856	0.914	0.843	1.030	0.780	0.911
		SRI (m/km)	0.639	0.634	0.525	0.996	0.510	0.699
		Peak LRI (m/km)	0.856	0.914	0.843	1.033	0.880	0.912
		Peak SRI (m/km)	0.991	0.939	0.942	1.268	0.990	1.035
Right	LWP	LRI (m/km)	1.026	0.963	0.746			0.912
		SRI (m/km)	1.132	0.945	0.749			0.942
		Peak LRI (m/km)	1.026	0.963	0.819			0.936
		Peak SRI (m/km)	1.330	1.011	0.829			1.057
	RWP	LRI (m/km)	0.791	0.642	0.626			0.686
		SRI (m/km)	1.018	0.902	0.851			0.924
		Peak LRI (m/km)	0.796	0.648	0.628			0.691
		Peak SRI (m/km)	1.094	0.944	0.914			0.984

From Table 4-2 it can be seen that all of the indices computed from the profiles are between the upper and lower threshold values. The highest values, on average, are the Peak SRI values in the left wheel path of the center passes (shown in bold).

4.4 Recommended Pavement Remediation

It is recommended that the transverse crack located at the transition from asphalt to concrete pavement 328 feet prior to the WIM scales be sealed and repaired as required to provide for a smoother transition between the pavements, and to prevent further deterioration of the pavement.

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5 Statistical Reliability of the WIM Equipment

5.1 Validation

The 40 validation test truck runs were conducted on October 18, 2011, beginning at approximately 8:46 AM and continuing until 1:52 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with stone, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.

- A Class 9, 5-axle truck, loaded with stone, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

The test trucks were weighed prior to the validation and re-weighed at the conclusion of the validation. The average test truck weights and measurements are provided in Table 5-1.

Table 5-1 - Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.6	10.8	14.6	14.6	17.9	17.9	15.0	4.3	27.9	4.1	51.3	56.3
2	66.1	11.0	13.7	13.7	13.8	13.8	15.0	4.3	23.1	4.1	46.5	51.5

Test truck speeds varied by 21 mph, from 45 to 66 mph. The measured validation pavement temperatures varied 37.5 degrees Fahrenheit, from 55.0 to 92.5. The sunny weather conditions provided for attaining the desired minimum 30 degree temperature range. Table 5-2 is a summary of post validation results.

Table 5-2 – Validation Overall Results – 18-Oct-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.4 ± 4.6%	Pass
Tandem Axles	±15 percent	0.0 ± 2.9%	Pass
GVW	±10 percent	-0.3 ± 2.2%	Pass
Vehicle Length	±3.0 percent (1.6 ft)	0.2 ± 0.9 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.2 ± 0.1 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement for all speeds was 0.4 ± 1.2 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of

0.2, and the speed and axle spacing length measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 65 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3.

Table 5-3 – Validation Results by Speed – 18-Oct-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		45.0 to 51.0 mph	51.1 to 59.1 mph	59.2 to 66.0 mph
Steering Axles	±20 percent	-2.3 ± 5.6%	-0.6 ± 4.9%	-1.3 ± 4.2%
Tandem Axles	±15 percent	-0.6 ± 2.5%	0.5 ± 2.6%	0.0 ± 3.3%
GVW	±10 percent	-0.9 ± 1.9%	0.2 ± 2.0%	-0.3 ± 2.5%
Vehicle Length	±3.0 percent (1.6 ft)	0.2 ± 1.0 ft	0.2 ± 0.9 ft	0.2 ± 0.9 ft
Vehicle Speed	± 1.0 mph	0.6 ± 1.1 mph	0.4 ± 1.4 mph	0.3 ± 1.3 mph
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.1 ft	0.2 ± 0.1 ft	0.2 ± 0.1 ft

From the table, it can be seen that the WIM equipment estimates all weights with reasonable accuracy and the range of errors is consistent at all speeds. There does not appear to be a relationship between weight estimates and speed at this site.

To aid in the speed analysis, several graphs were developed to illustrate the possible effects of speed on GVW, single axle, and axle group weights, and axle and overall length distance measurements, as discussed in the following paragraphs.

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment estimated GVW with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range.

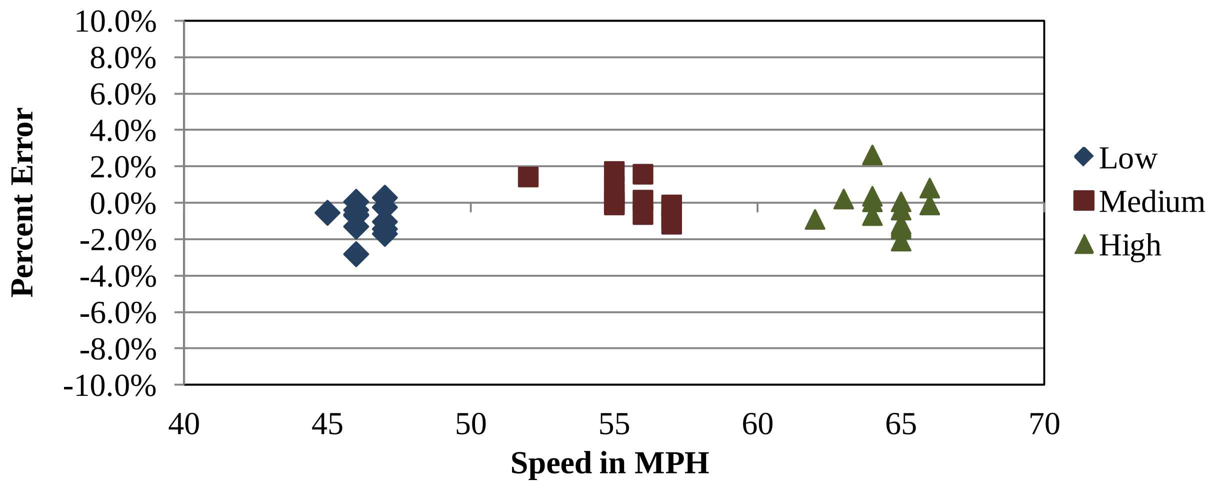

Figure 5-1 – Validation GVW Errors by Speed – 18-Oct-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment estimated steering axle weights with reasonable accuracy at all speeds. The range in error is similar throughout the entire speed range. There does not appear to be a correlation between speed and weight estimates at this site.

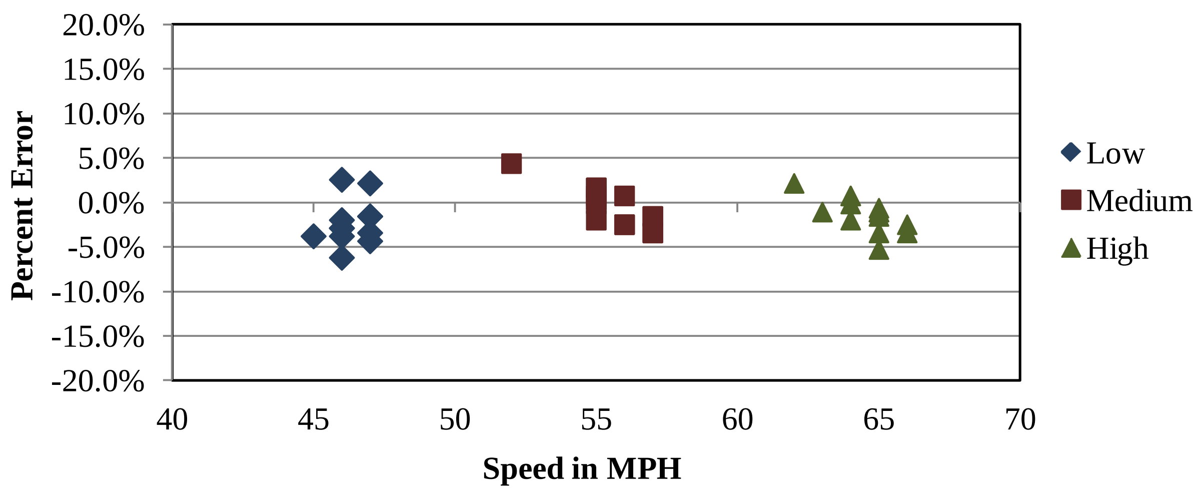

Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 18-Oct-11

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment estimated tandem axle weights with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range.

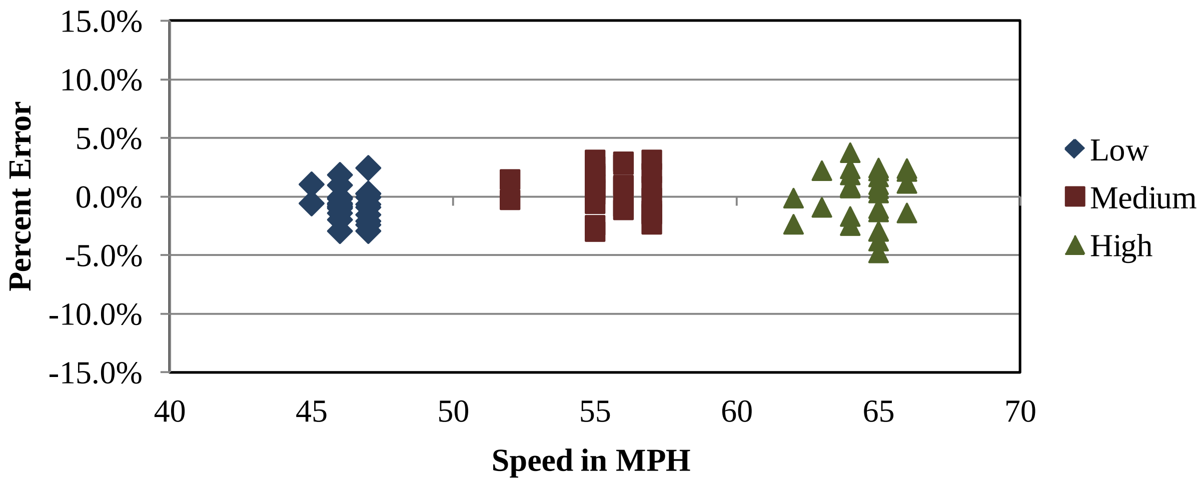

Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 18-Oct-11

5.1.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-4 that when the GVW errors are analyzed by truck type, the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck.

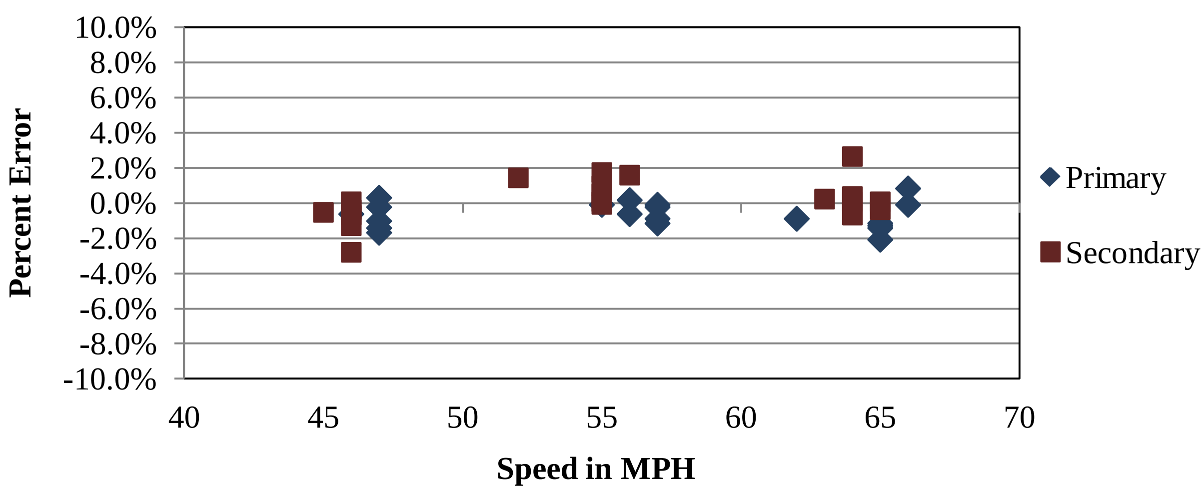

Figure 5-4 – Validation GVW Error by Truck and Speed – 18-Oct-11

5.1.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error was from 0.1 feet to 0.2 feet. Distribution of errors is shown graphically in Figure 5-5.

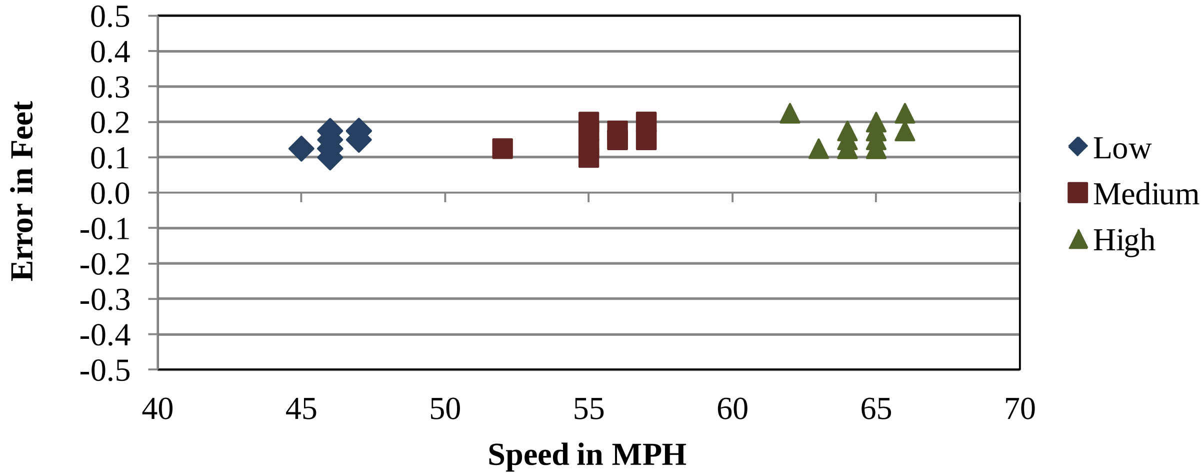

Figure 5-5 – Validation Axle Length Error by Speed – 18-Oct-11

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment measures overall length consistently over the entire range of speeds, with errors ranging from -0.5 to 0.7 feet. Distribution of errors is shown graphically in Figure 5-6.

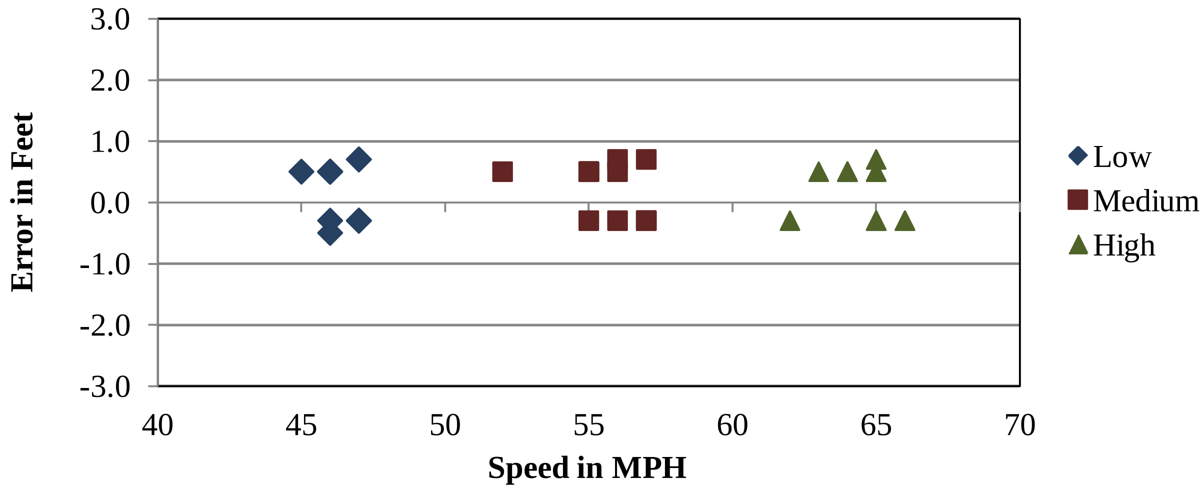

Figure 5-6 – Validation Overall Length Error by Speed – 18-Oct-11

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures was 37.5 degrees, from 55.0 to 92.5 degrees

Fahrenheit. The validation test runs are reported under three temperature groups – low, medium and high, as shown in Table 5-4 below.

Table 5-4 – Validation Results by Temperature – 18-Oct-11

Parameter	**95% Confidence Limit of Error**	**Low 55.0 to 67.5 degF**	**Medium 67.6 to 80.1 degF**	**High 80.2 to 92.5 degF**
Steering Axles	±20 percent	-0.6 ± 5.1%	-1.4 ± 7.1%	-1.8 ± 3.8%
Tandem Axles	±15 percent	-0.6 ± 2.8%	-0.3 ± 3.3%	0.5 ± 2.8%
GVW	±10 percent	-0.7 ± 1.8%	-0.5 ± 3.0%	0.1 ± 2.0%
Vehicle Length	±3.0 percent (1.6 ft)	0.3 ± 1.0 ft	0.2 ± 1.1 ft	0.2 ± 0.9 ft
Vehicle Speed	± 1.0 mph	0.4 ± 1.2 mph	0.7 ± 1.1 mph	0.3 ± 1.4 mph
Axle Length	± 0.5 ft [150mm]	0.2 ± 0.1 ft	0.2 ± 0.1 ft	0.1 ± 0.1 ft

To aid in the analysis, several graphs were developed to illustrate the possible effects of temperature on GVW, single axle weights, and axle group weights.

5.1.2.1 GVW Errors by Temperature

From Figure 5-7, it can be seen that the equipment appears to estimate GVW with acceptable accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and weight estimates at this site.

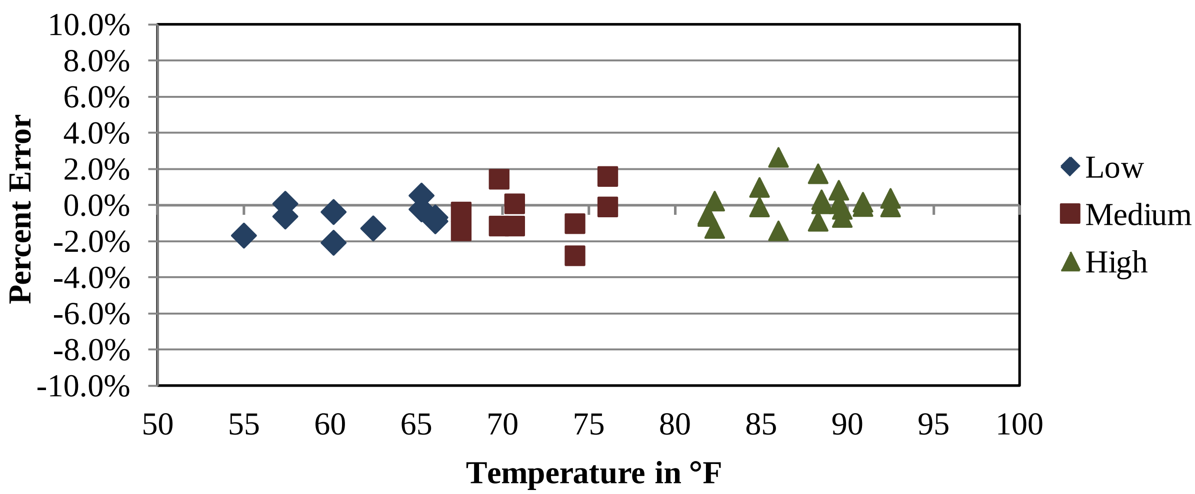

Figure 5-7 – Validation GVW Errors by Temperature – 18-Oct-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 demonstrates that for steering axles, the WIM equipment appears to estimate weights with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and steering axle weight estimates at this site. The range in error is similar for different temperature groups.

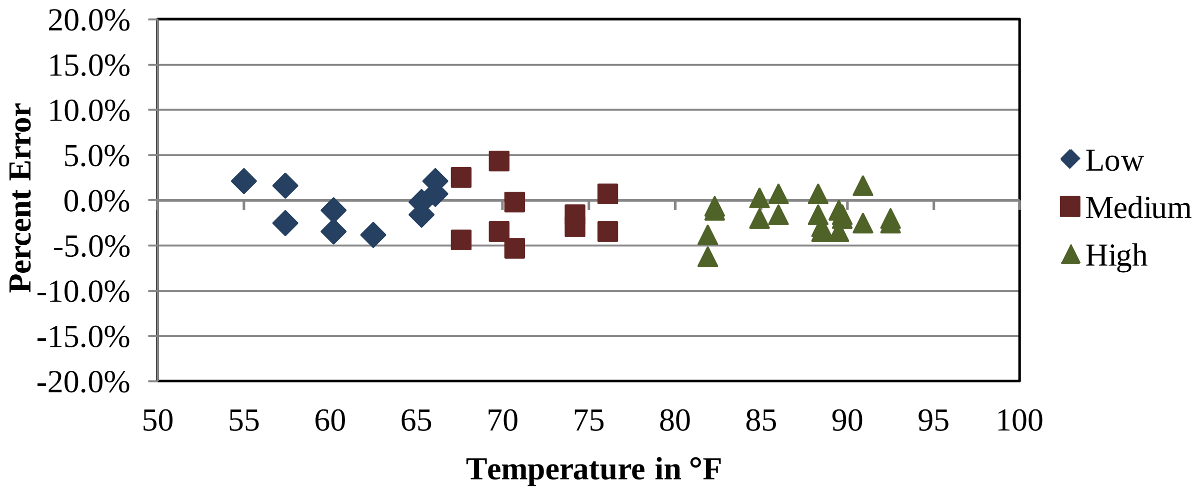

Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 18-Oct-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-10, the WIM equipment appears to estimate tandem axle weights with acceptable accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and tandem axle weight estimates at this site. The range in tandem axle errors is consistent for the three temperature groups.

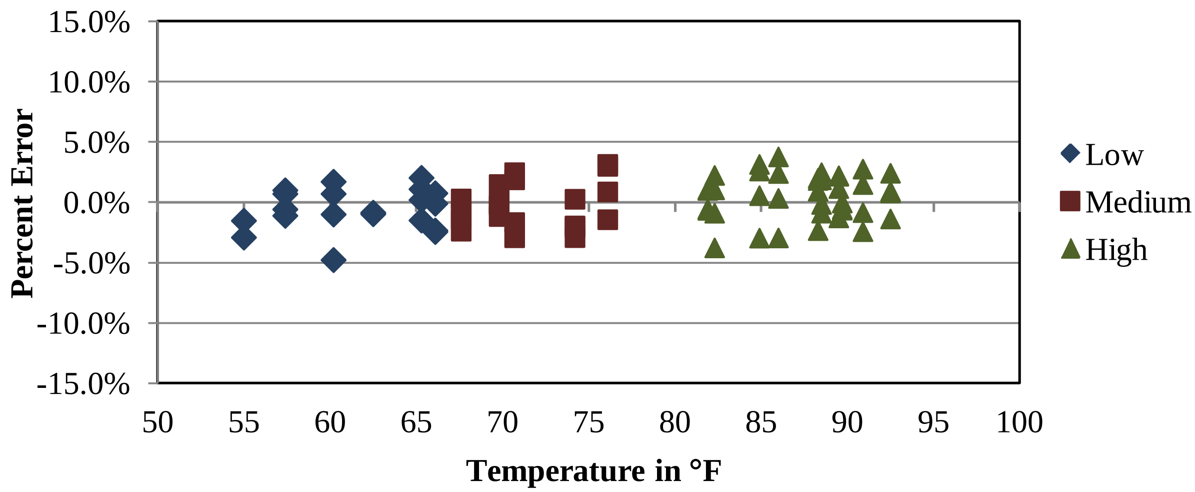

Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 18-Oct-11

5.1.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-11, when analyzed by truck type, GVW measurement errors for both trucks are similar at all temperatures. For both trucks, the range of errors and bias are reasonably consistent over the range of temperatures.

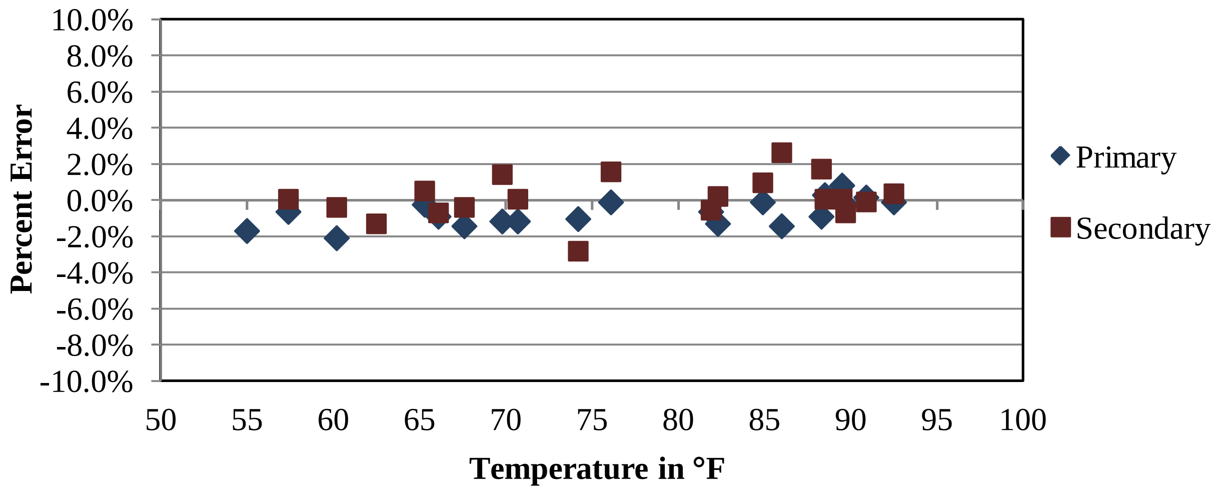

Figure 5-10 – Validation GVW Error by Truck and Temperature – 18-Oct-11

5.1.3 GVW and Steering Axle Trends

Figure 5-12 is provided to illustrate the predicted GVW error with respect to the validation errors by speed.

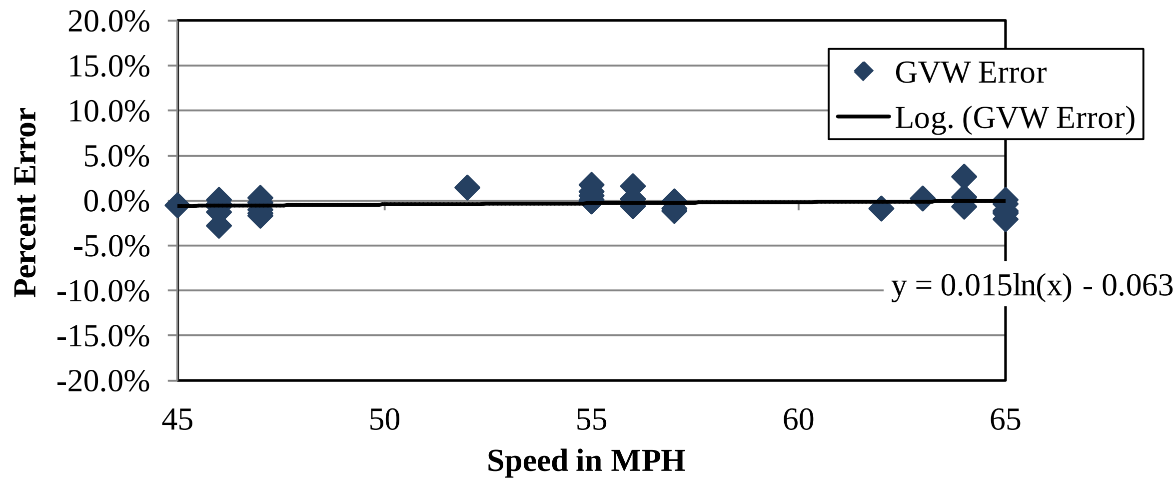

Figure 5-11 - GVW Error Trend by Speed

Figure 5-13 is provided to illustrate the predicted Steering Axle error with respect to the validation errors by speed.

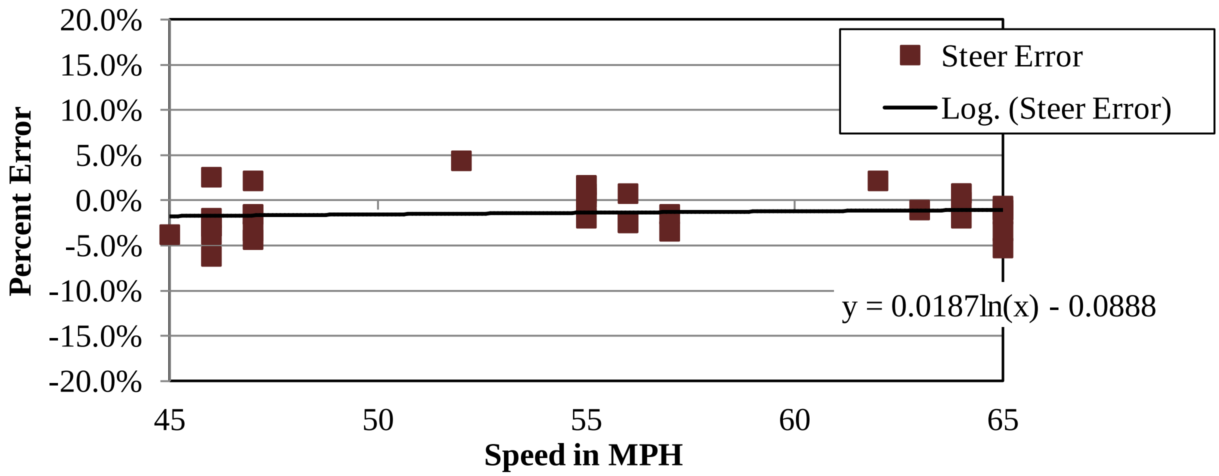

Figure 5-12 - Steering Axle Trend by Speed

The validation study demonstrated that the site is currently providing high-quality research-type traffic loading data. In addition, the average weight measurement errors are close to zero. For example, the average GVW measurement error was -0.7 percent for the primary truck and +0.1 percent and for the secondary truck. Consequently, considering the uncertainty that can be introduced by even marginal changes to the calibration factors, no calibration changes are recommended and none were made. Since no changes were made to any of the speed or distance compensation factors, a post-validation classification and speed study was not carried out.

5.1.4 Multivariable Analysis

This section provides additional analysis of validation results using a multivariable statistical technique of multiple linear regression. The same calibration data analyzed and discussed previously are analyzed again, but this time using a more sophisticated statistical methodology. The objective of the additional analysis is to investigate if the trends identified using previous analyses are statistically significant, and to quantify these trends.

Multivariable analyses provide additional insight on how speed, temperature, and truck type affect weight measurement errors for a specific site. It is expected that multivariable analyses done systematically for many sites will reveal overall trends.

5.1.4.1 Data

All errors from the weight measurement data collected by the equipment during the validation were analyzed. The percent error is defined as percentage difference between the weight measured by the WIM system and the static weight. Compared to analysis described previously, the weight of "axle group" was evaluated separately for tandem axles on tractors and on trailers.

The separate evaluation was carried out because the tandem axles on trailers may have different dynamic response to loads than tandem axles on tractors.

The measurement errors were statistically attributed to the following variables or factors:

- Truck type. Primary truck and secondary truck.
- Truck test speed. Truck test speed ranged from 45 to 66 mph.
- Pavement temperature. Pavement temperature ranged from 55.0 to 92.5 degrees Fahrenheit.
- Interaction between the factors such as the interaction between speed and pavement temperature.

5.1.4.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 5-5. The value of regression coefficients defines the slope of the relationship between the % error in GVW and the predictor variables (speed, temperature, and truck type). The values of the t-distribution (for the regression coefficients) given in Table 5-5 are for the null hypothesis that assumes that the coefficients are equal to zero. Only the effects of temperature and truck type were found to be statistically significant. For example, the probability that the effect of truck type on the observed GVW errors occurred by chance alone was less than 1 percent (p=0.0054).

Table 5-5 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-4.6310	1.4336	-3.2300	0.0026
Speed	0.0261	0.0196	1.3320	0.1912
Temp	0.0319	0.0125	2.5535	0.0151
Truck	0.8555	0.2889	2.9607	0.0054

The relationship between temperature and measurement errors is shown in Figure 5-14. Besides the visual assessment of the relationship, Figure 5-14 provides quantification and statistical assessment of the relationship.

The quantification is provided by the value of the regression coefficient, in this case 0.0319 (in Table 5-5). This means, for example, that for a 20 degree increase in temperature, the % error is increased by 0.638 % (0.0319 x 20). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

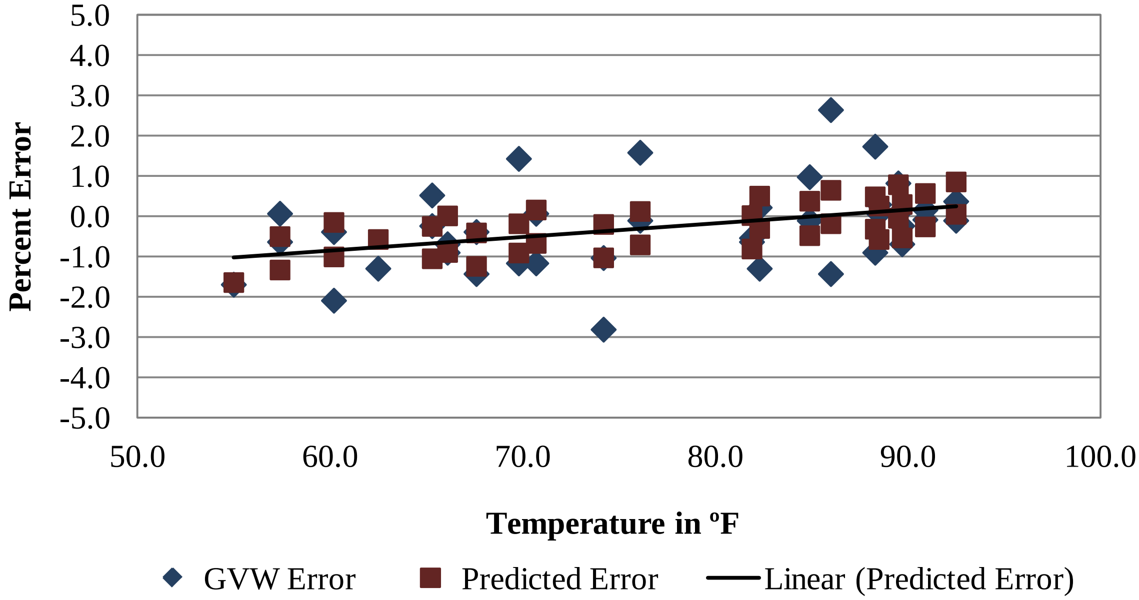

Figure 5-13 – Influence of Temperature on the Measurement Error of GVW

The effect of speed on GVW was not statistically significant. The probability that the regression coefficient for speed (0.0261 in Table 5-5) is not different from zero was 0.1912. In other words, there is about 19 percent chance that the value of the regression coefficient is due to the chance alone.

The interaction between speed, temperature, and truck type was investigated by adding an interactive variable (or variables) such as the product of speed and temperature. No interactive variables were statistically significant. The intercept was not statistically significant and does not have practical meaning.

5.1.4.3 Summary Results

Table 5-6 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. Entries in the table are provided only if the probability value was smaller than 0.20. The dash in Table 5-6 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-6 – Summary of Regression Analysis

	Factor					
	Speed		Temperature		Truck type	
Weight, % error	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	-	-	0.0319	0.015	0.856	0.0054
Steering axle	-	-	0.040	0.190	1.792	0.012
Tandem axle tractor	0.074	0.0037	0.043	0.007	-	
Tandem axle trailer	-	-	0.0521	0.0238	1.356	0.0022

5.1.4.4 Conclusions

1. Speed had had statistically significant effect on measurement errors of tandem axles on tractors.

2. Temperature had statistically significant effect on measurement errors GVW and tandem axle errors.

3. Truck type had statistically significant effect on measurement errors of GVW, steering axle, and tandem axles on trailers. The regression coefficient for truck type in Table 5-6, represent the difference between the mean errors for the primary and secondary trucks. (Truck type is an indicator variable with values of 0 or 1.). For example, the mean error in GVW for the secondary truck was about 0.86 % larger than the error for the primary truck.

4. Even though the speed, temperature and truck type had statistically significant effect on some of the measurement errors, the practical significance of these factors is small and does not affect the validity of the calibration.

5.1.5 Classification and Speed Evaluation

The validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the validation classification study at this site, a manual sample of 122 vehicles including 101 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field.

Table 5-7 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study. Misclassified vehicles are defined as those vehicles that are manually classified by observation as one type of vehicle but identified by the WIM equipment as another type of vehicle. As shown in Table 5-8, three Class 3 vehicles were identified as Class 5s, one Class 5 vehicle was identified as a Class 3, one Class 9 was identified as a Class 8, and one Class 10 was identified as a Class 13. The combined results presented an over count of two Class 5s, one Class 8, one Class 13 and an undercount of two Class 3s, one Class 9 and one Class 10, as shown in Table 5-7. There were no vehicles reported as unclassified by the equipment.

Table 5-7 – Validation Classification Study Results – 18-Oct-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	21	0	23	4	0	3	64	1	4	2	0
WIM Count	19	0	25	4	0	4	63	0	4	2	1
Observed Percent	17.2	0.0	18.9	3.3	0.0	2.5	52.5	0.8	3.3	1.6	0.0
WIM Percent	15.6	0.0	20.5	3.3	0.0	3.3	51.6	0.0	3.3	1.6	0.8
Misclassified Count	3	0	1	0	0	0	1	1	0	0	0
Misclassified Percent	14.3	0.0	4.3	0.0	0.0	0.0	1.6	100.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-8.

Table 5-8 – Validation Misclassifications by Pair – 18-Oct-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	3	6/4	0	9/5	0
4/5	0	6/7	0	9/8	1
4/6	0	6/8	0	9/10	0
5/3	1	6/9	0	10/9	0
5/4	0	6/10	0	10/13	1
5/6	0	7/6	0	11/12	0
5/7	0	8/3	0	12/11	0
5/8	0	8/5	0	13/10	0
5/9	0	8/9	0	13/11	0

As shown in the table, a total of 6 vehicles, including 2 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the validation study, the misclassification percentage is 2.6% (2 of 78) for heavy trucks (6 – 13), which is greater than the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 4.9%.

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-9.

Table 5-9 – Validation Unclassified Trucks by Pair – 18-Oct-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	7/15	0	11/15	0
4/15	0	8/15	0	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15	0		

Based on the manually collected sample of the 101 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was 1.3 mph; the range of errors was 1.6 mph.

6 Previous WIM Site Validation Information

The information reported in this section provides a summary of the performance of the WIM equipment since it was installed or since the first validation was performed on the equipment. The information includes historical data on weight and classification accuracies as well as a comparison of validation results.

6.1 Sheet 16s

This site has validation information from four previous visits as well as the current one as summarized in the tables below and provided on the Traffic Sheet 16. Table 6-1 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 6-1 – Classification Validation History

Date	Misclassification Percentage by Class										Pct Unclass
	4	5	6	7	8	9	10	11	12	13	
30-Jan-07	N/A	0	0	N/A	0	0	N/A	0	N/A	N/A	0
24-Jul-07	N/A	0	0	N/A	0	0	0	0	0	N/A	0
25-Jul-07	N/A	0	0	N/A	0	0	0	0	0	N/A	0
2-Dec-08	N/A	0	0	N/A	0	0	N/A	0	N/A	N/A	0
4-Dec-08	100	0	9	N/A	0	0	N/A	N/A	N/A	0	0
1-Mar-11	100	5	17	0	0	0	0	0	0	0	1
2-Mar-11	100	18	0	0	0	0	0	0	0	0	1
18-Oct-11	14.3	0	4.3	0	0	0	1.6	100	0	0	0

Table 6-2 data was extracted from the previous validation and was updated to include the results of this validation. The table provides the mean error and standard deviation for GVW, single axles and tandems for prior pre- and validations as reported on the LTPP Traffic Sheet 16s.

Table 6-2 – Weight Validation History

Date	Mean Error and SD		
	GVW	Single Axles	Tandem
30-Jan-07	0.7 ± 2.7	-2.6 ± 3.2	1.3 ± 3.5
1-Feb-07	-0.8 ± 2.7	-4.7 ± 2.6	-0.1 ± 3.6
24-Jul-07	-0.4 ± 3.1	-0.5 ± 4.2	0.4 ± 5.5
25-Jul-07	0.1 ± 3.0	-2.7 ± 5.1	0.9 ± 4.5
2-Dec-08	4.2 ± 1.3	0.8 ± 2.3	5.1 ± 2.9
4-Dec-08	1.0 ± 1.6	1.5 ± 2.5	1.2 ± 2.9
1-Mar-11	3.1 ± 1.7	1.8 ± 3.8	3.5 ± 2.2
2-Mar-11	-0.7 ± 1.8	-2.0 ± 2.6	-0.4 ± 2.5
18-Oct-11	-0.3 ± 1.1	-1.4 ± 2.3	0.0 ± 1.4

The variability of the weight errors appears to have remained reasonably consistent since the site was first validated. The table also demonstrates the effectiveness of the validations in keeping the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

A comparison of the validation results from previous visits is provided in Table 6-3. The table provides the historical performance of the WIM system with regard to the 95% confidence interval tolerances.

Table 6-3 – Comparison of Validation Results

Parameter	95 %Confidence Limit of Error	Site Values (Mean Error and 95% Confidence Interval)				
		1-Feb-07	25-Jul-07	4-Dec-08	2-Mar-11	18-Oct-11
Steering Axles	±20 percent	-4.7 ± 5.4	-2.7 ± 10.3	1.5 ± 5.0	-2.0 ± 5.2	-1.4 ± 4.6
Tandem Axles	±15 percent	-0.1 ± 7.2	0.9 ± 9.0	1.2 ± 5.8	-0.4 ± 5.1	0.0 ± 2.9
GVW	±10 percent	-0.8 ± 5.5	0.1 ± 6.1	1.0 ± 3.2	-0.7 ± 3.7	-0.3 ± 2.2

From Table 6-3, it appears that the mean error and the 95% confidence interval have remained reasonably consistent for all weights since the equipment was installed, with the exception of the July 25, 2007 validation, where some of the 95% confidence intervals were increased.

The final factors left in place at the conclusion of the validation are provided in Table 6-4.

Table 6-4 – Final Factors

Speed Points	**Left**	**Right**
	1	**2**
72	3331	3331
88	3309	3309
104	3314	3314
120	3314	3314
136	3314	3314
Axle Distance (cm)	371	
Dynamic Comp (%)	104	
Loop Width (cm)	185	

A review of the LTPP Standard Release Database 25 shows that there are 5 years of level "E" WIM data for this site. This site requires no additional years of data to meet the minimum of five years of research quality data.

7 Additional Information

The following information is provided in the attached appendix:

- Site Photographs
  - Equipment
  - Test Trucks
  - Pavement Condition
- Validation Sheet 16 – Site Calibration Summary
- Validation Sheet 20 – Classification and Speed Study

Additional information is available upon request through LTPP INFO at ltppinfo@dot.gov, or telephone (202) 493-3035. This information includes:

- Sheet 17 – WIM Site Inventory
- Sheet 18 – WIM Site Coordination
- Sheet 19 – Validation Test Truck Data
- Sheet 21 – WIM System Truck Records
- Sheet 22 – Site Equipment Assessment plus Addendum
- Sheet 24A/B/C – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

Virginia, SPS-1
SHRP ID: 510100

Validation Date: October 18, 2011

APPLIED RESEARCH ASSOCIATES, INC.

Photo 1 – Cabinet Exterior

Photo 4 – Leading Loop

Photo 2 – Cabinet Interior (Front)

Photo 5 – Leading WIM Sensor

Photo 3 – Cabinet Interior (Back)

Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Power Service Box

Photo 9 – Telephone Service Box

Photo 10 – Downstream

Photo 11 – Upstream

Photo 12 – Truck 1

Photo 13 – Truck 1 Tractor

Photo 14 – Truck 1 Trailer and Load

Photo 15 – Truck 1 Suspension 1

Photo 16 – Truck 1 Suspension 2

Photo 17 – Truck 1 Suspension 3

Photo 18 – Truck 1 Suspension 4

Photo 19 – Truck 1 Suspension 5

Photo 20 – Truck 2

Photo 21 – Truck 2 Tractor

Photo 22 – Truck 2 Trailer and Load

Photo 23 – Truck 2 Suspension 1

Photo 24 – Truck 2 Suspension 2

Photo 25 – Truck 2 Suspension 3

Photo 26 – Truck 2 Suspension 4

Photo 27 – Truck 2 Suspension 5

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 51 SPS WIM ID: 510100 DATE (mm/dd/yyyy) 10/18/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 10/18/11

2. **TYPE OF EQUIPMENT CALIBRATED:** Both

3. **REASON FOR CALIBRATION:** LTPP Validation

4. **SENSORS INSTALLED IN LTPP LANE AT THIS SITE** (Select all that apply):
   a. Inductance Loops   c.
   b. Bending Plates   d.

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. **CALIBRATION TECHNIQUE USED:** Test Trucks

Number of Trucks Compared:
Number of Test Trucks Used: 2
Passes Per Truck: 20

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	air	air
Truck 3:			

7. **SUMMARY CALIBRATION RESULTS** (expressed as a %):

Mean Difference Between -

Dynamic and Static GVW:	-0.3%	Standard Deviation:	1.1%
Dynamic and Static Single Axle:	-1.4%	Standard Deviation:	2.3%
Dynamic and Static Double Axles:	0.0%	Standard Deviation:	1.4%

8. **NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED:** 3

9. **DEFINE SPEED RANGES IN MPH:**

			Low		High	Runs
a.	Low	-		to		12
b.	Medium	-		to		14
c.	High	-		to		14
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 51 SPS WIM ID: 510100 DATE (mm/dd/yyyy) 10/18/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3314 | 3314

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	-2.0	FHWA Class	5	-	9.0
FHWA Class 8:	33.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort: **Dean Wolf**

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 20	STATE CODE:	51
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	510100
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	10/18/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
57	9	31576	57	9	64	9	31691	62	9
67	9	31578	64	9	59	9	31692	55	9
64	**13**	**31579**	**63**	**10**	64	9	31693	62	9
60	9	31580	59	9	65	9	31699	63	9
65	5	31582	64	5	68	9	31701	67	9
62	9	31588	59	9	61	5	31705	61	5
63	11	31589	61	11	64	9	31708	63	9
65	5	31612	65	5	68	5	31720	67	5
68	5	31617	67	5	55	9	31728	49	9
64	11	31618	62	11	55	9	31733	54	9
64	9	31620	63	9	56	9	31734	54	9
62	9	31621	60	9	65	9	31763	66	9
61	5	31622	60	5	68	9	31778	67	9
72	9	31623	71	9	60	9	31780	59	9
62	**8**	**31624**	**60**	**9**	61	9	31781	62	9
61	9	31626	60	9	61	9	31783	61	9
59	9	31629	58	9	64	9	31785	63	9
69	9	31646	67	9	55	9	31786	54	9
57	6	31650	54	6	62	9	31815	61	9
54	5	31651	53	5	60	5	31819	58	5
51	5	31652	50	5	64	5	31824	62	5
48	5	31654	44	5	**57**	**3**	**31833**	**59**	**5**
45	5	31655	44	5	59	5	31834	58	5
55	5	31657	54	5	59	5	31848	59	5
60	5	31659	59	5	67	9	31849	65	9

Sheet 1 - 0 to 50 Start: 10:09:00 Stop: 11:05:00

Recorded By: djw Verified By: anr

Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE: 51
LTPP MONITORED TRAFFIC DATA	SPS WIM ID: 510100
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy) 10/18/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	9	31855	63	9	66	11	31970	63	11
65	9	31860	64	9	63	5	31973	64	5
59	12	31865	55	12	60	9	31976	61	9
57	9	31867	53	9	59	9	31979	59	9
62	5	31893	63	5	63	6	31982	64	6
59	5	31904	54	5	66	9	31983	66	9
55	6	31905	52	6	68	9	31986	67	9
63	9	31912	60	9	67	9	31988	67	9
65	9	31918	63	9	59	9	31995	58	9
64	9	31925	63	9	**64**	**5**	**31997**	**67**	**3**
59	6	31931	59	6	66	9	32009	64	9
61	9	31934	61	9	68	5	32010	67	5
67	9	31935	65	9	63	9	32014	61	9
60	9	31945	55	9	65	8	32025	62	8
60	5	31948	60	5	65	9	32031	63	9
60	9	31950	60	9	64	9	32036	63	9
60	9	31954	55	9	60	9	32037	56	9
68	9	31956	68	9	59	12	32039	56	12
65	9	31958	65	9	67	9	32063	67	9
65	9	31960	65	9	67	9	32069	67	9
65	9	31962	65	9	64	5	32073	64	5
60	9	31963	59	9	65	9	32074	63	9
57	9	31965	55	9	59	9	32078	59	9
64	9	31968	64	9	59	9	32083	59	9
62	11	31969	61	11	62	8	32085	63	8

Sheet 2 - 51 to 100 Start: 11:06:00 Stop: 11:57:00

Recorded By: djw Verified By: anr

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 51 SPS WIM ID: 510100 DATE (mm/dd/yyyy) 10/18/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
68	3	32115	69	3					
65	3	32118	63	3					
63	3	32121	63	3					
64	**5**	**32123**	**63**	**3**					
61	3	32124	58	3					
62	3	32128	56	3					
68	3	32131	67	3					
56	8	32135	52	8					
60	9	32136	55	9					
62	3	32179	62	3					
59	**5**	**32191**	**59**	**3**					
68	3	32199	68	3					
60	3	32275	60	3					
63	3	32278	63	3					
61	3	32279	60	3					
67	3	32342	66	3					
45	3	32369	43	3					
52	3	32370	50	3					
71	3	32385	69	3					
68	3	32393	65	3					
58	3	32397	55	3					
60	3	32409	61	3					

Sheet 3 - 101 - 150 Start: 12:03:00 Stop: 1:08:00

Recorded By: djw Verified By: anr