WIM System Field Calibration and Validation Summary Report

New Mexico SPS-1
SHRP ID – 350100

Validation Date: August 2, 2012
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1 Executive Summary

A WIM validation was performed August 1 through 3, 2012 at the New Mexico SPS-1 site located on route I-25, milepost 36.1, 0.5 miles west of Rincon Road interchange.

This site was installed on April 30, 2008. The in-road sensors are installed in the northbound, righthand driving lane. The site is equipped with quartz WIM sensors and an 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 January 12, 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. None of the in-road sensors show signs of damage or excessive wear and appear to be fully secured in the pavement. 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 truck bouncing at a location approximatley 400 feet prior to the WIM scales. The bouncing appears to dimish prior to the trucks passing over the WIM scales and so does not appear to affect the accuracy of the WIM system. The 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 – Post-Validation Results – 2-Aug-12

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	0.5 ± 6.8%	Pass
Tandem Axles	±15 percent	-1.2 ± 8.6%	Pass
GVW	±10 percent	-0.9 ± 6.2%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	0.3 ± 1.2 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.2 ± 0.2 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 0.0 ± 0.6 mph, which is within the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. 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.

This site is providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 0.0% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 7.5% from the 106 vehicle sample (Class 4 – 13) was due to the 8 cross-classifications of Class 3, 4, 5, and 8 vehicles.

There were two test trucks used for the post-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 concrete blocks.

- The Secondary truck was a Class 9 vehicle with air suspension on the tractor tandem, steel spring suspension on the trailer tandem, standard tandem spacings on the tractor and the trailer. The Secondary truck was loaded with rock.

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 post-validation test truck weights and measurements are provided in Table 1-2.

Table 1-2 – Post-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	79.1	12.9	16.3	16.3	16.8	16.8	17.5	4.4	36.9	4.1	62.9	73.0
2	69.3	11.7	14.7	14.7	14.1	14.1	18.8	4.4	29.3	4.1	56.6	61.0

The posted speed limit at the site is 75 mph. During the testing, the speed of the test trucks ranged from to 48 to 68 mph, a variance of 20 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 83.1 to 139.2 degrees Fahrenheit, a range of 56.1 degrees Fahrenheit. The sunny weather conditions provided the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 25 shows that there are 3 years of level “E” WIM data for this site. This site requires 2 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 10, 2012 (Data) to the most recent Comparison Data Set (CDS) from January 13, 2011. The assessments performed prior to the site visits are used to develop expected traffic flow characteristics 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 3 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2008 to 2011.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2008	206	7
2009	361	12
2010	281	10
2011	261	9

As shown in the table, this site requires 2 years of data to meet the minimum of five years of research quality data. The data from 2008 does not meet the 210-day minimum requirement for each calendar year.

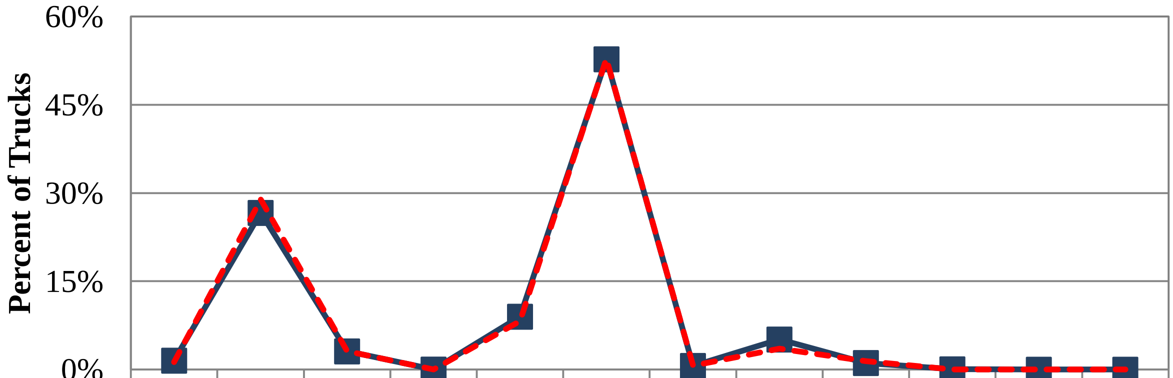
Table 2-2 provides a monthly breakdown of the available data for years 2008 through 2011.

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	
2008						29	31	24	30	31	30	31	7
2009	27	28	31	30	31	30	31	31	30	31	30	31	12
2010	31		31	30	23		13	31	30	31	30	31	10
2011	31	28	31	30	31	30	31	31	18				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 between the sample dataset from July 10, 2012 (Data) and the most recent comparison Data Set (CDS) from January 13, 2011.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	1.5%	26.6%	3.1%	0.0%	9.0%	52.7%	0.6%	5.1%	1.1%	0.1%	0.0%	0.0%
CDS	1.3%	28.9%	3.1%	0.0%	8.2%	52.8%	0.6%	3.5%	1.4%	0.0%	0.0%	0.0%

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 two most frequent truck types crossing the WIM scale are Class 9 (52.7%) and Class 5 (26.6%) vehicles.

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 0.0 percent of the vehicles at this site are unclassified.

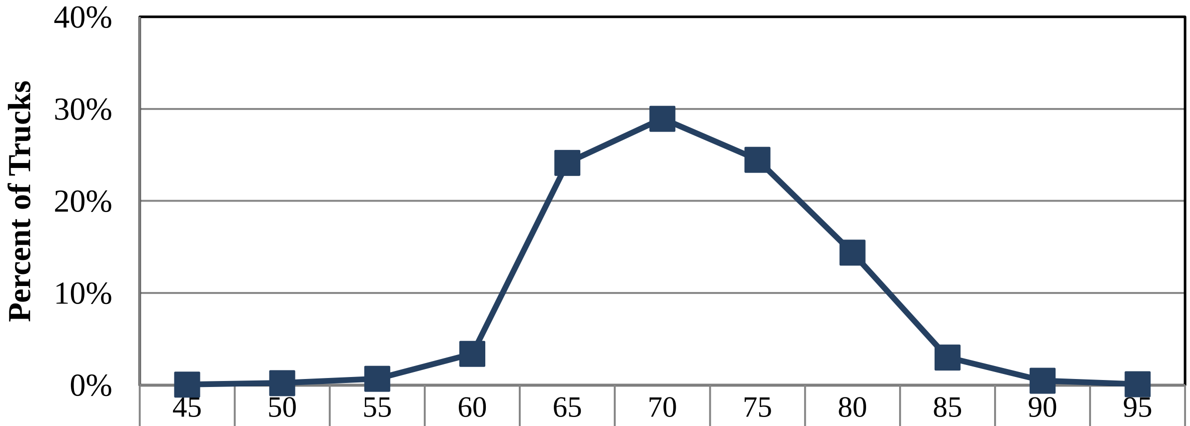
Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	1/13/2011		7/10/2012		
4	116	1.3%	146	1.5%	0.3%
5	2625	28.9%	2536	26.6%	-2.3%
6	282	3.1%	296	3.1%	0.0%
7	0	0.0%	2	0.0%	0.0%
8	748	8.2%	857	9.0%	0.8%
9	4794	52.8%	5021	52.7%	-0.1%
10	59	0.6%	61	0.6%	0.0%
11	321	3.5%	488	5.1%	1.6%
12	130	1.4%	108	1.1%	-0.3%
13	4	0.0%	6	0.1%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	0	0.0%	0	0.0%	0.0%

From the table it can be seen that the percentage of Class 9 vehicles has decreased by 0.1 percent from January 2011 and July 2012. Changes in the percentage of heavier trucks may be attributed to natural and seasonal variations in truck distributions and an increase in goods movement during current economic cycle. During the same time period, the percentage of Class 5 trucks decreased by 2.3 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.



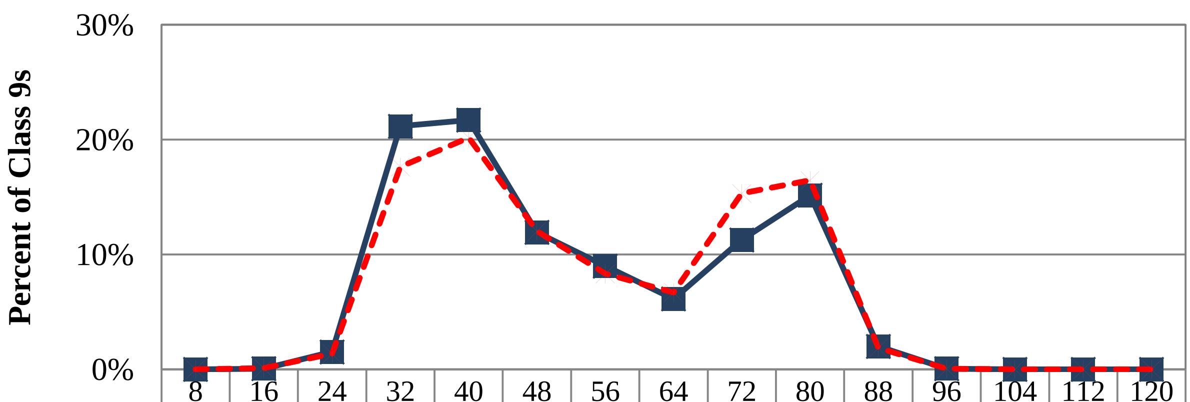
	45	50	55	60	65	70	75	80	85	90	95
Data	0.1%	0.2%	0.7%	3.4%	24.1%	28.9%	24.5%	14.4%	3.0%	0.5%	0.1%

Figure 2-2 – Truck Speed Distribution – 10-Jul-12

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 65 and 75 mph. The posted speed limit at this site is 75 and the 85th percentile speed for trucks at this site is 76 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 2012 and the Comparison Data Set from January 2011.



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.1%	1.5%	21.2	21.7	11.9	9.0%	6.1%	11.3	15.2	2.0%	0.1%	0.0%	0.0%	0.0%
CDS	0.0%	0.1%	1.4%	17.6	20.2	12.0	8.3%	6.7%	15.3	16.5	1.9%	0.0%	0.0%	0.0%	0.0%

Figure 2-3 – Comparison of Class 9 GVW Distribution

As shown in Figure 2-3, there is an upward shift for the unloaded peak and a downward shift for the loaded peak between the January 2011 Comparison Data Set (CDS) and the July 2012 two-week sample W-card dataset (Data). The results indicate that there may have been a small change in the type of commodity being transported by trucks traveling over the WIM system or a minor change in pavement or sensor condition.

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

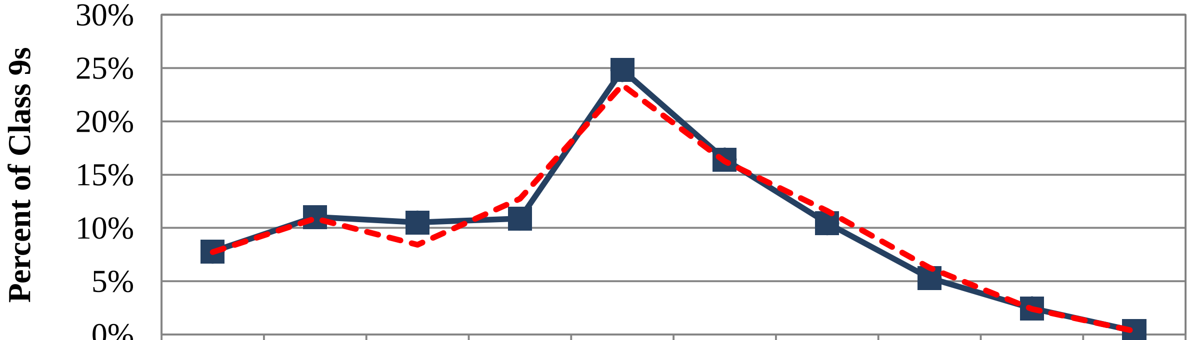
GVW weight bins (kips)	CDS		Data		Change
	Date				
	1/13/2011		7/10/2012		
8	0	0.0%	0	0.0%	0.0%
16	5	0.1%	3	0.1%	0.0%
24	64	1.4%	75	1.5%	0.1%
32	827	17.6%	1048	21.2%	3.5%
40	946	20.2%	1075	21.7%	1.5%
48	564	12.0%	591	11.9%	-0.1%
56	390	8.3%	445	9.0%	0.7%
64	314	6.7%	304	6.1%	-0.6%
72	719	15.3%	558	11.3%	-4.1%
80	772	16.5%	751	15.2%	-1.3%
88	87	1.9%	99	2.0%	0.1%
96	2	0.0%	3	0.1%	0.0%
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 =	50.6 kips		48.6 kips		-2.0 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range increased by 1.5 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 1.3 percent. During this time period the percentage of overweight trucks increased 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 4.1 percent, from 50.6 to 48.6 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 2012 and the Comparison Data Set from January 2011. The percentage of light axles (9.5 to 10.5 kips) increased by approximately 0.3 percent and the percentage of heavy axles (11.5 to 12.5 kips) decreased by approximately 2.2%, indicating possible minor negative bias (underestimation of loads) in front axle measurement.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5
Data	7.8%	11.0%	10.5%	10.9%	24.8%	16.4%	10.5%	5.3%	2.5%	0.3%
CDS	7.7%	10.9%	8.4%	12.7%	23.4%	16.3%	11.6%	6.3%	2.4%	0.3%

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 11.5 kips. The percentage of trucks in this range has decreased by 0.2 percent between the January 2011 Comparison Data Set (CDS) and the July 2012 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the January 2011 Comparison Data Set (CDS) and the July 2012 dataset (Data).

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

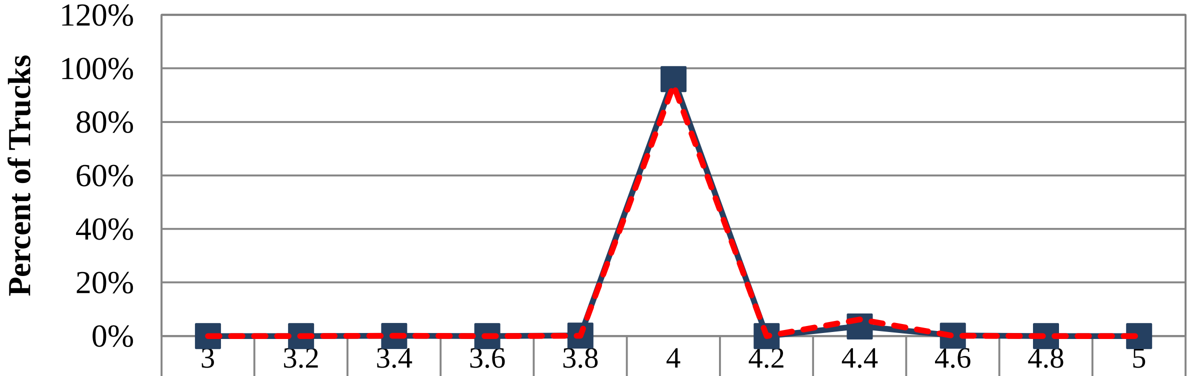
F/A weight bins (kips)	CDS		Data		Change
	Date				
	1/13/2011		7/10/2012		
9.0	361	7.7%	384	7.8%	0.1%
9.5	509	10.9%	544	11.0%	0.1%
10.0	394	8.4%	519	10.5%	2.1%
10.5	595	12.7%	537	10.9%	-1.8%
11.0	1094	23.4%	1225	24.8%	1.4%
11.5	760	16.3%	811	16.4%	0.2%
12.0	543	11.6%	516	10.5%	-1.2%
12.5	293	6.3%	262	5.3%	-1.0%
13.0	112	2.4%	122	2.5%	0.1%
13.5	15	0.3%	16	0.3%	0.0%
Average =	10.6 kips		10.6 kips		0.0 kips

The table shows that the average front axle weight for Class 9 trucks has remained the same between the January 2011 Comparison Data Set (CDS) and the July 2012 dataset (Data). According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 10.6 kips.

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	3.2	3.4	3.6	3.8	4	4.2	4.4	4.6	4.8	5
Data	0.0%	0.0%	0.0%	0.0%	0.2%	96.0%	0.0%	3.6%	0.1%	0.0%	0.0%
CDS	0.0%	0.0%	0.0%	0.0%	0.0%	93.7%	0.0%	6.1%	0.1%	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 January 2011 Comparison Data Set and the July 2012 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				
	1/13/2011		7/10/2012		
3.0	0	0.0%	0	0.0%	0.0%
3.2	0	0.0%	0	0.0%	0.0%
3.4	1	0.0%	2	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	2	0.0%	9	0.2%	0.1%
4.0	4395	93.7%	4756	96.0%	2.3%
4.2	0	0.0%	0	0.0%	0.0%
4.4	287	6.1%	178	3.6%	-2.5%
4.6	5	0.1%	7	0.1%	0.0%
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, which is identical to to the expected average of 4.0 from the CDS per vehicle records. Further axle spacing analyses are performed during the validation and post-validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (January 2011) based on the last calibration with the most recent two-week WIM data sample from the site (July 2012). Comparison of vehicle class distribution data indicates a 0.1 percent decrease of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have remained the same, and average Class 9 GVW has decreased by 4.1 percent for the July 2012 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical to the expected average of 4.0 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on January 12, 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 April 30, 2008 by International Road Dynamics. It is instrumented with quartz 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 pre-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 pre-validation test truck runs. Dynamic and static electronic checks of the in-road sensors were performed. Electronic tests of the power and communication devices indicated that they were operating normally.

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, there were no pavement distresses noted that may affect the accuracies of the WIM system.

4.2 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 would 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)	0.741	0.704	1.164			0.870
		SRI (m/km)	0.563	0.538	0.771			0.624
		Peak LRI (m/km)	0.774	0.714	1.181			0.890
		Peak SRI (m/km)	***0.686***	***0.675***	**1.825**			**1.062**
	RWP	LRI (m/km)	0.607	0.604	0.587			0.599
		SRI (m/km)	*0.458*	*0.392*	*0.297*			*0.382*
		Peak LRI (m/km)	0.617	0.641	0.659			0.639
		Peak SRI (m/km)	*0.511*	*0.446*	*0.496*			*0.484*
Center	LWP	LRI (m/km)	0.746	0.836	0.799	0.795	0.814	0.798
		SRI (m/km)	0.845	*0.424*	*0.302*	0.664	0.680	0.583
		Peak LRI (m/km)	0.759	0.836	0.799	0.796	0.815	0.801
		Peak SRI (m/km)	0.881	*0.554*	*0.613*	0.863	0.774	*0.737*
	RWP	LRI (m/km)	0.691	0.746	0.634	0.623	0.624	0.664
		SRI (m/km)	0.548	*0.383*	*0.304*	0.539	*0.457*	*0.446*
		Peak LRI (m/km)	0.695	0.749	0.678	0.631	0.630	0.677
		Peak SRI (m/km)	0.808	0.820	*0.623*	*0.701*	*0.689*	*0.728*
Right	LWP	LRI (m/km)	0.746	0.772	0.656			0.725
		SRI (m/km)	0.694	0.655	*0.479*			0.609
		Peak LRI (m/km)	0.753	0.789	0.659			0.734
		Peak SRI (m/km)	0.795	0.778	*0.640*			*0.738*
	RWP	LRI (m/km)	0.764	0.687	0.640			0.697
		SRI (m/km)	0.605	*0.460*	0.506			0.524
		Peak LRI (m/km)	0.772	0.726	0.661			0.720
		Peak SRI (m/km)	0.810	0.776	*0.727*			0.771

From Table 4-2 it can be seen that most of the indices computed from the profiles are between the upper and lower threshold values, with the remaining values under the lower threshold. Indices that are below the lower thresholds are shown in italics. The highest values, on average, are the Peak SRI values in the left wheel path of the left shift passes (shown in bold and italics).

4.3 Profile and Vehicle Interaction

Profile data was collected on January 25, 2012 by the Southern 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 is 129 in/mi and is located approximately 415 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 129 in/mi and is located approximately 415 feet prior to the WIM scale. These areas of the pavement were closely investigated during the validation visit, and truck dynamics in this area were closely observed. There were no distresses observed at these locations that would influence truck dynamics in the WIM scale area.

Additionally, a visual observation of the trucks as they approach, traverse and leave the sensor indicated truck bouncing at a location measured to be approximately 400 feet prior to the WIM scale location. Video was collected of trucks approaching the scales in this area. The adverse truck dynamics appeared to diminish prior to reaching the WIM scales and did not appear to affect the performance of the WIM scales. Trucks appear to track down the center of the lane.

4.4 Recommended Pavement Remediation

No pavement remediation is recommended.

5 Statistical Reliability of the WIM Equipment

The following section provides summaries of data collected during the pre-validation, the calibration, and the post-validation test truck runs, as well as information resulting from the classification and speed studies. All analyses of test truck data and information on necessary equipment adjustments are provided.

5.1 Pre-Validation

The first set of test runs provides a general overview of system performance prior to any calibration adjustments for the given environmental, vehicle speed and other conditions.

The 40 pre-validation test truck runs were conducted on August 1 and 2, 2012, beginning at approximately 4:30 PM and continuing until 5:44 PM on August 1 and beginning at 7:18 AM and continuing until 10:47 AM on August 2.

The two test trucks consisted of:

- A Class 9 truck, loaded with concrete blocks, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.
- A Class 9 truck, loaded with rock, and equipped with air suspension on the tractor, steel spring 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 pre-validation and were re-weighed at the conclusion of the pre-validation. The average test truck weights and measurements are provided in Table 5-1.

Table 5-1 – Pre-Validation Test Truck Weights and Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	79.0	12.8	16.3	16.3	16.8	16.8	17.5	4.4	36.9	4.1	62.9	72.7
2	69.3	11.7	14.7	14.7	14.1	14.1	18.8	4.4	29.3	4.1	56.6	61.1

Test truck speeds varied by 20 mph, from 48 to 68 mph. The measured pre-validation pavement temperatures varied 49.6 degrees Fahrenheit, from 77.0 to 126.6. The sunny weather conditions provided the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

As shown in Table 5-2, the site did not met LTPP requirements for GVW and vehicle length as a result of the pre-validation test truck runs.

Table 5-2 – Pre-Validation Overall Results – 2-Aug-12

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-4.9 ± 7.8%	Pass
Tandem Axles	±15 percent	-3.7 ± 8.2%	Pass
GVW	±10 percent	-3.7 ± 6.5%	FAIL
Vehicle Length	±3.0 percent (2.0 ft)	-1.2 ± 1.1 ft	FAIL
Axle Length	± 0.5 ft [150mm]	-0.3 ± 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 over all speeds was 0.0 ± 0.6 mph, which is within 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 -0.3 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 similar 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 75 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3.

Table 5-3 – Pre-Validation Results by Speed – 2-Aug-12

Parameter	95% Confidence Limit of Error	Low	Medium	High
		47.0 to 54.0 mph	54.1 to 61.1 mph	61.2 to 68.0 mph
Steering Axles	±20 percent	-8.1 ± 6.4%	-1.5 ± 5.1%	-5.0 ± 5.9%
Tandem Axles	±15 percent	-5.2 ± 8.7%	-2.3 ± 9.6%	-3.5 ± 6.4%
GVW	±10 percent	-5.6 ± 6.8%	-2.0 ± 7.3%	-3.6 ± 4.1%
Vehicle Length	±3.0 percent (2.0 ft)	-1.3 ± 1.0 ft	-1.2 ± 1.3 ft	-1.1 ± 1.5 ft
Vehicle Speed	± 1.0 mph	-0.3 ± 0.2 mph	-0.3 ± 0.1 mph	-0.2 ± 0.2 mph
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.8 ft	-0.1 ± 0.8 ft	-0.2 ± 1.3 ft

From the table, it can be seen that, on average, the WIM equipment underestimated all weights at all speeds for the pre-validation. The range in error appears to be greater at the medium speeds for tandem axles and GVW measurement errors and less at the medium speeds for steering axle errors.

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 sections.

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment generally underestimated GVW at all speeds. The range in error is higher at medium speeds when compared to low and high speeds.

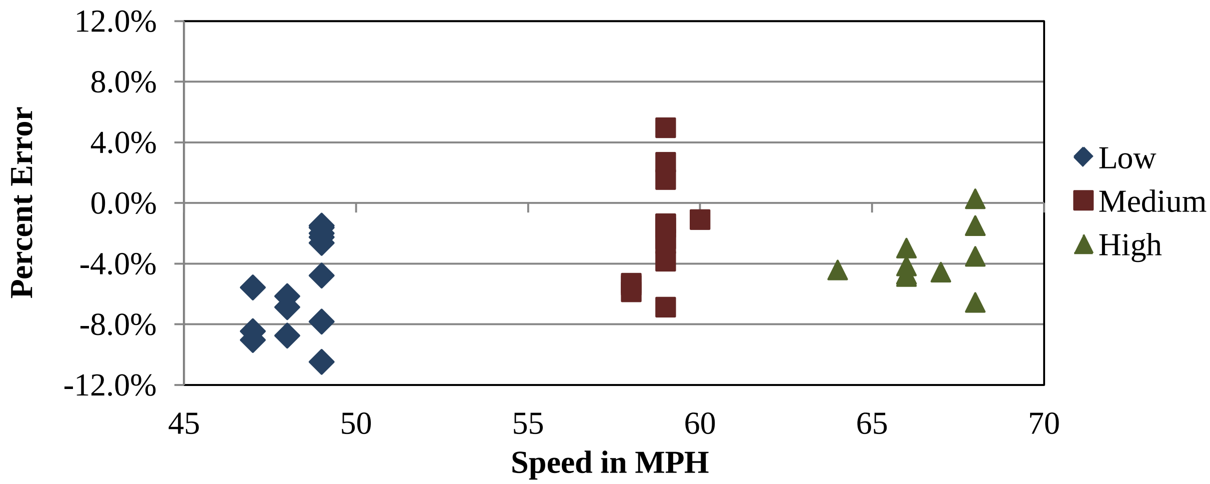


Figure 5-1 – Pre-Validation GVW Error by Speed – 2-Aug-12

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment generally underestimated steering axle weights at all speeds. The least bias is observed at medium speeds. The range in error is similar throughout the entire speed range.

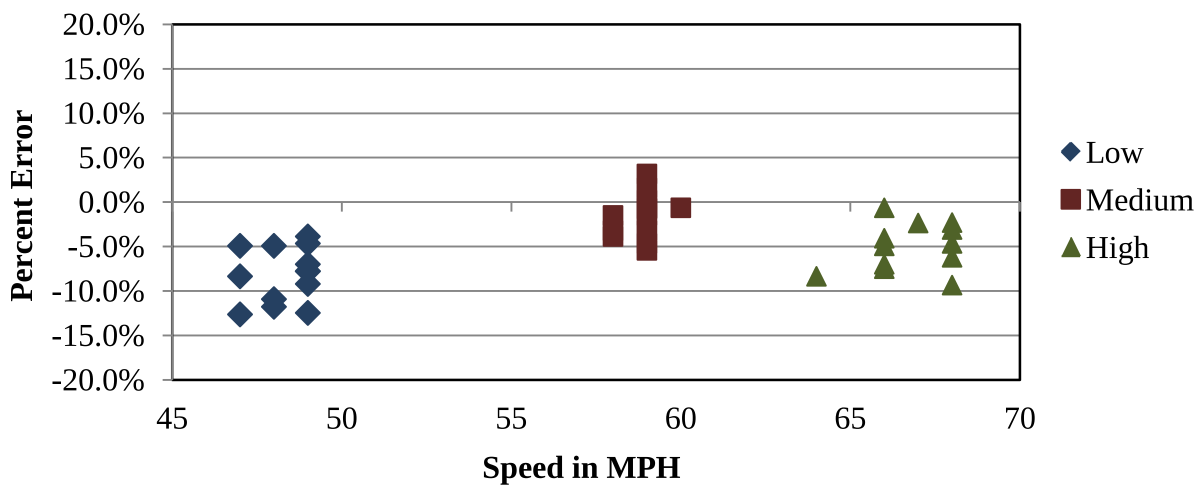


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 2-Aug-12

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment generally underestimates tandem axle weights at all speeds. The range in error is similar throughout the entire speed range.

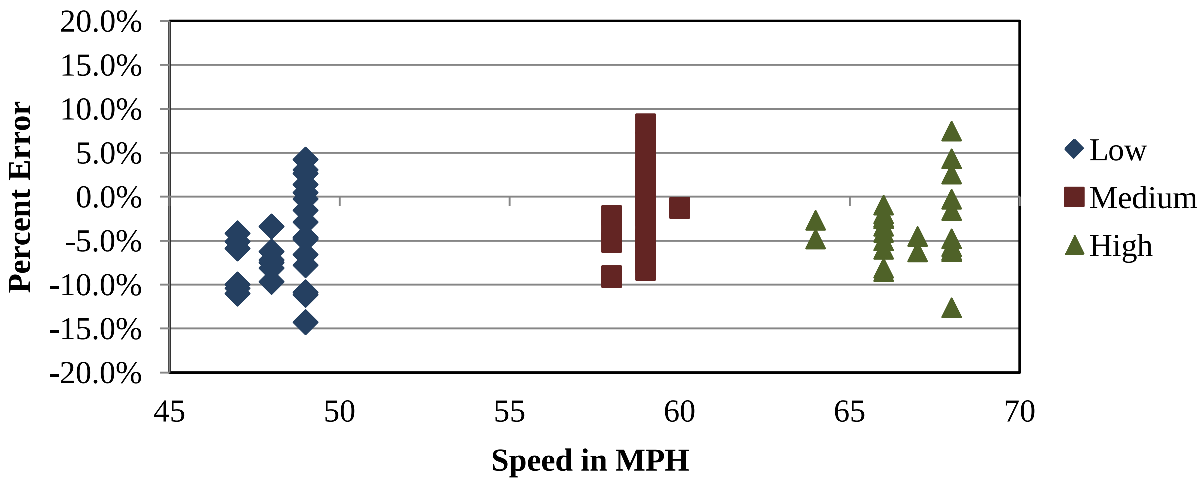


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 2-Aug-12

5.1.1.4 GVW Errors by Speed and Truck Type

When the GVW error for each truck is analyzed as a function of speed, it can be seen that the WIM equipment bias for the partially loaded (Secondary) truck is more negative than heavily loaded (Primary) truck at low and medium speeds and similar at the higher speeds. The range in GVW errors is greater for the heavily loaded (Primary) truck at all speeds. Distribution of errors is shown graphically in Figure 5-4.

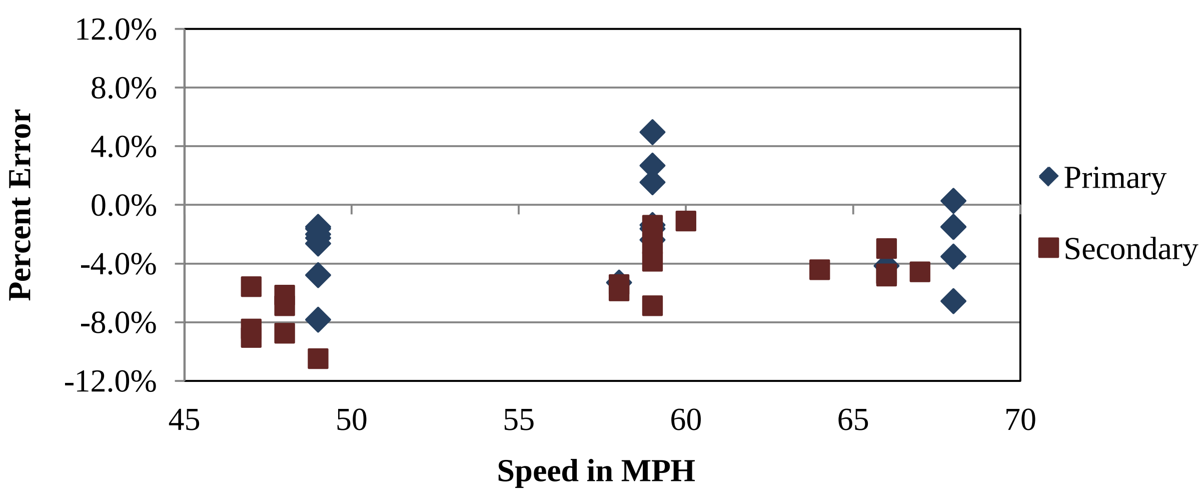


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 2-Aug-12

5.1.1.5 Axle Length Errors by Speed

For this site, the WIM equipment underestimated axle length consistently over the entire range of speeds with an error range of 0.0 to -0.4 feet. Distribution of errors is shown graphically in Figure 5-5.

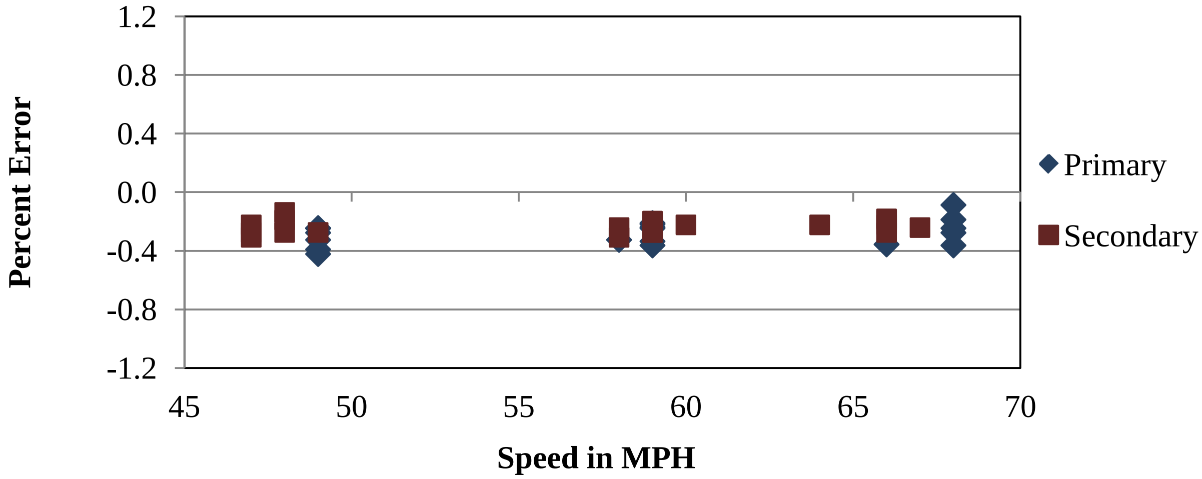


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 2-Aug-12

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment underestimated overall vehicle length consistently over the entire range of speeds, with an error range of 0.0 to -2.0 feet. Distribution of errors is shown graphically in Figure 5-6.

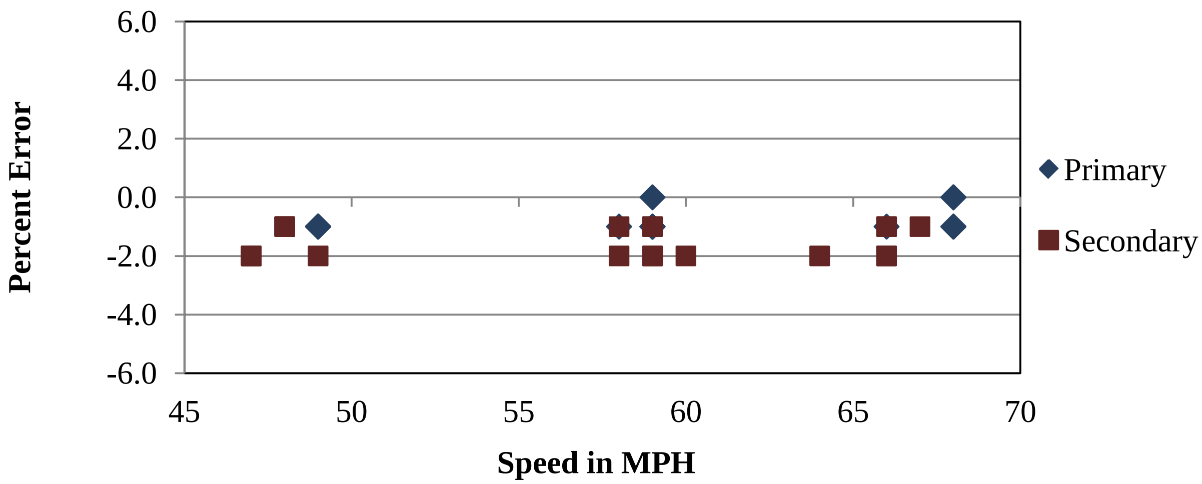


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 2-Aug-12

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 varied 49.6 degrees, from 77.0 to 126.6 degrees Fahrenheit. Since the desired 30 degree temperature range was met, the pre-validation test runs are being reported under three temperature groups – low, medium and high, as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 2-Aug-12

Parameter	95% Confidence Limit of Error	Low	Medium	High
		77.0 to 93.5 degF	93.6 to 110.2 degF	110.3 to 126.6 degF
Steering Axles	±20 percent	-2.2 ± 6.0%	-4.7 ± 7.8%	-6.5 ± 8.1%
Tandem Axles	±15 percent	-1.2 ± 9.5%	-3.1 ± 7.5%	-5.4 ± 7.8%
GVW	±10 percent	-1.3 ± 7.2%	-3.3 ± 5.8%	-5.4 ± 5.7%
Vehicle Length	±3.0 percent (2.0 ft)	-1.0 ± 1.5 ft	-1.2 ± 0.9 ft	-1.3 ± 1.3 ft
Vehicle Speed	± 1.0 mph	-0.2 ± 0.1 mph	-0.2 ± 0.1 mph	-0.3 ± 0.1 mph
Axle Length	± 0.5 ft [150mm]	-0.3 ± 1.5 ft	-0.2 ± 0.9 ft	-0.1 ± 0.5 ft

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

5.1.2.1 GVW Errors by Temperature

From Figure 5-7, it can be seen that the equipment increasingly underestimates GVW as temperature increases. The range in error is similar for different temperature groups. There does appear to be a negative association between temperature and GVW measurement error for this site.

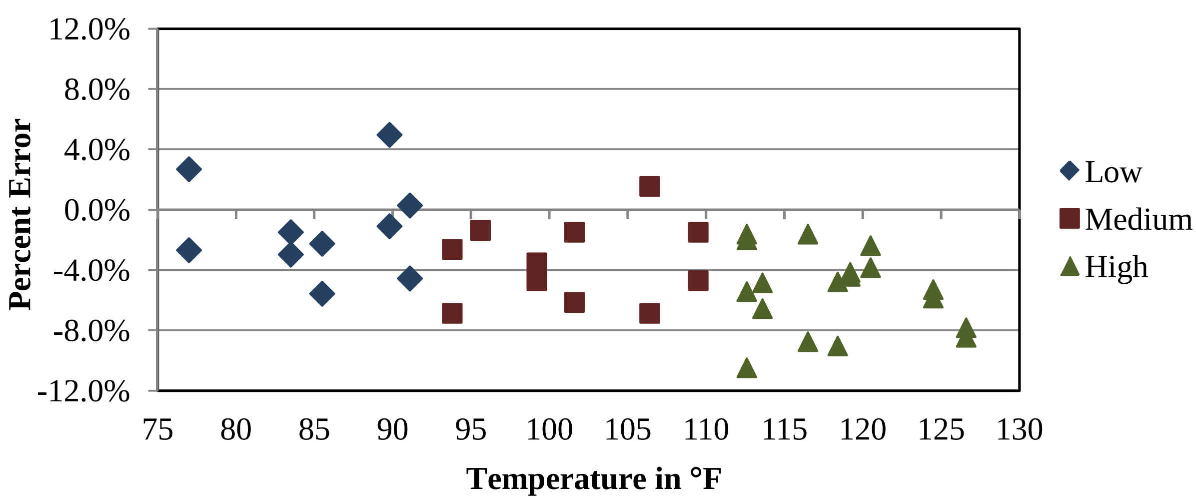


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 2-Aug-12

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that for steering axles, the WIM equipment increasingly underestimates weights as temperature increases. The range in error is similar for different temperature groups. There does appear to be a negative association between temperature and steering axle measurement errors for this site.

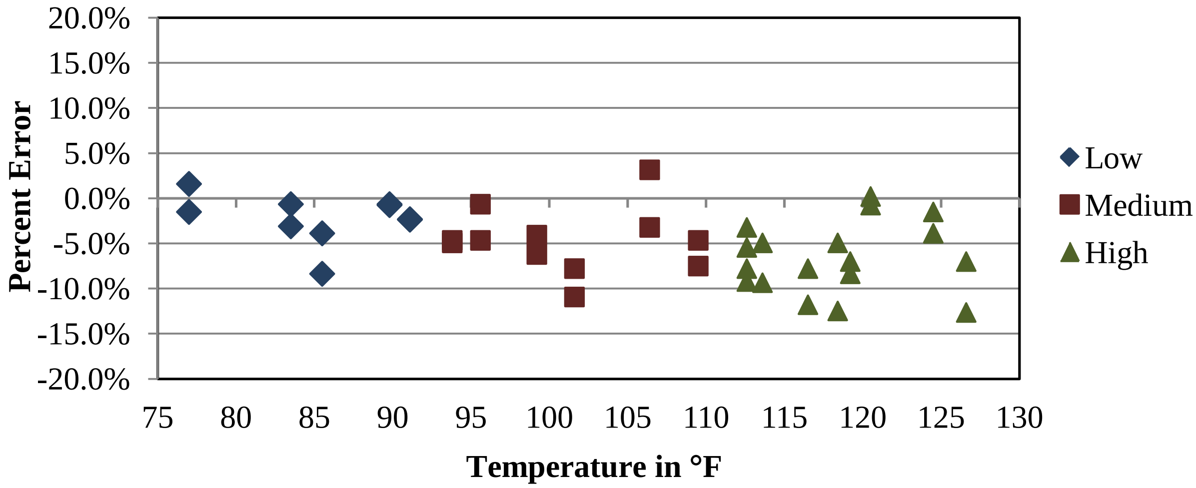


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 2-Aug-12

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment increasingly underestimates tandem axle weights as temperature increases. The range in tandem axle errors is consistent for the three temperature groups.

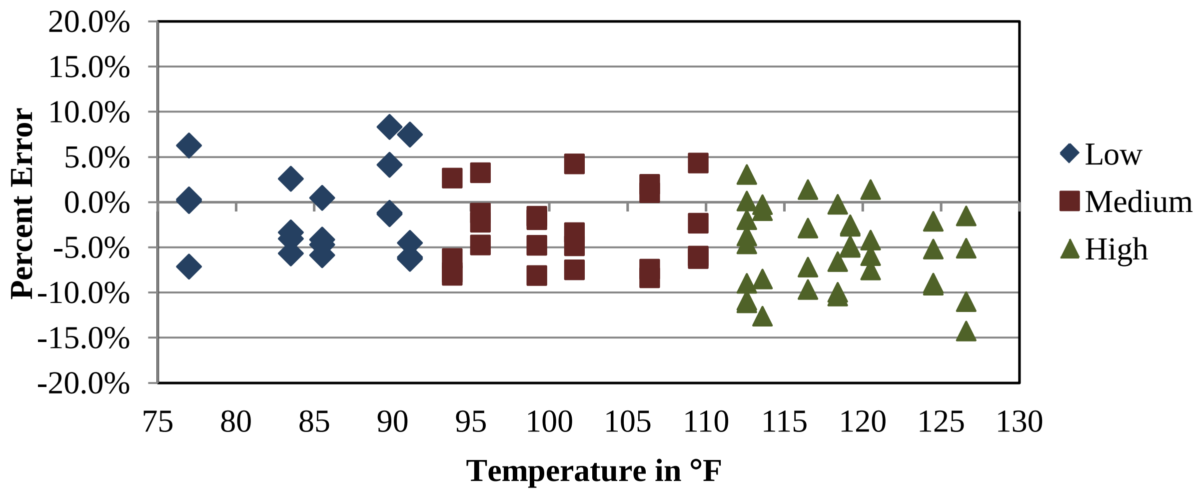


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 2-Aug-12

5.1.2.4 GVW Errors by Temperature and Truck Type

When analyzed for each test truck, it can be seen that WIM equipment bias for the partially loaded (Secondary) truck is more negative than heavily loaded (Primary) truck over the range of temperatures observed in the field. For both trucks, the range of errors is consistent over the range of temperatures. Distribution of errors is shown graphically in Figure 5-10.

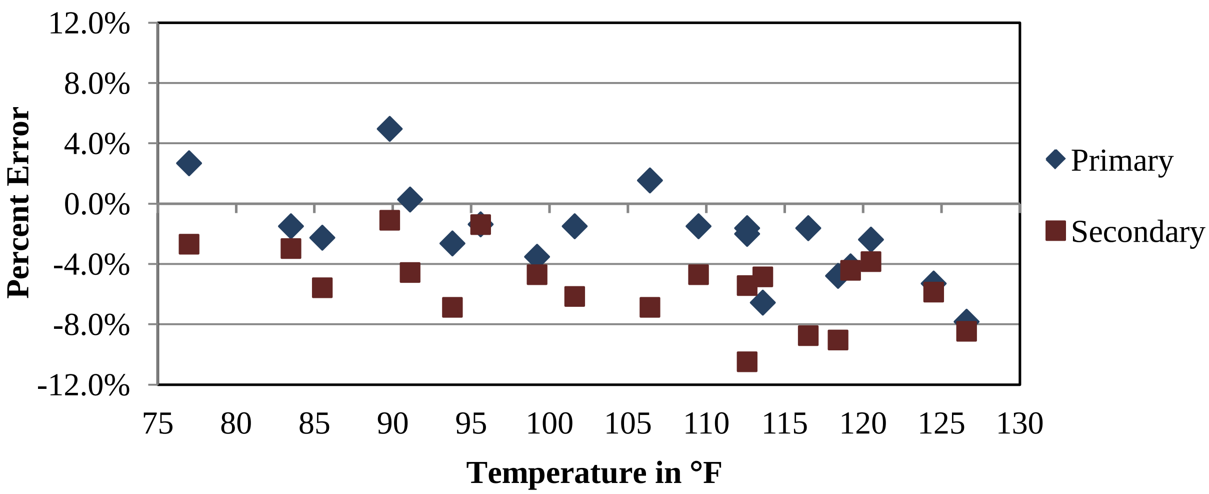


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 2-Aug-12

5.1.3 Classification and Speed Evaluation

The pre-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 pre-validation classification study at this site, a manual sample of 106 vehicles including 100 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.

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one class of vehicle but identified by the WIM equipment as another class of vehicle. The misclassifications by pair are provided in Table 5-5. The table illustrates the breakdown of vehicles observed and identified by the equipment for the manual classification study. As shown in Table 5-5, three Class 3 vehicles were misclassified as Class 5 vehicles and two Class 5 vehicles were misclassified as Class 8 vehicles by the equipment.

Table 5-5 – Pre-Validation Misclassifications by Pair – 2-Aug-12

		WIM											
		3	4	5	6	7	8	9	10	11	12	13	14
Observed	3	-		3									
	4		-										
	5			-			2						
	6				-								
	7					-							
	8						-						
	9							-					
	10								-				
	11									-			
	12										-		
	13											-	-

As shown in the table, a total of 5 vehicles, including 0 heavy trucks (vehicle classes 6 – 13) were misclassified by the equipment. Based on the vehicles observed during the pre-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 4.8% due to misclassification of lightweight vehicles in Class 3 and Class 5. One Class 3 vehicle was unclassified by the equipment (Class 15), which is not shown in the table above. The causes for the misclassifications were not investigated in the field.

The combined results produced an undercount of four Class 3 vehicles and an over count of one Class 5 vehicle and two Class 8 vehicles as shown in Table 5-6. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

Table 5-6 – Pre-Validation Classification Study Results – 2-Aug-12

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	4	0	14	1	0	2	78	2	2	1	0
WIM Count	0	0	15	1	0	4	78	2	2	1	0
Observed Percent	3.8	0.0	13.5	1.0	0.0	1.9	75.0	1.9	1.9	1.0	0.0
WIM Percent	0.0	0.0	14.4	1.0	0.0	3.8	75.0	1.9	1.9	1.0	0.0
Misclassified Count	3	0	2	0	0	0	0	0	0	0	0
Misclassified Percent	75.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unclassified Count	1	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

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 5-7.

Table 5-7 – Pre-Validation Unclassified Trucks by Pair – 2-Aug-12

Observed Class	Unclassified	Observed Class	Unclassified	Observed Class	Unclassified
3	1	7	0	11	0
4	0	8	0	12	0
5	0	9	0	13	0
6	0	10	0		

Based on the manually collected sample of the 106 vehicles, 0.9 percent 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 0.3 mph; the range of errors was 0.7 mph.

5.2 Calibration

The WIM equipment required one calibration iteration between the pre- and post-validations. Information regarding the basis for changing equipment compensation factors, supporting data for the changes, and the resulting WIM accuracies from the calibrations are provided in this section.

The operating system weight compensation parameters that were in place prior to the pre-validation are shown in Table 5-8.

Table 5-8 – Initial System Parameters – 2-Aug-12

Speed Point	MPH	Left		Right	
		1	3	2	4
88	55	3156	3156	2868	2868
96	60	3303	3303	3002	3002
104	65	3196	3196	2902	2902
112	70	3185	3185	2892	2892
120	75	3201	3201	2907	2907
Axle Distance (cm)		304			
Dynamic Comp (%)		105			
Loop Width (cm)		291			

5.2.1 Calibration Iteration 1

5.2.1.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall error of -3.7%. To compensate for the error at each speed factor, the changes in Table 5-9 were made to the compensation factors.

Table 5-9 – Calibration 1 Equipment Factor Changes – 2-Aug-12

Speed Points	Old Factors				New Factors			
	Left		Right		Left		Right	
	1	3	2	4	1	3	2	4
88	3156	3156	2868	2868	3288	3288	2988	2988
96	3303	3303	3002	3002	3320	3320	3017	3017
104	3196	3196	2902	2902	3261	3261	2961	2961
112	3185	3185	2892	2892	3250	3250	2951	2951
120	3201	3201	2907	2907	3266	3266	2966	2966
Axle Distance (cm)	304				305			
Dynamic Comp (%)	105				106			
Loop Width (cm)	291				254			

5.2.1.2 Calibration 1 Results

The results of the 11 first calibration verification runs are provided in Table 5-10 and Figure 5-11. As can be seen in the table, the mean error of all weight estimates was reduced as a result of the first calibration iteration.

Table 5-10 – Calibration 1 Results – 2-Aug-12

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-2.7 ± 5.4%	Pass
Tandem Axles	±15 percent	-1.7 ± 8.2%	Pass
GVW	±10 percent	-1.7 ± 5.3%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	0.0 ± 1.4 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.3 ± 0.1 ft	Pass

Figure 5-11 shows that the WIM equipment is estimating GVW with similar accuracy at all speeds.

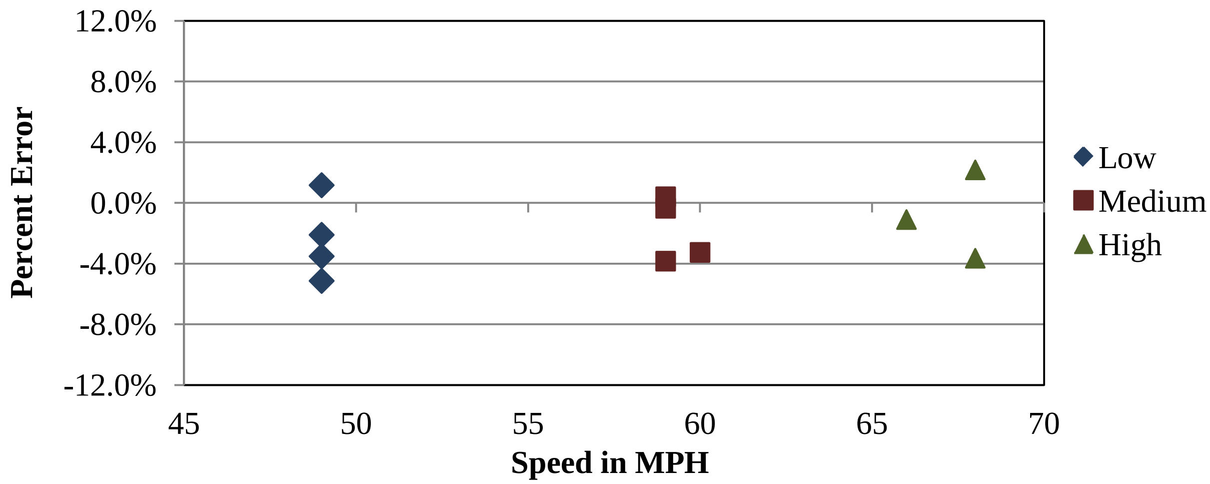


Figure 5-11 – Calibration 1 GVW Error by Speed – 2-Aug-12

Based on the results of the first calibration, where weight estimate bias decreased to -1.7 percent, a second calibration was not considered to be necessary. The 11 calibration runs were combined with 29 additional post-validation runs to complete the WIM system post-validation.

5.3 Post-Validation

The 40 post-validation test truck runs were conducted on August 2, 2012, beginning at approximately 12:28 PM and continuing until 13:39 PM, and completed on August 3, beginning at 7:39 AM and continuing until 11:29 AM.

The two test trucks consisted of:

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

- A Class 9 truck, loaded with rock, and equipped with air suspension on the tractor, steel spring 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 post-validation and re-weighed at the conclusion of the post-validation. The average test truck weights and measurements are provided in Table 5-11.

Table 5-11 – Post-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	79.1	12.9	16.3	16.3	16.8	16.8	17.5	4.4	36.9	4.1	62.9	73.0
2	69.3	11.7	14.7	14.7	14.1	14.1	18.8	4.4	29.3	4.1	56.6	61.0

Test truck speeds varied by 20 mph, from 48 to 68 mph. The measured post-validation pavement temperatures varied 56.1 degrees Fahrenheit, from 83.1 to 139.2. The sunny weather conditions provided the desired minimum 30 degree temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 2-Aug-12

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	0.5 ± 6.8%	Pass
Tandem Axles	±15 percent	-1.2 ± 8.6%	Pass
GVW	±10 percent	-0.9 ± 6.2%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	0.3 ± 1.2 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.2 ± 0.2 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 0.0 ± 0.6 mph, which is within the ±1.0 mph tolerance established by the LTPP Field Guide. Since the site is measuring axle spacing length with a mean error of -0.2 feet, 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 similar acceptable ranges.

5.3.1 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 75 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-13.

Table 5-13 – Post-Validation Results by Speed – 2-Aug-12

Parameter	95% Confidence Limit of Error	Low 48.0 to 54.7 mph	Medium 54.8 to 61.4 mph	High 61.5 to 68.0 mph
Steering Axles	±20 percent	0.1 ± 7.3%	1.2 ± 8.2%	0.2 ± 6.4%
Tandem Axles	±15 percent	-1.5 ± 10.8%	-0.6 ± 7.8%	-1.6 ± 9.0%
GVW	±10 percent	-1.2 ± 7.8%	-0.2 ± 6.3%	-1.2 ± 6.1%
Vehicle Length	±3.0 percent (2.0 ft)	0.2 ± 1.3 ft	0.2 ± 1.3 ft	0.4 ± 1.4 ft
Vehicle Speed	± 1.0 mph	-0.2 ± 0.1 mph	-0.2 ± 0.2 mph	-0.2 ± 0.2 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.0 ft	-0.2 ± 0.8 ft	0.1 ± 0.6 ft

From the table, it can be seen that the WIM equipment estimates all weights with similar accuracy 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.

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-12, the equipment estimated GVW with similar accuracy at all speeds. The range in error is lower at high speeds when compared to low and medium speeds.

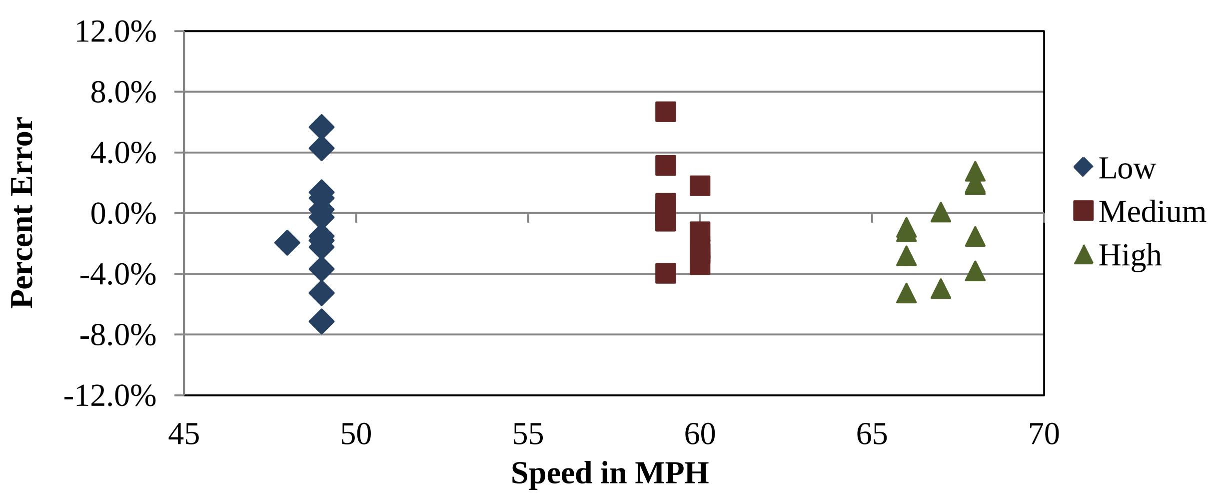


Figure 5-12 – Post-Validation GVW Errors by Speed – 2-Aug-12

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-13, the equipment estimated steering axle weights with similar 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.

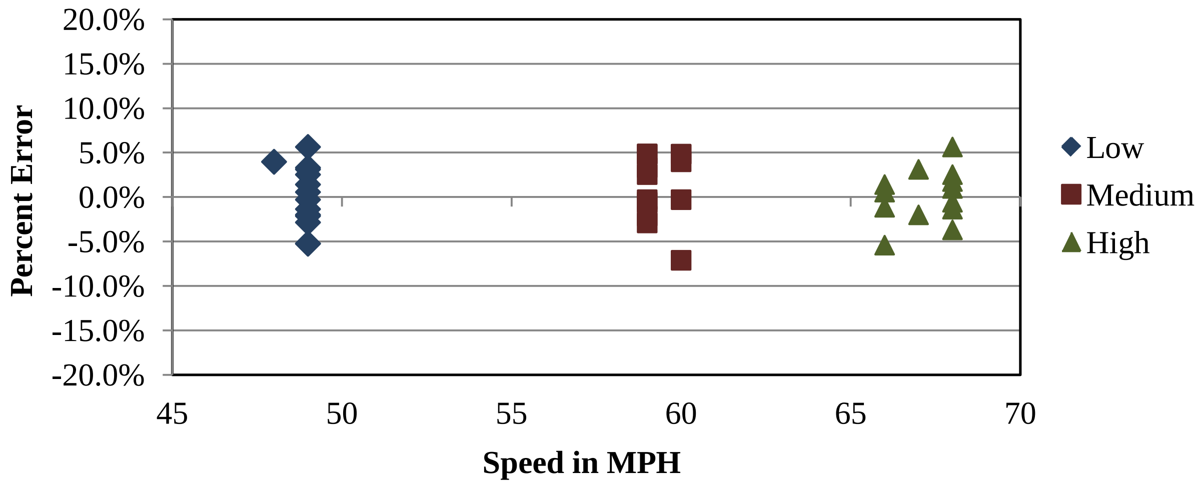


Figure 5-13 – Post-Validation Steering Axle Weight Errors by Speed – 2-Aug-12

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-14, the equipment estimated tandem axle weights with similar accuracy at all speeds. The range in error and bias is similar throughout the entire speed range.

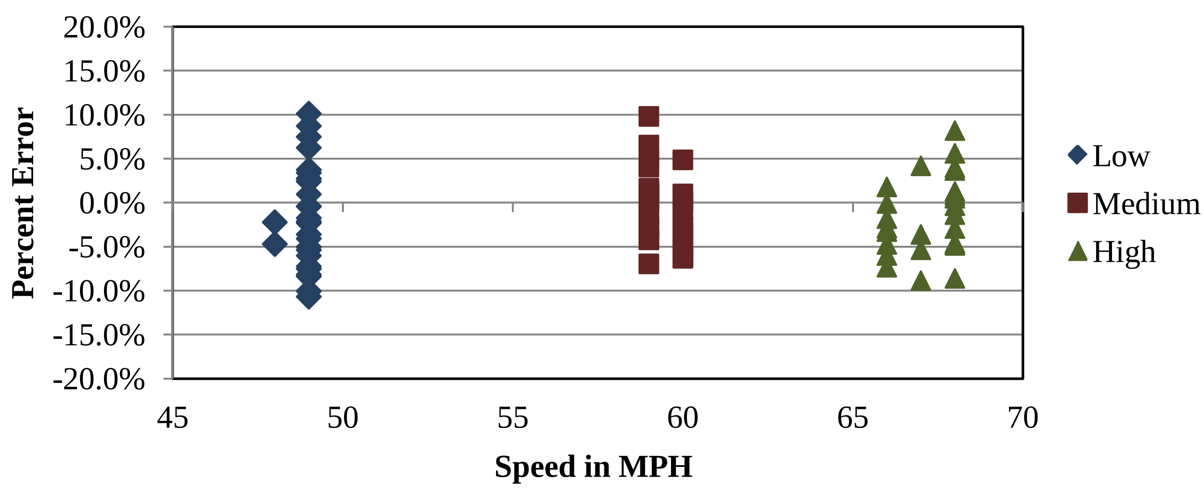


Figure 5-14 – Post-Validation Tandem Axle Weight Errors by Speed – 2-Aug-12

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-15 that when the GVW errors are analyzed by truck type, the WIM equipment underestimates GVW for the partially loaded (Secondary) truck at all speeds. The WIM system generally overestimates GVW for the heavily loaded truck (Primary) at the medium speeds. The WIM system estimates GVW for both trucks with similar precision and bias at the high speeds.

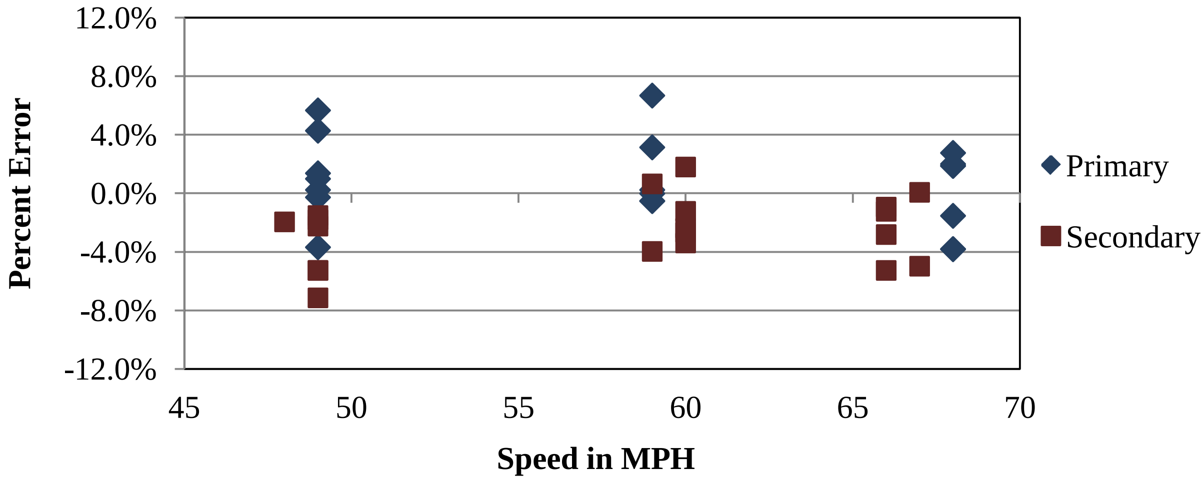


Figure 5-15 – Post-Validation GVW Error by Truck and Speed – 2-Aug-12

5.3.1.5 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 -0.4 feet. Distribution of errors is shown graphically in Figure 5-16.

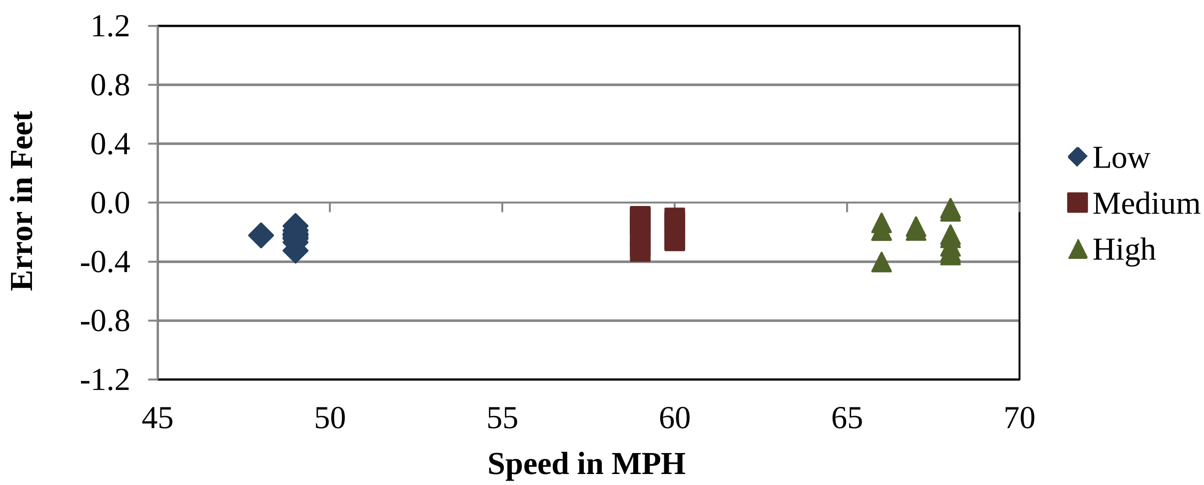


Figure 5-16 – Post-Validation Axle Length Error by Speed – 2-Aug-12

5.3.1.6 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 -1.0 to 1.0 feet. Distribution of errors is shown graphically in Figure 5-17.

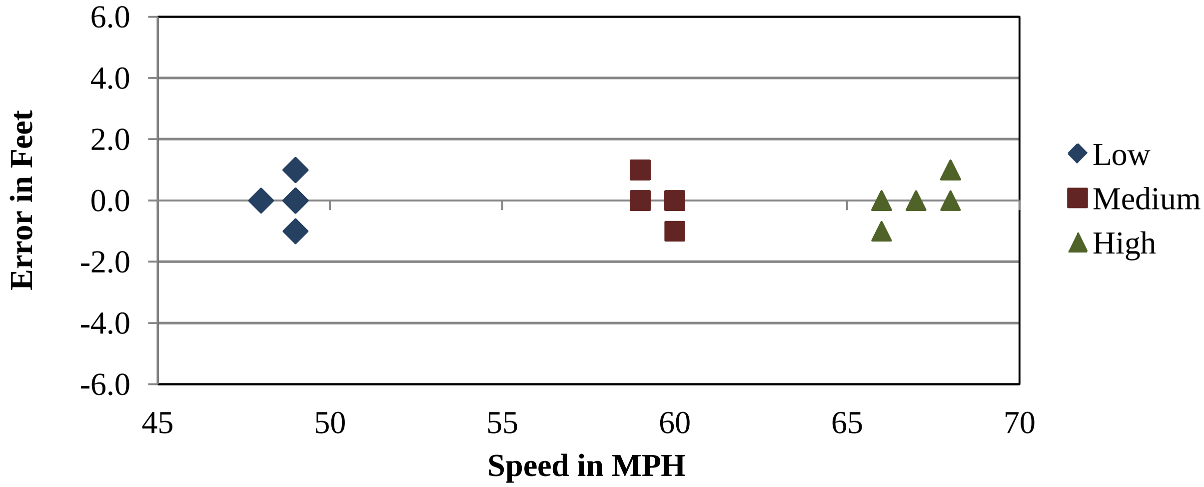


Figure 5-17 – Post-Validation Overall Length Error by Speed – 2-Aug-12

5.3.2 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 56.1 degrees, from 83.1 to 139.2 degrees Fahrenheit. The post-validation test runs are reported under three temperature groups – low, medium and high, as shown in Table 5-14 below.

Table 5-14 – Post-Validation Results by Temperature – 2-Aug-12

Parameter	95% Confidence Limit of Error	Low	Medium	High
		83.1 to 101.8 degF	101.9 to 120.6 degF	120.7 to 139.2 degF
Steering Axles	±20 percent	2.5 ± 5.4%	1.5 ± 5.1%	-2.8 ± 5.4%
Tandem Axles	±15 percent	-0.5 ± 10.6%	-1.2 ± 7.5%	-2.1 ± 8.5%
GVW	±10 percent	0.0 ± 7.8%	-0.7 ± 5.8%	-2.1 ± 5.1%
Vehicle Length	±3.0 percent (2.0 ft)	0.4 ± 1.1 ft	0.4 ± 1.5 ft	0.1 ± 1.4 ft
Vehicle Speed	± 1.0 mph	-0.2 ± 0.1 mph	-0.2 ± 0.1 mph	-0.3 ± 0.2 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.8 ft	0.0 ± 0.0 ft	-0.1 ± 0.6 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.

5.3.2.1 GVW Errors by Temperature

From Figure 5-18, it can be seen that the equipment appears to transition from an unbiased measurement of GVW at the low temperatures, to an underestimation of GVW at the higher temperatures, with similar range in error for the medium and high temperature groups. There appears to be a correlation between temperature and GVW estimates at this site.

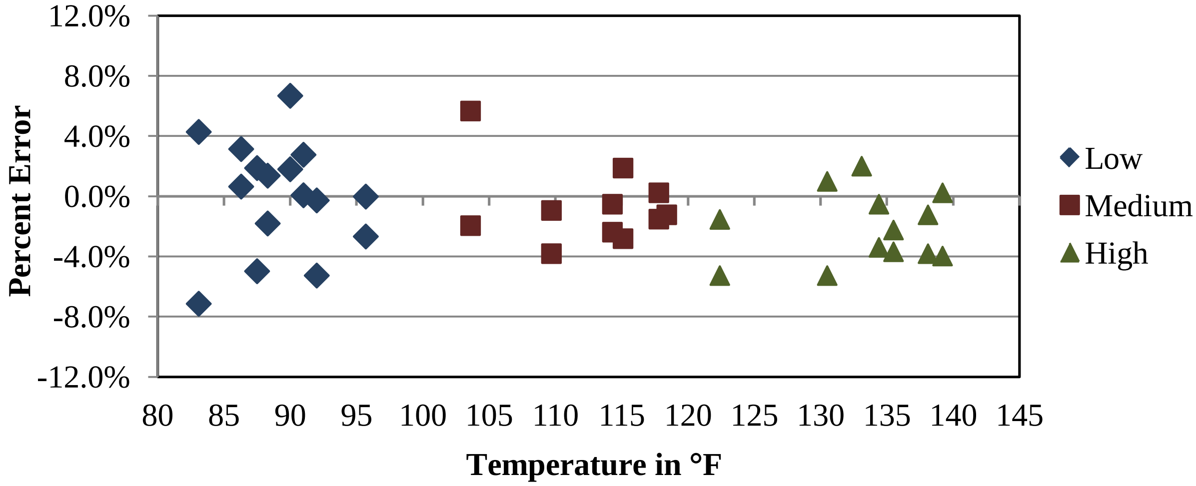


Figure 5-18 – Post-Validation GVW Errors by Temperature – 2-Aug-12

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-19 demonstrates that for steering axles, there is a relationship between steering axle weights and temperature where the estimation of steering axle weight decreases as temperature increases. The range in error is similar for different temperature groups. There appears to be a negative correlation between temperature and steering axle weight estimates at this site.

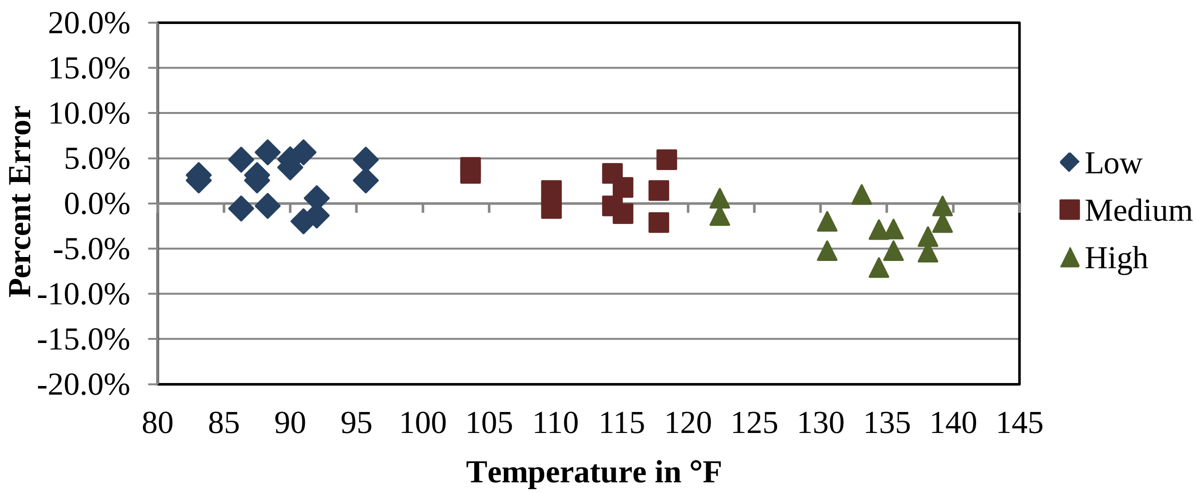


Figure 5-19 – Post-Validation Steering Axle Weight Errors by Temperature – 2-Aug-12

5.3.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-20, the WIM equipment appears to estimate tandem axle weights with similar accuracy across the range of temperatures observed in the field. There does appear to be a slight correlation between tandem axle measurement error and temperature at this site. The range in tandem axle errors is lower at high temperatures.

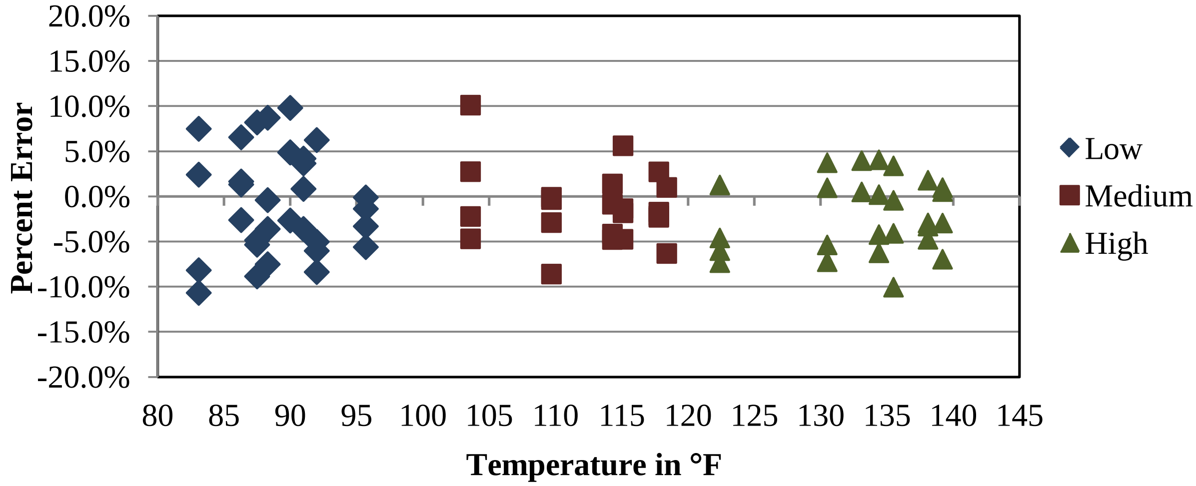


Figure 5-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 2-Aug-12

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-21, when analyzed by truck type, the system generally overestimates GVW for the Primary truck and underestimates GVW for the Secondary truck at the low temperatures, and underestimate GVW for the partially loaded (Secondary) at the medium and high temperatures. For both trucks, the range of errors is reasonably consistent over the range of temperatures.

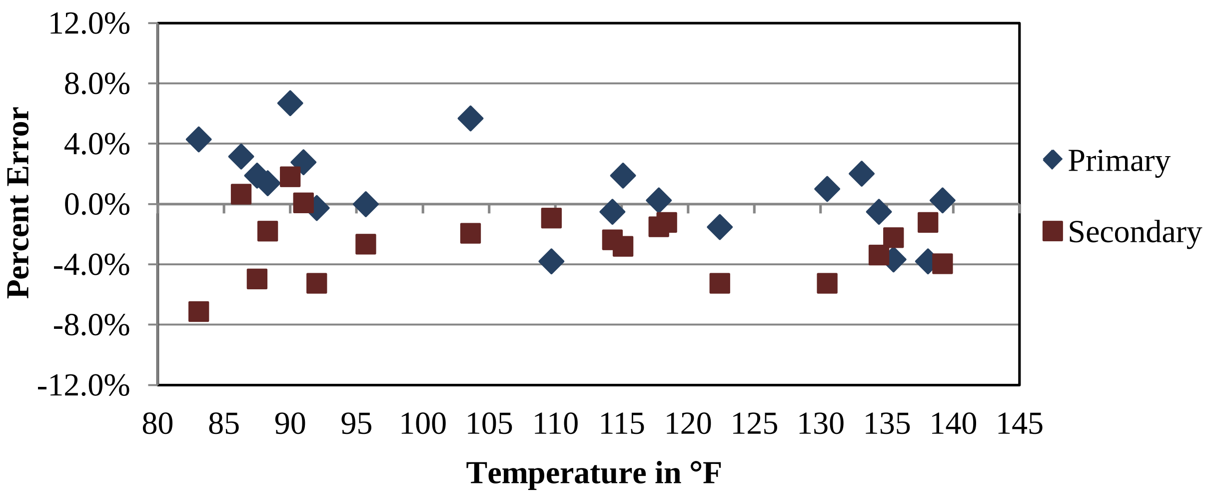


Figure 5-21 – Post-Validation GVW Error by Truck and Temperature – 2-Aug-12

5.3.3 Classification and Speed Evaluation

The post-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 post-validation classification study at this site, a manual sample of 106 vehicles including 100 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.

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. The misclassifications by pair are provided in Table 5-15. The table illustrates the breakdown of vehicles observed and identified by the equipment for the manual classification study. As shown in Table 5-15, a total of six Class 3 vehicles were misclassified – five as Class 5 vehicles and one as a Class 9 vehicle. Two Class 5 vehicles were misclassified – one as a Class 3 vehicle and one as a Class 8 vehicle.

Table 5-15 – Post-Validation Misclassifications by Pair – 2-Aug-12

	WIM												
Observed		3	4	5	6	7	8	9	10	11	12	13	14
	3	-		5				1					
	4		-										
	5	1		-			1						
	6				-								
	7					-							
	8						-						
	9							-					
	10								-				
	11									-			
	12										-		
	13											-	-

As shown in the table, a total of 8 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the post-validation study, the misclassification percentage is 0.0% for heavy trucks (vehicle classes 6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 7.5 percent due to misclassification of lightweight vehicles in Class 3 and Class 5. The causes for the misclassifications were not investigated in the field.

The combined results of the misclassifications resulted in an undercount of five Class 3 vehicles and an over count of three Class 5 vehicles, one Class 8 vehicle and one Class 9 vehicle as shown in Table 5-16. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

Table 5-16 – Post-Validation Classification Study Results – 2-Aug-12

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	6	1	27	3	0	2	64	2	1	0	0
WIM Count	1	1	30	3	0	3	65	2	1	0	0
Observed Percent	5.7	0.9	25.5	2.8	0.0	1.9	60.4	1.9	0.9	0.0	0.0
WIM Percent	0.9	0.9	28.3	2.8	0.0	2.8	61.3	1.9	0.9	0.0	0.0
Misclassified Count	6	0	2	0	0	0	0	0	0	0	0
Misclassified Percent	100.0	0.0	7.4	0.0	0.0	0.0	0.0	0.0	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

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. There were no unclassified vehicles, as shown in Table 5-17.

Table 5-17 – Post-Validation Unclassified Trucks by Pair – 2-Aug-12

Observed Class	Unclassified	Observed Class	Unclassified	Observed Class	Unclassified
3	0	7	0	11	0
4	0	8	0	12	0
5	0	9	0	13	0
6	0	10	0		

Based on the manually collected sample of the 106 vehicles, 0.0 percent 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 0.3 mph; the range of errors was 0.7 mph.

5.3.4 Final WIM System Compensation Factors

The final factors left in place at the conclusion of the validation are provided in Table 5-18.

Table 5-18 – Final Factors

Speed Point	**MPH**	**Left**		**Right**	
		1	**3**	**2**	**4**
88	55	3288	3288	2988	2988
96	60	3320	3320	3017	3017
104	65	3261	3261	2961	2961
112	70	3250	3250	2951	2951
120	75	3266	3266	2966	2966
Axle Distance (cm)		305			
Dynamic Comp (%)		106			
Loop Width (cm)		254			

6 Post-Visit Data Analysis

A post-visit data analysis is conducted to further evaluate the validation truck data to determine if any relationships exist between WIM system weight and distance measurement error based on speed, temperature and/or truck type. Additionally, an analysis of the post-visit misclassifications noted during the post-validation classification and speed study is conducted to possibly determine the cause of each truck misclassification.

If necessary, a traffic data sample from the days immediately following the validation to the date of the report submission may be conducted to further investigate anomalies in the traffic data that may have resulted from the calibration of the system or any other changes to the WIM system

6.1 Regression Analysis

This section provides additional results for the analysis carried out to determine the influence of truck type, speed and pavement temperature on WIM measurement errors. Multivariable linear regression analysis was applied to WIM data collected during calibration procedures. The same calibration data analyzed and discussed previously was used for this analysis; however a more comprehensive statistical methodology was applied. 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 analysis provides additional insight on how factors like speed, temperature, and truck type may affect weight measurement errors for a specific WIM site. It is expected that multivariable analysis done systematically for many sites may reveal overall trends.

6.1.1 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. 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 48 to 68 mph.
- Pavement temperature. Pavement temperature ranged from 83.1 to 139.2 degrees Fahrenheit.

6.1.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 6-1. 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 6-1 are for the null hypothesis that assumes that the regression coefficients are equal to zero. The p-value reported in Table 6-1 is for the probability that the regression coefficient, given in Table 5-5, occur by chance alone.

Table 6-1 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value (p-value)
Intercept	5.6920	3.6186	1.5730	0.1245
Speed	0.0099	0.0517	0.1915	0.8492
Temp	-0.0491	0.0203	-2.4218	0.0206
Truck	-3.4523	0.7798	-4.4269	0.0001

The lowest probability value given in Table 5-15 was 0.0001 for truck type. This means that there is about 0.01 percent chance that the value of regression coefficient for truck type (-3.4523) can occur by chance alone. Overall, temperature and truck type have the most significant effect on the GVW measurement errors for this site.

In addition, the relationship between speed and GVW measurement errors is shown in Figure 6-1. The figure includes a trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 6-1 provides quantification and statistical assessment of the relationship.

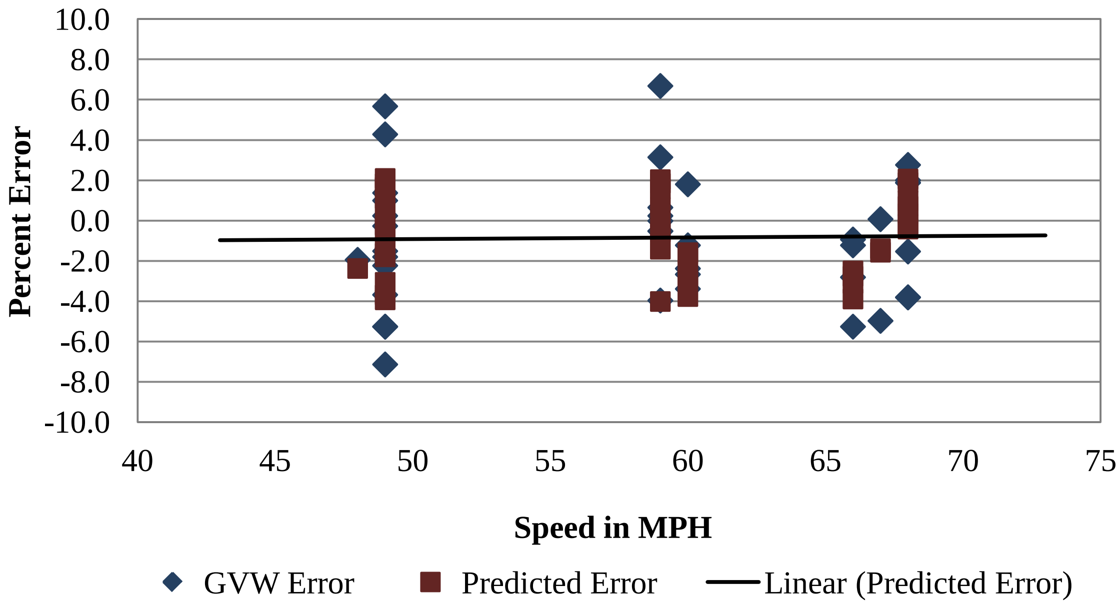


Figure 6-1 – Influence of Speed on the Measurement Error of GVW

As shown in Table 6-1, the effect of speed was not statistically significant (the probability that the regression coefficient of 0.0099 can occur by chance alone was about 85 percent). The value of the regression coefficient quantifies the influence of the speed on the GVW measurement error. For example, for a 10 MPH increase in speed, the GVW measurement error changes (increases) by about 0 .1 percent (0.0099 x 10).

6.1.3 Summary Results

Table 6-2 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 6-2 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 6-2 – Summary of Regression Analysis

Parameter	Factor					
	Speed		Temperature		Truck type	
	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)
GVW	-	-	-0.0491	0.0206	-3.4523	0.0001
Steering axle	-	-	-0.1184	$1.7\ 10^{-6}$	-	-
Tandem axle tractor	-	-	-0.0663	0.0287	-5.7940	$8.7\ 10^{-6}$
Tandem axle trailer	-	-	-		-3.0988	0.0100-

6.1.4 GVW and Steering Axle Trends

This section provides additional discussion regarding the effect of speed on measurement errors. This section is included to investigate if and how the influence of speed on measurement errors differs for the two calibration trucks. Figure 6-2 and Figure 6-3 are provided to illustrate the trend in GVW and steering axle weight errors with respect to speed separately for the Primary and Secondary trucks. Figure 6-2 shows GVW measurement errors; Figure 6-3 shows steering axle measurement errors.

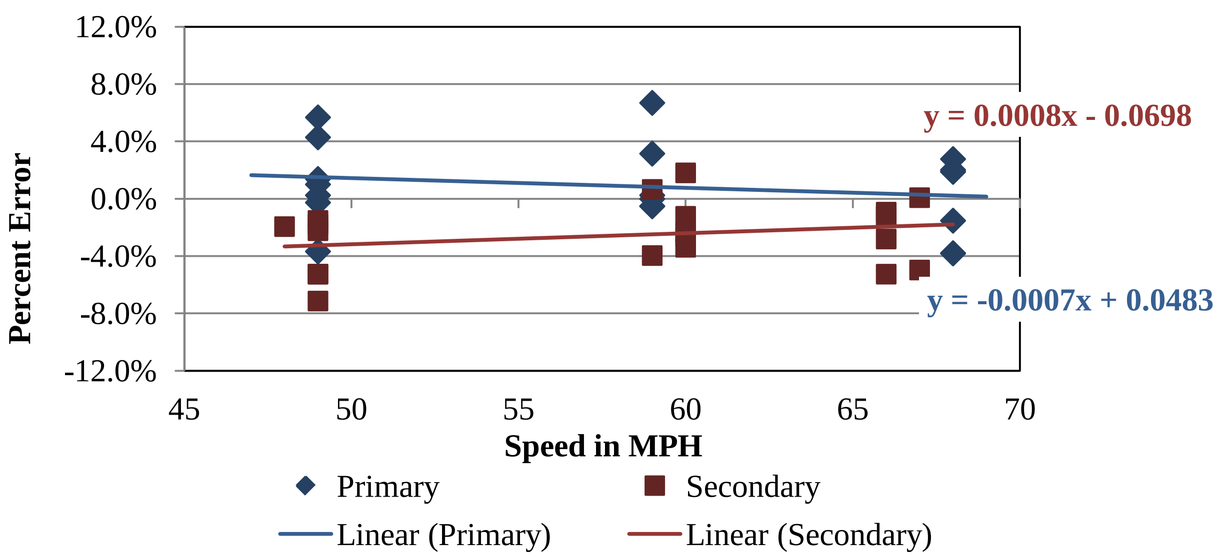


Figure 6-2 – GVW Error Trend by Speed by Truck

The trend lines shown in Figure 6-2 and Figure 6-2 indicate that the influence of speed on the GVW and steering axle weight measurement errors is very small. The highest slope value of 0.0008 was obtained for the GVW measurement error of the Secondary truck. In addition, the trend lines are not statistically significant. Consequently, the influence of speed on the measurement errors was the same for both calibration trucks.

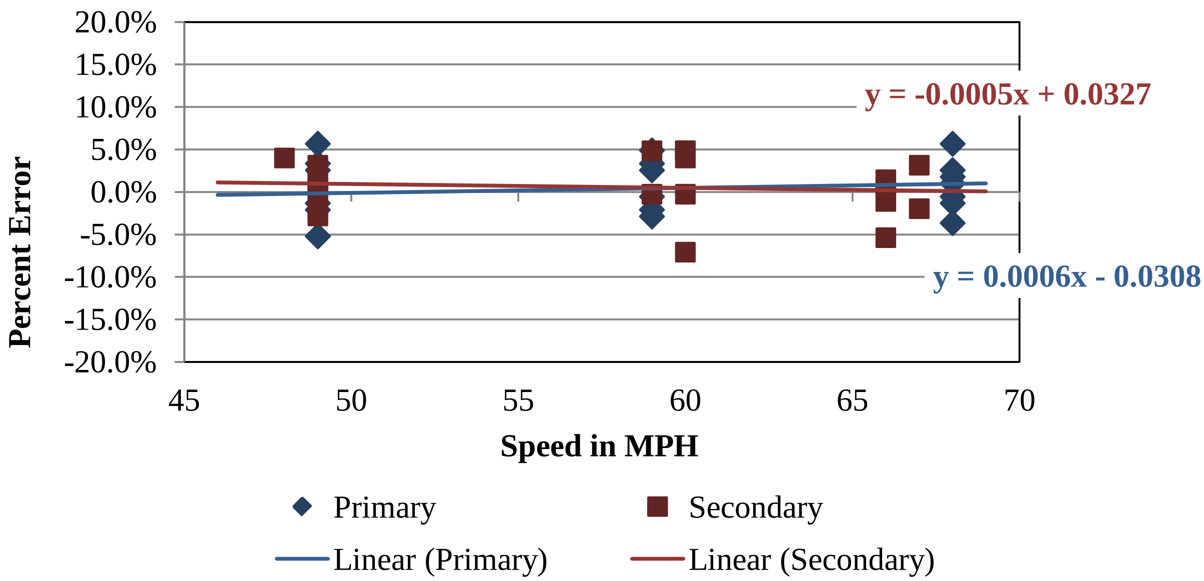


Figure 6-3 – Steering Axle Trend by Speed by Truck

For simplicity, the trend lines used in the previous three figures were assumed to be linear. The relationship between measurement errors and temperature appear to be linear. It is recalled that for the previous validation, a similar slope for the relationship between temperature and weight estimates existed between 35 degrees and 75 degrees Fahrenheit.

6.1.5 Conclusions

It is noted that the same calibration test trucks were used for both New Mexico sites (350500 and 350100). Following conclusions also address the differences between the two sites. Both sites are equipped with quartz sensors, and were validated during the same week under similar weather conditions. For ease of comparison, Table 6.3 provides summary of the regression results for Site 350500.

1. According to Table 6-2, speed had no statistically significant effect on measurement errors. For Site 350500, the effect of speed was statistically significant, but from the practical perspective the effect of speed was small.

2. Temperature affected measurement error GVW and tandem axle on tractor. The regression coefficients ranged from -0.1184 for the steering axle to -0.0491 for GVW. A similar temperature effect (i.e., decrease of the weight measurement error with the increase of temperature) was observed on Site 350500.

3. Truck type had statistically significant effect on GVW and tandem axle on tractors weight measurement. The regression coefficients for truck type in Table 6-2 represent the difference between the mean errors for the Primary and Secondary trucks. Thus, for example, the average GVW measurement error for the Primary truck was about 3.5 percent higher that for the Secondary truck. On both NM sides, the Primary truck was associated with higher measurement errors than the Secondary truck.

4. It appears that the weight measurement errors are influenced by both the site conditions and the calibration trucks used. The relative importance of the two factors cannot be ascertained using currently available data.

5. Even though temperature and truck type had statistically significant effect on measurement errors of some of the parameters, the practical significance of these effects on WIM system calibration tolerances was small and does not affect the validity of the validation. However, when compared with the results of the prior validation, conducted during the winter season, the relationship between temperature and all weight estimates is evident.

Table 6-3 – Summary of Regression Analysis for Site 350500

Parameter	**Factor**					
	Speed		**Temperature**		**Truck type**	
	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)	Regression coefficient	Probability value (p-value)
GVW	0.1360	0.0451	-0.0925	0.0037	–	–
Steering axle	0.1448	0.0544	-0.1138	0.0015	-2.8566	0.0240
Tandem axle tractor	0.0821	0.0828	-0.1149	$3.3\ 10^{-6}$	-2.2665	0.0054
Tandem axle trailer	0.1952	0.1017	-0.0695	0.1971	–	–

7 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 post-validation results.

7.1 Classification

The information in Table 7-1 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 7-1 – Classification Validation History

Date	Misclassification Percentage by Class											Pct Unclass
	3	4	5	6	7	8	9	10	11	12	13	
20-Aug-08	-	-	0	0	-	0	0	-	0	0	-	0
21-Aug-08	-	0	11	0	-	10	0	-	0	0	-	0
11-Jan-01	-	50	4	0	-	0	0	0	0	-	-	0
12-Jan-11	-	0	4	0	-	-	0	-	-	-	-	0
2-Aug-12	100	0	14	0	0	0	0	0	0	0	0	0
3-Aug-12	100	0	7	0	0	0	0	0	0	0	0	0

7.2 Weight

Table 7-2 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, steering and single axles and tandems for prior pre- and post-validations.

Table 7-2 – Weight Validation History

Date	Mean Error and 2SD		
	GVW	Single Axles	Tandem
20-Aug-08	5.0 ± 3.3	2.1 ± 4.6	5.7 ± 6.2
21-Aug-08	1.0 ± 4.9	0.8 ± 5.5	1.1 ± 7.1
11-Jan-11	-1.4 ± 6.8	-4.9 ± 8.5	-0.8 ± 8.6
12-Jan-11	-0.5 ± 7.0	-1.3 ± 6.5	-0.2 ± 9.1
2-Aug-12	-3.7 ± 6.5	-4.9 ± 7.8	-3.7 ± 8.2
3-Aug-12	-0.9 ± 6.2	0.5 ± 6.8	-1.2 ± 8.6

The variability of the weight errors for the post-validations appears to have remained reasonably consistent since the site was first validated. However, the 95% confidence interval has increased since the first validation in 2008, possibly reflecting the increase in pavement roughness at the WIM site. From this information, it appears that the system demonstrates a tendency for the equipment to move toward an underestimation of GVW over time. Based on an analysis of the preceding validation data and the current validation data, this is most likely due to the change in temperature. The table also demonstrates the effectiveness of the validations in bringing the weight estimations within LTPP SPS WIM equipment tolerances.

8 Additional Information

The following information is provided in the attached appendix:

- Site Photographs
    - Equipment
    - Test Trucks
    - Pavement Condition
- Pre-validation Sheet 16 – Site Calibration Summary
- Post-validation Sheet 16 – Site Calibration Summary
- Pre-validation Sheet 20 – Classification and Speed Study
- Post-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 – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

New Mexico, SPS-1
SHRP ID: 350100

Validation Date: August 2, 2012

APPLIED RESEARCH ASSOCIATES, INC.

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Cabinet Interior (Back)

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Solar Panel

Photo 9 – Cellular Modem

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 5

Photo 27 – Truck 2 Suspension 4

Traffic Sheet 16	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	8/1/2012

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 8/1/12

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
   - b. Quartz Piezo
   - c.
   - 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	steel spring
Truck 3:			

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

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	-3.7%	Standard Deviation:	3.2%
Dynamic and Static Single Axle:	-4.9%	Standard Deviation:	3.8%
Dynamic and Static Double Axles:	-3.7%	Standard Deviation:	4.0%

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

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

			Low		High	Runs
a.	Low	-	47.0	to	54.0	14
b.	Medium	-	54.1	to	61.1	14
c.	High	-	61.2	to	68.0	12
d.		-		to		
e.		-		to		

Traffic Sheet 16	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	8/1/2012

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3201 | 2907

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:	0.0	FHWA Class	5	-	7.0
FHWA Class 8:	100.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 1.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort:

Contact Information: Phone:

E-mail:

Traffic Sheet 16	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	8/2/2012

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 8/2/12

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. Quartz Piezo 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	steel spring
Truck 3:			

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

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	-0.9%	Standard Deviation:	3.1%
Dynamic and Static Single Axle:	0.5%	Standard Deviation:	3.3%
Dynamic and Static Double Axles:	-1.2%	Standard Deviation:	4.2%

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

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

			Low		High	Runs
a.	Low	-	48.0	to	54.7	14
b.	Medium	-	54.8	to	61.4	13
c.	High	-	61.5	to	68.0	13
d.		-		to		
e.		-		to		

Traffic Sheet 16	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	8/2/2012

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3266 | 2966

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	-	11.0
FHWA Class 8:	50.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Post

Person Leading Calibration Effort:

Contact Information: Phone:

E-mail:

Traffic Sheet 20					STATE CODE:			35	
LTPP MONITORED TRAFFIC DATA					SPS WIM ID:			350100	
SPEED AND CLASSIFICATION STUDIES					DATE (mm/dd/yyyy)			8/1/2012	

Count - 104 Time = 2:59:00 Trucks (4-15) - 100 Class 3s - 4

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	8	29	64	8	62	9	147	62	9
78	9	32	78	9	**75**	**5**	**149**	**74**	**3**
74	9	33	73	9	64	9	153	63	9
65	9	42	65	9	68	9	160	67	9
69	9	51	67	9	67	9	164	66	9
71	5	58	70	5	67	9	166	67	9
64	9	64	64	9	72	9	181	70	9
68	9	70	67	9	75	5	182	75	5
83	9	76	83	9	67	9	184	68	9
70	9	86	69	9	68	9	186	68	9
64	9	90	63	9	71	9	194	70	9
63	9	104	62	9	67	5	212	66	5
70	9	105	68	9	**68**	**8**	**213**	**67**	**5**
62	9	106	62	9	67	6	214	66	6
64	9	109	64	9	73	9	215	71	9
67	9	110	66	9	67	9	221	67	9
75	9	111	74	9	**72**	**15**	**224**	**71**	**3**
67	**5**	**115**	**67**	**3**	**73**	**5**	**229**	**73**	**3**
68	9	116	67	9	70	9	246	70	9
66	9	120	66	9	67	9	250	65	9
67	9	122	66	9	60	9	253	59	9
74	9	133	74	9	62	9	254	62	9
74	9	139	73	9	74	9	258	74	9
72	5	143	71	5	67	9	264	65	9
68	9	146	66	9	68	9	269	68	9

Sheet 1 - 0 to 50 Start: 14:05:00 Stop: 15:21:00

Recorded By: djw Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 35 SPS WIM ID: 350100 DATE (mm/dd/yyyy) 8/1/2012

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
68	5	279	68	5	68	9	478	67	9
70	9	281	70	9	68	9	483	67	9
69	5	287	67	5	70	9	484	70	9
56	9	289	55	9	67	9	485	69	9
70	9	291	70	9	62	9	489	61	9
67	9	292	66	9	49	9	496	49	9
67	9	295	67	9	47	9	497	47	9
55	9	304	54	9	64	10	498	65	10
65	9	306	65	9	65	10	499	65	10
68	9	314	67	9	**65**	**8**	**510**	**65**	**5**
75	5	319	74	5	65	12	520	65	12
70	9	332	70	9	68	9	523	68	9
62	9	350	62	9	75	9	526	75	9
70	9	357	70	9	77	9	527	77	9
70	9	379	69	9	69	9	528	70	9
68	9	382	68	9	68	9	530	68	9
76	5	392	75	5	73	8	542	72	8
74	9	397	72	9	71	9	543	70	9
62	11	405	62	11	68	5	545	67	5
65	9	406	67	9	70	9	551	70	9
72	5	410	72	5	63	5	552	64	5
70	5	425	70	5	72	9	562	70	9
60	9	435	60	9	58	9	569	58	9
66	9	441	66	9	58	9	571	58	9
80	9	473	78	9	65	9	572	65	9

Sheet 2 - 51 to 100 Start: 15:22:00 Stop: 16:55:00

Recorded By: djw Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 35 SPS WIM ID: 350100 DATE (mm/dd/yyyy) 8/1/2012

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
72	9	584	70	9					
59	11	586	60	11					
70	9	595	70	9					
68	9	597	68	9					

Sheet 3 - 101 - 150 Start: 16:56:00 Stop: 17:04:00

Recorded By: djw Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES					STATE CODE:			35	
					SPS WIM ID:			350100	
					DATE (mm/dd/yyyy)			8/2/2012	
Count - 106		Time = 3:09:00			Trucks (4-15) - 100			Class 3s - 6	
WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
67	10	2259	67	10	64	5	2429	64	5
73	5	2266	73	5	66	5	2432	66	5
75	5	2284	74	5	71	9	2435	71	9
67	9	2288	67	9	74	9	2437	74	9
69	9	2290	69	9	62	9	2441	61	9
75	5	2291	75	5	70	5	2443	68	5
75	5	2298	75	5	68	5	2461	68	5
64	9	2319	64	9	**65**	**5**	**2464**	**64**	**3**
64	**9**	**2321**	**64**	**3**	78	8	2465	76	8
62	9	2324	62	9	64	9	2474	65	9
66	9	2329	65	9	73	9	2475	73	9
72	9	2340	72	9	70	9	2485	70	9
62	9	2348	62	9	68	9	2486	67	9
65	9	2356	65	9	67	9	2487	67	9
65	9	2365	66	9	70	5	2488	70	5
65	9	2378	65	9	70	9	2503	70	9
71	5	2380	70	5	62	8	2504	62	8
63	9	2384	63	9	77	5	2506	76	5
56	**5**	**2389**	**55**	**3**	64	9	2510	62	9
57	11	2393	57	11	65	9	2512	65	9
62	9	2400	62	9	67	5	2514	67	5
49	9	2401	49	9	73	9	2537	72	9
49	9	2402	49	9	67	5	2556	67	5
73	9	2413	72	9	65	9	2573	65	9
76	5	2419	75	5	**79**	**5**	**2575**	**77**	**3**

Sheet 1 - 0 to 50 Start: 7:37:00 Stop: 9:11:00

Recorded By: djw Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	8/2/2012

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
72	10	2580	71	10	67	5	2798	67	5
59	9	2588	59	9	74	9	2803	74	9
67	9	2591	67	9	49	9	2819	49	9
68	5	2692	67	5	48	9	2823	48	9
71	9	2713	71	9	73	5	2824	73	5
66	9	2721	66	9	62	5	2825	62	5
70	9	2722	68	9	77	5	2831	75	5
71	9	2725	70	9	65	5	2835	65	5
68	9	2726	69	9	76	5	2841	77	5
65	9	2733	65	9	65	9	2849	65	9
65	9	2737	65	9	65	9	2859	65	9
70	9	2746	70	9	**76**	**3**	**2861**	**76**	**5**
77	6	2748	76	6	59	9	2864	59	9
71	9	2749	71	9	60	9	2865	60	9
74	6	2753	72	6	71	9	2874	71	9
75	4	2755	73	4	62	9	2875	62	9
73	9	2756	73	9	68	9	2876	67	9
66	9	2761	66	9	65	6	2878	66	6
77	**5**	**2763**	**76**	**3**	68	5	2883	68	5
74	**8**	**2765**	**74**	**5**	69	5	2891	68	5
70	**5**	**2768**	**70**	**3**	73	9	2895	71	9
68	9	2773	68	9	65	5	2897	65	5
66	9	2775	66	9	68	9	2921	68	9
60	9	2786	60	9	66	9	2923	66	9
68	5	2790	68	5	59	9	2924	59	9

Sheet 2 - 51 to 100 Start: 9:12:00 Stop: 10:46:00

Recorded By: djw Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 35 SPS WIM ID: 350100 DATE (mm/dd/yyyy) 8/2/2012

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
70	9	2932	72	9					
70	9	2949	69	9					
64	9	2955	65	9					
70	9	2956	71	9					
73	9	2958	73	9					
61	9	2970	61	9					

Sheet 3 - 101 - 150 Start: 10:47:00 Stop: ____________

Recorded By: djw Verified By: djw

Validation Test Truck Run Set - Post