WIM System Field Calibration and Validation Summary Report

Arkansas SPS-5
SHRP ID – 050200

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1 Executive Summary

A WIM validation was performed on March 08 and 09, 2011 at the Arkansas SPS-5 site located on route I-30 at milepost 101.8, 2.2 miles east of US 270.

This site was installed on mid-winter, 2006. The in-road sensors are installed in the westbound 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 October 29, 2008 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 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 discernable truck bouncing in the area of the WIM scales. The significant speed trends associated with steering axle weight estimates (and consequently, GVW) may be directly associated with the adverse truck dynamics and may have affected 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 – 09-Mar-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	1.7 ± 9.0%	Pass
Single Axles	±20 percent	0.8 ± 10.3%	Pass
Tandem Axles	±15 percent	0.9 ± 6.9%	Pass
GVW	±10 percent	1.6 ± 3.9%	Pass
Vehicle Length	±3.0 percent (2.1 ft)	0.3 ± 1.1 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 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 -0.5 ± 2.0 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 0.0 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 1.0% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 1.8% from the 109 truck sample (Class 4 – 13) was due to one Class 5 vehicle being misclassified as a Class 8, and one Class 9 misclassified as a Class 6.

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 barriers.

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

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	75.6	12.5	15.2	15.2	16.4	16.4	19.8	4.4	37.4	4.7	66.3	70.1
2	67.0	10.5	14.6	14.6	13.6	13.6	17.5	4.4	30.5	10.1	62.5	67.0

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 52 to 65 mph, a variance of 13 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 49.4 to 54.3 degrees Fahrenheit, a range of 4.9 degrees Fahrenheit. The cloudy weather conditions prevented attaining the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 24 shows that there are 24 consecutive months of level “E” WIM data for this site. This site requires at least 3 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 November 08, 2010 (Data) to the most recent Comparison Data Set (CDS) from November 10, 2008. 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 24 shows that there are 2 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2007 and 2009. The 2009 data does not meet the 210-day minimum requirement for a calendar year.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2007	229	8
2008	221	9
2009	94	5

As shown in the table, this site requires 3 additional years of data to meet the minimum of five years of research quality data.

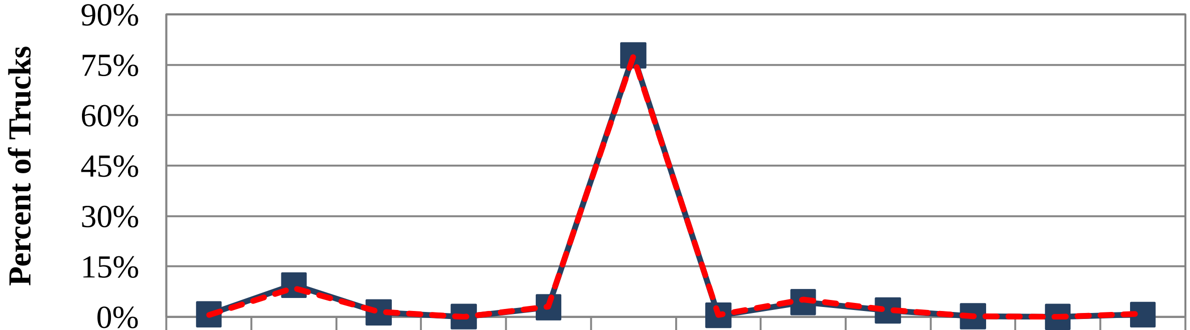
Table 2-2 provides a monthly breakdown of the available data for years 2007 through 2009.

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					15	30	31	31	30	31	30	31	8
2008		29		30	31	5		5	30	30	30	31	9
2009	13		13	30	31	7							5

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	0.8%	9.5%	1.3%	0.1%	2.9%	77.8%	0.5%	4.4%	1.9%	0.2%	0.0%	0.7%
CDS	0.6%	8.6%	1.5%	0.1%	3.0%	77.4%	0.5%	5.1%	2.0%	0.2%	0.0%	0.9%

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 (77.8%) and Class 5 (9.5%). 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 0.7 percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	11/10/2008		11/8/2010		
4	445	0.6%	573	0.8%	0.2%
5	6523	8.7%	7108	9.5%	0.8%
6	1179	1.6%	1010	1.3%	-0.2%
7	51	0.1%	66	0.1%	0.0%
8	2329	3.1%	2167	2.9%	-0.2%
9	57942	77.3%	58335	77.8%	0.5%
10	364	0.5%	349	0.5%	0.0%
11	3875	5.2%	3299	4.4%	-0.8%
12	1501	2.0%	1447	1.9%	-0.1%
13	113	0.2%	136	0.2%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	678	0.9%	510	0.7%	-0.2%

From the table it can be seen that the number of Class 9 vehicles has increased by 0.5 percent from November 2008 to November 2010. Changes in the number of heavier trucks may be attributed to seasonal variations in truck distributions and to natural variation in truck volumes. During the same time period, the number of Class 5 trucks increased by 0.8 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.

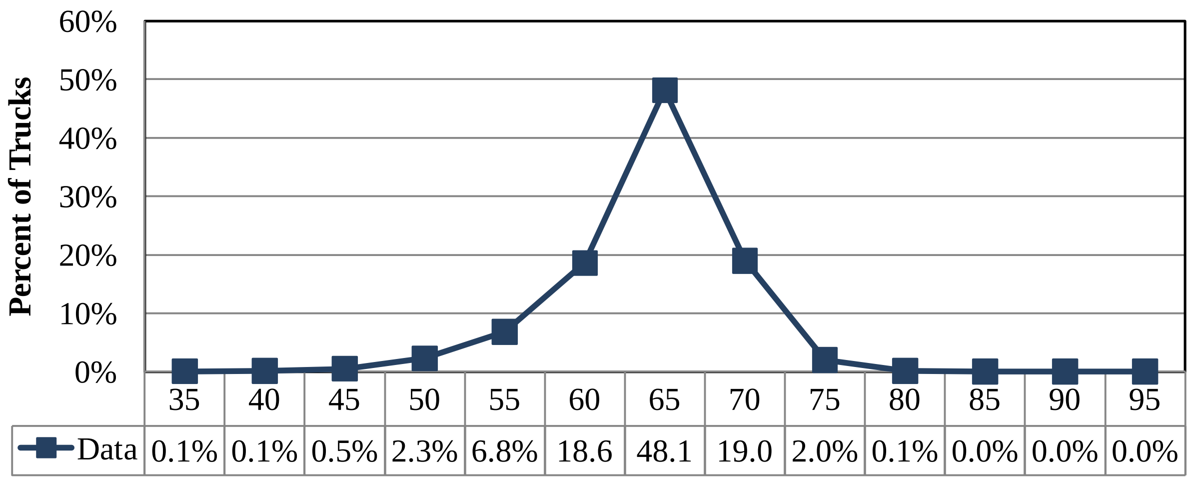


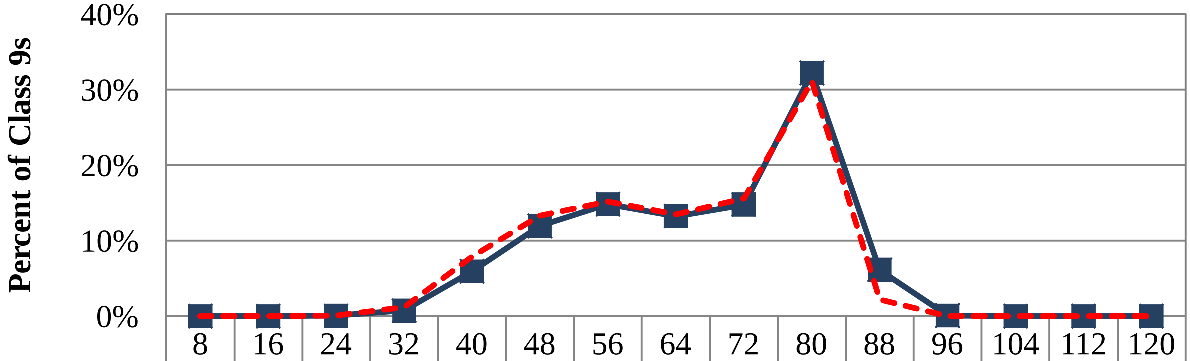
Figure 2-2 – Truck Speed Distribution – 11-Feb-11

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 66 mph. The range of truck speeds for the validation will be 55 and 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 November 2010 and the Comparison Data Set from November 2008.

As shown in Figure 2-3, there is a slight downward shift for the unloaded peak between the November 2008 Comparison Data Set (CDS) and the November 2010 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%	0.1%	0.7%	6.0%	12.0	14.9	13.3	14.8	32.2	6.1%	0.1%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	1.2%	7.9%	13.3	15.2	13.5	15.6	31.1	2.2%	0.0%	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

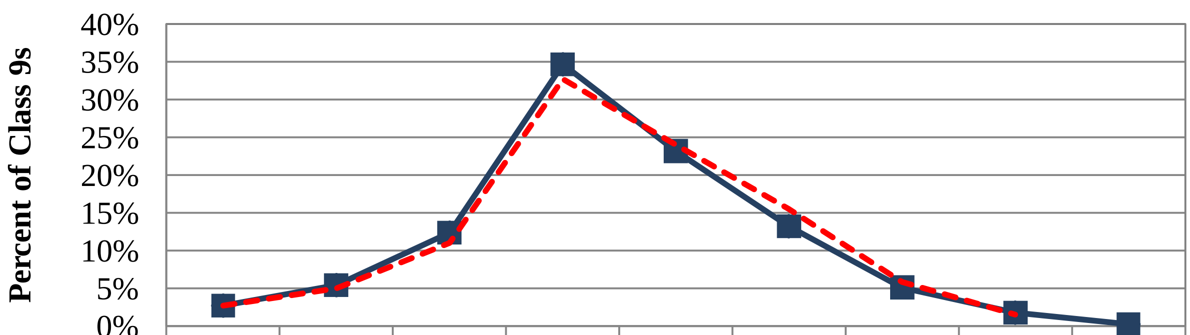
GVW weight bins (kips)	CDS		Data		Change
	Date				
	11/10/2008		11/8/2010		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	48	0.1%	33	0.1%	0.0%
32	685	1.2%	407	0.7%	-0.5%
40	4600	8.0%	3197	5.5%	-2.5%
48	7698	13.3%	6590	11.3%	-2.0%
56	8734	15.1%	8663	14.9%	-0.2%
64	7779	13.5%	7933	13.6%	0.2%
72	8952	15.5%	8520	14.6%	-0.9%
80	17964	31.1%	17994	30.9%	-0.2%
88	1246	2.2%	4797	8.2%	6.1%
96	17	0.0%	70	0.1%	0.1%
104	5	0.0%	3	0.0%	0.0%
112	3	0.0%	0	0.0%	0.0%
120	1	0.0%	2	0.0%	0.0%
Average =	60.6 kips		64.3 kips		3.7 kips

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range decreased by 2.5 percent while the number of loaded class 9 trucks in the 72 to 80 kips range decreased by 0.2 percent. The number of overweight trucks increased during this time period by 6.2 percent and based on the average Class 9 GVW values from the per vehicle records, the overall GVW average for this site increased 6.1 percent, from 60.6 kips to 64.3 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 November 2010 and the Comparison Data Set from November 2008.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Data	2.7%	5.4%	12.4%	34.7%	23.2%	13.2%	5.1%	1.8%	0.2%
CDS	2.7%	5.0%	11.0%	32.7%	24.0%	15.5%	5.9%	1.6%	

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 by 0.3% between the November 2008 Comparison Data Set (CDS) and the November 2010 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the November 2008 Comparison Data Set (CDS) and the November 2010 dataset (Data).

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

F/A weight bins (kips)	CDS		Data		Change
	Date				
	11/10/2008		11/8/2010		
9.0	3334	1.6%	734	1.3%	-0.3%
9.5	6287	3.0%	1476	2.5%	-0.4%
10.0	11515	5.5%	2937	5.1%	-0.4%
10.5	24918	11.9%	6740	11.6%	-0.2%
11.0	70127	33.4%	19541	33.7%	0.3%
11.5	49434	23.5%	13522	23.3%	-0.2%
12.0	30408	14.5%	8117	14.0%	-0.5%
12.5	10785	5.1%	3336	5.8%	0.6%
13.0	2860	1.4%	1356	2.3%	1.0%
13.5	301	0.1%	242	0.4%	0.3%
Average =	11.0 kips		11.1 kips		0.1 kips

The table shows that the average front axle weight for Class 9 trucks has increased by 0.1 kips, or 0.9 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 11.1 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 with the expected average tractor tandem spacing from the comparison data set.

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

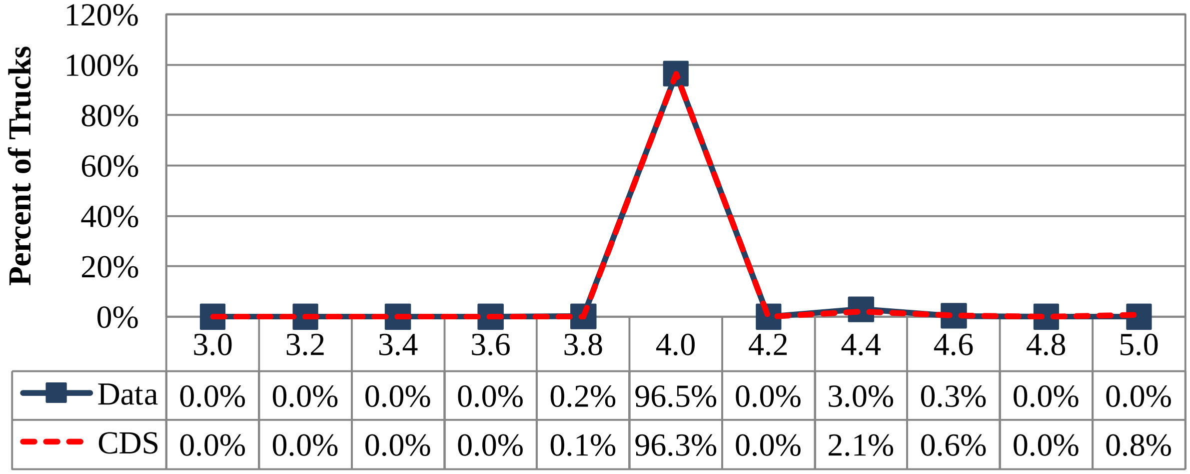


Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacing for the November 2008 Comparison Data Set and the November 2010 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 3 to 4 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	11/10/2008		11/8/2010		
3.0	3	0.0%	0	0.0%	0.0%
3.2	3	0.0%	4	0.0%	0.0%
3.4	21	0.0%	8	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	60	0.1%	143	0.2%	0.1%
4.0	55599	96.3%	56034	96.3%	0.0%
4.2	0	0.0%	0	0.0%	0.0%
4.4	1207	2.1%	1825	3.1%	1.0%
4.6	356	0.6%	194	0.3%	-0.3%
4.8	0	0.0%	0	0.0%	0.0%
5.0	483	0.8%	1	0.0%	-0.8%
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 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 (November 2008) based on the last calibration with the most recent two-week WIM data sample from the site (November 2010). Comparison of vehicle class distribution data indicates a 0.5 percent increase in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 0.9 percent and average Class 9 GVW has increased by 6.1 percent for the November 2010 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical 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 October 29, 2008 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 mid-winter, 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

During the pre-visit equipment operational check, it was reported that the equipment power had been inadvertently disconnected by nearby roadside construction, postponing the validation visit. Once power had been reestablished the site visit was rescheduled. During the physical inspection, it was discovered that pre-existing traffic monitoring equipment cabinets had been removed, as shown in

Figure 3-1 – Concrete Pedestals at Old Cabinet Location

Since power for the current system had been run from these cabinets, it was concluded that the removal of these cabinets was the cause for the temporary interruption.

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. 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.

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

The adverse truck dynamics within the WIM scale are should be further investigated to ensure that the WIM installation is not the contributing catalyst. It should be verified through close inspection of the WIM scales that they are level with the pavement surface and not protruding at the leading or trailing edges. No other 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 February 18, 2010 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 208 in/mi and is located approximately 682 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 245 in/mi and is located approximately 217 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 area indicated visible bouncing of the trucks at the WIM scale location that may have affected 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 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)	0.912	1.079	1.460			1.150
		SRI (m/km)	0.553	0.775	1.072			0.800
		Peak LRI (m/km)	0.978	1.774	1.581			1.444
		Peak SRI (m/km)	1.130	1.362	1.901			1.464
	RWP	LRI (m/km)	0.799	1.220	1.484			1.168
		SRI (m/km)	*0.453*	0.919	1.237			0.870
		Peak LRI (m/km)	0.959	1.401	1.580			1.313
		Peak SRI (m/km)	*0.675*	1.733	1.561			1.323
Center	LWP	LRI (m/km)	1.302	1.430	1.162	0.794	1.003	1.172
		SRI (m/km)	0.799	1.127	0.588	0.563	1.125	0.769
		Peak LRI (m/km)	1.500	1.546	1.712	1.046	1.501	1.451
		Peak SRI (m/km)	1.089	1.536	1.175	0.933	1.127	1.183
	RWP	LRI (m/km)	1.582	1.477	1.276	0.784	1.204	1.280
		SRI (m/km)	2.109	1.132	1.698	*0.400*	0.902	1.335
		Peak LRI (m/km)	1.680	1.799	1.653	0.881	1.936	1.503
		Peak SRI (m/km)	**2.390**	**1.571**	**1.725**	***0.734***	**1.724**	**1.605**
Right	LWP	LRI (m/km)	1.822	0.930	0.737			1.163
		SRI (m/km)	1.507	0.528	0.673			0.903
		Peak LRI (m/km)	1.868	0.970	0.854			1.231
		Peak SRI (m/km)	1.516	0.907	0.838			1.087
	RWP	LRI (m/km)	1.169	0.954	0.971			1.031
		SRI (m/km)	1.160	1.154	1.071			1.128
		Peak LRI (m/km)	1.787	0.979	0.981			1.249
		Peak SRI (m/km)	1.704	1.480	1.410			1.531

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 (shown in italics). The highest values, on average, are the Peak SRI values in the right wheel path of the center passes (shown in bold).

4.4 Recommended Pavement Remediation

Due to the higher SRI values for the center profile runs shown in Table 4-2, straightedge pavement smoothness testing is recommended in the area of the WIM scales to ensure that the pavement condition is not contributing to the adverse truck bouncing in the area of the WIM scales. No pavement remediation is recommended at this time.

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 41 pre-validation test truck runs were conducted on March 08, 2011, beginning at approximately 8:19 AM and continuing until 2:15 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with concrete barriers, 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 concrete barriers, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and split 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

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-3.8 ± 6.3%	Pass
Single Axles	±20 percent	1.3 ± 9.0%	Pass
Tandem Axles	±15 percent	4.6 ± 6.4%	Pass
GVW	±10 percent	3.6 ± 4.7%	Pass
Vehicle Length	±3.0 percent (2.1 ft)	-2.0 ± 1.1 ft	FAIL
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.1 ft	Pass

Test truck speeds varied by 13 mph, from 52 to 65 mph. The measured pre-validation pavement temperatures varied 5.4 degrees Fahrenheit, from 46.2 to 51.6. The cloudy and rainy weather conditions prevented attaining the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation test truck weights and measurements.

Table 5-2 – Pre-Validation Overall Results – 08-Mar-11

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.3	12.3	15.1	15.1	16.4	16.4	19.8	4.4	37.4	4.7	66.3	70.1
2	67.6	10.8	14.7	14.7	13.7	13.7	17.5	4.4	30.5	10.1	62.5	67.0

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 -1.2 ± 3.6 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 -0.1 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.

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 below.

Table 5-3 – Pre-Validation Results by Speed – 08-Mar-11

Parameter	**95% Confidence Limit of Error**	**Low**	**Medium**	**High**
		52.0 to 56.3 mph	**56.4 to 60.8 mph**	**60.9 to 65.0 mph**
Steering Axles	±20 percent	-3.3 ± 3.5%	-1.3 ± 3.1%	-7.0 ± 6.4%
Single Axles	±20 percent	0.1 ± 5.6%	1.7 ± 8.6%	2.2 ± 9.7%
Tandem Axles	±15 percent	2.7 ± 4.9%	6.5 ± 8.0%	4.9 ± 6.6%
GVW	±10 percent	2.1 ± 4.0%	4.8 ± 3.0%	4.2 ± 5.9%
Vehicle Length	±3.0 percent (2.1 ft)	-1.9 ± 1.1 ft	-2.0 ± 1.0 ft	-2.1 ± 1.3 ft
Vehicle Speed	± 1.0 mph	-1.3 ± 4.8 mph	-1.2 ± 3.9 mph	-1.1 ± 2.4 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	-0.1 ± 0.2 ft	-0.1 ± 0.1 ft

From the table, it can be seen that the WIM equipment underestimated steering axle weights at all speeds. The error and variance of error was greater at the higher speeds when compared with the low and medium speeds. GVW, single axle and tandem axle weights were overestimated at all speeds. There does appear to be a relationship between steering axle weight estimates and speed at this site, where variance in error is significantly greater at the higher speeds. This may be caused by rough pavement within or near the WIM scales, or a problem with the WIM scale installation.

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 overestimated GVW at all speeds. There does not appear to be a correlation between speed and weight estimates at this site.

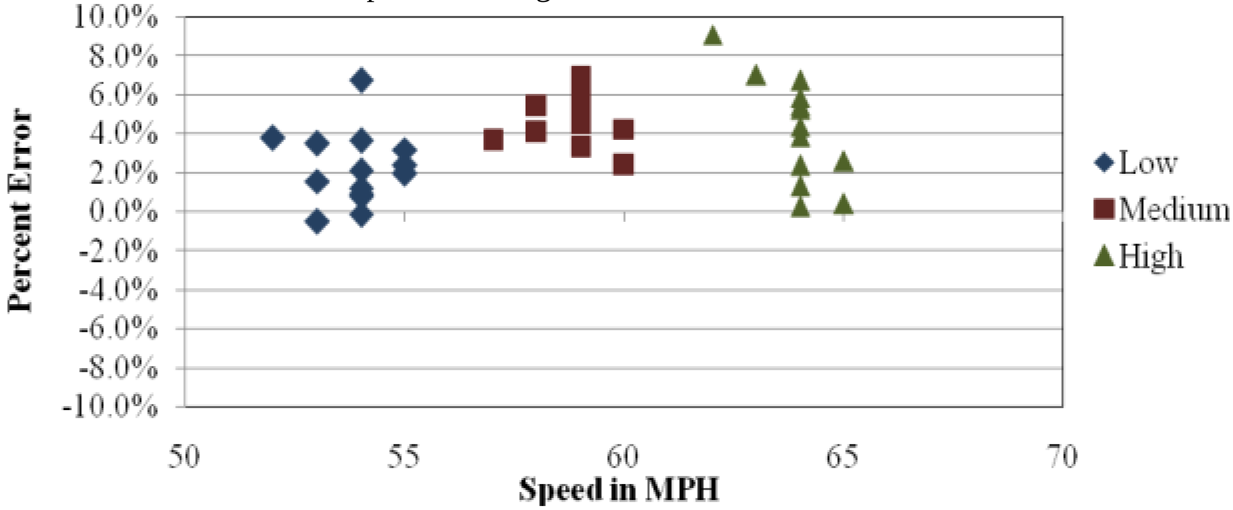


Figure 5-1 – Pre-Validation GVW Error by Speed – 08-Mar-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment underestimated steering axle weights at all speeds. The underestimation is significantly greater at the high speed group compared with low and medium speed groups. The range in error is also greater at the high speed.

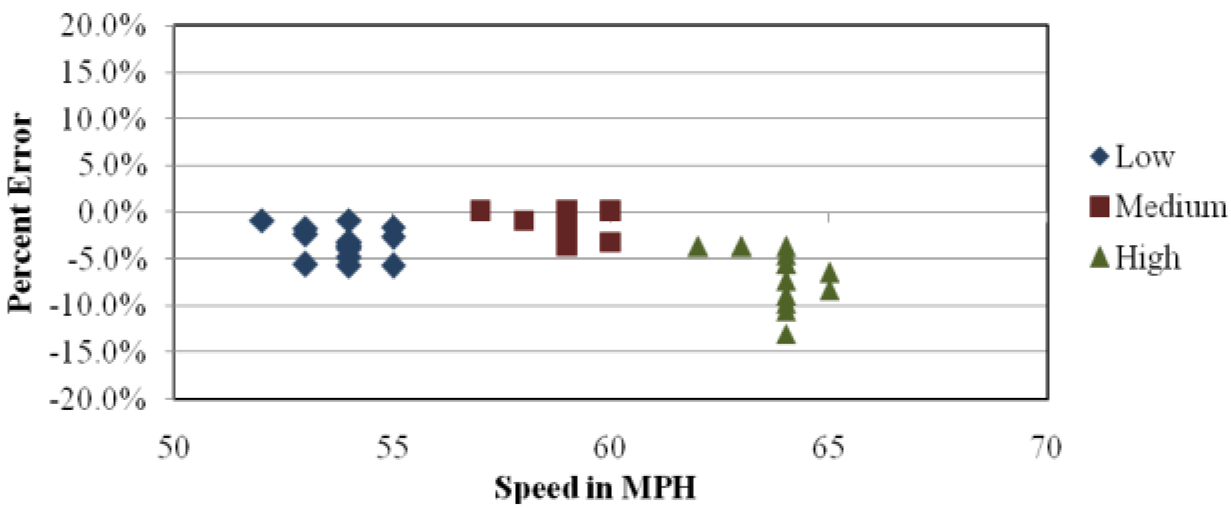


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 08-Mar-11

5.1.1.3 Single Axle Weight Errors by Speed

Single axles include the steering axles and any axles pairs on the either the truck or trailer that are separated by more than 10 feet. As shown in Figure 5-3, for the single axle population as a whole the equipment estimates the weights with similar accuracy at all speed groups. The range in error is largest at the high speed group.

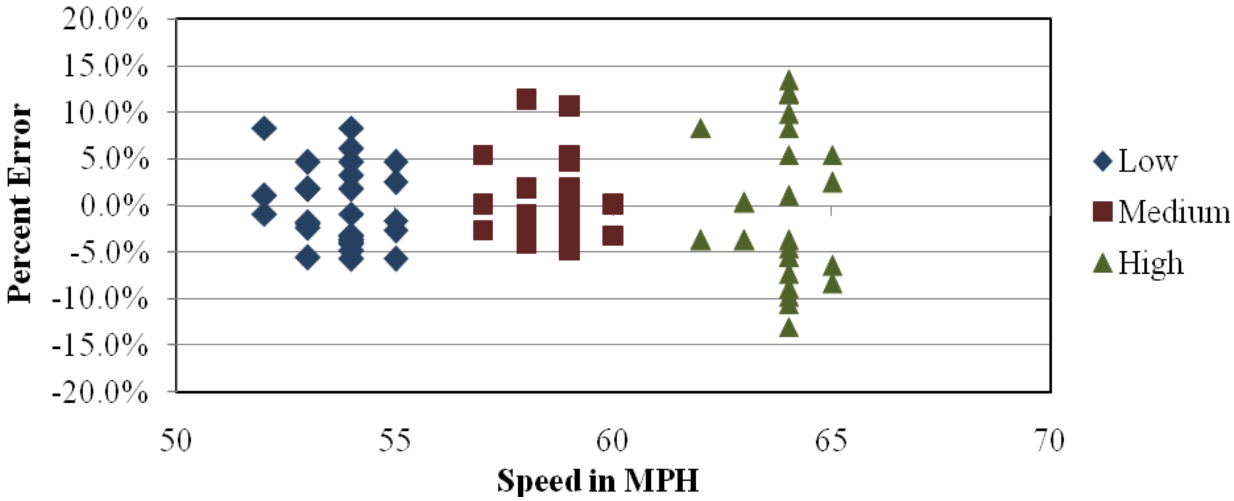


Figure 5-3 – Pre-Validation Single Axle Weight Errors by Speed – 08-Mar-11

5.1.1.4 Tandem Axle Weight Errors by Speed

As shown in Figure 5-4, the equipment overestimates tandem axle weights at all speeds. The range in error is similar throughout the entire speed range.

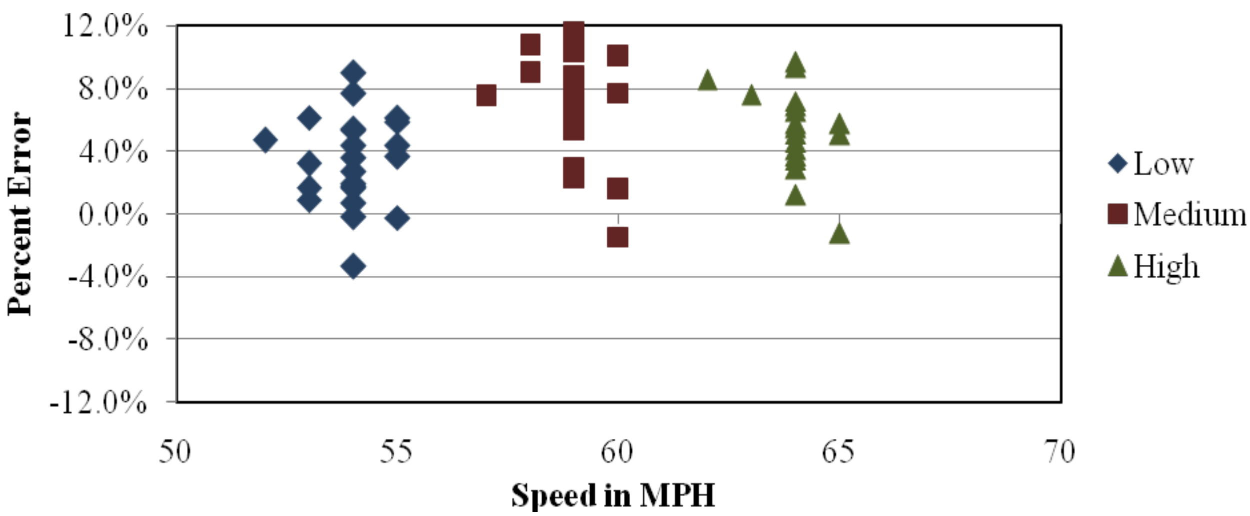


Figure 5-4 – Pre-Validation Tandem Axle Weight Errors by Speed – 08-Mar-11

5.1.1.5 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 overestimates GVW for the partially loaded (Secondary) truck to a greater degree than for the heavily loaded (Primary) truck at all speeds. Distribution of errors is shown graphically in Figure 5-5.

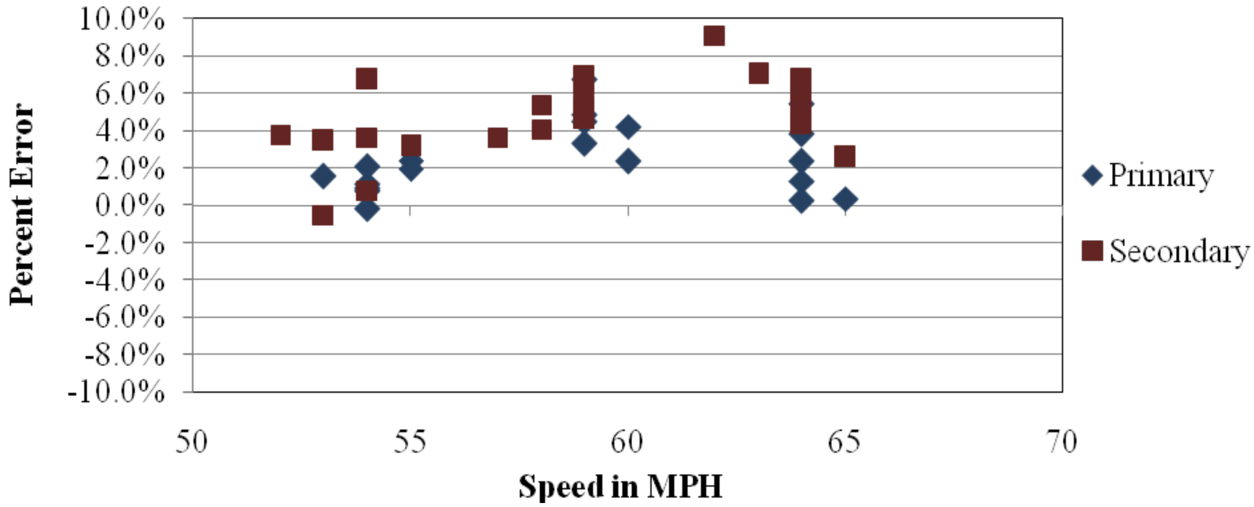


Figure 5-5 – Pre-Validation GVW Errors by Truck and Speed – 08-Mar-11

5.1.1.6 Axle Length Errors by Speed

For this site, the error in axle length measurements increased as speed increased. The range in axle length measurement error ranged from -0.3 feet to 0.0 feet. Distribution of errors is shown graphically in Figure 5-6.

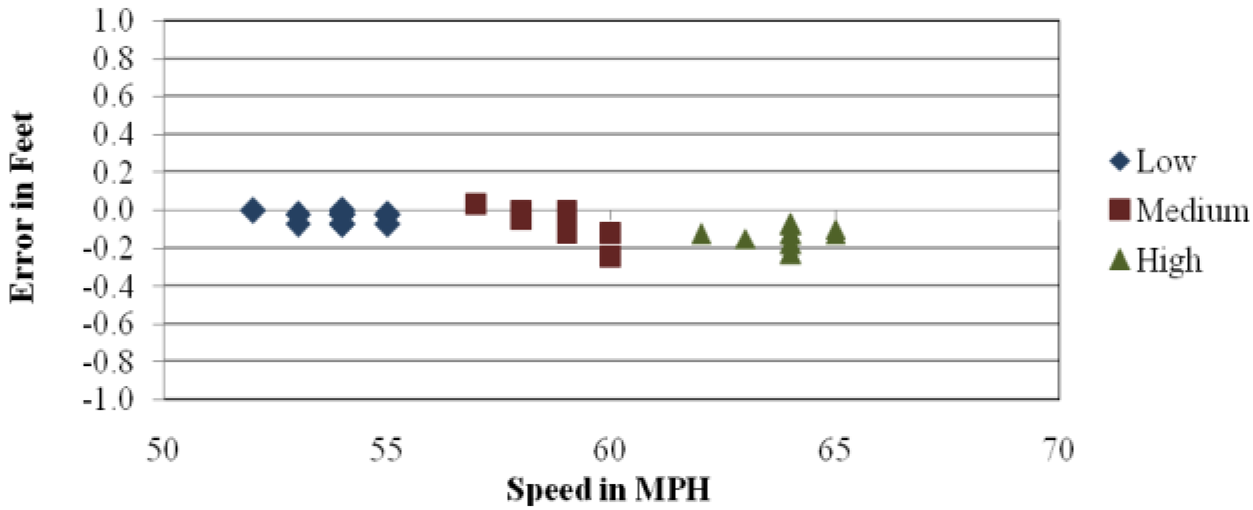


Figure 5-6 – Pre-Validation Axle Length Errors by Speed – 08-Mar-11

5.1.1.7 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 -3.0 to -1.1 feet. Distribution of errors is shown graphically in Figure 5-7.

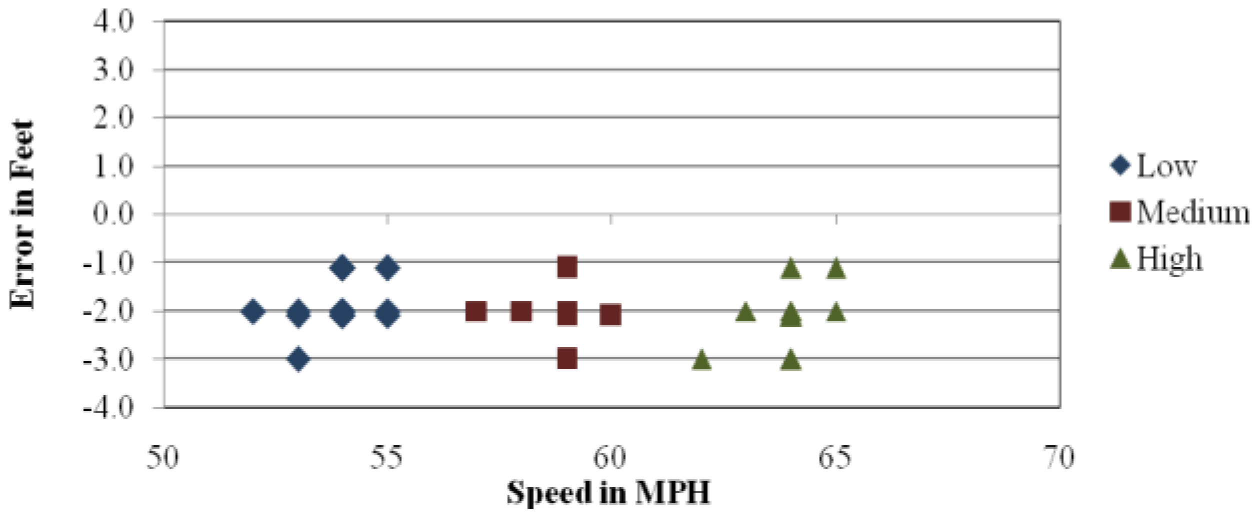


Figure 5-7 – Pre-Validation Overall Length Error by Speed – 08-Mar-11

5.1.2 Statistical Temperature Analysis

Due to a pavement temperature variation of only 5.4 degrees, from 46.2 to 51.6 degrees Fahrenheit, the statistical analysis for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy was limited. Consequently, the pre-validation test runs are being reported under one temperature group – medium, as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 08-Mar-11

Parameter	**95% Confidence Limit of Error**	**Medium**
		46.2 to 51.6 degF
Steering Axles	±20 percent	-3.8 ± 6.3%
Single Axles	±20 percent	1.3 ± 9.0%
Tandem Axles	±15 percent	4.6 ± 6.4%
GVW	±10 percent	3.6 ± 4.7%
Vehicle Length	±3.0 percent (2.1 ft)	-2.0 ± 1.1 ft
Vehicle Speed	± 1.0 mph	-1.2 ± 3.6 mph
Axle Length	± 0.5 ft [150mm]	-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, and axle group weights.

5.1.2.1 GVW Errors by Temperature

From Figure 5-8, it can be seen that the equipment appears to overestimate GVW across the range of temperatures observed in the field.

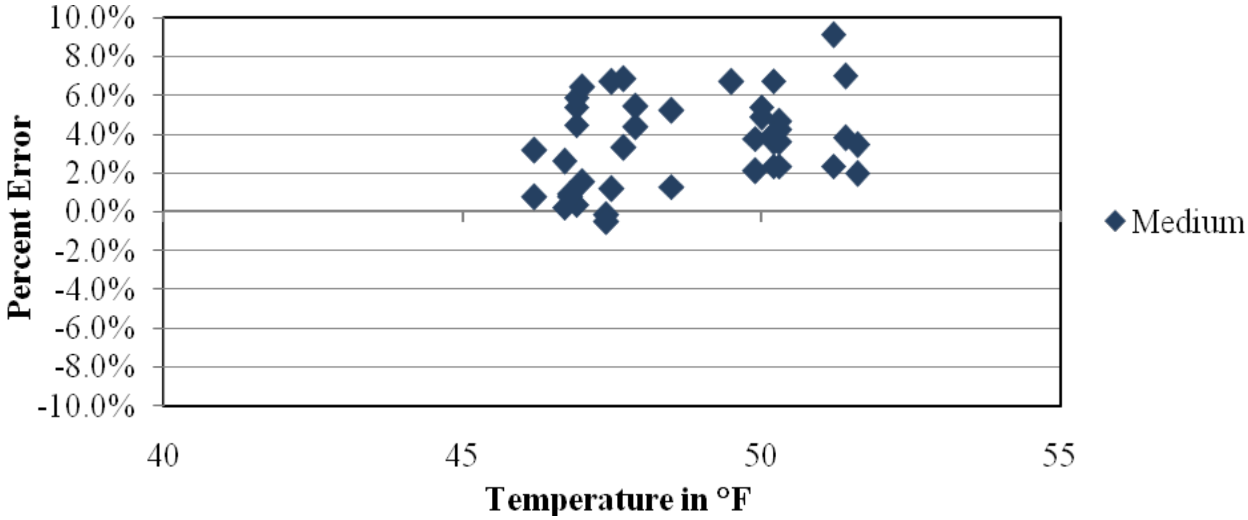


Figure 5-8 – Pre-Validation GVW Errors by Temperature – 08-Mar-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-9 illustrates that for steering axles, the WIM equipment appears to underestimate steering axle weights across the range of temperatures observed in the field.

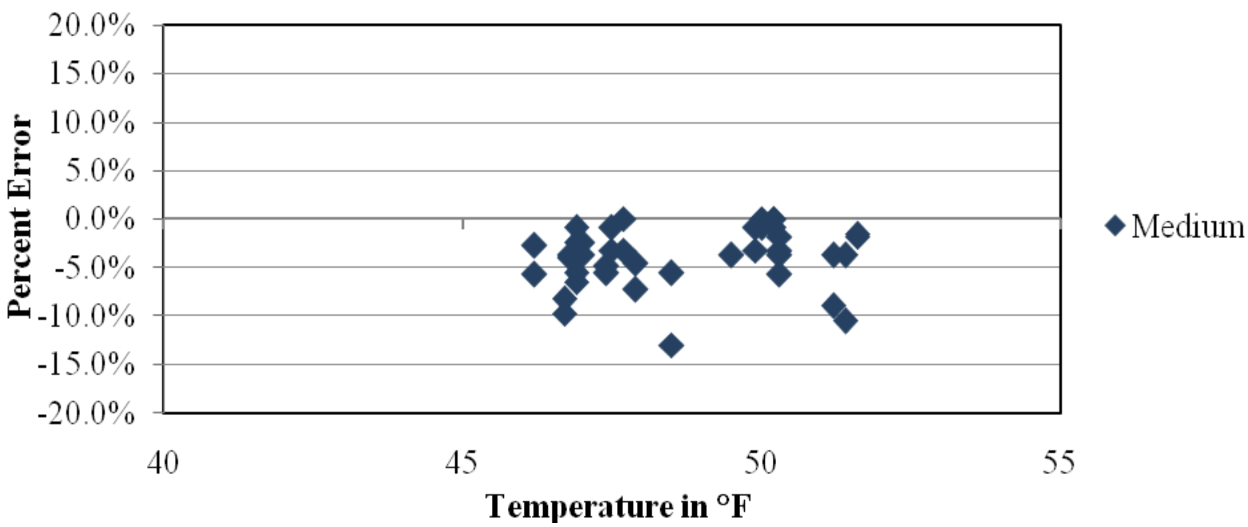


Figure 5-9 – Pre-Validation Steering Axle Weight Errors by Temperature – 08-Mar-11

5.1.2.3 Single Axle Weight Errors by Temperature

Figure 5-10 demonstrates that for loaded single axles, the WIM equipment appears to underestimate single axle weights across the range of temperatures observed in the field.

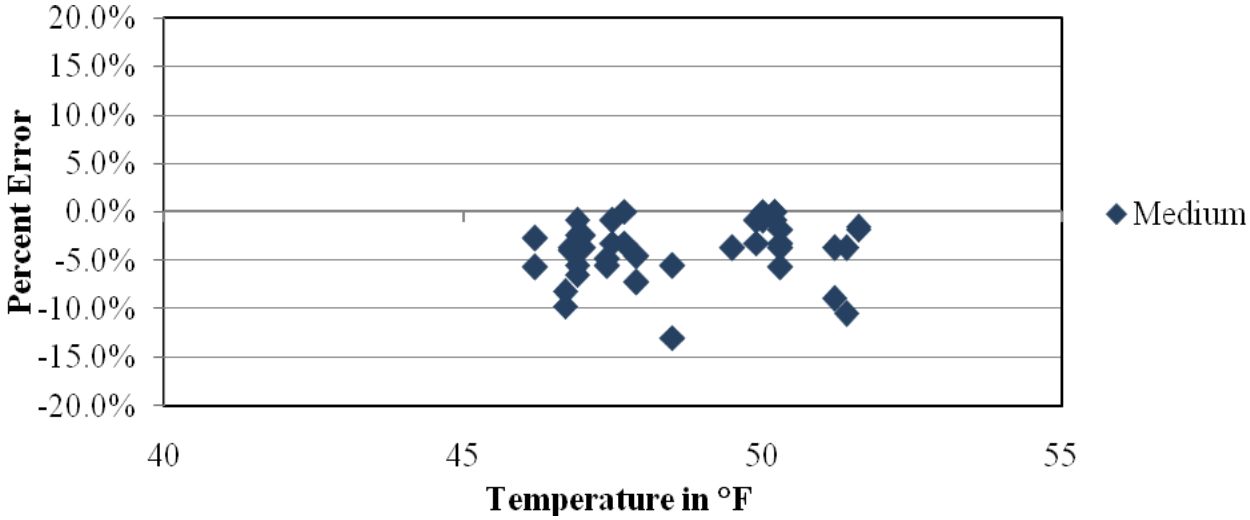


Figure 5-10 – Pre-Validation Single Axle Weight Errors by Temperature – 08-Mar-11

5.1.2.4 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-11, the WIM equipment appears to overestimate tandem axle weights across the range of temperatures observed in the field.

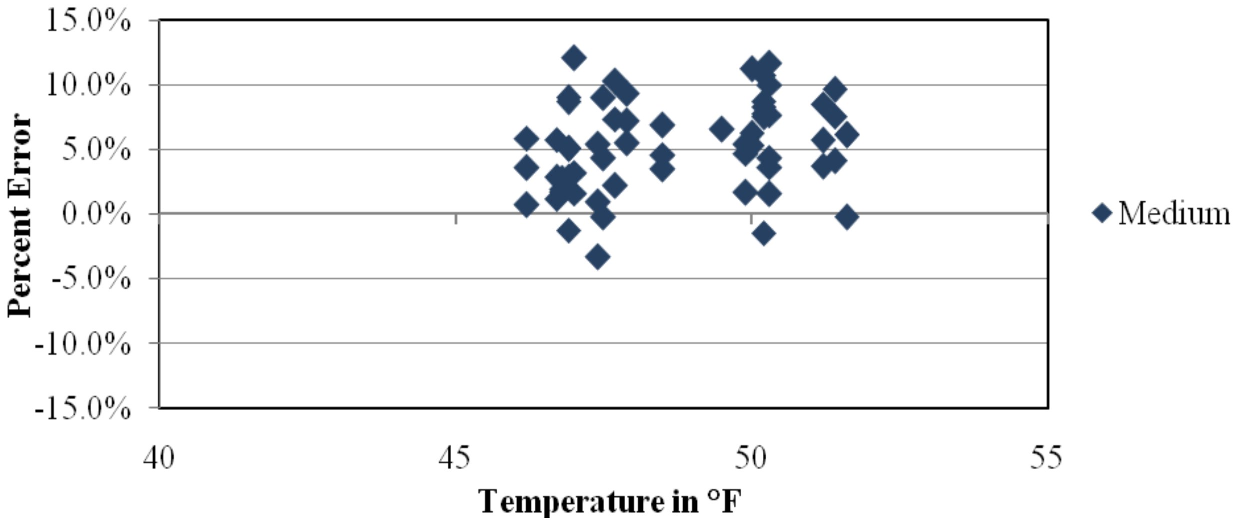


Figure 5-11 – Pre-Validation Tandem Axle Weight Errors by Temperature – 08-Mar-11

5.1.2.5 GVW Errors by Temperature and Truck Type

As shown in Figure 5-12, when analyzed for each test truck, it can be seen that the WIM equipment overestimates GVW for both the partially loaded (Secondary) and the heavily loaded (Primary) truck at all temperatures.

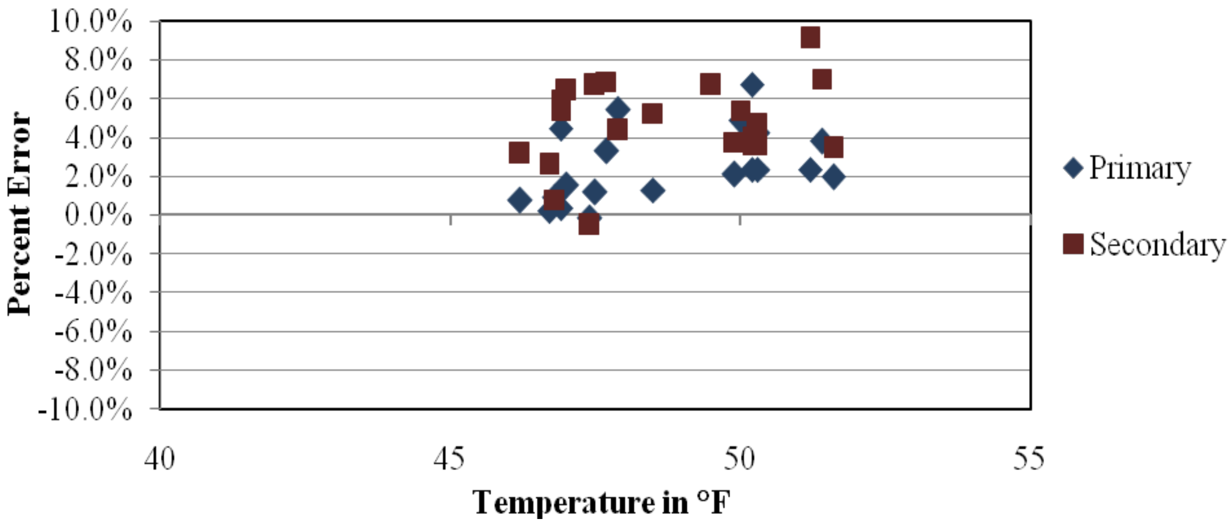


Figure 5-12 – Pre-Validation GVW Error by Truck and Temperature – 08-Mar-11

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 100 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.

Table 5-5 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 class of vehicle but identified by the WIM equipment as another class of vehicle. As shown in the table, one Class 10 was misclassified as a Class 13, resulting in an undercount of one Class 10 and an overcount of one Class 13. The cause of the misclassification was not investigated in the field. There were no unclassified vehicles reported by the equipment.

Table 5-5 – Pre-Validation Classification Study Results – 08-Mar-11

Class	4	5	6	7	8	9	10	11	12	13
Observed Count	0	4	0	0	2	93	1	0	0	0
WIM Count	0	4	0	0	2	93	0	0	0	1
Observed Percent	0.0	4.0	0.0	0.0	2.0	93.0	1.0	0.0	0.0	0.0
WIM Percent	0.0	4.0	0.0	0.0	2.0	93.0	0.0	0.0	0.0	1.0
Misclassified Count	0	0	0	0	0	0	1	0	0	0
Misclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Unclassified Count	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

The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-6.

Table 5-6 – Pre-Validation Misclassifications by Pair – 08-Mar-11

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

Based on the vehicles observed during the pre-validation study, the misclassification percentage is 1.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all trucks (4 – 15) is 1.0%.

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 – 08-Mar-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 100 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 -1.0 mph; the range of errors was 1.9 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 – 09-Mar-11

Speed Point	MPH	Left	Right
		1	2
80	50	3295	3133
88	55	3391	3224
96	60	3396	3229
104	65	3243	3083
112	70	3236	3077
Axle Distance (cm)		372	
Dynamic Comp (%)		100	
Loop Width (cm)		200	

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 3.6%, and errors of 2.1%, 4.8%, and 4.2% at the 55, 60 and 65 mph speed points respectively. The errors for the 55 mph and 65 mph speed points were extrapolated to derive new compensation factors for the 50 mph and 70 mph speed points. To compensate for these errors, the equipment factor changes given in Table 5-9 were made to the compensation factors. Note that the errors given in Table 5-9 reflect adjustments to the front axle correction factors, and so do not directly match the errors reported above.

Table 5-9 – Calibration 1 Equipment Factor Changes – 09-Mar-11

Speed Points	Old Factors		Error	New Factors	
	Left	Right		Left	Right
	1	2		1	2
80	3295	3133	3.50%	3070	3143
88	3391	3224	3.50%	3159	3235
96	3396	3229	6.62%	3071	3145
104	3243	3083	5.17%	2973	3044
112	3236	3077	5.17%	2967	3038
Axle Distance (cm)	372		0.2%	373	
Dynamic Comp (%)	100		-8.2%	109	
Loop Width (cm)	200		-2.0 ft	140	

5.2.1.2 Calibration 1 Results

The results of the 12 first calibration verification runs are provided in Table 5-10 and Figure 5-13. 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 – 09-Mar-11

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	0.8 ± 9.5%	Pass
Single Axles	±20 percent	0.0 ± 12.5%	Pass
Tandem Axles	±15 percent	0.0 ± 6.8%	Pass
GVW	±10 percent	0.8 ± 3.4%	Pass
Vehicle Length	±3.0 percent (2.1 ft)	0.2 ± 0.9 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.2 ft	Pass

Figure 5-13 shows that the WIM equipment is estimating GVW with reasonable accuracy at all speeds.

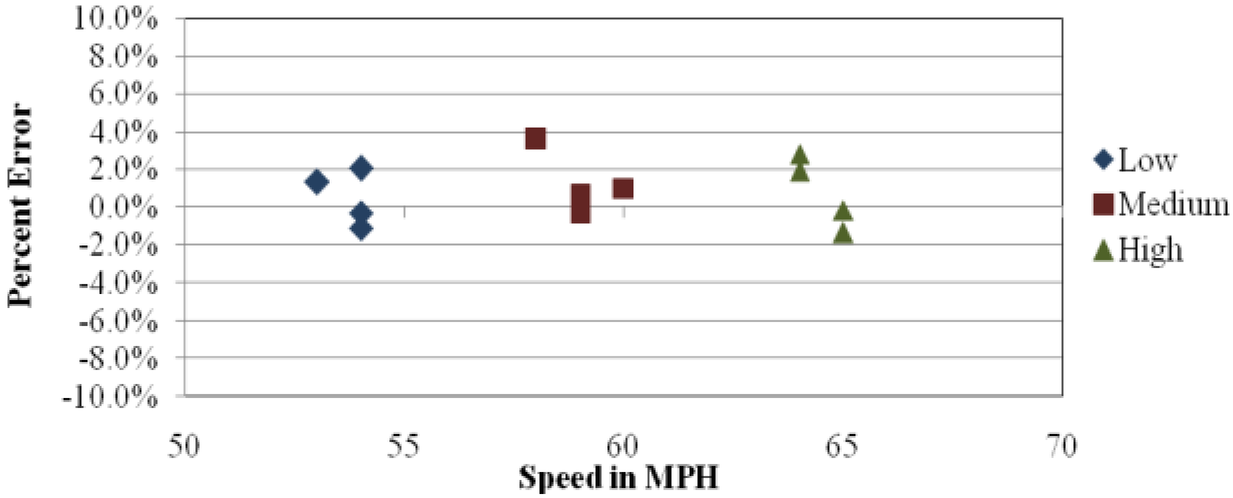


Figure 5-13 – Calibration 1 GVW Error by Speed – 09-Mar-11

Based on the results of the first calibration, where GVW estimate bias decreased to 0.8 percent, a second calibration was not considered to be necessary. The 12 calibration runs were combined with 28 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 40 post-validation test truck runs were conducted on March 09, 2011, beginning at approximately 7:16 AM and continuing until 2:23 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with concrete barriers, 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 concrete barriers, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and split 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	75.6	12.5	15.2	15.2	16.4	16.4	19.8	4.4	37.4	4.7	66.3	70.1
2	67.0	10.5	14.6	14.6	13.6	13.6	17.5	4.4	30.5	10.1	62.5	67.0

Test truck speeds varied by 13 mph, from 52 to 65 mph. The measured post-validation pavement temperatures varied 4.9 degrees Fahrenheit, from 49.4 to 54.3. The cloudy weather conditions prevented achieving the desired 30 degree temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 09-Mar-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	1.7 ± 9.0%	Pass
Single Axles	±20 percent	0.8 ± 10.3%	Pass
Tandem Axles	±15 percent	0.9 ± 6.9%	Pass
GVW	±10 percent	1.6 ± 3.9%	Pass
Vehicle Length	±3.0 percent (2.1 ft)	0.3 ± 1.1 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 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 -0.5 ± 2.0 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 0.0, 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.

5.3.1 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 65 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-13 below.

Table 5-13 – Post-Validation Results by Speed – 09-Mar-11

Parameter	95% Confidence Limit of Error	Low 52.0 to 56.3 mph	Medium 56.4 to 60.8 mph	High 60.9 to 65.0 mph
Steering Axles	±20 percent	4.8 ± 3.7%	3.4 ± 5.1%	-3.9 ± 7.0%
Single Axles	±20 percent	1.8 ± 6.5%	-0.4 ± 9.1%	0.9 ± 10.4%
Tandem Axles	±15 percent	0.4 ± 5.8%	1.1 ± 7.4%	1.1 ± 7.2%
GVW	±10 percent	1.9 ± 3.5%	1.7 ± 4.3%	1.1 ± 5.1%
Vehicle Length	±3.0 percent (2.1 ft)	0.3 ± 1.0 ft	0.2 ± 0.9 ft	0.2 ± 1.6 ft
Vehicle Speed	± 1.0 mph	-0.5 ± 1.8 mph	-0.8 ± 2.4 mph	-0.2 ± 2.1 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	-0.1 ± 0.1 ft	-0.1 ± 0.1 ft

From the table, it can be seen that the WIM equipment estimates all weights with acceptable accuracy and range at all speeds. There does appear to be a relationship between steering axle weight estimates and speed at this site, where variance in error is significantly greater at the higher speeds. This may be caused by rough pavement within or near the WIM scales, or a problem with the WIM scale installation.

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 5-14, the equipment estimated GVW with reasonable accuracy at all speeds. The range in error is reasonably consistent at all speeds, with a slight increase as speed increases.

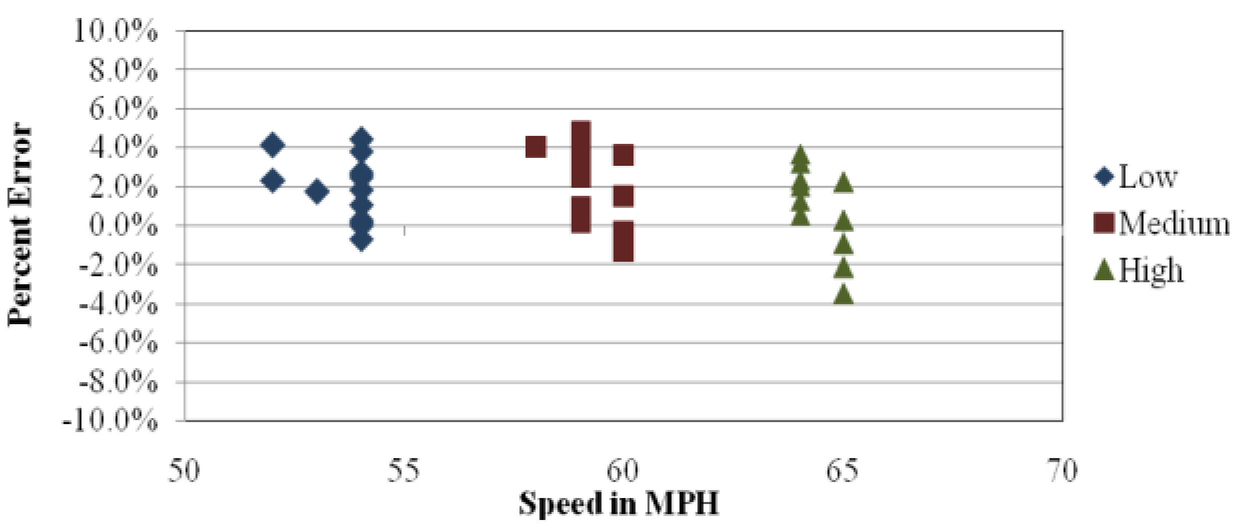


Figure 5-14 – Post-Validation GVW Errors by Speed – 09-Mar-11

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-15, the estimation of steering axle weights is correlated with the speed of the test trucks where as speed increases both mean error and variance increase. The estimation of steering axle weights transitions from an overestimation at low and medium speed groups to an underestimation at the high speed group.

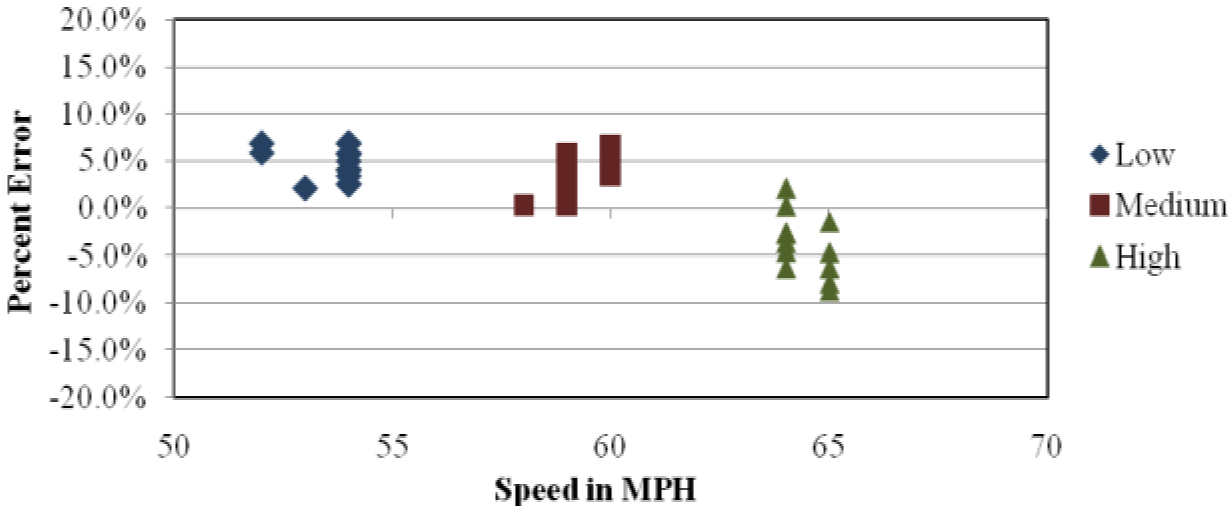


Figure 5-15 – Post-Validation Steering Axle Weight Errors by Speed – 09-Mar-11

5.3.1.3 Single Axle Weight Errors by Speed

As shown in Figure 5-16, the equipment estimated single axle weights with reasonable accuracy at all speeds. The range in error increases with increase in speed.

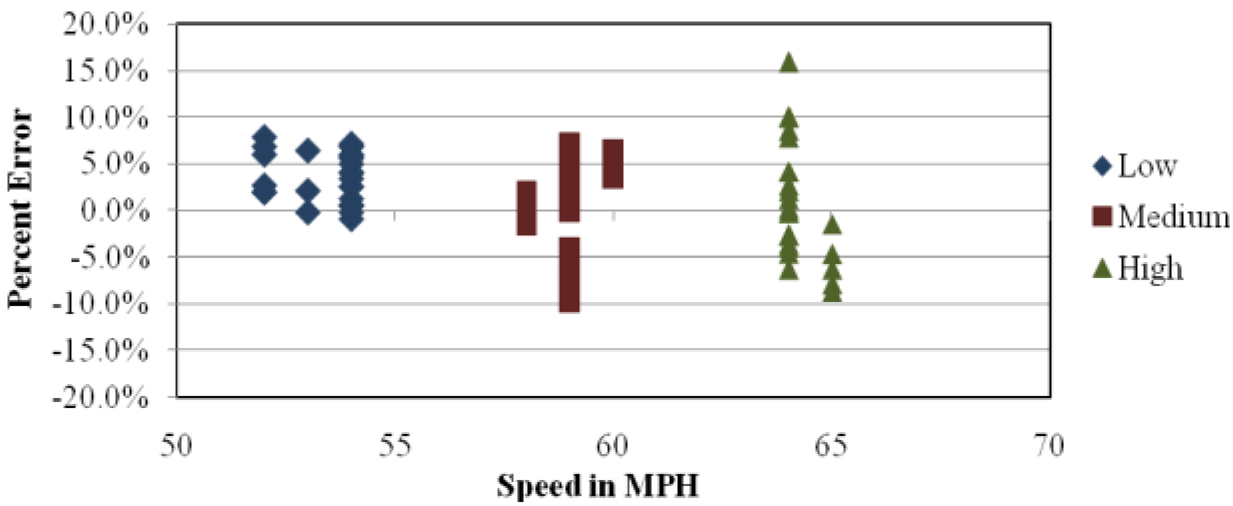


Figure 5-16 – Post-Validation Single Axle Weight Errors by Speed – 09-Mar-11

5.3.1.4 Tandem Axle Weight Errors by Speed

As shown in Figure 5-17, the equipment estimated tandem axle weights with reasonable accuracy at all speeds. There does not appear to be a correlation between speed and tandem axle weight estimates at this site.

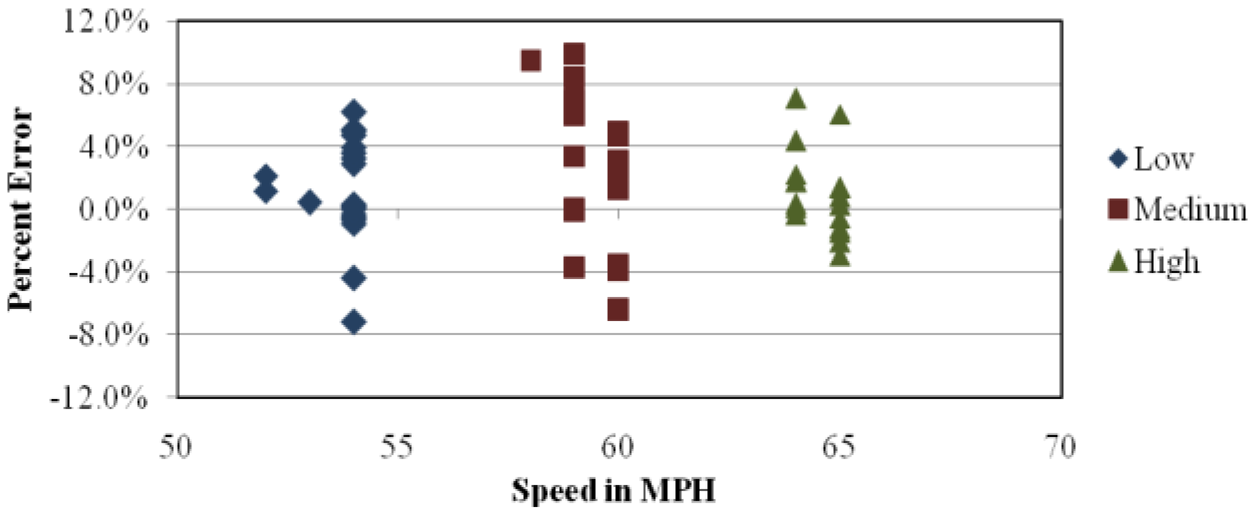


Figure 5-17 – Post-Validation Tandem Axle Weight Errors by Speed – 09-Mar-11

5.3.1.5 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-18 that when the GVW errors are analyzed by truck type, the error plot shows a consistent overestimation of GVW for the partially loaded (Secondary) truck over the entire speed range. For the fully loaded (Primary) truck, there is a transition from an overestimation to underestimation of GVW as speed increases. The GVW variance is greater for the fully loaded (Primary) truck when compared with the partially loaded (Secondary) truck.

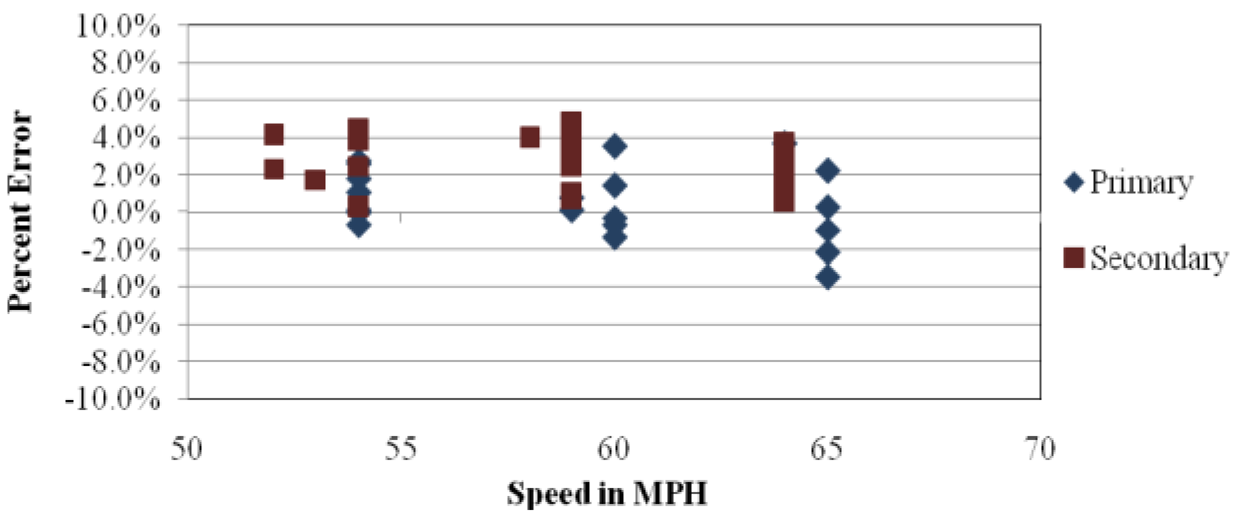


Figure 5-18 – Post-Validation GVW Error by Truck and Speed – 09-Mar-11

5.3.1.6 Steering Axle Errors by Speed and Truck Type

It can be seen in Figure 5-189 that when the steering axle errors are analyzed by truck type, the error plot shows a change from overestimation to underestimation of steering axle weights with increase in speed for both trucks. The pattern of errors and variance is similar for both trucks.

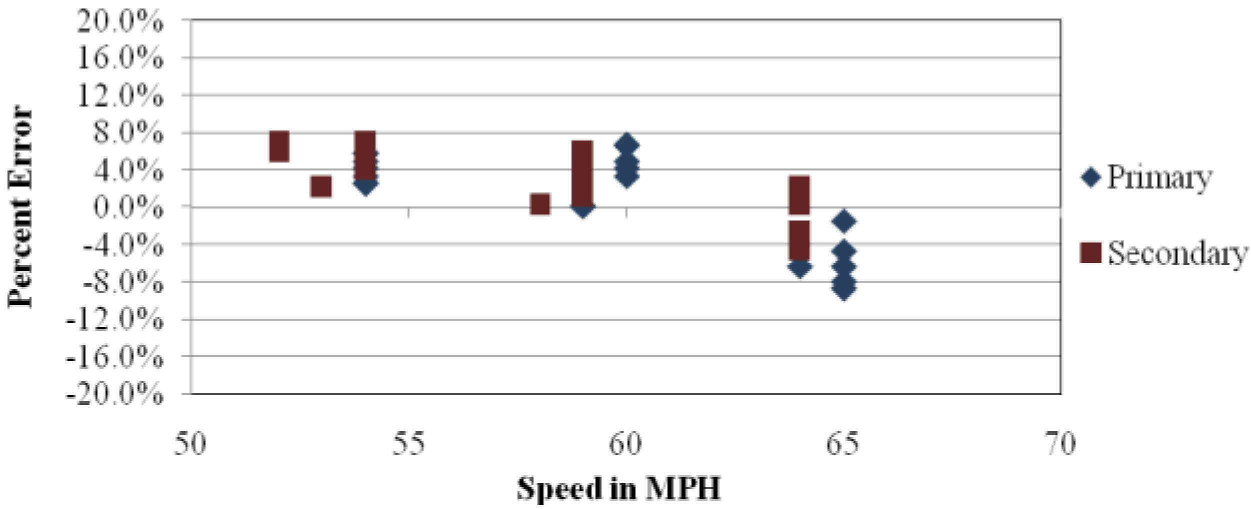


Figure 5-19 – Post-Validation Steering Axle Error by Truck and Speed – 09-Mar-11

5.3.1.7 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 ranged from -0.2 feet to 0.1 feet. Distribution of errors is shown graphically in Figure 5-20.

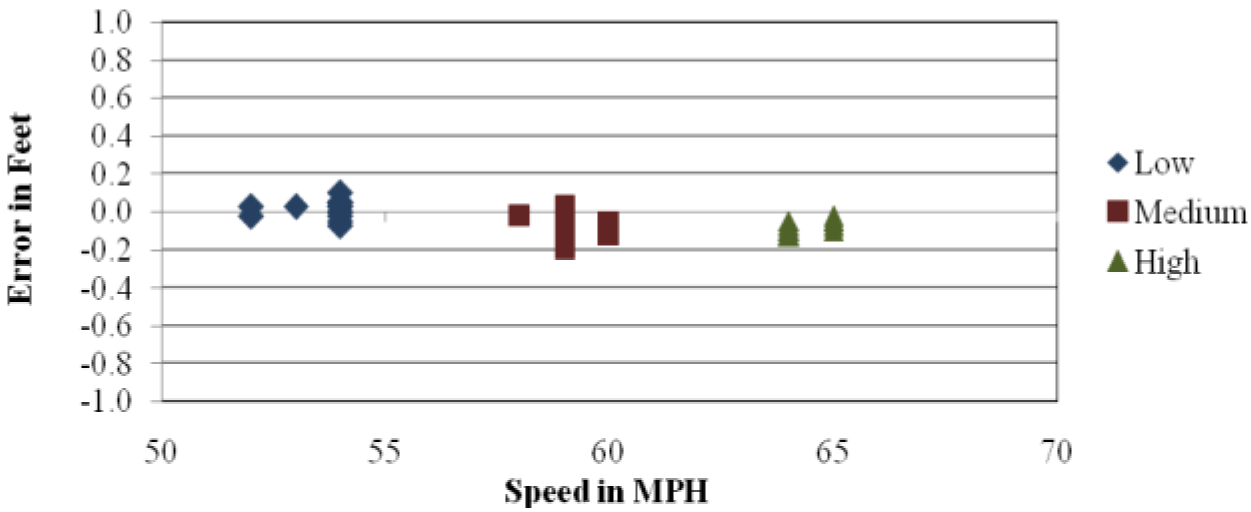


Figure 5-20 – Post-Validation Axle Length Error by Speed – 09-Mar-11

5.3.1.8 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 0.9 feet. Distribution of errors is shown graphically in Figure 5-21.

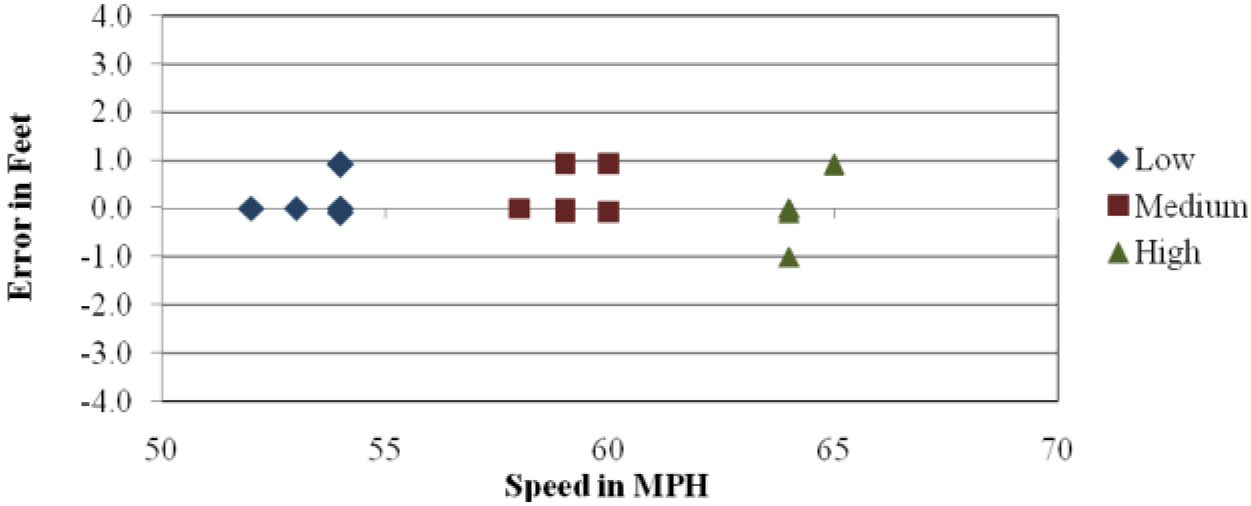


Figure 5-21 – Post-Validation Overall Length Error by Speed – 09-Mar-11

5.3.2 Statistical Temperature Analysis

Due to a pavement temperature variation of only 4.9 degrees, from 49.4 to 54.3 degrees Fahrenheit, the statistical analysis for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy was limited. Consequently, the pre-validation test runs are being reported under one temperature group – medium, as shown in Table 5-14.

Table 5-14 – Post-Validation Results by Temperature – 09-Mar-11

Parameter	95% Confidence Limit of Error	Medium
		49.4 to 54.3 degF
Steering Axles	±20 percent	1.7 ± 9.0%
Single Axles	±20 percent	0.8 ± 10.3%
Tandem Axles	±15 percent	0.9 ± 6.9%
GVW	±10 percent	1.6 ± 3.9%
Vehicle Length	±3.0 percent (2.1 ft)	0.3 ± 1.1 ft
Vehicle Speed	± 1.0 mph	-0.5 ± 2.0 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 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.

5.3.2.1 GVW Errors by Temperature

From Figure 5-22, it can be seen that the equipment appears to estimate GVW with similar acceptable accuracy across the range of temperatures observed in the field.

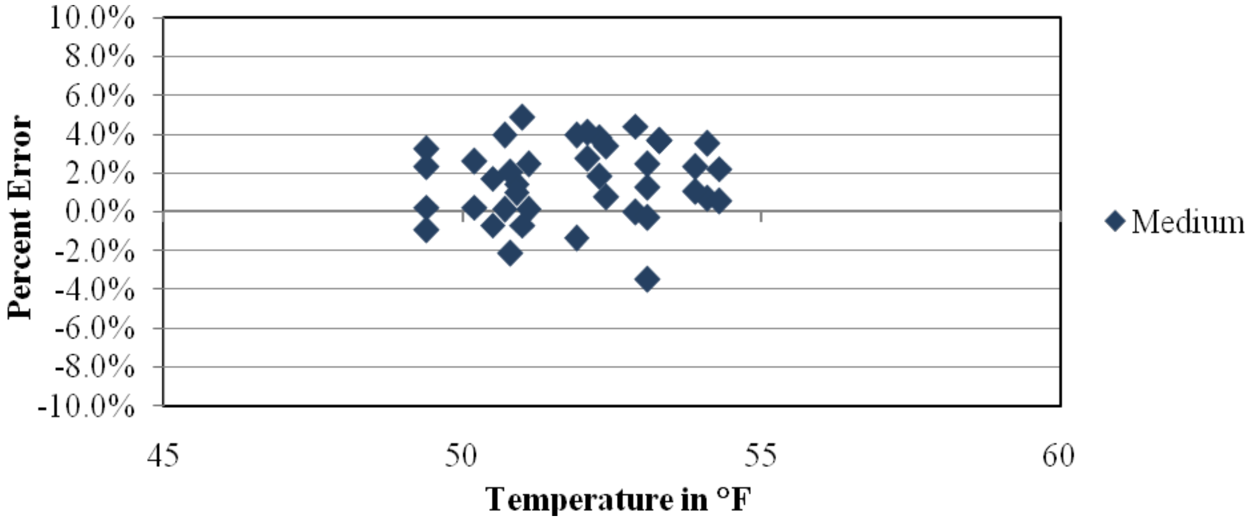


Figure 5-22 – Post-Validation GVW Errors by Temperature – 09-Mar-11

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-23 demonstrates that for steering axles, the WIM equipment appears to estimate steering axle weights with similar acceptable accuracy across the range of temperatures observed in the field.

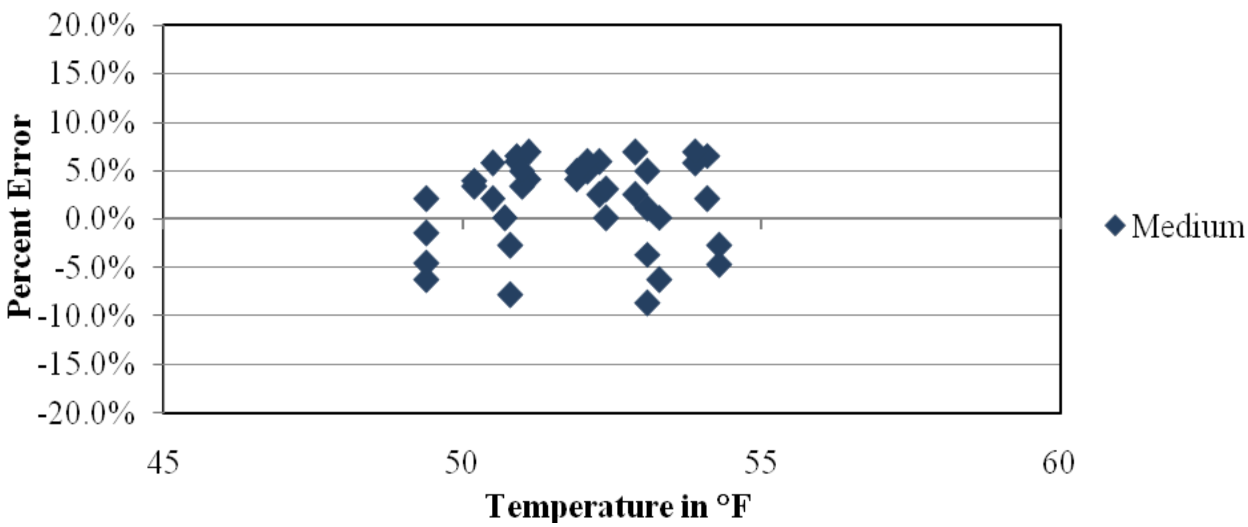


Figure 5-23 – Post-Validation Steering Axle Weight Errors by Temperature – 09-Mar-11

5.3.2.3 Single Axle Weight Errors by Temperature

Figure 5-24 demonstrates that for loaded single axles, the WIM equipment appears to estimate single axle weights with similar acceptable accuracy across the range of temperatures observed in the field.

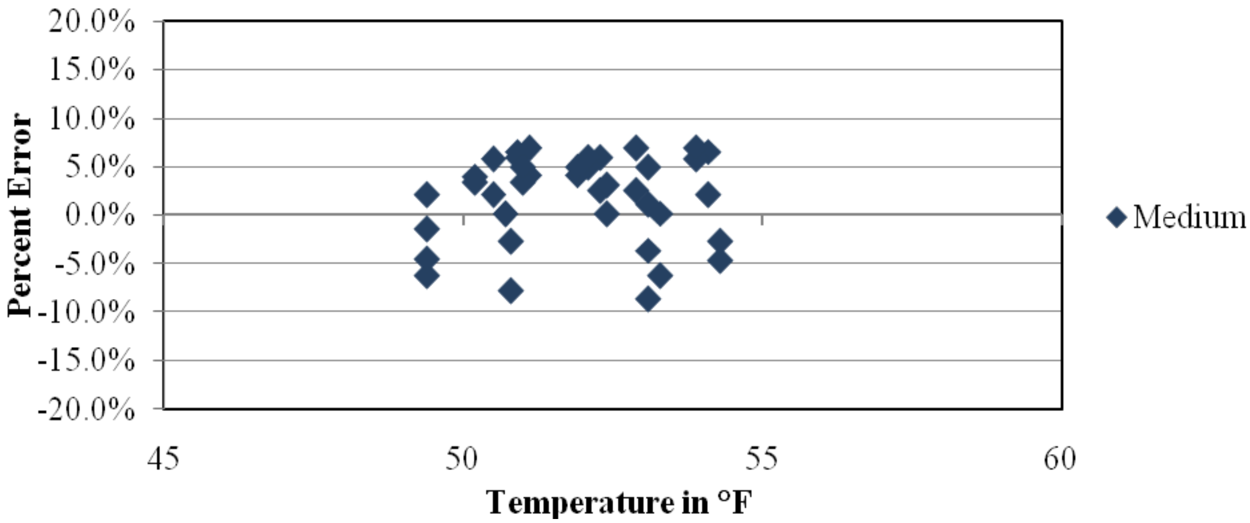


Figure 5-24 – Post-Validation Single Axle Weight Errors by Temperature – 09-Mar-11

5.3.2.4 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-25, the WIM equipment appears to estimate tandem axle weights with acceptable accuracy across the range of temperatures observed in the field.

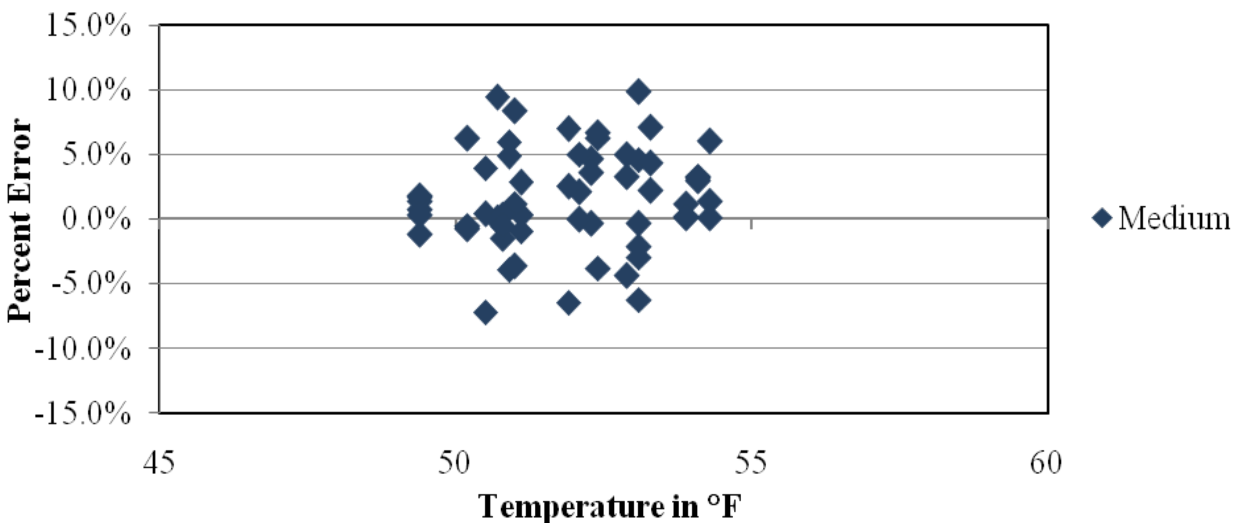


Figure 5-25 – Post-Validation Tandem Axle Weight Errors by Temperature – 09-Mar-11

5.3.2.5 GVW Errors by Temperature and Truck Type

As shown in Figure 5-26, 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.

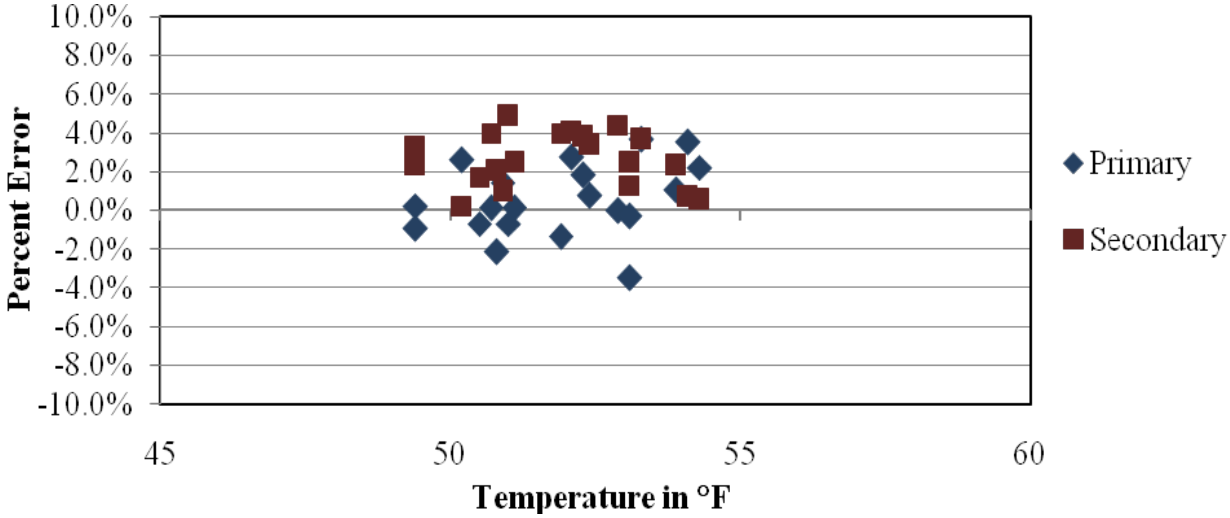


Figure 5-26 – Post-Validation GVW Error by Truck and Temperature – 09-Mar-11

5.3.3 GVW and Steering Axle Trends

Figure 5-27 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed.

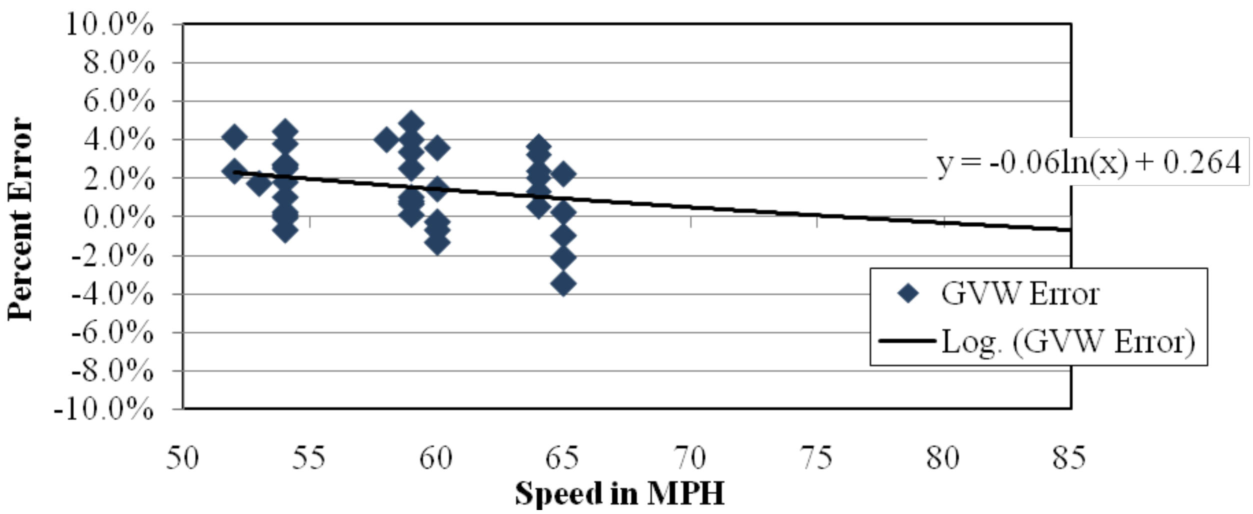


Figure 5-27 – GVW Error Trend by Speed

Figure 5-28 is provided to illustrate the predicted steering axle error with respect to the post-validation errors by speed.

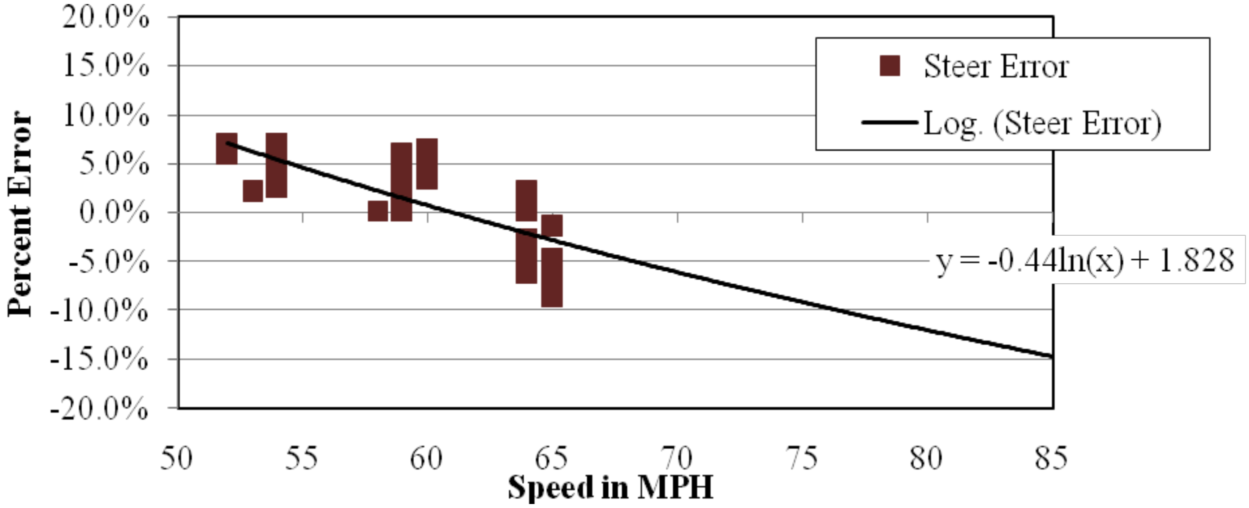


Figure 5-28 – Steering Axle Trend by Speed

5.3.4 Multivariable Analysis

This section provides additional analysis of post-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.

5.3.4.1 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 tandem axles was evaluated separately for conventional tandem axles and split tandems axles (on Secondary truck). The separate evaluation was carried out because the conventional tandem axles may have different dynamic response to loads than split tandem axles.

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 52 to 65 mph.

- Pavement temperature. Pavement temperature ranged from 49.4 to 54.3 degrees Fahrenheit.

- Interaction between the factors such as the interaction between speed and pavement temperature.

5.3.4.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 5-15. 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 5-15 are for the null hypothesis that assumes that the coefficients are equal to zero. Only the effect of truck type was found to be statistically significant. The probability that the effect of truck type on the observed GVW errors occurred by chance alone was less than 1 percent.

Table 5-15 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-2.1418	9.9593	-0.2151	0.8309
Speed	-0.0822	0.0595	-1.3820	0.1755
Temp	0.1456	0.1766	0.8244	0.4151
Truck type	2.0239	0.5214	3.8818	0.0004

The relationship between truck type and measurement errors is shown in Figure 5-29. The figure includes a trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-29 provides quantification and statistical assessment of the relationship.

The quantification is provided by the value of the regression coefficient, in this case 2.039 (in Table 5-15). The regression coefficient for the truck type represents the difference between the mean errors for the primary and secondary trucks. (Truck type is an indicator variable with values of 0 or 1.). The mean error in GVW for the secondary truck was about 2 % larger than the error for the primary truck.

The statistical assessment of the relationship is provided by the probability value of the regression coefficient. For example, the probability that the regression coefficient for speed (-0.0822 in Table 5-15) is not different from zero was 0.1755. In other words, there is about 18 percent chance that the value of the regression coefficient is due to the chance alone.

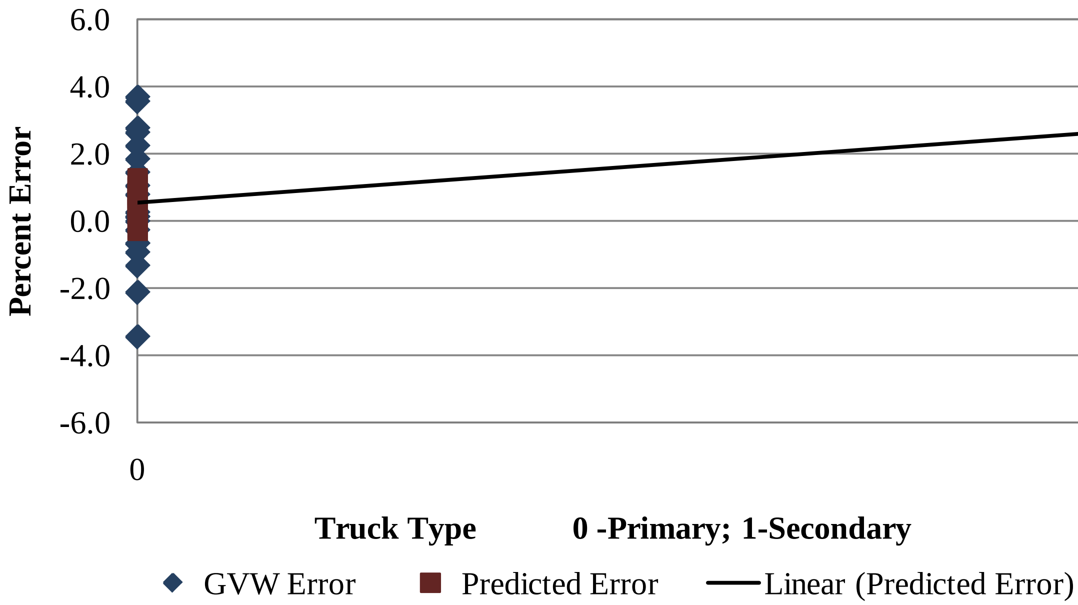


Figure 5-29 – Influence of Truck Type on the Measurement Error of GVW

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.

5.3.4.3 Summary Results

Table 5-16 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 5-16 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-16 – Summary of Regression Analysis

	Factor					
	Speed		Temperature		Truck type	
Weight, % error	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	-0.0822	0.1755	-	-	-2.034	0.0004
Steering axle	-0.7584	0.0000	-	-	-	-
Tandem axles	-0.1494	0.1675	-	-	-	-
Tandem split axle	0.2735	0.1483	0.8355	0.1342	N/A	N/A

5.3.4.4 Conclusions

1. Speed had statistically significant effect on measurement errors of GVW, steering axles, and tandem axles.

2. Temperature did not have statistically significant effect on measurement errors. However, the change in the pavement temperatures was limited to 4.9 °F.

3. Truck type had statistically significant effect on the measurement error of GVW only.

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

5.3.5 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 109 vehicles including 109 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 5-17 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 the table, one Class 5 truck identified by the WIM equipment as a Class 8 and one Class 9 was identified by the equipment as a Class 6. The cause of the misclassification was not investigated in the field. There were no unclassified vehicles reported by the equipment.

Table 5-17 – Post-Validation Classification Study Results – 09-Mar-11

Class	4	5	6	7	8	9	10	11	12	13
Observed Count	1	5	2	0	1	94	1	4	1	0
WIM Count	1	4	3	0	2	93	1	4	1	0
Observed Percent	0.9	4.6	1.8	0.0	0.9	86.2	0.9	3.7	0.9	0.0
WIM Percent	0.9	3.7	2.8	0.0	1.8	85.3	0.9	3.7	0.9	0.0
Misclassified Count	0	1	0	0	0	1	0	0	0	0
Misclassified Percent	0.0	20.0	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
Unclassified Percent	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 5-18.

Table 5-18 – Post-Validation Misclassifications by Pair – 09-Mar-11

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

Based on the vehicles observed during the post-validation study, the misclassification percentage is 1.0% 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 (4 – 15) is 1.8%.

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 5-19.

Table 5-19 – Post-Validation Unclassified Trucks by Pair – 09-Mar-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 109 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 -0.7 mph; the range of errors was 2.1 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 post-validation results.

6.1 Sheet 16s

This site has validation information from two 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	
15-May-07	100	50	0	N/A	63	0	N/A	0	0	N/A	0
16-May-07	100	50	N/A	N/A	50	0	0	0	0	N/A	0
28-Oct-08	0	0	0	N/A	0	0	0	0	0	N/A	0
29-Oct-08	N/A	N/A	0	0	0	0	N/A	0	0	N/A	0
8-Mar-11	0	0	0	0	0	0	100	0	0	0	0
9-Mar-11	0	20	0	0	0	0	0	0	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 post-validations as reported on the LTPP Traffic Sheet 16s.

Table 6-2 – Weight Validation History

Date	Mean Error and SD		
	GVW	Single Axles	Tandem
15-May-07	2.0 ± 3.1	-0.6 ± 3.3	2.5 ± 4.2
16-May-07	1.1 ± 1.8	-2.0 ± 3.4	1.6 ± 2.9
28-Oct-08	0.9 ± 2.4	-1.0 ± 2.7	1.2 ± 3.8
29-Oct-08	1.3 ± 1.8	-0.7 ± 2.5	1.6 ± 3.4
8-Mar-11	3.6 ± 2.3	1.3 ± 4.4	4.6 ± 3.1
9-Mar-11	1.6 ± 1.9	0.8 ± 5.1	0.9 ± 3.4

For GVW and tandem axles, the variability of the weight errors appears to have remained reasonably consistent since the site was first validated. Single axle variance has increased. The table also demonstrates the effectiveness of the validations in bringing the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

A comparison of the post-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 Post-Validation Results

Parameter	95 %Confidence Limit of Error	Site Values (Mean Error and 95% Confidence Interval)		
		16-May-07	29-Oct-08	9-Mar-11
Steering Axles	±20 percent	-2.0 ± 7.0	-0.7 ± 5.1	0.8 ± 10.3
Tandem Axles	±15 percent	1.6 ± 5.7	1.6 ± 6.7	0.9 ± 6.9
GVW	±10 percent	1.1 ± 3.6	1.3 ± 3.7	1.6 ± 3.9

From the table, it appears that the variance for GVW and tandem axle weights has remained reasonably consistent since the equipment was installed. Variance in steering axle weight error has slightly 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	Final Factors	
	Left	Right
	1	2
80	3070	3143
88	3159	3235
96	3071	3145
104	2973	3044
112	2967	3038
Axle Distance (cm)	373	
Dynamic Comp (%)	109	
Loop Width (cm)	140	

A review of the LTPP Standard Release Database 24 shows that there are 2 years of level "E" WIM data for this site. This site requires 3 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
- 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/C – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

Arkansas, SPS-2
SHRP ID: 050200

Validation Date: March 8, 2011

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 – 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	STATE CODE:	05
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	050200
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	3/8/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 3/8/11

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: 21

	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:	3.6%	Standard Deviation:	2.3%
Dynamic and Static Single Axle:	1.3%	Standard Deviation:	4.4%
Dynamic and Static Double Axles:	4.6%	Standard Deviation:	3.1%

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

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

			Low		High	Runs
a.	Low	-	52.0	to	56.3	15
b.	Medium	-	56.4	to	60.8	13
c.	High	-	60.9	to	65.0	13
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 3/8/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3084 | 2931

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 ____ - ____

FHWA Class 8: 0.0 FHWA Class ____ - ____

FHWA Class ____ - ____

FHWA Class ____ - ____

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort: ____

Contact Information: Phone: ____

E-mail: ____

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	05 050200 3/9/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 3/9/11

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:	1.6%	Standard Deviation:	1.9%
Dynamic and Static Single Axle:	0.8%	Standard Deviation:	5.1%
Dynamic and Static Double Axles:	0.9%	Standard Deviation:	3.4%

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

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

			Low		High	Runs
a.	Low	-	52.0	to	56.3	14
b.	Medium	-	56.4	to	60.8	14
c.	High	-	60.9	to	65.0	12
d.		-		to		
e.		-		to		

Traffic Sheet 16	STATE CODE:	05
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	050200
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	3/9/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 2942 | 3012

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:	-1.0	FHWA Class		-	
FHWA Class 8:	100.0	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:	05
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	050200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	3/8/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	9	40543	64	9	69	9	40975	70	9
59	9	40552	60	9	65	9	40976	66	9
60	9	40559	60	9	62	9	40981	68	9
65	9	40825	66	9	64	8	40982	64	8
70	9	40845	69	9	61	9	40991	63	9
66	9	40849	67	9	64	9	40992	64	9
65	9	40850	65	9	67	9	40994	68	9
65	9	40853	66	9	64	9	40995	63	9
64	9	40866	65	9	62	9	40997	65	9
68	9	40868	68	9	64	9	40999	64	9
68	9	40872	69	9	69	9	41022	70	9
68	9	40874	68	9	65	9	41024	66	9
72	9	40879	72	9	64	9	41025	64	9
70	9	40880	70	9	68	9	41026	68	9
65	9	40886	69	9	65	9	41027	66	9
66	9	40887	64	9	61	9	41028	62	9
62	9	40888	63	9	64	9	41030	65	9
64	9	40909	65	9	64	5	41031	64	5
64	9	40912	69	9	65	9	41032	65	9
67	9	40928	68	9	66	9	41066	66	9
60	9	40929	67	9	62	9	41069	64	9
64	9	40939	65	9	67	9	41070	68	9
52	9	40940	53	9	60	9	41081	66	9
66	9	40942	67	9	61	9	41082	62	9
69	9	40964	69	9	61	9	41083	62	9

Sheet 1 - 0 to 50 Start: ____________ Stop: ____________

Recorded By: sc Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 3/8/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
59	9	41112	60	9	67	9	41230	67	9
66	9	41114	68	9	68	9	41231	68	9
67	9	41115	67	9	64	8	41238	67	8
64	9	41116	64	9	67	9	41239	64	9
64	9	41117	65	9	59	9	41240	59	9
60	9	41128	61	9	59	9	41241	59	9
60	9	41129	64	9	65	9	41243	65	9
60	9	41130	61	9	64	5	41244	65	5
61	9	41131	62	9	65	9	41245	66	9
59	5	41132	65	5	65	9	41273	66	9
64	9	41133	65	9	**64**	**13**	**41274**	**65**	**10**
67	9	41158	67	9	68	9	41275	67	9
66	9	41162	65	9	65	9	41290	64	9
65	9	41163	65	9	67	9	41295	67	9
64	9	41164	69	9	70	9	41296	67	9
63	9	41167	64	9	68	9	41297	68	9
64	9	41168	64	9	64	9	41298	64	9
59	9	41190	64	9	59	9	41300	61	9
63	9	41191	61	9	70	9	41318	70	9
60	9	41192	59	9	68	9	41319	70	9
60	9	41193	61	9	57	5	41323	60	5
62	9	41205	66	9	59	9	41324	64	9
65	9	41207	66	9	65	9	41333	63	9
66	9	41208	65	9	60	9	41334	66	9
68	9	41209	68	9	58	9	41335	62	9

Sheet 2 - 51 to 100 Start: ______ Stop: 17:06:00

Recorded By: sc Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 1/0/1900

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class

Sheet 3 - 101 - 150 Start: ____________ Stop: ____________

Recorded By: sc Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE:	05
	SPS WIM ID:	050200
	DATE (mm/dd/yyyy)	3/9/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
68	6	50046	65	6	64	9	50195	64	9
65	9	50047	65	9	64	9	50196	63	9
65	9	50054	67	9	64	5	50197	64	5
64	9	50063	62	9	64	9	50215	65	9
64	**8**	**50072**	**64**	**5**	66	9	50216	66	9
64	9	50073	65	9	67	9	50217	67	9
65	9	50074	66	9	62	9	50219	62	9
68	9	50079	67	9	65	9	50220	66	9
64	9	50080	69	9	65	9	50221	65	9
68	6	50081	68	6	66	9	50225	68	9
65	9	50082	69	9	64	9	50226	65	9
66	9	50085	67	9	62	11	50229	62	11
62	9	50086	65	9	63	9	50252	63	9
66	9	50087	65	9	64	9	50253	64	9
69	10	50129	70	10	67	9	50259	67	9
72	5	50130	70	5	67	9	50260	66	9
62	9	50131	67	9	60	9	50261	65	9
67	9	50132	67	9	68	9	50262	66	9
62	9	50133	63	9	64	9	50263	64	9
64	9	50134	69	9	68	9	50264	68	9
63	9	50135	63	9	**67**	**6**	**50266**	**68**	**9**
65	9	50136	64	9	67	9	50268	67	9
59	9	50167	60	9	64	8	50269	66	8
63	9	50168	62	9	68	9	50270	64	9
64	11	50169	64	11	64	9	50271	64	9

Sheet 1 - 0 to 50 Start: 15:02:00 Stop: 15:23:00

Recorded By: sc Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 3/9/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
67	9	50328	68	9	62	5	50462	63	5
67	9	50329	68	9	64	9	50463	65	9
64	9	50341	65	9	64	11	50464	64	11
65	9	50342	66	9	60	9	50472	64	9
61	9	50354	66	9	60	9	50473	61	9
62	9	50355	62	9	64	9	50475	65	9
67	9	50359	67	9	57	9	50490	62	9
64	9	50362	60	9	64	9	50493	64	9
64	9	50373	65	9	64	9	50496	64	9
67	9	50375	67	9	67	9	50505	67	9
62	9	50385	62	9	66	9	50506	67	9
64	9	50389	61	9	65	9	50518	65	9
61	11	50390	61	11	64	9	50520	64	9
65	9	50401	68	9	64	9	50521	62	9
67	9	50402	67	9	62	9	50522	62	9
66	9	50411	66	9	61	9	50523	64	9
60	9	50412	65	9	62	9	50525	62	9
70	9	50420	66	9	62	9	50526	61	9
63	9	50422	64	9	64	9	50527	64	9
68	4	50427	67	4	66	9	50529	66	9
65	9	50434	66	9	66	9	50531	62	9
66	9	50435	74	9	65	9	50552	65	9
66	9	50436	72	9	66	5	50587	67	5
70	9	50437	71	9	68	12	50615	69	12
59	9	50451	59	9	60	9	50624	62	9

Sheet 2 - 51 to 100 Start: 15:23:00 Stop: 15:57:00

Recorded By: sc Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 05 SPS WIM ID: 050200 DATE (mm/dd/yyyy) 1/0/1900

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
65	9	50641	65	9					
64	9	50648	65	9					
64	9	50652	64	9					
69	9	50661	70	9					
64	9	50667	65	9					
64	9	50671	66	9					
65	9	50679	65	9					
64	9	50681	69	9					
62	9	50682	64	9					

Sheet 3 - 101 - 150 Start: 15:58:00 Stop: 16:02:00

Recorded By: sc Verified By: djw

Validation Test Truck Run Set - Post