WIM System Field Calibration and Validation Summary Report

Maryland SPS-5
SHRP ID – 240500

Validation Date: December 07, 2011
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1 Executive Summary

A WIM validation was performed from December 6 to December 8, 2011 at the Maryland SPS-5 site located on route US-15 at milepost 4.6, .53 miles south of Mountville Road.

This site was installed on October 26, 2005. The in-road sensors are installed in the northbound 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 August 25, 2010 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

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

During the on-site pavement evaluation, a pavement transition was noted at approximately 300 feet prior to the WIM scale area. The transition did appear to cause the trucks to bounce, but these dynamics appeared to diminish prior to the trucks crossing over the WIM scale area. A visual observation of the trucks as they approach, traverse, and leave the sensor area did not indicate any adverse dynamics that would 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 – 08-Dec-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	0.1 ± 4.6%	Pass
Single Axles	±20 percent	0.1 ± 4.6%	Pass
Tandem Axles	±15 percent	-0.4 ± 3.0%	Pass
GVW	±10 percent	-0.2 ± 1.3%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	0.8 ± 0.3 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 -0.3 ± 1.9 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 0.0% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 2.0% from the 100 truck sample (Class 4 – 13) was due to the 2 misclassifications of Class 5 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 crane counter-weights.

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

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	76.8	8.9	17.1	17.1	16.8	16.8	11.7	4.3	38.3	4.2	58.5	66.2
2	66.1	9.4	14.4	14.4	13.9	13.9	11.8	4.3	37.5	4.5	58.1	65.2

The posted speed limit at the site is 55 mph. During the testing, the speed of the test trucks ranged from to 42 to 54 mph, a range of 12 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 36.2 to 54.7 degrees Fahrenheit, a range of 18.5 degrees Fahrenheit. The rainy weather conditions prevented the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 25 shows that there are 6 years of level "E" WIM data for this site. This site requires no additional years of data to meet the minimum of five years of research quality data.

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 September 05, 2011 (Data) to the most recent Comparison Data Set (CDS) from August 23, 2010. 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 6 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2006 to 2011.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2006	304	10
2007	356	12
2008	361	12
2009	352	12
2010	325	12
2011	250	9

As shown in the table, this site requires no additional years of data to meet the minimum of five years of research quality data. The data meets the 210-day minimum requirement for a calendar year for years 2006 through 2011.

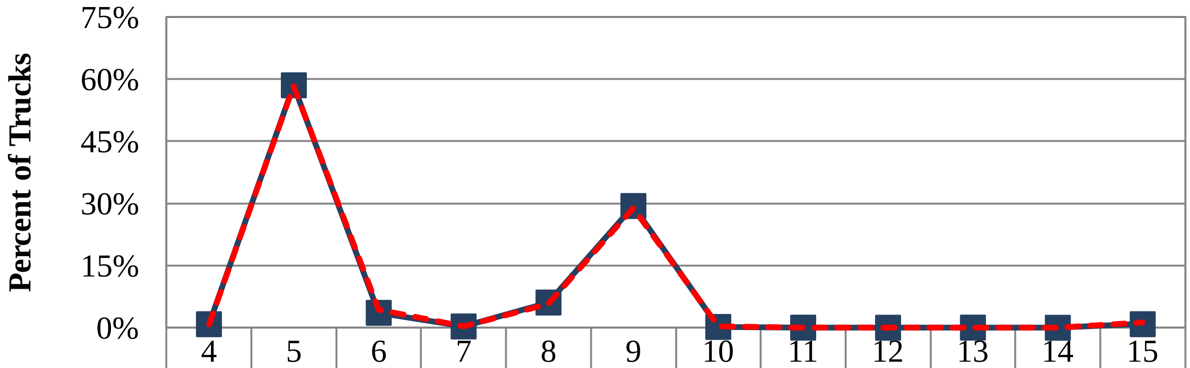
Table 2-2 provides a monthly breakdown of the available data for years 2006 through 2011.

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	
2006			31	28	31	30	31	31	30	31	30	31	10
2007	31	24	30	29	30	30	31	29	30	31	30	31	12
2008	31	27	31	30	31	30	28	31	30	31	30	31	12
2009	31	28	31	30	31	29	19	31	30	31	30	31	12
2010	28	13	29	29	31	29	27	31	30	25	22	31	12
2011	28	27	31	30	31	30	31	31	11				9

2.2 Classification Data Analysis

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



	4	5	6	7	8	9	10	11	12	13	14	15
Data	0.9%	58.6%	3.6%	0.3%	6.1%	29.4%	0.2%	0.0%	0.0%	0.0%	0.0%	0.9%
CDS	0.8%	58.4%	4.3%	0.3%	5.7%	28.9%	0.2%	0.0%	0.0%	0.0%	0.0%	1.3%

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 5 (58.6%) and Class 9 (29.4%). 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 0.9 percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	8/23/2010		9/5/2011		
4	84	0.8%	80	0.9%	0.1%
5	6277	58.4%	5419	58.6%	0.2%
6	460	4.3%	334	3.6%	-0.7%
7	33	0.3%	30	0.3%	0.0%
8	615	5.7%	564	6.1%	0.4%
9	3108	28.9%	2721	29.4%	0.5%
10	26	0.2%	19	0.2%	0.0%
11	2	0.0%	3	0.0%	0.0%
12	3	0.0%	1	0.0%	0.0%
13	5	0.0%	4	0.0%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	138	1.3%	80	0.9%	-0.4%

From the table it can be seen that the number of Class 5 vehicles has increased by 0.2 percent from August 2010 and September 2011. 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. During the same time period, the number of Class 9 trucks increased by 0.5 percent. Changes in the number of heavier trucks may be attributed to seasonal variations in truck distributions and natural variation 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.

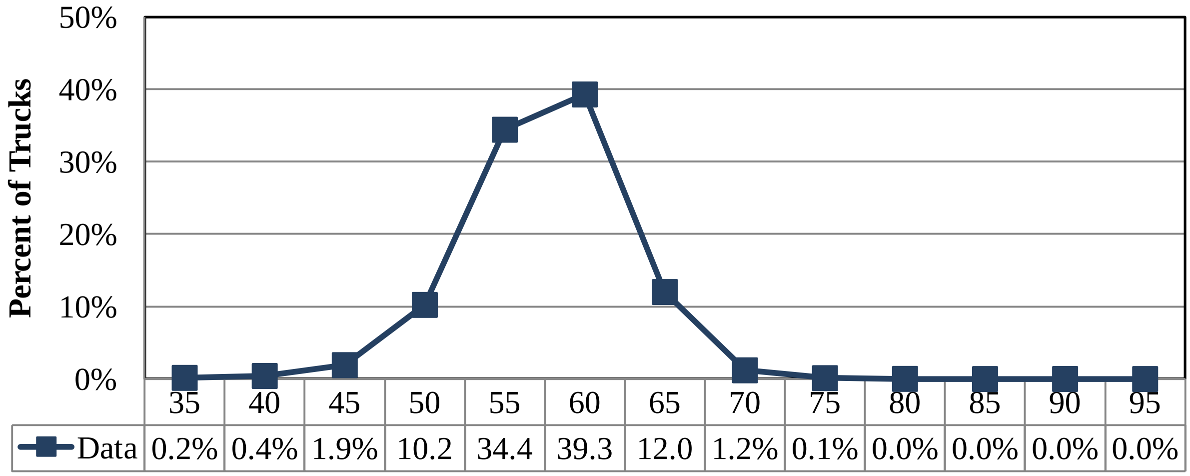


Figure 2-2 – Truck Speed Distribution – 19-Sep-11

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 55 and 65 mph. The posted speed limit at this site is 55 and the 85th percentile speed for trucks at this site is 60 mph. The range of truck speeds for the validation will be 45 to 55 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 September 2011 and the Comparison Data Set from August 2010.

As shown in Figure 2-3, there is an increase in the percentage of unloaded trucks and a decrease in the number of loaded trucks between the August 2010 Comparison Data Set (CDS) and the September 2011 two-week sample W-card dataset (Data).

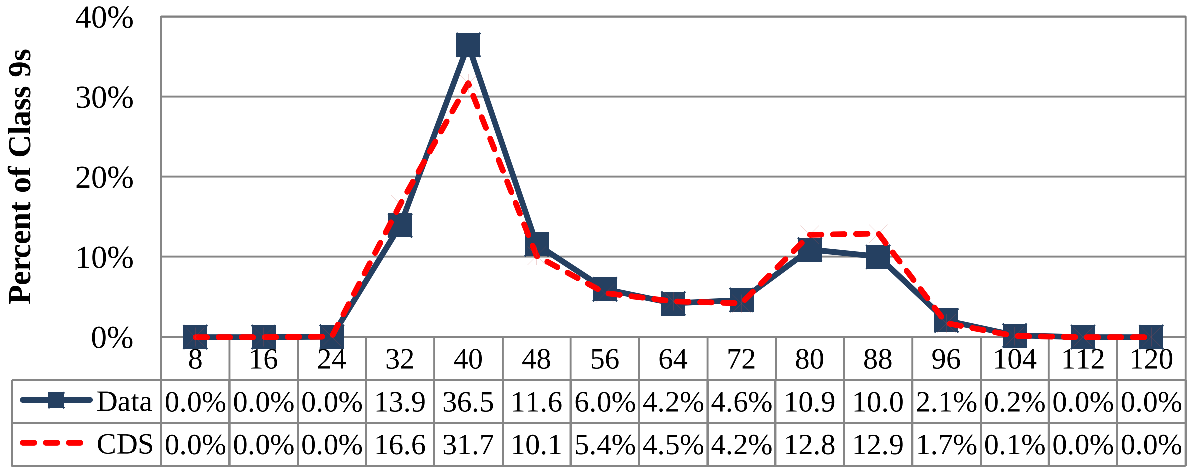


Figure 2-3 – Comparison of Class 9 GVW Distribution

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

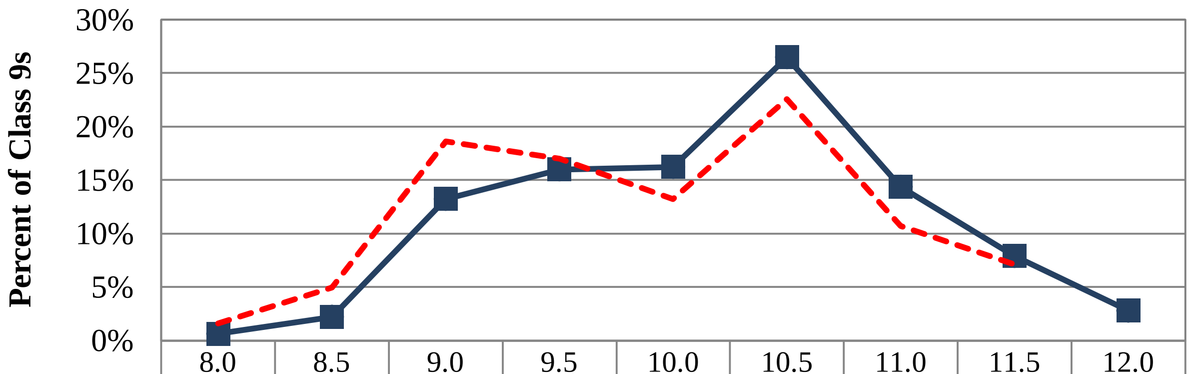
GVW weight bins (kips)	CDS		Data		Change
	Date				
	8/23/20010		9/5/2011		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	1	0.0%	1	0.0%	0.0%
32	512	16.6%	376	13.9%	-2.6%
40	979	31.7%	985	36.5%	4.8%
48	313	10.1%	312	11.6%	1.4%
56	168	5.4%	161	6.0%	0.5%
64	138	4.5%	113	4.2%	-0.3%
72	129	4.2%	125	4.6%	0.5%
80	395	12.8%	295	10.9%	-1.9%
88	399	12.9%	270	10.0%	-2.9%
96	52	1.7%	56	2.1%	0.4%
104	3	0.1%	5	0.2%	0.1%
112	0	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	51.1 kips		49.6 kips		-1.5 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range increased by 4.8 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 1.9 percent. During this time period the percentage of overweight trucks decreased by 2.4 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site decreased by 2.9 percent, from 51.1 kips to 49.6 kips kips.

2.5 Class 9 Front Axle Weight Data Analysis

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

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from September 2011 and the Comparison Data Set from August 2010.



	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0
Data	0.6%	2.2%	13.2%	16.0%	16.2%	26.5%	14.4%	7.9%	2.8%
CDS	1.6%	4.9%	18.6%	17.0%	13.2%	22.6%	10.7%	7.1%	

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 10.0 and 10.5 kips. The percentage of trucks in this range has increased between the August 2010 Comparison Data Set (CDS) and the September 2011 dataset (Data), possibly due to small calibration drift.

Table 2-5 provides the Class 9 front axle weight distribution data for the August 2010 Comparison Data Set (CDS) and the September 2011 dataset (Data).

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

F/A weight bins (kips)	CDS		Data		Change
	Date				
	8/23/20010		9/5/2011		
8.0	20	0.7%	8	0.3%	-0.4%
8.5	47	1.6%	16	0.6%	-1.0%
9.0	145	4.9%	58	2.2%	-2.7%
9.5	547	18.6%	349	13.2%	-5.4%
10.0	499	17.0%	422	16.0%	-1.0%
10.5	388	13.2%	428	16.2%	3.0%
11.0	664	22.6%	699	26.5%	3.9%
11.5	314	10.7%	379	14.4%	3.7%
12.0	208	7.1%	208	7.9%	0.8%
12.5	108	3.7%	73	2.8%	-0.9%
Average =	10.4 kips		10.5 kips		0.1 kips

The table shows that the average front axle weight for Class 9 trucks has increased by 0.1 kips, or 1.0 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 10.5 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.

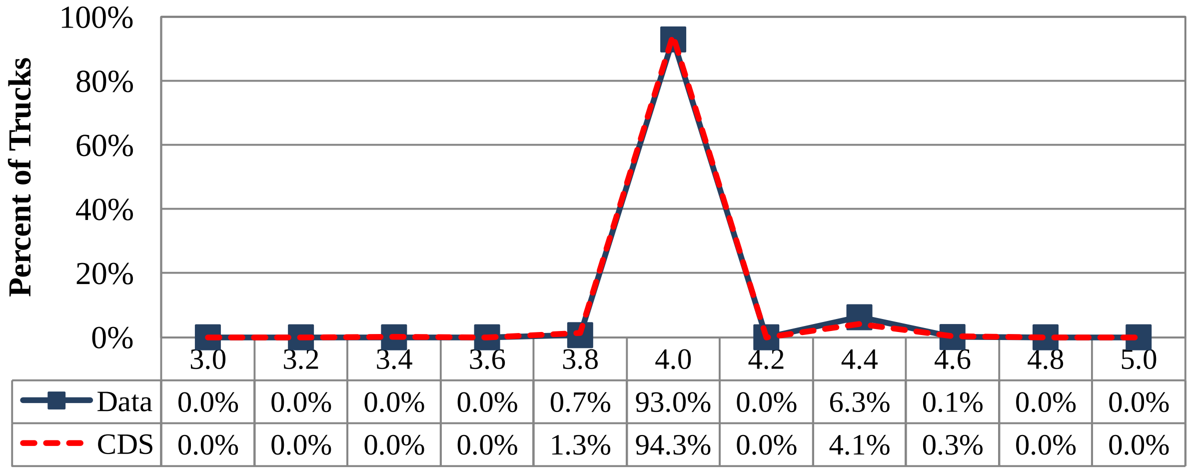


Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacings for the August 2010 Comparison Data Set and the September 2011 Data are nearly identical.

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

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

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	8/23/20010		9/5/2011		
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%	0	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	41	1.3%	18	0.7%	-0.7%
4.0	2912	94.3%	2510	93.0%	-1.3%
4.2	0	0.0%	0	0.0%	0.0%
4.4	126	4.1%	169	6.3%	2.2%
4.6	9	0.3%	2	0.1%	-0.2%
4.8	0	0.0%	0	0.0%	0.0%
5.0	0	0.0%	0	0.0%	0.0%
Average =	4.0 feet		4.0 feet		0.0 feet

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

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (August 2010) based on the last calibration with the most recent two-week WIM data sample from the site (September 2011). Comparison of vehicle class distribution data indicates a 0.2 percent increase in the number of Class 5 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 0.1 kips and average Class 9 GVW has decreased by 2.9 percent for the September 2011 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 August 25, 2010 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 October 26, 2005 by International Road Dynamics. It is instrumented with bending plate weighing sensors and 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. 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

No unscheduled equipment maintenance actions are recommended.

4 Pavement Discussion

4.1 Pavement Condition Survey

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

4.2 Profile and Vehicle Interaction

Profile data was collected on March 07, 2011 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 204 in/mi and is located approximately 888 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 187 in/mi and is located approximately 303 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. A pavement transition was noted at approximately 300 feet prior to the WIM scale area. The transition did appear to cause the trucks to bounce, but these dynamics appeared to diminish prior to the trucks crossing over the WIM scale area.

Additionally, a visual observation of the trucks as they approach, traverse and leave the sensor area did not indicate any visible motion of the trucks that would affect the performance of the WIM scales. Trucks appear to track down the center of the lane.

4.3 LTPP Pavement Profile Data Analysis

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

Table 4-1 – Recommended WIM Smoothness Index Thresholds

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

When all values are less than the lower threshold shown in Table 4-1, it is unlikely that pavement conditions will significantly influence sensor output. Values between the threshold values may or may not influence the accuracy of the sensor output and values above the upper threshold would lead to sensor output that 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)	0.577	0.649	0.666			0.631
		SRI (m/km)	1.012	1.064	1.063			1.046
		Peak LRI (m/km)	1.014	1.019	1.036			1.023
		Peak SRI (m/km)	1.183	1.171	1.229			1.194
	RWP	LRI (m/km)	0.635	*0.488*	0.620			0.581
		SRI (m/km)	*0.374*	*0.447*	0.616			0.479
		Peak LRI (m/km)	0.817	*0.742*	0.818			0.792
		Peak SRI (m/km)	0.782	0.812	0.845			0.813
Center	LWP	LRI (m/km)	0.669	0.583	0.752	0.613	0.661	0.654
		SRI (m/km)	0.684	0.562	0.680	0.607	0.707	0.633
		Peak LRI (m/km)	0.818	*0.728*	0.877	*0.738*	0.822	0.790
		Peak SRI (m/km)	0.849	*0.706*	0.955	0.913	0.894	0.856
	RWP	LRI (m/km)	0.806	0.854	0.846	0.802	0.845	0.827
		SRI (m/km)	0.806	1.009	0.833	1.088	0.757	0.934
		Peak LRI (m/km)	1.023	1.008	0.939	0.933	0.976	0.976
		Peak SRI (m/km)	1.053	1.151	1.027	1.156	0.967	1.097
Right	LWP	LRI (m/km)	0.647	0.890	0.724			0.754
		SRI (m/km)	0.594	0.754	0.641			0.663
		Peak LRI (m/km)	0.790	0.948	0.804			0.847
		Peak SRI (m/km)	0.876	1.022	0.967			0.955
	RWP	LRI (m/km)	0.785	0.684	0.685			0.718
		SRI (m/km)	1.264	1.122	1.117			1.168
		Peak LRI (m/km)	0.883	0.954	0.952			0.930
		Peak SRI (m/km)	**1.328**	**1.219**	**1.168**			**1.238**

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 right shift passes (shown in bold).

4.4 Recommended Pavement Remediation

Pavement remediation in the area of the pavement transition located approximately 300 feet prior to the WIM scale area 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 December 6, 2011, beginning at approximately 10:07 AM and continuing until 6:52 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with crane counter-weights, 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 crane counter-weights, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

The test trucks were weighed prior to the 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	76.2	8.7	16.9	16.9	16.8	16.8	11.7	4.3	38.3	4.2	58.5	66.2
2	65.9	9.3	14.3	14.3	13.9	13.9	11.8	4.3	37.5	4.5	58.1	65.2

Test truck speeds varied by 12 mph, from 42 to 54 mph. The measured pre-validation pavement temperatures varied 3.2 degrees Fahrenheit, from 56.5 to 59.7. The rainy weather conditions prevented the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

Table 5-2 – Pre-Validation Overall Results – 06-Dec-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-2.4 ± 2.7%	Pass
Tandem Axles	±15 percent	-3.2 ± 3.1%	Pass
GVW	±10 percent	-3.1 ± 1.6%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	-1.3 ± 0.5 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.2 ± 0.1 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement over all speeds was -0.8 ± 2.3 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of -0.2 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 *55* 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 – 06-Dec-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		42.0 to 46.0 mph	46.1 to 50.1 mph	50.2 to 54.0 mph
Steering Axles	±20 percent	-1.7 ± 2.4%	-2.2 ± 2.8%	-3.1 ± 2.8%
Tandem Axles	±15 percent	-3.8 ± 2.2%	-3.1 ± 3.0%	-2.7 ± 2.4%
GVW	±10 percent	-3.5 ± 1.6%	-2.9 ± 1.8%	-2.9 ± 1.3%
Vehicle Length	±3.0 percent (2.0 ft)	-1.3 ± 0.6 ft	-1.2 ± 0.0 ft	-1.3 ± 0.8 ft
Vehicle Speed	± 1.0 mph	-1.3 ± 2.1 mph	-1.1 ± 2.2 mph	-0.1 ± 2.5 mph
Axle Length	± 0.5 ft [150mm]	-0.2 ± 0.1 ft	-0.2 ± 0.1 ft	-0.2 ± 0.1 ft

From the table, it can be seen that, on average, the WIM equipment underestimates all weights at all speeds. The range in all errors appears to be consistent over the entire speed range.

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 underestimated GVW at all speeds. The range in error is consistent over the range of speeds observed in the field.

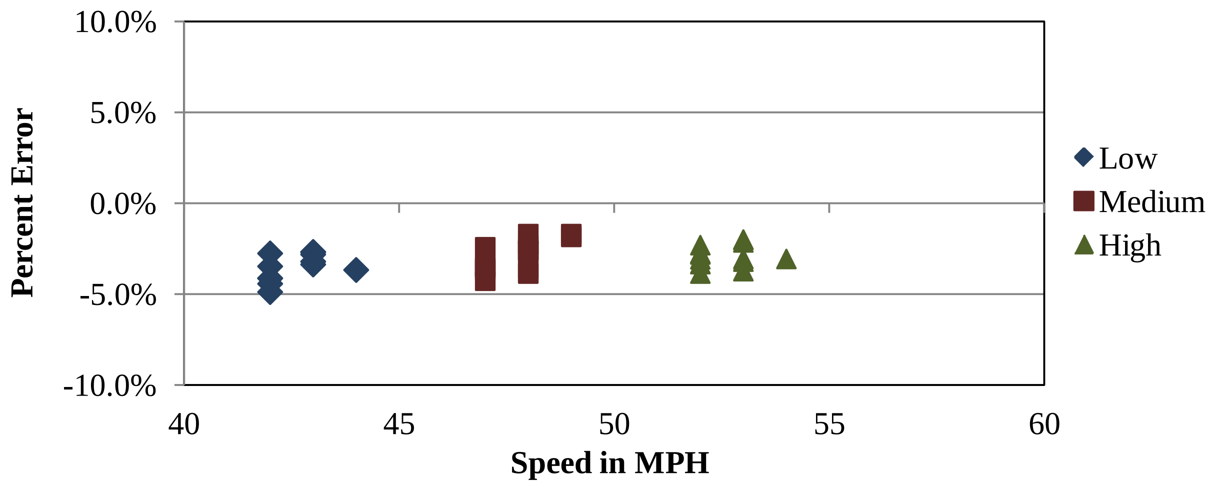


Figure 5-1 – Pre-Validation GVW Error by Speed – 06-Dec-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment generally underestimates steering axle weights at all speeds. The bias appears to become increasingly negative as speed increases. The range in error is consistent over the range in speeds. There does appear to be a relationship between speed and steering axle measurement at this site.

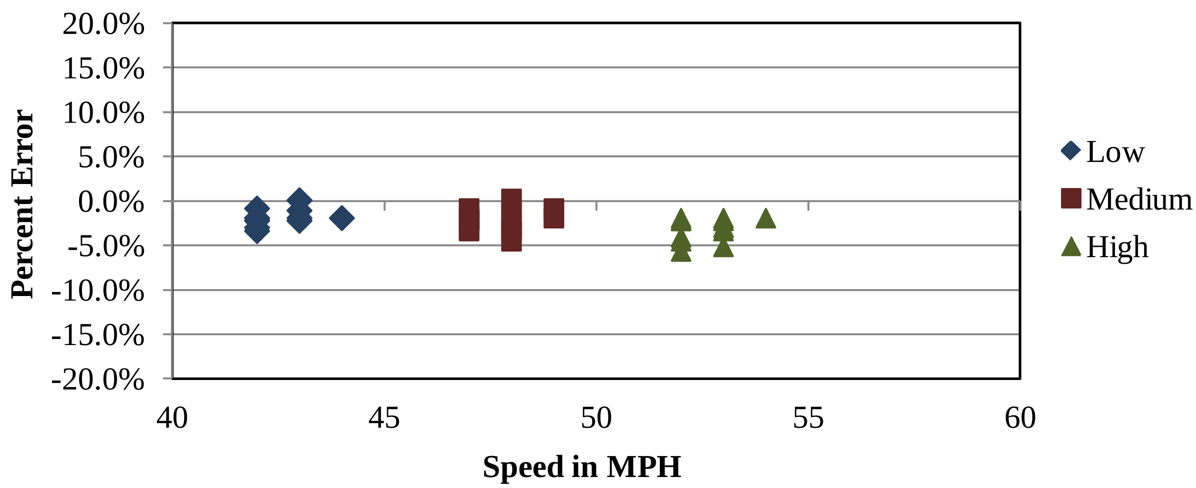


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 06-Dec-11

5.1.1.3 Tandem Axle Weight Errors by Speed

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

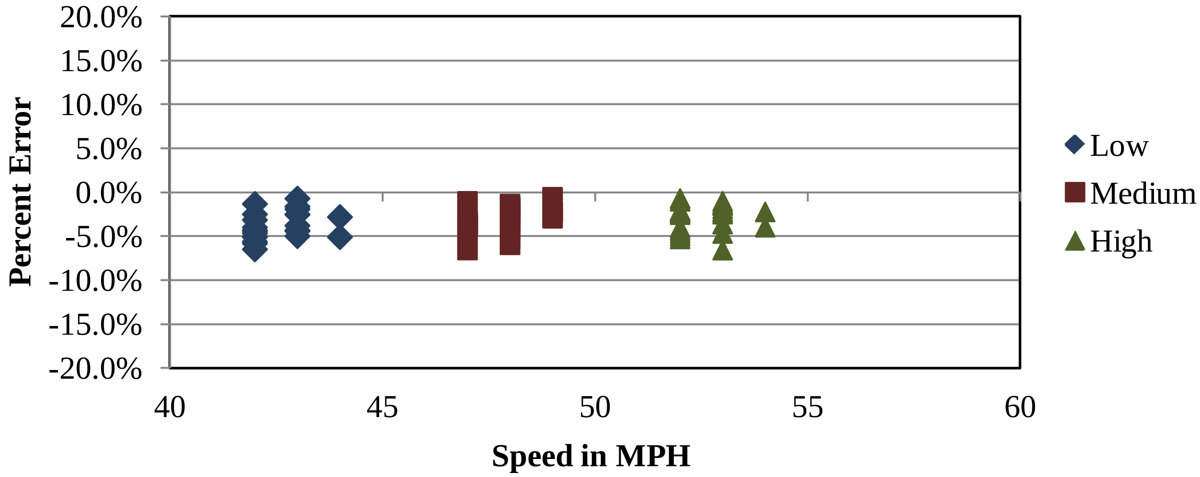


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 06-Dec-11

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 precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck. Distribution of errors is shown graphically in Figure 5-4.

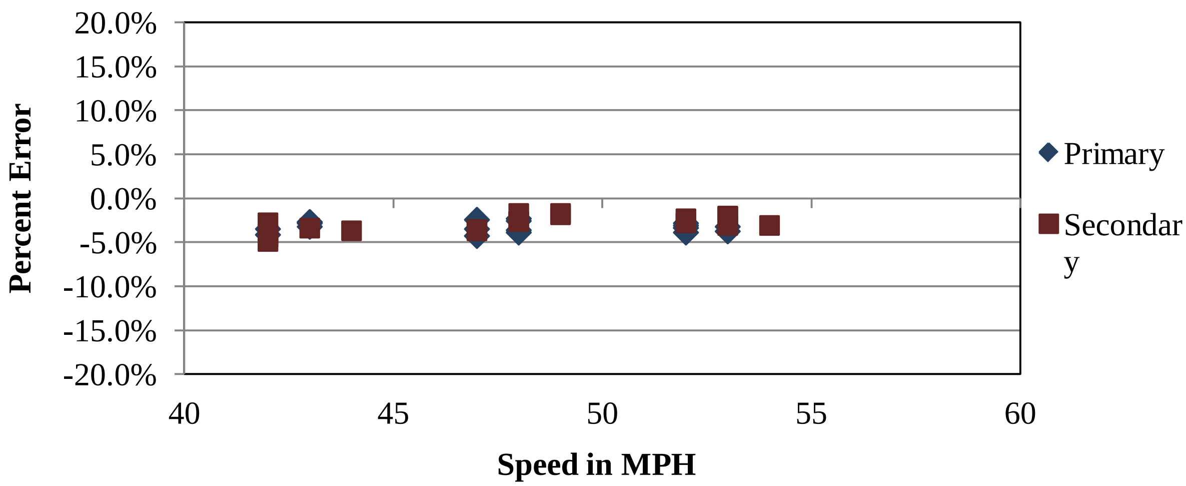


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 06-Dec-11

5.1.1.5 Axle Length Errors by Speed

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

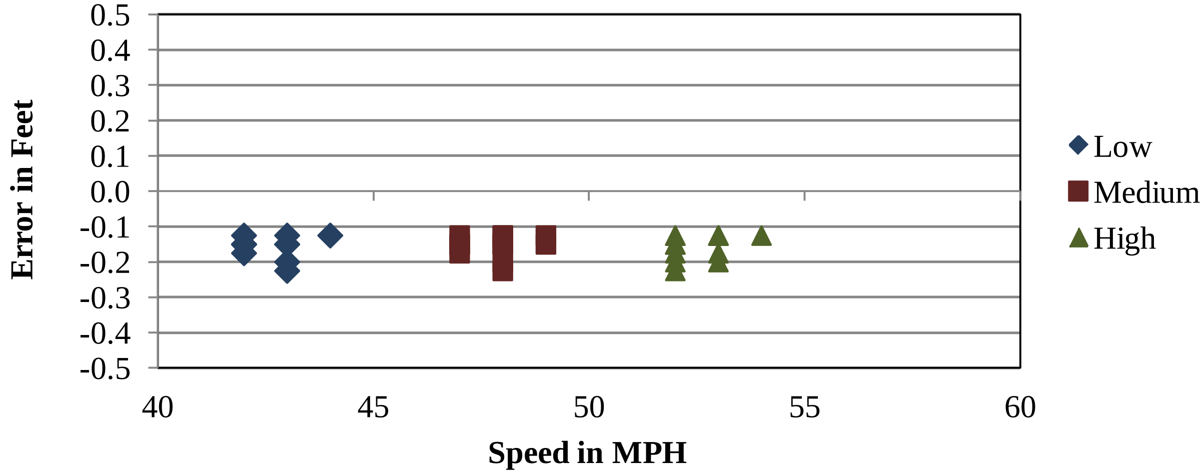


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 06-Dec-11

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment estimated overall vehicle length consistently over the entire range of speeds, with an error range of -1.2 to -2.2 feet. Distribution of errors is shown graphically in Figure 5-6.

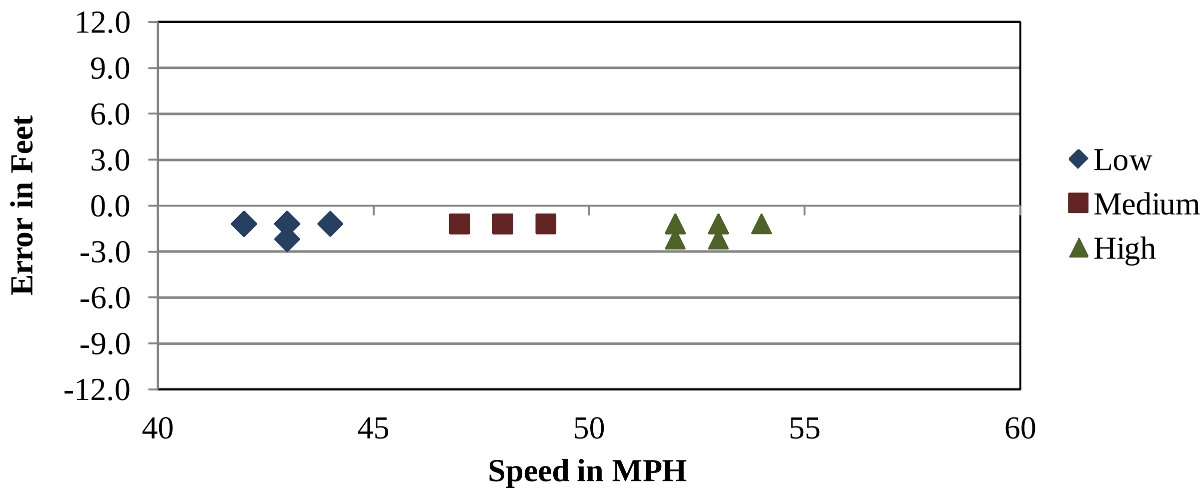


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 06-Dec-11

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. Since the range of pavement temperatures only varied 3.2 degrees, from 56.5 to 59.7 degrees Fahrenheit, the analysis was very limited, and conclusive results on the relationship could not be developed. The pre-validation test runs are being reported under one temperature groups, as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 06-Dec-11

Parameter	**95% Confidence Limit of Error**	**Medium**
		56.5 to 59.7 degF
Steering Axles	±20 percent	-2.4 ± 2.7%
Tandem Axles	±15 percent	-3.2 ± 3.1%
GVW	±10 percent	-3.1 ± 1.6%
Vehicle Length	±3.0 percent (2.0 ft)	-1.3 ± 0.5 ft
Vehicle Speed	± 1.0 mph	-0.8 ± 2.3 mph
Axle Length	± 0.5 ft [150mm]	-0.2 ± 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 5-7, it can be seen that the equipment underestimates GVW across the range of temperatures observed in the field.

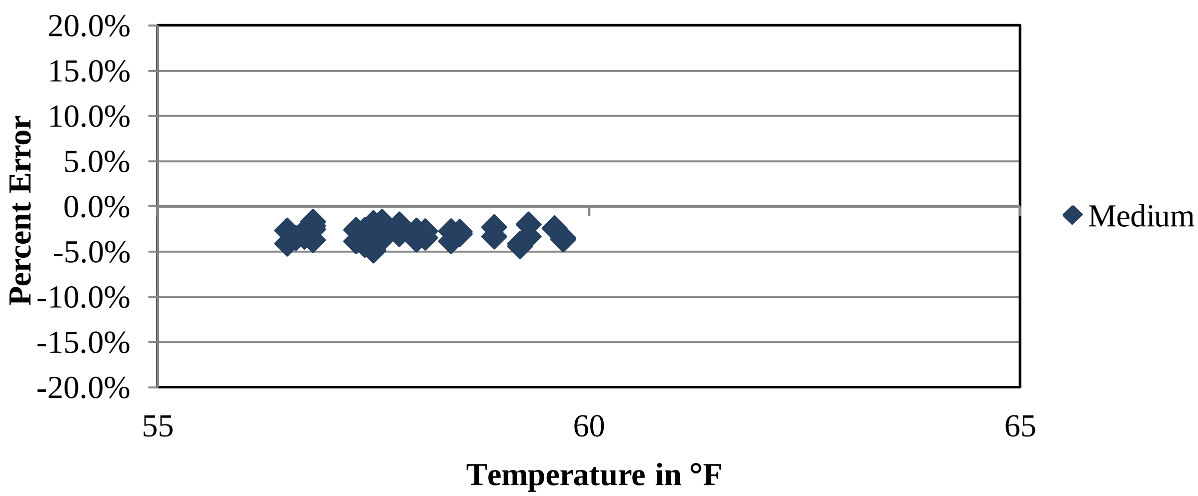


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 06-Dec-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that for steering axles, the WIM equipment generally underestimates at all temperatures.

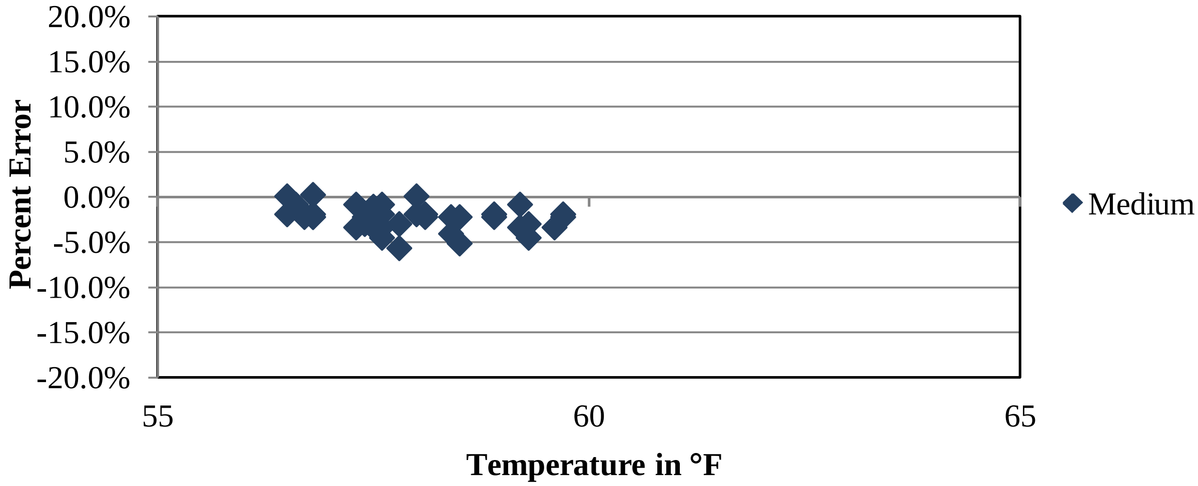


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 06-Dec-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment underestimates tandem axle weights across the range of temperatures observed in the field.

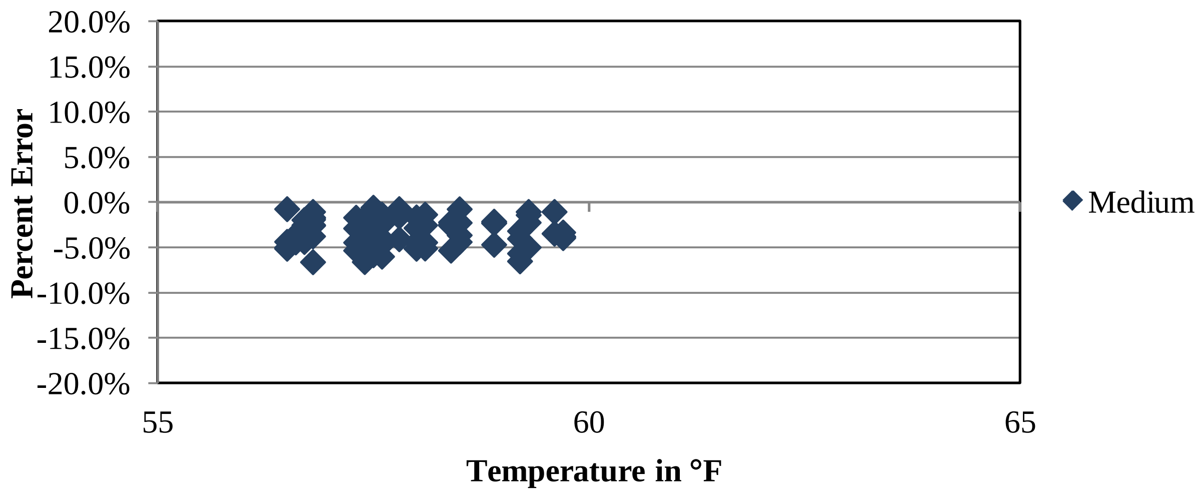


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 06-Dec-11

5.1.2.4 GVW Errors by Temperature and Truck Type

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

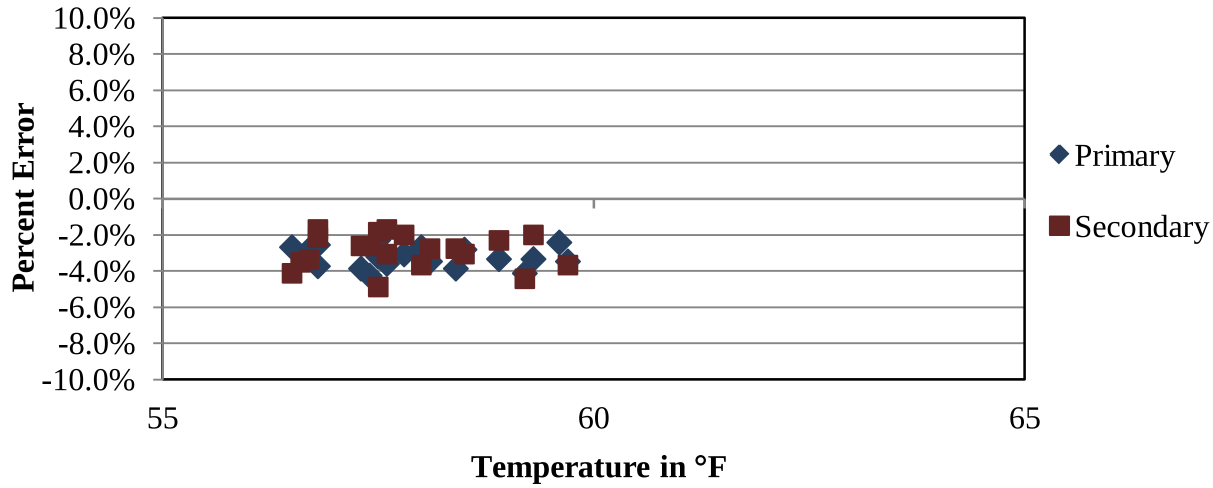


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 06-Dec-11

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 103 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 5-6. The table illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study. As shown in Table 5-6, one Class 3 was misclassified as a Class 5, one Class 4 was misclassified as a Class 5, two Class 5s were misclassified as Class 3s and two Class 5s were identified as Class 4 vehicles by the equipment.

Table 5-5 – Pre-Validation Misclassifications by Pair – 06-Dec-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	1	6/4	0	9/5	0
4/5	1	6/7	0	9/8	0
4/6	0	6/8	0	9/10	0
5/3	2	6/9	0	10/9	0
5/4	2	6/10	0	10/13	0
5/6	0	7/6	0	11/12	0
5/7	0	8/3	0	12/11	0
5/8	0	8/5	0	13/10	0
5/9	0	8/9	0	13/11	0

As shown in Table 5-6, a total of 6 vehicles, including 0 heavy trucks (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 5.8%. The causes for the misclassifications were not investigated in the field. More detailed post-visit investigations of misclassified vehicles may be performed using the collected video.

The combined results produced an undercount of two Class 5s and an overcount of one Class 3 and one Class 4 vehicle, 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 – 06-Dec-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	3	1	59	3	0	10	27	0	0	0	0
WIM Count	4	2	57	3	0	10	27	0	0	0	0
Observed Percent	2.9	1.0	57.3	2.9	0.0	9.7	26.2	0.0	0.0	0.0	0.0
WIM Percent	3.9	1.9	55.3	2.9	0.0	9.7	26.2	0.0	0.0	0.0	0.0
Misclassified Count	1	1	4	0	0	0	0	0	0	0	0
Misclassified Percent	0.0	100.0	6.8	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. The unclassified vehicles by pair are provided in Table 5-7.

Table 5-7 – Pre-Validation Unclassified Trucks by Pair – 06-Dec-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 1.3 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 – 06-Dec-11

Speed Point	MPH	Left	Right
		1	2
72	45	3688	3318
80	50	3727	3354
88	55	3714	3343
96	60	3714	3343
104	65	3714	3343
Axle Distance (cm)		366	
Dynamic Comp (%)		104	
Loop Width (cm)		208	

5.2.1.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall GVW error of -3.1% and errors of -3.5%, -2.9%, and -2.9% at the 45, 50 and 55 mph speed points respectively. To compensate for these errors, the changes in Table 5-9 were made to the compensation factors. The errors for the 55 mph speed point were extrapolated to derive new compensation factors for the 60 mph and 65 mph speed points.

Table 5-9 – Calibration Equipment Factor Changes – 07-Dec-11

Speed Points	Old Factors		New Factors	
	Left	Right	Left	Right
	1	2	1	2
72	3688	3318	3827	3443
80	3727	3354	3838	3454
88	3714	3343	3824	3442
96	3714	3343	3824	3442
104	3714	3343	3824	3442
Axle Distance (cm)	366		370	
Dynamic Comp (%)	104		104	
Loop Width (cm)	208		208	

5.2.1.2 Calibration Results

The results of the 12 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 Results – 07-Dec-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	$\pm$20 percent	1.2 ± 4.9%	Pass
Tandem Axles	$\pm$15 percent	-0.2 ± 3.3%	Pass
GVW	$\pm$10 percent	0.0 ± 1.9%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	0.7 ± 0.6 ft	Pass
Axle Length	$\pm$ 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

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

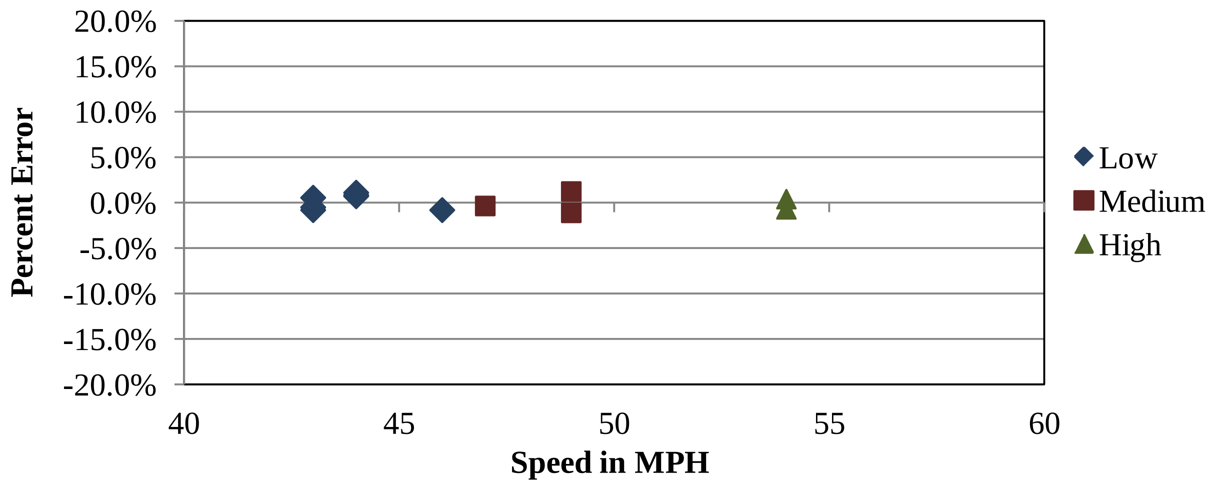


Figure 5-11 – Calibration GVW Error by Speed – 07-Dec-11

Based on the results of the first calibration, where weight estimate bias decreased to -0.2 percent, a second calibration was not considered to be necessary. The 12 calibration runs were combined with 30 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 42 post-validation test truck runs were conducted on December 7, 2011, beginning at approximately 8:56 AM and continuing until 1:35 PM, and on December 8, 2011, beginning at approximately 9:40 AM and continuing until 1:55 PM..

The two test trucks consisted of:

- A Class 9 truck, loaded with crane counter-weights, 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 crane counter-weights, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

The test trucks were weighed prior to the 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	76.8	8.9	17.1	17.1	16.8	16.8	11.7	4.3	38.3	4.2	58.5	66.2
2	66.1	9.4	14.4	14.4	13.9	13.9	11.8	4.3	37.5	4.5	58.1	65.2

Test truck speeds varied by 12 mph, from 42 to 54 mph. The measured post-validation pavement temperatures varied 18.5 degrees Fahrenheit, from 36.2 to 54.7. The rainy weather conditions prevented the desired minimum 30 degree temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 08-Dec-11

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	0.1 ± 4.6%	Pass
Tandem Axles	±15 percent	-0.4 ± 3.0%	Pass
GVW	±10 percent	-0.2 ± 1.3%	Pass
Vehicle Length	±3.0 percent (2.0 ft)	0.8 ± 0.3 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 -0.3 ± 1.9 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 55 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 – 08-Dec-11

Parameter	95% Confidence Limit of Error	Low 42.0 to 46.0 mph	Medium 46.1 to 50.1 mph	High 50.2 to 54.0 mph
Steering Axles	±20 percent	1.6 ± 4.8%	-0.2 ± 2.9%	-1.8 ± 3.6%
Tandem Axles	±15 percent	-0.5 ± 2.8%	-0.3 ± 2.8%	-0.2 ± 2.8%
GVW	±10 percent	-0.2 ± 1.4%	-0.2 ± 1.4%	-0.4 ± 1.6%
Vehicle Length	±3.0 percent (2.0 ft)	0.7 ± 0.5 ft	0.8 ± 0.0 ft	0.8 ± 0.0 ft
Vehicle Speed	± 1.0 mph	-0.5 ± 2.0 mph	-0.4 ± 2.6 mph	0.1 ± 1.1 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.1 ft	0.0 ± 0.1 ft

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

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

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-12, the equipment estimated GVW with similar accuracy at all speeds. The range in error and bias is similar throughout the entire speed range.

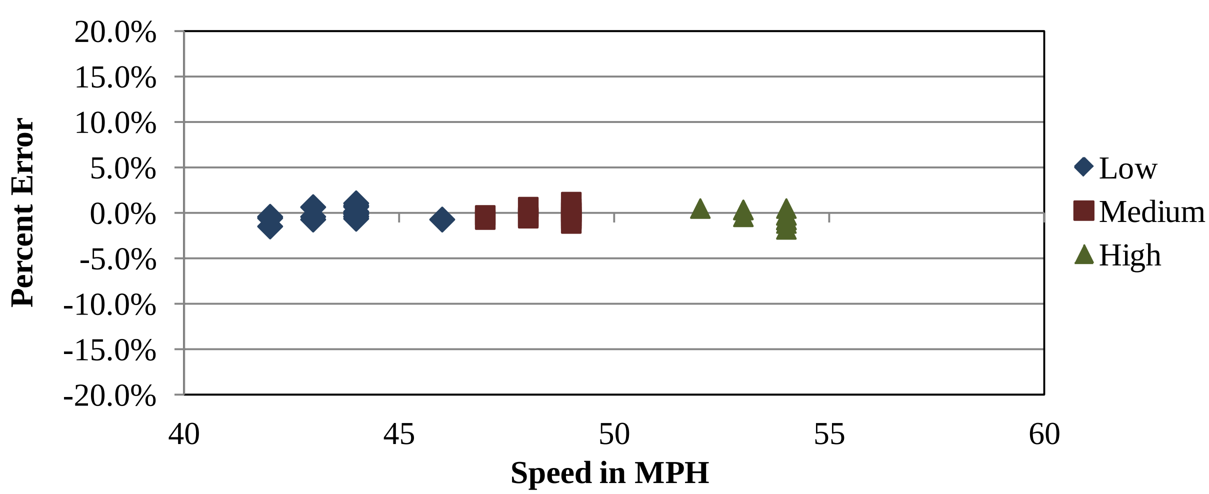


Figure 5-12 – Post-Validation GVW Errors by Speed – 08-Dec-11

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-13, the equipment overestimated steering axle weights at the low speed and moved toward an underestimation of steering axle weights at the higher speeds. The range in error is similar throughout the entire speed range. There does appear to be a correlation between speed and steering axle weight estimates at this site.

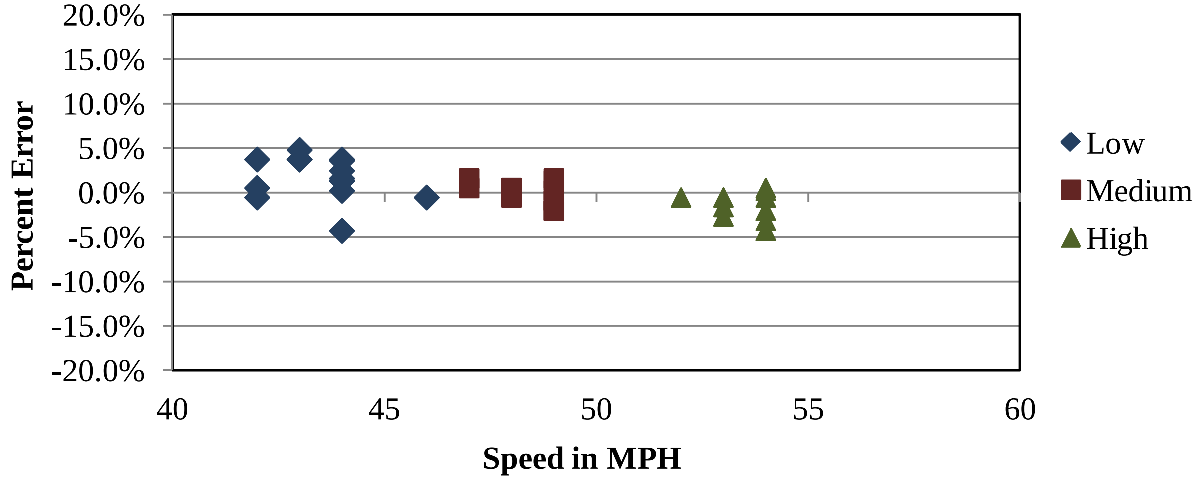


Figure 5-13 – Post-Validation Steering Axle Weight Errors by Speed – 08-Dec-11

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.

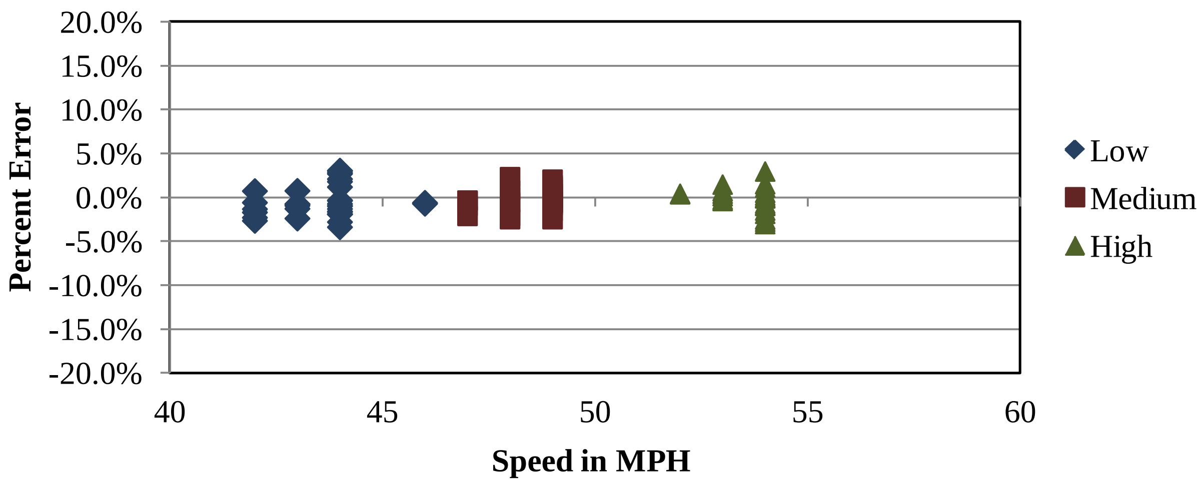


Figure 5-14 – Post-Validation Tandem Axle Weight Errors by Speed – 08-Dec-11

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 precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck.

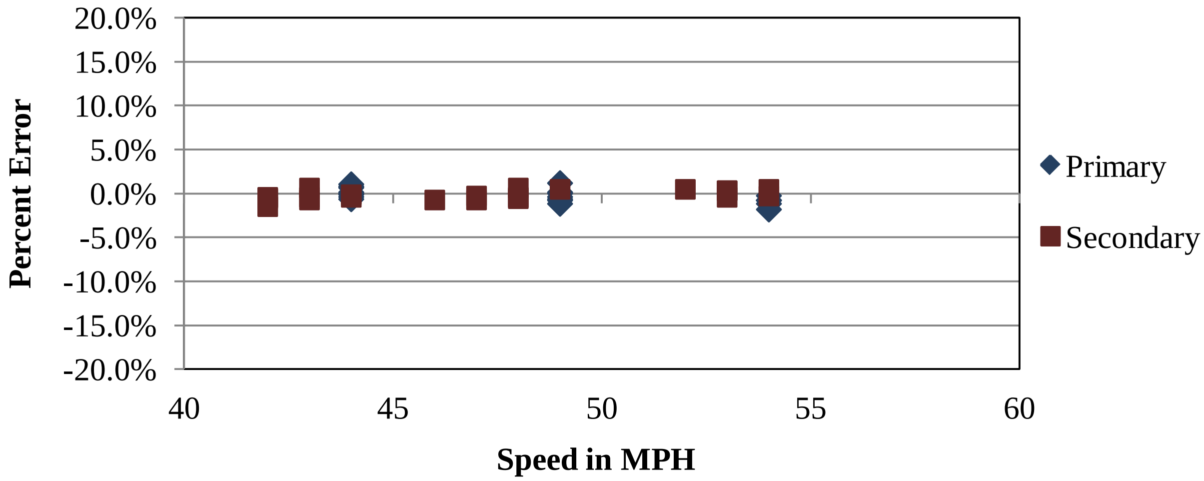


Figure 5-15 – Post-Validation GVW Error by Truck and Speed – 08-Dec-11

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

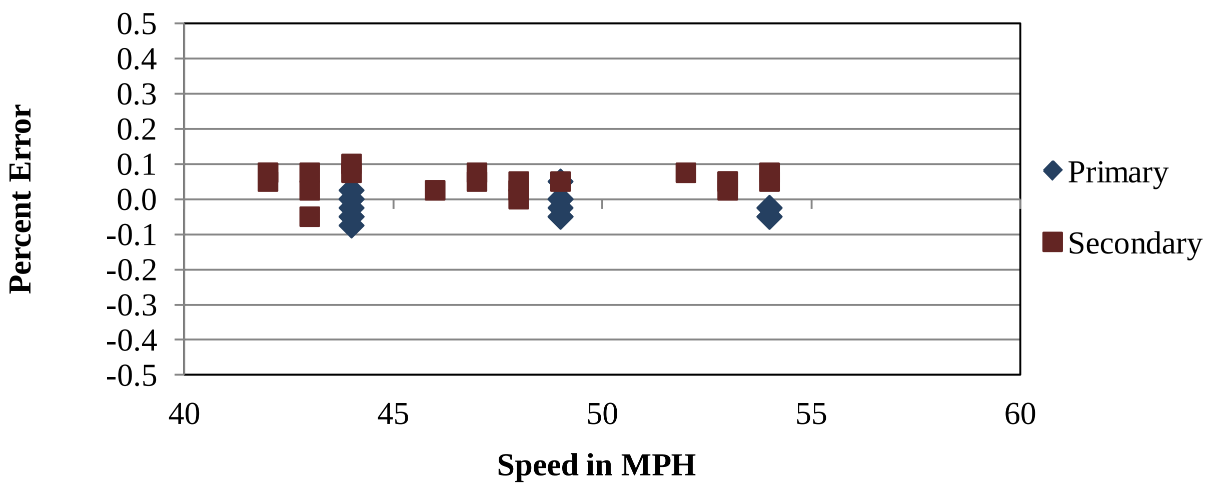


Figure 5-16 – Post-Validation Axle Length Error by Speed – 08-Dec-11

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 -0.2 to 0.8 feet. Distribution of errors is shown graphically in Figure 5-17.

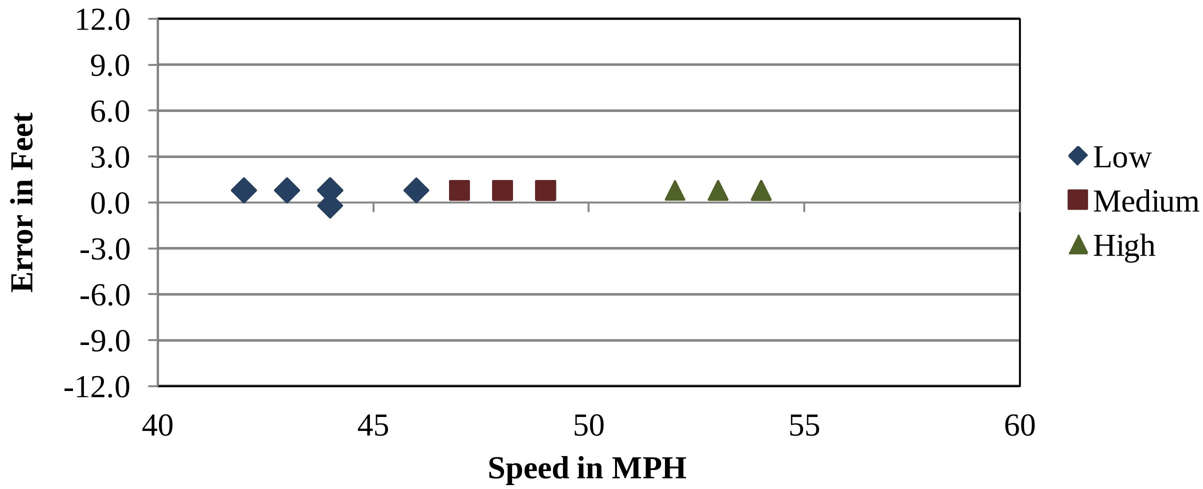


Figure 5-17 – Post-Validation Overall Length Error by Speed – 08-Dec-11

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 18.5 degrees, from 36.2 to 54.7 degrees Fahrenheit. The post-validation test runs are reported under two temperature groups – low and high, as shown in Table 5-14 below.

Table 5-14 – Post-Validation Results by Temperature – 08-Dec-11

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 estimate GVW with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and GVW estimates at this site.

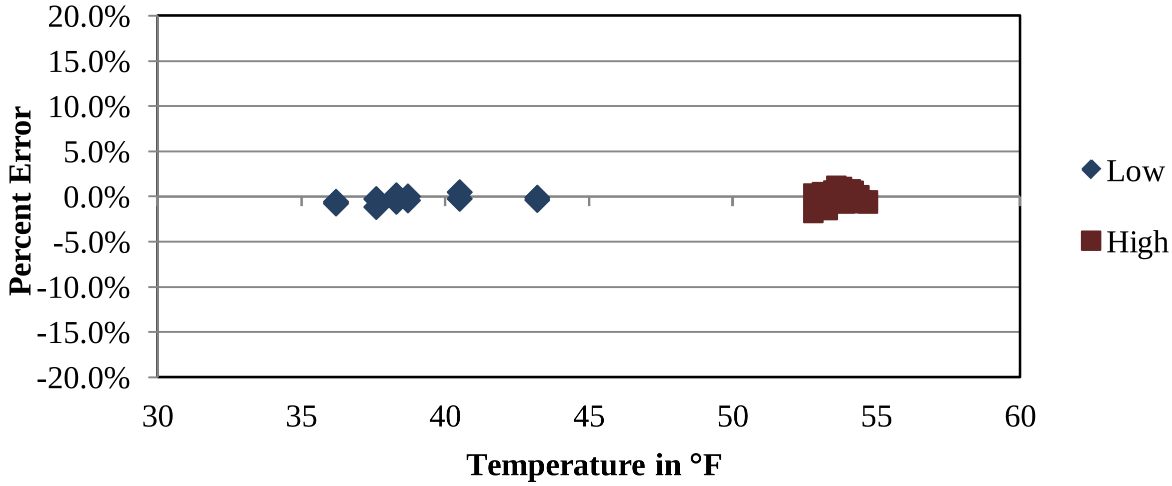


Figure 5-18 – Post-Validation GVW Errors by Temperature – 08-Dec-11

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-19 demonstrates that for steering axles, the WIM equipment appears to estimate weights with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and steering axle weight estimates at this site. The range in error is similar for different temperature groups.

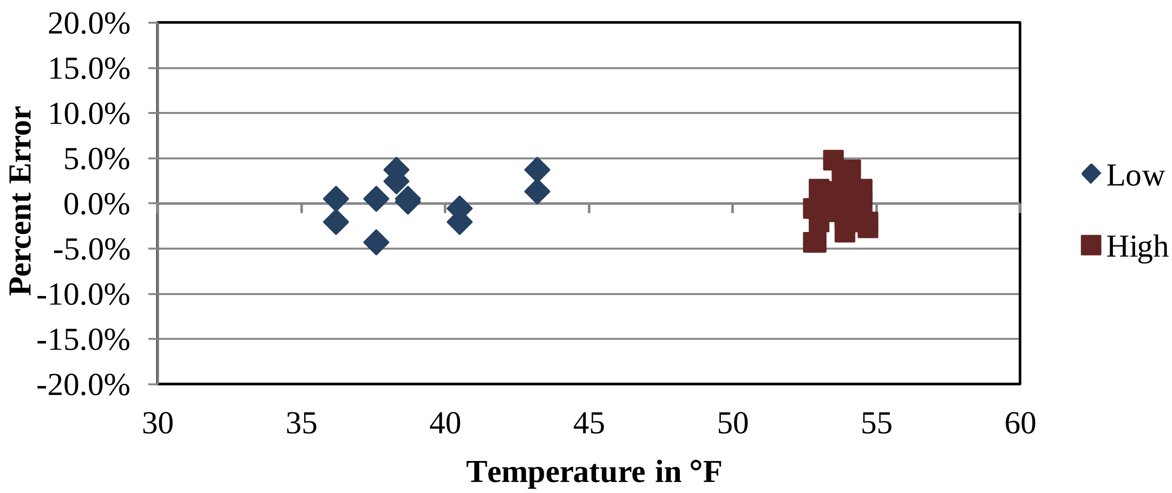


Figure 5-19 – Post-Validation Steering Axle Weight Errors by Temperature – 08-Dec-11

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 not appear to be a correlation between temperature and tandem axle weight estimates at this site. The range in tandem axle errors is consistent for the two temperature groups.

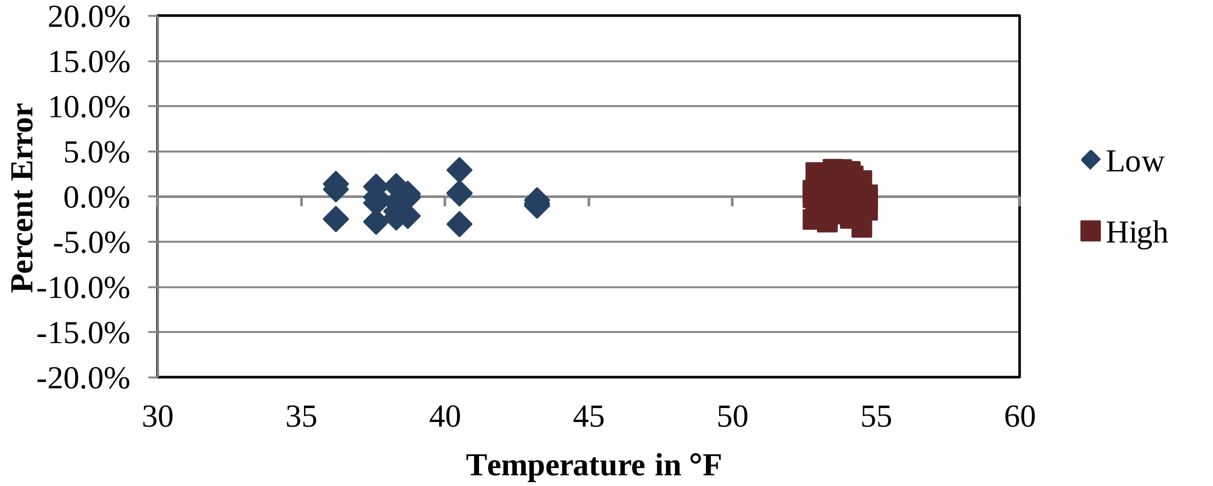


Figure 5-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 08-Dec-11

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-21, 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.

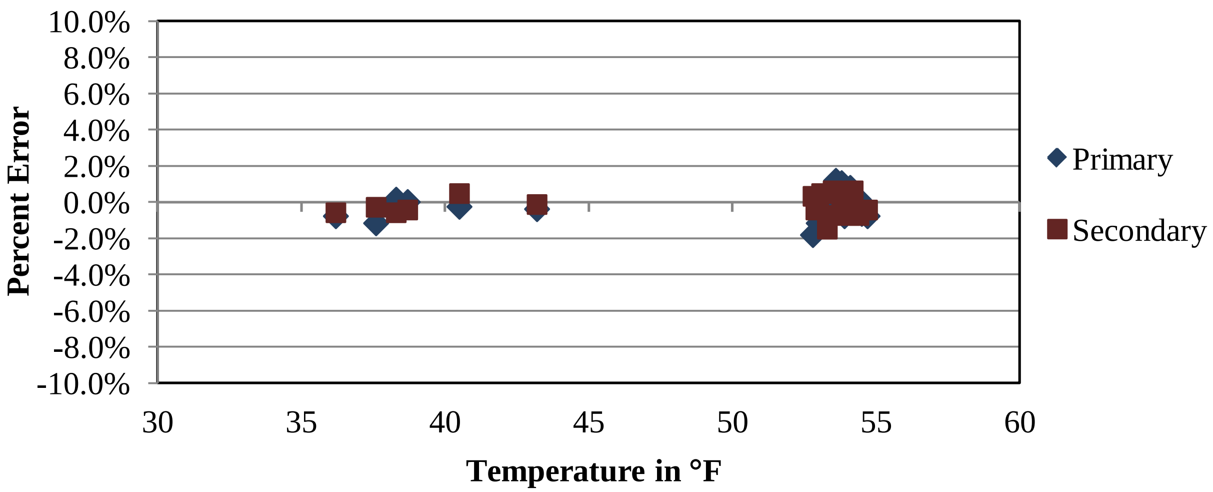


Figure 5-21 – Post-Validation GVW Error by Truck and Temperature – 08-Dec-11

5.3.3 GVW and Steering Axle Trends

Figure 5-22 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed.

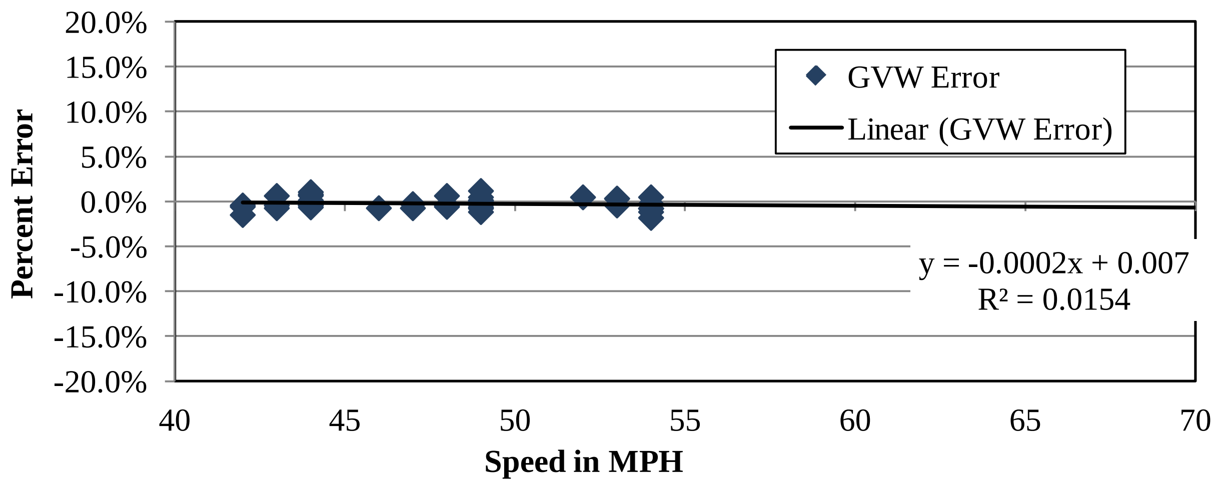


Figure 5-22 – GVW Error Trend by Speed

Figure 5-23 is provided to illustrate the predicted Steering Axle error with respect to the post-validation errors by speed.

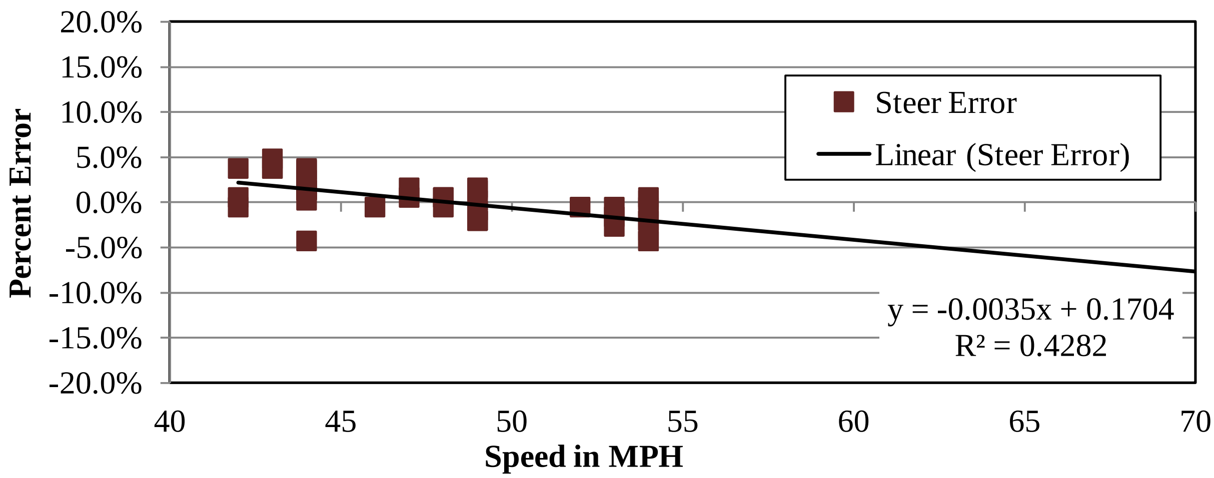


Figure 5-23 – Steering Axle Trend by Speed

5.3.4 Multivariable 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.

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 “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 42 to 54 mph.
- Pavement temperature. Pavement temperature ranged from 36.2 to 54.7 degrees Fahrenheit.

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 regression coefficients are equal to zero. The probability values reported in Table 5-15 are for the probability that the regression coefficients, given in Table 5-15, occur by chance alone.

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

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	0.1002	1.6696	0.0600	0.9525
Speed	-0.0174	0.0270	-0.6466	0.5220
Temperature	0.0100	0.0166	0.5999	0.5523
Truck type	0.0325	0.2233	0.1456	0.8851

The lowest probability value given in Table 5-15 (with the exception of the intercept), was 0.5220 for speed. This means that there is about 52 percent chance that the value of regression coefficient for speed (-0.0174) can occur by chance alone. Consequently, speed, temperature and truck type did not have statistically significant effect on the GVW measurement error.

The relationship between speed and the GVW measurement error is shown in Figure 5-24. The figure includes trend line for the predicted percent error, and provides a visual assessment of the relationship.

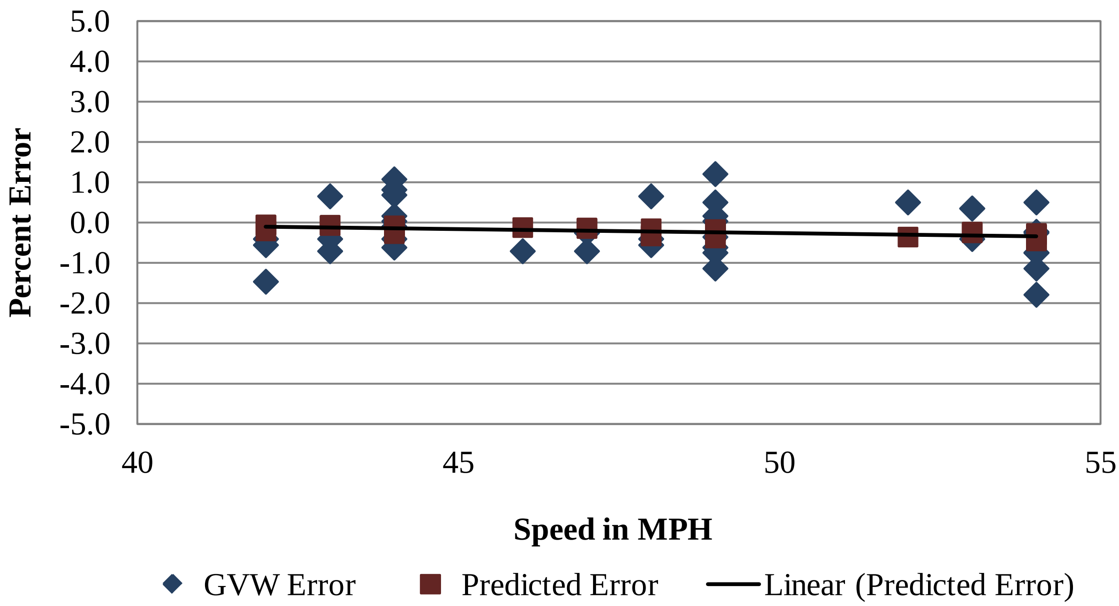


Figure 5-24 – Influence of Speed on the Measurement Error of GVW

The quantification of the relationship is provided by the value of the regression coefficient, in this case -0.0174 (in Table 5-15). This means, for example, that for a 10 mph increase in speed, the % error is decreased by about 0.2% (-0.0174 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient and is not statistically significant.

5.3.4.3 Summary Results

Table 5-16 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated that had some statistical significance. 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	-	-	-	-	-	-
Steering axle	-0.3263	0.0000	-	-	1.1999	0.0324
Tandem axle tractor	0.2074	0.0000	-	-	-	-
Tandem axle trailer	-0.1342	0.0332	0.0532	0.1620	-	-

5.3.4.4 Conclusions

1. Speed had a statistically significant effect on the steering axle and tandem axle measurement errors. The regression coefficients ranged from -0.3263 for the steering axles to +0.2074 for the tandem axles on tractors. It is notable that whereas the relationship between the speed and measurement errors was negative for steering axles and tandem axles on trailers (as shown by the negative values of the regression coefficients in Table 5-26), the corresponding relationship for the tandem axles on tractors was positive (the mean measurement error was increasing at the rate of 0.2074 % per one mph). Consequently, it is not surprising that the relationship between speed and measurement errors for GVW was not statistically significant and that its regression coefficient was close to zero (0.0174 in Table 5-15).

2. Temperature may have affected the measurement error of tandem axles on trailers, but the probability that the relationship can occur by chance alone was about 16.2 %, which is relatively high.

3. Truck type had statistically significant effect on the measurement errors of steering axle weights only. The regression coefficient for truck type in Table 5-16, represent the difference between the mean errors for the Primary and Secondary trucks. (Truck type is an indicator variable with values of 0 or 1.) Thus, the mean error for steering axle

weights for the Secondary truck was about 1.2 % larger than the corresponding mean error for the Primary truck.

4. Even though speed, temperature, and truck type had statistically significant effects 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.

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 102 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 misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-18.

Table 5-17 – Post-Validation Misclassifications by Pair – 08-Dec-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/8	0	6/4	0	9/5	0
4/5	0	6/7	0	9/8	0
4/6	0	6/8	0	9/10	0
5/3	2	6/9	0	10/9	0
5/4	0	6/10	0	10/13	0
5/6	0	7/6	0	11/12	0
5/7	0	8/3	0	12/11	0
5/8	0	8/5	0	13/10	0
5/9	0	8/9	0	13/11	0

As shown in the table, a total of 2 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 (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 2.0%.

Table 5-17 also shows that two Class 5 vehicles were identified as Class 3 vehicles by the equipment. The cause of the misclassifications was not investigated in the field.

The combined results of the misclassifications resulted in an over-count of two Class 3 vehicles, and under-count of two Class 5 vehicles as shown in Table 5-18.

Table 5-18 – Post-Validation Classification Study Results – 08-Dec-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	2	0	43	6	2	8	41	0	0	0	0
WIM Count	4	0	41	6	2	8	41	0	0	0	0
Observed Percent	2.0	0.0	42.2	5.9	2.0	7.8	40.2	0.0	0.0	0.0	0.0
WIM Percent	3.9	0.0	40.2	5.9	2.0	7.8	40.2	0.0	0.0	0.0	0.0
Misclassified Count	0	0	2	0	0	0	0	0	0	0	0
Misclassified Percent	0.0	0.0	4.7	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. The unclassified vehicles by pair are provided in Table 5-19.

Table 5-19 – Post-Validation Unclassified Trucks by Pair – 08-Dec-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 -0.6 mph; the range of errors was 2.0 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 four previous visits as well as the current one as summarized in the tables below and provided on the Traffic Sheet 16. Table 6-1 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 6-1 – Classification Validation History

Date	Misclassification Percentage by Class										Pct Unclass
	4	5	6	7	8	9	10	11	12	13	
21-Mar-06	100	39	0	-	14	4	-	-	-	-	0
22-Mar-06	100	20	0	-	0	0	-	-	-	-	0
4-Sep-07	-	0	-	-	-	0	-	-	-	-	0
5-Sep-07	-	0	0	0	0	0	0	-	-	-	0
13-May-08	-	7	14	-	-	-	-	-	-	-	1
14-May-08	-	0	0	0	0	0	100	-	-	-	1
24-Aug-10	80	5	0	100	0	0	-	-	-	-	1
25-Aug-10	100	28	0	67	0	0	0	-	-	-	2
6-Dec-11	100	7	0	0	0	0	0	-	-	-	0
8-Dec-11	-	5	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 One SD		
	GVW	Single Axles	Tandem
21-Mar-06	1.0 ± 2.6	1.1 ± 4.2	0.9 ± 2.8
22-Mar-06	2.8 ± 3.1	2.5 ± 3.7	2.9 ± 3.3
4-Sep-07	0.5 ± 2.8	0.3 ± 4.7	0.6 ± 3.4
5-Sep-07	1.1 ± 3.4	0.5 ± 5.5	1.3 ± 4.1
13-May-08	1.7 ± 5.1	1.1 ± 6.0	1.8 ± 5.3
14-May-08	2.2 ± 3.4	1.5 ± 5.0	2.3 ± 3.7
24-Aug-10	-0.9 ± 1.5	-2.8 ± 3.5	1.3 ± 2.2
25-Aug-10	-0.1 ± 1.3	-1.4 ± 4.0	1.5 ± 1.6
6-Dec-11	-3.1 ± 0.8	-2.4 ± 1.3	-3.2 ± 1.6
8-Dec-11	-0.2 ± 0.7	0.1 ± 2.3	-0.4 ± 1.5

The variability of the weight errors appears to have remained reasonably consistent since the site was first validated, decreasing slightly for the past two validations. From this information, it appears that the system demonstrates a tendency for the equipment to move toward an underestimation of GVW over time. The table also demonstrates the effectiveness of the validations in keeping the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

A comparison of the 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)				
		22-Mar-06	5-Sep-07	14-May-08	25-Aug-10	8-Dec-11
Steering Axles	±20 percent	2.5 ± 7.5	0.5 ± 11.0	1.5 ± 10.2	-1.4 ± 8.1	0.1 ± 4.6
Tandem Axles	±15 percent	2.9 ± 6.5	1.3 ± 8.1	2.3 ± 7.3	1.5 ± 3.3	-0.4 ± 3.0
GVW	±10 percent	2.8 ± 6.2	1.1 ± 6.9	2.2 ± 6.9	-0.1 ± 2.6	-0.2 ± 1.3

From Table 6-3, it appears that the mean error and the 95% confidence interval have decreased for all weights since the equipment was installed, although they increased slightly for the validations in 2007 and 2008.

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

Table 6-4 – Final Factors

Speed Point	MPH	Left	Right
		1	2
72	45	3827	3443
80	50	3838	3454
88	55	3824	3442
96	60	3824	3442
104	65	3824	3442
Axle Distance (cm)		370	
Dynamic Comp (%)		104	
Loop Width (cm)		208	

A review of the LTPP Standard Release Database 25 shows that there are 6 years of level "E" WIM data for this site. This site requires no additional years of data to meet the minimum of five years of research quality data.

7 Additional Information

The following information is provided in the attached appendix:

- Site Photographs
  - Equipment
  - Test Trucks
  - Pavement Condition
- 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

Maryland, SPS-5
SHRP ID: 240500

Validation Date: December 8, 2011

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

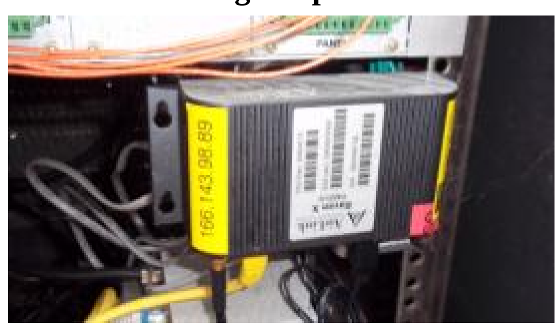


Photo 8 – Cellular Modem

Photo 9 – Downstream

Photo 10 – Upstream

Photo 11 – Truck 1

Photo 12 – Truck 1 Tractor

Photo 13 – Truck 1 Trailer and Load

Photo 14 – Truck 1 Suspension 1

Photo 15 – Truck 1 Suspension 2

Photo 16 – Truck 1 Suspension 3

Photo 17 – Truck 1 Suspension 4

Photo 18 – Truck 1 Suspension 5

Photo 19 – Truck 2

Photo 20 – Truck 2 Tractor

Photo 21 – Truck 2 Trailer and Load

Photo 22 – Truck 2 Suspension 1

Photo 23 – Truck 2 Suspension 2

Photo 24 – Truck 2 Suspension 3

Photo 25 – Truck 2 Suspension 4

Photo 26 – Truck 2 Suspension 5

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 24 SPS WIM ID: 240500 DATE (mm/dd/yyyy) 12/6/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 12/6/11

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:	-3.1%	Standard Deviation:	0.8%
Dynamic and Static Single Axle:	-2.4%	Standard Deviation:	1.3%
Dynamic and Static Double Axles:	-3.2%	Standard Deviation:	1.6%

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

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

			Low		High	Runs
a.	Low	-	42.0	to	46.0	12
b.	Medium	-	46.1	to	50.1	14
c.	High	-	50.2	to	54.0	14
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 24 SPS WIM ID: 240500 DATE (mm/dd/yyyy) 12/6/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3824 | 3442

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: ______

13. METHOD TO DETERMINE LENGTH OF COUNT: ______

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9: ______ FHWA Class 5 - ______

FHWA Class 8: ______ FHWA Class ______ - ______

FHWA Class ______ - ______

FHWA Class ______ - ______

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort: **Dean Wolf**

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 16	STATE CODE:	24
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	240500
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	12/7/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 12/7/11

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
   b. Bending Plates
   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: 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:	-0.2%	Standard Deviation:	0.7%
Dynamic and Static Single Axle:	0.1%	Standard Deviation:	2.3%
Dynamic and Static Double Axles:	-0.4%	Standard Deviation:	1.5%

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

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

			Low		High	Runs
a.	Low	-	42.0	to	46.0	17
b.	Medium	-	46.1	to	50.1	13
c.	High	-	50.2	to	54.0	12
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 24 SPS WIM ID: 240500 DATE (mm/dd/yyyy) 12/7/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3842 | 3458

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:

13. METHOD TO DETERMINE LENGTH OF COUNT:

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:		FHWA Class	5	-	
FHWA Class 8:		FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Post

Person Leading Calibration Effort: **Dean Wolf**

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 24 SPS WIM ID: 240500 DATE (mm/dd/yyyy) 12/6/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
49	8	35698	53	8	32	5	36004	33	5
55	9	35709	55	9	**53**	**5**	**36016**	**55**	**3**
55	5	35714	55	5	53	5	36017	54	5
42	5	35769	44	5	59	9	36031	60	9
39	9	35772	43	9	58	5	36086	60	5
39	5	35773	43	5	62	8	36087	62	8
52	5	35779	53	5	60	5	36090	61	5
57	9	35780	59	9	54	5	36094	54	5
52	8	35807	54	8	57	5	36097	58	5
55	9	35816	56	9	54	5	36102	53	5
45	5	35827	45	5	44	8	36109	46	8
52	5	35875	53	5	**57**	**3**	**36206**	**58**	**5**
54	8	35880	55	8	52	9	36233	52	9
55	5	35891	55	5	55	8	36235	56	8
48	5	35903	49	5	57	9	36242	59	9
48	5	35905	50	5	58	5	36256	60	5
53	5	35916	55	5	54	5	36262	55	5
58	9	35921	59	9	53	5	36323	55	5
60	9	35952	62	9	57	9	36324	58	9
52	5	35959	51	5	53	5	36345	56	5
54	8	35965	54	8	55	5	36346	54	5
55	9	35982	55	9	61	5	36355	60	5
56	8	35992	58	8	53	5	36359	54	5
59	5	35994	59	5	48	5	36373	48	5
44	5	35997	45	5	57	5	36436	54	5

Sheet 1 - 0 to 50　　Start: 10:58:40　　Stop: 13:14:47

Recorded By: kt　　Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 24 SPS WIM ID: 240500 DATE (mm/dd/yyyy) 12/6/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
52	5	36443	53	5	40	5	36757	40	5
55	5	36467	57	5	50	5	36758	48	5
54	8	36474	57	8	57	9	36791	60	9
53	**4**	**36547**	**54**	**5**	55	5	36801	56	5
55	6	36550	56	6	54	5	36806	55	5
45	5	36552	46	5	54	5	36812	55	5
53	5	36556	53	5	54	6	36823	55	6
57	**4**	**36563**	**60**	**5**	52	5	36838	53	5
45	9	36575	45	9	57	3	36840	57	3
57	9	36582	63	9	51	9	36847	51	9
55	5	36585	55	5	**50**	**3**	**36848**	**52**	**5**
55	9	36593	55	9	57	9	36849	58	9
49	5	36599	50	5	53	9	36850	54	9
44	5	36604	45	5	54	8	36852	55	8
44	5	36605	43	5	52	5	36867	54	5
53	6	36616	53	6	54	9	36876	54	9
55	3	36617	54	3	56	9	36877	57	9
46	5	36678	46	5	**57**	**5**	**36927**	**58**	**4**
53	9	36681	54	9	45	5	36930	47	5
56	9	36687	58	9	60	9	36931	62	9
53	5	36697	54	5	53	5	36954	54	5
56	5	36702	58	5	55	5	36955	53	5
51	5	36731	52	5	53	5	36956	54	5
48	9	36743	50	9	52	9	36963	54	9
48	9	36744	50	9	53	5	36965	53	5

Sheet 2 - 51 to 100 Start: 13:17:16 Stop: 14:34:50

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20	
LTPP MONITORED TRAFFIC DATA	STATE CODE: 24
SPEED AND CLASSIFICATION STUDIES	SPS WIM ID: 240500
	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
49	9	36980	49	9					
60	5	36988	61	5					
55	5	37004	55	5					

Sheet 3 - 101 - 150 Start: 14:37:30 Stop: 14:39:00

Recorded By: kt Verified By: djw

Traffic Sheet 20	STATE CODE:	24
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	240500
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	12/7/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
53	8	42833	53	8	55	3	43777	52	3
47	9	42840	48	9	63	5	43862	55	5
43	5	42850	43	5	54	5	43873	55	5
57	9	42909	58	9	57	5	43882	58	5
52	9	42911	53	9	50	9	43883	50	9
52	9	42938	54	9	46	5	43890	47	5
57	8	42940	58	8	50	5	43896	51	5
59	5	42941	59	5	52	9	43897	52	9
57	5	43141	57	5	54	5	43899	55	5
49	6	43204	49	6	53	8	43915	52	8
53	5	43253	54	5	45	9	43925	46	9
50	5	43286	51	5	49	5	43926	49	5
46	9	43297	48	9	49	5	43973	50	5
57	5	43312	58	5	42	5	43979	43	5
47	5	43355	48	5	44	5	43983	47	5
47	8	43356	47	8	56	6	43989	57	6
41	5	43360	42	5	54	5	43990	54	5
54	9	43368	55	9	55	9	44008	56	9
58	5	43369	58	5	55	9	44021	56	9
55	5	43464	55	5	55	9	44143	54	9
52	9	43693	52	9	44	5	44150	47	5
50	9	43694	51	9	47	5	44155	47	5
50	5	43695	50	5	54	6	44187	56	6
54	5	43701	54	5	50	9	44201	50	9
52	9	43718	53	9	45	5	44209	46	5

Sheet 1 - 0 to 50 Start: 8:53:22 Stop: 12:53:35

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20	STATE CODE:	24
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	240500
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	12/7/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
52	9	44216	55	9	57	9	44467	57	9
54	5	44218	54	5	56	9	44468	58	9
53	9	44219	52	9	59	5	44528	59	5
50	5	44220	50	5	55	9	44534	60	9
55	5	44227	55	5	53	5	44538	55	5
50	5	44236	53	5	59	6	44562	60	6
55	**3**	**44238**	**56**	**5**	54	6	48025	54	6
41	7	44273	42	7	**59**	**3**	**48051**	**51**	**5**
55	8	44294	56	8	54	9	48073	54	9
51	9	44300	54	9	59	9	48091	59	9
54	5	44307	58	5	55	8	48092	56	8
50	9	44309	50	9	49	9	48118	47	9
46	8	44312	44	8	52	9	48123	58	9
43	9	44327	47	9	61	9	48147	62	9
43	9	44328	44	9	52	9	48163	52	9
41	5	44329	42	5	50	9	48165	51	9
54	5	44389	54	5	55	9	48181	56	9
58	9	44395	58	9	54	5	48182	54	5
54	9	44399	55	9	54	5	48183	54	5
58	9	44404	58	9	60	5	48198	63	5
59	3	44408	60	3	40	5	48204	42	5
57	9	44437	64	9	45	5	48025	44	5
59	9	44446	59	9	39	6	48212	41	6
52	7	44454	52	7	49	9	48233	48	9
55	9	44465	55	9	47	8	48234	47	8

Sheet 2 - 51 to 100 Start: 12:55:26 Stop: 10:21:45

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 24 SPS WIM ID: 240500 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
48	9	48235	48	9					
62	5	48297	58	5					

Sheet 3 - 101 - 150 Start: 10:21:48 Stop: 10:32:16

Recorded By: kt Verified By: djw