

Installation and Evaluation of Weigh-In-Motion Utilizing Quartz-Piezo Sensor Technology

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BACKGROUND

In 1996 personnel at the Connecticut Department of Transportation identified the need to install a Weigh-In-Motion system to collect continuous traffic data for a FHWA Long Term Pavement Performance (LTPP) Special Pavement Study (SPS)-9A, "Verification of SHRP Asphalt Specification and Mix Design." A review of WIM systems on the market revealed areas of concern that included system accuracy, temperature dependency, speed dependency, signal degradation, and cost effectiveness. At this time, we became aware of a state-of-the art technology that promised to address many of the stated concerns. The new technology that had been developed in Switzerland and used in Europe is the Quartz-Piezoelectric Sensor.

In 1997, a three-year research study was established at the Connecticut Department of Transportation to install and evaluate the Quartz-Piezoelectric or "Quartz-Piezo" sensor technology for use in weigh-in-motion (WIM). Funding for the cost of the sensor technology was provided from the FHWA Priority Technologies (PTP) Program, a program established under The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) Section 6005. The Quartz-Piezo sensor study matches well with the goals of the PTP including: leading edge technology, results within a short time, potential for greater use beyond the immediate project and public or private partnerships which leverage other resources. Results of the research will be reported annually through the PTP.

The Quartz-Piezo Sensor

Many WIM practitioners are familiar with the piezo electric ceramic coaxial cables and commonly refer to them as "PIEZO." In actuality, "piezo" simply refers to "the generation of electricity or of electric polarity in dielectric crystals subjected to mechanical stress." (Reference 1) The Quartz-Piezo sensor applies the same piezoelectric principle to generate a signal, but uses completely different materials and design.

As labeled in the cross-section of the quartz-piezo sensor in Appendix A, Figure 1 the sensor is made up of a quartz sensing element placed in an aluminum housing and then constructed with elastic material around it. A load pad of epoxy-silica sand compound is attached to the top of the aluminum housing. The sides of the load pad are wrapped with a closed-cell foam padding. The sensors are manufactured in one-meter lengths. A one-meter length sensor has twenty quartz-sensing elements distributed evenly throughout.

TEST LOCATION

This test represents the first installation of the Quartz-Piezo sensor technology on a highway in the United States. The test site is located on Connecticut Route 2 in both the Eastbound (EB) and Westbound (WB) directions at milepost 29.61, in the town of Lebanon. Route 2 is a four-lane, median divided highway, functionally classified as a principal arterial. It is also part of the National Highway System (NHS) established as a result of ISTEA. The test location selected was based on the need to measure traffic for the FHWA-LTPP SPS-9A program, the availability of power and telephone, the roadway grade and proximity to nearby structures. The pavement is a Superpave bituminous mix, which was placed on existing bituminous pavement that had undergone partial depth milling. The Superpave surface layer was placed during 1997 and therefore is in excellent condition.

WIM SENSOR LAYOUT

The sensor layout was selected in order to gather data for direct comparison with conventional piezoelectric WIM systems. The layout configuration is induction loop, two full lane-width strips of WIM sensors and a second induction loop. (Appendix A, Figure 2) The full lane-width strip of quartz-piezo sensors is assembled by laying four, one-meter sensors end-to-end. The sensors are attached to each other with a metal plate screwed to the base ends of the sensors. (Shown upside-down in Appendix A, Figure 3) A distance between sensors of sixteen feet was recommended by the sensor manufacturer based on the average speed of vehicles at the location.

Both lanes in each direction were instrumented, for a total of four-lanes of instrumentation. (Appendix A, Figure 4) The instrumentation for the high-speed and low-speed lanes was installed at staggered intervals, as is conventionally done with WIM installations. The sensors were placed from the center of the centerline marking to extend (1.11 ft or .34 meters) into the shoulder in order to accommodate the four-meter strip of sensors within the (12 ft or 3.66m) lane width. A cabinet was installed in the center median of the highway to house the electronics for the WIM system from both the EB and WB directions.

A pavement temperature sensor was installed in the westbound high-speed lane for the purposes of this study only. The quartz-piezo sensors are supposed to be independent of temperature. The pavement temperature data collected will be used to validate this. There has been concern voiced in the past concerning the influence of wind speed on the collection of traffic data. A complete Roadway Weather Information System (RWIS) has been installed at the test site and can be used to obtain roadway weather data for comparison with the traffic data collection, if needed.

This WIM system design has the unique capability to differentiate between wheel-path weight data. For the purposes of this experiment it was decided to collect wheel-path specific data in the slow-speed lane of each direction.

SENSOR INSTALLATION

Due to several factors, but primarily the paving work required at the test site prior to the instrumentation, sensor installation did not take place until October 23 and 24, 1997. These dates are on the fringe of the temperature dependent fieldwork season in Connecticut. On the installation dates, the weather sustained approximately 45 degree Fahrenheit temperatures; unseasonably cold, however, warm enough to install the grout. The minimum temperature recommended for grout installation is 40 degrees Fahrenheit.

The sensor manufacturer delivered the sensors to the site. Normally a 2 1/8 inch high by 2 3/4 inch wide channel is cut in the pavement to accommodate the Quartz-Piezo sensors. The pavement overlay was placed in a 2 1/2 inch lift at this location to accommodate the testing needs of the FHWA-LTPP SPS-9A program. In order to not have any loose material in the sensor channel, a dry-cut 2-1/2 inch deep channel was removed for the sensor placement.

The sensors were installed using a proprietary compound of epoxy and silica-sand grout. The system is designed to not cover the top of the sensor, but instead to embed the sensor into the grout and then to level the surface as much is possible using a trowel. When dry to the touch, the surface is designed to be sanded to remove any high points. Due to the low ambient temperature the sanding of the grout could not be successfully accomplished on the same day as placement. The EB sensors were then opened to traffic and sanded the next day. (October 24, 1997) The WB sensors were installed on October 24, 1997 and sanded a couple of weeks later (November 6, 1997) when lane-closure was available. Upon installation, the sensor manufacturer representative checked the sensor signals at the cabinet and all were found to be within the desirable range.

During the WB sanding of the sensors on November 6, 1997, it was observed that very fine and tight (less than 1/32 inch) cracks existed at one location in each strip of sensors. The crack was located between the center, or mid-point of the four sensors in seven of the eight strips and at the one-quarter mark in the eighth strip. It was determined that the cracking was formed from the top-surface down because sanding temporarily removed the cracking in the WB direction.

INSTALLATION OF ELECTRONICS AND INITIAL CALIBRATION

The electronics were scheduled for installation during the week of December 16, 1997. During the set-up of the electronics it was discovered that four sensors (located as shown in Figure 5) did not produce a signal in the desirable range. Investigation by the sensor manufacturer determined that the problem was not in the wiring from the cabinet to the handholes. Oddly the sensor malfunctions were distributed evenly, one per lane, but not in the same location per lane.

Due to the unique configuration of these sensor strips, it was possible to reconfigure the installations to function, by removing ability to isolate data collection by wheel-path for the one

malfunctioning sensor in each lane. Being that it was December and cold temperatures, the immediate reinstallation of the problematic sensors was not an option. The decision was made to calibrate the systems using trucks of known weight according to the contract specifications in the interim. After all adjustments to the sensors were conducted, two trucks of known weight (from an approved calibrated scale) were used to conduct twenty-five passes in each lane. The two trucks were specified to be fully loaded FHWA Class 9, five-axle semi-trailers, one air-suspension and the other conventional-suspension. The trucks that were acquired by the contractor were bulk-hauler type trailers. The results from the data collection effort are included in tables located in Appendix B. (These tables contain only three points of WIM measurement for each vehicle pass.)

Speed data were checked using radar and were deemed acceptable. Testing of the vehicle-type classification was found to be acceptable based on a comparison using Digital-S format images that were acquired from the Connecticut Department of Transportation photolog vans. In actuality, classification is more a function of the software algorithm than the WIM sensors.

ADDITIONAL SENSOR TESTING

On January 12,1998 and February 24,1998 the twenty-eight sensor signals were tested at the cabinet. All signals registered in the desirable range. On March 16,1998 the signals were tested and three additional sensors did not have output in the desirable range. At the time, it was not possible to determine whether the new problems were located in the wiring between the handhole and the cabinet. The sensor manufacturer was contacted regarding these new findings.

ADDITIONAL PRELIMINARY DATA COLLECTION

Preliminary data from the month of January indicate a pattern of truck distributions and a concurrence that the system was functional. (Appendix A Figure 6) In April 1998 an opportunity arose where a lane closure and a State two-axle dump truck were available at the WIM location. Although the 2-axle dump truck is characteristically not a very good vehicle for calibration/validation practices, it could serve for informational purposes. Data were collected for three travelling speeds (15,22 and 50 mph.) Tables in Appendix C show the data collected. No temperature adjustment factors were applied over the four months of system operation, and yet the output was within three percent of the static weight. These results are encouraging. (Output listed in Appendix C.)

SENSOR REPLACEMENTS AND FUTURE WORK

Rather than replace only the malfunctioning sensors, the sensor manufacturer offered to replace all the sensors with an improved design at no cost to the state. The improved design will ruggedize the cabling including: stranded versus solid core, a Teflon inner-jacket, double-thickness-braided shield, PVC outer-jacket, and an improved cabling exit from the sensor. In addition, an 18-inch reinforcing rope

will be embedded in the grout in a design to strengthen the areas where fine cracking was observed.

Given the promising early data collection results and the offer by the manufacturer, the State has accepted a corrective action plan to replace all thirty-two sensors. The replacement of the sensors is scheduled for mid-June 1998.

After the reinstallation of the sensors, the research study will continue to collect and provide information regarding the accuracy and durability of this state-of-the art WIM technology.

REFERENCED DOCUMENTS

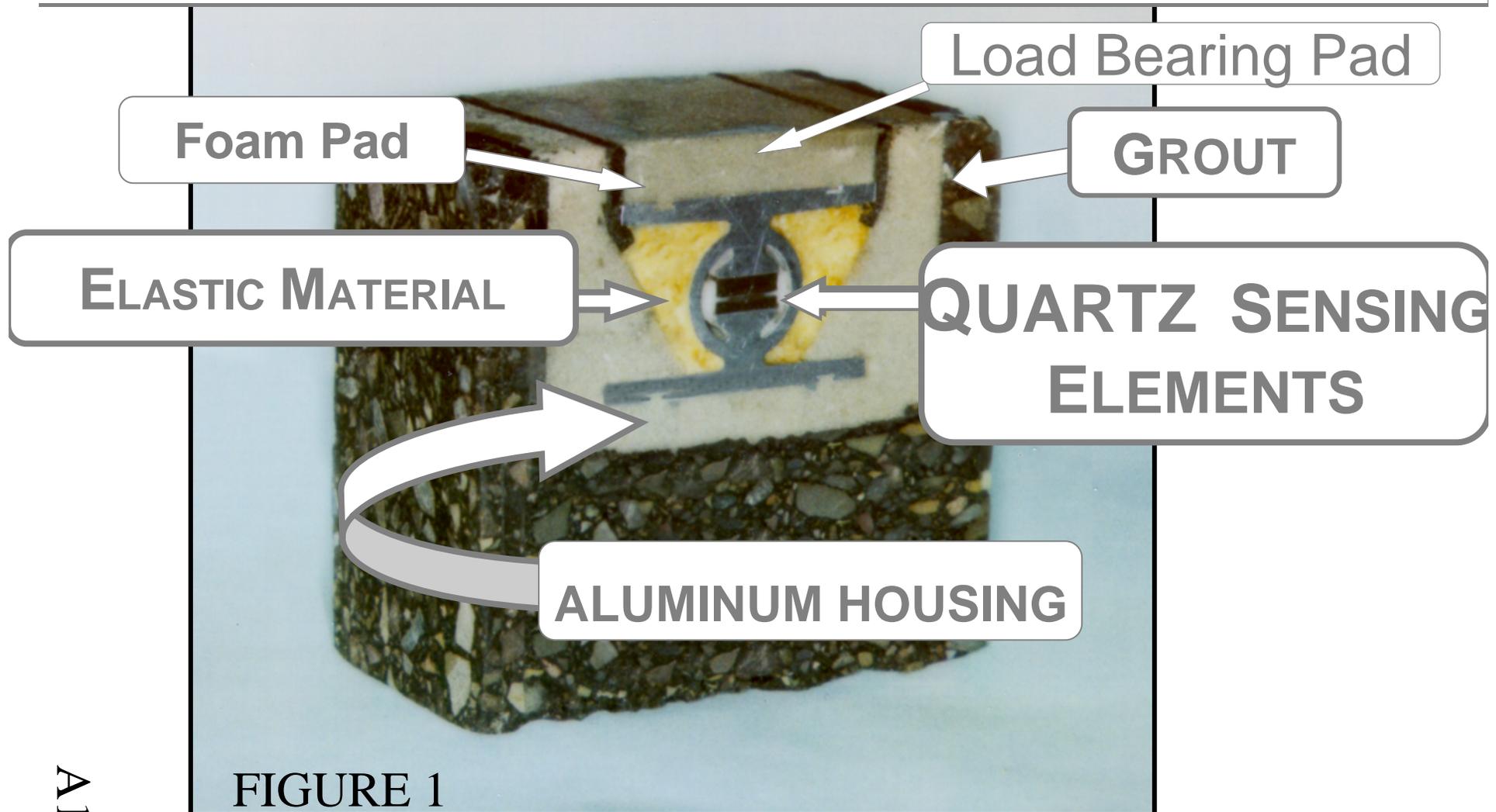
1. The American Heritage Dictionary, Second College Edition, Houghton Mifflin Company, Boston, 1985.
2. FHWA Traffic Monitoring Guide. Publication No. FHWA-PL-92-017. Federal Highway Administration, Office of Highway Information Management. U.S. Department of Transportation, Washington D.C./ October 1992.

DISCLAIMER

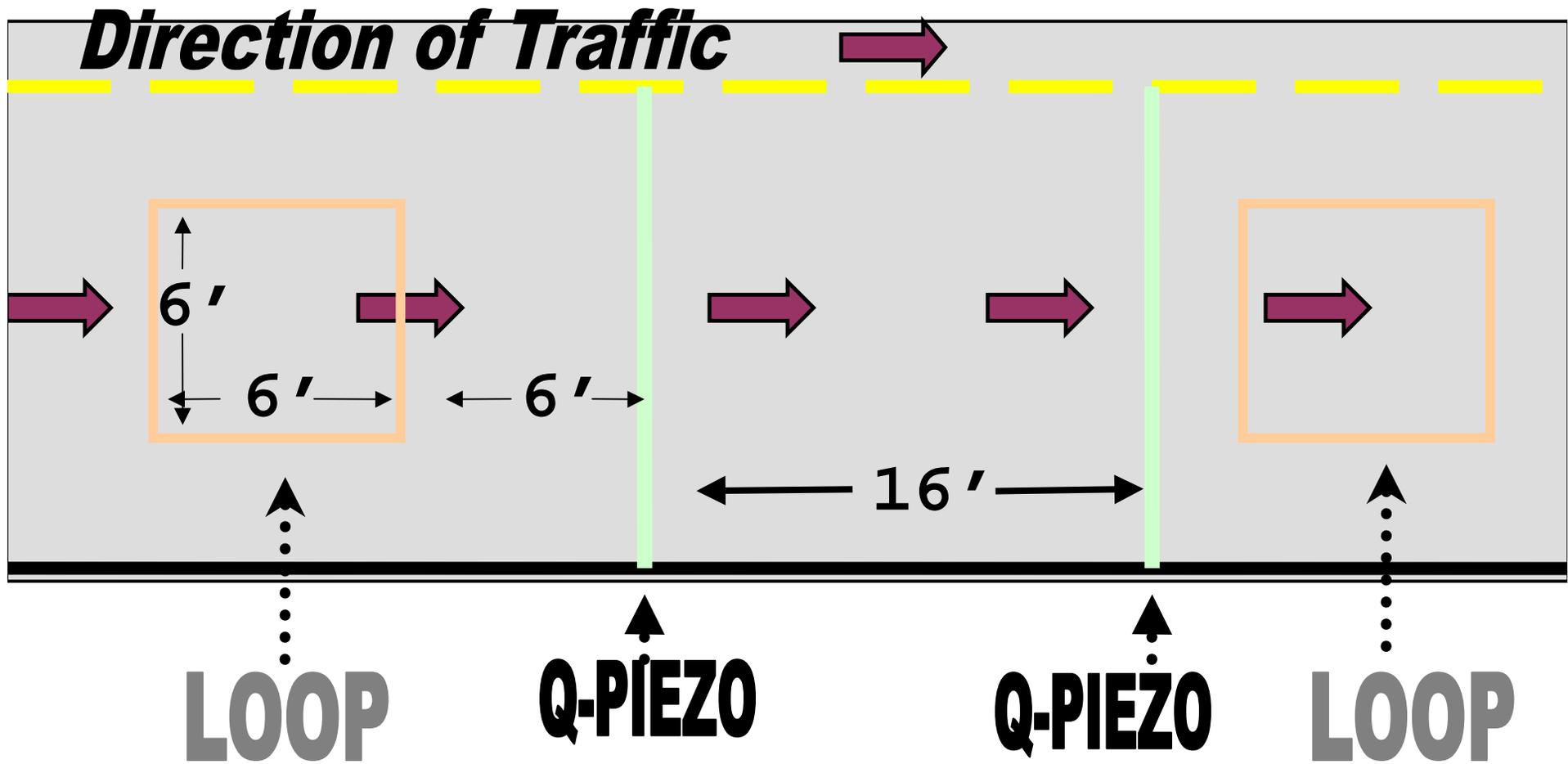
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The U.S. Government and the Connecticut Department of Transportation do not endorse products or manufacturers.

CROSS SECTION OF QUARTZ-PIEZO SENSOR



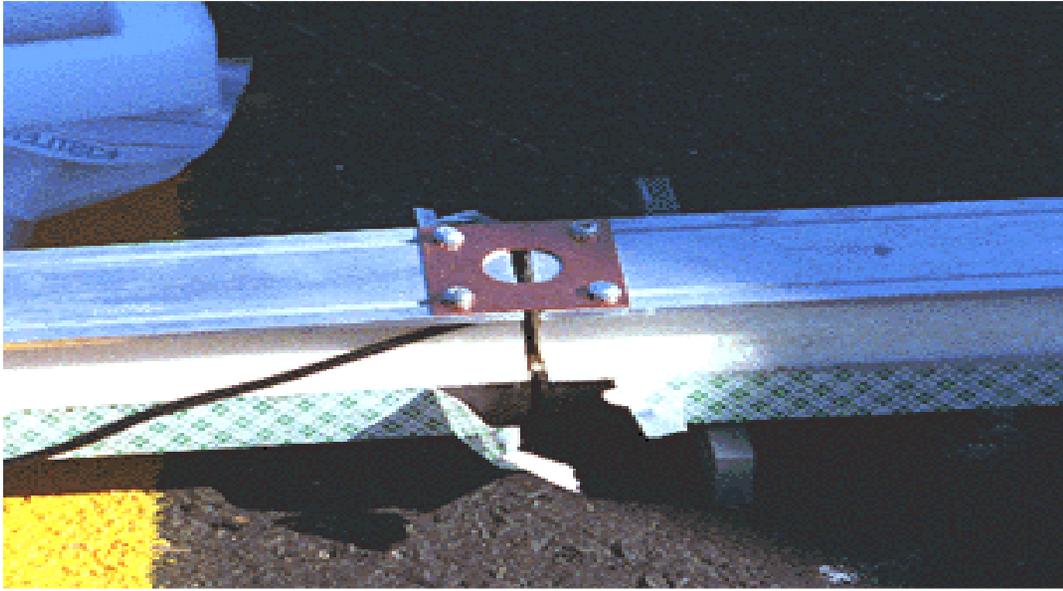
WIM Sensor Layout



A2

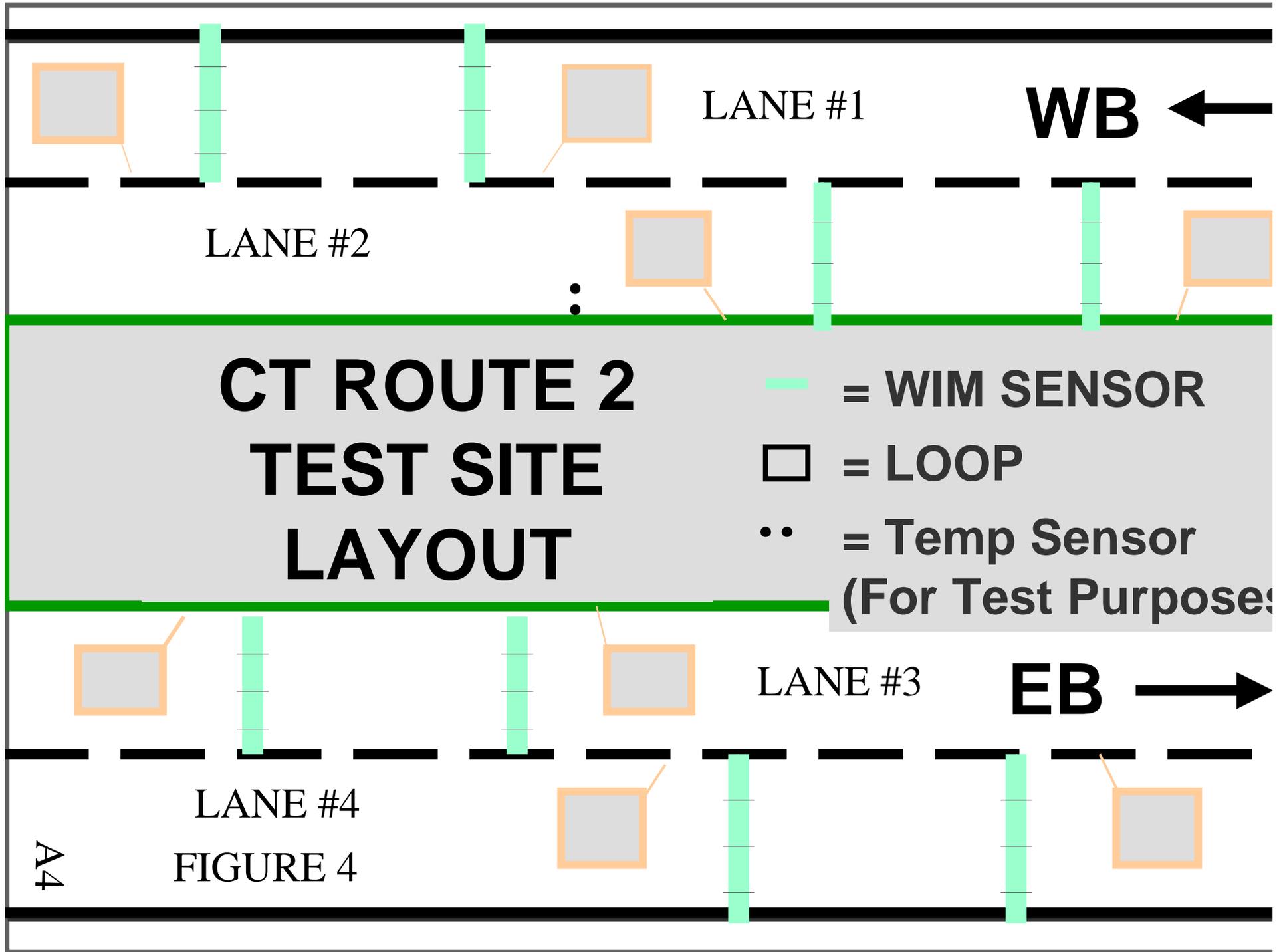
FIGURE 2

SENSOR ASSEMBLY



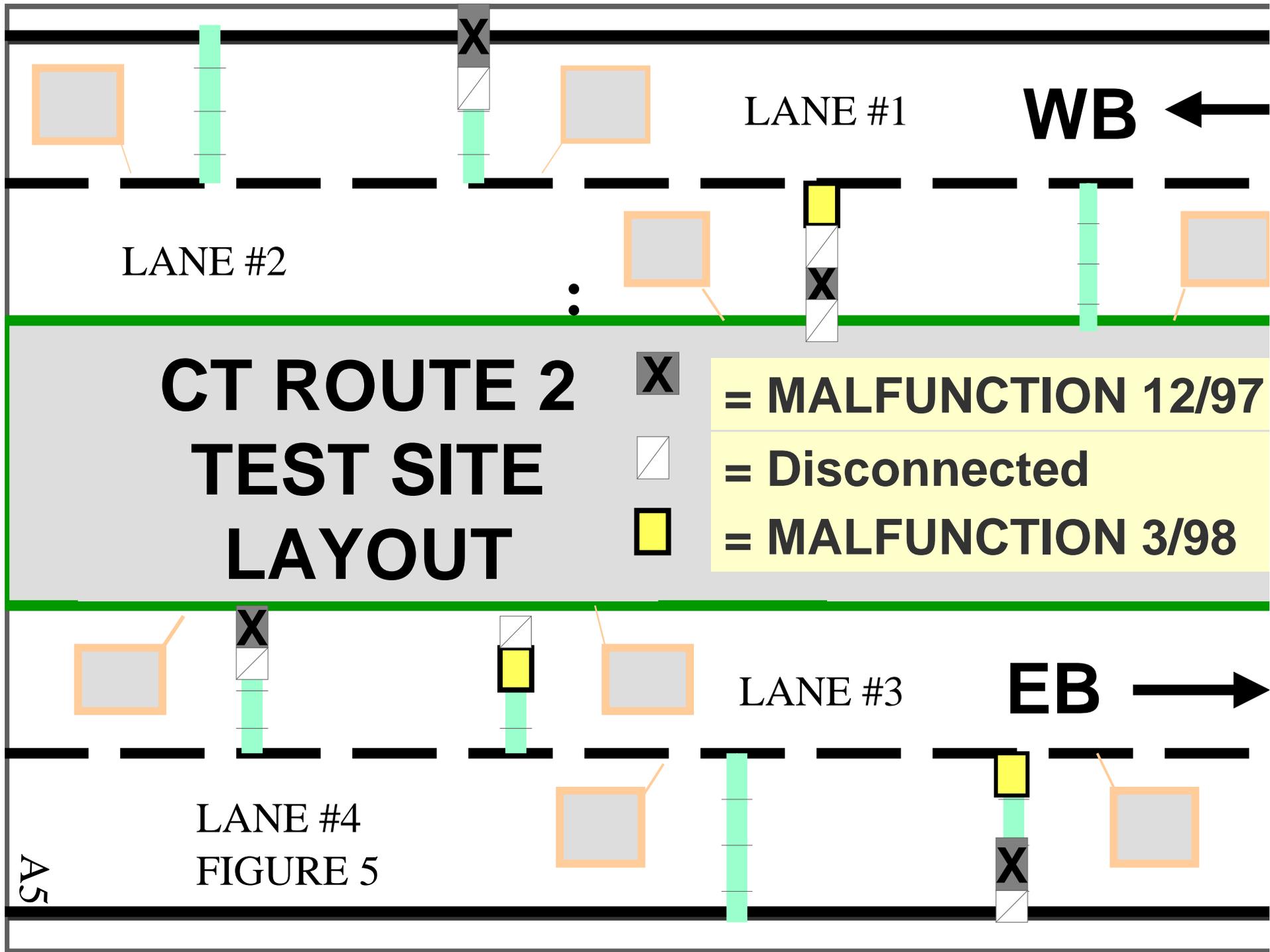
A3

FIGURE 3



A4

FIGURE 4



DISTRIBUTION OF GROSS VEHICLE WEIGHT

LEBANON CONNECTICUT / LANE 1

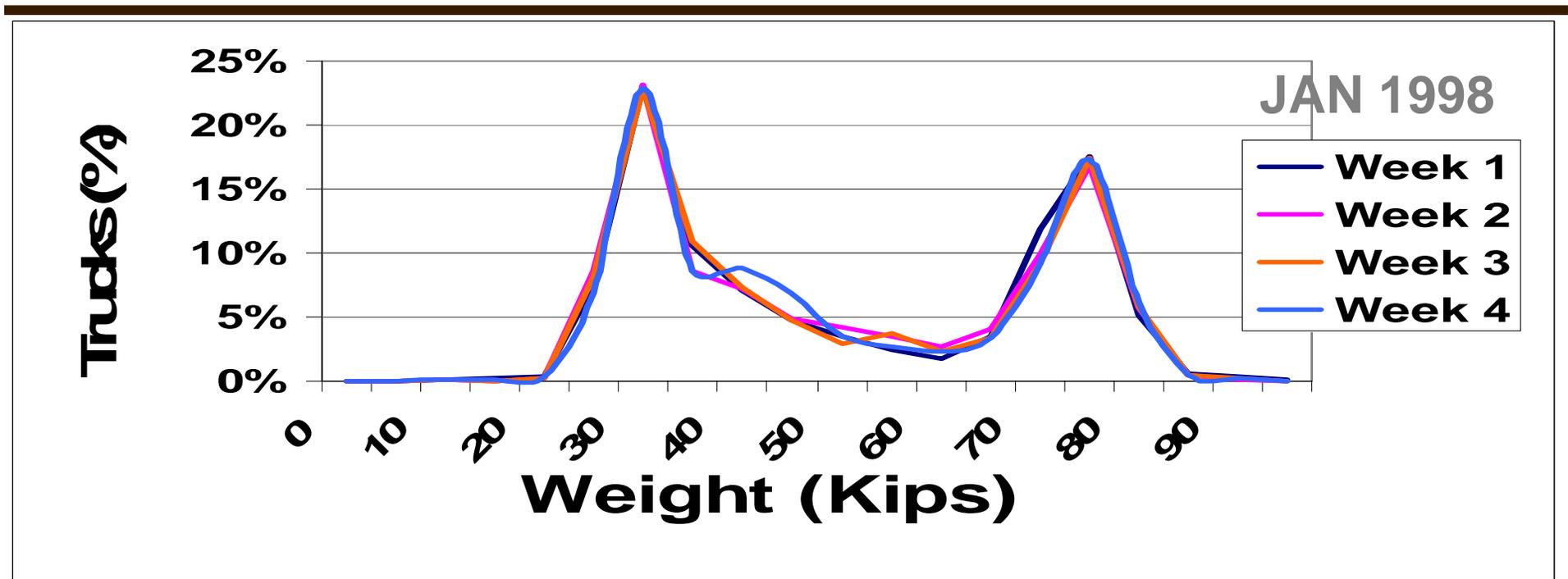


TABLE 1 WIM INITIAL FIELD DATA VALIDATION AIR-RIDE, 5-AXLE SEMI-TRAILER

LANE #1, SLOW LANE WESTBOUND
ROUTE 2, LEBANON CT
(DECEMBER 1997)

FIELD DATA															CALCULATED DATA				
	Actual	Front Axle	Drive (lbs.)			Trailer (lbs.)			(lbs.)	(inches)				(feet)	(mph)	Steer	Drive	Trailer	GVW
		8760	Axle 2	Axle 3	Total	Axle 4	Axle 5	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	% DIFF				
PASS	Veh No.	1st Axle	2nd Axle	3rd Axle	Total	4th Axle	5th Axle	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed				
1	5173	8487	17841	18066	35907	15757	16992	32749	77143	181	52	374	48	64	55				
2	5452	8891	17766	18041	35807	16288	16249	32537	77235	181	52	374	49	64	54				
3	5722	8849	18425	18262	36687	16795	16198	32993	78529	181	52	374	49	64	54				
4	5965	8593	17706	18158	35864	16149	16414	32563	77020	181	52	374	49	63	54				
5	6197	8346	18831	18180	37011	16200	16229	32429	77786	181	52	374	49	61	55				
6	9577	8055	18738	18881	37619	16414	16716	33130	78804	181	52	374	49	64	57				
7	10798	8185	18346	18449	36795	16238	16526	32764	77744	181	52	374	49	65	57				
8	11130	8185	17786	18641	36427	16024	16163	32187	76799	181	52	375	49	63	56				
9	11443	8544	18394	18480	36874	16132	15995	32127	77545	181	52	375	48	63	57				
10	255	8335	17616	18339	35955	16030	15845	31875	76165	181	52	374	48	63	56				
11	665	8154	18284	18564	36848	16209	16518	32727	77729	181	52	374	49	64	55				
12	1110	8203	18288	18701	36989	16432	15889	32321	77513	181	52	373	49	63	57				
13	1542	7973	18476	18134	36610	16482	16471	32953	77536	181	52	374	49	62	55				
14	1999	8913	19038	18491	37529	16518	16937	33455	79897	181	52	374	49	64	56				
16	3698	8813	19386	19184	38570	16985	16738	33723	81106	181	52	373	49	63	57				
17	4006	8558	16729	17964	34693	16487	16507	32994	76245	181	52	374	49	64	54				
18	4314	8454	18229	18057	36286	16152	16030	32182	76922	181	52	374	49	63	57				
19	4608	8955	19012	18623	37635	16612	16657	33269	79859	181	52	374	49	64	55				
20	4917	8211	18434	17946	36380	15395	16257	31652	76243	181	52	374	48	64	54				
21	5187	8416	18264	18191	36455	16121	16260	32381	77252	181	52	374	49	63	57				
22	5465	8361	16418	18035	34453	16429	16432	32861	75675	181	52	373	49	63	54				
23	5752	8361	17662	17887	35549	16370	16304	32674	76584	181	52	374	49	64	54				
24	6337	8494	18368	18612	36980	16249	16251	32500	77974	181	52	375	49	62	54				
25	6854	8428	18242	18522	36764	16324	16663	32987	78179	181	52	373	49	63	56				
26	10510	8736	18370	17680	36050	16310	16588	32898	77684	181	52	374	49	63	54				
															average	-3.42%	-1.94%	-1.46%	-1.90%
															std dev	3.17%	2.40%	1.45%	1.59%

TABLE 2 WIM INITIAL FIELD DATA VALIDATION

CONVENTIONAL SUSPENSION, 5-AXLE SEMI-TRAILER

LANE #1, SLOW LANE WESTBOUND ROUTE 2, LEBANON CT (DECEMBER 1997)

FIELD DATA															CALCULATED DATA					
	Actual	Front Axle	Drive (lbs.)			Trailer (lbs.)			(lbs.)	(inches)				(feet)	(mph)	Steer % DIFF	Drive % DIFF	Trailer % DIFF	GVW % DIFF	
		8280	Axle 2	Axle 3	Total	Axle 4	Axle 5	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed					
PASS	Veh No.	1st Axle	2nd Axle	3rd Axle	Total	4th Axle	5th Axle	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed					
1	5180	8326	21882	17916	39798	16851	16694	33545	81669	162	51	366	48	58	55		0.56%	6.24%	2.05%	3.89%
2	5454	7737	18107	19322	37429	16696	16227	32923	78089	162	50	367	48	58	55		-6.56%	-0.08%	0.16%	-0.66%
3	5724	7532	19117	20804	39921	17098	16174	33272	80725	162	50	367	48	59	55		-9.03%	6.57%	1.22%	2.69%
4	5972	8441	17843	19810	37653	15999	16844	32843	78937	162	50	367	48	59	54		1.94%	0.52%	-0.08%	0.42%
5	6200	8377	17995	18187	36182	17847	16637	34484	79043	162	50	367	48	58	55		1.17%	-3.41%	4.91%	0.55%
6	10802	7848	24965	20678	45643	18370	16824	35194	88685	162	50	367	48	57	55		-5.22%	21.84%	7.07%	12.82%
7	11133	8291	21223	19655	40878	15605	16361	31966	81135	162	50	367	48	57	57		0.13%	9.12%	-2.75%	3.21%
8	11450	7191	18994	20526	39520	16132	16661	32793	79504	161	50	367	47	57	55		-13.15%	5.50%	-0.23%	1.14%
9	261	7810	19649	18593	38242	17005	16701	33706	79758	162	50	367	48	59	54		-5.68%	2.09%	2.54%	1.46%
10	667	8024	20787	18564	39351	17051	16696	33747	81122	162	50	367	48	60	56		-3.09%	5.05%	2.67%	3.20%
11	1118	8498	20244	20127	40371	16884	16321	33205	82074	161	50	367	48	58	56		2.63%	7.77%	1.02%	4.41%
12	1547	7872	20127	20249	40376	16418	16308	32726	80974	162	50	368	48	58	55		-4.93%	7.78%	-0.44%	3.01%
13	2004	7956	23750	20537	44287	17036	16474	33510	85753	162	50	367	48	58	55		-3.91%	18.22%	1.95%	9.09%
14	3701	7878	17552	20692	38244	16780	16352	33132	79254	162	50	367	48	58	56		-4.86%	2.09%	0.80%	0.82%
16	4009	7905	21069	20365	41434	16983	16910	33893	83232	162	50	367	47	59	55		-4.53%	10.61%	3.11%	5.88%
17	4319	8533	16855	20652	37507	17347	16282	33629	79669	163	50	367	48	57	57		3.06%	0.13%	2.31%	1.35%
18	4610	7777	18319	20066	38385	16154	16564	32718	78880	162	50	367	48	58	55		-6.07%	2.47%	-0.46%	0.34%
19	4919	8441	23380	18654	42034	16941	16853	33794	84269	161	50	367	48	58	54		1.94%	12.21%	2.81%	7.20%
20	5194	7263	18921	18917	37838	17393	16544	33937	79038	162	50	367	48	60	56		-12.28%	1.01%	3.25%	0.54%
21	5477	7881	18101	19722	37823	16339	16687	33026	78730	162	50	367	48	57	54		-4.82%	0.97%	0.47%	0.15%
22	5756	8011	18130	19190	37320	16743	16670	33413	78744	161	50	367	48	59	55		-3.25%	-0.37%	1.65%	0.17%
23	9466	7486	21644	18189	39833	17327	16643	33970	81289	162	50	367	48	58	54		-9.59%	6.33%	3.35%	3.41%
24	9719	7453	19181	18866	38047	17069	16952	34021	79521	163	50	366	47	59	55		-9.99%	1.57%	3.50%	1.16%
25	9957	8024	21510	19406	40916	17675	16033	33708	82648	162	50	366	48	58	55		-3.09%	9.23%	2.55%	5.14%
26	10222	7940	20751	22553	43304	16584	16743	33327	84571	162	50	367	48	57	61		-4.11%	15.60%	1.39%	7.58%
															average	-4.11%	5.96%	1.79%	3.16%	
															std dev	4.53%	6.21%	1.99%	3.29%	

TABLE 3 WIM INITIAL FIELD DATA VALIDATION

AIR-RIDE, 5-AXLE SEMI-TRAILER

LANE #2, WESTBOUND HIGH SPEED LANE ROUTE 2, LEBANON CT (DECEMBER 1997)

FIELD DATA															CALCULATED DATA					
	Actual	Front Axle	Drive (lbs.)			Trailer (lbs.)			(lbs.)	(inches)				(feet)	(mph)	Steer	Drive	Trailer	GVW	
		8760	Axle 2	Axle3	Total	Axle 4	Axle 5	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	% DIFF					% DIFF
PASS	Veh No.	1st Axle	2nd Axle	3rd Axle	Total	4th Axle	5th Axle	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed					
1	6439	9138	18716	18643	37359	16562	16747	33309	79806	182	52	376	49	60	52					
2	6689	8794	18694	18346	37040	17062	16637	33699	79533	182	52	376	49	62	54					
3	7115	8919	18727	18645	37372	16804	16698	33502	79793	182	52	376	49	60	54					
4	7349	8835	17682	18496	36178	17025	16659	33684	78697	182	53	376	49	60	56					
5	7629	8943	18952	18798	37750	17062	16811	33873	80566	182	52	376	49	59	56					
6	7848	8802	19157	18661	37818	17464	17142	34606	81226	182	52	376	49	61	56					
7	8080	8851	18363	18723	37086	16829	17148	33977	79914	181	52	376	49	62	59					
8	8403	8774	19056	18862	37918	17025	17267	34292	80984	182	52	375	49	60	56					
9	9305	8734	19367	18692	38059	17082	16577	33659	80452	182	52	376	49	60	58					
10	9831	8540	18491	18665	37156	17358	17380	34738	80434	182	53	376	49	59	57					
11	10110	8628	19144	18657	37801	17184	16869	34053	80482	182	52	376	49	59	55					
12	10483	8862	18187	17993	36180	16582	16372	32954	77996	182	52	375	49	54	55					
13	6009	8639	18928	18835	37763	16800	16553	33353	79755	182	52	376	49	62	55					
14	6622	8827	17525	18374	35899	16859	16804	33663	78389	182	52	375	49	60	55					
16	7142	8800	17591	18665	36256	15528	17089	32617	77673	181	52	375	49	60	57					
17	7441	8829	19243	18749	37992	17303	17106	34409	81230	182	52	376	49	61	56					
18	7715	8529	18434	18998	37432	17243	16674	33917	79878	182	52	376	49	60	57					
19	7977	8906	18198	18773	36971	16998	16257	33255	79132	181	52	375	49	59	55					
20	8202	8672	18776	18676	37452	17164	17236	34400	80524	182	52	376	48	60	57					
21	8937	8829	18811	18597	37408	18094	16654	34748	80985	182	52	376	49	60	56					
22	9197	8738	19448	18436	37884	17093	16923	34016	80638	182	52	376	49	60	59					
23	9463	8705	18222	18105	36327	16987	16418	33405	78437	181	52	375	49	61	55					
24	9718	8765	18469	18683	37152	17073	17126	34199	80116	182	52	376	49	58	54					
25	9956	8542	18070	18310	36380	17325	16504	33829	78751	182	52	376	49	59	56					
26	10219	8454	18187	18310	36497	16584	16313	32897	77848	182	52	376	49	59	59					
																average	0.03%	-0.17%	1.94%	0.73%
																std dev	1.73%	1.78%	1.71%	1.37%

TABLE 4 WIM INITIAL FIELD DATA VALIDATION

CONVENTIONAL SUSPENSION, 5-AXLE SEMI-TRAILER

LANE #2 WESTBOUND HIGH SPEED LANE ROUTE 2, LEBANON CT (DECEMBER 1997)

FIELD DATA															CALCULATED DATA					
	Actual	Front Axle	Drive (lbs.)			Trailer (lbs.)			(lbs.)	(inches)				(feet)	(mph)	Steer % DIFF	Drive % DIFF	Trailer % DIFF	GVW % DIFF	
		8280	Axle 2	Axle 3	Total	Axle 4	Axle 5	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed					
PASS	Veh No.	1st Axle	2nd Axle	3rd Axle	Total	4th Axle	5th Axle	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed					
1	5180	8915	17148	16584	33732	16701	16921	33622	76269	162	51	367	48	56	55					
2	5454	8747	16253	19016	35269	16359	16970	33329	77345	162	50	368	48	56	56					
3	5724	8401	19016	17836	36852	16893	16359	33252	78505	163	51	368	48	56	57					
4	5972	8434	13995	18778	32773	16421	15949	32370	73577	163	50	367	48	55	55					
5	6200	9038	17861	18835	36696	17351	16729	34080	79814	163	50	367	48	56	55					
6	10802	8873	19909	20568	40477	16992	15854	32846	82196	162	50	367	48	55	55					
7	11133	8275	17867	18346	36213	16418	16368	32786	77274	162	50	368	48	56	56					
8	11450	8888	15839	19267	35106	17677	17228	34905	78899	163	50	367	48	55	56					
9	261	9045	15581	18908	34489	15980	16108	32088	75622	163	51	368	48	56	57					
10	667	8344	16659	18319	34978	15691	16313	32004	75326	163	51	368	48	55	57					
11	1118	8692	17532	18859	36391	16549	16601	33150	78233	163	51	367	48	55	55					
12	1547	8388	15521	17922	33443	16738	16293	33031	74862	163	51	367	48	54	56					
13	2004	8600	17863	20326	38189	17111	17384	34495	81284	163	50	368	48	55	55					
14	3701	8450	16831	19649	36480	16698	16716	33414	78344	163	50	367	48	54	55					
16	4009	9131	16701	18392	35093	16619	17003	33622	77846	163	50	367	48	55	55					
17	4319	8128	17162	17166	34328	17730	16983	34713	77169	163	50	367	48	55	55					
18	4610	7539	15281	17181	32462	15764	15503	31267	71268	163	50	368	48	55	57					
19	4919	8600	18421	17267	35688	15733	16493	32226	76514	163	50	368	48	56	57					
20	5194	7775	16074	20103	36177	16595	16965	33560	77512	163	50	367	48	57	55					
21	5477	8238	15863	20804	36667	16736	17014	33750	78655	162	50	368	48	54	56					
22	5756	7995	16855	19642	36497	16685	16011	32696	77188	163	50	367	48	56	55					
23	9466	8525	17894	18593	36487	16209	16716	32925	77937	163	51	369	48	55	57					
24	9719	8304	13029	17717	30746	15808	16295	32103	71153	163	50	368	48	56	57					
25	9957	8666	20756	20665	41421	17067	16712	33779	83866	162	51	367	48	55	54					
26	10222	8970	13887	19278	33165	17530	16379	33909	76044	163	50	376	48	56	55					
																average	2.88%	-4.98%	0.99%	-1.66%
																std dev	4.84%	6.24%	2.72%	3.69%

TABLE 5 WIM INITIAL FIELD DATA VALIDATION

AIR-RIDE SUSPENSION, 5-AXLE SEMI-TRAILER

LANE # 3 EASTBOUND DIRECTION, HIGH SPEED LANE ROUTE 2, LEBANON CT (DECEMBER 1997)

FIELD DATA															CALCULATED DATA					
	Actual	Front Axle	Drive (lbs.)			Trailer (lbs.)			(lbs.)	(inches)				(feet)	(mph)	Steer % DIFF	Drive % DIFF	Trailer % DIFF	GVW % DIFF	
		8760	Axle 2	Axle 3	Total	Axle 4	Axle 5	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length						
PASS	Veh No.	1st Axle	2nd Axle	3rd Axle	Total	4th Axle	5th Axle	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed					
1	6364	8955	19543	19613	39156	16520	17067	33587	81698	181	52	374	48	60	56					
2	6620	9466	18562	19133	37695	16771	17587	34358	81519	181	52	374	48	61	58					
3	6926	8871	18987	19583	38570	16665	17025	33690	81131	181	52	375	48	60	57					
4	7273	9142	19292	19351	38643	16692	17100	33792	81577	181	52	374	49	59	57					
5	7541	8699	18083	19351	37434	16383	16500	32883	79016	180	52	374	49	60	56					
6	7795	8974	19206	19748	38954	16769	16875	33644	81572	181	52	375	49	61	59					
7	8008	8981	18399	19647	38046	15986	17241	33227	80254	181	52	375	49	60	58					
8	8328	8961	19757	19611	39368	16480	17146	33626	81955	181	52	375	49	60	57					
9	8575	8540	19252	19375	38627	16954	16692	33646	80813	181	52	375	49	60	57					
10	9246	8999	18044	19856	37900	17051	16879	33930	80829	181	52	374	49	60	57					
11	9509	9237	19230	19521	38751	16579	17267	33846	81834	181	52	374	49	61	57					
12	9750	9034	19080	19960	39040	16842	17029	33871	81945	181	52	374	49	60	57					
13	10030	8851	19823	19680	39503	17023	17532	34555	82909	181	52	375	49	61	59					
14	10394	8783	18584	19583	38167	17060	17208	34268	81218	181	52	375	49	61	55					
16	10707	9515	19455	19631	39086	16787	17038	33825	82426	181	52	374	48	60	57					
17	11027	9047	19527	19311	38838	16842	16809	33651	81536	181	52	375	49	60	58					
18	6258	8816	18974	19704	38678	16807	17170	33977	81471	181	52	375	49	59	56					
19	6556	8685	18789	19327	38116	16308	16974	33282	80083	181	52	375	48	59	55					
20	6792	9358	18881	19492	38373	16370	16626	32996	80727	181	52	374	49	61	56					
21	7059	9482	18698	19481	38179	16866	16886	33752	81413	181	52	375	49	60	57					
22	7365	9153	19594	19512	39106	16760	17378	34138	82397	181	52	375	48	60	57					
23	7638	8979	18926	19406	38332	16676	17023	33699	81010	181	52	375	49	60	57					
24	7893	8685	18654	19016	37670	17073	16650	33723	80078	181	52	374	49	61	56					
25	8135	8738	19228	19636	38864	16231	16546	32777	80379	181	52	374	49	60	56					
26	8379	9246	18692	19201	37893	16632	17042	33674	80813	181	52	374	49	60	57					
																average	2.83%	3.46%	1.62%	2.62%
																std dev	3.04%	1.51%	1.28%	1.09%

TABLE 6 WIM INITIAL FIELD DATA VALIDATION

CONVENTIONAL SUSPENSION, 5-AXLE SEMI-TRAILER

LANE #3 EASTBOUND, HIGH SPEED DIRECTION ROUTE 2, LEBANON CT (DECEMBER 1997)

FIELD DATA															CALCULATED DATA				
	Actual	Front Axle	Drive (lbs.)			Trailer (lbs.)			(lbs.)	(inches)				(feet)	(mph)	Steer % DIFF	Drive % DIFF	Trailer % DIFF	GVW % DIFF
		8280	Axle 2	Axle 3	Total	Axle 4	Axle 5	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed				
PASS	Veh No.	1st Axle	2nd Axle	3rd Axle	Total	4th Axle	5th Axle	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed				
1	6368	8353	21433	19190	40623	17508	17913	35421	84397	161	50	366	48	55	55	0.88%	8.44%	7.76%	7.36%
2	6624	8884	21287	18114	39401	16352	18193	34545	82830	161	50	367	48	55	57	7.29%	5.18%	5.10%	5.37%
3	6928	9032	17517	17250	34767	16630	16972	33602	77401	161	50	367	48	55	55	9.08%	-7.19%	2.23%	-1.54%
4	7276	8114	18242	18077	36319	17505	17984	35489	79922	161	50	367	48	56	55	-2.00%	-3.05%	7.97%	1.67%
5	7544	8194	18216	18873	37089	16932	17270	34202	79485	161	50	367	47	55	56	-1.04%	-0.99%	4.05%	1.11%
6	7797	8033	15137	18601	33738	16851	18346	35197	76968	161	50	367	48	55	55	-2.98%	-9.94%	7.08%	-2.09%
7	8010	7883	15611	17406	33017	17865	18795	36660	77560	161	50	367	48	57	55	-4.73%	-11.86%	11.53%	-1.34%
8	8330	7920	18372	18127	36499	17508	18021	35529	79948	161	50	366	48	55	55	-4.35%	-2.57%	8.09%	1.70%
9	8578	8128	19550	16632	36182	17843	17133	34976	79286	161	50	367	48	56	55	-1.84%	-3.41%	6.41%	0.86%
10	9247	8445	16646	17991	34637	14090	12538	26628	69710	161	50	366	48	54	54	1.99%	-7.54%	-18.99%	-11.32%
11	9512	9018	15510	17880	33390	16776	16923	33699	76107	161	50	366	48	55	55	8.91%	-10.86%	2.52%	-3.18%
12	9752	8125	18890	18707	37597	17741	18368	36109	81831	161	50	367	48	55	55	-1.87%	0.37%	9.85%	4.10%
13	10033	8917	16952	16893	33845	16504	16526	33030	75792	161	50	367	48	55	54	7.69%	-9.65%	0.49%	-3.58%
14	10397	7574	21093	20013	41106	18037	17737	35774	84454	161	50	366	48	55	55	-8.53%	9.73%	8.83%	7.43%
16	10711	7735	16024	18590	34614	17175	18348	35523	77872	161	50	365	48	55	55	-6.58%	-7.60%	8.07%	-0.94%
17	11028	7914	18112	19816	37928	17519	18767	36286	82128	161	50	366	48	57	55	-4.42%	1.25%	10.39%	4.48%
18	6260	8064	16996	17841	34837	17655	16967	34622	77523	161	50	366	48	55	54	-2.61%	-7.00%	5.33%	-1.38%
19	6557	7806	15389	17786	33175	16807	18824	35631	76612	161	50	366	48	55	55	-5.72%	-11.44%	8.40%	-2.54%
20	6793	7927	16491	18438	34929	17691	16182	33873	76729	161	51	366	48	55	54	-4.26%	-6.76%	3.05%	-2.39%
21	7061	8079	17477	20555	38032	17199	17810	35009	81120	161	50	367	48	56	53	-2.43%	1.53%	6.51%	3.19%
22	7367	8670	16235	18273	34508	18930	17126	36056	79234	161	50	367	48	56	54	4.71%	-7.88%	9.69%	0.79%
23	7641	7402	16482	17245	33727	18213	17880	36093	77222	161	50	367	48	55	55	-10.60%	-9.97%	9.81%	-1.77%
24	7894	8626	17746	19649	37395	16560	16723	33283	79304	161	50	368	48	55	54	4.18%	-0.17%	1.26%	0.88%
25	8137	7358	18013	18820	36833	17867	18134	36001	80192	161	50	366	48	55	55	-11.14%	-1.67%	9.53%	2.01%
26	8380	8238	14829	19477	34306	18238	17662	35900	78444	161	50	367	48	54	55	-0.51%	-8.42%	9.22%	-0.21%
															average	-1.24%	-4.06%	5.77%	0.35%
															std dev	5.70%	6.09%	6.00%	3.94%

TABLE 7 WIM INITIAL FIELD DATA VALIDATION

AIR-RIDE, 5-AXLE SEMI-TRAILER

LANE #4 EASTBOUND SLOW LANE

ROUTE 2, LEBANON CT

(DECEMBER 1997)

FIELD DATA																CALCULATED DATA				
	Actual	Front Axle	Drive (lbs.)			Trailer (lbs.)			(lbs.)	(inches)				(feet)	(mph)	Steer % DIFF	Drive % DIFF	Trailer % DIFF	GVW % DIFF	
		8760	Axle 2	Axle3	Total	Axle 4	Axle 5	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed					
PASS	Veh No.	1st Axle	2nd Axle	3rd Axle	Total	4th Axle	5th Axle	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed	% DIFF	% DIFF	% DIFF	% DIFF	
1	6364	8068	19402	19479	38881	17530	17212	34742	81691	181	52	374	48	59	56	-7.90%	4.43%	4.77%	3.21%	
2	5369	9135	18623	18599	37222	15825	17014	32839	79196	181	52	374	49	59	59	4.28%	-0.02%	-0.97%	0.06%	
3	5663	8893	18540	18727	37267	16705	16665	33370	79530	181	52	375	49	59	55	1.52%	0.10%	0.63%	0.48%	
4	5892	9347	18604	18507	37111	16513	16661	33174	79632	181	52	374	49	60	56	6.70%	-0.32%	0.04%	0.61%	
5	6129	8529	19466	19708	39174	17596	17558	35154	82857	181	52	375	49	59	55	-2.64%	5.22%	6.01%	4.68%	
6	160	9078	19417	18879	38296	17400	17117	34517	81891	181	52	374	49	59	58	3.63%	2.86%	4.09%	3.46%	
7	527	9376	18407	18610	37017	16811	16888	33699	80092	181	52	374	49	60	56	7.03%	-0.57%	1.63%	1.19%	
8	971	9093	18648	18826	37474	15854	16385	32239	78806	181	52	375	48	58	57	3.80%	0.66%	-2.78%	-0.43%	
9	11348	8846	18235	19029	37264	16906	16820	33726	79836	181	52	374	49	58	57	0.98%	0.09%	1.71%	0.87%	
10	1427	9272	19093	18707	37800	16745	16939	33684	80756	181	52	374	48	59	57	5.84%	1.53%	1.58%	2.03%	
11	1853	9082	18892	18634	37526	16350	16595	32945	79553	181	52	374	49	60	56	3.68%	0.80%	-0.65%	0.51%	
12	3923	9005	18780	18879	37659	15889	16809	32698	79362	181	52	374	49	60	55	2.80%	1.15%	-1.39%	0.27%	
13	4229	8476	18842	18720	37562	16851	16652	33503	79541	181	52	375	49	60	55	-3.24%	0.89%	1.03%	0.49%	
14	4514	8260	19638	19567	39205	17060	17336	34396	81861	181	52	374	48	60	55	-5.71%	5.30%	3.73%	3.43%	
16	4825	8147	19219	19435	38654	17977	17964	35941	82742	181	52	374	49	60	55	-7.00%	3.82%	8.39%	4.54%	
17	5118	8897	18365	18998	37363	17239	16877	34116	80376	181	52	374	49	61	55	1.56%	0.36%	2.88%	1.55%	
18	5396	9556	19225	19082	38307	16586	16412	32998	80861	181	52	374	49	59	57	9.09%	2.89%	-0.49%	2.16%	
19	5670	9195	18330	18846	37176	16930	16824	33754	80125	181	52	375	48	60	56	4.97%	-0.15%	1.79%	1.23%	
20	5939	9085	18361	18817	37178	16612	16103	32715	78978	181	52	375	48	60	55	3.71%	-0.14%	-1.34%	-0.22%	
21	9119	9219	18597	18773	37370	17051	16811	33862	80451	181	52	375	49	59	58	5.24%	0.38%	2.12%	1.64%	
22	9389	9122	18599	18908	37507	16818	16632	33450	80079	181	52	375	49	60	57	4.13%	0.74%	0.87%	1.17%	
23	9641	9166	18657	18859	37516	16418	17053	33471	80153	181	52	375	49	59	52	4.63%	0.77%	0.94%	1.27%	
24	9864	9316	19093	18723	37816	16361	16681	33042	80174	181	52	374	49	59	58	6.35%	1.57%	-0.36%	1.29%	
25	9956	8542	18070	18310	36380	17325	16504	33829	78751	182	52	376	49	59	56	-2.49%	-2.28%	2.02%	-0.50%	
26	10159	8496	19203	19453	38656	17380	17384	34764	81916	181	52	375	49	60	56	-3.01%	3.83%	4.84%	3.49%	
																average	1.92%	1.36%	1.64%	1.54%
																std dev	4.63%	1.94%	2.58%	1.49%

TABLE 8 WIM INITIAL FIELD DATA VALIDATION

CONVENTIONAL SUSPENSION, 5-AXLE SEMI-TRAILER

LANE # 4 EASTBOUND SLOW LANE

ROUTE 2, LEBANON CT (DECEMBER 1997)

FIELD DATA															CALCULATED DATA				
	Actual	Front Axle	Drive (lbs.)			Trailer (lbs.)			(lbs.)	(inches)				(feet)	(mph)	Steer % DIFF	Drive % DIFF	Trailer % DIFF	GVW % DIFF
		8280	Axle 2	Axle3	Total	Axle 4	Axle 5	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed				
PASS	Veh No.	1st Axle	2nd Axle	3rd Axle	Total	4th Axle	5th Axle	Total	GVW	Axle 1-2	Axle 2-3	Axle 3-4	Axle 4-5	Length	Speed				
1	5101	8130	19139	19464	38603	16835	15532	32367	79100	163	50	367	48	55	55	-1.81%	3.05%	-1.53%	0.62%
2	5371	8978	16696	18339	35035	16562	16410	32972	76985	162	50	367	48	54	54	8.43%	-6.47%	0.31%	-2.07%
3	5666	8165	18335	20145	38480	16793	15691	32484	79129	162	50	367	48	55	54	-1.39%	2.72%	-1.17%	0.66%
4	5894	8747	18032	19095	37127	17517	16046	33563	79437	161	50	367	48	55	54	5.64%	-0.89%	2.11%	1.05%
5	6136	8214	21314	21095	42409	16782	16760	33542	84165	162	50	367	48	55	54	-0.80%	13.21%	2.04%	7.07%
6	11348	8679	20306	19012	39318	16310	15536	31846	79843	161	50	367	48	56	56	4.82%	4.96%	-3.12%	1.57%
7	165	8015	20731	19373	40104	18789	15753	34542	82661	162	50	367	48	55	55	-3.20%	7.06%	5.09%	5.15%
8	535	7724	19106	18154	37260	15876	15755	31631	76615	162	50	367	48	54	54	-6.71%	-0.53%	-3.77%	-2.54%
9	975	7821	18769	19880	38649	17283	15973	33256	79726	162	50	367	48	56	54	-5.54%	3.17%	1.17%	1.42%
10	1430	7729	18903	18769	37672	16588	14957	31545	76946	162	50	367	48	53	54	-6.65%	0.57%	-4.03%	-2.12%
11	1863	8090	20934	19258	40192	14443	15799	30242	78524	161	50	367	48	54	54	-2.29%	7.29%	-8.00%	-0.11%
12	3926	8670	19543	18407	37950	16657	15547	32204	78824	162	50	368	48	55	54	4.71%	1.31%	-2.03%	0.27%
13	4233	9199	20039	21369	41408	16679	14882	31561	82168	162	50	366	48	54	54	11.10%	10.54%	-3.98%	4.53%
14	4519	9210	17184	18723	35907	17924	16264	34188	79305	163	50	367	48	55	55	11.23%	-4.15%	4.01%	0.88%
16	4827	8573	17633	21397	39030	15402	15812	31214	78817	163	50	366	48	56	54	3.54%	4.19%	-5.04%	0.26%
17	5121	8862	18165	19927	38092	16976	16024	33000	79954	162	50	368	48	54	54	7.03%	1.69%	0.40%	1.71%
18	5399	8196	21942	18564	40506	17199	15521	32720	81422	162	50	367	48	55	55	-1.01%	8.13%	-0.46%	3.58%
19	5672	9060	17481	18692	36173	16866	15728	32594	77827	162	50	367	48	56	54	9.42%	-3.44%	-0.84%	-1.00%
20	5941	7632	17468	20191	37659	16853	15786	32639	77930	161	50	367	48	55	55	-7.83%	0.53%	-0.70%	-0.87%
21	9126	9109	18372	18804	37176	16809	15265	32074	78359	162	50	367	48	54	54	10.01%	-0.76%	-2.42%	-0.32%
22	9390	7865	19153	18835	37988	17012	16022	33034	78887	161	50	367	48	55	54	-5.01%	1.41%	0.50%	0.35%
23	9644	9157	17256	18370	35626	16127	15433	31560	76343	162	50	367	48	55	52	10.59%	-4.90%	-3.99%	-2.88%
24	9868	8683	22899	17631	40530	16628	15816	32444	81657	161	50	366	48	54	55	4.87%	8.20%	-1.30%	3.88%
25	9957	8024	21510	19406	40916	17675	16033	33708	82648	162	50	366	48	58	55	-3.09%	9.23%	2.55%	5.14%
26	10163	8529	21572	20641	42213	17620	16584	34204	84946	162	50	368	48	54	54	3.01%	12.69%	4.06%	8.06%
															average	1.96%	3.15%	-0.81%	1.37%
															std dev	6.24%	5.37%	3.14%	2.92%

TABLE 9 WIM FIELD VALIDATION CHECK

Route 2, Lebanon CT LANE #1 CONNDOT 2-AXLE DUMP TRUCK

FIELD DATA APRIL 2, 1998												
Static	Axle 1		Axle 1		Axle 2		Axle 2		Axle 2		GVW	
	LEFT	RIGHT	Total		LEFT	RIGHT	Total		lbs.	inches	Speed	
	→		10980		→		19760		30740			
Veh ID	Axle 1	Axle 1	Total		Axle 2	Axle 2	Total		GVW	Axle 1-2	Length	Speed
Pass No.	left	right			left	right						
1	8263	5054	5385	10439	8024	9823	17847	28286	168	24	11	
2	8276	5237	5429	10666	9371	9731	19102	29768	167	25	13	
3	8289	5127	5457	10584	9603	10375	19978	30562	168	24	13	
4	8298	5462	5834	11296	8840	8851	17691	28987	168	24	13	
5	8328	5429	5532	10961	9314	9945	19259	30220	168	24	14	
6	8354	5257	5651	10908	8738	9695	18433	29341	168	24	14	
7	8374	4880	5180	10060	8335	11455	19790	29850	167	23	13	
8	8423	4853	5325	10178	9210	10383	19593	29771	168	24	14	
9	8448	5255	5449	10704	9748	10101	19849	30553	167	24	14	
10	8466	5202	5385	10586	9206	10575	19781	30367	168	24	14	
11	8490	4963	5354	10317	8747	10366	19113	29430	168	24	14	
12	8504	5171	5356	10527	6485	12564	19049	29576	168	23	14	
13	8527	4979	5341	10320	9102	10573	19675	29995	168	24	14	
14	8548	4800	5153	9953	9612	10375	19987	29940	168	24	14	
15	8568	5142	5554	10696	10251	9777	20028	30724	168	23	16	
16	8590	5660	6033	11693	9814	10308	20122	31815	168	24	15	
17	8606	4911	5700	10611	8882	9878	18760	29371	168	25	14	
18	8643	5027	5453	10480	8760	10273	19033	29513	168	24	14	
19	8659	5102	5407	10509	8086	10513	18599	29108	168	24	14	

CALCULATED DATA				
1st axle	2nd axle	GVW	% Diff	%Diff
% diff	% diff	% diff	L to R	L to R
			1st axle	2nd Axle
-4.93%	-9.68%	-7.98%	-6.55%	-18.31%
-2.86%	-3.33%	-3.16%	-3.67%	-3.70%
-3.61%	1.10%	-0.58%	-6.44%	-7.44%
2.88%	-10.47%	-5.70%	-6.81%	-0.12%
-0.17%	-2.54%	-1.69%	-1.90%	-6.34%
-0.66%	-6.72%	-4.55%	-7.49%	-9.87%
-8.38%	0.15%	-2.90%	-6.15%	-27.24%
-7.30%	-0.85%	-3.15%	-9.73%	-11.30%
-2.51%	0.45%	-0.61%	-3.69%	-3.49%
-3.59%	0.11%	-1.21%	-3.52%	-12.95%
-6.04%	-3.27%	-4.26%	-7.88%	-15.62%
-4.13%	-3.60%	-3.79%	-3.58%	-48.38%
-6.01%	-0.43%	-2.42%	-7.27%	-13.91%
-9.35%	1.15%	-2.60%	-7.35%	-7.35%
-2.59%	1.36%	-0.05%	-8.01%	4.85%
6.49%	1.83%	3.50%	-6.59%	-4.79%
-3.36%	-5.06%	-4.45%	-16.07%	-10.08%
-4.55%	-3.68%	-3.99%	-8.47%	-14.73%
-4.29%	-5.88%	-5.31%	-5.98%	-23.09%

Average % Diff	-3.42%	-2.60%	-2.89%	-6.69%	-12.31%
Standard Dev	3.74%	3.68%	2.50%	3.04%	11.65%

TABLE 10 WIM FIELD VALIDATION CHECK

Route 2, Lebanon CT LANE #1 CONNDOT 2-AXLE DUMP TRUCK

FIELD DATA APRIL 2, 1998											
		Axle 1	Axle 1	Axle 1	Axle 2	Axle 2	Axle 2	GVW	Axle 1-2	Length	Speed
		LEFT	RIGHT	Total	LEFT	RIGHT	Total	lbs.	inches	feet	mph
Static		▶ 10980			▶ 19760			30740			
Pass No.	Veh ID	Axle 1	Axle 1	Total	Axle 2	Axle 2	Total	GVW	Axle 1-2	Length	Speed
		left	right		left	right					
1	7793	5094	5464	10558	9962	11354	21316	31874	168	25	19
2	7833	5281	5111	10392	10262	10893	21155	31547	168	24	21
3	7978	5360	5398	10758	8886	10692	19578	30336	168	24	21
4	8006	5193	5327	10520	10339	11003	21342	31862	168	24	19
5	8039	5541	5585	11126	9607	11212	20819	31945	168	24	19
6	8066	5592	5658	11250	8553	10061	18614	29864	168	24	18
7	8081	5856	5945	11801	9424	11010	20434	32235	168	24	18
8	8109	5440	5486	10926	10487	10928	21415	32341	167	24	19
9	8127	5332	5226	10558	9515	11358	20873	31431	168	23	19
10	8149	5466	5486	10952	9224	10423	19647	30599	168	24	19
11	8171	5162	5559	10721	9704	10824	20528	31249	168	25	19
12	8190	5473	5726	11199	8527	10480	19007	30206	168	24	19
13	8212	5603	5971	11574	8910	10359	19269	30843	168	24	18
14	8223	5250	5541	10791	8710	10055	18765	29556	168	24	20
15	8705	4941	5140	10081	8873	10725	19598	29679	168	24	22
16	8716	4974	5385	10359	8145	10796	18941	29300	168	23	22
17	8762	5246	5281	10527	9519	8957	18476	29003	168	23	24
18	8797	5398	5166	10564	6406	13133	19539	30103	169	23	22
19	8820	5272	5100	10372	9107	9665	18772	29144	168	23	21
20	8850	5162	5316	10478	8930	11358	20288	30766	168	24	20
21	8874	4968	5449	10417	8271	9894	18165	28582	168	23	21
22	8907	5773	5510	11283	9087	9369	18456	29739	168	24	22
23	8937	5546	5241	10787	9530	9975	19505	30292	168	24	22
24	8966	5038	5343	10381	9726	11193	20919	31300	169	25	21
25	8999	5100	5435	10535	9534	10683	20217	30752	168	23	21
26	9021	5303	5949	11252	8869	8714	17583	28835	168	24	22
27	9047	2075	5360	7435	2655	10595	13250	20685	169	22	21
28	9077	5052	5431	10483	9378	10419	19797	30280	168	23	21
29	9110	5693	5759	11452	9166	11043	20209	31661	169	24	22

CALCULATED DATA				
1st axle	2nd axle	GVW	% Diff	%Diff
% diff	% diff	% diff	L to R	L to R
			1st axle	2nd Axle
-3.84%	7.87%	3.69%	-7.26%	-12.26%
-5.36%	7.06%	2.63%	3.22%	-5.79%
-2.02%	-0.92%	-1.31%	-0.71%	-16.89%
-4.19%	8.01%	3.65%	-2.58%	-6.03%
1.33%	5.36%	3.92%	-0.79%	-14.32%
2.46%	-5.80%	-2.85%	-1.18%	-14.99%
7.48%	3.41%	4.86%	-1.52%	-14.41%
-0.49%	8.38%	5.21%	-0.85%	-4.04%
-3.84%	5.63%	2.25%	1.99%	-16.23%
-0.26%	-0.57%	-0.46%	-0.37%	-11.50%
-2.36%	3.89%	1.66%	-7.69%	-10.35%
1.99%	-3.81%	-1.74%	-4.62%	-18.64%
5.41%	-2.48%	0.34%	-6.57%	-13.99%
-1.72%	-5.04%	-3.85%	-5.54%	-13.38%
-8.19%	-0.82%	-3.45%	-4.03%	-17.27%
-5.66%	-4.14%	-4.68%	-8.26%	-24.56%
-4.13%	-6.50%	-5.65%	-0.67%	6.27%
-3.79%	-1.12%	-2.07%	4.30%	-51.22%
-5.54%	-5.00%	-5.19%	3.26%	-5.77%
-4.57%	2.67%	0.08%	-2.98%	-21.38%
-5.13%	-8.07%	-7.02%	-9.68%	-16.40%
2.76%	-6.60%	-3.26%	4.56%	-3.01%
-1.76%	-1.29%	-1.46%	5.50%	-4.46%
-5.46%	5.87%	1.82%	-6.05%	-13.11%
-4.05%	2.31%	0.04%	-6.57%	-10.76%
2.48%	-11.02%	-6.20%	-12.18%	1.78%
-32.29%	-32.95%	-32.71%	-158.31%	-74.94%
-4.53%	0.19%	-1.50%	-7.50%	-9.99%
4.30%	2.27%	3.00%	-1.16%	-17.00%

wimcal19.xls

Average % Diff
Standard Dev
w/o #27 AVG% Diff
w/o #27STDev

-2.79%	-1.15%	-1.73%	-8.08%	-14.99%
6.85%	8.09%	6.89%	29.25%	15.26%
-1.74%	-0.01%	-0.63%	4.34%	13.42%
3.90%	5.39%	3.53%	3.10%	9.37%

TABLE 11 WIM FIELD VALIDATION CHECK

Route 2, Lebanon CT LANE #1 CONNDOT 2-AXLE DUMP TRUCK

FIELD DATA APRIL 2, 1998												CALCULATED DATA						
		Axle 1	Axle 1	Axle 1	Axle 2	Axle 2	Axle 2	GVW	Axle 1-2	Length	Speed							
		LEFT	RIGHT	Total	LEFT	RIGHT	Total	lbs.	inches	feet	mph							
Static		→		10980	→		19760	30740										
Veh ID	Axle 1	Axle 1	Total	Axle 2	Axle 2	Total	GVW	Axle 1-2	Length	Speed								
Pass No.	left	right		left	right													
1	10512	5129	5812	10941	8697	11356	20053	30994	172	22	49							
2	10666	4974	5592	10566	8818	10375	19193	29759	163	20	47							
3	10831	5259	5890	11149	8996	10086	19082	30231	165	20	47							
4	10986	5409	5508	10917	8827	10022	18849	29766	166	20	45							
5	11145	4990	5856	10846	7559	10300	17859	28705	165	20	45							
6	11286	4933	5281	10214	9669	9206	18875	29089	166	20	45							
7	11430	5519	5793	11312	10079	10097	20176	31488	165	20	45							
8	11591	5063	5691	10754	9107	9903	19010	29764	166	20	49							
9	11775	4825	5118	9943	8441	10271	18712	28655	169	20	47							
												Average % Diff		-2.20%	-3.39%	-2.97%	-9.71%	-12.09%
												Standard Dev		3.97%	3.53%	3.14%	4.95%	10.21%