

Replacement of Rolling Straightedge with Automated Profile Based Devices

FINAL REPORT
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16. Abstract A study was performed to evaluate the applicability of using automated highway profilers to replace the Rolling Straightedges (RSE's) currently used by NJDOT to implement the department smoothness specifications. Two categories of profilers were considered in the study, low speed profilers (2 devices) and high speed profilers (3 devices), in addition to two of NJDOT RSE's. The scope of the study was limited to asphalt surfaced pavements. Three levels of initial smoothness were considered in the study, very smooth, smooth and relatively rough pavements. Several analyses were performed on the collected data. These analyses included; preliminary analysis, RSE simulation, statistical analysis, effect of speed analysis and correlation analysis. The preliminary analysis was performed on the results of the RSE inspection to select test sections that match the study requirements. RSE simulation analysis was performed on the collected profiles to simulate the RSE inspection. This analysis consisted of driving a 10-ft straightedge over the profile and calculate the tolerance at the mid-point of the straightedge and then calculate the Percentage Defective Length (%DL). Several statistical analyses were performed on the collected and simulated data to investigate the equipment repeatability and the differences among devices, including the two RSE's. In these analyses, the F-Test and the Student T-Test were used. The analyses were performed on the %DL measured with the RSE's and that resulted from the simulation analysis, as well as on the IRI measured using the automated profilers. The effect of speed analysis was performed on the data collected using the light weight profilers and the high speed profiler. Three correlation analysis studies were performed on the collected data. The objectives of these studies are to correlate the RSE measurements with the results of the simulation analysis performed on the profiles measured using the automated devices, to correlate the IRI measured with different devices and to correlate the IRI and %DL of the same device.			
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1.0 INTRODUCTION AND STUDY OBJECTIVES

Improving the performance of asphalt pavements is an on-going goal for highway agencies, pavement designers and contractors. Advances in pavement design, asphalt mix testing and design, and construction equipment may help in achieving this goal. However, no real improvement will be achieved without improving the current Quality Control/Quality Assurance (QC/QA) practices. Smoothness testing is one of the QC/QA tests that requires improvements. The current New Jersey Department of Transportation (NJDOT) QC/QA specifications require inspecting the finished asphalt surface with a 10-foot Rolling Straightedge (RSE). Surface tolerances measured with the RSE are then used to evaluate the initial pavement smoothness and the construction quality. Although the RSE inspection is simple and does not require expensive equipment or operators with engineering training, it is time consuming and requires lane closures. Also, the repeatability of RSE is not always high.

A study was performed to evaluate the applicability of using automated highway profilers to replace RSE's currently used by NJDOT to implement the department smoothness specifications. Two categories of profilers were considered in the study, low speed and high speed profilers. The low speed profilers included the K. J. Law Light Weight Profiler (T 6400) and the ICC Light Weight Profiler (MDR 4082-PLT). The high speed profilers included: the K. J Law Road Surveyor Profiler (T 6600) and an ARAN with a profiling subsystem. A Stantec RT 3000 equipped with laser sensors was also used in the project to scan several candidate sites.

The scope of the study was limited to asphalt surfaced pavements. A Design of Experiment (DOE) was prepared to allow selecting the test sections. Three levels of initial smoothness were considered in the DOE as follows:

- Very smooth pavements (Level 1) - % Defective Length (%DL) ≤ 1.5 .
- Smooth pavements (Level 2) - $1.5 < \%DL \leq 3.5$.
- Relatively rough pavements (Level 3) - $\%DL > 3.5$.

Based on the DOE, three sections were required for each smoothness level, as shown in table 1. Each of the selected sections has to be tested with two NJDOT Rolling Straightedges, the two light weight profilers and the two full size profiles.

2.0 SCAN TESTS AND SITE SELECTION

Figure 1 outlines the steps followed to achieve the project objects. An initial list of test sections was compiled from the construction projects of 1997, 1998 and 1999 construction seasons. The as-built RSE measurements of these sections were reviewed and used to classify these sections into the appropriate initial smoothness group. Since the RSE and low speed profilers tests require lane closures, site conditions, such as traffic and number of lanes, were considered in the selection process. Test sections with high traffic volumes or with a single lane per direction were excluded from the initial list.

Table 1. Design of Experiment (DOE)

Device	Initial Smoothness Category	Number of Sections
RSE I	Very Smooth	3
RSE II		3
K.J Law Light Weight Profiler (T 6400)		3
ICC Light Weight Profiler (MDR 4082-PLT)		3
K.J Law Profiler (T 6500/6600)		3
ARAN (equipped with profiling sub-system)		3
Stantec RT 3000		3
RSE I	Smooth	3
RSE II		3
K.J Law Light Weight Profiler (T 6400)		3
ICC Light Weight Profiler (MDR 4082-PLT)		3
K.J Law Profiler (T 6500/6600)		3
ARAN (equipped with profiling sub-system)		3
Stantec RT 3000		3
RSE I	Relatively Rough	3
RSE II		3
K.J Law Light Weight Profiler (T 6400)		3
ICC Light Weight Profiler (MDR 4082-PLT)		3
K.J Law Profiler (T 6500/6600)		3
ARAN (equipped with profiling sub-system)		3
Stantec RT 3000		3

Total Number of Sections = 9

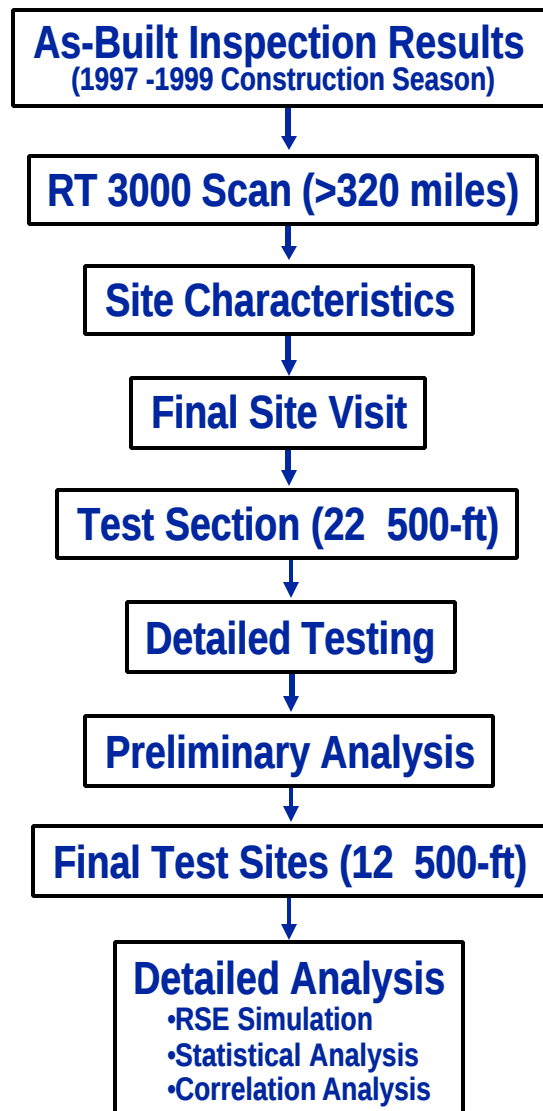


Figure 1. Project Steps

The field testing program of the project consisted of three phases. In Phase I, the RT 3000 was used to scan the test sections of the initial list. Analysis was performed on the collected data to select test sections that satisfy the DOE requirements. In Phase II, the selected sections were then surveyed using NJDOT Rolling Straightedges (two devices) and the light weight profilers. In Phase III, the selected test sections were surveyed using the high speed profilers.

Table 2 shows a list of the sections that were scanned in Phase I. As can be seen from this table, more than 320 miles were scanned to ensure getting the required number of test sites (9 sites, 500-ft each).

Table 2. Scanned Highway Sections

Section	Hwy	Direction	From	To	Length (mile)
93234	17	S	27	23.486	3.514
93235	17	N	23	26.553	3.553
97460	18	N	8	16.995	8.995
97461	18	S	17	8.089	8.911
95434	23	N	7.929	29.236	21.307
95435	23	S	29	17.798	11.202
95435	23	S	17.677	4.569	13.108
922315	24	E	7	10.363	3.363
922325	24	W	10.4	7.169	3.231
95211	28	E	7.007	13.317	6.31
95211	28	W	13.297	10.009	3.288
952103	31	N	0.285	4	3.715
95404	31	S	4	0.27	3.73
95231	36	N	9	12.04	3.04
95230	36	S	12	8.996	3.004
95426	55	S	28	25.028	2.972
95425	55	N	24.607	28.004	3.397
95227	70	E	54	54.971	0.971
95226	70	W	55	53.961	1.039
932225	78	E	49	54.066	5.066
932235	78	W	54	49.045	4.955
922635	80	E	61	67.88	6.88
922635	80	W	66.358	60.86	5.498
922645	80	E	6	32.603	26.603
932545	80	E	32.7	39.039	6.339
932545	80	E	39.198	61	21.802
932545	80	W	67.778	66.358	1.42
952191	157	N	0	0.874	0.874
952192	157	S	0.877	0	0.877
94241	169	N	1.363	2.12	0.757
94242	169	N	2	4.124	2.124
1000003	195	E	0	9.908	9.908
103	195	E	16	18.003	2.003
113	195	W	18	15.993	2.007
94203	208	S	9.416	2.819	6.597
94204	208	N	2.869	9.877	7.008
94230	287	N	8	9.035	1.035
952153	287	N	14	22.98	8.98
942255	287	N	46	67.838	21.838
942265	287	S	68	46.241	21.759
94234	287	S	31	5.455	25.545
952143	295	S	12	1.149	10.851
952133	295	N	1.029	12	10.971
954231	322	E	17	17.866	0.866
954232	322	W	17.862	17	0.862
Total					322.075

2.1 Analysis of the Scanning Tests

The 100-ft IRI values were calculated for the scanned sections and used to calculate the 500-ft moving average IRI values. In total, over 16,500 500-ft moving averages were obtained from the scanned sections. These moving averages were analyzed to categorize the sections as very smooth, smooth or relatively rough, using the limits shown in table 3. Plots of the 500-ft moving average IRI values were developed to allow identifying candidate test sections. A sample of these plots is shown in figure 2.

A short list of candidate sections was prepared based on the results of the scan data analysis. This list is provided in appendix A. The candidate sections were then visited to evaluate the site characteristics from the safety viewpoint, such as number of lanes and sight distance. As a result, the following two sites were selected for the detailed testing:

- The slow lane of NJ 55 South from mile post 27.500 to mile post 25.5000.
- The slow lane of Interstate 195 West from mile post 19.000 to mile post 17.500.

Table 3. Roughness Categories

Roughness Category	Minimum 500-ft		Maximum 500-ft	
	IRI*	PSI **	IRI*	PSI**
Very Smooth			< 0.85	< 4.29
Smooth	0.85	4.29	1.00	4.29
Relatively Rough	> 1.00	> 4.18		

*IRI in m/km (1 m/km = 63.5 m/km)

** 0-5 scale

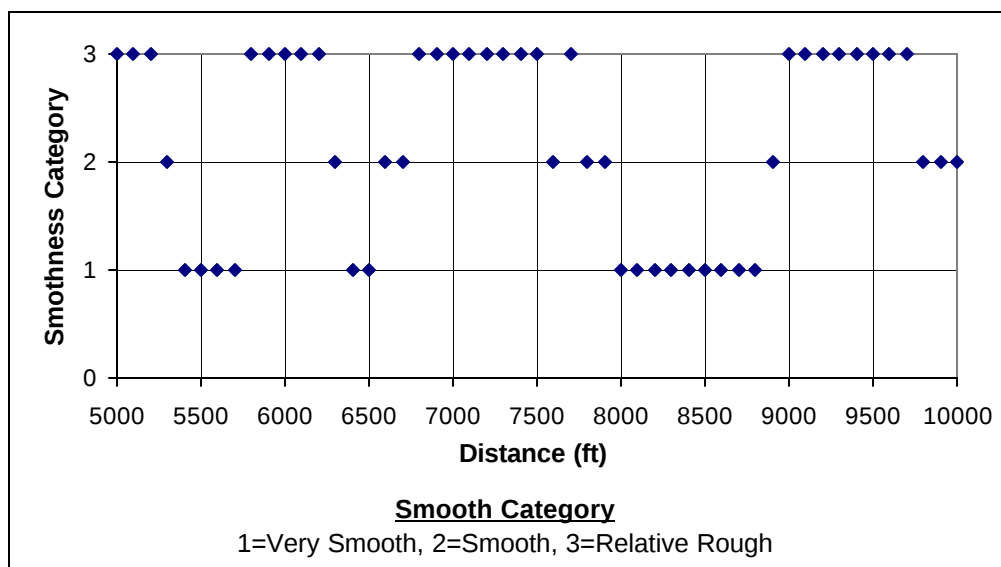


Figure 2. 500-HRolling Average IRI

3.0 DETAILED FIELD TESTS

3.1 Low Speed Equipment

The light weight profilers considered in this study are equipped with a single laser sensor and a single accelerometer. These profilers measure the longitudinal profile of only one wheel path and record it at a sample ratio of 1-inch. The testing speed may vary between 10-20 mph. However, the typical testing speed, as recommended by the equipment manufacturers, is 20 mph.

Traffic control was provided to close the slow lanes of the selected sections. Test sections (500-ft each) were marked and numbered. In total, 22 test sections (12 test sections from NJ 55 South and 10 test sections from I 195 West) were tested using the ICC and K.J. Law Light Weight Profilers and two NJDOT RSE. The light weight profilers testing consisted of testing the right and left wheel paths, three times each, at the speed recommended by the manufacturer. Also, three runs were performed at speeds of 10, 15 and 20 mph to investigate the impact of speed on the light weight profiler measurements. It should be noted that the data of the 15 mph run of the ICC light weight profiler was not recorded properly. Therefore, the results of this run were not included in the analysis.

Two NJ DOT RSE's were considered in this study. Both RSE's were calibrated prior of the testing on the same bench. The RSE's were calibrated following the standard NJ DOT procedure. The cut-off limit for the RSE's was set to 1/8". Therefore, the RSE's will mark areas where the tolerance exceeds 1/8".

A single RSE test was performed on each wheel path of the test sections. Also, 10 repeated runs were planned for 2 test sections (one from the very smooth group and one from the relative rough group). However, these repeated runs provided inaccurate results because it was hard to isolate the trace of water of each run. Figures 3 to 6 show some pictures of the low speed equipment tests.

3.2 High Speed Equipment

The high speed profilers included in this study were equipped with at least 2 laser sensors and 2 accelerometers. These profilers measure the longitudinal profiles of both wheel paths and record them at sampling rate in the range of 1 to 6 inches.

The marked test sections were also tested using the high speed profilers. The number of runs varied among the equipment. As a minimum, three repeated runs were performed on each of the test sections. In some cases, the number of repeated runs was increased to 5. Also, three speeds were used in the ARAN tests (40, 50 and 60 mph), with at least 3 runs at each speed.

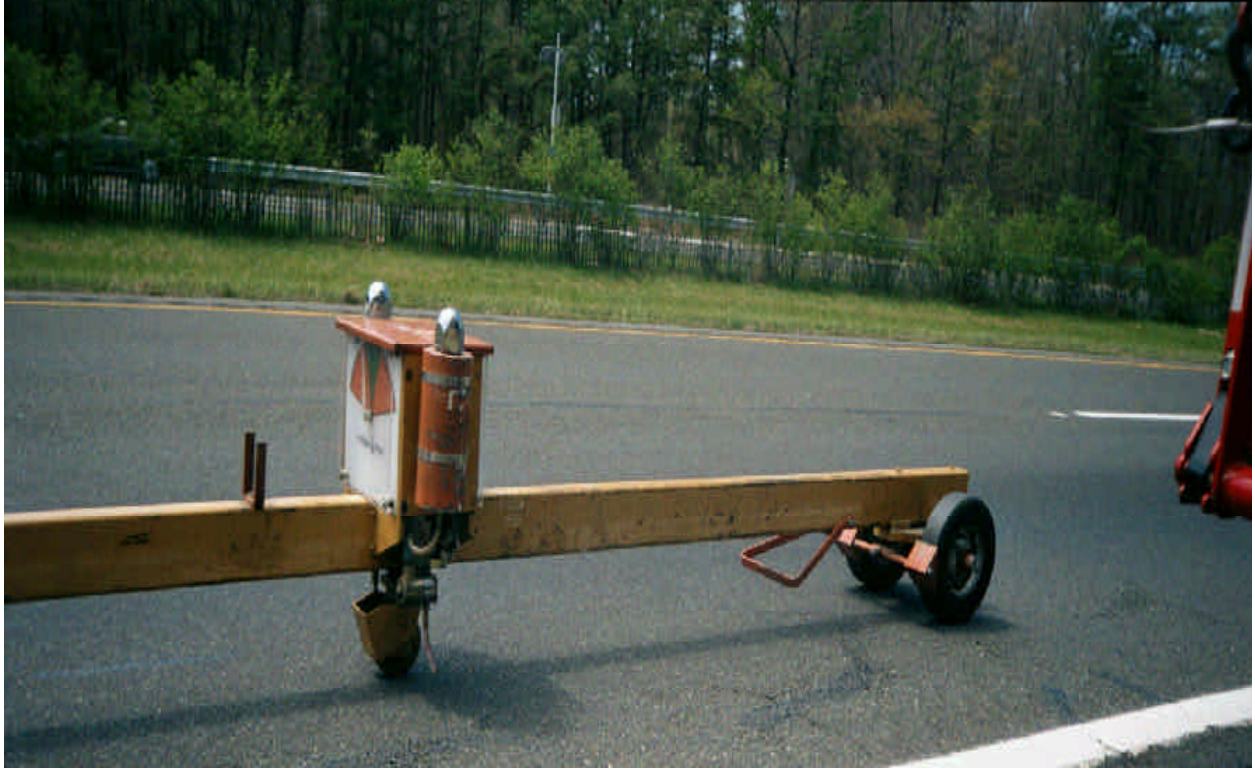


Figure 3. NJDOT RSE



Figure 4. Phase II Testing (NJDOT RSE's)



Figure 5. Phase II Testing (K. J. Law Light Weight Profiler)



Figure 6. Phase II Testing (ICC Light Weight Profiler)

4.0 PRELIMINARY ANALYSIS AND RSE SIMULATION

Several analyses were performed on the collected data. These analyses included: preliminary analysis, RSE simulation, statistical analysis, effect of speed analysis and correlation analysis.

4.1 Preliminary Analysis

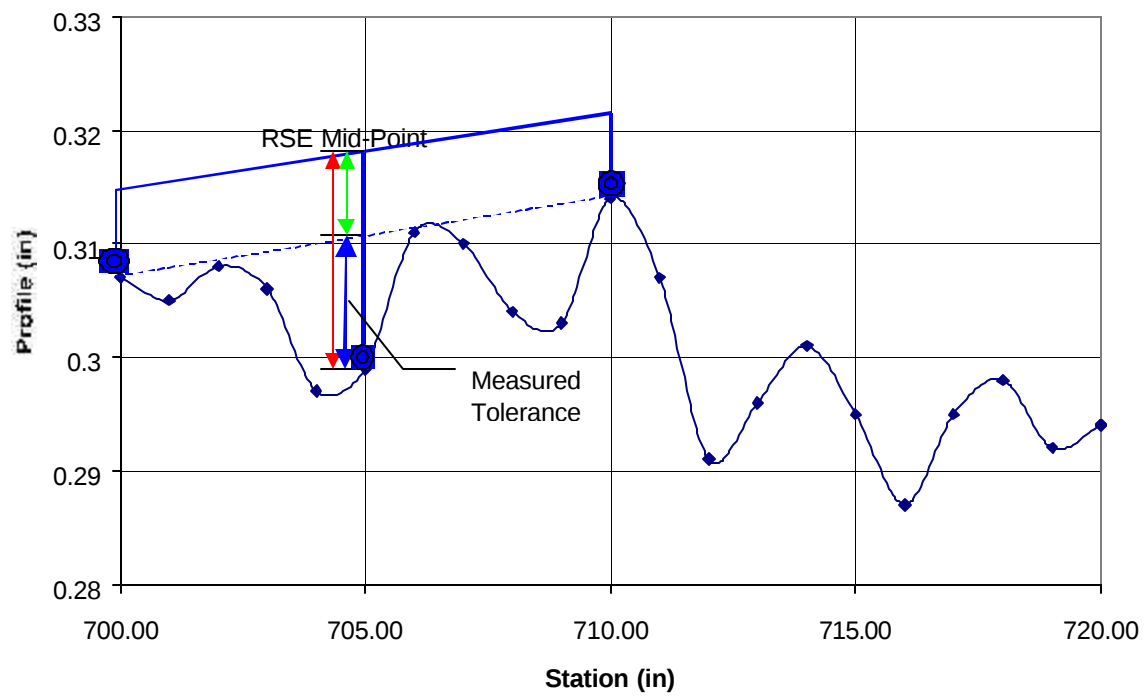
Results of the RSE tests were reviewed to identify the test sections that match the DOE requirements. Table 4 shows the selected test sections that are considered for further analysis. As can be seen from this table, 12 500-ft test sections were selected. The first 9 sections satisfy the DOE requirements, while the remaining 3 sections (10 to 12) are selected to verify the analysis results. It should be noted that both RSE's detected no defective length, i.e., locations with tolerance greater than 0.125 in, in any of the NJ 55 South sections. Therefore, based on the RSE results all sections of NJ 55 South are in the Very Smooth Category.

Table 4. Final List of Test Sections

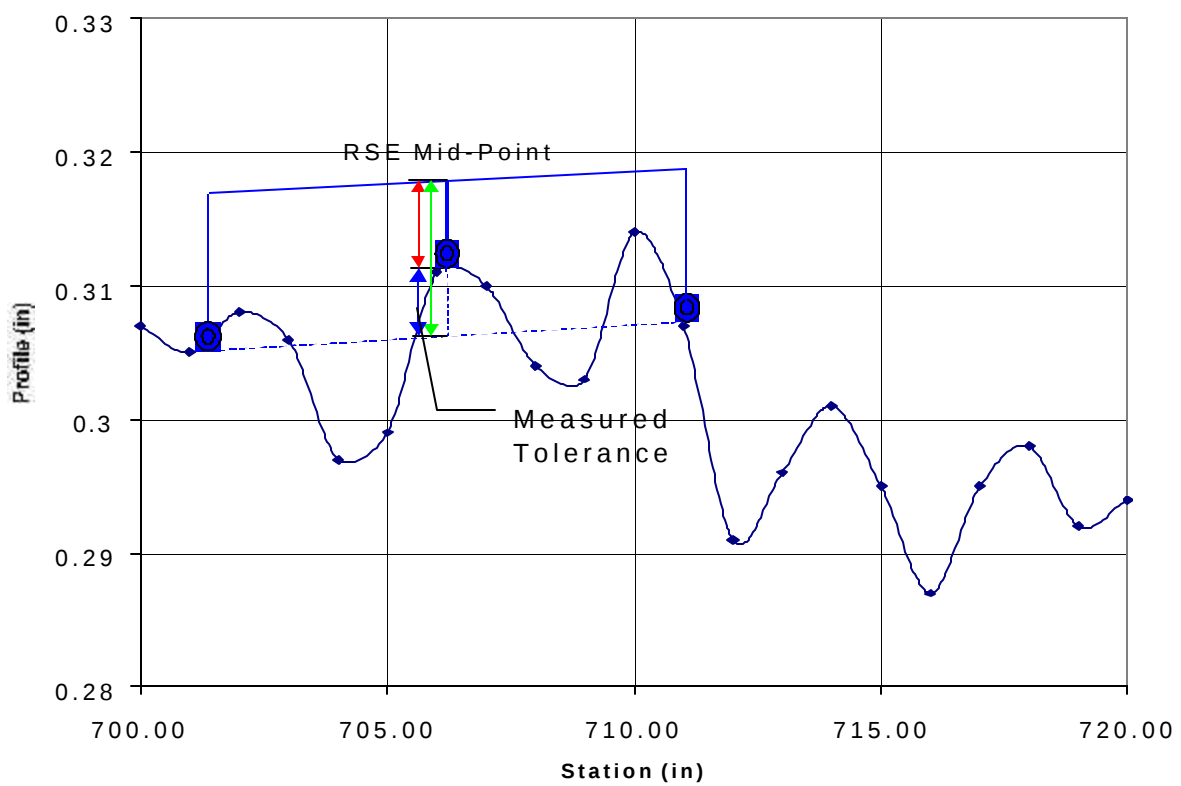
Section Number	Highway	Roughness Class	From (ft)	To (ft)	Wheel Path
1	I-195W	RR	0	500	LWP
2	I-195W	RR	100	600	LWP
3	I-195W	RR	100	600	LWP
4	I-195W	S	200	700	LWP
5	I-195W	S	2500	3000	LWP
6	I-195W	S	2600	3100	LWP
7	I-195W	VS	1900	2400	LWP
8	I-195W	VS	4000	4500	LWP
9	I-195W	VS	4500	5000	LWP
10	NJ55S	VS	1000	1500	RWP
11	NJ55S	VS	1500	2000	RWP
12	NJ55S	VS	2000	2500	RWP

4.1 RSE Simulation Analysis

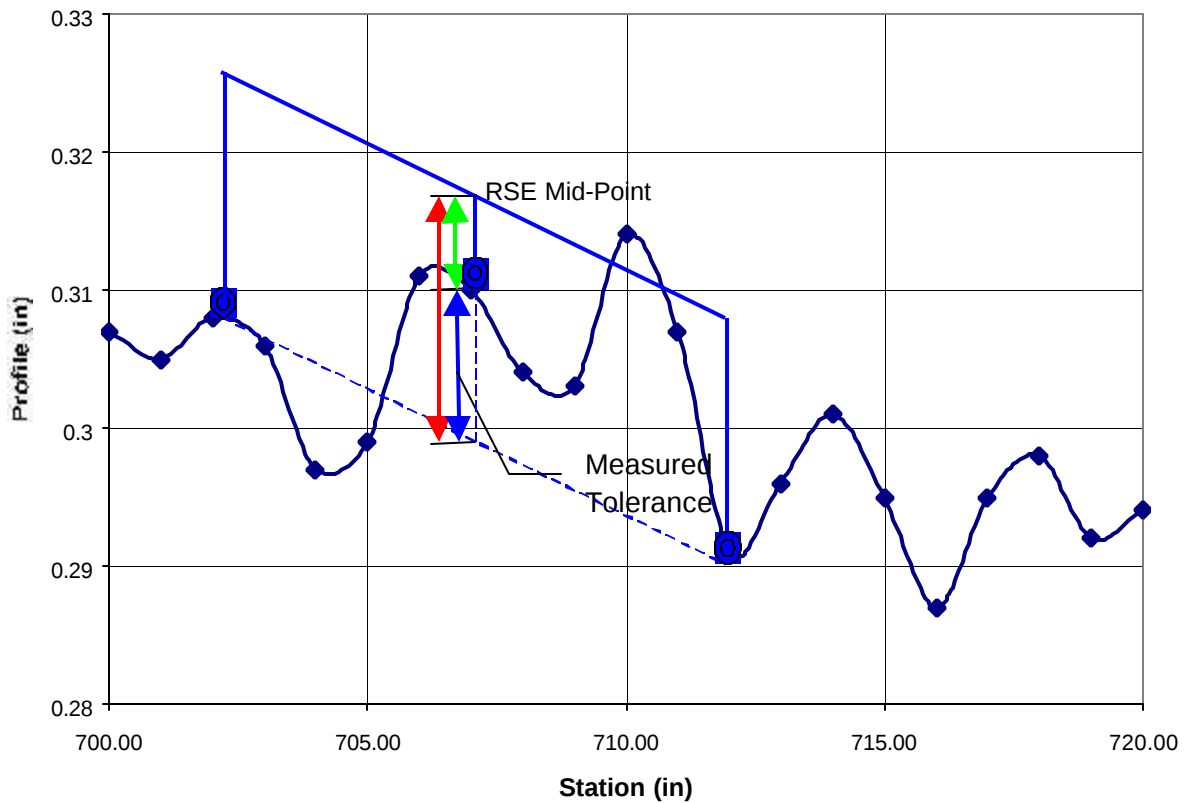
RSE computer simulation analysis was performed on the measured profiles. The simulation analysis consisted of driving a 10-ft straightedge over the measured profiles and calculating the deviation at the mid-point of the straightedge, as shown in figure 7. The step used to forward move the RSE was set equal to the sampling rate used in the data collection. This sampling rate varied among the devices and ranged from 1 in to 6 inches. The results of the computer simulation analysis were verified manually. Tolerances were manually calculated for a few profiles and compared with the computer simulation results. Perfect agreement was obtained for all cases considered in this verification.



(a) Position 1



(b) Position 2



c) Position 3

Figure 7. RSE Simulation

Locations where tolerance exceeded the limit (0.125 in) were identified. The total defective length is then calculated as the summation of the lengths where the tolerance exceeded the limit. The Percentage Defective Length (%DL) was then calculated as the total defective length divided by the total section length. Results of the simulation analysis performed on different devices/test sections, along with the corresponding results of the RSE's are presented in table 5. It should be noted that defective lengths less than 6 inches were ignored.

The simulation analysis results from the collected profiles were further analyzed by sectioning each of the 500-ft sections into a set of 50-ft segments. The main reason for this is to have enough degrees of freedom for the statistical analysis. appendix B shows the detailed results of the simulation analysis (results for the 50-ft segments).

Table 5. Results of the Simulation Analysis

Section Number	Highway Number	From(ft)	To (ft)	Simulated %DL				Measured %DL	
				ICC Light	K.J. Law Light	K.J. Law Full	ARAN	RSE I	RSE II
1	I-195W	0	500	4.35	1.22	2.38	0.60	4.20	3.60
2	I-195W	100	600	4.99	1.22	1.32	0.54	4.60	3.80
3	I-195W	100	600	4.62	5.94	2.69	0.54	4.20	3.00
4	I-195W	200	700	2.00	0.33	1.28	0.42	1.80	0.80
5	I-195W	2500	3000	3.89	0.79	1.15	1.58	2.80	0.20
6	I-195W	2600	3100	3.22	2.53	0.35	1.24	2.40	0.20
7	I-195W	1900	2400	2.03	3.14	1.18	0.90	1.20	0.60
8	I-195W	4000	4500	1.44	4.13	1.08	0.18	1.00	0.60
9	I-195W	4500	5000	0.71	5.24	0.01	1.84	0.80	0.80
10	NJ55S	1000	1500	0.00	0.00	0.10	0.00	0.00	0.00
11	NJ55S	1500	2000	0.00	0.03	0.00	0.00	0.00	0.00
12	NJ55S	2000	2500	0.00	0.02	0.27	0.04	0.00	0.00

Analysis was also performed on the IRI measured using the automated devices, low-speed and high-speed profilers. The IRI values of the test sections are presented in table 6. It should be noted that IRI measurements of the ICC Light Weight Profiler were not available.

Table 6. IRI Results (m/km)

Section Number	Highway Number	From(ft)	To (ft)	IRI m/km				
				K.J. Law Light	K.J. Law Full	ARAN40	ARAN50	ARAN60
1	I-195W	0	500	1.253	1.600	1.503	1.489	1.563
2	I-195W	100	600	1.322	1.399	1.363	1.360	1.457
3	I-195W	100	600	1.860	1.612	1.506	1.457	1.571
4	I-195W	200	700	1.390	1.404	1.432	1.529	1.560
5	I-195W	2500	3000	1.782	1.554	1.443	1.399	1.434
6	I-195W	2600	3100	1.728	1.570	1.421	1.422	1.475
7	I-195W	1900	2400	1.818	1.712	1.708	1.719	1.748
8	I-195W	4000	4500	1.642	1.192	1.298	1.235	1.291
9	I-195W	4500	5000	2.511	1.360	1.296	0.764	1.309
10	NJ55S	1000	1500	0.947	1.138	0.987	1.489	0.996
11	NJ55S	1500	2000	0.947	1.024	0.911	0.879	1.010
12	NJ55S	2000	2500	0.867	1.013	0.925	0.945	0.971

Table 7. IRI Results (in/mi)

Section Number	Highway Number	From(ft)	To (ft)	IRI in/mile				
				K.J. Law Light	K.J. Law Full	ARAN40	ARAN50	ARAN60
1	I-195W	0	31750	79.6	101.6	95.4	94.6	99.3
2	I-195W	100	38100	83.9	88.8	86.6	86.4	92.5
3	I-195W	100	38100	118.1	102.4	95.6	92.5	99.8
4	I-195W	200	44450	88.3	89.2	90.9	97.1	99.1
5	I-195W	2500	190500	113.2	98.7	91.6	88.8	91.1
6	I-195W	2600	196850	109.7	99.7	90.2	90.3	93.7
7	I-195W	1900	152400	115.4	108.7	108.5	109.2	111.0
8	I-195W	4000	285750	104.3	75.7	82.4	78.4	82.0
9	I-195W	4500	317500	159.4	86.4	82.3	48.5	83.1
10	NJ55S	1000	95250	60.1	72.3	62.7	94.6	63.2
11	NJ55S	1500	127000	60.1	65.0	57.8	55.8	64.1
12	NJ55S	2000	158750	55.1	64.3	58.7	60.0	61.7

5.0 STATISTICAL ANALYSIS

Several statistical analyses were performed on the collected and simulated data to investigate the equipment repeatability and the differences among devices, including the two RSE's. In these analyses, the F-Test and the Student T-test were used. The confidence level was always selected to be 90%. The analyses were performed on the %DL measured with the RSE's and that resulted from the simulation analysis, as well as on the IRI measured using the automated profiles. In all cases, it was assumed that the %DL and IRI data are normally distributed. Some of the analyses were performed on the detailed section measurements (each section is sub-sectioned into a set of 50-ft segments), while other analyses were performed on the overall section measurement (each section is represented as one unit).

The following section summarizes the performed statistical analyses. In each case, the purpose of the analysis, the hypothesis, the type of measurement (detailed or summary), the statistical test and the cases analyzed are presented.

5.1 Evaluate the Difference Among Devices

Purpose:	To evaluate the significance of the difference among different devices by comparing the %DL of all devices/sections.
Null Hypothesis:	No significant difference among devices for all test sections.
Type of Measurements:	Summary measurements.
Statistical Test:	F-Test with a 90% confidence level.
Cases Analyzed:	Analysis was performed on the %DL for the average of the runs of ICC Light, KJ Law Light, ARAN (including ARAN40, ARAN50 and ARAN60), KJ Law Full, RSE I and RSE II.
Results:	The analysis results indicate that the null hypothesis of no difference among devices is rejected, as can be seen from table 8. Therefore, the differences among the devices/test sections are significant at 90% confidence level.

Table 8. Difference Among Devices

Section Number	Highway Number	From (ft)	To (ft)	%DL					
				ICC Light	K.J. Law Light	K.J. Law Full	ARAN	RSE I	RSE II
1	I-195W	0	500	4.35	1.22	2.38	0.60	4.20	3.60
2	I-195W	100	600	4.99	1.22	1.32	0.54	4.60	3.80
3	I-195W	100	600	4.62	5.94	2.69	0.54	4.20	3.00
4	I-195W	200	700	2.00	0.33	1.28	0.42	1.80	0.80
5	I-195W	2500	3000	3.89	0.79	1.15	1.58	2.80	0.20
6	I-195W	2600	3100	3.22	2.53	0.35	1.24	2.40	0.20
7	I-195W	1900	2400	2.03	3.14	1.18	0.90	1.20	0.60
8	I-195W	4000	4500	1.44	4.13	1.08	0.18	1.00	0.60
9	I-195W	4500	5000	0.71	5.24	0.01	1.84	0.80	0.80
10	NJ55S	1000	1500	0.00	0.00	0.10	0.00	0.00	0.00
11	NJ55S	1500	2000	0.00	0.03	0.00	0.00	0.00	0.00
12	NJ55S	2000	2500	0.00	0.02	0.27	0.04	0.00	0.00

F 2.20
 F*(5,66,.1) 1.86
 F > F* Reject H₀

5.2 Evaluate the Significance of Difference Between Pairs of Devices

Purpose:	To evaluate the significance of the difference between pairs of devices by comparing the average %DL of different pairs of devices for all sections.
Hypothesis:	No significant difference between the average %DL of the two devices for all test sections.
Type of Measurements:	Summary measurements – Analyses are performed on the difference between the measurements of the pair of devices under consideration.
Statistical Test:	Two-Sided T-Tests with a 90% confidence level.
Cases Analyzed:	See table 9.
Results:	Table 10 shows the results of the analysis. As can be seen, the difference between any two devices is significant.

Table 9. Pair-wise Device Comparisons

Device 1	Device 2	Number of Test Sections
ICC Light	KJ Law Light	12
ICC Light	KJ Law Full	12
ICC Light	ARAN	12
ICC Light	RSE I	12
ICC Light	RSE II	12
ICC Light	Average RSE I and RSE II	12
KJ Law Light	KJ Law Full	12
KJ Law Light	ARAN	12
KJ Law Light	RSE I	12
KJ Law Light	RSE II	12
KJ Law Light	Average RSE I and RSE II	12
KJ Law Full	ARAN	12
KJ Law Full	RSE I	12
KJ Law Full	RSE II	12
KJ Law Full	Average RSE I and RSE II	12
ARAN	RSE I	12
ARAN	RSE II	12
ARAN	Average RSE I and RSE II	12
RSE I	RSE II	12
RSE I	Average RSE I and RSE II	12
RSE II	Average RSE I and RSE II	12

Table 10. Significance of Difference Between Pairs of Devices

Device 1	Device 2	Calculated t	*Significant
ICC Light	KJ Law Light	4.06	Yes
ICC Light	KJ Law Full	3.76	Yes
ICC Light	ARAN	3.99	Yes
ICC Light	RSE I	3.47	Yes
ICC Light	RSE II	3.36	Yes
ICC Light	Average RSE I and RSE II	3.43	Yes
KJ Law Light	KJ Law Full	3.29	Yes
KJ Law Light	ARAN	2.96	Yes
KJ Law Light	RSE I	4.06	Yes
KJ Law Light	RSE II	4.12	Yes
KJ Law Light	Average RSE I and RSE II	4.12	Yes
KJ Law Full	ARAN	4.10	Yes
KJ Law Full	RSE I	3.33	Yes
KJ Law Full	RSE II	3.32	Yes
KJ Law Full	Average RSE I and RSE II	2.92	Yes
ARAN	RSE I	3.34	Yes
ARAN	RSE II	3.25	Yes
ARAN	Average RSE I and RSE II	2.58	Yes
RSE I	RSE II	3.14	Yes
RSE I	Average RSE I and RSE II	3.14	Yes
RSE II	Average RSE I and RSE II	3.14	Yes

$t^* = 1.798$

5.3 Evaluate Equipment Repeatability

Purpose: To evaluate the repeatability of each device by comparing the repeated runs (pair-wise) for each test section.

Hypothesis: No significant difference among repeated runs on each test section.

Type of Measurements: Detailed measurements - Analyses are performed on the difference between the measurements of the pair of devices under consideration.

Statistical Test: Two-Sided T-Tests with a 90% confidence level.

Cases Analyzed: See table 11.

Results: Table 12 shows a summary of the analysis results. In this table, the total number of tests is presented for each device/parameter combination. Also, the percentage of tests that show no significant difference is presented, as well as the percentage of tests that show significant difference. For example, 36 tests were performed for the ICC Light/%DL combination. Fifty percent of these tests, i.e. 18 tests, show no significant difference, while the other 50% show significant difference. The complete results are presented in table 28 of appendix C.

Table 11. Equipment Repeatability

Device	Parameter	Number of Runs	Number of Sections	Number of Points per Section	Total Number of Tests
ICC Light	%DL	3	12	10	36
KJ Law Light	%DL	3	12	10	36
ARAN 40	%DL	5	12	10	120
ARAN 40	IRI	5	12	10	120
ARAN 50	%DL	3	12	10	36
ARAN 50	IRI	3	12	10	36
ARAN 60	%DL	3	12	10	36
ARAN 60	IRI	3	12	10	36
KJ Law Full	%DL	5	12	10	120
KJ Law Full	IRI	5	12	10	120

Table 12. Summary of the Equipment Repeatability Results

Device	Parameter	Total Number of Tests	No Significant Difference (Conclude H_0)	Significant Difference (Reject H_0)
ICC Light	%DL	36	50%	50%
KJ Law Light	%DL	36	44%	56%
ARAN 40	%DL	120	50%	50%
ARAN 40	IRI	120	0%	100%
ARAN 50	%DL	36	60%	40%
ARAN 50	IRI	36	0%	100%
ARAN 60	%DL	36	69%	31%
ARAN 60	IRI	36	0%	100%
KJ Law Full	%DL	120	74%	26%
KJ Law Full	IRI	120	5%	95%

5.4 Speed Effect on ARAN Measurements

Purpose:	To evaluate the speed effect on ARAN measurements by comparing the repeated runs at different speeds (pair-wise) for each test section.
Hypothesis:	No significant difference among repeated runs at different speeds on each test section.
Type of Measurements:	Detailed measurements - Analyses are performed on the difference between the measurements of the pair of speeds.
Statistical Test:	Two-Sided T-Tests with a 90% confidence level.
Cases Analyzed:	ARAN 40, ARAN 50 and ARAN 60.
Results:	Table 13 shows a summary of the analysis results. The complete results are presented in table 29 of appendix C.

Table 13. Summary of ARAN-Speed Results

Device	Parameter	Total Number of Tests	No Significant Difference (Conclude H_0)	Significant Difference (Reject H_0)
ARAN40/ARAN50/ARAN60	%DL	36	61%	39%
ARAN40/ARAN50/ARAN60	IRI	36	0%	100%

5.5 Analysis of the Statistical Test Results

Several conclusions can be drawn from the results of the statistical tests performed to evaluate equipment repeatability and the differences among different devices, as follows:

- The differences among %DL measured with different devices are found to be statistically significant. The same is also true for the IRI measurements. Also, the difference between the two RSE's is significant and cannot be ignored. Figures 8 to 12 show some comparisons of the %DL measured using the two RSE's and the %DL resulting from the simulation analysis. Figures 8 and 9 show the %DL of all devices for Test Sections 1-12 and 1-9, respectively. As can be seen, the differences among devices are significant and not consistent. For example, the KJ Law Light shows the highest %DL among all devices for Sections 3, 7, 8 and 9, while the same device shows much lower %DL than some of the other devices for Sections 1, 2, 4 and 5.
- Figure 10 shows a comparison between the two RSE's (RSE I and RSE II). As can be seen, RSE I always reads higher deviations than RSE II. It should be noted that both RSE's were calibrated on the same bench by the same crew prior to the field inspection. Figure 11 shows the percentage difference between the two RSE's. This percentage difference is calculated as the difference between the RSE readings

divided by RSE II readings. The difference ranges from 0% (no difference) to 1300 (the difference is 13 times the value of the RSE II measurement).

- Figures 12 and 13 show comparisons between the RSE I and RSE II measurements and the %DL simulated from the KJ Law Light and the ICC Light, respectively. As can be seen from these figures, the differences between the RSE measurements and those of the light weight profilers are significant and not consistent, except for ICC Light and RSE I. [ICC & RSE I are consistent from figure 13.]
- Figures 14 to 16 show comparisons between the RSE I and RSE II measurements and the %DL simulated from the ARAN 40 mph, 50 mph and 60 mph measurements, respectively. As can be seen, the differences between the RSE measurements and the ARAN measurements at all speeds are significant.
- Figure 17 shows the effect of speed on ARAN measurements. As can be seen, the speed effect on ARAN measurements is significant and not consistent. For example, comparing Sections 3, 5 and 7 show that ARAN40 gives the highest %DL of the 3 speeds for Section 5, while ARAN50 and ARAN60 give the highest %DL for Sections 3 and 7, respectively.
- Figure 18 shows a comparison between the RSE results and the %DL simulated from the KJ Law Full measurements. As can be seen, the difference between the RSE measurements and the KJ Law full is significant and not consistent.
- Figures 19 to 21 show comparisons between the IRI values measured using different devices, while figures 22 to 24 show the % difference among the IRI values. The % difference of a section is calculated as a percentage of the average IRI for the section. As can be seen, the percentage difference exceeds in some cases 150%, which is significant. However, the results of some of the tests, such as those performed using the KJ Law Full and ARAN at 40 and 50 MPH, are very close.
- Figures 25 and 26 show the effect of speed on the IRI measured using ARAN. The speed effect, as can be seen from figure 26, can be as high as 50%.

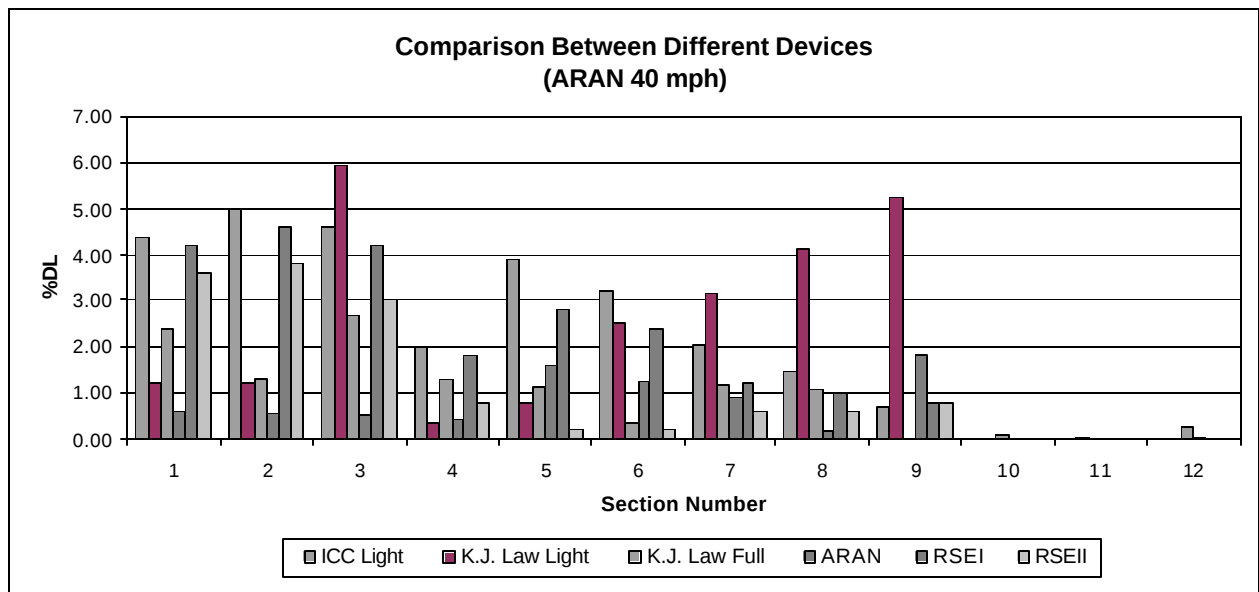


Figure 8. % DL (12 Sections)

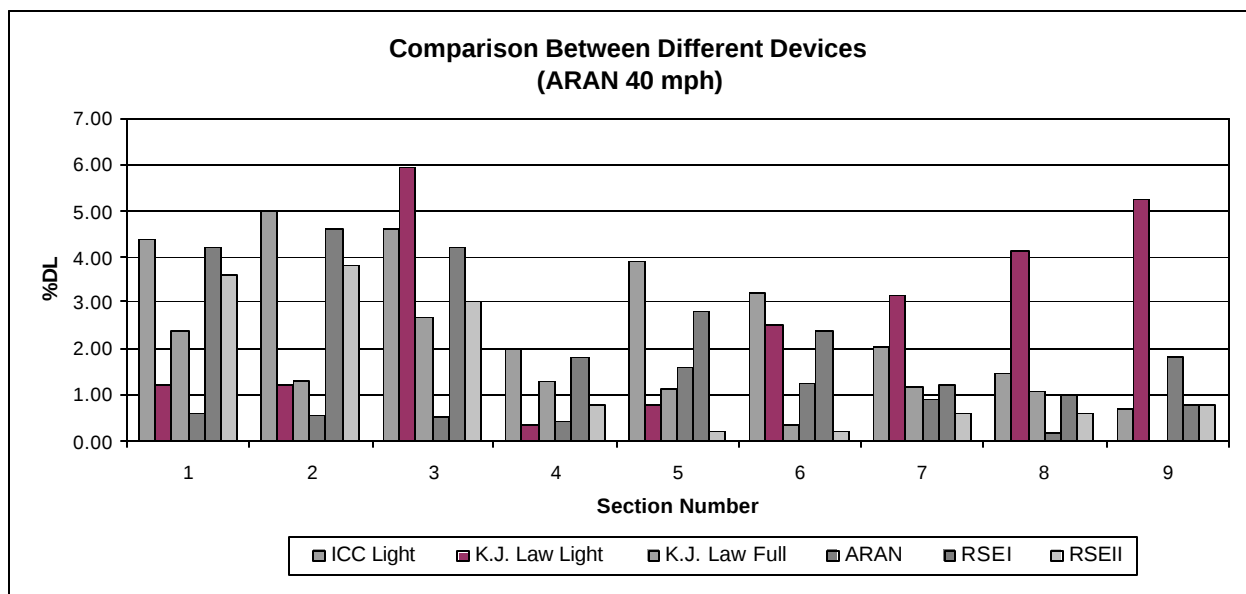


Figure 9. % DL (9 Sections)

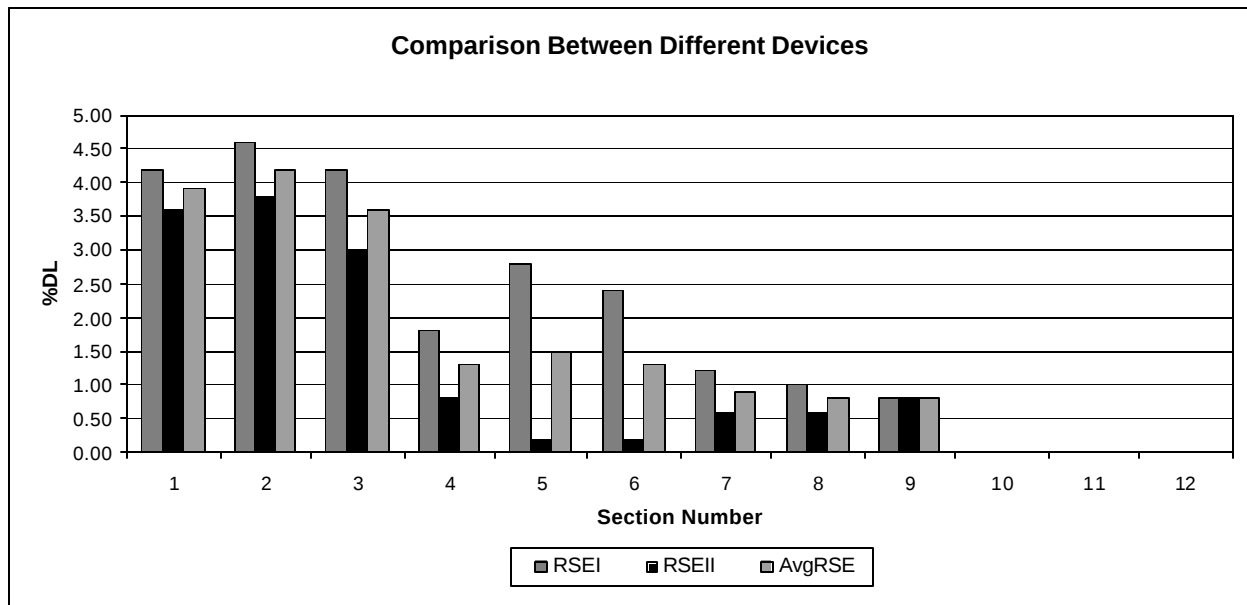


Figure 10. % DL (Two RSE's)

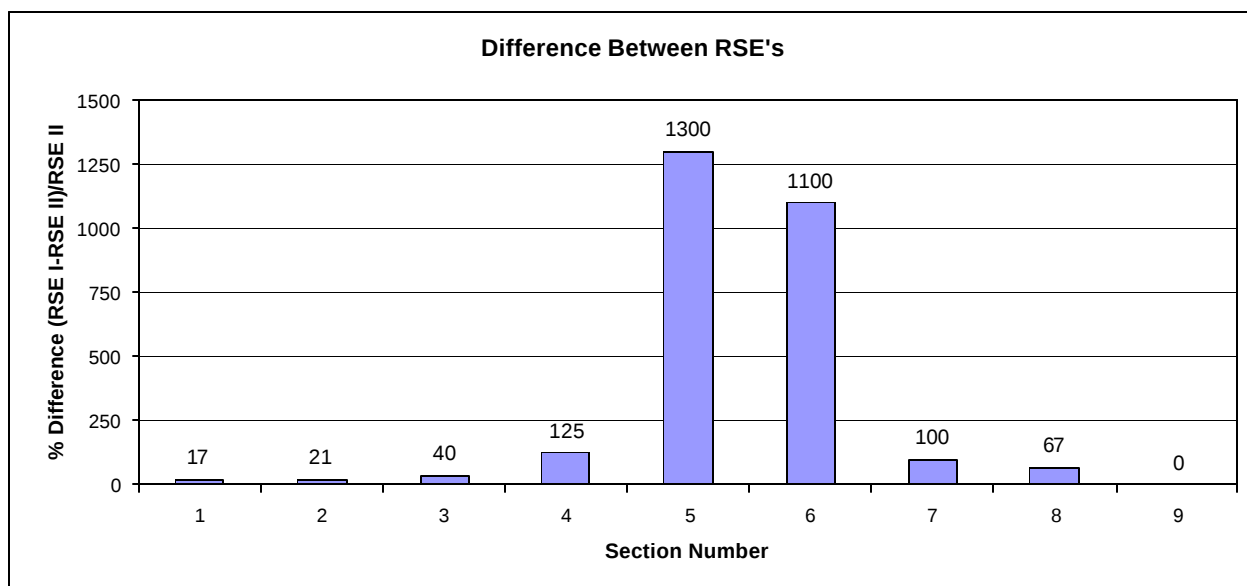


Figure 11. Difference Between the Two RSE's

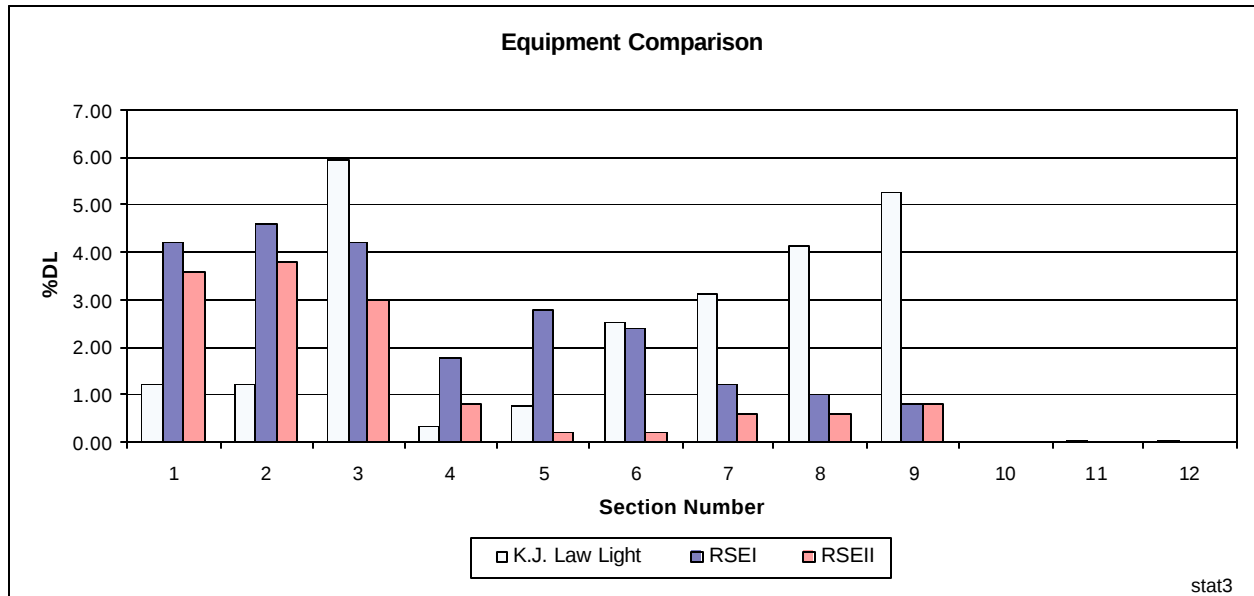


Figure 12. % DL (KJ Law Light and RSE's)

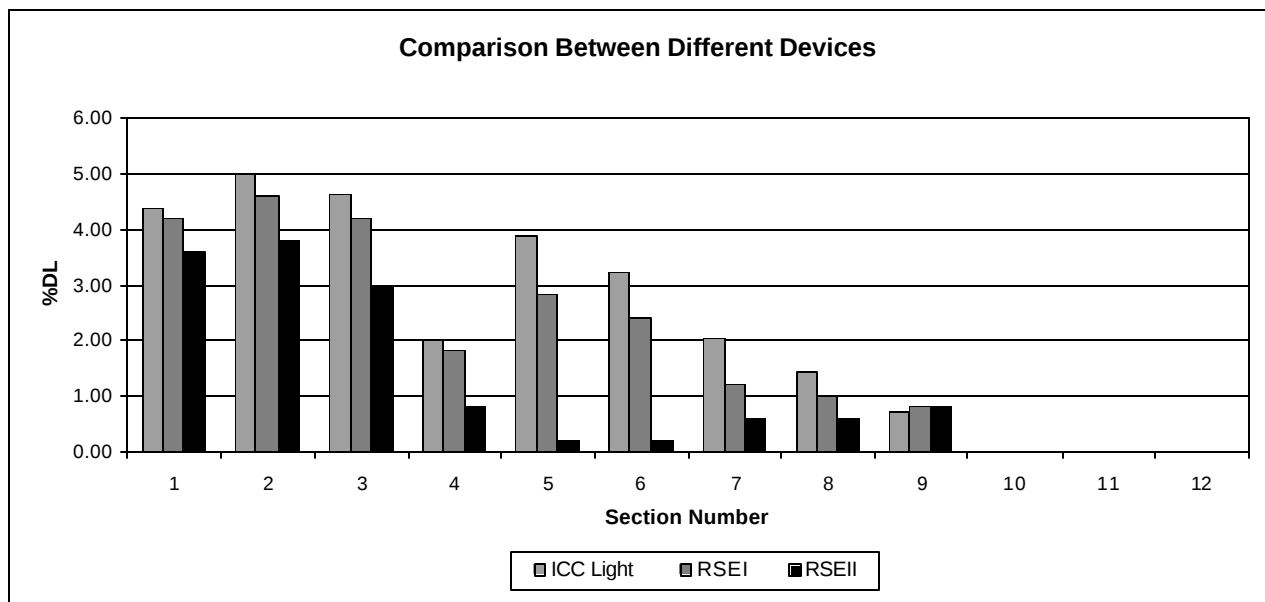


Figure 13. % DL – ICC Light

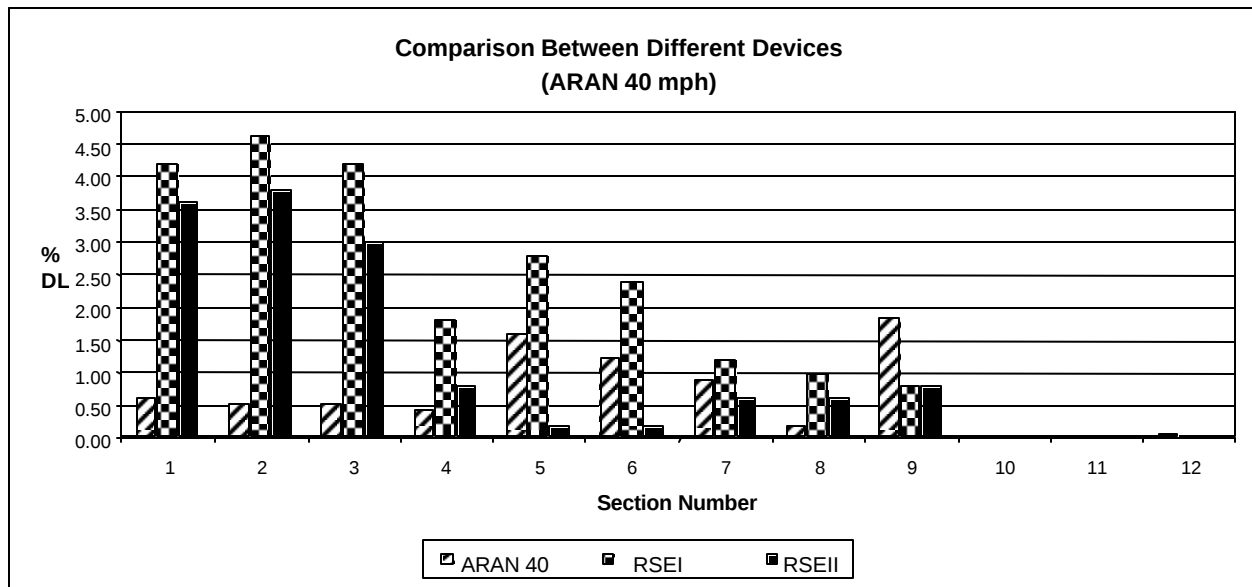


Figure 14. % DL (ARAN 40)

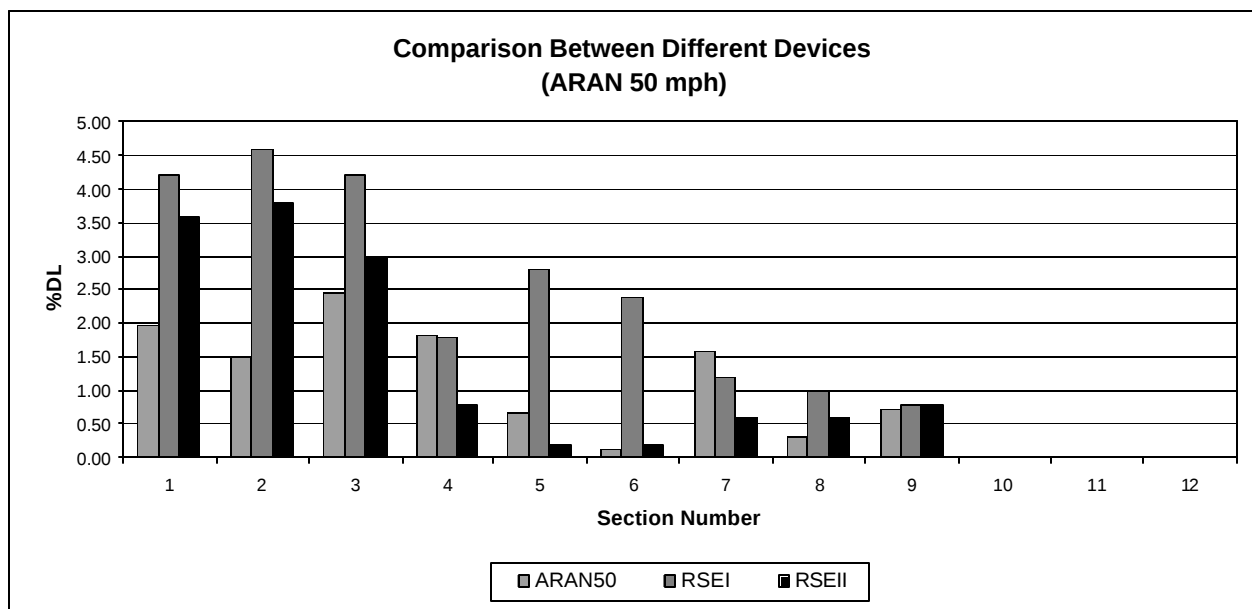


Figure 15. % DL (ARAN 50)

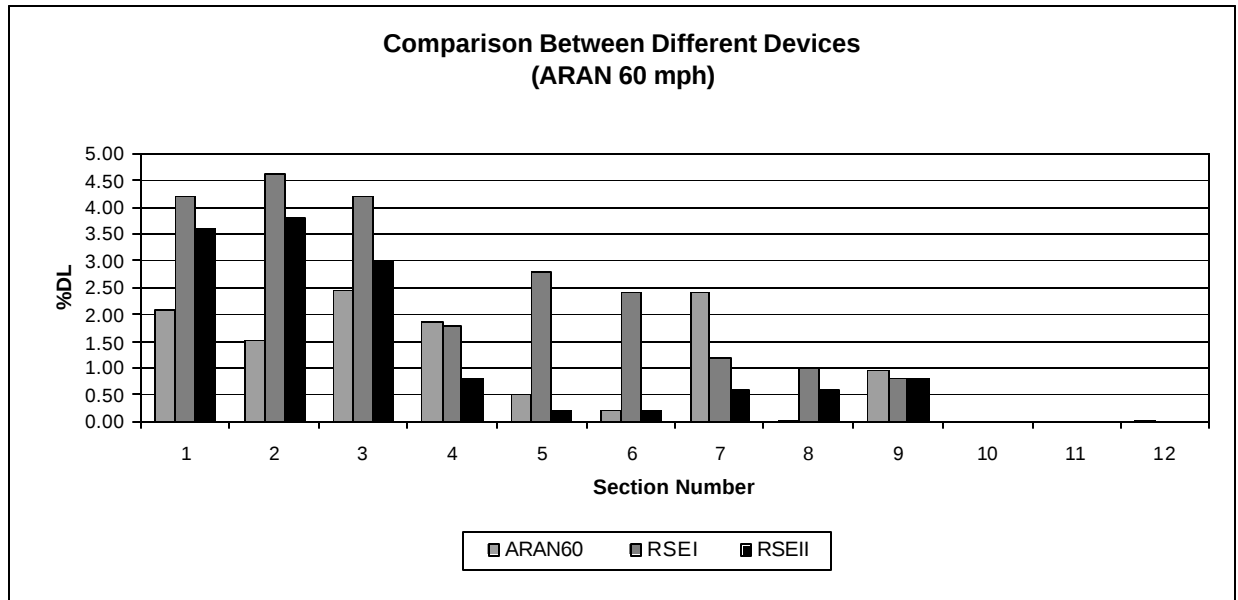


Figure 16. % DL (ARAN 60)

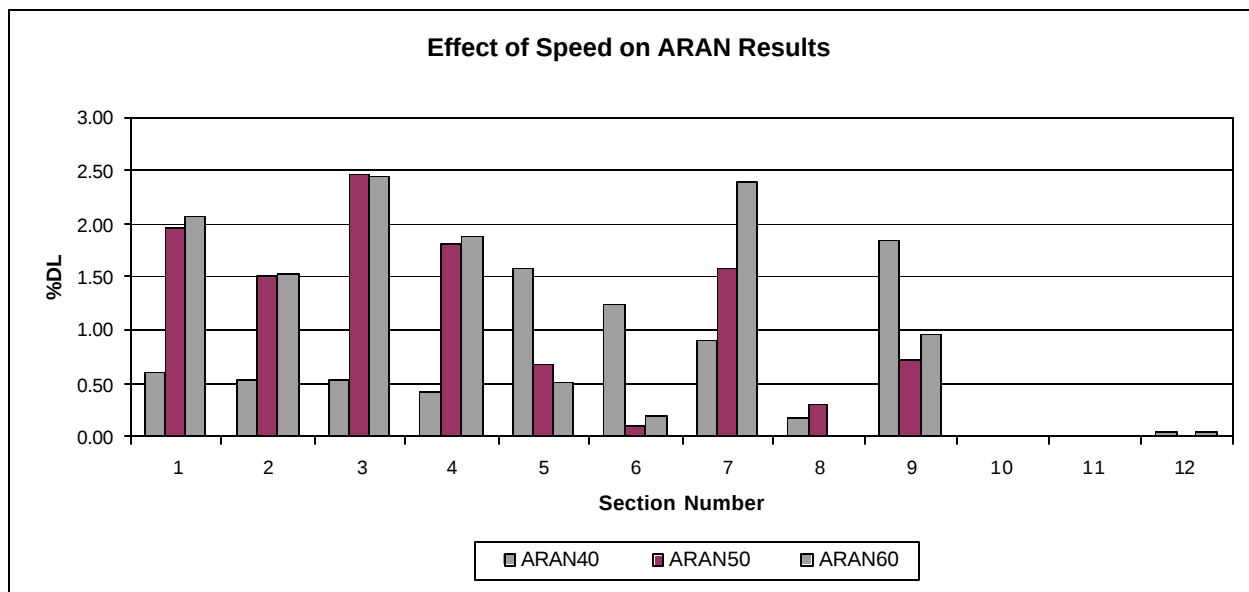


Figure 17. Effect of Speed on ARAN Measurements

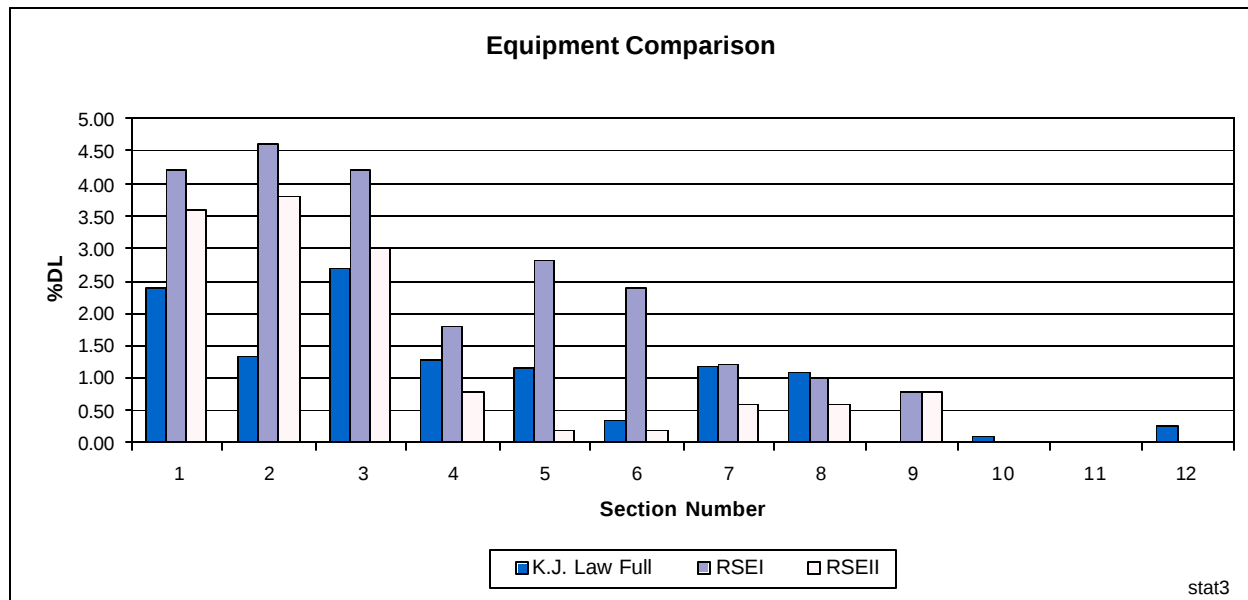


Figure 18. % DL (KJ Law Full and RSE's)

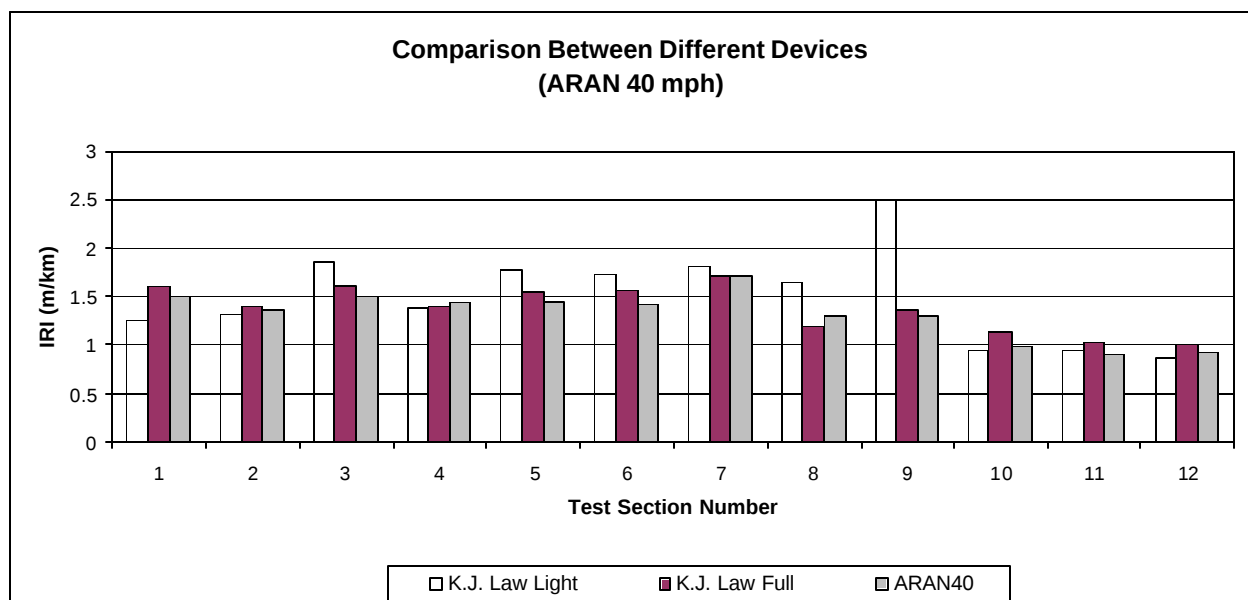


Figure 19. IRI Comparison (ARAN 40)

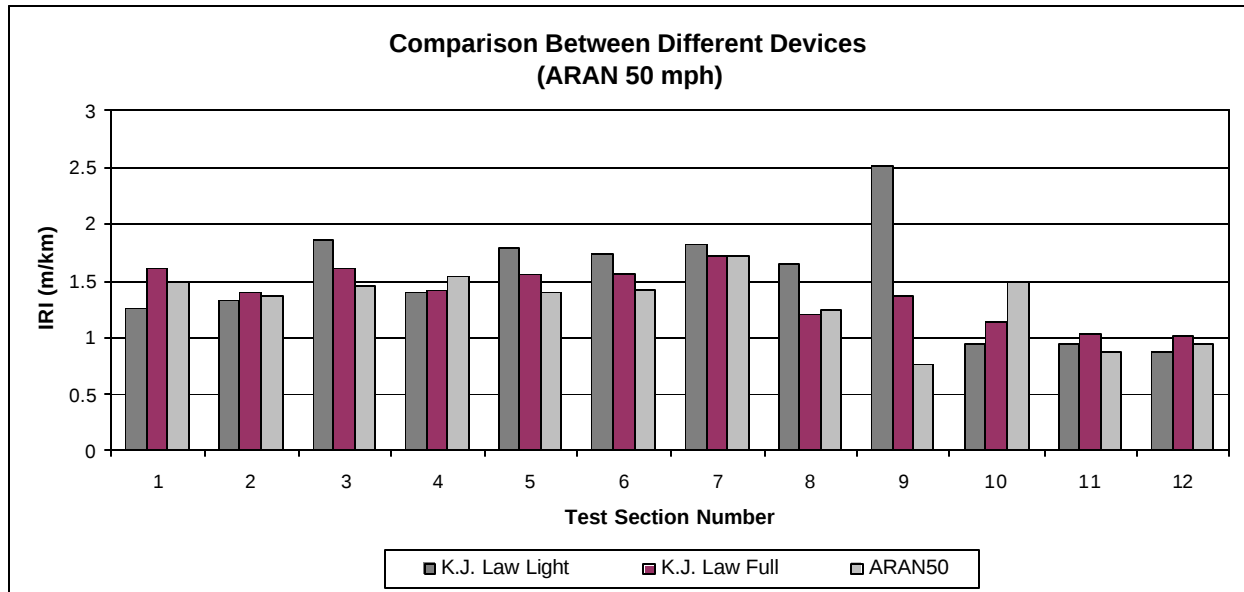


Figure 20. IRI Comparison (ARAN 50)

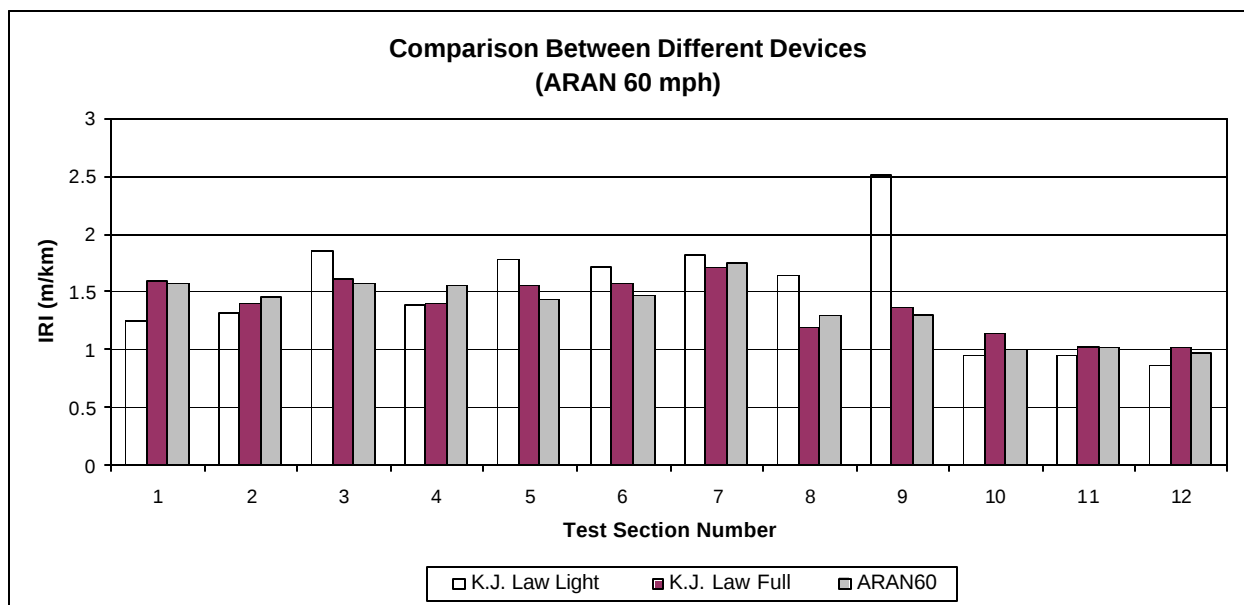


Figure 21. IRI Comparison (ARAN 60)

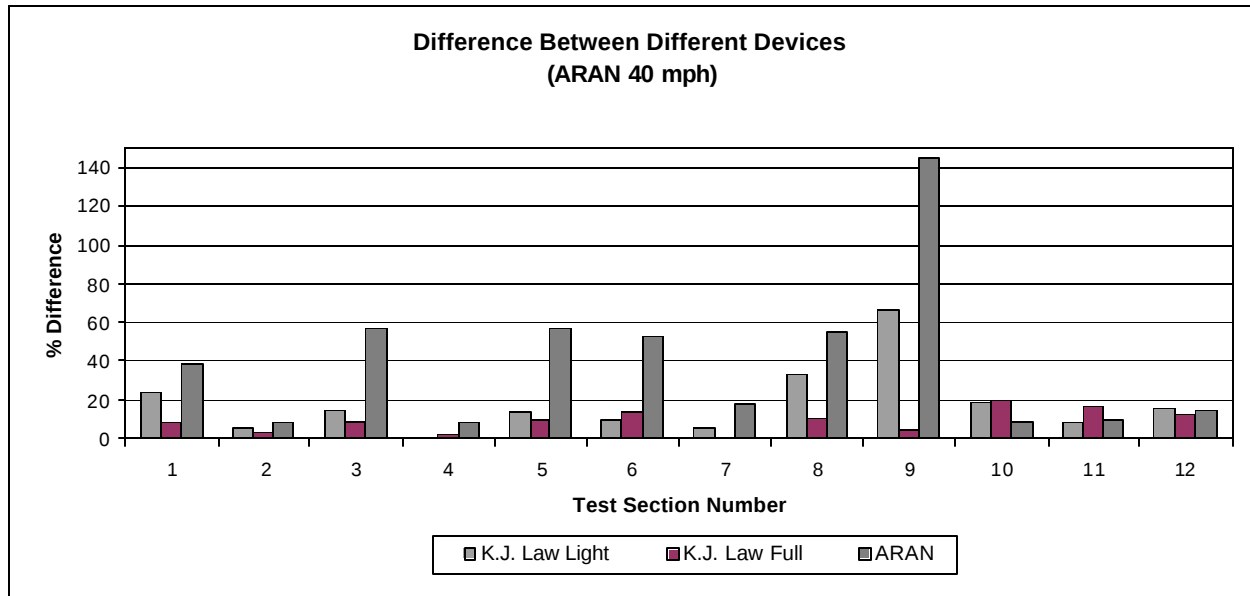


Figure 22. % Difference in IRI (ARAN 40)

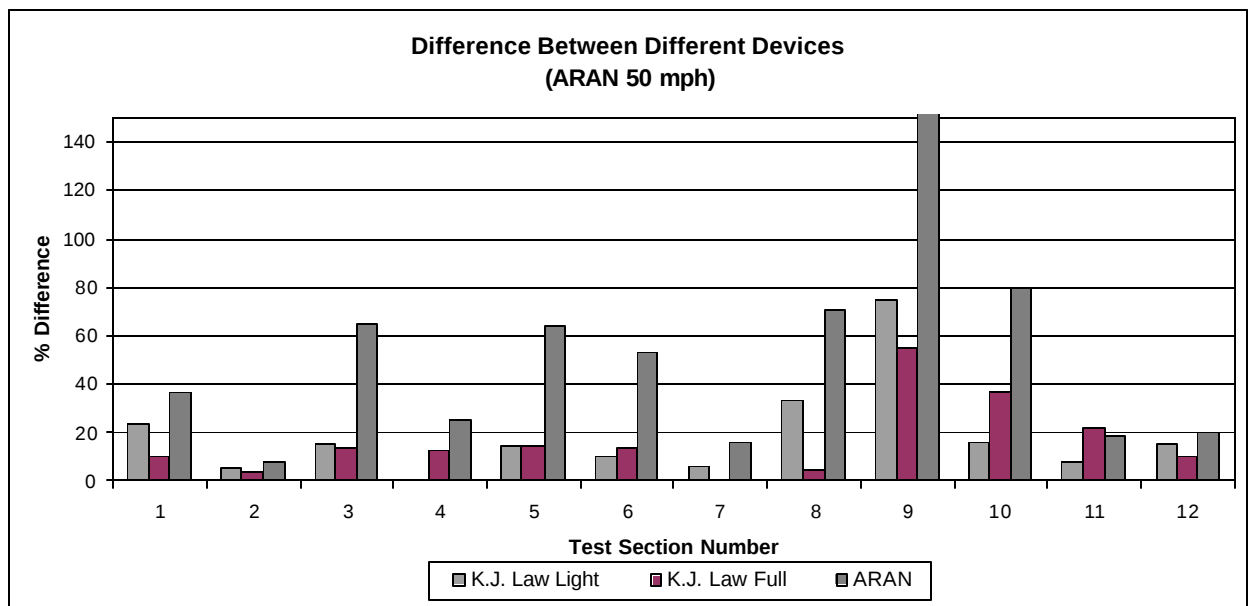


Figure 23. % Difference in IRI (ARAN 50)

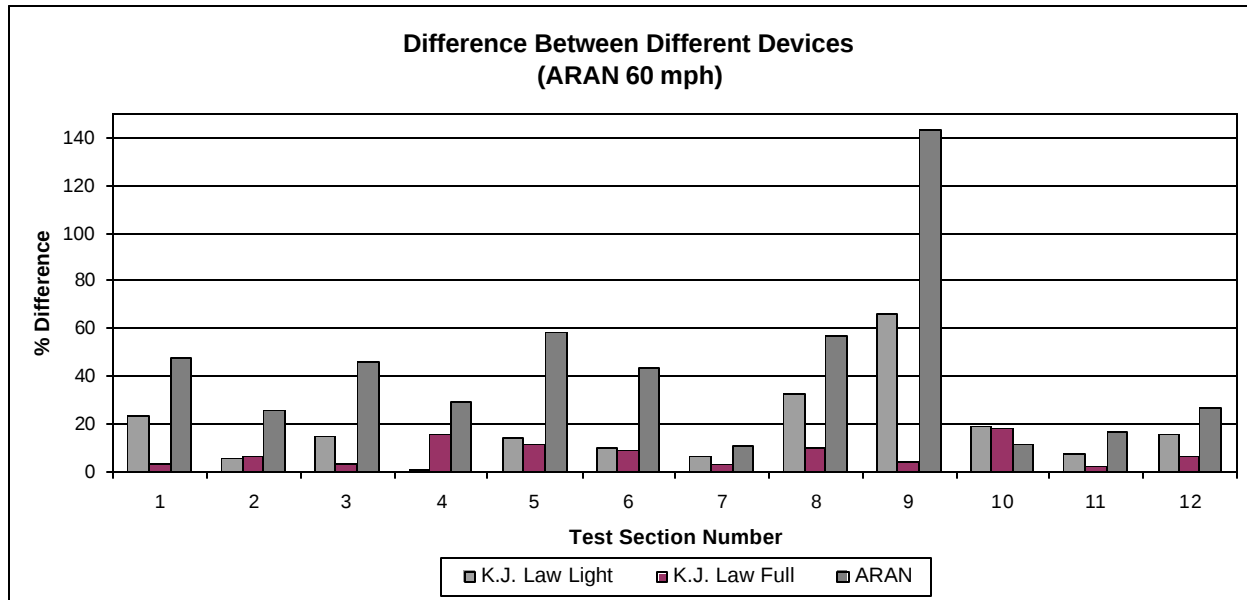


Figure 24. % Difference in IRI (ARAN 60)

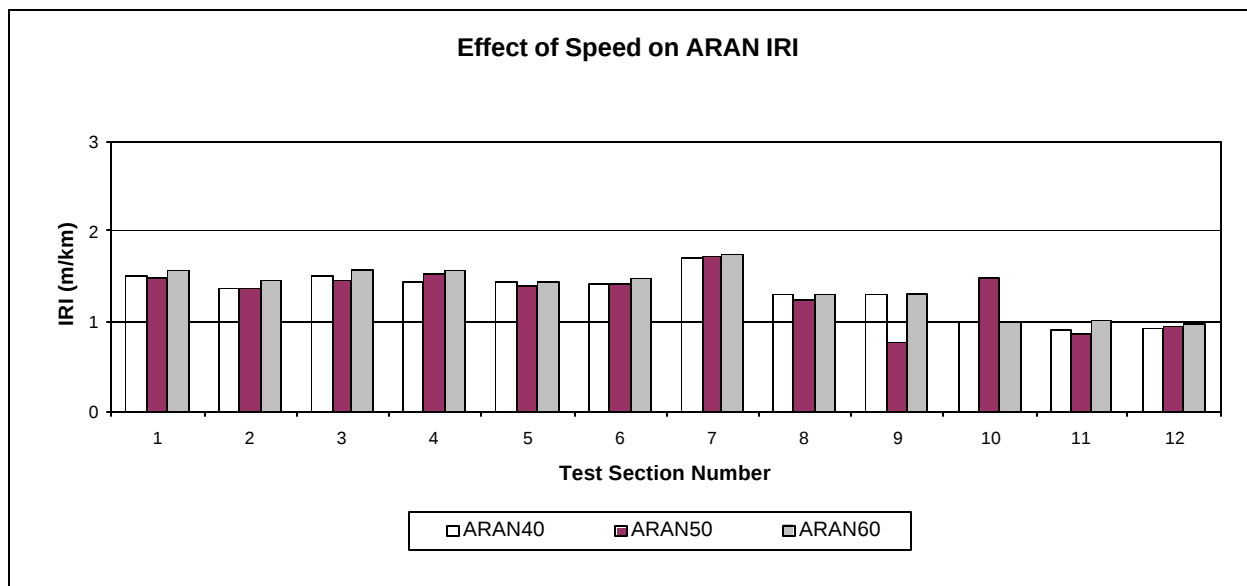


Figure 25. Effect of Speed on ARAN Measurements

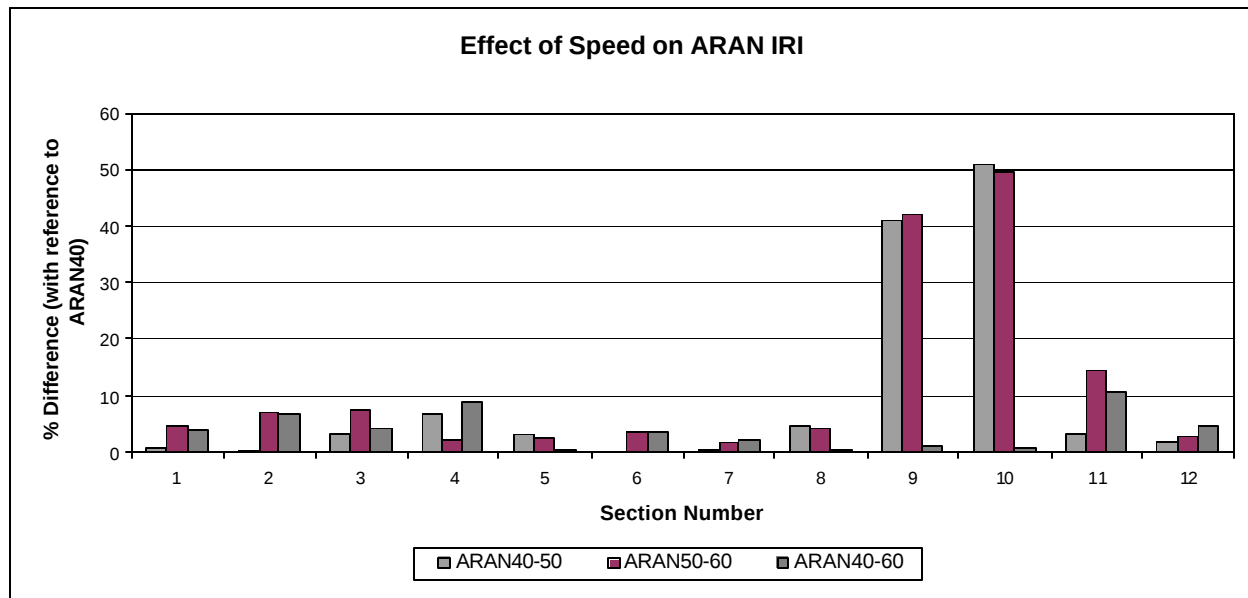


Figure 26. % Difference in IRI with ARAN Speed

6.0 EFFECT OF SPEED ON THE LIGHT WEIGHT PROFILERS

Test trials were performed at two speeds (10 mph and 20 mph) using the KJ Law and ICC Light Weight Profilers to evaluate the impact of speed on their measurements. The tests were performed on only one section of I-195 West, from Stations 100 ft to 600 ft. This section is a relatively rough section. The speed runs consisted of one run at 10 mph and 3 runs at 20 mph. The results of these 3 runs were averaged and used to represent the 20 mph speed. Figures 27 and 28 show the profiles measured at different speeds using the KJ Law Light and ICC Light, respectively. As can be seen, the effect of speed on the measured profile is much higher for the KJ Law Light. The effect of speed on the simulated %DL is shown in figures 29 and 30 for the KJ Law and ICC Light Weight Profilers, respectively.

The correlation between the %DL at speeds 10 and 20 mph are shown in figures 31 and 32 for the KJ Law and ICC Light Weight Profilers, respectively. As can be seen from these figures the effect of speed on the KJ Law Light Weight Profiler is more significant. The correlation between the % DL at different speeds is lower for the KJ Law Light (0.71) than that for the ICC Light (0.99). This implies that although there is a difference between the profiles measured at difference speeds, this difference is consistent in the case of the ICC Light and can be eliminated by using a correlation model.

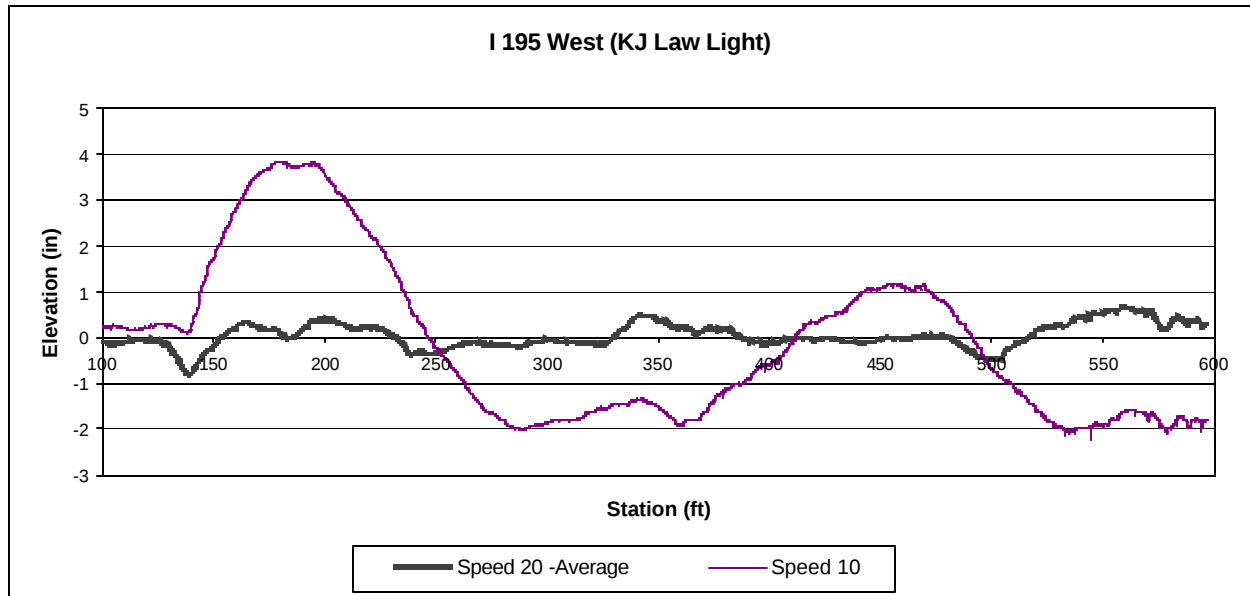


Figure 27. Effect of Speed on KJ Law Light Measurements

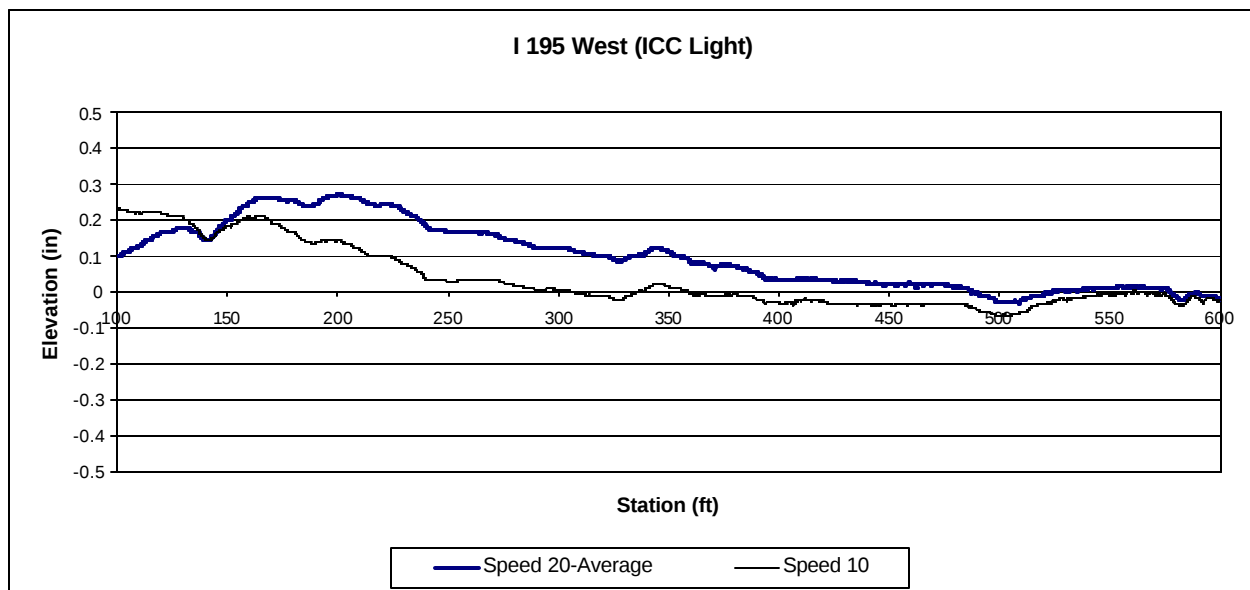


Figure 28. Effect of Speed on ICC Light Measurements

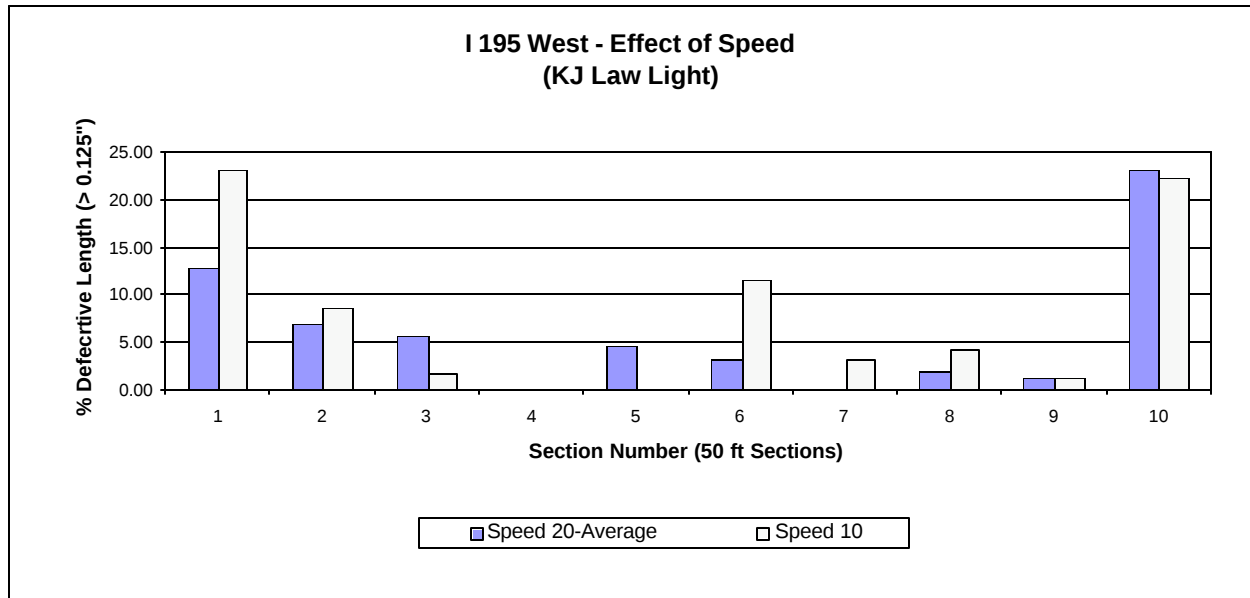


Figure 29. Effect of Speed on KJ Law Light Measurements

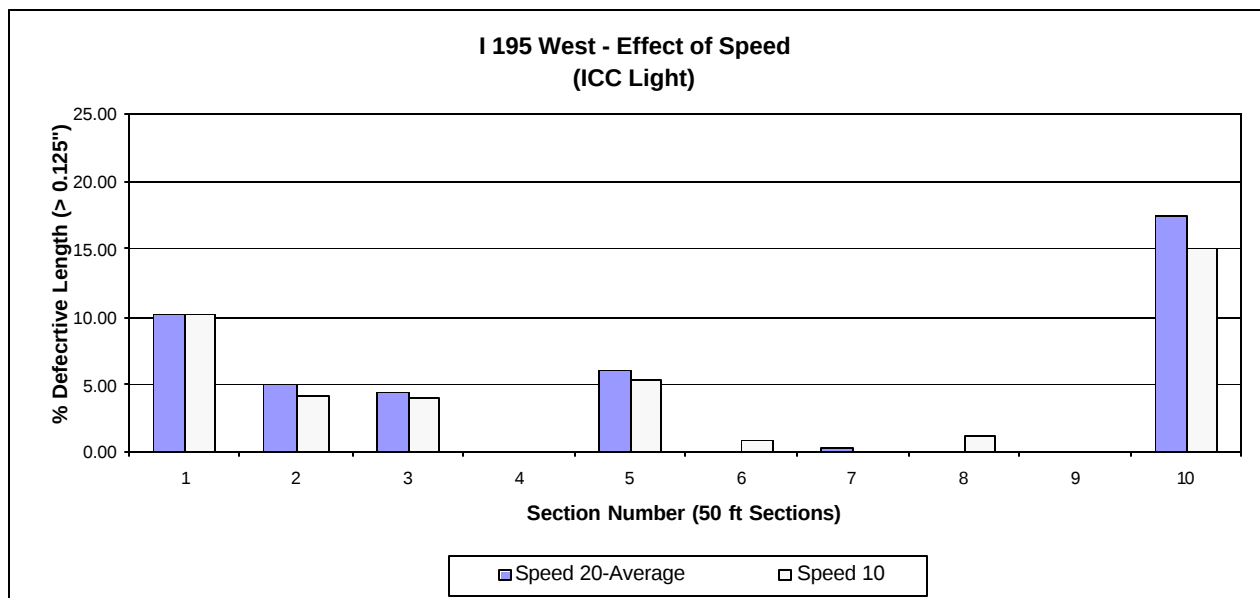


Figure 30. Effect of Speed on ICC Measurements

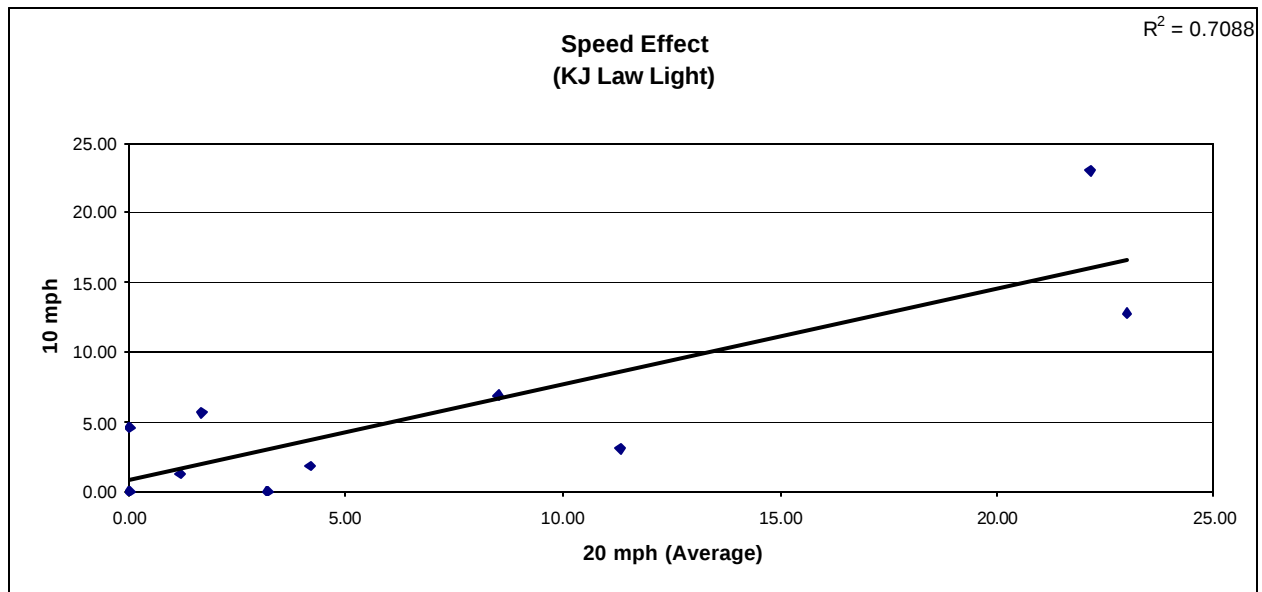


Figure 31. Speed Correlation (KJ Law Light)

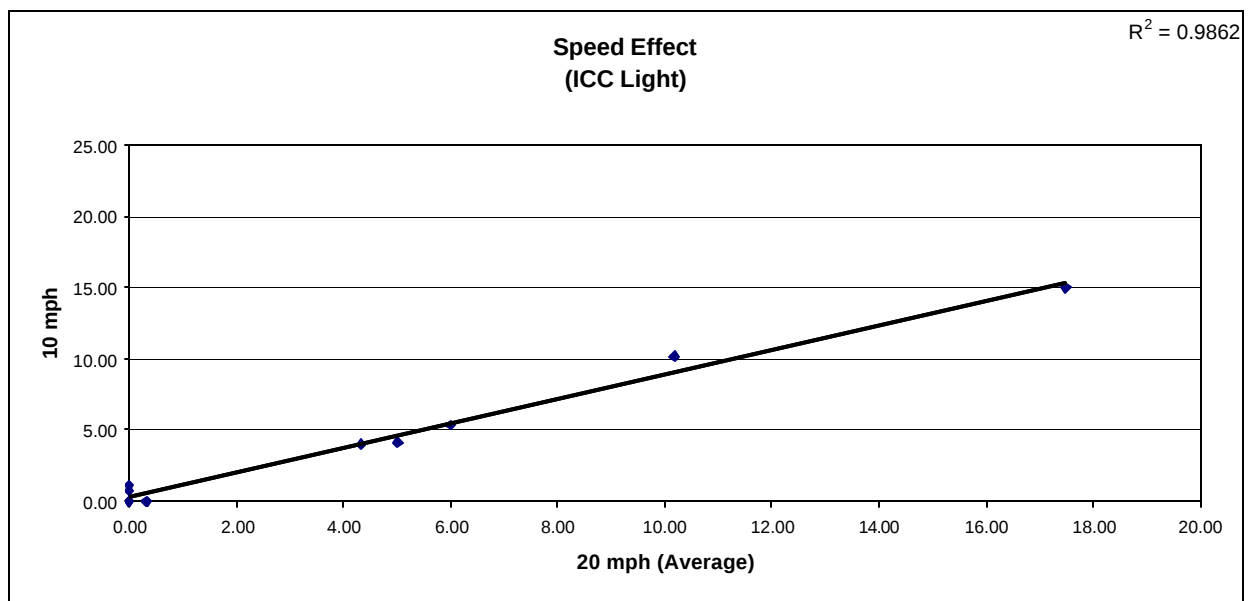


Figure 32. Speed Correlation (ICC Light)

7.0 CORRELATION ANALYSIS

Three correlation analysis studies were performed on the collected data. The objectives of these studies are to correlate the RSE measurements with the results of the simulation analysis performed on the profiles measured using the automated devices, to correlate the IRI measured with different devices and to correlate the IRI and %DL of the RSE's.

7.1 Correlation of %DL Between RSE and Automated Devices

The objective of this correlation analysis is to correlate the %DL measured using the two RSE's with that resulting from the simulation analysis performed on the profiles measured using the automated devices. In this analysis, the measurements of the both RSE's, as well as the average of their measurements, were correlated with the results of the simulation analysis performed on the profiles measured using the automated devices. Figures 33 to 50 show the results of the correlation analysis. These figures are grouped in sets of 3, as follows:

- RSE's vs. KJ Law Light (figures 33 – 35).
- RSE's vs. ICC Light (figures 36 – 38).
- RSE's vs. ARAN40 (figures 39 – 41).
- RSE's vs. ARAN 50 (figures 42 – 44).
- RSE's vs. ARAN 60 (figures 45 – 47).
- RSE's vs. KJ Law Full (figures 48 – 50).

Table 14 and figures 51 to 53 show a summary of the correlation analysis results. As can be seen, RSE II correlated the best with the profilers, followed by the average of the two RSE's. ICC Light Weight Profiler was the device that correlated best with RSE I and the average of the two RSE's, while ARAN60 and KJ Law Light Weight Profiles were the devices that correlated best with RSE II. It should be noted that only linear correlation was considered in this analysis to evaluate the applicability of this approach. Higher degree correlation analysis is performed on selected cases. Results of this analysis are presented in the recommended approach section.

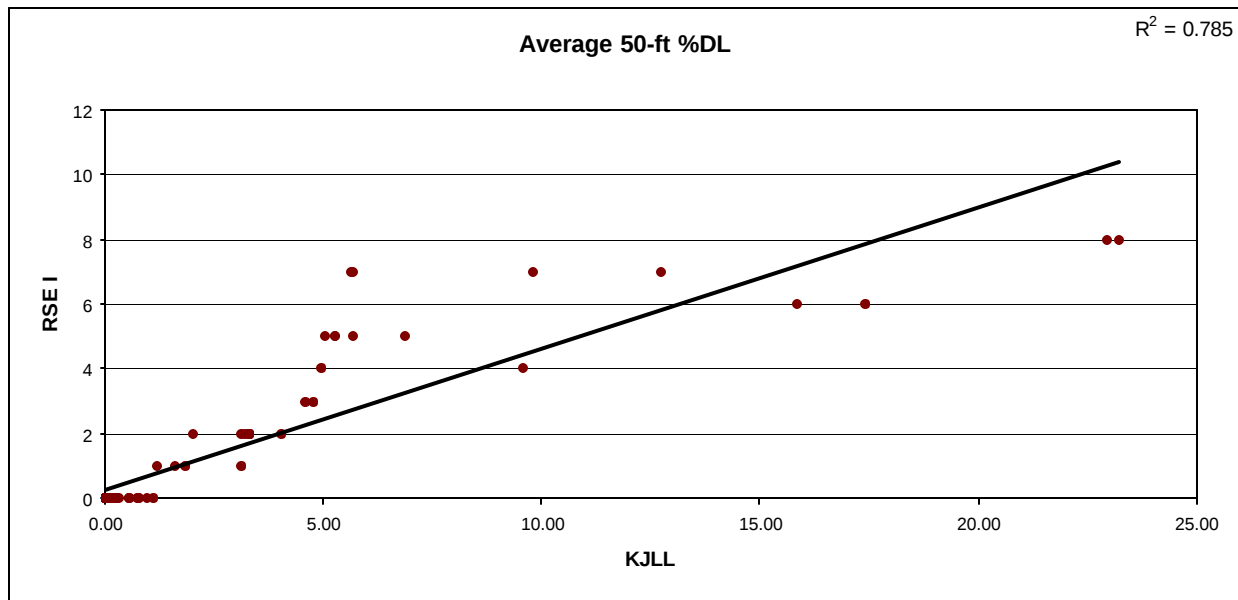


Figure 33. RSE I – KJ Law Light

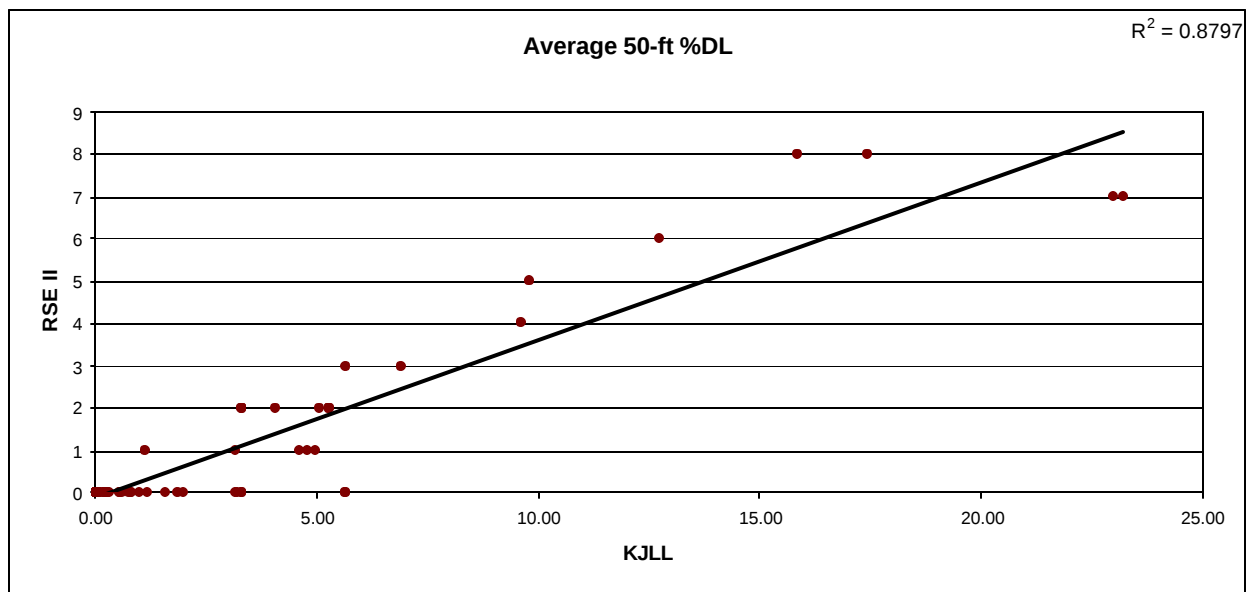


Figure 34. RSEII – KJ Law Light

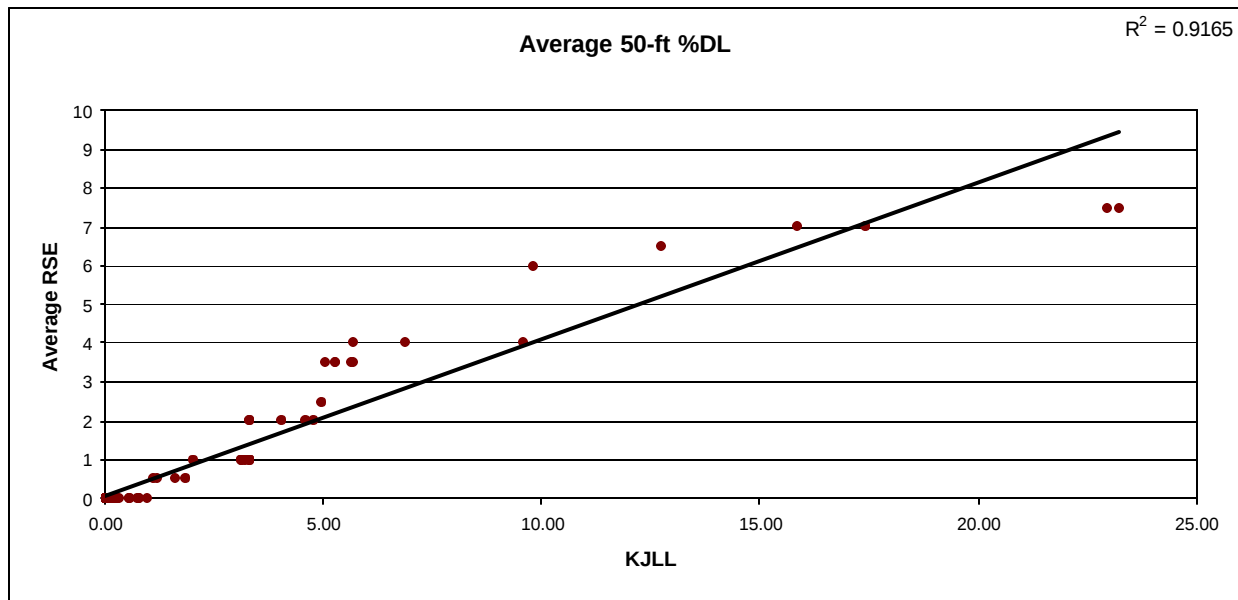


Figure 35. Average RSE – KJ Law Light

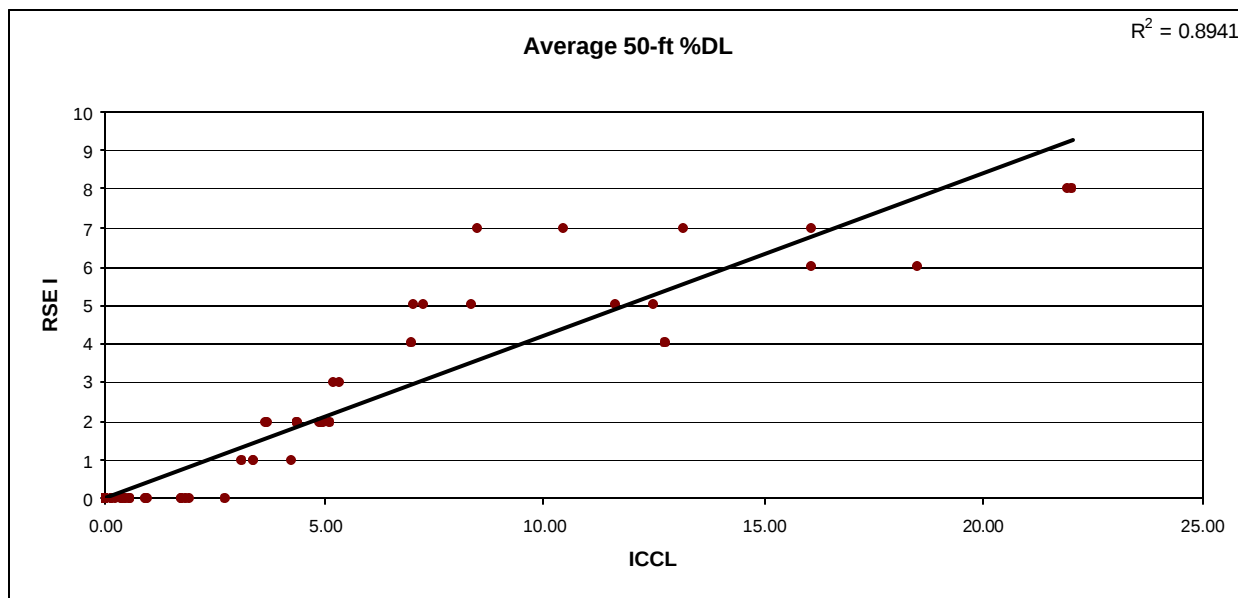


Figure 36. RSE I – ICC Light

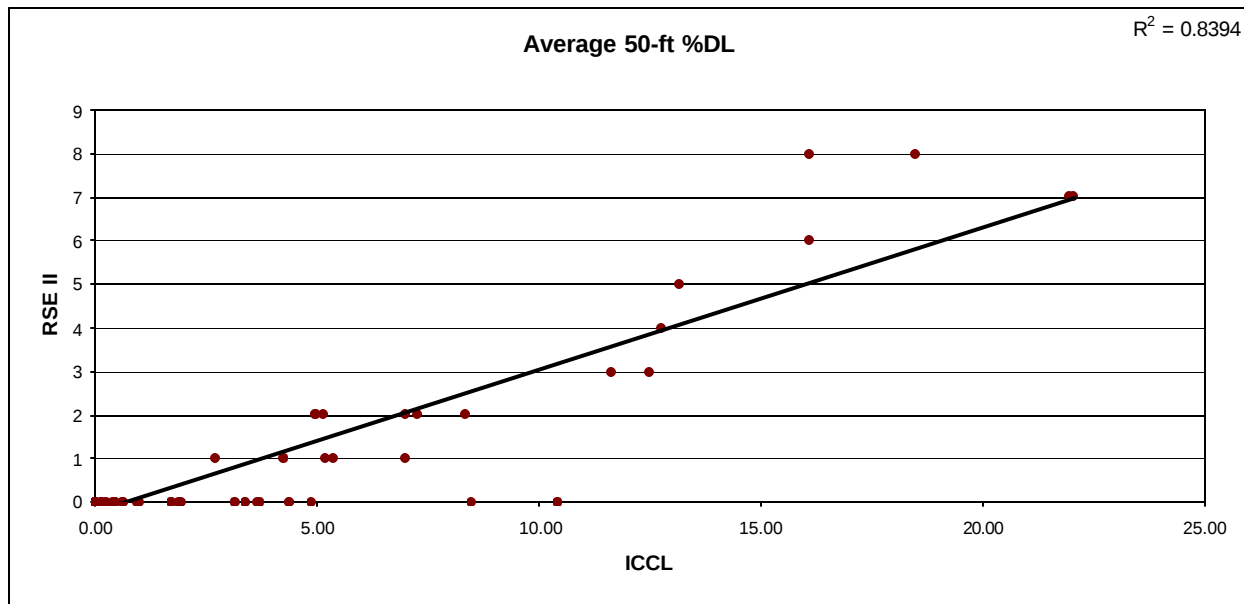


Figure 37. RSE II – ICC Light

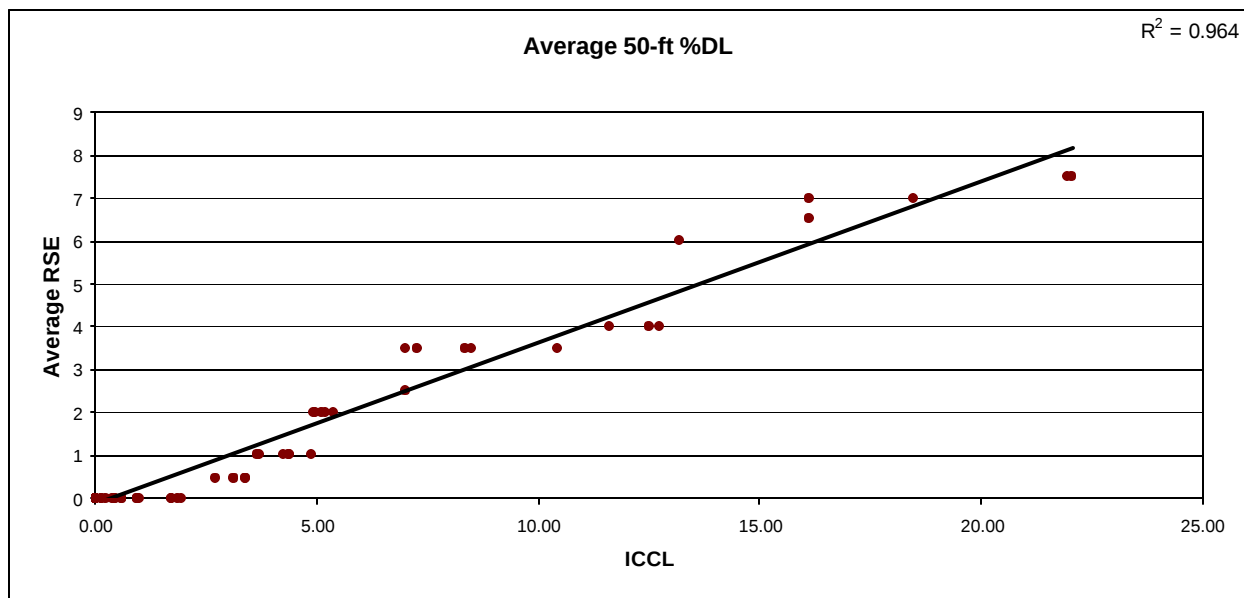


Figure 38. Average RSE – ICC Light

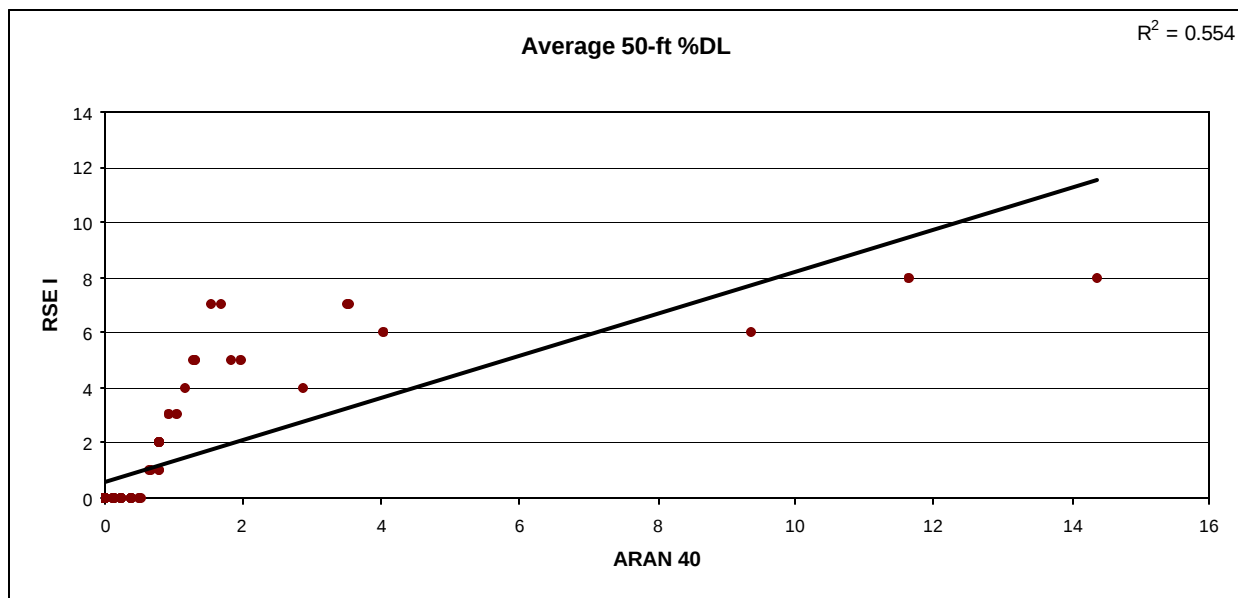


Figure 39. RSE I – ARAN 40

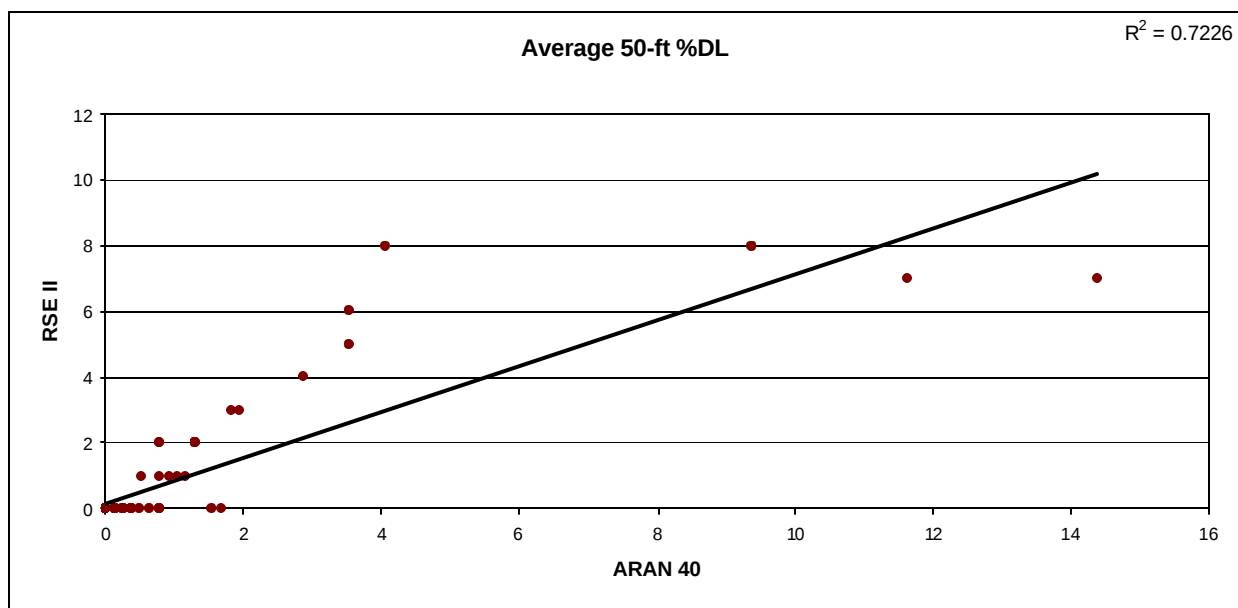


Figure 40. RSE II – ARAN 40

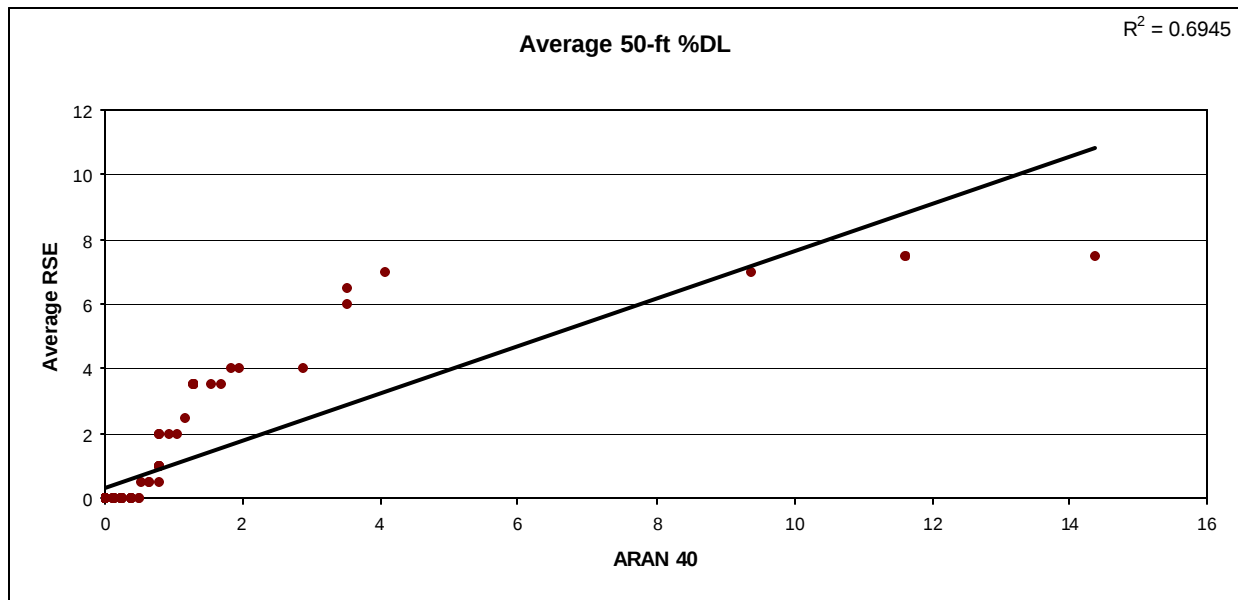


Figure 41. Average RSE – ARAN 40

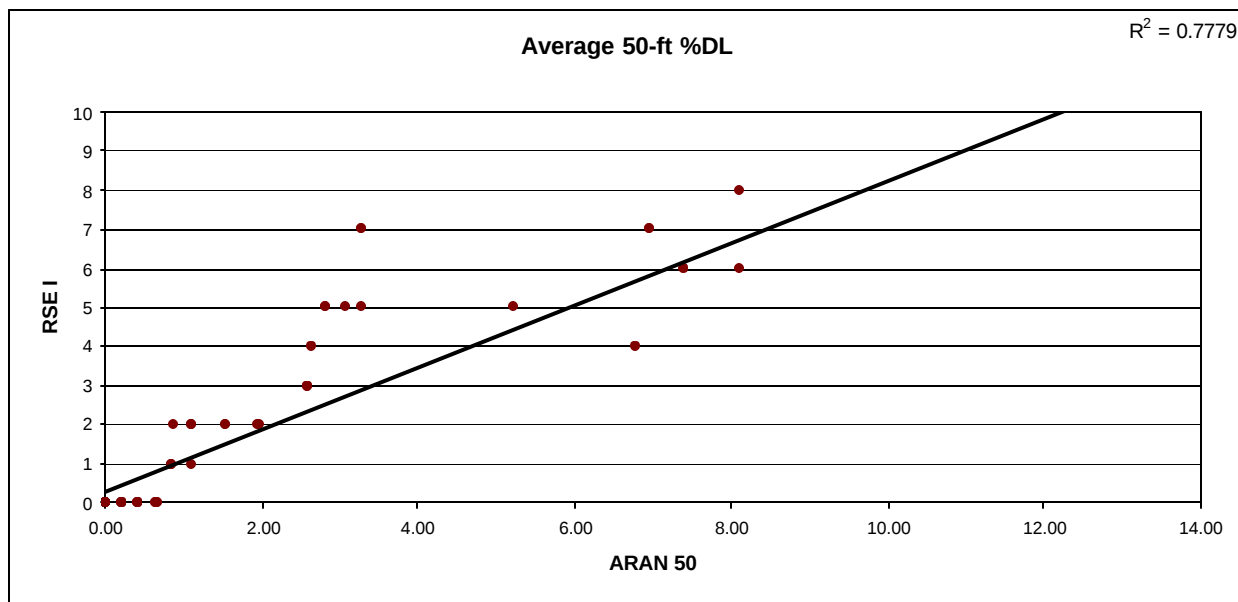


Figure 42. RSE I – ARAN 50

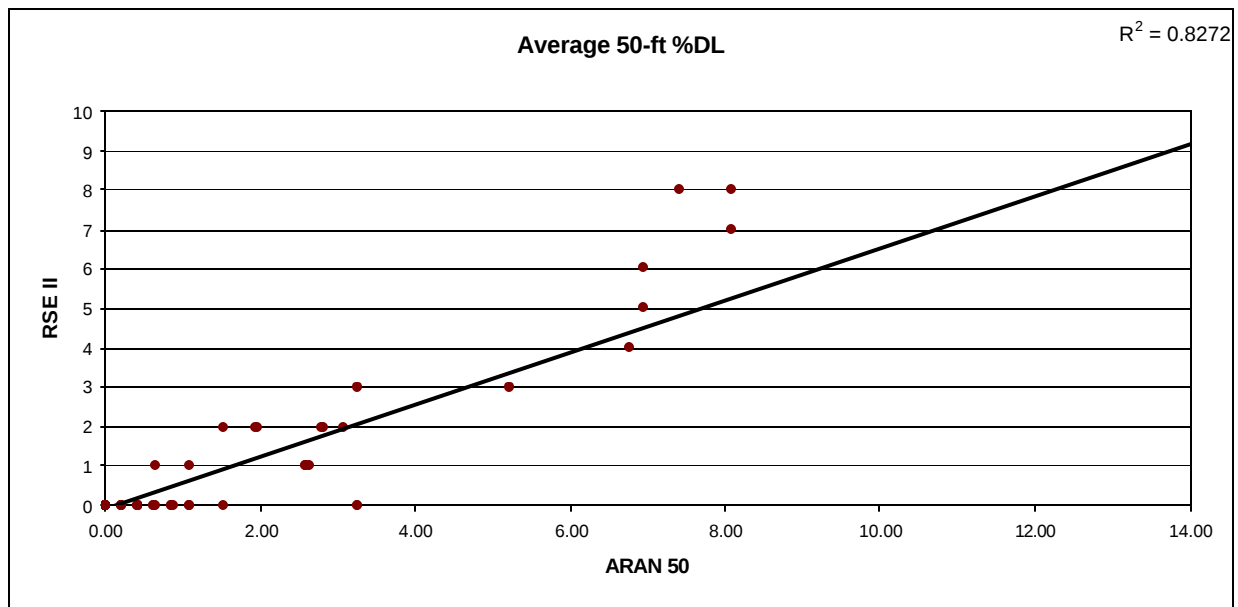


Figure 43. RSE II – ARAN 50

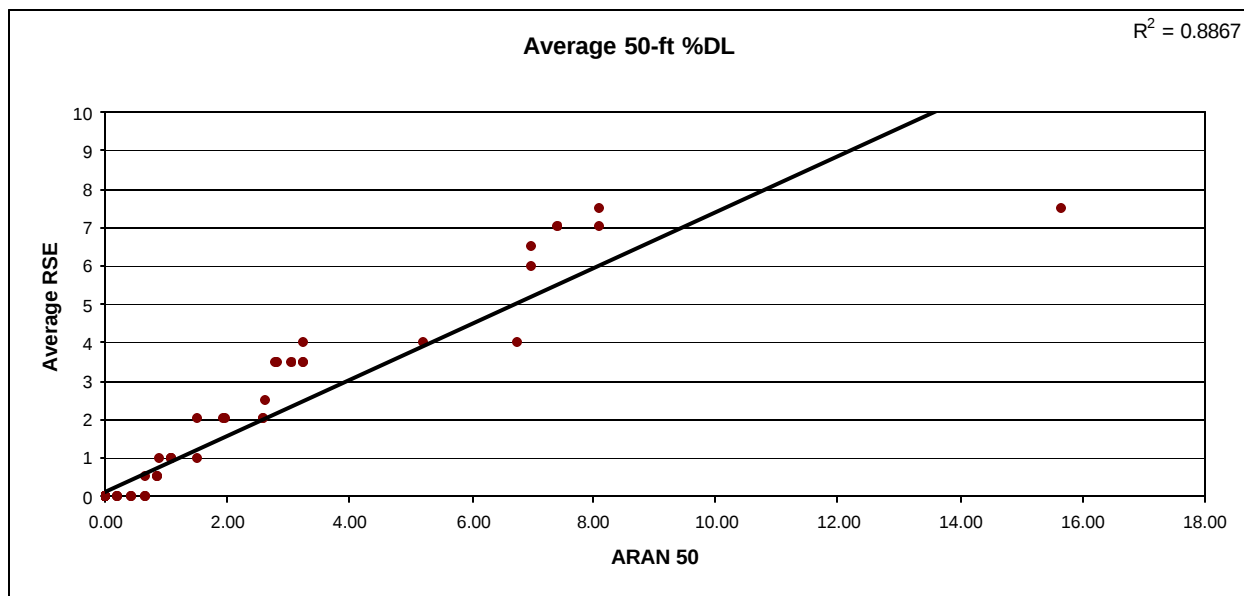


Figure 44. Average RSE – ARAN 50

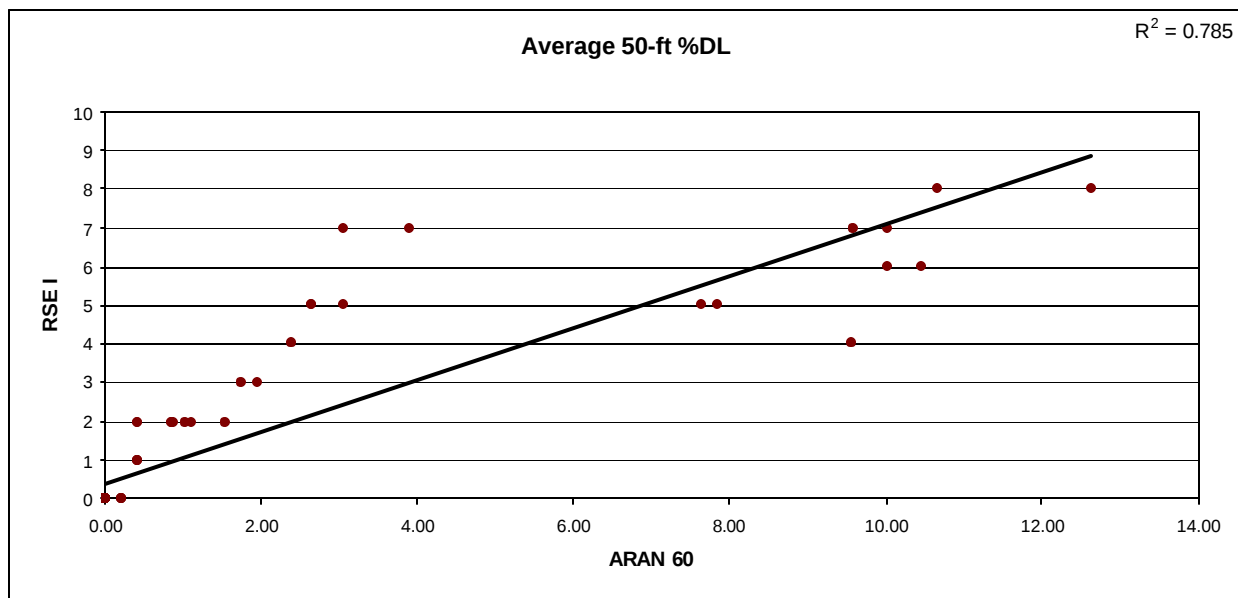


Figure 45. RSE I – ARAN 60

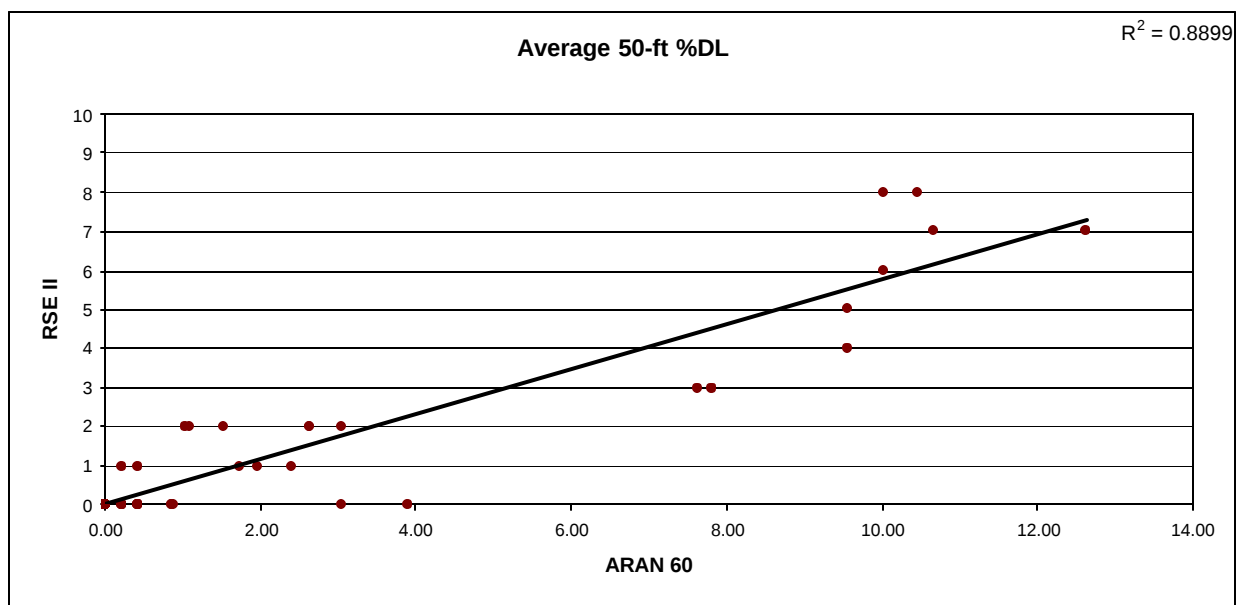


Figure 46. RSE II – ARAN 60

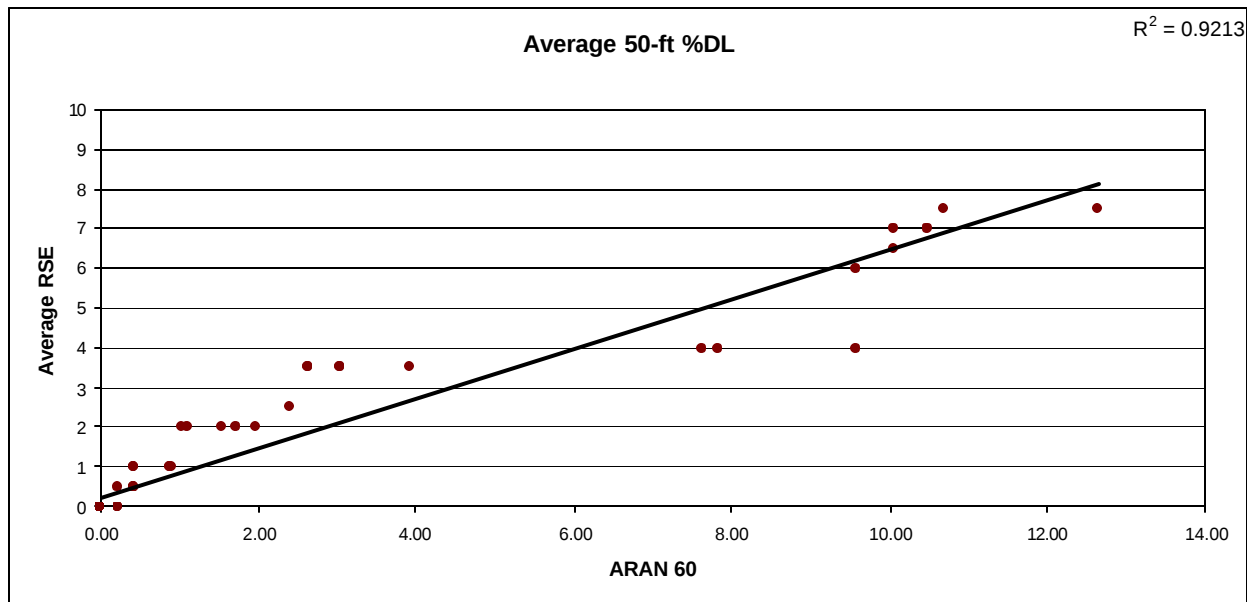


Figure 47. Average RSE – ARAN 60

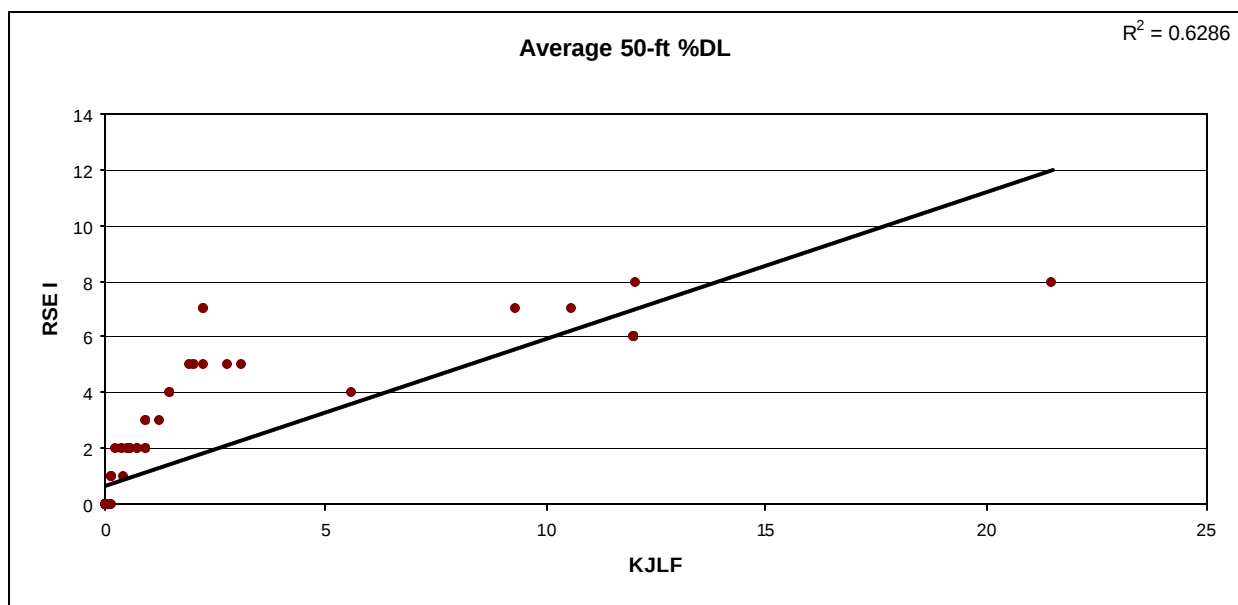


Figure 48. RSE I – KJ Law Full

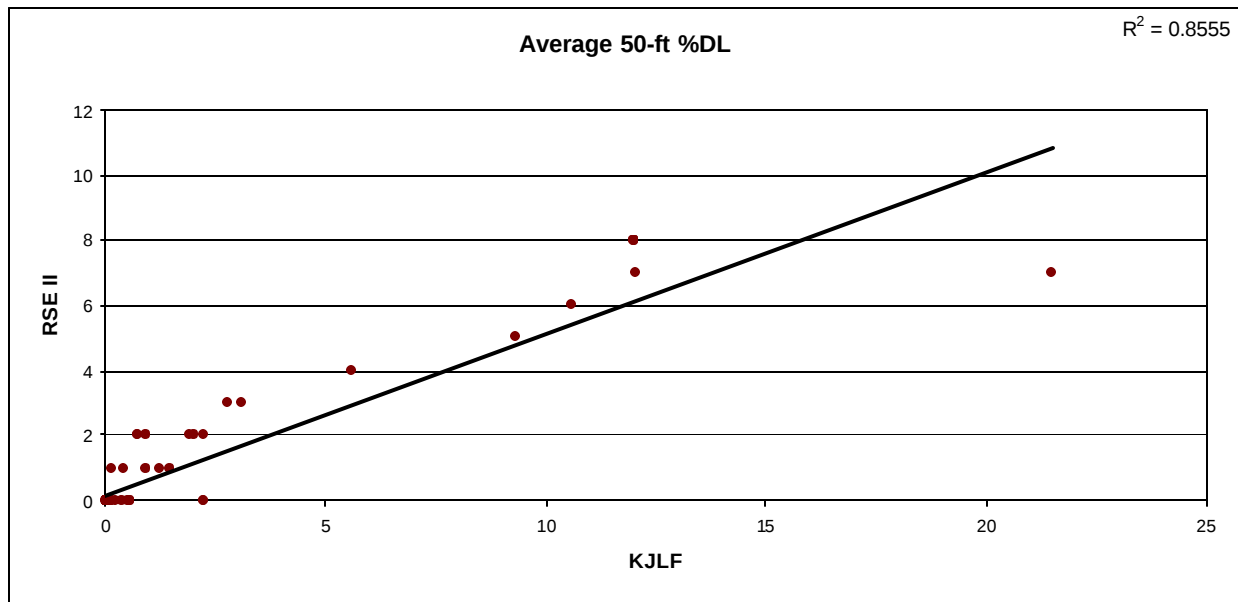


Figure 49. RSE II – KJ Full

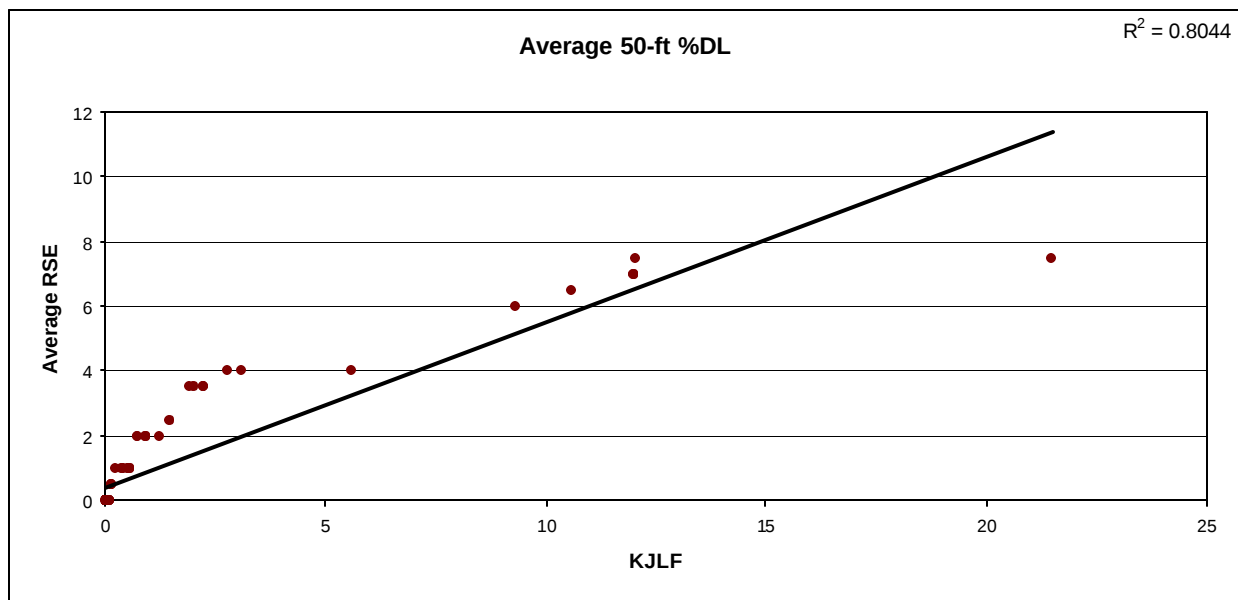


Figure 50. Average RSE – KJ Full

Table 14. Summary of the % DL Correlation Analysis Results

Profiler	RSE I	RSE II	Average(RSE I-RSE II)
ARAN40	0.55	0.72	0.69
ARAN50	0.78	0.83	0.92
ARAN60	0.79	0.89	0.89
KJ Law Light	0.79	0.88	0.92
ICC Light	0.89	0.84	0.96
KJ Law Full	0.63	0.86	0.8
Maximum	0.89	0.89	0.96
Minimum	0.55	0.72	0.69

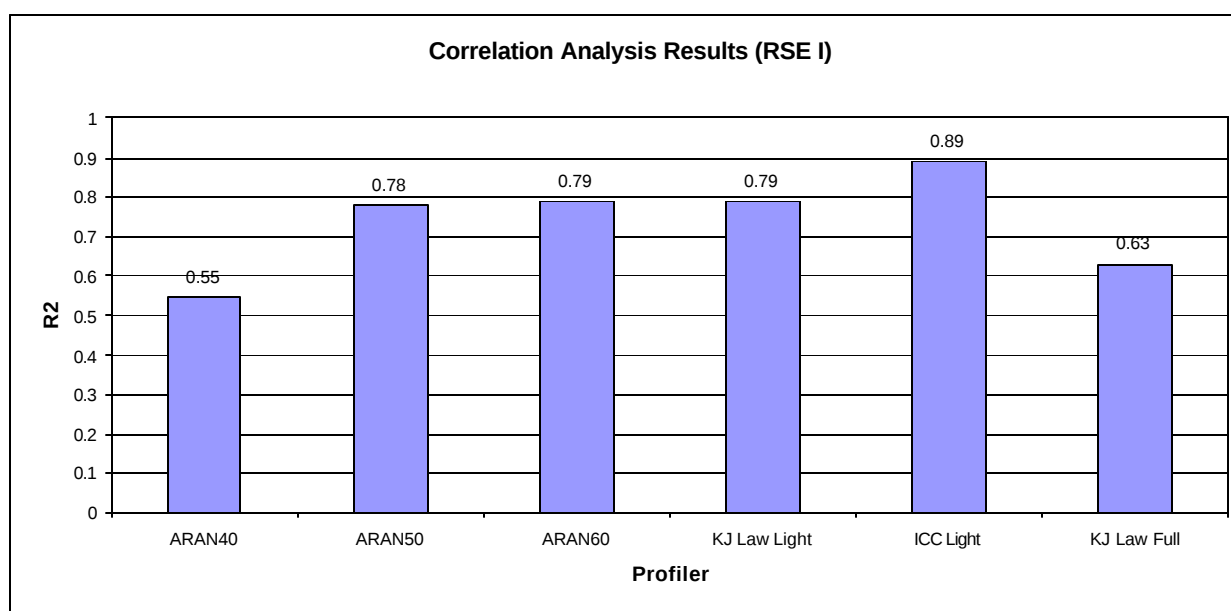


Figure 51. Summary of RSE I Correlation Analysis Results

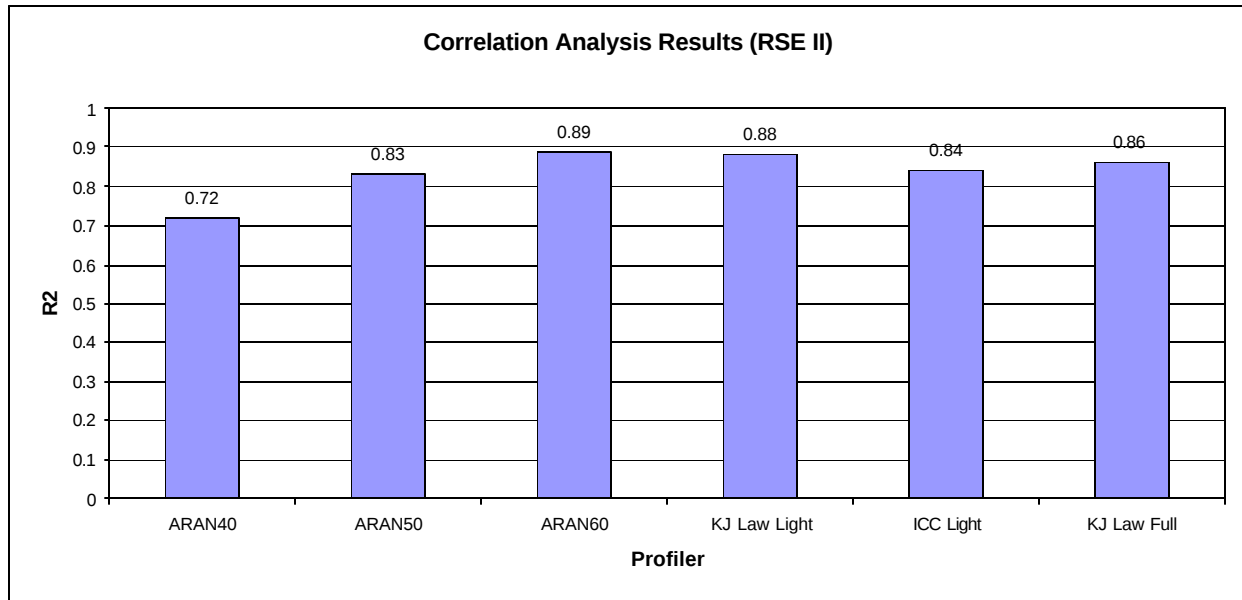


Figure 52. Summary of RSE II Correlation Analysis Results

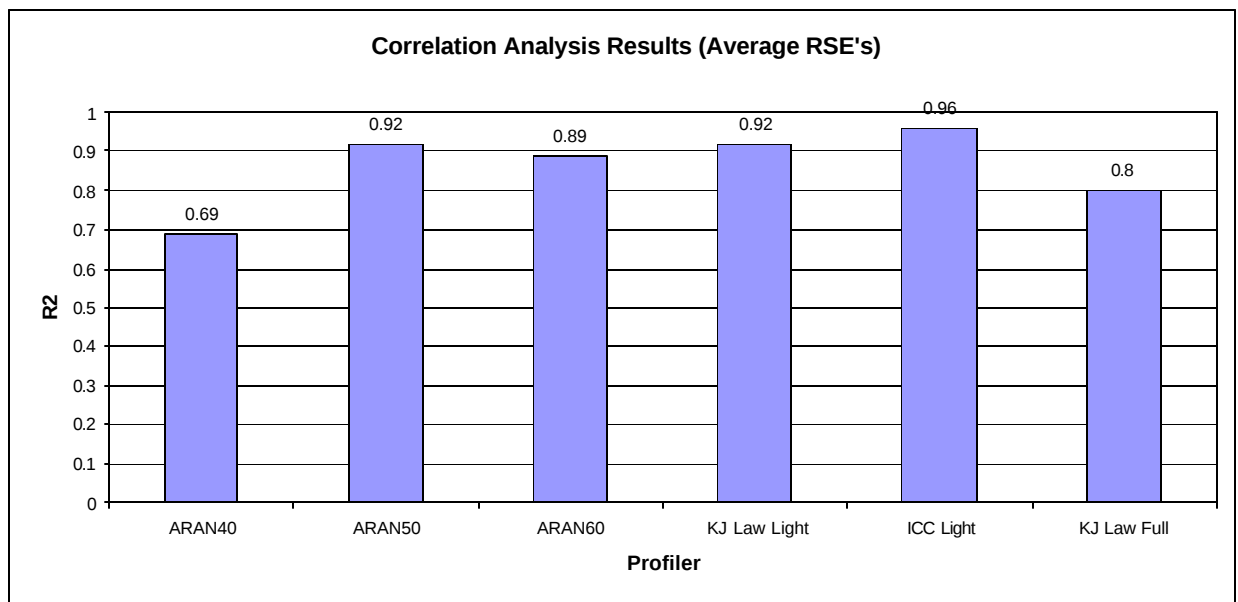


Figure 53. Summary of RSE Correlation Analysis Results – Average of RSE's

7.2 Correlation Between IRI Measured Using Different Devices

Correlation analysis was performed on the IRI measured using the KJ Law Light, the KJ Law Full and the ARAN (40, 50 and 60 mph), figures 54 to 63 show the results of the correlation analysis. Table 15 shows a summary of the correlation results. As can be seen, some devices correlate very well with each other, such as ARAN 40 and ARAN 60 and ARAN 40 and KJ Law Light. On the other hand, some devices correlated very poorly, such as ARAN 50 and KJ Full and ARAN 60 and KJ Full.

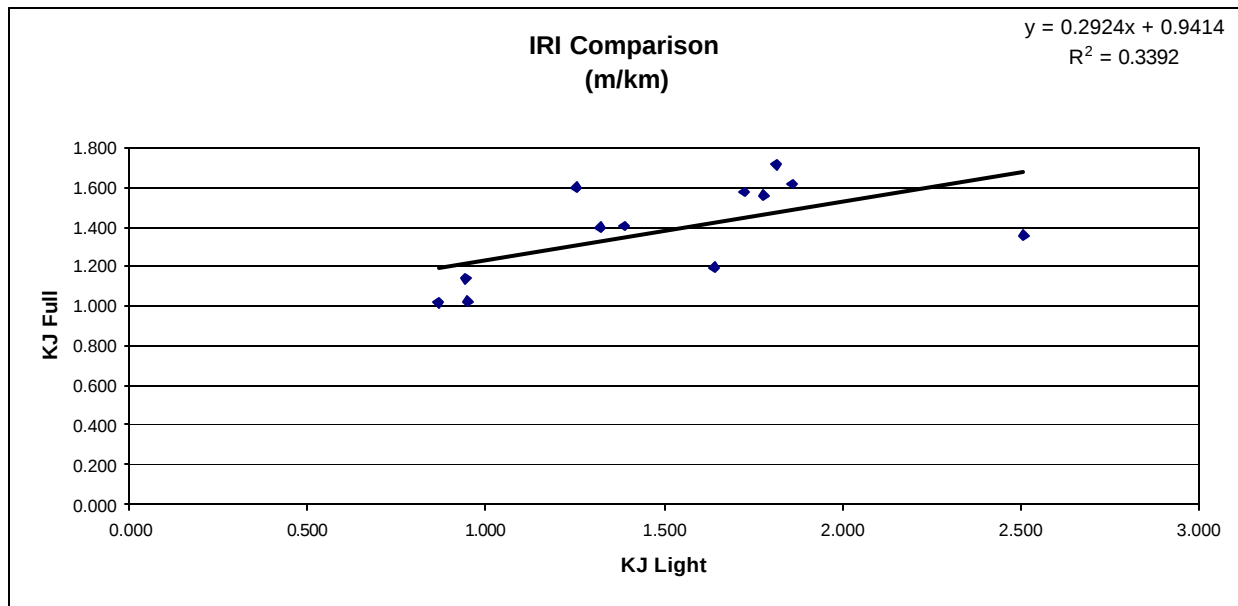


Figure 54. IRI Correlation (KJ Full – KJ Light)

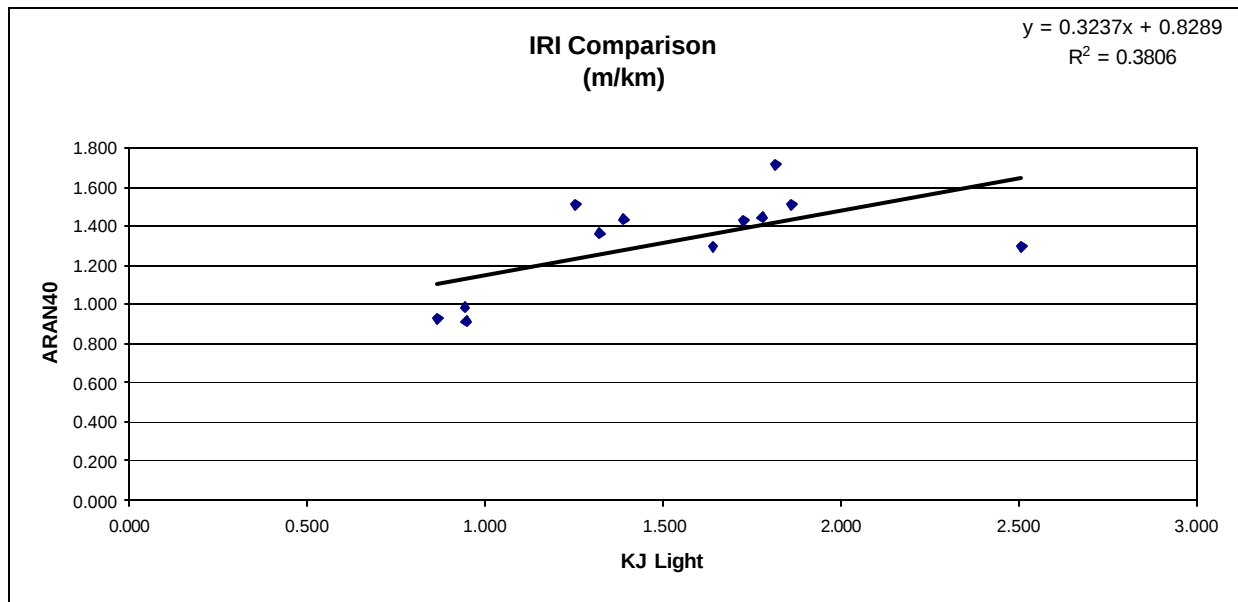


Figure 55. IRI Correlation (KJ Light – ARAN 40)

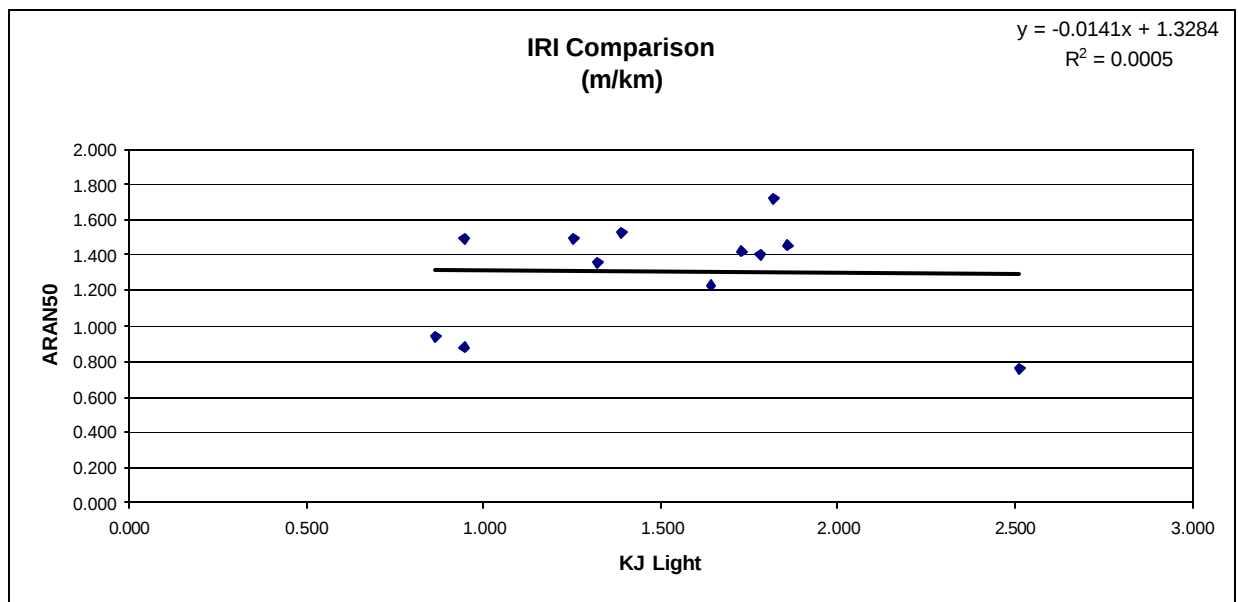


Figure 56. IRI Correlation (KJ Light – ARAN 50)

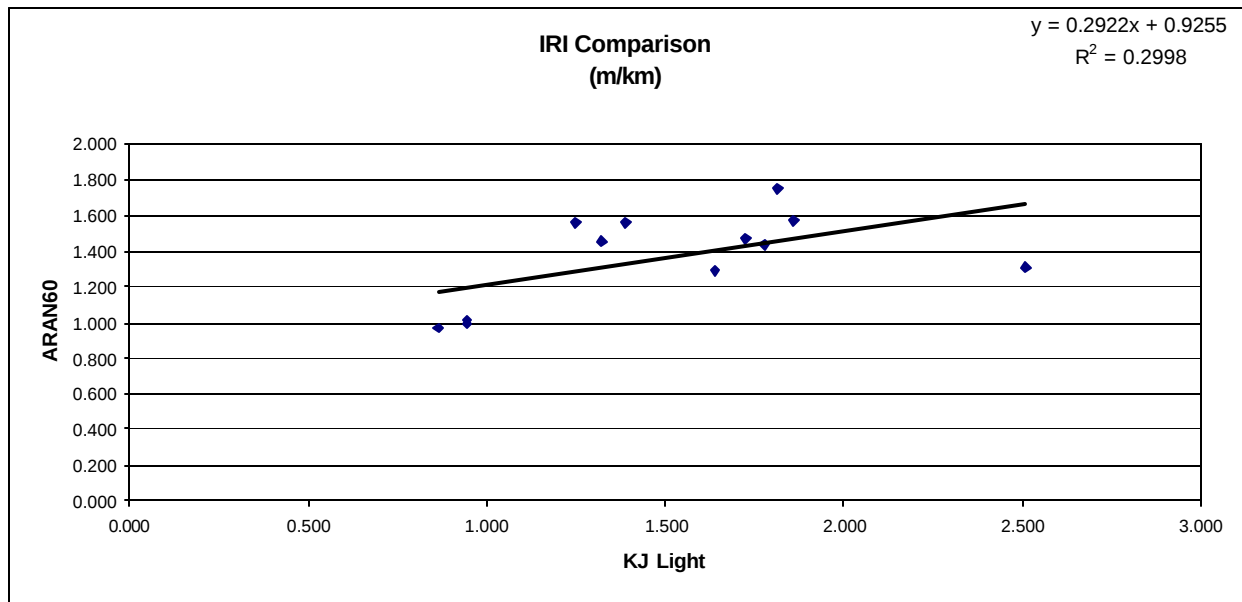


Figure 57. IRI Correlation (KJ Light – ARAN 60)

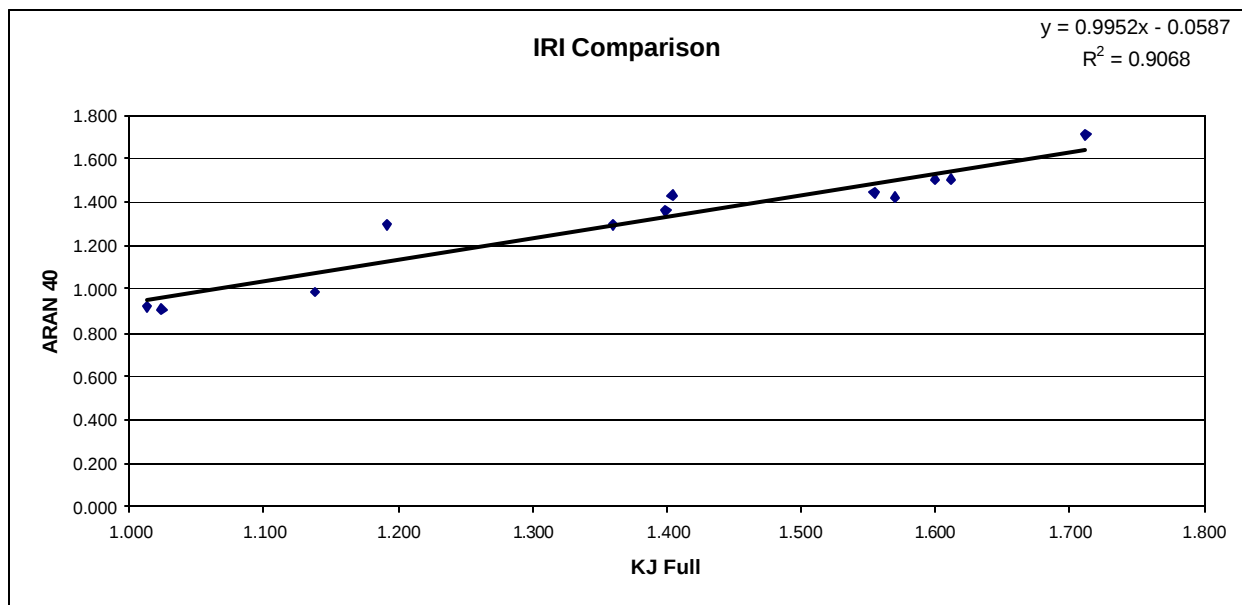


Figure 58. IRI Correlation (KJ Full – ARAN 40)

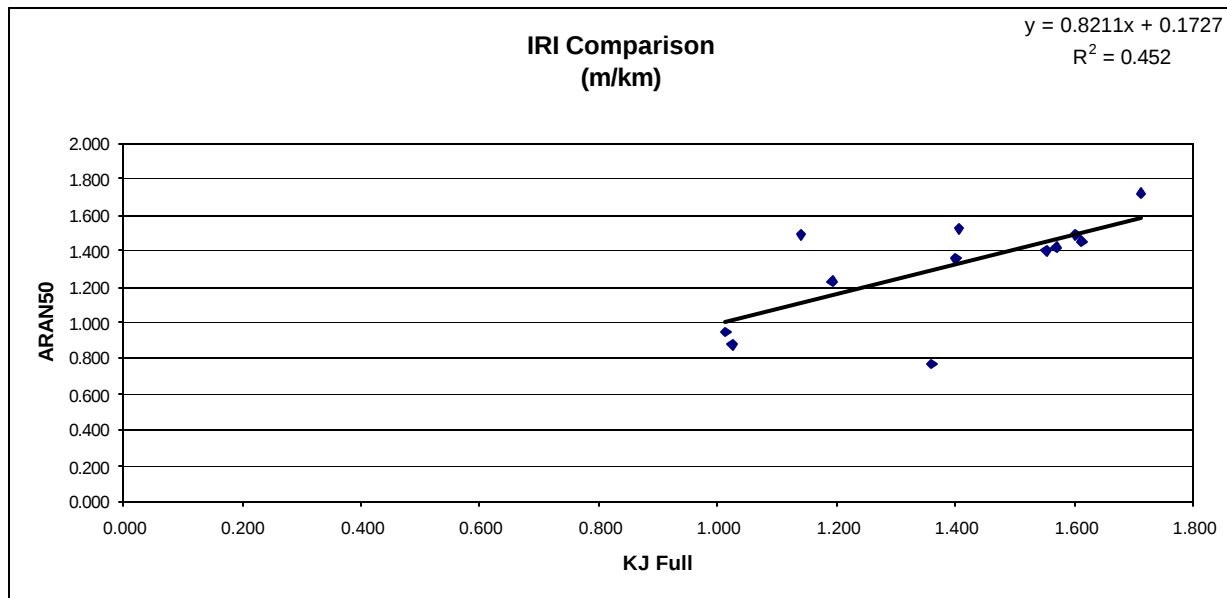


Figure 59. IRI Correlation (KJ Full – ARAN 50)

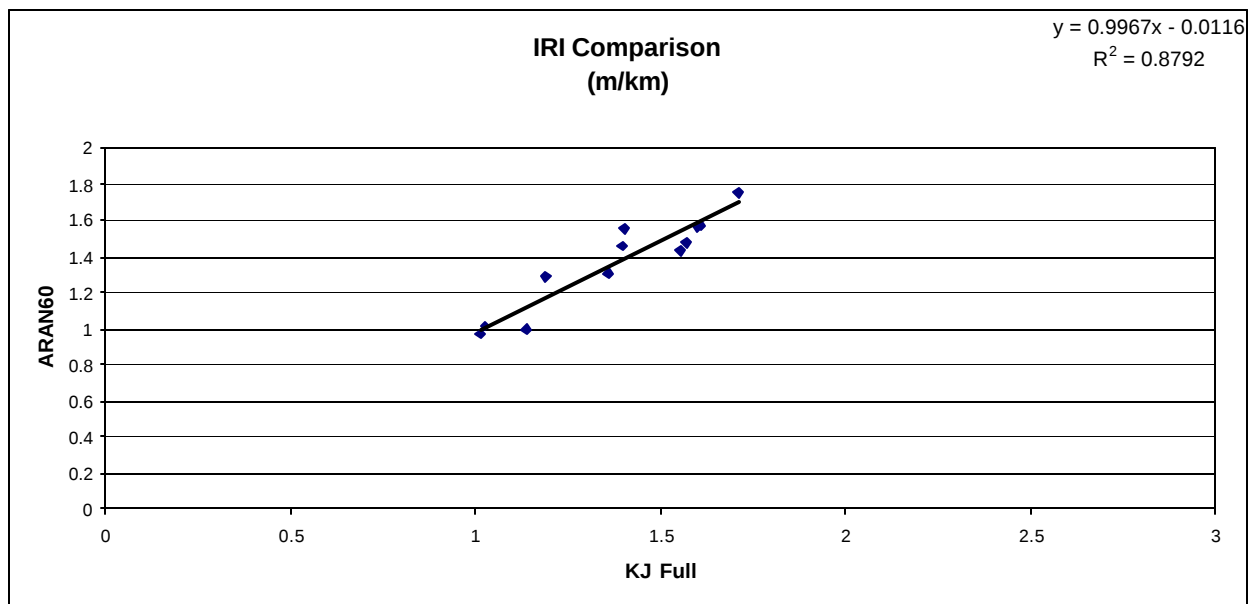


Figure 60. IRI Correlation (KJ Full – ARAN 60)

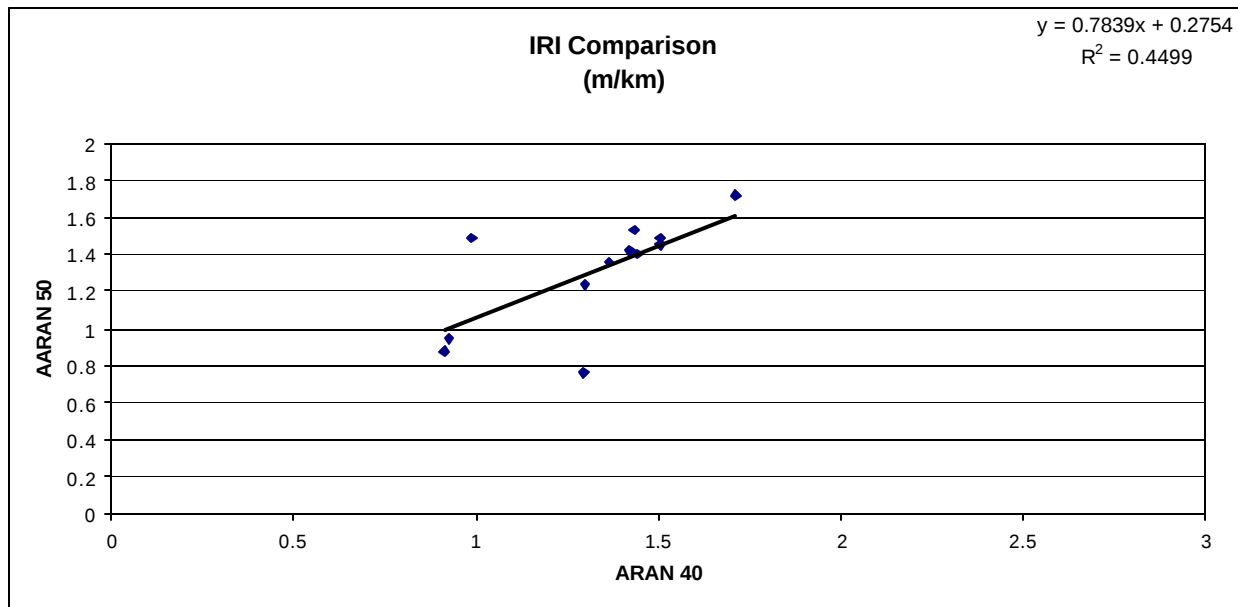


Figure 61. IRI Correlation (ARAN 40 – AARAN 50)

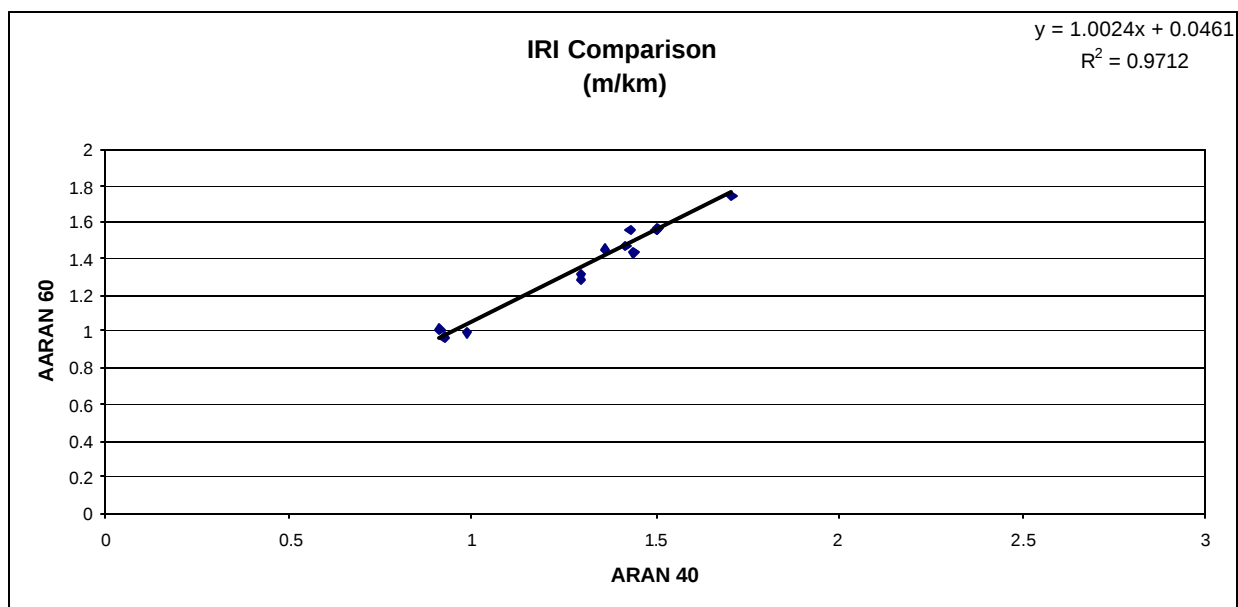


Figure 62. IRI Correlation (ARAN 40 – AARAN 60)

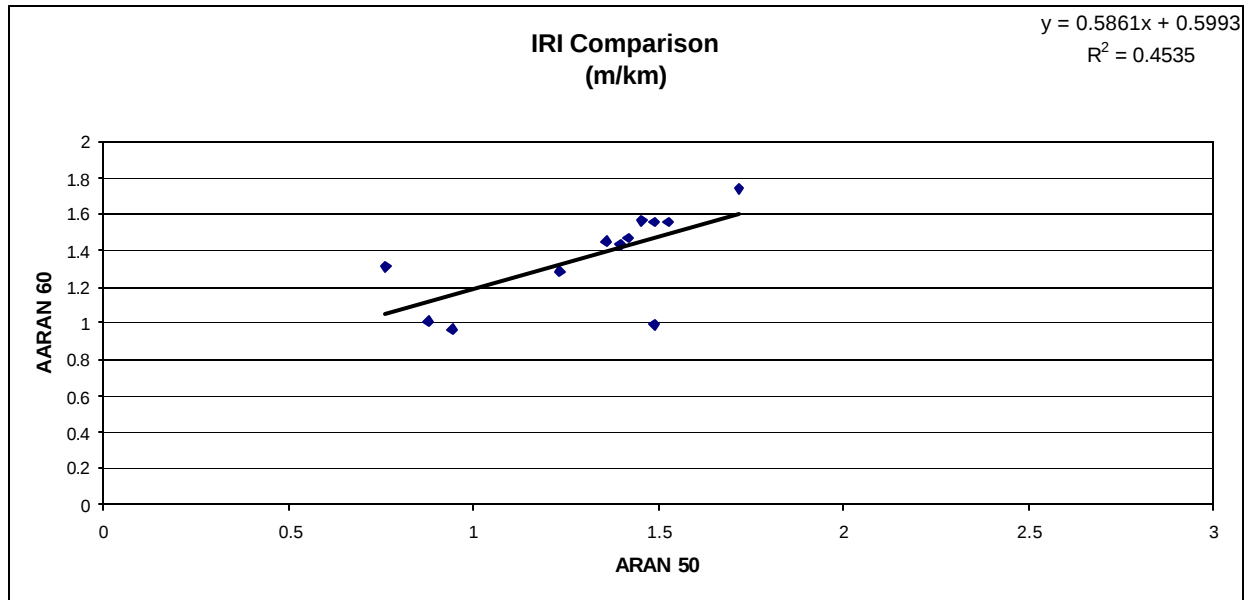


Figure 63. IRI Correlation (ARAN 50 – ARAN 60)

Table 15. Summary of the IRI Correlation Analysis Results

Profiler	ARAN40	ARAN50	ARAN60	KJ Law Light	KJ Law Full
ARAN40	-	0.45	0.97	0.91	0.38
ARAN50		-	0.45	0.45	0.01
ARAN60			-	0.88	0.3
KJ Law Light				-	0.34
KJ Law Full					-

7.3 Correlation Between % DL and IRI

Correlation analysis was performed to correlate the RSE's %DL and the corresponding IRI values that were measured using the KJ Law Light, KJ Law Full and ARAN. The objective of this analysis is to evaluate the applicability of using IRI as a measure for initial smoothness, instead of % DL. Results of the correlation analysis are shown in figures 64 to 78. Table 16 and figures 79 to 81 summarize the analysis results. As can be seen, the R^2 value ranged from 0.01 (no correlation) to a maximum value of 0.48 (poor correlation). These results are expected because of the difference in the concept behind the % DL and IRI. In simple terms, IRI is calculated as the total vertical movement of the quarter-car model, divided by a selected base length. On the other hand, the % DL is calculated as the total length, which has tolerance greater than 0.125", divided by the section length. Therefore, based on the analysis results, it can be concluded that IRI cannot be used to replace % DL in the smoothness acceptance testing.

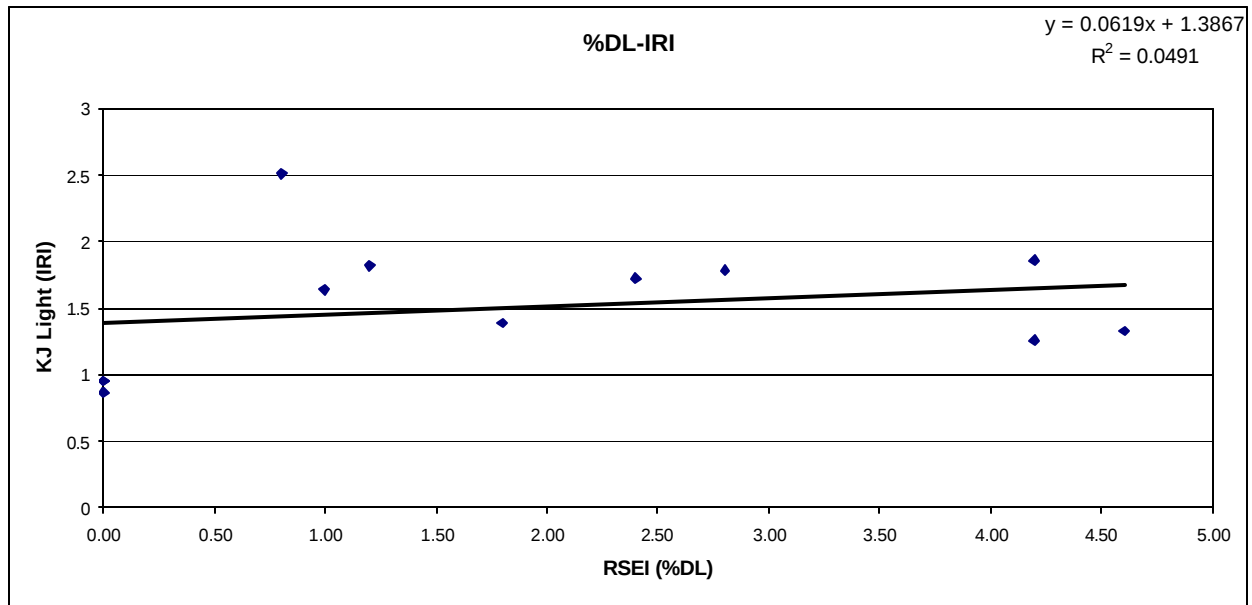


Figure 64. KJ Light IRI - % DL RSE I

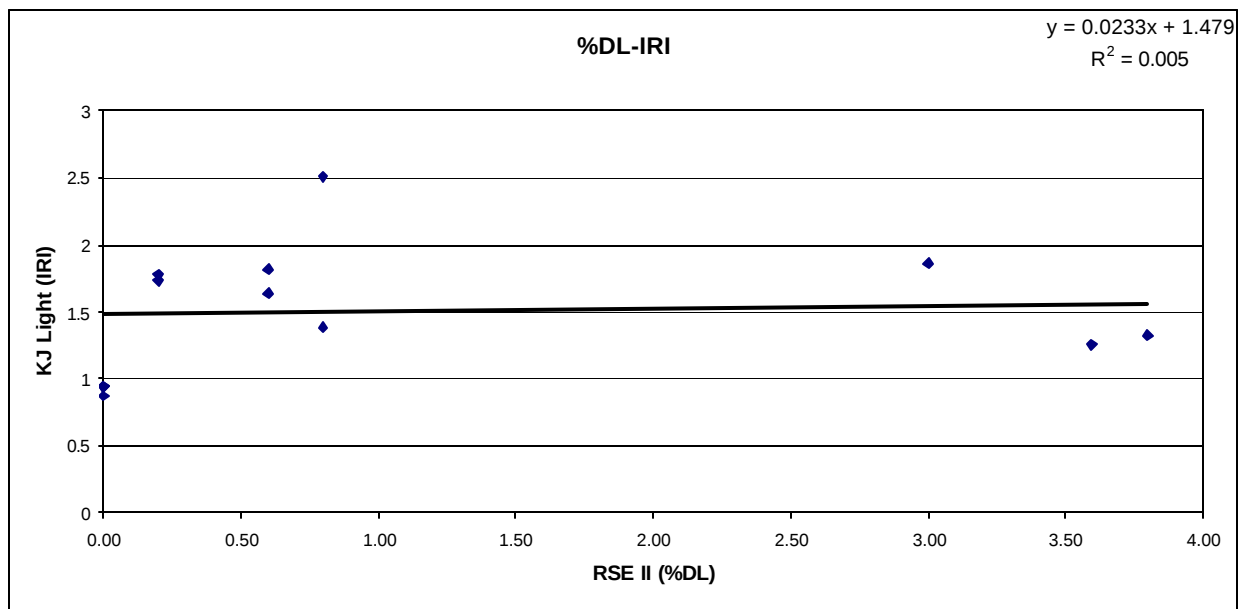


Figure 65. KJ Light IRI - % DL RSE II

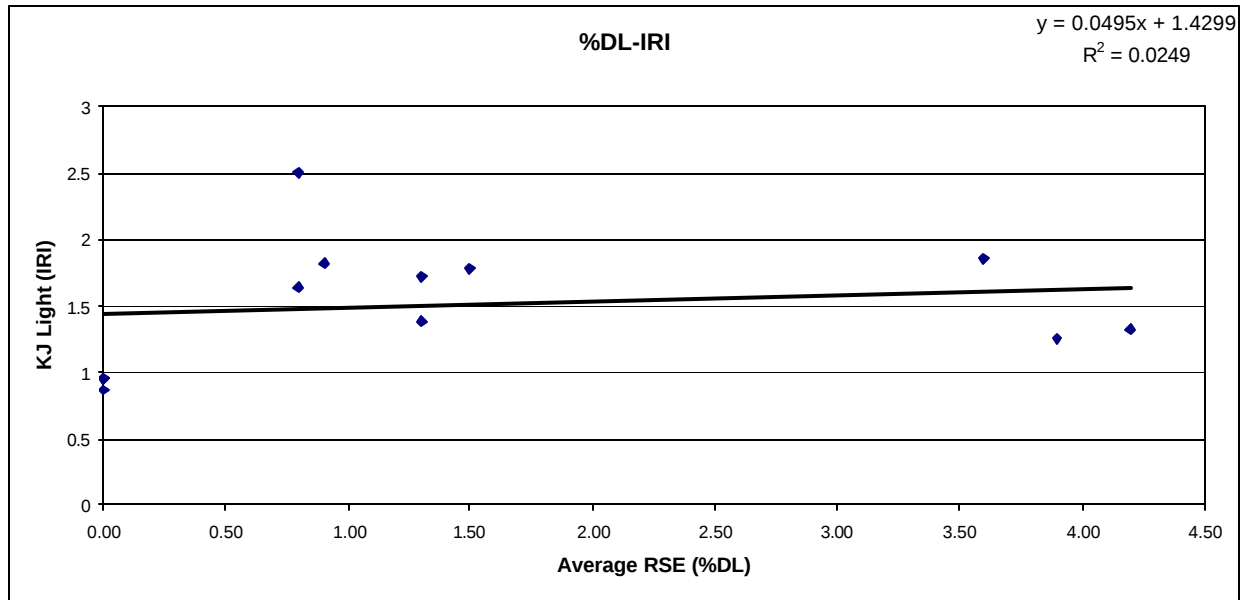


Figure 66. KJ Light IRI –% DL Average RSE

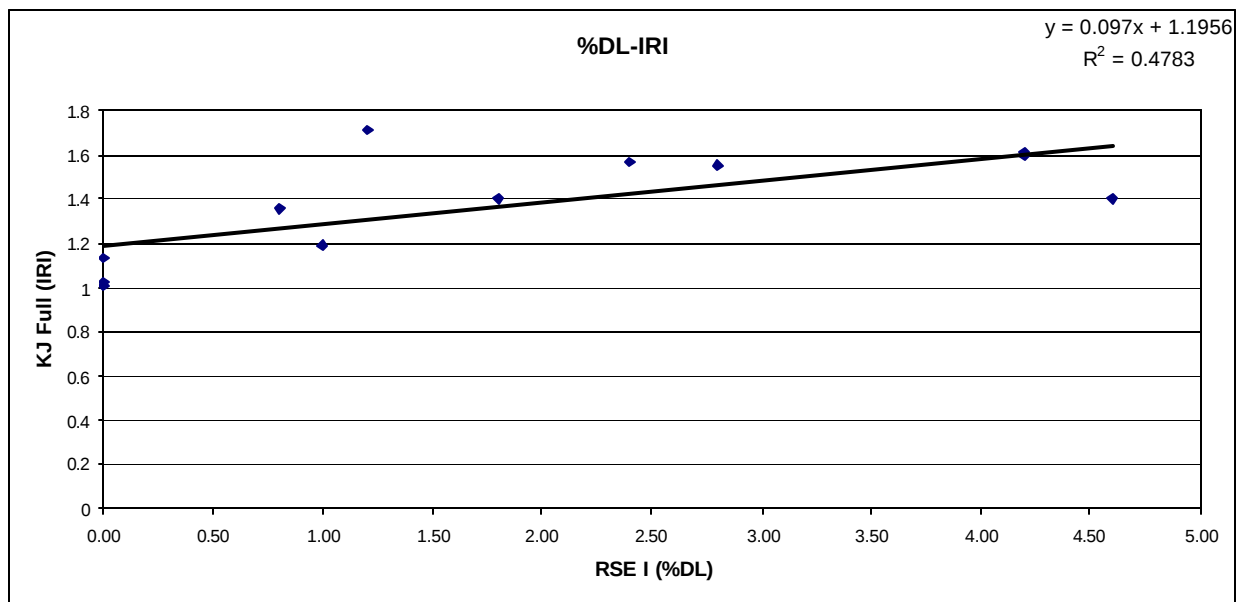


Figure 67. KJ Full IRI - % DL RSE I

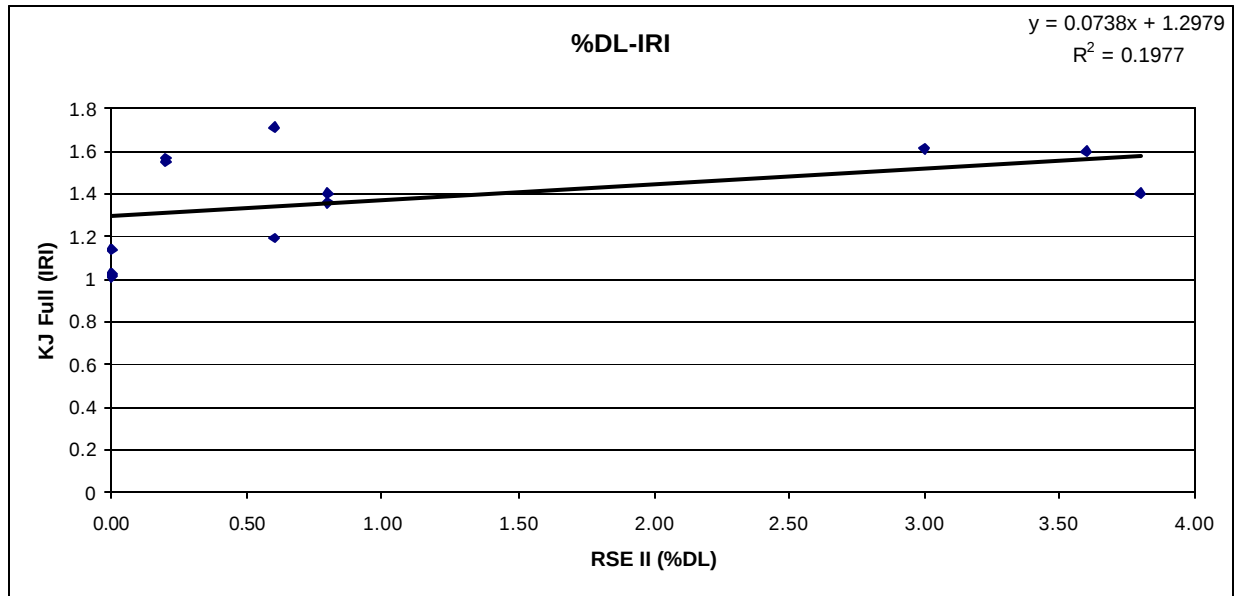


Figure 68. KJ Full IRI - % DL RSE II

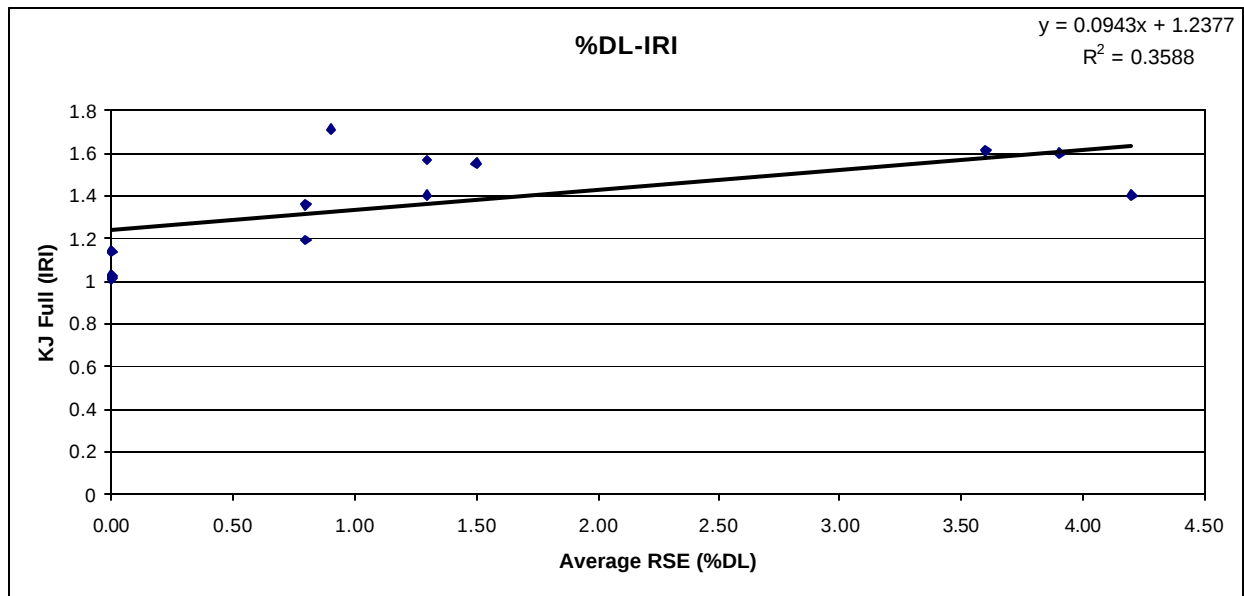


Figure 69. KJ Full IRI - % DL Average RSE

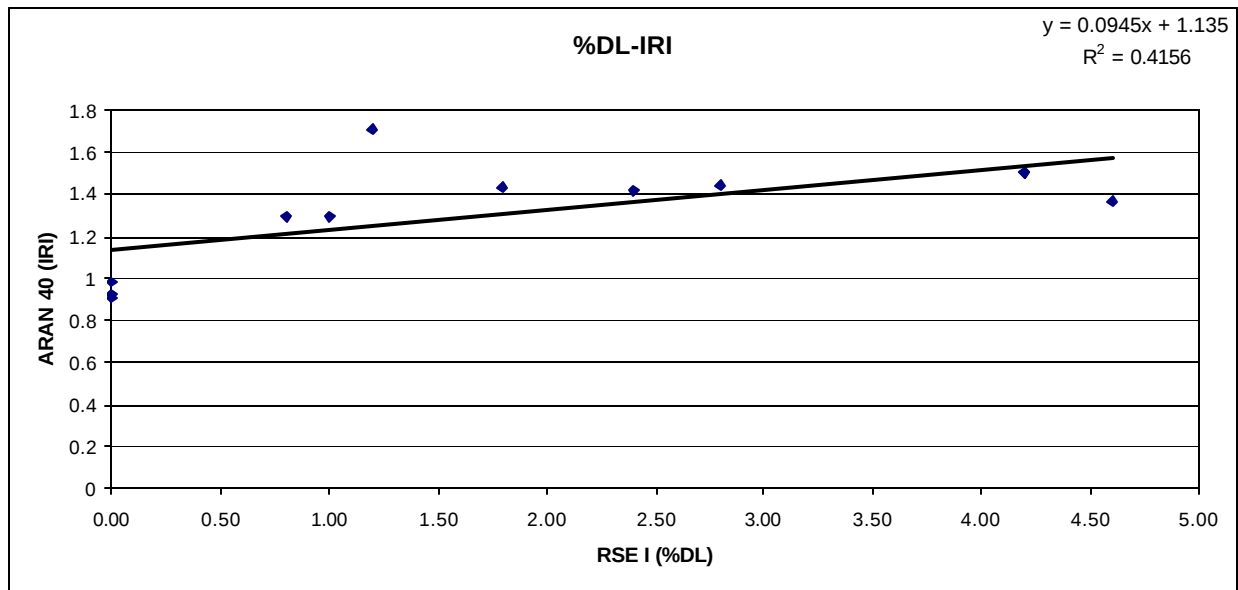


Figure 70. ARAN 40 IRI - % DL RSE I

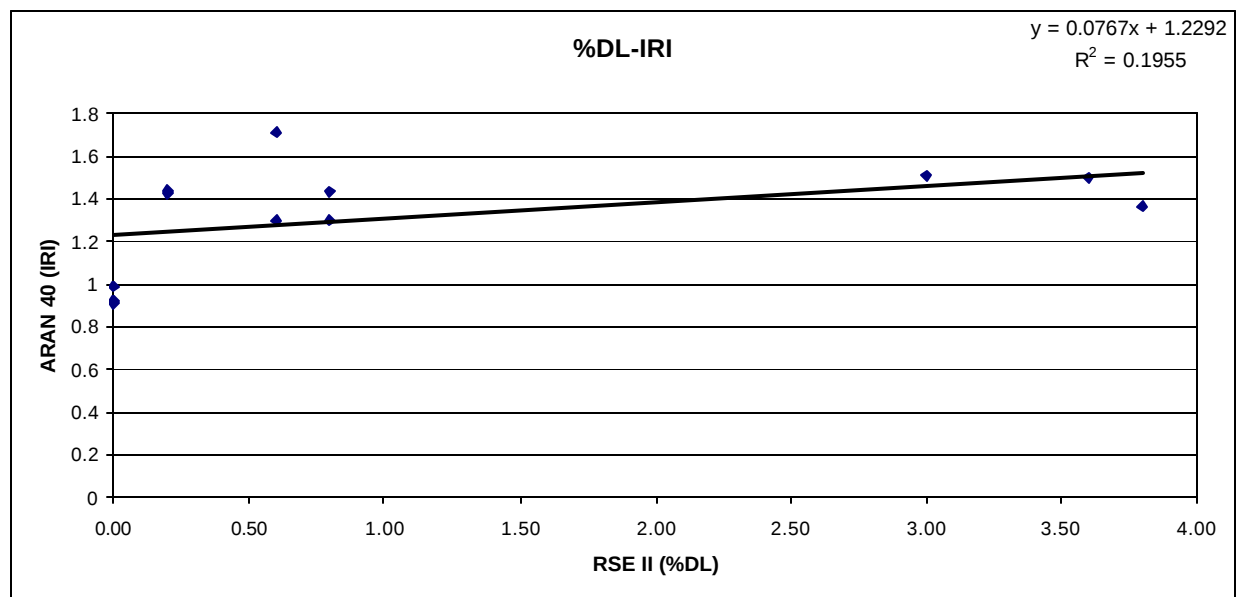


Figure 71. ARAN 40 IRI - % DL RSE II

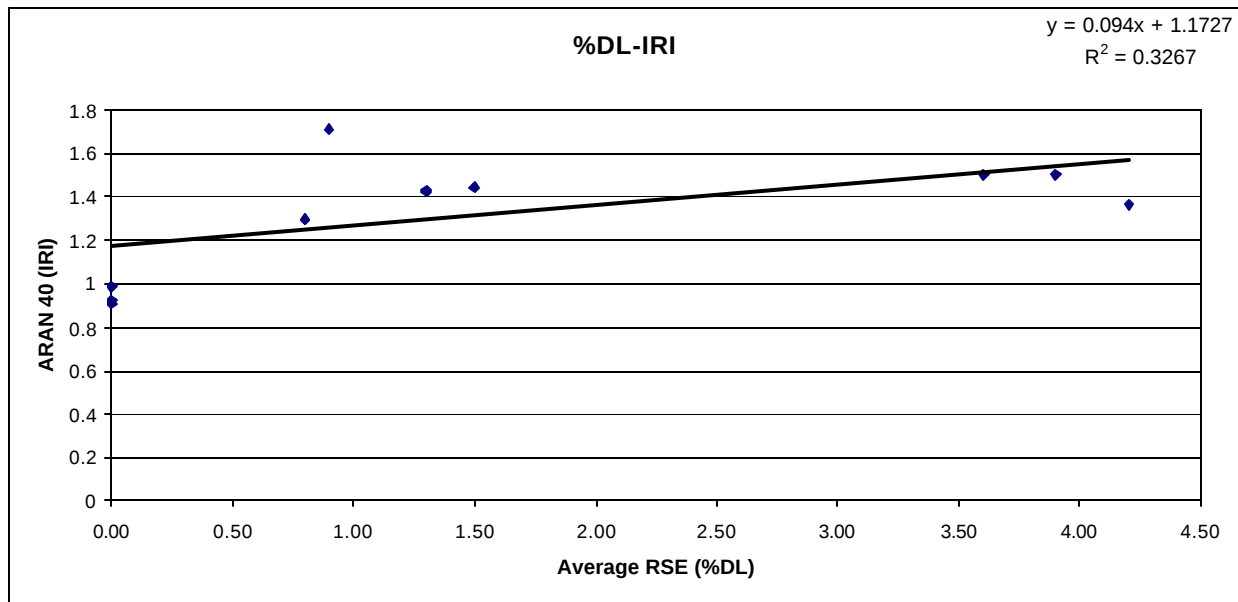


Figure 72. ARAN 40 IRI - % DL Average RSE

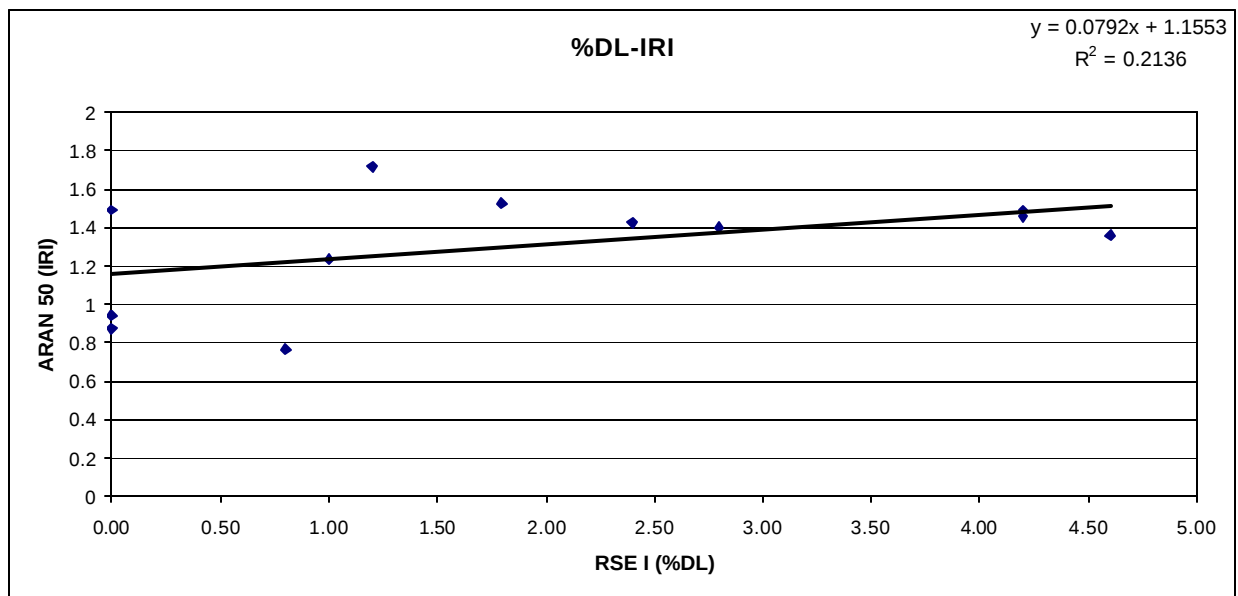


Figure 73. ARAN 50 IRI - % DL RSE I

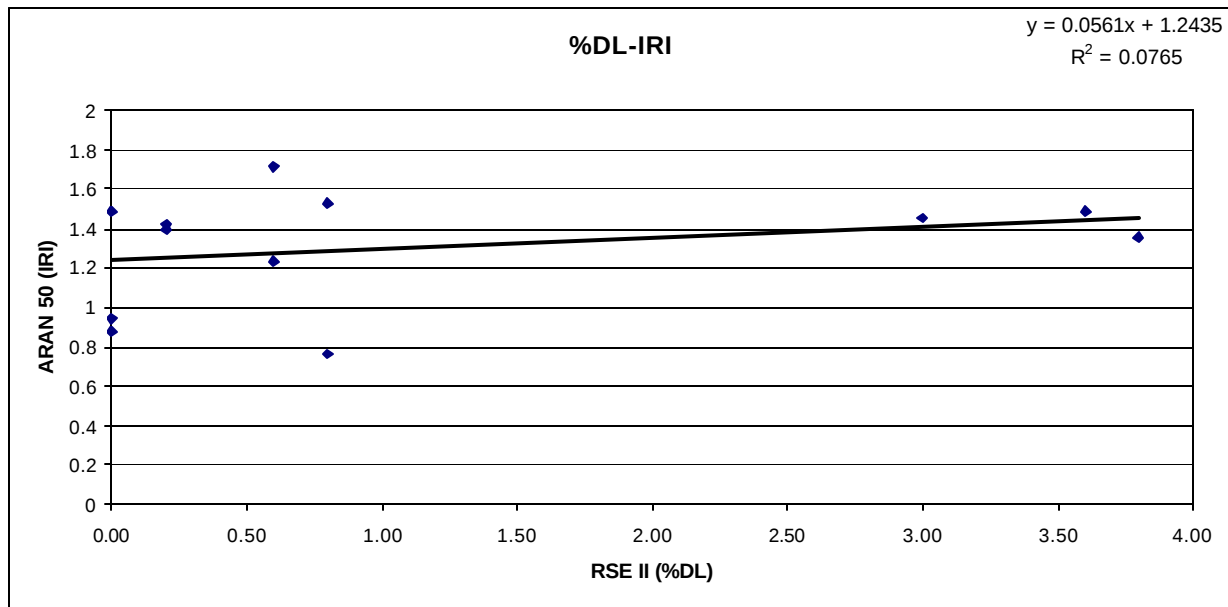


Figure 74. ARAN 50 IRI - % DL RSE II

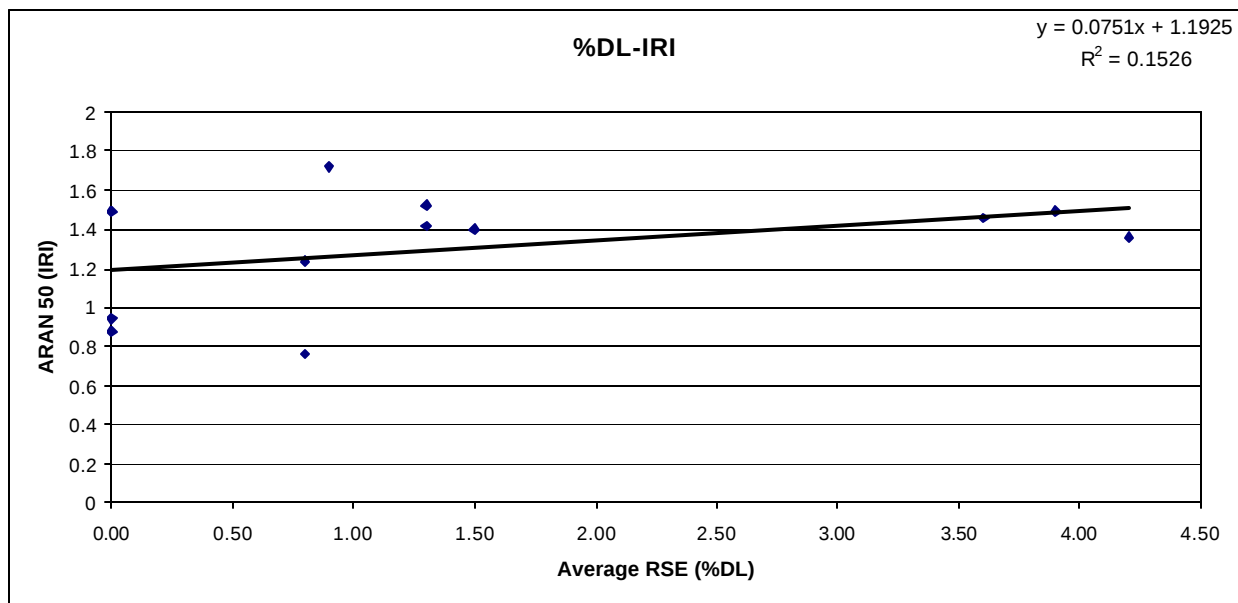


Figure 75. ARAN 50 IRI - % DL Average RSE

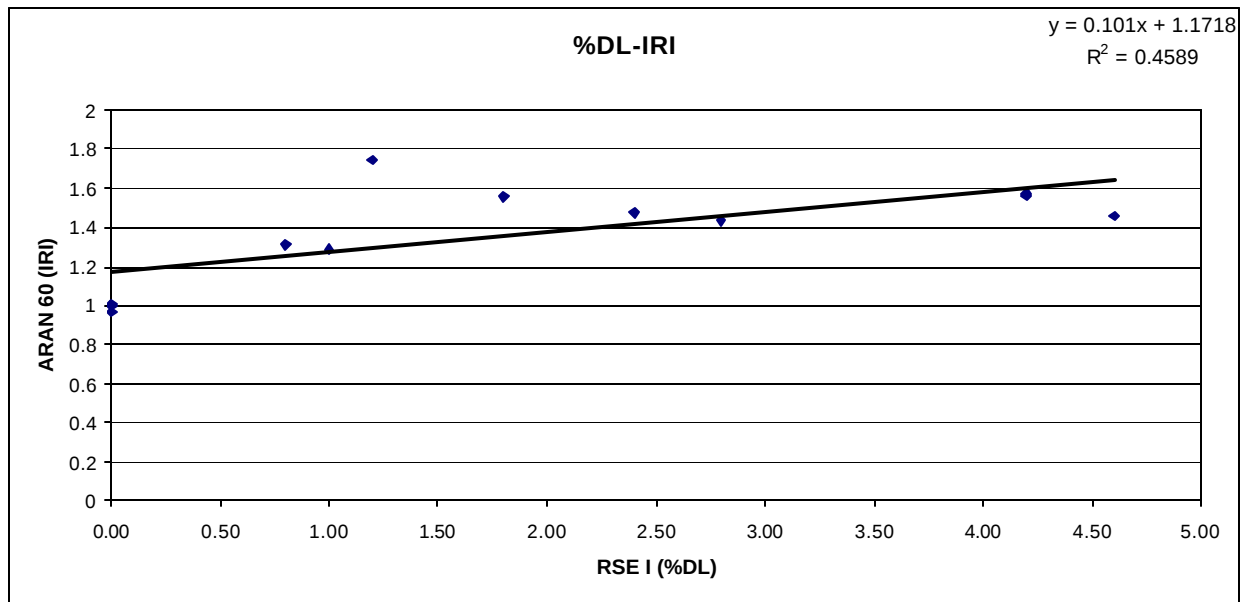


Figure 76. ARAN 60 IRI - % DL RSE I

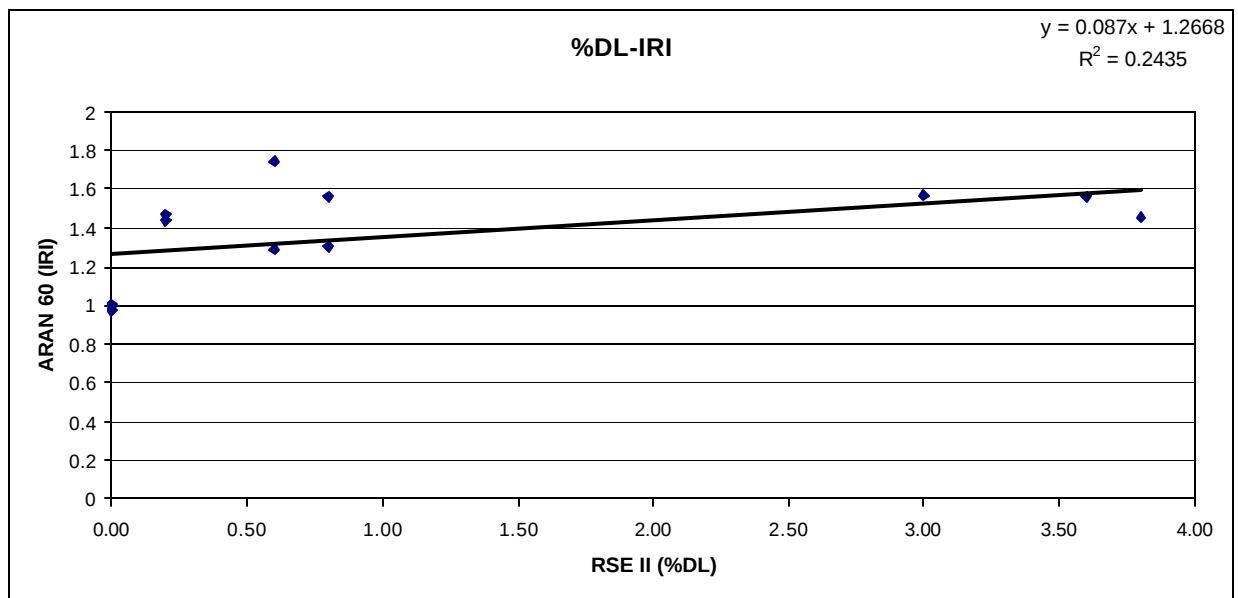


Figure 77. ARAN 60 IRI - % DL RSE II

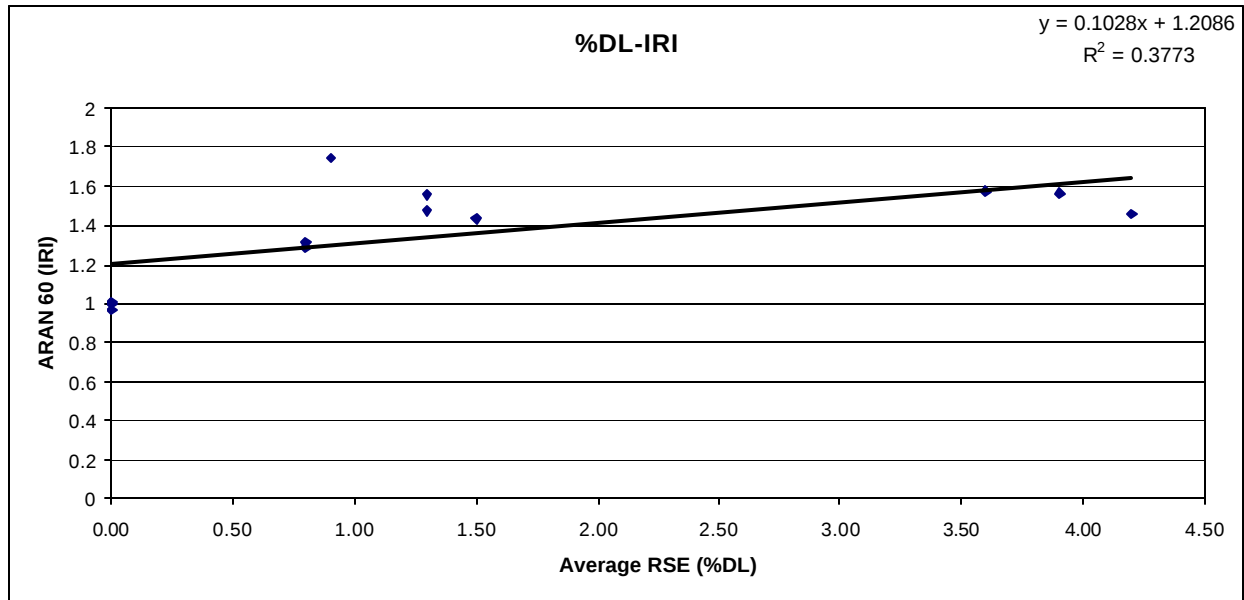


Figure 78. ARAN 60 IRI - % DL Average RSE

Table 16. Summary of the % DL-IRI Correlation Analysis Results

Profiler	RSE I	RSE II	Average(RSE I-RSE II)
ARAN40	0.42	0.2	0.33
ARAN50	0.21	0.08	0.15
ARAN60	0.46	0.24	0.38
KJ Law Light	0.48	0.2	0.36
KJ Law Full	0.05	0.01	0.02

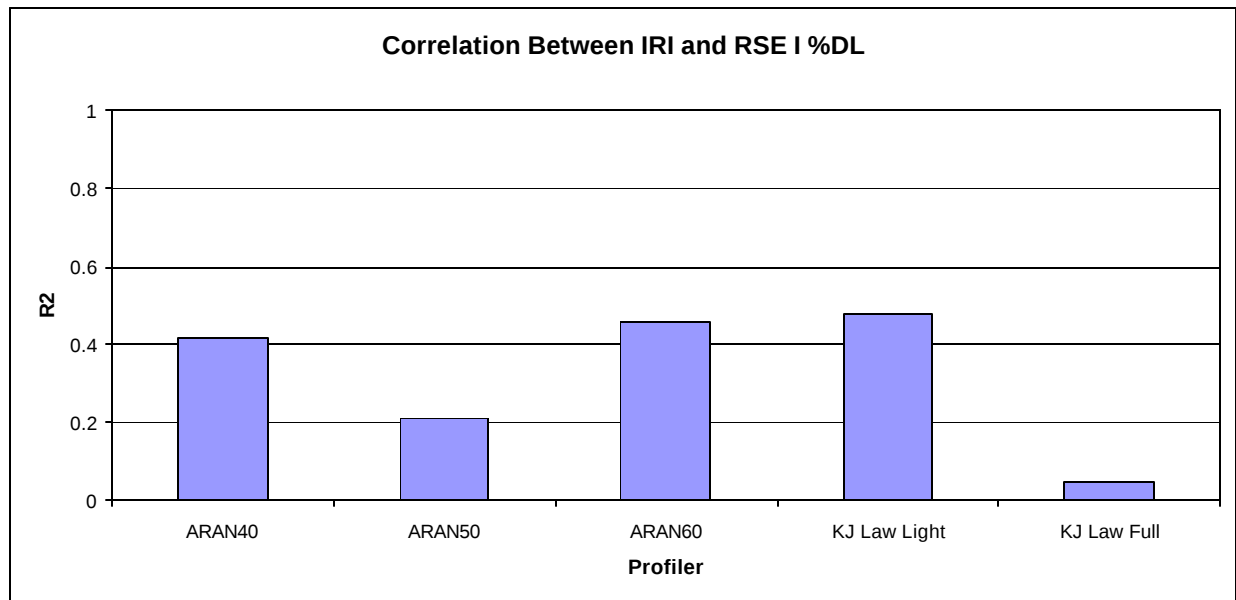


Figure 79. Summary of the % DL – IRI Correlation Analysis Results (RSE I)

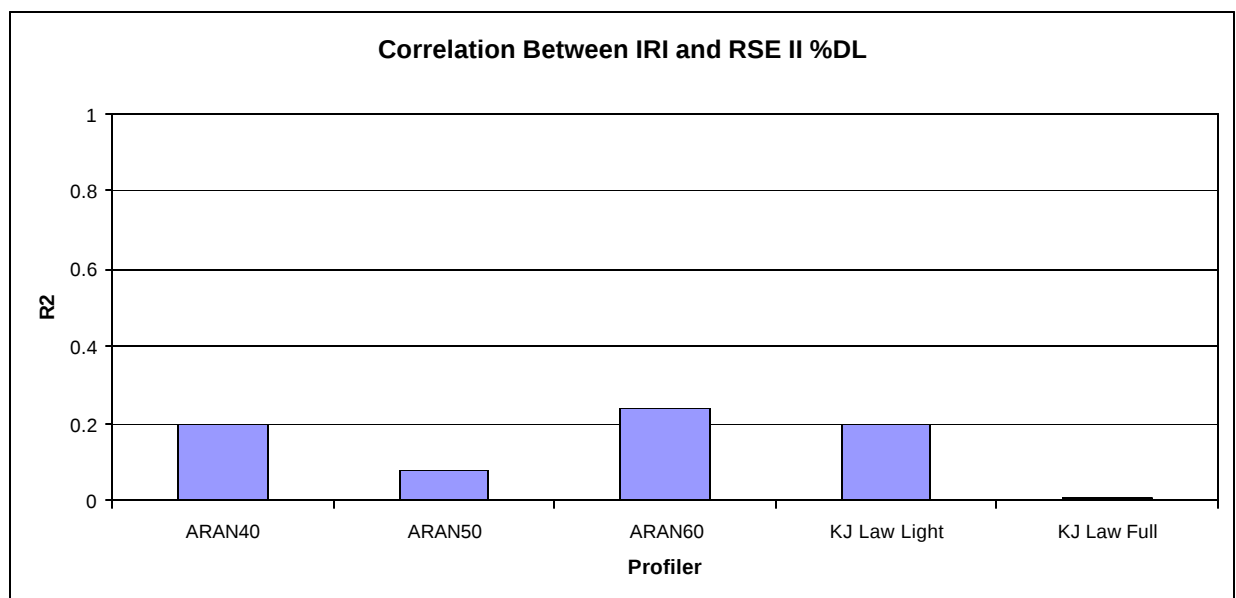


Figure 80. Summary of the % DL – IRI Correlation Analysis Results (RSE II)

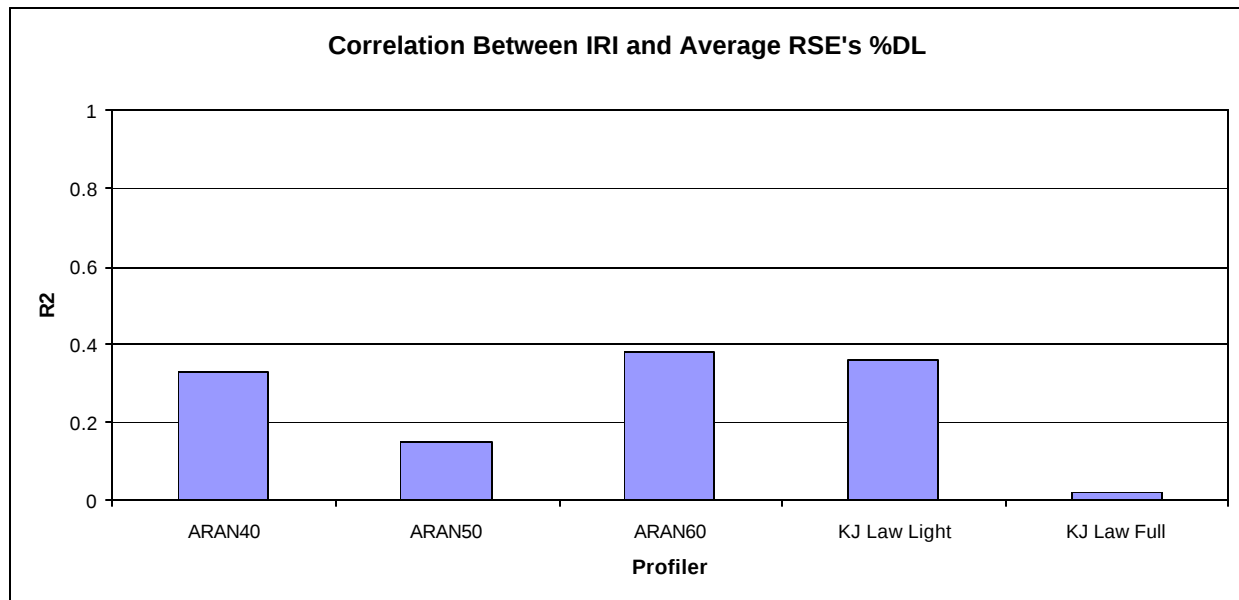


Figure 81. Summary of the % DL – IRI Correlation Analysis Results (Average RSE's)

8.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 Summary

A study was performed to evaluate the applicability of using automated highway profilers to replace RSE's currently used by NJDOT to implement the department's smoothness specifications. Two categories of profilers were considered in the study, low speed and high speed profilers. The low speed profilers included the K. J. Law Light Weight Profiler (T 6400) and the ICC Light Weight Profiler (MDR 4082-PLT). The high speed profilers included: the K. J Law Road Surveyor Profiler (T 6600), an ARAN with a profiling subsystem, and the Stantec RT 3000 equipped with laser sensors.

The scope of the study was limited to asphalt surfaced pavements. A Design of Experiment (DOE) was prepared to allow selecting the test sections. Three levels of initial smoothness were considered in the DOE as follows:

- Very smooth pavements (Level 1) - % Defective Length (%DL) ≤ 1.5 .
- Smooth pavements (Level 2) - $1.5 < \%DL \leq 3.5$.
- Relatively rough pavements (Level 3) - $\%DL > 3.5$.

The initial list of sections considered for field tests included the construction projects of 1997, 1998 and 1999 construction seasons. The as-built RSE measurements of these sections were reviewed and used to classify sections into the appropriate initial smoothness group. Since the RSE and low speed profilers tests require lane closures,

site conditions, such as traffic and number of lanes were considered. Therefore, some of the sections were excluded because of the site conditions.

Field testing was performed on three phases. In Phase I, the RT 3000 was used to scan most of the asphalt surfaced sections of the 1997, 1998 and 1999 construction seasons. Analysis was performed on the collected data to select test sections that satisfies the DOE. In total, 22 test sections (12 test sections from NJ 55 South and 10 test sections from I 195 West) were selected for the detail field testing.

Traffic control was provided to close the slow lanes of the selected sections. Test sections (500-ft each) were marked, numbered and tested using two NJDOT RSE's and the Light Weight Profilers. A single RSE test was performed on each wheel path of the test sections. The light weight profilers testing consisted of testing the right and left wheel paths, three times each, at the speed recommended by the manufacturer. Also, three runs were performed at speeds ranged from 10 to 20 mph to investigate the impact of speed on the light weight profiler measurements.

The marked test sections were also tested using the high speed profilers. The number of runs varied among the equipment. As a minimum, three repeated runs were performed on each of the test sections. In some cases, the number of repeated runs was increased to 5. Also, three speeds were used in the ARAN tests (40, 50, and 60 mph), with at least 3 runs at each speed.

Several analyses were performed on the collected data. These analyses included: preliminary analysis, RSE simulation, statistical analysis, effect of speed analysis, and correlation analysis. The preliminary analysis was performed on the results of the RSE inspection to identify the test sections that match the DOE requirements. Twelve, 500-ft test sections were selected for further analysis. Nine sections were selected to satisfy the DOE requirements, while the remaining 3 sections were selected to verify the analysis results. It should be noted that both RSE's detected no defective length, tolerance greater than 0.125 in, for the additional 3 test sections.

RSE simulation analysis was performed on the profiles of the 12 test sections. The simulation analysis consisted of driving a 10-ft straightedge over the profile and calculating the tolerance at the mid-point of the straightedge. Locations where tolerances exceeded the limit (0.125 in) were identified. The total defective length is then calculated as the summation of the lengths where tolerance exceeded the limit. The Percentage Defective Length (%DL) was then calculated as the total defective length divided by the total section length.

Several statistical analyses were performed on the collected and simulated data to investigate the equipment repeatability and the differences among devices, including the two RSE's. In these analyses, the F-Test and the Student T-test were used. The confidence level was always selected to be 90%. The analyses were performed on the %DL measured with the RSE's and that resulted from the simulation analysis, as well as on the IRI measured using the automated profiles. Some of the analyses were performed on the detailed section measurements (each section is sub-sectioned into a set of 50-ft segments), while other analyses were performed on the overall section measurement (each section is represented as one unit).

Results of the tests that were performed at different speeds using the KJ Law and ICC Light Weight Profilers were analyzed to evaluate the impact of speed on their measurements. Results of the analysis indicated that the effect of speed on the measured profile is much higher for the KJ Law Light.

Three correlation analysis studies were performed on the collected data. The objectives of these studies are to correlate the RSE measurements with the results of the simulation analysis performed on the profiles measured using the automated devices, to correlate the IRI measured with different devices and to correlate the IRI and %DL of the same device.

8.2 Conclusions

Several conclusions can be made from the analysis results. The following are some of these conclusions:

- The differences among devices are significant. This includes the %DL and IRI measurements. Also, the difference among the RSE's is significant and cannot be ignored.
- The speed effect on ARAN measurements is significant and not consistent, for both %DL and IRI.
- The differences between the RSE measurements and those of the light weight profilers are significant and not consistent.
- The differences among IRI values measured using different devices/speeds are significant.
- RSE simulation provides reasonably accurate estimate of the RSE %DL. Results of the correlation between the measured and simulated %DL are found to be as high as 99% in some cases.
- Results of the correlation between IRI and %DL indicated that IRI does not sufficiently correlate with %DL, and therefore should not be used to replace %DL.

8.3 Recommendations

- Since the results of the correlation studies indicated that the IRI does not correlate sufficiently with %DL, %DL is recommended to remain the primary indicator for smoothness evaluation of new and rehabilitated pavements. Further investigations are required to select an indicator that better represents the user's opinions.
- The required investigations are out of the scope of this study. These investigations should include a panel rating survey and more detailed profile analysis. A simulation model that represents the user's opinions should be a part of these investigations.
- Since the RSE simulation results correlate very well with the actual RSE measurements, the following scenario is recommended as a step towards replacing the RSE with automated devices.

- NJDOT selects a profiler as the official NJDOT profiler. Results of the simulation analysis performed on the profiles measured using this profiler will be considered as the official results based on which the construction quality will be evaluated. As an example, ARAN may be considered as the NJDOT official profiler. Tests performed at 40 mph speed will be considered as the official tests.
- Since the profiler measurements vary, correlation curves are required to correlated the %DL that is based on other profilers with that of the NJDOT official profiler.
- Using these correlation models will allow contractors to run tests using any profiler and correlate the results with the NJDOT official profiler.

More details about this approach are presented in the following section.

9.0 RECOMMENDED APPROACH

Pavement smoothness represents an important factor for users. Recent studies indicated that pavement smoothness represents the number one factor that concerns users. Therefore, most of the highway agencies are trying hard to control the initial pavement smoothness by implementing smoothness specifications for new and rehabilitated pavements. Many State DOT's adopt a bonus system to encourage contractor to built smoother pavements. Some State DOT's award a yearly prize to the contractor who built the smoothest pavement in that year.

Initial pavement smoothness plays an important role in how a pavement section will perform during its service life. Shorter service lives and high maintenance costs are typical results for high initial roughness. Therefore, controlling the initial smoothness has a significant impact on the pavement life cycle cost. The economic return of paying a contractor a bonus for an extra smooth pavement always exceeds the value of this bonus.

Several factors influence the initial smoothness of pavements, and hence the ride quality as felt by the users. These factors include vehicle characteristics, speed and pavement characteristics. Quality of the construction is one of the major pavement related factors that influence the as-built pavement smoothness. Good smoothness acceptance specifications should target the construction related factors in an objective manner.

9.1 Current NJDOT Smoothness Acceptance Procedure

The current NJDOT smoothness acceptance procedure uses a 10-ft RSE to measure tolerances that exceed 0.125 in. This approach has several advantages and disadvantages. The following are some of them:

Advantages

- Simple, easy to perform and understand and does not require high initial cost equipment.
- Does not require operators with engineering training.
- Contractors and highway agencies are familiar with it.

Disadvantages

- Time consuming and requires lane closure.
- Labor intensive.
- Less sensitive to the ride quality felt by the users.
- Not as repeatable as desired.
- Cannot address the roughness associated with wave lengths longer than the straightedge base length.
- Does not provide the information required for long-term monitoring, required for PMS.
- Can be misleading, as shown in figure 82.

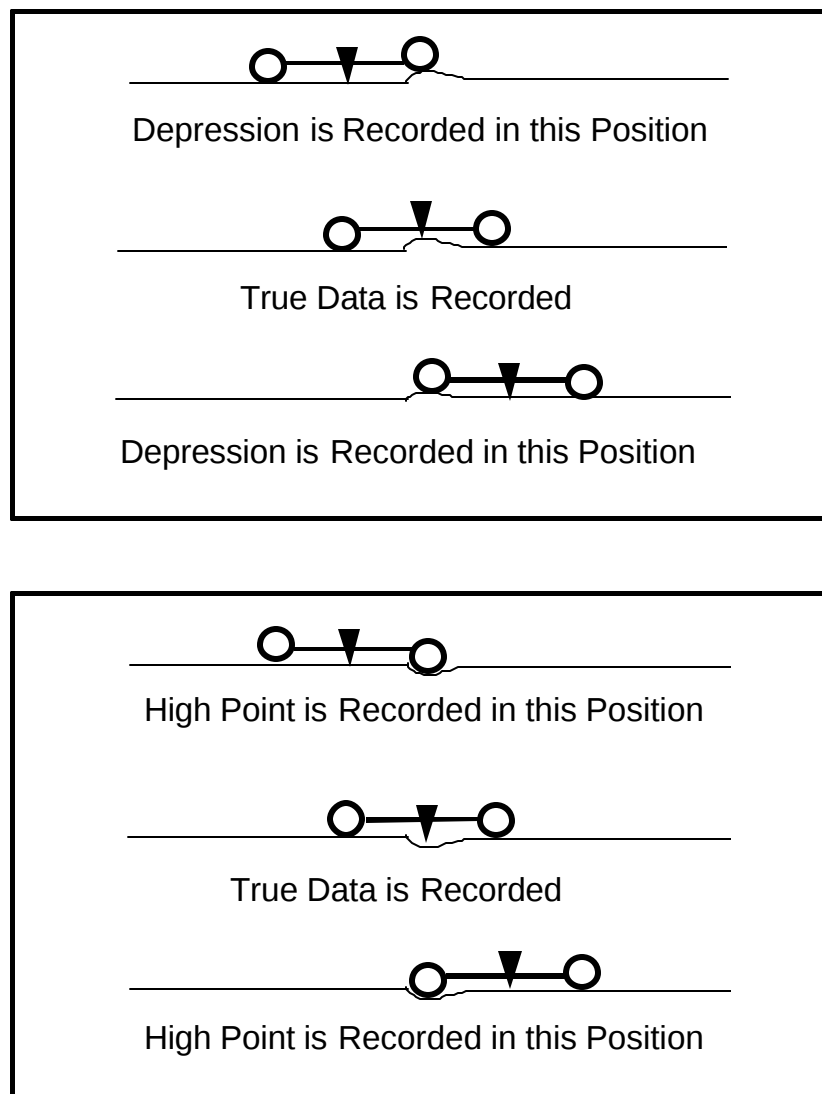


Figure 82. Limitations of Straightedge Inspections

The results of the correlation analyses presented earlier in this report indicated that IRI does not correlate well enough with %DL. Therefore, %DL is recommended to remain the primary indicator for smoothness evaluation. The study also concluded that the RSE measurements can be predicted with reasonable accuracy through the simulation analysis and correlation models. This accuracy varies among the profilers. One of the factors that contributes to this issue is the high variation between the %DL measured with the two RSE's. This variation made it hard to have a unique set of measured %DL to correlate different devices with. However, the results of this study indicated that the automated profilers can be used to simulate the RSE inspection with reasonable accuracy, and hence can be used to implement the current smoothness specifications.

Several steps are recommended to proceed to the full implementation. The following are the recommended steps:

- The first step in the implementation should be selecting an official NJDOT profiler. This official profiler will be considered as a bench mark. NJDOT should allow contractors and consultants to calibrate their profilers with the official profiler. This calibration will be in form of developing correlation models, as will be explained later in this section. This calibration process can be done in different ways. Calibration sites can be selected by NJDOT every year. NJDOT will perform several runs with the official profiler on the calibration site(s). NJDOT post the final results of these runs on NJDOT Web Site. Contractors and consultants interested in calibrating their profilers can perform several runs on the calibration site and develop the required calibration model. This process should be repeated annually, as a minimum.
- As an example, we can assume that the ARAN will be selected as the NJDOT official profiler and the acceptance testing will be performed at 40 mph speed.
- Contractors and consultants running other profilers, such as KJ Law Light and Full, need to test the calibration sites and develop correlation curves to correlate their measurements with the ARAN40. Examples of these correlation models are shown in figures 83 to 85.
- Using these correlation models will allow contractors and consultants to run tests using other profilers and correlated the results to those of the official profiler, ARAN40 in this example.

9.2 Advantages and Disadvantages of Replacing the RSE with Automated Profiler

Replacing the RSE with automated profilers is considered as the first step of improving the practice of evaluating pavement smoothness. This will give the contractors the opportunity to early detect problems and perform the remedial action in timely manner. Automated profilers will eliminate the need for lane closure and will significantly reduce the inspection time. In addition, automated profilers will simultaneously provide roughness indices, such as IRI, which are required for the PMS group. Collecting as-built roughness indices will help the PMS group to improve their performance prediction models, as well as allow them to quantify the impact of initial roughness on the pavement life cycle cost.

As can be seen, replacing the RSE with automated profilers is very beneficial and has many positive impacts. However, it should be considered only as the first step in improving the construction quality control procedure. Replacing the RSE with automated devices will not solve some of the RSE inspection problems, such as the misleading results and the repeated waves problem, which is explained below.

The longitudinal pavement profile may be regarded as a stochastic process made up of an infinite number of sinusoids with different wave lengths and amplitudes. The frequency of these waves and their amplitude significantly contribute to the ride quality. In addition to wave frequencies and amplitudes, the ride quality of pavement sections dominated by long or short wave lengths that have some harmonies with very high amplitudes is always poor. These dominant waves are called repeated waves. Repeated waves reduce the pavement smoothness and affect its long-term functional performance. Also, they may affect the pavement structural performance only if they are severe enough to increase the dynamic or impact loading of heavy trucks. RSE inspection does not address the repeated waves problem, nor do other roughness indices. Therefore, another approach is required to address this issue.

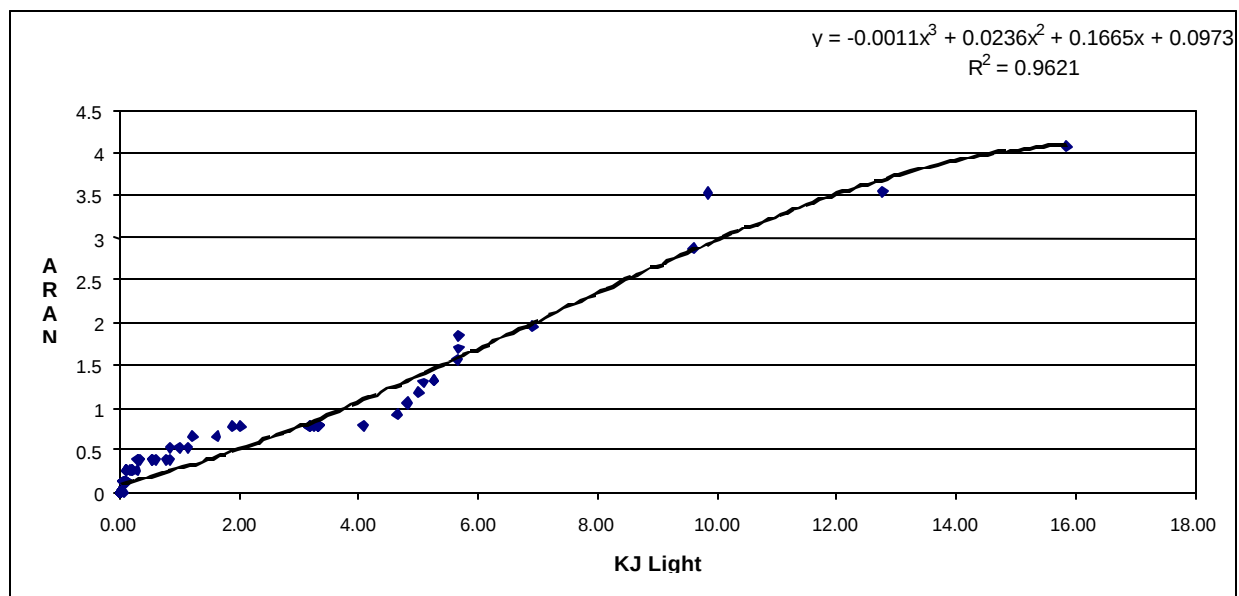


Figure 83. Correlation Between KJ Law Light and ARAN 40 (% DL)

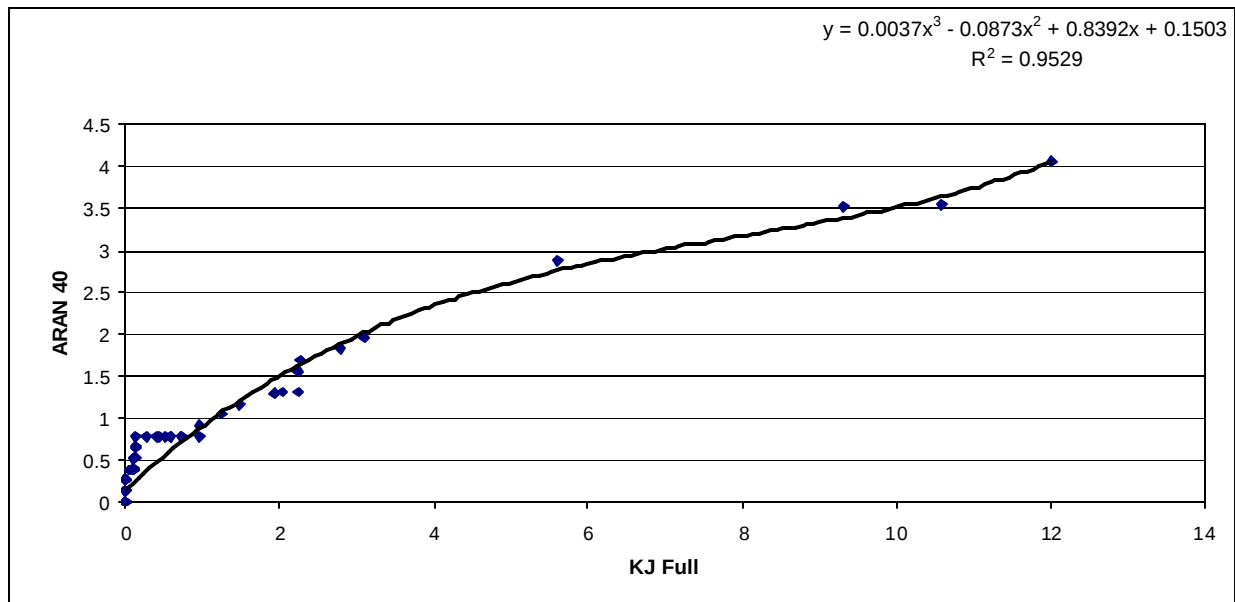


Figure 84. Correlation Between KJ Law Full and ARAN 40 (% DL)

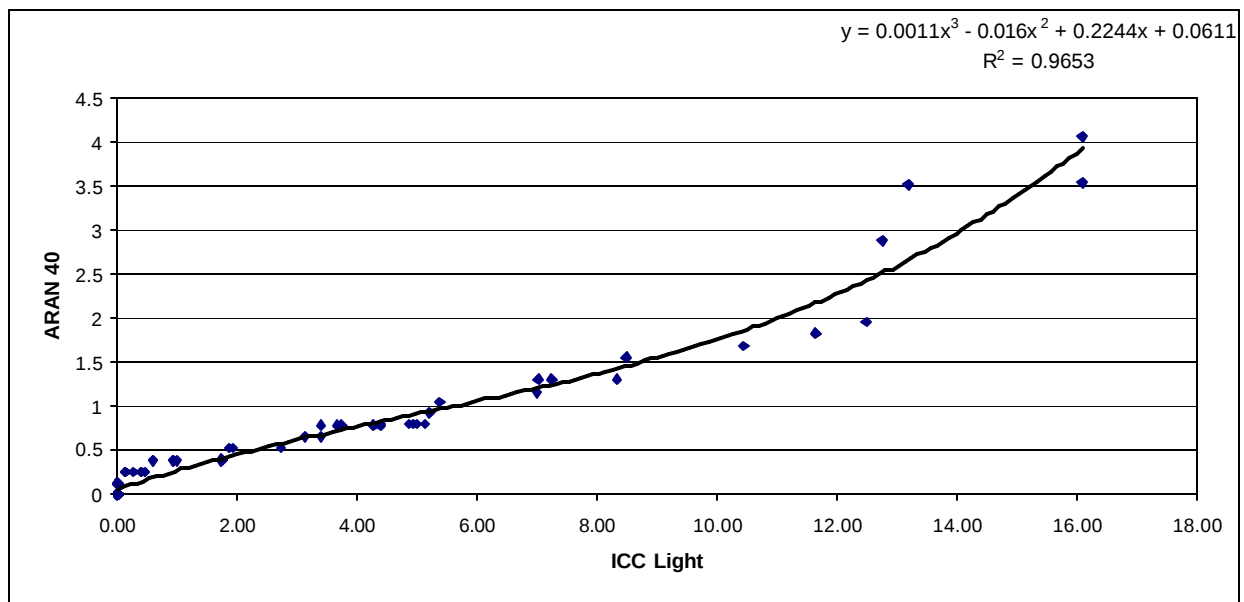


Figure 85. Correlation Between ICC Light and ARAN 40 (% DL)

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11.0 APPENDIX A CANDIDATE TEST SECTIONS

Table 17 shows the short list of candidate sections that was prepared based on the results of the scan data analysis. The sections in this list were selected based on the 500-ft moving average IRI values. The moving averages were analyzed to categorize the sections as very smooth, smooth or relatively rough, using the limits shown in table 3.

Table 17. Candidate Test Sections

Highway Number	Direction	From (ft)	To (ft)	From (Mile Marker)	To (Mile Marker)	Average IRI	Smoothness Category	Estimated PSI
287	North	7700	8200	47.458	47.553	1.43	Relatively Rough	3.86
287	North	8200	8700	47.553	47.648	0.83	Very Smooth	4.30
287	North	8700	9200	47.648	47.742	1.05	Relatively Rough	4.14
287	North	9200	9700	47.742	47.837	0.83	Very Smooth	4.31
287	North	9700	10200	47.837	47.932	1.13	Relatively Rough	4.08
287	North	10200	10700	47.932	48.027	1.07	Relatively Rough	4.12
287	North	10700	11200	48.027	48.121	1.12	Relatively Rough	4.09
287	North	11200	11700	48.121	48.216	2.19	Relatively Rough	3.37
287	North	11700	12200	48.216	48.311	1.18	Relatively Rough	4.04
287	North	12200	12700	48.311	48.405	1.25	Relatively Rough	3.99
287	North	12700	13200	48.405	48.500	0.86	Smooth	4.29
287	North	13200	13700	48.500	48.595	0.90	Smooth	4.25
287	North	13700	14200	48.595	48.689	0.99	Smooth	4.18
287	North	31700	32200	52.004	52.098	1.03	Relatively Rough	4.16
287	North	32200	32700	52.098	52.193	1.22	Relatively Rough	4.01
287	North	32700	33200	52.193	52.288	0.88	Smooth	4.27
287	North	33200	33700	52.288	52.383	0.79	Very Smooth	4.34
287	North	33700	34200	52.383	52.477	0.83	Very Smooth	4.31
287	North	34200	34700	52.477	52.572	0.89	Smooth	4.26
287	North	34700	35200	52.572	52.667	1.10	Relatively Rough	4.10
287	North	86700	87200	62.420	62.515	0.92	Smooth	4.23
287	North	87200	87700	62.515	62.610	0.94	Smooth	4.22
287	North	87700	88200	62.610	62.705	0.82	Very Smooth	4.31
287	North	88200	88700	62.705	62.799	1.26	Relatively Rough	3.99
287	North	88700	89200	62.799	62.894	0.96	Smooth	4.21

Highway Number	Direction	From (ft)	To (ft)	From (Mile Marker)	To (Mile Marker)	Average IRI	Smoothness Category	Estimated PSI
287	North	89200	89700	62.894	62.989	0.84	Very Smooth	4.30
287	North	89700	90200	62.989	63.083	0.84	Very Smooth	4.30
287	North	90200	90700	63.083	63.178	0.84	Very Smooth	4.30
287	North	90700	91200	63.178	63.273	1.27	Relatively Rough	3.98
287	North	91200	91700	63.273	63.367	1.09	Relatively Rough	4.11
287	North	91700	92200	63.367	63.462	1.07	Relatively Rough	4.12
287	North	92200	92700	63.462	63.557	1.19	Relatively Rough	4.04
287	South	85700	86200	51.769	51.674	1.728	Relatively Rough	3.66
287	South	86200	86700	51.674	51.580	0.994	Smooth	4.18
287	South	86700	87200	51.580	51.485	1.015	Relatively Rough	4.17
287	South	87200	87700	51.485	51.390	0.846	Very Smooth	4.29
287	South	87700	88200	51.390	51.295	0.742	Very Smooth	4.37
287	South	88200	88700	51.295	51.201	0.737	Very Smooth	4.38
287	South	88700	89200	51.201	51.106	0.759	Very Smooth	4.36
287	South	89200	89700	51.106	51.011	0.893	Smooth	4.26
287	South	89700	90200	51.011	50.917	1.057	Relatively Rough	4.13
287	South	90200	90700	50.917	50.822	0.937	Smooth	4.22
287	South	90700	91200	50.822	50.727	0.839	Very Smooth	4.30
287	South	91200	91700	50.727	50.633	1.021	Relatively Rough	4.16
287	South	91700	92200	50.633	50.538	0.986	Smooth	4.19
287	South	92200	92700	50.538	50.443	1.461	Relatively Rough	3.84
287	South	92700	93200	50.443	50.348	1.185	Relatively Rough	4.04
287	South	93200	93700	50.348	50.254	1.089	Relatively Rough	4.11
287	South	93700	94200	50.254	50.159	1.132	Relatively Rough	4.08
287	South	94200	94700	50.159	50.064	1.383	Relatively Rough	3.90
287	South	94700	95200	50.064	49.970	0.909	Smooth	4.25
287	South	95200	95700	49.970	49.875	0.814	Very Smooth	4.32
287	South	99700	100200	49.117	49.023	1.197	Relatively Rough	4.03
287	South	100200	100700	49.023	48.928	0.978	Smooth	4.19
287	South	100700	101200	48.928	48.833	0.993	Smooth	4.18
287	South	101200	101700	48.833	48.739	1.03	Relatively Rough	4.15
287	South	101700	102200	48.739	48.644	0.981	Smooth	4.19

Highway Number	Direction	From (ft)	To (ft)	From (Mile Marker)	To (Mile Marker)	Average IRI	Smoothness Category	Estimated PSI
287	South	102200	102700	48.644	48.549	0.96	Smooth	4.21
287	South	102700	103200	48.549	48.455	1.211	Relatively Rough	4.02
287	South	103200	103700	48.455	48.360	2.846	Relatively Rough	3.00
287	South	103700	104200	48.360	48.265	1.05	Relatively Rough	4.14
287	South	104200	104700	48.265	48.170	0.916	Smooth	4.24
287	South	104700	105200	48.170	48.076	1.08	Relatively Rough	4.12
287	South	105200	105700	48.076	47.981	0.8	Very Smooth	4.33
287	South	105700	106200	47.981	47.886	0.823	Very Smooth	4.31
287	South	106200	106700	47.886	47.792	1.14	Relatively Rough	4.07
287	South	106700	107200	47.792	47.697	1.154	Relatively Rough	4.06
195	North	36400	36900	6.894	6.989	1.422	Relatively Rough	3.87
195	North	36900	37400	6.989	7.083	0.921	Smooth	4.24
195	North	37400	37900	7.083	7.178	1.091	Relatively Rough	4.11
195	North	37900	38400	7.178	7.273	1.447	Relatively Rough	3.85
195	North	38400	38900	7.273	7.367	1.342	Relatively Rough	3.93
195	North	38900	39400	7.367	7.462	1.302	Relatively Rough	3.96
195	North	39400	39900	7.462	7.557	0.997	Smooth	4.18
195	North	39900	40400	7.557	7.652	0.916	Smooth	4.24
195	North	40400	40900	7.652	7.746	1.057	Smooth	4.13
195	North	40900	41400	7.746	7.841	0.808	Very Smooth	4.32
195	North	41400	41900	7.841	7.936	0.776	Very Smooth	4.35
195	North	41900	42400	7.936	8.030	0.781	Very Smooth	4.34
195	North	42400	42900	8.030	8.125	0.953	Smooth	4.21
195	North	42900	43400	8.125	8.220	0.883	Smooth	4.27
195	North	43400	43900	8.220	8.314	1.284	Relatively Rough	3.97
55	South	4500	5000	27.148	27.053	1.125	Relatively Rough	4.08
55	South	5000	5500	27.053	26.958	0.744	Very Smooth	4.37
55	South	5500	6000	26.958	26.864	1.159	Relatively Rough	4.06
55	South	6000	6500	26.864	26.769	0.834	Very Smooth	4.30
55	South	6500	7000	26.769	26.674	1.316	Relatively Rough	3.95
55	South	7000	7500	26.674	26.580	1.046	Relatively Rough	4.14
55	South	7500	8000	26.580	26.485	0.766	Very Smooth	4.36

Highway Number	Direction	From (ft)	To (ft)	From (Mile Marker)	To (Mile Marker)	Average IRI	Smoothness Category	Estimated PSI
55	South	8000	8500	26.485	26.390	0.736	Very Smooth	4.38
55	South	8500	9000	26.390	26.295	1.003	Smooth	4.17
55	South	9000	9500	26.295	26.201	1.083	Relatively Rough	4.11
55	South	9500	10000	26.201	26.106	0.88	Smooth	4.27
55	South	10000	10500	26.106	26.011	0.828	Very Smooth	4.31
55	South	10500	11000	26.011	25.917	0.927	Smooth	4.23
55	South	11000	11500	25.917	25.822	0.703	Very Smooth	4.41
55	South	11500	12000	25.822	25.727	0.9	Smooth	4.25
55	South	12000	12500	25.727	25.633	1.018	Relatively Rough	4.16
55	South	12500	13000	25.633	25.538	1.786	Relatively Rough	3.63
55	South	13000	13500	25.538	25.443	1.383	Relatively Rough	3.90
287	North	200	700	30.962	30.867	0.926	Smooth	4.23
287	North	700	1200	30.867	30.773	0.799	Very Smooth	4.33
287	North	1200	1700	30.773	30.678	0.765	Very Smooth	4.36
287	North	1700	2200	30.678	30.583	0.737	Very Smooth	4.38
287	North	2200	2700	30.583	30.489	0.907	Smooth	4.25
287	North	2700	3200	30.489	30.394	0.928	Smooth	4.23
287	North	3200	3700	30.394	30.299	2.066	Relatively Rough	3.45
287	North	3700	4200	30.299	30.205	1.719	Relatively Rough	3.67
287	North	4200	4700	30.205	30.110	1.561	Relatively Rough	3.78
287	North	4700	5200	30.110	30.015	1.489	Relatively Rough	3.82
287	North	27600	28100	25.773	25.678	1.139	Relatively Rough	4.07
287	North	28100	28600	25.678	25.583	0.753	Very Smooth	4.37
287	North	28600	29100	25.583	25.489	0.87	Smooth	4.28
287	North	29100	29600	25.489	25.394	1.211	Relatively Rough	4.02
287	North	29600	30100	25.394	25.299	1.099	Relatively Rough	4.10
287	North	30100	30600	25.299	25.205	0.88	Smooth	4.27
287	North	30600	31100	25.205	25.110	0.83	Very Smooth	4.31
287	North	31100	31600	25.110	25.015	1.025	Relatively Rough	4.16
287	North	31600	32100	25.015	24.920	0.985	Smooth	4.19
287	North	32100	32600	24.920	24.826	1.176	Relatively Rough	4.05
287	North	32600	33100	24.826	24.731	0.86	Smooth	4.28

Highway Number	Direction	From (ft)	To (ft)	From (Mile Marker)	To (Mile Marker)	Average IRI	Smoothness Category	Estimated PSI
287	North	33100	33600	24.731	24.636	1.073	Relatively Rough	4.12
287	North	47900	48400	21.928	21.833	0.96	Smooth	4.21
287	North	48400	48900	21.833	21.739	0.935	Smooth	4.23
287	North	48900	49400	21.739	21.644	0.867	Smooth	4.28
287	North	49400	49900	21.644	21.549	0.882	Smooth	4.27
287	North	49900	50400	21.549	21.455	1.33	Relatively Rough	3.94
287	North	50400	50900	21.455	21.360	1.312	Relatively Rough	3.95
287	North	50900	51400	21.360	21.265	1.457	Relatively Rough	3.85
287	North	51400	51900	21.265	21.170	1.168	Relatively Rough	4.05
287	North	51900	52400	21.170	21.076	1.195	Relatively Rough	4.03
287	North	52400	52900	21.076	20.981	1.066	Relatively Rough	4.13
287	North	52900	53400	20.981	20.886	1.173	Relatively Rough	4.05
287	North	90800	91300	13.803	13.708	1.041	Smooth	4.15
287	North	91300	91800	13.708	13.614	1.074	Smooth	4.12
287	North	91800	92300	13.614	13.519	1.072	Smooth	4.12
287	North	92300	92800	13.519	13.424	0.987	Smooth	4.19
287	North	92800	93300	13.424	13.330	0.804	Very Smooth	4.33
287	North	93300	93800	13.330	13.235	0.936	Smooth	4.22
287	North	93800	94300	13.235	13.140	1.275	Relatively Rough	3.97
287	North	94300	94800	13.140	13.045	1.052	Relatively Rough	4.14
287	North	94800	95300	13.045	12.951	1.604	Relatively Rough	3.75
287	North	95300	95800	12.951	12.856	2.709	Relatively Rough	3.07
287	North	95800	96300	12.856	12.761	1.963	Relatively Rough	3.51
287	North	96300	96800	12.761	12.667	1.355	Relatively Rough	3.92

12.0 APPENDIX B SIMULATION ANALYSIS RESULTS

The 500-ft test sections were divided into sets of 50-ft segments. The main reason for this is to have enough degrees of freedom for the statistical analysis. Results of the simulation analysis performed on the collected profiles, as well as the measured IRI values were summarized for the 50-ft segments and presented in this appendix, tables 18 to 27.

Table 18. Simulation Analysis Results (40 mph ARAN)

Section Number	Highway	From (ft)	To (ft)	%Defective Length					
				ICC Light	K.J. Law Light	K.J. Law Full	ARAN	RSE I	RSE II
1	I-195W	0	500	4.35	1.22	2.38	0.60	4.20	3.60
2	I-195W	100	600	4.99	1.22	1.32	0.54	4.60	3.80
3	I-195W	100	600	4.62	5.94	2.69	0.54	4.20	3.00
4	I-195W	200	700	2.00	0.33	1.28	0.42	1.80	0.80
5	I-195W	2500	3000	3.89	0.79	1.15	1.58	2.80	0.20
6	I-195W	2600	3100	3.22	2.53	0.35	1.24	2.40	0.20
7	I-195W	1900	2400	2.03	3.14	1.18	0.90	1.20	0.60
8	I-195W	4000	4500	1.44	4.13	1.08	0.18	1.00	0.60
9	I-195W	4500	5000	0.71	5.24	0.01	1.84	0.80	0.80
10	NJ55S	1000	1500	0.00	0.00	0.10	0.00	0.00	0.00
11	NJ55S	1500	2000	0.00	0.03	0.00	0.00	0.00	0.00
12	NJ55S	2000	2500	0.00	0.02	0.27	0.04	0.00	0.00

The speed of ARAN is 40mph (5 runs)

Table 19. Simulation Analysis Results (50 mph ARAN)

Section Number	Highway	From (ft)	To (ft)	%Defective Length					
				ICC Light	K.J. Law Light	K.J. Law Full	ARAN	RSE I	RSE II
1	I-195W	0	500	4.351	1.22	2.38	1.96	4.20	3.60
2	I-195W	100	600	4.991	1.22	1.32	1.51	4.60	3.80
3	I-195W	100	600	4.623	5.94	2.69	2.46	4.20	3.00
4	I-195W	200	700	1.997	0.33	1.28	1.82	1.80	0.80
5	I-195W	2500	3000	3.885	0.79	1.15	0.68	2.80	0.20
6	I-195W	2600	3100	3.22	2.53	0.35	0.11	2.40	0.20
7	I-195W	1900	2400	2.031	3.14	1.18	1.57	1.20	0.60
8	I-195W	4000	4500	1.443	4.13	1.08	0.30	1.00	0.60
9	I-195W	4500	5000	0.707	5.24	0.01	0.72	0.80	0.80
10	NJ55S	1000	1500	0	0.00	0.10	0.00	0.00	0.00
11	NJ55S	1500	2000	0	0.03	0.00	0.00	0.00	0.00
12	NJ55S	2000	2500	0	0.02	0.27	0.02	0.00	0.00

The speed of Aran is 50mph (3 runs)

Table 20. Simulation Analysis Results (60 mph ARAN)

Section Number	Highway	From (ft)	To (ft)	%Defective Length					
				ICC Light	K.J. Law Light	K.J. Law Full	ARAN	RSE I	RSE II
1	I-195W	0	500	4.351	1.22	2.38	2.07	4.20	3.60
2	I-195W	100	600	4.991	1.22	1.32	1.53	4.60	3.80
3	I-195W	100	600	4.623	5.94	2.69	2.44	4.20	3.00
4	I-195W	200	700	1.997	0.33	1.28	1.87	1.80	0.80
5	I-195W	2500	3000	3.885	0.79	1.15	0.50	2.80	0.20
6	I-195W	2600	3100	3.22	2.53	0.35	0.20	2.40	0.20
7	I-195W	1900	2400	2.031	3.14	1.18	2.40	1.20	0.60
8	I-195W	4000	4500	1.443	4.13	1.08	0.02	1.00	0.60
9	I-195W	4500	5000	0.707	5.24	0.01	0.96	0.80	0.80
10	NJ55S	1000	1500	0	0.00	0.10	0.00	0.00	0.00
11	NJ55S	1500	2000	0	0.03	0.00	0.00	0.00	0.00
12	NJ55S	2000	2500	0	0.02	0.27	0.04	0.00	0.00

The speed of Aran is 60mph (3 runs)

Table 21. IRI Analysis Results (40 mph ARAN)

Section Number	Highway	From (ft)	To (ft)	IRI					
				ICC Light	K.J. Law Light	K.J. Law Full	ARAN	RSE I	RSE II
1	I-195W	0	500		1.253	1.600	1.503		
2	I-195W	100	600		1.322	1.399	1.363		
3	I-195W	100	600		1.860	1.612	1.506		
4	I-195W	200	700		1.390	1.404	1.432		
5	I-195W	2500	3000		1.782	1.554	1.443		
6	I-195W	2600	3100		1.728	1.570	1.421		
7	I-195W	1900	2400		1.818	1.712	1.708		
8	I-195W	4000	4500		1.642	1.192	1.298		
9	I-195W	4500	5000		2.511	1.360	1.296		
10	NJ55S	1000	1500		0.947	1.138	0.987		
11	NJ55S	1500	2000		0.947	1.024	0.911		
12	NJ55S	2000	2500		0.867	1.013	0.925		

The speed of Aran is 40mph (5 runs)

Table 22. IRI Analysis Results (50 mph ARAN)

Section Number	12.1.1.1 Highway	From (ft)	To (ft)	IRI					
				ICC Light	K.J. Law Light	K.J. Law Full	ARAN	RSE I	RSE II
1	I-195W	0	500		1.253	1.600	1.489		
2	I-195W	100	600		1.322	1.399	1.360		
3	I-195W	100	600		1.860	1.612	1.457		
4	I-195W	200	700		1.390	1.404	1.529		
5	I-195W	2500	3000		1.782	1.554	1.399		
6	I-195W	2600	3100		1.728	1.570	1.422		
7	I-195W	1900	2400		1.818	1.712	1.719		
8	I-195W	4000	4500		1.642	1.192	1.235		
9	I-195W	4500	5000		2.511	1.360	0.764		
10	NJ55S	1000	1500		0.947	1.138	1.489		
11	NJ55S	1500	2000		0.947	1.024	0.879		
12	NJ55S	2000	2500		0.867	1.013	0.945		

The speed of Aran is 50mph (3 runs)

Table 23. IRI Analysis Results (60 mph ARAN)

Section Number	Highway	From (ft)	To (ft)	IRI					
				ICC Light	K.J. Law Light	K.J. Law Full	ARAN	RSE I	RSE II
1	I-195W	0	500		1.253	1.600	1.563		
2	I-195W	100	600		1.322	1.399	1.457		
3	I-195W	100	600		1.860	1.612	1.571		
4	I-195W	200	700		1.390	1.404	1.560		
5	I-195W	2500	3000		1.782	1.554	1.434		
6	I-195W	2600	3100		1.728	1.570	1.475		
7	I-195W	1900	2400		1.818	1.712	1.748		
8	I-195W	4000	4500		1.642	1.192	1.291		
9	I-195W	4500	5000		2.511	1.360	1.309		
10	NJ55S	1000	1500		0.947	1.138	0.996		
11	NJ55S	1500	2000		0.947	1.024	1.010		
12	NJ55S	2000	2500		0.867	1.013	0.971		

The speed of Aran is 60mph (3 runs)

Table 24. ARAN 40 mph

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
1	I-195W	0	50	24.4	23.4	23.8	22	23.8	77.08	86.24	66.12	72.91	68.96
1	I-195W	50	100	21.8	20	20.2	19.4	19	161.53	157.78	164.26	166.81	167.45
1	I-195W	100	150	24.4	22.6	23.8	23.4	24.8	79.05	79.51	86.00	86.46	89.12
1	I-195W	150	200	13.2	13.2	14.2	14	11.8	65.97	51.99	52.76	48.80	52.32
1	I-195W	200	250	0	0	0	0	0	114.52	118.43	101.29	114.89	117.55
1	I-195W	250	300	0	0	0	0	0	91.21	91.00	70.56	61.21	90.13
1	I-195W	300	350	0	0	0	0	0	83.97	88.36	100.62	89.36	74.31
1	I-195W	350	400	0	0	0	0	0	100.58	98.25	98.71	92.29	95.34
1	I-195W	400	450	0	0	0	0	0	91.80	101.57	97.18	103.45	106.80
1	I-195W	450	500	0	0	0	0	0	89.62	97.80	111.05	102.15	98.00
2	I-195W	100	150	0.8	0.2	0.4	0.8	0.8	79.05	79.51	86.00	86.46	89.12
2	I-195W	150	200	0	0	0	0	0	65.97	51.99	52.76	48.80	52.32
2	I-195W	200	250	0	0	0	0	0	114.52	118.43	101.29	114.89	117.55
2	I-195W	250	300	0	0	0	0	0	91.21	91.00	70.56	61.21	90.13
2	I-195W	300	350	0	0	0	0	0	83.97	88.36	100.62	89.36	74.31
2	I-195W	350	400	0	0	0	0	0	100.58	98.25	98.71	92.29	95.34
2	I-195W	400	450	0	0	0	0	0	91.80	101.57	97.18	103.45	106.80
2	I-195W	450	500	0	0	0	0	0	89.62	97.80	111.05	102.15	98.00
2	I-195W	500	550	0	0	0	0	0	79.00	86.00	82.09	96.05	94.42
2	I-195W	550	600	0	0	0	0	0	60.12	54.33	61.96	68.23	62.02
3	I-195W	100	150	0.8	0.8	0.6	0.8	0.6	106.88	63.42	86.05	78.57	78.26
3	I-195W	150	200	0	0	0	0	0	73.96	52.26	52.7	47.06	60.66
3	I-195W	200	250	0	0	0	0	0	117.4	117.3	111.29	112.71	103.94

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
3	I-195W	250	300	0	0	0	0	0	97.87	115.41	79.8	87.67	108.26
3	I-195W	300	350	0	0	0	0	0	103.81	151.08	175.05	146.81	146.57
3	I-195W	350	400	0	0	0	0	0	119.23	87.66	99.42	103.04	101.22
3	I-195W	400	450	0	0	0	0	0	104.54	112.32	95.97	99.52	103.66
3	I-195W	450	500	0	0	0	0	0	93.79	104.58	112.43	106.08	88.39
3	I-195W	500	550	0	0	0	0	0	84.65	81.01	92.55	92.48	84.76
3	I-195W	550	600	0	0	0	0	0	59.92	71.14	80.98	86.71	39.7
4	I-195W	200	250	0.2	0.2	0.2	0.4	0.4	114.52	118.43	101.29	114.89	117.55
4	I-195W	250	300	0	0	0	0	0	91.21	91.00	70.56	61.21	90.13
4	I-195W	300	350	0	0	0	0	0	83.97	88.36	100.62	89.36	74.31
4	I-195W	350	400	0	0	0	0	0	100.58	98.25	98.71	92.29	95.34
4	I-195W	400	450	0	0	0	0	0	91.80	101.57	97.18	103.45	106.80
4	I-195W	450	500	0	0	0	0	0	89.62	97.80	111.05	102.15	98.00
4	I-195W	500	550	0	0	0	0	0	79.00	86.00	82.09	96.05	94.42
4	I-195W	550	600	0	0	0	0	0	60.12	54.33	61.96	68.23	62.02
4	I-195W	600	650	0	0	0	0	0	102.77	101.86	72.60	90.88	125.19
4	I-195W	650	700	0	0	0	0	0	113.23	68.70	68.70	60.49	106.37
5	I-195W	2500	2550	0.4	0.4	0.4	0.4	0.4	91.66	93.10	69.30	85.87	102.33
5	I-195W	2550	2600	0	0	0	0	0	107.85	86.70	117.74	121.54	112.49
5	I-195W	2600	2650	0	0	0	0	0	102.13	104.21	116.27	105.15	115.35
5	I-195W	2650	2700	0	0	0	0	0	98.86	86.99	94.31	96.57	92.42
5	I-195W	2700	2750	0	0	0	0	0	114.48	117.62	125.79	113.73	106.29
5	I-195W	2750	2800	0	0	0	0	0	92.58	84.15	83.65	96.27	91.98
5	I-195W	2800	2850	0	0	0	0	0	56.15	62.30	61.24	52.32	53.35

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
5	I-195W	2850	2900	0	0	0	0	0	69.31	58.39	63.39	68.10	68.98
5	I-195W	2900	2950	0	0	0	0	0	110.11	95.00	102.20	107.40	115.59
5	I-195W	2950	3000	0	0	0	0	0	74.99	95.61	73.76	82.20	82.77
6	I-195W	2600	2650	12.8	14.2	13.4	13.2	14	102.13	104.21	116.27	105.15	115.35
6	I-195W	2650	2700	0	0	0	0	0	98.86	86.99	94.31	96.57	92.42
6	I-195W	2700	2750	0	0	0	0	0	114.48	117.62	125.79	113.73	106.29
6	I-195W	2750	2800	0	0	0	0	0	92.58	84.15	83.65	96.27	91.98
6	I-195W	2800	2850	0	0	0	0	0	56.15	62.30	61.24	52.32	53.35
6	I-195W	2850	2900	0	0	0	0	0	69.31	58.39	63.39	68.10	68.98
6	I-195W	2900	2950	0	0	0	0	0	110.11	95.00	102.20	107.40	115.59
6	I-195W	2950	3000	0	0	0	0	0	74.99	95.61	73.76	82.20	82.77
6	I-195W	3000	3050	0	0	0	0	0	78.63	82.47	93.33	88.05	73.97
6	I-195W	3050	3100	0	0	0	0	0	109.96	100.56	94.84	99.23	99.79
7	I-195W	1900	1950	0.6	0.6	0.6	0.6	0.4	74.52	72.25	74.42	61.78	61.79
7	I-195W	1950	2000	0	0	0	0	0	132.84	137.78	131.92	138.83	126.96
7	I-195W	2000	2050	0	0	0	0	0	117.46	99.58	126.39	109.70	98.94
7	I-195W	2050	2100	0	0	0	0	0	89.43	65.81	75.35	74.15	73.92
7	I-195W	2100	2150	0	0	0	0	0	98.38	107.18	94.61	111.91	117.01
7	I-195W	2150	2200	0	0	0	0	0	111.89	143.53	124.92	111.70	141.46
7	I-195W	2200	2250	0	0	0	0	0	132.82	126.45	115.29	126.49	129.14
7	I-195W	2250	2300	0	0	0	0	0	128.34	160.13	178.09	145.25	151.37
7	I-195W	2300	2350	0	0	0	0	0	111.14	88.53	116.86	97.92	93.94
7	I-195W	2350	2400	0	0	0	0	0	87.58	83.23	85.29	78.98	80.91

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
8	I-195W	4000	4050	20.4	18.8	21.2	21	21.8	123.17	109.63	75.71	85.44	115.74
8	I-195W	4050	4100	18.6	16.8	17.6	15.2	17.8	83.20	88.63	100.12	93.57	109.95
8	I-195W	4100	4150	0	0	0	0	0	89.04	88.24	71.92	64.42	92.38
8	I-195W	4150	4200	0	0	0	0	0	62.47	48.97	54.02	64.36	68.15
8	I-195W	4200	4250	0	0	0	0	0	43.73	60.10	45.31	48.27	52.83
8	I-195W	4250	4300	0	0	0	0	0	52.21	50.67	37.93	45.95	57.90
8	I-195W	4300	4350	0	0	0	0	0	164.47	159.27	167.56	171.41	167.09
8	I-195W	4350	4400	0	0	0	0	0	100.55	106.86	97.82	112.00	105.80
8	I-195W	4400	4450	0	0	0	0	0	56.32	64.90	58.00	65.08	52.95
8	I-195W	4450	4500	0	0	0	0	0	54.64	62.78	52.42	61.39	55.64
9	I-195W	4500	4550	0.6	0.8	0.8	0.8	0.6	73.21	84.25	66.76	74.54	79.72
9	I-195W	4550	4600	0	0	0	0	0	99.61	100.80	85.99	98.06	92.30
9	I-195W	4600	4650	0	0	0	0	0	82.48	70.93	75.78	79.80	91.18
9	I-195W	4650	4700	0	0	0	0	0	82.59	98.58	78.29	94.66	98.81
9	I-195W	4700	4750	0	0	0	0	0	74.32	88.82	70.90	83.54	80.53
9	I-195W	4750	4800	0	0	0	0	0	47.43	69.50	54.79	66.61	65.57
9	I-195W	4800	4850	0	0	0	0	0	93.24	95.60	112.26	87.65	91.46
9	I-195W	4850	4900	0	0	0	0	0	119.80	116.92	110.80	131.36	106.88
9	I-195W	4900	4950	0	0	0	0	0	59.15	55.27	63.94	60.52	62.27
9	I-195W	4950	5000	0	0	0	0	0	69.39	72.26	67.42	65.56	62.41
10	NJ 55S	1000	1050	20.8	19.8	20.4	19.2	22.4	44.37	34.48	44.32	44.75	49.4
10	NJ 55S	1050	1100	18	18.4	19.2	17.2	17.4	68.04	76.5	73.29	77.31	71.55
10	NJ 55S	1100	1150	24.4	25.6	25.2	26.4	24.4	59.15	59.34	59.56	40.87	45.8
10	NJ 55S	1150	1200	15.6	17.4	15.8	14.8	18	43.45	78.81	58.66	57.45	54.54

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
10	NJ 55S	1200	1250	18	20.6	18.2	18.8	16.6	57.95	43.56	48.58	48.65	39.03
10	NJ 55S	1250	1300	20	17.8	19	20.6	17.4	58.79	70	67.68	65.02	55.47
10	NJ 55S	1300	1350	19.2	19.4	18	21.2	21.2	66.7	63.63	68.31	62.97	73.07
10	NJ 55S	1350	1400	23.8	23.6	24.4	22.6	24.4	67.43	78.98	68.26	67.45	65.21
10	NJ 55S	1400	1450	17.4	16.2	19.4	16.8	19.6	77.51	83.09	78.5	86.69	80.03
10	NJ 55S	1450	1500	13.8	17	15.2	15	17.2	72.42	65.3	74.15	63.37	74.16
11	NJ 55S	1500	1550	6	6.8	8.4	7.4	6	47.99	47.89	47.4	50.65	46.16
11	NJ 55S	1550	1600	0	0	0	0	0	52.68	51.96	60.56	52.57	45.5
11	NJ 55S	1600	1650	0	0	0	0	0	54.91	53.45	55.97	57.69	58.63
11	NJ 55S	1650	1700	0	0	0	0	0	87.02	79.61	83.06	89.29	76.22
11	NJ 55S	1700	1750	0	0	0	0	0	69.09	77.31	66.54	78.12	66.94
11	NJ 55S	1750	1800	0	0	0	0	0	48.27	35.71	44.84	40.06	42.89
11	NJ 55S	1800	1850	0	0	0	0	0	51.17	62.01	53.95	54.44	54.31
11	NJ 55S	1850	1900	0	0	0	0	0	42.98	43.15	46.25	47.47	52.76
11	NJ 55S	1900	1950	0	0	0	0	0	42.24	56.85	41.53	59.75	52.45
11	NJ 55S	1950	2000	0	0	0	0	0	65.02	72.2	85.19	70.32	68.5
12	NJ 55S	2000	2050	0.2	0.4	0.4	0	0	75.06	73.4	59.02	80.81	75.4
12	NJ 55S	2050	2100	0	0	0	0	0	63.36	64.9	53.17	68.08	52.55
12	NJ 55S	2100	2150	0	0	0	0	0	65.96	77.61	71.94	74.74	69.43
12	NJ 55S	2150	2200	0	0	0	0	0	77.29	74.43	76.64	74.84	74.13
12	NJ 55S	2200	2250	0	0	0	0	0	45.08	50.8	48.97	50.47	44.85
12	NJ 55S	2250	2300	0	0	0	0	0	64.06	69.58	69.76	64.28	69.43
12	NJ 55S	2300	2350	0	0	0	0	0	61.36	55.87	58.6	56.78	46.21
12	NJ 55S	2350	2400	0	0	0	0	0	51.9	46.87	49.87	48.87	52.63

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
12	NJ 55S	2400	2450	0	0	0	0	0	44.72	42.83	48.5	45.07	52.39
12	NJ 55S	2450	2500	0	0	0	0	0	46.69	41.25	35.99	37.43	34.38

Table 25. ARAN 50mph

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
1	I-195W	0	50	17.8	25	20	55.54	162.20	58.07
1	I-195W	50	100	24.4	23.8	25	157.77	108.34	152.08
1	I-195W	100	150	24.4	20.6	25	82.36	58.47	98.60
1	I-195W	150	200	11.4	15.2	12.2	49.90	108.03	53.30
1	I-195W	200	250	0	0	0	109.20	63.16	114.61
1	I-195W	250	300	0	0	0	81.00	94.45	53.38
1	I-195W	300	350	0	0	0	115.56	104.09	91.42
1	I-195W	350	400	0	0	0	88.49	98.28	98.98
1	I-195W	400	450	0	0	0	83.01	97.75	97.74
1	I-195W	450	500	0	0	0	103.35	90.34	106.93
2	I-195W	100	150	0.8	0.6	0.8	82.36	58.47	98.60
2	I-195W	150	200	0	0	0	49.90	108.03	53.30
2	I-195W	200	250	0	0	0	109.20	63.16	114.61
2	I-195W	250	300	0	0	0	81.00	94.45	53.38
2	I-195W	300	350	0	0	0	115.56	104.09	91.42
2	I-195W	350	400	0	0	0	88.49	98.28	98.98
2	I-195W	400	450	0	0	0	83.01	97.75	97.74
2	I-195W	450	500	0	0	0	103.35	90.34	106.93
2	I-195W	500	550	0	0	0	100.09	57.15	91.37

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
2	I-195W	550	600	0	0	0	61.28	87.28	51.91
3	I-195W	100	150	0.8	0.6	0.8	86.4	47.67	95.94
3	I-195W	150	200	0	0	0	56.68	115.3	44.99
3	I-195W	200	250	0	0	0	101.64	75.36	106.77
3	I-195W	250	300	0	0	0	94.14	142.28	75.12
3	I-195W	300	350	0	0	0	169.62	96.53	158.85
3	I-195W	350	400	0	0	0	94.44	84.19	104.49
3	I-195W	400	450	0	0	0	105.37	98.78	90.36
3	I-195W	450	500	0	0	0	106.26	102.82	100.89
3	I-195W	500	550	0	0	0	84.46	49.28	94.01
3	I-195W	550	600	0	0	0	53.94	91.82	46.51
4	I-195W	200	250	0.4	0.4	0.4	109.20	63.16	114.61
4	I-195W	250	300	0	0	0	81.00	94.45	53.38
4	I-195W	300	350	0	0	0	115.56	104.09	91.42
4	I-195W	350	400	0	0	0	88.49	98.28	98.98
4	I-195W	400	450	0	0	0	83.01	97.75	97.74
4	I-195W	450	500	0	0	0	103.35	90.34	106.93
4	I-195W	500	550	0	0	0	100.09	57.15	91.37
4	I-195W	550	600	0	0	0	61.28	87.28	51.91
4	I-195W	600	650	0	0	0	109.10	149.49	93.64
4	I-195W	650	700	0	0	0	205.80	95.32	117.82
5	I-195W	2500	2550	0	0.4	0.4	80.74	115.10	66.73
5	I-195W	2550	2600	0	0	0	112.89	113.46	102.80

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
5	I-195W	2600	2650	0	0	0	106.83	103.16	97.70
5	I-195W	2650	2700	0	0	0	95.89	118.22	85.59
5	I-195W	2700	2750	0	0	0	111.70	79.78	115.68
5	I-195W	2750	2800	0	0	0	85.01	57.70	79.23
5	I-195W	2800	2850	0	0	0	54.19	53.08	58.05
5	I-195W	2850	2900	0	0	0	62.14	101.77	58.12
5	I-195W	2900	2950	0	0	0	107.46	91.63	100.53
5	I-195W	2950	3000	0	0	0	92.84	71.52	87.24
6	I-195W	2600	2650	14.4	13.8	12.8	106.83	103.16	97.70
6	I-195W	2650	2700	0	0	0	95.89	118.22	85.59
6	I-195W	2700	2750	0	0	0	111.70	79.78	115.68
6	I-195W	2750	2800	0	0	0	85.01	57.70	79.23
6	I-195W	2800	2850	0	0	0	54.19	53.08	58.05
6	I-195W	2850	2900	0	0	0	62.14	101.77	58.12
6	I-195W	2900	2950	0	0	0	107.46	91.63	100.53
6	I-195W	2950	3000	0	0	0	92.84	71.52	87.24
6	I-195W	3000	3050	0	0	0	91.60	135.44	97.22
6	I-195W	3050	3100	0	0	0	96.35	119.68	93.36
7	I-195W	1900	1950	0.6	0.6	0.4	69.36	132.17	65.59
7	I-195W	1950	2000	0	0	0	117.89	133.10	133.21
7	I-195W	2000	2050	0	0	0	128.29	87.32	140.50
7	I-195W	2050	2100	0	0	0	95.45	111.20	81.68
7	I-195W	2100	2150	0	0	0	111.43	122.51	111.68
7	I-195W	2150	2200	0	0	0	108.23	111.59	105.69

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
7	I-195W	2200	2250	0	0	0	126.54	151.71	107.41
7	I-195W	2250	2300	0	0	0	150.75	105.31	141.02
7	I-195W	2300	2350	0	0	0	75.57	81.40	110.50
7	I-195W	2350	2400	0	0	0	96.36	76.36	85.29
8	I-195W	4000	4050	23.4	14.8	22.2	109.24	90.39	88.15
8	I-195W	4050	4100	13.8	12	14	88.41	68.04	90.70
8	I-195W	4100	4150	0	0	0	88.60	62.86	65.15
8	I-195W	4150	4200	0	0	0	75.34	45.01	61.33
8	I-195W	4200	4250	0	0	0	53.23	38.65	48.84
8	I-195W	4250	4300	0	0	0	44.69	172.07	39.71
8	I-195W	4300	4350	0	0	0	175.30	95.45	163.43
8	I-195W	4350	4400	0	0	0	95.10	55.14	98.66
8	I-195W	4400	4450	0	0	0	50.48	54.11	50.21
8	I-195W	4450	4500	0	0	0	47.64	84.24	52.15
9	I-195W	4500	4550	0	0.6	0.2	70.77	92.51	71.53
9	I-195W	4550	4600	0	0	0	90.46	74.38	86.32
9	I-195W	4600	4650	0	0	0	86.00	103.91	70.28
9	I-195W	4650	4700	0	0	0	95.23	76.90	100.84
9	I-195W	4700	4750	0	0	0	82.99	63.44	82.64
9	I-195W	4750	4800	0	0	0	58.22	102.58	55.78
9	I-195W	4800	4850	0	0	0	87.37	116.07	99.04
9	I-195W	4850	4900	0	0	0	116.82	57.82	115.69
9	I-195W	4900	4950	0	0	0	59.66	70.65	57.43
9	I-195W	4950	5000	0	0	0	76.95	37.55	64.78

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
10	NJ 55S	1000	1050	21.8	20.4	20	47.05	49.29	36.67
10	NJ 55S	1050	1100	18.8	18.2	19.8	72.29	67.85	74.29
10	NJ 55S	1100	1150	23.2	25	25.2	69.41	73.73	49.42
10	NJ 55S	1150	1200	19.2	17.8	17.4	73.85	54.91	50.37
10	NJ 55S	1200	1250	16.8	17.8	15	50.52	50.86	35.85
10	NJ 55S	1250	1300	19.2	20.6	19.6	66.43	58.88	61.52
10	NJ 55S	1300	1350	21.4	16.8	19.6	75	80.42	70.33
10	NJ 55S	1350	1400	23.6	24	24.6	66.17	73.21	68.12
10	NJ 55S	1400	1450	16	13	16	85.48	78.34	79.35
10	NJ 55S	1450	1500	14.4	15.8	15	69.94	72.39	74.54
11	NJ 55S	1500	1550	6.8	5.6	6.2	49.38	53.3	44.27
11	NJ 55S	1550	1600	0	0	0	53.68	48.76	50.44
11	NJ 55S	1600	1650	0	0	0	56.37	51.52	56.62
11	NJ 55S	1650	1700	0	0	0	82.78	83.08	87.47
11	NJ 55S	1700	1750	0	0	0	65.47	67.06	67.63
11	NJ 55S	1750	1800	0	0	0	55.6	49.41	48.53
11	NJ 55S	1800	1850	0	0	0	56.35	48.11	43.09
11	NJ 55S	1850	1900	0	0	0	38.97	45.33	42.36
11	NJ 55S	1900	1950	0	0	0	46.75	56.44	48.03
11	NJ 55S	1950	2000	0	0	0	57.19	56.05	63.54
12	NJ 55S	2000	2050	0.4	0.4	0.2	76.07	84.08	69.21
12	NJ 55S	2050	2100	0	0	0	65.2	72.98	53.06
12	NJ 55S	2100	2150	0	0	0	64.5	62.87	66.8

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
12	NJ 55S	2150	2200	0	0	0	81.9	81.61	75.35
12	NJ 55S	2200	2250	0	0	0	48.94	55.09	49.32
12	NJ 55S	2250	2300	0	0	0	61.7	64.17	68.11
12	NJ 55S	2300	2350	0	0	0	64.19	60.63	62.12
12	NJ 55S	2350	2400	0	0	0	48.65	52.49	47.11
12	NJ 55S	2400	2450	0	0	0	48.32	49.89	50.68
12	NJ 55S	2450	2500	0	0	0	40.17	39.41	34.81

Table 26. ARAN 60 mph

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
1	I-195W	0	50	20.8	20.4	22.4	65.27	65.55	75.75
1	I-195W	50	100	24.6	22.8	25.2	182.03	177.90	150.33
1	I-195W	100	150	24.6	24.6	23.6	94.85	100.21	97.96
1	I-195W	150	200	10.4	13.6	12.6	54.78	64.04	80.34
1	I-195W	200	250	0	0	0	109.73	126.42	119.54
1	I-195W	250	300	0	0	0	82.63	84.97	72.80
1	I-195W	300	350	0	0	0	94.89	109.40	108.56
1	I-195W	350	400	0	0	0	99.19	83.73	97.38
1	I-195W	400	450	0	0	0	94.02	89.17	100.00
1	I-195W	450	500	0	0	0	92.52	105.83	97.31
2	I-195W	100	150	0.2	0.8	0.8	94.85	100.21	97.96
2	I-195W	150	200	0	0	0	54.78	64.04	80.34
2	I-195W	200	250	0	0	0	109.73	126.42	119.54
2	I-195W	250	300	0	0	0	82.63	84.97	72.80
2	I-195W	300	350	0	0	0	94.89	109.40	108.56
2	I-195W	350	400	0	0	0	99.19	83.73	97.38

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
2	I-195W	400	450	0	0	0	94.02	89.17	100.00
2	I-195W	450	500	0	0	0	92.52	105.83	97.31
2	I-195W	500	550	0	0	0	94.46	112.65	101.18
2	I-195W	550	600	0	0	0	72.95	65.15	69.34
3	I-195W	100	150	0.8	0.8	0.6	108.73	97.45	109.37
3	I-195W	150	200	0	0	0	43.84	53.91	70.88
3	I-195W	200	250	0	0	0	113.77	102.57	115.42
3	I-195W	250	300	0	0	0	76.47	108.32	79.08
3	I-195W	300	350	0	0	0	173.33	147.62	168.32
3	I-195W	350	400	0	0	0	81.55	95.01	92.76
3	I-195W	400	450	0	0	0	92.95	111.82	98.28
3	I-195W	450	500	0	0	0	121.03	104.8	106.3
3	I-195W	500	550	0	0	0	104.26	84.75	90.42
3	I-195W	550	600	0	0	0	67.89	99.35	73.06
4	I-195W	200	250	0.2	0.4	0.4	109.73	126.42	119.54
4	I-195W	250	300	0	0	0	82.63	84.97	72.80
4	I-195W	300	350	0	0	0	94.89	109.40	108.56
4	I-195W	350	400	0	0	0	99.19	83.73	97.38
4	I-195W	400	450	0	0	0	94.02	89.17	100.00
4	I-195W	450	500	0	0	0	92.52	105.83	97.31
4	I-195W	500	550	0	0	0	94.46	112.65	101.18
4	I-195W	550	600	0	0	0	72.95	65.15	69.34
4	I-195W	600	650	0	0	0	113.38	105.95	104.02
4	I-195W	650	700	0	0	0	182.82	78.51	103.32
5	I-195W	2500	2550	0.4	0.4	0.4	77.61	96.47	70.94
5	I-195W	2550	2600	0	0	0	122.27	103.90	124.98
5	I-195W	2600	2650	0	0	0	108.89	103.54	103.36

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
5	I-195W	2650	2700	0	0	0	92.68	97.97	95.51
5	I-195W	2700	2750	0	0	0	111.76	113.23	121.97
5	I-195W	2750	2800	0	0	0	82.75	81.15	73.36
5	I-195W	2800	2850	0	0	0	54.47	58.06	77.53
5	I-195W	2850	2900	0	0	0	74.51	61.96	63.01
5	I-195W	2900	2950	0	0	0	90.32	96.75	111.83
5	I-195W	2950	3000	0	0	0	87.00	92.21	81.97
6	I-195W	2600	2650	13	11	10	108.89	103.54	103.36
6	I-195W	2650	2700	0	0	0	92.68	97.97	95.51
6	I-195W	2700	2750	0	0	0	111.76	113.23	121.97
6	I-195W	2750	2800	0	0	0	82.75	81.15	73.36
6	I-195W	2800	2850	0	0	0	54.47	58.06	77.53
6	I-195W	2850	2900	0	0	0	74.51	61.96	63.01
6	I-195W	2900	2950	0	0	0	90.32	96.75	111.83
6	I-195W	2950	3000	0	0	0	87.00	92.21	81.97
6	I-195W	3000	3050	0	0	0	113.67	73.15	101.91
6	I-195W	3050	3100	0	0	0	88.57	126.64	170.29
7	I-195W	1900	1950	0.6	0.2	0.4	62.94	57.17	60.15
7	I-195W	1950	2000	0	0	0	127.96	131.85	132.21
7	I-195W	2000	2050	0	0	0	135.25	120.44	113.04
7	I-195W	2050	2100	0	0	0	87.95	92.12	78.73
7	I-195W	2100	2150	0	0	0	107.57	106.23	102.70
7	I-195W	2150	2200	0	0	0	146.70	133.54	141.84
7	I-195W	2200	2250	0	0	0	108.63	137.22	117.60
7	I-195W	2250	2300	0	0	0	157.18	144.48	161.03
7	I-195W	2300	2350	0	0	0	131.95	121.08	108.38
7	I-195W	2350	2400	0	0	0	78.19	64.66	60.88

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
8	I-195W	4000	4050	23.2	21.4	24.6	87.65	82.07	90.67
8	I-195W	4050	4100	14.4	14	14.4	90.95	101.63	90.29
8	I-195W	4100	4150	0	0	0	72.91	62.08	76.71
8	I-195W	4150	4200	0	0	0	77.48	72.68	87.88
8	I-195W	4200	4250	0	0	0	71.68	38.05	62.12
8	I-195W	4250	4300	0	0	0	39.76	50.10	46.21
8	I-195W	4300	4350	0	0	0	173.82	163.06	162.50
8	I-195W	4350	4400	0	0	0	103.96	100.55	95.77
8	I-195W	4400	4450	0	0	0	56.22	56.58	73.40
8	I-195W	4450	4500	0	0	0	60.50	56.29	54.83
9	I-195W	4500	4550	0.8	0.8	0.6	61.13	75.77	74.05
9	I-195W	4550	4600	0	0	0	98.44	96.32	92.89
9	I-195W	4600	4650	0	0	0	78.40	80.78	70.52
9	I-195W	4650	4700	0	0	0	91.98	100.32	101.16
9	I-195W	4700	4750	0	0	0	70.50	89.04	102.45
9	I-195W	4750	4800	0	0	0	47.36	58.27	68.43
9	I-195W	4800	4850	0	0	0	111.79	91.95	94.05
9	I-195W	4850	4900	0	0	0	105.95	119.26	103.60
9	I-195W	4900	4950	0	0	0	64.09	60.03	79.84
9	I-195W	4950	5000	0	0	0	69.95	69.11	66.30
10	NJ 55S	1000	1050	19.8	21	19.2	44.04	40.37	45.77
10	NJ 55S	1050	1100	18.2	20.2	18	66	72.15	62.54
10	NJ 55S	1100	1150	25.4	22.6	25	49.4	48.86	52.3
10	NJ 55S	1150	1200	18.8	17.4	16.6	50.9	74.53	46.32
10	NJ 55S	1200	1250	18.2	17.8	15.8	50.05	39.95	57.09
10	NJ 55S	1250	1300	17	20.8	19.4	59.75	83.39	62.82
10	NJ 55S	1300	1350	20.8	18.6	21	70.76	75.77	73.25
10	NJ 55S	1350	1400	25.2	23.2	24.8	66.01	78.69	68.53

Section Number	Highway Number	From (ft)	To (ft)	%DL			IRI		
				Run 1	Run 2	Run3	Run 1	Run 2	Run3
10	NJ 55S	1400	1450	18.6	18.8	18.4	74.38	69.94	78.25
10	NJ 55S	1450	1500	18.6	14.2	19	75.53	78.88	81.23
11	NJ 55S	1500	1550	7.2	8	7	52.78	54.65	53.61
11	NJ 55S	1550	1600	0	0	0	37.42	52.88	58.03
11	NJ 55S	1600	1650	0	0	0	59.66	57.04	58.28
11	NJ 55S	1650	1700	0	0	0	78.55	81.8	86
11	NJ 55S	1700	1750	0	0	0	73.14	73.06	78.41
11	NJ 55S	1750	1800	0	0	0	52.34	43.42	49.16
11	NJ 55S	1800	1850	0	0	0	52.82	78.87	56.04
11	NJ 55S	1850	1900	0	0	0	94.8	61.04	76.53
11	NJ 55S	1900	1950	0	0	0	61.19	56.33	62.8
11	NJ 55S	1950	2000	0	0	0	73.98	87.82	61.29
12	NJ 55S	2000	2050	0.4	0.4	0.4	65.26	68.23	74.11
12	NJ 55S	2050	2100	0	0	0	72.44	65.68	74.06
12	NJ 55S	2100	2150	0	0	0	71.92	87.29	71.41
12	NJ 55S	2150	2200	0	0	0	70.32	71.27	66.47
12	NJ 55S	2200	2250	0	0	0	53.97	35.89	47.34
12	NJ 55S	2250	2300	0	0	0	71.01	70.47	60.01
12	NJ 55S	2300	2350	0	0	0	64.65	47.44	52.31
12	NJ 55S	2350	2400	0	0	0	57.54	58.91	59.95
12	NJ 55S	2400	2450	0	0	0	63.85	52.81	42.97
12	NJ 55S	2450	2500	0	0	0	62.37	46.34	43.82

Table 27. KJ Law Full

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
1	I-195W	0	50	10.6	10	9.8	10	10.2	2.51	2.35	2.47	2.47	2.46
1	I-195W	50	100	0	0	0	0	0	1.58	1.81	1.72	1.75	1.74
1	I-195W	100	150	0	0	0	0	0	0.84	0.88	0.9	0.96	0.93
1	I-195W	150	200	0	0	0	0	0	1.09	1.19	1.19	1.45	1.45
1	I-195W	200	250	0	0	0	0	0	1.79	1.09	1.86	1.89	1.92
1	I-195W	250	300	0	0	0	0	0	1.5	2.04	1.71	1.81	1.69
1	I-195W	300	350	0	0	0	0	0	1.33	1.42	1.31	1.38	1.35
1	I-195W	350	400	0	0	0	0	0	1.25	1.22	1.19	1.21	1.17
1	I-195W	400	450	0	0	0	0	0	1.74	1.79	1.76	1.77	1.78
1	I-195W	450	500	0	0	0	0	0	1.72	2.09	1.73	1.8	1.96
2	I-195W	100	150	26.2	23.4	25.8	26.6	25.2	0.84	0.88	0.9	0.96	0.93
2	I-195W	150	200	0	0	0	0	0	1.09	1.19	1.19	1.45	1.45
2	I-195W	200	250	0	0	0	0	0	1.79	1.09	1.86	1.89	1.92
2	I-195W	250	300	0	0	0	0	0	1.5	2.04	1.71	1.81	1.69
2	I-195W	300	350	0	0	0	0	0	1.33	1.42	1.31	1.38	1.35
2	I-195W	350	400	0	0	0	0	0	1.25	1.22	1.19	1.21	1.17
2	I-195W	400	450	0	0	0	0	0	1.74	1.79	1.76	1.77	1.78
2	I-195W	450	500	0	0	0	0	0	1.72	2.09	1.73	1.8	1.96
2	I-195W	500	550	0	0	0	0	0	1.28	1.55	1.29	1.33	1.45
2	I-195W	550	600	0	0	0	0	0	0.84	0.74	0.8	0.8	0.73
3	I-195W	100	150	24.4	25	24.2	23.2	24.2	0.79	0.99	0.91	0.97	0.9
3	I-195W	150	200	0	0	0	0	0	1.03	1.15	1.14	1.24	1.16
3	I-195W	200	250	0	0	0	0	0	1.87	2.22	1.84	2.02	2.03

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
3	I-195W	250	300	0	0	0	0	0	2.76	3.56	2.88	2.89	2.19
3	I-195W	300	350	0	0	0	0	0	1.14	1.52	1.14	1.16	1.18
3	I-195W	350	400	0	0	0	0	0	1.19	1.43	1.29	1.34	1.36
3	I-195W	400	450	0	0	0	0	0	2.12	2.24	2.12	2.19	2.28
3	I-195W	450	500	0	0	0	0	0	1.75	2.15	1.78	1.87	1.92
3	I-195W	500	550	0	0	0	0	0	1.27	1.22	1.26	1.22	1.19
3	I-195W	550	600	0	0	0	0	0	1.27	1.43	1.31	1.32	1.43
4	I-195W	200	250	56	57	56.4	57	56.4	1.79	1.09	1.86	1.89	1.92
4	I-195W	250	300	0	0	0	0	0	1.5	2.04	1.71	1.81	1.69
4	I-195W	300	350	0	0	0	0	0	1.33	1.42	1.31	1.38	1.35
4	I-195W	350	400	0	0	0	0	0	1.25	1.22	1.19	1.21	1.17
4	I-195W	400	450	0	0	0	0	0	1.74	1.79	1.76	1.77	1.78
4	I-195W	450	500	0	0	0	0	0	1.72	2.09	1.73	1.8	1.96
4	I-195W	500	550	0	0	0	0	0	1.28	1.55	1.29	1.33	1.45
4	I-195W	550	600	0	0	0	0	0	0.84	0.74	0.8	0.8	0.73
4	I-195W	600	650	0	0	0	0	0	1.35	1.54	1.37	1.3	1.48
4	I-195W	650	700	0	0	0	0	0	0.74	0.78	1.08	0.81	0.7
5	I-195W	2500	2550	38.6	38.6	40.2	40.2	40.6	1.29	1.3	1.26	1.23	1.18
5	I-195W	2550	2600	0	0	0	0	0	1.73	1.51	1.56	1.56	1.55
5	I-195W	2600	2650	0	0	0	0	0	1.91	1.75	1.8	1.78	1.8
5	I-195W	2650	2700	0	0	0	0	0	1.9	1.83	1.78	1.75	1.74
5	I-195W	2700	2750	0	0	0	0	0	1.96	1.88	2.02	2.01	1.99
5	I-195W	2750	2800	0	0	0	0	0	1.78	1.69	1.65	1.51	1.68
5	I-195W	2800	2850	0	0	0	0	0	2.07	2.09	2.1	2.15	2.13

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
5	I-195W	2850	2900	0	0	0	0	0	1.54	1.53	1.53	1.5	1.5
5	I-195W	2900	2950	0	0	0	0	0	0.82	1.01	0.9	1	0.92
5	I-195W	2950	3000	0	0	0	0	0	0.99	0.91	0.87	0.91	0.87
6	I-195W	2600	2650	25.4	25	26.4	27	25.4	1.91	1.75	1.8	1.78	1.8
6	I-195W	2650	2700	0	0	0	0	0	1.9	1.83	1.78	1.75	1.74
6	I-195W	2700	2750	0	0	0	0	0	1.96	1.88	2.02	2.01	1.99
6	I-195W	2750	2800	0	0	0	0	0	1.78	1.69	1.65	1.51	1.68
6	I-195W	2800	2850	0	0	0	0	0	2.07	2.09	2.1	2.15	2.13
6	I-195W	2850	2900	0	0	0	0	0	1.54	1.53	1.53	1.5	1.5
6	I-195W	2900	2950	0	0	0	0	0	0.82	1.01	0.9	1	0.92
6	I-195W	2950	3000	0	0	0	0	0	0.99	0.91	0.87	0.91	0.87
6	I-195W	3000	3050	0	0	0	0	0	1.63	1.59	1.64	1.64	1.64
6	I-195W	3050	3100	0	0	0	0	0	1.18	1.41	1.29	1.44	1.5
7	I-195W	1900	1950	55.8	52.4	54	53.6	53.4	1.58	1.75	1.41	1.53	1.5
7	I-195W	1950	2000	0	0	0	0	0	1.14	1.05	1.14	1.08	1.1
7	I-195W	2000	2050	0	0	0	0	0	2.14	2.01	2.18	2.15	2.1
7	I-195W	2050	2100	0	0	0	0	0	1.97	1.82	1.92	1.93	1.89
7	I-195W	2100	2150	0	0	0	0	0	1.13	1.17	1.07	1.09	1.09
7	I-195W	2150	2200	0	0	0	0	0	1.6	1.36	1.5	1.66	1.55
7	I-195W	2200	2250	0	0	0	0	0	1.87	2.14	2.02	2.01	2.02
7	I-195W	2250	2300	0	0	0	0	0	1.97	1.88	1.93	1.96	1.88
7	I-195W	2300	2350	0	0	0	0	0	2.08	2.13	2.13	2.2	2.11
7	I-195W	2350	2400	0	0	0	0	0	1.59	2.01	1.78	1.47	1.84

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
8	I-195W	4000	4050	91.6	92.4	95.8	98.6	91.2	0.6	0.6	0.62	0.51	0.66
8	I-195W	4050	4100	105.2	101.4	100.2	105.4	101.2	0.84	0.59	0.81	0.86	0.82
8	I-195W	4100	4150	106.2	102.2	103.6	100.2	101.6	1.04	1.13	1.01	1.09	1.02
8	I-195W	4150	4200	113.6	113	112	113	111.2	1.58	1.73	1.69	1.67	1.81
8	I-195W	4200	4250	106	106.6	103.6	107.8	105.8	1.94	1.77	1.85	1.85	1.9
8	I-195W	4250	4300	107.8	108.4	107.2	106.8	107	1.15	1.27	1.27	1.09	1.11
8	I-195W	4300	4350	104.8	107.6	105.8	108	103.8	0.96	0.93	1.01	0.9	0.89
8	I-195W	4350	4400	96.8	100	105.4	102.4	102.2	0.8	1.03	0.99	0.84	0.79
8	I-195W	4400	4450	100.4	102.8	105	106.8	106.2	0.53	0.56	0.54	0.57	0.54
8	I-195W	4450	4500	91.8	92.4	93	91	89.2	2.38	2.05	2.46	2.52	2.45
9	I-195W	4500	4550	111.8	115.2	110.2	114	111.8	2.11	2.3	2.1	2.07	2.09
9	I-195W	4550	4600	95.2	98	99.2	99.8	95.6	1.46	1.63	1.38	1.41	1.37
9	I-195W	4600	4650	107	105.2	102	102	105	0.82	0.83	0.87	0.8	0.79
9	I-195W	4650	4700	110.6	111.2	110.6	107.2	108.2	1	0.85	1.01	1.09	0.97
9	I-195W	4700	4750	109.6	105.4	108.6	110	108	1.51	1.48	1.5	1.63	1.55
9	I-195W	4750	4800	102.4	103.6	108	109.2	104.8	1.65	1.63	1.65	1.55	1.61
9	I-195W	4800	4850	102.6	102.8	104.4	104.4	103.8	1.27	1.38	1.34	1.43	1.27
9	I-195W	4850	4900	106.2	102.8	106.6	107.8	106.8	1.5	1.45	1.75	1.68	1.53
9	I-195W	4900	4950	106.2	101.2	102.8	99.4	104.2	1.29	1.36	1.21	1.32	1.24
9	I-195W	4950	5000	79.6	83.8	85	83.4	83	0.9	0.78	0.87	0.9	0.85
10	NJ 55S	1000	1050	4.2	2.6	3.2	4.6	3.2	1.29	1.21	1.28	1.31	1.21
10	NJ 55S	1050	1100	0	0	0	0	0	1.12	1.08	1.15	1.14	1.15
10	NJ 55S	1100	1150	0	0	0	0	0	1.26	1.28	1.27	1.3	1.22
10	NJ 55S	1150	1200	0	0	0	0	0	1.49	1.48	1.47	1.43	1.49

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
10	NJ 55S	1200	1250	0	0	0	0	0	0.83	0.91	0.85	0.9	0.86
10	NJ 55S	1250	1300	0	0	0	0	0	0.99	0.96	0.94	0.93	0.96
10	NJ 55S	1300	1350	0	0	0	0	0	1.51	1.49	1.43	1.31	1.48
10	NJ 55S	1350	1400	0	0	0	0	0	1.1	1.11	1.11	1.13	1.16
10	NJ 55S	1400	1450	0	0	0	0	0	0.95	0.89	0.94	0.93	0.93
10	NJ 55S	1450	1500	0	0	0	0	0	0.95	0.95	0.93	0.92	0.92
11	NJ 55S	1500	1550	31.4	32.2	33.6	34	36.2	0.76	0.68	0.81	0.73	0.76
11	NJ 55S	1550	1600	0	0	0	0	0	0.81	0.83	0.81	0.77	0.82
11	NJ 55S	1600	1650	0	0	0	0	0	1.1	1.03	0.96	1.01	0.91
11	NJ 55S	1650	1700	0	0	0	0	0	0.84	0.83	0.9	0.86	0.94
11	NJ 55S	1700	1750	0	0	0	0	0	0.98	0.96	0.93	0.92	0.92
11	NJ 55S	1750	1800	0	0	0	0	0	0.63	0.67	0.73	0.65	0.66
11	NJ 55S	1800	1850	0	0	0	0	0	1.06	1.12	1.12	1.11	1.07
11	NJ 55S	1850	1900	0	0	0	0	0	1.93	1.94	1.88	1.96	1.93
11	NJ 55S	1900	1950	0	0	0	0	0	1.32	1.31	1.2	1.34	1.32
11	NJ 55S	1950	2000	0	0	0	0	0	0.87	0.85	0.88	0.87	0.92
12	NJ 55S	2000	2050	37.6	35	36.6	36.2	35.6	0.87	0.8	0.78	0.8	0.79
12	NJ 55S	2050	2100	0	0	0	0	0	0.7	0.71	0.7	0.71	0.7
12	NJ 55S	2100	2150	0	0	0	0	0	1.15	1.14	1.22	1.18	1.15
12	NJ 55S	2150	2200	0	0	0	0	0	0.97	1.08	1.05	1.06	1.03
12	NJ 55S	2200	2250	0	0	0	0	0	1.79	1.81	1.77	1.78	1.72
12	NJ 55S	2250	2300	0	0	0	0	0	1.17	1.12	1.16	1.1	1.17
12	NJ 55S	2300	2350	0	0	0	0	0	0.68	0.73	0.79	0.71	0.84
12	NJ 55S	2350	2400	0	0	0	0	0	1.26	0.27	1.3	1.31	1.27

Section Number	Highway Number	From (ft)	To (ft)	%DL					IRI (inch/mile)				
				Run 1	Run 2	Run3	Run 4	Run5	Run 1	Run 2	Run3	Run 4	Run5
12	NJ 55S	2400	2450	0	0	0	0	0	0.72	0.7	0.69	0.72	0.8
12	NJ 55S	2450	2500	0	0	0	0	0	0.97	0.93	0.88	0.96	0.95

13.0 APPENDIX C EQUIPMENT REPEATABILITY

Table 28 shows the complete results of the analysis performed to evaluate the repeatability of the devices by comparing the repeated runs (pair-wise) for each test section.

Table 28. Equipment Repeatability

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ICC Light Run 1	ICC Light Run 2	1	%DL	H ₁	
ICC Light Run 2	ICC Light Run 3	1	%DL	H ₁	
ICC Light Run 1	ICC Light Run 3	1	%DL	H ₁	
ICC Light Run 1	ICC Light Run 2	2	%DL	H ₁	
ICC Light Run 2	ICC Light Run 3	2	%DL	H ₁	
ICC Light Run 1	ICC Light Run 3	2	%DL	H ₁	
ICC Light Run 1	ICC Light Run 2	3	%DL	H ₁	
ICC Light Run 2	ICC Light Run 3	3	%DL	H ₀	
ICC Light Run 1	ICC Light Run 3	3	%DL	H ₀	
ICC Light Run 1	ICC Light Run 2	4	%DL	H ₁	
ICC Light Run 2	ICC Light Run 3	4	%DL	H ₀	
ICC Light Run 1	ICC Light Run 3	4	%DL	H ₀	
ICC Light Run 1	ICC Light Run 2	5	%DL	H ₁	
ICC Light Run 2	ICC Light Run 3	5	%DL	H ₁	
ICC Light Run 1	ICC Light Run 3	5	%DL	H ₁	
ICC Light Run 1	ICC Light Run 2	6	%DL	H ₁	
ICC Light Run 2	ICC Light Run 3	6	%DL	H ₁	
ICC Light Run 1	ICC Light Run 3	6	%DL	H ₀	
ICC Light Run 1	ICC Light Run 2	7	%DL	H ₁	
ICC Light Run 2	ICC Light Run 3	7	%DL	H ₀	
ICC Light Run 1	ICC Light Run 3	7	%DL	H ₁	
ICC Light Run 1	ICC Light Run 2	8	%DL	H ₀	
ICC Light Run 2	ICC Light Run 3	8	%DL	H ₀	
ICC Light Run 1	ICC Light Run 3	8	%DL	H ₁	
ICC Light Run 1	ICC Light Run 2	9	%DL	H ₁	
ICC Light Run 2	ICC Light Run 3	9	%DL	H ₀	
ICC Light Run 1	ICC Light Run 3	9	%DL	H ₁	
ICC Light Run 1	ICC Light Run 2	10	%DL	H ₀	
ICC Light Run 2	ICC Light Run 3	10	%DL	H ₀	
ICC Light Run 1	ICC Light Run 3	10	%DL	H ₀	
ICC Light Run 1	ICC Light Run 2	11	%DL	H ₀	
ICC Light Run 2	ICC Light Run 3	11	%DL	H ₀	
ICC Light Run 1	ICC Light Run 3	11	%DL	H ₀	
ICC Light Run 1	ICC Light Run 2	12	%DL	H ₀	
ICC Light Run 2	ICC Light Run 3	12	%DL	H ₀	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ICC Light Run 1	ICC Light Run 3	12	%DL	H ₀	
KJL Light Run 1	KJL Light Run 2	1	%DL	H ₁	
KJL Light Run 2	KJL Light Run 3	1	%DL	H ₀	
KJL Light Run 1	KJL Light Run 3	1	%DL	H ₁	
KJL Light Run 1	KJL Light Run 2	2	%DL	H ₁	
KJL Light Run 2	KJL Light Run 3	2	%DL	H ₀	
KJL Light Run 1	KJL Light Run 3	2	%DL	H ₁	
KJL Light Run 1	KJL Light Run 2	3	%DL	H ₁	
KJL Light Run 2	KJL Light Run 3	3	%DL	H ₁	
KJL Light Run 1	KJL Light Run 3	3	%DL	H ₁	
KJL Light Run 1	KJL Light Run 2	4	%DL	H ₀	
KJL Light Run 2	KJL Light Run 3	4	%DL	H ₀	
KJL Light Run 1	KJL Light Run 3	4	%DL	H ₀	
KJL Light Run 1	KJL Light Run 2	5	%DL	H ₁	
KJL Light Run 2	KJL Light Run 3	5	%DL	H ₀	
KJL Light Run 1	KJL Light Run 3	5	%DL	H ₁	
KJL Light Run 1	KJL Light Run 2	6	%DL	H ₁	
KJL Light Run 2	KJL Light Run 3	6	%DL	H ₁	
KJL Light Run 1	KJL Light Run 3	6	%DL	H ₁	
KJL Light Run 1	KJL Light Run 2	7	%DL	H ₁	
KJL Light Run 2	KJL Light Run 3	7	%DL	H ₁	
KJL Light Run 1	KJL Light Run 3	7	%DL	H ₁	
KJL Light Run 1	KJL Light Run 2	8	%DL	H ₀	
KJL Light Run 2	KJL Light Run 3	8	%DL	H ₁	
KJL Light Run 1	KJL Light Run 3	8	%DL	H ₁	
KJL Light Run 1	KJL Light Run 2	9	%DL	H ₁	
KJL Light Run 2	KJL Light Run 3	9	%DL	H ₁	
KJL Light Run 1	KJL Light Run 3	9	%DL	H ₁	
KJL Light Run 1	KJL Light Run 2	10	%DL	H ₀	
KJL Light Run 2	KJL Light Run 3	10	%DL	H ₀	
KJL Light Run 1	KJL Light Run 3	10	%DL	H ₀	
KJL Light Run 1	KJL Light Run 2	11	%DL	H ₀	
KJL Light Run 2	KJL Light Run 3	11	%DL	H ₀	
KJL Light Run 1	KJL Light Run 3	11	%DL	H ₀	
KJL Light Run 1	KJL Light Run 2	12	%DL	H ₀	
KJL Light Run 2	KJL Light Run 3	12	%DL	H ₀	
KJL Light Run 1	KJL Light Run 3	12	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 2	1	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 3	1	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 4	1	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 5	1	%DL	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN40 Run 2	ARAN40 Run 3	1	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 4	1	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 5	1	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 4	1	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 5	1	%DL	H ₀	
ARAN40 Run 4	ARAN40 Run 5	1	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 2	1	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	1	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	1	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	1	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	1	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	1	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	1	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	1	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	1	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	1	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	2	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 3	2	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 4	2	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 5	2	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 3	2	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 4	2	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 5	2	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 4	2	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 5	2	%DL	H ₁	
ARAN40 Run 4	ARAN40 Run 5	2	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 2	2	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	2	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	2	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	2	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	2	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	2	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	2	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	2	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	2	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	2	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	3	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 3	3	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 4	3	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 5	3	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 3	3	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 4	3	%DL	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN40 Run 2	ARAN40 Run 5	3	%DL	H ₀	
ARAN40 Run 3	ARAN40 Run 4	3	%DL	H ₀	
ARAN40 Run 3	ARAN40 Run 5	3	%DL	H ₀	
ARAN40 Run 4	ARAN40 Run 5	3	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 2	3	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	3	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	3	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	3	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	3	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	3	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	3	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	3	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	3	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	3	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	4	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 3	4	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 4	4	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 5	4	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 3	4	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 4	4	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 5	4	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 4	4	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 5	4	%DL	H ₁	
ARAN40 Run 4	ARAN40 Run 5	4	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 2	4	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	4	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	4	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	4	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	4	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	4	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	4	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	4	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	4	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	4	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	5	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 3	5	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 4	5	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 5	5	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 3	5	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 4	5	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 5	5	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 4	5	%DL	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN40 Run 3	ARAN40 Run 5	5	%DL	H ₁	
ARAN40 Run 4	ARAN40 Run 5	5	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 2	5	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	5	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	5	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	5	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	5	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	5	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	5	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	5	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	5	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	5	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	6	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 3	6	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 4	6	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 5	6	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 3	6	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 4	6	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 5	6	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 4	6	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 5	6	%DL	H ₀	
ARAN40 Run 4	ARAN40 Run 5	6	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 2	6	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	6	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	6	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	6	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	6	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	6	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	6	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	6	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	6	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	6	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	7	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 3	7	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 4	7	%DL	H ₁	
ARAN40 Run 1	ARAN40 Run 5	7	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 3	7	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 4	7	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 5	7	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 4	7	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 5	7	%DL	H ₁	
ARAN40 Run 4	ARAN40 Run 5	7	%DL	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN40 Run 1	ARAN40 Run 2	7	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	7	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	7	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	7	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	7	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	7	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	7	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	7	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	7	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	7	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	8	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 3	8	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 4	8	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 5	8	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 3	8	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 4	8	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 5	8	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 4	8	%DL	H ₀	
ARAN40 Run 3	ARAN40 Run 5	8	%DL	H ₀	
ARAN40 Run 4	ARAN40 Run 5	8	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 2	8	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	8	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	8	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	8	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	8	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	8	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	8	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	8	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	8	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	8	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	9	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 3	9	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 4	9	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 5	9	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 3	9	%DL	H ₁	
ARAN40 Run 2	ARAN40 Run 4	9	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 5	9	%DL	H ₀	
ARAN40 Run 3	ARAN40 Run 4	9	%DL	H ₁	
ARAN40 Run 3	ARAN40 Run 5	9	%DL	H ₀	
ARAN40 Run 4	ARAN40 Run 5	9	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 2	9	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	9	IRI	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN40 Run 1	ARAN40 Run 4	9	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	9	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	9	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	9	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	9	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	9	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	9	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	9	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	10	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 3	10	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 4	10	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 5	10	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 3	10	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 4	10	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 5	10	%DL	H ₀	
ARAN40 Run 3	ARAN40 Run 4	10	%DL	H ₀	
ARAN40 Run 3	ARAN40 Run 5	10	%DL	H ₀	
ARAN40 Run 4	ARAN40 Run 5	10	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 2	10	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	10	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	10	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	10	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	10	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	10	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	10	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	10	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	10	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	10	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	11	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 3	11	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 4	11	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 5	11	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 3	11	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 4	11	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 5	11	%DL	H ₀	
ARAN40 Run 3	ARAN40 Run 4	11	%DL	H ₀	
ARAN40 Run 3	ARAN40 Run 5	11	%DL	H ₀	
ARAN40 Run 4	ARAN40 Run 5	11	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 2	11	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	11	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	11	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	11	IRI	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN40 Run 2	ARAN40 Run 3	11	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	11	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	11	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	11	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	11	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	11	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 2	12	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 3	12	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 4	12	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 5	12	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 3	12	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 4	12	%DL	H ₀	
ARAN40 Run 2	ARAN40 Run 5	12	%DL	H ₀	
ARAN40 Run 3	ARAN40 Run 4	12	%DL	H ₀	
ARAN40 Run 3	ARAN40 Run 5	12	%DL	H ₀	
ARAN40 Run 4	ARAN40 Run 5	12	%DL	H ₀	
ARAN40 Run 1	ARAN40 Run 2	12	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 3	12	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 4	12	IRI	H ₁	
ARAN40 Run 1	ARAN40 Run 5	12	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 3	12	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 4	12	IRI	H ₁	
ARAN40 Run 2	ARAN40 Run 5	12	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 4	12	IRI	H ₁	
ARAN40 Run 3	ARAN40 Run 5	12	IRI	H ₁	
ARAN40 Run 4	ARAN40 Run 5	12	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	1	%DL	H ₁	
ARAN50 Run 1	ARAN50 Run 3	1	%DL	H ₁	
ARAN50 Run 2	ARAN50 Run 3	1	%DL	H ₁	
ARAN50 Run 1	ARAN50 Run 2	1	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 3	1	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	1	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	2	%DL	H ₁	
ARAN50 Run 1	ARAN50 Run 3	2	%DL	H ₀	
ARAN50 Run 2	ARAN50 Run 3	2	%DL	H ₁	
ARAN50 Run 1	ARAN50 Run 2	2	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 3	2	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	2	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	3	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 3	3	%DL	H ₀	
ARAN50 Run 2	ARAN50 Run 3	3	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 2	3	IRI	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN50 Run 1	ARAN50 Run 3	3	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	3	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	4	%DL	H ₁	
ARAN50 Run 1	ARAN50 Run 3	4	%DL	H ₁	
ARAN50 Run 2	ARAN50 Run 3	4	%DL	H ₁	
ARAN50 Run 1	ARAN50 Run 2	4	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 3	4	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	4	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	5	%DL	H ₁	
ARAN50 Run 1	ARAN50 Run 3	5	%DL	H ₀	
ARAN50 Run 2	ARAN50 Run 3	5	%DL	H ₁	
ARAN50 Run 1	ARAN50 Run 2	5	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 3	5	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	5	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	6	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 3	6	%DL	H ₀	
ARAN50 Run 2	ARAN50 Run 3	6	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 2	6	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 3	6	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	6	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	7	%DL	H ₁	
ARAN50 Run 1	ARAN50 Run 3	7	%DL	H ₀	
ARAN50 Run 2	ARAN50 Run 3	7	%DL	H ₁	
ARAN50 Run 1	ARAN50 Run 2	7	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 3	7	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	7	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	8	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 3	8	%DL	H ₀	
ARAN50 Run 2	ARAN50 Run 3	8	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 2	8	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 3	8	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	8	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	9	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 3	9	%DL	H ₀	
ARAN50 Run 2	ARAN50 Run 3	9	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 2	9	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 3	9	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	9	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	10	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 3	10	%DL	H ₀	
ARAN50 Run 2	ARAN50 Run 3	10	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 2	10	IRI	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN50 Run 1	ARAN50 Run 3	10	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	10	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	11	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 3	11	%DL	H ₀	
ARAN50 Run 2	ARAN50 Run 3	11	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 2	11	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 3	11	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	11	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 2	12	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 3	12	%DL	H ₀	
ARAN50 Run 2	ARAN50 Run 3	12	%DL	H ₀	
ARAN50 Run 1	ARAN50 Run 2	12	IRI	H ₁	
ARAN50 Run 1	ARAN50 Run 3	12	IRI	H ₁	
ARAN50 Run 2	ARAN50 Run 3	12	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	1	%DL	H ₁	
ARAN60 Run 1	ARAN60 Run 3	1	%DL	H ₁	
ARAN60 Run 2	ARAN60 Run 3	1	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 2	1	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 3	1	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	1	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	2	%DL	H ₁	
ARAN60 Run 1	ARAN60 Run 3	2	%DL	H ₁	
ARAN60 Run 2	ARAN60 Run 3	2	%DL	H ₁	
ARAN60 Run 1	ARAN60 Run 2	2	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 3	2	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	2	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	3	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 3	3	%DL	H ₀	
ARAN60 Run 2	ARAN60 Run 3	3	%DL	H ₁	
ARAN60 Run 1	ARAN60 Run 2	3	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 3	3	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	3	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	4	%DL	H ₁	
ARAN60 Run 1	ARAN60 Run 3	4	%DL	H ₀	
ARAN60 Run 2	ARAN60 Run 3	4	%DL	H ₁	
ARAN60 Run 1	ARAN60 Run 2	4	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 3	4	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	4	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	5	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 3	5	%DL	H ₀	
ARAN60 Run 2	ARAN60 Run 3	5	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 2	5	IRI	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN60 Run 1	ARAN60 Run 3	5	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	5	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	6	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 3	6	%DL	H ₀	
ARAN60 Run 2	ARAN60 Run 3	6	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 2	6	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 3	6	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	6	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	7	%DL	H ₁	
ARAN60 Run 1	ARAN60 Run 3	7	%DL	H ₁	
ARAN60 Run 2	ARAN60 Run 3	7	%DL	H ₁	
ARAN60 Run 1	ARAN60 Run 2	7	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 3	7	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	7	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	8	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 3	8	%DL	H ₀	
ARAN60 Run 2	ARAN60 Run 3	8	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 2	8	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 3	8	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	8	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	9	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 3	9	%DL	H ₀	
ARAN60 Run 2	ARAN60 Run 3	9	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 2	9	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 3	9	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	9	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	10	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 3	10	%DL	H ₀	
ARAN60 Run 2	ARAN60 Run 3	10	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 2	10	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 3	10	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	10	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	11	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 3	11	%DL	H ₀	
ARAN60 Run 2	ARAN60 Run 3	11	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 2	11	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 3	11	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	11	IRI	H ₁	
ARAN60 Run 1	ARAN60 Run 2	12	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 3	12	%DL	H ₀	
ARAN60 Run 2	ARAN60 Run 3	12	%DL	H ₀	
ARAN60 Run 1	ARAN60 Run 2	12	IRI	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN60 Run 1	ARAN60 Run 3	12	IRI	H ₁	
ARAN60 Run 2	ARAN60 Run 3	12	IRI	H ₁	
KJF Run 1	KJF Run 2	1	%DL	H ₀	
KJF Run 1	KJF Run 3	1	%DL	H ₀	
KJF Run 1	KJF Run 4	1	%DL	H ₀	
KJF Run 1	KJF Run 5	1	%DL	H ₀	
KJF Run 2	KJF Run 3	1	%DL	H ₀	
KJF Run 2	KJF Run 4	1	%DL	H ₀	
KJF Run 2	KJF Run 5	1	%DL	H ₀	
KJF Run 3	KJF Run 4	1	%DL	H ₀	
KJF Run 3	KJF Run 5	1	%DL	H ₀	
KJF Run 4	KJF Run 5	1	%DL	H ₀	
KJF Run 1	KJF Run 2	1	IRI	H ₁	
KJF Run 1	KJF Run 3	1	IRI	H ₁	
KJF Run 1	KJF Run 4	1	IRI	H ₁	
KJF Run 1	KJF Run 5	1	IRI	H ₁	
KJF Run 2	KJF Run 3	1	IRI	H ₁	
KJF Run 2	KJF Run 4	1	IRI	H ₁	
KJF Run 2	KJF Run 5	1	IRI	H ₁	
KJF Run 3	KJF Run 4	1	IRI	H ₁	
KJF Run 3	KJF Run 5	1	IRI	H ₁	
KJF Run 4	KJF Run 5	1	IRI	H ₁	
KJF Run 1	KJF Run 2	2	%DL	H ₀	
KJF Run 1	KJF Run 3	2	%DL	H ₀	
KJF Run 1	KJF Run 4	2	%DL	H ₀	
KJF Run 1	KJF Run 5	2	%DL	H ₀	
KJF Run 2	KJF Run 3	2	%DL	H ₀	
KJF Run 2	KJF Run 4	2	%DL	H ₀	
KJF Run 2	KJF Run 5	2	%DL	H ₀	
KJF Run 3	KJF Run 4	2	%DL	H ₀	
KJF Run 3	KJF Run 5	2	%DL	H ₀	
KJF Run 4	KJF Run 5	2	%DL	H ₀	
KJF Run 1	KJF Run 2	2	IRI	H ₁	
KJF Run 1	KJF Run 3	2	IRI	H ₁	
KJF Run 1	KJF Run 4	2	IRI	H ₁	
KJF Run 1	KJF Run 5	2	IRI	H ₁	
KJF Run 2	KJF Run 3	2	IRI	H ₁	
KJF Run 2	KJF Run 4	2	IRI	H ₁	
KJF Run 2	KJF Run 5	2	IRI	H ₁	
KJF Run 3	KJF Run 4	2	IRI	H ₁	
KJF Run 3	KJF Run 5	2	IRI	H ₁	
KJF Run 4	KJF Run 5	2	IRI	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
KJF Run 1	KJF Run 2	3	%DL	H ₁	
KJF Run 1	KJF Run 3	3	%DL	H ₁	
KJF Run 1	KJF Run 4	3	%DL	H ₁	
KJF Run 1	KJF Run 5	3	%DL	H ₀	
KJF Run 2	KJF Run 3	3	%DL	H ₁	
KJF Run 2	KJF Run 4	3	%DL	H ₁	
KJF Run 2	KJF Run 5	3	%DL	H ₁	
KJF Run 3	KJF Run 4	3	%DL	H ₀	
KJF Run 3	KJF Run 5	3	%DL	H ₁	
KJF Run 4	KJF Run 5	3	%DL	H ₁	
KJF Run 1	KJF Run 2	3	IRI	H ₁	
KJF Run 1	KJF Run 3	3	IRI	H ₁	
KJF Run 1	KJF Run 4	3	IRI	H ₁	
KJF Run 1	KJF Run 5	3	IRI	H ₁	
KJF Run 2	KJF Run 3	3	IRI	H ₁	
KJF Run 2	KJF Run 4	3	IRI	H ₁	
KJF Run 2	KJF Run 5	3	IRI	H ₁	
KJF Run 3	KJF Run 4	3	IRI	H ₁	
KJF Run 3	KJF Run 5	3	IRI	H ₁	
KJF Run 4	KJF Run 5	3	IRI	H ₁	
KJF Run 1	KJF Run 2	4	%DL	H ₀	
KJF Run 1	KJF Run 3	4	%DL	H ₀	
KJF Run 1	KJF Run 4	4	%DL	H ₁	
KJF Run 1	KJF Run 5	4	%DL	H ₀	
KJF Run 2	KJF Run 3	4	%DL	H ₀	
KJF Run 2	KJF Run 4	4	%DL	H ₀	
KJF Run 2	KJF Run 5	4	%DL	H ₀	
KJF Run 3	KJF Run 4	4	%DL	H ₁	
KJF Run 3	KJF Run 5	4	%DL	H ₀	
KJF Run 4	KJF Run 5	4	%DL	H ₀	
KJF Run 1	KJF Run 2	4	IRI	H ₁	
KJF Run 1	KJF Run 3	4	IRI	H ₁	
KJF Run 1	KJF Run 4	4	IRI	H ₁	
KJF Run 1	KJF Run 5	4	IRI	H ₁	
KJF Run 2	KJF Run 3	4	IRI	H ₁	
KJF Run 2	KJF Run 4	4	IRI	H ₁	
KJF Run 2	KJF Run 5	4	IRI	H ₁	
KJF Run 3	KJF Run 4	4	IRI	H ₁	
KJF Run 3	KJF Run 5	4	IRI	H ₁	
KJF Run 4	KJF Run 5	4	IRI	H ₁	
KJF Run 1	KJF Run 2	5	%DL	H ₁	
KJF Run 1	KJF Run 3	5	%DL	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
KJF Run 1	KJF Run 4	5	%DL	H ₁	
KJF Run 1	KJF Run 5	5	%DL	H ₀	
KJF Run 2	KJF Run 3	5	%DL	H ₁	
KJF Run 2	KJF Run 4	5	%DL	H ₀	
KJF Run 2	KJF Run 5	5	%DL	H ₁	
KJF Run 3	KJF Run 4	5	%DL	H ₁	
KJF Run 3	KJF Run 5	5	%DL	H ₁	
KJF Run 4	KJF Run 5	5	%DL	H ₁	
KJF Run 1	KJF Run 2	5	IRI	H ₁	
KJF Run 1	KJF Run 3	5	IRI	H ₁	
KJF Run 1	KJF Run 4	5	IRI	H ₁	
KJF Run 1	KJF Run 5	5	IRI	H ₁	
KJF Run 2	KJF Run 3	5	IRI	H ₁	
KJF Run 2	KJF Run 4	5	IRI	H ₁	
KJF Run 2	KJF Run 5	5	IRI	H ₁	
KJF Run 3	KJF Run 4	5	IRI	H ₁	
KJF Run 3	KJF Run 5	5	IRI	H ₁	
KJF Run 4	KJF Run 5	5	IRI	H ₁	
KJF Run 1	KJF Run 2	6	%DL	H ₁	
KJF Run 1	KJF Run 3	6	%DL	H ₀	
KJF Run 1	KJF Run 4	6	%DL	H ₀	
KJF Run 1	KJF Run 5	6	%DL	H ₁	
KJF Run 2	KJF Run 3	6	%DL	H ₀	
KJF Run 2	KJF Run 4	6	%DL	H ₀	
KJF Run 2	KJF Run 5	6	%DL	H ₁	
KJF Run 3	KJF Run 4	6	%DL	H ₁	
KJF Run 3	KJF Run 5	6	%DL	H ₁	
KJF Run 4	KJF Run 5	6	%DL	H ₀	
KJF Run 1	KJF Run 2	6	IRI	H ₁	
KJF Run 1	KJF Run 3	6	IRI	H ₁	
KJF Run 1	KJF Run 4	6	IRI	H ₁	
KJF Run 1	KJF Run 5	6	IRI	H ₁	
KJF Run 2	KJF Run 3	6	IRI	H ₁	
KJF Run 2	KJF Run 4	6	IRI	H ₁	
KJF Run 2	KJF Run 5	6	IRI	H ₁	
KJF Run 3	KJF Run 4	6	IRI	H ₁	
KJF Run 3	KJF Run 5	6	IRI	H ₁	
KJF Run 4	KJF Run 5	6	IRI	H ₁	
KJF Run 1	KJF Run 2	7	%DL	H ₁	
KJF Run 1	KJF Run 3	7	%DL	H ₁	
KJF Run 1	KJF Run 4	7	%DL	H ₁	
KJF Run 1	KJF Run 5	7	%DL	H ₀	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
KJF Run 2	KJF Run 3	7	%DL	H ₁	
KJF Run 2	KJF Run 4	7	%DL	H ₁	
KJF Run 2	KJF Run 5	7	%DL	H ₁	
KJF Run 3	KJF Run 4	7	%DL	H ₀	
KJF Run 3	KJF Run 5	7	%DL	H ₁	
KJF Run 4	KJF Run 5	7	%DL	H ₁	
KJF Run 1	KJF Run 2	7	IRI	H ₁	
KJF Run 1	KJF Run 3	7	IRI	H ₁	
KJF Run 1	KJF Run 4	7	IRI	H ₁	
KJF Run 1	KJF Run 5	7	IRI	H ₁	
KJF Run 2	KJF Run 3	7	IRI	H ₁	
KJF Run 2	KJF Run 4	7	IRI	H ₁	
KJF Run 2	KJF Run 5	7	IRI	H ₁	
KJF Run 3	KJF Run 4	7	IRI	H ₁	
KJF Run 3	KJF Run 5	7	IRI	H ₁	
KJF Run 4	KJF Run 5	7	IRI	H ₁	
KJF Run 1	KJF Run 2	8	%DL	H ₀	
KJF Run 1	KJF Run 3	8	%DL	H ₀	
KJF Run 1	KJF Run 4	8	%DL	H ₀	
KJF Run 1	KJF Run 5	8	%DL	H ₀	
KJF Run 2	KJF Run 3	8	%DL	H ₀	
KJF Run 2	KJF Run 4	8	%DL	H ₀	
KJF Run 2	KJF Run 5	8	%DL	H ₀	
KJF Run 3	KJF Run 4	8	%DL	H ₀	
KJF Run 3	KJF Run 5	8	%DL	H ₀	
KJF Run 4	KJF Run 5	8	%DL	H ₀	
KJF Run 1	KJF Run 2	8	IRI	H ₁	
KJF Run 1	KJF Run 3	8	IRI	H ₁	
KJF Run 1	KJF Run 4	8	IRI	H ₁	
KJF Run 1	KJF Run 5	8	IRI	H ₁	
KJF Run 2	KJF Run 3	8	IRI	H ₁	
KJF Run 2	KJF Run 4	8	IRI	H ₁	
KJF Run 2	KJF Run 5	8	IRI	H ₁	
KJF Run 3	KJF Run 4	8	IRI	H ₁	
KJF Run 3	KJF Run 5	8	IRI	H ₁	
KJF Run 4	KJF Run 5	8	IRI	H ₁	
KJF Run 1	KJF Run 2	9	%DL	H ₀	
KJF Run 1	KJF Run 3	9	%DL	H ₀	
KJF Run 1	KJF Run 4	9	%DL	H ₀	
KJF Run 1	KJF Run 5	9	%DL	H ₀	
KJF Run 2	KJF Run 3	9	%DL	H ₀	
KJF Run 2	KJF Run 4	9	%DL	H ₀	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
KJF Run 2	KJF Run 5	9	%DL	H ₀	
KJF Run 3	KJF Run 4	9	%DL	H ₀	
KJF Run 3	KJF Run 5	9	%DL	H ₀	
KJF Run 4	KJF Run 5	9	%DL	H ₀	
KJF Run 1	KJF Run 2	9	IRI	H ₁	
KJF Run 1	KJF Run 3	9	IRI	H ₁	
KJF Run 1	KJF Run 4	9	IRI	H ₁	
KJF Run 1	KJF Run 5	9	IRI	H ₁	
KJF Run 2	KJF Run 3	9	IRI	H ₁	
KJF Run 2	KJF Run 4	9	IRI	H ₁	
KJF Run 2	KJF Run 5	9	IRI	H ₁	
KJF Run 3	KJF Run 4	9	IRI	H ₁	
KJF Run 3	KJF Run 5	9	IRI	H ₁	
KJF Run 4	KJF Run 5	9	IRI	H ₁	
KJF Run 1	KJF Run 2	10	%DL	H ₀	
KJF Run 1	KJF Run 3	10	%DL	H ₀	
KJF Run 1	KJF Run 4	10	%DL	H ₀	
KJF Run 1	KJF Run 5	10	%DL	H ₀	
KJF Run 2	KJF Run 3	10	%DL	H ₀	
KJF Run 2	KJF Run 4	10	%DL	H ₀	
KJF Run 2	KJF Run 5	10	%DL	H ₀	
KJF Run 3	KJF Run 4	10	%DL	H ₀	
KJF Run 3	KJF Run 5	10	%DL	H ₀	
KJF Run 4	KJF Run 5	10	%DL	H ₀	
KJF Run 1	KJF Run 2	10	IRI	H ₁	
KJF Run 1	KJF Run 3	10	IRI	H ₁	
KJF Run 1	KJF Run 4	10	IRI	H ₁	
KJF Run 1	KJF Run 5	10	IRI	H ₁	
KJF Run 2	KJF Run 3	10	IRI	H ₁	
KJF Run 2	KJF Run 4	10	IRI	H ₁	
KJF Run 2	KJF Run 5	10	IRI	H ₀	
KJF Run 3	KJF Run 4	10	IRI	H ₁	
KJF Run 3	KJF Run 5	10	IRI	H ₁	
KJF Run 4	KJF Run 5	10	IRI	H ₀	
KJF Run 1	KJF Run 2	11	%DL	H ₀	
KJF Run 1	KJF Run 3	11	%DL	H ₀	
KJF Run 1	KJF Run 4	11	%DL	H ₀	
KJF Run 1	KJF Run 5	11	%DL	H ₀	
KJF Run 2	KJF Run 3	11	%DL	H ₀	
KJF Run 2	KJF Run 4	11	%DL	H ₀	
KJF Run 2	KJF Run 5	11	%DL	H ₀	
KJF Run 3	KJF Run 4	11	%DL	H ₀	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
KJF Run 3	KJF Run 5	11	%DL	H ₀	
KJF Run 4	KJF Run 5	11	%DL	H ₀	
KJF Run 1	KJF Run 2	11	IRI	H ₁	
KJF Run 1	KJF Run 3	11	IRI	H ₁	
KJF Run 1	KJF Run 4	11	IRI	H ₁	
KJF Run 1	KJF Run 5	11	IRI	H ₁	
KJF Run 2	KJF Run 3	11	IRI	H ₁	
KJF Run 2	KJF Run 4	11	IRI	H ₁	
KJF Run 2	KJF Run 5	11	IRI	H ₁	
KJF Run 3	KJF Run 4	11	IRI	H ₁	
KJF Run 3	KJF Run 5	11	IRI	H ₁	
KJF Run 4	KJF Run 5	11	IRI	H ₁	
KJF Run 1	KJF Run 2	12	%DL	H ₀	
KJF Run 1	KJF Run 3	12	%DL	H ₀	
KJF Run 1	KJF Run 4	12	%DL	H ₀	
KJF Run 1	KJF Run 5	12	%DL	H ₀	
KJF Run 2	KJF Run 3	12	%DL	H ₀	
KJF Run 2	KJF Run 4	12	%DL	H ₀	
KJF Run 2	KJF Run 5	12	%DL	H ₀	
KJF Run 3	KJF Run 4	12	%DL	H ₀	
KJF Run 3	KJF Run 5	12	%DL	H ₀	
KJF Run 4	KJF Run 5	12	%DL	H ₀	
KJF Run 1	KJF Run 2	12	IRI	H ₀	
KJF Run 1	KJF Run 3	12	IRI	H ₁	
KJF Run 1	KJF Run 4	12	IRI	H ₁	
KJF Run 1	KJF Run 5	12	IRI	H ₁	
KJF Run 2	KJF Run 3	12	IRI	H ₀	
KJF Run 2	KJF Run 4	12	IRI	H ₀	
KJF Run 2	KJF Run 5	12	IRI	H ₀	
KJF Run 3	KJF Run 4	12	IRI	H ₁	
KJF Run 3	KJF Run 5	12	IRI	H ₁	
KJF Run 4	KJF Run 5	12	IRI	H ₁	

Table 29. ARAN Speed Results

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN40	ARAN50	1	%DL	H ₁	
ARAN40	ARAN60	1	%DL	H ₁	
ARAN50	ARAN60	1	%DL	H ₁	
ARAN40	ARAN50	1	IRI	H ₁	
ARAN40	ARAN60	1	IRI	H ₁	
ARAN50	ARAN60	1	IRI	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN40	ARAN50	2	%DL	H ₁	
ARAN40	ARAN60	2	%DL	H ₁	
ARAN50	ARAN60	2	%DL	H ₁	
ARAN40	ARAN50	2	IRI	H ₁	
ARAN40	ARAN60	2	IRI	H ₁	
ARAN50	ARAN60	2	IRI	H ₁	
ARAN40	ARAN50	3	%DL	H ₀	
ARAN40	ARAN60	3	%DL	H ₀	
ARAN50	ARAN60	3	%DL	H ₁	
ARAN40	ARAN50	3	IRI	H ₁	
ARAN40	ARAN60	3	IRI	H ₁	
ARAN50	ARAN60	3	IRI	H ₁	
ARAN40	ARAN50	4	%DL	H ₁	
ARAN40	ARAN60	4	%DL	H ₁	
ARAN50	ARAN60	4	%DL	H ₁	
ARAN40	ARAN50	4	IRI	H ₁	
ARAN40	ARAN60	4	IRI	H ₁	
ARAN50	ARAN60	4	IRI	H ₁	
ARAN40	ARAN50	5	%DL	H ₀	
ARAN40	ARAN60	5	%DL	H ₀	
ARAN50	ARAN60	5	%DL	H ₁	
ARAN40	ARAN50	5	IRI	H ₁	
ARAN40	ARAN60	5	IRI	H ₁	
ARAN50	ARAN60	5	IRI	H ₁	
ARAN40	ARAN50	6	%DL	H ₀	
ARAN40	ARAN60	6	%DL	H ₀	
ARAN50	ARAN60	6	%DL	H ₀	
ARAN40	ARAN50	6	IRI	H ₁	
ARAN40	ARAN60	6	IRI	H ₁	
ARAN50	ARAN60	6	IRI	H ₁	
ARAN40	ARAN50	7	%DL	H ₁	
ARAN40	ARAN60	7	%DL	H ₁	
ARAN50	ARAN60	7	%DL	H ₀	
ARAN40	ARAN50	7	IRI	H ₁	
ARAN40	ARAN60	7	IRI	H ₁	
ARAN50	ARAN60	7	IRI	H ₁	
ARAN40	ARAN50	8	%DL	H ₀	
ARAN40	ARAN60	8	%DL	H ₁	
ARAN50	ARAN60	8	%DL	H ₀	
ARAN40	ARAN50	8	IRI	H ₁	
ARAN40	ARAN60	8	IRI	H ₁	
ARAN50	ARAN60	8	IRI	H ₁	

Device 1	Device 2	Test Section	Measure	Conclude	Comments
ARAN40	ARAN50	9	%DL	H ₀	
ARAN40	ARAN60	9	%DL	H ₀	
ARAN50	ARAN60	9	%DL	H ₀	
ARAN40	ARAN50	9	IRI	H ₁	
ARAN40	ARAN60	9	IRI	H ₁	
ARAN50	ARAN60	9	IRI	H ₁	
ARAN40	ARAN50	10	%DL	H ₀	
ARAN40	ARAN60	10	%DL	H ₀	
ARAN50	ARAN60	10	%DL	H ₀	
ARAN40	ARAN50	10	IRI	H ₁	
ARAN40	ARAN60	10	IRI	H ₁	
ARAN50	ARAN60	10	IRI	H ₁	
ARAN40	ARAN50	11	%DL	H ₀	
ARAN40	ARAN60	11	%DL	H ₀	
ARAN50	ARAN60	11	%DL	H ₀	
ARAN40	ARAN50	11	IRI	H ₁	
ARAN40	ARAN60	11	IRI	H ₁	
ARAN50	ARAN60	11	IRI	H ₁	
ARAN40	ARAN50	12	%DL	H ₀	
ARAN40	ARAN60	12	%DL	H ₀	
ARAN50	ARAN60	12	%DL	H ₀	
ARAN40	ARAN50	12	IRI	H ₁	
ARAN40	ARAN60	12	IRI	H ₁	
ARAN50	ARAN60	12	IRI	H ₁	