Laser Scanner: an Iowa DOT evaluation study

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Center for Transportation Research and Education

Presentation Outline

- Introduction
- Testing Plan
- Control sites / Test Sites
- Data
- Data Analysis
- Conclusions

Introduction

- Project funded by:
  - The Iowa DOT
  - FHWA Priority Technology Program
  - MANDLI, Inc contributed staff time
- Interim report completed in April
- Final report will be completed this month

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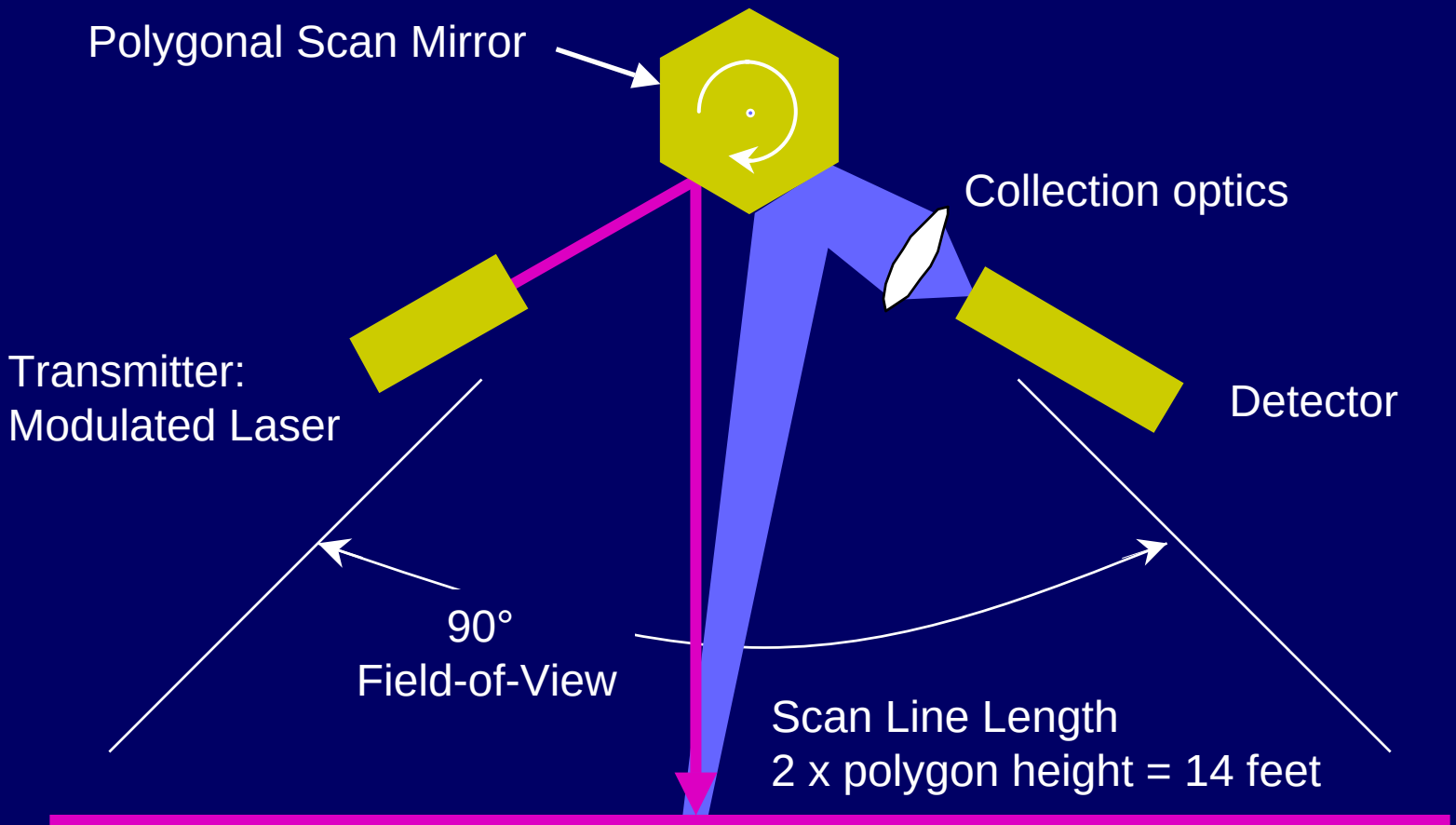
Introduction

- Iowa DOT data collection practices:
  - Service contract with Roadware
  - MANDLI Videolog van
  - Profiler (for new construction and QC/QA)

What is a Laser Scanner?

- A sensor that measures the profile of the pavement along a line
  - Optimized Laser Radar measures range
  - Rotating polygon scans a line
- Software
  - Converts range-angle data to X,Y profile points
  - Analyzes transverse (Rutting) & longitudinal profile

Sensor and Polygon *



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* From Phoenix Scientific Inc (www.phnx-sci.com)

Laser Scanner System

- MANDLI's Pavement Profiler Scanner (PPS) – Developed by Phoenix Scientific
- Uses a phase-measurement laser radar
- Scanner is rear mounted

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Laser Scanner System Features

- Data collection at highway speeds
- 14 feet wide continuous coverage pavement
- 940 points in one transverse scan
- Each scan collected in 1/1000 of a second
- Non-obtrusive system contained within width of vehicle

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Major System Components

- PPS: consists of a

  rotating polygon that directs a Laser radar beam rapidly along a line of the pavement orthogonal to the vehicle's direction of travel. The core of the optical mechanical system is a rotating 6 sided polygon which synchronizes the modulated laser beam and receiver field-of-view as it sweeps the measurement spot through a 90º arc at a constant 1,000 times per second. The resulting profile width is twice the height at which the polygon is mounted. The design point is for a 14 feet (4.3 meter) profile, but this may be adjusted by moving the scanner up or down. The separation between each new profile depends on the vehicle speed.

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From MANDLI, Inc (www.mandli.com)

Major System Components (cont.)

- Scanner Mount
- Distance Measurement Instrument
- System Controller and LCD Monitor

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From MANDLI, Inc (www.mandli.com)

Testing Plan

- Scanner was mounted on the Iowa DOT Videolog van
- The van was updated with new computers and other equipment (GPS unit, DMI, etc…)
- Data collection in July to coincide with Roadware
- Collect IRI and Rutting
- 6 control sites + State DOT routes in 7 counties

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Testing Plan

- Testing direction on two lane roads is from west to east and south to north (primary direction)
- On four or more lane roads, there will be a secondary testing direction (from east to west and north to south)
- The outside lane will be tested in both primary and secondary directions
- The Iowa DOT will conduct the majority of the data collection during the month of July
- The Iowa DOT will be collecting data on the interstate system in Iowa
- The primary system (US and IA routes) in 7 counties (5, 39, 43, 65, 78, 79, and 83) will be collected by both Iowa DOT and Roadware (see Map)
- Roadware will be collecting the majority of I-29 (except Fremont-36), all of I-480 and I-680, I-35 from Polk/Story county border to the Iowa/Minnesota state line, and I-80 in Pottawattamie (78) and Poweshiek (79)

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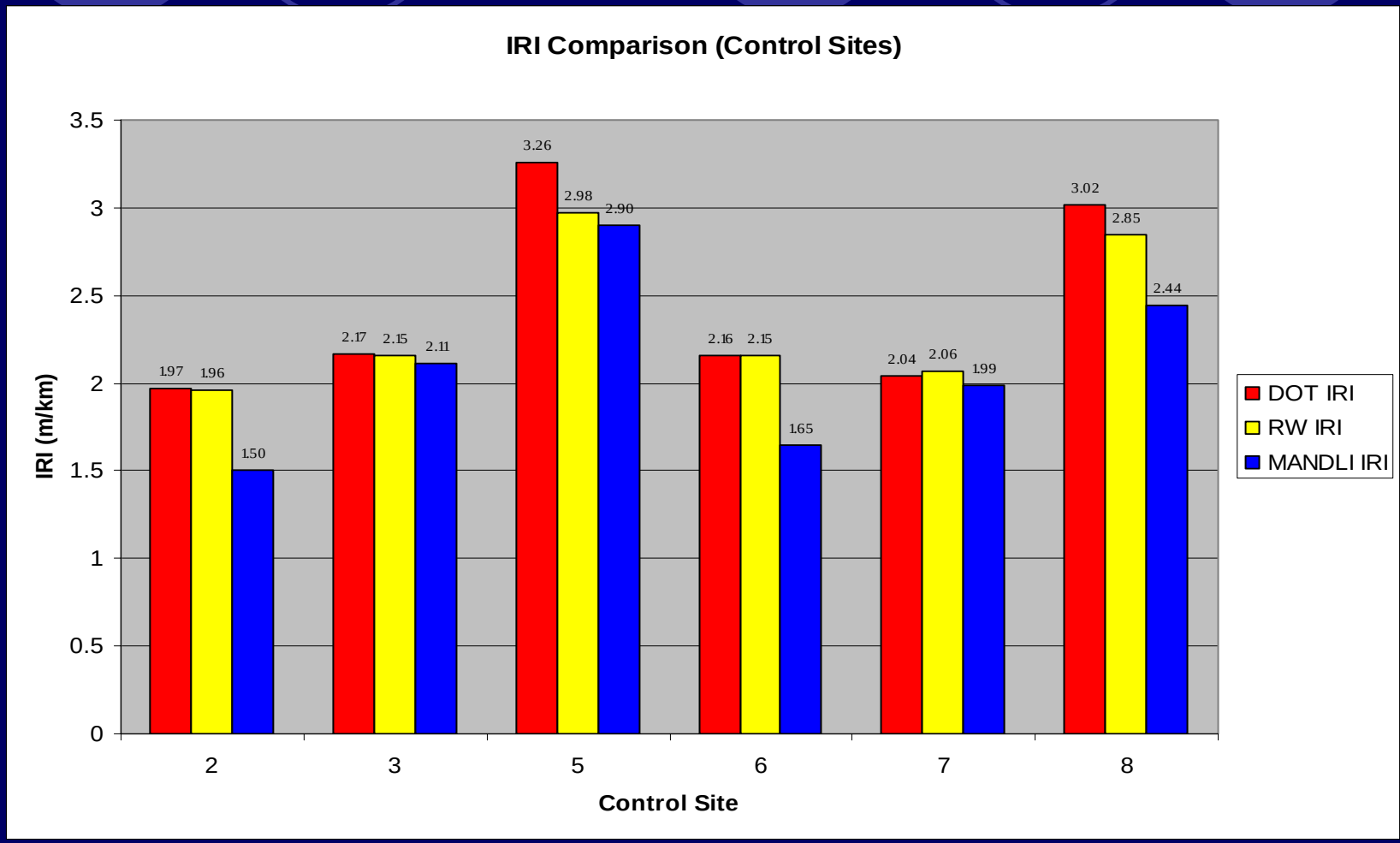
Control Sites

- Six 500 m segments
- Asphalt and concrete
- Collected by:
  - DOT high-speed profiler
  - Roadware (part of the Iowa Pavement Management Program data collection contract)
  - MANDLI PPS system (using their equipment)

Control Sites



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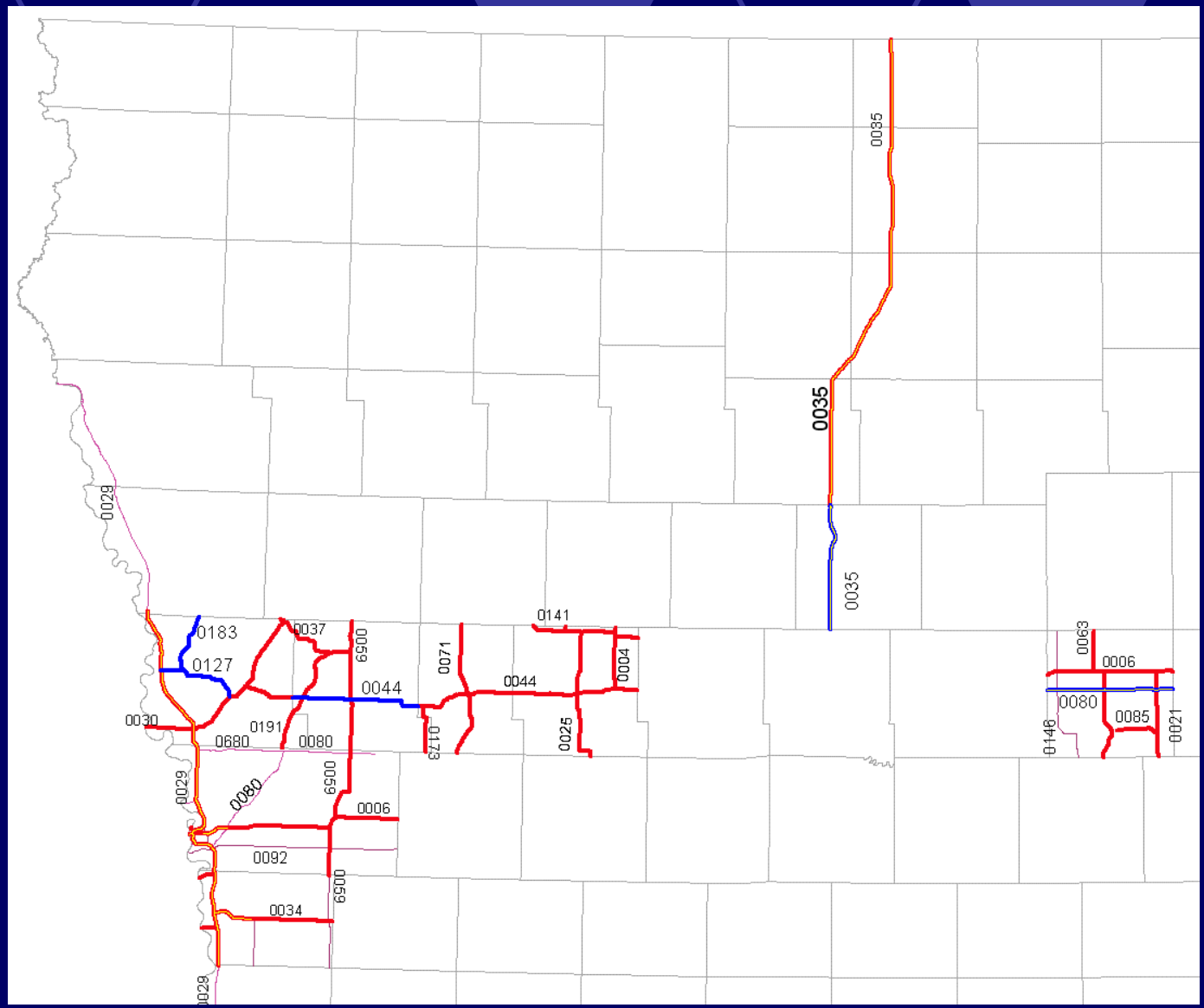
Testing Sites



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Testing Sites

- Approximately 1000 lane miles of interstate, US, and IA highways
- A wide variety of conditions (2003 and 2002 data):
  - PCI range : 90 to 10
  - IRI range : 0.80 to over 3.0
  - Rutting : 0.1 to 15 mm

Data Collection

- IRI and rutting with 100% coverage
- Report data based on 10 m segments
- Tag segments with GPS coordinates

Fmiskey	Length	Rowid	Ipmp_rte	Cover_lgth	Count	Ave_lri	Max_lri	Ave_rri	Max_rri	Ave_lrut	Max_lrut
02911019 07025 4936	335.132	43	0029	0.06	2	1691.4700	1724.21	4086.7500	5531.31	6.7750	7.19
02911025 49032 1765	1000.000	44	0029	1.00	100	2123.5248	9250.93	1887.2133	8810.48	5.0892	18.61
02911025 49032 1765	1000.000	45	0029	1.00	100	1884.3301	6204.04	1799.1137	4870.27	5.3452	11.84
02911025 49032 1765	1000.000	46	0029	1.00	100	1891.1462	7230.54	1840.9671	5519.67	4.6422	10.29
02911025 49032 1765	1000.000	47	0029	1.00	100	1587.0130	5173.22	1803.9645	7914.73	3.7516	9.82
02911025 49032 1765	1000.000	48	0029	0.99	99	2396.5888	6036.69	2522.1221	11734.63	4.6831	17.66
02911025 49032 1765	1000.000	49	0029	1.00	100	2078.5739	5656.27	2343.5079	9923.80	3.9389	9.54
02911025 49032 1765	1000.000	50	0029	1.00	100	1691.2194	6468.89	2524.5634	9382.10	2.8434	9.31

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Data Analysis

- Summarize data based on DOT pavement management segments
- Divide PM segments into 1-km units
- Compare with Roadware collected data in 2004 and historical DOT data from 2003 and 2002
- DOT profiler collected 750 miles of the testing sites for additional comparison

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Data Analysis

- Two PPS data sets:
  - Segments collected by the MANDLI van (120 miles) -- good data
  - Segments collected in July by the Iowa DOT videolog van (1000 miles) – questionable data
- Roadware data set (1000 miles)
- Iowa DOT profiler data set (750 miles)

Results

- Pavement management section based

- 1-km segment based

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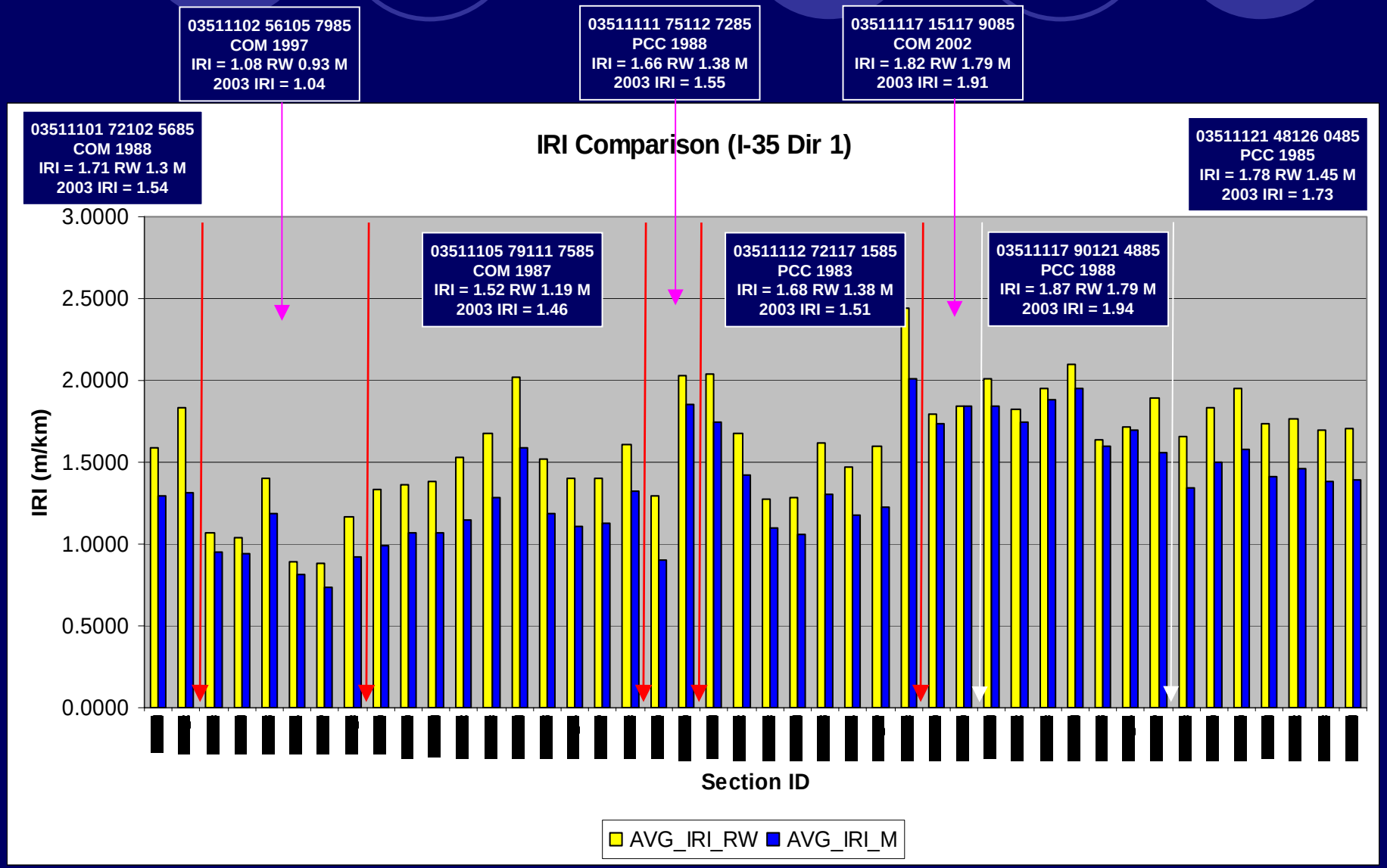
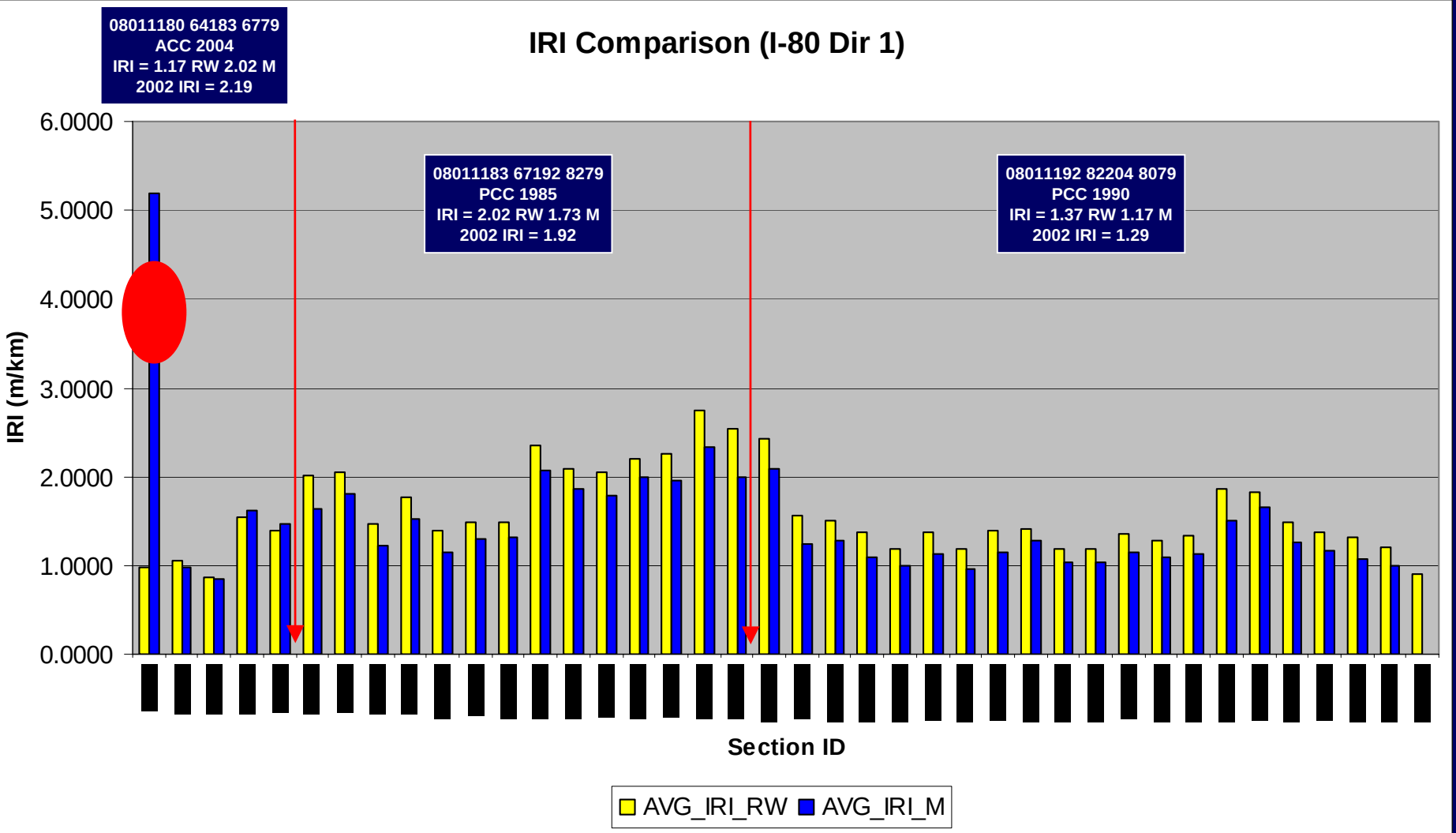
Results – Good data set

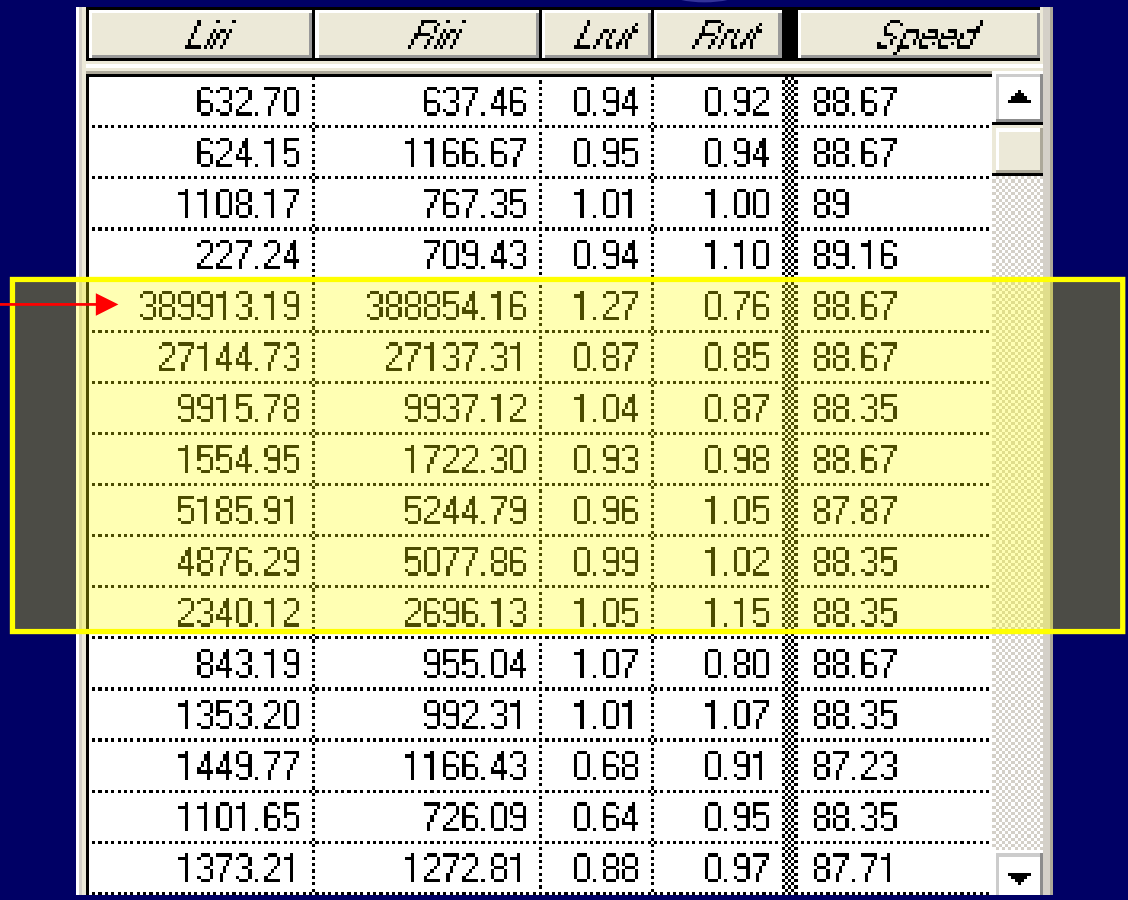


Results – Good data set



INT 80 – Section 1

IRI over 380 m/km



Liri	Riri	Lrut	Rrut	Speed
632.70	637.46	0.94	0.92	88.67
624.15	1166.67	0.95	0.94	88.67
1108.17	767.35	1.01	1.00	89
227.24	709.43	0.94	1.10	89.16
389913.19	388854.16	1.27	0.76	88.67
27144.73	27137.31	0.87	0.85	88.67
9915.78	9937.12	1.04	0.87	88.35
1554.95	1722.30	0.93	0.98	88.67
5185.91	5244.79	0.96	1.05	87.87
4876.29	5077.86	0.99	1.02	88.35
2340.12	2696.13	1.05	1.15	88.35
843.19	955.04	1.07	0.80	88.67
1353.20	992.31	1.01	1.07	88.35
1449.77	1166.43	0.68	0.91	87.23
1101.65	726.09	0.64	0.95	88.35
1373.21	1272.81	0.88	0.97	87.71

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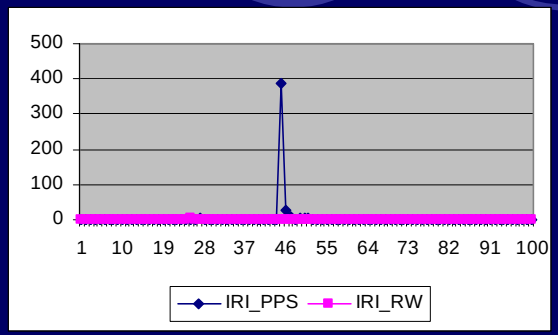
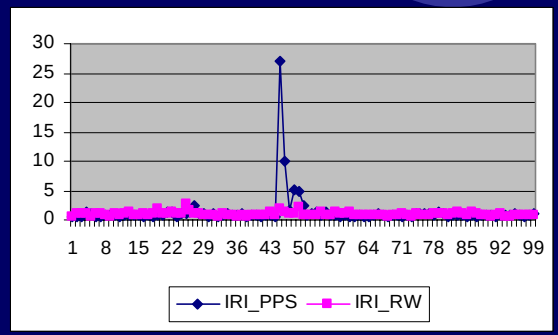
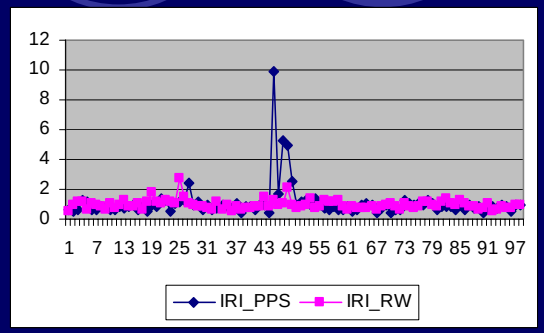
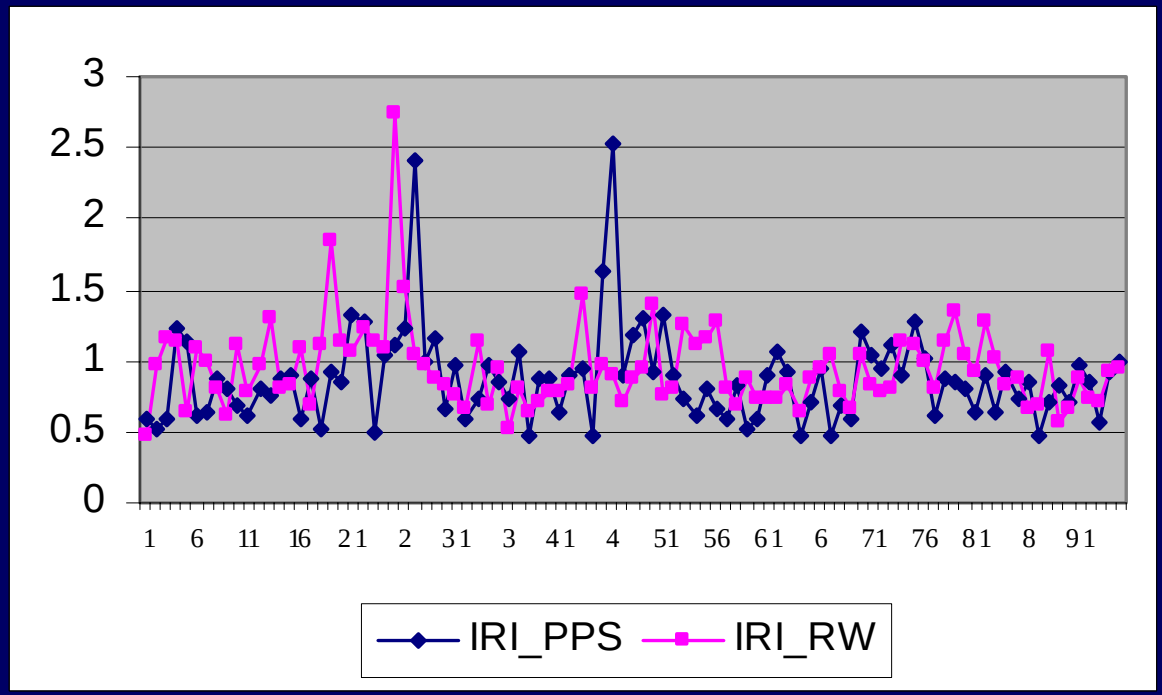
INT 80 – Section 1 (100 10-m segments)









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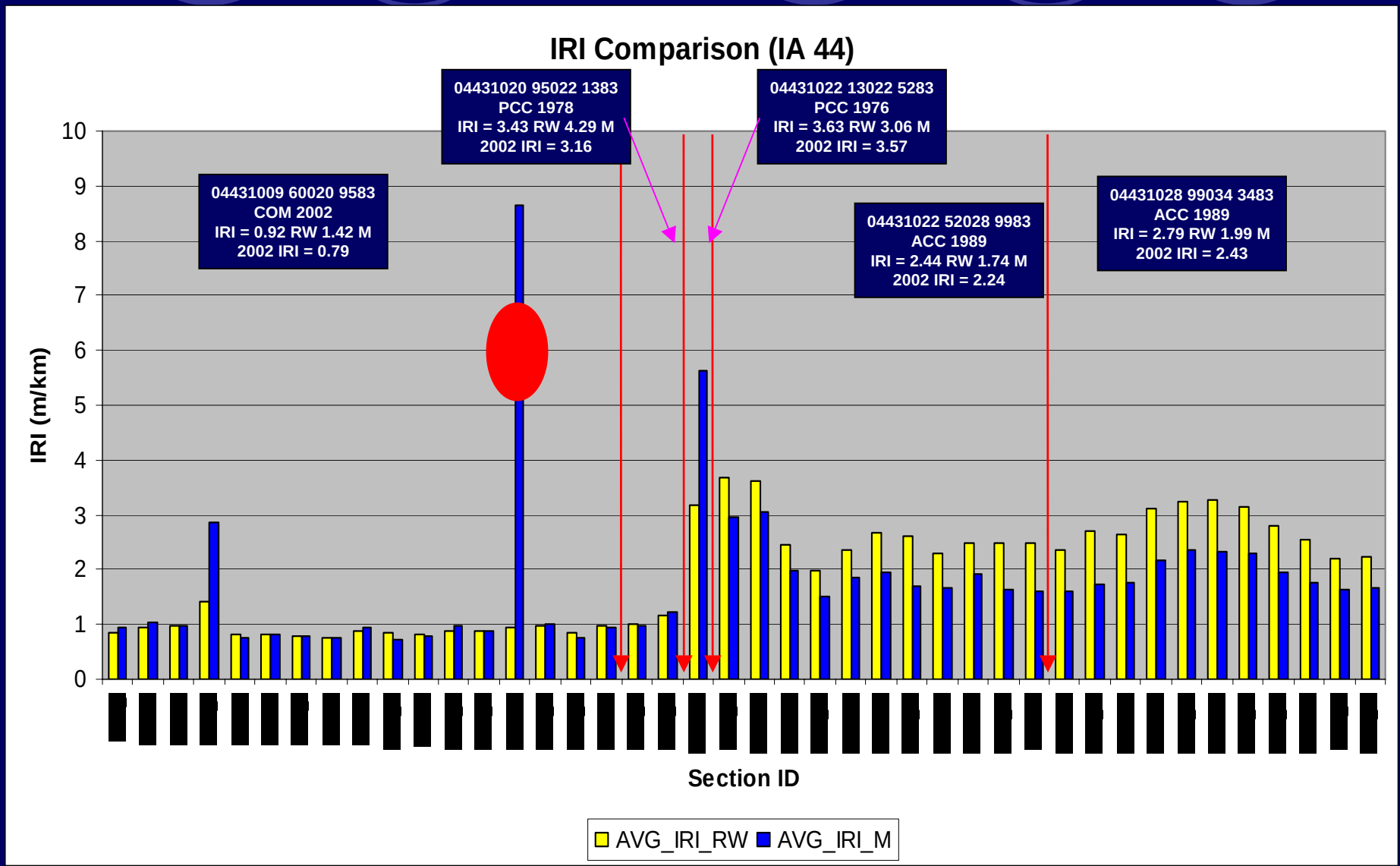
Results – Good data set



IA 44 – Section 14

IRI over 4790 m/km

Excluded from analysis because of speed

26 out of 100 segments with high IRI

Liri	Riri	Lrut	Rrut	Speed
806.52	931.90	1.11	1.37	49.73
855.93	1177.25	1.08	1.81	45.71
977.48	912.46	1.41	1.46	40.72
1313.13	1008.05	1.05	1.38	34.76
2211.92	2141.02	1.16	1.56	26.88
6189.13	6094.54	1.11	1.41	16.25
4790735.39	4791287.79	1.01	2.11	0.16
1126886.03	1127283.76	1.04	1.69	10.3
515789.13	515973.79	0.99	1.42	22.05
87243.53	86965.43	1.04	1.57	28.16
149684.97	149981.53	1.00	1.38	32.83
182375.31	182413.19	1.01	2.10	36.69
127023.51	127045.93	1.07	2.35	39.91
49932.61	49863.48	1.02	2.00	42.97
14106.85	14199.49	1.11	2.55	45.54
37620.11	37408.46	1.02	2.84	47.48
40856.69	41044.98	1.13	2.81	50.37
29569.13	29493.53	1.11	2.51	52.79
14778.11	14739.68	1.28	2.38	54.72
3429.94	3435.31	0.91	2.45	56.17
4547.05	4265.44	1.09	2.60	58.42
6388.75	6052.49	0.93	2.20	60.19
5552.38	5669.18	0.99	2.59	61.64
3174.46	3159.15	1.31	2.72	63.25
1847.33	1915.67	1.44	3.30	64.86
2168.06	1635.43	1.14	3.26	66.3
1882.12	1580.97	1.29	3.51	67.75
1353.86	1240.26	1.11	3.96	68.88
1307.41	1245.17	0.99	3.33	69.85
1048.06	646.92	1.03	2.11	71.13
794.50	778.83	1.34	1.49	71.78
1741.59	1698.75	1.21	1.26	72.9

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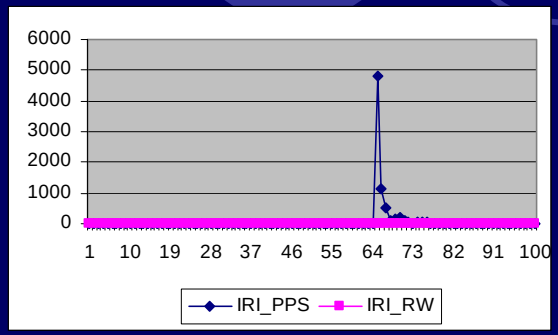
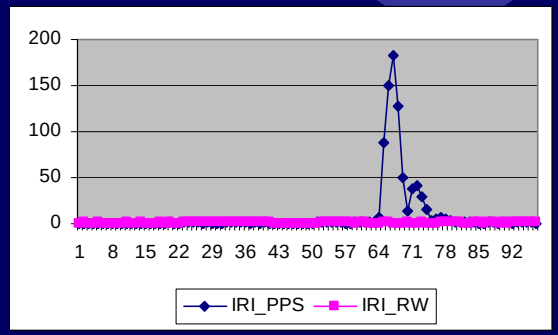
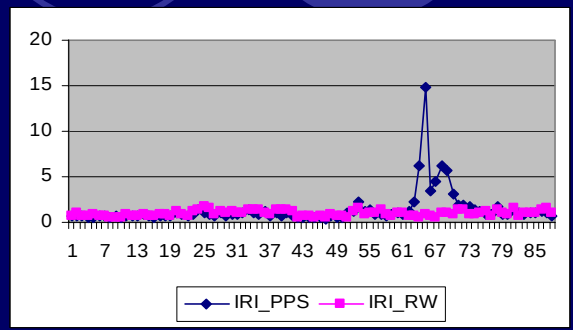
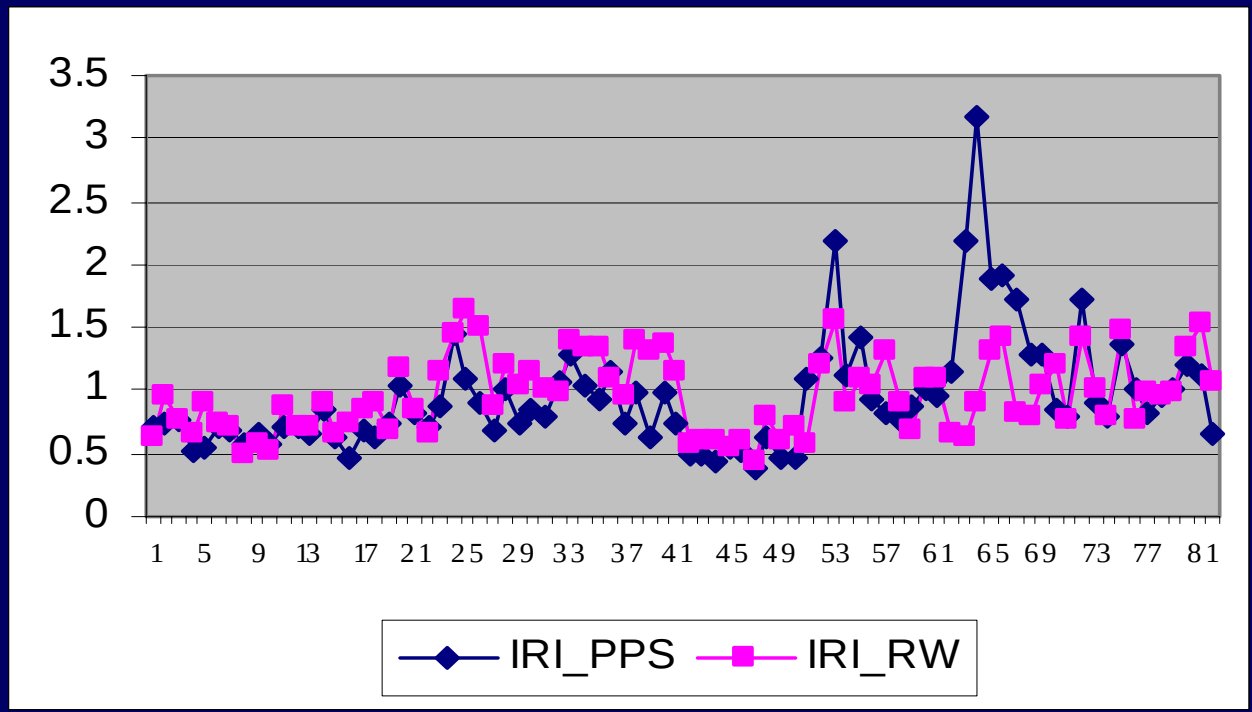
IA 44 – Section 14 (100 10-m segments)









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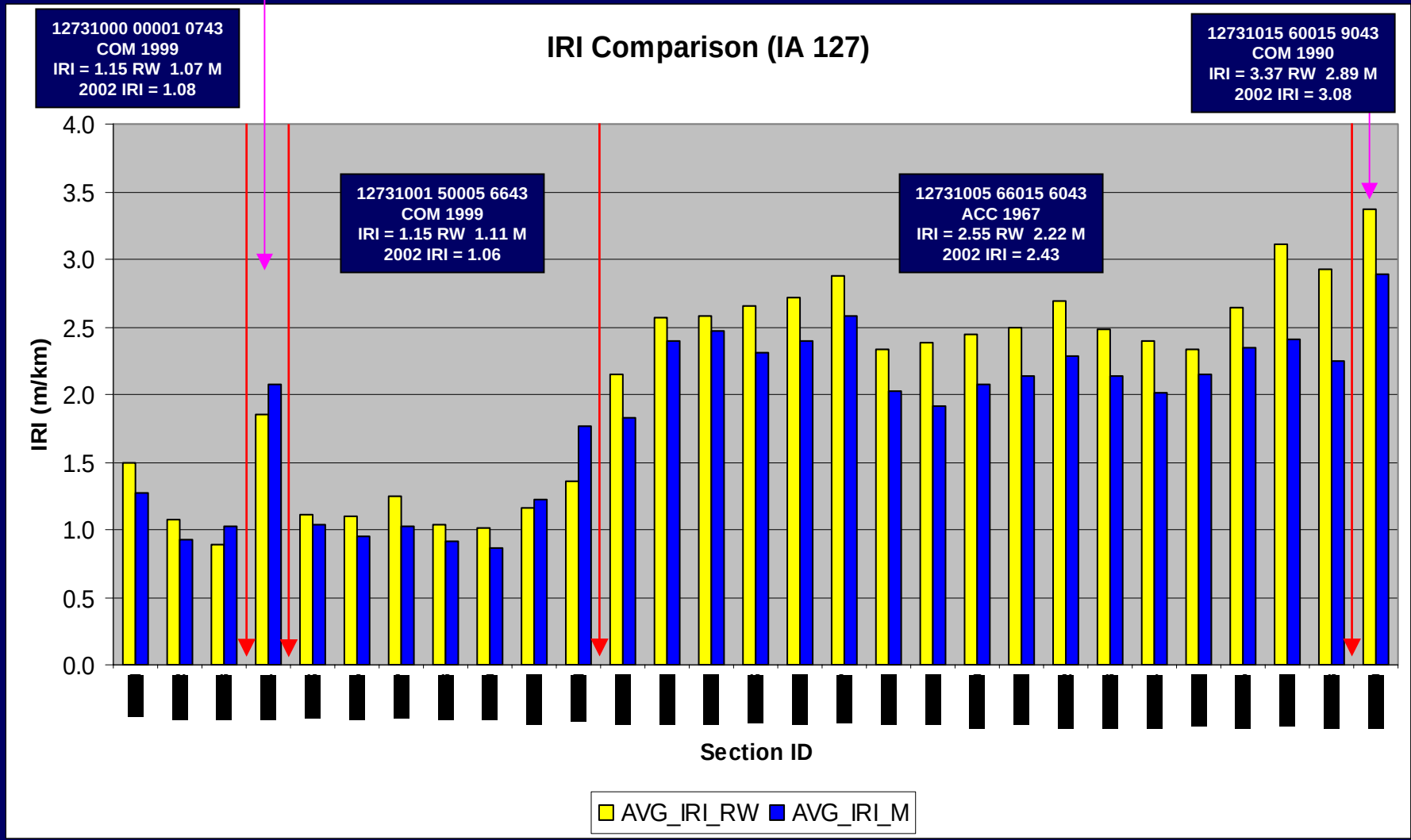
Results – Good data set



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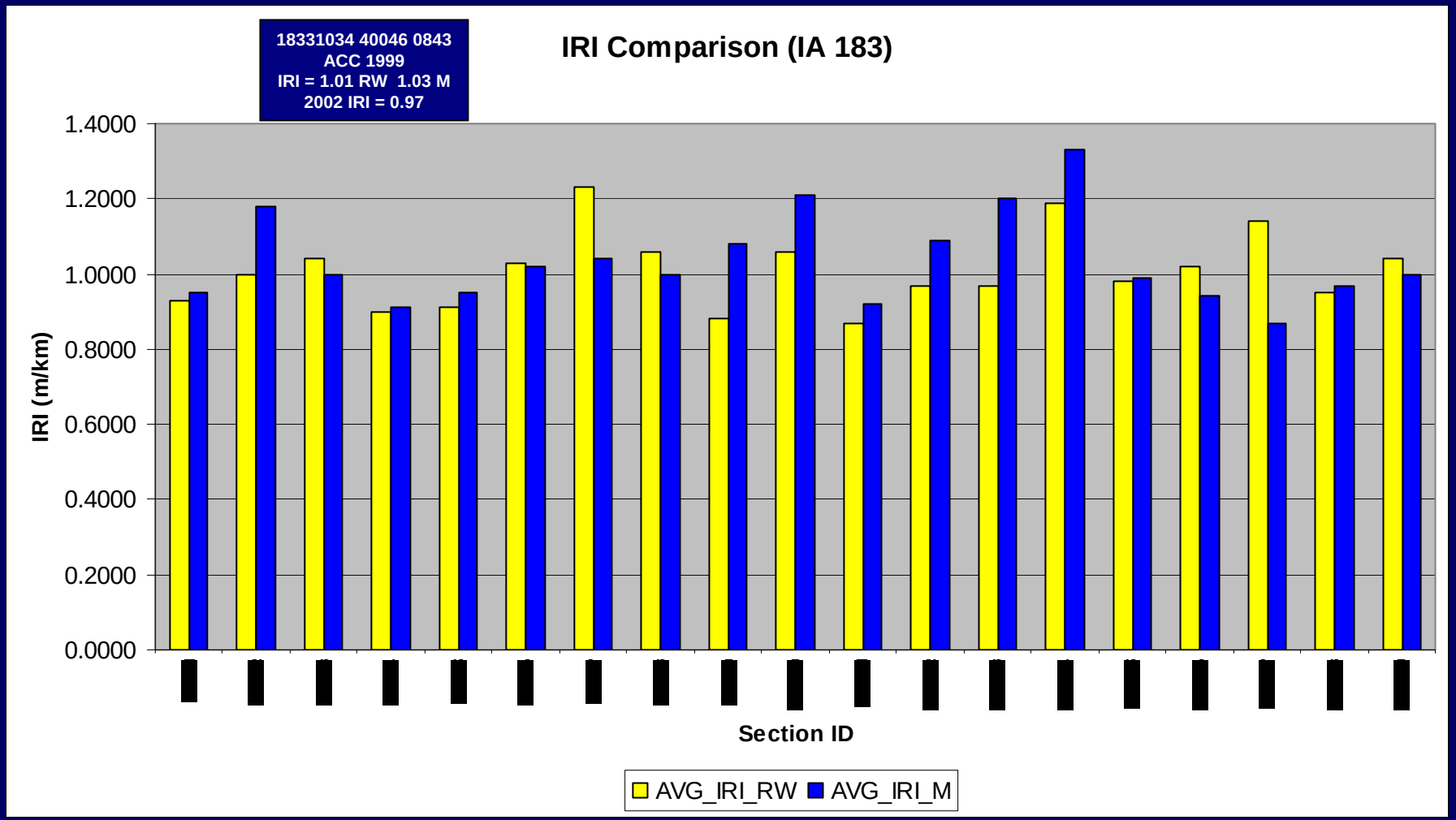
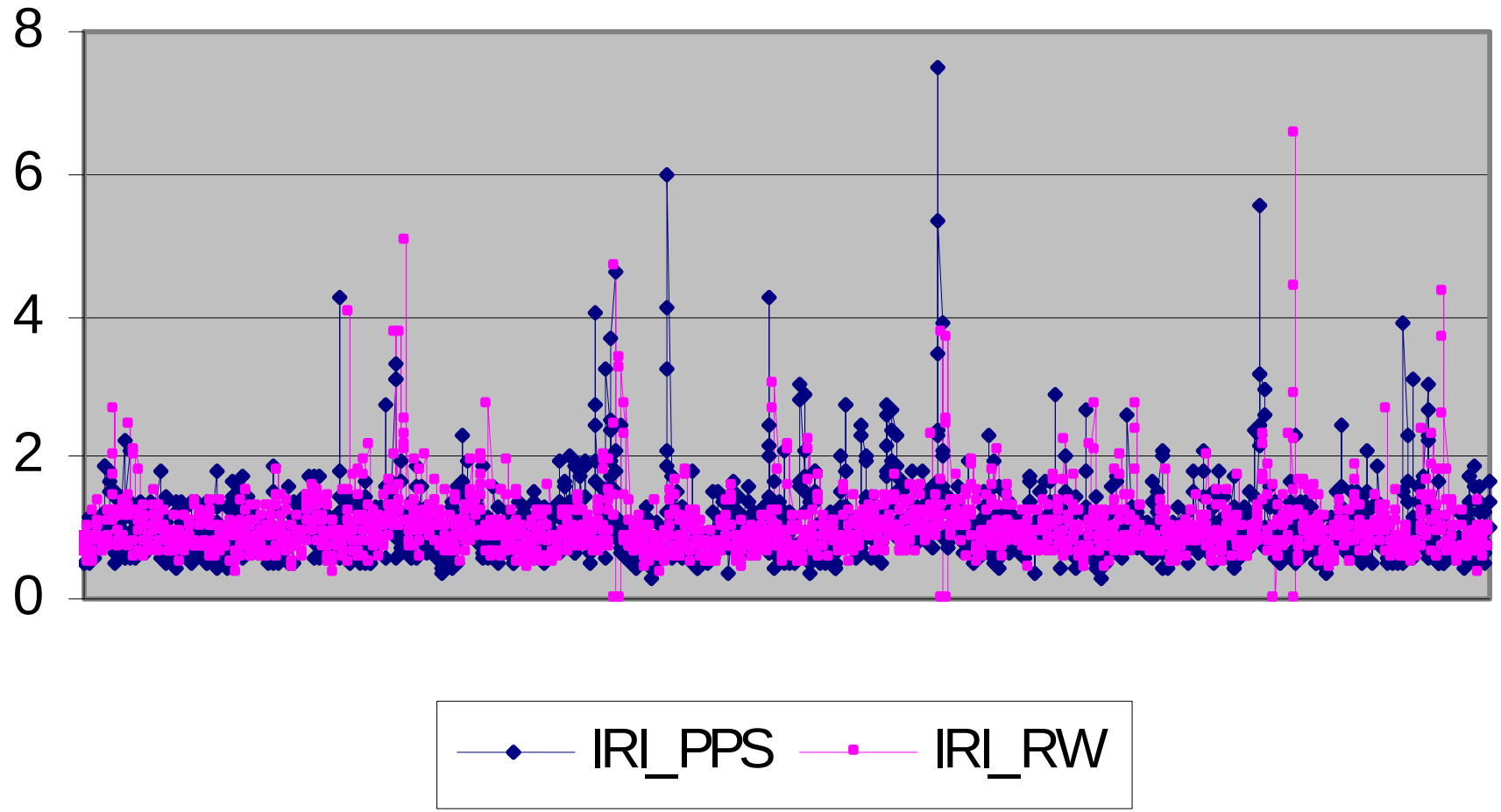
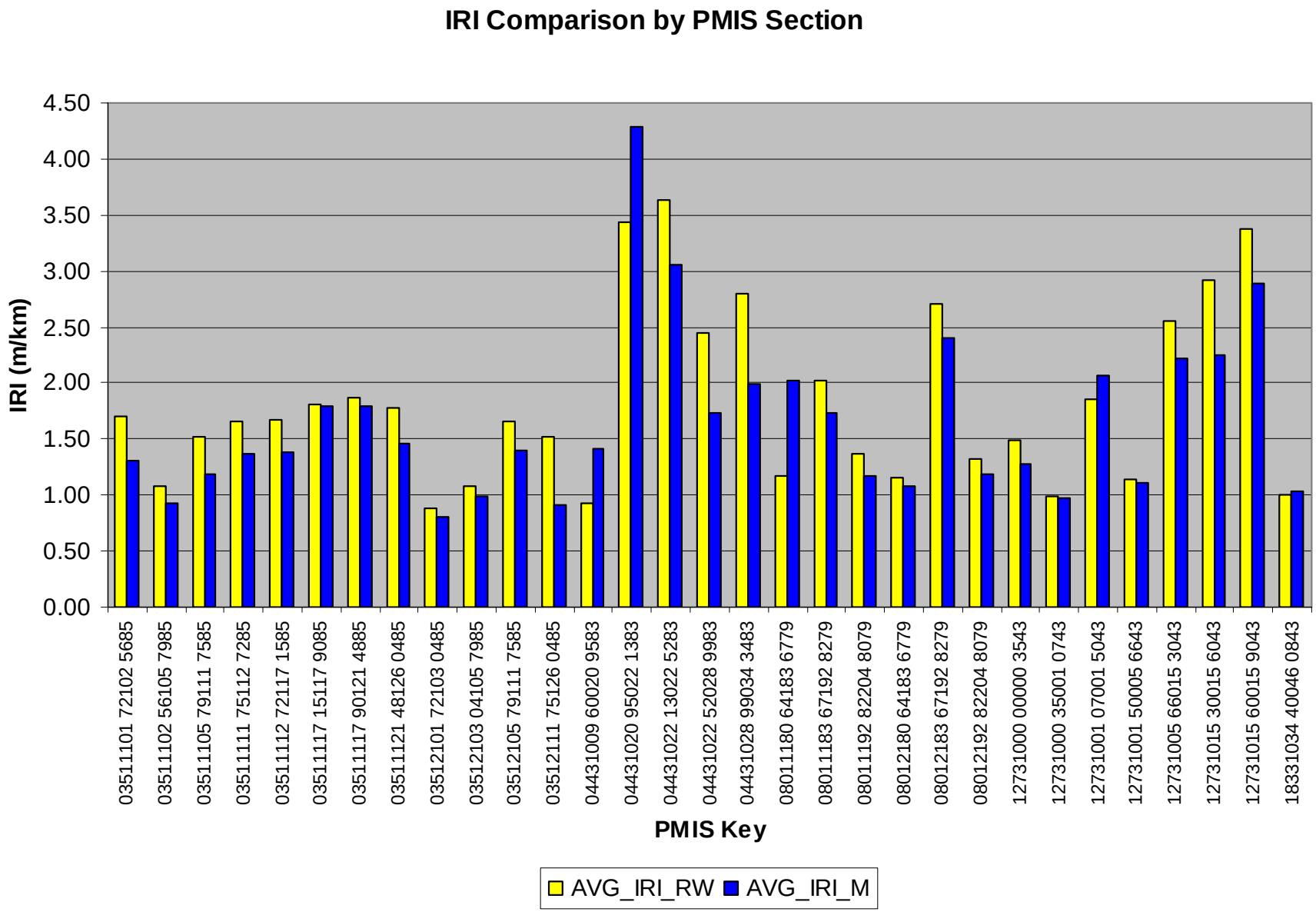


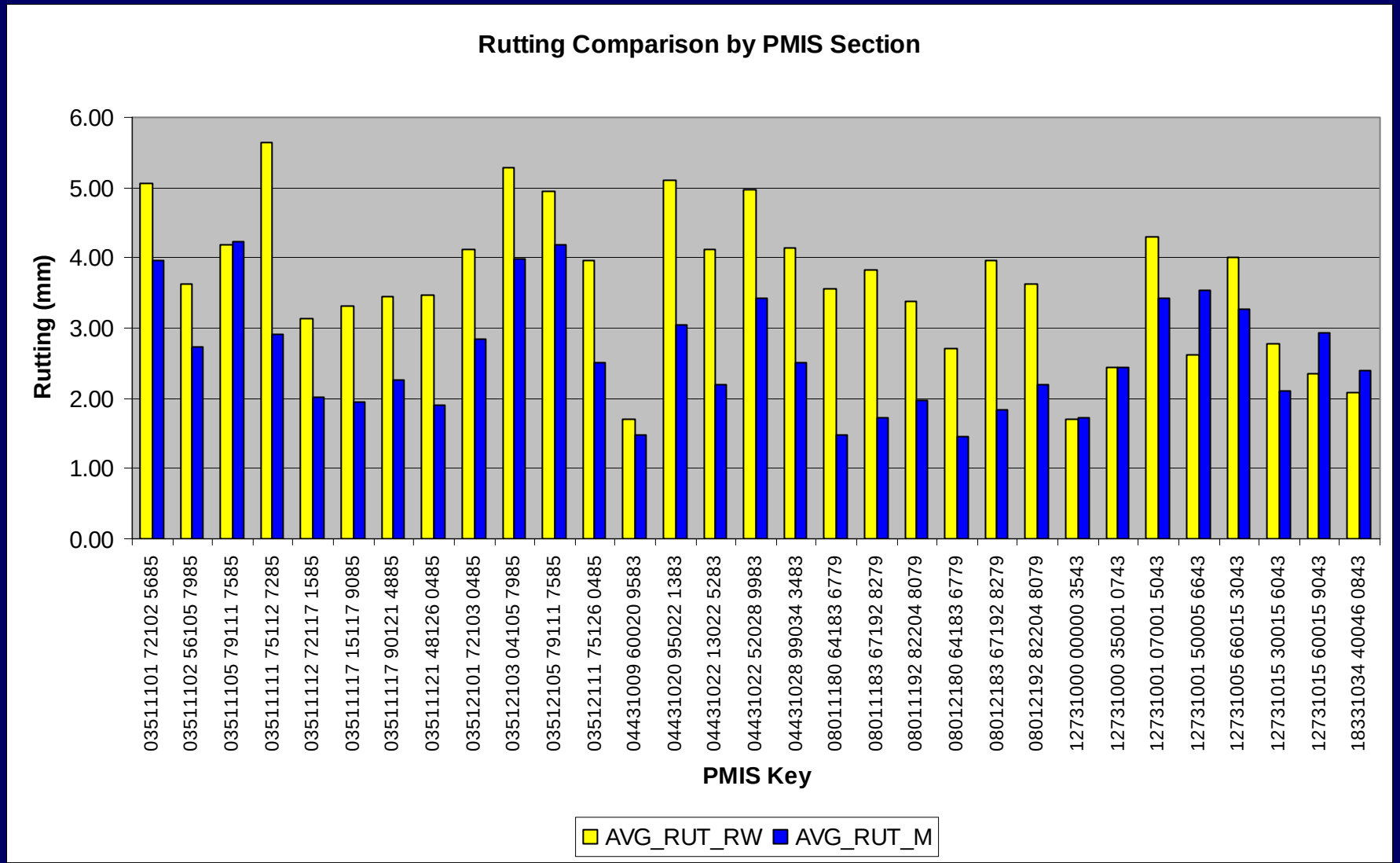
IA 183 – Section 1(over 1800 10-m segments)



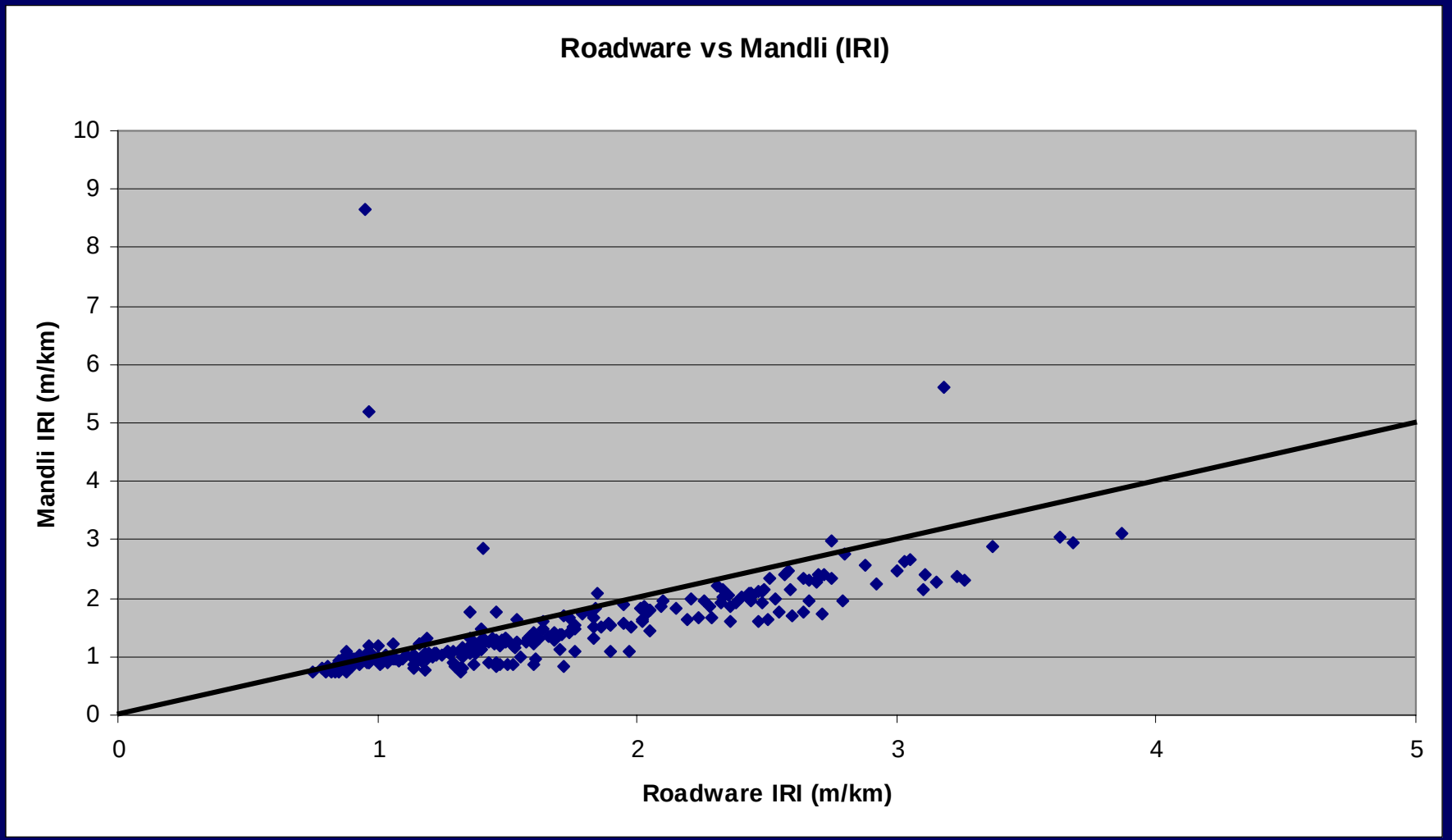
Results - PM Segments based



Results - PM Segments based



Results – 1km based segments



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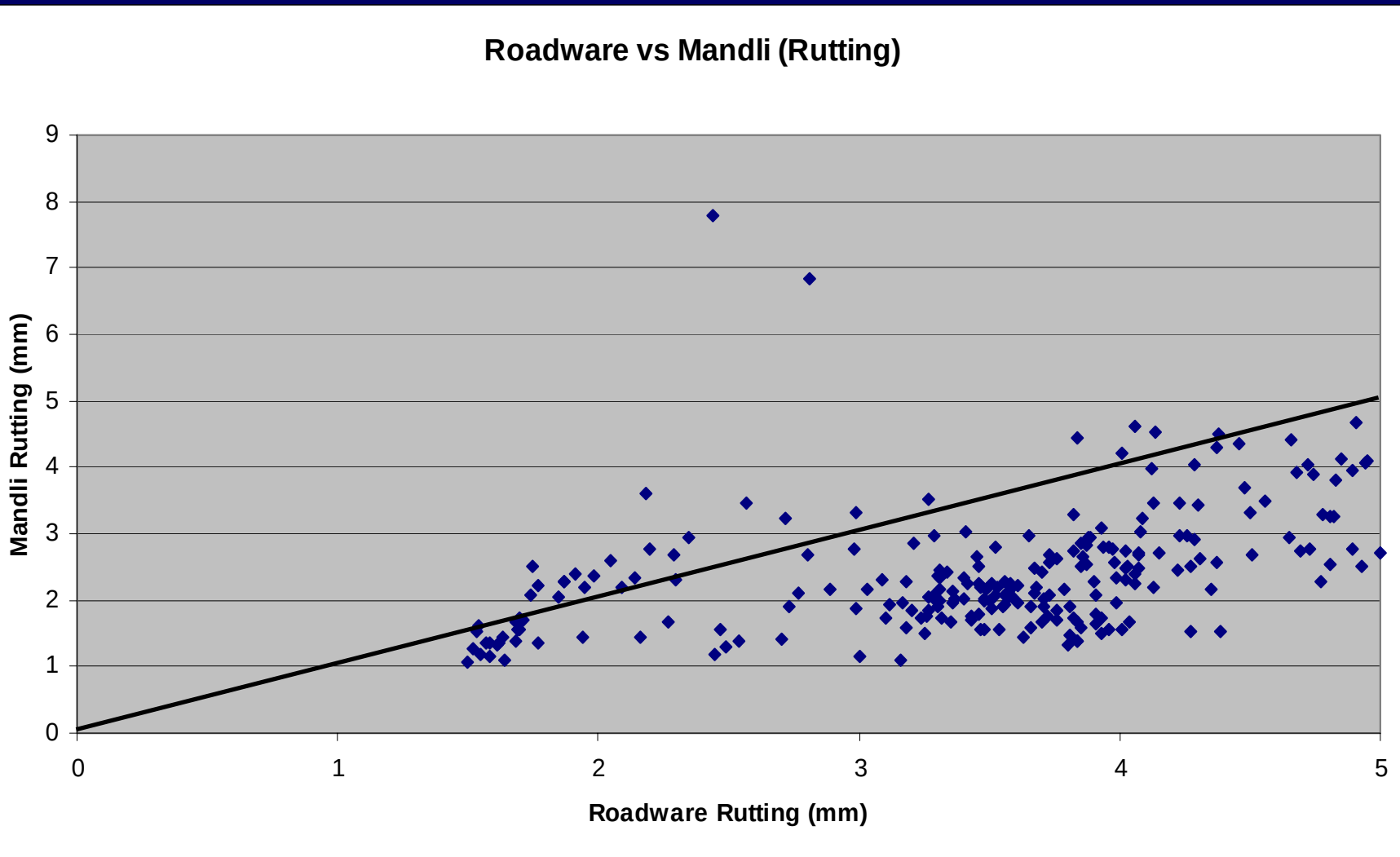

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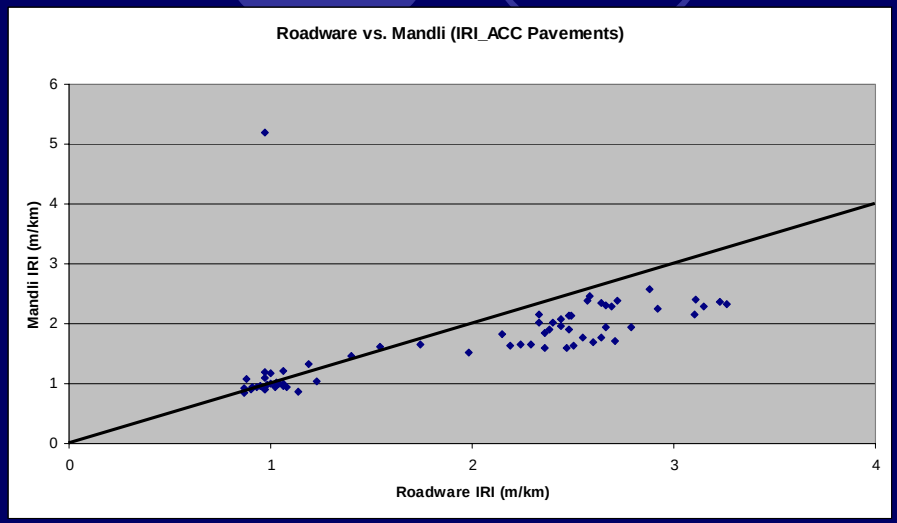

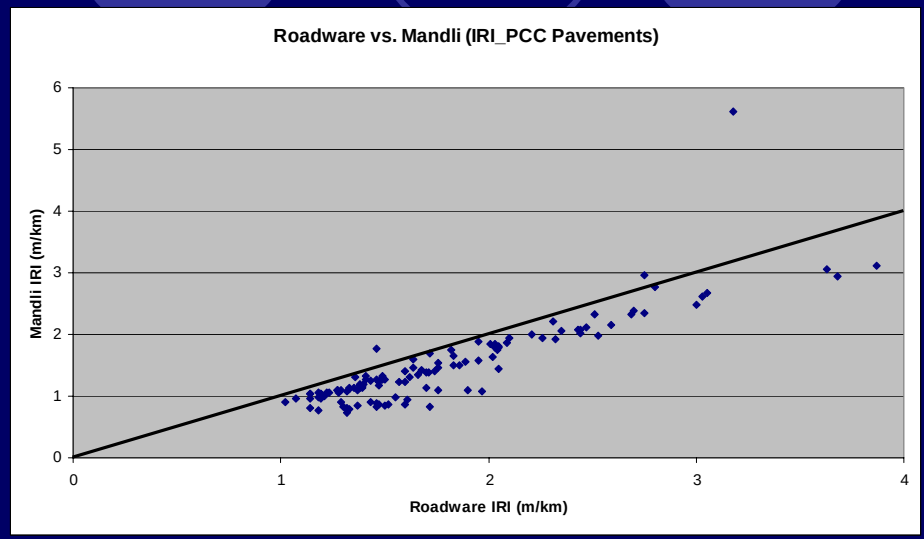

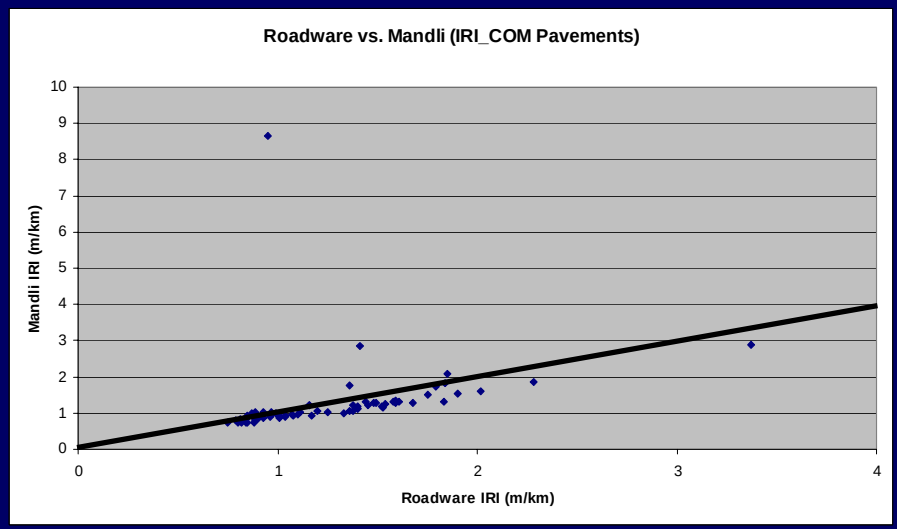

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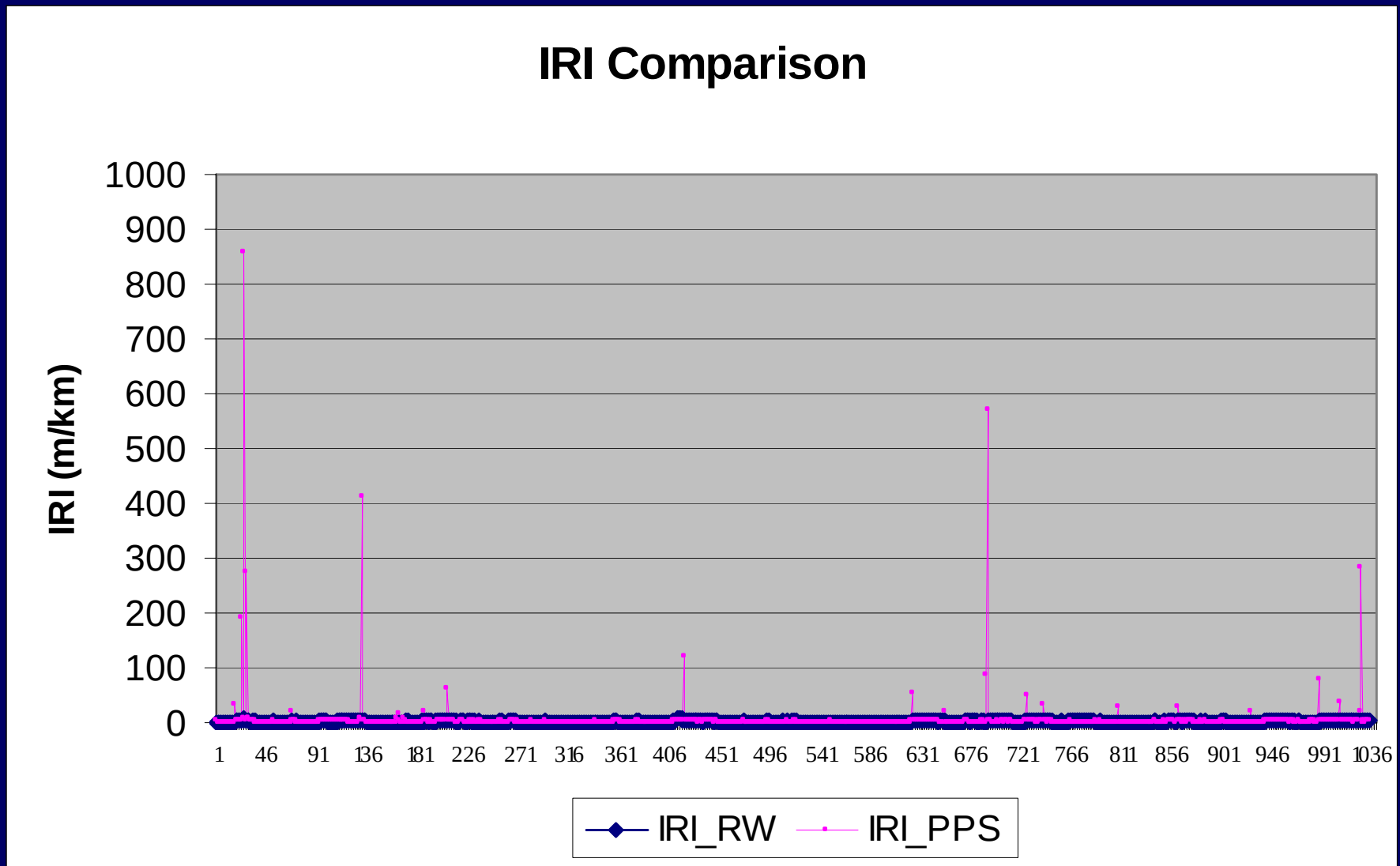
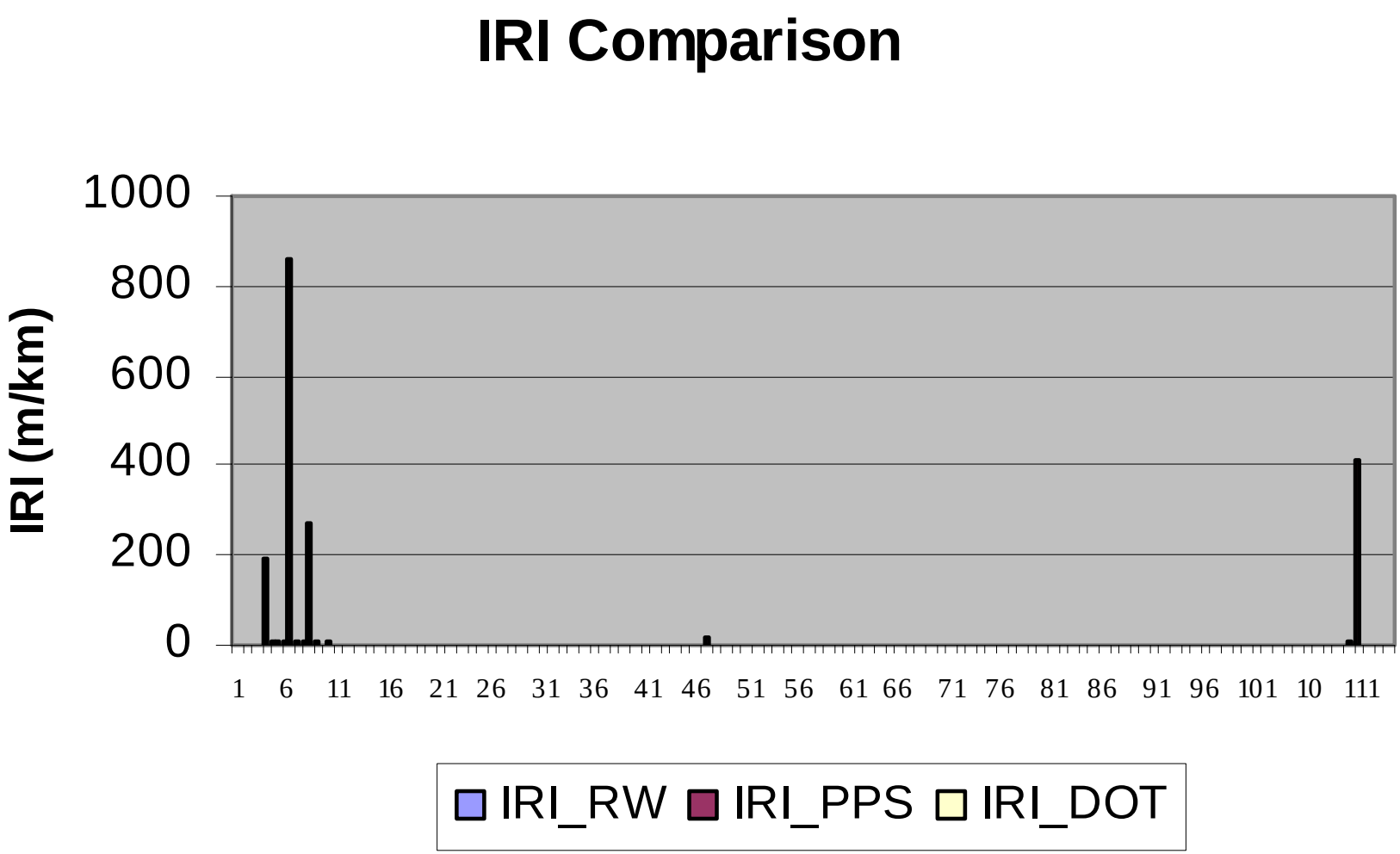
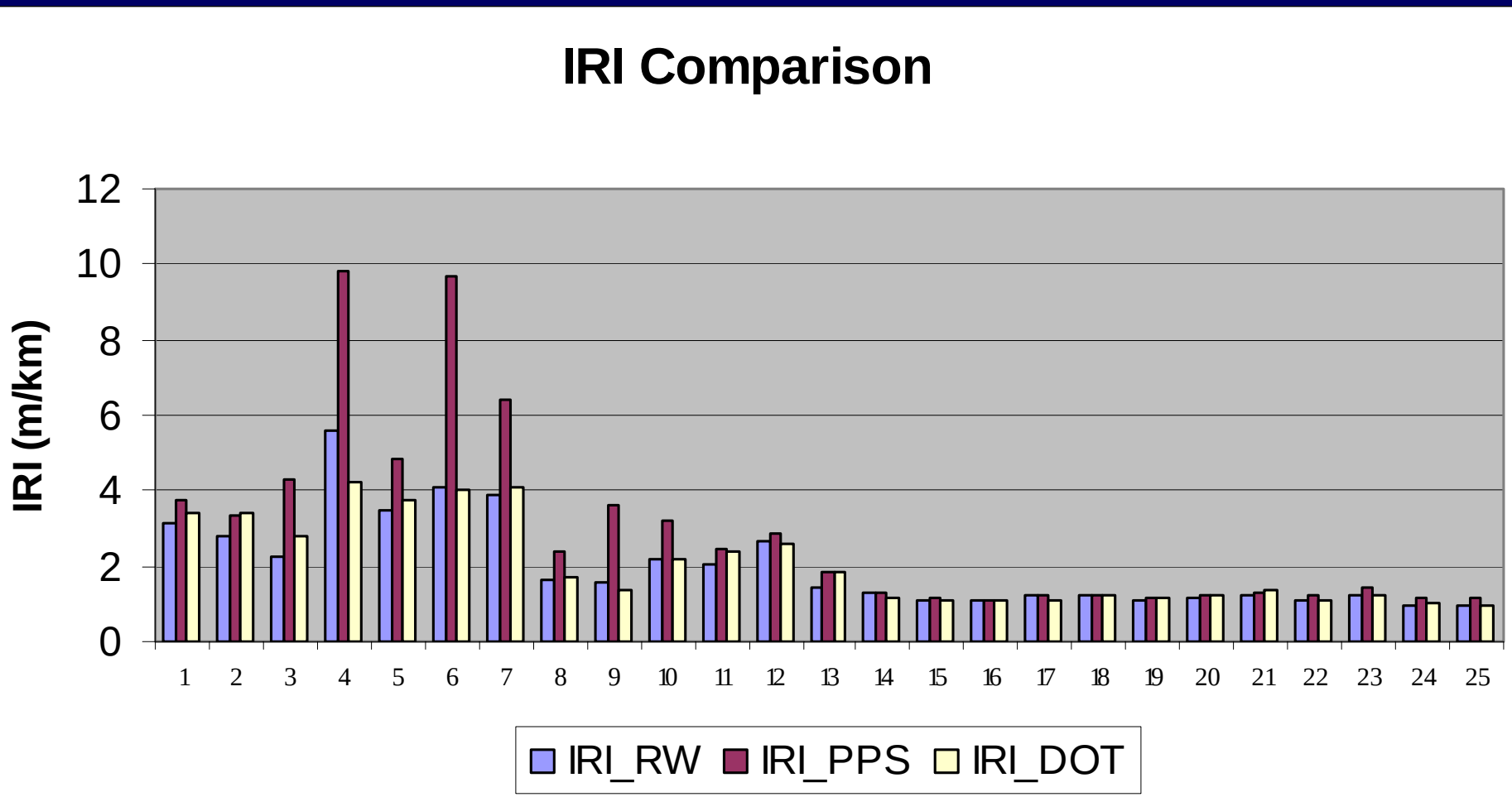
Questionable Data – IRI (all segments)



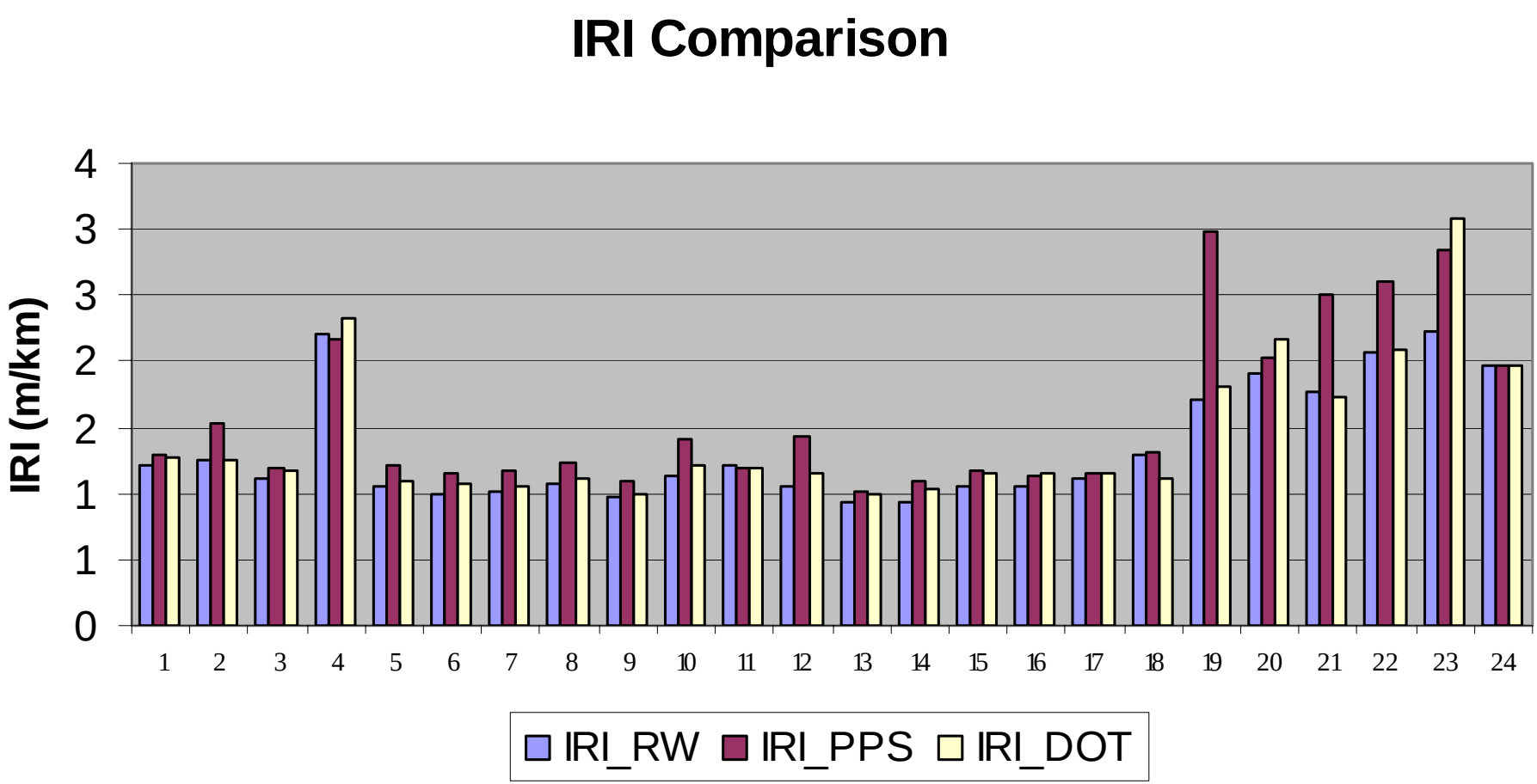
Questionable Data – IRI (US 6--all)



Questionable Data – IRI (US 6--cleaned)



Questionable Data – IRI (US 6--cleaned)



Conclusions

- Data collection issues:
  - Collection process
    - all data collected by the Iowa DOT was tagged questionable
    - PPS is not integrated with the rest of the data collection components
  - Vehicle wander
  - Acceleration/deceleration

Conclusions

- Technology issues
  - Sensor (PPS) – IRIs over 100 m/km
    - Outstanding problem with the PPS that need to be addressed
    - More research and evaluations are needed
  - DMI – High IRIs
    - PPS and DMI relationship
    - PPS measured random bursts of tones from the DMI:
      - Very high speeds (over 300 kmph)
      - Very low speeds (less than 10 kmph)

Conclusions

- Technology issues
  - Rutting – High values
    - Being close to the pavement edge (pavement marking)
    - Increased rutting in some cases