Performance of Cold In-place Recycling Technologies in Ontario

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Outline

Ministry of Transportation Ontario experience with:

- Cold in-place recycling (CIR)
- CIR with expanded asphalt (CIREAM)
- Challenges
- Performance

Implementation of Cold In-Place Pavement Recycling in Ontario

- Cold in-place recycling - 1989
- CIR with expanded (foamed) asphalt - 2003

Cold In-place Recycling (CIR)	6,848,943 m^2
CIR with Expanded Asphalt (CIREAM)	3,241,653 m^2

> 10,000,000 m^2

Cold In-Place Recycling - CIR

Cold In-place Recycling

- CIR is a pavement rehabilitation method that mills up an existing asphalt pavement, sizes it, mixes in additional asphalt cement, and lays it back down without off-site hauling and processing.
- The added asphalt cement is typically an **asphalt emulsion**, a blend of asphalt cement and water droplets.

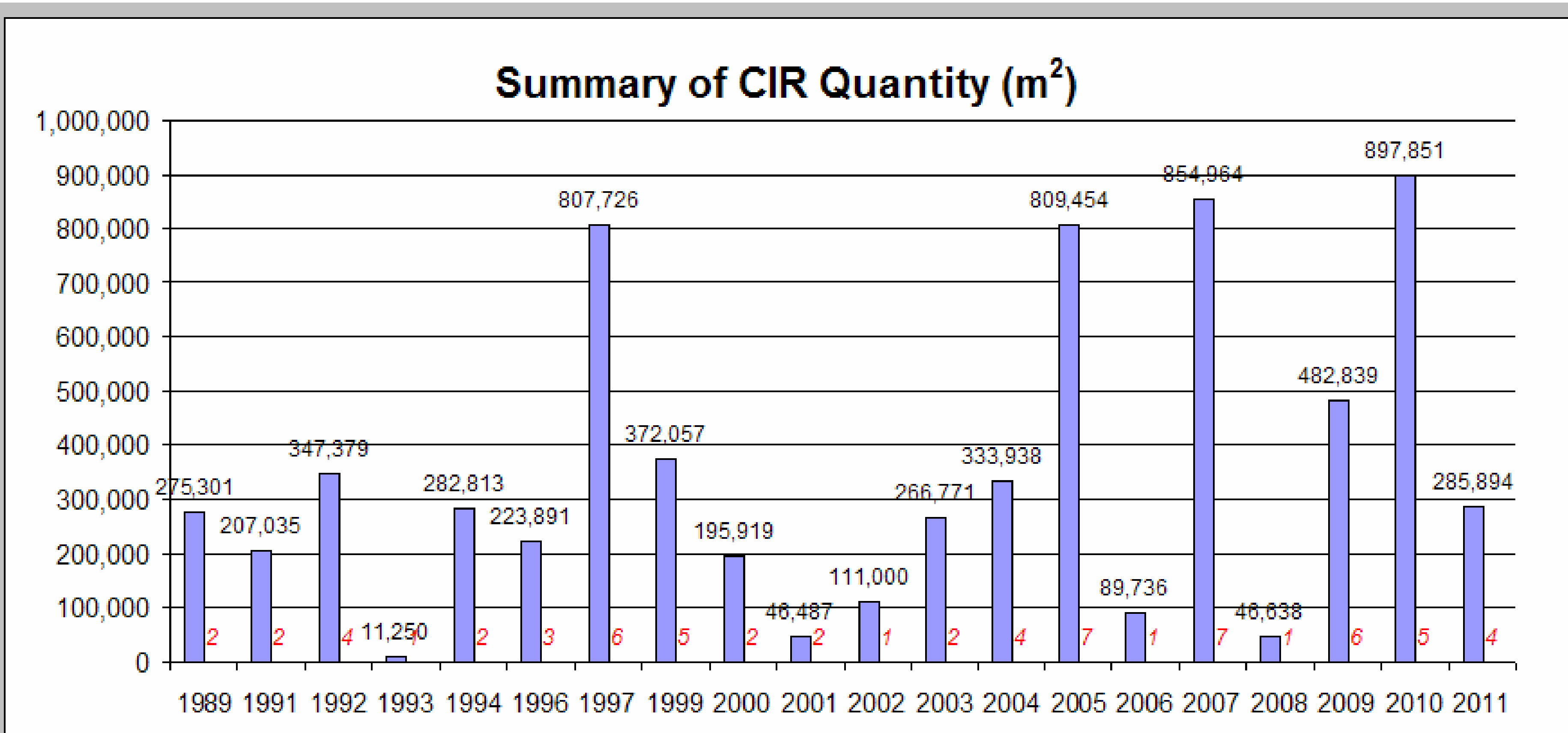
CIR Design Considerations

- Suitable for a wide range of pavement deterioration including:
  - Thermal, fatigue and reflection cracking
  - Rutting due to mix instability
  - Ravelling / coarse aggregate loss
  - Loss of bond between layers
- Requires minimum existing pavement thickness of 100 mm
- Typical treatment depth 75 –125 mm
- Warm, dry weather and curing period required

Advantages

- Conserves aggregate
- Conserves asphalt cement
- Conserves energy
- Mitigates reflection cracking
- Increases structural adequacy
- Restores smooth ride

Historical Quantities for CIR



Note: No. of Projects shown in red

All Year Total:	6,948,943 m2
No. of Project:	67

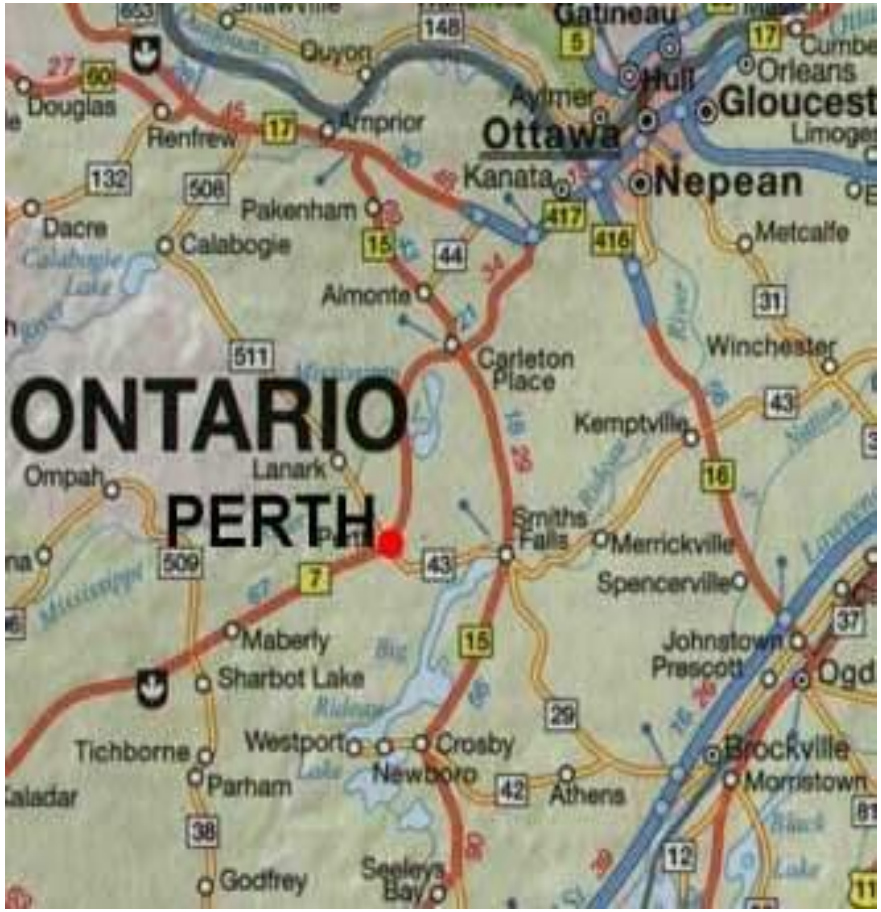
Cold In-Place Recycling with Expanded Asphalt (CIREAM)

Cold In-place Recycling with Expanded Asphalt (CIREAM)

- A new development in CIR technology is the use of **expanded (foamed) asphalt**, rather than emulsified asphalt.
- The expanded asphalt is then mixed with the reclaimed asphalt pavement.

CIREAM Trial, Hwy 7, Perth

- MTO's first use of CIREAM was in 2003 on Highway 7, southwest of Ottawa.



CIR vs CIREAM

- A 5-km section of CIREAM was constructed adjacent to 8-km of conventional CIR mix.
- This gave the Ministry an excellent opportunity to compare the performance of the new technology to conventional CIR.

CIR with expanded asphalt

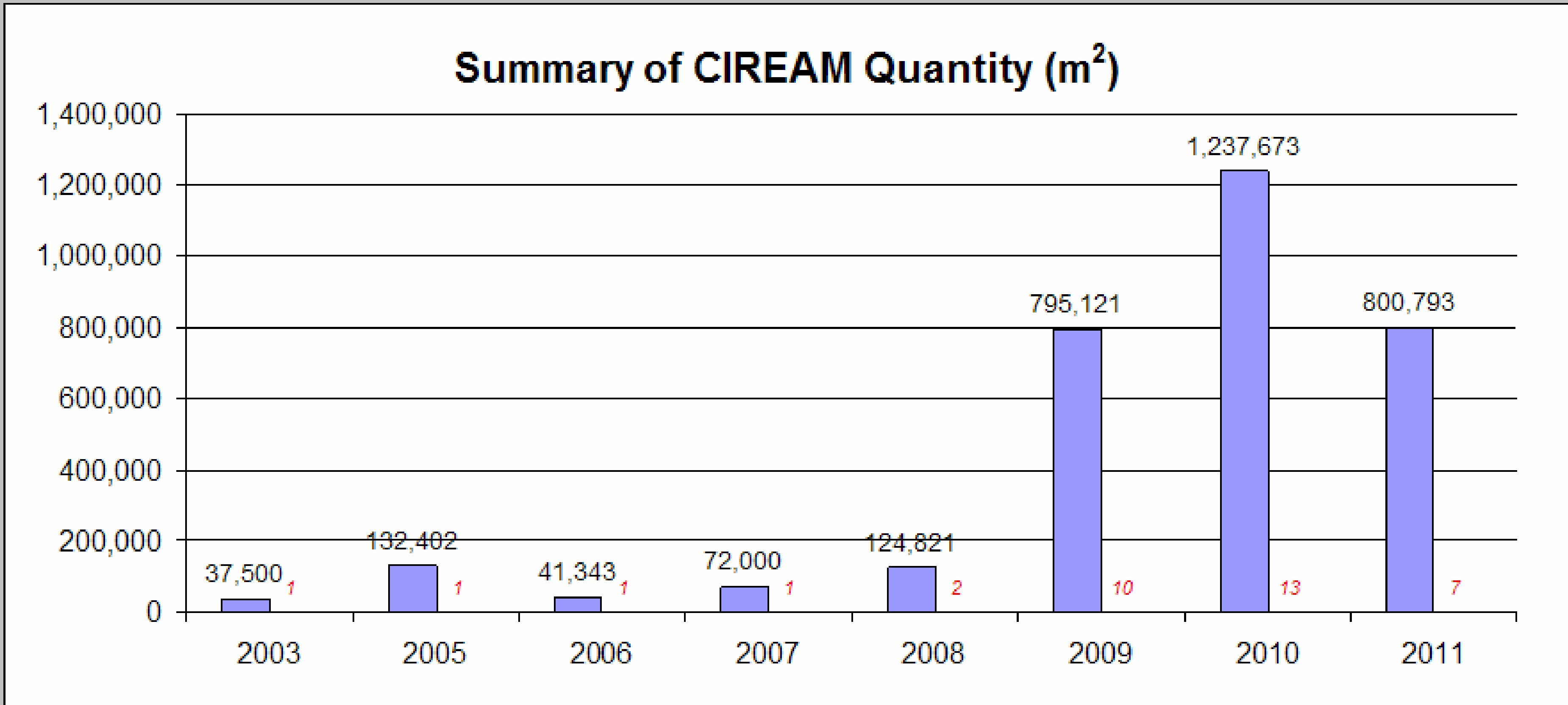

25002

Conventional CIR


Conventional
CIR mat


CIR with EA mat

Historical Quantities for CIREAM



Note: No. of Projects shown in red

All Year Total: 3,241,653 m2

No. of Project: 36

Challenges

- Constructability
  - Pavement widening
  - Width of screed
  - Shoulder treatment
  - Optimum moisture
- Acceptance testing
  - Moisture content & compaction
  - ITS
  - AC content
  - Corrective aggregate

Using a Milling Machine for Pavement Widening

Excavation for pavement widening performed with milling machine. Trench with mostly straight, vertical faces.

Pavement widening trench for CIR paving to extend under PPS.

Using milling machine for pavement widening

- using a small milling machine for the narrow excavation
- providing a straight, clean, vertical trench for the widening
- a much better result than a grader equipped with a boot

Hwy 6 (2011-3004) from Durham to Dornoch

Widening for CIREAM PPS performed by milling machine.

Straight, clean, vertical trench created for widening.

No Screed at Paver Extension

- paver extensions without a proper screed at the extension portion
- potential for low density at the extension portion
- also causing break in cross-fall starting from the mid-lane

Hwy 4 (2011-3005)
from Kippen to Clinton

CIR material at pave extensions do not pass under the screed. Otherwise uniform appearance.

Hwy 7/8 (2011-3020)
Shakespeare to New Hamburg

No proper screed at paver extensions.

Optimal moisture for field compaction

- Some labs recommend 75% OMC in the field.
- Mix design's OMC = 5.8%. Field moisture should be 5.8% x 0.75 = 4.35%
- Some sublots fail in compaction

Hwy 3 (2011-3014) Dry Lake Road to Cayuga

Close-up of loose, coarse mat at centreline. Material was kicked up easily with boot.

Coarse, segregated areas noted in mat behind CIREAM paver.

Pulverizing PPS after CIR

- Conventional way: pulverizing PPS prior to CIR
- Hwy 17 - conducting CIR first and pulverize PPS at the final stage
- Did not see any instances where the newly placed CIR mat was affected by the process

QA lab testing summary for CIR (2011)

- All contracts pass in moisture.
- 2011-3005, one lot passes and one lot fails at 95.6% compaction.
- 2011-3005, 2011-3006 target density using mix design BRD.

Contracts	Hwy	Moisture			Compaction		
		Avg. (%)	Sublot Acceptable	Lot Acceptable	Avg. (%)	Sublot Acceptable	Lot Acceptable
2010-3001	21	1.97	100%	100%	97.8	100%	100%
2011-3005	4	1.30	100%	100%	96.9	70%	50%
2011-3006	3	1.63	100%	100%	98.1	100%	100%
2011-4048	17	1.96	100%	100%	99.3	100%	100%

QA lab testing summary for CIREAM (2011)

- Poor QA results in NE Region (softer AC?)
- High failure rate for TSR in 2010 and 2011 (after changing of curing temp.?)
- Compaction results always good!

Contracts	Hwy	Dry Tensile Strength			Wet Tensile Strength			TSR	Compaction		
		Avg. (kPa)	Sublot Accept-able	Lots Accept-able	Avg. (kPa)	Sublot Accept-able	Lots Accept-able	Sublot Accept-able	Avg. (%)	Sublot Accept-able	Lots Accept-able
2010-5133	11	268	96.6%	85.7%	126	93.1%	71.4%	48.3%	104.3	100%	100%
2010-5142	11	245	69.8%	66.7%	100	72.1%	44.4%	11.6%	101.7	100%	100%
2011-3004	6	294	100.0%	100.0%	232	100.0%	100.0%	100.0%	102.0	100%	100%
2011-3013	8	319	100.0%	100.0%	183	100.0%	100.0%	75.0%	102.5	100%	100%
2011-3014	3	318	100.0%	100.0%	164	100.0%	100.0%	80.0%	100.3	90%	100%
2011-3020	7/8	305	100.0%	100.0%	224	100.0%	100.0%	100.0%	102.6	100%	100%
2011-4033	17	319	100.0%	100.0%	193	100.0%	100.0%	100.0%	102.4	100%	100%

Effectiveness of Adding Corrective Aggregates

- showing improvement in mix design only
- very poor QA results in terms of ITS

Hwy 11 – Hearst (2010-5142)

Original Mix Design (no corrective agg.)

- ITS_{dry} = 176.8 KPa
- ITS_{wet} = 101.7 KPa
- AC added = 1.0%

Improved Mix Design (with corrective agg.)

- ITS_{dry} = 268 KPa
- ITSwet = 182 KPa
- AC added = 1.3%
- Add 10% screening

ITS_{dry}

- **Range: 147 to 354 KPa**
- **Average: 245 KPa**
- **Lots fail: 3 out of 9**
- **Sublots fail: 18 out of 43**

ITS_{wet}

- **Range: 57 to 183 KPa**
- **Average: 100 KPa**
- **Lots fail: 5 out of 9**
- **Sublots fail: 12 out of 43**

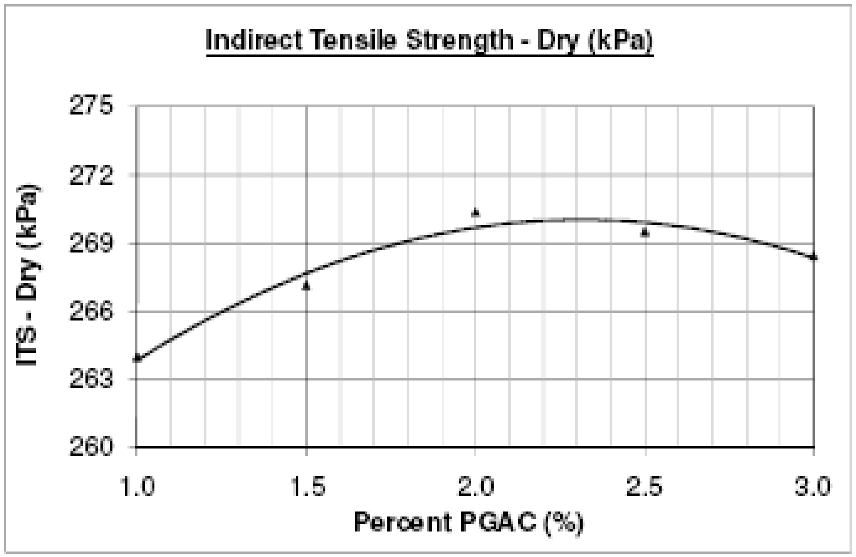
TSR

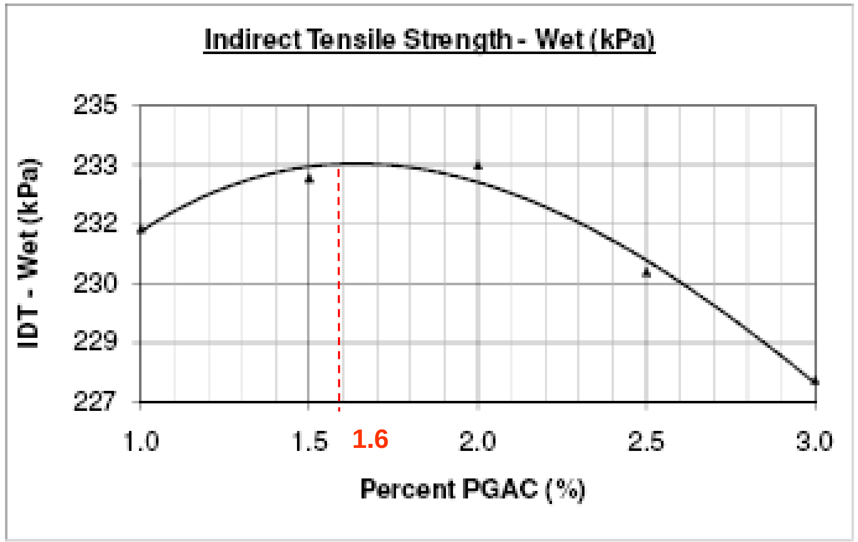
- **Sublots fail: 38 out of 43**

Min AC (1%) vs. optimal AC

- Current spec. – design % AC that passes dry/wet tensile strength, and min. AC of 1%
- Optimal AC when dry/wet tensile strength reach the maximum

Hwy 7/8 - Shakespeare to New Hamburg (2011-3020)





Incorporating shoulder granular into CIR / CIREAM

- Permit a narrow strip of shoulder gravel to be processed as part of the CIR / CIREAM mix (addition of 3% granular)
- Eliminate the 0.1m wide excavation for pavement widening.

Hwy 8 – Stratford (2011-3013)

Original Mix Design (without 3% granular)

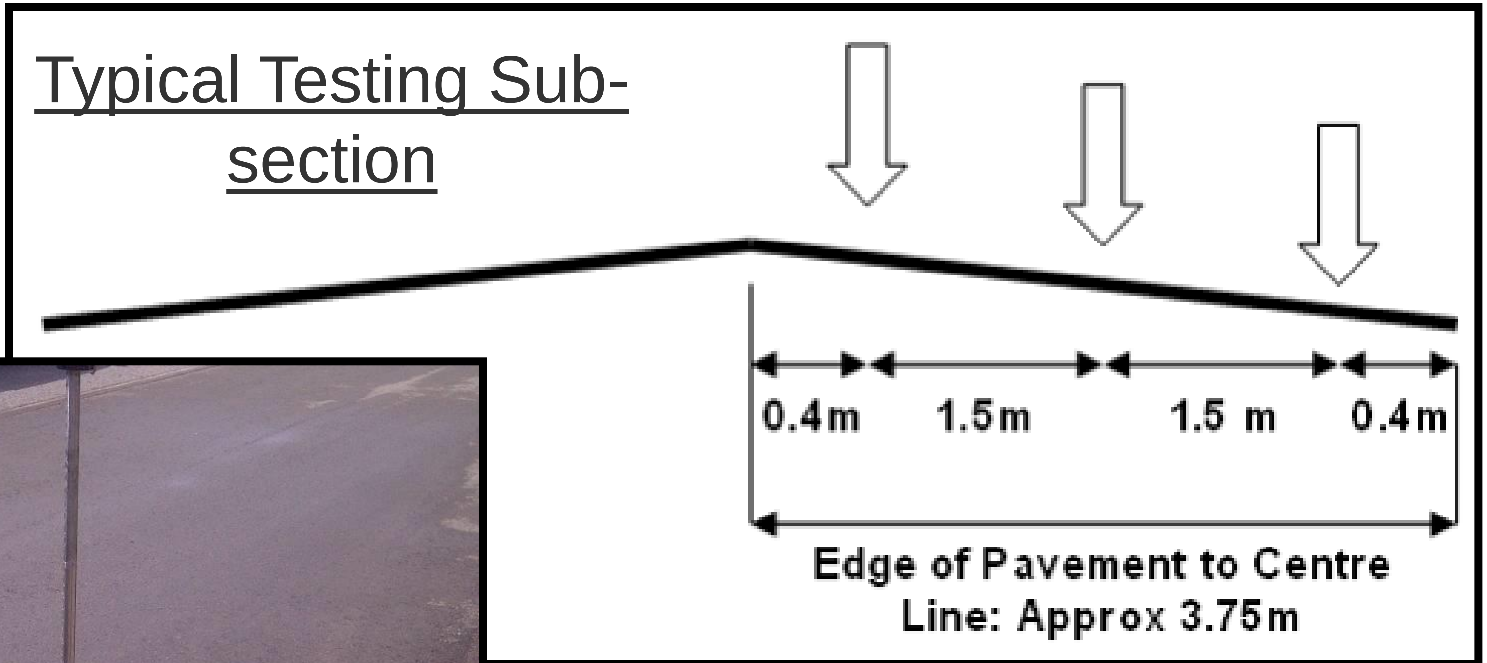
- ITS_{dry} = 327 KPa
- ITS_{wet} = 181 KPa
- % fines = 5.2%
- % AC added = 1.2%

Revised Mix Design (with 3% granular)

- ITS_{dry} = 405 KPa
- ITS_{wet} = 220 KPa
- % fines = 5.37%
- % AC added = 1.2%

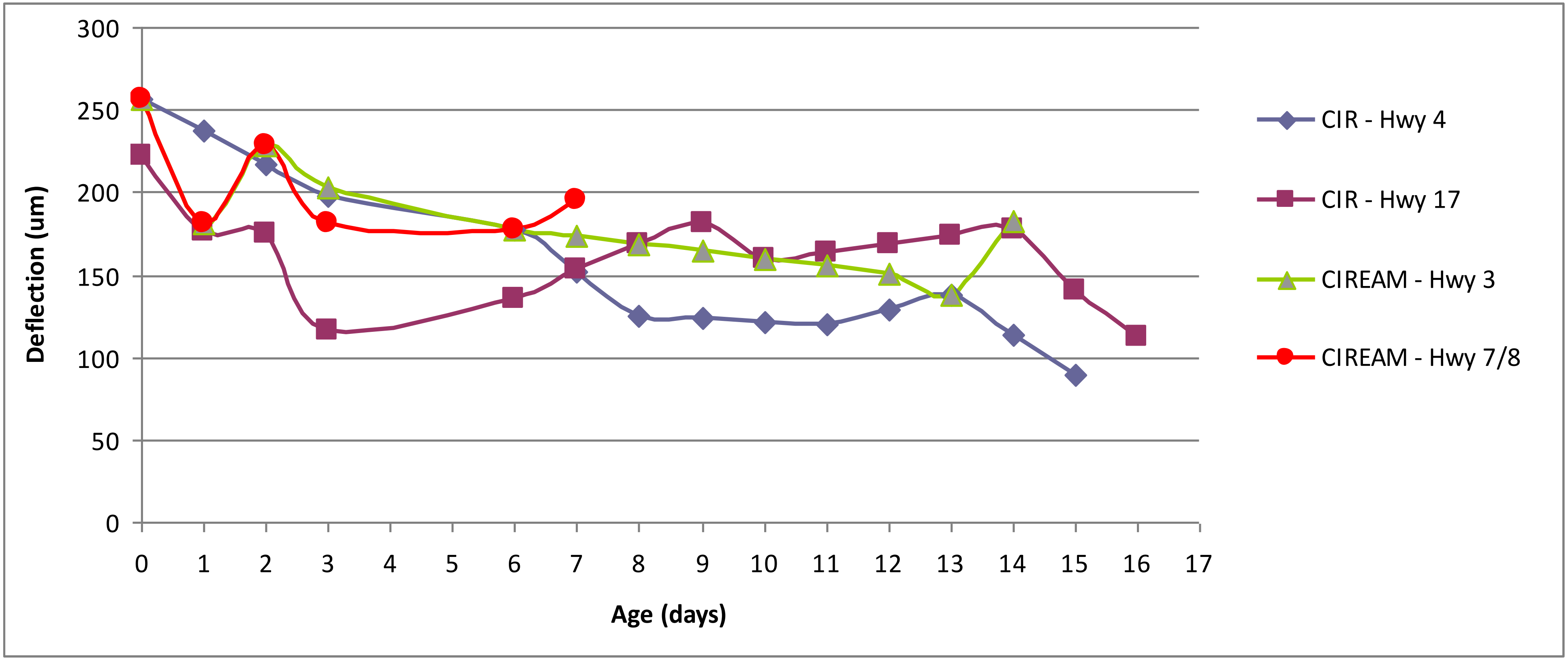
LWD testing of CIR & CIREAM

- Testing in two CIR sites and two CIREAM sites
- 5 sub-sections for each site (10 to 25 m apart)
- Continually testing for 17 days.



LWD testing of CIR & CIREAM

- See a general trend of reduction in deflection.
- Results sensitive to temperature and moisture.
- Spatial-specific results (must be tested at the same location).
- Need correlation if intending to use as QA tools.

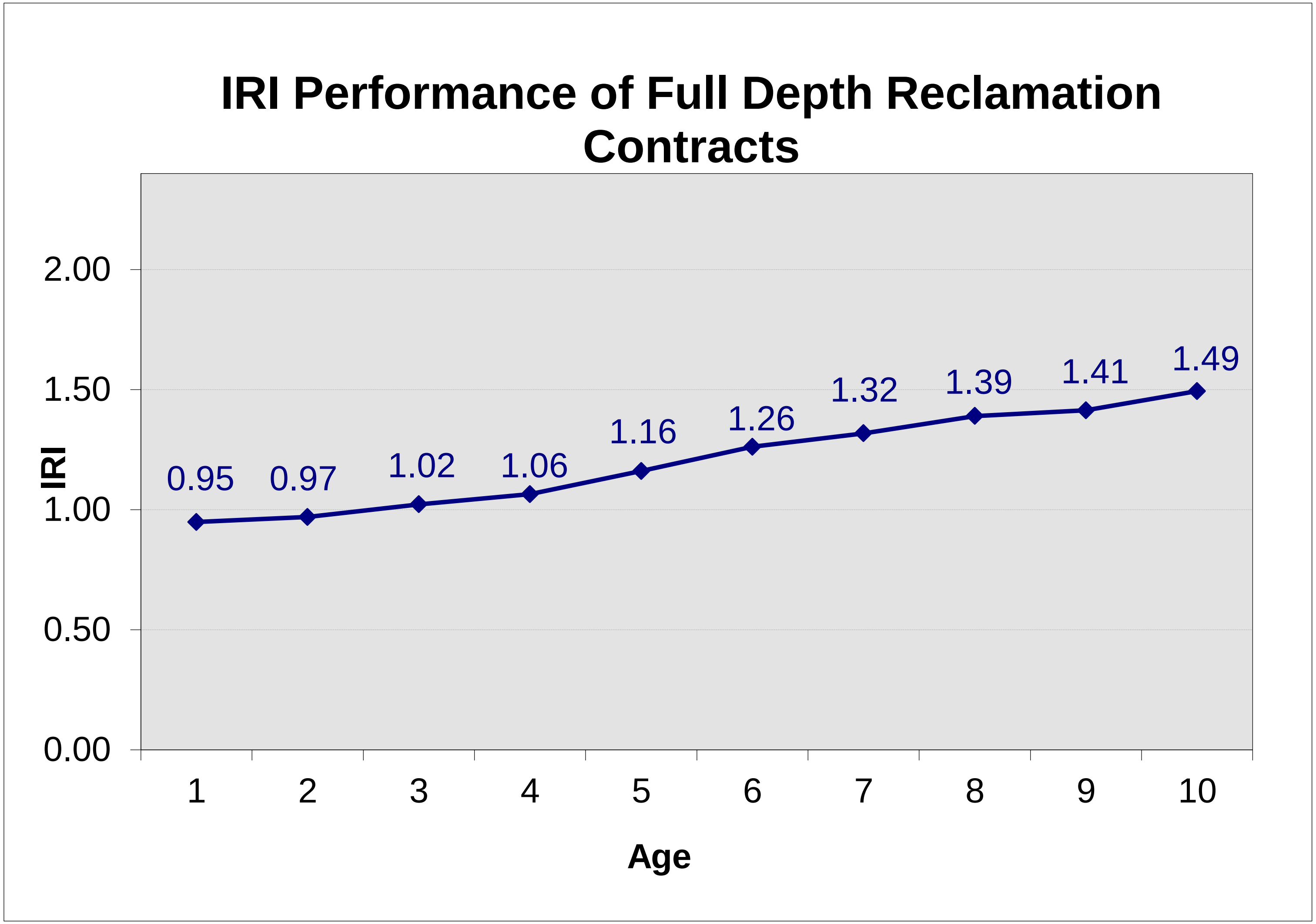


Monitoring

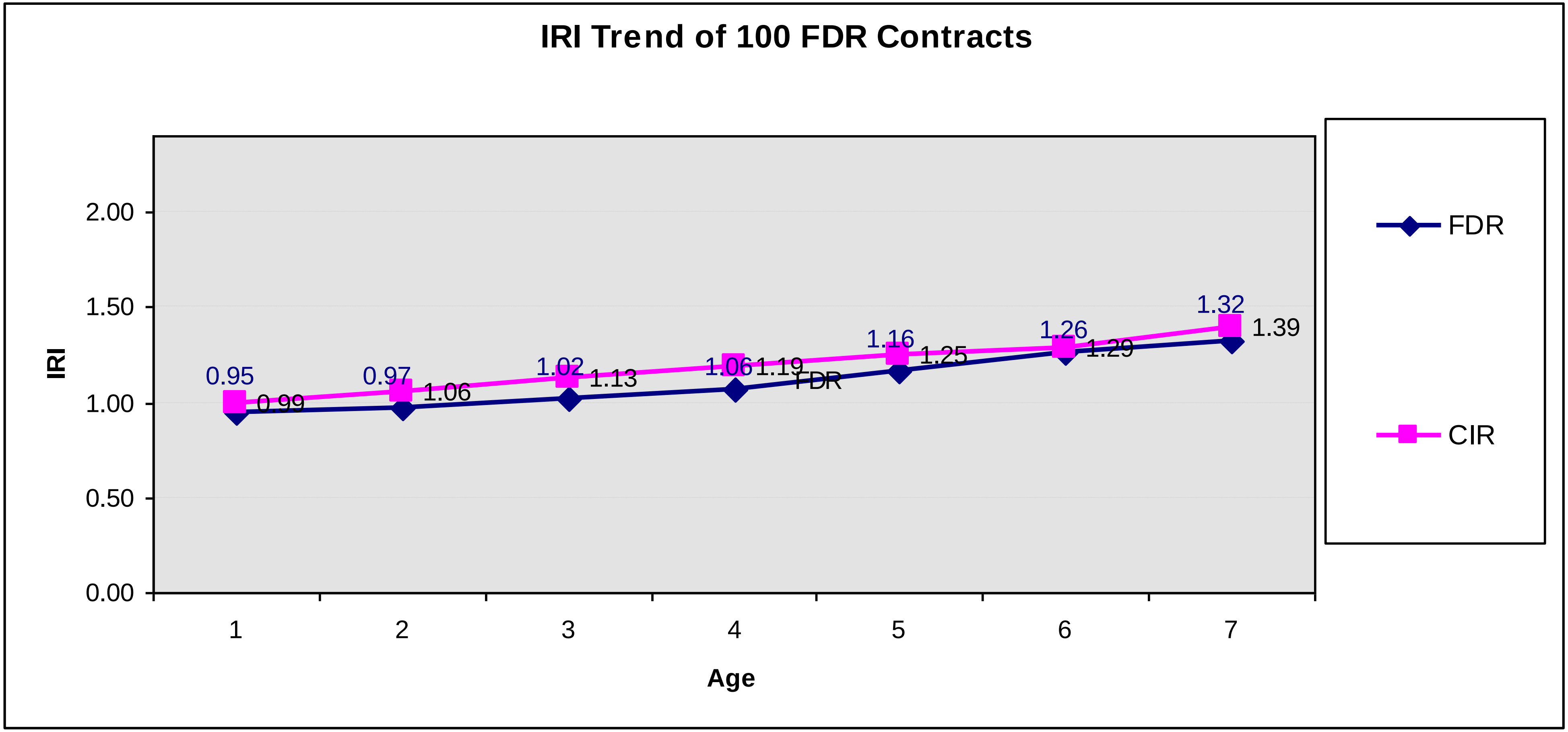
- To monitor short and long term performance, MTO carries out annual field reviews of the in-place recycling projects:
  - Roughness (IRI) and rutting surveys using the ARAN
  - Visual distress data collection

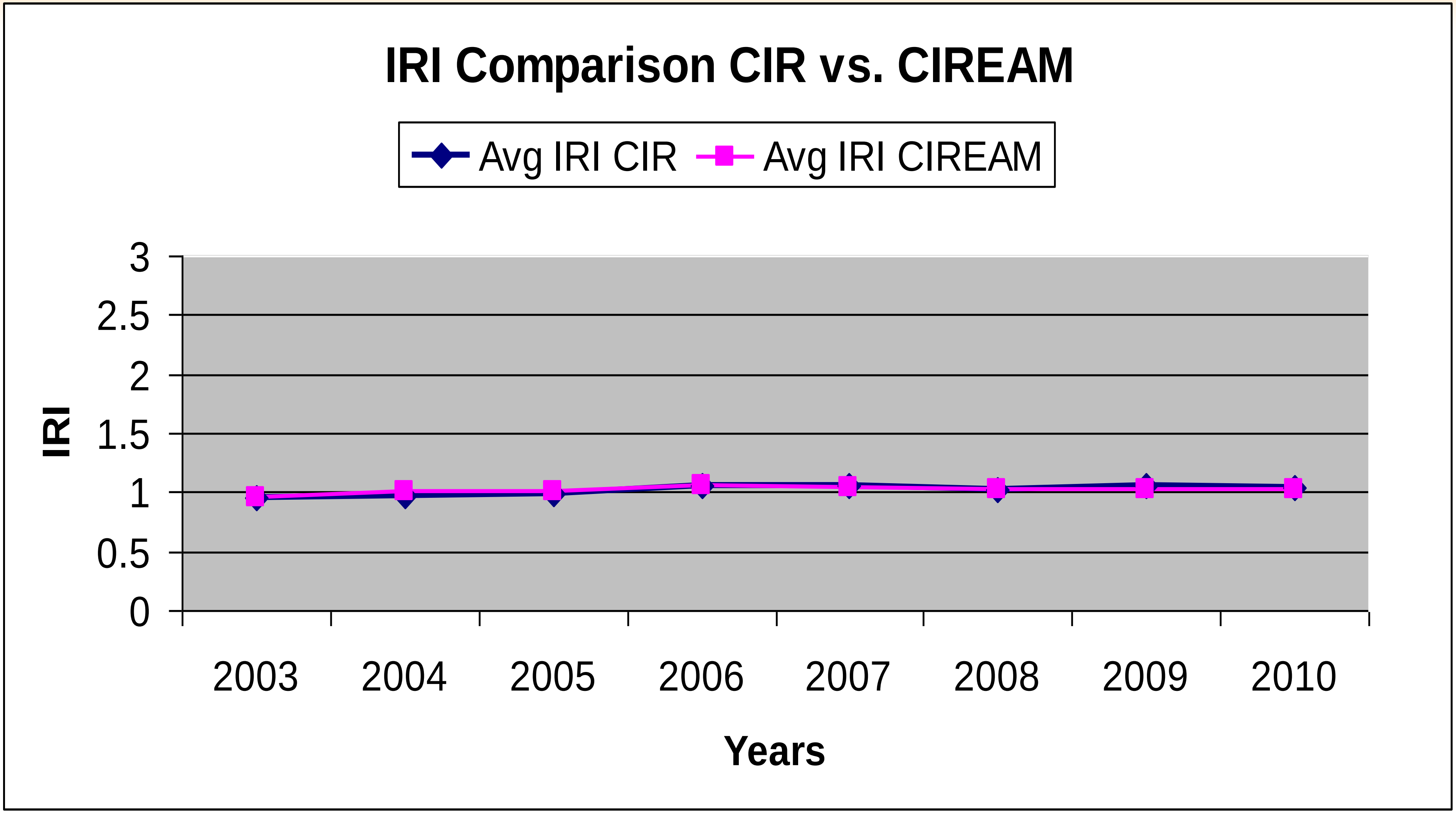
Full Depth Reclamation

- Compare the performance of in place recycling technologies to full depth reclamation treatments
  - Full depth reclamation involves in-place full depth processing of the existing Hot Mix Asphalt (HMA) and underlying granular base, then shaping and compacting the processed materials as granular base.
  - Typically place 2 lift hot mix overlay (90 mm).

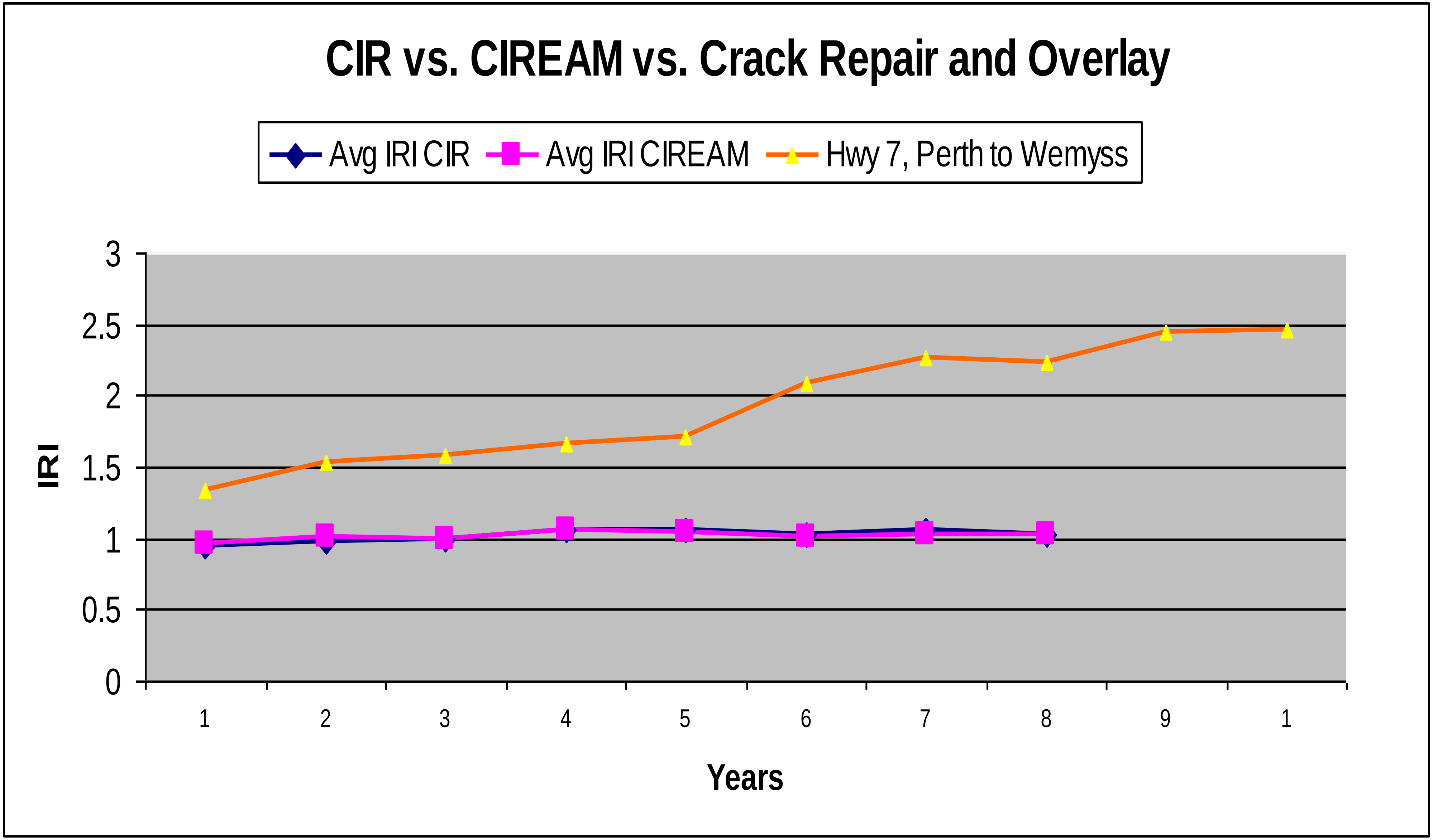

IRI Performance of Full Depth Reclamation Contracts
IRI
2.00
1.50
1.00
0.50
0.00
0.95
0.97
1.02
1.06
1.16
1.26
1.32
1.39
1.41
1.49
1
2
3
4
5
6
7
8
9
10
Age

Performance of CIR vs FDR




IRI Comparison CIR vs. CIREAM
Avg IRI CIR
Avg IRI CIREAM
IRI
3
2.5
2
1.5
1
0.5
0
2003
2004
2005
2006
2007
2008
2009
2010
Years

Highway 7 Perth – 2002-4040


CIR vs. CIREAM vs. Crack Repair and Overlay
Avg IRI CIR
Avg IRI CIREAM
Hwy 7, Perth to Wemyss
IRI
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
9
1
Years

Conclusions

- Cold In Place Recycling technologies are performing very well in Ontario.
- Performance monitoring indicates very similar performance characteristics between the conventional CIR and the CIREAM.
- There are still challenges with contract administration.
- Use of recycling technologies is cost effective, conserves natural resources, saves on transportation, energy and GHG emissions, and results in similar performance to conventional techniques.

Thank you!

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