Quantifying the Sustainable Benefits of Flexible Pavement Preservation Techniques in Canada

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Outline

- Past - What have we learned
- Present - Current practices and improvements
- Case Study - PaLATE
- Sustainable Future – Challenges

Green Pavement Initiatives

Environmentally friendly pavement design, preservation and rehabilitation strategies include:

- Reuse and recycling of materials
  - Pavement recycling
  - Roof shingles, rubber tires, glass and ceramics
  - Blast furnace slag, fly ash and silica fume
- Warm mix asphalt concrete
- Drainable/permeable pavements
- Reduced noise and perpetual pavements

What is Pavement Preservation?

- Coordinated approach to pavement maintenance/rehabilitation:
  - Planned not reactive
  - Treatments are performed before the appearance of significant distresses
  - Extends the service life

Preservation vs. Routine Maintenance

- Preservation treatments are designed to be proactive, applied while the pavement is still in good condition and maintains the pavement at a high level of service

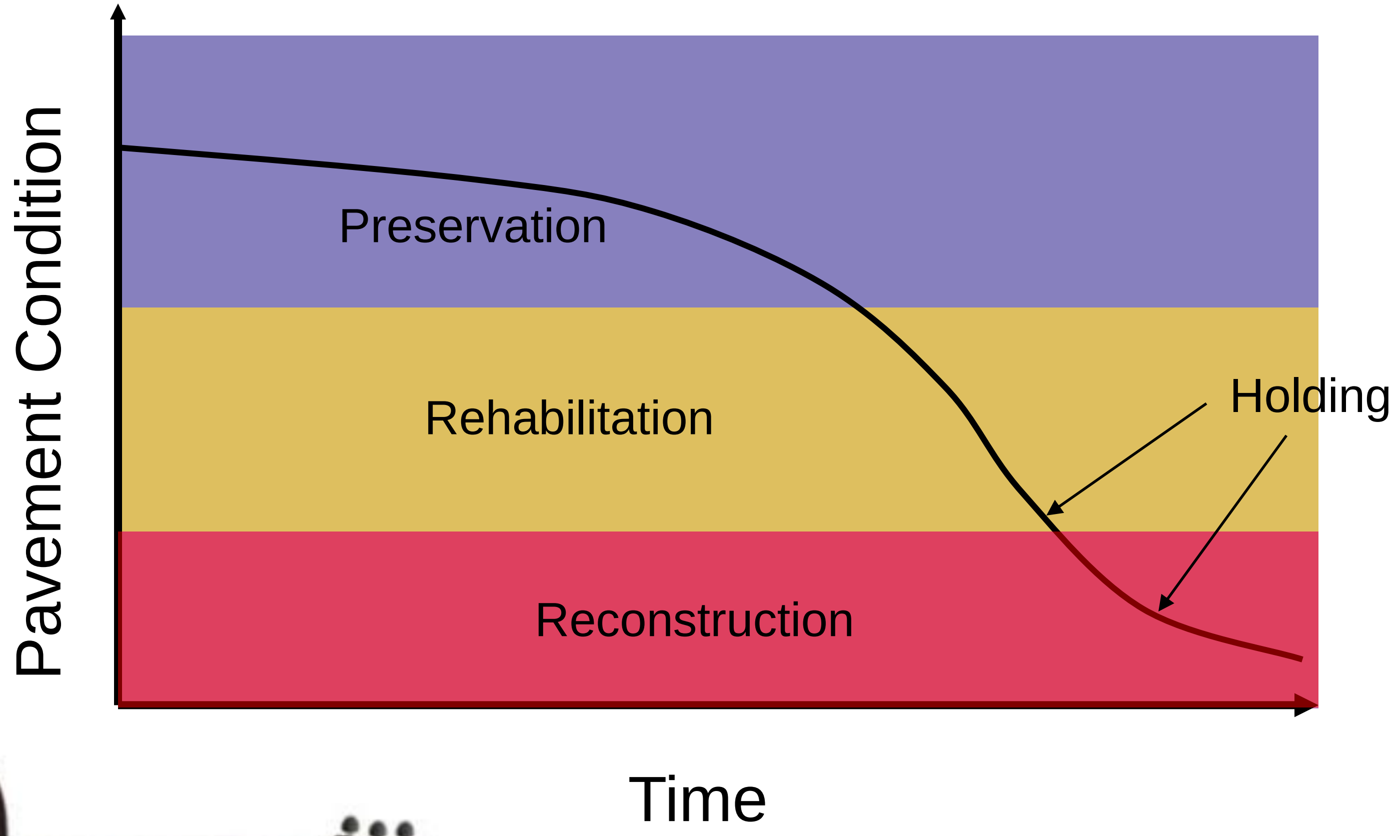
Versus

- Worst-first & reactive types of major maintenance
  - repairs made to existing distresses
  - most common approach to pavement maintenance

Strategy Definitions

- Preservation
  - planned strategy to extend the life of the pavement
  - preserves the system, retards deterioration, and maintains or improves the functional condition of the system (without increasing structural capacity)
- Rehabilitation
  - renews the life of the pavement
  - work undertaken to restore serviceability and improve an existing pavement to a condition of structural or functional adequacy
- Reconstruction
  - removal and replacement of the existing pavement structure
- Holding
  - strategy that prolongs the life of an asset (for a *planned* period of time). Strategy employed to maintain acceptable levels of functionality or safety until full rehabilitation or reconstruction can be completed.

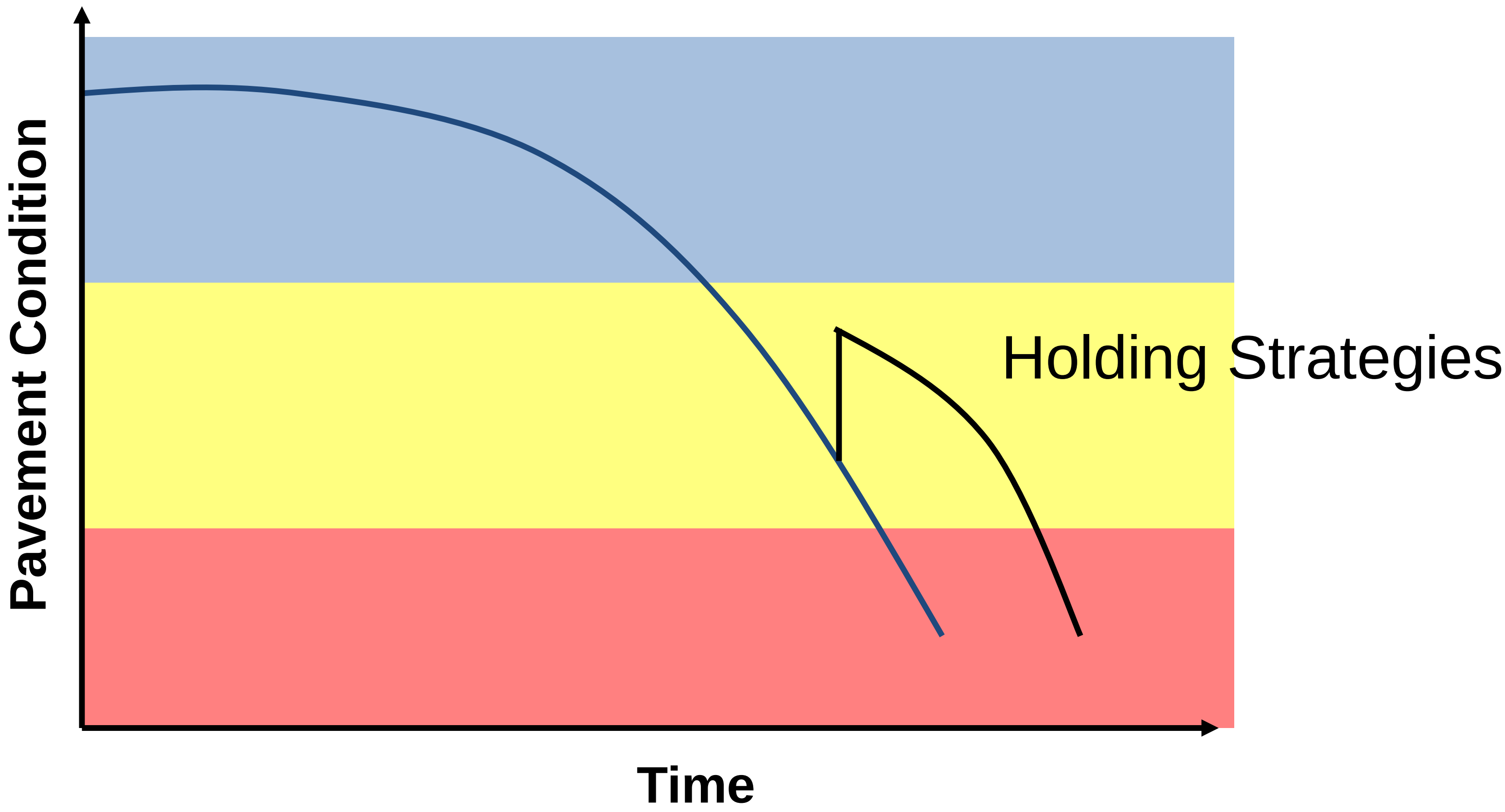
Pavement Treatment Strategies



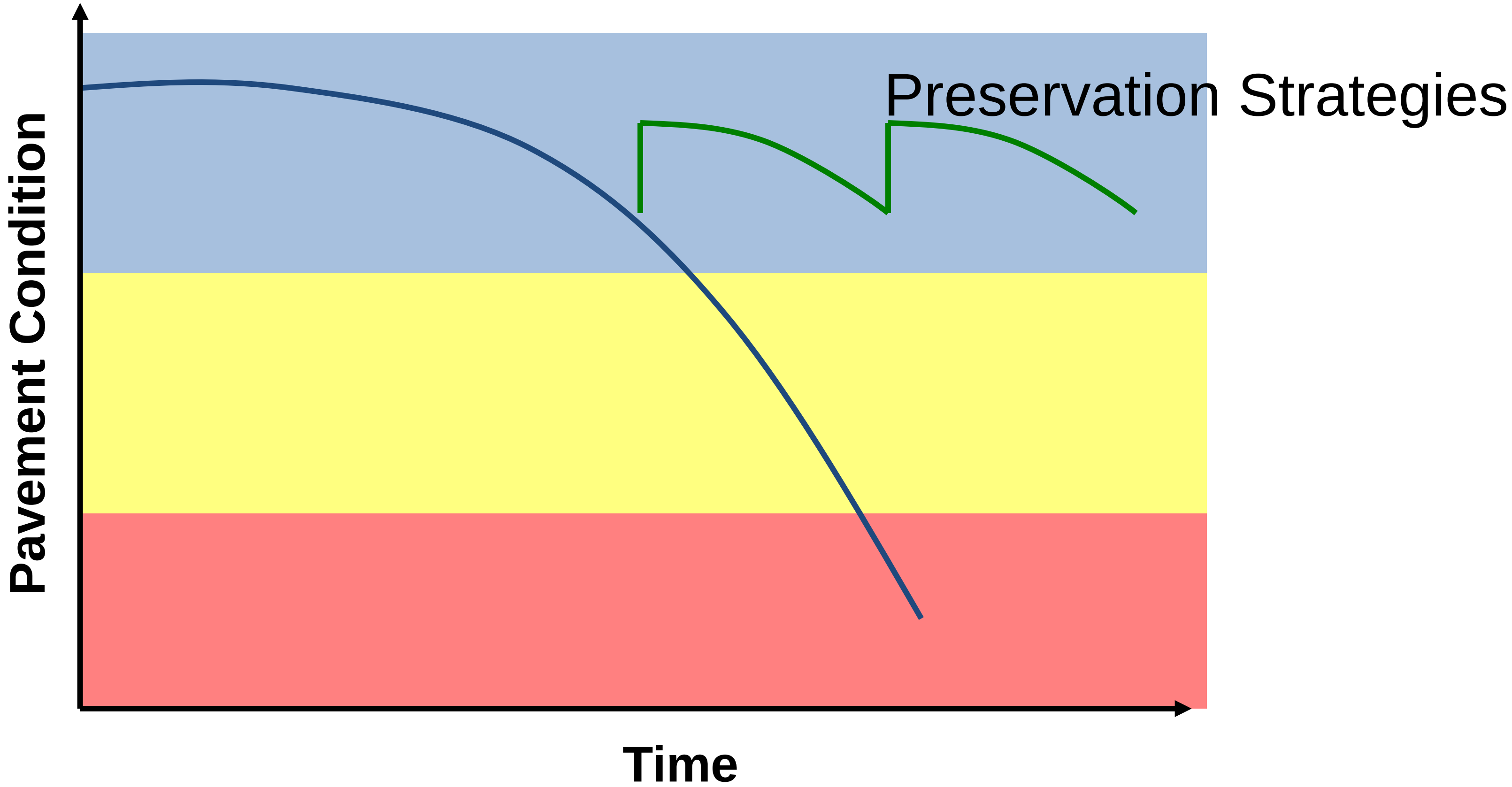
“Mix of Fixes”

- Preservation
  - Microsurfacing
  - Mill 50 mm, Pave 50 mm (Recycled Hot Mix, Warm Mix)
  - Hot In-Place Recycling, chip seals, crack sealing, etc.
- Rehabilitation
  - Mill 50 mm, Pave 90 mm (Recycled Hot Mix)
  - Cold In-Place Recycling and Pave 50 mm
- Reconstruction
  - Rubblize, granular grade raise, and thick HMA overlays
  - Full depth reclamation (FDR) and HMA paving
  - Full depth removal and replacement with new pavement structure
- Holding
  - Hot Mix Patching
  - Thin Resurfacing

Holding Strategies



Preservation Strategies

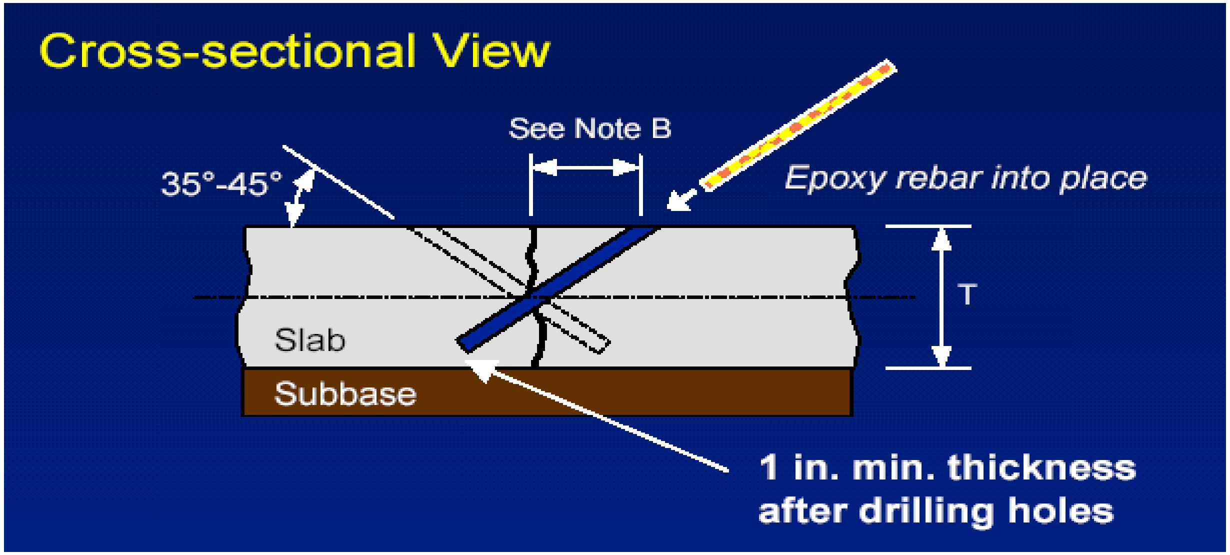


Preservation Strategies – Rigid Pavements

- Dowel bar retrofit of cracks and joints,
- Cross-stitching of longitudinal cracks
- Joint and crack sealing / resealing
- Diamond grinding to address ride, friction or noise issues
- Partial depth repairs
- Pre-cast concrete pavement repairs

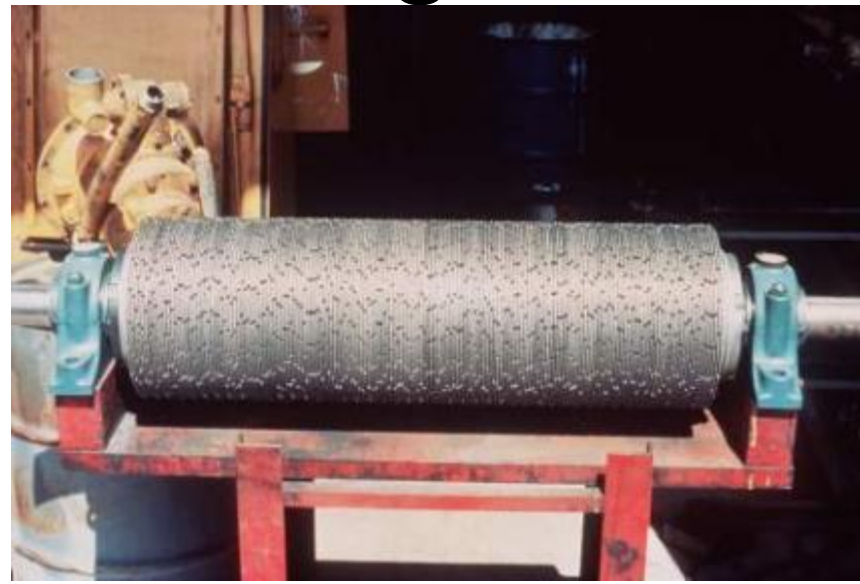
Dowel Bar Retrofit

Cross - Stitching

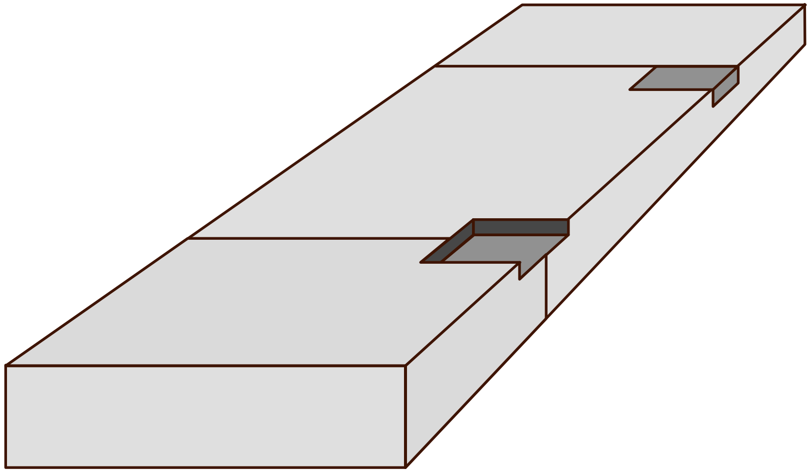


Joint and Crack Sealing

Diamond Grinding



Partial Depth Repairs



Remove and Replace Deteriorated Surface Concrete

Precast Slab Repairs

Preservation Strategies – Flexible Pavements

- Thin Surfacing
  - Micro-surfacing
  - Slurry Seal
  - Chip Seal
  - Fibre modified Chip Seal
  - Ultra thin Bonded Friction Course
- Crack Sealing
- Hot In-place Recycling
- Warm Mix Asphalt

Crack Sealing

Typically used to prevent water and debris from entering cracks in the HMA pavement surface

Thin Surfacings

Typically used to:

- seal cracks
- waterproof surface
- improve friction
- improve rideability
- rejuvenate surface

- *Slurry seal*
- *Micro-surfacing*
- *Chip seal / Dynapatch*
- *Novachip*
- *FMCS*
- *Ultrathin (premium sand mix)*

Slurry Seal

- Description
  - mixture of well-graded aggregate and slow setting asphalt emulsion
- Purpose
  - seal surface cracks
  - address raveling/oxidation
  - fill minor surface irregularities
  - restore friction

Micro-Surfacing

- a polymer-modified cold slurry paving system
- a mixture of dense-graded aggregate, asphalt emulsion, water and mineral fillers
- typically 10 mm thick

Chip Seals (Dynapatch)

Description

- Mechanical spray patching application of asphalt and single-sized aggregate chips rolled onto the pavement

Purpose

- seal pavement surface
- enrich hardened/ oxidized asphalt
- improve surface friction

Ultrathin Bonded Friction Course (Nova Chip)

Description

- gap-graded, polymer-modified HMA placed on a heavy, emulsified asphalt tack coat

Purpose

- address surface distress
- increase surface friction

Fiber Modified Chip Seal (FiberMat)

Description

FMCS consists of a chip seal application incorporating chopped fiberglass strands in the polymer modified emulsion and a covering aggregate layer.

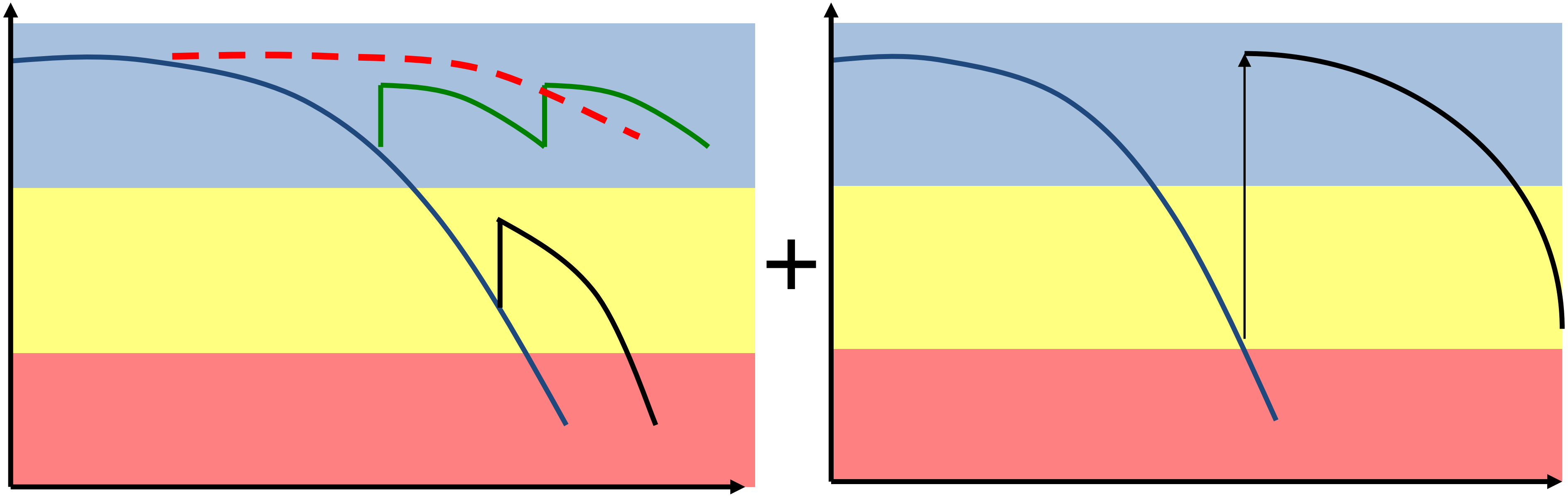
Hot In-Place Recycling - HIR

ROAD TRIP: DRIVING THE MESSAGE FOR CHANGE

Warm Mix Asphalt

- Description
  - Reduction in the asphalt mixtures temperatures (~50 °C) while still achieving adequate compaction
- Purpose
  - Lower temperature
  - Reduce fuel consumption
  - Reduce GHG emissions

Coordinated Approach to Investment



Preservation or Holding   Rehabilitation

= Optimized Asset Performance

10 Years Pavement Preservation Treatment Quantities (2003-2012)

Treatment	Quantities (m2)
Micro-surfacing	7,239,117
Slurry Seal	906,050
Chip Seal	849,178
FMCS	440,641
Ultra-thin	450,223
HIR	324,124
Total	**10,209,333**

Current Practice

Recent improvements in **design**, **materials** and **construction** processes have significantly increased the benefits of pavement preservation techniques.

Improvements in technology have provided cost effective designs and optimization of preservation strategies.

Design Improvements

Comprehensive Construction and Material Specs:

- OPSS 341 and 369, Crack Sealing
- OPSS 303 and 304, Chip Seal and Surface Treatment
- OPSS 337, Slurry Seal
- OPSS 336, Micro-Surfacing
- OPSS 332, Hot in-place recycling
- OPSS 333, Cold in-place recycling
- OPSS 335, CIR with Expanded Asphalt

Available online: **http://www.mto.gov.on.ca/english/transrd**

Sustainability Concepts within Pavement Preservation

Towards a Sustainable Future

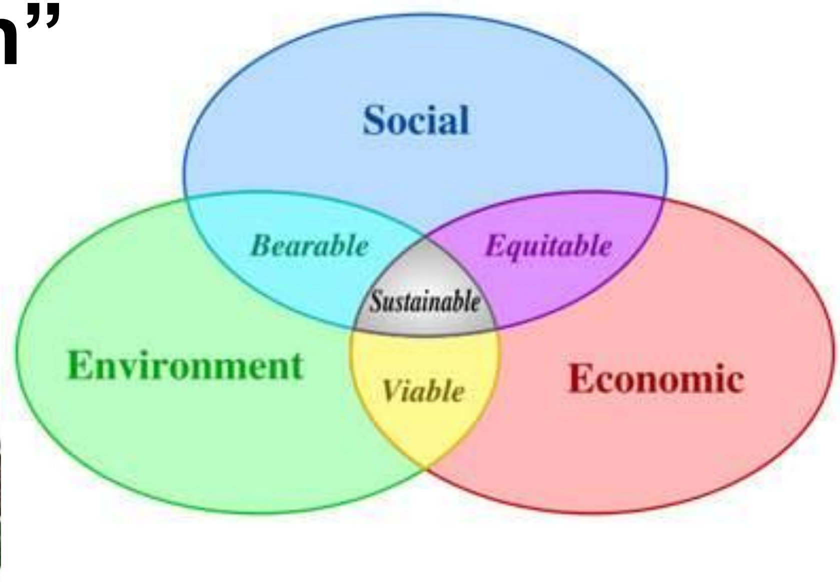
What is Sustainable Development?

"…. Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

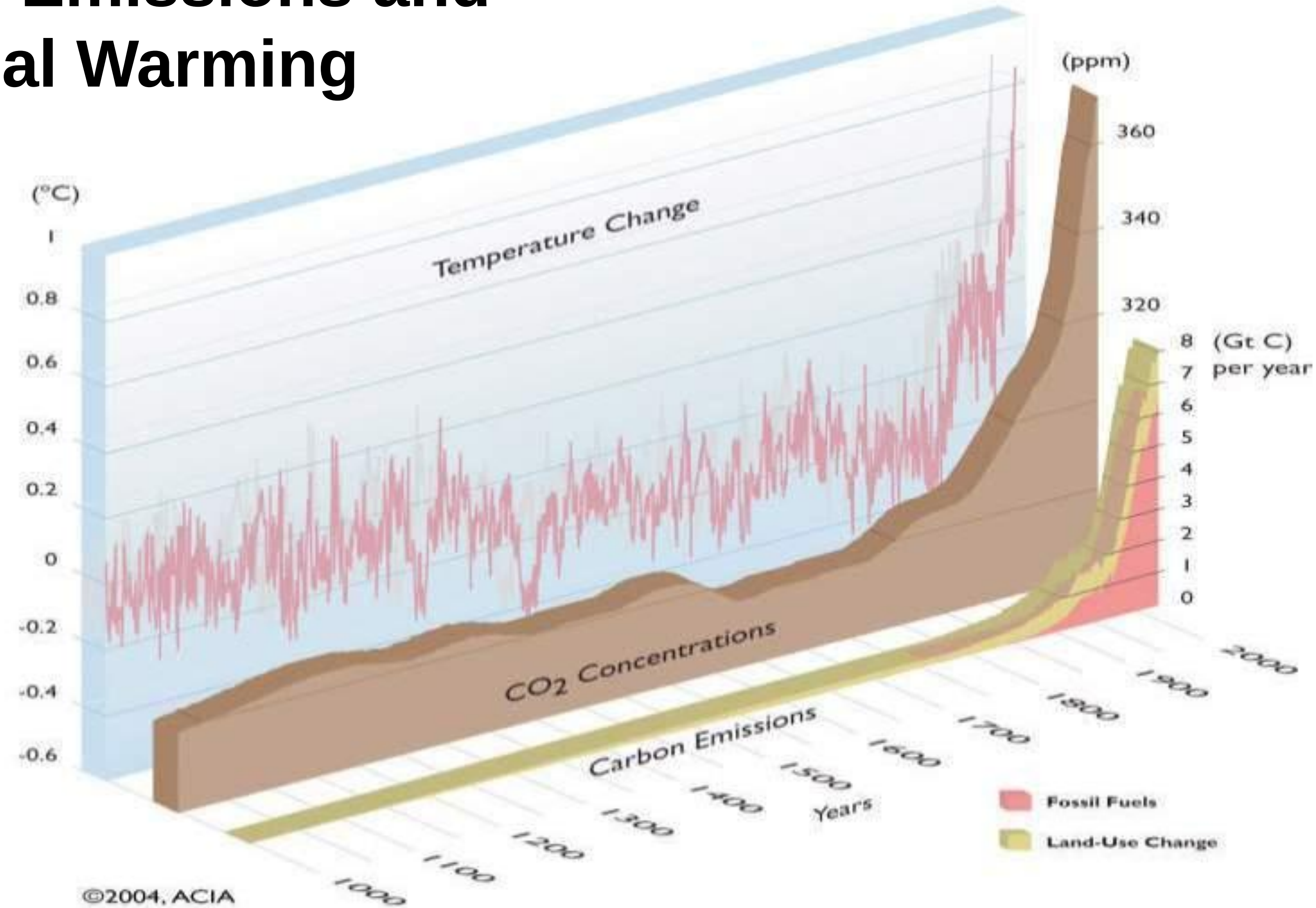
Towards a Sustainable Future

To achieve sustainability, every corporate decision should consider the impact of the triple-bottom-line.

“What are the Social, Economic, and Environmental (SEE) Impacts of the decision”



GHG Emissions and Global Warming



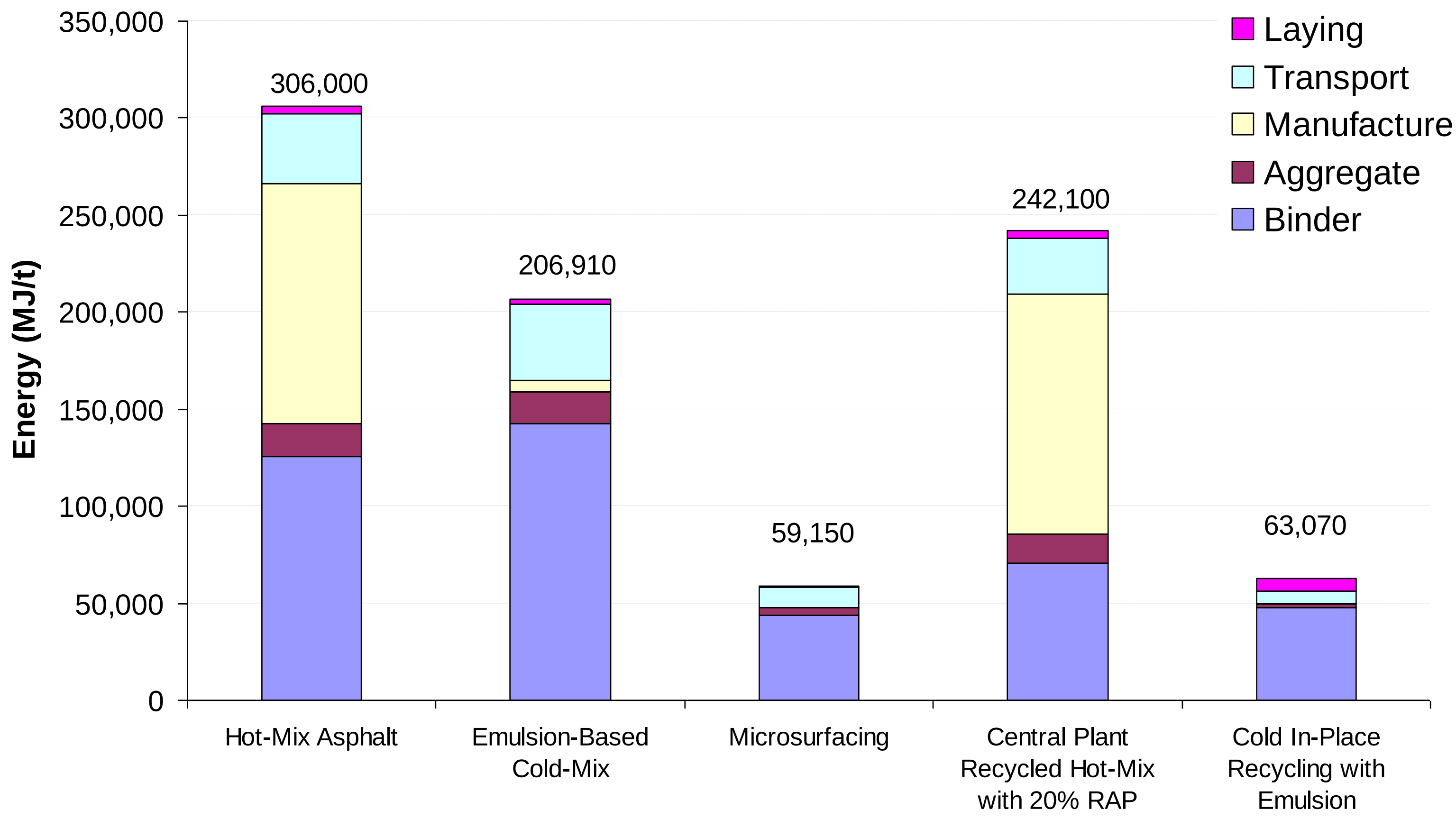
Variation in Mean Surface Temp and CO_2 Concentration

Sustainable Pavement Criteria

“ ….safe, efficient, environmentally friendly pavements meeting the needs of present-day users without compromising those of future generations”

- Pavement preservation technologies address the main criteria for a sustainable pavement:
  - Optimizing the use of natural resources
  - Reducing energy consumption
  - Reducing greenhouse gas emissions
  - Limiting pollution
  - Improving health, safety and risk prevention
  - Ensuring a high level of user comfort and safety

Energy Used per Lane-Kilometer of Material Laid Down



Adapted from '*The Environmental Road of the Future, Life Cycle Analysis*'

by Chappat, M. and Julian Bilal, Colas Group, 2003.

Case Study

Quantifying the Sustainable Benefits of

Flexible Pavement Preservation Treatments

versus

Traditional Mill and Overlay

Impact Evaluation

- **PaLATE** software -

  Pavement Life-cycle Assessment for Environmental and Economic Effect
- Created by Dr. Horvath of the University of California at Berkley
- Assists decision-makers in evaluating the use of pavement materials in highway construction (both LCC and Environmental Impacts).

Case Study

- Three pavement preservation treatments are compared to conventional "Shave & Pave":
  - Mill 50 mm and overlay 50 mm WMA
  - 50 mm HIR
  - 10 mm Micro-surfacing

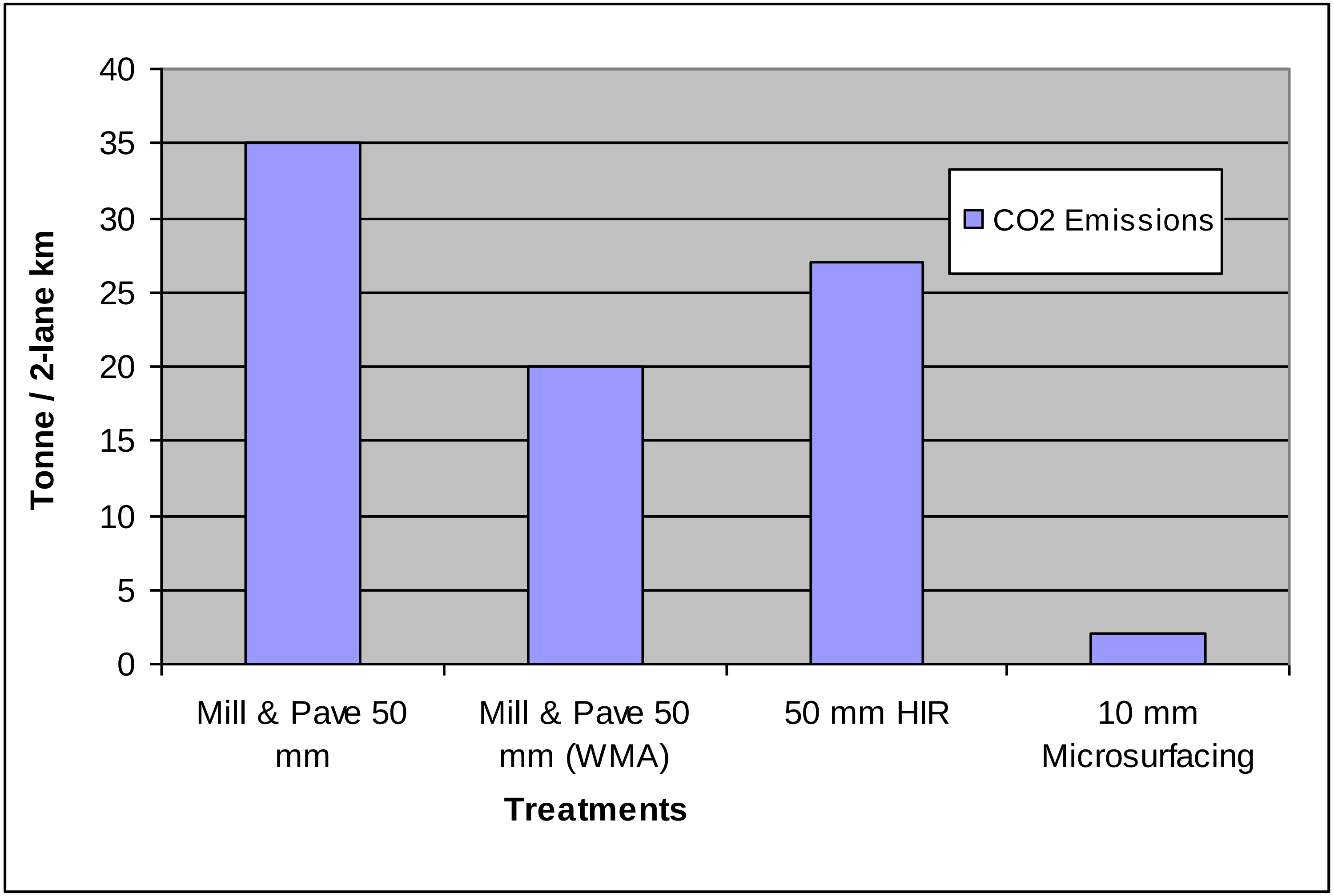
    Versus
  - Mill 50 mm and overlay 50 mm HMA

Quantify Environmental Effects

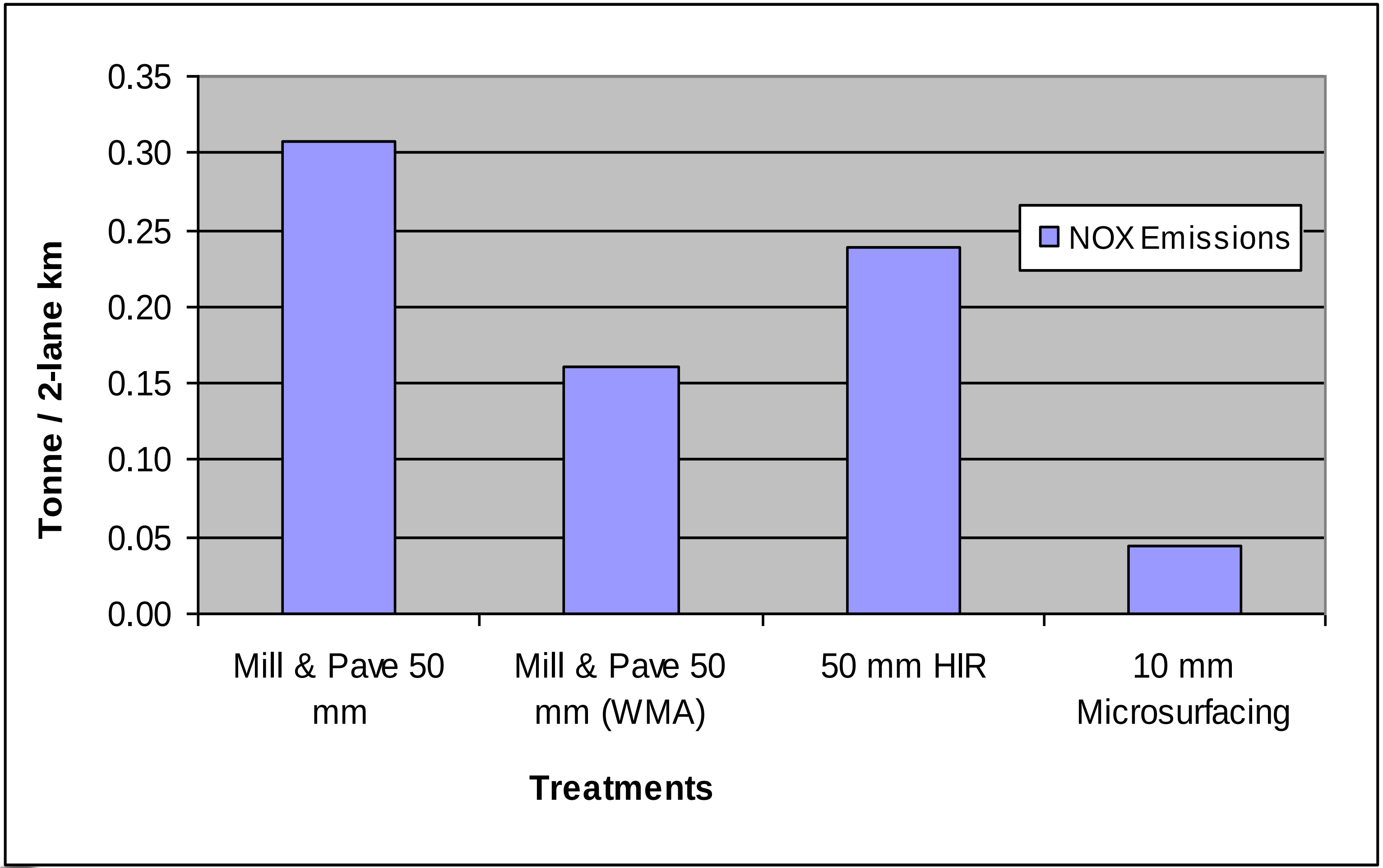
- Using PaLATE model, the following emissions were calculated and compared for each treatment:
- Based on typical 7.0 meter wide 2-lane km section of hwy.

Treatments	Energy (MJ)	CO_2 (tonne)	NO_x (kg)	SO_x (kg)
Mill 50mm, Pave 50 mm	674,925	35	307	9,581
Mill 50 mm, Pave 50 mm WMA	477,822	20	161	6,708
50 mm HIR	566,937	27	239	7473
10 mm Microsurfacing	56,451	2	45	1,970

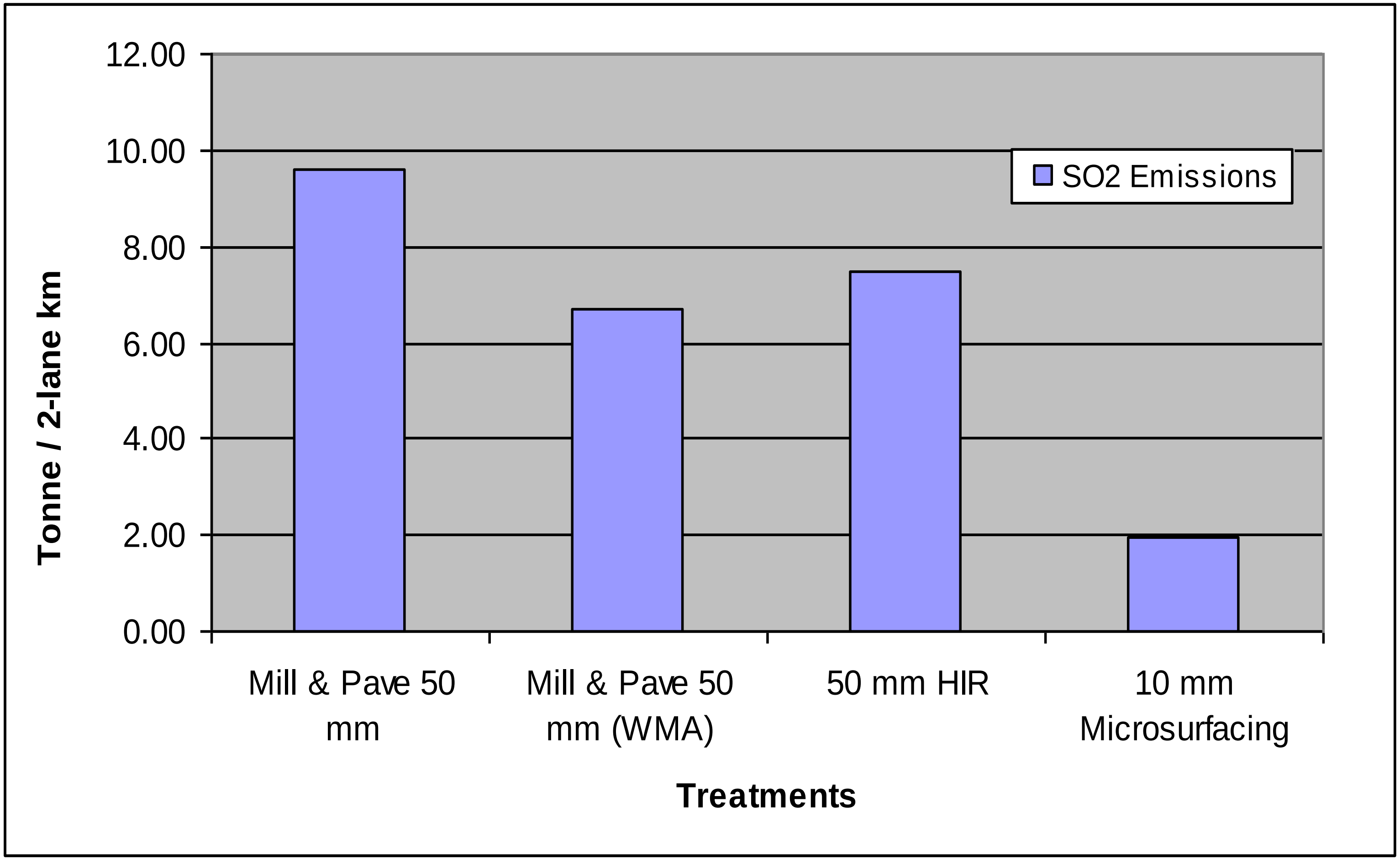
CO_2 Emissions



NO_X Emissions



SO_2 Emissions



Environmental Benefits

- Per 2-lane km, micro-surfacing consumes only 8% of the energy, emits approximately 6% of the CO_2, 15% of the NO_X, and 20% of the SO_X and costs 40-50% less when compared to a conventional mill and overlay treatment

- Since the implementation of micro-surfacing contracts, assuming a 7 year life for micro-surfacing and a 10 year life for conventional mill and overlay, MTO has reduced annualized GHG emissions by:
  - **35,600 t** of CO_2
  - **270 t** of NO_x
  - **7,500 t** of SO_2

  And saved **702,000** tonnes of aggregates

Economic Benefits

- Over the past 10 years, MTO has constructed 7,239,000 m^2 of micro-surfacing. If MTO were to have performed a traditional mill and overlay instead of micro-surfacing over the past 10 years, $57,913,000 more would have been spent based on initial construction costs.
- From a life cycle costing perspective, the 10 year annualized cost associated with using mill and overlay would be **$36,196,000** more than the cost of micro-surfacing.

Sustainable Pavements in Canada

- MTO currently uses numerous innovative pavement preservation technologies that conserve aggregates, reduce GHG emissions, and minimize energy consumption
- A key MTO sustainability strategy is to implement these technologies on a larger scale and encourage their use province wide.
- These technologies support a “zero waste” approach and will assist in meeting our GHG reduction commitments while addressing the triple-bottom-line (SEE).

What's next?

- Current Life Cycle Costing (LCC) includes:
    - Initial, and discounted main/rehab costs and remaining life costs
    - User costs
- We now have the tools to calculate GHG emissions and energy savings – PaLATE software
- MTO has developed a rating system to quantify and encourage pavement sustainability
- We are moving towards including an environmental component into LCC (Environmental benefits/credits).
- Insures that the best treatment is selected to benefit economic, social and environmental needs

  - a Sustainable Approach.

GreenPave

What is it?

- A simple points based rating system designed to assess the “greenness” of pavements.

Our Goal:

- To provide an assessment of the sustainability of pavement designs and pavement construction for the purpose of promoting greener pavements.

Existing Green Rating Systems

- LEED® for Buildings
- University of Washington Green Roads
- NYSDOT GreenLITES Project Design Certification Program
- Alberta/Stantec Green Guide for Roads
- TAC Green Guide for Roads

GreenPave Categories

Category	Goal	Points
Pavement Design Technologies	To optimize sustainable designs. These include long life pavements, permeable pavements, noise mitigating pavements, and pavements that minimize the heat island effect.	9
Materials & Resources	To optimize the use/reuse of recycled materials and to minimize material transportation distances.	11
Energy & Atmosphere	To minimize energy consumption and GHG emissions.	8
Innovation & Design Process	To recognize innovation and exemplary efforts made to foster sustainable pavement designs.	4
	Maximum Total:	**32**

GreenPave Overview

Category / Sub-Category

Pavement Technologies — *9 Points*	Materials & Resources — *11 Points*	Energy & Atmosphere — *8 Points*	Innovation & Design Process — *4 Points*
Long-Life Pavements — *3 Points*	Recycled Content — *5 Points*	Reduce Energy Consumption — *3 Points*	Innovation in Design — *2 Points*
Permeable Pavements — *2 Points*	Undisturbed Pavement Structure — *2 Points*	GHG Emissions Reduction — *3 Points*	Exemplary Process — *2 Points*
Noise Mitigation — *2 Points*	Local Materials — *2 Points*	Pavement Smoothness — *1 Point*	
Cool Pavements — *2 Points*	Construction Quality — *2 Points*	Pollution Reduction — *1 Point*	

Blue font designates sections applicable only to constructed pavements

(Blue font: Pavement Smoothness, Construction Quality, Pollution Reduction)

Summary

We will better achieve our sustainable pavement goals through:

- Building on current industry/ministry partnerships in the development of improved specifications and design/construction procedures
- Encouraging continued innovation by our pavement preservation contractors
- Supporting dedicated research programs to advance the technology
- Increasing technology transfer to accelerate adoption of pavement preservation concepts

Conclusions

- Pavement preservation solutions satisfy the definition of sustainable pavements:
  - Pavement preservation programs begin with the concept that the treatments are proactive and they are applied when the pavement is still in relatively good condition
  - Thinner, faster, less disruptive, less contract administration, less GHG emissions and less energy consumption
  - With coordinated pavement preservation/rehabilitation programs the value of the road network will increase

Conclusions

- There is an increased focus on sustainable asset preservation, both at the state/provincial and municipal levels
- Pavement preservation and rehabilitation treatments applied at the right time can significantly extend pavement life and result in improved network performance over time
- Implementation of **sustainable** AM principles and performance measures are critical to addressing infrastructure investment requirements and **environmental stewardship** over the long-term

Thank you!

Questions?

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