



# Pavement Preservation and Maintenance Schedule Evaluation Using a Life-Cycle Assessment Tool

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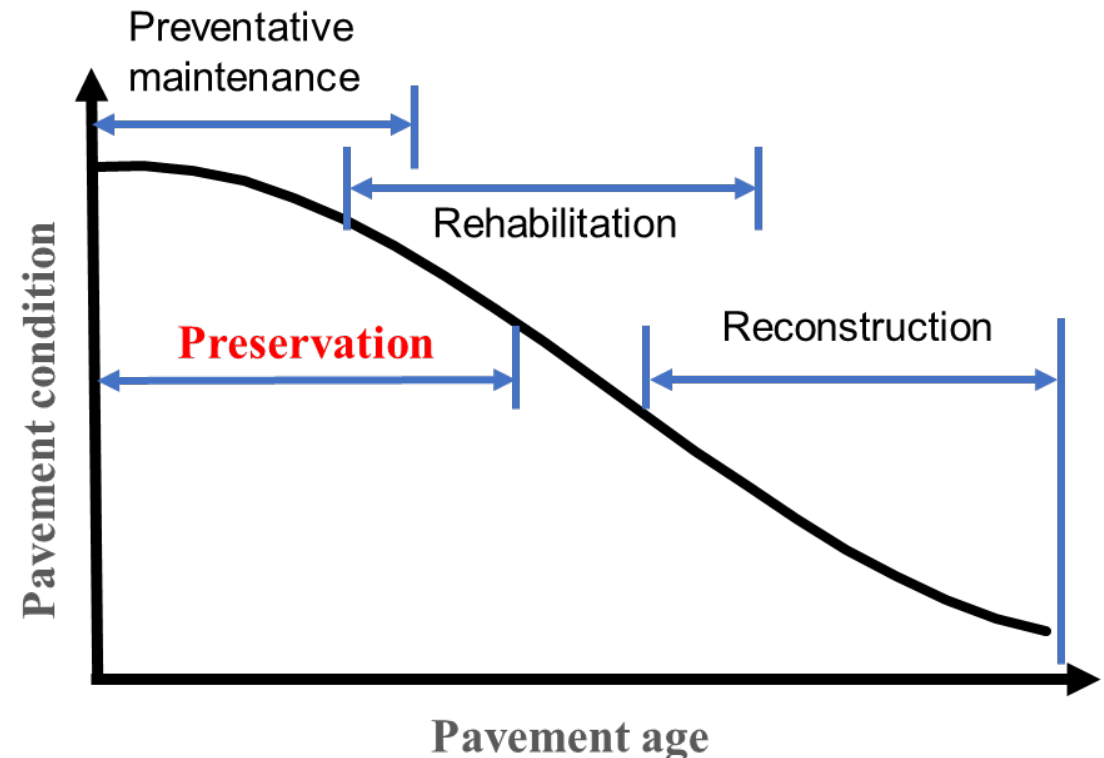
**1/13/2021**

# Outline

- **Pavement Preservation**
- **Preservation Schedules Design**
- **Life-cycle Assessment**
- **Tool Development**
- **Case Studies**
- **Summary**

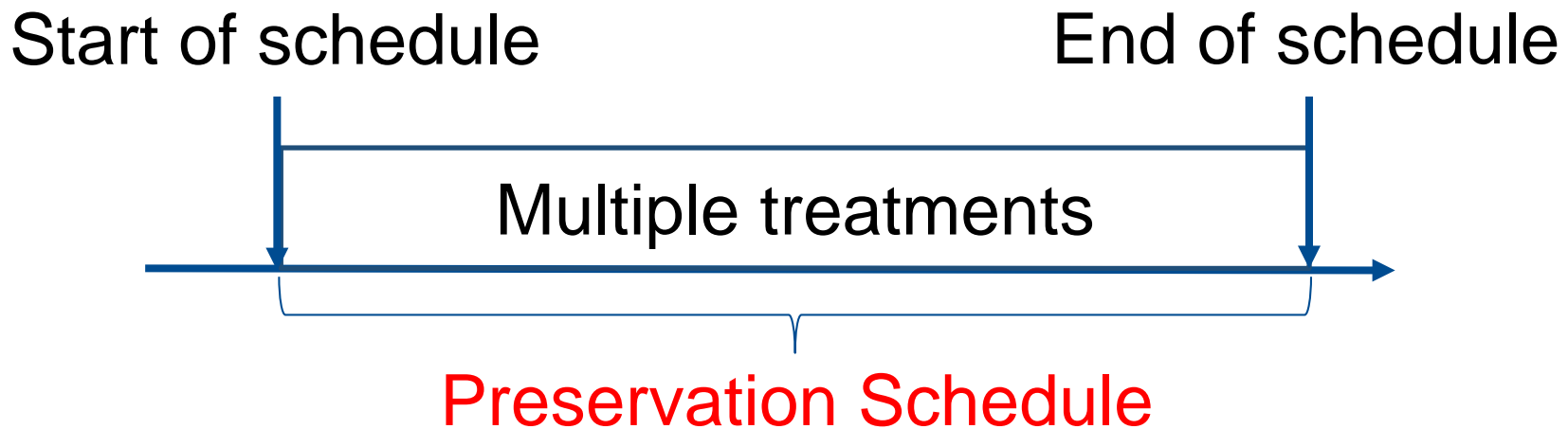
# Pavement Preservation

- A cost-effective and environmentally sustainable strategy : **maintaining pavement serviceability and extending pavement service life while utilizing less resources.**
- It encompasses preventive and routine maintenance as well as minor rehabilitation activities.

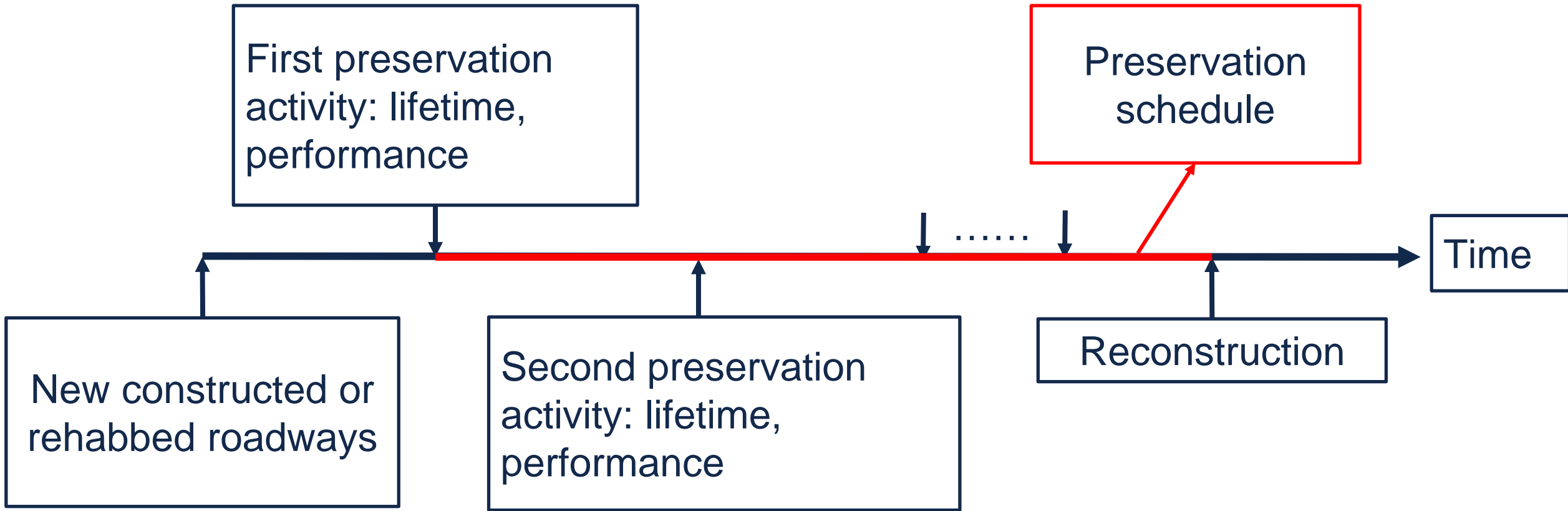


# Motivation and Objective

- Most of existing studies focus on cost benefits of a **single** pavement preservation treatment using life-cycle cost analysis (LCCA) tools.
- This study aimed to design and analyze an optimal pavement preservation schedule.



# Preservation Schedule



# Preservation and Maintenance Treatments Considered

Preservation Treatment for AC Surfaces	Preservation Treatment for Concrete Surfaces
<ul style="list-style-type: none"> <li>Crack sealing/crack filling</li> <li>Fog seal</li> <li>Chip seal</li> <li>Cape seal</li> <li>Slurry seal</li> <li>Microsurfacing</li> <li>Thin AC overlay</li> <li>Ultra-thin bonded wearing course (UTBWC)</li> <li>Bonded-concrete overlay (BCO)</li> <li>Hot in-place recycling (HIR) and chip seal</li> <li>HIR and microsurfacing</li> <li>HIR and thin AC overlay</li> <li>Cold in-place recycling (CIR) and chip seal</li> <li>CIR and microsurfacing</li> <li>CIR and thin AC overlay</li> <li>CIR and medium AC overlay</li> </ul>	<ul style="list-style-type: none"> <li>Diamond grinding/grooving</li> <li>Joint resealing</li> <li>Dowel-bar retrofitting</li> <li>Partial depth repair</li> <li>Full-depth repair</li> <li>Ultra-thin bonded wearing course</li> <li>Thin AC overlay</li> <li>Crack sealing/crack filling</li> </ul>

# Lifetime Estimation Framework

Step 1: Basic linear model

$$PCI_t = PCI_0 - m * t$$



Step 2: Data collection



Step 3: Analytical  
hierarchy method

$$PCI_0 = 100;$$

$PCI_t$  = PCI value at the end of treatment lifetime

$m$  = pavement deterioration rate

$t$  = lifetime.

Preservation activity lifetime is collected under various pavement conditions and traffic data.

$$m = m_{mean} * F_{adj}$$

$$= m_{mean} * (F_{PCI} + F_{AADT} + F_{Tr})$$

$$PCI_t = PCI_0 - m_{average} * (\alpha * PCI + \beta * \ln(AADT) + \gamma * Tr + \epsilon) * t$$

# Lifetime Estimation Models

- **Microsurfacing**

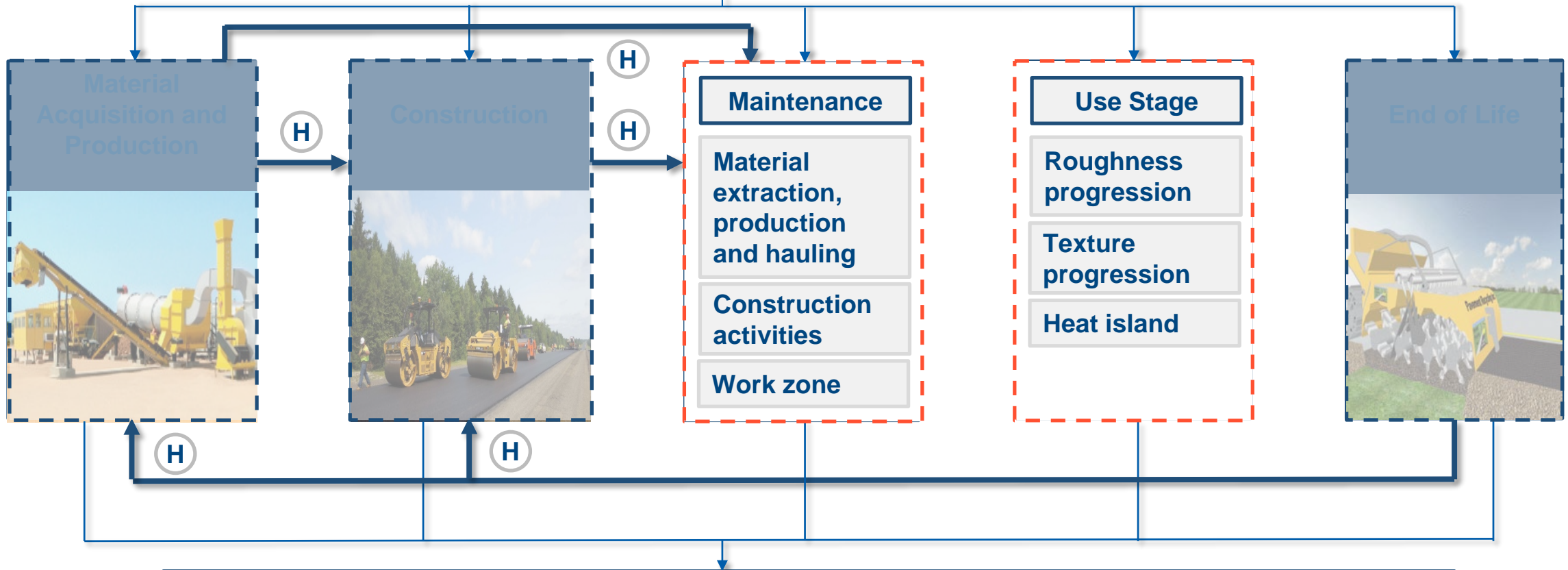
- $PCI(t) = 100 - 9.93 \times (0.0044 \times \ln(AADT) - 0.0076 \times$

Poor condition	Good condition	Literature review
5.4	6.6	[5, 7]

# LCA System Boundary

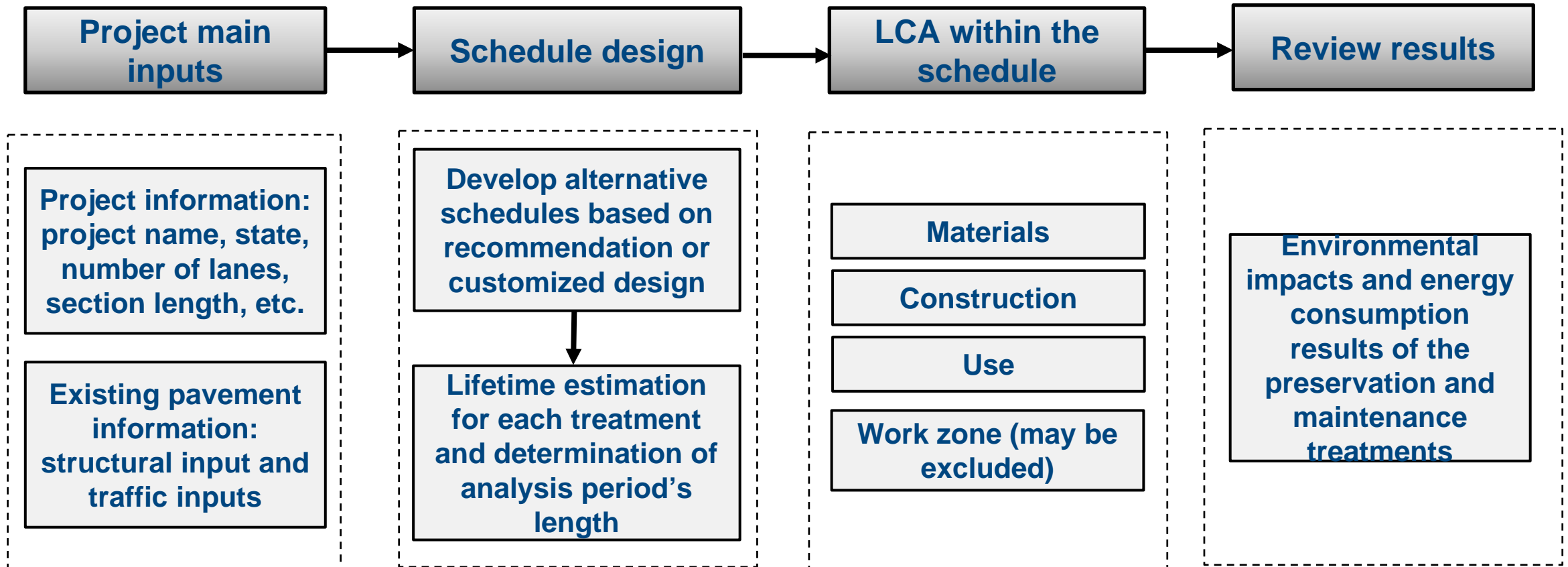
Inputs: Energy, Water, Equipment

(H) Hauling



Outputs: Emission to Air, Wastes to land and water, hazards to humans

# Tool Framework



# Tool Shortcut

Modify Pay Item Composition

## MODIFY A PAY ITEM

Pay Item ID: **J1440227** (SQ YD) *Status (Default/User-modified):* **D**

General | Materials | Mixtures | Equipment

**General** Clear All

Load inputs from an existing pay item: Choose an Existing ID

Pay Item ID: J1440227  
 Date Created: Sep 2015  Is this a Maintenance Pay Item?  
 Description: HOT-MIX ASPHALT REMOVAL OVER PATCHES, 2"  
 Quality of Data: Estimated  
 Unit: SQ YD  
 Productivity (units/hour): 15.63  
 Material Wasted (%): 0 ?  
 Mix Designs required: 0  
 Pay Item Apply Year (yr): 4  
 Cost (\$) per Unit: 16.34 2015\$ \*not required  This is a baseline pay item

Notes:  
Asphalt Removal x 2" Deep, 145 lb/ft3 for HMA. Productivity based on IDOT rates for "Class C & D Patching". . .

Save & Finish Cancel

Modify Mix Design

## MIX DESIGN

*Status (Default/User-modified):* **D**

Load inputs from existing mix design: Choose an Existing ID

Date Used: Dec 2014  
 Mix Design ID: HMASurface  
 Mix Type: HMA Plant  
 Mix Description: HMA Surface

**Asphalt Mix Volumetrics**

Gmb (design) 2.394  
 Gmm 2.494  
 Voids (%) 4  
 Asphalt Content (%) 5.5

	Material	AC Content (%)	Amount (% mix)	Mode of Transport	Terminal-to-Plant Distance (mi)
1	Binder, straight binder		5.5	Hauling Truck	60
2	Aggregate, crushed		46.2	Hauling Truck	24
3	Aggregate, crushed		12.4	Hauling Truck	24
4	Aggregate, crushed		29.3	Hauling Truck	24
5	Aggregate, natural aggregate		10.4	Hauling Truck	29
6	Filler, mineral		1.7	Hauling Truck	42
7					
8					
9					

Total Material: 100

Notes

Save/Finish Cancel

# Case I: Pavement Preservation on High & Low Volume Road

- **To quantify the benefits of a planned preservation treatment schedule under high- and low- volume roads was conducted.**
  - **Two preservation treatments were analyzed.**
  - **The schedule was applied under three traffic volume levels.**

Basic Information	Input
Pavement type	Conventional AC pavement
Surface depth	4 in
Mileage	2 mi
Lane number	2 (12-ft-wide lanes)
Present PCI	70
AADT levels	5,000/15,000/30,000
Traffic growth percent	2
Speed limit	60 mph
Truck percent	10
Small-truck percent	30
Medium-truck percent	30
Large-truck percent	40

# Schedule Design

- The lifetime of each treatment is calculated by setting

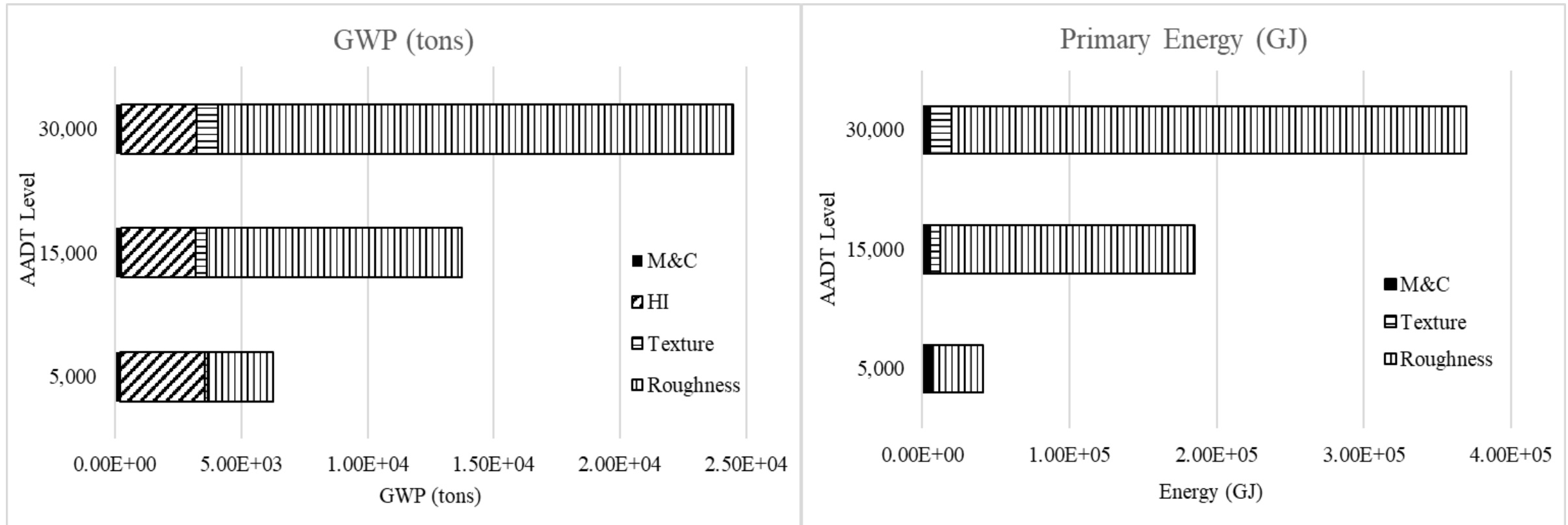
$$PCI_0=100 \text{ and } PCI_t=65.$$

- IRI progression rate increases as traffic volume increases for both Microsurfacing and thin AC overlay; the rate of the first is greater than the latter.

AADT	Schedule	Total Lifetime (yrs)
5,000	1) Microsurfacing (4 yrs) 2) Thin AC overlay 1 in (5 yrs)	9
15,000	1) Microsurfacing (3.5 yrs) 2) Thin AC overlay 1 in (4.5 yrs)	8
30,000	1) Microsurfacing (3 yrs) 2) Thin AC overlay 1 in (4.5 yrs)	7.5

# GWP and Primary Energy

- Results are categorized into two parts: materials and construction (M&C) and use stages (texture and roughness).



## Case II: Sensitivity to Existing Pavement Condition

- The impact of existing pavement condition was evaluated considering the preservation schedule selected for LCA.
- Four existing pavement conditions and two traffic levels were considered to select a preservation treatment.

### A4ADT=5,000

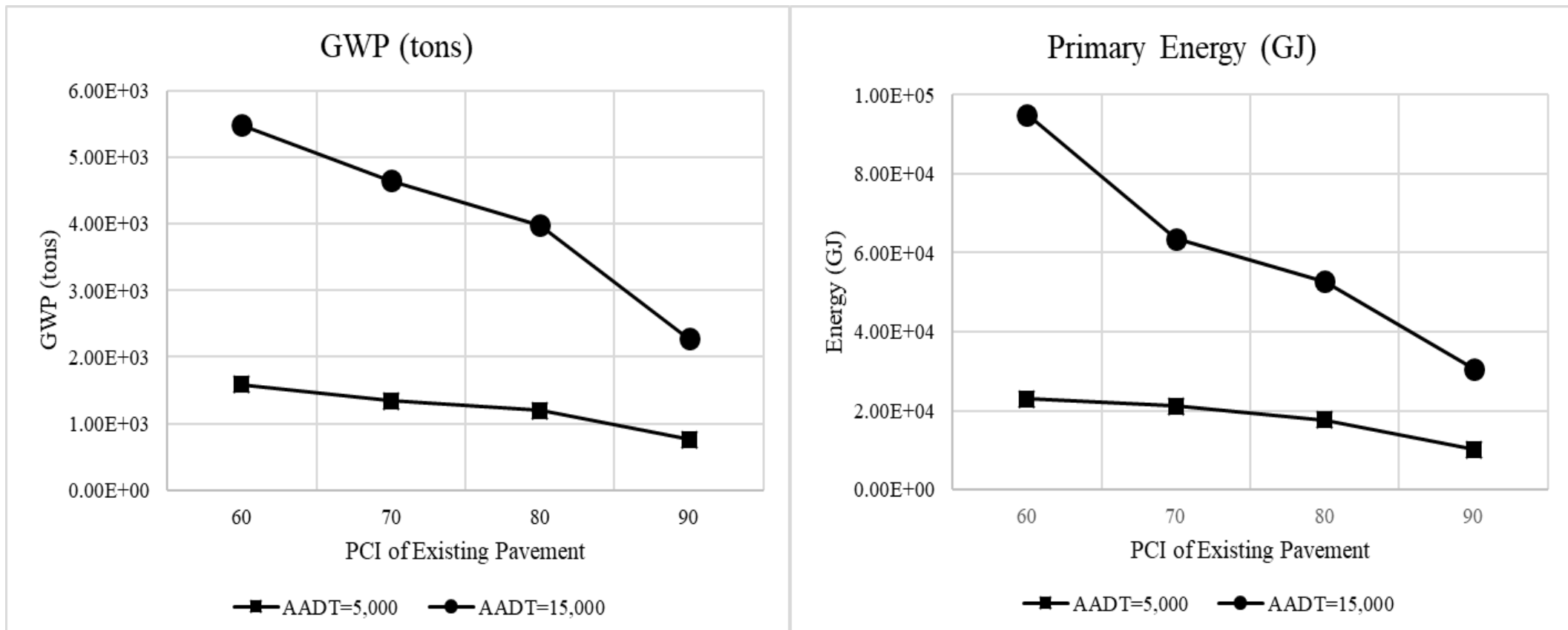
Existing PCI	Treatment Applied	Lifetime (yrs)	IRI Reduction Rate (in/mi/yr)
60	HIR + thin AC overlay	5	25
70	Thin AC overlay	5	20
80	Microsurfacing	4	15
90	Fog seal	2	10

### A4ADT=15,000

Existing PCI	Treatment Applied	Lifetime (yrs)	IRI Reduction Rate (in/mi/yr)
60	HIR + thin AC overlay	4.5	30
70	Thin AC overlay	4.5	25
80	Microsurfacing	3.6	20
90	Fog seal	2	15

# GWP and Prime Energy

- The lower the existing PCI value, the more GWP emissions and total energy consumption it takes to preserve the pavement.



# Summary

- **A tool was developed and applied to support project-level decision making on preservation activities.**
- **The tool is intended to assess environmental impacts of pavement preservation and maintenance alternatives for highway pavements.**
- **The traffic impact was demonstrated through the importance of including use stage for preservation treatment.**
- **There is a trade-off between treatment application time and application frequency.**



# THANK YOU

*Any Questions?*

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