A Quick Overview of Best Practices in Pavement for Local Government

University of California Pavement Research Center

City and County Pavement Improvement Center

6 April 2018

Meeting with:

City of Berkeley

City of Davis

City of Martinez

Framework for Decision Support

Measuring Sustainability

- Life Cycle Cost Analysis (LCCA)
  - Economic
- Life Cycle Assessment (LCA)
  - Range of environmental impacts, quantitative
- Sustainability Rating Systems (e.g., INVEST)
  - Environmental and social impacts, qualitative

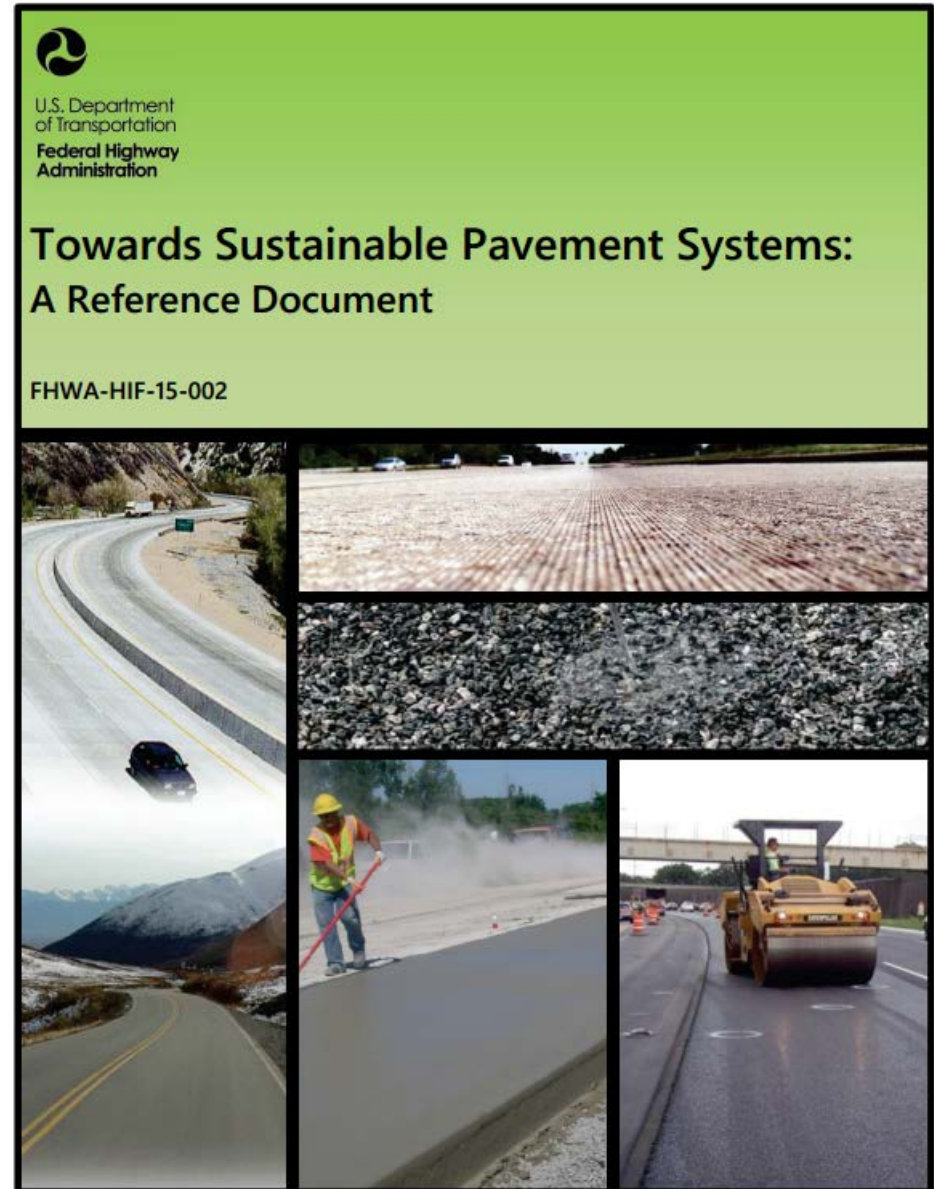**Reasons to Measure**
Decision support
Establish baselines for process improvement
Reporting for public, industry and government

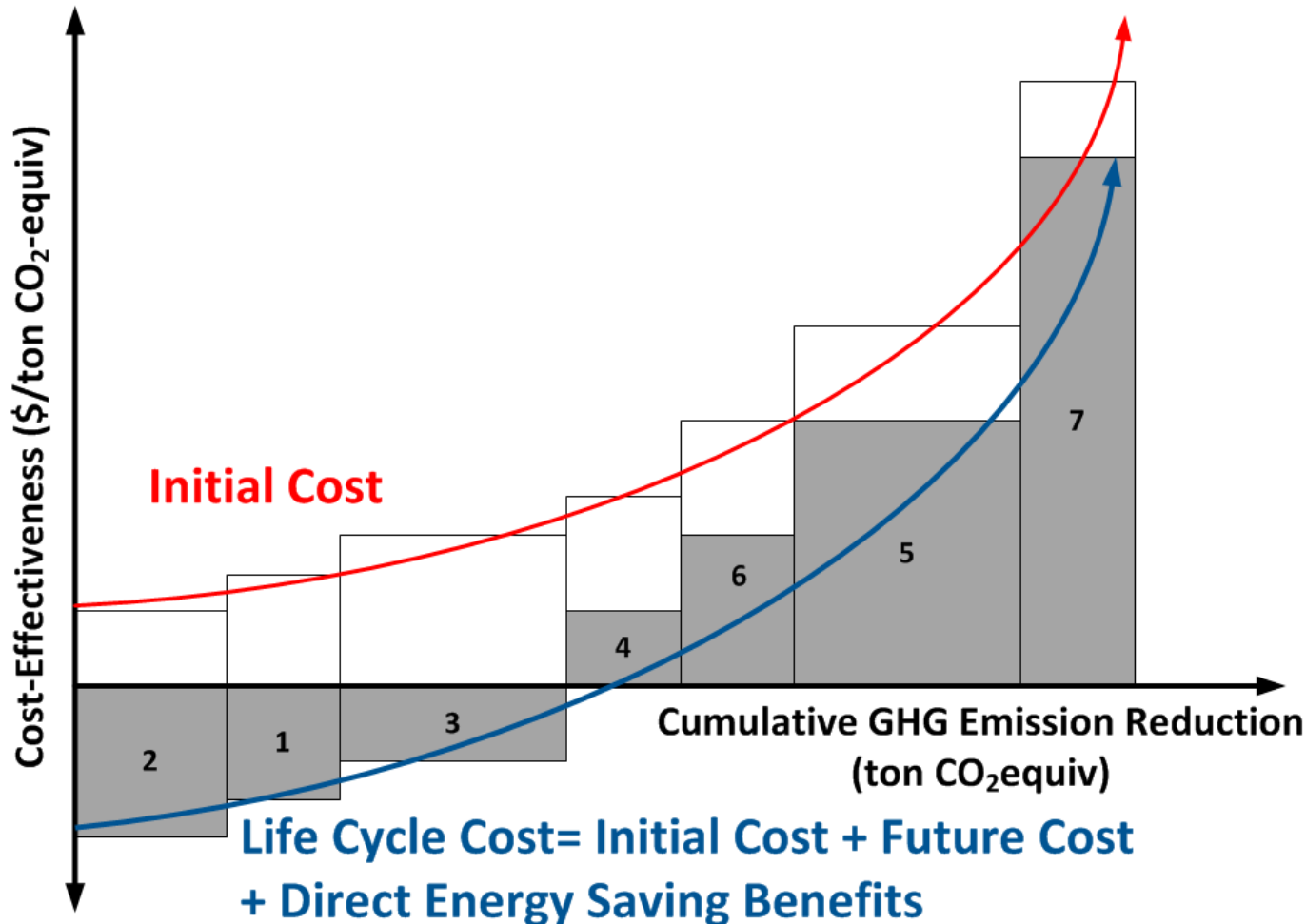# So what can be done to make pavements more sustainable?

- FHWA Sustainable Pavements Task Group
  - More sustainable pavement reference document (2015)
  - Covers everything about pavement and sustainability
  - Tech briefs and webinars

http://www.fhwa.dot.gov/pavement/sustainability/ref_doc.cfm

U.S. Department of Transportation
Federal Highway Administration

Towards Sustainable Pavement Systems: A Reference Document

FHWA-HIF-15-002

What Should be Done for Sustainability?

Bang for your buck metric: $/ton CO_2e vs CO_2e reduction

Cost-Effectiveness ($/ton CO_2-equiv)

Initial Cost

Cumulative GHG Emission Reduction (ton CO_2equiv)

Life Cycle Cost= Initial Cost + Future Cost + Direct Energy Saving Benefits

- Many alternatives to improve sustainability
- How to prioritize?
- Cost from Life Cycle Cost Analysis (LCCA)
- Environment from Life Cycle Assessment (LCA)

Adapted from Lutsey, N (2008) Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-08-15

Where can LCCA be implemented?

- PMS decision tree optimization
  - Condition trigger levels for treatment (timing)
  - Treatment selection
- Pavement type selection
- Policy evaluation
  - Materials changes
  - Construction quality specifications
 - Design methods

Where can LCCA be implemented?

- Accurate estimation of timing and costs is important for accurate LCCA

- Where multiple alternatives with similar benefits are being considered over identical analysis periods- USE Net Present Value(NPV)

- Alternatives with similar benefits over different analysis periods- USE Equivalent Uniform Annual Cost(EUAC)
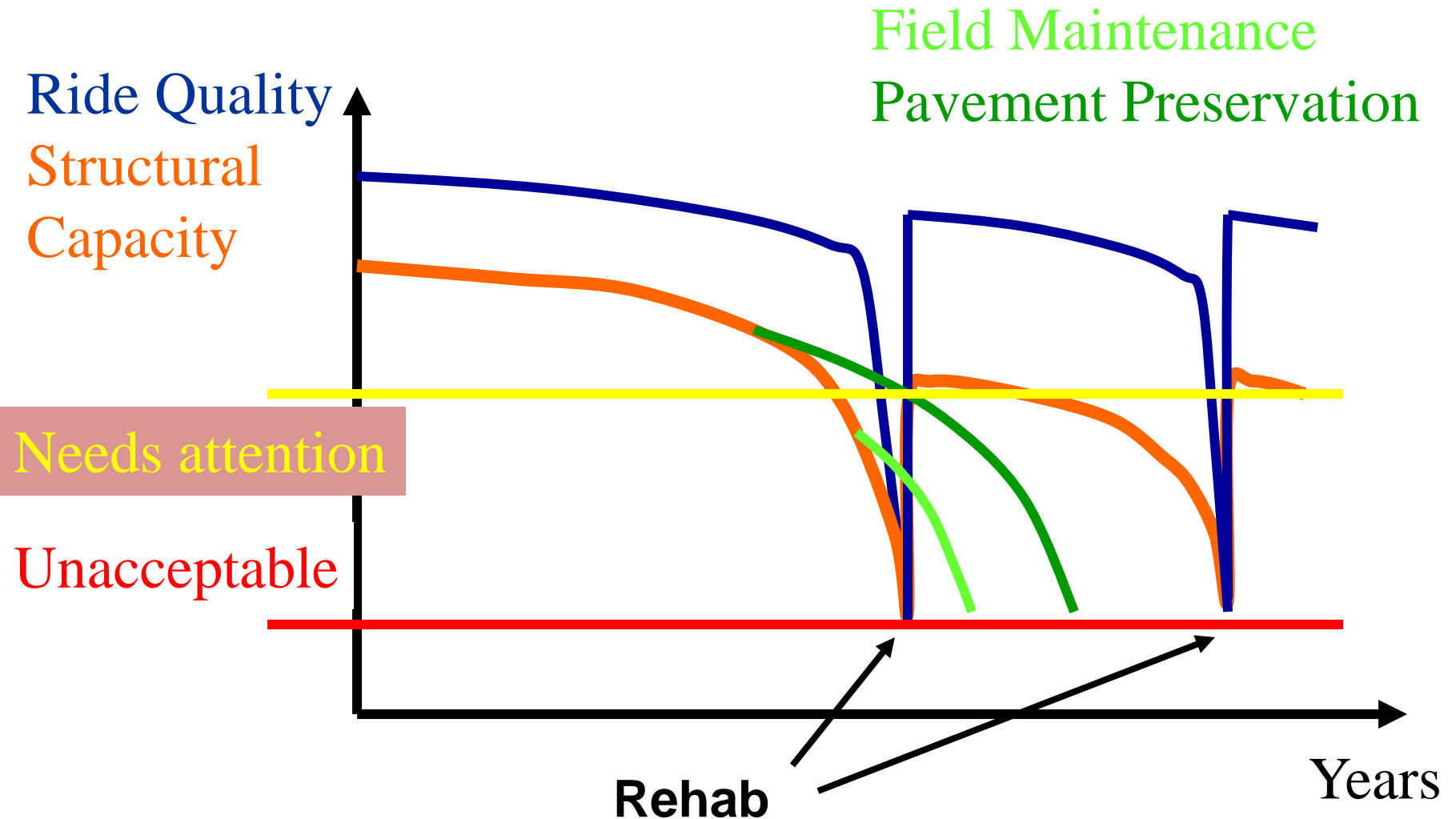
Source: FHWA reference document (2015)

Maintaining competition in pavement
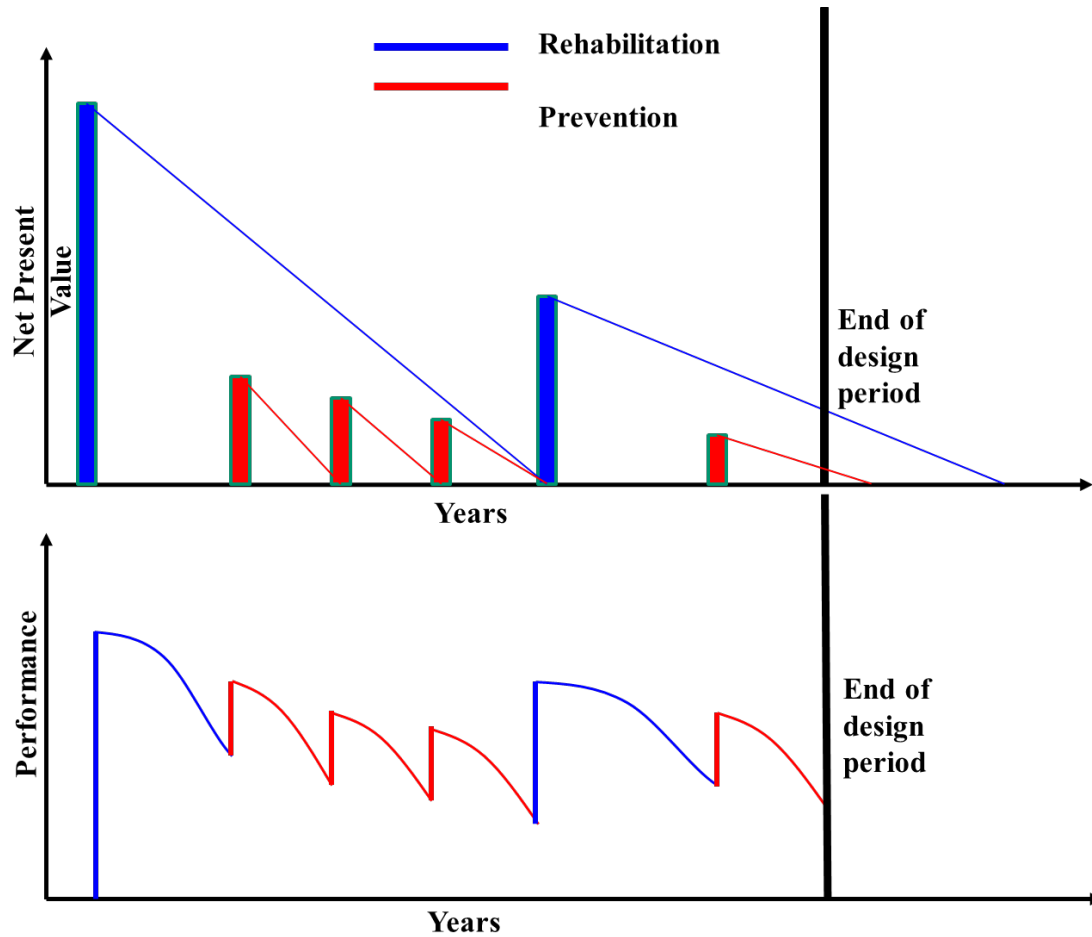California Relative Asphalt and Concrete Costs
1978-2017
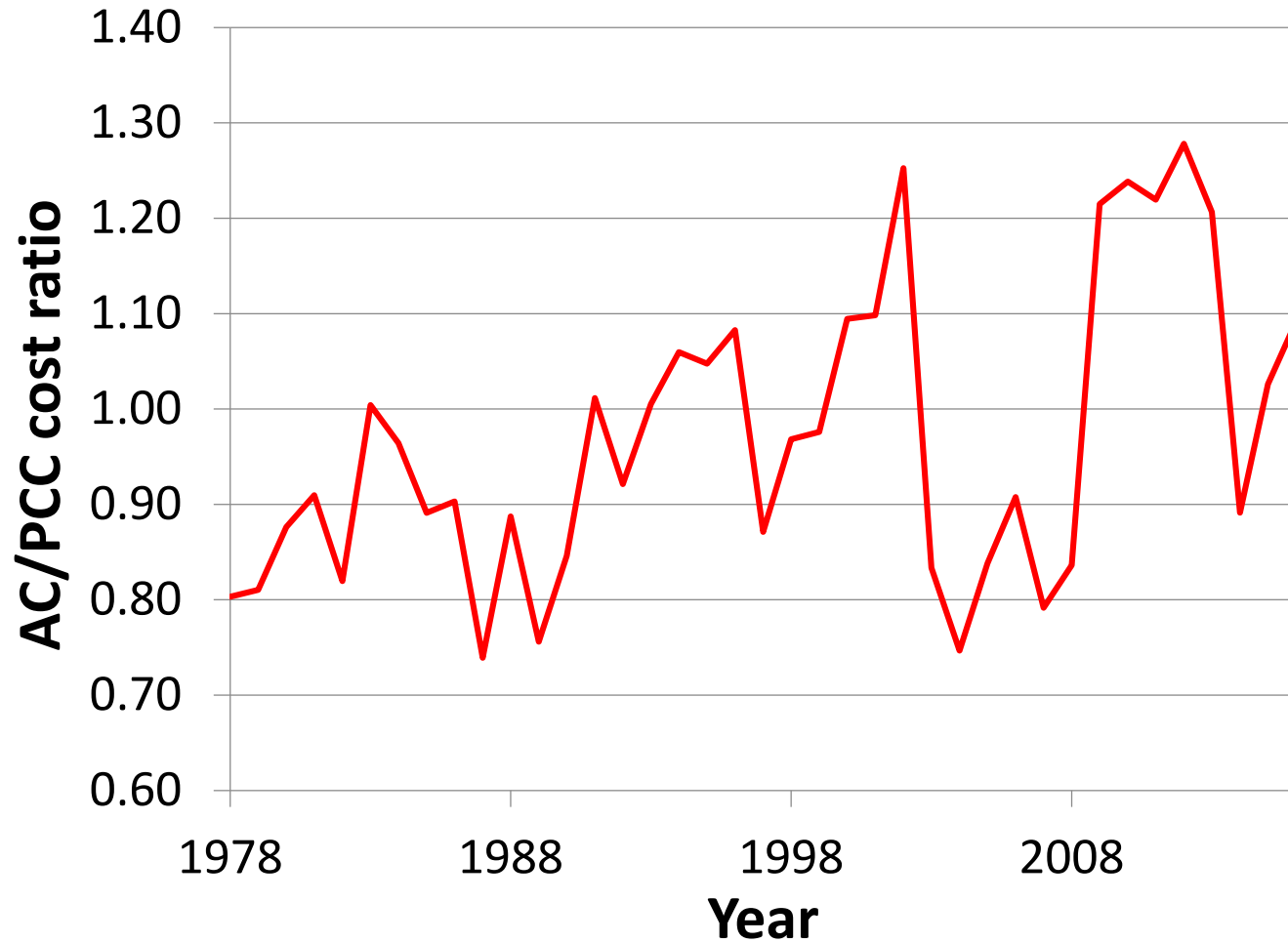
Life Cycle Cost Analysis (LCCA) Basics

Life Cycle Cost Analysis (LCCA) Basics

Pavement management:
Use of PCI vs measured cracking, rutting

- PCI is amalgamation of different distresses
- Can have same PCI for very different conditions
- Engineering meaning in the condition survey is lost

- Recommend
  - Use PCI as communication tool for management/public
  - Manage asphalt pavement considering:
    - Cracking type (traffic related wheelpath cracks, aging/shrinkage related out of wheelpath cracks)
   - Other distresses (rutting, raveling)
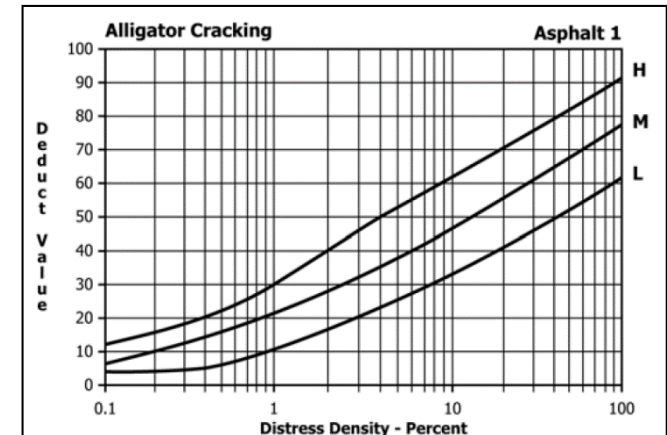
Same PCI, different pavement condition

CASE 1: TRAFFIC LOADING RELATED, PCI = 34			
DISTRESS	SEVERITY	QUANTITY	DV
Alligator Cracks	High	1x6	18
Alligator Cracks	Medium	1x4 1x5 1x7	17
Potholes	Medium	3	48
Potholes	Low	3	30
Rutting	Low	2x5 2x8	10
CASE 2: AGE, CONSTRUCTION, UTILITIES, OTHER FACTORS, PCI = 32			
Long/Trans Crack	High	15 20 8 6 12 18 6x7	43
Long/Trans Crack	Medium	25x2 18 13 9 10	20
Patching/Utility	High	25x4 25x2	40
Patching/Utility	Medium	12x6 4x7	20
Block Cracks	High	4x6 6x5	13

Pavement management
Rehab with no preservation

- Net present value = sum of costs to year 0, discounted in future years

$ (Agency Costs)

Years

Initial   R   R   R

Analysis Period

Salvage Value
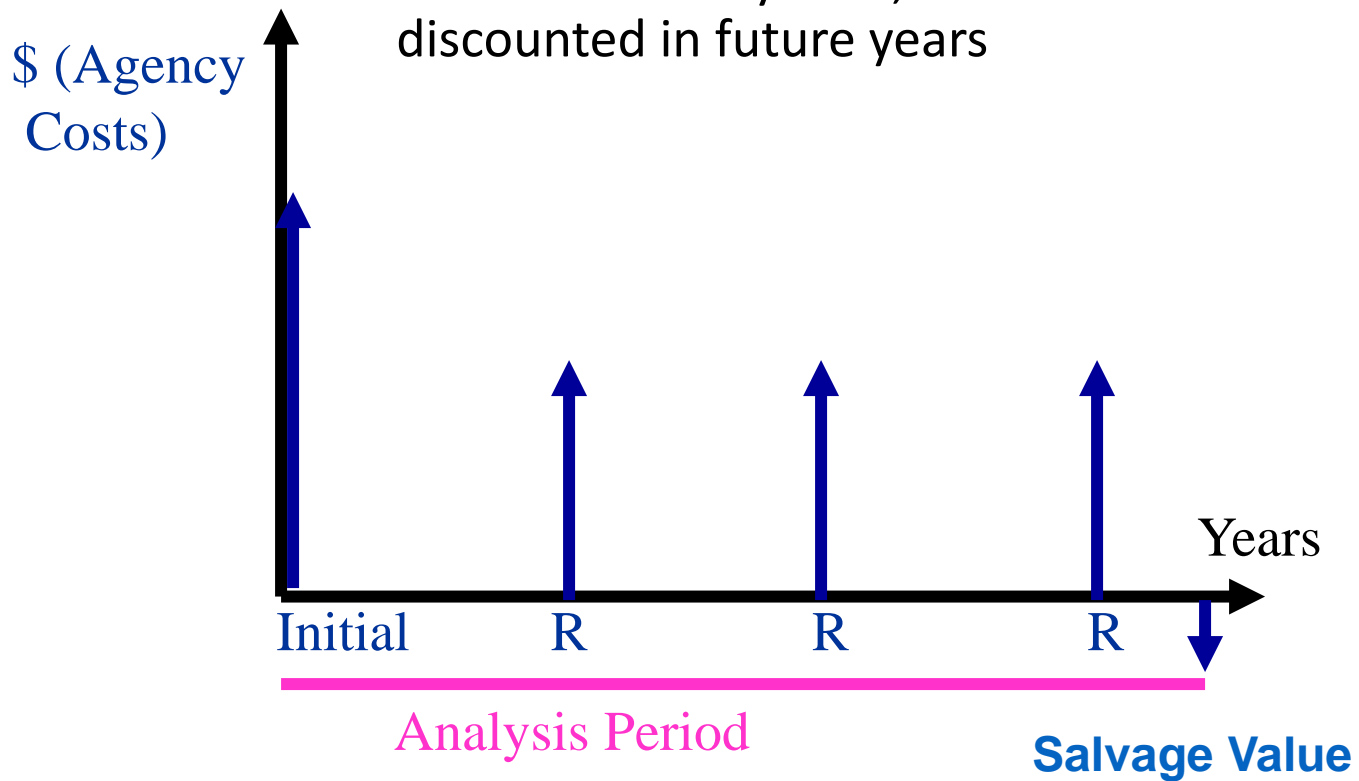
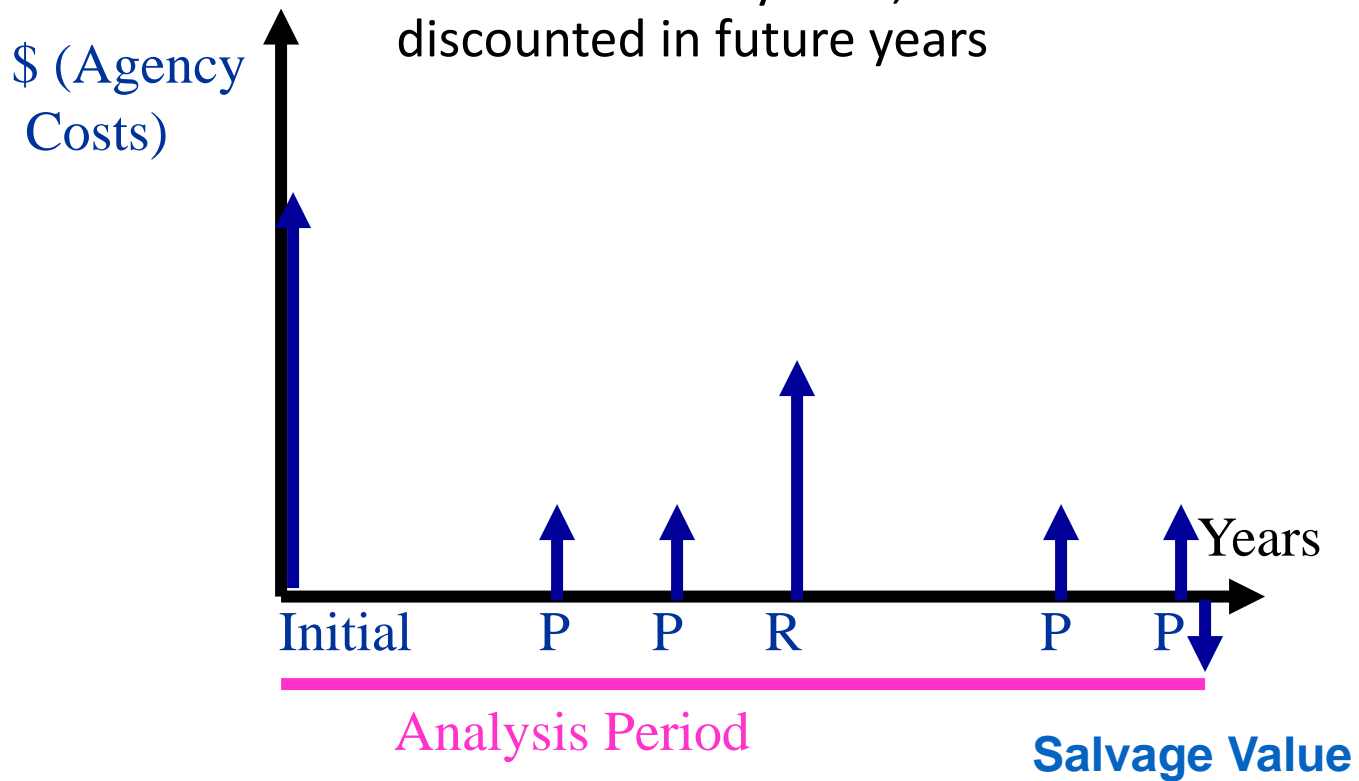# Pavement management
Rehab with preservation

- Net present value =
  sum of costs to year 0,
  discounted in future years

$ (Agency Costs)

Years

Initial   P   P   R   P   P

Analysis Period

Salvage Value

LCCA results
Urban alternatives

Activity	$/sy	Year
HMA 2 inch mill and fill	38	0
HMA 2 inch mill and fill	38	20
HMA 2 inch mill and fill	38	40

Activity	$/sy	Year
HMA 2 inch mill and fill	52	0
Remove, replace 6 inches HMA	52	25

Activity	$/sy	Year
HMA 2 inch mill and fill	38	0
Slurry seal	7	12
Slurry seal	7	19
Slurry seal	7	26
HMA 2 inch mill and fill	38	33
Slurry seal	7	45

- 50 year analysis, 2% discount rate
- Remove and replace scenario 14% more cost
- Preservation scenario 12% less cost; 8% less GHG

What you need to do

- Pavement management
  - Do engineering work based on truck traffic level, cracking and surface defects data, not PCI
  - Use your costs and LCCA to develop best treatment practice and preservation timing
    - Need performance models
    - Requires condition survey, traffic and as-built data
  - Learn to use LCCA to discuss preservation spending with council/board
  - CCPIC has created simple LCCA spreadsheet tool, currently being piloted

Building pavement knowledge and getting it into practice

- CCPIC is developing a Pavement Engineering professional development certificate
  - Aimed for local government staff and their consultants
  - Through ITS Berkeley Tech Transfer
- Are you selecting pavement consultants based on pavement knowledge?
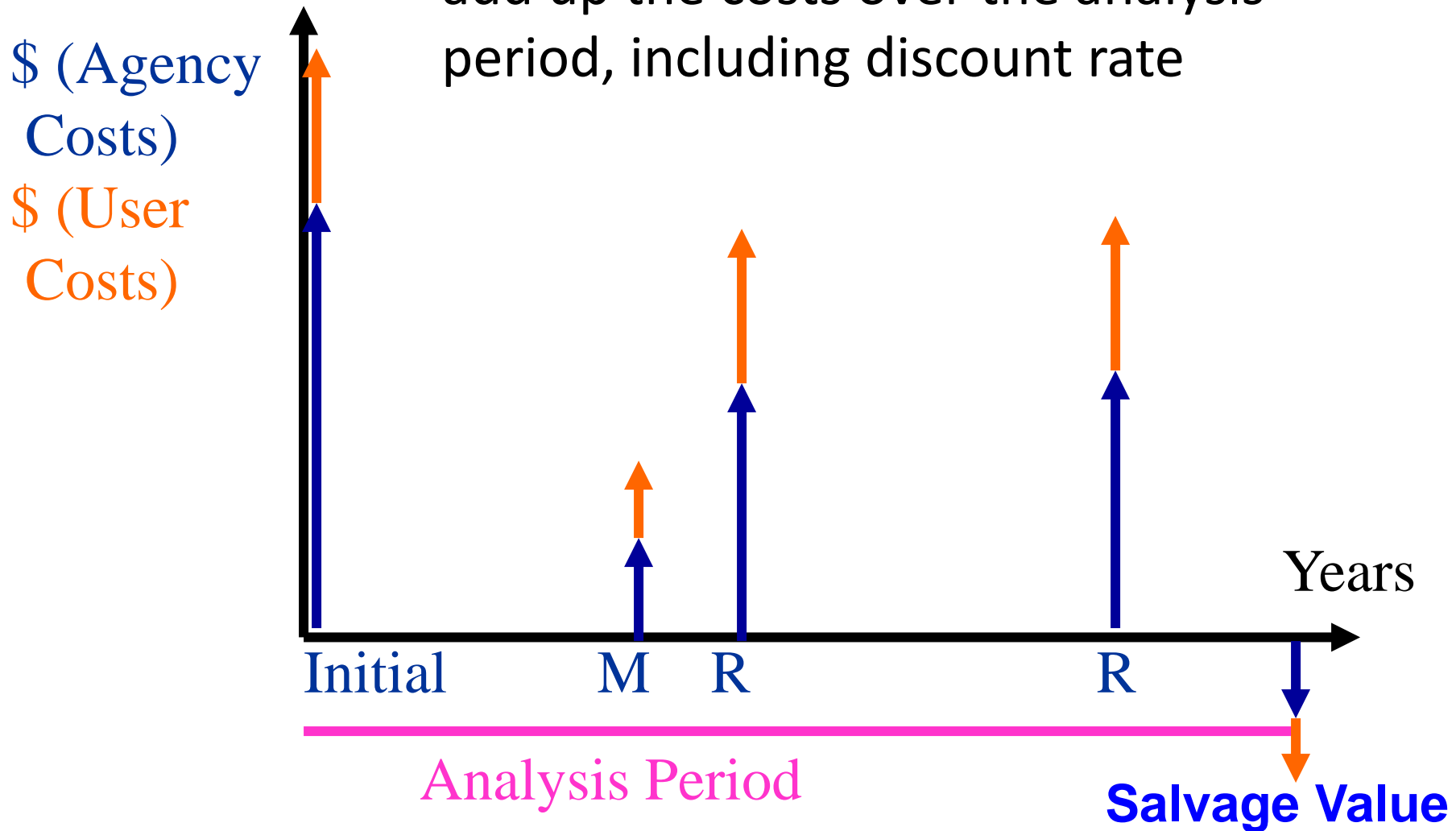 - What questions are you asking in the interview?

LCCA calculations

$$NPV = \frac{F}{(1+i)^n}$$

$$EUAC = \frac{F.i.(1+i)^n}{(1+i)^n - 1}$$

NPV = Net Present Value, EUAC = Equivalent Uniform Annual Cost
F = Future value, *I* = Interest Rate, *n* = Year of work

LCCA calculations

- Net present value =
  add up the costs over the analysis
  period, including discount rate

$ (Agency Costs)

$ (User Costs)

Years

Initial   M   R   R

Analysis Period

Salvage Value

LCCA Excel tool

- Excel tool to calculate Net Present Value, Salvage Value and Equivalent Uniform Annual Cost
- Can compare 3 scenarios side by side
- Can choose and edit the list and sequence of treatments

LCCA Excel tool

Inputs
1. Treatment type
2. Year of work
3. Discount rate
4. Analysis period

Outputs
1. Total NPV
2. Total SV
3. EUAC

Scenario 1

| Analysis Period | 50 | Discount Rate | 3 | | Total Net Present Value | $0.00 |

Clear table for Scenario 1

| | | | | Total Salvage Value | $0.00 |

Sequence of treatments	Treatment	Treatment No.	Year of work	Inclusion in Analysis Period	NPV @ Discount Rate	SV @ Discount Rate	Remarks	Equivalent Uniform Annual Cost

Slurry Seal-Type II
Slurry Seal-Type III
Microsurfacing-Type II
Microsurfacing-Type III
Chip Seal
Rubberized Cape Seal
Asphalt Overlay-1.5"
Asphalt Overlay-2.5"
Asphalt Mill and Fill
Rubberized Asphalt Over
FDR-PC-10"
FDR-PC-12"
FDR-PC-18"
FDR-FA-10"
FDR-FA-12"

NPV and SV | Calculations | Sheet1 | (+)

LCCA Excel tool

Editable:
- Functional Unit
- Treatment List: Cost, Life of Treatment

		SY			
Functional Unit		7040	1 ln mi		
Treatment Name	**Treatment No.**	**Cost/SY**		**Total Cost**	**Life of Investment**
Slurry Seal-Type II	1	7		49280	3
Slurry Seal-Type III	2	7		49280	7
Microsurfacing-Type II	3	7		49280	5
Microsurfacing-Type III	4	7		49280	5
Chip Seal	5	10		70400	5
Rubberized Cape Seal	6	6		42240	7
Asphalt Overlay-1.5"	7	10		70400	10
Asphalt Overlay-2.5"	8	20		140800	13
Asphalt Mill and Fill	9	38		267520	20
Rubberized Asphalt Overlay	10	30		211200	20
FDR-PC-10"	11	40		281600	10
FDR-PC-12"	12	45		316800	15
FDR-PC-18"	13	50		352000	20
FDR-FA-10"	14	35		246400	7
FDR-FA-12"	15	40		281600	10
CIR-4"	16	25		176000	5
CIR-5"	17	27		190080	7
CIR-6"	18	30		211200	10
BCOA-4"	19	35		246400	7
BCOA-5"	20	37		260480	10
BCOA-6"	21	40		281600	12
Cape seal-2.5"	22	10		70400	5
Remove/replace	23	52		366080	20
Pulv HMA/compact	24	26		183040	20

Treatment DB | NPV and SV | Calculations | Sheet1 | +

LCCA Excel tool

Can be used to compare different treatments, and preventive and maintenance strategies. A study was conducted to understand the sensitivity of different maintenance strategies to interval changes.

Rural prevention and maintenance strategies:
- Rehab-Prevention
- Rehab-Prevention-Prevention-Prevention
- Rehab-Rehab-Rehab

Urban prevention and maintenance strategies:
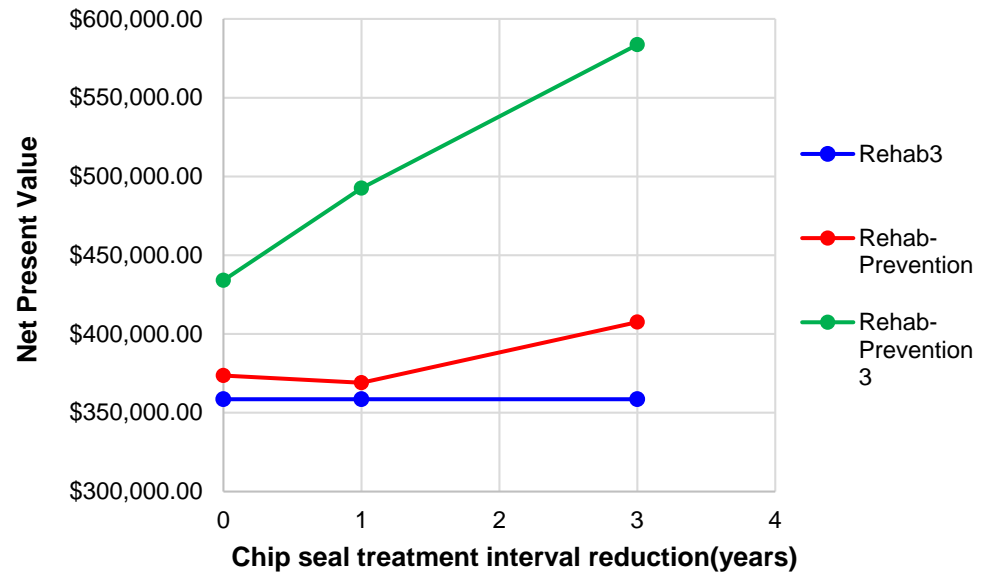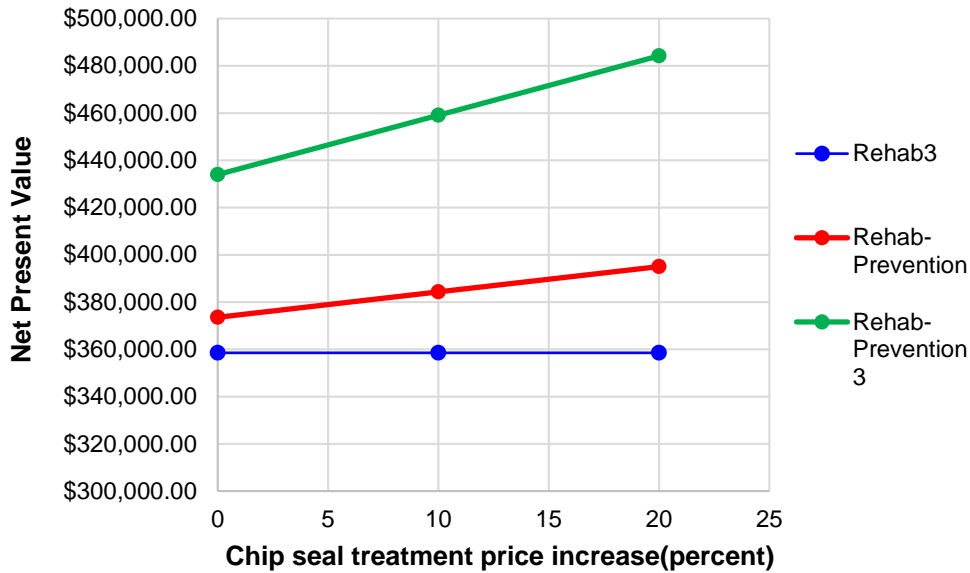- Rehab-Prevention
- Rehab-Prevention-Prevention-Prevention
- Rehab-Rehab-Rehab
- Rehab-Reconstruction

Legend:
RURAL
R-Pulverize &
Compact HMA
P-Chip Seal

Legend:
URBAN
R-Asphalt mill and
fill
C- Remove/replace
6 inch HMA
P-Slurry Seal

LCCA Excel tool: RURAL analysis

LCCA Excel tool: URBAN analysis