Life Cycle Cost Analysis and Its Impact on Pavement Type Selection

North Central Asphalt
User-Producer Meeting

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Acknowledgements

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What is LCCA?

"A process for evaluating the total economic worth of a useable project segment by analyzing initial costs and discounted future costs, such as maintenance, reconstruction, rehabilitation, restoring, and resurfacing costs, over the life of the project segment. "

TEA 21 (98)

How is it used?

- To make Go/No Go decisions concerning projects.
- To evaluate economic impacts of engineering decisions.
- To select the most economical choice among alternatives.
- To drive competition in initial bids.
  - Alt. A – lower initial, higher rehab costs
  - Alt. B – higher initial, lower rehab costs

$$(\text{Alt. A})_{\text{initial bid}} + (\text{Alt. A} - \text{Alt. B})_{\text{rehab costs}}$$

How is it done?

- Net Present Value (NPV)
  - FHWA recommendation
  - APA method
  - Requires equal analysis period
- Equivalent Uniform Annual Cost or Worth (EUAC or EUAW)
  - ACPA recommendation
  - Does not require equal life, BUT
  - Does require analysis being extended to common multiple

FHWA Approach

- Use Net Present Value method of costing
  - Sum of initial cost and discounted future costs
- Use Real Discount Rate
  - Difference between interest and inflation
- Use of User Cost as Separate Consideration

LCCA Policy Statement (9/96)

- FHWA Philosophy ...
  - Decision support tool
  - Results are not decisions
  - Use process to improve maintenance and rehabilitation strategies
  - Logical evaluation process is as important as results

Policy Statement Con't ...

- Agency and user costs should be included
- Future costs should be discounted to their net present value (NPV)

LCCA Policy Statement (9/96)

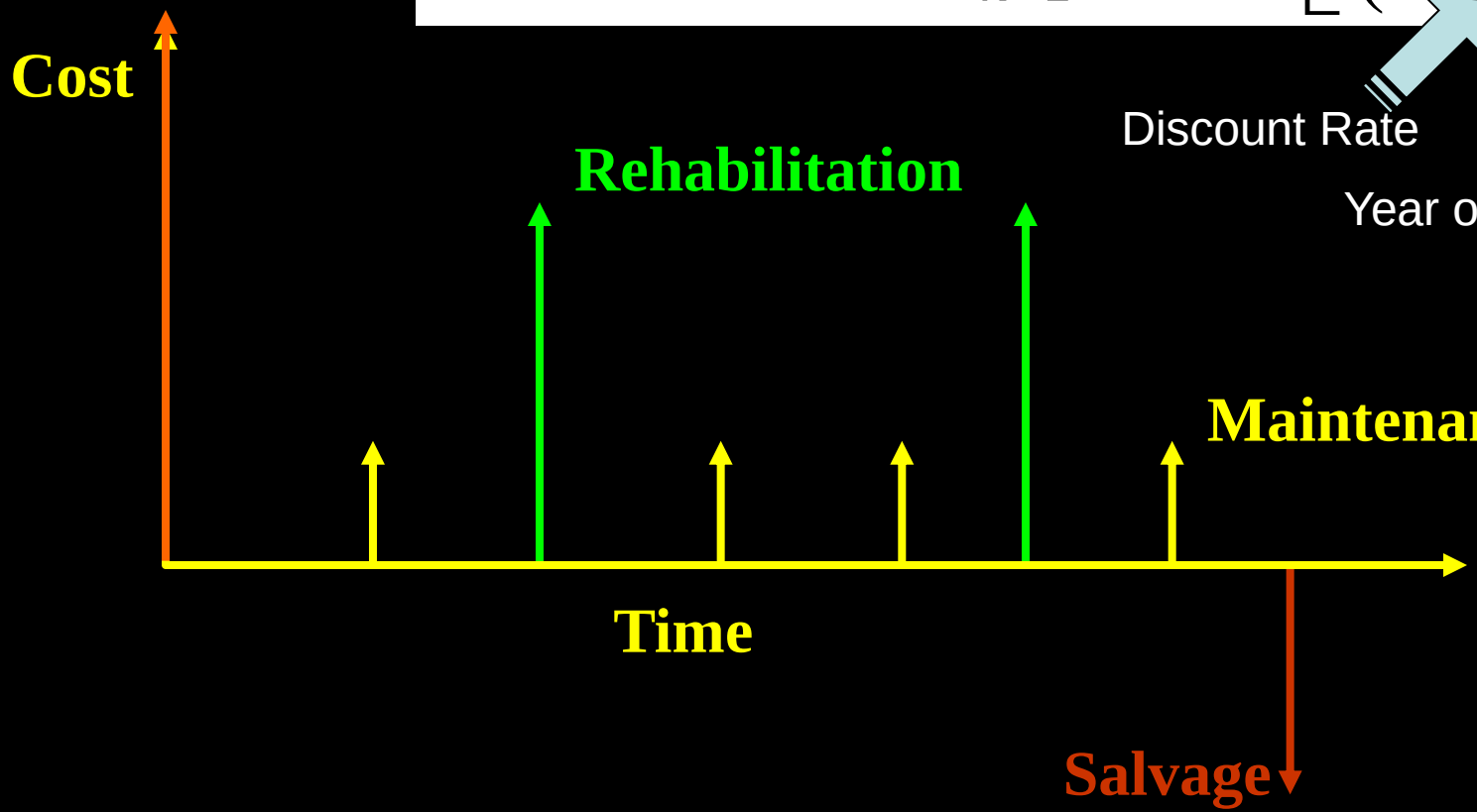
- LCCA important consideration in all highway investment decisions
- Level of detail commensurate with level of investment
- Long analysis periods
  - Pavements - min. 35 years
  - Bridges - min. 75 years

Life Cycle Cost Components

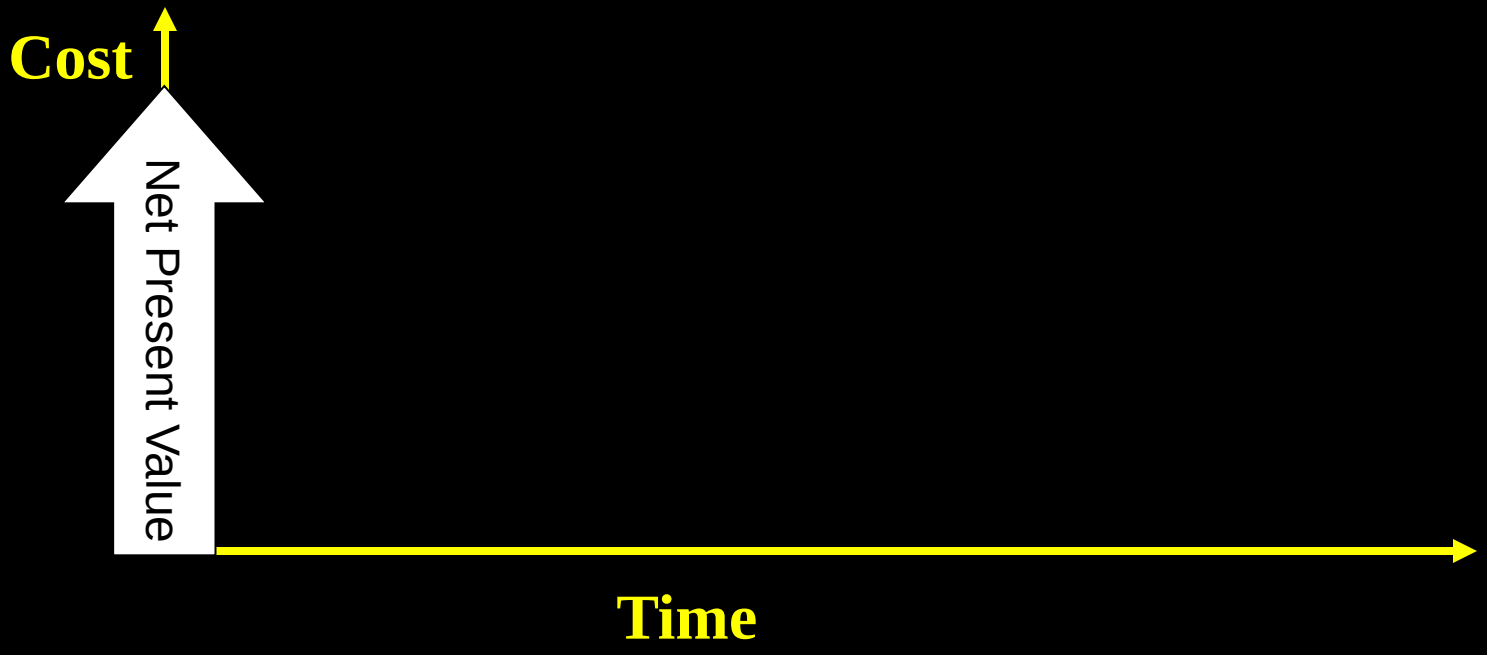
$$NPV = I.C. + \sum_{k=1}^{N} R.C._k \left[\frac{1}{(1+i)^{n_k}} \right]$$

Discount Rate

Year of Activity



Life Cycle Cost – Net Present Value



Carlos Rosenberger

“Thou shall not use a strategy that cannot actually occur!”

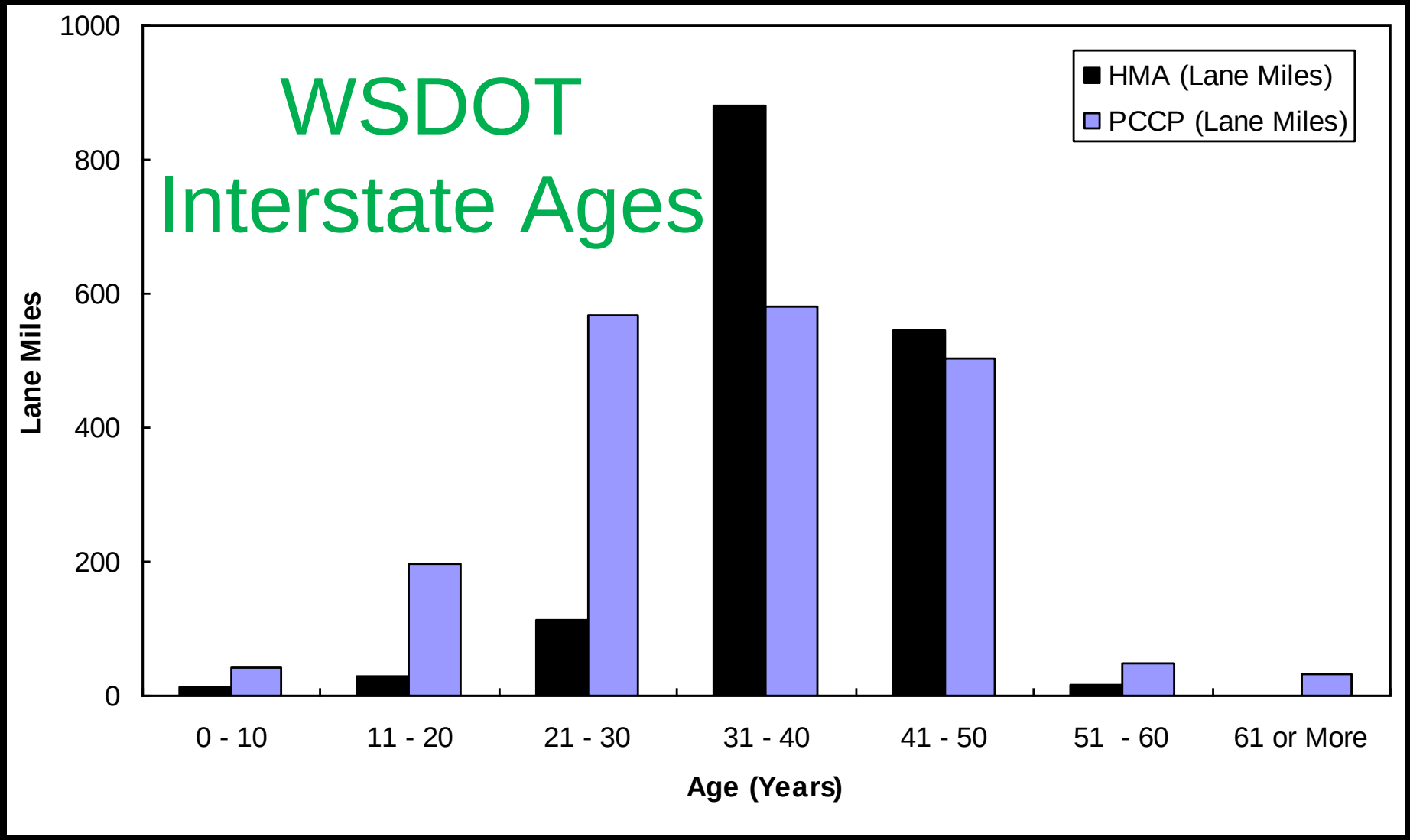
Examples:

- No or very little rehabilitation
- Unrealistically close rehabilitation intervals
- Unrealistically frequent maintenance
- Unrealistically thick pavements at end of analysis

Tricks of the Trade Associations

- They say - Equivalent Uniform Annual Cost allows comparison of options of “unequal lives”.
- The wrong way:
  - NPV of each alternate over each of their “lives” and annualize the amount.
  - Shorter “lives” and more frequent maintenance will have higher EUAC.
- The right way:
  - NPV of each alternative out to a common year multiplier and annualize the amount.
  - Repeatedly do the same strategy.

As for Asphalt Being “Short Lived”



Other Sources of Information

- Kansas (Cross) Study
  - Asphalt pavements last as long as concrete, but much cheaper
- Ohio Interstate Study
  - Long life asphalt with low maintenance
- Minnesota
  - ½ of PCC overlaid before year 20
  - ½ of remaining PCC had major repairs
  - 1st resurfacing for asphalt ~18 years
  - Asphalt pavements > 60 years old

Initial Cost

- Usually accounts for 70% or so of LCC
- Materials
  - Unit prices and quantities
- Labor
  - Daily/hourly rates
    - May be part of material unit prices
- Traffic Control
  - Daily/hourly costs
- Only consider mutually exclusive costs

General Conditions

- Four lanes (2 way)
- 40-year Analysis
- 4% Discount Rate
- Level Terrain
- Rural Area
- 25000 ADT 15% Trucks
- 2% Growth
- Work Zone Speed Limit 40 mph

HMA

- Pavement Section – Perpetual

- Rehabilitation – 2” mill & fill at various times.

PCC

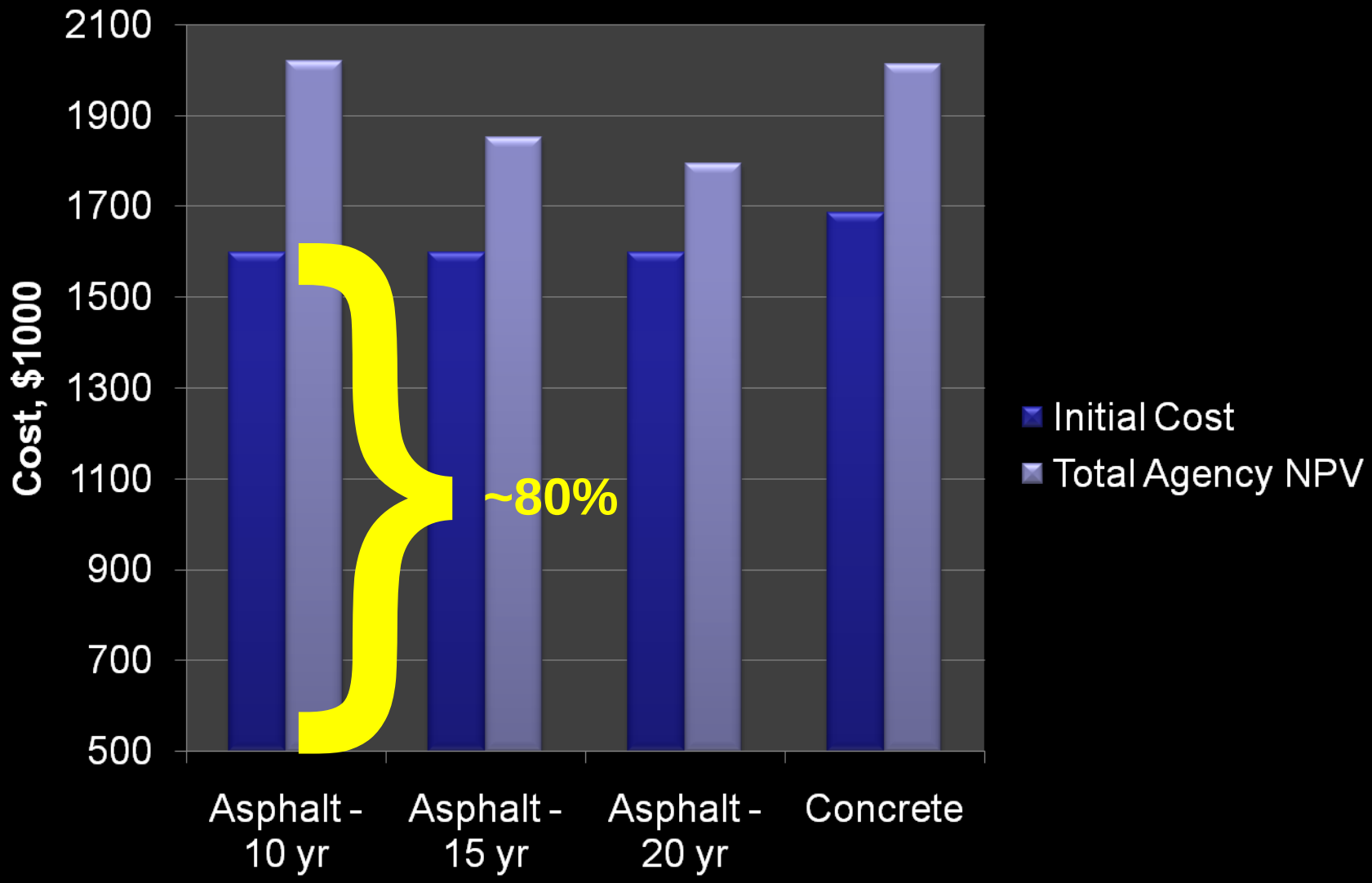
- Pavement Section:

- Rehabilitation:
  - Grinding at year 18 with 5% patching.
  - 4” Overlay at year 30 with 5% patching.

Sensitivity Analysis

- Rehabilitation Interval
  - 10-year
  - 15-year
  - 20-year
- Discount Rate
  - Vary between 1 and 8 percent
- User Costs
  - 24-hr lane closure for both
  - 10-hr night lane closure for HMA

Rehabilitation Interval



Data from GPS-6 (FHWA-RD-00-165)

Conclusions

- Thicker overlays mean less:
  - Fatigue Cracking
  - Transverse Cracking
  - Longitudinal Cracking
- Most AC Overlays ≥ 15 years before Rehab
- Many AC Overlays > 20 years before Significant Distress

Need Credit for:

- Superpave
  - Improved performance, but higher costs
- Premium Surface Materials
  - Polymers for high traffic and climate considerations
  - SMA
  - Improved performance
- OGFC
  - Usually requires more frequent resurfacing, BUT. . .
  - It is an elective safety improvement and
  - It saves lives!

Accident Data: FM 1431 - Travis County - Near Jonestown

(PFC mixture was placed in February 2004)

Year	2001	2002	2003	2004	2005	2006	AVG 2001 to 2003	AVG 2004 to 2006	% Change in Avg since PFC
Total # of accidents	25	48	36	17	6	22	36.3	15.0	-58.7
Dry weather accidents	10	22	13	15	5	21	15.0	13.7	-8.9
Wet weather accidents	15	26	23	2	1	1	21.3	1.3	-93.8
Fatalities	0	1	5	0	0	1	2.0	0.3	-83.3
Total injuries	25	16	21	6	2	13	20.7	7.0	-66.1
Incapacitating injuries*	6	4	3	0	1	0	4.3	0.3	-92.3
Non-incapacitating injuries	19	12	18	6	1	5	16.3	4.0	-75.5
Annual rainfall (inches)	42.9	36.0	21.4	52.0	22.3	34.7	33.4	36.3	8.7
Total rain days (>0.1 in.)	57	56	37	70	45	43	50.0	52.7	5.3

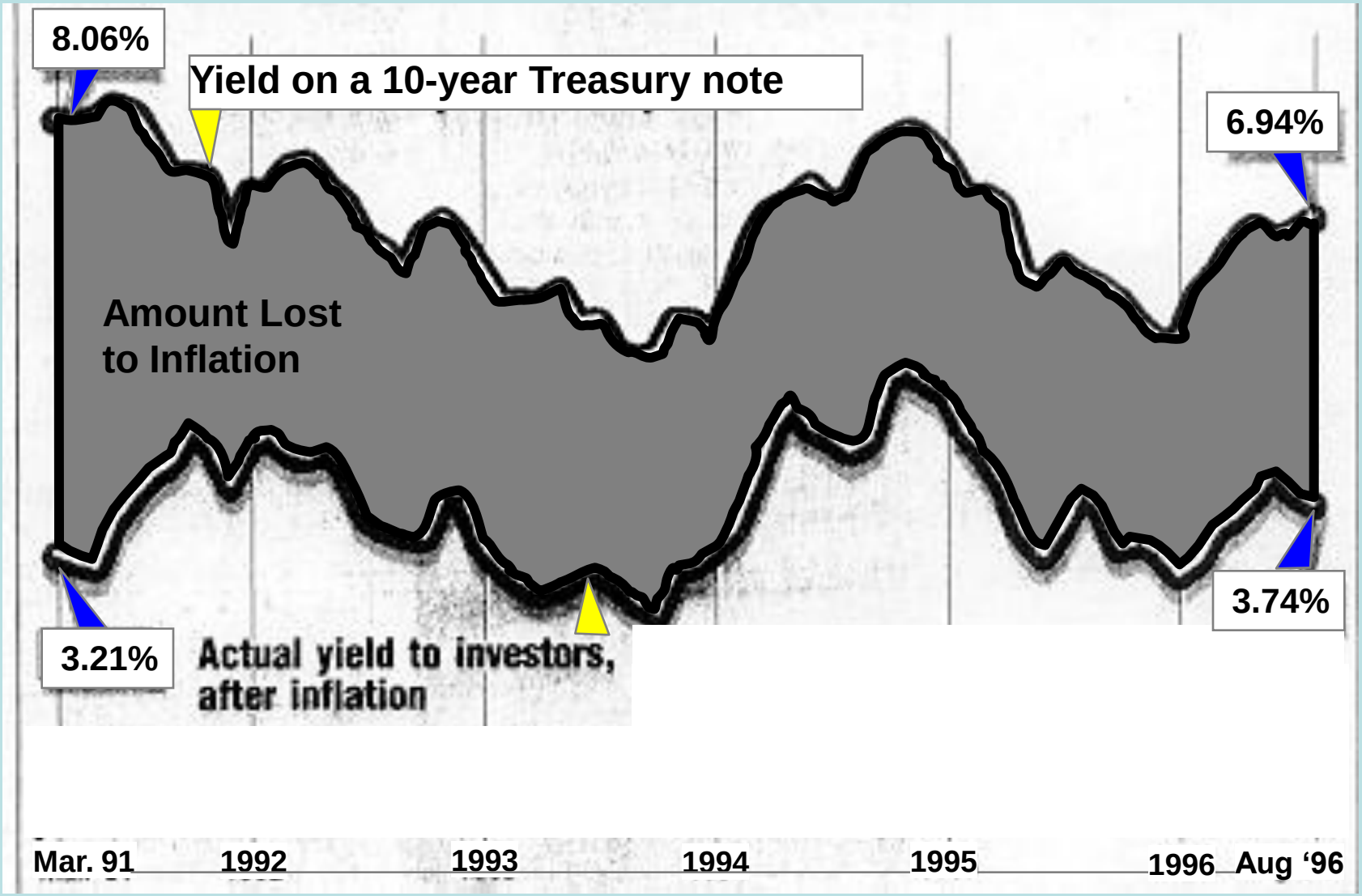
* Some of these injuries later became fatalities

Source: Cedar Park Police Department & Austin Mabry Weather Station

Discount Rate

- Used in NPV equation to bring future costs to present value
- FHWA recommends using real discount rate
  - Does not include inflation
    - Future cost estimates should not include inflation
- FHWA recommends 4% discount rate
  - Most state DOT's used values between 3 and 5% in 1996

Real Discount Rate



Real Discount Rates

Source: OMB Circular A-94

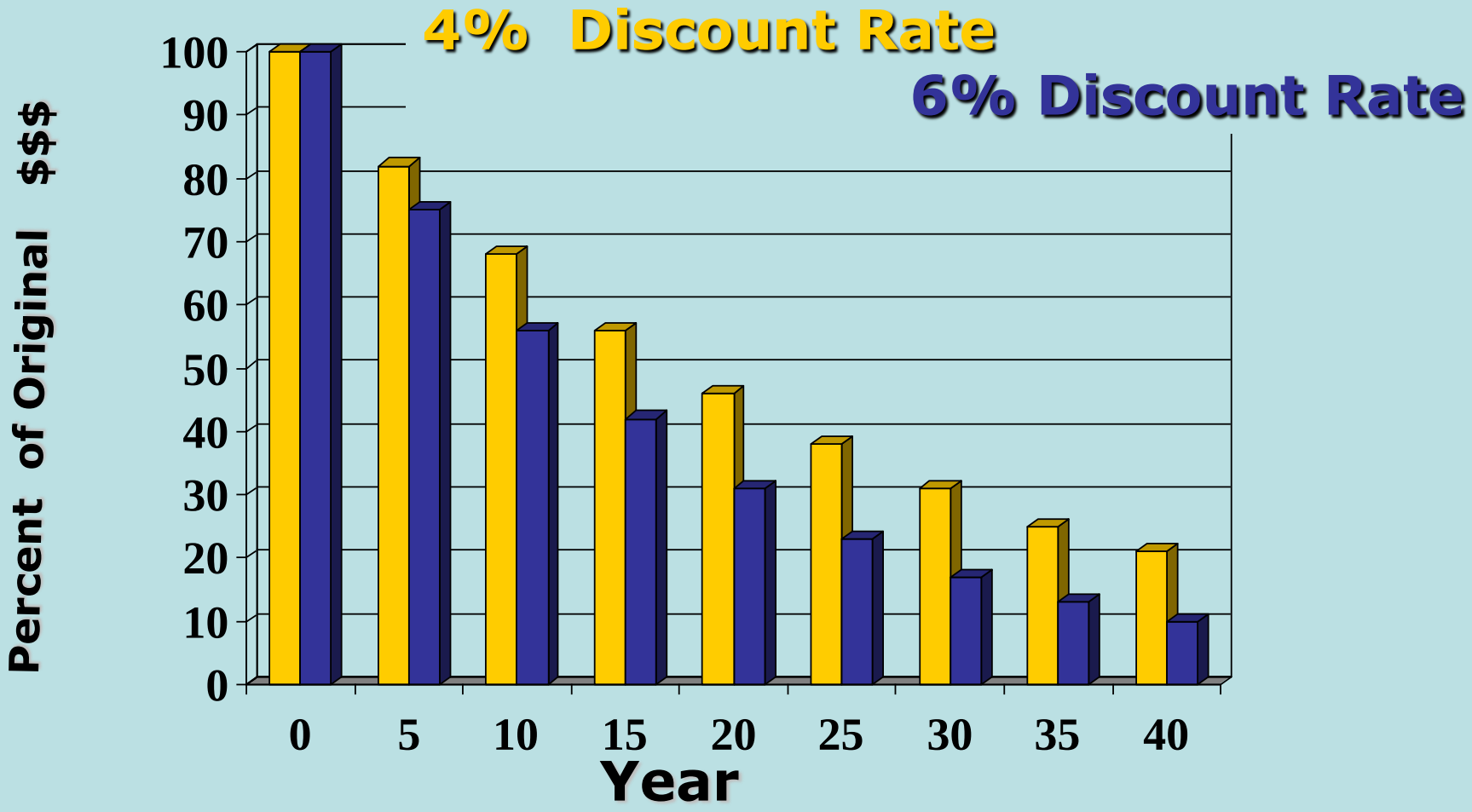
	Investment Maturity				
YEAR	3	5	7	10	30
Nov 92	2.7	3.1	3.3	3.6	3.8
Feb 93	3.1	3.6	4.0	4.3	4.5
Feb 94	2.1	2.3	2.5	2.7	2.8
Feb 95	4.2	4.5	4.6	4.8	4.9
Feb 96	2.7	2.7	2.8	2.8	3.0
Feb 97	3.2	3.3	3.4	3.5	3.6
Jan 98	3.4	3.5	3.5	3.6	3.8
Avg	3.1	3.3	3.4	3.6	3.8
Std	0.6	0.7	0.7	0.7	0.7

(No Inflation Premium)

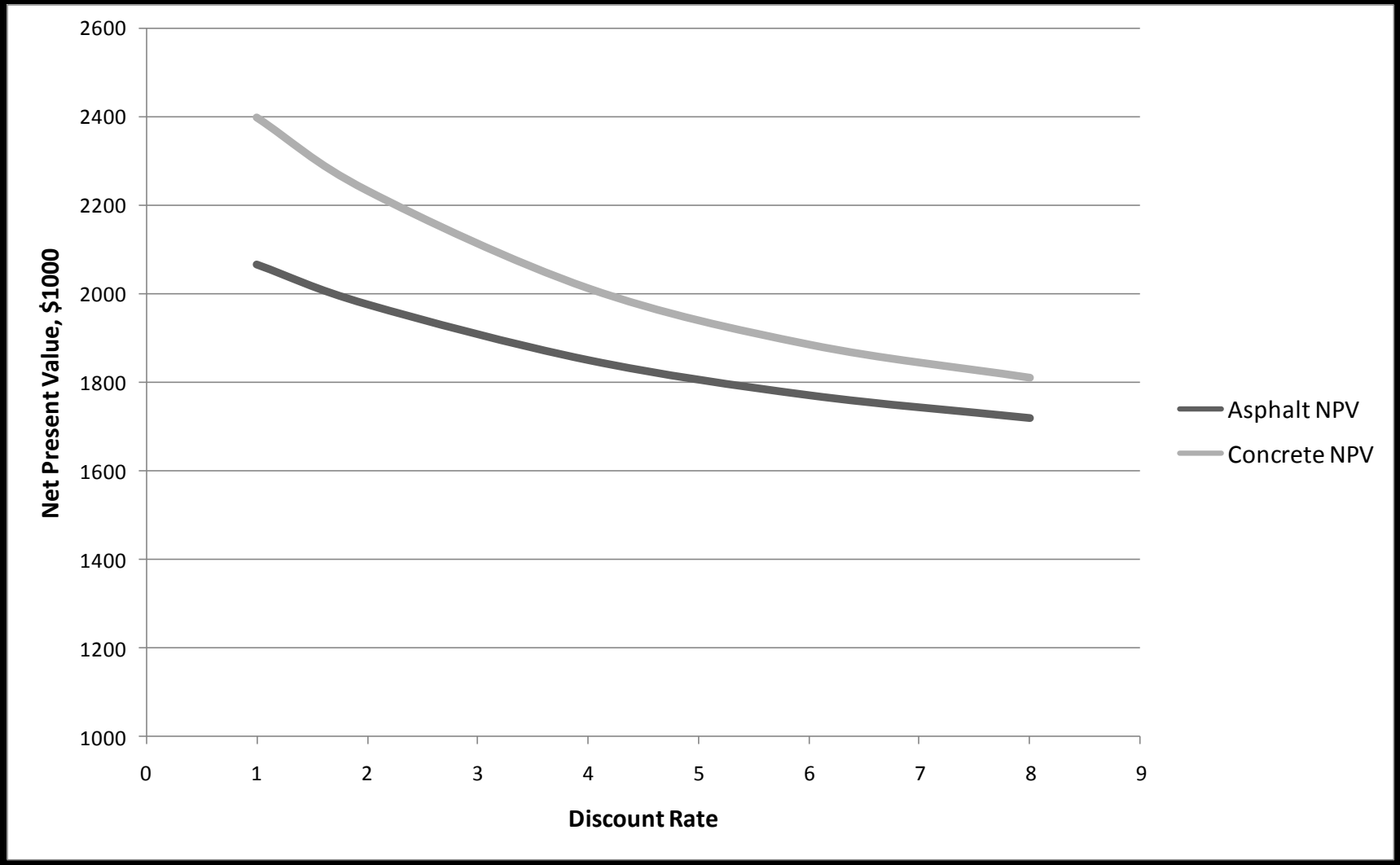
Present Value Factors

	Discount Rate (I)				
Year	4.0%	4.5%	5.0%	5.5%	6%
0	1.0000	1.0000	1.0000	1.0000	1.0000
1	0.9615	0.9569	0.9524	0.9479	0.9434
2	0.9246	0.9157	0.9070	0.8985	0.8900
3	0.8890	0.8763	0.8638	0.8516	0.8396
4	0.8548	0.8386	0.8227	0.8072	0.7921
5	0.8219	0.8025	0.7835	0.7651	0.7473
⋮	⋮		⋮		⋮

Effect of Discount Rate on NPV



Discount Rate



Tricks of the Trade Associations

- Discount Rate
  - Argument: Governments cannot invest money they might save so they don't really have "lost opportunity".
    - They argue that the bond rate for a specific issue and not the interest rate should be used.
    - They argue that a sector specific inflation rate should be used.
    - The conclusion is that you can have a NEGATIVE discount rate!
  - Negative DR = Money is worth more in the future than it is today! Can you buy more with $1 now than in 1970?

User Costs - General Conditions

- Four lanes (2 way)
- 40-year Analysis
- 4% Discount Rate
- Level Terrain
- Rural Area
- 25000 ADT 15% Trucks
- 2% Growth
- Work Zone Speed Limit 40 mph

Sensitivity Analysis

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User Costs

Alternative	24-hour lane closure	10-hour lane closure
Asphalt – 10 year	>$5,000,000	$8,359
Asphalt – 15 year	$2,249,567	$5,299
Asphalt – 20 year	>$5,000,000	$7,021
Concrete	$3,291,737	---

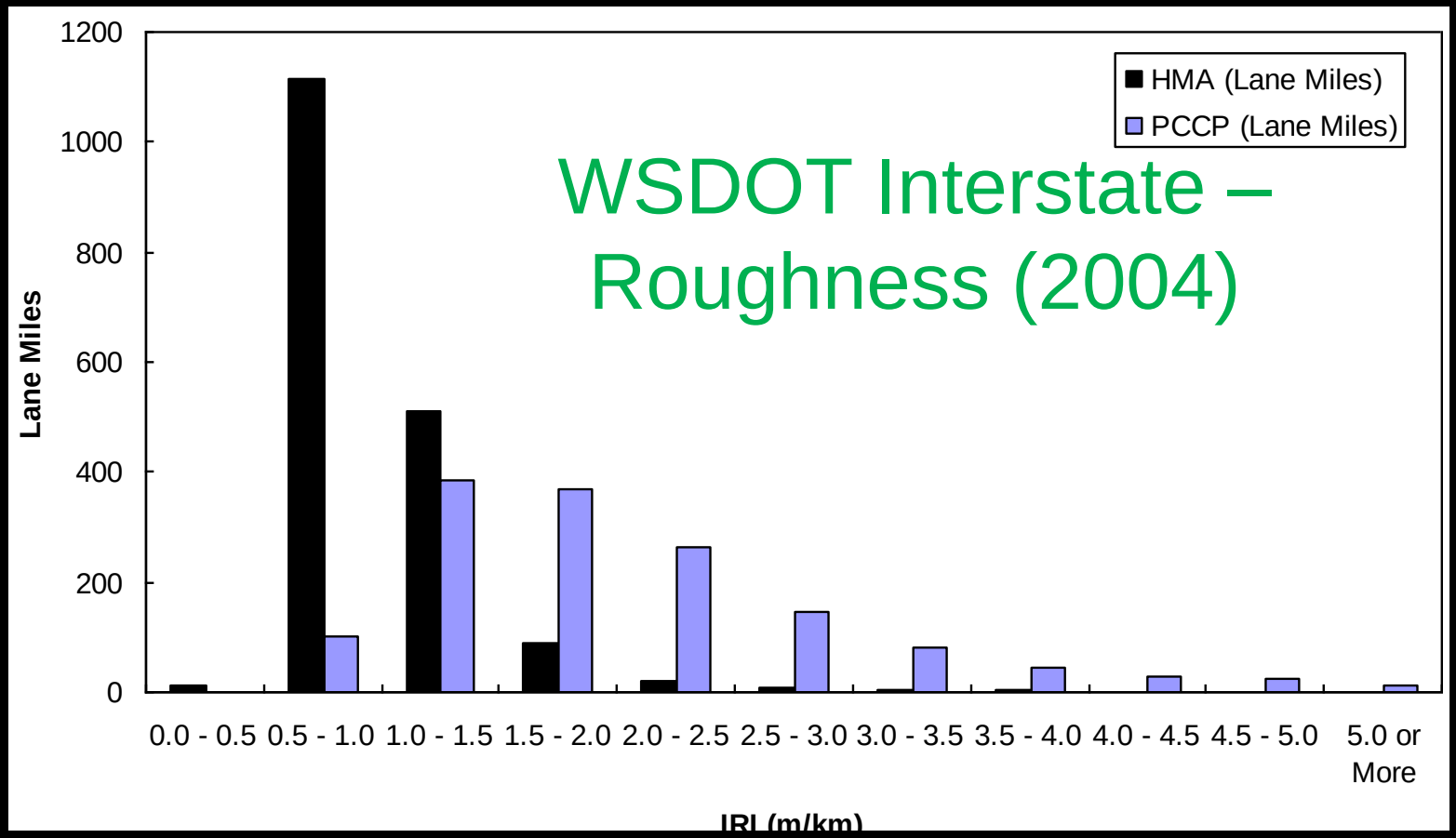
Are these costs absolutely accurate?

Absolutely not!

But they do indicate the importance of working in off-peak traffic hours and the magnitude of the impact!

Smoothness

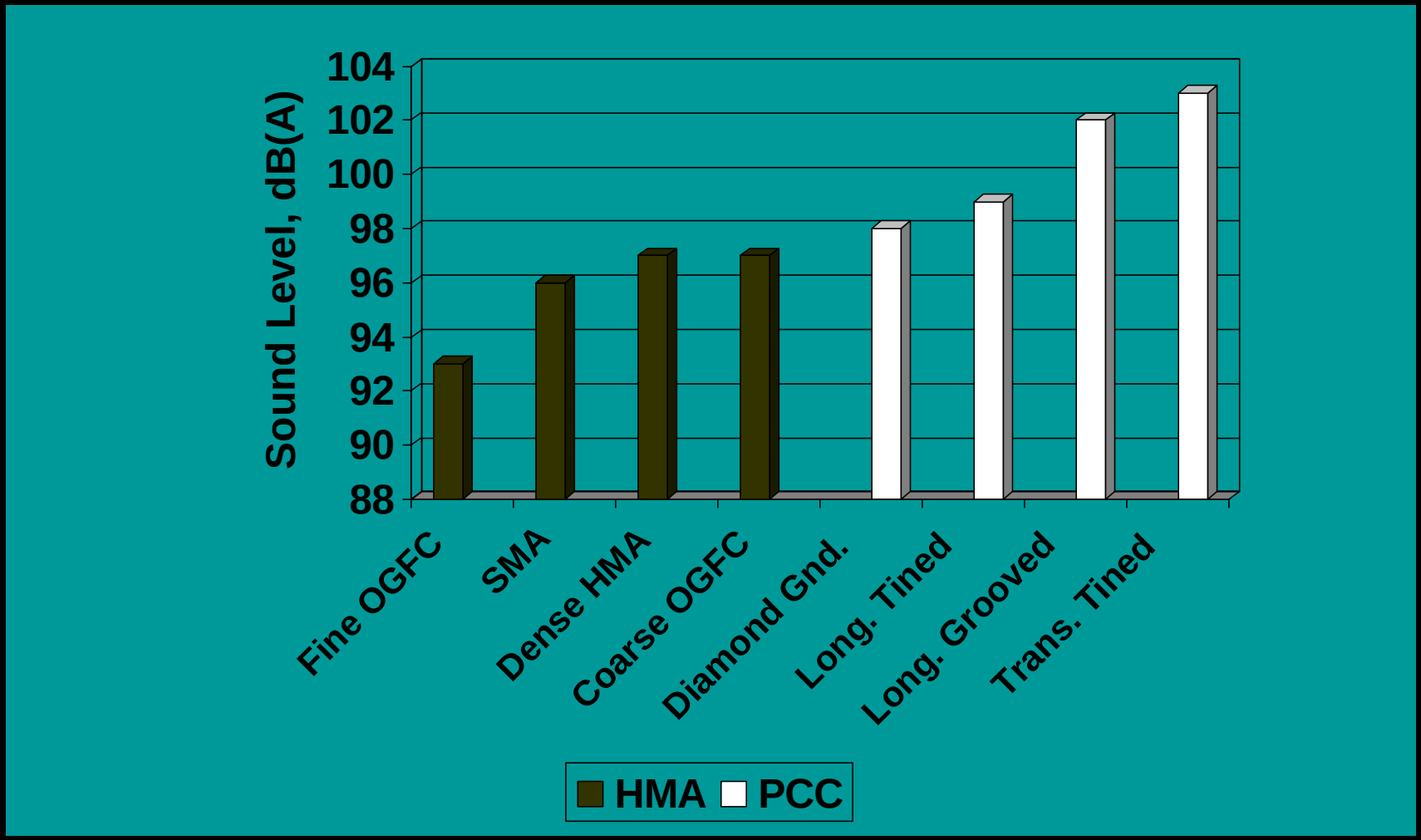
- Requirements need to be the same for both pavement types – initially and at the value that triggers rehab



Other Considerations

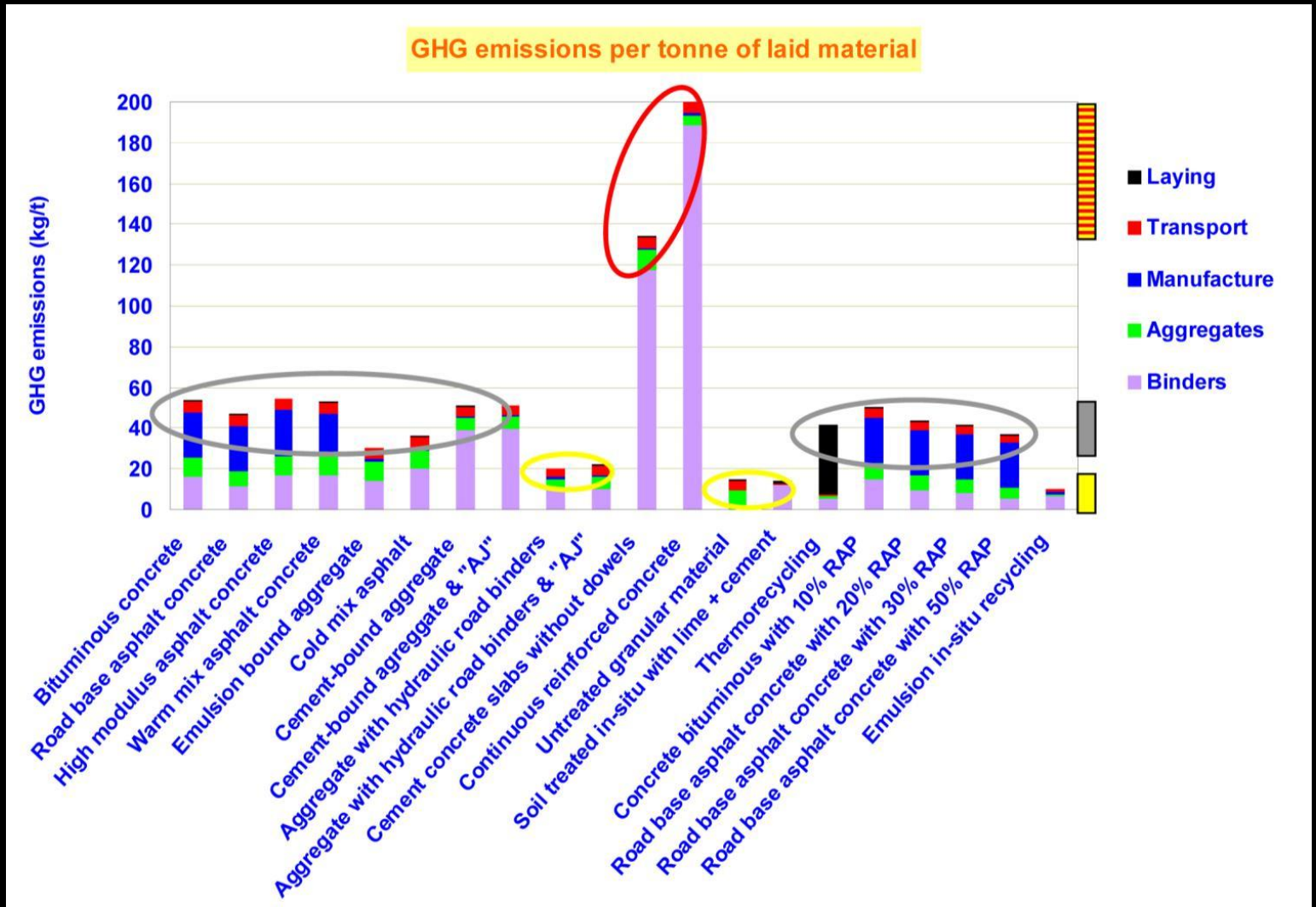
- Such as Noise – Cannot quantify direct cost, but Noise Walls cost about $50,000 per affected home.
- 1dB reduction allows reduction of noise wall height by 3 ft.
- Even allowing for slight degradation in noise reduction over pavement surface life would result in huge savings.

NCAT Study of 244 Pavements



Environmental Benefits

- Recycling – Reuse binder – can't do that with cement.
- Carbon Footprint – Source: The Colas Group



Summary

- LCCA needs to be a PART of an overall pavement type selection process.
- Rehabilitation intervals are important
  - Use real performance data, not guesses
- Discount Rate needs to be realistic
  - No negative values
- User costs are important
  - But should not be added directly to agency costs
  - NEED to be considered

Summary

- Don’t forget about all the other reasons to use asphalt pavements
  - Smoothness
  - Noise Reduction
  - Recycling – Reuse of Binder
  - Low Carbon Footprint – Carbon is Sequestered
  - You don’t have to paint the white lines black in order to see them.