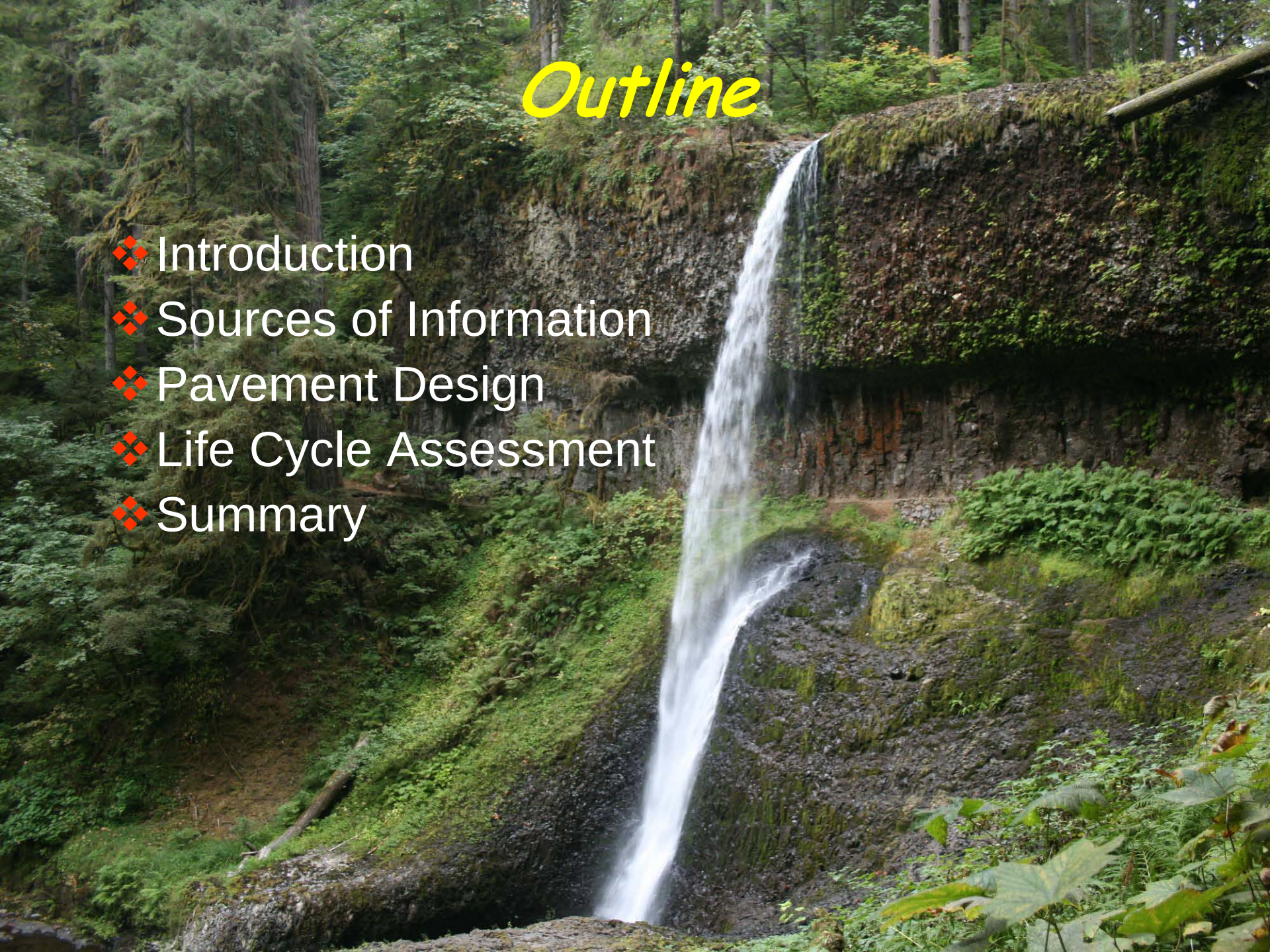
Hot Central Plant Recycling Benefits

October 9, 2008

National Center for Asphalt Technology



Outline

- Introduction
- Sources of Information
- Pavement Design
- Life Cycle Assessment
- Summary

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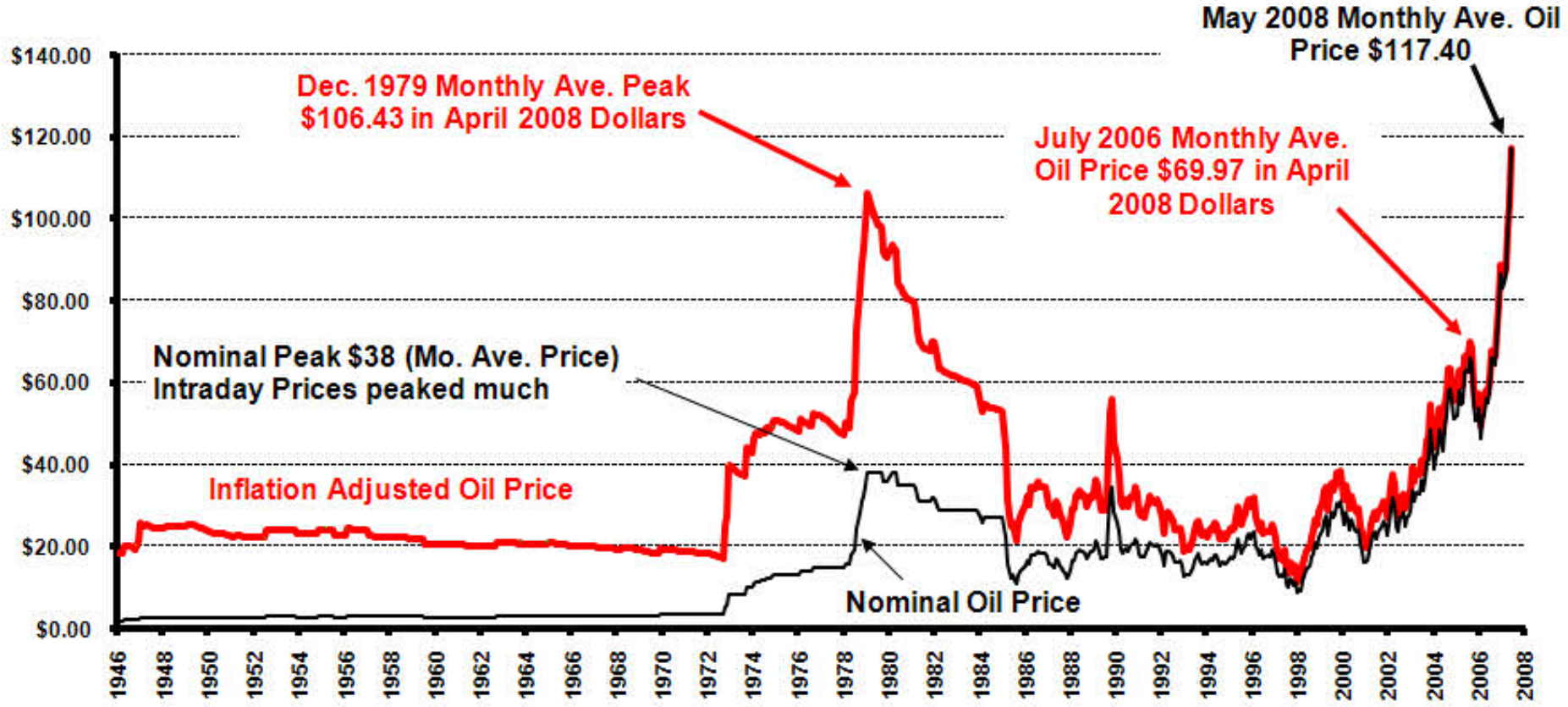
Historical Perspective

Concerns	1970's	2000's
Price of Asphalt Binder	X	X
Availability of Asphalt Binder	X	X
Limited Funds Available	X	X
Environmental Concerns	X	X
Energy Concerns	X	X
Inflation	X	

Inflation Adjusted
Monthly CRUDE OIL PRICES
(1946-Present) In April 2008 Dollars

Updated 6/12/2008



Nominal Monthly Ave. Oil Price
Inflation Adjusted Monthly Average Oil Price

Source of Data:
Oil Prices- www.ioga.com/Special/crudeoil_Hist.htm
CPI-U Inflation index- www.bls.gov

Price Trends

Year	Material		
	Crude Oil, $/bbl	Asphalt Binder, $/ton	HMA, $/ton
1970	3.39	20.00	8.04
1980	37.42	160.00	25.29
1990	23.19	142.00	24.52
2000	27.39	200.00	35.15
2005	50.04	232.00	45.56
2008	120.00?	650.00?	80.00?

Products of the 1970's

- Development and use of cold milling machines
- Popularization of reclaimed asphalt pavement (RAP) in hot mix asphalt (HMA)
- RAP processing
- Introduction of drum mix plant
- Vibratory roller
- Pavement Management Programs

Recycling Benefits

- Conservation
  - Materials (aggregate and asphalt binder)
  - Energy (burner fuel, trucking, etc.)
- Preservation of environment
  - Landfill
  - Green house gases (global warming)
  - Sustainability
- Economics
  - Reduce first and life cycle cost
  - Complete reconstruction vs. alternative methods
  - Increased contractor competition

Objectives

- Analyze benefits of Reclaimed Asphalt Pavement
- Analysis metrics
  - Energy
  - Emissions (CO_2, CO, NO_x, SO_2 and PM-10)
  - Resource conservation
  - Price of construction, maintenance and rehab

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Information Sources

	NCHRP 214	Colas Group	PaLATE	Contractor Data	DOT Data
	1980	2003	2003	2007	2004-2007
Energy Consumption	X	X	X		
Emissions Generation			X		
Conservation of Resources				X	
Price of Construction				X	X

Energy Consumption – Btu/sq yd-in

Operations	Rep. Range	Rep. Value
Cold Milling Asphalt Pavement	1,000 – 2,500	1,800
HMA Paving – 0% RAP	27,000 – 34,000	30,000
15% RAP in HMA	27,900	27,900
25% RAP in HMA	26,600	26,600
50% RAP in HMA	23,100	23,100

Emissions Generation - lb/sq yd-in

Operations		CO_2
Cold Milling Asphalt Pavement	Total	0.609
HMA Paving - 0% RAP	Materials	10.551
	Equip & Trucking	0.540
	Total	11.091
15% RAP in HMA	Materials	9.544
25% RAP in HMA	Materials	8.873
50% RAP in HMA	Materials	7.194

Note: Emissions for CO, NO_x, SO_2 and PM-10 were also estimated

Conservation of Natural Resources

- Engineering assumptions are necessary
- RAP
  - 4-percent asphalt binder
  - 96-percent aggregate

Price of Construction - $/sq yd-in*

Operations	Cold Milling Asphalt Pavement	Hot Mix Asphalt
California		4.75
Colorado		2.85
Indiana	0.35	2.65
New Hampshire		3.43
New York		3.71
Texas	0.40	3.07
Utah	0.38	3.55
Washington	0.54	3.30
Wyoming	0.31	
Contractor	0.62	3.84
Rep. Range	0.30 - 0.60	2.60 - 3.90
Rep. Value	0.45	3.25

***2007 Average Bid Prices**

Why Use RAP in HMA

- **Assumptions:**
  - **Asphalt binder price: $650/ton**
  - **Aggregate price: $7/ton**
  - **Asphalt content: 4-percent**
  - **RAP processing, stockpiling and handling cost: $6/ton**

Value of RAP		Cost, $/ton	Savings, $/ton	Savings, %
HMA	0% RAP	52.37	-	-
	15% RAP	48.36	4.01	7.66
	25% RAP	45.69	6.68	12.76
	50% RAP	39.01	13.36	25.51
Aggregate Base	0% RAP	7.00	-	-
	50% RAP	6.50	0.50	7.14
	100% RAP	6.00	1.00	14.29

Alternative RAP Uses

- Shoulder backing
  - Material removed from roadway
  - Material pushed up to roadway shoulder when construction finished
  - Value = eliminates transportation + cost conventional shoulder material
- Credit to City/County
  - DOT gives to City/County for transportation programs
  - Value = cost of dust palliative + transportation savings

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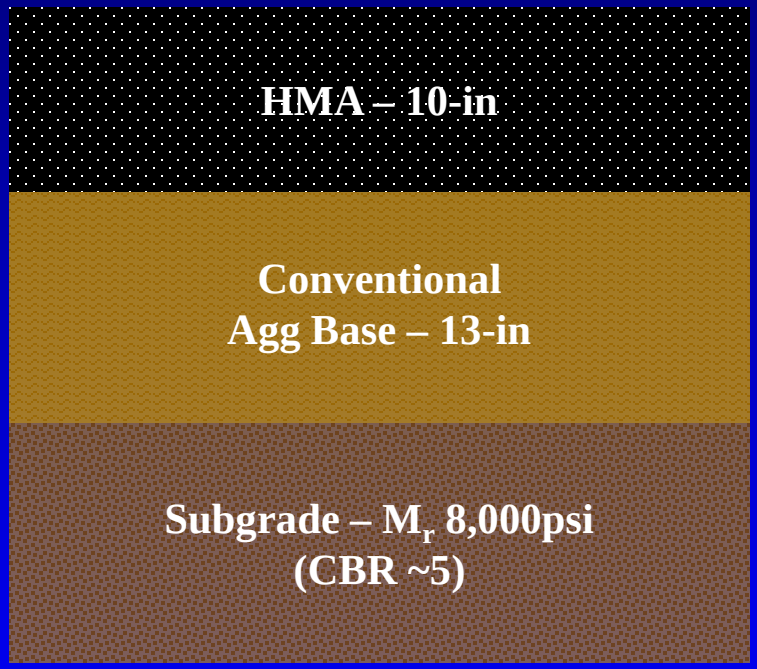
High Traffic Volume Roadway

Pavement Structure - Materials Alternatives

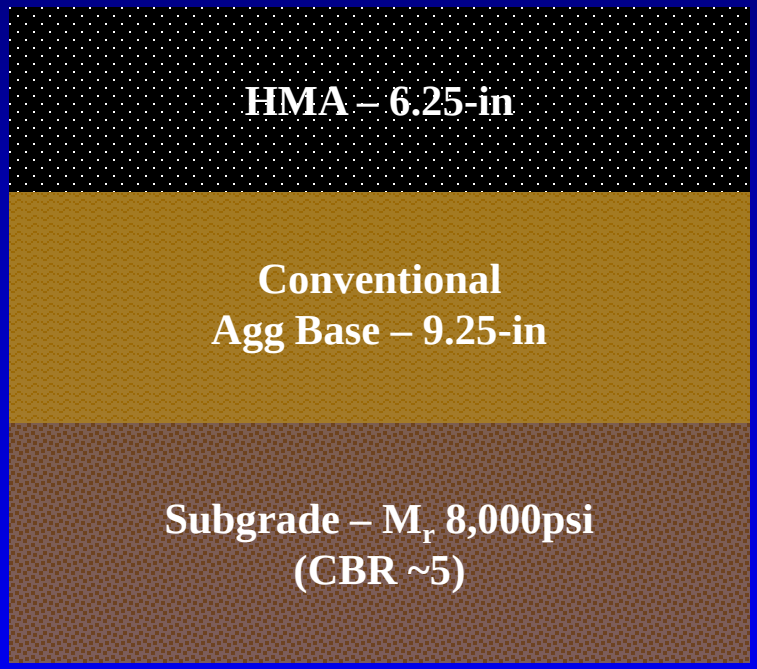


Rehabilitation	**Years of Rehab**
Mill & Fill 2-in Overlay 2.5-in	14 / 23 / 32
Maintenance	**Years of Maintenance**
Crack Seal	7 / 11 / 19 / 28 / 37

High Traffic Volume – 20M ESALs

Low Traffic Volume Roadway

Pavement Structure - Materials Alternatives



Rehabilitation	**Years of Rehab**
Mill & Fill 2-in Overlay 1.5-in	14 / 23 / 32
Maintenance	**Years of Maintenance**
Crack Seal	7 / 11 / 19 / 28 / 37

Low Traffic Volume – 1M ESALs

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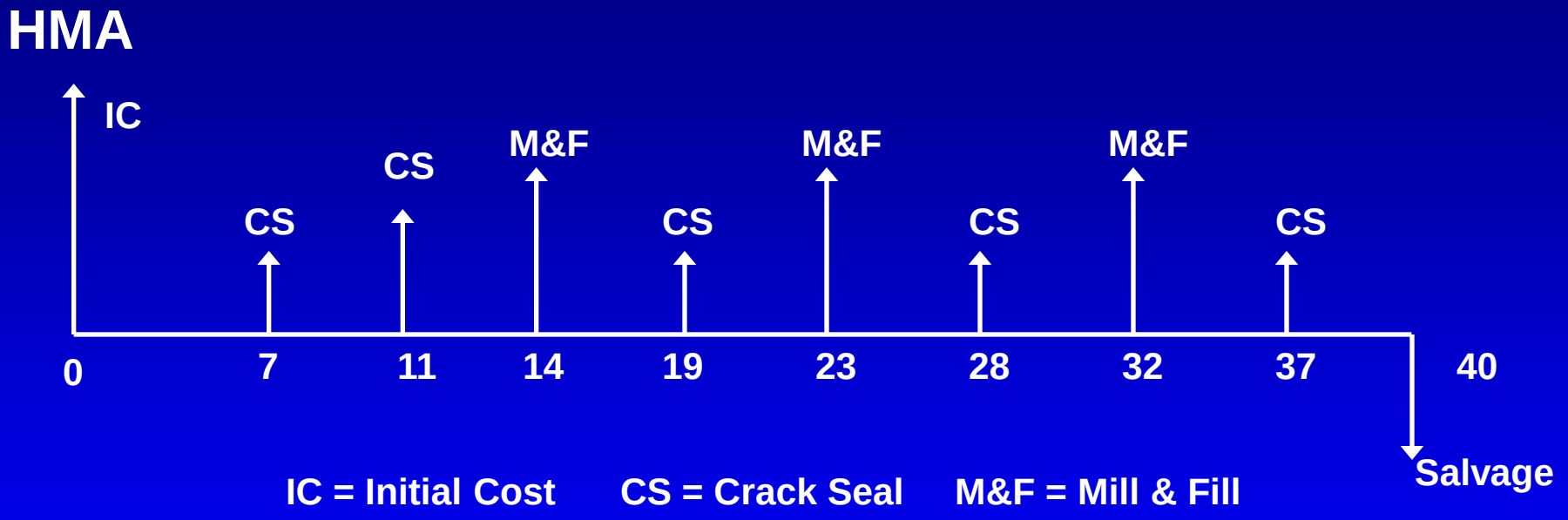
Life Cycle Assessment Format



- 40-year period was selected
- 4-percent discount rate – inflation free rate

LCA Spreadsheet

- Granite West Recycling Group document
- Deterministic and Probabilistic Analyses
- Outputs
  - Energy consumption
  - Emissions generation
  - Natural resource consumption
  - Price of construction

Value of Recycling – Percent Savings Relative to Conventional Materials – Initial Construction*

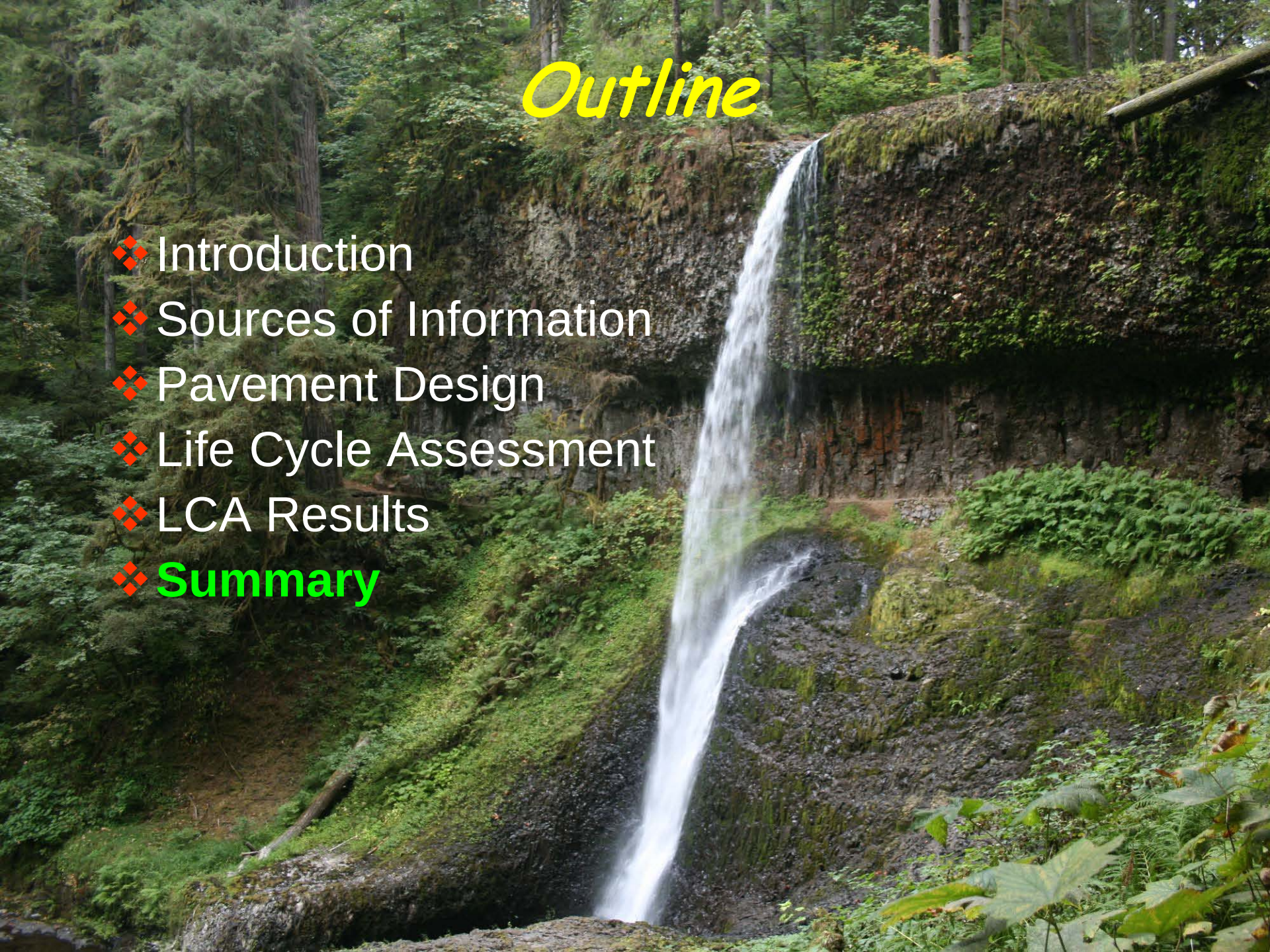
	15% RAP in HMA	25% RAP in HMA	50% RAP in HMA
Energy, BTU	5	8	16
AC Consumed, tons	12	19	39
Aggregate Consumed, tons	6	10	22
Price, $	3	5	11
CO_2, lb	7	12	25

*equivalent square yards

Value of Recycling – Percent Savings Relative to Conventional Materials – LCA*

	15% RAP in HMA	25% RAP in HMA	50% RAP in HMA
Energy, BTU	6	10	21
AC Consumed, tons	12	19	39
Aggregate Consumed, tons	8	13	31
Price, $	4	6	13
CO_2, lb	9	15	30

*equivalent square yards



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Impact on the US

	Annual Consumption/ Production	Estimated Annual Savings		
		15% RAP	25% RAP	50% RAP
Asphalt Binder, tons	29M	3.5M	5.5M	11.3M
Aggregate, tons	521M	31.2M	52.1M	114.6M
HMA Price, $	44B	1.3B	2.2B	4.8B
Energy, 10^{12} Btu*	300	15	24	48
CO_2, tons	55.5M	3.9M	6.7M	13.9M

*Annual Energy Consumption is 100×10^{15}-Btu


Questions