Asphalt Mixture Environmental Product Declarations (EPDs)

Key Drivers and Improvement Opportunities

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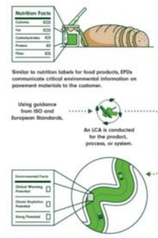
Environmental Product Declaration (EPD)

Environmental Product Declaration (EPD)

- **Third-party verified document** that publicly discloses the environmental impacts associated with sourcing, manufacturing, use, transportation, and disposal of your product.
- **Provide** verifiable and transparent information on **life-cycle environmental impact data** for materials or products.
- **Allow meaningful comparisons of the environmental performance of materials** (if they were developed using the same product category rules, PCRs, which are industry consensus standards and guidelines used in developing and reporting EPDs).
- **Identify areas** for environmental performance **improvement,** encouraging industry efficiency.



TRACI Impact Indicator	Unit	Materials	Transport	Production
Global Warming Potential	kg CO_2-Equiv.	83.4	11.8	168
Ozone Depletion	kg CFC-11-Equiv.	1.81e-08	5e-10	8.55e-11
Acidification	kg SO_2-Equiv.	0.486	0.0577	1.08
Eutrophication	kg N-Equiv.	0.0263	0.00373	0.0207
Smog Air	kg O_3-Equiv.	8.23	1.81	13.3

EPD Steps…
1. *Develop the PCR*
2. *Conduct the LCA*
3. *Develop the EPD*
4. *Publish the EPD*

https://ofmpub.epa.gov/sor_internet/registry/termreg/searchandretrieve/termsandacronyms/search.do
https://www.fhwa.dot.gov/pavement/sustainability/hif19087.pdf

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NAPA Emerald Eco Label Tool

https://asphaltepd.org/

Easy to Use Tool for EPD Development

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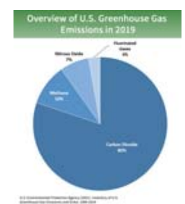
Greenhouse Gases

- Gases that trap heat in the atmosphere are called greenhouse gases.
- **Carbon dioxide (CO2)** is the primary greenhouse gas emitted through human activities. In 2019, CO2 accounted for about 80 percent of all U.S. greenhouse gas emissions from human activities
- **Methane (CH4)** is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices, land use and by the decay of organic waste in municipal solid waste landfills.
- **Nitrous oxide (N2O)** is emitted during agricultural, land use, industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater
- **Fluorinated gases:** Hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, and nitrogen trifluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes.

Fossil carbon dioxide	Biogenic carbon dioxide	Methane	Nitrous oxide	Hydro-fluoro-carbons	Perfluoro-carbons	Sulfur hexafluoride	Nitrogen trifluoride
CO_2	CO_{2b}	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3

https://www.climfoot-project.eu/en/what-emission-factor



https://www.appropedia.org/Glossary_of_sustainability_terms

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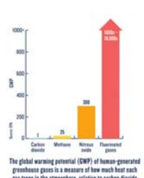
Global Warming Potential (GWP) of GHGs

- **CO2**, by definition, has a **GWP of 1** regardless of the time period used, because it is the gas being used as the reference. CO2 remains in the climate system for a very long time: CO2 emissions cause increases in atmospheric concentrations of CO2 that will last thousands of years.
- Methane (**CH4**) is estimated to have a **GWP of 28–36** over 100 years. CH4 emitted today lasts about a decade on average, which is much less time than CO2. But CH4 also absorbs much more energy than CO2. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. The CH4 GWP also accounts for some indirect effects, such as the fact that CH4 is a precursor to ozone, and ozone is itself a GHG.
- Nitrous Oxide (**N2O**) has a **GWP 265–298** times that of CO2 for a 100-year timescale. N2O emitted today remains in the atmosphere for more than 100 years, on average.
- Chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6) are sometimes called high-GWP gases because, for a given amount of mass, they trap substantially more heat than CO2. (**The GWPs for these gases can be in the thousands or tens of thousands.**)

https://www.epa.gov/ghgemissions/understanding-global-warming-potentials



The global warming potential (GWP) of human-generated greenhouse gases is a measure of how much heat each gas traps in the atmosphere, relative to carbon dioxide.

https://www.caro.ie/knowledge-hub/general-information/science-of-climate-change/greenhouse-gases

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Carbon Dioxide Equivalent (CO2e)

- The unit used to measure the impacts of releasing (or avoiding the release of) different greenhouse gases; it is obtained by multiplying the mass of the greenhouse gas by its global warming potential.
- CO2e puts all GHG emissions in relation to carbon dioxide, which is considered to have a GWP of 1.

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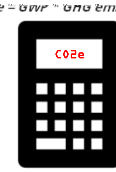

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Before We Go Further…

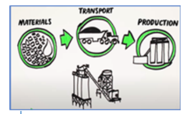
- Calculating emissions is highly dependent upon the LCA for the particular material and/or product (asphalt, aggregate, rejuvenator, fuel, etc.)
- LCAs….
  - May vary greatly
  - Will evolve
- "Impossible" to get an exact value for every unique situation. Fluid design and production process.
- Data quality is an absolute key.

Potential CO2e Influencers (EPD)

Materials
- Liquid
  - Total binder content
  - Recycle
- Aggregate
  - Recycle

Transport
- Materials haul distance

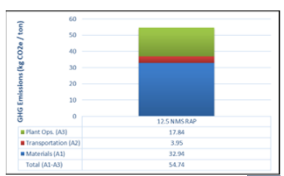
Production
- BTU consumption
  - Moisture
  - Production temperature
- Burner Fuel



Discussion Format

1. What are the key drivers of CO2e generation in an asphalt mixture?
2. For each key driver what are the "levers" to move the CO2e in the right direction?

- Emissions (kg CO2e / Ton)
  - A1 (Materials)
  - A2 (Transport)
  - A3 (Production)



What are the Controllable Factors?

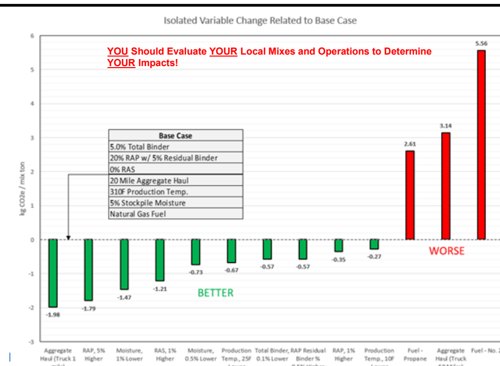
Controllable
1. **Stockpile Moisture**
2. **Recycle Amount and "Quality"**
   - Especially Non-Agency
3. **Total Binder**
4. **Production Temperature**
5. **Plant Insulation/Electrical**

Controllable to Lesser Degrees
1. Aggregate Haul Distance
2. Plant Fuel Type

YOU Should Evaluate YOUR Local Mixes and Operations to Determine YOUR Impacts!

How Do the Factors Influence CO2e?

Factor	How it Helps	EPD Category
Lower Binder %	Lowers the Impact of the Highest CO2 Generator (Binder)	A1
Higher RAP	Lowers Impact of Binder and Virgin Binder + Aggregate Haul	A1, A2
Higher RAS	Lowers Impact of Binder and Virgin Binder Haul	A1, A2
Lower Aggregate Binder Abs.	Lowers the Impact of Binder	A1
Local Aggregate Use	Lowers the Haul Distance	A2
Lower Production Temp. (WMA)	Lowers the Production Energy (BTU), varies on fuel source	A3
Lower Stockpile Moisture	Lowers the Production Energy (BTU), varies on fuel source	A3
Variable Frequency Drives	Lowes the Plant Energy (Electricity)	A3
Plant Piping Insulation	Lowers the Plant Energy	A3
Plant Fuel Type	Significant Impact, NG is lowest impact	A3
Balanced Mix Design	Optimize binder, aggregate, recycle contents	A1
Rejuvenators	Increase Recycle	A1
Additives	Maybe increase recycle, lower binder demand	A1
All Factors Might Also Inluence Service Life and Associated Emissions		

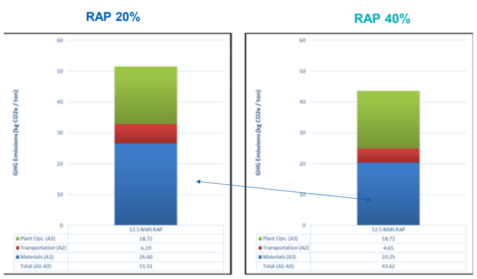


MATERIALS

Materials Items

- Asphalt Binder
- Aggregates
- Recycle
- Additives

RAP 20% vs RAP 40%

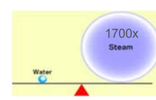


1% RAP ~ 0.35 kg CO2e / ton

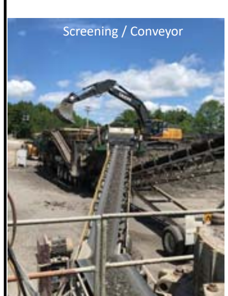
Recycle "Levers"

1. **RAP and/or RAS max addition**
   - Maximize addition on non-agency mixes
   - Rejuvenator use
2. **Maximize Residual Binder in Recycle**
   - Better RAP management and processing
   - Finer grind size on RAS (¼")
3. **Plant modifications (e.g., recycle bins, flights, type (counter/parallel flow, RAP collar, etc.) to accommodate higher recycle**
4. **Limit moisture in RAP (limit steam explosion w/ batch plants).**
5. **Favorable agency specifications**

Multiple Levers = Higher Impact!



RAP Processing for "Better RAP" Quality



"Better" RAP Impact

- **What is "better" RAP?**

1. Higher stockpile binder content.
2. More consistent aggregate grading.
3. More consistent residual binder grading.
4. Less / more consistent P200.

Tips…

1. Monitor in-coming RAP to limit contamination
2. Separate RAP sources
3. Process / screen / crush correctly
   - **Don't** crush RAP that doesn't need crushing.
   - Too much dust generated, lower binder %
4. Fractionate **if** it makes sense
   - Can you make one fraction work and have outlet for other fractions?

"Better" RAP Impact – Residual Binder %

- Increase Residual RAP Binder Content by 0.5% w/ +$3 cost.

RAP IMPACT ON BINDER REPLACEMENT AND COST		
Mix Design Binder %	5.0	
Virgin Binder, $ / ton	500.00	
Virgin Aggregate, $ / ton	15.00	
RAP Used, %	20.0	
RAP Cost / RAP Ton, $	5.00	8.00
RAP Stockpile Binder, %	5.00	5.50
Binder Replacement, %	20.00	22.00
Materials Cost, $ / mix ton	32.40	31.92
Binder Replacement % Impact		2.00
Mix Materials Cost Impact / Ton		$ (0.485)

Critical that each individual situation be evaluated at the local level. DO NOT rely on assumptions, opinions, other data to make YOUR decision.

*Use **YOUR** data to make **YOUR** decision.*

0.5% Higher Residual = ~ 0.57 kg CO2e / ton

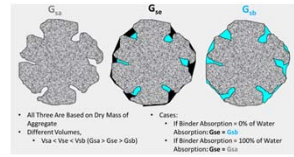
Asphalt Binder (Liquid) Demand (Levers)

1. **Right size the total liquid in your mixes.**
   - Avoid overdesign (e.g., VMA)

0.25% VMA = 0.1% liquid ~ 0.57 kg CO2e / ton

2. **Consider asphalt absorption when selecting aggregates, if possible.**
   - Example: Agg blend w/ 1% abs vs 0.75% abs

0.75% abs ~ 0.72 kg CO2e / ton



Multiple Levers = Higher Impact!

TRANSPORT

Transport Items

- Transport Distance from Plant
  - Aggregate Blend
  - Asphalt Binder
  - Recycle

Aggregate Transport Impact

"In regions without a local supply of suitable aggregates for asphalt mixtures, transportation (A2) can become a significant contribution to cradle-to-gate GHG emissions, in some cases overwhelming the emissions associated with raw materials (A1) and production (A3)."

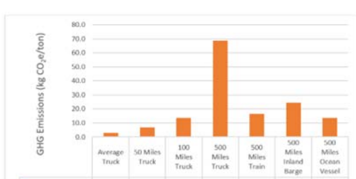


Figure 5. Impact of transport distance on transportation related (A2) GHG emissions. The Average Truck scenario assumes transport distances of 21.5 miles for aggregates and 3.9 miles for asphalt binder (Mukherjee, 2016).

Aggregate Sourcing Can Greatly Impact the CO2e. Locally Available Aggregate Use Reduces the CO2e Impact, but Performance Must be Achieved.

Aggregate Transport Impact (Comparison)

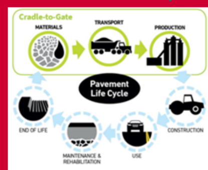
ACRONYM	INDICATOR	UNIT	QUANTITY PER METRIC TONNE ASPHALT MIXTURE (PER SHORT TON ASPHALT MIXTURE)			
			MATERIALS (A1)	TRANSPORT (A2)	PRODUCTION (A3)	TOTAL (A1-A3)
GWP-100	Global warming potential, incl. biogenic CO2	kg CO2 Equiv.	26.27 (23.83)	0.52 (0.47)	19.36 (17.56)	46.15 (41.86)

Asphalt Plant in Quarry (All Agg. From Quarry)

ACRONYM	INDICATOR	UNIT	QUANTITY PER METRIC TONNE ASPHALT MIXTURE (PER SHORT TON ASPHALT MIXTURE)			
			MATERIALS (A1)	TRANSPORT (A2)	PRODUCTION (A3)	TOTAL (A1-A3)
GWP-100	Global warming potential, incl. biogenic CO2	kg CO2 Equiv.	20.89 (18.95)	32.08 (29.10)	22.98 (20.85)	75.95 (68.90)

Rail + Ship + Truck (Aggregate from Multiple Off-Site Locations)

PRODUCTION



Production Items

- Burner Fuel Type
- Burner Tuning
- Moisture
- Equipment
- Electricity
- Hot Oil Heater

British Thermal Unit (BTU)

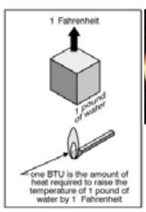
- BTU: Energy (heat) to raise 1 lb water by 1°F.
- Production goal is to **dry** and heat the aggregate
- Aggregate moisture increases the BTU demand because the water has to be removed in addition to the aggregate being heated
- BTU demand can be reduced with proper stockpile moisture management practices

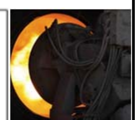
TECH NOTE

- 1% aggregate moisture requires an additional 24,000 BTUs to dry a ton of aggregate.
- Every one degree increase in mix temperature requires 440 BTUs.

1% Moisture ~ 11% BTU ~ 11% Production Rate

BTU





Carbon Dioxide from Fuel Sources

Pounds of CO2 emitted per million BTU of energy for various fuels

- The amount of CO2 produced when a fuel is burned is a function of the carbon content of the fuel.

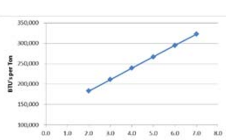
Carbon Dioxide Emissions Coefficients by Fuel

Carbon Dioxide (CO_2) Factors:	Pounds CO_2 Per Unit of Volume or Mass	Kilograms CO_2 Volume or Mass	Pounds CO_2 Per Million Btu	Kilograms CO_2 Per Million Btu
For homes and businesses				
Propane	12.68 gallon	5.75 gallon	138.63	62.88
Diesel and Home Heating Fuel (Distillate Fuel Oil)	22.46 gallon	10.19 gallon	163.45	74.14
Kerosene	21.78 gallon	9.88 gallon	161.35	73.19
Coal (All types)	4,027.93 short ton	1,827.04 short ton	211.06	95.74
Natural Gas	120.96 thousand cubic feet	54.87 thousand cubic feet	116.65	52.91
Finished Motor Gasoline[3]	17.87 gallon	8.10 gallon	148.54	67.38
Motor Gasoline	19.37 gallon	8.78 gallon	155.77	70.66
Residual Heating Fuel (Businesses only)	24.78 gallon	11.24 gallon	165.55	75.09

https://www.eia.gov/environment/emissions/co2_vol_mass.php

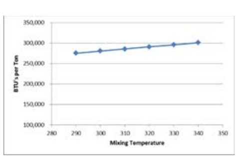
BTU Demand Comparison

Moisture



1% change in moisture equals a ~24,000 BTU change per ton of mix

Temperature



Every 5°F change equals a ~2,200 BTU change per ton of mix

1% moisture reduction = ~55°F temperature reduction

Water Quantities on a Stockpile During a Rain Event

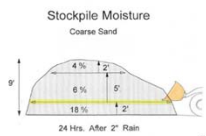
- The amount of water falling on a stockpile during a rain event is very significant.
  - Example: 100 ft. x 100 ft. stockpile will collect **26 tons of water** after a 1" rainfall event.
  - This water has to either be 1) drained out or 2) dried out.

Stockpile Footprint (sf)	Approximate Dimensions, ft	Water Tonnage Over Footprint After Given Rainfall Events (in)			
		0.5	1	2	3
5000	70 x 70	7	13	26	39
10000	100 x 100	13	26	52	78
15000	125 x 125	20	39	78	117
20000	140 x 140	26	52	104	156
25000	160 x 160	33	65	130	195
30000	175 x 175	39	78	156	234

Stockpile Moisture Variation

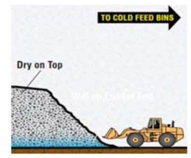
- Mississippi Case Study
- Moisture in a coarse sand stockpile 24 hr. after a 2 in. rain
  - Moisture varied widely (18 to 4%) throughout 9' tall stockpile
- CRITICAL to Keep the bucket off the ground!

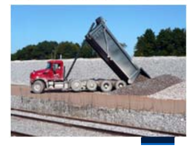
1% Moisture…
~ 1.47 kg CO2e / ton (Natural Gas)
~ 1.75 kg CO2e / ton (Propone)
~ 2.06 kg CO2e / ton (RFO)



Stockpile Moisture "Levers"

1. **Paved - Sloped Stockpile Areas**
   - Paved and sloped (correctly).
2. **Covered Stockpiles**
   - Benefit is more than just $$$ now, it's now emissions.
3. **Loadout Best Practices**
   - Bucket Up (1 to 2 ft.)
   - Load out from "high side"
   - *Cost = ZERO*
4. **Aggregate Supply Management**
   - Wet material being shipped? (significant issue)
   - Use dry material 1st!
   - Communication needed w/ supplier.





Paved Stockpile Area Payback Example - Michigan Paving

Same aggregate used at two plants, Grand North/South (~8 miles apart)

Stockpile area paved at Grand North plant.

Paving costs ~$10K

Stockpile Moisture Mitigation Payback Evaluator

INPUT				
Item	As-Is	Mitigation	Mitigation Total Cost, $	10,000
Annual Production, Tons	80,000			
Agg. Composite Moisture, %	5.2	4.6		
Plant Burner Fuel (Drop Down)	Natural Gas			

% Moisture	Paved	Non-Paved
AVG	4.6	5.2
STD DEV	0.74	0.77

ANALYSIS					
BTU/ Ton Reduction	14,400	Savings, $		Payback	
Plant Burner Fuel	Natural Gas	Per Ton	Per Year	Years	Months
		0.13	10,164.71	1.0	11.8

Production Temperature

Determine if a lower temperature is achievable

- Is the production temperature too hot?
- Has the temperature "creeped" up over the years?
- Do you have a plant foaming device?
- Are you using your plant foaming device optimally?
- Can you run chemical WMA technologies to drop temperature without undue risks?
  - How low can you go?
  - Have you run the numbers?
  - Have you tried?

Warm Mix Asphalt Economics Evaluator

INPUT			
Temperature Reduction w/ WMA, F	25		
Annual WMA Production, Tons	150,000		
Plant Burner Fuel (Drop Down)	Natural Gas		
ANALYSIS		**SAVINGS**	
BTU/ Ton Reduction	12,500	Per Ton	Per Year
Plant Burner Fuel	Natural Gas	0.095	14,250.00

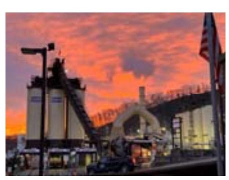
$8 / dekatherm

25F Temperature…
~ 0.67 kg CO2e / ton (Natural Gas)
~ 0.80 kg CO2e / ton (Propane)
~ 0.95 kg CO2e / ton (RFO)

Other Production Related Energy Savers

- Proper Burner Sizing and Tuning
- Minimize Start/Stops
- Consistent Production (Mix Consolidation)
- Minimize Waste
- Adequate and Proper Drum Flighting
- Insulated Piping (asphalt, hot oil/flanges, jumpers)
- Air Leaks (Seals, Baghouse, Inlet/Discharge)
- Variable Frequency Drives (VFD) on Plant Components

- *Energy Audits Recommended for Plant Facilities*



Sustainability Impacts


RAP


WMA


LIQUID


MOISTURE

Recycled Asphalt Pavement (RAP)
- 1% RAP ~ 0.35 kg CO2e / ton

Warm Mix Asphalt (WMA)
- 25F Temp. ~ 0.67 kg CO2e / ton (Natural Gas) / 0.80 (Propane) / 0.95 (RFO)

Liquid Asphalt
- 0.1% liquid = 0.25% VMA = ~ 0.57 kg CO2e / ton

Moisture
- 1% Moisture ~ 1.47 kg CO2e / ton (Natural Gas) / 1.75 (Propane) / 2.06 (RFO)

CO2e

General Estimates: Local Conditions Will Drive Actual Data

Aggregation of Marginal Gains

British Cycling Team Example:

- Between 1908 and 2003, British riders had won just a single gold medal in Olympic games.
- In 2003, Dave Brailsford joined as the head of British cycling team with a dream to make the team successful in the Olympics.
- To make the above possible, he started with a principle called ***The Aggregation of Marginal Gains***.
- **5 years later (2008 Olympics), Britain won 7 gold medals.**

Every Aspect, Every Day!

https://jamesclear.com/marginal-gains

Key Points…

Leading practices that save $$$ almost always have a positive sustainability impact.

- Reduce Aggregate Moisture
- Lower Production Temperature
- Reduced Virgin Binder Demand
- Increased Recycle Use
- Using Locally Available Aggregates

Sustainability impacts must be considered in decision making process (i.e. CAPEX)

- Cost / [Benefit ($ + Sustainability)]

Being Green Can Make you Green!

Need for Partnering to Lower Emissions

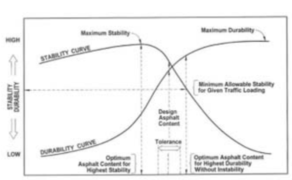
FHWA's Climate Challenge identified more than 35 projects from 27 agencies (including 2 local agencies), providing $7.1 million to 25 state departments of transportation.

CLIMATE CHALLENGE

State	Agency Name	Project Description	Funding Awarded
Alabama	Alabama DOT	Quantifying Emissions from the Production and Construction of Balanced Mix Design (BMD) Asphalt Mixtures with Recycled Materials, Warm Mix Asphalt, and Recycling Agents.	$312,000
Louisiana	Louisiana DOT & Development	Sustainability through Development of Life Cycle Information Models for Pavements in Louisiana.	$312,000
Mississippi	Mississippi DOT	Conducting LCA for Asphalt Pavements Constructed with Cold Mixes.	$312,000
Oklahoma	Oklahoma DOT	Evaluating the Broader Impacts of Balanced Mix Design (BMD) and Warm Mix Asphalt (WMA) Specifications and Incentives in Oklahoma through a LCA Framework.	$283,448
Texas	Texas DOT	Developing Capacity for Whole-Life LCA.	$312,000
Virginia	Virginia DOT	Quantifying Greener Pavements in Virginia.	$312,000
West Virginia	West Virginia DOT; Division of Highways	Investigating Sustainable Asphalt Mix Design Solutions in West Virginia.	$79,671

Balanced Mix Design (BMD)

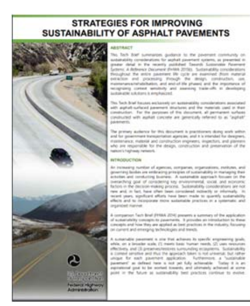
- An **innovative** BMD approach offers the **potential to enhance the sustainability footprint** of mixes through optimization of binder, recycle and aggregate use.



BMD Checks All the Boxes…

Resources

Sustainable Asphalt Pavements: A Practical Guide



FHWA Strategies for Sustainability

Thank You