eLCAP and PaveM: California's Network and Project Level Quantification Tools

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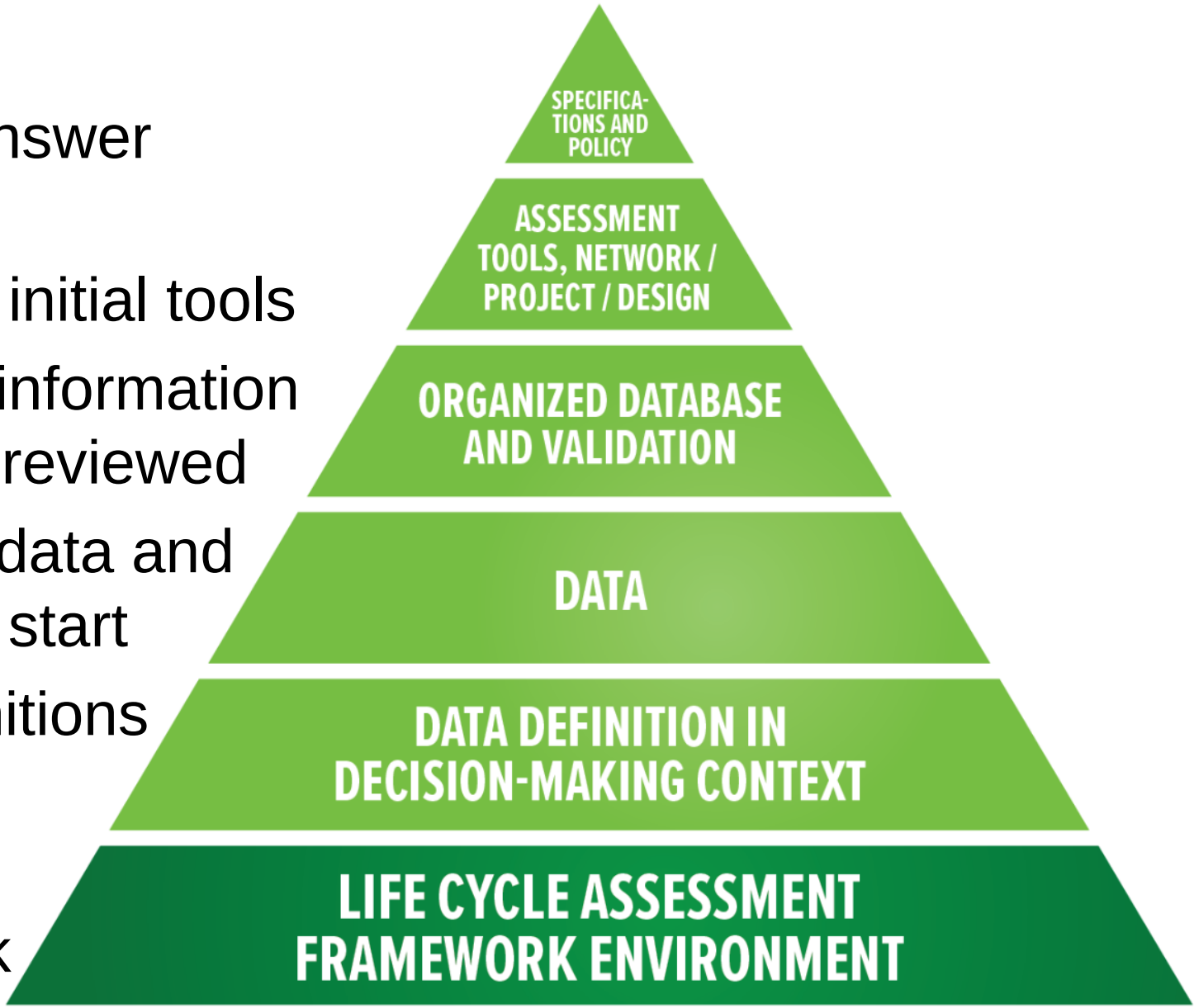
The need for pavement LCA tools

- Pavement LCA information awareness and knowledge growing; need to start doing
- Tools are available (examples)
  - Conceptual-level tool for GHG, national data (ICE)
  - Commercial interfaces to databases not specific to pavement (GaBi Envision)
  - Pavement tools with incomplete life cycles (Athena, Roadprint [web based])
  - Web based tools specific to another DOT (PLCA)
  - Strong regional inventory excel tool (Tollway)

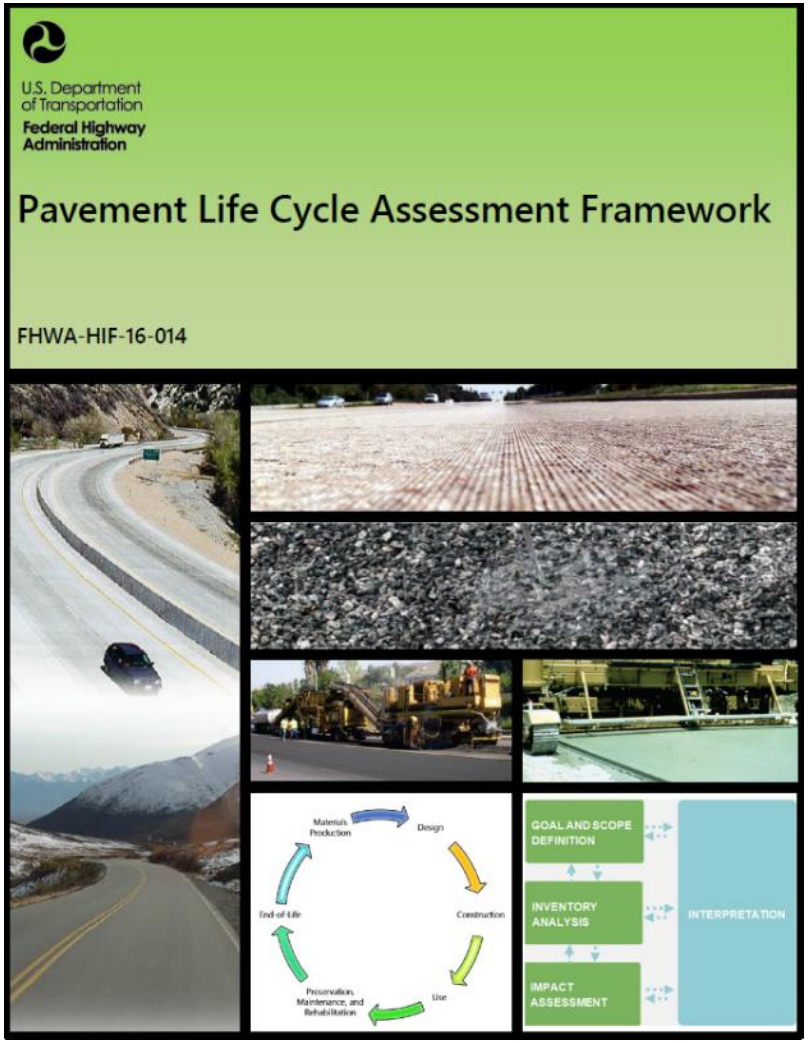
Ready to produce pavement LCA tools?

- Want to answer questions
- Ready for initial tools
- Inventory information available, reviewed
- Sufficient data and models to start
- Data definitions ready
- FHWA framework



FHWA Pavement LCA Framework Document

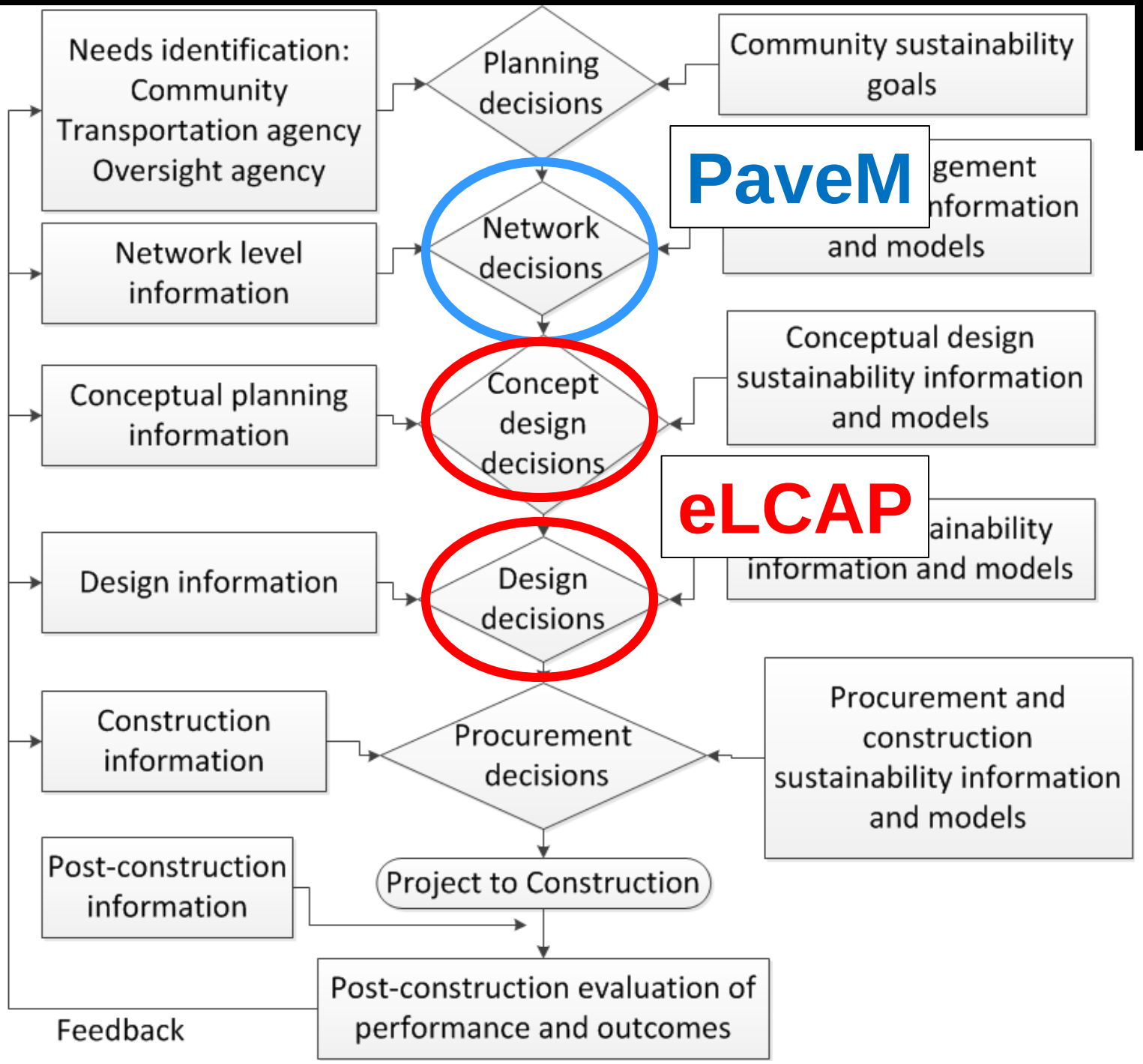
- Published January 2016
- Downloadable on FHWA Sustainable Pavements website
- Guidance on uses, overall approach, methodology, system boundaries, and current knowledge gaps
- Specific to pavements
- Includes recommended guidelines for EPDs



Objective: web-based integrated tools for:

- Network
- Concept
- Design

With complete life cycle and regionally applicable data



Considerations for implementation

- Relevancy
  - Address relevant pavement decisions and questions, goals and scopes
  - Flexibility: ability to add new questions, materials, designs, practices, data
  - Regional and temporal relevant data and models
- Trustworthiness
  - Transparency of data, models, processes
  - Follow FHWA Pavement LCA and other appropriate guidelines
  - Critically reviewed inventories and approaches

Considerations for implementation

- Practicality
  - Studies can be completed:
    - In reasonable time
    - With available data
    - With reasonable training
  - User input interface able to:
    - Provide reasonable default data
    - Ability to take more detailed user-defined data, including from EPDs
  - Reporting
    - Targeted to decisions, documentation requirements
    - Easy-to-understand

Traffic Database for PaveM and eLCAP

- Use same traffic data from Caltrans databases

Caltrans Truck Annually published, 3,400 stations CA highways

- Annual Average Daily Traffic (AADT)
- Daily Truck Count (2, 3, 4 and 5+ Axle Counts)
- 1 to 2 year time-lag

PeMS Traffic Real-time/time series DB, 17,600 stations

- Daily and hourly traffic flowrate, speed, lane distribution

TASAS-TSN* Continuous updates in Highway Log, pull as needed

- AADT of segment in Highway Log (Network definition)

Weigh-In-Motion 110 stations

- Axle weight and gross weight, axle spacing, vehicle classification, speed

*** TASAS-TSN: Traffic Accident Surveillance and Analysis System – Transportation Systems Network**

PaveM approach for network LCA

- Decision trees select Treatment or Do Nothing
- Calculate GHG over analysis period for Treatment and Do Nothing cases for each segment,
  - Simplified equations from eLCAP for GHG from materials, construction for each treatment (default thicknesses)
  - Simplified equations for GHG from vehicle interaction with roughness for each vehicle type x volume x length
- Prioritize segments for treatment on benefit/cost
  - Reduction of GHG vs Do Nothing is benefit
  - Select projects with greatest benefit/cost
- GHG reduction for network over analysis period is summed over selected treated segments

eLCAP approach for conceptual and design level LCA

- Web based, US/SI units, multiple languages
- Cradle to laid or cradle to grave
- Follows FHWA framework (18 impacts, TRACI+)
- Functional unit definition
  - Conceptual: user defined configuration using general treatment type from PaveM, other considerations
  - Design: user defined pavement design, layers, materials
  - User selected traffic
    - State highway data from annually updated database for segments and post-mile
    - User defined for cities and counties

Impact calculation (18, TRACi+

Selected Impact Categories and Inventories	Material Production	Material as Cons
Acidification	1.7178E-03	93
Ecotoxicity (recommended)	6.4297E-01	92
Eutrophication	5.5258E-05	89
Global Warming Air, excl. biogenic carbon	3.3580E-01	94
Global Warming Air, incl. biogenic carbon	3.3581E-01	94
Human Health Particulate Air	1.4940E-04	96
Human toxity, cancer (recommended)	2.2114E-10	97
Human toxity, non-cancer (recommended)	5.2534E-08	94
Ozone Depletion	1.1043E-09	99
Resources, Fossil fuels	5.5400E-01	93
Smog Air	2.4085E-02	88
Primary Energy Demand used as raw materials (Feedstock Energy)	2.4120E+00	10
Primary energy demand from ren. and non ren. resources (gross cal. value)	5.1562E+00	94
Primary energy demand from ren. and non ren. resources (net cal. value)	4.8278E+00	94
Primary energy from non renewable resources (gross cal. value)	5.0339E+00	94
Primary energy from non renewable resources (net cal. value)	4.7055E+00	94
Primary energy from renewable resources (gross cal. value)	1.2232E-01	10
Primary energy from renewable resources (net cal. value)	1.2232E-01	10

eLCAP approach for conceptual and design level LCA

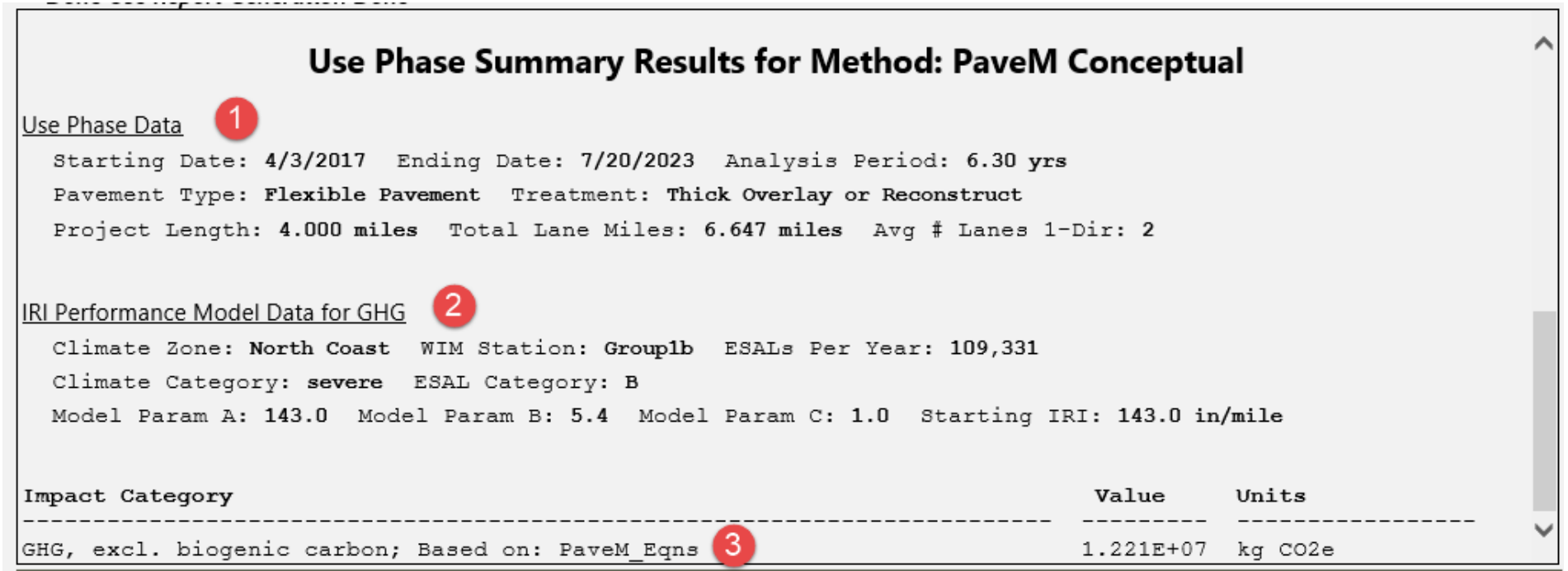
- Materials, transport, construction models
  - Models
    - Built by UCPRC using models, GaBi, other data for materials and construction processes
    - GaBi data updated annually and then kept constant (thinkstep agreement)
  - Default materials design for each type
  - User capability to adjust materials designs or input impacts from EPDs
  - User defined transport distances and modes
  - Construction equipment operation tied to material and quantity, default or user defined
- Repeat for subsequent M&R

eLCAP approach for conceptual and design level LCA

- Use stage
  - Excess fuel consumption from vehicle roughness interaction difference (Wang et al) vs “ideal” 40 in/mile
  - Uses PaveM IRI models
  - To be added soon:
    - Texture models vs ideal 0.5 mm MPD or MTD
    - Calibrated structural response models vs ideal no response, considering hourly traffic flow, speed and temperature across years
- EOL
  - Stops at reconstruction or land fill
  - If no real EOL, follows FHWA framework

IRI models

- Simple IRI models used in PaveM and eLCAP
  - Continuous models from PMS data
  - Simplified: Average_IRI (inches/mile) = a+b*Age^c
    a, b, c depend on treatment, ESAL/yr, climate category
  - Future:
    - Use continuous models for design level eLCAP



Use Phase Summary Results for Method: PaveM Conceptual

Use Phase Data (1)

Starting Date: **4/3/2017** Ending Date: **7/20/2023** Analysis Period: **6.30 yrs**
Pavement Type: **Flexible Pavement** Treatment: **Thick Overlay or Reconstruct**
Project Length: **4.000 miles** Total Lane Miles: **6.647 miles** Avg # Lanes 1-Dir: **2**

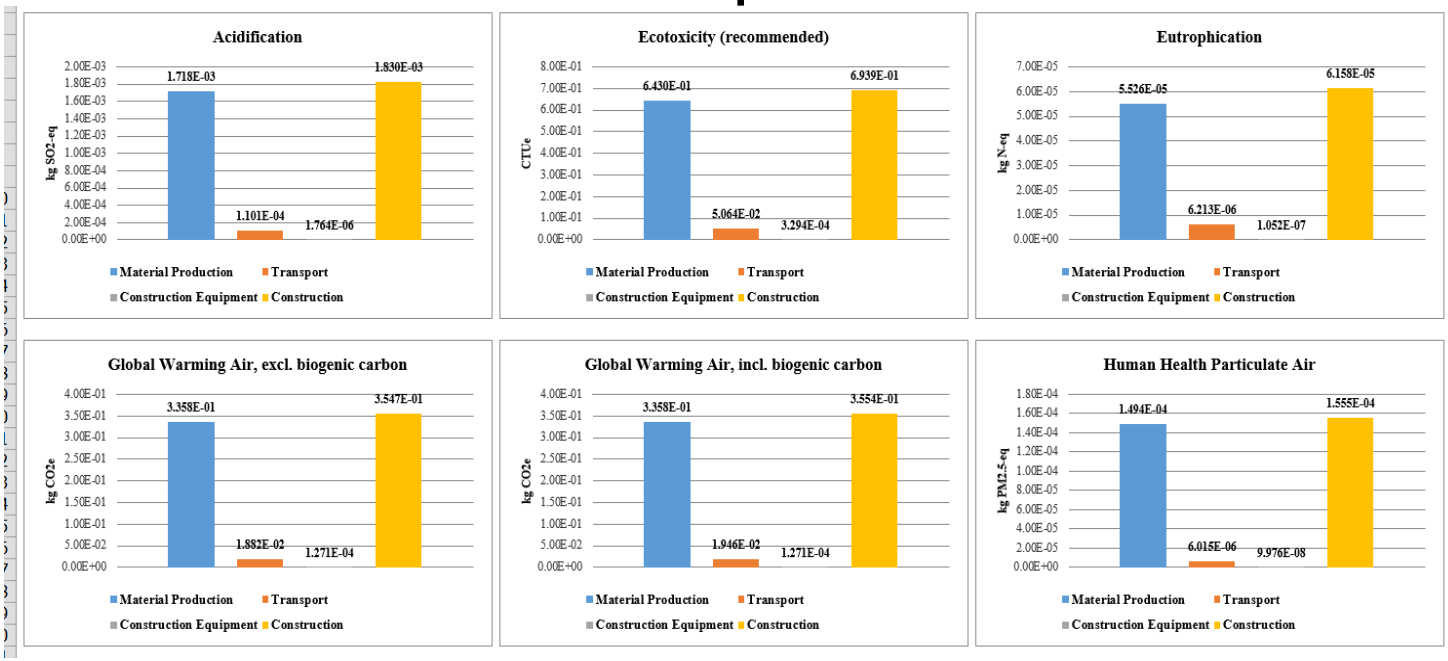
IRI Performance Model Data for GHG (2)

Climate Zone: **North Coast** WIM Station: **Group1b** ESALs Per Year: **109,331**
Climate Category: **severe** ESAL Category: **B**
Model Param A: **143.0** Model Param B: **5.4** Model Param C: **1.0** Starting IRI: **143.0 in/mile**

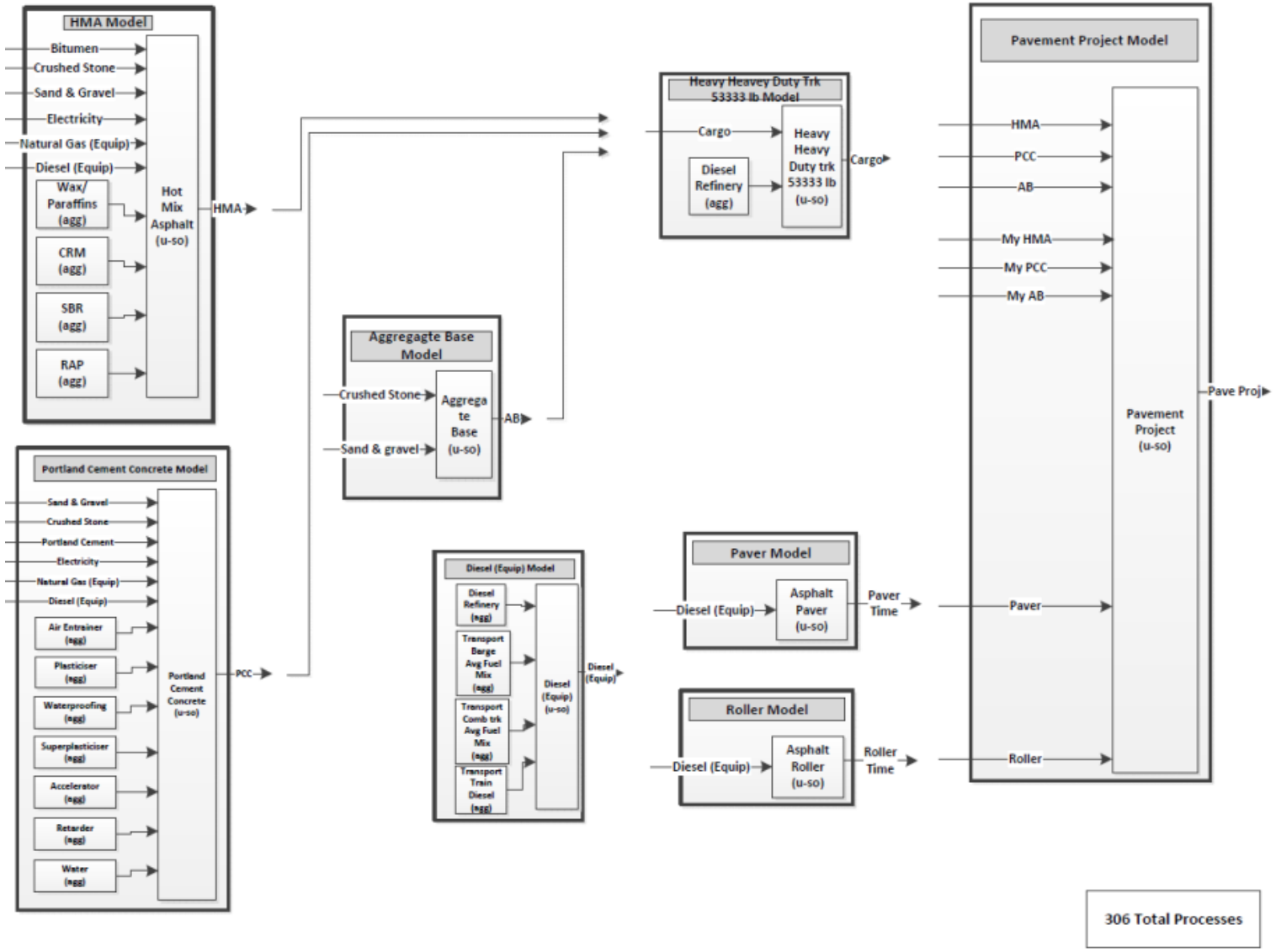
Impact Category	Value	Units
GHG, excl. biogenic carbon; Based on: PaveM_Eqns (3)	1.221E+07	kg CO2e

Reporting

- Impacts can be broken down by:
  - Each impact category
  - Life cycle stage
  - Elements (material types, material components, construction, transport) within stage
- Tables, bar charts and pie charts



Documentation of all data, models and assumptions, necessary for critical review

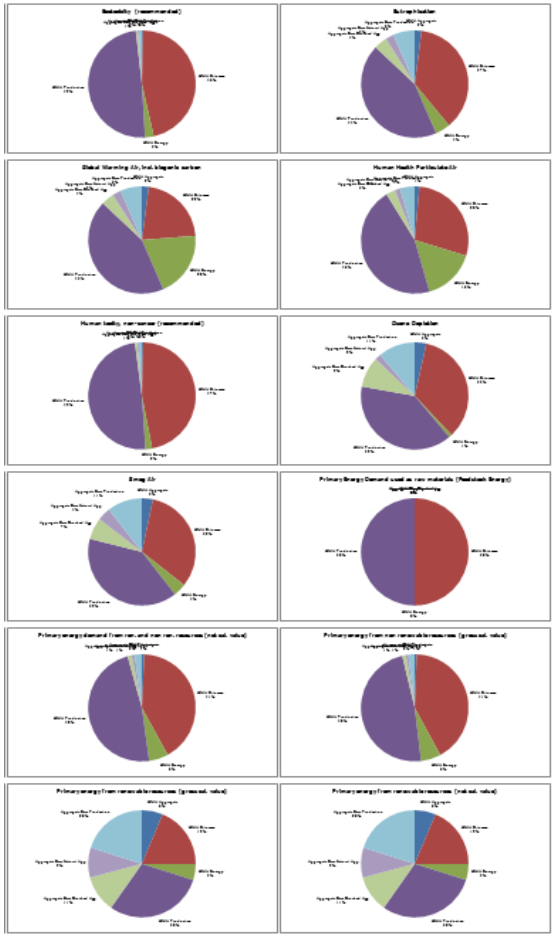


Critical review

- Initial eLCAP main inventory for materials and construction data reviewed by outside critical review team in 2016
  - Benchmarked against other data
  - Review of data quality assessment
- Annual updates to eLCAP LCI and processes will be similarly critically reviewed by independent outside team

Advances with these tools

- Builds on progress of other tools
- Integration between network-, conceptual- and design-level LCA
  - Data, models
  - Assumptions, impacts, reporting
- Integration with LCCA
  - Traffic data, performance models, treatments
- Web-based, complete life cycle, flexibility of data, critical review



Future developments

- Future developments in next year
  - Continuous IRI models for design use
  - Excess fuel use from structural response and texture
  - Tie materials to item codes, expanded use of EPDs
  - Better construction work zone traffic impacts model
  - Post-construction evaluation tied to pay items
- Annual updates
  - LCI data from GaBi to update impacts
  - Update models for new materials and processes
- Tri-annual updates
  - Performance models in PaveM, eLCAP, RealCost-CA

Thoughts on future development of tools

- Training, support, transparency, trustworthiness
- Keeping tools practical within time, data availability, cost constraints of users
- Use of EPDs, regional data, better models for everything, licensing of proprietary data
- Customized user interfaces and data
- Platforms
  - Web-based for more complex tools
    - Updates are easy
  - Python for simpler tools
    - Avoids problems with VB updating, good interfaces
    - Example is LBNL heat island LCA tool

Questions

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