PREP-ME: AN MULTI-AGENCY EFFORT TO PREPARE TRAFFIC DATA FOR PAVEMENT ME DESIGN

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Outline

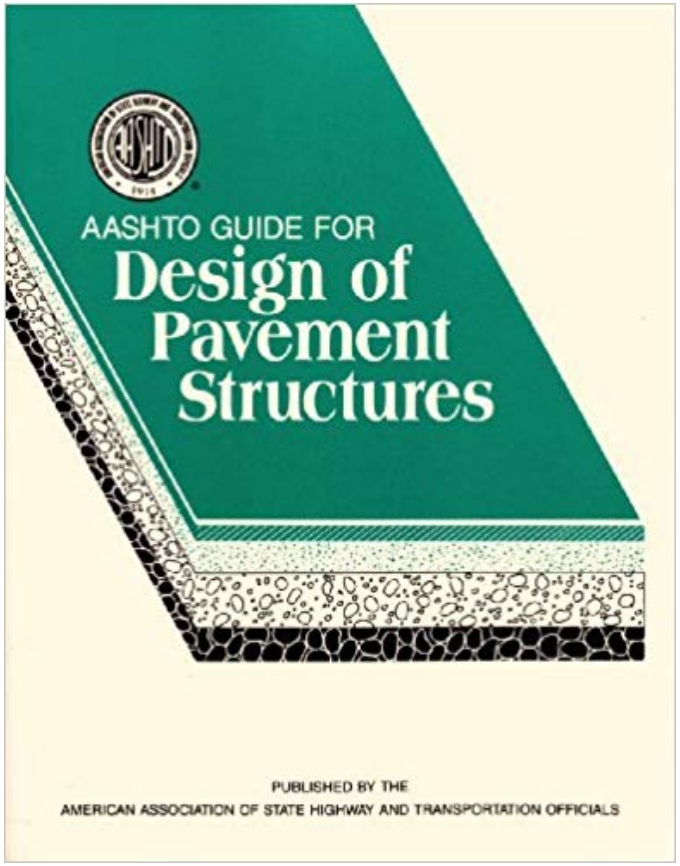
- Brief History: Pavement Design
- Prep-ME: Development and Capabilities
- Looking Forward: Future Plans

Brief History: Pavement Design

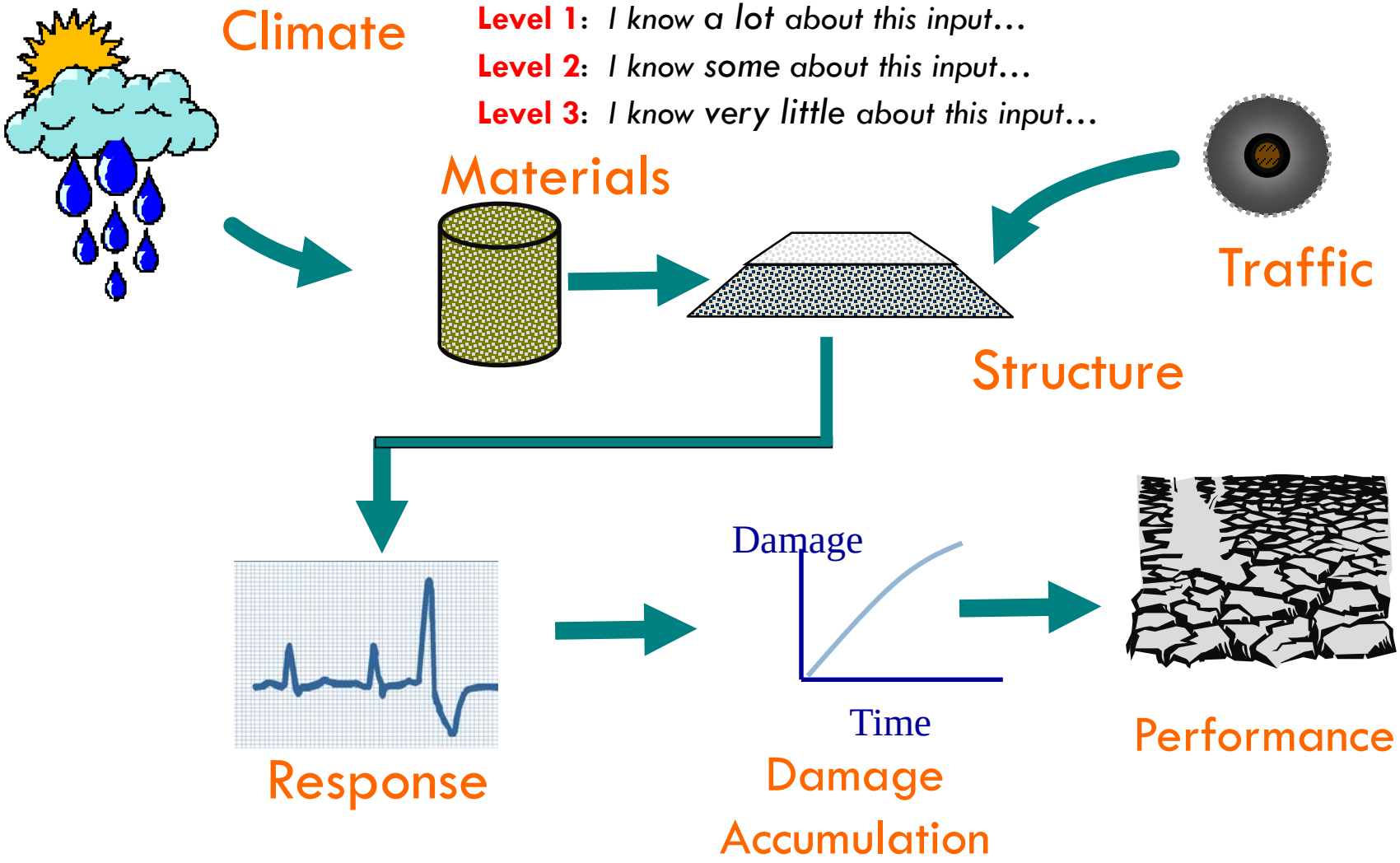
AASHO Road Test (1958-1960)

EISENHOWER INTERSTATE SYSTEM

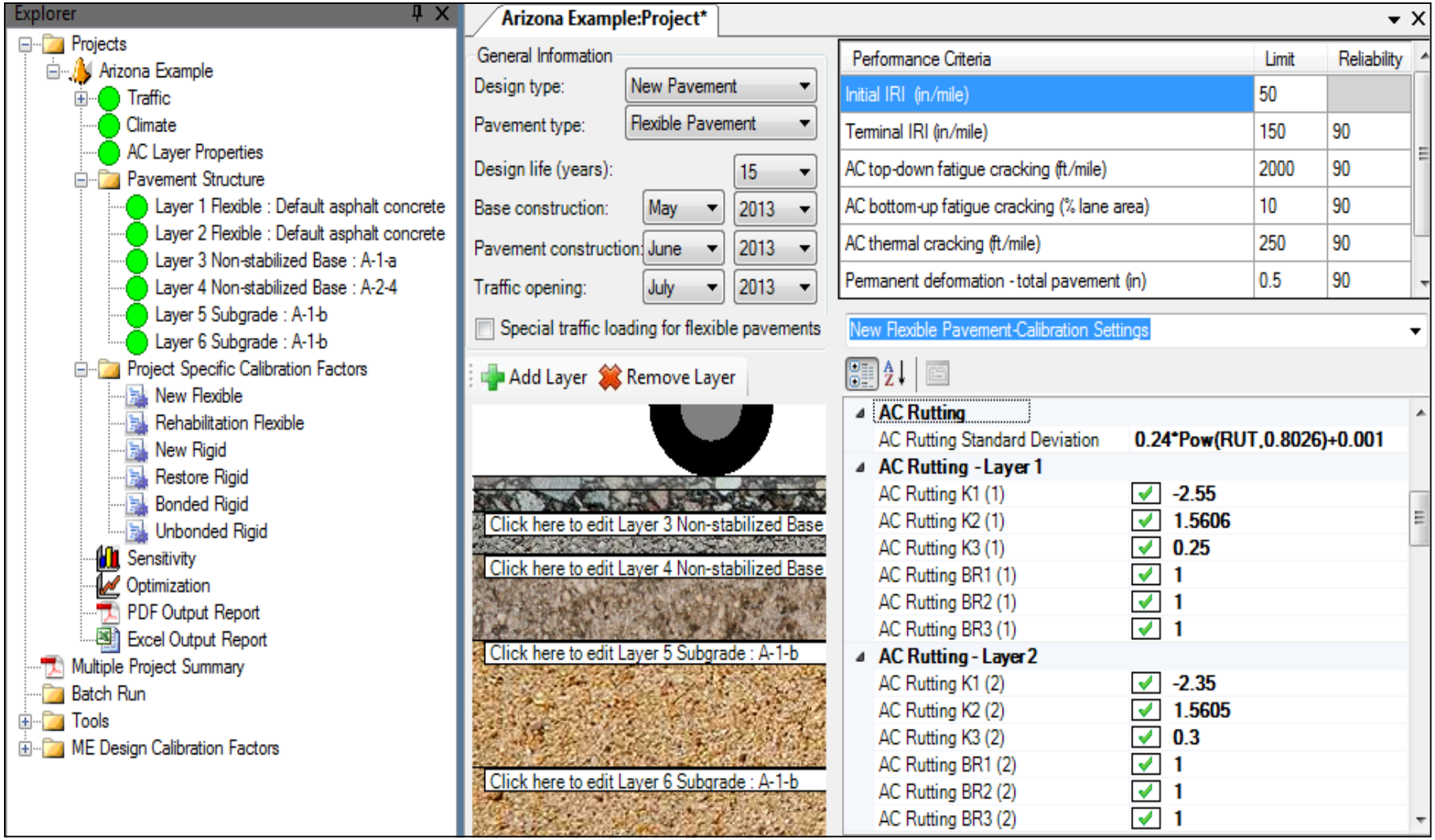
$$\log W_{18} = Z_R \times S_0 + 9.36\log(SN+1) - 0.20 + \frac{\log\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\log(M_R) - 8.07$$



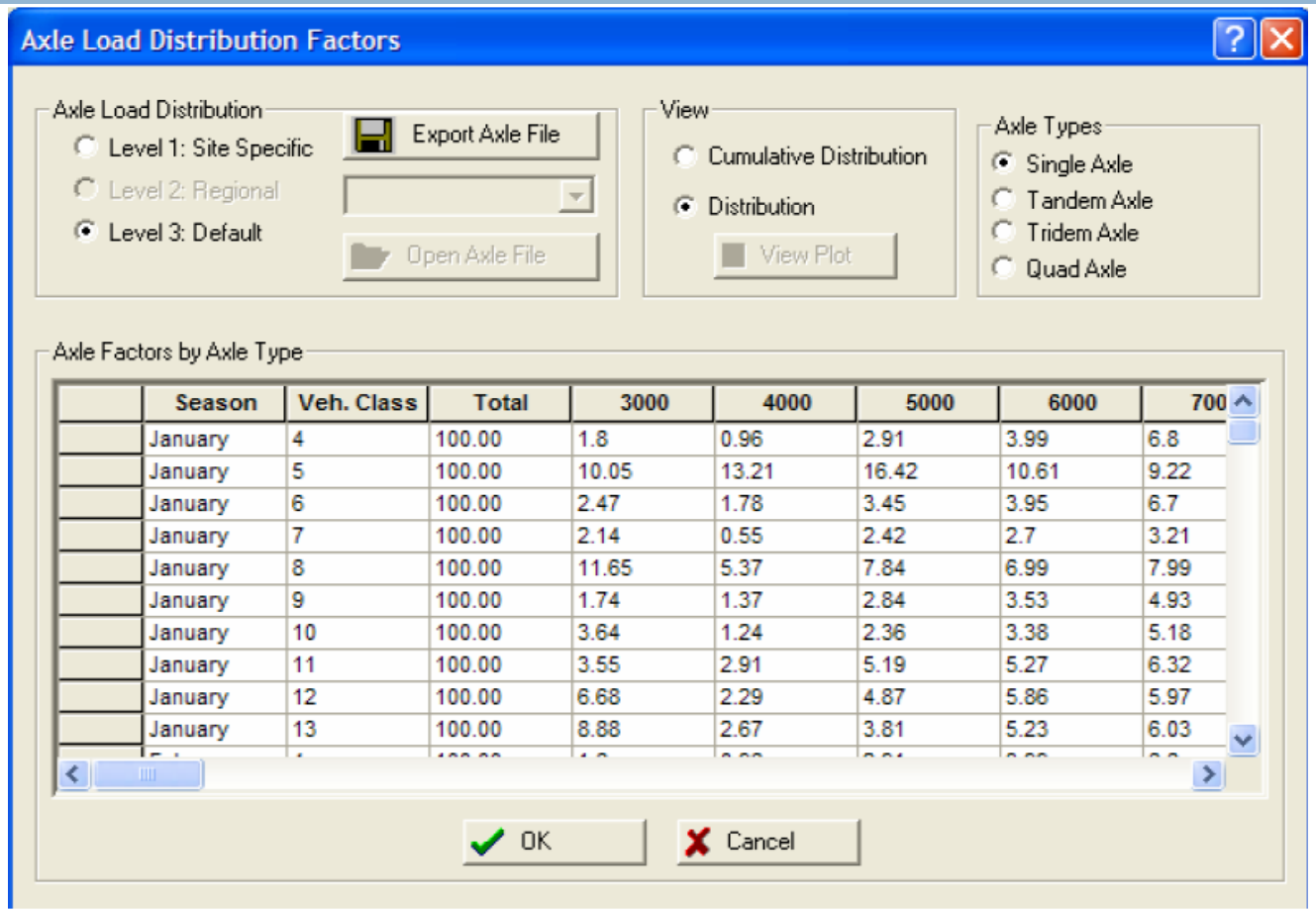
Pavement ME Design / MEPDG



Pavement ME Design



Pavement ME Design



	Season	Veh. Class	Total	3000	4000	5000	6000	700
	January	4	100.00	1.8	0.96	2.91	3.99	6.8
	January	5	100.00	10.05	13.21	16.42	10.61	9.22
	January	6	100.00	2.47	1.78	3.45	3.95	6.7
	January	7	100.00	2.14	0.55	2.42	2.7	3.21
	January	8	100.00	11.65	5.37	7.84	6.99	7.99
	January	9	100.00	1.74	1.37	2.84	3.53	4.93
	January	10	100.00	3.64	1.24	2.36	3.38	5.18
	January	11	100.00	3.55	2.91	5.19	5.27	6.32
	January	12	100.00	6.68	2.29	4.87	5.86	5.97
	January	13	100.00	8.88	2.67	3.81	5.23	6.03

Axle load spectra: 12 months x 10 vehicle classes x 41 load bins x 4 axle types = **19,680 numbers !!!**

Problem Statement

- Extensive amount of data inputs
  - Traffic: axle loading spectra instead of ESALs
  - Climate: hourly climatic data
  - Materials: dynamic modulus (E*), coefficient thermal expansion (CTE), resilient modulus (M_R)
- Challenges of data availability, quality & process
  - Availability: either not available or stored somewhere
  - Data quality: data huge in size but poor in quality
  - Data process: how to use limited available data for new designs at locations without historical data

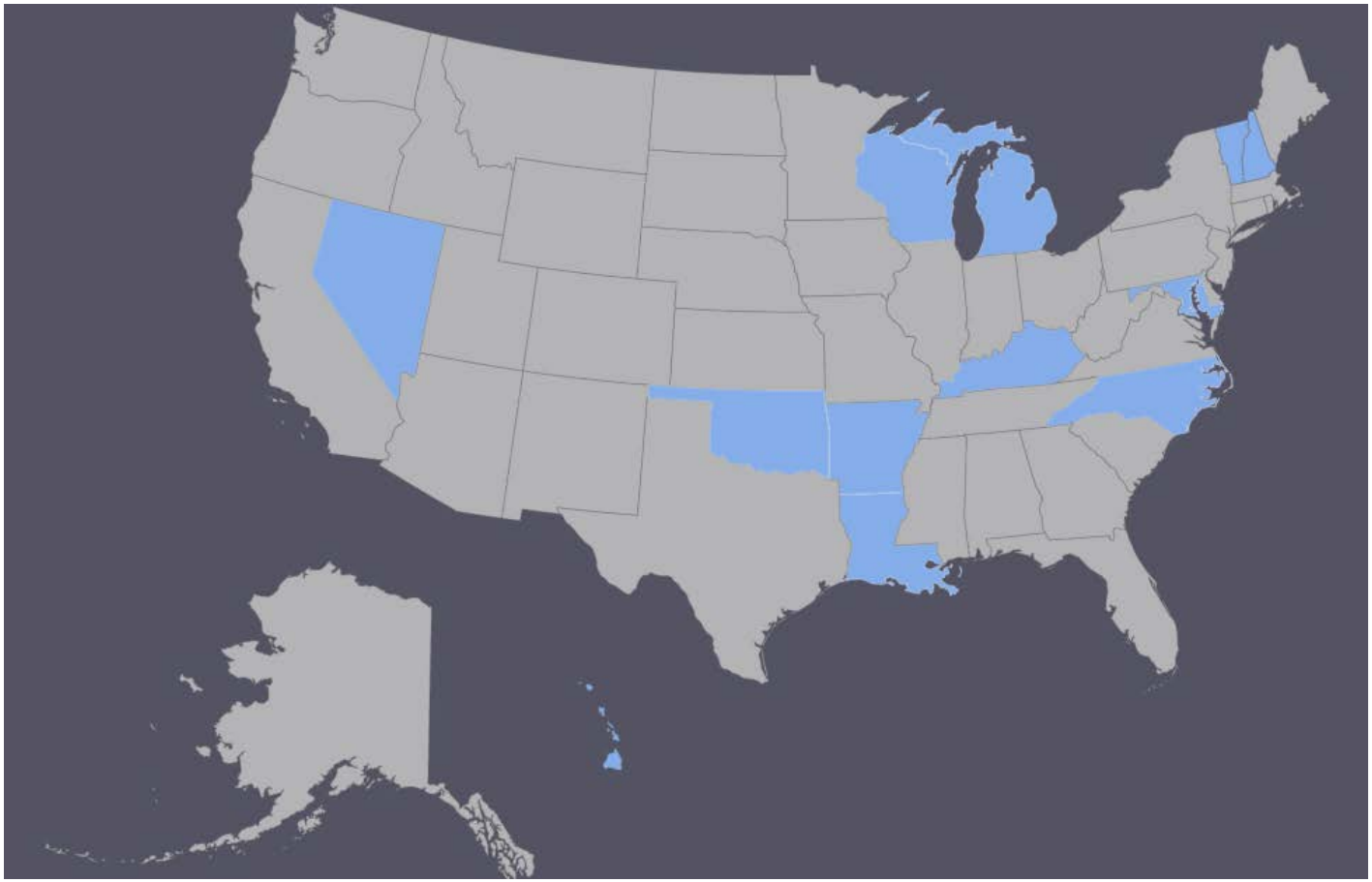
Goals of Prep-ME

- Assist DOTs with data preparation for ME implementation and local calibration
- Improve management and workflow of input data for Pavement ME Design in a production environment
- Provide high quality input data sets that can be directly imported into ME Design in accordance with the XML formats

Prep-ME Memory Lane

- Initial development: AHTD/ARDOT 2006 - 2008
- TPF-5(242) Phase II: *Traffic and Data Preparation for AASHTO DARWin-ME Analysis and Design*, 2011 - 2014
- TPF-5(242) Phase III: Training and implementation, 2015-2017
- Post Phase III: individual contracts with State Highway Agencies (SHAs), 2018-

Prep-ME User Group



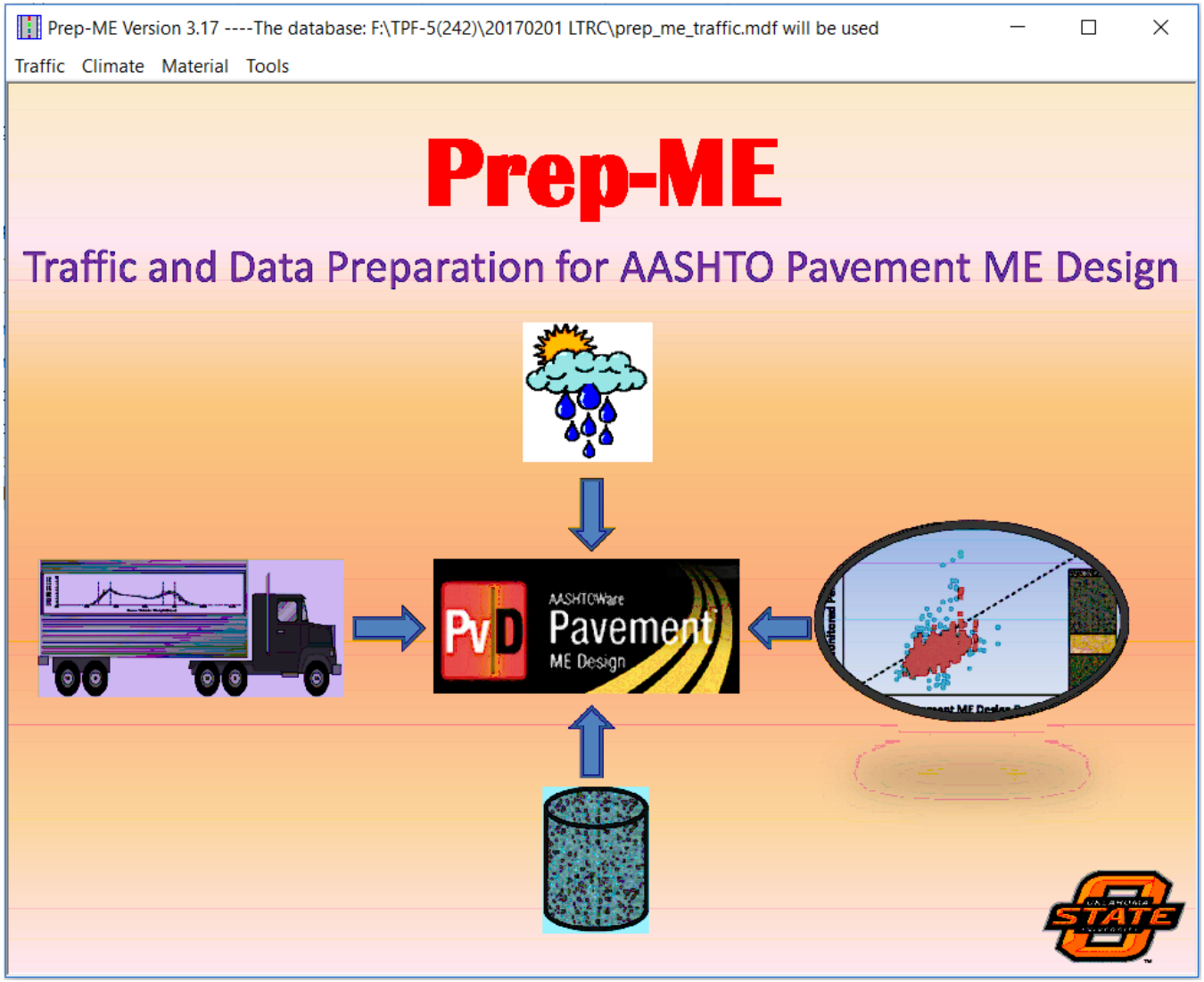
Actively used: 13 States

Software tested in: additional 10+ States

Prep-ME Capabilities

- Traffic Module
- Climate Module
- Material Module
- Others and Future Development

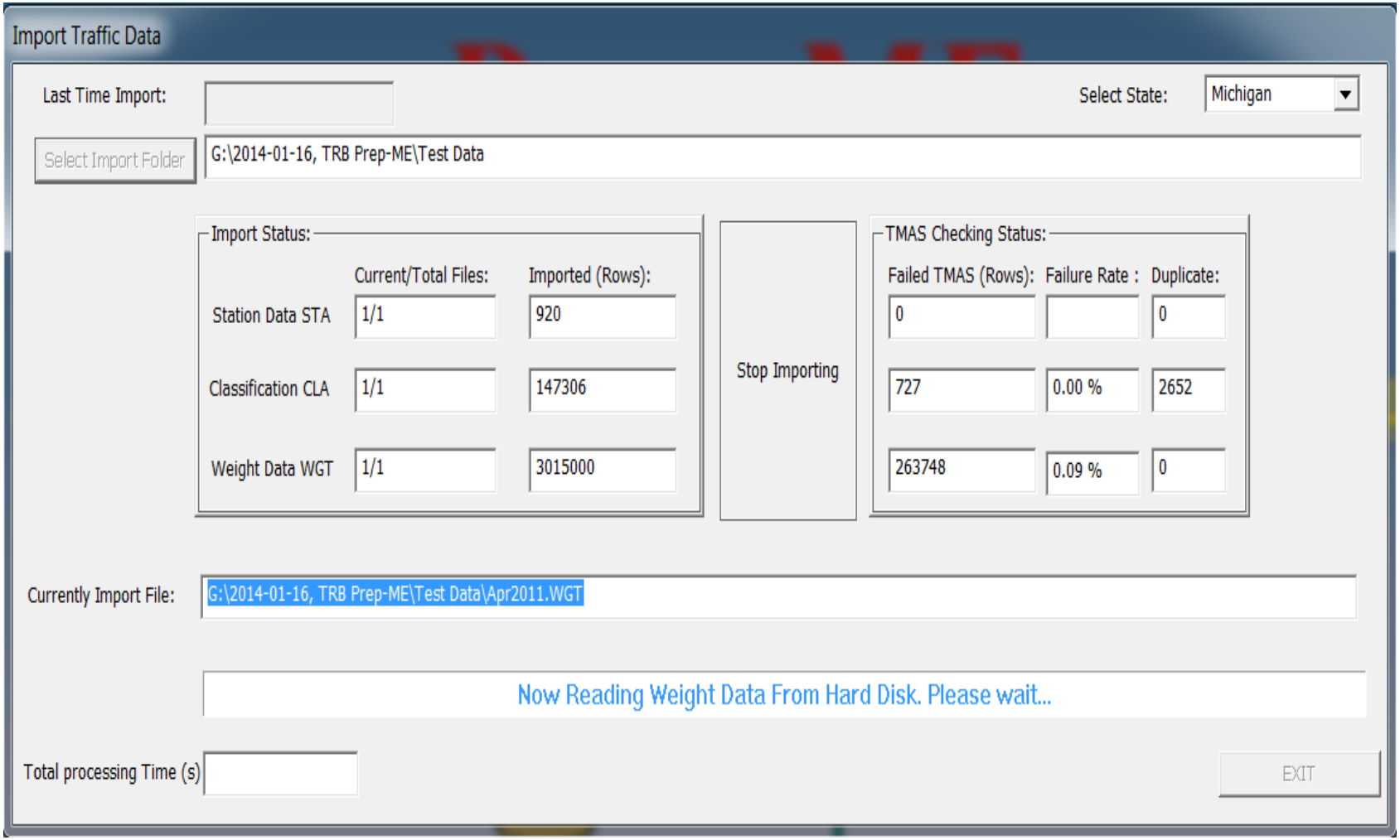
Prep-ME Interface



Traffic Module

- Import & process raw WIM data (both 2001 & 2013 FHWA Traffic Monitoring Guide format) into SQL DB: parallel computing & DB techniques (dozens of GB in size in txt format)
- Implement algorithms and check WIM data quality: rigorous & flexible to meet various needs
- Generate loading spectra inputs for ME Design at any location using available WIM data: cluster analysis

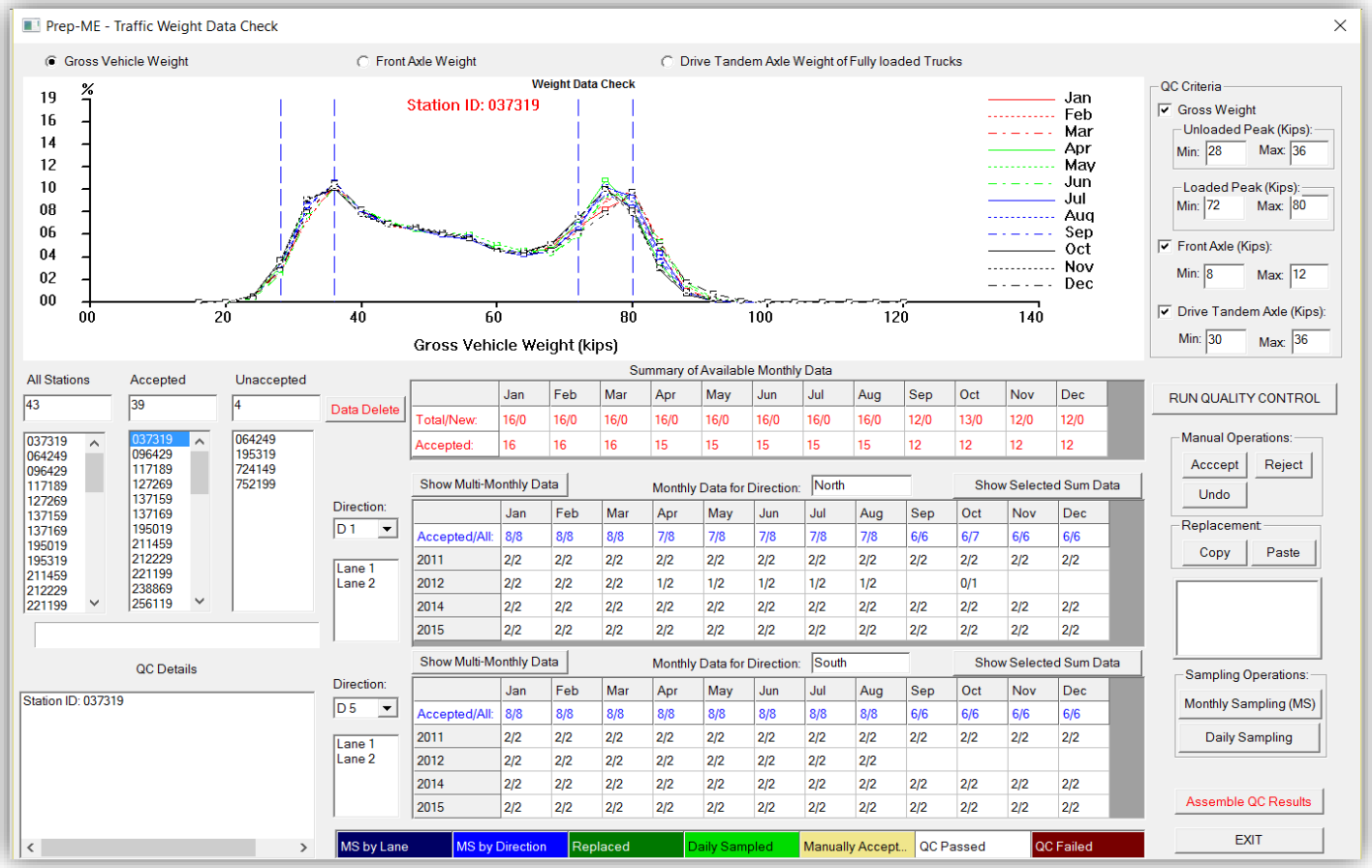
Traffic Data Import



Traffic Data Check

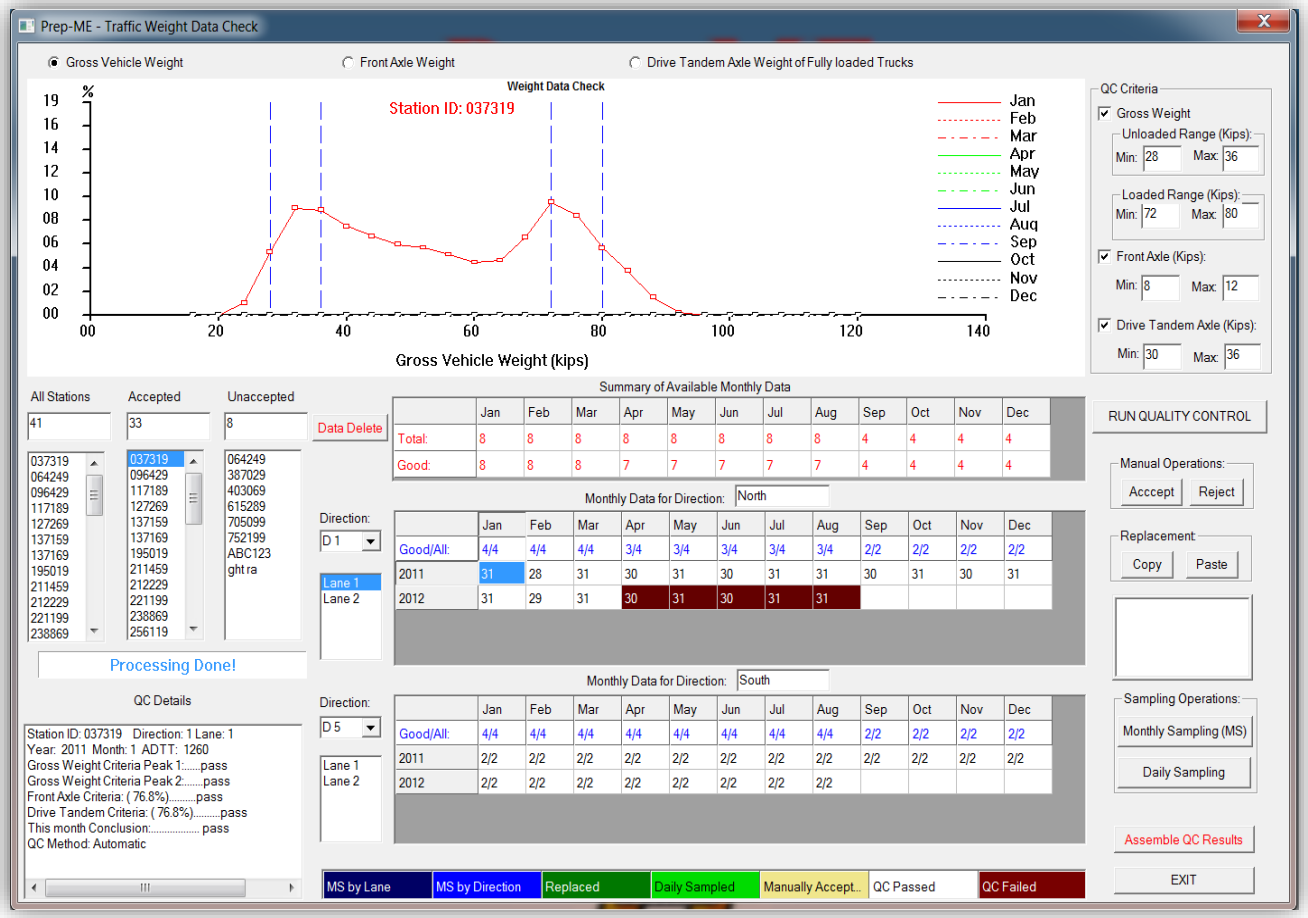
- TMG QC – automatically check data quality in batch mode (QC criteria customizable)
- Daily Sampling – select good days when a month has some invalid data
- Monthly Sampling – used when focusing on a particular time period
- Copy & Paste – borrow data from one month to represent a missing month
- Manual Accept/Reject – available if the standard QC is not suitable for a station
- Provide alternatives to investigate sites with low truck volume

Traffic Data Check



Auto & manual operations: by station, by direction, by lane (for various checks and comparisons)

Traffic Data Check



Review lanes for each month

Traffic Data Check

Look for pattern change – by day & week

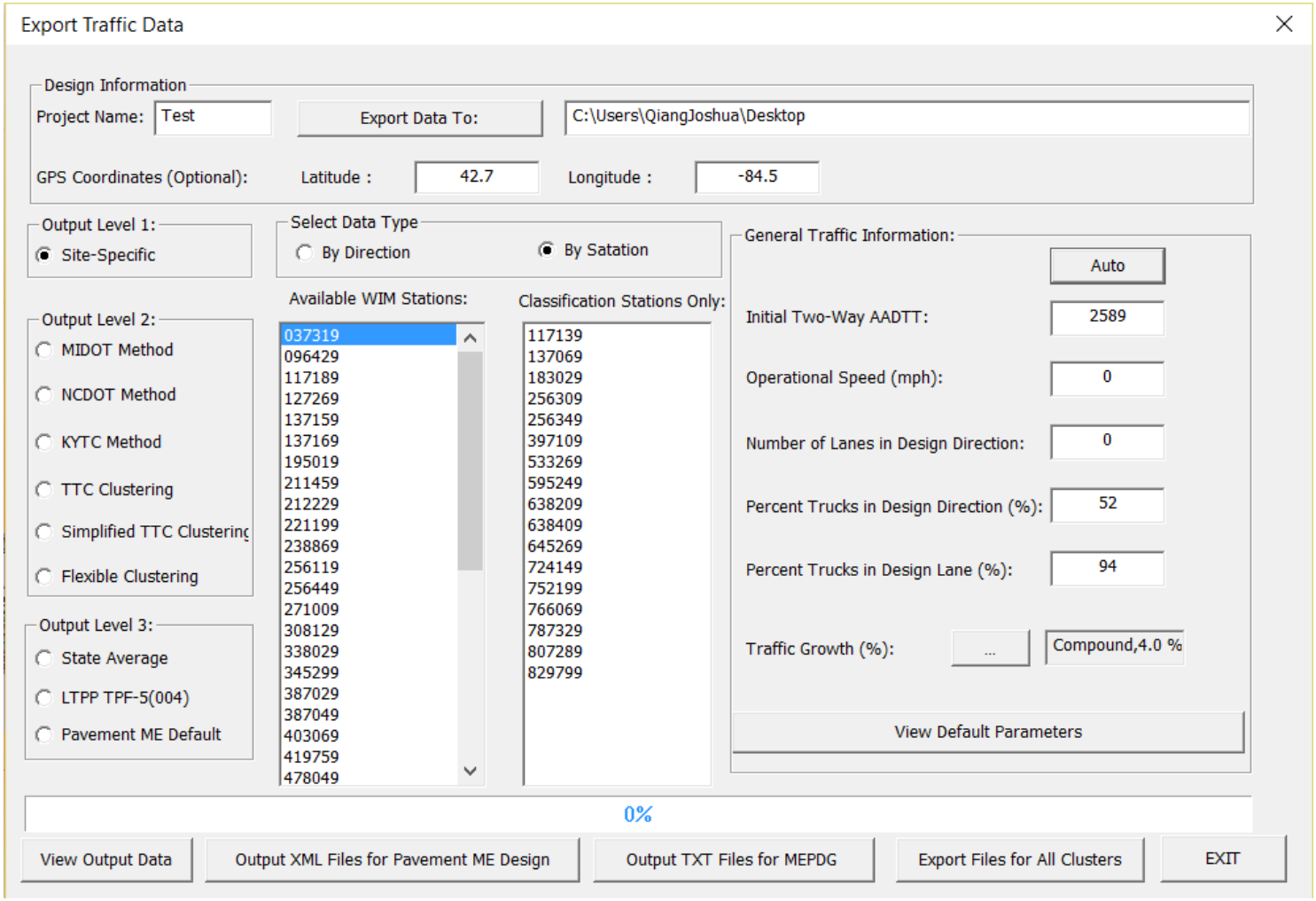
Load Spectra Export

- Provide 3 levels of outputs (can be mixed)
- Level 2 clustering methods
  - Michigan DOT method
  - NCDOT method
  - Kentucky method
  - Nevada method
  - Truck Traffic Class (TTC) method
  - Simplified TTC method: low volume road
  - Flexible method: manual clusters
  - Modified LTPP TPF-5(004) method

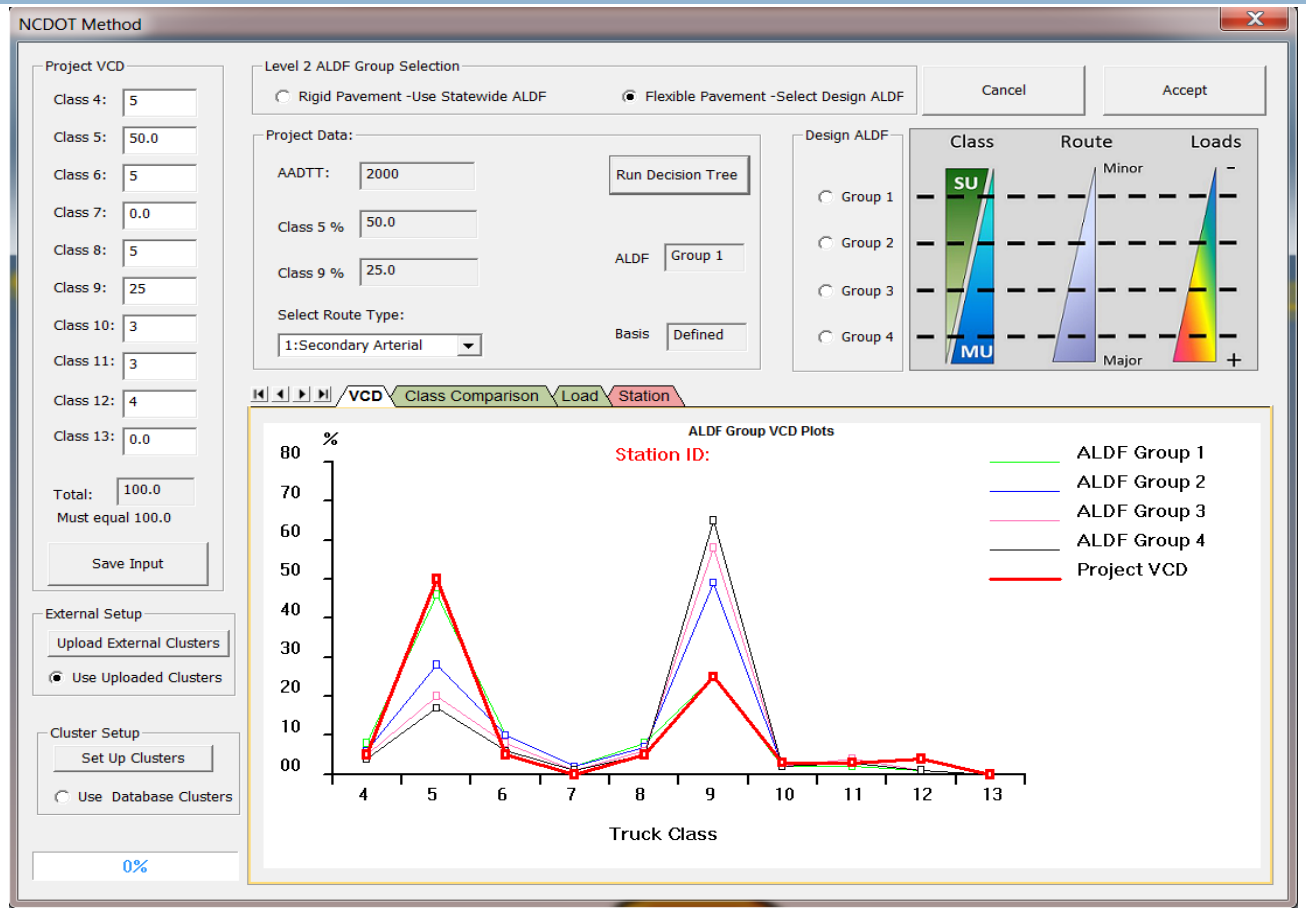
Load Spectra Export

- Fully implemented C++ Ward-based hierarchical clustering algorithm
  - Allow users to evaluate existing clusters and define new clusters if necessary (such as with new data sets)
- Allow mixed three levels of traffic outputs
- Generate traffic input files for MEPDG (11 text files) and Pavement ME Design software (2 xml files)

Load Spectra Export – Level 1

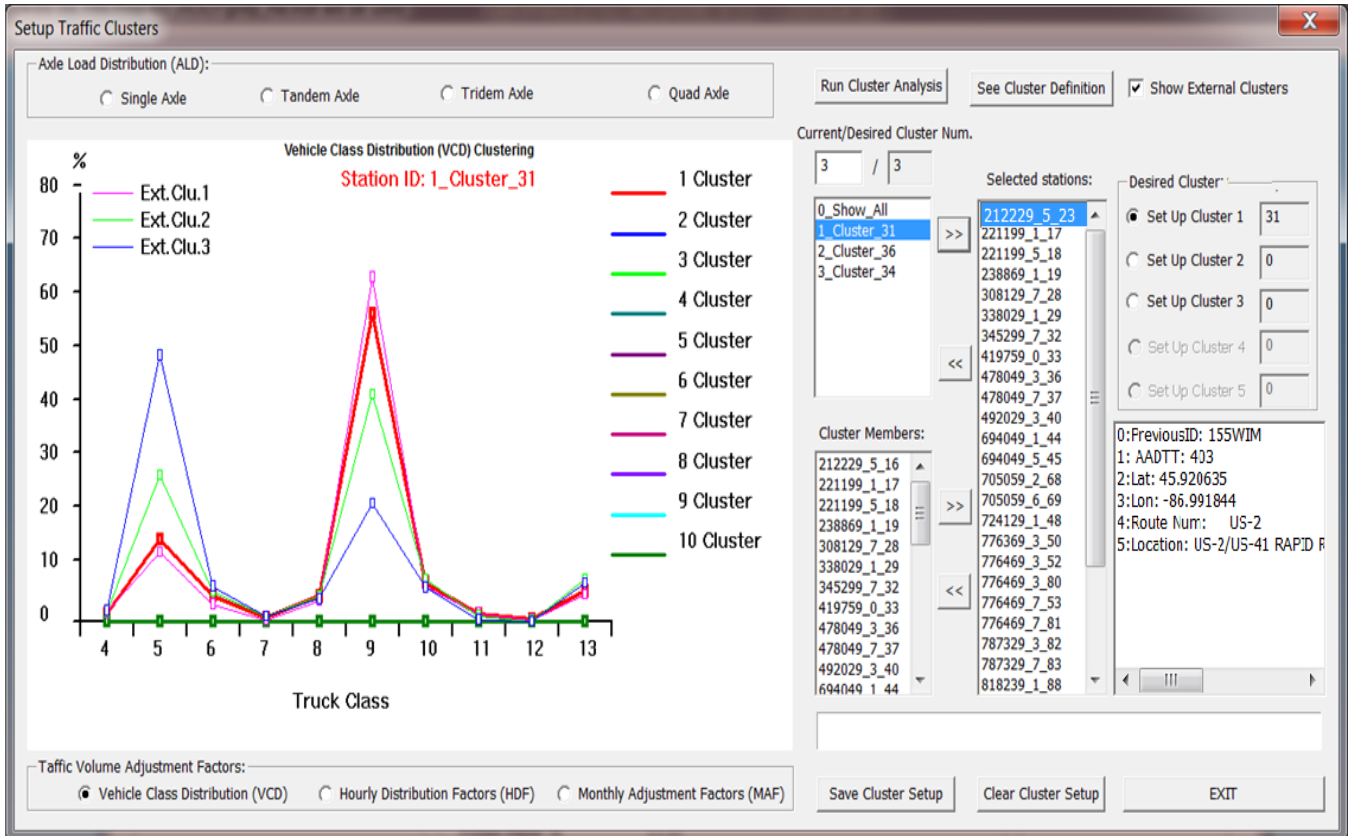


NCDOT Method – Level 2



Project specific VCD; Decision-tree based method: designer selects ALDF

Setup Clusters



Compare new data and new stations to research groups and identify new patterns

Traffic Module Summary

- High efficient data import: 2001 & 2013 TMG format; TMAS check
- Targeted QC – evaluates weight measures that are relatively consistent
- Manage Data – able to select the data used to generate statistics
- Clustering – able to cluster data to identify patterns for each input with multiple methodologies

Climate Module

- Import climate data
  - Any climate data that comply with Pavement ME Design Hourly Climate Data (HCD) format
  - Conduct preliminary data checks
- Interpolate ICM file for MEPDG and XML file for Pavement ME Design

Materials Module

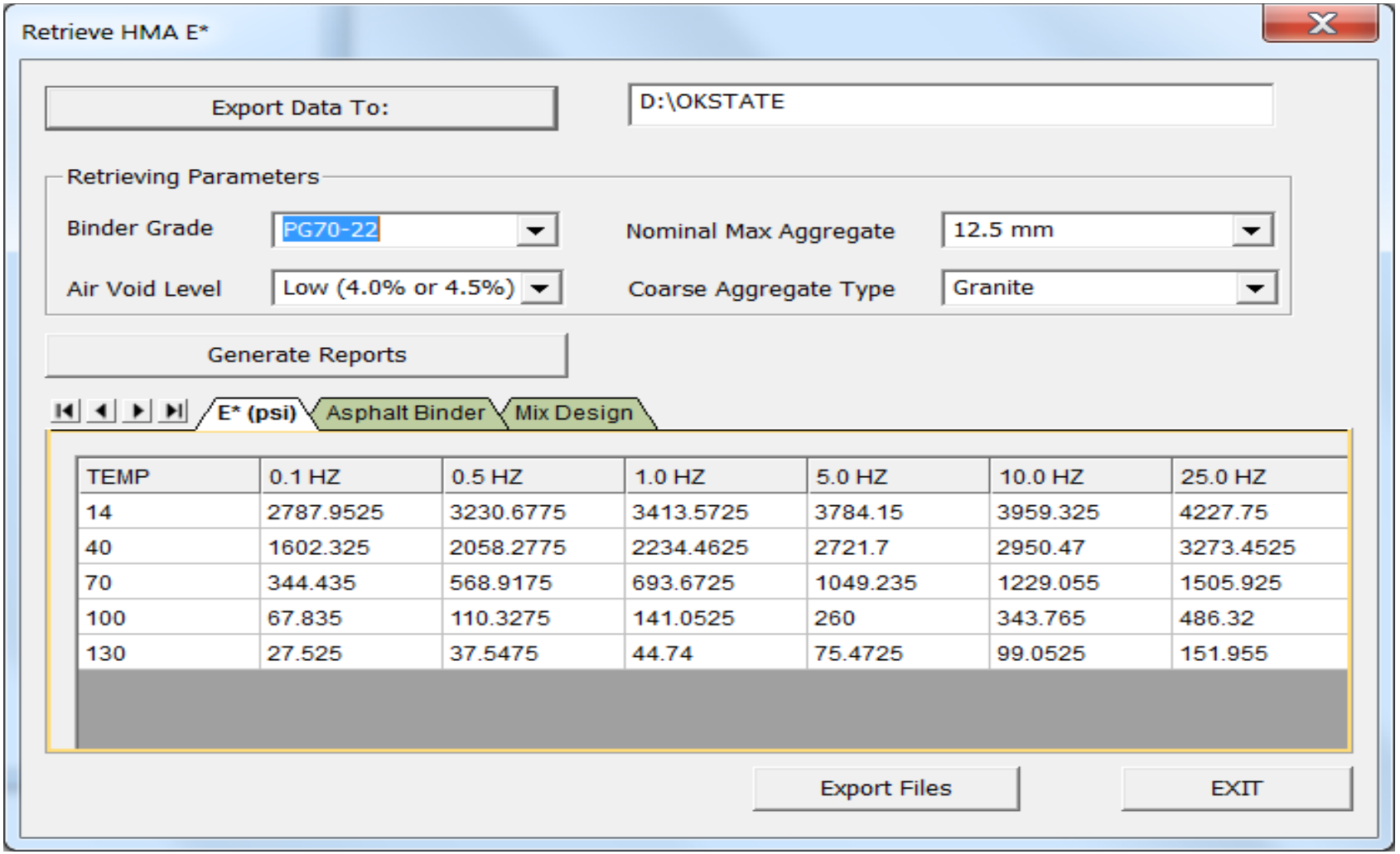
- Retrieve material data from **statewide material library**
  - HMA materials: dynamic modulus (E*)
  - PCC materials: Coefficient of Thermal Expansion (CTE)
  - Subgrade: Resilient modulus (M_R) from subgrade soil map data (NCHRP 9-23A)

Materials Module: E*

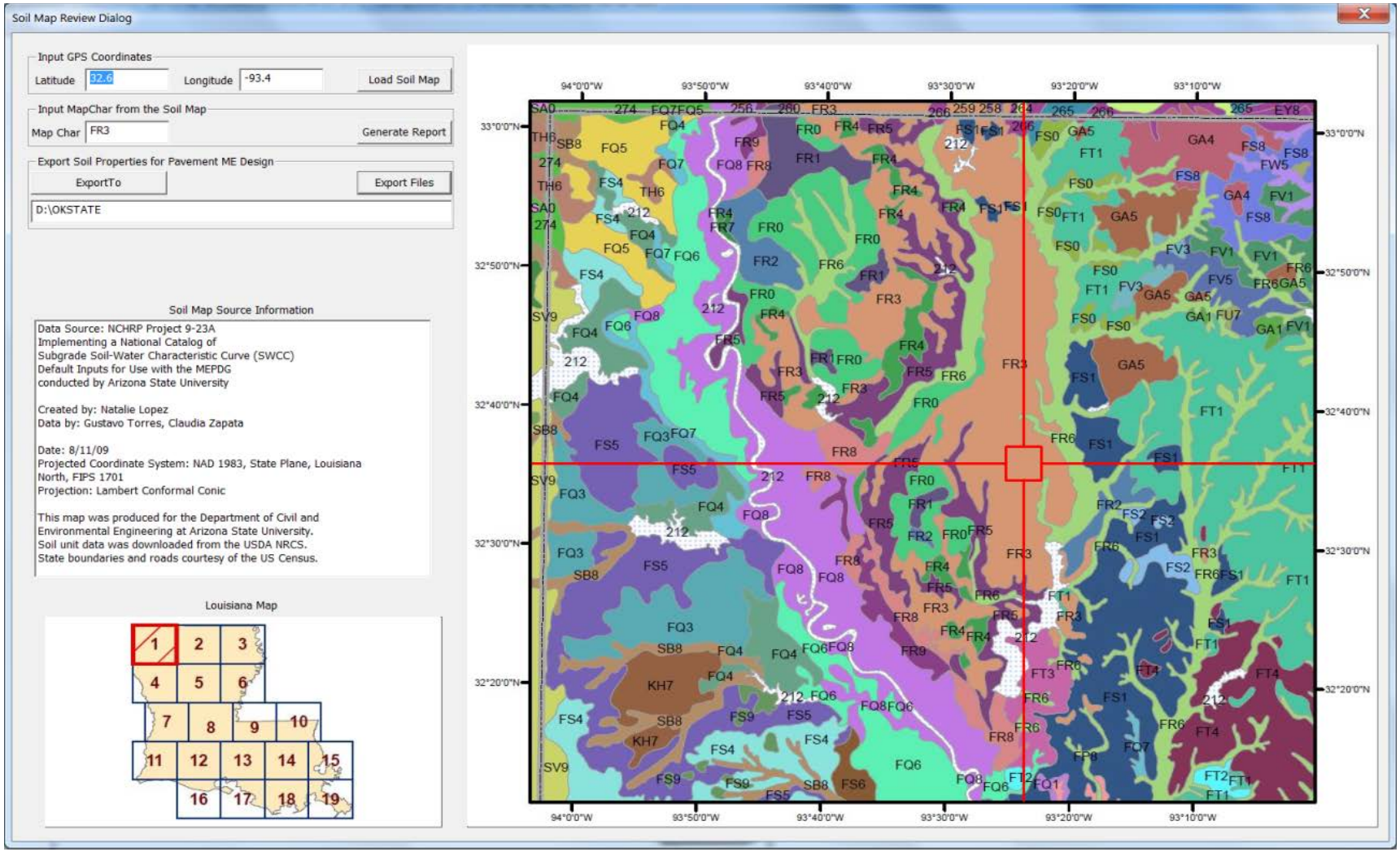
- Catalog of E* data
  - 3 nominal max agg sizes
  - 3 binder grades
  - 4 agg types
  - 2 gradations
  - 4 temperatures
  - 5 loading frequencies

(Hall, 2007)

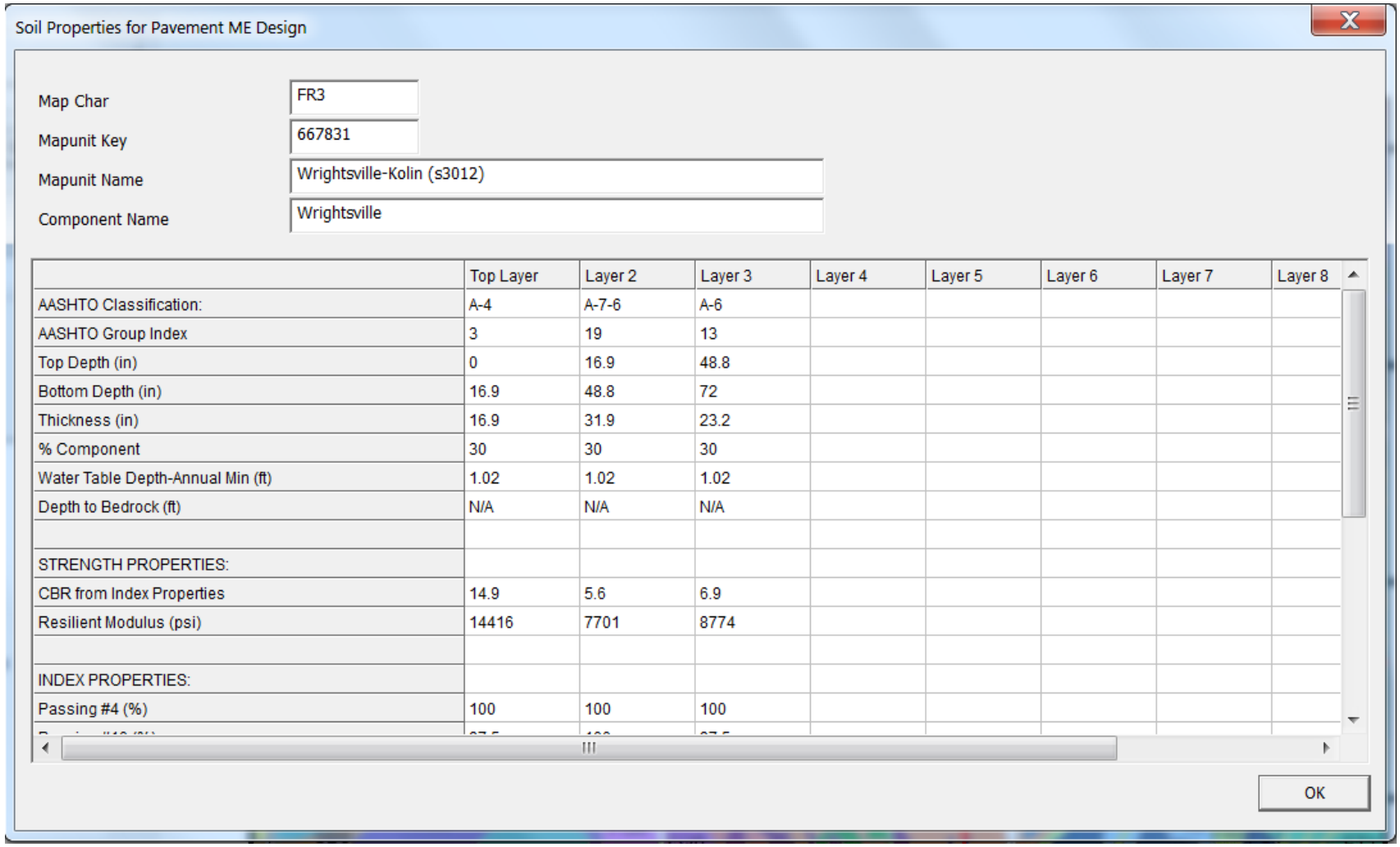
Materials Module: E*



Materials Module: M_R



Materials Module: M_R

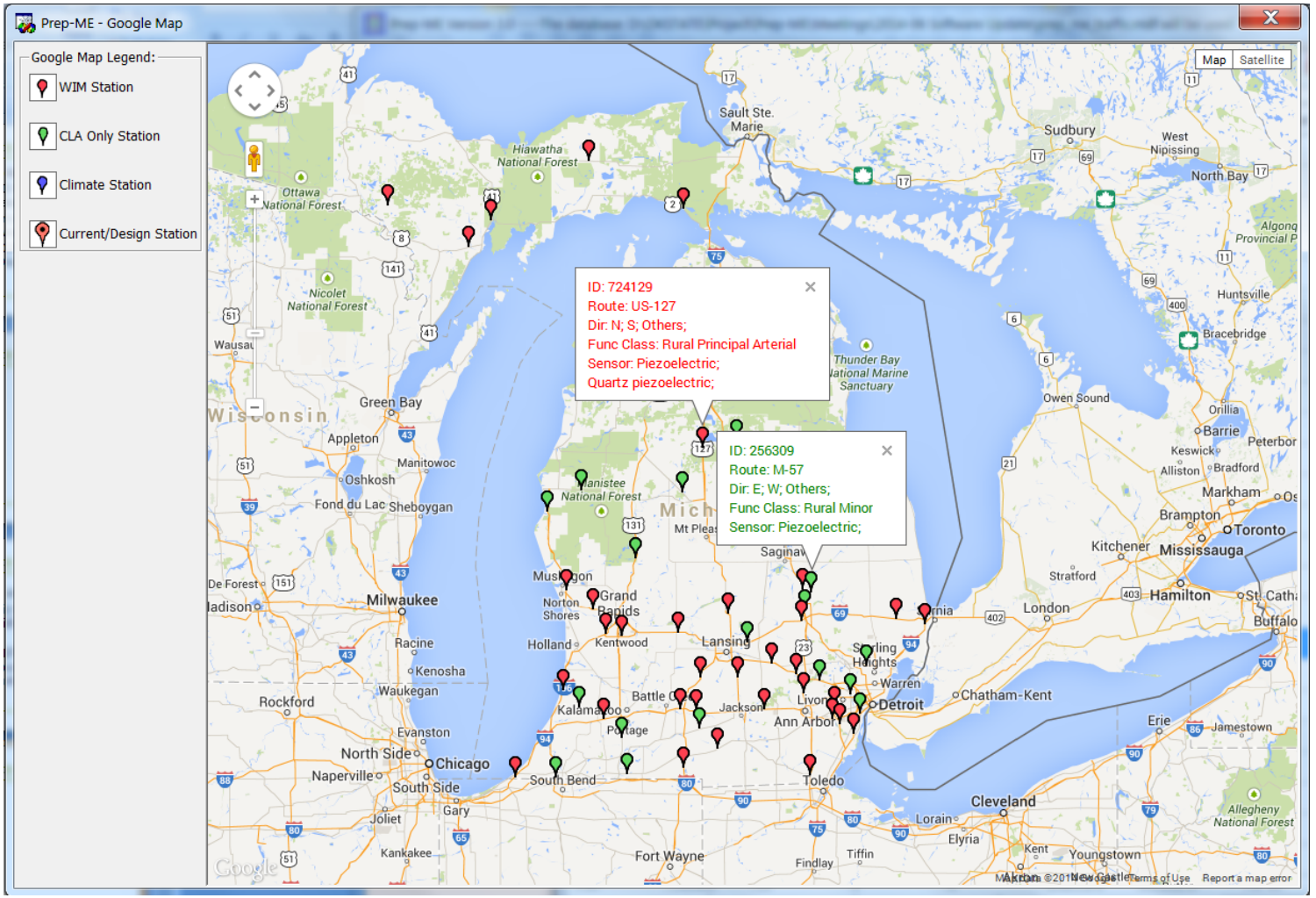


	Top Layer	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8
AASHTO Classification:	A-4	A-7-6	A-6					
AASHTO Group Index	3	19	13					
Top Depth (in)	0	16.9	48.8					
Bottom Depth (in)	16.9	48.8	72					
Thickness (in)	16.9	31.9	23.2					
% Component	30	30	30					
Water Table Depth-Annual Min (ft)	1.02	1.02	1.02					
Depth to Bedrock (ft)	N/A	N/A	N/A					
STRENGTH PROPERTIES:								
CBR from Index Properties	14.9	5.6	6.9					
Resilient Modulus (psi)	14416	7701	8774					
INDEX PROPERTIES:								
Passing #4 (%)	100	100	100					

Other Capabilities

- Up-to-date Google Map v3.22 API
- Traffic file name change: those don't comply with the TMG name convention
- AADTT and VCD factors calculator: based on 24-h or 48-h short term count data
- State material library data import
- ALD to XML loading spectra converter

Other Capabilities



Future Plans

- Implementation of Prep-ME for SHAs
  - Customization and feature improvements
  - Technical support
- Automated/assisted local calibration module
  - Develop functions to read ME analysis files into Prep-ME DB tables
  - Import required performance data from state PMS, and LTPP database
  - Automate many of the AASHTO (2014) local calibration steps, especially Step 7, 8, 9, 10, 11, which involve extensive computational & repeating efforts when additional & better data sets are available

How Prep-ME Can Be Used

- Traffic data collection engineers
  - To conduct effective traffic data QA/QC for various applications
- Pavement design engineers
  - To analyze axle loading data and select the best spectra among WIMs, national, and local defaults
  - To prepare all input data based on ME designated XML import format with minor efforts
- Improve the productivities of above operations tremendously

Thank You

Questions?

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