

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

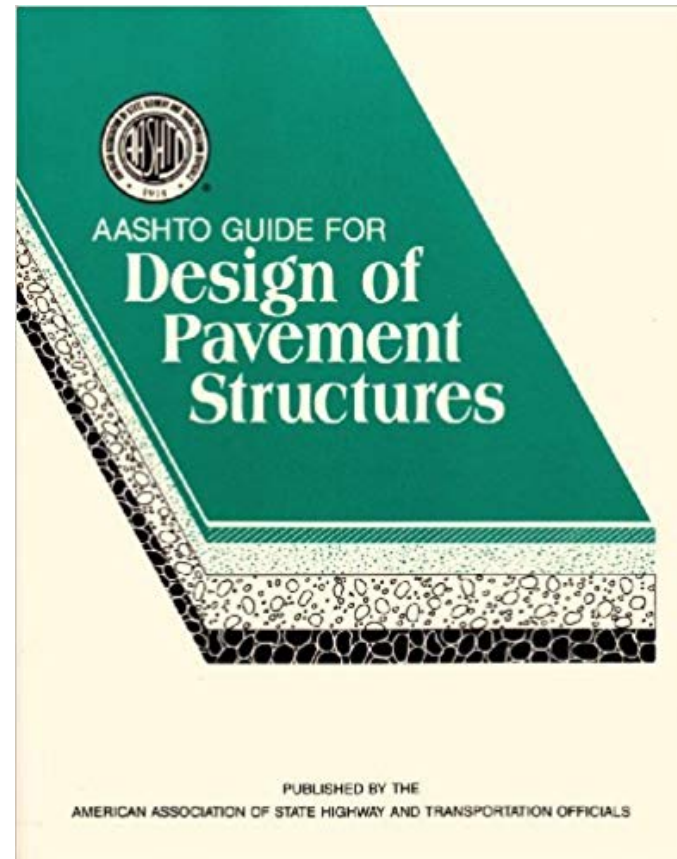
Brief History: Pavement Design



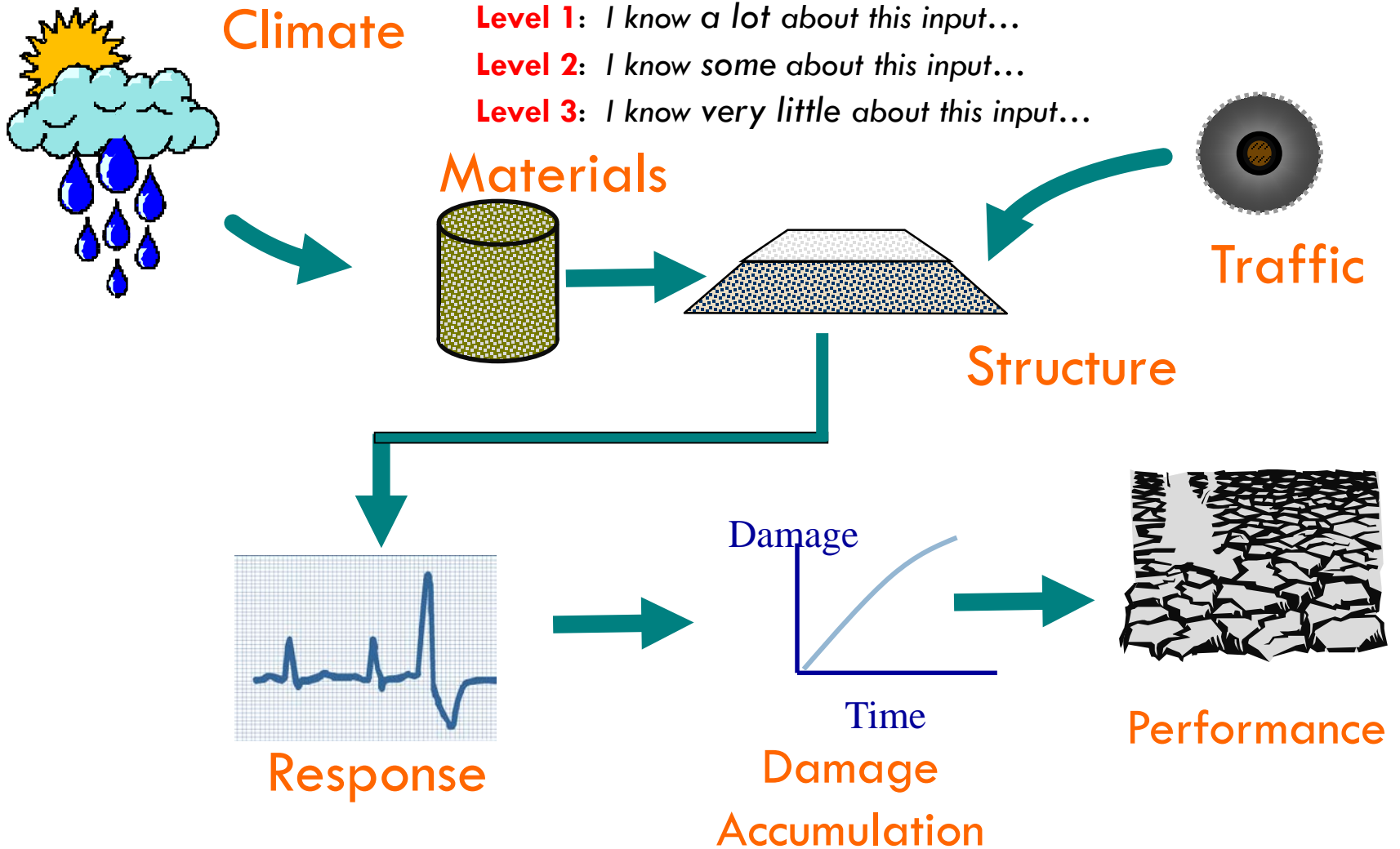
*AASHTO
Road Test
(1958-1960)*



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



Pavement ME Design / MEPDG



Pavement ME Design

Explorer

- Projects
 - Arizona Example
 - Traffic
 - Climate
 - AC Layer Properties
 - Pavement Structure
 - Layer 1 Flexible : Default asphalt concrete
 - Layer 2 Flexible : Default asphalt concrete
 - Layer 3 Non-stabilized Base : A-1-a
 - Layer 4 Non-stabilized Base : A-2-4
 - Layer 5 Subgrade : A-1-b
 - Layer 6 Subgrade : A-1-b
 - Project Specific Calibration Factors
 - New Flexible
 - Rehabilitation Flexible
 - New Rigid
 - Restore Rigid
 - Bonded Rigid
 - Unbonded Rigid
 - Sensitivity
 - Optimization
 - PDF Output Report
 - Excel Output Report
 - Multiple Project Summary
 - Batch Run
 - Tools
 - ME Design Calibration Factors

Arizona Example:Project*

General Information

Design type: New Pavement

Pavement type: Flexible Pavement

Design life (years): 15


Base construction: May 2013

Pavement construction: June 2013

Traffic opening: July 2013

Special traffic loading for flexible pavements

+ Add Layer ✗ Remove Layer




[Click here to edit Layer 3 Non-stabilized Base](#)

[Click here to edit Layer 4 Non-stabilized Base](#)

[Click here to edit Layer 5 Subgrade : A-1-b](#)

[Click here to edit Layer 6 Subgrade : A-1-b](#)



Performance Criteria	Limit	Reliability
Initial IRI (in/mile)	50	
Terminal IRI (in/mile)	150	90
AC top-down fatigue cracking (ft/mile)	2000	90
AC bottom-up fatigue cracking (% lane area)	10	90
AC thermal cracking (ft/mile)	250	90
Permanent deformation - total pavement (in)	0.5	90

New Flexible Pavement-Calibration Settings

AC Rutting

AC Rutting Standard Deviation **0.24*Pow(RUT,0.8026)+0.001**

AC Rutting - Layer 1

AC Rutting K1 (1)	✓	-2.55
AC Rutting K2 (1)	✓	1.5606
AC Rutting K3 (1)	✓	0.25
AC Rutting BR1 (1)	✓	1
AC Rutting BR2 (1)	✓	1
AC Rutting BR3 (1)	✓	1

AC Rutting - Layer 2

AC Rutting K1 (2)	✓	-2.35
AC Rutting K2 (2)	✓	1.5605
AC Rutting K3 (2)	✓	0.3
AC Rutting BR1 (2)	✓	1
AC Rutting BR2 (2)	✓	1
AC Rutting BR3 (2)	✓	1

Pavement ME Design

Axle Load Distribution Factors

Axle Load Distribution

- Level 1: Site Specific
- Level 2: Regional
- Level 3: Default

View

- Cumulative Distribution
- Distribution

Axle Types

- Single Axle
- Tandem Axle
- Tridem Axle
- Quad Axle

Axle Factors by Axle Type

	Season	Veh. Class	Total	3000	4000	5000	6000	7000
	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

OK Cancel

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

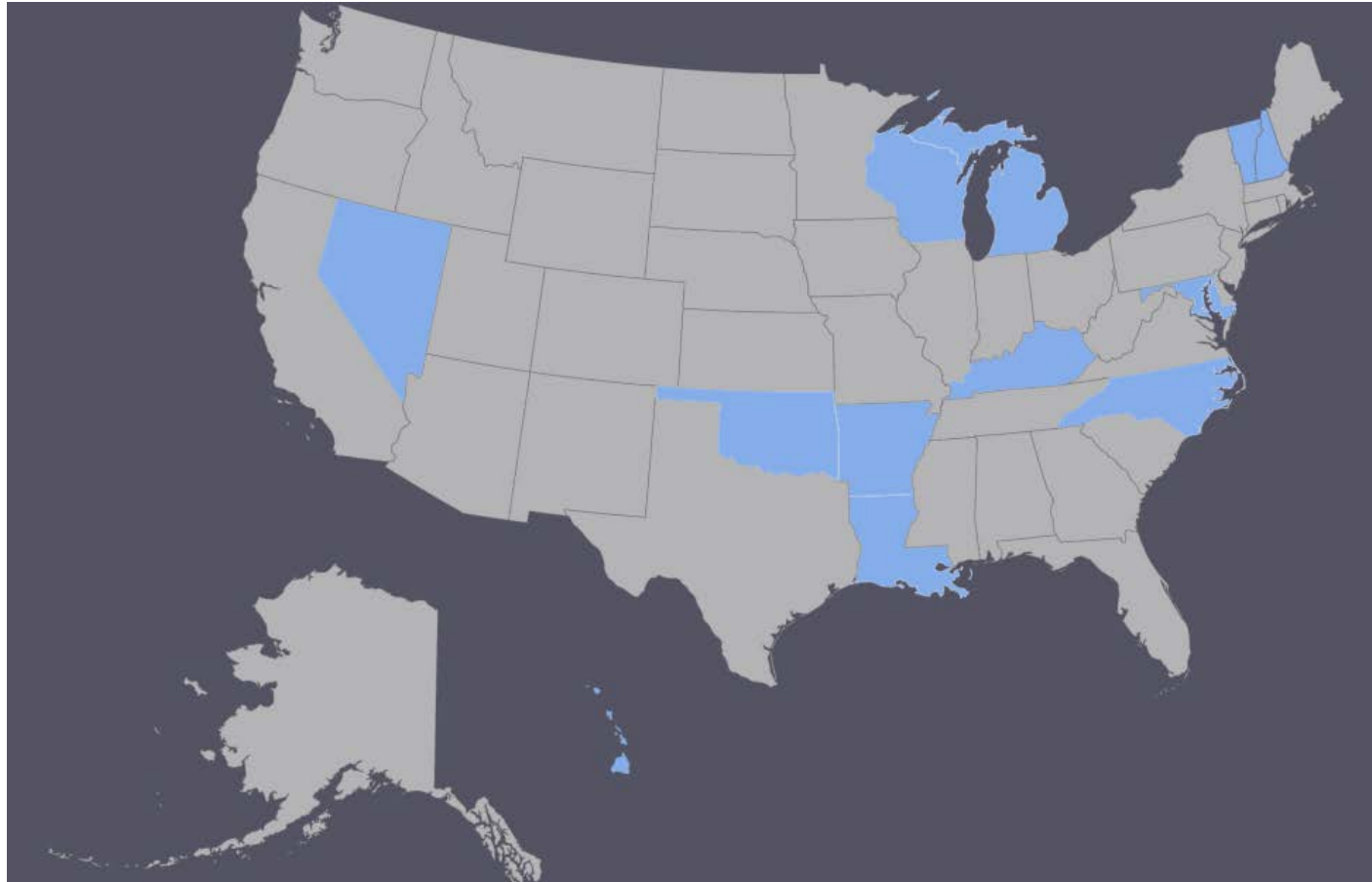
Goals of Prep-ME

- 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



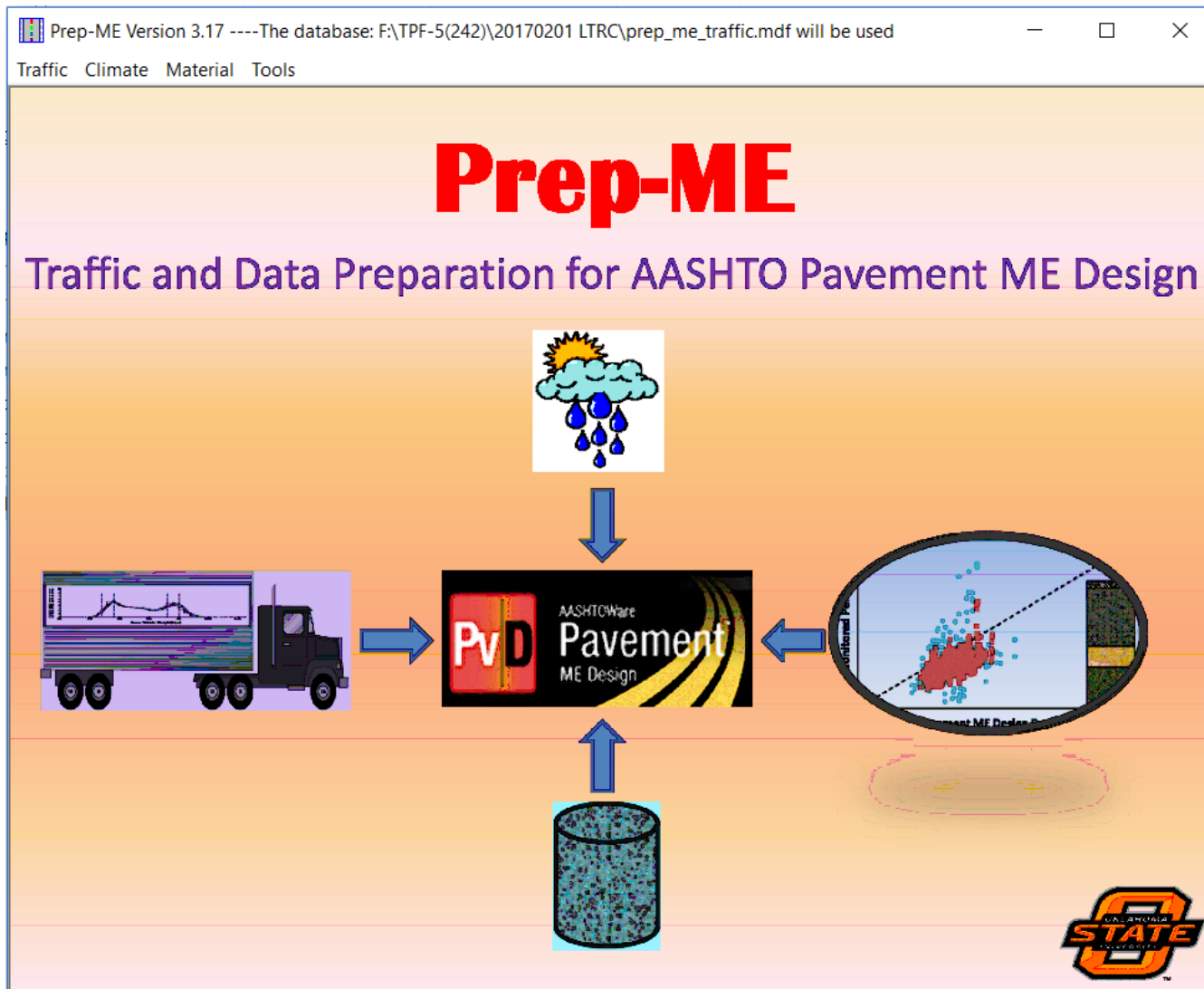
Actively used: 13 States

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

Import Traffic Data

Last Time Import: Select State:

Select Import Folder:

Import Status:		TMAS Checking Status:			
	Current/Total Files:	Imported (Rows):	Failed TMAS (Rows):	Failure Rate :	Duplicate:
Station Data STA	<input type="text" value="1/1"/>	<input type="text" value="920"/>	<input type="text" value="0"/>	<input type="text" value=""/>	<input type="text" value="0"/>
Classification CLA	<input type="text" value="1/1"/>	<input type="text" value="147306"/>	<input type="text" value="727"/>	<input type="text" value="0.00 %"/>	<input type="text" value="2652"/>
Weight Data WGT	<input type="text" value="1/1"/>	<input type="text" value="3015000"/>	<input type="text" value="263748"/>	<input type="text" value="0.09 %"/>	<input type="text" value="0"/>

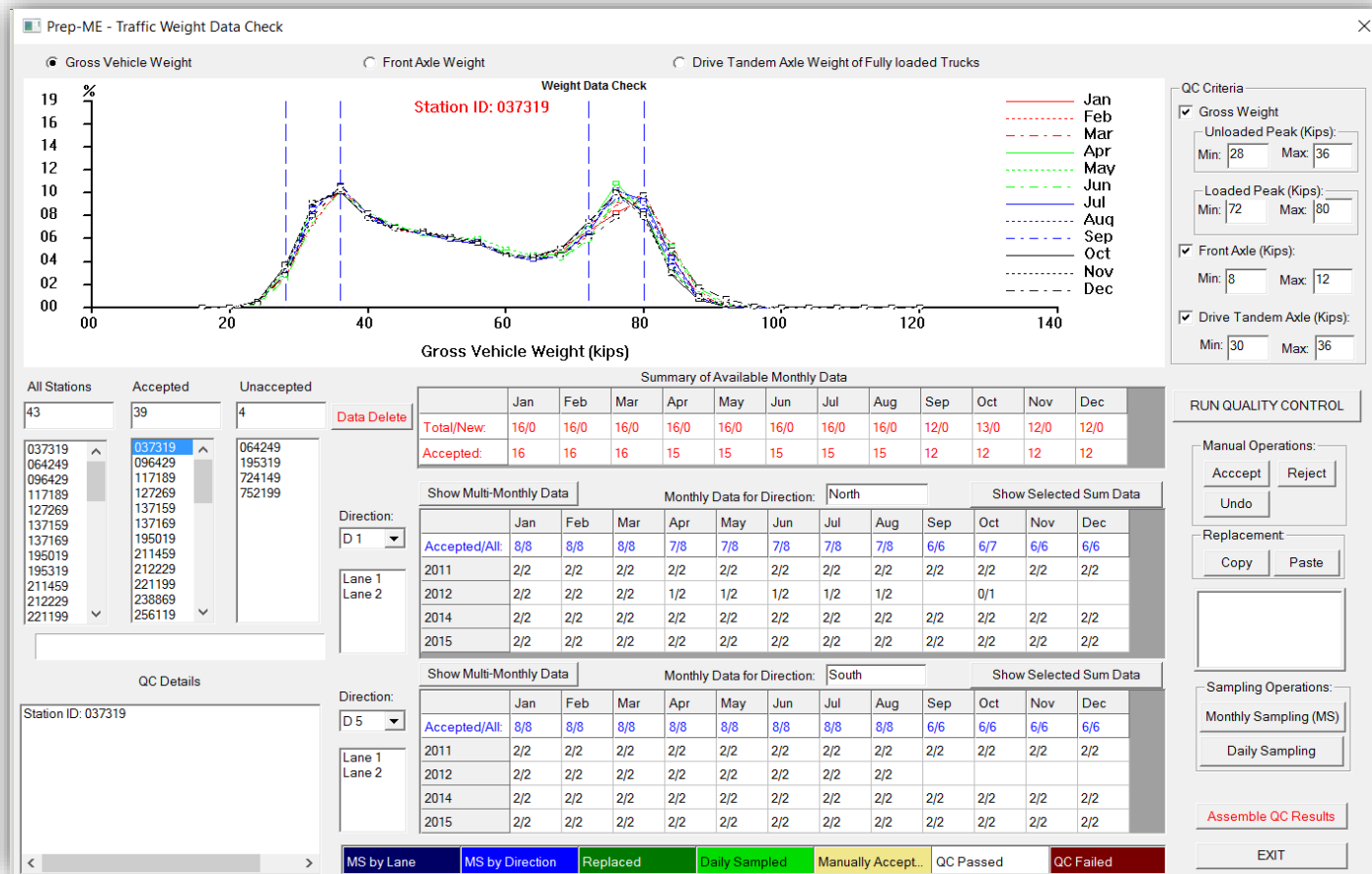
Currently Import File:

Total processing Time (s)

Traffic Data Check

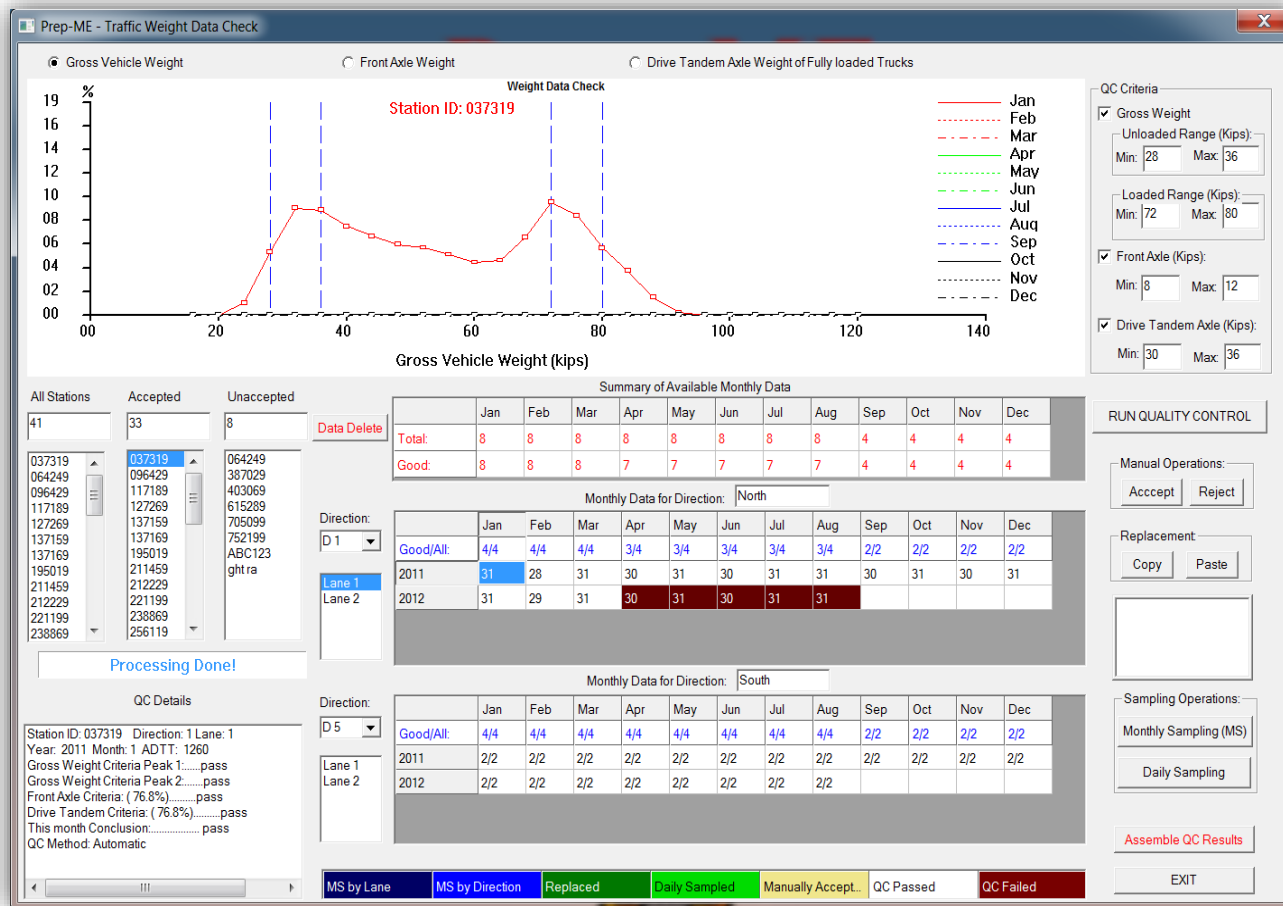
- TMG QC – automatically check data quality in batch mode (QC criteria customizable)
- Daily Sampling – select good days when a month has some invalid data
- Monthly Sampling – used when focusing on a particular time period
- Copy & Paste – borrow data from one month to represent a missing month
- Manual 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

Export Traffic Data ✕

Design Information

Project Name: Export Data To:

GPS Coordinates (Optional): Latitude : Longitude :

Output Level 1:

Site-Specific

Select Data Type

By Direction By Satation

Output Level 2:

MIDOT Method

NCDOT Method

KYTC Method

TTC Clustering

Simplified TTC Clustering

Flexible Clustering

Output Level 3:

State Average

LTPP TPF-5(004)

Pavement ME Default

Available WIM Stations:

037319
096429
117189
127269
137159
137169
195019
211459
212229
221199
238869
256119
256449
271009
308129
338029
345299
387029
387049
403069
419759
478049

Classification Stations Only:

117139
137069
183029
256309
256349
397109
533269
595249
638209
638409
645269
724149
752199
766069
787329
807289
829799

General Traffic Information:

Initial Two-Way AADTT:

Operational Speed (mph):

Number of Lanes in Design Direction:

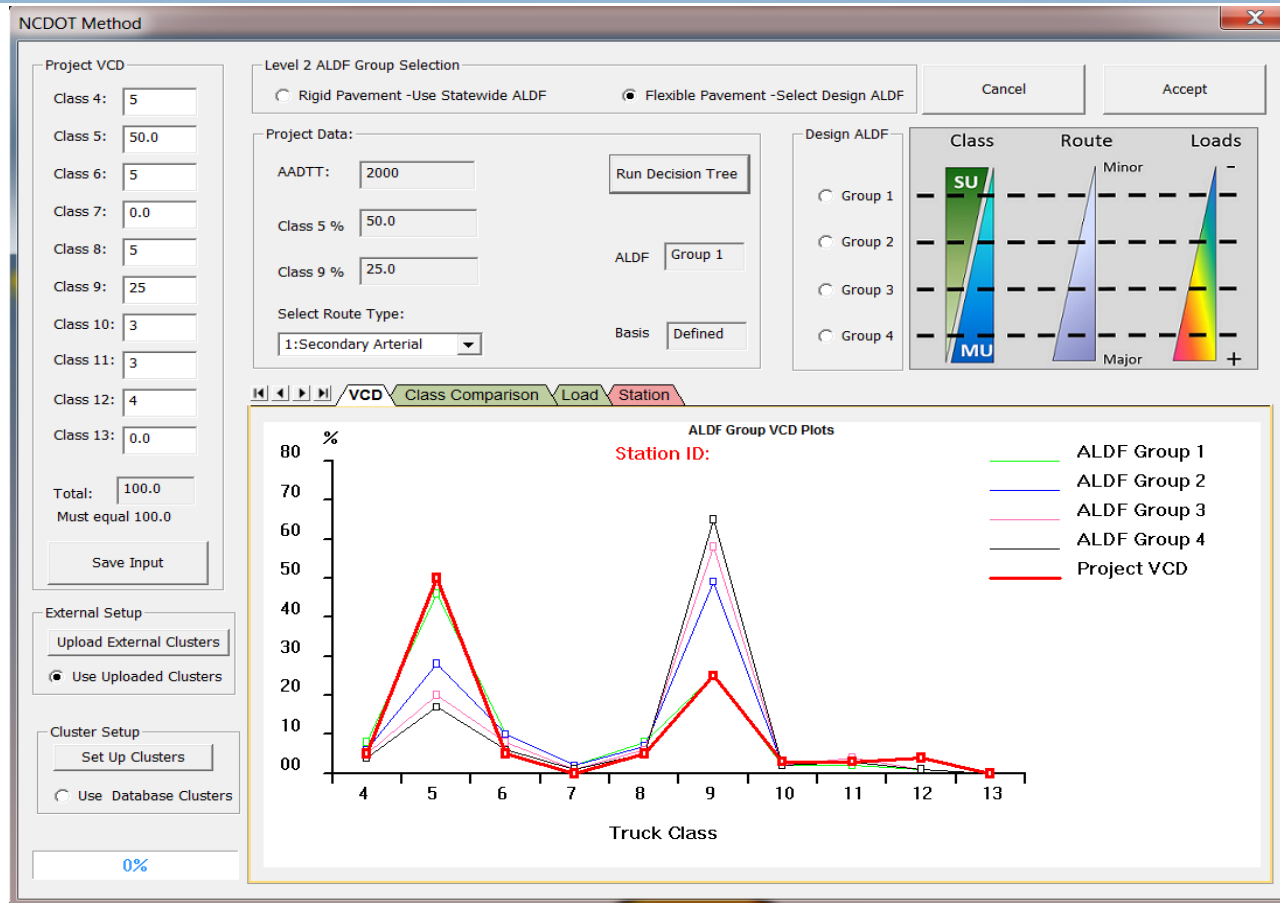
Percent Trucks in Design Direction (%):

Percent Trucks in Design Lane (%):

Traffic Growth (%):

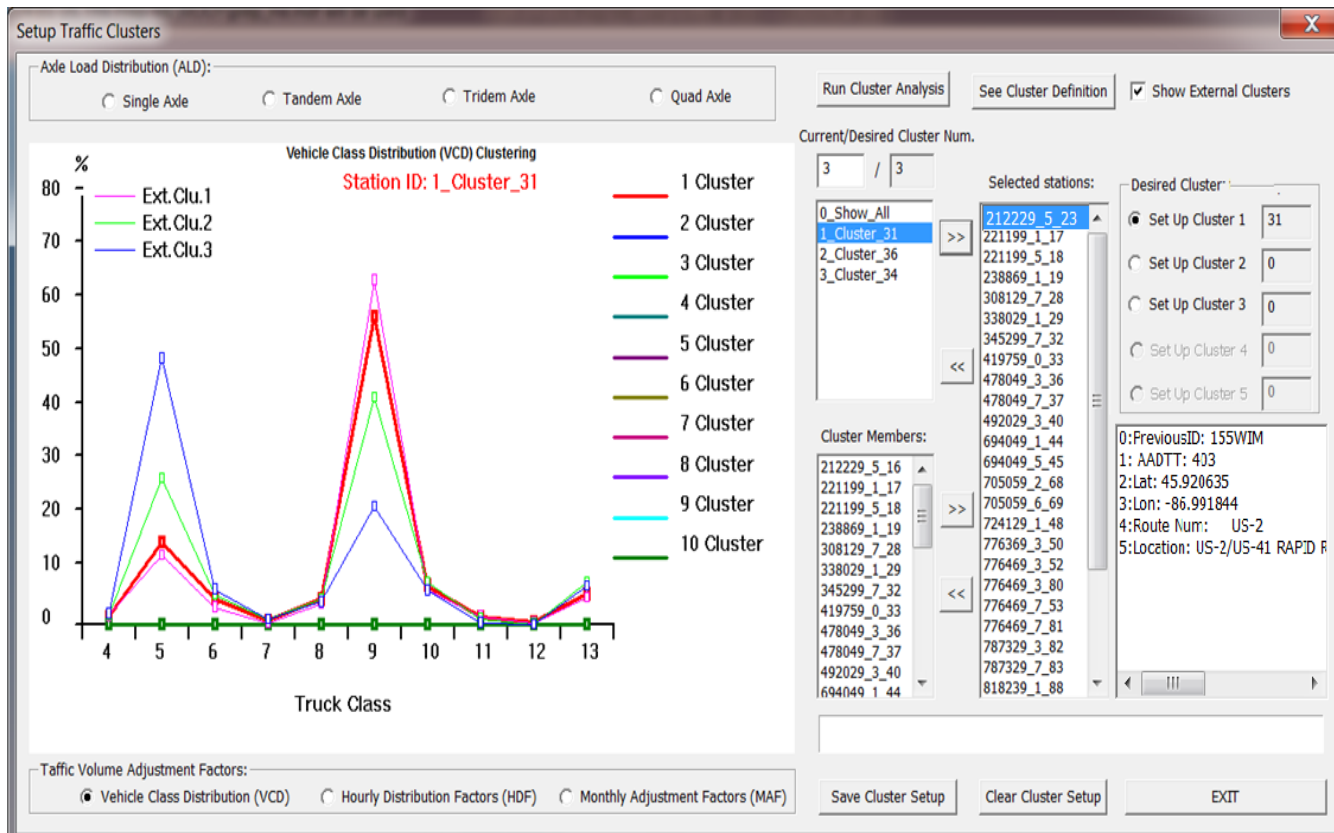
0%

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*

Retrieve HMA E*

Export Data To:

Retrieving Parameters

Binder Grade: Nominal Max Aggregate:

Air Void Level: Coarse Aggregate Type:

Generate Reports

Navigation: **E* (psi)** Asphalt Binder Mix Design

TEMP	0.1 HZ	0.5 HZ	1.0 HZ	5.0 HZ	10.0 HZ	25.0 HZ
14	2787.9525	3230.6775	3413.5725	3784.15	3959.325	4227.75
40	1602.325	2058.2775	2234.4625	2721.7	2950.47	3273.4525
70	344.435	568.9175	693.6725	1049.235	1229.055	1505.925
100	67.835	110.3275	141.0525	260	343.765	486.32
130	27.525	37.5475	44.74	75.4725	99.0525	151.955

Export Files EXIT

Materials Module: M_R

Soil Map Review Dialog

Input GPS Coordinates
Latitude Longitude

Input MapChar from the Soil Map
Map Char

Export Soil Properties for Pavement ME Design

D:\OKSTATE

Soil Map Source Information

Data Source: NCHRP Project 9-23A
Implementing a National Catalog of
Subgrade Soil-Water Characteristic Curve (SWCC)
Default Inputs for Use with the MEPDG
conducted by Arizona State University

Created by: Natalie Lopez
Data by: Gustavo Torres, Claudia Zapata

Date: 8/11/09
Projected Coordinate System: NAD 1983, State Plane, Louisiana
North, FIPS 1701
Projection: Lambert Conformal Conic

This map was produced for the Department of Civil and
Environmental Engineering at Arizona State University.
Soil unit data was downloaded from the USDA NRCS.
State boundaries and roads courtesy of the US Census.

Louisiana Map

1	2	3		
4	5	6		
7	8	9	10	
11	12	13	14	15
	16	17	18	19

The main map displays a detailed soil distribution across a geographic area. The x-axis represents longitude from 94°0'0"W to 93°10'0"W, and the y-axis represents latitude from 33°0'0"N to 32°20'0"N. The map is divided into numerous soil units, each labeled with a code such as FR0, FR1, FR2, FR3, FR4, FR5, FR6, FR7, FR8, FR9, FS0, FS1, FS2, FS3, FS4, FS5, FS6, FS7, FS8, FS9, FQ0, FQ1, FQ2, FQ3, FQ4, FQ5, FQ6, FQ7, FQ8, FQ9, GA0, GA1, GA2, GA3, GA4, GA5, FT0, FT1, FT2, FT3, FT4, FT5, FT6, FT7, FT8, FT9, SV0, SV1, SV2, SV3, SV4, SV5, SV6, SV7, SV8, SV9, TH0, TH1, TH2, TH3, TH4, TH5, TH6, TH7, TH8, TH9, SB0, SB1, SB2, SB3, SB4, SB5, SB6, SB7, SB8, SB9, KH0, KH1, KH2, KH3, KH4, KH5, KH6, KH7, KH8, KH9, EY0, EY1, EY2, EY3, EY4, EY5, EY6, EY7, EY8, EY9. A red box highlights a specific area on the map, centered around the coordinates 93°20'0"W and 32°30'0"N.

Materials Module: M_R

Soil Properties for Pavement ME Design

Map Char: FR3
 Mapunit Key: 667831
 Mapunit Name: Wrightsville-Kolin (s3012)
 Component Name: Wrightsville

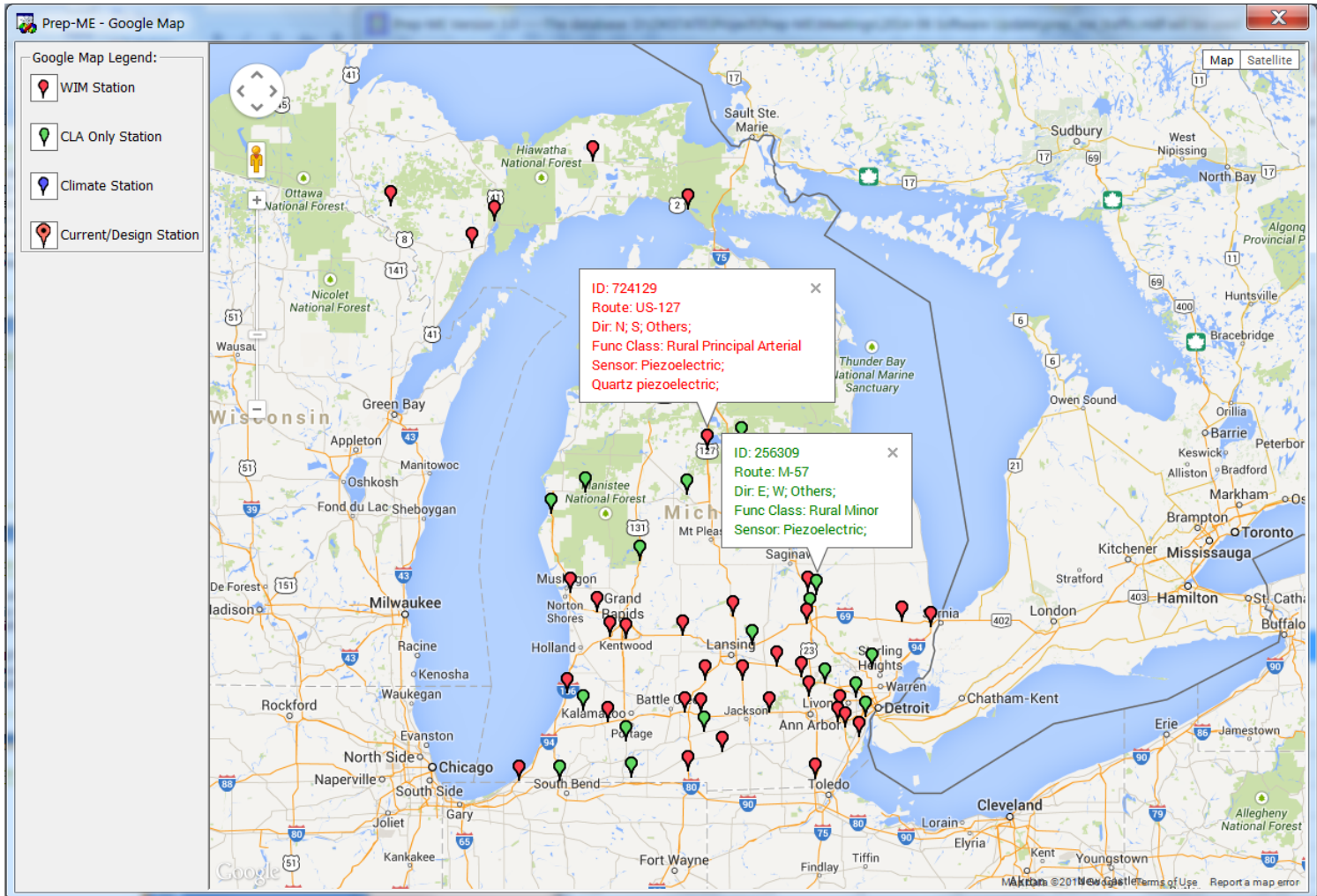
	Top Layer	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8
AASHTO Classification:	A-4	A-7-6	A-6					
AASHTO Group Index	3	19	13					
Top Depth (in)	0	16.9	48.8					
Bottom Depth (in)	16.9	48.8	72					
Thickness (in)	16.9	31.9	23.2					
% Component	30	30	30					
Water Table Depth-Annual Min (ft)	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					
Passing #10 (%)	87.5	100	87.5					

OK

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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