

Long-Term Pavement Performance Pavement Loading User Guide (LTPP PLUG)

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FOREWORD

This guide addresses the selection and use of axle loading defaults for Mechanistic-Empirical Pavement Design Guide (MEPDG) applications. The defaults were developed based on weigh-in-motion (WIM) data from the Long-Term Pavement Performance (LTPP) Special Pavement Study (SPS) Transportation Pooled Fund Study (TPF). The guide consists of two parts. The first part provides guidelines for selecting and using LTPP SPS TPF axle loading defaults with the MEPDG and DARWin-ME software. These defaults provide a source of axle loading information for pavement analysis for locations where site-specific axle load spectra are not available. The second part of the guide provides practical guidelines that States and LTPP can use to generate additional MEPDG traffic loading defaults based on their own WIM data or for specific analysis purposes. In addition, this guide contains an operator's manual that supports the use of the LTPP PLUG software. This software helps users select site-specific or default axle loading conditions from its traffic loading library and produces axle load distribution input files for use with the MEPDG or DARWin-ME software. The software can be used to store, view, and group multiple normalized axle load spectra (NALS) and to develop MEPDG inputs and defaults using agency-provided data.

Jorge E. Pagán-Ortiz
Director, Office of Infrastructure
Research and Development

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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LIST OF ABBREVIATIONS AND ACRONYMS

AADTT	Average Annual Daily Truck Traffic
AASHTO	American Association of State Highway and Transportation Officials
APC	Axle-per-Truck Coefficient
ASTM	ASTM International (formerly American Society for Testing and Materials)
AVC	Automated Vehicle Classification
DOW	Day-of-the-Week
ESAL	Equivalent Single-Axle Load
FHWA	Federal Highway Administration
GPS	General Pavement Studies
I	Interstate
JPCP	Jointed Plain Concrete Pavement
LTPP	Long-Term Pavement Performance
MEPDG	Mechanistic-Empirical Pavement Design Guide
MPO	Metropolitan Planning Organization
NALS	Normalized Axle Load Spectra
NCHRP	National Cooperative Highway Research Program
PLUG	Pavement Loading User Guide
QA	Quality Assurance
QC	Quality Control
RANALS	Representative Annual Normalized Axle Load Spectra
RPPIF	Relative Pavement Performance Impact Factor
RV	Recreational Vehicle
SHRP	Strategic Highway Research Program
SPS	Specific Pavement Studies
TPF	Transportation Pooled-Fund (study)
TWRG	Truck Weight Road Group
WIM	Weigh-in-Motion

INTRODUCTION

BACKGROUND

Many State highway agencies are evaluating and implementing the American Association of State Highway and Transportation Officials (AASHTO) Mechanistic-Empirical Pavement Design Guide (MEPDG) and the DARWin-ME software.⁽¹⁾ The main MEPDG traffic inputs are normalized axle load spectra (NALS), a percentile truck classification volume distribution, truck volumes, and truck growth rates. In most earlier pavement design and analysis methodologies, the effect of traffic loads was accounted for in the design by using the AASHTO equivalency factors to compute the number of equivalent single-axle loads (ESAL).⁽²⁾ Instead of using the computed ESAL values, the MEPDG and DARWin-ME software use the load spectra that can be used directly to estimate truck statistics.

NALS are percentile distributions of axle type counts by load range. Individual NALS are computed for each axle type and truck class. The axle types included in the MEPDG design procedure are single, tandem, tridem, and quad, and the truck classes are vehicle classes 4 through 13 from the Federal Highway Administration (FHWA) classification scheme.⁽³⁾ The MEPDG uses NALS representative of a “typical day of the month.” For roads that do not show significant seasonal variations in percentages of heavy and light loads, the same NALS are used for all calendar months.

Of all MEPDG traffic loading inputs, NALS are the most challenging owing to the high cost and considerable time to collect an adequate quantity of accurate axle load data. Therefore, the majority of pavement designs and analyses using the MEPDG and DARWin-ME software do not use site-specific NALS. Instead, most analyses rely on regional, agency-wide, or national NALS traffic loading defaults, combined with site-specific truck volume counts. It is important that these default NALS tables be as representative as possible of the actual truck traffic loading characteristics at the project site.

The original default traffic datasets for the MEPDG were developed during National Cooperative Highway Research Program (NCHRP) Project 1-37A using Long-Term Pavement Performance (LTPP) traffic data available in 1998.⁽⁴⁾ At that time, these data represented the best available and most comprehensive national set of weigh-in-motion (WIM) and automated vehicle classification (AVC) data. However, some concerns existed regarding the lack of documented quality of the data that were used to determine the truck traffic default values—specifically, the NALS values for each axle type within each class of trucks. Just as important, many agency personnel also questioned the quality and adequate quantity of their own State’s truck traffic data. Consequently, a new set of default NALS has been produced for use with the MEPDG and DARWin-ME software. In addition, detailed instructions have been developed to help States create NALS tables that reflect the unique truck types and trucking patterns in their State.

To develop the improved default tables, LTPP undertook a Specific Pavement Studies (SPS) Transportation Pooled-Fund (TPF) study that focused on installation of highly reliable, well-calibrated, permanent WIM systems, and collection of axle loading data using a uniform vehicle classification scheme and rigorous quality control procedures. One outcome of that ongoing effort is the production of research-quality traffic data (classification and weight), primarily to

support LTPP analysis projects. The SPS TPF study has generated high-quality traffic loading information for 26 LTPP SPS sites located in 23 different States that represent moderate- and high-volume rural principal arterial interstate and non-interstate highways. These data also allow the update of the original MEPDG axle loading defaults. The SPS TPF data and their use as default NALS tables are described in Part I of this guide.

PURPOSE AND SCOPE OF THIS GUIDE

This guide addresses two issues critical for MEPDG use:

- How to select LTPP axle loading defaults (Part I).
- How to develop axle loading defaults (Part II).

This guide primarily focuses on NALS, but it also addresses other defaults computed from WIM data, including axle spacing, wheelbase, and axles-per-truck defaults.

This guide is designed for analysts working with LTPP pavement performance data. It is designed specifically to aid in the selection of the default axle loading inputs computed using the SPS TPF data and application of those defaults to LTPP sites that do not have reliable site-specific axle loading data, when such data are required for use in pavement design analysis.

This guide also can be used outside of LTPP research and analysis. For example, the new SPS TPF based axle loading defaults can be used for any MEPDG-based pavement analysis when the pavement sites do not have reliable site-specific axle loading data. Agencies can also use this guide to help develop their own NALS defaults for use with the MEPDG and the DARWin-ME software.

ORGANIZATION OF THE GUIDE

As noted above, Part I of this guide provides guidance on selecting LTPP axle loading defaults for MEPDG use. Part II provides guidance on developing additional axle loading default tables for MEPDG use. Appendix A contains an operator's manual for an accompanying software application and database application CD, and appendix B contains the data dictionary for the LTPP Pavement Loading User Guide (PLUG) database application. The LTPP PLUG database application can also be requested through the LTPP Customer Support Service Center at:

E-mail: LTPPinfo@dot.gov

Telephone: (202) 493-3035

Fax: (202) 493-3161

PART I—GUIDELINES FOR USING LTPP SPS TPF AXLE LOADING DEFAULTS

WHEN AXLE LOADING DEFAULTS SHOULD AND SHOULD NOT BE USED

Many factors can affect the truck loading patterns on a roadway (e.g., the vehicle types observed, the axle configurations on those vehicles, and the axle weights carried). These different patterns result in the application of very different load spectra on those pavements. Among the most important factors affecting the traffic load applied to any given pavement are:

- State's truck size, weight, and permitting laws.
- Degree to which those laws are enforced, both in general and on specific roads.
- Commodities carried on specific roads.
- Distances between origins and destinations served by truck traffic using that roadway (local service versus long haul operations).

To account for the wide variation in traffic loading patterns, the best traffic data to use for pavement analysis are data collected with well-calibrated equipment on road segments directly leading to or from the site in question. Unfortunately, accurate truck and axle weight data are difficult and expensive to collect. In addition, rough pavement increases the dynamic motion (bouncing) of trucks, making it nearly impossible for WIM scales to collect accurate data on these roads. Thus, site-specific truck weight data frequently are not available for pavement analysis. When this situation occurs, the pavement analyst must use truck characteristic data (load spectra) collected elsewhere.

As a general guide, a pavement analyst should use data from one specific WIM scale when:

- The load spectra data from that scale have been collected at a site that serves the same traffic stream that is operating over the pavement for which load spectra are desired. For example, this may be the case if the scale is located upstream or downstream of the pavement analysis site on the same road and no major change in truck traffic occurs on that road between the scale and the pavement analysis site.
- The scale is located on a road known to carry trucks with unique characteristics that are also present on the road for which load spectra data are needed. For example, this situation may occur if the scale is present on a coal hauling route in the same State as the pavement design site, which is also located on a road used for hauling coal.

Selecting one specific WIM site from another location generally is not encouraged unless the pavement analyst is confident that the trucking patterns at the data collection site match those of the analysis site, even when the scale is on the same road as the pavement analysis site. Loading patterns frequently change from one segment of road to another. For example, Interstate (I)-405 in the Seattle metropolitan region has a very different loading pattern south of the interchange with I-90 than it has north of that interchange. South of the I-90 interchange, I-405 carries a mix of urban delivery trucks and trucks serving the long haul movements that use I-90 to reach the

Port of Seattle and the large warehouse district located in the southern part of the metropolitan area. North of I-90, the vast majority of trucks are urban delivery trucks.

If a single scale is not an obvious choice to provide load spectra data, the next option is to select a default load spectrum that represents the average of the loading patterns observed on a group of similar roads within the same State as the pavement analysis site. Part II of this guide describes how to develop these State-specific defaults. The advantage of selecting data that represent a group of sites is that the effects of any unusual condition that may exist at any one site is minimized by the lack of that unusual condition at the other sites in the group. Group averages are thus likely to be more representative of the loading patterns at other locations around the State. Selecting load spectra data collected only from the same State as the pavement to be analyzed also improves the accuracy of the default load spectra because it ensures that the trucks for which data are being collected follow the same truck size and weight laws.

Unfortunately, some States do not have strong truck weighing programs or have yet to produce default load spectra in formats that are available to users of the MEPDG and DARWin-ME software. For example, some States have had considerable difficulty maintaining WIM scale calibration and do not trust much of the truck load data they have collected.

When a State does not have reliable load spectra data, or the pavement analyst does not have access to a specific State's load spectra data (which may be the case with many LTPP analyses), the best option is to use default load spectra developed at the national level.

Using the high-quality data available from the SPS TPF study, the LTPP program has developed national-level load spectra defaults. These defaults were developed to represent a variety of alternative loading conditions observed in the national data sample. This variety helps pavement analysts select appropriate load spectra for their work, and it allows them to test the sensitivity of their analyses by re-running MEPDG analyses using different (e.g., lighter or heavier) default load spectra to determine the degree to which changes in load spectra affect their specific pavement analysis outcome.

When using national-level defaults, analysts are encouraged to perform at least a few MEPDG sensitivity tests simply because load spectra developed at the national level cannot adequately account for the differences in trucking patterns that result from State-specific size and weight laws. Neither can national defaults account for trucking patterns unique to specific roads or regions within a State. At a minimum, MEPDG sensitivity tests provide pavement analysts with insight into the reliability of their analysis results, given the uncertainties inherent in the traffic inputs used to generate those results.

MEPDG TRAFFIC LOADING DEFAULTS BASED ON LTPP SPS TPF WIM SITES

The LTPP program worked with 22 States to install and operate 26 WIM scales under a set of rigorous quality control (QC) procedures, with frequent equipment calibration, testing, and validation. The result is a wealth of reliable traffic loading data that has been used to develop defaults for use with the MEPDG and DARWin-ME software instead of the initial set of defaults created as part of the NCHRP 1-37A study.

Overview of Traffic Loading Defaults Based on SPS TPF WIM Data

NALS are the primary traffic loading defaults produced with the SPS TPF data. Other defaults produced are axle-per-truck coefficients (APC) and other axle spacing and wheelbase parameters used by the MEPDG software.

Two tiers of NALS defaults were developed based on SPS TPF WIM data, as described in the following sections:

- Tier 1—global defaults based on all applicable SPS TPF data. These defaults were computed by averaging the NALS produced for each of the 26 SPS TPF sites. Default global NALS are computed for each vehicle class and axle type.
- Tier 2—supplemental defaults that represent different loading conditions (e.g., conditions heavier or lighter than the global default) observed in the SPS TPF.

In addition to NALS, this guide contains one set of default APCs based on SPS TPF sites. Representative axle spacing and wheelbase values were also computed based on data from all SPS TPF sites and included in this guide.

All defaults are included in the LTPP PLUG database application and can be viewed in graphical or tabular form. These defaults can be used to develop MEPDG or DARWin-ME files using the LTPP PLUG database application.

Global Axle Loading Defaults Based on LTPP SPS TPF Sites (Tier 1)

Global NALS defaults were computed based on a simple averaging of the representative annual NALS (RANALS) for the 26 SPS TPF sites. This computation was done separately for each vehicle class and axle type.

Compared with the original MEPDG NALS defaults developed under the NCHRP 1-37A project, the SPS TPF NALS defaults have fewer very light and fewer very heavy loads. This is most likely because the new defaults were collected with more consistently calibrated WIM equipment. The better calibration of the WIM scales used to collect the SPS TPF data means that fewer very light loads (caused by under-calibrated scales “observing” very light loads) and fewer very heavy loads (caused by over-calibrated scales “observing” very heavy loads) are contained in the LTPP SPS TPF database. Because the SPS TPF-based NALS have smaller percentages of overloads, pavement life predicted using these global defaults is likely to be longer than predicted using the old global defaults.¹ However, these differences are not likely to be significant for many designs because the new global defaults also have a higher percentage of legally loaded heavy axles.

¹ “Overload,” as used here, means axles that exceed the legal Federal limit. The axles may or may not exceed the legal limit for the State in question or for the load being moved.

Axle Load Spectra Defaults Representing Alternative Loading Conditions (Tier 2)

Tier 2 defaults are supplemental defaults that represent different loading conditions (e.g., conditions heavier or lighter than the global default) observed in the SPS TPF study. Each of the Tier 2 NALS represents a different loading condition. Part II of this guide describes the methodology to develop these alternative NALS groups so that States can follow similar procedures to develop additional, State-specific, axle loading defaults for the trucks operating on their roads. For analysts who do not have access to State-specific NALS, national defaults are available.

Analysis of the loading conditions observed in the LTPP SPS TPF study revealed that truck loading characteristics (axle weights) can vary considerably from location to location. Therefore, it was determined that default NALS should be developed that allowed users of the MEPDG and DARWin-ME software to select from alternative default loading conditions for their analyses to account for those observed differences in traffic loading per vehicle. For example, alternative loading conditions (Tier 2 NALS) can be required when one set of sites experiences a high percentage of trucks in a specific vehicle class that are fully legally loaded while another set of sites exhibits a high percentage of that same vehicle class that is unloaded. A third NALS might be needed to represent sites that experience a much higher than normal percentage of trucks carrying loads that exceed Federal legal limits.

Alternative NALS also may be needed to account for differences in State truck size and weight laws. Differences in State laws can result in trucks of similar FHWA classifications having very different axle configurations and loading conditions for axles of a similar type. For example, many western States use flexible permitting rules to allow multi-trailer trucks to carry additional gross vehicle weight. These trucks are often found in FHWA Class 13. States that allow these additional weights have trucks with both different axle configurations and different axle weight patterns for FHWA Class 13 than States that do not routinely permit these kinds of loads.

Table 1 summarizes the Tier 2 default NALS that have been developed from the SPS TPF datasets. The first two columns in the table allow the user to select the specific FHWA vehicle class and type of axle of interest. For example, FHWA vehicle Class 4, axle type 1, is the row for single axles on buses. On the far right of table 1 is the number of Tier 2 NALS, or different groups of loading patterns, that have been developed for each class of vehicle and type of axle. If only one NALS is present, it means that, from a pavement design perspective, little difference was found in the axle load spectra observed at the 26 sites in the LTPP SFS TPF data, and all pavement analyses can use a single NALS for that type of axle for that class of vehicles.

The third column of table 1 indicates how frequently axles of each specific type appear on U.S. primary roads. This information is based on the data present in the LTPP database. This column is provided to give users an idea of whether specific kinds of trucks are commonly found on roads for which the MEPDG is likely to be used. (Note that individual roads may have truck volumes that are different than those commonly found in the LTPP database.)

The fourth column in table 1 provides two pieces of information. First, it describes the NALS group that contains the largest number of SPS TPF sites. It is recommended that this group be used as the default Tier 2 NALS if no other information is available about loads carried by that

class of vehicle. If the analyst has information about loads, he or she may use that information to choose a different NALS for that type of axle and vehicle classification. Second, the term used in the fourth column of the table (e.g., Moderate or Light) describes the relative weight (or pavement damaging potential) of the average axle in that group *relative to other axles*. Table 2 provides a quantitative definition of this descriptive loading condition, as well as full and abbreviated names of alternative NALS.

As an example of how to read this fourth column of table 1, the default NALS for Class 5 single axles is Very Light. Thus, the average Class 5 single axle is lighter and causes much less damage than the average default axle for either Class 4 or Class 6 single axles. The default single axles for both Class 4 and Class 6 trucks are considered moderate in weight/damage potential.

The next five columns in table 1, labeled “NALS Clusters Observed in Multiple States (Recommended for National Use),” describe the characteristics of the various NALS groups identified in the review of SPS TPF data. They use the same relative description of axle weight/pavement damaging potential as is used in column 4 and in table 2. For example, the symbol “M” in the “Moderate” column indicates that a group of SPS TPF sites was found to have NALS similar to each other for that class of vehicle and type of axle, and the default NALS developed based on site-specific NALS included in this group is of moderate weight/damage potential.

The next five columns, labeled “NALS Clusters in a Single State (Recommended for Use in That State on Roads with Similar Truck Traffic),” describe the relative weight/damage potential of the “special case” or outlier conditions identified in the SPS TPF dataset. Also included in these five columns is an abbreviated name of the State where the WIM site was located that produced the outlier described. For example, Class 6 single axle has two light outlier sites, one in Washington and one in Ohio. Possible reasons for the existence of these special-case NALS include:

- Specific commodity hauls and State/local trucking regulations are present that cause unusual truck types and loads unique to that location (or State) to dominate the loading characteristics of a given vehicle class at the site.
- Differences in the vehicle classification algorithm implemented on some State-installed SPS TPF WIM sites can cause some vehicles to be classified differently in the State-supplied data than would be the case in the LTPP classification algorithm. These differences in vehicle classification outcome can cause differences in the load spectra for those affected classes at those sites.
- The road containing the SPS TPF WIM site may serve commodity movements that result in a larger than usual percentage of trucks operating under special permits and thus have axles weighing more than at other sites.
- Trucking regulations often differ from one State to another. Axle weight limits adopted by one State can be different from Federal limits, resulting in unusual axle weights for roads in that State that do not carry much interstate traffic.
- Truck fleet characteristics can also differ from one State to another as a result of differences in trucking regulations. States may actively encourage specific truck

categories and actively discourage others. Consequently, States with unusual truck types can exhibit unusual loading conditions for the FHWA categories that contain those specific truck types. For example, a few western States allow triple trailer trucks. These trucks are classified as Class 13, and their presence generally increases the number of single axles found on Class 13 trucks and changes the load distribution of Class 13 single axles.

The following example illustrates how to read table 1. For Class 6 tandem axles, the review of SPS TPF data resulted in the formation of three NALS. Two of these NALS are formed based on groups of sites. One of these two groups has moderate weight tandem axles. This group contained the greatest number of SPS TPF sites and is thus the default NALS initially recommended for Class 6 tandem axles. A second identified group of SPS TPF sites produced NALS for heavy axles. This NALS is also considered reasonably common on roads throughout the nation. In addition to these two fairly common groups, one SPS TPF site was an outlier. That site, observed in Florida, exhibited very heavy Class 6 tandem axles. This result would indicate that it is possible to have very heavy Class 6 tandem axles but that such a condition is considered unusual. This NALS should be used only if the analyst has specific knowledge that such a loading condition is likely to occur at the analysis site.

NALS for each cluster group shown in table 1 are available in the LTPP PLUG database.

Table 1. Summary of NALS cluster groups representing different loading conditions by vehicle class and axle type

FHWA Vehicle Class	Axle Type	Frequency of Vehicle Class (by Volume) on U.S. Primary Road System	Default NALS Category by Loading Condition	NALS Clusters Observed in Multiple States (Recommended for National Use)					NALS Clusters Observed in a Single State (Recommended for Use in That State on Roads with Similar Truck Traffic)					Total NALS Clusters by Weight
				Very Light (VL)	Light (L)	Moderate (M)	Heavy (H)	Very Heavy (VH)	Very Light (VL)	Light (L)	Moderate (M)	Heavy (H)	Very Heavy (VH)	
4	1	Moderate	Moderate			M								1
	2		Very Heavy				H	VH1, VH2						3
5	1	Frequent	Very Light	VL						L (FL)				2
	2		Very Light	VL										1
6	1	Low or Moderate	Moderate			M				L (WA) L (OH)				3
	2		Moderate			M	H						VH (FL)	3
7	1	Low	Heavy			M	H		VL (WA)		M (OH)			4
	2		Heavy			M		VH	VL (WA)		M (OH)	H (OH)	VH (DE), VH (FL1), VH (FL2), VH (TN)	7
	3		Very Heavy					VH1, VH2					VH (TN)	3
	4		Very Heavy					VH						1
8	1	Moderate	Light		L							H (FL)		2
	2		Light		L					L (AZ) ²			VH (FL)	3
9	1	Most Frequent	Light		L									1
	2		Moderate or Heavy			M	H1, H2				M (FL)		VH (AZ) ¹	5
10	1	Low	Light		L									1
	2		Very Heavy			M		VH					VH (AZ)	3
	3		Heavy				H	VH		L (ME)	M (MN)			4
	4		Heavy				H							1
11	1	Low	Moderate		L	M						H (AZ)		3
12	1	Low	Light		L				VL (NM) VL(LA)		M (ME)			4
	2		Light		L									1
13	1	Low	Moderate			M	H				M (OH) ²		VH (OH)	4
	2		Very Heavy				H	VH1, VH2						3
	3		Very Heavy				H	VH1, VH2				H (OH)		4
	4		Very Heavy				H	VH				H (OH)**		3

¹NALS has very heavy overloads

²NALS identified as outlier based on classification issue (high percentage of very light weight axles)

FL = Florida, WA = Washington (State), OH = Ohio, DE = Delaware, TN = Tennessee. AZ = Arizona, ME = Maine, MN = Minnesota, NM = New Mexico, LA = Louisiana

Table 2. Summary of axle loading categories by weight for different axle types

Axle Category by Weight	Average RPPIF per Cluster	Percentage of Single Axles >= 15 kip	Percentage of Tandem Axles >=26 kip	Percentage of Tridem Axles >=39 kip	Percentage of Quad Axles >=54 kip
Very Light (VL)	<0.05	<3	0	N/A	N/A
Light (L)	0.05–0.15	<10	<10	N/A	N/A
Moderate (M)	0.15–0.30	10–30	10–30	N/A	N/A
Heavy (H)	0.30–0.50	>30	30–50	<50	<30
Very Heavy (VH)	>0.50	n/a	>50	>50	>30

RPPIF = Relative Pavement Performance Impact Factor (described in Part II of this guide)

N/A = not applicable

NALS Clusters for Class 9 Tandems

Although for many vehicle classes and axle types there is one clearly defined default loading condition for many vehicle classes and axle types (i.e., the majority of SPS TPF sites have a common axle loading distribution), no one loading condition dominated the Class 9 tandem data. The loading condition of Class 9 tandems varied among the SPS TPF sites, ranging from moderately loaded conditions (less than 30 percent of tandem axles were more than 26 kips) to very heavily loaded (up to 70 percent of tandem axles were more than 26 kips). All of these conditions can be found routinely on U.S. roads.

A sensitivity analysis using the MEPDG procedures indicated that pavement design outcomes are very sensitive to the selection of the Class 9 tandem NALS, primarily because this is the most frequently observed truck carrying heavy loads on U.S. primary roads. Also, the majority of the load on these trucks is carried on their two sets of tandem axles. Hence, the number and weight of Class 9 trucks using a road typically has a major impact on pavement design.

No one loading condition dominated the Class 9 tandem-axle NALS in the SPS TPF dataset; therefore, instead of one default loading condition, all three NALS cluster groups developed for Class 9 tandems (one moderate and two heavy) are recommended as potential defaults.

If no site-specific loading information is available, the moderate (M) loading condition is recommended for roads serving predominately urban delivery trucking movements, where a large percentage of trucks are empty (returning to their distribution centers) or partially full after having made one or more stops. Alternatively, the heavy #1 (H1) loading condition is recommended for roads where long haul trucking or heavy directional hauls overlap with urban delivery movements. The heavy #2 (H2) loading condition is recommended for rural roads where almost all Class 9 truck traffic is fully loaded long haul traffic and few heavy trucks are expected to be operating in a partially full or empty condition.

Characteristics and Recommended Use of Tier 2 NALS Clusters

To help characterize the NALS representing default and alternative axle loading conditions so that pavement analysts can more easily choose between alternative loading conditions, several statistical parameters were computed for each Tier 2 default NALS cluster, including Relative Pavement Performance Impact Factor (RPPIF) values and percentage of heavy axles (i.e., the

percentage of axles that are at or above 75 percent of the Federal legal weight limit). In addition, text descriptions were developed of alternative NALS axle loading conditions for each vehicle class and axle type and recommendations for their use. This information is presented in the following subsections.

Vehicle Class 4: Buses (Table 3)

There are multiple styles of buses, ranging from over-the-road coaches (e.g., Greyhound buses), to two- and three-axle urban transit buses, to recreational vehicles (RV) that have been constructed using bus frames and bodies (e.g., tour buses used by many traveling bands). Buses commonly have one steering axle and either a single rear drive axle or a tandem rear axle.

Because none of the SPS TPF WIM scales observed large numbers of urban transit buses, which can have very heavy single axles, a large portion of the observed single axles were steering axles. As a result, all of the observed sites had similar single-axle loading patterns and were grouped into one national NALS, with a moderate loading condition. On the other hand, three different tandem-axle loading conditions were identified. Tandem axles on buses are generally at least moderately loaded because they tend to carry the weight of the bus engine. As the number of passengers carried increases, the axle weight increases further, often approaching or exceeding the Federal axle limits. Lighter tandem axles generally are observed when the buses are lightly loaded with passengers, as is often the case when the “buses” are RVs rather than over-the-road motor coaches. Table 3 describes the alternative Class 4 axle loading conditions.

Table 3. Description of alternative Class 4 axle loading conditions

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
4	1	M(T)	0.20	14	Only one national NALS exists for single axles on buses. It shows a relatively normal distribution of moderately heavily loaded axles with the majority of the load distribution occurring between 10,000 and 16,000 lb.	For use on all roads
4	2	H	0.42	46	This NALS has a large percentage (greater than 65 percent) of tandem axles that weigh less than 28,000 lb and a third of the axles weighing less than 22,000 lb. These lighter axles may be caused by the site observing a mix of RVs built on bus chassis mixed with heavier, more conventional over-the-road motor coaches.	For use on roads where a moderate percentage of buses are “bus style” RVs
		VH1(T)	0.56	68	This NALS is recommended as the default. Most of tandem axles are heavy (approximately 70 percent are greater than 26,000 lb), but relatively few (less than 2 percent) exceed the Federal legal limit. Therefore, these sites likely have a lower percentage of RV traffic mixed with the over-the-road coaches.	For use on rural roads where RV traffic is modest
		VH2	0.69	85	This NALS contains almost exclusively heavy tandem axles. Less than 16 percent of tandem axles weigh less than 26,000 lb.	For use on roads carrying heavily loaded transit buses and over-the-road coaches

Vehicle Class 5: Two-Axle, Six-Tire Single Unit Vehicles (Table 4)

Class 5 consists of smaller two-axle trucks. This class includes large pick-up trucks (those with dual wheels on their rear axle), as well as urban delivery vehicles, such as panel trucks and smaller tow trucks. By definition, when these vehicles pull trailers, they become Class 8 trucks. (This is unlike conventional Class 3 pick-ups, which remain in Class 3, even when they are pulling small trailers.) However, some classification algorithms do classify Class 5 trucks pulling trailers as Class 5. This results in some TPF sites observing tandem axles in Class 5.

In the SPS TPF dataset, all but one condition for both single and tandem axles are grouped into just one NALS group for each type of axle. There is one special case. In that case, a Florida site was observed at which much heavier single axles were observed than at all other sites. This was because two-axle farm vehicles transport very heavy loads on this road (when compared with normal Class 5 axle loads). Table 4 describes the alternative Class 5 axle loading conditions.

Table 4. Description of alternative Class 5 axle loading conditions

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
5	1	VL(T)	0.04	3	This NALS is recommended as a Tier 2 default. It is appropriate for all roads that are not subject to unusual loading conditions.	For use on all roads
		SP L(FL)	0.13	8	This special case is caused by a permitted farm-to-market haul that causes an unusually heavy loading condition for Class 5 trucks. It was found only at one Florida site.	A special case where a large percentage of large pick-ups and other two-axle trucks carry unusually heavy loads for two axle vehicles
5	2	VL(T)	0.00	0	This NALS is recommended as a Tier 2 default. These axles are generally found on small trailers pulled by small trucks and are invariably light.	For use on all roads

Vehicle Class 6: Three-Axle Single Unit Vehicles (Table 5)

Class 6 trucks are frequently smaller natural resource haulers (e.g., sand trucks, small dump trucks) and heavier urban delivery vehicles, such as trucks delivering cases of soft drinks. For these trucks, the weight on the front axle is primarily from the engine, not the load carried, and thus these axles are rarely either unloaded or very heavily loaded. The Class 6 classification also includes tractors operating without trailers. The presence of large numbers of these vehicles in the traffic stream can result in large numbers of lightly loaded tandem axles. Finally, many heavy (Class 7) single unit vehicles are equipped with “lift axles” (i.e., axles which, when not needed, can be lifted off the ground). Thus, trucks that are Class 7 vehicles when full (and all of their axles are on the ground to support the load) are often classified as Class 6 trucks when they are empty because only two of their load axles are touching the pavement. This often increases the number of lightly loaded Class 6 trucks recorded, increasing the percentage of lightly loaded tandem axles at many sites. Table 5 describes the alternative Class 6 axle loading conditions.

Table 5. Description of alternative Class 6 axle loading conditions

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
6	1	M(T)	0.17	10	This NALS is recommended as a Tier 2 default. The vast majority of roads fall into this loading group. Most single axles are steering axles. The weight on the steering axle is primarily from the engine not the load carried. Few axles weighing more than 14,000 lb are observed.	For use on all roads
6	1	SP L(OH)	0.10	3	The vehicle classification scheme used by Ohio can classify some vehicles pulling trailers as Class 6. These light trailers produce much lighter single-axle load spectra than are commonly found elsewhere, with many axles weighing less than 6,000 lb.	For use on some Ohio roads
6	1	SP L(WA)	0.08	3	Washington's WIM data produced load spectra with an unusual percentage (greater than 20 percent) of light axles.	For use on Washington State roads
6	2	M(T)	0.24	20	This NALS is recommended as a Tier 2 default. This NALS represents roadways where up to 50 percent of Class 6 trucks are operating empty or lightly loaded (approximately 40 percent of tandem axles weigh less than 12,000 lb, and approximately 50 percent of tandem axles weigh less than 16,000 lb). The vast majority of roads fall into this default loading group.	For use on most roads, especially where more than 40 percent of Class 6 trucks are operating empty
6	2	H	0.43	30	This NALS represents roadways where less than 30 percent of Class 6 trucks are operating empty. A commensurately larger percentage of trucks are carrying full loads. This is a good NALS to select for roads with a strong directional haul that uses Class 6 trucks (e.g., a farm to market road where this direction is the loaded direction of the haul).	For use on roads with strong directional hauls where Class 6 trucks carry heavy roads
6	2	SP VH(FL)	0.63	36	Data at one Florida site showed a large percentage of very heavily loaded Class 6 tandem axles. This site had 5 percent of its tandem-axle loads greater than 40,000 lb, which is highly unusual for Class 6.	For use on roads experiencing high overloading conditions with Class 6 trucks

Vehicle Class 7: Four-or-More Axle Single Unit Vehicles (Table 6)

Class 7 consists of very large single unit trucks. These trucks are most commonly used for hauling heavy natural resources. They are often very large dump trucks. In the Midwest, they are often used to carry coal. The most common configuration is a single steering axle and a tridem axle that carries the majority of the load. Less common configurations use a quad axle instead of a tridem axle, or a tridem with an extended lift axle (observed as a single), or even a quintuple

axle. A larger percentage of these vehicles use lift axles. These axles are usually lowered (used to carry load) when the vehicle is carrying a load, and raised (so that they do not touch the pavement) when the vehicle is empty. As a result, relatively few empty Class 7 trucks are observed at scales. When empty, these trucks are most commonly configured as Class 6 vehicles. The use and configuration of Class 7 trucks varies considerably across the nation based on State-specific size and weight regulations. Both the axle configurations and axle weights are quite variable. Class 7 trucks, along with Class 13 trucks, are possibly the most diverse categories within FHWA's vehicle classification scheme. In addition, the Class 7 truck is uncommon in some States but quite common in others. Tandems are reasonably rare axles on Class 7 trucks. Only 17 of 26 sites observed enough tandems on Class 7 vehicles to construct a site-specific NALS. Table 6 describes the alternative Class 7 axle loading conditions.

Table 6. Description of alternative Class 7 axle loading conditions

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
7	1	M	0.26	26	This group of NALS contains few axles (less than 10 percent) that weigh less than 10,000 lb. The majority of single axles at sites belonging to this group weigh between 11,000 and 18,000 lb, with a mean axle weight of about 13,000 lb.	For use on roads where dirt and other heavy natural resources are typically carried by Class 10 trucks not Class 7 trucks
7	1	H(T)	0.41	52	This NALS is recommended as a Tier 2 default. This NALS contains few lightly loaded axles. The majority of single axles that fall in this group weigh between 13,000 and 22,000 lb, with a mean axle weight of about 18,000 lb. This default group contains axles that are slightly heavier than the alternative moderate (M) group.	For use on roads where five-axle and larger Class 7 trucks are routinely found or where state laws routinely permit very heavy single unit trucks
7	1	SP VL(WA)	0.04	4	The Washington SPS TPF site observed a larger number of light single axles on Class 7 vehicles (approximately 70 percent weighing less than 6,000 lb). This may be the result of a limitation in the Washington vehicle classification algorithm.	For use on roads in Washington State
7	1	SP M(OH)	0.18	18	One of the two Ohio SPS TPF sites observed a larger number of light single axles on Class 7 vehicles. (More than 40 percent weigh less than 7,000 lb.) This may be the result of a limitation in the Ohio vehicle classification algorithm. The large percentage of light axles was somewhat offset by 35 percent of the axles being heavier than 14,000 lb.	For use on roads in Ohio, where large percentages of non-Class 7 vehicles may be classified as Class 7 trucks
7	2	M	0.24	22	Tandems are reasonably rare axles on Class 7 trucks. For this NALS, more than 50 percent of quad axles weigh less than 12,000 lb.	For use on roads serving the “light” direction (backhaul) of a directional natural resource haul
7	2	VH(T)	0.85	64	This NALS is recommended as a Tier 2 default. Tandems are reasonably rare axles on Class 7 trucks. The default has a low percentage of tandem axles supporting little weight but also does not have a concentration of any specific axle weight. Less than 10 percent of these axles carry less than 12,000 lb, and while more than 40 percent of tandem axles weigh more than 30,000 lb, less than 15 percent weigh more than 40,000 lb.	For use on roads where Class 7 trucks use tandem axles and for directional, resource hauls
7	2	SP H(OH)	0.41	28	Ohio has two special-case Class 7 NALS. This specific special case is the heavier of the two special Ohio cases. It has more than 15 percent of axles with little or no load (weighing less than 6,000 lb) and 35 percent of its axles weighing between 20,000 and 36,000 lb.	For use in Ohio, where heavy loads are observed

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
7	2	SP M(OH)	0.29	16	Ohio has two special case Class 7 NALS. This specific special case has 45 percent of its axles weighing between 16,000 and 26,000 lb. Less than 10 percent of axles weigh more than 32,000 lb. More than 15 percent of axles carry little or no load (weighing less than 6,000 lb).	For use in Ohio, where few very heavy loads are observed
7	2	SP VH(DE)	2.42	81	The Delaware TPF is very heavy. Very few unloaded axles were observed. More than half the tandem axles observed weigh more than 40,000 lb.	For use in Delaware
7	2	SP VH(FL1)	3.48	100	This Florida NALS is very heavy. Less than 10 percent of axles weigh less than 40,000 lb.	For use in Florida, and only where heavy overloads of Class 7 trucks are expected
7	2	SP VH(FL2)	6.11	98	This Florida NALS is very heavy. More than 50 percent of the observed Class 7 tandem axles weigh more than 48,000 lb.	For use in Florida only where extreme overloads of Class 7 trucks are expected
7	2	SP VH(TN)	9.94	91	This Tennessee NALS is very heavy. More than 85 percent of the observed Class 7 tandem axles weigh more than 50,000 lb.	For use on roads in Tennessee where tandem axles are heavily overloaded
7	2	SP VL(WA)	0.03	3	This Washington NALS is very light. More than 60 percent of its tandem axles weigh less than 12,000 lb.	For use only where a high percentages of Class 7 trucks are not loaded
7	3	VH1(T)	0.65	55	This NALS is recommended as a Tier 2 default. The default NALS has most axles weighing between 30,000 and 54,000 lb.	For use on roads where tridem axles are routinely fully loaded
7	3	VH2	1.55	96	This tridem NALS should be used where Class 7 tridem axles are primarily loaded well over the Federal legal limit. The median axle weight for this NALS is roughly 54,000 lb.	For use on roads where tridem axles are heavily overloaded
7	3	SP VH(TN)	2.25	98	This special case NALS has extremely heavy tridem axles. The median axle weight is just under 60,000 lb.	For use on roads in Tennessee where tridem axles are heavily overloaded
7	4	VH(T)	0.78	31	This NALS is recommended as a Tier 2 default. The SPS TPF data showed only a few sites that contain quad axles in Class 7. Thus, only one NALS is provided for quad axles.	For use on all roads

Vehicle Class 8: Four-or-Less Axle, Single Trailer Vehicles (Table 7)

Class 8 consists of smaller two-unit trucks. Common configurations include two-axle tractors pulling a semitrailer with a tandem axle, or a three-axle tractor pulling a semitrailer with a single trailer axle, or a dual axle truck pulling a two-axle trailer. The trailer can consist of two single axles, or it can be a semitrailer with one tandem axle. These trucks tend to be lightly loaded because heavier tractors are needed to pull heavy loads, and the trailers pulled by most dual axle

trucks tend to be light-duty configurations. Table 7 describes the alternative Class 8 axle loading conditions.

Table 7. Description of alternative Class 8 axle loading conditions

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
8	1	L (T)	0.11	9	This NALS is recommended as a Tier 2 default. The SPS TPF data found only one group NALS and one outlier for Class 8 single axles. This NALS is dominated by loads associated with the steering axle weight of two- and three-axle tractors, with the vast majority of single-axle weights in the range of 8,000 to 14,000 lb. Generally, less than 20 percent of axles are heavier than 13,000 lb.	For use on all roads
8	1	SP H (FL)	0.34	31	One Florida site had a very different NALS for Class 8 single axles. It showed more than 25 percent of single axles weighing more than 17,000 lb.	For use on Florida roads serving farms where overloaded axles are common
8	2	L (T)	0.10	5	This NALS is recommended as a Tier 2 default. The default NALS has the vast majority of Class 8 tandem axles weighing less than 24,000 lb, and almost no illegal tandem axles.	For use on all roads
8	2	SP L (AZ)	0.09	6	One special case was observed in Arizona. This site had more than 40 percent of tandem axles weighing less than 6,000 lb. The rest of the distribution resembled the typical NALS.	For use on roads in Arizona where a high percentage of unloaded axles is common
8	2	SP VH (FL)	1.09	56	The Florida special case captured a farm-to-market movement where trucks pulling tandem-axle trailers were very heavily loaded. More than 50 percent of tandem axles weighed more than 34,000 lb.	For use on Florida roads serving farms where overloaded axles are common

Vehicle Class 9: Five-Axle, Single Trailer Vehicles (Table 8)

Class 9 is by far the most common truck in use in the United States and, as such, dominates the vast majority of pavement loading computations. Although a number of configurations can be found, the most common Class 9 truck is the “classic” three-axle tractor pulling a tandem-axle equipped semitrailer. Infrequently, the semitrailer can use “split tandems,” which, depending on the distance between those axles, can be classified as either two single axles or one tandem. In addition, the common European configuration of a two-axle tractor pulling a tridem-equipped semitrailer can be observed occasionally in the United States. Finally, some full trucks pulling full trailers are correctly classified as Class 9 trucks.

Because so many Class 9 trucks have single-tandem, tandem-axle configurations, the axle weights for single axles are dominated by the steering axle weight of the truck tractor. Because the steering axle on even a fully loaded truck does not approach the legal load limit for single axles, the axle damaging characteristics of the single axles at all of the SPS TPF sites are similar. Thus, only a single-axle NALS group exists.

Unlike the single axles, considerable variety exists in the tandem-axle loads carried by Class 9 trucks. This variety is driven in part by the wide variety of loads carried by these trucks, as well as by their use in both urban delivery modes (where some trailers are full, some are partially full after completing one of several deliveries, and others are empty as the trucks return to their terminals after completing a delivery) and long haul transport (where the vast majority of trucks are fully loaded). But even in long haul travel, a “fully loaded” truck may not approach the legal limit because many commodities (e.g., computer parts) are bulky but not heavy.

Consequently, three different loading conditions are considered “typical” or commonly found. Any one of them can be found in any U.S. State. These three loading conditions differ primarily in the percentage of heavy (fully loaded) axles that were observed. When selecting from among these three conditions, the primary consideration is the percentage of tandem axles that are lightly loaded (weigh less than 20,000 lb) and the percentage that are heavily loaded (weigh more than 30,000 lb). Table 8 describes the alternative Class 9 axle loading conditions.

Table 8. Description of alternative Class 9 axle loading conditions

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
9	1	L(T)	0.14	9	This NALS is recommended as the Tier 2 default. Only one Class 9 single-axle NALS was observed because the majority of Class 9 trucks have only one single axle (the steering axle) and its load is only modestly affected by the load carried by the truck.	All roads
9	2	M	0.30	31	This NALS represents the loading condition frequently observed at SPS TPF sites. This loading condition has more lightly loaded tandem axles (axles between 12,000 and 16,000 lb) than heavily loaded axles (30,000 and 34,000 lb). In this NALS, 40 percent of axles carry loads greater than 20,000 lb.	For use in urban areas and on other roads where 70 percent or more of trucks are not fully loaded
9	2	H1(T)	0.38	39	This loading condition NALS has more loaded axles (between 30,000 and 34,000 lb) than unloaded axles (between 12,000 and 16,000 lb). This is a balanced distribution with similar total percentages of light and heavy loads. In this NALS, 55 percent of axles carry loads greater than 20,000 lb.	For use on highways that serve a mix of urban delivery and long haul truck movements
9	2	H2	0.48	49	This heavy loading NALS is representative of roads where a sizeable majority of tandem axles are heavily loaded. It is commonly found on rural highways that serve significant long haul truck movements.	For use on rural highways that serve significant long haul truck movements
9	2	SP M(FL)	0.27	22	This NALS contains very few loaded axles with no defined loaded peak of distribution. It also does not have a high concentration of axle weights near the conventional unloaded axle weights of 10,000 to 16,000 lb.	For use on roads in Florida with little long haul or “through movement” traffic
9	2	SP VH(AZ)	0.68	70	This NALS is a special very heavy case that contains 70 percent of axles with weights greater than 26,000 lb.	For use on roads with almost all tandem axles fully loaded

Vehicle Class 10: Six-or-More Axle, Single Trailer Vehicles (Table 9)

Class 10 consists of a variety of heavy truck configurations. These trucks have two basic styles: a three-axle tractor pulling a semitrailer with three or more axles, and large trucks pulling full trailers. The first configuration is commonly used by trucks carrying, for example, heavy shipping containers. The second configuration is common in States that allow longer trucking configurations. For example, in many western States, the most common truck for delivering gasoline to gas stations is a four-axle tank truck pulling a three- or four-axle tank trailer. In some States, Class 10 trucks are also the primary vehicles used for hauling heavy natural resources. In these instances, a common Class 10 vehicle is a four-axle dump truck pulling a large three- or four-axle “pup trailer” on a long steel beam. In some States, the primary resource haulers are Class 7 trucks, whereas in other States, this job is mostly performed by Class 10 vehicles. Generally, a State uses one or the other of these truck styles for this task. Thus, a State that commonly uses Class 10 trucks for natural resource hauling will tend to have few very large Class 7 trucks, and vice versa. Table 9 describes the alternative Class 10 axle loading conditions.

Table 9. Description of alternative Class 10 axle loading conditions

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
10	1	L(T)	0.12	4	Only one NALS was observed because single axles are mostly used on Class 10 vehicles as the steering axle of the tractor. Thus, single-axle loads are driven by common steering axle loading patterns.	For use on all roads
10	2	M	0.18	15	This NALS pattern for tandems is dominated by unloaded axles. In this NALS, more than 80 percent of tandem axles weigh less than 20,000 lb.	For use on roads where the Class 10 trucks are primarily unloaded
10	2	VH(T)	0.52	45	This NALS is recommended as a Tier 2 default. It has slightly more loaded axles (weighing 26,000 to 34,000 lb) than unloaded or lightly axles (12,000 to 20,000 lb). It also includes about 5 percent of axles exceeding the Federal legal limit.	For use on roads with an even mix of heavy and light Class 10 trucks
10	2	SP VH(AZ)	1.04	38	This special case NALS did not fit either pattern. Although it has more unloaded axles than the default NALS, it also has more than 12 percent of its axles weighing more than the Federal legal limit, which results in the very heavy loading condition.	For use on roads with high levels of overloaded Class 10 tandem axles
10	3	H(T)	0.35	23	This NALS is recommended as a Tier 2 default. It contains a significant number of both loaded and unloaded tridem axles. More than 40 percent of axles weigh less than 21,000 lb. However, more than 30 percent of the axles weigh between 33,000 and 48,000 lb.	For use on roads with a mix of fully and lightly loaded Class 10 tridem axles
10	3	VH	0.56	43	This alternative to the default NALS has a lower percentage of lightly loaded axles, and a much greater percentage of heavy axles. Less than 22 percent of axles weigh less than 21,000 lb, and more than 50 percent of axles are heavier than 36,000 lb, with more than 10 percent heavier than 48,000 lb.	For use on roads with a mix of loaded and unloaded tridem axles, where a significant portion of the axles exceed the Federal weight limit
10	3	SP L(ME)	0.09	5	This special case is for a Maine site that has a very high percentage of light axles, and a low weight for loaded axles. Almost 75 percent of axles weigh less than 15,000 lb, and less than 5 percent of axles weigh more than 39,000 lb.	For use on Maine roads where almost all tridem axles are unloaded or lightly loaded
10	3	SP M(MN)	0.18	9	This special case in Minnesota also reflects a very high percentage of lightly loaded axles, but with a larger percentage of heavy axles. Fifty-six percent of axles weigh less than 15,000 lb, with another 25 percent of axles weighing between 27,000 and 48,000 lb.	For use on Minnesota roads with a high percentage of unloaded tridem axles
10	4	H(T)	0.46	7	This NALS is recommended as a Tier 2 default. It contains both a significant number of loaded and unloaded quad axles but less than 5 percent of axles weigh more than 57,000 lb.	For use on roads with a mix of heavy and lightly loaded Class 10 quad axles

Vehicle Class 11: Five-or-Less Axle, Multi-Trailer Vehicles (Table 10)

Class 11 trucks are multi-trailer trucks mostly intended for carrying light, bulky cargo. For example, they are good choices for carrying large quantities of mixed packages and other light but high-volume cargo. The vast majority of trucks in this classification consist of a two-axle tractor pulling a smaller (28-ft) single-axle semitrailer and a small two-axle trailer. Because the drive axle of the tractor and the load-bearing axles on the trailers are all single axles, this configuration is one of the heavy truck configurations for which changes in truck loading characteristics (i.e., the commodities being hauled and whether the truck is loaded or not) have a significant effect on the single-axle loading pattern observed for single axles. Consequently, three different single-axle NALS patterns were developed for this class of trucks. Table 10 describes the alternative Class 11 axle loading conditions.

Table 10. Description of alternative Class 11 axle loading conditions

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
11	1	M(T)	0.19	18	This NALS is recommended as a Tier 2 default. The default NALS has relatively few very light axles. Less than 15 percent of axles weigh less than 8,000 lb. It differs from the primary alternative NALS group in that 35 percent of the axles in this group weigh more than 14,000 lb.	For use on all roads
11	1	L	0.08	5	This alternative NALS is lighter than the default. Only 10 percent of axles in this group are heavier than 14,000 lb, while 35 percent are lighter than 8,000 lb.	For use when a high percentage of Class 11 trucks are running empty
11	1	SP H(AZ)	0.38	53	This special case represents a very heavy loading condition observed in Arizona. Two peaks are observed in the load spectra, one represents the steering axles of these trucks with weights near 10,000 lb, and the other represents the loaded single axles with weights ranging between 16,000 and 22,000 lb. More than 45 percent of all axles weigh more than 16,000 lb.	For use when nearly all Class 10 trucks are fully loaded, such as roads used exclusively by long haul trucks, observed in Arizona

Vehicle Class 12: Six-Axle, Multi-Trailer Vehicles (Table 11)

Class 12 trucks are long multi-trailer trucks. They typically have one set of tandem axles and four single axles, one of which is the steering axle. The most common Class 12 truck configuration is a three-axle tractor pulling a single-axle semitrailer and a full trailer with two single axles. Less common configurations include a two-axle tractor pulling either a two-axle semitrailer and two-axle full trailer, or a two-axle tractor pulling a single-axle semitrailer and a three-axle full trailer. These vehicles carry a wide variety of commodities and can exhibit a variety of loading conditions. One NALS group was identified for single axles, but three special-case outliers were also noted in the SPS TPF dataset. Only one tandem-axle NALS group was identified. Table 11 describes the alternative Class 12 axle loading conditions.

Table 11. Description of alternative Class 12 axle loading conditions

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
12	1	M(T)	0.12	7	This NALS is recommended as a Tier 2 default. The default NALS for Class 12 single axles has an almost normal distribution. There are very few very light axles (weights less than 6,000 lb), and very few heavy axles (weights greater than 18,000 lb). The majority of axles weigh between 10,000 and 16,000 lb.	For use on all roads
12	1	SP M(ME)	0.25	25	This special case differs from the default NALS because more than 20 percent of its axles are heavier than 16,000 lb, compared with 5 percent in the default NALS. It represents a site where Class 12 trucks are carrying heavier loads than typically found elsewhere in the country.	For use on all roads where at least 20 percent of Class 12 trucks are carrying heavy commodity loads
12	1	SP VL (LA)	0.04	3	This special case represents a very light loading condition. Two peaks are present in the loading spectra; the larger peak represents unloaded single axles, weighing about 7,000 to 8,000 lb. The smaller peak represents the steering axle of the tractor, weighing about 10,000 to 12,000 lb.	For use on roads where almost all Class 12 trucks are operating empty
12	1	SP VL (NM)	0.03	1	This special case from New Mexico represents a very light axle loading condition. Less than 4 percent of axles weigh more than 12,000 lb. The light single axles in this NALS form a single-peak distribution between 7,000 and 11,000 lb rather than having two peaks.	For use on roads in New Mexico, where almost all Class 12 trucks are observed to be operating empty
12	2	L(T)	0.14	2	This NALS is recommended as a Tier 2 default. Only one NALS was observed for Class 12 tandem axles.	For use on all roads

Vehicle Class 13: Seven-or-More Axle, Multi-Trailer Vehicles (Table 12)

Class 13 is the classification that contains multi-trailer trucks specifically designed for carrying heavy loads. This classification of vehicles contains a wide variety of both truck configurations and axle configurations. They are common in some States but fairly rare in others. In Canada, one specific configuration (the “Canadian B Train”) was designed to meet Canada’s long haul trucking needs. In return for specific safety improvements (the use of a “B-style” connection between the first and second trailer) and the use of a tridem axle supporting the back of the first trailer and front of the second trailer, the Canadian B Train is permitted to carry additional load and therefore is extremely common in Canada and is also found in many northern States.

In addition, the adjustment of many State-specific truck size and weight laws to meet the needs of local heavy industry has resulted in classification of State-specific truck configurations as Class 13. For example, some western States have allowed the use of triple-trailer trucks. The result is considerable diversity in the number and weight of different types of axles on Class 13 trucks. Table 12 describes the alternative Class 13 axle loading conditions.

Table 12. Description of alternative Class 13 axle loading conditions

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
13	1	M(T)	0.18	11	This NALS is recommended as a Tier 2 default. The default NALS for Class 13 single axles has the rough shape of a triangle with the peak between 12,000 and 13,000 lb. This default NALS has very few unloaded and very few heavily loaded single axles.	For use on all roads, especially where fewer Class 13 trucks use single axles to carry heavy trailer loads
13	1	H	0.32	29	This alternative NALS is similar to the default distribution, but has fewer lightly loaded axles (fewer axles between 9,000 and 12,000 lb) and more axles greater than 15,000 lb. This NALS has 30 percent of axles exceeding 16,000 lb with more than 10 percent exceeding 18,000 lb.	For use on all roads where single axles on Class 13 trailers are routinely carrying heavy loads
13	1	SP M(OH)	0.21	21	This special case comes from Ohio. It differs from the default in three areas. First, it has a very high percentage of very light single axles (more than 35 percent weigh less than 5,000 lb). Second, it has almost 20 percent of loads weighing more than 17,000 lb compared with less than 9 percent for the default, and third, it has more than 7 percent of axles weighing more than the Federal legal limit.	For use in Ohio, where both classification issues place many very light axles in Class 13, and where a high percentage of overloads are observed on Class 13 trucks
13	1	SP VH(OH)	0.55	48	This special case comes from Ohio. This NALS has a high percentage of heavy and overloaded axles. More than 20 percent of axles in this NALS exceed 18,000 lb.	For use in Ohio, where many single axles exceed the Federal legal limit
13	2	VH1(T)	0.87	54	This NALS is recommended as a Tier 2 default. The default NALS has very few light axles. There are two peaks in the axle load distribution. One centers on 22,000 to 24,000 lb and the other centers on 34,000 to 36,000 lb. Roughly 25 percent of tandem axles exceed the Federal legal limit of 34,000 lb.	For use on all roads, with a balance of moderate and heavily loaded axles
13	2	H	0.49	37	This alternative NALS has axles that are not as heavy as found in the default NALS. In this loading pattern, about 17 percent of axles weigh less than 12,000 lb. Only 12 percent of the observed axles exceed the Federal legal limit.	For use on roads where the majority of Class 13 trucks are not fully loaded
13	2	VH2	1.46	58	This alternative NALS differs from the default primarily in that it has a much higher percentage of very heavy axles. More than 40 percent of all axles observed exceed the 34,000 lb Federal limit.	For use on roads where loads Class 13 loads routinely exceed the Federal limits
13	3	VH1(T)	1.12	76	This NALS is recommended as a Tier 2 default. The default NALS contains very few light tridem axles. Fifty percent of the axles in this NALS exceed 48,000 lb.	For use on roads where a large percentage of Class 13 tridem axles are very heavily loaded

Vehicle Class	Axle Type	NALS Cluster	RPPIF	% Heavy Axles	Description	Recommended Use
13	3	H	0.47	28	This alternative NALS is lighter than the default NALS but it still represents a reasonably heavy loading condition. Twenty percent of the axles are lightly loaded (weigh less than 21,000 lb). The peak of the loaded distribution is between 36,000 and 39,000 lb. Only 5 percent of axles exceed 48,000 lb.	For use on all roads where most tridem axles are fully loaded but where overloads are not routine
13	3	VH2	1.76	86	This alternative NALS is even heavier than the default NALS. It contains very few lightly loaded tridem axles. More than 60 percent of the observed axles exceed 48,000 lb.	For use on roads where overloaded tridem axles are very common
13	3	SP H(OH1)	0.44	24	This special case from Ohio has a very large percentage of very light axles (24 percent weighing less than 15,000 lb). Another 36 percent weigh less than 36,000 lb. However, the NALS also has 11 percent of axles weighing more than 50,000 lb, and 1 percent of axles that weigh more than 70,000 lb.	For use only on roads in Ohio, where some tridem axles exceed 70,000 lb
13	3	SP H(OH2)	0.50	31	This special case is also from Ohio. It has a large percentage of light axles. Only 6 percent are lighter than 15,000 lb, but 20 percent are less than 18,000 lb. Seventy percent of these axles are heavier than 30,000 lb, but only 18 percent exceed 42,000 lb.	For use only in Ohio, on roads where few tridem axles exceed 57,000 lb
13	4	VH(T)	0.83	39	This NALS is recommended as a Tier 2 default. The default NALS for Class 13 quad axles is reasonably flat with no loads in the range between 12,000 and 72,000 lb having less than 2.5 percent of the axles or more than 9 percent of the axles. A small peak exists between 18,000 and 21,000 lb, and a second small peak occurs between 60,000 and 63,000 lb. Thirty-five percent of axles weigh more than 57,000 lb.	For use on all roads where Class 13 quad axles are routinely very heavy
13	4	H	0.43	14	This alternative NALS is lighter than the default NALS, but it is still fairly heavy. It contains a higher percentage of lighter quad axles (a peak value near 12 percent) and many fewer very heavy axles (less than 12 percent of axles weigh more than 57,000 lb).	For use on all roads where only a modest percentage of quad axles are very heavily loaded
13	4	SP H(OH)	0.46	21	The special case site in Ohio has a very large fraction (43 percent) of very light axles. These very light axles are offset by the fact that 16 percent of axles weigh more than 69,000 lb.	For use only in Ohio, where vehicles with very light quad axles are being observed

Description of APC Defaults

APC defaults were computed for each vehicle class and axle type based on data from the 26 SPS TPF sites. Averaging the APC values computed for all SPS TPF sites resulted in one set of global default values, shown in table 13.

Table 13. Global default APC based on 26 SPS TPF sites

Vehicle Class	Single	Tandem	Tridem	Quad
4	1.43	0.57	0.00	0.00
5	2.16	0.02	0.00	0.00
6	1.02	0.99	0.00	0.00
7	1.26	0.20	0.63	0.15
8	2.62	0.49	0.00	0.00
9	1.27	1.86	0.00	0.00
10	1.09	1.15	0.79	0.05
11	4.99	0.00	0.00	0.00
12	3.99	1.00	0.00	0.00
13	1.59	1.26	0.69	0.31

The APC global defaults computed from the LTPP SPS TPF data were compared with the defaults developed in the NCHRP1-37A study.⁽⁴⁾ Although some differences were found (especially in classes 11 and 13), these differences were relatively small. The small changes do not result in any significant difference in the required layer thickness or predicted distress for either flexible or rigid pavements. If States have State-specific APC statistics, these should be used in place of the global defaults; otherwise, the global defaults are the best available statistics for use in the MEPDG and DARWin-ME software.

Description of Wheelbase and Axle Spacing Defaults

SPS TPF data were used to investigate the distribution of axle spacing (wheelbase) of the tractor unit of tractor-semitrailer combination trucks for FHWA vehicle classes 8 and above. These statistics can be used to define the categories of “short,” “medium,” and “long” axle spacing that are used in the analysis of jointed plain concrete pavement (JPCP) slab cracking.

Because 15 ft is the most frequently used joint spacing for JPCP design, the following percentages of axles in the short, medium, and long categories should be used as defaults in the MEPDG and DARWin-ME software for 15-ft joint spacing:

- Short (≤ 12 ft): 4.3 percent.
- Medium (>12 and ≤ 15 ft): 16.2 percent.
- Long (>15 feet): 79.5 percent.

If a different joint spacing is used, the values presented in table 14 can be used to compute the correct percentage of short, medium, and long axles for that desired joint spacing.

Table 14. Distribution of axle spacing on tractor units for FHWA classes 8 through 13

Axle Spacing (ft)	Percentage of Axle Spacings on the Tractor Unit
<=7	0.0
>7 and <=8	0.0
>8 and <=9	0.0
>9 and <=10	0.1
>10 and <=11	0.7
>11 and <=12	3.5
>12 and <=13	7.8
>13 and <=14	5.4
>14 and <=15	3.0
>15 and <=16	8.1
>16 and <=17	12.9
>17 and <=18	32.9
>18 and <=19	9.8
>19 and <=20	7.3
>20 and <=21	6.9
>21 and <=22	0.9
>22 and <=23	0.3
>23 and <=24	0.2
>24	0.2

In addition, the MEPDG states that if other vehicles in the traffic stream have the axle spacings in the range of the short, medium, and long spacings defined above, the frequency of those vehicles could be added to the axle spacing distribution of truck tractors. For example, if 10 percent of truck traffic is multiple trailers (Class 11 and above) that have the trailer-to-trailer axle spacings in the “short” range, 10 percent should be added to the percentage of truck tractors that have “short” axles. Thus, the sum of the percentages of trucks in the short, medium, and long categories will be greater than 100. Table 15 shows the results of the analysis of the axle spacing distribution for units other than tractors for vehicle classes 4 through 13 based on the SPS TPF data. These results provide additional insights regarding the vehicle classes that are likely to have axle spacings that could contribute to the development of top-down cracking in JPCP.

Table 15. Distribution of axle spacing by vehicle class using sample of SPS TPF WIM data

Axle Spacing (ft)	Percentage of Axle Spacing by Class									
	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
<=8	37	13	49	66	25	47	62	0	20	50
>8 and <=9	0	1	0	0	3	0	0	2	6	4
>9 and <=10	0	1	0	1	1	0	1	17	11	5
>10 and <=11	0	2	0	3	1	3	1	3	3	3
>11 and <=12	0	12	1	11	2	1	1	2	5	3
>12 and <=13	0	7	2	9	8	1	2	12	2	3
>13 and <=14	0	21	3	3	8	1	2	7	0	2
>14 and <=15	0	12	3	2	4	1	1	2	0	2
>15 and <=16	0	4	6	1	2	2	2	2	2	3
>16 and <=17	0	3	6	0	2	4	2	2	3	3
>17 and <=18	0	4	9	0	4	9	3	4	6	3
>18 and <=19	0	3	6	1	4	3	4	2	2	5
>19 and <=20	0	3	5	0	4	2	2	1	5	4
>20 and <=21	0	4	6	0	6	2	1	6	13	2
>21 and <=22	0	5	2	0	5	0	1	24	8	2
>22 and <=23	1	3	1	0	3	0	0	15	12	1
>23 and <=24	20	1	0	0	1	0	0	1	1	1
>24	42	2	0	0	16	25	15	0	0	5

Description of Default Axle Spacings for Multi-Axle Groups

SPS TPF axle spacing data were used to compute the average axle spacing for tandem, tridem, and quad axle groups. These averages were then compared with current MEPDG defaults. The results are presented in table 16.

Table 16. Average axle spacing for multi-axle groups

Source	Axle Spacing (inches)		
	Tandem	Tridem	Quad
NCHRP 1-37A	51.6	49.2	49.2
LTPP SPS TPF	49.0	50.8	51.8

As table 16 shows, the values are very close. SPS TPF-based averages are slightly lower for tandem axles and higher for tridem and quad axles compared with the current MEPDG default values.

The values based on SPS TPF WIM sites reported in table 16 are recommended for use as the new MEPDG defaults because these values are obtained from accurately calibrated WIM sites.

GUIDELINES FOR SELECTING AXLE LOAD SPECTRA FOR THE MEPDG

Knowledge of Local Traffic Loading Conditions

Before an analyst chooses among the alternative NALS defaults, it is recommended that every effort be made to understand the expected traffic-loading pattern at the site for which default

NALS selections are being made. For example, analysts who work at a State department of transportation can talk to the staff in the department's freight office, individuals involved in collecting truck data, and individuals in the department's maintenance office who actively work on that roadway. Another source of commodity information is Metropolitan Planning Organizations (MPO). Personnel from these agencies often can provide a reasonable description of the truck traffic using a specific road that can be used to identify the most appropriate NALS tables to apply. Topics to discuss include the following:

- Dominant commodities carried by trucks and the types of trucks used.
- Presence of specific directional hauls that may cause one direction of a roadway to be loaded heavily and the other to be lightly loaded.
- Routine axle weight of tridem and quad axles of classes 7, 10, and 13 trucks in the State.
- Percentage of through trucks versus local delivery trucks.
- Truck sizes and weight laws of different States (which can result in different truck body/configurations for the same FHWA truck class).
- Presence and effectiveness of weight enforcement activities.
- Number of roadway lanes.

This information should be used to establish a descriptive understanding of the traffic loading conditions for at least the dominant heavy vehicle classes observed at the site ("dominant" is defined at the end of this subsection). The intent is to learn whether the trucks producing the majority of traffic load at this site are loaded, unloaded, or an even mix of these two conditions. This will help determine whether they are of "typical" or "usual" weight, or whether they are heavier or lighter than typical, which in turn helps the analyst choose between the Tier 2 default NALS options. Table 3 through table 12 can help the analyst select specific Tier 2 default NALS based on this information. The guidance from these tables is also built into the LTPP PLUG Interactive Traffic Library Database. In addition to defaults created using SPS TPF data, State agencies may choose to put their own default NALS into the PLUG Library Database, including their own information for tables 3 through 12.

Determination of the Dominant Truck Classes

In the selection of NALS defaults, the most care should be applied in selecting the appropriate default for the *dominant* truck class. The dominant trucks for a given site are those that apply the largest percentage of the total traffic load at that site. (That is, the truck classes that are expected to cause a large amount of the expected pavement damage.) "Dominant" is a function of both the volume of a class of trucks and the expected pavement damage each truck causes. Dominant trucks generally are heavy trucks, and they generally contribute a high percentage of the total truck volume.

The LTPP PLUG software provides several methods to determine dominant truck classes. One such method is described below. Table 17 demonstrates how to estimate the percentage of total load (or load-related damage) carried by each truck class for determining the most dominant truck classes at a site. This table uses RPPIF per truck values as a simplified measure of the expected amount of damage caused by each truck. It is not meant to be used for direct damage or distress prediction but rather to rate the relative importance of loads from the perspective of their potential to cause damage to the pavement. These values are shown in the third column of the table. Analysts may replace the values in this column with their own statistics for “damage per truck.” For example, they can insert conventional ESAL/truck values.

Table 17 is an example of how to compute dominant truck classes. To use a table like table 17, determine the percentage of truck traffic for FHWA vehicles in classes 4 through 13 that uses the pavement sections being analyzed. Place these values in the second column of the table. Multiply the value in the second column by the value in the third column and place this value in the fourth column. This is a measure of the relative damage each class of trucks will apply at this site. In the fifth column, convert the value in the fourth column to a percentage of that total traffic load by dividing each value in the fourth column by the total of the fourth column. The “dominant truck class” is the class of trucks that has the highest percentage of the estimated load. In the example shown in table 17, Class 9 is the dominant truck class because no other class of trucks produces more than 12 percent of the total estimated load. All classes that provide more than 25 percent of the traffic load should be considered dominant classes.

To use a table like table 17 effectively, and to perform a good pavement analysis, the analyst should have access to site-specific truck volume data. These data can be collected at almost any pavement analysis section in the United States at a cost that is small relative to their importance in the pavement analysis process. (The vast majority of LTPP test sections have valid, accurate vehicle classification count data.)

Table 17. Example of computing dominant truck classes

Vehicle Class	Percentage of Truck Traffic	RPPIF/Truck	Load Applied by Truck Class (Percentage of Truck Traffic times RPPIF/Truck)	Percentage of Total Load Applied by Class
4	5	0.60	0.0302	5.9
5	40	0.08	0.0317	6.2
6	6	0.50	0.0303	5.9
7	2	0.53	0.0107	2.1
8	4	0.34	0.0138	2.7
9	36	0.93	0.3339	65.2
10	1	0.53	0.0053	1.0
11	3	0.67	0.0200	3.9
12	1	0.46	0.0046	0.9
13	2	1.58	0.0316	6.2

Applying What the Analyst Has Learned About Truck Loads

The questions that the analyst asks those in the traffic data collection, freight mobility, and maintenance groups are intended to give him or her an understanding of where unloaded, loaded,

and over-loaded trucks are operating. Because different kinds of trucks carry different kinds of commodities, loaded, unloaded, and overloaded conditions may vary considerably among types of trucks on a single road. For example, on one road, long haul Class 9 tractor-semitrailers may be operating fully loaded, but rarely overloaded, because they routinely pass port of entry enforcement stations at the State borders. At the same time, natural resource haulers on that same road may frequently be operating in an overloaded condition because their trips are a shorter distance and that distance does not include passing a weight enforcement site.

Insight into the commodities carried on the road helps determine whether loaded trucks are expected to be near the Federal legal limit. Some commodities, such as general household goods or computer parts, tend to be light. These goods “fill up” a truck or container (bulk out), but the “full” truck’s axles do not reach the Federal legal limit. (For example, most consumer packages have large amounts of packaging to protect the contents. This makes the packages large but relatively light, filling up the trailer box but not heavily loading the truck’s axles.) Other commodities can be quite heavy. For example, frozen food shipped from eastern Washington to the Port of Seattle in containers are very heavy loads. Little packaging is needed and the foods are tightly packed, resulting in very dense containers, and thus heavy axle loads.

If it is known that the pavement analysis section is on a road that carries heavy natural resource loads—and this direction of traffic is the direction that carries the loaded natural resource trucks—then the analyst should select a heavy NALS for the class of trucks used to carry heavy natural resources in that State. If, on the other hand, the side of the road that contains the analysis segment carries the unloaded trucks returning to pick up more natural resources, the analyst should select one of the lighter Class 6 or Class 10 NALS and a moderate Class 7 and/or Class 10 NALS.

Another key question for the analyst to learn about natural resource hauls is what kind of trucks most commonly carry natural resources on that road and what kinds of axle loads are present. In some parts of the country, Class 7 is the primary natural resource hauler. In other parts of the country, Class 10 trucks fulfill this role. In either case, it is also important to understand the common axle weights that these trucks exhibit when loaded. In some parts of the country, these trucks are renowned for having overloaded axles. In other parts of the country, these loads are maintained near the legal limits owing to tight enforcement and specific truck size and weight regulations. The Tier 2 NALS provide a number of different loading conditions for these trucks and discussing likely loading conditions for them with knowledgeable State traffic data personnel increases the accuracy of the NALS selected for these trucks and axle types.

Most trucks hauling natural resources do not travel very long distances. (Natural resources are generally shipped by rail for long distance hauls.) However, many truck classes do operate in long haul, urban delivery, and single-day return modes of operation. These kinds of operating patterns affect how often a truck is observed as being loaded, partially loaded, or empty.

Trucks that operate over very long distances (more than 1 day’s travel) tend to operate loaded during the vast majority of time. The longer the distances traveled, the more likely the truck is full (although its axles may still be well below legal Federal axle load limits if it is carrying bulky cargo) because the economics of trucking are such that the cost of finding a return load is lower than the cost of traveling a long distance empty. However, if a roundtrip can be made in

1 day, the likelihood that such the truck is full in one direction and empty in the other increases considerably. This is simply because the labor cost of waiting for a return load can be high relative to the cost of driving back to base. Similarly, in urban areas, delivery trips that start and end at a terminal are commonly full at the start of the trip, partially loaded during the middle of a trip, and empty by the end of the trip.

When considering these operating conditions together, and looking at the loading patterns for truck classes 8, 9, 11, 12, and 13 (but usually not Class 10), it becomes clear why it is important to understand the percentage of through trips versus local delivery trips made. Each of these truck classes is commonly used for both local delivery and long haul trips. The greater the percentage of local delivery (and single-day return) movements occurring on a road, the higher the percentage of light axles should be in the selected NALS. On the other hand, the greater the percentage of through traffic, the smaller the percentage of lightly loaded axles. These conditions reach their extreme on roads like I-10 near the New Mexico/Arizona border. Because there are few local destinations in this area, almost all truck traffic on I-10 is loaded.

Finally, the size and weight laws in place in the State, and the degree to which those laws are enforced on that road, are useful information for the analyst. In some cases, States routinely allow additional axle loads on specific styles of trucks to meet the needs of important State-specific industries. Similarly, there are some commodity movements that are renowned for being overloaded (e.g., some coal movements have this reputation). When these conditions are known to exist, the analyst can select Tier 2 NALS that feature larger percentages of axles that exceed the Federal axle weight limits.

Selection of NALS

Once an analyst understands the basic truck volumes at a site and has obtained the available knowledge on the truck loading conditions, especially for the dominant truck classes, table 3 through table 12 could be used to identify NALS best representing identified loading conditions. To facilitate the selection of Tier 2 NALS, information from these tables has been included in the LTPP PLUG database and software application. Details are provided in the appendices of this guide.

For vehicle classes where no loading conditions are identified because of lack of knowledge or because these classes carry a low percentage of the total volume, it is recommended that analysts use the SPS TPF NALS defaults (either Tier 1 or Tier 2).

MEPDG Sensitivity Test

When NALS defaults are used, and if time and resources permit, the analyst is strongly encouraged to run at least some sensitivity tests of the MEPDG analysis outputs, especially if very limited knowledge of loading conditions exists. The minimum recommended sensitivity tests include two runs. Both are performed by keeping all inputs the same except the NALS. The first test substitutes a heavier Tier 2 NALS than the initial default NALS for the dominant trucks in the design. The second test substitutes a lighter Tier 2 NALS for the dominant trucks classes using the site.

The sensitivity test is intended to simply increase and decrease the total load applied to determine whether the MEPDG outputs for a particular design change significantly based on changing traffic load. If they do, then the analyst can decide how conservative a design to build, given the uncertainty in the traffic loading.

Limitations of Loading Cluster NALS Defaults

The Tier 1 and Tier 2 defaults are useful estimates when site-specific information is not available. However, because they were developed from only 26 WIM sites in 23 States, and all of those sites are LTPP test sites (which means they tend to be on larger roads), they are not truly representative of all the locations at which traffic loading estimates are needed. The small number of SPS TPF WIM sites also limits the geographic scope of the weight data. These estimates may not be representative of specific roads in specific States where loading conditions are dominated by State regulations or specific commodity movements that differ from national norms. When State- or site-specific trucking movements dominate the use of a road, those roadways may experience loading conditions that are different than those observed in the SPS TPF data. Consequently, when analysts believe that these State-specific conditions are present, they are encouraged to (1) work with their State to develop State-specific NALS defaults, (2) talk to their State's traffic data collection personnel to gain more insight into which loading patterns to apply, and (3) perform sensitivity tests of the MEPDG outputs using a variety of different NALS.

MEPDG TRAFFIC INPUTS BEYOND AXLE LOAD SPECTRA

The estimation of traffic load requires a number of factors in addition to the NALS, including:

- Truck volumes distributions for classes 4 through 13.
- Expected rate of truck traffic growth for future pavement performance prediction (or back-casted traffic for analysis of historical pavement performance data).
- Distribution of truck traffic by time of day.
- Distribution of truck traffic by month of the year.
- Distribution of truck traffic by lane and by direction.

States are encouraged to develop their own defaults or site-specific values for these statistics.

Although truck volumes will change with the national economy, State economic growth will likely have an even greater impact on truck traffic on most roads. Truck volume time of day distributions are easily collected as part of site-specific truck volume counts. Truck travel distributions are important in States where truck travel varies by season and are especially important where seasonal environmental changes significantly affect material properties. (That is, it is especially important to understand how truck volume patterns change during the year in States with significant freeze-thaw conditions.) All of these data are available to some degree in the LTPP traffic database, but additional information on these factors should also be available through State sources.

PART II—GUIDELINES FOR DEVELOPING AXLE LOADING DEFAULTS

INTRODUCTION

Although the SPS TPF data provide an improved set of traffic loading defaults compared with the original MEPDG defaults because they were collected with better calibrated WIM equipment, the SPS TPF data, by necessity, represent national conditions. Unfortunately, many truck characteristics differ markedly from State to State. Consequently, if a State operates well-calibrated WIM scales, summarizing the data obtained from those scales can provide default truck characteristic data that are more accurate for designs in that State than if national defaults are used. Therefore, States are encouraged to develop and apply their own NALS and other truck characteristics when their WIM data have been carefully checked for quality assurance (QA) and found to be accurate.

Analysis of WIM data from the LTPP program indicates that axle loading distributions vary among different axle types, different truck types (vehicle classes), and different roadways. Differences in axle load spectra between different axle types can, in part, be attributed to a variety of factors related to different truck configurations, including differences in:

- Axle configuration.
- The legal axle load limits that apply to single, tandem, tridem, and quad axles.
- Truck body structure needed to carry different commodities (e.g., flatbeds versus tanks versus basic cargo boxes).
- Vehicle length and the number of units (single unit versus multiple units) pulled by the truck's power unit.
- The purpose of an axle (steering or load-carrying axle).

Even for the same vehicle class and axle type, axle weights vary based on local conditions for reasons such as:

- Differences in truck size and weight laws between States.
- Presence and effectiveness of weight enforcement activities.
- Dominant commodities carried by specific classes of trucks on each road (e.g., a standard five-axle tractor semitrailer weighs much more when carrying a full load of wood chips than it does carrying a full load of computer parts shipped with large amounts of padding).
- Number of roadway lanes (outer lanes typically are loaded more heavily than inner lanes on multilane roads).

In addition, the percentage of trucks carrying full or partial loads versus those returning empty to a terminal is a function of the type of trucking movement, the type of commodity hauled, and the

location of the road segment being analyzed. Factors that can significantly affect the percentage of loaded trucks observed include:

- Percentage of long haul trucking movements occurring versus the percentage of local delivery movements.
- Proximity of the roadway to urban areas (roads in or near urban areas are more likely to see partial or empty loads).
- Nature of the commodities hauled on the road (e.g., most trucks carrying natural resources operate loaded in one direction and empty in the other).
- Lane of traffic monitored (heavier trucks are more frequently in the outside lanes).

Local site conditions are more likely to have a significant effect on load spectra for locations that have a high percentage of local traffic and a low percentage of through traffic (i.e., traffic that is generated from far away, especially when that through traffic must cross State boundaries).

HOW TO CAPTURE DIFFERENCES IN AXLE LOADING IN DEFAULTS

The key to successful development of NALS defaults is an understanding of differences in loading conditions within the road network for which defaults are being developed. This guide emphasizes the need to identify different trucking patterns and collect data on those patterns to develop an understanding of the NALS associated with those patterns. State agency personnel need to work with their freight community to accomplish this task. Once loading conditions are identified, the number of WIM sites that should be used to develop a default NALS could be determined based on observed variability in loading data.

This guide does not prescribe the number of WIM sites that should be used to develop a default NALS. This information can be found in the FHWA's *Traffic Monitoring Guide* and NCHRP Reports 538, *Traffic Data Collection, Analysis, and Forecasting for Mechanistic Pavement Design*, and 509, *Equipment for Traffic Load Data*.^(3,5,6) In general, it is advisable to use all available WIM sites in development of the defaults, provided that these sites have data that satisfy the data selection criteria described in the following section.

At the same time, to keep this data analysis task manageable, those developing and applying the default NALS should focus on the truck and loading patterns that will significantly affect the outcome of the pavement analysis—in other words, the dominant vehicle classes. For example, if one type of truck carries a highly variable load (axles on these trucks can be very heavy or not too heavy), but only 1 of 1,000,000 trucks is of that truck type, then it is not necessary to spend much time or effort understanding when and where this specific truck type occurs, or what it weighs when it is observed. On the other hand, if 9 of 10 heavy trucks are of a specific type in a given State, understanding the differences in load carried by these trucks, and being able to correctly select the loading condition occurring on specific road segments, is very important. Alternatively, if a specific truck type never carries heavy weights, it is not important to understand the variation in that type of truck's weights, even if the percentage of variation is large. (That is, the analyst does care whether truck axles vary from 2,000 to 4,000 lb, even

though that is a 100-percent variation, because neither of these axles will cause significant pavement damage.) In both the case of the “rare truck type” and the case of the “very light truck type,” significant amounts of variability are acceptable simply because the effects of that variability will have little effect on the pavement analysis.

For the majority of the LTPP sites (and the majority of U.S. primary roads), Class 9 is the dominant heavy vehicle type and is responsible for a very high percentage of the traffic load applied to pavements. Therefore, when developing and applying NALS, a special effort should be made to identify different loading conditions for Class 9 vehicles. While Class 5 vehicles are frequently dominant in terms of truck volume, they normally are not heavy enough to make a significant contribution to total traffic loading and thus may be excluded from determination of the dominant heavy vehicle classes (unless local knowledge exists of heavier-than-usual Class 5 vehicles at the site).

Finally, it is advised that when NALS are developed, they should be accompanied by descriptive information about the loading conditions to help users correctly identify the NALS that should be applied for any given analysis. In this guide, these descriptions begin with the identification of the “typical” loading condition. This represents the most commonly observed loading condition. This designation serves as a useful starting point in selecting a NALS. Alternative NALS are then defined as lighter or heavier than the default, meaning that trucks exhibiting these alternative patterns will cause less or more pavement damage than trucks exhibiting the pattern most commonly observed. These designations are meant to help analysts select the appropriate NALS and understand whether the NALS they are using will provide a particularly conservative design.

It is also recommended to use all available loading information (both quantitative and qualitative) when assigning the available default loading conditions to specific pavement analysis sections.

APPROACH FOR DEVELOPMENT OF AXLE LOADING DEFAULTS

Two types of NALS defaults are frequently used with MEPDG applications. Each of these types of defaults should be computed at the State level whenever possible:

- Tier 1, or global, defaults representing statewide or nationwide default loading conditions.
- Tier 2, or alternate, defaults representing specific loading conditions. These defaults are developed from, and assigned to, groups of roads that have common loading conditions for specific truck class–truck weight road groups.

As described in Part I, Tier 1 NALS defaults are used for sites that have no information regarding expected traffic loading patterns on a specific pavement analysis segment. These defaults represent an average traffic loading condition observed at all sites used in the development of the default. The benefit of Tier 2 defaults is that they provide multiple choices for selecting traffic loading conditions for different truck classes and axle types. Appropriate

selection of these defaults requires some knowledge about the expected traffic loading condition at the pavement design site.

In some cases, Tier 2 roads can be grouped and/or identified based on regional trucking patterns that affect the nature of truck loads carried on those roads. For example, a “regional pattern” might be based primarily on the commodity routinely carried on the road (coal, cut trees, specific agricultural products), or “regional” may simply refer to roads that are or are not in proximity to large metropolitan areas (rural versus urban). Some truck weight road groups and regional designations may only apply to specific classes of trucks. For example, the “coal region” in a midwestern State may only apply to Class 7 and Class 10 trucks, because other truck classes (e.g., Class 9) may not be involved in the specific commodity movements identified by the group or regional designation. This also means that more than one “truck weight group” may need to be applied for any given pavement analysis to reflect the different loading patterns applied by different classes of trucks.

In addition, the availability of Tier 2 defaults allows easy testing of the sensitivity of the pavement analysis outcomes to differences in NALS inputs. That is, the user can perform two different runs, one using the selected NALS and one using a heavier NALS. The differences in the analysis outcomes provide the analyst with considerable insight into the consequences of using different NALS for pavement design.

The development of MEPDG traffic-loading defaults starts with the selection of WIM sites that satisfy specific data selection criteria, followed by the development of representative NALS for each of the sites with data that meet those criteria. Then, NALS from selected individual sites (or all the sites, in the case of global defaults) are averaged to compute Tier 1 default NALS or grouped in clusters with similar loading characteristics and averaged for each cluster group. Based on this approach, the methodology for development of the MEPDG traffic loading defaults includes the following sequence of tasks:

1. QA testing of available WIM data and selection of sites.
2. Development of site-specific representative NALS for all selected WIM sites.
3. Development of one set of global defaults using data for all selected WIM sites (Tier 1).
4. Development of supplemental sets of NALS using subsets of data for sites with similar loading conditions (Tier 2).

Guidelines to accomplish these tasks are described in the following sections.

DATA SELECTION AND DEVELOPMENT OF RANALS FOR INDIVIDUAL SITES

MEPDG NALS are produced by vehicle class and axle type for a typical day of a month. Each NALS represents the expected frequency with which an axle within each specified load range will be encountered for that vehicle type and class of axle.

Because seasonal changes in axle load frequency distributions are not uniform across different States and are likely to be observed only on the roads that carry a large percentage of seasonally

affected loads, national default NALS values are developed to represent axle load frequency distributions for a typical day of the year. These distributions are called “representative annual normalized axle load spectra,” or RANALS. If truck loads change seasonally owing to truck volume changes, monthly adjustment coefficients are used to adjust truck volumes between different months. If a State has a group of roads subject to seasonal changes in load distribution frequencies, default NALS should be developed to represent each month or season in the year.

Data Selection Criteria for Development of Site-Specific Representative NALS

These guidelines address WIM data requirements to develop representative site-specific NALS for computation of the default NALS. To take full advantage of the available WIM data, the data selection criteria focus on maximizing the use of available data without compromising the quality of MEPDG defaults. WIM data selection criteria address the following data selection categories:

- Data availability: maximized use of available data that satisfy data quality criterion.
- Data quality: identification and utilization of reliable, high-quality axle loading data.
- Data reasonableness: identification of data that are not only accurate but also represent typical/expected conditions for a given site or a group of sites that have similar traffic-loading patterns.

The following conservative minimum data availability criteria were identified to remove any potential day-of-the-week (DOW) and monthly bias from the computation of RANALS for individual WIM sites:

- Availability of at least 1 of each 7 DOW per month to avoid potential DOW bias. Days do not need to be consecutive.
- Availability of at least 1 of each 12 calendar months to avoid potential seasonal bias. Months do not need to be consecutive or from the same calendar year.

These minimums were developed through a number of statistical analyses designed to evaluate the reliability of computed NALS using different data quality and availability scenarios.

When more than 7 DOWs per month or more than 12 calendar months of acceptable quality data are available, all available data for that site should be used in the computation of site-specific RANALS. If less than these minimums are present, the lack of data may create bias in the RANALS such that they underestimate the effects of loading patterns missing from the data. For example, if no data are present from the spring months owing to equipment failure, and loads are lighter in the spring months than during the rest of the year owing to spring thaw load restrictions, the RANALS will overestimate the average loading condition. Similarly, in urban areas, weekend loads may be heavier than weekday loads as the percentage of through traffic to local traffic increases.

The following acceptable data quality criteria were identified for RANALS to be used in the LTPP project:

- Data should be from a WIM site conforming to ASTM (ASTM International, formerly American Society for Testing and Materials) 1318 specification for Type I WIM system accuracy and performance requirements specified in the LTPP SPS Field Operation Guide.^(7,8)
- Selected data must pass quality review using LTPP QC procedures for the SPS TPF study and be identified as Level E data in the LTPP database.⁽⁹⁾

States developing NALS default tables for their own use are encouraged to follow these same data quality standards but are not expected to follow LTPP reporting requirements. It is also advisable to limit the maximum acceptable bias in axle weight measurements to less than 5 percent to avoid significant differences in MEPDG outcomes owing to bias in axle weight data.

In addition to the basic quality of the data and the number of days for which data are available at each site, data from specific sites should be evaluated for reasonableness for inclusion in default NALS used to represent the traffic load expected to occur on other roads in a State. In some circumstances, data may be valid but (1) are atypical because of atypical conditions that occurred at a site (for example, a 6-month-long, temporary load restriction imposed during bridge construction downstream of the data collection site); (2) truck volumes for a particular vehicle class are so low, given a specific truck class distribution at the site, that data are not sufficient to produce a representative axle load spectrum for some vehicle classes; or (3) the loading pattern observed at a site is significantly different from other sites owing to unique truck traffic generators in the vicinity of the site.

In the first two conditions, data for vehicle classes affected by the loading restriction are not suitable for use in default RANALS. In the first case, the data are not representative of “normally observed” loading conditions. In the second case, the very low frequency of vehicles makes the values in the RANALS unstable statistically. When averaged with other RANALS, these few axles have too much impact on the NALS for any group in which they are placed. For example, if only four axles are measured at a site and two fall into one load range in the NALS, that load range contains 50 percent of all axles in the RANALS for that site. When averaged with any other set of RANALS, the 50-percent value badly biases the computation of the average percentage of axles that fall into that load range.

In the third case, the RANALS should not be included in a load group with data from other sites. Instead, it should be treated as a “special case.” This means that a “special case” description of why it is unique should be developed for that condition so that it can be used in pavement analysis when other pavements also experience that condition.

All of these data would be useful for site-specific MEPDG analysis but should not be used for creation of generalized defaults, which are designed to represent typical traffic loading conditions for sites without site-specific axle load spectra.

Procedure for Development of RANALS Estimates

The following procedure describes the steps for developing RANALS using daily axle load spectra stored in a format consistent with LTPP LTAS DD_AX tables:

1. Identify all sites for which the available data meet the selection criteria of having data for at least 7 DOWs, for each calendar month, and at least 12 calendar months. These data must have passed the LTPP SPS TPF QC checks for data and performance of the WIM equipment. They must also pass the data reasonableness checks described in the LTPP report *MEPDG Traffic Loading Defaults Derived from LTPP Transportation Pooled Fund Study*.⁽¹⁰⁾
2. Extract daily axle load spectra from the LTPP LTAS DD_AX tables for all years and months from all sites that were identified in the previous step, where the resulting data are expressed as daily axle load counts by weight bin.
3. For each site, compute axle load spectra representing the typical day of the month for each month, by year, axle type, and vehicle class (classes 4 through 13). The daily axle load spectra should be averaged first by DOW and then across DOWs to produce an unbiased monthly axle load spectra (as representative loading for a day of the month for a given year) for each vehicle class, axle type, month, and year.
4. For each site, year, month, axle type, and vehicle class, normalize the axle load spectra representing the typical day of the month to obtain monthly NALS.
5. For each site, axle type, vehicle class, and calendar month (January through December), compute average monthly NALS (as representative loading for a day of the month) by averaging data across all available years. This will result in 12 representative monthly NALS for each calendar month, axle type, and vehicle class for each site.
6. For each site, axle type, and vehicle class, average the 12 monthly NALS. This will result in one RANALS representing the typical day of the year for each axle type and vehicle class for each site.

Each set of RANALS includes a normalized axle load spectrum for each vehicle class (for classes 4 through 13) and each axle type (single, tandem, tridem, and quad as applicable) representing the expected axle loading distribution for a typical day of the year for that site.

DEVELOPMENT OF GLOBAL NALS DEFAULTS (TIER 1)

Overview

The purpose of the global NALS defaults is to serve as input to the MEPDG when very little or no information about existing or expected future traffic loading patterns is available for a design site. Global NALS defaults follow the exact format of the original MEPDG defaults and can be implemented easily. These defaults are based on averaging RANALS from all the WIM sites that have sufficient data.

Procedure for Development of Global NALS Defaults (Tier 1)

This procedure is based on averaging RANALS from the WIM sites that have sufficient data. To avoid biasing NALS as a result of unstable load spectra distributions caused by very low axle counts (which are considered insufficient to define a load spectra frequency distribution for a given class and axle), if a site has fewer than 100 axles and/or an APC of less than 0.01, that site should not be included in the computation of global NALS defaults for that vehicle class and axle type.

The computational steps and data availability criteria are presented below:

1. Obtain RANALS for all sites that satisfy the data selection criteria presented in this guide.
2. For each vehicle class and axle type, exclude from further computations RANALS that are based on very low axle counts, using the following criteria:
 - RANALS that are based on very low axle counts (fewer than 100 axles and/or axles per class less than 0.01).
 - RANALS representing highly unusual or unique loading conditions that are not likely to be encountered on road classes where global defaults will be used.
3. For each vehicle class and axle type, average the available RANALS.
4. Save the results in a table format provided in the LTPP PLUG database (see appendix B).

DEVELOPMENT OF ALTERNATE NALS DEFAULTS REPRESENTING ALTERNATIVE AXLE LOADING CONDITIONS (TIER 2)

This section provides guidelines for States to use their own WIM data to develop NALS representing different loading conditions within the State for use with the MEPDG and DARWin-ME software. NALS representing different loading conditions within the State's road network provide flexibility to MEPDG users in the selection of axle loading defaults so that they can more accurately describe their local loading conditions.

Tier 2 NALS are designed to be used independently to specify different truck loading conditions by class and axle type. For example, a pavement designer may select a "heavy" axle load spectrum for Class 9 vehicles but a "light" load spectrum for Class 6 vehicles because those loading conditions are appropriate for the truck traffic using the roadway they are designing.

Methodology for Grouping WIM Sites With Similar Loading Conditions

To create Tier 2 NALS, the site-specific RANALS should be grouped in clusters based on similarities in the axle loading conditions. For each cluster, alternative default NALS should be computed for each vehicle class and axle type in such a way that there is a high probability that the use of these alternative NALS will result in a significant differences in the expected pavement life or design thickness predictions.

The grouping of site-specific NALS into Tier 2 defaults should be done separately for each class and axle type. That is, just because tandem axles for Class 9 trucks from sites 1 and 2 are shown to belong to the same Tier 2 NALS does not mean that tandem axles for Class 10 trucks from those same two sites should also be placed together in a default NALS.

The recommended way to create Tier 2 NALS is to use the hierarchical clustering technique, available in most statistical software packages, to group RANALS from State WIM sites that have similar pavement damaging potential. Step-by-step instructions are given below. The methodology and detailed analysis behind this procedure are presented in chapters 8 through 10 of the LTPP report, *MEPDG Traffic Loading Defaults Derived from LTPP Transportation Pooled Fund Study*.⁽¹⁰⁾

Procedure for Development of NALS Defaults Representing Different Loading Conditions

The procedures described below are based on the methodology described in the LTPP report, *MEPDG Traffic Loading Defaults Derived from LTPP Transportation Pooled Fund Study*.⁽¹⁰⁾ Other mechanisms to group load spectra into “similar” groups are also possible. The steps required to create Tier 2 NALS are as follows:

1. Ensure that the WIM data used to compute State-specific defaults come from data collection equipment that is calibrated and functioning properly.
2. Develop RANALS for each site.
3. Using the RANALS, compute an RPPIF summary statistic associated with each load spectrum that takes into account both the pavement damage potential of different axle load weights and the frequency of the application of those loads (i.e., the fraction of loads of a given magnitude in the axle load spectra).
4. Determine the importance of each vehicle class and axle type based on the frequency with which specific classes of vehicles are observed and the loading characteristics of those vehicles (i.e., identify types of trucks that cause heavy damage to the pavement because of their weight and volume).
5. Determine the sensitivity of the MEPDG to the variation inherent in the truck fleets observed by the agency, given the pavement design philosophy of the agency, and establish maximum RPPIF differences for cluster analysis.
6. Perform a cluster analysis of the RPPIFs (by vehicle class and type of axle) using the output of the sensitivity of the MEPDG as a guide for determining when to stop the clustering process.

The first two steps above were discussed as part of constructing the Tier 1 default NALS. Each of the remaining steps is described below.

Step 3: Compute RPPIF Statistics Using RANALS

The RPPIF summary statistics were used in the creation of the new national default NALS based on SPS TPF data. The intent of the RPPIF is to allow simple summary comparisons of the size of different loading conditions by providing a single statistic associated with each load spectrum. RPPIF is computed by taking into account both the pavement damage potential of different axle load weights and the frequency of the application of those loads (i.e., the fraction of loads of a given magnitude in the axle load spectra). It is computed using the *W*-factors shown in table 18. These factors provide a generic measure of the relative pavement damaging potential caused by axles of specific weights and configurations, as determined through MEPDG analysis in the report, *MEPDG Traffic Loading Defaults Derived from LTPP Transportation Pooled Fund Study*.⁽¹⁰⁾

The RPPIF statistic is used to identify axle loading conditions within each vehicle class and axle type that are likely to produce significantly different MEPDG outcomes. States wishing to group “similar” RANALS using other criteria are welcome to do so.

To compute the RPPIF statistics, use the equation shown in figure 1. Start with the RANALS computed for each vehicle class and axle type. For each of those RANALS, multiply the load frequency corresponding to each load bin in those load spectra by the corresponding *W*-factor from table 18. Sum these values across all load bins (*i* = 1 to *n*) for that load spectra.

$$RPPIF_{jk} = \sum_{i=1}^n (F_{ijk} * W_{ij})$$

Figure 1. Equation. Computation of RPPIF statistics

Where:

$RPPIF_{jk}$ = relative pavement performance impact factor for axle type *j* and vehicle class *k*

i = load bin

j = the type of axle

k = the class of vehicle

W_{ij} = the impact factor for load range *i*, for axle type *j* from table 18

F_{ijk} = the fraction of axles in load range *i*, for axle type *j*, and vehicle class *k*

Table 18. Pavement performance impact factors, W_{ij}

Load Bin	Single Axle		Tandem Axle		Tridem Axle		Quad Axle	
	Load Range (lb)	Weight Factor	Load Range (lb)	Weight Factor	Load Range (lb)	Weight Factor	Load Range (lb)	Weight Factor
BIN 01	0–2,999	0.00	0–5,999	0.00	0–11,999	0.00	0–11,999	0.00
BIN 02	3,000–3,999	0.00	6,000–7,999	0.00	9,000–11,999	0.00	9,000–11,999	0.00
BIN 03	4,000–4,999	0.00	8,000–9,999	0.00	12,000–14,999	0.00	12,000–14,999	0.00
BIN 04	5,000–5,999	0.00	10,000–11,999	0.00	15,000–17,999	0.04	15,000–17,999	0.00
BIN 05	6,000–6,999	0.00	12,000–13,999	0.01	18,000–20,999	0.09	18,000–20,999	0.02
BIN 06	7,000–7,999	0.00	14,000–15,999	0.04	21,000–23,999	0.15	21,000–23,999	0.05
BIN 07	8,000–8,999	0.02	16,000–17,999	0.08	24,000–26,999	0.21	24,000–26,999	0.09
BIN 08	9,000–9,999	0.04	18,000–19,999	0.14	27,000–29,999	0.28	27,000–29,999	0.14
BIN 09	10,000–10,999	0.08	20,000–21,999	0.22	30,000–32,999	0.35	30,000–32,999	0.20
BIN 10	11,000–11,999	0.12	22,000–23,999	0.30	33,000–35,999	0.43	33,000–35,999	0.27
BIN 11	12,000–12,999	0.18	24,000–25,999	0.40	36,000–38,999	0.53	36,000–38,999	0.34
BIN 12	13,000–13,999	0.24	26,000–27,999	0.51	39,000–41,999	0.64	39,000–41,999	0.42
BIN 13	14,000–14,999	0.31	28,000–29,999	0.62	42,000–44,999	0.76	42,000–44,999	0.52
BIN 14	15,000–15,999	0.40	30,000–31,999	0.75	45,000–47,999	0.92	45,000–47,999	0.62
BIN 15	16,000–16,999	0.49	32,000–33,999	0.89	48,000–50,999	1.10	48,000–50,999	0.73
BIN 16	17,000–17,999	0.59	34,000–35,999	1.04	51,000–53,999	1.32	51,000–53,999	0.85
BIN 17	18,000–18,999	0.71	36,000–37,999	1.21	54,000–56,999	1.58	54,000–56,999	0.99
BIN 18	19,000–19,999	0.85	38,000–39,999	1.40	57,000–59,999	1.90	57,000–59,999	1.14
BIN 19	20,000–20,999	1.01	40,000–41,999	1.63	60,000–62,999	2.27	60,000–62,999	1.30
BIN 20	21,000–21,999	1.19	42,000–43,999	1.90	63,000–65,999	2.71	63,000–65,999	1.47
BIN 21	22,000–22,999	1.41	44,000–45,999	2.23	66,000–68,999	3.22	66,000–68,999	1.66
BIN 22	23,000–23,999	1.67	46,000–47,999	2.63	69,000–71,999	3.82	69,000–71,999	1.87
BIN 23	24,000–24,999	1.99	48,000–49,999	3.13	72,000–74,999	4.51	72,000–74,999	2.10
BIN 24	25,000–25,999	2.38	50,000–51,999	3.74	75,000–77,999	5.30	75,000–77,999	2.35
BIN 25	26,000–26,999	2.85	52,000–53,999	4.49	78,000–80,999	6.20	78,000–80,999	2.63
BIN 26	27,000–27,999	3.43	54,000–55,999	5.42	81,000–83,999	7.22	81,000–83,999	2.93
BIN 27	28,000–28,999	4.12	56,000–57,999	6.56	84,000–86,999	8.37	84,000–86,999	3.26
BIN 28	29,000–29,999	4.96	58,000–59,999	7.95	87,000–89,999	9.66	87,000–89,999	3.62
BIN 29	30,000–30,999	5.97	60,000–61,999	9.64	90,000–92,999	11.09	90,000–92,999	4.02
BIN 30	31,000–31,999	7.18	62,000–63,999	11.67	93,000–95,999	12.68	93,000–95,999	4.46
BIN 31	32,000–32,999	8.62	64,000–65,999	14.11	96,000–98,999	14.44	96,000–98,999	4.94
BIN 32	33,000–33,999	10.33	66,000–67,999	17.00	99,000–101,999	16.37	99,000–101,999	5.47
BIN 33	34,000–34,999	12.35	68,000–69,999	20.43	102,000–104,999	18.48	102,000–104,999	6.06
BIN 34	35,000–35,999	14.72	70,000–71,999	24.47	105,000–107,999	20.78	105,000–107,999	6.71
BIN 35	36,000–36,999	17.48	72,000–73,999	29.19	108,000–110,999	23.28	108,000–110,999	7.42
BIN 36	37,000–37,999	20.70	74,000–75,999	34.68	111,000–113,999	25.98	111,000–113,999	8.20
BIN 37	38,000–38,999	24.41	76,000–77,999	41.04	114,000–116,999	28.90	114,000–116,999	9.06
BIN 38	≥ 39,000	28.70	≥ 78,000	48.37	≥ 117,000	32.03	≥ 117,000	10.01

Step 4: Determine the Importance of Specific Vehicle Classes and Axle Types

If the criteria used for the creation of the national Tier 2 NALS are acceptable (see step 6), simply skip to step 6 and use the criteria presented in table 20, along with State-specific RANALS, to develop State-specific Tier 2 NALS. If State-specific traffic attributes and design criteria/performance models are to be used, then steps 4 and 5 must be followed to develop a State-specific criteria table that replaces table 20 in step 6.

Because of their complexity, this guide only summarizes steps 4 and 5. They are discussed in greater detail in chapter 9 of the LTPP report, *MEPDG Traffic Loading Defaults Derived from LTPP Transportation Pooled Fund Study*.⁽¹⁰⁾

In step 4, a State determines the truck volumes to test the sensitivity of the MEPDG pavement designs to State-specific loading conditions. The Tier 2 national defaults described in Part I of this guide are based on the truck volume patterns observed in the LTPP traffic database. As a result, they may or may not be representative of the kinds of trucks traveling on a given State's roads. For example, roads in the western States often have a much higher percentage of multi-trailer truck travel than roads in most eastern States. Consequently, the use of national averages tends to overestimate multi-trailer truck travel and importance to pavement performance in eastern States and underestimate their importance in western States. Similarly, in portions of some midwestern States (e.g., Ohio, Pennsylvania, and Kentucky), very heavy, multi-axle single-unit trucks (i.e., four, five, and six+ axle, single-unit trucks) are commonly found on roads that serve natural resource extraction industries (e.g., coal). The largest of these trucks is rarely found in many other States.

The primary purpose of step 4 is to determine the upper bounds of the volume of trucks occurring and the maximum percentage of all truck traffic that occurs in that class. These two factors are used to set up tests of the sensitivity of the MEPDG's outputs to different observed loading conditions for that class of trucks.

To obtain the maximum observed truck volumes per lane and the maximum observed truck percentages by class of truck, the agency should examine the data in its own historical traffic database. The intent is to find those traffic conditions that maximize the impact of each vehicle class on pavement design. That is, under what truck volume and vehicle class distribution conditions does a given vehicle class represent the largest percentage of the total truck load on roads found in the State? Identified maximum truck volume conditions (relative to other truck volumes) can then be used to determine how sensitive the MEPDG outcomes are to the possible changes in load observed in that class. Table 19 shows an example of the outcome of this data analysis task. The highlighted percentage values and average annual daily truck traffic (AADTT) values can then be taken into the MEPDG sensitivity tests.

Table 19. Example of traffic design conditions for each vehicle class

Class	Site Number	AADTT	Vehicle Class Distribution for Vehicle Class (percent)									
			4	5	6	7	8	9	10	11	12	13
4	1	5,560	50.5	3.8	0.0	14.9	21.4	0.1	0.3	2.2	6.6	0.0
5	2	1,560	6.4	75.3	14.9	0.0	0.7	2.6	0.1	0.0	0.0	0.0
6	3	450	1.5	19.2	53.6	9.3	7.1	5.5	1.3	0.5	0.0	2.0
7	4	1,210	2.9	27.1	17.0	10.6	8.0	32.6	1.0	0.8	0.1	0.0
8	5	610	15.0	22.1	7.9	5.9	38.4	5.9	2.3	0.3	0.2	2.1
9	6	3,040	0.3	4.8	1.6	0.1	2.3	85.7	0.5	3.1	1.3	0.2
10	7	1,890	4.5	8.8	5.2	3.3	1.1	14.3	28.9	0.0	0.6	33.2
11	8	1,860	1.1	45.0	9.6	0.7	6.6	24.3	0.0	12.3	0.1	0.2
12	9	1,220	2.7	25.9	6.1	0.8	3.7	33.0	4.9	0.6	7.8	14.6
13	7	1,890	4.5	8.8	5.2	3.3	1.1	14.3	28.9	0.0	0.6	33.2

Note: The boldface percentage values and average annual daily truck traffic (AADTT) values can be used in the MEPDG sensitivity tests.

Step 5: Determine MEPDG Sensitivity

This task uses the RANALS obtained in step 2 and the traffic volume data developed in step 4 to test the sensitivity of the selected MEPDG designs to the loading conditions present in the State.

States implementing this step should identify a set of typical pavement designs and pavement distress modes frequently observed in the State, determine pavement performance criteria for MEPDG design, and use locally calibrated pavement design models.

To test MEPDG sensitivity to a single class of trucks at a time, all traffic loading conditions other than the axle load spectra for the class being studied should be held constant for a selected pavement design. For each class of trucks being tested, the truck traffic volume and vehicle class distribution parameters should represent the case when the test truck class contributes the largest percentage of total load, compared with other vehicle classes, observed in that State (using the AADTT and the percentage shown in the State-specific version of table 19).

Different MEPDG runs are then performed for the class of vehicles being examined, with all inputs held constant, except that different RANALS are used as inputs. The RANALS developed in step 2 for that vehicle class are selected from the State's WIM data to represent the range of axle weight conditions those trucks are observed to carry in that State.

The output from the MEPDG is then used to determine the degree to which differences in observed axle loads for each vehicle class can change pavement analysis outcomes. When two RANALS for a given vehicle class produce "significantly different" pavement analysis results, the RPPIF values that represent those two RANALS can be compared. The difference in the RPPIF values between those two RANALS can be used to establish criteria for determining when two RANALS should be kept as part of two different Tier 2 NALS clusters. That is, if two RANALS produce significantly different pavement analysis outcomes, they are not "similar," and they should not be combined into the same group for computation of default NALS. The difference in their RPPIF values then becomes a measure that can be used to determine the size of required boundaries between Tier 2 NALS clusters.

Each State may select its own definition of "significantly different" MEPDG outcome. For example, a change in asphalt concrete or portland cement concrete thickness of $\frac{1}{2}$ inch could be used as one measure of "significantly different." So when differences in load spectra do not produce a change in thickness equal to or greater than $\frac{1}{2}$ inch, those load spectra are determined to be "similar." Another measure of significance could be a difference in predicted pavement service life greater than 20 percent.

By summarizing the RPPIF differences that resulted in significant differences in MEPDG outcomes for each class of truck, it is possible to produce a table such as table 20, shown in step 6 below. This table is then used as the criterion for when to stop the clustering process that produces Tier 2 NALS.

Step 6: Perform Cluster Analysis

The final step in the development of agency-specific default load spectra is the actual clustering of "similar" load spectra into a limited number of groups. This is best done with a statistical program such as SPSS, SAS, or similar programs.

The clustering of agency-supplied RPPIFs (computed in step 3 above for each site, vehicle class, and axle type) is controlled by the sensitivity of the pavement design process to traffic loadings.

If State-specific sensitivity tests have been performed, use those results to control the clustering process. If no State-specific tests have been performed, use the values in table 20.

Table 20. Difference in RPPIF per axle likely to cause change in pavement performance

Class	Frequency of Truck Occurrence (percent of total truck volume)	Truck Type by Weight	Axle Type			
			Single	Tandem	Tridem	Quad
7, 10, 13	Infrequent (<35)	Heavy	>0.55	0.41	0.49	0.8
6, 8, 11, 12	Moderate to Infrequent (<50)	Moderate	0.25	0.23	N/A	N/A
9, 4	Frequent to Moderate (>50)	Heavy	>0.13	0.09	N/A	N/A
5	Frequent (>75)	Light	>0.09	N/A	N/A	N/A

N/A = not applicable

In the clustering process, the difference between the mean RPPIF for two nearest-neighbor clusters should not exceed the values in table 20. Thus, the cluster process should be stopped one step prior to the step when that distance is exceeded.

Once all clusters are identified, RANALS for the sites that belong to the same cluster should be averaged to compute default NALS representing that cluster group. This should be done for each vehicle class and axle type. For each computed average NALS, RPPIF and percentage heavy statistics should be computed and compared with the values in table 2 or a similar table defined by the agency. Based on these statistics, a name and/or code should be assigned to the NALS cluster, similar to the names/codes included in the first column of table 2. If more than one cluster is identified for the same loading category, then sequential codes should be assigned to these NALS. For example, if two NALS clusters for Class 9 tandems fall within the “heavy” (H) loading category, cluster codes H1 and H2 should be used. H1 should be used for the lighter of the two NALS and H2 for the heavier. A cluster that has a majority of sites for a given vehicle class and axle type should be selected as the default or “typical” cluster, and the letter code (T) should be added to the cluster code, for example, H1(T). All computed NALS should be saved to the database. Appendix B provides a data dictionary to facilitate appending State-defined Tier 2 NALS to the LTPP PLUG database.

DEVELOPMENT OF REPRESENTATIVE SITE-SPECIFIC AND DEFAULT AXLE- PER-CLASS COEFFICIENTS

Overview

The MEPDG requires users to specify the number of axles per truck type as a part of traffic inputs for pavement design and analysis. These values are used in the computation of total axle loading. These numbers are also called APC coefficients. The MEPDG procedure uses APC as a multiplier in the process of converting NALS to projected axle load spectra for use in pavement design.

APC values are required for each vehicle class and axle type. If a specific axle type is not used for a given vehicle class, then a zero value is entered as the APC for that axle type. One set of APCs is used per pavement design, representing the typical number of axles observed for each axle type for each vehicle class.

APCs are computed for each vehicle class and axle type by dividing axle load counts by vehicle volumes collected for the same periods of time and the same vehicle class. Because the MEPDG requires only one set of APCs per design, these values are computed based on the annual axle count and vehicle volume estimates.

Procedure to Develop Site-Specific and Default APC Coefficients

The following approach is recommended to compute a default set of APCs using the daily axle weight and vehicle volume data stored in database tables that are consistent with the LTAS DD_AX and DD_WT_CT tables:

1. Extract daily vehicle and axle count summaries from the LTPP LTAS DD_AX and DD_WT_CT tables for each site for the years and months that satisfy the data selection criteria of having data during at least 7 DOWs for each calendar month and at least 12 calendar months per site that pass the LTPP SPS TPF QC checks for data and WIM equipment.
2. Compute site-specific APC for each site (MEPDG Level 1 inputs) using the following procedure:
 - a. Develop a list of all matching dates in the DD_AX and DD_WT_CT tables.
 - b. For all matching dates, compute the total daily axle counts by class and axle type by summing axle counts reported in individual load bins. If no axle counts are found for a given axle type, vehicle class, year, month, and day while a non-zero volume is computed for the matching vehicle class, year, month, and day, enter 0 for the total axle counts for this axle type, vehicle class, month, and year.
 - c. For all matching dates in DD_AX and DD_WT_CT tables, compute the total daily vehicle volumes by vehicle class for each month and year.
 - d. For each day, month, and year that had non-zero total vehicle class volume, divide the total axle counts by the total vehicle volumes for each axle type and vehicle class. This step results in an APC for each axle type and vehicle class by day, month, and year.
 - e. For each axle type and vehicle class, average the computed daily APC over all available days. This step results in site-specific APC for each axle type and vehicle class for a given site (MEPDG Level 1 inputs for individual site).
3. To compute a default APC based on all sites, average the site-specific APCs among all sites for each axle type and vehicle class. This step results in a global default APC for each axle type and vehicle class (MEPDG Level 3 input).

DEVELOPMENT OF DEFAULT AXLE SPACING AND WHEELBASE VALUES

Average Axle Spacing and Wheelbase for JPCP Model

Average axle spacing or wheelbase information is used for MEPDG applications involving the top-down slab cracking failure mode in JPCP. For this failure mode, the critical loading is caused by a combination of axles that place axle loads close to both ends of the same slab (in the direction of travel) at the same time. For JPCP designs with 15-ft-long slabs, axle spacings of between 12 and 15 ft would result in the axle loading positions most critical to development of

top-down slab cracking. For JPCP with 20-ft joint spacings, the most critical axle spacings would be between 17 and 20 ft.

The current MEPDG top-down slab cracking model assumes that the majority of axle spacings that could induce top-down slab cracking are attributed to the wheelbase of the tractor (power) units in tractor-semitrailer combination trucks (FHWA classes 8 through 13). To account for these axles and axle spacings, the MEPDG directly considers the wheelbase of the tractor unit in the form of three inputs: the percentages of tractor units with short, medium, and long wheelbases. The MEPDG states that the percentage of trucks in each of these three categories should be based on the axle spacing distribution (or wheelbase) of truck tractors in Class 8 and above. The MEPDG recommends the following three-axle spacings or “tractor” wheelbase categories for analysis:

- Short—12 ft.
- Medium—15 ft.
- Long—18 ft.

By default, the MEPDG software assumes an even distribution of short, medium, and long axle spacing occurrences: 33, 33, and 34 percent, respectively.

Axle spacing can be estimated based on a sample of per-vehicle records obtained for each of the LTPP WIM sites. One month of data for each WIM site is considered sufficient, unless it is a low truck volume site. This sample size is considered to be representative based on an evaluation of the consistency of the axle spacing measurements through the year.

Procedure to Compute Average Axle Spacing and Wheelbase

1. Extract axle spacing values from per-vehicle records by vehicle class for all the sites.
2. Filter records corresponding to the first axle spacing for classes 8 and above.
3. Determine ranges for short, medium, and long axle spacing relative to JPCP joint spacing values used by the agency, or use the MEPDG values of 12, 15, and 18 ft.
4. Compute percentages of the first axle spacing for classes 8 and above for each of the three categories referenced in step 3.

In addition, the MEPDG states that if other vehicles in the traffic stream have axle spacings in the range of the short, medium, and long spacing defined above, the frequency of those vehicles could be added to the axle spacing distribution of truck tractors. For example, if 10 percent of truck traffic is multiple trailers (Class 11 and above) that have trailer-to-trailer axle spacings in the “short” range, 10 percent should be added to the percentage of truck tractors with “short” axles. Thus, the sum of the percentages of trucks in the short, medium, and long categories can be greater than 100. “Short” spacing should not include multi-axle groups such as tandem, tridem, and quad in the computation.

Procedure to Compute Axle Spacing for Multi-Axle Groups

Axle spacing for multi-axle groups is the distance between the two consecutive axles of a tandem, tridem, or quad. Default axle spacing values can be computed based on averaging the values extracted from per-vehicle records for all the sites, using the following procedure:

1. Extract axle spacing values from per-vehicle records for all sites.
2. Filter records that have axle spacings of less than 8 ft for vehicle classes 4 through 13.
3. Review filtered records and identify multi-axle groups as follows:
 - a. Mark two consecutive spacings of less than 8 ft each per record as tridem axles.
 - b. Mark three consecutive spacing less than 8 ft each per record as quad axles.
 - c. If there is only one spacing less than 8 ft in sequence per record, mark it as tandem axle.
4. Compute average axle spacing values among axles marked as tandem, tridem, and quad axles.

For tridem and quad axles, compute average axle-to-axle spacing.

USE OF AXLE LOADING DEFAULTS WITH DARWIN-ME

Currently, the DARWin-ME software contains the NALS defaults developed under NCHRP Project 1-37A. If the user wants to use NALS defaults generated based on SPS TPF data, there are four ways to enter these data into the Axle Distribution table in the DARWin-ME project file:

- Enter data manually.
- Import default NALS file in MEPDG (*.alf) format.
- Import default NALS file in an XML format.

The LTPP PLUG software provides the options of generating an axle load file in both the MEPDG (*.alf) format and the DARWin-ME XML formats for any of the default or site-specific NALS included in the LTPP PLUG database. Generated *.alf or XML files could be stored in a user-specified directory and uploaded in DARWin-ME using the data import option. *.alf files work with both NCHRP 1-37A and DARWin-ME software products.

APPENDIX A. LTPP PLUG SOFTWARE OPERATOR'S MANUAL

PURPOSE AND APPLICABILITY

This manual and accompanying software program were developed to aid users in estimating traffic loading inputs for MEPDG applications for sites with insufficient site-specific traffic loading data.

This application is beneficial for developing MEPDG Level 2 or 3 traffic loading inputs for LTPP sites that have site-specific vehicle classification and/or truck volume data but no axle load information (or if the accuracy of the loading information is questionable owing to limited data availability or traffic monitoring equipment type). Traffic loading inputs are developed by selecting or computing NALS for each vehicle class and axle type based on available LTPP NALS defaults or site-specific NALS for SPS TPF WIM sites. Once default or surrogate NALS are established for a given LTPP site, the software develops a NALS input file for use with the DARWin-ME software (*.alf or *.xml file).

The LTPP PLUG database and software also can be used to develop MEPDG levels 2 and 3 traffic loading inputs and NALS defaults using agency-specific NALS (site-specific and/or defaults) or a combination of agency-specific data and LTPP-based loading defaults. The software includes a data import function for this purpose. The LTPP PLUG data dictionary is provided in appendix B to facilitate the integration of agency-specific axle load distributions and vehicle classification data.

STARTING THE APPLICATION

This application is embedded in a Microsoft® Access database file and can run on any computer on which Access is installed. No LTPP PLUG software installation is required.

Start the application by opening the LTPP PLUG database file, LTPP_PLUG.mdb. Based on the user's computer and Microsoft® Access security settings, the user may need to ensure that macros/content is enabled in the application. This is accomplished by clicking the "Options..." frame located on the security warning ribbon and clicking the "Enable this content" radio button.

Microsoft® Access Reference Libraries

This application was developed using Microsoft® Access 2007. If the user is using this application with a different version of Access, references to some of the Microsoft® libraries used in this application could be lost, and these libraries will be marked as "Missing." In these circumstances, the user should add and activate the necessary reference libraries. To accomplish this task, open the VBA code window by pressing Alt+F11 and choosing "References" from the Tools menu. This will display the form showing all available reference libraries. The user should make sure that the three reference libraries shown with the checkmarks in figure 2 are available and selected.

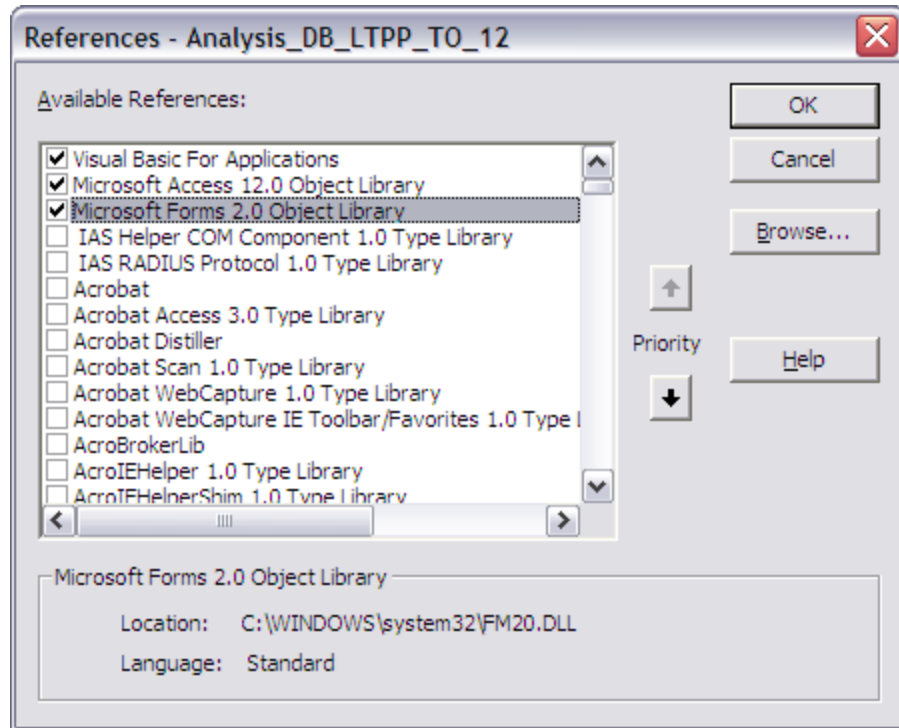


Figure 2. Screen capture. Selection of necessary library references

FUNCTIONALITY DESCRIPTION

Select Actions from the Main Menu

When the user starts LTPP PLUG database application, the main menu, shown in figure 3, displays.

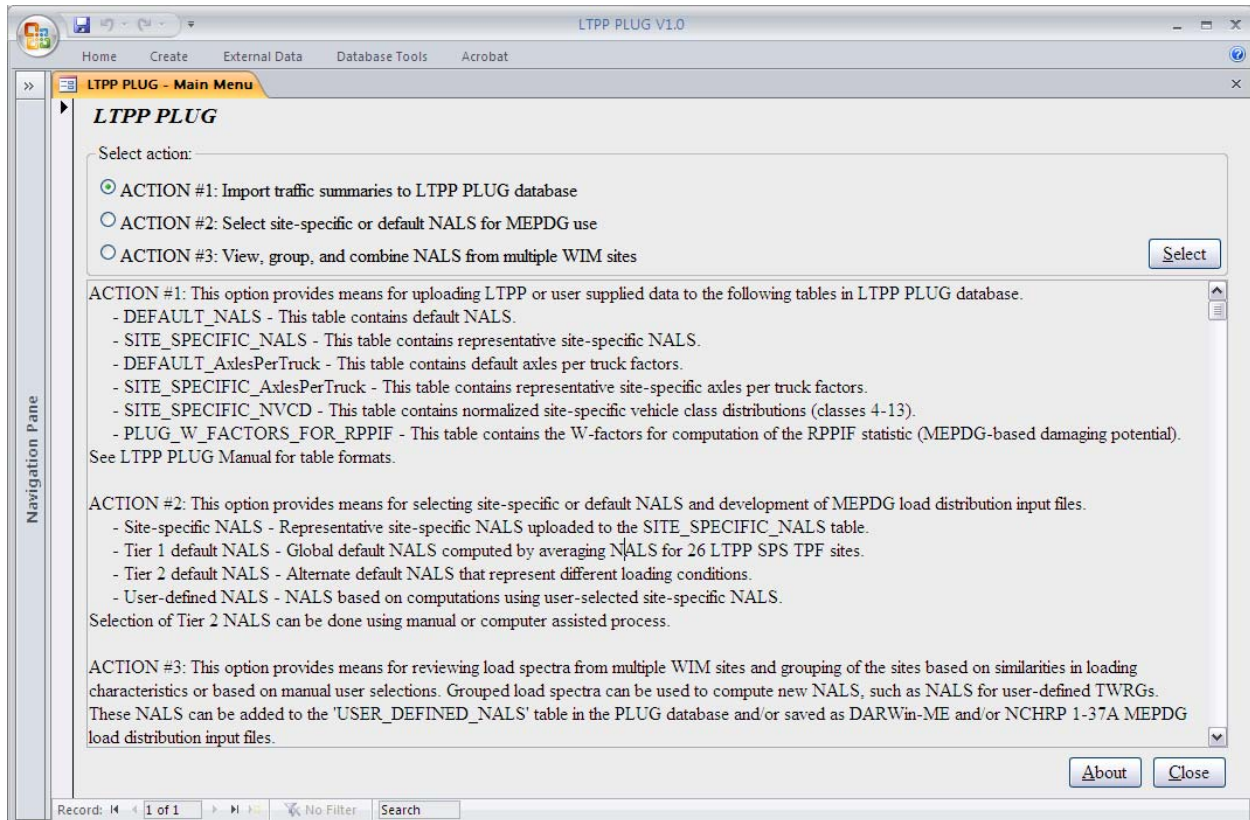


Figure 3. Screen capture. Main menu for selecting different actions

This menu offers three action options:

- ACTION #1: Import traffic summaries to LTPP PLUG database.
- ACTION #2: Select site-specific or default NALS for MEPDG use.
- ACTION #3: View, group, and combine NALS from multiple WIM sites.

ACTION #1 provides means for uploading LTPP or user-supplied data to the following tables in the LTPP PLUG database:

- DEFAULT_NALS—This table contains default NALS.
- SITE_SPECIFIC_NALS—This table contains representative site-specific NALS.
- DEFAULT_AxlesPerTruck—This table contains default axles per truck factors.
- SITE_SPECIFIC_AxlesPerTruck—This table contains representative site-specific axles per truck factors.
- SITE_SPECIFIC_NVCD—This table contains normalized site-specific vehicle class distributions (classes 4 through 13).

- **PLUG_W_FACTORS_FOR_RPPIF**—This table contains the *W*-factors for computation of the RPPIF statistic (MEPDG-based damaging potential).

See appendix B for table formats.

ACTION #2 provides means for selecting site-specific or default NALS and development of MEPDG load distribution input files:

- **Site-specific NALS**—Representative site-specific NALS uploaded to the **SITE_SPECIFIC_NALS** table.
- **Tier 1 default NALS**—Global default NALS computed by averaging NALS for 26 LTPP SPS TPF sites.
- **Tier 2 default NALS**—Alternate default NALS that represent different loading conditions. Tier 2 NALS can be selected using manual or computer-assisted processes.
- **User-defined NALS**—NALS based on computations using user-selected, site-specific NALS.

ACTION #3 provides means for reviewing load spectra from multiple WIM sites and grouping of the sites based on similarities in loading characteristics or based on manual user selections. Grouped load spectra can be used to compute new NALS, such as NALS for user-defined truck weight road groups (TWRG). These NALS can be added to the **USER_DEFINED_NALS** table in the PLUG database and/or saved as DARWin-ME and/or NCHRP 1-37A MEPDG load distribution input files.

To select ACTION #1, ACTION #2, or ACTION #3, click the radio button next to the desired action on the main menu and then click the “Select” button.

Import Traffic Summaries to LTPP PLUG Database

To import traffic summaries to the LTPP PLUG database, select ACTION #1 on the main menu and click the “Select” button (see figure 3). This action displays a data import form, shown in figure 4.

LTPP / User Data Import

Select traffic data source for upload:

☒ Upload LTPP Traffic Data Summaries

☐ Upload User Traffic Data Summaries

Select tables to upload:

☐ DEFAULT_NALS

☐ SITE_SPECIFIC_NALS

☐ DEFAULT_AxlesPerTruck

☐ SITE_SPECIFIC_AxlesPerTruck

☐ SITE_SPECIFIC_NVCD

☐ PLUG_W_FACTORS_FOR_RPPIF

Based on user selections, the following information will be uploaded to the LTPP PLUG database:

- DEFAULT_NALS - This table contains default NALS based on user supplied or LTPP data.
- SITE_SPECIFIC_NALS - This table contains representative site-specific NALS based on user supplied or LTPP data.
- DEFAULT_AxlesPerTruck - This table contains default axles per truck factors based on on user supplied or LTPP data.
- SITE_SPECIFIC_AxlesPerTruck - This table contains representative site-specific axles per truck factors based on user supplied or LTPP data.
- SITE_SPECIFIC_NVCD - This table contains normalized site-specific vehicle class distributions (classes 4-13).
- PLUG_W_FACTORS_FOR_RPPIF - This table contains damage factors for computation of the RPPIF statistic (MEPDG-based damaging potential). Users may supply their own damage factors.

Import Close

Record: 1 of 1 No Filter Search

Figure 4. Screen capture. Data import form for importing traffic data summaries

The current version of the PLUG database requires user-supplied data in the Microsoft® Access database tables. The database table format is described in appendix B. A blank database with preset table formats is available for download along with the LTPP PLUG software application from the LTPP Customer Support Service Center (e-mail: LTPPinfo@dot.gov, telephone: (202) 493-3035, or fax: (202) 493-3161.).

To import data:

1. Use the radio buttons at the top of the form to specify the source of traffic data: LTPP or user-supplied data.
2. Use the check boxes in the middle of the form to select the tables (data summaries) that will be uploaded to the LTPP PLUG database:
 - DEFAULT_NALS—This table contains default NALS based on user-supplied or LTPP data.
 - DEFAULT_AxlesPerTruck—This table contains default axles per truck factors based on user-supplied or LTPP data.
 - SITE_SPECIFIC_NALS—This table contains representative site-specific NALS based on user-supplied or LTPP data.

- SITE_SPECIFIC_AxlesPerTruck—This table contains representative site-specific axles per truck factors based on user-supplied or LTPP data.
- SITE_SPECIFIC_NVCD—This table contains normalized site-specific vehicle class distributions (classes 4 through 13) for sites with and without WIM data.
- PLUG_W_FACTORS_FOR_RPPIF—This table contains damage factors for computation of the RPPIF statistic (MEPDG-based damaging potential). Users may supply their own damage factors.

3. Click the “Import” button at the bottom of the screen to import data.

To close the form, click the “Close” button at the bottom of the screen.

Select NALS Source for MEPDG Use

To select the source of NALS for MEPDG use, select ACTION #2 on the main menu and click the “Select” button (see figure 3). This action displays the form shown in figure 5.

The screenshot shows the 'LTPP PLUG V1.0' application window. The 'Select NALS source for MEPDG use' form is active. It features a 'Navigation Pane' on the left with a tree view showing 'LTPP PLUG - Main Menu' and 'Select NALS source for MEPDG use'. The form itself has a title bar and a menu bar with 'Home', 'Create', 'External Data', 'Database Tools', and 'Acrobat'. The main content area is divided into two sections. The top section, 'Select type of NALS:', contains three radio buttons: 'OPTION #1 - Site-Specific NALS', 'OPTION #2 - Default NALS' (which is selected), and 'OPTION #3 - User Defined NALS'. To the right of this section is a 'Default Selection Method:' section with two radio buttons: 'Manual Selection' (selected) and 'Assisted, Interactive Assignment'. A 'Select' button is located to the right of the 'Default Selection Method' section. Below these sections are three text boxes providing detailed descriptions for each option. The bottom right of the form has 'Back' and 'Close' buttons. The bottom status bar shows 'Record: 1 of 1', 'No Filter', and a search field.

Select type of NALS:

☐ OPTION #1 – Site-Specific NALS

☒ OPTION #2 – Default NALS

☐ OPTION #3 – User Defined NALS

Default Selection Method:

☒ Manual Selection

☐ Assisted, Interactive Assignment

Select

OPTION #1: This option provides a graphical review and facilitates the development of MEPDG axle loading input files using NALS computed for LTPP SPS TPF sites or any other NALS uploaded in the SITE_SPECIFIC_NALS table of the LTPP PLUG database. This option is recommended if the pavement analyst has determined that identified site-specific NALS are the best for the specific pavement design or analysis needs (See LTPP PLUG report for guidance).

OPTION #2: This option provides a graphical review and facilitates the development of MEPDG axle loading input files using the Tier 1 global or Tier 2 Alternate default NALS. Tier 1 NALS are recommended where no site-specific information about truck loading conditions at the site in question is available. It assigns a loading condition computed as average of 26 SPS TPF NALS. Tier 2 NALS allow the analyst to apply knowledge about traffic loading at the site in question. It is also recommended for setting up sensitivity analyses through selection of NALS representing different loading conditions (e.g., light vs. heavy). If the Tier 2 option is selected, the analyst has two additional options: choosing all NALS manually or using the assisted interactive NALS assignment option that utilizes a decision tree algorithm for making NALS selection based on interactive user responses.

OPTION #3: This option provides a graphical review and facilitates the development of MEPDG axle loading input files based on NALS included in USER_DEFINED_NALS table, such as NALS representing different TWRGs. These NALS are the results of computations based on user-selected site-specific NALS.

Back Close

Record: 1 of 1 No Filter Search

Figure 5. Screen capture. Select NALS source form for selecting loading inputs for MEPDG use

The LTPP PLUG provides three types of NALS for development of MEPDG axle loading distribution inputs:

- OPTION #1: Site-Specific NALS.
- OPTION #2: Default NALS.
- OPTION #3: User-Defined NALS.

Option #1 provides a graphical review and facilitates development of MEPDG axle loading input files using NALS computed for LTPP SPS TPF sites or any other NALS uploaded to the SITE_SPECIFIC_NALS table of the LTPP PLUG database. This option is recommended if the pavement analyst has determined that identified site-specific NALS are the best for the specific pavement design or analysis needs (see the LTPP PLUG report for guidance).

Option #2 provides a graphical review and facilitates development of MEPDG axle loading input files using the Tier 1 global or Tier 2 default NALS based on LTPP data or any other default NALS uploaded by the user to the DEFAULT_NALS table. Tier 1 NALS are recommended where no site-specific information is available regarding truck loading conditions at the site in question. It assigns a loading condition computed as the average of the 26 SPS TPF NALS. Tier 2 NALS allow the user to apply knowledge about traffic loading at the site in question. Tier 2 NALS also are recommended for setting up sensitivity analyses through the selection of NALS representing different loading conditions (e.g., light versus heavy). If the Tier 2 option is selected, the user has two additional options: choosing all NALS manually or using the assisted interactive NALS assignment option that uses a decision tree algorithm to make NALS selections based on user responses.

Option #3 provides a graphical review and facilitates development of MEPDG axle loading input files based on NALS included in the USER_DEFINED_NALS table, such as NALS representing different TWRGs. These NALS are the results of computations based on user-selected site-specific NALS.

To select the desired the NALS option, click the appropriate radio button and then click the “Select” button.

Use the “Back” and “Close” buttons at the bottom of the screen to go back to the previous form or to close the form, respectively.

Select Site-Specific NALS for MEPDG Use

After selecting the site-specific NALS source from the options shown in figure 5, the user should click the “Select” button. This action displays the form shown in figure 6. This screen allows the user to view the NALS for each type of axle for each class of truck for a selected site (from the SITE_SPECIFIC_NALS table) to compare site-specific data with the defaults and to generate site-specific MEPDG axle load distribution files.

The screenshot shows the LTPP PLUG V1.0 software interface. The main window is titled "Review NALS and Generate Input Files for Single Site". It contains a "Select state and site" list on the left, a "Select class and axle" table in the middle, and a "Generate" button at the bottom. The "Generate" button is highlighted in pink. The "Select class and axle" table has columns for "Plot", "Class", and "Axle". The "Plot" column has radio buttons for each row. The "Class" column has values 4, 5, 6, 7, 8, 9, 10, 11, 12, 13. The "Axle" column has values 1, 2, 3, 4. The "Generate" button is highlighted in pink.

Select state and site:	Select class and axle:
Select State	Plot Class Axle
10-0100	☐ 4 1
12-0100	☐ 4 2
12-0500	☐ 5 1
17-0600	☐ 5 2
18-0600	☐ 6 1
20-0200	☐ 6 2
22-0100	☐ 7 1
23-0500	☐ 7 2
24-0500	☐ 7 3
26-0100	☐ 7 4
27-0500	☐ 8 1
35-0100	☐ 8 2
35-0500	☐ 9 1
39-0100	☒ 9 2
39-0200	☐ 10 1
4-0100	☐ 10 2
4-0200	☐ 10 3
42-0600	☐ 10 4
47-0600	☐ 11 1
48-0100	☐ 12 1
5-0200	☐ 12 2
51-0100	☐ 13 1
53-0200	☐ 13 2
55-0100	☐ 13 3
6-0200	☐ 13 4

INSTRUCTIONS:
 Select a site from the list on the left side and then click on a radio button in the table on the left to select vehicle class and axle type for plotting.
 - Use file export options in the lower left corner to create MEPDG load distribution files in *.ALF or *.XML format.
 - Use options at the bottom of the form to compare selected spectra with Tier 1 or 2 defaults.

Select file format for export:
☐ ALF ☐ XML

Select type of default to compare/view: ☐ Tier 1 NALS - Global ☐ Tier 2 NALS - Typical ☒ None Max X-axis: 81999

Back Close

Record: 1 of 1 No Filter Search

Form View Num Lock

Figure 6. Screen capture. Review and generation of MEPDG input files for site-specific NALS

A list of the sites for which NALS are available is displayed on the left side of the screen. To select a site, click its site ID in the list. Use scroll bars to see all available sites. To filter sites for a specific State, select from the “Select State” drop-down box displayed above the list.

To the right of the site ID list is another list showing all available vehicle classes and axle types. Click a radio button in the “Plot” column to display a NALS plot for the corresponding vehicle class and axle type. One NALS may be selected/displayed at a time.

To generate a MEPDG NALS input file, select the desired file format (*.alf and/or *.xml) at the bottom of the screen and click the “Generate” button. The MEPDG NALS input file(s) is saved to a user-specified directory.

For the example shown in figure 7, Class 9 tandem axles have been selected for a non-LTPP site uploaded by the user to the SITE_SPECIFIC_NALS table. This NALS is displayed as a pink line. In addition, for comparison purposes, the user could display either Tier 1 default NALS (national average) or Tier 2 default NALS (“typical” default) for that type of axle and class of truck by selecting the appropriate radio buttons at the bottom of the form. The comparison NALS is displayed in blue. A text description of the NALS is provided in the box below the NALS plot.

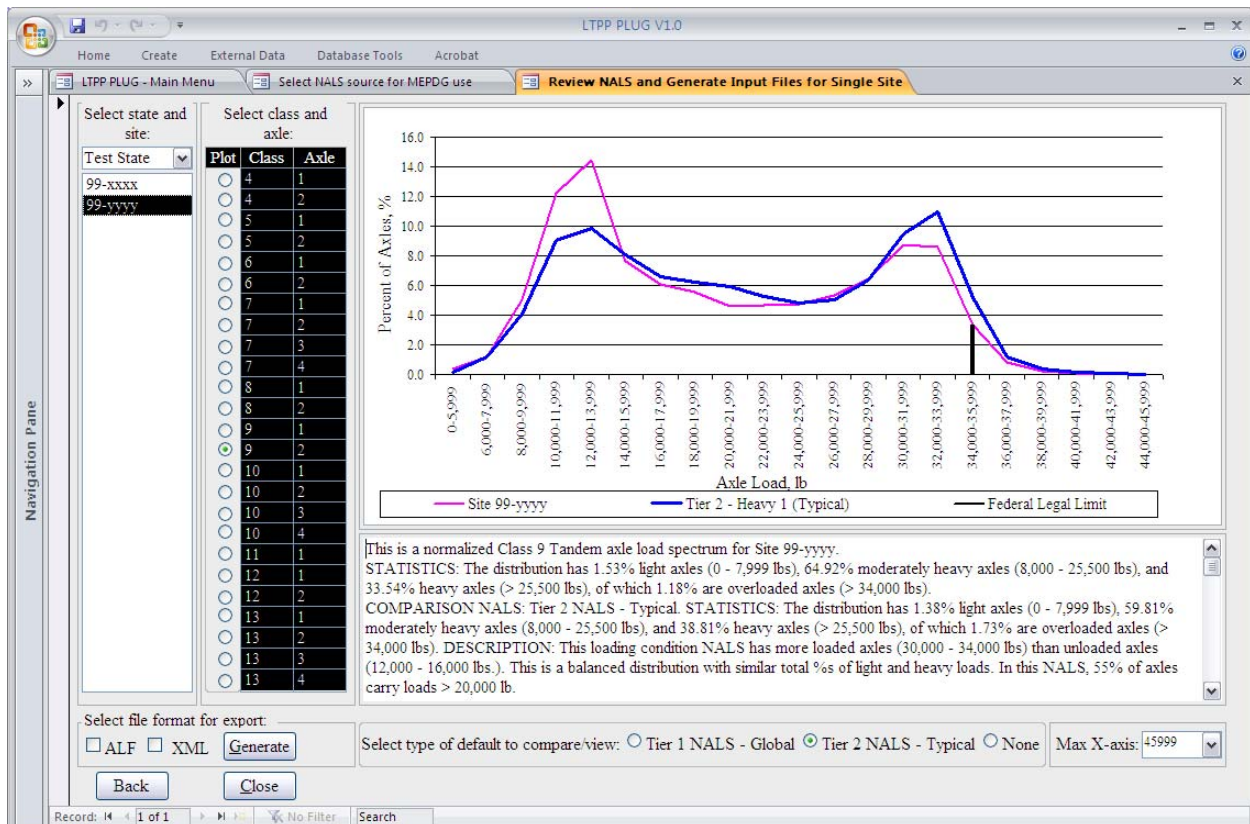


Figure 7. Screen capture. Review of site-specific NALS

Select Default NALS for MEPDG Use—Manual Selection

If the Manual Selection option was selected (see figure 5), a screen displays like that shown in figure 8. This screen allows the user to select the default NALS for each type of axle for each class of truck. The same default type can be selected for all vehicle classes and axle types, or different defaults can be assigned to different vehicle classes and axle types.

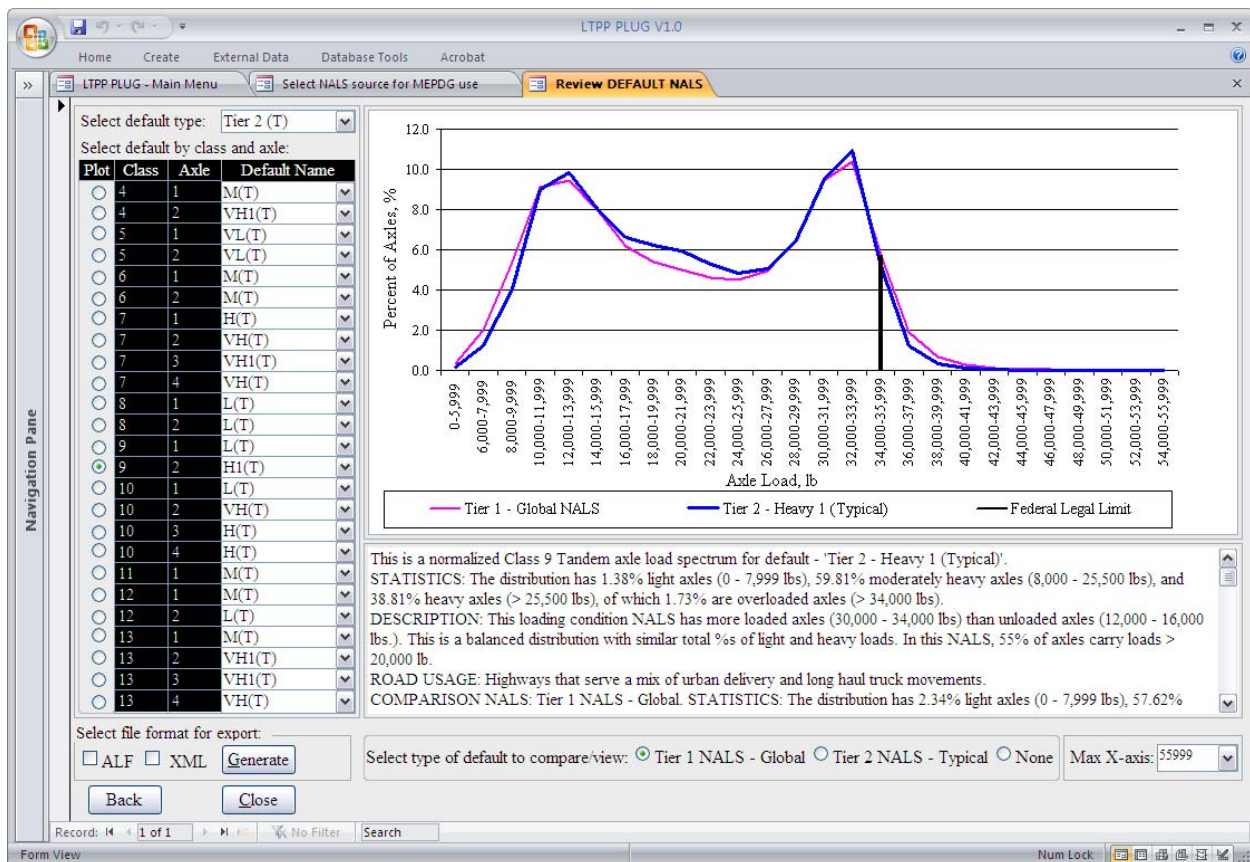


Figure 8. Screen capture. Manual selection and generation of MEPDG input files using default NALS

To apply the same default selection to all vehicle classes and axle types, choose the desired default type from the “Select default type” drop-down box.

To apply a different default to a selected vehicle class and axle type, use the “Select default by class and axle” table shown on the left side of the screen. Identify the row with the desired vehicle class and axle type and use the drop-down box in the “Default Name” column to make a different default selection.

To view NALS for the selected vehicle class and axle type, click the radio button for the appropriate “Plot.” (For example, in figure 8, Class 9 tandem axles have been selected.)

To compare the selected default with either Tier 1 or Tier 2 default NALS for that type of axle and class of truck, click the appropriate radio buttons at the bottom of the form. These two default options provide means for comparing the manually selected alternative NALS with the default NALS.

A text description of the NALS is provided in the box displayed below the NALS plot.

To generate a MEPDG NALS input file, select the desired file format (*.alf and/or *.xml) at the bottom left and click the “Generate” button. The MEPDG NALS input file(s) is saved to a user-specified directory.

To compare all of the available alternative Tier 2 default NALS against the Tier 1 national average defaults, click the drop-down list for the desired class of trucks and type of axle in the “Default Name” column. These manual selections must be made for each class of vehicles and type of axles. The intent of this selection process is to allow the user to apply known information about the site loading conditions to select the NALS alternative that best describes these conditions. The user should step through each class of trucks and type of axles, comparing the alternative Tier 2 NALS against the Tier 1 default.

For example, the user can compare the selected and default NALS to determine which is heavier. Figure 9 shows that the selected Tier 2 heavy (H2) NALS has a much higher percentage of heavy axles than the Tier 1 NALS. Thus, the Tier 2 heavy (H2) NALS for Class 7 tridem axles will cause the MEPDG software to predict more pavement damage than the Tier 1 global default.

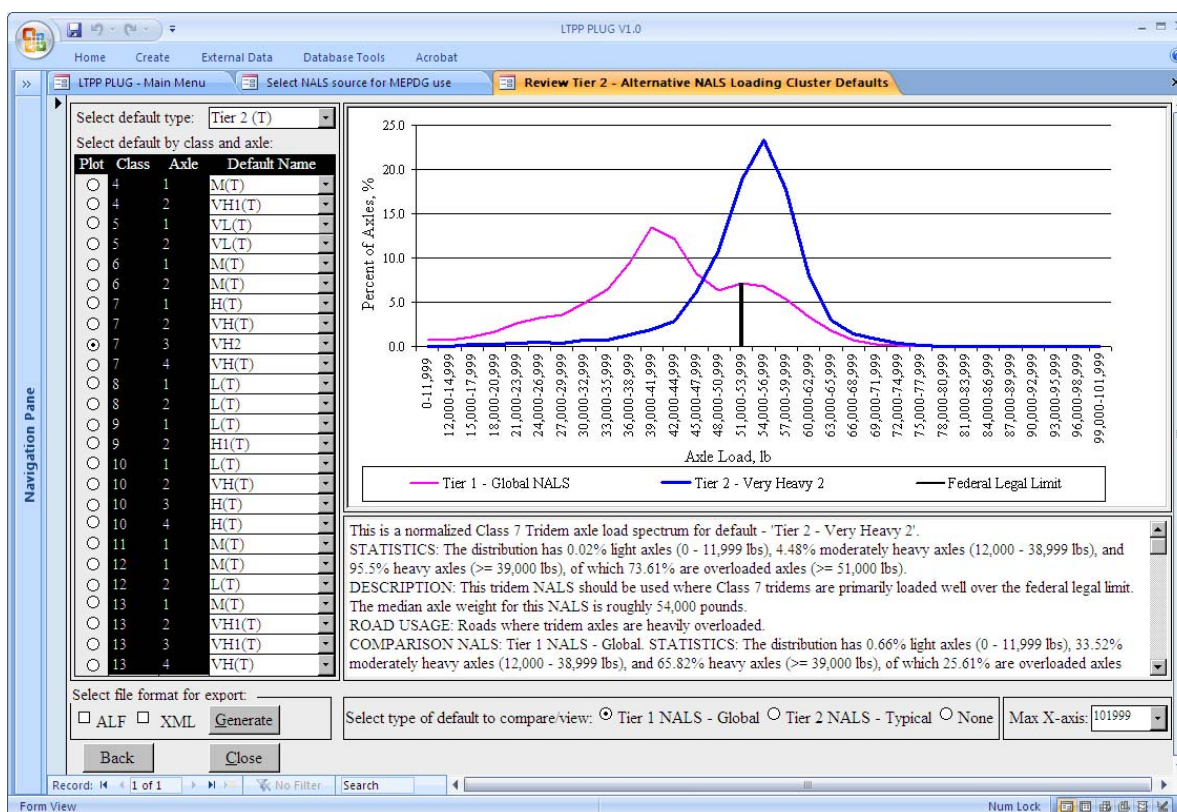


Figure 9. Screen capture. Review of manually selected default NALS

Select Default NALS for MEPDG Use—Assisted, Interactive NALS Assignment

If the user chooses the Assisted, Interactive NALS Assignment option (see figure 5), the software displays a screen that looks like that shown in figure 10. At the top of this screen, the user should identify the LTPP test site for which the NALS selection will apply. This could be any LTPP site that has truck volume by class information or any other site with truck volume by

class information added to the LTPP PLUG database table SITE_SPECIFIC_NVCD. The site ID is formed by using the numerical State Code ID and Strategic Highway Research Program (SHRP) ID, which together uniquely identify an LTPP site. The optional “State Filter” drop-down box at the top of the form allows the user to narrow the selection to a specific State. If no State name is selected, all sites available in the LTPP traffic database are displayed.

Navigation Pane

Record: 1 of 1

Form View

Num Lock

Assisted, Interactive Assignment

Select NALS source for MEPDG use

Select LTPP site for NALS default assignment: 24-5807 State Filter (optional): Maryland

Select type of traffic characteristic for determination of dominant vehicle class:

Select	Vehicle Class:	4	5	6	7	8	9	10	11	12	13
☐	% of Volume by Class:	16	44	8	1	14	16	0	0	0	0
☐	% of Total Load (ESAL)	23	13	10	3	16	34	0	0	0	0
☒	% of Total Load (RPIIF)	25	10	10	3	14	38	0	0	0	0

Note: 1. Class 5s should be excluded from determination of dominant heavy vehicle class by volume only.
Note: 2. If no dominant class is identified, select different traffic characteristic above.

1st dominant heavy vehicle class: 9 Are 50% or more of these trucks empty or almost empty? ☐ Yes ☒ No ☐ Don't know

Select all that apply:

☒ High % of loads close to federal legal load limit

☐ High % of loads above federal legal load limit by permit or due to illegal activity

☐ None of the above

2nd dominant heavy vehicle class: 4 Are 50% or more of these trucks empty or almost empty? ☐ Yes ☐ No ☒ Don't know

Select road use:

Urban roads carrying heavily loaded transit buses and over the road coaches.

Select any other truck classes that are likely to carry unusually heavy loads:

☐ Class 4 ☐ Class 5 ☐ Class 6 ☒ Class 7 ☐ Class 8 ☐ Class 9 ☐ Class 10 ☐ Class 11 ☐ Class 12 ☐ Class 13

Back Next

Figure 10. Screen capture. Assisted, interactive assignment of default NALS

For each of the identified dominant truck classes, the user is asked whether 50 percent or more of these trucks are empty or almost empty. If the user answers “Yes,” then the load spectrum best describing this loading condition is selected from the list of available defaults. If the user answers “No,” then a list of options with check boxes displays to help better define the expected loading condition. The following options are provided:

- High percentage of loads in the dominant class close to the Federal legal weight limit.
- High percentage of loads in the dominant class above the Federal legal weight limit due to permitted loads or illegal activity.
- None of the above.

The first two options provide means to determine a likely shape of a heavy loading distribution that helps identify heavy NALS defaults. One or both of these options could be selected. If the user selects the “None of the above” option, a Tier 2 default “typical” distribution is used for the dominant vehicle class.

If the user has no knowledge of the loading condition and specifies the “Don’t know” option on the form, a drop-down list displays to provide different road use options for the user to select. The number and type of entries in this list depends on the vehicle class. Each default has assigned road use recommendations in the LTPP PLUG database DEFAULT_NALS table. This list could be updated when new default NALS are added to the database or new road uses are identified for the LTPP Tier 2 NALS.

This input screen is designed to accommodate up to two dominant classes. If the user wishes to identify additional heavily loaded vehicle classes, this can be done by selecting those additional classes at the bottom of the screen.

When all questions have been answered and appropriate selections made on the form, click the “Next” button at the bottom of the screen. This displays a screen similar to the one shown in figure 8, except, unlike the manual selection of Tier 2 NALS, not all vehicle class and axle types are set to the “typical” (default) Tier 2 NALS conditions. Instead, the data entered for the dominant truck classes have been used to select specific Tier 2 NALS defaults. Also, vehicle classes and axle types that are likely to have a significant effect on pavement damage for the selected site will be colored black in the table displaying all available vehicle classes and axle types.

The user may now review and change any or all of the cluster assignments for each class of vehicle and type of axle. Thus, even if this NALS selection option is used, the user may still manually apply information previously learned about trucking patterns at the test site. This screen also may be used to select other NALS to test the sensitivity of MEPDG outputs to different loading conditions.

Select User-Defined NALS for MEPDG Use

This option facilitates the review of NALS computed using ACTION #3 (View, group, and combine NALS from multiple WIM sites) provided in the LTPP PLUG software. Once user-defined NALS have been added to the LTPP PLUG database by executing ACTION #3, these NALS can be viewed by selecting “user-defined” as the NALS source from the options shown in figure 5 and clicking the “Select” button on that form. Clicking the “Select” button displays the form shown in figure 11.

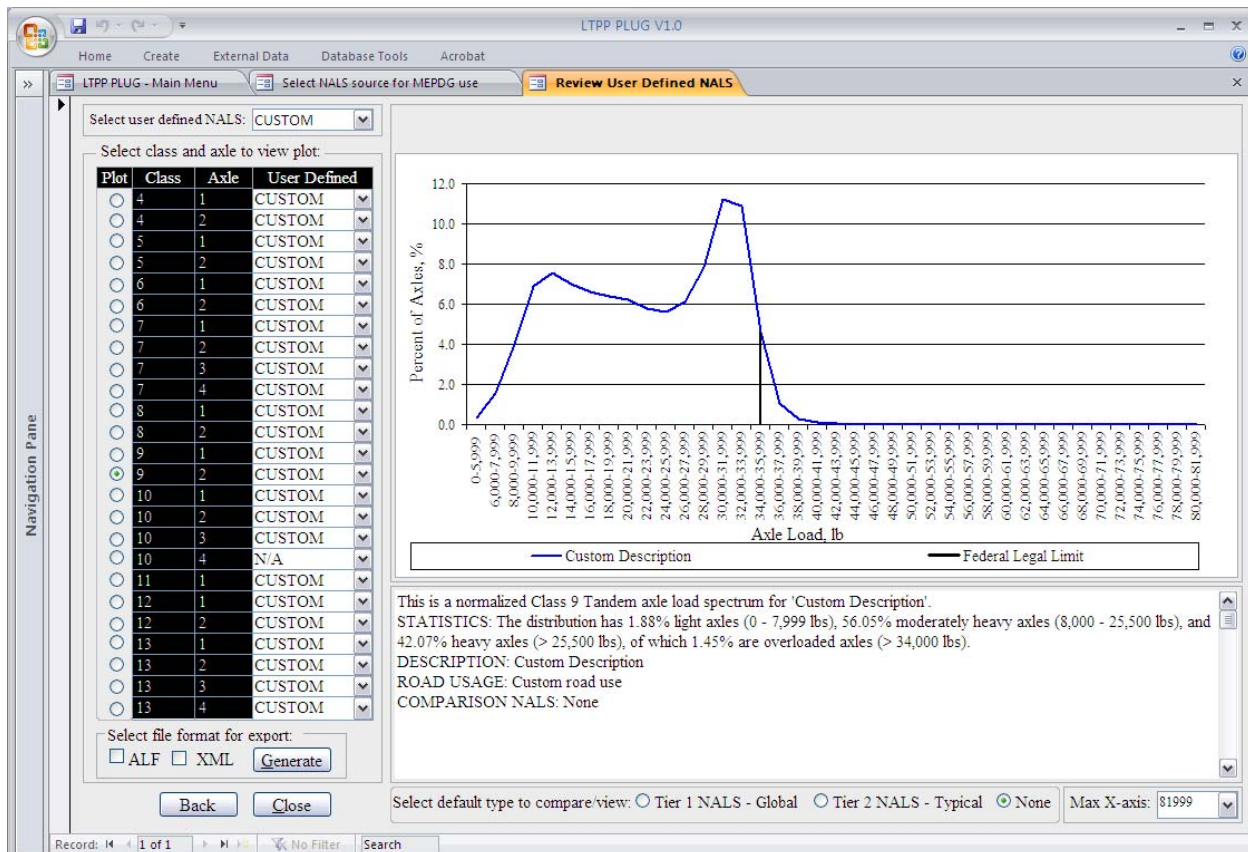


Figure 11. Screen capture. Review of user-defined NALS

This screen allows the user to view the NALS for each type of axle for each class of truck for a user-defined NALS, such as NALS computed for TWRGs (from the LTPP PLUG USER_DEFINED_NALS table), to compare user-defined NALS with the defaults, and to generate site-specific MEPDG axle load distribution files. The same user-defined NALS type can be selected for all vehicle classes and axle types, or different user-defined NALS types can be assigned to different vehicle classes and axle types.

To apply the same user-defined NALS type to all vehicle classes and axle types, select the desired user-defined NALS type from the “Select user-defined NALS” drop-down box in the top left corner of the screen.

To apply a different user-defined NALS type to a selected vehicle class and axle type, use the table shown on the left side of the screen. Identify the row with the desired vehicle class and axle type and click the appropriate drop-down box in the “User-Defined” column.

To view user-defined NALS for the selected vehicle class and axle type, click the appropriate “Plot” button on the left of the screen.

To compare the selected user-defined NALS with either Tier 1 or Tier 2 default NALS for that type of axle and class of truck, select the appropriate radio button at the bottom of the form. These two default options provide means for comparing user-defined NALS to the default NALS.

A text description of the NALS is provided in the box displayed below the NALS plot.

To generate a MEPDG NALS input file, select the desired file format (*.alf and/or *.xml) and click the “Generate” button. The MEPDG NALS input file(s) is saved to a user-specified directory.

Generate MEPDG NALS Input Files

Functionality to generate the MEPDG NALS input file is provided for each “Select NALS for MEPDG Use” option. The button to generate MEPDG NALS input files is located at the bottom left corner of the “Review NALS and Generate Input Files” form presented in figure 9. MEPDG axle load spectra files are developed automatically by a software routine using two of the file formats supported by DARWin-ME: *.alf and *.xml. Files are saved to a user-specified directory. To execute this function, select the file format and click the “Generate” button. The NALS selection displayed in the table located above the “Generate” button will be used in the development of the MEPDG NALS input file.

View, Group, and Combine NALS from Multiple WIM Sites

To view, group, and combine NALS from multiple WIM sites, select ACTION #3 on the main menu and click the “Select” button (see figure 3). This action displays the data import form shown in figure 12.

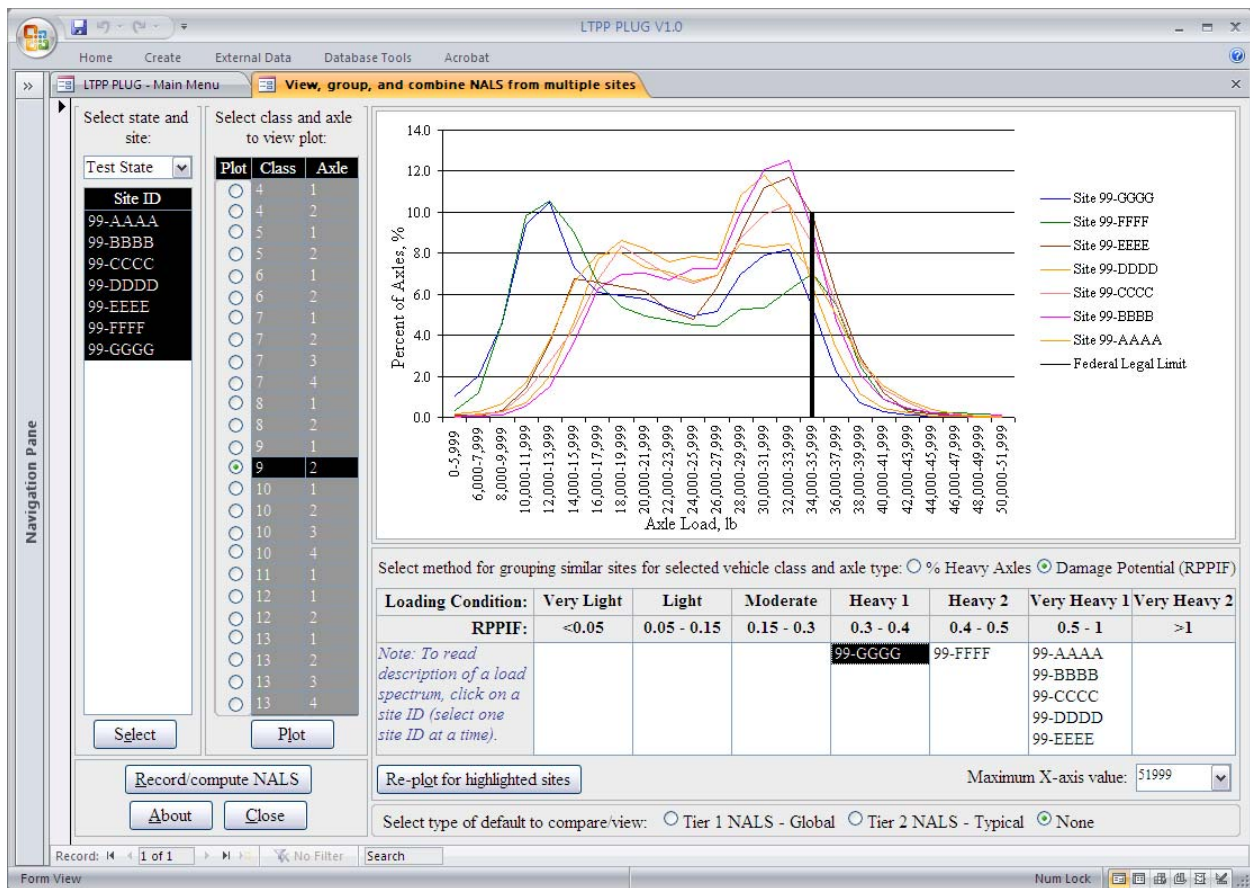


Figure 12. Screen capture. View, group, and combine NALS from multiple WIM sites

A list of the sites for which NALS are available is displayed on the left side of the screen. To filter sites for a specific State, select from the “Select State” drop-down box displayed above the site list. To select the sites for comparison and viewing of NALS, select the site IDs displayed in the list. Hold the Ctrl or Shift key to select multiple sites. Use scroll bars to see all available sites. Click the “Select” button under the site ID list to apply the selection.

To the right of the site ID list is a list of all available vehicle classes and axle types. Click a radio button in the “Plot” column to display a NALS plot for the corresponding vehicle class and axle type. One class and axle combination may be selected at a time.

If site selection has been changed, click the “Plot” button at the bottom of the table to refresh the plot for the selected class and axle.

The site IDs for the selected sites display in a table located under the axle load spectra plot. Site IDs display in different columns depending on the percentages of heavy axles or the damaging potential of the axle load spectrum. Use this information to group sites with similar loading conditions. To change the method for grouping load spectra, click the radio buttons displayed above the table to specify the statistical parameter used for grouping: “% of Heavy Loads” or “Damage Potential (RPPIF).”

Vehicle classes and axle types that are likely to have a significant effect on pavement damage for the selected site(s) are colored black; purple indicates that the selected class-axle combination is likely to have a significant effect for some but not all of the selected sites. This determination is made based on vehicle class distributions and axle load spectra for the selected sites.

In addition to site-specific load spectra, default load spectra can be displayed using the radio buttons at the bottom of the screen.

To narrow down site selection or plot only a few sites at a time, hold the Shift or Ctrl key to highlight site IDs in the table below the load spectra plot and click the “Re-plot for highlighted sites” button.

To record average NALS for sites displayed in the table below the load spectra plot, and to generate MEPDG load distribution files, click the “Record/Compute NALS” button at the bottom of the screen.

Compute and Record User-Defined NALS for Groups of Sites

This function facilitates development of user-defined NALS by vehicle class and axle type. This is accomplished by grouping sites with similar loading conditions, or based on manual selection of site IDs, and computing average NALS for each group of sites. Groupings are performed for the sites selected by the user on the “View, group, and combine NALS from multiple WIM sites” screen (see figure 12). Click the “Record/Compute NALS” button on that form to display a form containing the selected sites, as shown in figure 13.

LTTP PLUG V1.0

Home Create External Data Database Tools Acrobat

LTTP PLUG - Main Menu View, group, and combine NALS from multiple sites Record NALS

LTTP PLUG - Record User Defined NALS (Average for Selected Sites)

Step 1: Site selection applies to:

- ☒ Selected vehicle class and axle type only
- ☐ Selected vehicle class, all axle types
- ☐ All vehicle classes and axle types

Step 2: Compute Average NALS:

- ☒ By combining sites highlighted in table
- ☐ By combining all sites displayed in table
- ☐ For each loading condition specified in table

Step 3: Select output format:

- ☒ Database Table (USER_DEFINED_NALS)
- ☐ MEPDG *.ALF File
- ☐ DARWin-ME *.XML File

Step 4: Enter label/ID for computed NALS:

Note: This ID will be used in the USER_DEFINED_NALS table and as a file name for ALF and XML files.

Label/ID:

Description:

Road use:

Grouping of sites based on loading conditions observed for vehicle class 9 tandem axles:

Loading Condition:	Very Light	Light	Moderate	Heavy 1	Heavy 2	Very Heavy 1	Very Heavy 2
RPPIF:	≤0.05	0.05 - 0.15	0.15 - 0.3	0.3 - 0.4	0.4 - 0.5	0.5 - 1	>1
				99-GGGG	99-FFFF	99-AAAA 99-BBBB 99-CCCC 99-DDDD 99-EEEE	

Note: Site selection could be changed manually by clicking on site IDs.

Record: 1 of 1 No Filter Search

Form View Num Lock

Figure 13. Screen capture. Compute and record user-defined NALS.

This form shows instructions for four steps and a table at the bottom of the form populated with the site IDs selected on the previous screen. The site IDs are placed in different columns of the table based on axle loading conditions observed for the selected vehicle class and axle type.

The LTTP PLUG provides multiple options for computation of average NALS for the selected group of sites. Step 1 on the form asks the user to select whether site selection for computation of average NALS should apply to:

- Selected vehicle class and axle type only.
- Selected vehicle class, all axle types.
- All vehicle classes and axle types.

It is recommended that the loading conditions observed for the dominant vehicle class are used as the basis for grouping of sites, at least to develop alternative NALS for that vehicle class. For the light vehicle classes and axle types that do not contribute much to the total loading, all sites may be combined to compute an average NALS. In some circumstances, where several heavy vehicle types are well represented on the road or loading conditions observed for different

vehicle classes are different (for example, for a road with moderate Class 9 trucks and very heavy Class 7 trucks), it is recommended that NALS alternatives are computed based on grouping of sites for individual vehicle classes and axle types.

Step 2 offers the following options for grouping the sites for computation of the average NALS for each group:

- By combining NALS for the sites highlighted in the table.
- By combining NALS for all the sites displayed in the table.
- For each loading condition specified in the table header.

To change the selection of sites for grouping, highlight the desired site IDs in the table by clicking them. Use Shift or Ctrl key to select multiple sites.

Step 3 asks the user to select the output format from the following options:

- Database table (USER_DEFINED_NALS).
- MEPDG *.alf file.
- DARWin-ME *.xml file.

In step 4, the user is asked to provide several characteristics for the average NALS being computed based on user selection, including:

- Label to use in the LTPP PLUG database USER_DEFINED_NALS table or in *.alf and *.xml file names to identify computed NALS.
- Description of the computed NALS (what loading condition or group of roads this NALS represents).
- Recommended road use (for which roads this new NALS is recommended).

After steps 1 through 4 have been completed, click the “Generate NALS” button to compute and save the new user-defined NALS. If NALS have been written to the USER_DEFINED_NALS table of the LTPP PLUG database, use Option #3 of the “Select NALS Source for MEPDG Use” form (see figure 5) to view the computed NALS.

Click the “Close” button to close the form.

APPENDIX B: LTPP PLUG DATABASE DATA DICTIONARY

This appendix provides a data dictionary containing field names and descriptions for the tables included in the LTPP PLUG database. This information can aid in understanding the data in the database tables and to facilitate uploading of the additional information (LTPP updates or State-specific information) to the database tables.

Listed below are brief descriptions of the tables present in the database:

- **ALF_DEFAULT_ALS** and **ALF_Gen_Axle_Group**—These tables are used internally by the LTPP PLUG software to generate *.alf files. Table 21 and table 22 contain the field names and descriptions.
- **DEFAULT_AxlesPerTruck**—This table contains default APCs based on all applicable SPS TPF data. Table 23 contains the field names and descriptions.
- **DEFAULT_NALS**—This table contains Tier 1 or Tier 2 NALS defaults, based on all applicable SPS TPF data or user-defined defaults. Table 24 contains the field names and descriptions.
- **LTPP_CODES**—This table, imported from the LTPP LTAS database, contains numeric codes and names for all the States and Provinces in the United States and Canada. Table 25 contains the field names and descriptions.
- **PLUG_LEF_FOR_ESAL**—This table contains load equivalency factors by axle type and is used for Percentage of Total Load (ESAL) computations. Table 26 contains the field names and descriptions.
- **PLUG_W_FACTORS_FOR_RPPIF**—This table contains W-factors by axle type and is used for Percentage of Total Load (RPPIF) computations. Table 27 contains the field names and descriptions.
- **SITE_SPECIFIC_AxlesPerTruck**—This table contains APCs for each site. Table 28 contains the field names and descriptions.
- **SITE_SPECIFIC_NALS**—This table contains representative annual NALS for each SPS TPF or user-supplied site. Table 29 contains the field names and descriptions.
- **SITE_SPECIFIC_NVCD**—This table contains the normalized vehicle class distribution for the most recent year for all SPS and GPS sites or user-supplied sites. Table 30 contains the field names and descriptions.
- **USER_DEFINED_NALS**—This table contains user-defined NALS based on the computation performed under Action 3 of the LTPP PLUG software (multiple sites selection and computation of NALS). Table 31 contains the field names and descriptions.

- XMLGen_AxleLoadDistribution, XMLGen_AxleLoadMain_Template, and XMLGen_DEFAULT_NALS_By>Loading_Cluster—These tables are used internally by the LTPP PLUG software to generate DARWin-ME *.xml files. Table 32 through table 34 contain the field names and descriptions.

Table 21. Field names and descriptions for ALF_DEFAULT_ALS

Field Name	Data Type	Description
Month	NUMBER(2,0)	Code specifying the month in text format (January–December)
Veh_Class	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
Sum_Axles	NUMBER(3,0)	A constant value of 100 populated in each record for ALF file generation
Axle_Group	NUMBER(1,0)	Type of axle for which these percentages of axles apply

Table 22. Field names and descriptions for ALF_Gen_Axle_Group

Field Name	Data Type	Description
Veh_Class	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
Axle_Group	NUMBER(1,0)	Type of axle for which these percentages of axles apply

Table 23. Field names and descriptions for DEFAULT_AxlesPerTruck

Field Name	Data Type	Description
classNumber	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
numberAxle	NUMBER(1,0)	Type of axle for which the values in the field “truckAxleConfig” apply
truckAxleConfig	NUMBER(2,2)	Number of this type of axle for a vehicle in this class

Table 24. Field names and descriptions for DEFAULT_NALS

Field Name	Data Type	Description
VEH_CLASS	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
AXLE_GROUP	NUMBER(1,0)	Type of axle for which these percentages of axles apply
NALS_CLUSTERS	VARCHAR2(255)	Text field indicating the type of NALS cluster
MEPDG_LG01	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 0–2,999 lb for single axles; 0–5,999 lb for tandem axles; 0–11,999 lb for tridem and quad axles.
MEPDG_LG02	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 3,000–3,999 lb for single axles; 6,000–7,999 lb for tandem axles; 12,000–14,999 lb for tridem and quad axles.
MEPDG_LG03	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 4,000–4,999 lb for single axles; 8,000–9,999 lb for tandem axles; 15,000–17,999 lb for tridem and quad axles
MEPDG_LG04	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 5,000–5,999 lb for single axles; 10,000–11,999 lb for tandem axles; 18,000–20,999 lb for tridem and quad axles
MEPDG_LG05	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 6,000–6,999 lb for single axles; 12,000–13,999 lb for tandem axles; 21,000–23,999 lb for tridem and quad axles
MEPDG_LG06	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 7,000–7,999 lb for single axles; 14,000–15,999 lb for tandem axles; 24,000–26,999 lb for tridem and quad axles
MEPDG_LG07	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 8,000–8,999 lb for single axles; 16,000–17,999 lb for tandem axles; 27,000–29,999 lb for tridem and quad axles
MEPDG_LG08	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 9,000–9,999 lb for single axles; 18,000–19,999 lb for tandem axles; 30,000–32,999 lb for tridem and quad axles

Field Name	Data Type	Description
MEPDG_LG09	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 10,000–10,999 lb for single axles; 20,000–21,999 lb for tandem axles; 33,000–35,999 lb for tridem and quad axles
MEPDG_LG10	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 11,000–11,999 lb for single axles; 22,000–23,999 lb for tandem axles; 36,000–38,999 lb for tridem and quad axles
MEPDG_LG11	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 12,000–12,999 lb for single axles; 24,000–25,999 lb for tandem axles; 39,000–41,999 lb for tridem and quad axles
MEPDG_LG12	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 13,000–13,999 lb for single axles; 26,000–27,999 lb for tandem axles; 42,000–44,999 lb for tridem and quad axles
MEPDG_LG13	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 14,000–14,999 lb for single axles; 28,000–29,999 lb for tandem axles; 45,000–47,999 lb for tridem and quad axles
MEPDG_LG14	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 15,000–15,999 lb for single axles; 30,000–31,999 lb for tandem axles; 48,000–50,999 lb for tridem and quad axles
MEPDG_LG15	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 16,000–16,999 lb for single axles; 32,000–33,999 lb for tandem axles; 51,000–53,999 lb for tridem and quad axles
MEPDG_LG16	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 17,000–17,999 lb for single axles; 34,000–35,999 lb for tandem axles; 54,000–56,999 lb for tridem and quad axles
MEPDG_LG17	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 18,000–18,999 lb for single axles; 36,000–37,999 lb for tandem axles; 57,000–59,999 lb for tridem and quad axles
MEPDG_LG18	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 19,000–19,999 lb for single axles; 38,000–39,999 lb for tandem axles; 60,000–62,999 lb for tridem and quad axles
MEPDG_LG19	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 20,000–20,999 lb for single axles; 40,000–41,999 lb for tandem axles; 63,000–65,999 lb for tridem and quad axles
MEPDG_LG20	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 21,000–21,999 lb for single axles; 42,000–43,999 lb for tandem axles; 66,000–68,999 lb for tridem and quad axles
MEPDG_LG21	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 22,000–22,999 lb for single axles; 44,000–45,999 lb for tandem axles; 69,000–71,999 lb for tridem and quad axles
MEPDG_LG22	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 23,000–23,999 lb for single axles; 46,000–47,999 lb for tandem axles; 72,000–74,999 lb for tridem and quad axles
MEPDG_LG23	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 24,000–24,999 lb for single axles; 48,000–49,999 lb for tandem axles; 75,000–77,999 lb for tridem and quad axles
MEPDG_LG24	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 25,000–25,999 lb for single axles; 50,000–51,999 lb for tandem axles; 78,000–80,999 lb for tridem and quad axles
MEPDG_LG25	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 26,000–26,999 lb for single axles; 52,000–53,999 lb for tandem axles; 81,000–83,999 lb for tridem and quad axles
MEPDG_LG26	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 27,000–27,999 lb for single axles; 54,000–55,999 lb for tandem axles; 84,000–86,999 lb for tridem and quad axles

Field Name	Data Type	Description
MEPDG_LG27	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 28,000–28,999 lb for single axles; 56,000–57,999 lb for tandem axles; 87,000–89,999 lb for tridem and quad axles
MEPDG_LG28	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 29,000–29,999 lb for single axles; 58,000–59,999 lb for tandem axles; 90,000–92,999 lb for tridem and quad axles
MEPDG_LG29	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 30,000–30,999 lb for single axles; 60,000–61,999 lb for tandem axles; 93,000–95,999 lb for tridem and quad axles
MEPDG_LG30	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 31,000–31,999 lb for single axles; 62,000–63,999 lb for tandem axles; 96,000–98,999 lb for tridem and quad axles
MEPDG_LG31	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 32,000–32,999 lb for single axles; 64,000–65,999 lb for tandem axles; 99,000–101,999 lb for tridem and quad axles
MEPDG_LG32	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 33,000–33,999 lb for single axles; 66,000–67,999 lb for tandem axles
MEPDG_LG33	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 34,000–34,999 lb for single axles; 68,000–69,999 lb for tandem axles
MEPDG_LG34	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 35,000–35,999 lb for single axles; 70,000–71,999 lb for tandem axles
MEPDG_LG35	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 36,000–36,999 lb for single axles; 72,000–73,999 lb for tandem axles
MEPDG_LG36	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 37,000–37,999 lb for single axles; 74,000–75,999 lb for tandem axles
MEPDG_LG37	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 38,000–38,999 lb for single axles; 76,000–77,999 lb for tandem axles
MEPDG_LG38	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 39,000–39,999 lb for single axles; 78,000–79,999 lb for tandem axles
MEPDG_LG39	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 40,000–40,999 lb for single axles; 80,000–81,999 lb for tandem axles
Description	VARCHAR2(255)	Text description for NALS CLUSTERS field
Recommended_Road_Usage	VARCHAR2(255)	Text description indicating the recommended road usage for the selected cluster

Table 25. Field names and descriptions for LTPP_CODES

Field Name	Data Type	Description
CODETYPE	VARCHAR2(40)	Name assigned to a set of codes for a field in another table
CODE	NUMBER(2,0)	Unique text value whose meaning is defined in CODES.DETAIL
DETAIL	VARCHAR2(200)	Textual description defining the meaning of the code
ADDL_CODE	VARCHAR2(2)	Additional code needed to uniquely define the meaning of a code. For example, both State and county code are needed to uniquely identify a county
ADDL_CODETYPE	VARCHAR2(20)	Codetype of the code entered in the ADDL_CODE field

Table 26. Field names and descriptions for PLUG_LEF_FOR_ESAL

Field Name	Data Type	Description
PAVEMENT TYPE	VARCHAR2(255)	Code indicating pavement type
AXLE TYPE	NUMBER(1,0)	Type of axle for which these values apply
AX_01	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 0.5 times WEIGHT_BIN_SIZE
AX_02	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 1.5 times WEIGHT_BIN_SIZE
AX_03	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 3.5 times WEIGHT_BIN_SIZE
AX_04	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 4.5 times WEIGHT_BIN_SIZE
AX_05	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 5.5 times WEIGHT_BIN_SIZE
AX_06	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 6.5 times WEIGHT_BIN_SIZE
AX_07	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 7.5 times WEIGHT_BIN_SIZE
AX_08	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 8.5 times WEIGHT_BIN_SIZE
AX_09	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 9.5 times WEIGHT_BIN_SIZE
AX_10	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 10.5 times WEIGHT_BIN_SIZE
AX_11	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 11.5 times WEIGHT_BIN_SIZE
AX_12	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 12.5 times WEIGHT_BIN_SIZE
AX_13	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 13.5 times WEIGHT_BIN_SIZE
AX_14	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 14.5 times WEIGHT_BIN_SIZE
AX_15	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 15.5 times WEIGHT_BIN_SIZE
AX_16	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 16.5 times WEIGHT_BIN_SIZE
AX_17	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 17.5 times WEIGHT_BIN_SIZE
AX_18	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 18.5 times WEIGHT_BIN_SIZE
AX_19	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 19.5 times WEIGHT_BIN_SIZE
AX_20	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 20.5 times WEIGHT_BIN_SIZE
AX_21	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 21.5 times WEIGHT_BIN_SIZE
AX_22	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 22.5 times WEIGHT_BIN_SIZE
AX_23	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 23.5 times WEIGHT_BIN_SIZE
AX_24	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 24.5 times WEIGHT_BIN_SIZE
AX_25	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 25.5 times WEIGHT_BIN_SIZE

Field Name	Data Type	Description
AX_26	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 26.5 times WEIGHT_BIN_SIZE
AX_27	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 27.5 times WEIGHT_BIN_SIZE
AX_28	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 28.5 times WEIGHT_BIN_SIZE
AX_29	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 29.5 times WEIGHT_BIN_SIZE
AX_30	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 30.5 times WEIGHT_BIN_SIZE
AX_31	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 31.5 times WEIGHT_BIN_SIZE
AX_32	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 32.5 times WEIGHT_BIN_SIZE
AX_33	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 33.5 times WEIGHT_BIN_SIZE
AX_34	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 34.5 times WEIGHT_BIN_SIZE
AX_35	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 35.5 times WEIGHT_BIN_SIZE
AX_36	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 36.5 times WEIGHT_BIN_SIZE
AX_37	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 37.5 times WEIGHT_BIN_SIZE
AX_38	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 38.5 times WEIGHT_BIN_SIZE
AX_39	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 39.5 times WEIGHT_BIN_SIZE
AX_40	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 40.5 times WEIGHT_BIN_SIZE
AX_41	NUMBER(2,20)	LEF for axles in bin with mid-point weight equal to 41.5 times WEIGHT_BIN_SIZE
WEIGHT_BIN_SIZE	NUMBER(4,0)	Value of the increment for a bin for the axle type as loaded. 1,000 for single axles; 2,000 for tandem axles; 3,000 for tridem axles; 3,000 or 4,000 for quad axles, depending on the software version used to load the data

Table 27. Field names and descriptions for PLUG_W_FACTORS_FOR_RPIIF

Field Name	Data Type	Description
Axle Type	NUMBER(1, 0)	Type of axle for which these W-factors apply
AX_CT_01	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 0–999 lb for single axles; 0–1,999 lb for tandem axles; 0–2,999 lb for tridem and quad axles
AX_CT_02	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 1,000–1,999 lb for single axles; 2,000–3,999 lb for tandem axles; 3,000–5,999 lb for tridem and quad axles
AX_CT_03	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 2,000–2,999 lb for single axles; 4,000–5,999 lb for tandem axles; 6,000–8,999 lb for tridem and quad axles
AX_CT_04	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 3,000–3,999 lb for single axles; 6,000–7,999 lb for tandem axles; 9,000–11,999 lb for tridem and quad axles

Field Name	Data Type	Description
AX_CT_05	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 4,000–4,999 lb for single axles; 8,000–9,999 lb for tandem axles; 12,000–14,999 lb for tridem and quad axles
AX_CT_06	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 5,000–5,999 lb for single axles; 10,000–11,999 lb for tandem axles; 15,000–17,999 lb for tridem and quad axles
AX_CT_07	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 6,000–6,999 lb for single axles; 12,000–13,999 lb for tandem axles; 18,000–20,999 lb for tridem and quad axles
AX_CT_08	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 7,000–7,999 lb for single axles; 14,000–15,999 lb for tandem axles; 21,000–23,999 lb for tridem and quad axles
AX_CT_09	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 8,000–8,999 lb for single axles; 16,000–17,999 lb for tandem axles; 24,000–26,999 lb for tridem and quad axles
AX_CT_10	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 9,000–9,999 lb for single axles; 18,000–19,999 lb for tandem axles; 27,000–29,999 lb for tridem and quad axles
AX_CT_11	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 10,000–10,999 lb for single axles; 20,000–21,999 lb for tandem axles; 30,000–32,999 lb for tridem and quad axles
AX_CT_12	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 11,000–11,999 lb for single axles; 22,000–23,999 lb for tandem axles; 33,000–35,999 lb for tridem and quad axles
AX_CT_13	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 12,000–12,999 lb for single axles; 24,000–25,999 lb for tandem axles; 36,000–38,999 lb for tridem and quad axles
AX_CT_14	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 13,000–13,999 lb for single axles; 26,000–27,999 lb for tandem axles; 39,000–41,999 lb for tridem and quad axles
AX_CT_15	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 14,000–14,999 lb for single axles; 28,000–29,999 lb for tandem axles; 42,000–44,999 lb for tridem and quad axles
AX_CT_16	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 15,000–15,999 lb for single axles; 30,000–31,999 lb for tandem axles; 45,000–47,999 lb for tridem and quad axles
AX_CT_17	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 16,000–16,999 lb for single axles; 32,000–33,999 lb for tandem axles; 48,000–50,999 lb for tridem and quad axles
AX_CT_18	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 17,000–17,999 lb for single axles; 34,000–35,999 lb for tandem axles; 51,000–53,999 lb for tridem and quad axles
AX_CT_19	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 18,000–18,999 lb for single axles; 36,000–37,999 lb for tandem axles; 54,000–56,999 lb for tridem and quad axles
AX_CT_20	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 19,000–19,999 lb for single axles; 38,000–39,999 lb for tandem axles; 57,000–59,999 lb for tridem and quad axles
AX_CT_21	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 20000–20999 lb for single axles; 40,000–41,999 lb for tandem axles; 60,000–62,999 lb for tridem and quad axles
AX_CT_22	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 21,000–21,999 lb for single axles; 42,000–43,999 lb for tandem axles; 63,000–65,999 lb for tridem and quad axles

Field Name	Data Type	Description
AX_CT_23	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 22000–22999 lb for single axles; 44,000–45,999 lb for tandem axles; 66,000–68,999 lb for tridem and quad axles
AX_CT_24	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 23,000–23,999 lb for single axles; 46,000–47,999 lb for tandem axles; 69,000–71,999 lb for tridem and quad axles
AX_CT_25	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 24,000–24,999 lb for single axles; 48,000–49,999 lb for tandem axles; 72,000–74,999 lb for tridem and quad axles
AX_CT_26	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 25,000–25,999 lb for single axles; 50,000–51,999 lb for tandem axles; 75,000–77,999 lb for tridem and quad axles
AX_CT_27	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 26,000–26,999 lb for single axles; 52,000–53,999 lb for tandem axles; 78,000–80,999 lb for tridem and quad axles
AX_CT_28	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 27,000–27,999 lb for single axles; 54,000–55,999 lb for tandem axles; 81,000–83,999 lb for tridem and quad axles
AX_CT_29	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 28,000–28,999 lb for single axles; 56,000–57,999 lb for tandem axles; 84,000–86,999 lb for tridem and quad axles
AX_CT_30	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 29,000–29,999 lb for single axles; 58,000–59,999 lb for tandem axles; 87,000–89,999 lb for tridem and quad axles
AX_CT_31	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 30,000–30,999 lb for single axles; 60,000–61,999 lb for tandem axles; 90,000–92,999 lb for tridem and quad axles
AX_CT_32	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 31,000–31,999 lb for single axles; 62,000–63,999 lb for tandem axles; 93,000–95,999 lb for tridem and quad axles
AX_CT_33	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 32,000–32,999 lb for single axles; 64,000–65,999 lb for tandem axles; 96,000–98,999 lb for tridem and quad axles
AX_CT_34	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 33,000–33,999 lb for single axles; 66,000–67,999 lb for tandem axles; 99,000–101,999 lb for tridem and quad axles
AX_CT_35	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 34,000–34,999 lb for single axles; 68,000–69,999 lb for tandem axles; 102,000–104,999 lb for tridem and quad axles
AX_CT_36	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 35,000–35,999 lb for single axles; 70,000–71,999 lb for tandem axles; 105,000–107,999 lb for tridem and quad axles
AX_CT_37	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 36,000–36,999 lb for single axles; 72,000–73,999 lb for tandem axles; 108,000–110,999 lb for tridem and quad axles
AX_CT_38	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 37,000–37,999 lb for single axles; 74,000–75,999 lb for tandem axles; 111,000–113,999 lb for tridem and quad axles
AX_CT_39	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 38,000–38,999 lb for single axles; 76,000–77,999 lb for tandem axles; 114,000–116,999 lb for tridem and quad axles
AX_CT_40	NUMBER(2,20)	W-factors for axles whose weight falls in the lowest bin 39,000–39,999 lb for single axles; 78,000–79,999 lb for tandem axles; 117,000–119,999 lb for tridem and quad axles

Table 28. Field names and descriptions for SITE_SPECIFIC_AxlesPerTruck

Field Name	Data Type	Description
STATE_CODE	NUMBER(2,0)	Numerical code for State or Province. U.S. codes are consistent with Federal Information Processing Standards
SHRP_ID	VARCHAR2(255)	Test section identification number assigned by LTPP program. Must be combined with STATE_CODE to be unique
classNumber	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
numberAxle	NUMBER(1,0)	Type of axle for which the values in the field “truckAxleConfig” apply
truckAxleConfig	NUMBER(1,2)	Number of this type of axle for a vehicle in this class

Table 29. Field names and descriptions for SITE_SPECIFIC_NALS

Field Name	Data Type	Description
STATE_CODE	NUMBER(2,0)	Numerical code for State or Province. U.S. codes are consistent with Federal Information Processing Standards
SHRP_ID	VARCHAR2(255)	Test section identification number assigned by LTPP program. Must be combined with STATE_CODE to be unique
VEH_CLASS	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
AXLE_GROUP	NUMBER(1,0)	Type of axle for which these percentages of axles apply
MEPDG_LG01	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 0–2,999 lb for single axles; 0–5,999 lb for tandem axles; 0–11,999 lb for tridem and quad axles
MEPDG_LG02	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 3,000–3,999 lb for single axles; 6,000–7,999 lb for tandem axles; 12,000–14,999 lb for tridem and quad axles
MEPDG_LG03	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 4,000–4,999 lb for single axles; 8,000–9,999 lb for tandem axles; 15,000–17,999 lb for tridem and quad axles
MEPDG_LG04	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 5,000–5,999 lb for single axles; 10,000–11,999 lb for tandem axles; 18,000–20,999 lb for tridem and quad axles
MEPDG_LG05	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 6,000–6,999 lb for single axles; 12,000–13,999 lb for tandem axles; 21,000–23,999 lb for tridem and quad axles
MEPDG_LG06	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 7,000–7,999 lb for single axles; 14,000–15,999 lb for tandem axles; 24,000–26,999 lb for tridem and quad axles
MEPDG_LG07	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 8,000–8,999 lb for single axles; 16,000–17,999 lb for tandem axles; 27,000–2,9999 lb for tridem and quad axles
MEPDG_LG08	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 9,000–9,999 lb for single axles; 18,000–19,999 lb for tandem axles; 30,000–32,999 lb for tridem and quad axles
MEPDG_LG09	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 10,000–10,999 lb for single axles; 20,000–21,999 lb for tandem axles; 33,000–35,999 lb for tridem and quad axles
MEPDG_LG10	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 11,000–11,999 lb for single axles; 22,000–23,999 lb for tandem axles; 36,000–38,999 lb for tridem and quad axles

Field Name	Data Type	Description
MEPDG_LG11	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 12,000–12,999 lb for single axles; 24,000–25,999 lb for tandem axles; 39,000–41,999 lb for tridem and quad axles
MEPDG_LG12	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 13,000–13,999 lb for single axles; 26,000–27,999 lb for tandem axles; 42,000–44,999 lb for tridem and quad axles
MEPDG_LG13	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 14,000–14,999 lb for single axles; 28,000–29,999 lb for tandem axles; 45,000–47,999 lb for tridem and quad axles
MEPDG_LG14	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 15,000–15,999 lb for single axles; 30,000–31,999 lb for tandem axles; 48,000–50,999 lb for tridem and quad axles
MEPDG_LG15	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 16,000–16,999 lb for single axles; 32,000–33,999 lb for tandem axles; 51,000–53,999 lb for tridem and quad axles
MEPDG_LG16	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 17,000–17,999 lb for single axles; 34,000–35,999 lb for tandem axles; 54,000–56,999 lb for tridem and quad axles
MEPDG_LG17	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 18,000–18,999 lb for single axles; 36,000–37,999 lb for tandem axles; 57,000–59,999 lb for tridem and quad axles
MEPDG_LG18	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 19,000–19,999 lb for single axles; 38,000–39,999 lb for tandem axles; 60,000–62,999 lb for tridem and quad axles
MEPDG_LG19	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 20,000–20,999 lb for single axles; 40,000–41,999 lb for tandem axles; 63,000–65,999 lb for tridem and quad axles
MEPDG_LG20	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 21,000–21,999 lb for single axles; 42,000–43,999 lb for tandem axles; 66,000–68,999 lb for tridem and quad axles
MEPDG_LG21	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 22,000–22,999 lb for single axles; 44,000–45,999 lb for tandem axles; 69,000–71,999 lb for tridem and quad axles
MEPDG_LG22	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 23,000–23,999 lb for single axles; 46,000–47,999 lb for tandem axles; 72,000–74,999 lb for tridem and quad axles
MEPDG_LG23	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 24,000–24,999 lb for single axles; 48,000–49,999 lb for tandem axles; 75,000–77,999 lb for tridem and quad axles
MEPDG_LG24	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 25,000–25,999 lb for single axles; 50,000–51,999 lb for tandem axles; 78,000–80,999 lb for tridem and quad axles
MEPDG_LG25	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 26,000–26,999 lb for single axles; 52,000–53,999 lb for tandem axles; 81,000–83,999 lb for tridem and quad axles
MEPDG_LG26	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 27,000–27,999 lb for single axles; 54,000–55,999 lb for tandem axles; 84,000–86,999 lb for tridem and quad axles
MEPDG_LG27	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 28,000–28,999 lb for single axles; 56,000–57,999 lb for tandem axles; 87,000–89,999 lb for tridem and quad axles
MEPDG_LG28	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 29,000–29,999 lb for single axles; 58,000–59,999 lb for tandem axles; 90,000–92,999 lb for tridem and quad axles

Field Name	Data Type	Description
MEPDG_LG29	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 30,000–30,999 lb for single axles; 60,000–61,999 lb for tandem axles; 93,000–95,999 lb for tridem and quad axles
MEPDG_LG30	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 31,000–31,999 lb for single axles; 62,000–63,999 lb for tandem axles; 96,000–98,999 lb for tridem and quad axles
MEPDG_LG31	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 32,000–32,999 lb for single axles; 64,000–65,999 lb for tandem axles; 99,000–101,999 lb for tridem and quad axles
MEPDG_LG32	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 33,000–33,999 lb for single axles; 66,000–67,999 lb for tandem axles
MEPDG_LG33	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 34,000–34,999 lb for single axles; 68,000–69,999 lb for tandem axles
MEPDG_LG34	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 35,000–35,999 lb for single axles; 70,000–71,999 lb for tandem axles
MEPDG_LG35	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 36,000–36,999 lb for single axles; 72,000–73,999 lb for tandem axles
MEPDG_LG36	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 37,000–37,999 lb for single axles; 74,000–75,999 lb for tandem axles
MEPDG_LG37	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 38,000–38,999 lb for single axles; 76,000–77,999 lb for tandem axles
MEPDG_LG38	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 39,000–39,999 lb for single axles; 78,000–79,999 lb for tandem axles
MEPDG_LG39	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 40,000–40,999 lb for single axles; 80,000–81,999 lb for tandem axles

Table 30. Field names and descriptions for SITE_SPECIFIC_NVCD

Field Name	Data Type	Description
STATE_CODE	NUMBER(2,0)	Numerical code for State or Province. U.S. codes are consistent with Federal Information Processing Standards
SHRP_ID	VARCHAR2(255)	Test section identification number assigned by LTPP program. Must be combined with STATE_CODE to be unique
YEAR	NUMBER(4,0)	Year for which values apply
VEHICLE_CLASS	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
Pct_Trucks_Class	NUMBER(3,2)	Percentage of the truck population represented by this class

Table 31. Field names and descriptions for USER_DEFINED_NALS

Field Name	Data Type	Description
VEH_CLASS	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
AXLE_GROUP	NUMBER(1,0)	Type of axle for which these percentages of axles apply
NALS_CLUSTERS	VARCHAR2(255)	Text field indicating the type of NALS cluster
MEPDG_LG01	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 0–2,999 lb for single axles; 0–5,999 lb for tandem axles; 0–11,999 lb for tridem and quad axles
MEPDG_LG02	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 3,000–3,999 lb for single axles; 6,000–7,999 lb for tandem axles; 12,000–14,999 lb for tridem and quad axles
MEPDG_LG03	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 4,000–4,999 lb for single axles; 8,000–9,999 lb for tandem axles; 15,000–17,999 lb for tridem and quad axles

Field Name	Data Type	Description
MEPDG_LG04	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 5,000–5,999 lb for single axles; 10,000–11,999 lb for tandem axles; 18,000–20,999 lb for tridem and quad axles
MEPDG_LG05	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 6,000–6,999 lb for single axles; 12,000–13,999 lb for tandem axles; 21,000–23,999 lb for tridem and quad axles
MEPDG_LG06	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 7,000–7,999 lb for single axles; 14,000–15,999 lb for tandem axles; 24,000–26,999 lb for tridem and quad axles
MEPDG_LG07	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 8,000–8,999 lb for single axles; 16,000–17,999 lb for tandem axles; 27,000–29,999 lb for tridem and quad axles
MEPDG_LG08	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 9,000–9,999 lb for single axles; 18,000–19,999 lb for tandem axles; 30,000–32,999 lb for tridem and quad axles
MEPDG_LG09	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 10,000–10,999 lb for single axles; 20,000–21,999 lb for tandem axles; 33,000–35,999 lb for tridem and quad axles
MEPDG_LG10	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 11,000–11,999 lb for single axles; 22,000–23,999 lb for tandem axles; 36,000–38,999 lb for tridem and quad axles
MEPDG_LG11	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 12,000–12,999 lb for single axles; 24,000–25,999 lb for tandem axles; 39,000–41,999 lb for tridem and quad axles
MEPDG_LG12	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 13,000–13,999 lb for single axles; 26,000–27,999 lb for tandem axles; 42,000–44,999 lb for tridem and quad axles
MEPDG_LG13	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 14,000–14,999 lb for single axles; 28,000–29,999 lb for tandem axles; 45,000–47,999 lb for tridem and quad axles
MEPDG_LG14	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 15,000–15,999 lb for single axles; 30,000–31,999 lb for tandem axles; 48,000–50,999 lb for tridem and quad axles
MEPDG_LG15	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 16,000–16,999 lb for single axles; 32,000–33,999 lb for tandem axles; 51,000–53,999 lb for tridem and quad axles
MEPDG_LG16	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 17,000–17,999 lb for single axles; 34,000–35,999 lb for tandem axles; 54,000–56,999 lb for tridem and quad axles
MEPDG_LG17	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 18,000–18,999 lb for single axles; 36,000–37,999 lb for tandem axles; 57,000–59,999 lb for tridem and quad axles
MEPDG_LG18	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 19,000–19,999 lb for single axles; 38,000–39,999 lb for tandem axles; 60,000–62,999 lb for tridem and quad axles
MEPDG_LG19	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 20,000–20,999 lb for single axles; 40,000–41,999 lb for tandem axles; 63,000–65,999 lb for tridem and quad axles
MEPDG_LG20	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 21,000–21,999 lb for single axles; 42,000–43,999 lb for tandem axles; 66,000–68,999 lb for tridem and quad axles
MEPDG_LG21	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 22,000–22,999 lb for single axles; 44,000–45,999 lb for tandem axles; 69,000–71,999 lb for tridem and quad axles

Field Name	Data Type	Description
MEPDG_LG22	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 23,000–23,999 lb for single axles; 46,000–47,999 lb for tandem axles; 72,000–74,999 lb for tridem and quad axles
MEPDG_LG23	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 24,000–24,999 lb for single axles; 48,000–49,999 lb for tandem axles; 75,000–77,999 lb for tridem and quad axles
MEPDG_LG24	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 25,000–25,999 lb for single axles; 50,000–51,999 lb for tandem axles; 78,000–80,999 lb for tridem and quad axles
MEPDG_LG25	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 26,000–26,999 lb for single axles; 52,000–53,999 lb for tandem axles; 81,000–83,999 lb for tridem and quad axles
MEPDG_LG26	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 27,000–27,999 lb for single axles; 54,000–55,999 lb for tandem axles; 84,000–86,999 lb for tridem and quad axles
MEPDG_LG27	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 28,000–28,999 lb for single axles; 56,000–57,999 lb for tandem axles; 87,000–89,999 lb for tridem and quad axles
MEPDG_LG28	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 29,000–29,999 lb for single axles; 58,000–59,999 lb for tandem axles; 90,000–92,999 lb for tridem and quad axles
MEPDG_LG29	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 30,000–30,999 lb for single axles; 60,000–61,999 lb for tandem axles; 93,000–95,999 lb for tridem and quad axles
MEPDG_LG30	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 31,000–31,999 lb for single axles; 62,000–63,999 lb for tandem axles; 96,000–98,999 lb for tridem and quad axles
MEPDG_LG31	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 32,000–32,999 lb for single axles; 64,000–65,999 lb for tandem axles; 99,000–101,999 lb for tridem and quad axles
MEPDG_LG32	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 33,000–33,999 lb for single axles; 66,000–67,999 lb for tandem axles
MEPDG_LG33	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 34,000–34,999 lb for single axles; 68,000–69,999 lb for tandem axles
MEPDG_LG34	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 35,000–35,999 lb for single axles; 70,000–71,999 lb for tandem axles
MEPDG_LG35	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 36,000–36,999 lb for single axles; 72,000–73,999 lb for tandem axles
MEPDG_LG36	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 37,000–37,999 lb for single axles; 74,000–75,999 lb for tandem axles
MEPDG_LG37	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 38,000–38,999 lb for single axles; 76,000–77,999 lb for tandem axles
MEPDG_LG38	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 39,000–39,999 lb for single axles; 78,000–79,999 lb for tandem axles
MEPDG_LG39	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 40,000–40,999 lb for single axles; 80,000–81,999 lb for tandem axles
Description	VARCHAR2(255)	User-defined description for the NALS
Cluster_Description	VARCHAR2(255)	Text description for NALS_CLUSTERS field
Recommended_Road_Usage	VARCHAR2(255)	Text description indicating the recommended road usage for the selected cluster

Table 32. Field names and descriptions for XMLGen_AxleLoadDistribution

Field Name	Data Type	Description
classNumber	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
numberAxle	NUMBER(1,0)	Type of axle (1–4) for which these values apply
month	NUMBER(2,0)	Code specifying the month in numeric format (1–12)
axleLoad	NUMBER(2,0)	Code specifying load bins in DARWin-ME (1–39)
percentTrucksPerLoad	NUMBER(3,14)	Percentage of axles whose weight falls in the specified DARWin-ME load bin

Table 33. Field names and descriptions for XMLGen_AxleLoadMain_Template

Field Name	Data Type	Description
classNumber	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
numberAxle	NUMBER(1,0)	Type of axle (1–4) for which these values apply
month	NUMBER(2,0)	Code specifying the month in numeric format (1–12)
axleLoad	NUMBER(2,0)	Code specifying load bins in DARWin-ME (1–39)

Table 34. Field names and descriptions for XMLGen_DEFAULT_NALS_By>Loading_Cluster

Field Name	Data Type	Description
VEH_CLASS	NUMBER(2,0)	Code indicating the 13-bin classification into which trucks have been grouped
AXLE_GROUP	NUMBER(1,0)	Type of axle for which these percentages of axles apply
MEPDG_LG01	NUMBER(3,14)	Percent of axles whose weight falls in the bin 0–2,999 lb for single axles; 0–5,999 lb for tandem axles; 0–11,999 lb for tridem and quad axles
MEPDG_LG02	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 3,000–3,999 lb for single axles; 6,000–7,999 lb for tandem axles; 12,000–14,999 lb for tridem and quad axles
MEPDG_LG03	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 4,000–4,999 lb for single axles; 8,000–9,999 lb for tandem axles; 15,000–17,999 lb for tridem and quad axles
MEPDG_LG04	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 5,000–5,999 lb for single axles; 10,000–11,999 lb for tandem axles; 18,000–20,999 lb for tridem and quad axles
MEPDG_LG05	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 6,000–6,999 lb for single axles; 12,000–13,999 lb for tandem axles; 21,000–23,999 lb for tridem and quad axles
MEPDG_LG06	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 7,000–7,999 lb for single axles; 14,000–15,999 lb for tandem axles; 24,000–26,999 lb for tridem and quad axles
MEPDG_LG07	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 8,000–8,999 lb for single axles; 16,000–17,999 lb for tandem axles; 27,000–29,999 lb for tridem and quad axles
MEPDG_LG08	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 9,000–9,999 lb for single axles; 18,000–19,999 lb for tandem axles; 30,000–32,999 lb for tridem and quad axles
MEPDG_LG09	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 10,000–10,999 lb for single axles; 20,000–21,999 lb for tandem axles; 33,000–35,999 lb for tridem and quad axles

Field Name	Data Type	Description
MEPDG_LG10	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 11,000–11,999 lb for single axles; 22,000–23,999 lb for tandem axles; 36,000–38,999 lb for tridem and quad axles
MEPDG_LG11	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 12,000–12,999 lb for single axles; 24,000–25,999 lb for tandem axles; 39,000–41,999 lb for tridem and quad axles
MEPDG_LG12	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 13,000–13,999 lb for single axles; 26,000–27,999 lb for tandem axles; 42,000–44,999 lb for tridem and quad axles
MEPDG_LG13	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 14,000–14,999 lb for single axles; 28,000–29,999 lb for tandem axles; 45,000–47,999 lb for tridem and quad axles
MEPDG_LG14	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 15,000–15,999 lb for single axles; 30,000–31,999 lb for tandem axles; 48,000–50,999 lb for tridem and quad axles
MEPDG_LG15	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 16,000–16,999 lb for single axles; 32,000–33,999 lb for tandem axles; 51,000–53,999 lb for tridem and quad axles
MEPDG_LG16	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 17,000–17,999 lb for single axles; 34,000–35,999 lb for tandem axles; 54,000–56,999 lb for tridem and quad axles
MEPDG_LG17	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 18,000–18,999 lb for single axles; 36,000–37,999 lb for tandem axles; 57,000–59,999 lb for tridem and quad axles
MEPDG_LG18	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 19,000–19,999 lb for single axles; 38,000–39,999 lb for tandem axles; 60,000–62,999 lb for tridem and quad axles
MEPDG_LG19	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 20,000–20,999 lb for single axles; 40,000–41,999 lb for tandem axles; 63,000–65,999 lb for tridem and quad axles
MEPDG_LG20	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 21,000–21,999 lb for single axles; 42,000–43,999 lb for tandem axles; 66,000–68,999 lb for tridem and quad axles
MEPDG_LG21	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 22,000–22,999 lb for single axles; 44,000–45,999 lb for tandem axles; 69,000–71,999 lb for tridem and quad axles
MEPDG_LG22	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 23,000–23,999 lb for single axles; 46,000–47,999 lb for tandem axles; 72,000–74,999 lb for tridem and quad axles
MEPDG_LG23	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 24,000–24,999 lb for single axles; 48,000–49,999 lb for tandem axles; 75,000–77,999 lb for tridem and quad axles
MEPDG_LG24	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 25,000–25,999 lb for single axles; 50,000–51,999 lb for tandem axles; 78,000–80,999 lb for tridem and quad axles
MEPDG_LG25	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 26,000–26,999 lb for single axles; 52,000–53,999 lb for tandem axles; 81,000–83,999 lb for tridem and quad axles
MEPDG_LG26	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 27,000–27,999 lb for single axles; 54,000–55,999 lb for tandem axles; 84,000–86,999 lb for tridem and quad axles
MEPDG_LG27	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 28,000–28,999 lb for single axles; 56,000–57,999 lb for tandem axles; 87,000–89,999 lb for tridem and quad axles

Field Name	Data Type	Description
MEPDG_LG28	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 29,000–29,999 lb for single axles; 58,000–59,999 lb for tandem axles; 90,000–92,999 lb for tridem and quad axles
MEPDG_LG29	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 30,000–30,999 lb for single axles; 60,000–61,999 lb for tandem axles; 93,000–95,999 lb for tridem and quad axles
MEPDG_LG30	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 31,000–31,999 lb for single axles; 62,000–63,999 lb for tandem axles; 96,000–98,999 lb for tridem and quad axles
MEPDG_LG31	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 32,000–32,999 lb for single axles; 64,000–65,999 lb for tandem axles; 99,000–101,999 lb for tridem and quad axles
MEPDG_LG32	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 33,000–33,999 lb for single axles; 66,000–67,999 lb for tandem axles
MEPDG_LG33	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 34,000–34,999 lb for single axles; 68,000–69,999 lb for tandem axles
MEPDG_LG34	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 35,000–35,999 lb for single axles; 70,000–71,999 lb for tandem axles
MEPDG_LG35	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 36,000–36,999 lb for single axles; 72,000–73,999 lb for tandem axles
MEPDG_LG36	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 37,000–37,999 lb for single axles; 74,000–75,999 lb for tandem axles
MEPDG_LG37	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 38,000–38,999 lb for single axles; 76,000–77,999 lb for tandem axles
MEPDG_LG38	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 39,000–39,999 lb for single axles; 78,000–79,999 lb for tandem axles
MEPDG_LG39	NUMBER(3,14)	Percentage of axles whose weight falls in the bin 40,000–40,999 lb for single axles; 80,000–81,999 lb for tandem axles

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