ARIZONA DEPARTMENT OF TRANSPORTATION

REPORT NUMBER: FHWA-AZ99-455

# DEVELOPMENT OF NEW PAVEMENT DESIGN EQUIVALENT SINGLE AXLE LOAD (ESAL)

**Final Report**

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16. Abstract Establishing, maintaining, and enhancing the statewide network of roads are among the most important goals of any state highway agency. These require huge investments of both financial and human resources year in and year out. Accordingly, it makes good sense to apply sound engineering practices to ensure these resources are allocated wisely.

One of the fundamental and universally sought parameters that influence all new pavement and rehabilitation design decisions is *traffic*. For a given road segment, accurate estimates of current and projected traffic (in terms of Equivalent Single Axle Loads (ESALs)) can result in significant cost savings, either from the standpoint of initial construction cost or future maintenance and rehabilitation cost.

The primary objective of this project is to prepare a new ESAL design table for Arizona's highway network. This new table is based on analysis of current traffic data collection procedures, traffic forecasting methodology, and ESAL development procedures, including the assignment of traffic ESAL levels to the various highway segments. It is also based on new information such as provided by weigh-in-motion (WIM) systems. There are recommendations made for installing WIMs at a series of sites. System methodology for assessment of future needs for WIM and AVC installations is presented in this report focusing on technology installation, operation, and maintenance issues. The new ESAL table is provided to Arizona DOT in an electronic format on a CD ROM.

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# SI* (MODERN METRIC) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS TO SI UNITS

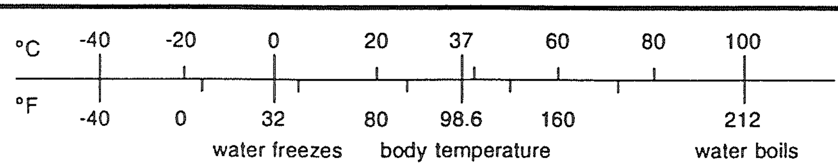
| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | 25.4 | millimeters | mm |
| ft | feet | 0.305 | meters | m |
| yd | yards | 0.914 | meters | m |
| ml | miles | 1.61 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 645.2 | millimeters squared | $mm^2$ |
| $ft^2$ | square feet | 0.093 | meters squared | $m^2$ |
| $yd^2$ | square yards | 0.836 | meters squared | $m^2$ |
| ac | acres | 0.405 | hectares | ha |
| $mi^2$ | square miles | 2.59 | kilometers squared | $km^2$ |
| | | **VOLUME** | | |
| ft oz | fluid ounces | 29.57 | milliliters | mL |
| gal | gallons | 3.785 | liters | L |
| $ft^3$ | cubic feet | 0.028 | meters cubed | $m^3$ |
| $yd^3$ | cubic yards | 0.765 | meters cubed | $m^3$ |

NOTE: Volumes greater than 1000 L shall be shown in $m^3$.

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **MASS** | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams | Mg |

### TEMPERATURE (exact)

| Symbol | When You Know | Do The Following | To Find | Symbol |
|---|---|---|---|---|
| °F | Fahrenheit temperature | °F - 32 ÷ 1.8 | Celcius temperature | °C |




## 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** | | |
| $mm^2$ | millimeters squared | 0.0016 | square inches | $in^2$ |
| $m^2$ | meters squared | 10.764 | square feet | $ft^2$ |
| $m^2$ | meters squared | 1.19 | square yards | $yd^2$ |
| ha | hectares | 2.47 | acres | ac |
| $km^2$ | kilometers squared | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| mL | milliliters | 0.034 | fluid ounces | fl oz |
| L | liters | 0.264 | gallons | gal |
| $m^3$ | meters cubed | 35.315 | cubic feet | $ft^3$ |
| $m^3$ | meters cubed | 1.31 | cubic yards | $yd^3$ |
| | | **MASS** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.205 | pounds | lb |
| Mg | megagrams | 1.102 | short tons (2000 lb) | T |

### TEMPERATURE (exact)

| Symbol | When You Know | Do The Following | To Find | Symbol |
|---|---|---|---|---|
| °C | Celcius temperature | °C x 1.8 + 32 | Fahrenheit temperature | °F |

| | |
|---|---|
| **METER:** | a little longer than a yard (about 1.1 yards) |
| **LITER:** | a little larger than a quart (about 1.06 quarts) |
| **GRAM:** | a little more than the weight of a paper clip |
| **MILLIMETER:** | diameter of a paper clip wire |
| **KILOMETER:** | somewhat further than 1/2 mile (about 0.6 mile) |

*SI is the symbol for the International System of Measurement

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The NCE project team was led by Dr. Sirous Alavi, the principal investigator. Mr. Kevin Senn was the project manager, and the project engineers were Mr. Weston Ott, Mr. Joseph Mactutis and Mr. Tony Lorenzi. The project team received valuable assistance from two consultants: Dr. Tom Papagiannakis of Washington State University and Mr. Earl Laird of TP&R. Last but not least, Mrs. Carol Chiappetta and Mrs. Barbara Milliken provided administrative support.

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AADT | Annual Average Daily Traffic |
| AAWDT | Annual Average Weekday Traffic |
| ADOT | Arizona Department of Transportation |
| ATR | Automated Traffic Recorder |
| AVC | Automatic Vehicle Classifier |
| CV | Coefficient of Variation |
| ESAL | Equivalent Single Axle Load |
| FHWA | Federal Highway Administration |
| GVW | Gross Vehicle Weight |
| KESAL | Thousand Equivalent Single Axle Loads |
| LDF | Lane Distribution Factor |
| LTPP | Long-Term Pavement Performance |
| NCE | Nichols Consulting Engineers |
| NRBA | No Recommendation by AASHTO |
| QC/QA | Quality Control/Quality Assurance |
| RV | Recreational Vehicle |
| SR | State Route |
| TPG | Traffic Planning Group |
| TWS | Truck Weight Study |
| TAC | Technical Advisory Committee |
| WIM | Weigh-in-motion |

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# CHAPTER 1: INTRODUCTION

## PROBLEM STATEMENT

Establishing, maintaining, and enhancing the statewide network of roads are among the most important goals of any State highway agency. These require huge investments of both financial and human resources year in and year out. Accordingly, it makes good sense to apply sound engineering practices to ensure these resources are allocated wisely.

For designing the new roadways (or rehabilitating existing ones), there are alternative methodologies available to engineers (including those used by ADOT) which call for a number of inputs that can significantly affect the design output. One of the fundamental and universally sought parameters that influences all new pavement and rehabilitation design decisions is *traffic*. For a given road segment, accurate estimates of current and projected traffic (in terms of Equivalent Single Axle Loads (ESALs)) can result in significant cost savings, either from the standpoint of initial construction cost or future maintenance and rehabilitation cost. In other words, accurate ESAL estimates help produce better pavement thickness designs and/or more realistic determinations of the performance lives of newly-constructed (or rehabilitated) pavements.

ADOT currently has an ESAL design table developed in the mid-80s that, for a given road segment, uses average ESAL vehicle factors, traffic volume, and vehicle classification data to generate base year, 10-year and 20-year estimates of accumulated ESALs. Since that time, significant progress has been made in the automated collection of vehicle weight and classification data. ADOT currently has 14 weigh-in-motion (WIM) sites and nine automatic vehicle classifier (AVC) sites maintained as a part of the Long-Term Pavement Performance (LTPP) Program. The Traffic Planning Group (TPG) maintains an additional six WIM sites and two AVC sites.

Thus, research was needed to evaluate and then enhance the existing ESAL design table incorporating the new monitoring data that is now available. It was also important to determine whether existing monitoring systems are collecting quality data, and whether the existing systems satisfactorily cover the key highway segments in Arizona.

## OBJECTIVE

The primary objective of the project was to prepare a new ESAL design table for Arizona's highway network. This new table is based on analysis of current traffic data collection procedures, traffic forecasting methodology, and ESAL development procedures including the assignment of traffic ESAL levels to the various highway segments. It is also based on new information such as those provided by WIM systems. Through the course of this project, a plan was developed and presented in this report for future review and update of the ESAL table on a routine (i.e., yearly) basis. There are recommendations made for installing 10 WIM sites. Also, a system methodology for assessment of future needs for WM and AVC sites is presented in this report focusing on technology, installation, operation, and maintenance issues.

## SCOPE

As stated in the Objective, the primary focus of this project was to develop a new ESAL table for future pavement designs. This table was developed using the best available data provided by ADOT. No data was collected by the project team.

## RESEARCH APPROACH (NEW ESAL TABLE)

There are three major types of data collected by ADOT, namely: vehicle counts, vehicle classification, and vehicle weights. The first two are collected either manually or automatically, while the latter is collected using WIM technology. The research team analyzed all types of available collected data and utilized the most representative data to produce the new ESAL table. The existing ESAL table consists of over 1,000 highway segments. These segments were not changed as a part of this study. Each segment has:

- An annual average daily traffic (AADT).
- The percent trucks based on the total traffic stream.
- The class breakdown of vehicle types based upon the Federal Highway's 13 class scheme.
- An annual growth factor and an ESAL value for both a flexible and a rigid pavement.

ADOT performs vehicle counts on all segments either annually (for high volume roads) or every 3 years (for all other roads). Classification data is collected either manually using 6-hour counts or automatically using 48-hour counts and also follows either an annual or a 3-year rotation. Given the costs of collecting classification data, a number of segments in the ESAL table are assigned to the most representative classification station. There are also a number of AVC/WIM systems that were installed primarily to support the LTPP program. The TPG does have four AVC/WIM sites that collect classification and weight data. The data from the WIM sites were utilized to determine the average ESAL factors for each Federal Highway Administration (FHWA) vehicle class 4-13. Final ESAL values were based upon the weighted average of the vehicles on each particular roadway segment. Sections that had a WIM representing its classification station used ESAL values based on measured data. Sections with no WIM systems representing their classification station used average ESAL factors based on a statewide average.

## OVERVIEW OF REPORT

Accomplishment of this project required the following tasks.

Task A. Review the scope of work and work plan at a kick-off meeting between the ADOT project Technical Advisory Committee (TAC) and key members of the investigating team.

Task B. Review the current traffic data collection, analysis and forecasting procedures used by ADOT. This included WIM and AVC information as well as other manual and automated collection techniques.

Task C. Review ADOT's procedures for developing its existing ESAL design table. The information gathered under Task B was used extensively in this task and a thorough review of the existing design tables (as provided by ADOT) was performed.

Task D. Recommend changes to the current procedures which can be incorporated into ADOT's practice. Formulate a plan for updating these in future years. The future data should be utilized to improve the existing traffic distribution, growth factor estimates, weight distribution algorithms, and ESAL calculations.

Task E. Prepare a new ESAL design table for the ADOT highway network based upon the new procedures and the best available traffic data.

Task F. Undertake an assessment of WIM and AVC data needs with due consideration as to cost, towards optimizing the contribution of continuous automated data sites in the development of ESAL table. Recommend 10-12 core sites along with another list of key sites, making an estimate of installed cost (where applicable), operation and maintenance costs in both equipment and staff.

This report contains a separate chapter for each task, as well as a final chapter containing the conclusions and recommendations of the research team.

# CHAPTER 2: KICK-OFF MEETING

Shortly after the awarding of the contract, a kick-off meeting was scheduled between the project team and the ADOT TAC. The purpose of this meeting was to discuss the key elements of the project, identifying the data sources that would be required and establishing key contact for providing the data.

## MEETING OVERVIEW

The kick-off meeting between ADOT project TAC and key members of the NCE team took place on December 2, 1998. NCE's principal investigator, project engineer, and technical advisor participated in a 1-day meeting with the TAC to review the scope of work and work plan in detail. A draft agenda for this meeting was prepared by NCE and was circulated among the project team (ADOT and NCE) for their review and comment in advance of the meeting date. A final meeting agenda based on input from the ADOT TAC and NCE project team was prepared and circulated just prior to the meeting date.

The meeting lasted over 3 hours, during which the NCE team was able to become familiar with the ADOT groups (and points of contact) involved the in traffic data collection and analysis. The project objectives were discussed and the work plan was thoroughly reviewed. The topics that received significant attention were the importance of getting as much information as possible regarding the existing ADOT ESAL tables and the traffic growth rates. It was decided that NCE would generate growth information based on the best available data and forecasting methods currently used by ADOT and other relevant agencies (i.e., the Maricopa Association of Governments in the Greater Phoenix Area). In the latter part of the meeting, NCE presented a wish list for data that needed to be evaluated in this project. Contact persons were identified for each data element. Table 2.1 summarizes all the materials provided to the NCE team.

Table 2.1. Data provided by ADOT.

| Data Type |
|---|
| Hardcopy and electronic version of existing ESAL table |
| ADT File from Traffic Planning Group--not known if it will be hardcopy or electronic |
| ADOT's adaptation of American Association of State Highway and Transportation Officials (AASHTO) ESAL Calculation (George Way and John Eisenberg) |
| "Interesting" trends in traffic data as identified by George Way (waywim.xls) |
| Data related to how growth factors are/were calculated |
| Data related to how growth factors are/were calculated |
| Vehicle volume and classification data |
| Transportation Planning Group WIM data--three WIM sites |
| Transportation Planning Group WIM data--fourth WIM site |
| List of weigh scales in Arizona |
| A1MRSNVJ.xls--Growth factors for key segments for 1997 |
| A2USSNVJ.xls--Seasonal distributions for key segments for 1997 |
| A3FTSNVJ.xls--Load factors by axle group for 1997 |

Table 2.1. Data provided by ADOT (continued).

| Data Type |
|---|
| Transportation Planning Group traffic count data |
| Transportation Planning Group classification data--138 sites with classification data for 1997 (vcls9704.xls); manual classification surveys from 1996, 1997 and 1998 |
| Relevant literature and reports from 1986 ESAL study |
| ADT Growth regression performed in 1990 (hardcopy) |
| Maricopa Association of Governments Conformity Analysis Appendices, Volume 2 |
| Pima Association of Governments Regional Transportation Improvement Program Tucson) |
| Information regarding base year for ESAL table |
| Input files for TRAFPROG or TRAF18K (as applicable) |
| Description of WIM systems for TPG WIM systems |
| Locations of classification sites |
| Definition of percent trucks in "Traffic on the Arizona State Highway System 1997" |
| Information regarding which fields in "Traffic on the Arizona State Highway System 1997" are measured and which are calculated |
| Description of how growth factors are determined in the Excel file containing regional growth factors |
| Documentation describing the Axle Factors by Axle Factor Group Excel spreadsheet--Chaparral may have, ADOT does not |
| Conversion from FHWA classification scheme to ADOT ESAL table classification scheme |
| Information on how much data the ADOT ATR sites collect |
| Information on regional groups 8 and 99 |
| 1996 classification data |

Following the meeting, NCE compiled the meeting notes and submitted a draft set to the project manager for review. Upon receiving feedback on those draft minutes, the official minutes were sent to all members of the TAC. The final minutes form this meeting are found in appendix A.

# CHAPTER 3: REVIEW PROCEDURES FOR TRAFFIC DATA COLLECTION, ANALYSIS, AND FORECASTING

The State of Arizona has a roadway network comprised of interstates, primary and secondary roads. The roadway network maintained by ADOT has been divided up into segments, which represent roadway sections with unique traffic and/or geometric constraints. The traffic data used in this study was collected almost entirely by ADOT. Understanding this data was of utmost importance before any meaningful progress could be made. This chapter reviews the traffic data collection, analysis, and forecasting methodologies currently used by ADOT.

## COLLECTED TRAFFIC DATA

The following is a brief description of each data type that is currently available for use in the new ESAL table. Each data group is important in either the determination of the number of vehicles passing a roadway segment or the type and weight of vehicles.

## AVERAGE ANNUAL DAILY TRAFFIC COUNTS

The vast majority (over 90 percent) of traffic volume counts performed by ADOT consist of either 24-hour or 48-hour counts using pneumatic road tubes or inductive loops. These counts are collected on a rotational basis, with some high volume areas being counted annually, but most areas being collected every 3 years. These counts are expanded into AADT values using a series of factors that will be described later in the ADOT data analysis section of this report.

## 6-HOUR MANUAL TRAFFIC COUNTS FOR VEHICLE CLASSIFICATION

This data is collected by ADOT on a 3-year rotational basis. The 6-hour manual classifications are not factored in any way and are used primarily to provide ADOT with two sources of information. The first piece of information is axle correction factors for pneumatic tube-based traffic counts and the second is the percentage of the AADT that is generated by commercial vehicles. The collection process of manual data is very labor intensive and costly. Only 30 percent of the approximately 140 classification stations use manual counts.

## 48-HOUR COUNTS FOR VEHICLE CLASSIFICATION

Like the 6-hour manual counts, the 48-hour counts are collected on a 3-year rotational basis. The data is collected with portable programmable classification equipment. As with the manual counts, axle correction factors and percentage of commercial vehicles is determined. However, unlike the 6-hour counts, the 48-hour counts are also used to determine AADT for the section of roadway in which they are collecting data. Seventy percent of the classification stations use these machine counts.

## AUTOMATED TRAFFIC RECORDER (ATR)

This data is collected by ADOT, and has passed all internal quality checks, for different time intervals throughout the year. This data was not supplied to NCE in raw form, but it is used by ADOT to develop growth, seasonal, and axle factors for AADT calculations. In discussions with ADOT, it was learned that there are approximately 80 ATR sites in Arizona that ideally would all be collecting data continuously. However, due to equipment maintenance requirements and manpower constraints, there are typically 50 ATR sites functioning at any one time.

## LTPP AND ADOT TRAFFIC PLANNING GROUP (TPG) AVC/WIM COLLECTED DATA

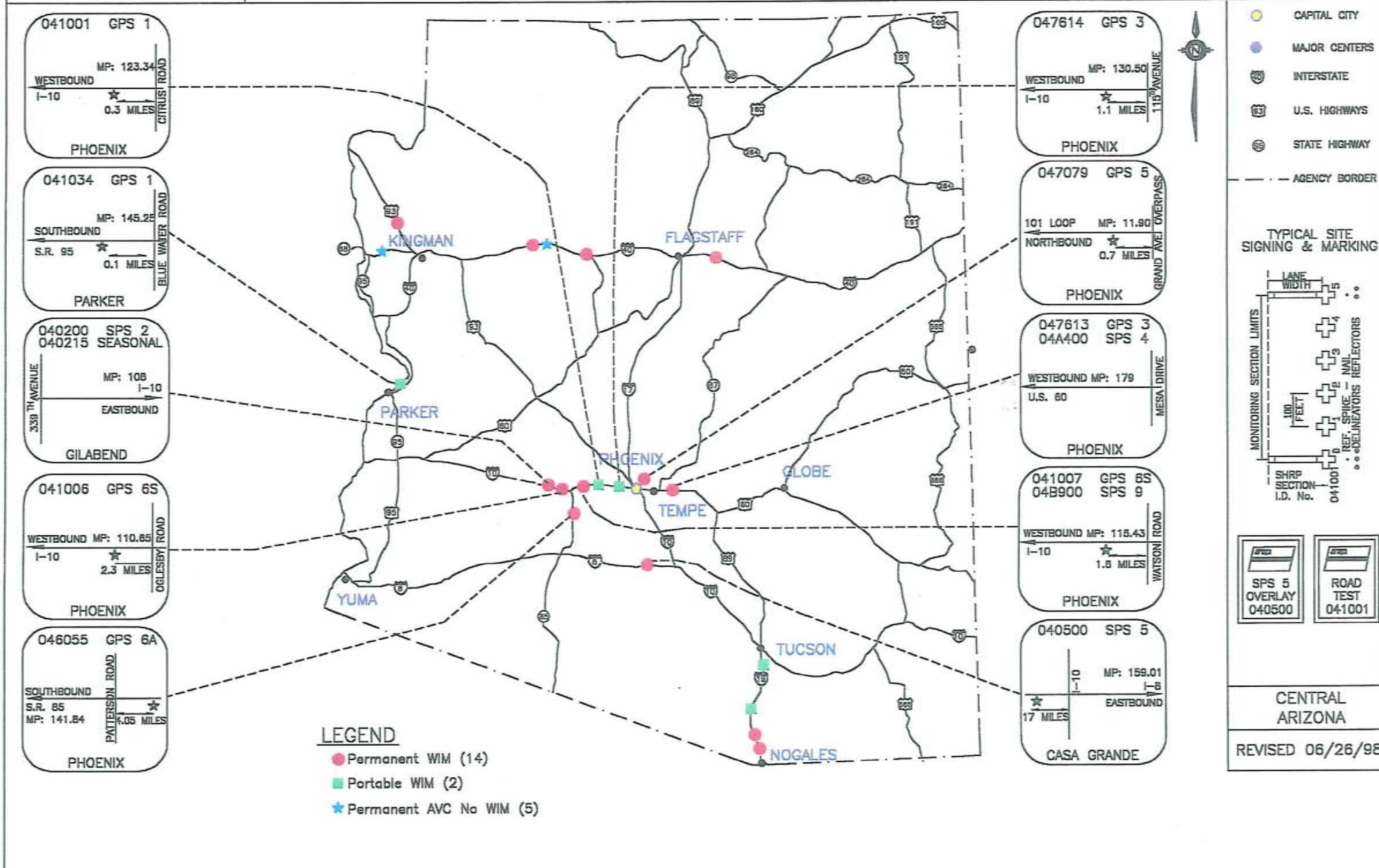
As part of the LTPP program, there is a requirement to collect AVC and WIM data. ADOT currently has nine AVC sites and 16 WIM sites functioning as part of the LTPP program. Table 3.1 and figures 3.1 and 3.2 list these sites and show their locations. The TPG has four additional sites at which AVC/WIM data is collected. This data includes calculations of the yearly truck volumes by truck classification and trucks as a percent of total traffic.

Table 3-1. LTPP Arizona WIM/AVC sites.

| Arizona/ATRC Site # and Pavement Type | Site Location Route & MP (KIM) | SHRP ID | WIM/AVC | | |
|---|---|---|---|---|---|
| | | | Status | Make | Sensor |
| 025 RIGID | US-93 NB 052 | 0100 | PERM WIM | PAT | BENDING PLATE |
| 026 RIGID | I-10 EB 108 | 0200 | PERM WIM | IRD | BENDING PLATE |
| 009 FLEX | I-8 EB 159 | 0500 | PERM WIM | PAT | PIEZO |
| 202 RIGID | I-40 EB 202 | 0600 | PERM WIM | PAT | BENDING PLATE |
| 204 RIGID | I-40 WB 202 | 0600 | PERM WIM | PAT | BENDING PLATE |
| 020 FLEX | I-40 WB 145 | 1002 | PERM WIM | PAT | PIEZO |
| 012 FLEX | I-10 WB 110 | 1006 | PERM WIM | PAT | PIEZO |
| 011 FLEX | I-10 WB 115 | 1007 | PERM WIM | PAT | PIEZO |
| 005 FLEX | I-19 SB (029) | 1015 | PERM WIM | IRD | PIEZO |
| 018 FLEX | I-40 EB 106 | 1024 | PERM WIM | PAT | PIEZO |
| 010 FLEX | SR-85 SB 141 | 6055 | PERM WIM | PAT | PIEZO |
| 006 FLEX | I-19 NB (023) | 6060 | PERM WIM | PAT | PIEZO |
| 021 RIGID | SR-101 NB 011 | 7079 | PERM WIM | PAT | PIEZO |
| 024 RIGID | US-60 WB 179 | 7613 | PERM WIM | PAT | PIEZO |
| 019 FLEX | I-40 WB 113 | 1025 | PERM AVC PORT WIM | PAT | PIEZO |
| 015 FLEX | SR-68 EB 001 | 1037 | PERM AVC PORT WIM | PAT | PIEZO |
| 023 FLEX | I-10 WB 123 | 1001 | PERM AVC NO WIM | PAT | PIEZO |
| 007 FLEX | I-19 NB (054) | 1017 | PERM AVC NO WIM | PAT | PIEZO |
| 013 FLEX | R-95 SB 145 | 1034 | PERM AVC NO WIM | PAT | PIEZO |
| 008 FLEX | I-19 SB (084) | 6054 | PERM AVC NO WIM | PAT | PIEZO |
| 022 RIGID | I-10 WB 130 | 7614 | PERM AVC NO WIM | PAT | PIEZO |

# SHRP-LTPP CENTRAL ARIZONA WIM & AVC SITE LOCATIONS
## General Pavement Studies and Specific Pavement Studies

NICHOLS CONSULTING ENGINEERS, Chtd.



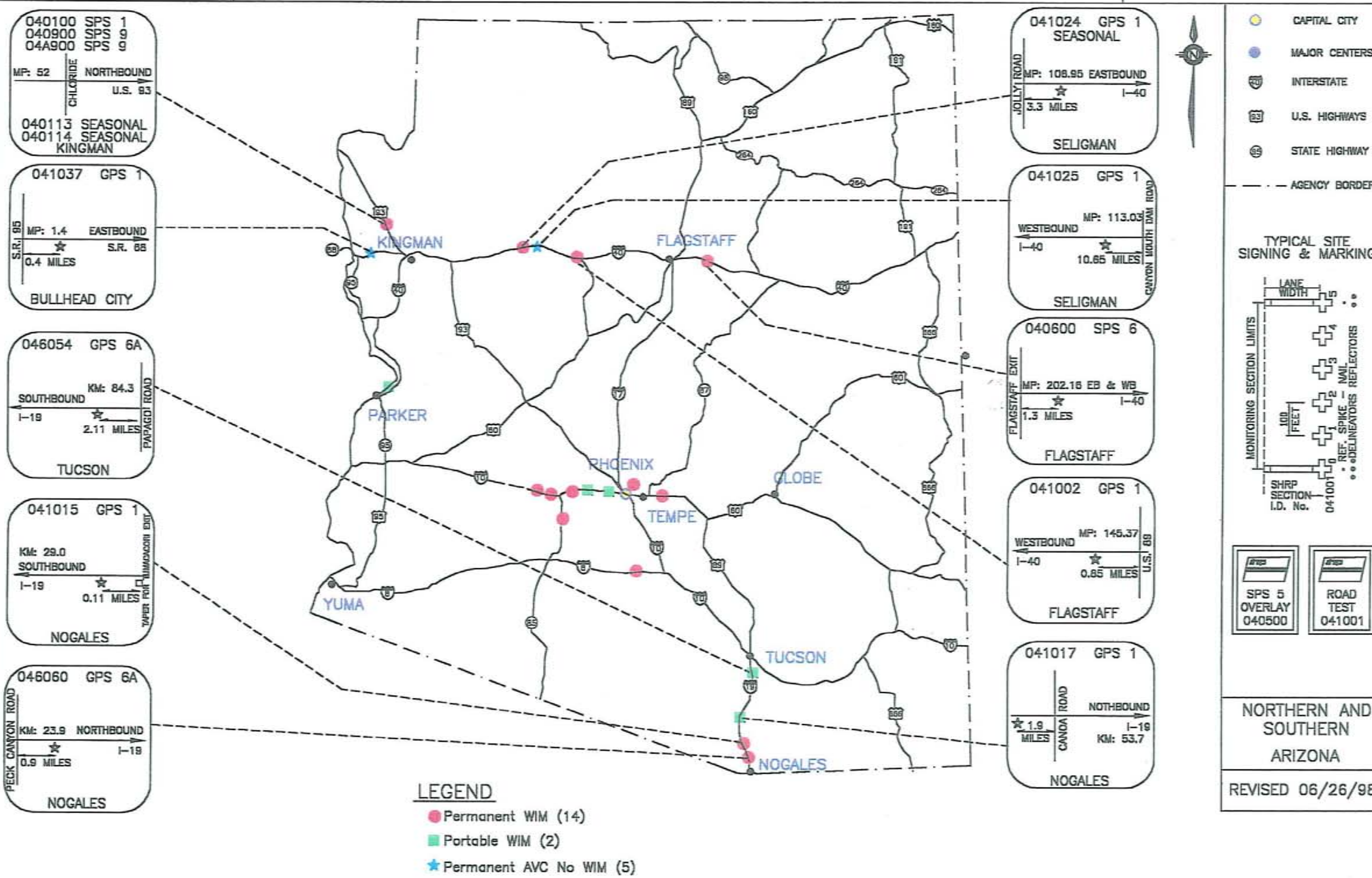

CENTRAL ARIZONA

REVISED 06/26/98

# SHRP-LTPP NORTHERN AND SOUTHERN ARIZONA WIM & AVC SITE LOCATIONS

## General Pavement Studies and Specific Pavement Studies

NICHOLS CONSULTING ENGINEERS, Chtd.




NORTHERN AND SOUTHERN ARIZONA

REVISED 06/26/98

For the LTPP data, quality checks of the collected AVC/WIM data were performed following the LTPP traffic Quality Control/Quality Assurance (QC/QA) procedure. Once the data is processed using the LTPP traffic software, a LTPP regional traffic engineer reviews the data, and a summary of questionable data is flagged. The flagged data is then compiled for review by a senior traffic engineer familiar with AVC/WIM data.

After the data review by the LTPP regional contractor is complete, the flagged QC/QA packets are sent to the State DOT that collected the raw data. A State traffic engineer reviews the flag list and decides if the DOT agrees with the findings. Once the edited flag list is received from the DOT by the LTPP regional contractor, the data is edited and summarized for use in the LTPP project. The edited LTPP AVC/WIM data is then summarized for used by pavement researchers and designers. For the ADOT TPG WIM data, the flag list process was done internally at NCE.

### Maricopa County Traffic Data

An investigation was conducted for incorporating the traffic information from Maricopa County into the ESAL tables. The information provided by Maricopa County consisted of a report entitled *Conformity Analysis for the Fiscal Year 1999-2003 MAG Transportation Improvement Program and the MAG Long Range Transportation Plan Summary and 1997 Update with 1998 Addendum*. The report provides more of a network summary of traffic information and is therefore not directly applicable to the segment specific ESAL table. It is important to mention, however, that the report states that "MAG (Maricopa Association of Governments) model estimates of 1997 VMT (vehicle miles of travel) are within one percent of the 1997 HPMS (Highway Performance Monitoring System) VMT that the Arizona Department of Transportation reported to the FHWA on July 16, 1998."(1) Assuming the HPMS VMT is calculated from the same ADOT traffic counts that the ESAL table is based on, it can be concluded that the ADOT data being incorporated into the ESAL table is sufficiently close to MAG data. Therefore, no special measures for incorporating MAG data into the ESAL table were taken.

### Pima County Data

Traffic data provided by Pima County was evaluated for its applicability and possible incorporation into the ESAL tables. The information provided by Pima County consisted of a map entitled *Traffic Volumes in Metropolitan Tucson and Eastern Pima County 1997-1998*, and maps illustrating AADT estimates for the year 2020. The maps illustrate AADT values for various freeway and arterial segments within the City of Tucson and portions of Pima County. As a test, the 1997-1998 AADT values for all of the freeway segments illustrated on the map were compared with the AADT values provided by ADOT within its report *Traffic on the Arizona Highway System 1997*.(2) The AADT values matched exactly for all segments. As the map lists the Arizona Department of Transportation as a source of traffic count information, this is not surprising. As it was concluded that Pima County data was based upon ADOT traffic counts, no special measures for incorporating it into the ESAL table were taken. However, a comparison of the Pima County AADT estimates for 2020 with the new ESAL table forecasted AADT values is reported in chapter 5.

## ADOT Data Analysis

As mentioned in the previous section, traffic volume counts are collected over a 24-hour or a 48-hour period. In order to convert these counts into annual values, it is necessary to apply a number of factors. The methodology followed in expanding the counts to AADT values is explained below.

### *Factor Groups*

As explained by the TPG, Arizona is divided into sixteen factor groups, with one extra group for "weird sites." The groupings are based solely on geographical locations and do not account for the functional class of the road located within the group (i.e., interstate highway or state route), although there are factor groups named for I-8, I-10, I-15, I-17, I-19, and I-40. The "weird site" grouping contains very few sections and these are primarily segments that have relatively high percentages of recreational traffic where seasonal and daily variations are not observed. These factor groups contain at least two continuously operating automatic traffic recorders (ATRs) located within the group, except for group 6 (one ATR), group 8 (zero ATRs), group 16 (zero ATR) and group 99 Weird Sites (zero ATRs). Group 8 had an ATR that is currently out of service but there are plans to have it repaired.

There are three different factors applied to the factor groups, namely: growth, seasonal, and axle factors. For sections that have no data collected during the year for which the traffic tables are being completed, the previous year's data is adjusted based on the factor group factors. The factor groups were determined by the contractor that processes ADOT's traffic data, and this process has been approved by FHWA.

### *Growth Factors*

This data was provided by the TPG and contains the growth factors by growth factor group for Arizona (table 3.2). The growth factors are calculated by comparing AADTs from 1996 to those from 1997 at the ATRs. The growth rates from multiple ATRs in a growth factor group are averaged to determine a single value for all sections within a growth factor group. As mentioned above, if a particular section has not had any measurements made in 1997, then the growth factor for the respective growth factor group will be applied to the 1996 AADT. This value is a moving average from year to year and therefore does not reflect any long-term trends. For growth factor groups that do not contain a functional ATR, a growth factor of one is assumed.

The factors listed in table 3.2 for determining average annual weekday traffic (AAWDT) and average annual weekend traffic (AAWET) values had no relevance to this study.

Table 3.2. Growth factors.

| Growth Factor Group | Incl'd Sites 96-97 | AADT Growth Factor | Incl'd Sites 1997 | AAWDT Conversion Factor | AAWET Conversion Factor |
|---|---|---|---|---|---|
| 0-Yuma Metro | 2 | 1.2 | 2 | 0.99 | 0.95 |
| 1-I-8 | 1 | 1.17 | 2 | 0.92 | 1.06 |
| 2-I-10 West of PHX | 1 | 1.17 | 2 | 0.95 | 1.03 |
| 3-Phoenix Metro | 3 | 1.01 | 4 | 1.1 | 0.72 |
| 4-I-10 PHX-TUC | 1 | 1.1 | 2 | 0.94 | 1.05 |
| 5-Tucson Metro | * | 1.06 | 2 | 1.03 | 0.91 |
| 6-I-10 East of TUC | * | 1 | 1 | 0.95 | 1.09 |
| 7-I-17 | 1 | 0.88 | 3 | 0.85 | 1.22 |
| 8-I-19 | * | 1 | * | 0.91 | 1.09 |
| 9-I-40 West of FLAG | 1 | 0.99 | 2 | 0.96 | 1.07 |
| 10-I-40 East of FLAG | 1 | 1.08 | 2 | 0.97 | 1.06 |
| 11-Southwest | 1 | 1.19 | 3 | 0.93 | 1.06 |
| 12-West Central | 4 | 1.04 | 9 | 0.96 | 1.01 |
| 13-East Central | 7 | 1 | 14 | 0.95 | 1.01 |
| 14-North of I-40 | 3 | 0.91 | 6 | 0.99 | 0.97 |
| 15-Extreme SE Corner | 4 | 1.03 | 5 | 0.99 | 0.99 |
| 16-I-15 | * | 1 | * | 1 | 1 |
| 99-Weird Sites | * | 1 | * | 1 | 1 |

Note 1: AAWDT conversion factor = AAWDT/AADT. AAWDT includes Monday - Thursday.
Note 2: AAWET conversion factor = AAWET/AADT. AAWET includes Saturday - Sunday.
Note 3: Included sites must have at least one month of data.
Each month must have at least one day(s) of data for each day of week.
Note 4: * - Factor value was supplied by system operator.
Note 5: + - Factor value was supplied by system operator and replaced a value calculated from data.

*Seasonal Factors*

This data was provided by the TPG and contains the daily and seasonal adjustment factors by seasonal factor group for Arizona. These values are determined by comparing the AADT values by day of the week and by month of the year at each ATR in each growth factor group. In seasonal factor groups that have multiple ATRs, the values from each ATR are averaged. Each factor group has its own seasonal factor. Table 3.3 shows seasonal factor group 0.

For days of the month and months of the year for which no ATR data is available, these factors are estimated by the system operator.

*Axle Factors*

This data was provided by the TPG and contains monthly axle factors by axle factor group (table 3.4). Although monthly factors are shown, there is no variation from month-to-month for an axle factor within a particular axle factor group. The reason for this is that each value is determined based upon the vehicle classification data, and the classification data is only collected for a maximum of 48 hours at a particular site. If continuous classification data were to be collected, then this table could show variation from month-to-month.

These factors are only applied to data that was collected by road tubes (as opposed to the ATRs or inductive loops). When applying the axle factor, the value from the table should be doubled and then factored out to be a 24-hour count (if it was collected as a 48-hour sample) to obtain the adjusted raw volume.

## FORECASTING

Very little information was provided discussing forecasting methodologies utilized by ADOT, and the information that was provided fits most appropriately in the next chapter, which discusses the existing ESAL table.

Table 3.3. Seasonal factors for seasonal factor group 0.

Seasonal Factor Group: 0-Yuma Metro

| Factor | Jan | # | Feb | # | Mar | # | Apr | # | May | # | Jun | # | Jul | # | Aug | # | Sep | # | Oct | # | Nov | # | Dec | # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAF | 0.816 | 1 | 0.831 | 1 | 0.778 | 2 | 1.050 | * | 1.202 | 2 | 1.228 | 2 | 1.169 | 2 | 1.163 | 2 | 1.177 | 2 | 1.046 | 1 | 0.940 | 1 | 0.820 | 1 |
| Sunday | 1.170 | 1 | 1.057 | 1 | 1.162 | 2 | 1.118 | * | 1.084 | 2 | 1.086 | 2 | 1.005 | 2 | 1.054 | 2 | 1.132 | 2 | 1.029 | 1 | 1.079 | 1 | 1.282 | 1 |
| Monday | 1.009 | 1 | 0.952 | 1 | 0.990 | 2 | 0.962 | * | 1.011 | 2 | 1.017 | 2 | 1.024 | 2 | 1.020 | 2 | 0.930 | 2 | 1.333 | 1 | 1.090 | 1 | 0.951 | 1 |
| Tuesday | 0.979 | 1 | 1.084 | 1 | 1.019 | 2 | 1.035 | * | 1.052 | 2 | 1.031 | 2 | 1.079 | 2 | 1.074 | 2 | 0.998 | 2 | 1.032 | 1 | 1.139 | 1 | 0.913 | 1 |
| Wednesday | 1.041 | 1 | 1.042 | 1 | 1.011 | 2 | 0.984 | * | 1.065 | 2 | 1.010 | 2 | 1.056 | 2 | 1.054 | 2 | 1.022 | 2 | 0.990 | 1 | 0.855 | 1 | 0.942 | 1 |
| Thursday | 1.018 | 1 | 1.071 | 1 | 0.998 | 2 | 1.012 | * | 1.003 | 2 | 0.978 | 2 | 0.952 | 2 | 1.013 | 2 | 1.067 | 2 | 0.982 | 1 | 1.054 | 1 | 1.121 | 1 |
| Friday | 0.891 | 1 | 0.942 | 1 | 0.877 | 2 | 0.928 | * | 0.839 | 2 | 0.896 | 2 | 0.908 | 2 | 0.841 | 2 | 0.875 | 2 | 0.854 | 1 | 0.850 | 1 | 0.880 | 1 |
| Saturday | 0.937 | 1 | 0.887 | 1 | 0.998 | 2 | 0.982 | * | 1.007 | 2 | 1.008 | 2 | 1.005 | 2 | 0.988 | 2 | 1.046 | 2 | 0.901 | 1 | 1.015 | 1 | 1.017 | 1 |

Table 3.4. Axle factors.

| Axle Factor Group | Jan | # | Feb | # | Mar | # | Apr | # | May | # | Jun | # | Jul | # | Aug | # | Sep | # | Oct | # | Nov | # | Dec | # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-Yuma Metro | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * |
| 1-I-8 | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * |
| 2-I-10 West of PHX | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * |
| 3-Phoenix Metro | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * |
| 4-I-10 PHX-TUC | 0.39 | * | 0.39 | * | 0.39 | * | 0.39 | * | 0.39 | * | 0.39 | * | 0.39 | * | 0.39 | * | 0.39 | * | 0.39 | * | 0.39 | * | 0.39 | * |
| 5-Tucson Metro | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * |
| 6-I-10 East of TUC | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * |
| 7-I-17 | 0.41 | * | 0.41 | * | 0.41 | * | 0.41 | * | 0.41 | * | 0.41 | * | 0.41 | * | 0.41 | * | 0.41 | * | 0.41 | * | 0.41 | * | 0.41 | * |
| 8-I-19 | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * |
| 9-I-40 West of FLAG | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * | 0.34 | * |
| 10-I-40 East of FLAG | 0.38 | * | 0.38 | * | 0.38 | * | 0.38 | * | 0.38 | * | 0.38 | * | 0.38 | * | 0.38 | * | 0.38 | * | 0.38 | + | 0.38 | + | 0.38 | * |
| 11-Southwest | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * |
| 12-West Central | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * | 0.44 | * |
| 13-East Central | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | + | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * | 0.45 | * |
| 14-North of I-40 | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * | 0.46 | * |
| 15-Extreme SE Corner | 0.47 | * | 0.47 | * | 0.47 | * | 0.47 | * | 0.47 | * | 0.47 | * | 0.47 | * | 0.47 | * | 0.47 | * | 0.47 | * | 0.47 | * | 0.47 | * |
| 16-I-15 | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * |
| 99-Weird Sites | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * | 0.5 | * |

Note 1: # - This column indicates number of vehicle classification count sites.

Note 2: * - Factor value was supplied by system operator.

Note 3: + - Factor value was supplied by system operator and replaced a value calculated from data.

# CHAPTER 4: REVIEW PROCEDURES FOR DEVELOPING ESAL DESIGN TABLES

The focus of this chapter is to review the current ADOT ESAL table. This table was originally developed in 1986 and was most recently updated in 1997.

## CURRENT ESAL TABLE

As referenced in table 2.1, the current ADOT ESAL table was received in electronic and hardcopy formats. This table has been examined to determine the number of highway segments and analysis methodologies included within the spreadsheet. The document explaining ADOT's current method for calculating ESALs has also been received and reviewed. Table 4.1 is a portion of the existing ESAL table.

There are 1,040 segments in the existing ESAL table. Each row in the table contains the same types of information. The first three columns, highway and milepost, give the location of the traffic section (column 4). The traffic section number is unique and is generally consecutive, although there are occasions when the traffic volume increases to the point where a section needs to be subdivided. In these instances, a new section number is introduced (such as section 1161 in between sections 6 and 7 in table 4.1).

In chapter 3, it was noted that there are approximately 140 classification stations located throughout Arizona. The traffic sections have classification data from the most representative station, as determined by ADOT, assigned to them (e.g., sections 1-5 use the classification data from station 42). Columns 10-16 contain the information collected at these classification stations. Column 10 is the percent of commercial traffic, which ranges from 20 percent to 69 percent with an average of 43 percent. Columns 11-15 are the percent of each truck classification within the percent commercial traffic identified in column 10. Table 4.2 shows the range and mean values for each classification. Column 16 contains information on bus traffic, which ranges from 0.1 percent to 1.6 percent with a mean of 0.4 percent.

Column 9 contains the 1997 percent annual growth factors. These factors have generally remained unchanged since 1991. Some factors were manually changed over time by experts from ADOT using their best judgement observing changing trends between 1991 and 1997. Column 6 contains the two way AADT as calculated in 1991 (this is a discrete value in the spreadsheet). Columns 7 and 8, however, contain equations that calculate the AADTs in 1997 and 2017, respectively. The basic equation is: 1991 AADT*(1+(Year X-1991)*(percent annual growth)), where Year X is 1997 or 2017.

Table 4.1. Sample from existing ESAL table.

LT = LIGHT TRUCK MT = MEDIUM TRUCK TS = TRACTOR & SEMI-TRAILOR
TT = TRUCK & TRAILOR TST = TRACTOR & SEMI-TRAILOR

| | | | | TWO - WAY | | | 1997 PERCENT | CLASSIFICATION PERCENTAGES | | | | | | | 100% OF THE ONE-WAY ACCUMMULATED 18 KIP ESAL (THOUSANDS) THROUGH THE YEARS: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TRAF | CLASS | 1991 | 1997 | 2017 | ANNUAL | | | | | | | | 1997 | 2007 | 2017 | 1997 | 2007 | 2017 | 1997 | 2007 | 2017 | 1997 | 2007 | 2017 |
| HIGHWAY | MILEPOST | SEC | STA | ADT | ADT | ADT | GROWTH | COM | LT | MT | TS | TT | TST | BUS | | FLEXIBLE | | | RIGID | | FLEXIBLE | FLEXIBLE | FLEXIBLE | RIGID | RIGID | RIGID |
| I 8 | 0.0 - 0.57 | 1 | 42 | 10172 | 12857 | 24172 | 4.4 | 44.7 | 66.8 | 13.2 | 16.4 | 2.1 | 1.5 | 0.3 | 488 | 6094 | 15113 | 546 | 6825 | 16927 | 488 | 6094 | 15113 | 546 | 6825 | 16927 |
| I 8 | 0.57- 2.23 | 2 | 42 | 11915 | 14989 | 27880 | 4.3 | 44.7 | 66.8 | 13.2 | 16.4 | 2.1 | 1.5 | 0.3 | 568 | 7104 | 17619 | 637 | 7957 | 19733 | 568 | 7104 | 17619 | 637 | 7957 | 19733 |
| I 8 | 2.23- 3.98 | 3 | 42 | 14553 | 18919 | 37838 | 5.0 | 44.7 | 66.8 | 13.2 | 16.4 | 2.1 | 1.5 | 0.3 | 717 | 8967 | 22238 | 803 | 10043 | 24906 | 717 | 8967 | 22238 | 803 | 10043 | 24906 |
| I 8 | 3.98- 7.63 | 4 | 42 | 13083 | 17479 | 37055 | 5.6 | 44.7 | 66.8 | 13.2 | 16.4 | 2.1 | 1.5 | 0.3 | 663 | 8284 | 20545 | 742 | 9279 | 23011 | 663 | 8284 | 20545 | 742 | 9279 | 23011 |
| I 8 | 7.63- 9.40 | 5 | 42** | 13418 | 18248 | 40147 | 6.0 | 44.7 | 66.8 | 13.2 | 16.4 | 2.1 | 1.5 | 0.3 | 692 | 8649 | 21450 | 775 | 9687 | 24024 | 692 | 8649 | 21450 | 775 | 9687 | 24024 |
| I 8 | 9.40- 12.21 | 6 | 41** | 16589 | 21964 | 45685 | 5.4 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 727 | 9091 | 22546 | 815 | 10182 | 25251 | 727 | 9091 | 22546 | 815 | 10182 | 25251 |
| I 8 | 12.21-14.24 | 1161 | 41 | 18000 | 23400 | 46800 | 5.0 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 775 | 9685 | 24020 | 868 | 10848 | 26902 | 775 | 9685 | 24020 | 868 | 10848 | 26902 |
| I 8 | 12.21- 21.03 | 7 | 41 | 8821 | 9774 | 13292 | 1.8 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 324 | 4045 | 10033 | 362 | 4531 | 11237 | 324 | 4045 | 10033 | 362 | 4531 | 11237 |
| I 8 | 21.03- 30.80 | 8 | 41 | 8322 | 9770 | 15437 | 2.9 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 324 | 4044 | 10029 | 362 | 4529 | 11232 | 324 | 4044 | 10029 | 362 | 4529 | 11232 |
| I 8 | 30.80- 37.95 | 9 | 41 | 8789 | 10687 | 18382 | 3.6 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 354 | 4424 | 10971 | 396 | 4954 | 12287 | 354 | 4424 | 10971 | 396 | 4954 | 12287 |
| I 8 | 37.95- 42.06 | 10 | 41 | 8443 | 10216 | 17367 | 3.5 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 338 | 4229 | 10487 | 379 | 4736 | 11745 | 338 | 4229 | 10487 | 379 | 4736 | 11745 |
| I 8 | 42.06- 54.96 | 11 | 41 | 8277 | 10214 | 18181 | 3.9 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 338 | 4228 | 10484 | 379 | 4735 | 11743 | 338 | 4228 | 10484 | 379 | 4735 | 11743 |
| I 8 | 54.96- 67.41 | 12 | 41 | 7226 | 8223 | 12006 | 2.3 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 272 | 3404 | 8441 | 305 | 3812 | 9454 | 272 | 3404 | 8441 | 305 | 3812 | 9454 |
| I 8 | 67.41- 73.48 | 13 | 41 | 5655 | 5994 | 7193 | 1.0 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 198 | 2481 | 6153 | 222 | 2779 | 6892 | 198 | 2481 | 6153 | 222 | 2779 | 6892 |
| I 8 | 73.48- 78.46 | 14 | 41 | 5416 | 5741 | 6889 | 1.0 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 190 | 2376 | 5893 | 213 | 2661 | 6600 | 190 | 2376 | 5893 | 213 | 2661 | 6600 |
| I 8 | 78.46- 87.04 | 15 | 41 | 5838 | 6188 | 7426 | 1.0 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 205 | 2561 | 6352 | 230 | 2869 | 7115 | 205 | 2561 | 6352 | 230 | 2869 | 7115 |
| I 8 | 87.04-102.23 | 16 | 41 | 6365 | 6938 | 9019 | 1.5 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 230 | 2872 | 7122 | 257 | 3216 | 7976 | 230 | 2872 | 7122 | 257 | 3216 | 7976 |
| I 8 | 102.23-106.51 | 17 | 41 | 7520 | 9009 | 14955 | 3.3 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 298 | 3729 | 9248 | 334 | 4176 | 10357 | 298 | 3729 | 9248 | 334 | 4176 | 10357 |
| I 8 | 106.51-111.42 | 18 | 41 | 7620 | 9266 | 15937 | 3.6 | 45 | 71.2 | 12.5 | 13.2 | 1.7 | 1.4 | 0.2 | 307 | 3835 | 9511 | 344 | 4295 | 10653 | 307 | 3835 | 9511 | 344 | 4295 | 10653 |
| I 8 | 111.42-115.14 | 19 | 15 | 6696 | 7741 | 11766 | 2.6 | 45 | 36.2 | 18 | 39.1 | 3.2 | 3.5 | 0.3 | 568 | 7098 | 17602 | 636 | 7949 | 19714 | 568 | 7098 | 17602 | 636 | 7949 | 19714 |
| I 8 | 115.14-115.62 | 20 | 15** | 3844 | 4813 | 8855 | 4.2 | 45 | 36.2 | 18 | 39.1 | 3.2 | 3.5 | 0.3 | 353 | 4413 | 10944 | 395 | 4942 | 12257 | 353 | 4413 | 10944 | 395 | 4942 | 12257 |
| I 8 | 115.62-119.42 | 21 | 15 | 3517 | 4002 | 5843 | 2.3 | 45 | 36.2 | 18 | 39.1 | 3.2 | 3.5 | 0.3 | 294 | 3670 | 9101 | 329 | 4110 | 10193 | 294 | 3670 | 9101 | 329 | 4110 | 10193 |
| I 8 | 119.42-140.81 | 22 | 16** | 5718 | 6061 | 7273 | 1.0 | 45 | 28.1 | 14.1 | 51 | 3.6 | 3.2 | 0.3 | 501 | 6263 | 15533 | 561 | 7015 | 17397 | 501 | 6263 | 15533 | 561 | 7015 | 17397 |
| I 8 | 140.81-144.57 | 23 | 16 | 7941 | 9704 | 16885 | 3.7 | 45 | 28.1 | 14.1 | 51 | 3.6 | 3.2 | 0.3 | 802 | 10027 | 24868 | 898 | 11231 | 27852 | 802 | 10027 | 24868 | 898 | 11231 | 27852 |
| I 8 | 144.57-151.68 | 24 | 16 | 7854 | 9550 | 16427 | 3.6 | 45 | 28.1 | 14.1 | 51 | 3.6 | 3.2 | 0.3 | 790 | 9869 | 24475 | 884 | 11053 | 27412 | 790 | 9869 | 24475 | 884 | 11053 | 27412 |
| I 8 | 151.68-161.53 | 25 | 62 | 8310 | 9307 | 13030 | 2.0 | 45 | 31.2 | 11.3 | 50.8 | 3.9 | 2.8 | 0.2 | 736 | 9203 | 22823 | 825 | 10307 | 25562 | 736 | 9203 | 22823 | 825 | 10307 | 25562 |
| I 8 | 161.53-167.53 | 26 | 62 | 5336 | 5720 | 7093 | 1.2 | 45 | 31.2 | 11.3 | 50.8 | 3.9 | 2.8 | 0.2 | 452 | 5656 | 14027 | 507 | 6335 | 15710 | 452 | 5656 | 14027 | 507 | 6335 | 15710 |

The table also includes two identical sets of ESAL values for 1997, 2007 and 2017. The first set (columns 17-22) are calculated by multiplying the value in each corresponding column (23-28) by 1 (e.g., column 23 multiplied by 1 equals column 17). The key value in columns 17-28 is found in column 23. This is the 1997 flexible ESAL value. This cell contains an equation that is found by taking the 1997 ADT (two-way) divided by two multiplied by percent commercial vehicles divided by 100 multiplied by 100 minus light trucks multiplied by 100 multiplied by 1.4 (or 1.7) multiplied by 365 divided by 1000 (i.e., (((((1997 ADT/2)*((% Com/100)))*((100-% LT)/100))*1.4 (or 1.7)*365)/1000)). The flexible 2007 (column 24) value takes the flexible 1997 value and multiplies it by 12.5, while the flexible 2017 ESAL value (column 25) multiplies the flexible 1997 ESAL value by 31. The corresponding rigid ESAL values (columns 26-28) are determined by multiplying the flexible ESAL value by 1.12.

Table 4.2. Range and mean values for Arizona truck classifications.

| | Light Truck | Medium Truck | Tractor and Semi-Trailer | Truck and Trailer | Tractor and Semi-Trailer |
|---|---|---|---|---|---|
| Minimum (%) | 28.1 | 3 | 0.3 | 0 | 0 |
| Maximum (%) | 95.2 | 36.6 | 53.8 | 5.3 | 5.6 |
| Mean (%) | 73 | 12.1 | 12.5 | 1.4 | 1.1 |

Discussions with ADOT personnel revealed that there have been a number of simplifying assumptions made that may not have been documented, but of which the ADOT materials group are well aware. The primary assumptions are that for 1997, the commercial vehicles (excluding the light truck category) contribute a factor of 1.4 ESALs per vehicle (except for the Interstate 40 and U.S. 93 corridors for which the factor is 1.7 ESALs per vehicle), the 10-year ESAL multiplier is 12.5, and the 20-year ESAL multiplier is 31. These numbers were determined to be defendable by the materials group and account for such factors as expected increases in tire pressures and vehicle weights over time.

# CHAPTER 5: RECOMMEND CHANGES TO CURRENT PROCEDURES

There is significant overlap between items in chapter 5 and their subsequent application in chapter 6. This is due to the close tie between the NCE team's recommendations and their subsequent effect on the revised ESAL table. Ideally, every segment in Arizona would have its own continuous and calibrated AVC/WIM system. However, the cost of this instrumentation (not to mention the labor to maintain the systems and collect and process the data) is prohibitive. The recommendations in this chapter are believed to be implementable without significantly affecting the current expenditures for traffic data collection.

## FHWA VEHICLE CLASSIFICATION SYSTEM

Vehicles traveling in the United States come in many shapes and axle configurations. This creates difficulties for State DOT personnel in the classification of vehicle types on roadway networks. The FHWA has developed two methods of vehicle classification that have been used in the Truck Weight Study (TWS). The two methods developed are the 6-digit classification system and the 13-bin classification system. The 13-bin system is currently the most accepted system and is the current FHWA required classification system (figure 5.1).

Prior to the 13-bin FHWA system; the USDOT used what is referred to as the 6-digit system. This system is extremely flexible; however, it produces many different vehicle types (i.e., more than 13). ADOT is currently using the 13-bin FHWA vehicle classification system.

The 13-bin system allows a better understanding of the vehicle types on the ADOT road network, and reflects the state-of-the-practice for State DOTs in the United States. Additionally, the 13-bin system can be easily reduced into the more general vehicle class system that has been used in the past (i.e., the LT, MT, TS, TT, TST scheme in the existing ESAL table) if necessary. Both the TPG and the LTPP data is reported in the 13-bin classification system, so no work will be required on behalf of ADOT to implement this classification scheme into the new ESAL table.

## TRAFFIC FORECASTING METHODOLOGY

As mentioned in chapter 4, there is not currently a mechanism by which AADT forecasts are updated aside from manually updating growth factors. The existing growth factors were determined by applying a linear regression to AADT data that extended through 1991.

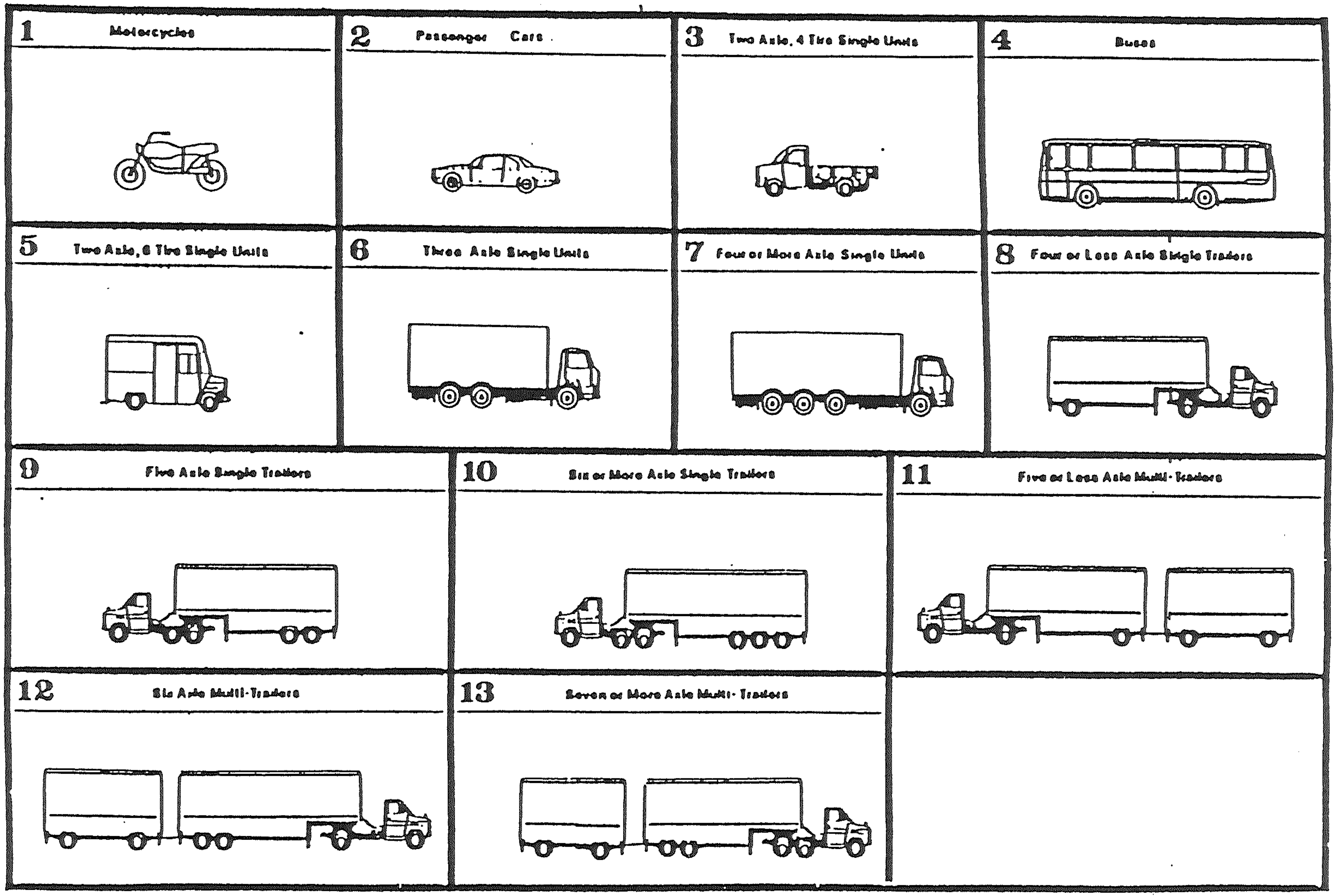



Figure 5.1. FHWA vehicle classification.

## NCE APPROACH TO AADT FORECASTING

The forecasting of AADT is important in the understanding of traffic movements and for the calculation of ESALs in the ADOT ESAL table. ADOT has been collecting AADT data for 1,040 traffic segment locations since 1974. This has been accomplished by manual surveys, automated counting equipment, and more recently by AVC and WIM systems. Upon the recommendation of the TAC, only the last 6 years of data was to be used in any forecasting models.

The forecasting of AADT for all segments is critical in the revisions to the ADOT ESAL table. The difficulty with forecasting traffic data is that not all traffic segments have the same pattern of traffic growth. Additionally, traffic growth is triggered by many factors that can not be foreseen or modeled. The NCE team decided to initiate the growth factor analysis with the assumption that a linear trend in growth exists for most traffic segments. However, given the relatively small data set (as sites where traffic volumes were collected every three years would only have two measured data points and four points calculated using growth factors), only about 40 percent of the data showed a strong linear correlation (i.e., $R^2 > 0.6$).

It was then determined by the project team that the most reasonable method to determine the AADT growth factors was to average the average annual growth factors for each year between 1992 and 1997. For sections with low AADTs, this resulted in some extremely large growth factors, and there was some discussion whether to limit the maximum annual growth, but it was decided that this would be outside the scope of the project (since more familiarity with each specific site was required) and should be decided by ADOT personnel. Sections with annual growth factors over 15 percent are identified in the new ESAL table. In future years, as AADT values are added, it is expected that fewer segments will need to be flagged as having questionable growth factors.

## NEGATIVE GROWTH

Another trend that was discovered in the AADT data during the analysis was that some sections exhibited negative growth trends. A negative trend in AADT will directly affect the trend in yearly and cumulative ESALs. After discussing this matter with the TAC, it was decided that the minimum growth factor for any section would be 2 percent, so sections with negative growth trends, or positive growth trends less than 2 percent, would be modified to have a growth factor of 2 percent.

## COMPARISON OF 2020 AADT ESTIMATES (PIMA COUNTY VS. NEW ESAL TABLE DATA)

As a quality assurance check, the 2020 AADT estimates from the maps provided by Pima County were compared with 2020 estimates of AADT from the new ADOT ESAL table. Table 5.1 contains a listing of the 2020 AADT values provided by Pima County, the 2020 AADT values computed by the new ESAL table, the percentage difference between the two, for 26 ADOT segments in Pima County and the *theoretical capacity* (this will be defined in chapter 6) of each segment. The majority of the 2020 AADT values have a percent difference of less than 40 percent. These numbers compare even better when they are constrained by the maximum theoretical capacity for each roadway segment. While there would still be segments that differ significantly (segment 533 is the prime example), other segments (e.g., 245 and 246) would match almost exactly. Considering the fact that 20-year traffic estimates are difficult to closely estimate, the NCE team feels that this comparison confirms the AADT forecasting methodology.

Table 5.1. Comparison of Pima County and ESAL table 2020 AADT values.

| ADOT Segment # | Pima County 2020 AADT | NEW ADOT 2020 AADT | % Diff. | Theoretical Capacity |
|---|---|---|---|---|
| **100** | 129,000 | 159,029 | -23.3 | 110,000 |
| **101** | 139,000 | 85,487 | 38.5 | 165,000 |
| **102** | 147,000 | 170,905 | -16.3 | 165,000 |
| **103** | 139,000 | 106,395 | 23.5 | 165,000 |
| **104** | 152,000 | 110,589 | 27.2 | 165,000 |
| **105** | 172,000 | 156,098 | 9.2 | 165,000 |
| **106** | 173,000 | 184,629 | -6.7 | 165,000 |
| **107** | 175,000 | 172,756 | 1.3 | 165,000 |
| **108** | 170,000 | 246,769 | -45.2 | 165,000 |
| **110** | 176,000 | 235,846 | -34.0 | 165,000 |
| **111** | 184,000 | 206,412 | -12.2 | 165,000 |
| **115** | 82,000 | 93,363 | -13.9 | 110,000 |
| **116** | 76,000 | 152,664 | -100.9 | 110,000 |
| **117A** | 66,000 | 160,495 | -143.2 | 110,000 |
| **117B** | 79,000 | 160,495 | -103.2 | 110,000 |
| **244** | 85,000 | 92,074 | -8.3 | 110,000 |
| **999** | 94,000 | 111,941 | -19.1 | 110,000 |
| **245** | 110,000 | 139,949 | -27.2 | 110,000 |
| **246** | 110,000 | 140,316 | -27.6 | 110,000 |
| **988** | 12,000 | 68,927 | -474.4 | 55,000 |
| **551** | 20,000 | 38,791 | -94.0 | 55,000 |
| **552** | 54,000 | 139,277 | -157.9 | 110,000 |
| **553** | 55,000 | 587,170 | -967.6 | 110,000 |
| **554** | 57,000 | 45,260 | 20.6 | 110,000 |
| **555** | 66,000 | 106,676 | -61.6 | 110,000 |
| **556** | 60,000 | 122,552 | -104.3 | 110,000 |

## ESAL DEVELOPMENT PROCEDURES

The new ESAL table was sorted according to traffic volumes as well as percent commercial vehicles. The segments in each area with the highest volumes or percent vehicles were selected for the purposes of determining whether FHWA class 1-3 vehicles (motorcycles, passenger cars and pick-up trucks) have a significant impact on the overall number of ESALs a segment will experience. It was found that these classes of vehicles may be ignored for the purpose of calculating ESALs. As an example, a 4,000-pound passenger car would generate 0.0004 ESALs. Therefore it would take over 6,000 passenger cars to equal the number of ESALs of one fully loaded FHWA class 9 tractor semi-trailer.

## PROCESS FOR ESAL DISTRIBUTION

The data provided by the TPG and LTPP WIM sites provides the most consistent source of weight data for each vehicle classification. While there is no need to modify the classification sections set up by ADOT, it was important to incorporate the LTPP and TPG WIM sites into the existing classification sections. Tables 5.2 and 5.3 present this information.

Table 5.2. The location of LTPP WIM site relative to ADOT classification stations.

| ADOT Classification Station | Corresponding LTPP WIM Sites |
|---|---|
| 20 | 0214, 1001, 1003, 1006, 1007, 7614 |
| 21 | 1034 |
| 26 | 1037 |
| 29 | 0114 |
| 31 | 1024, 1025, 1062, 1065 |
| 32 | 1002 |
| 46 | 6053 |
| 53 | 1036 |
| 62 | 0501 |
| 75 | 6054 |
| 76 | 1015, 1016, 1017, 1018, 6060 |
| 127 | 6055 |
| 142 | 7079 |
| 148 | 7613 |
| 151 | 0601 |

Table 5.3. The location of ADOT TPG WIM sites relative to ADOT classification stations.

| ADOT Classification Station | Corresponding ADOT TPG WIM Sites |
|---|---|
| 5 | 9006 |
| 21 | 9003 |
| 22 | 9004 |
| 46 | 9001 |

The WIM data passing the QC/QA checks described in chapter 3 was summarized by site to yield yearly average load and percent vehicle truck data. The summaries included percent trucks, average ESALs per truck type, and axle load spectrum. For vehicle class 4-13, a reasonableness check was applied consisting of comparing the average ESALs per class for all years of data to the corresponding ESALs calculated using the maximum legal gross vehicle weights (GVWs) for each class. Table 5.4 summarizes this comparison for flexible pavements.

Table 5.4. ADOT network average ESALs by vehicle class for flexible pavement for all years.

| Vehicle Class | ESALs from WIM Average | ESALs From Maximum GVW* | Standard Deviation of WIM Averages |
|---|---|---|---|
| **4** | 0.81 | 2.3 | 0.397 |
| **5** | 0.20 | 1.9 | 0.122 |
| **6** | 0.66 | 1.5 | 0.354 |
| **7** | 0.53 | 2.3 | 0.288 |
| **8** | 0.59 | 3.2 | 0.439 |
| **9** | 1.29 | 2.4 | 0.532 |
| **10** | 1.25 | 1.8 | 0.707 |
| **11** | 1.76 | 6.1 | 1.083 |
| **12** | 0.96 | 5.7 | 0.644 |
| **13** | 3.06 | 5.4 | 1.334 |

*Note: ESAL table values are based on SN=4 and $P_t$=2.5, using the AASHTO(3) design procedure and 14 kip single unit front axle, 12 kip multiple unit front axle, 20 kip single axle, and 34 kip dual tandem axle weights.

As expected, the average ESALs per class from the WIM sites is less than the ESALs from the estimated maximum GVW. This is because some trucks are empty or carrying a light cargo that fills the truck before loading the truck to the maximum GVW. This is commonly observed and has been thoroughly studied by C. Dahlin of the Minnesota DOT.(4)

Similarly, the ESALs by vehicle class for rigid pavements were also determined (table 5.5). These values are similar to those in table 5.4, but are not exactly the same. The ESALs from maximum gross vehicle weight were not computed (although they would be very similar to those calculated in table 5.4). The pavement type of the LTPP site, not the pavement type in which the sensors themselves are housed, were used to determine whether the pavement was flexible or rigid.

Table 5.5. ADOT network average ESALs by vehicle class for rigid pavement for all years.

| Vehicle Class | ESALs from WIM Average | Standard Deviation of WIM Averages | Two Standard Deviations of WIM Averages |
|---|---|---|---|
| 4 | 0.89 | 0.213 | 0.426 |
| 5 | 0.15 | 0.080 | 0.161 |
| 6 | 1.07 | 0.464 | 0.929 |
| 7 | 2.25 | 1.095 | 2.191 |
| 8 | 0.73 | 0.537 | 1.073 |
| 9 | 2.13 | 0.634 | 1.268 |
| 10 | 1.68 | 0.607 | 1.213 |
| 11 | 1.77 | 0.832 | 1.664 |
| 12 | 0.92 | 0.369 | 0.739 |
| 13 | 4.75 | 1.455 | 2.910 |

An important distinction that needs to be made is that the standard deviation noted in tables 5.4 and 5.5 is the standard deviation of the average values of each WIM site. It is not the standard deviation of all data collected at the sites within the flexible or rigid pavement type groupings.

## COMPARISON OF DATA FROM TWO ADJACENT LTPP WIM SITES

A study was undertaken to determine if similar traffic patterns existed between relatively close WIM sites on a major interstate in Arizona. Two LTPP WIM sites were selected: 041007 and 041006 on westbound I-10 west of Phoenix. The chosen sites were 5 miles apart and LTPP WIM data was collected for the truck lane at both sites.

The comparison results were very encouraging, as most heavy vehicle classes showed little percent difference between the two sites using daily and yearly comparisons. However, two vehicle classes did show differences that triggered further investigation. The vehicle classes of concern were 5 and 8 (see appendix B, daily comparisons). Figure 5.2 shows the comparison between vehicle types for the year 1996.

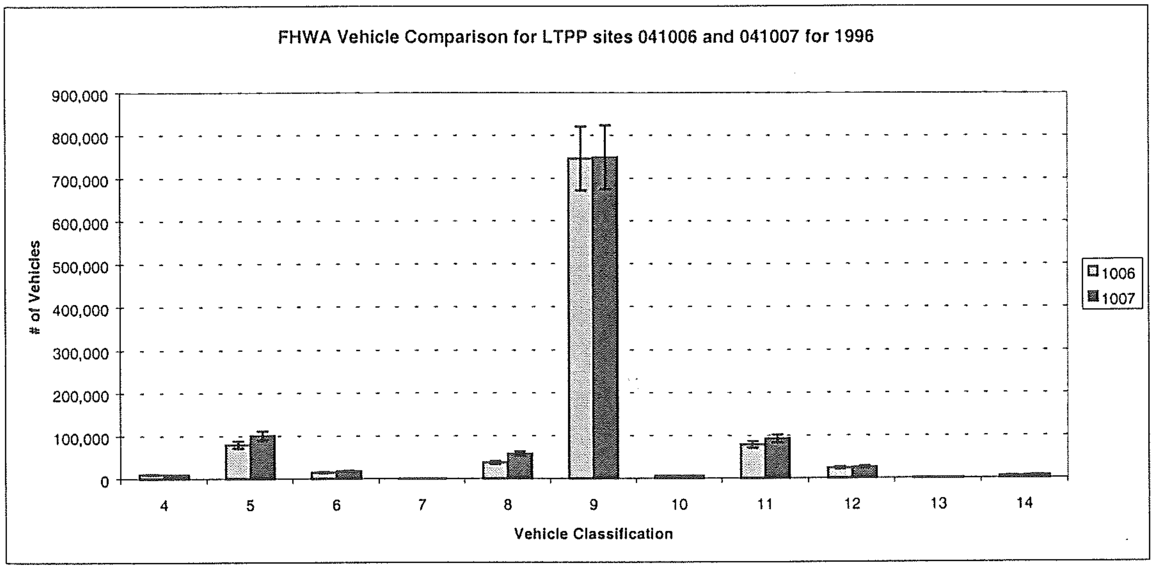



Figure 5.2. Annual comparison of FHWA class 4-13 vehicles between 041006 and 041007.

The experience NCE has gained through processing the Western Region WIM data caused the team to question if the difference was due to Recreational Vehicles (RVs). This suspicion was further fueled by the consistent trend of more vehicle classes 5 and 8 being observed at LTPP site 041007 as compared to site 041006. The team questioned if these vehicles were leaving I-10 and traveling south on SR85. This movement of vehicles was confirmed by ADOT personnel as SR85 is a route to a popular resort destination on the Gulf of Mexico. Further, it was verified by ADOT TPG that the actual number of class 5 and 8 vehicles is much less than what the data shows because the AVC equipment is misclassifying these vehicles based on axle spacing parameters. Other members of TAC stated that a significant number of class 9 vehicles also use the SR855 by-pass, but as can be seen in figure 5.2, this is not shown in the data provided to NCE.

## COMPARITON OF LTPP AND TPG DATA FROM THE SAME CLASSIFICATION STATION

There were two classification stations that have LTPP and TPG AVC/WIM equipment installed: stations 21 and 46. The TPG data for station 21 did not pass the QC/QA analysis, but the data for station 46 did. Unfortunately, there was not any common year between the LTPP and TPG data, but it was possible to compare the annual trends. This comparison is shown in table 5.6. For most classes, the data compares quite well. However, almost 12 percent of the TPG vehicles fell in class 14 (unclassified). In 1998, almost 48 percent of the vehicles fell in class 14, which suggests that the TPG system is in need of calibration (not included in table 5.6).

Table 5.6. Comparison of LTPP and TPG AVC data in station 46.

| | Vehicle Classification (% by Class) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1993 - LTPP | 2 | 15.2 | 1.8 | 0.6 | 3.6 | 68 | 0.3 | 5.8 | 1.7 | 0.2 | 0.8 |
| 1994 - LTPP | 1.7 | 13.3 | 1.8 | 0.6 | 6.7 | 67.3 | 0.4 | 5.5 | 1.6 | 0.4 | 0.6 |
| 1995 - LTPP | 0.9 | 5.7 | 1.1 | 0 | 14.5 | 59.5 | 0.2 | 4.7 | 1.4 | 0.1 | 0.4 |
| 1996 - LTPP | 1 | 14.6 | 1.2 | 0 | 14.9 | 61.1 | 0.3 | 4.9 | 1.3 | 0.2 | 0.4 |
| 1997 - TPG | 1.1 | 14 | 1.7 | 0 | 3.3 | 64.3 | 0.3 | 2.3 | 0.9 | 0.1 | 11.9 |

## COMPARISON OF TPG DATA WITH CONTINUOUS AVC/WIM DATA

Within classification station 151 is an LTPP WIM system where the sensors collect data in all lanes and both directions (typically, the sensors are only in the single lane that contains the LTPP test section). At sites with all lanes instrumented, it is possible to calculate the AADT and percent trucks (which otherwise is impossible without making assumptions about traffic distribution, see appendix B). Table 5.7 shows the results of the comparison between the continuous data collection and the TPG 6-hour manual count for classification and mechanical count for AADT.

Table 5.7. Comparison of AADT and percent trucks between TPG and LTPP data.

| Year | TPG AADT | TPG % Trucks | LTPP AADT | LTPP % Trucks | % Difference AADT | % Difference Trucks |
|---|---|---|---|---|---|---|
| 1994 | 14068 | 31.3 | 12122 | 41.8 | 16 | 25 |
| 1995 | 14304 | 36.4 | 14210 | 40.6 | 0.7 | 10 |
| 1996 | 24900 | 11.5 | 14590 | 42.3 | 71 | 73 |

Between 1995 and 1996, the TPG data changes drastically while there is no such fluctuation in the LTPP data. This highlights the variability inherent in expanding short periods of data collection into annual values.

## GROWTH FACTORS FOR ESAL PER VEHICLE CLASS AND CHANGES IN MAKEUP OF TRUCK TRAFFIC

Observation of the LTPP WIM data has shown that the traffic makeup changes in many ways with time. Change in AADT with time has already been discussed. Two analyses were performed to look at other parameters that also change with time. Namely, the change in the ESAL factors associated with each vehicle class over time and the change in the makeup of the truck traffic over time.

The LTPP data revealed that the ESAL factors calculated from WIM data for each truck classification varies from year-to-year. An investigation was conducted to see if a general trend in the calculated ESAL factors could be established and consequently a recommendation be made on whether to incorporate the trend into the ESAL table. This investigation revealed that although calculated ESAL factors may increase or decrease over time for specific sites, in general, the ESAL factors appear to have remained relatively constant from 1993 through 1997. This is logical as the maximum allowable axle weights have not changed during that period. For this reason, the ESAL factors incorporated into the ESAL table have not been adjusted with time.

In addition, the makeup of the truck traffic also changes over time. It has been found that for the LTPP WIM sites for the years 1993 through 1997, the class 9 truck percentage relative to the total truck traffic has increased in increments of approximately 2.5 percent per year.

$$\% \text{ Class 9 Trucks}_{(n)} = \% \text{ Class 9 Trucks}_{(1993)} + 2.5\% * (\text{Year} - 1993)$$

Note: Percent class 9 trucks in the above equation is relative to the total truck traffic.

Relative to the entire traffic stream, class 9 trucks have increased in increments of approximately 0.8 percent per year.

$$\% \text{ Class 9 Trucks}_{(n)} = \% \text{ Class 9 Trucks}_{(1993)} + 0.8\% * (\text{Year} - 1993)$$

Note: Percent class 9 trucks in the above equation is relative to the total traffic stream.

This issue is worth revisiting in another 3 to 5 years to see if the trend in increasing percentages of class 9 vehicles in the traffic stream is continuing. If it is, consideration should be given to modifying the growth factor by vehicle class.

## INVESTIGATION OF AVC AND WIM CALIBRATION

### Current Practice

As discussed in chapter 3, the ADOT maintains a network of 14 permanent WIM sites, five AVC sites and two additional AVC sites equipped with portable WIM systems (i.e., the sensors are installed permanently, while the data acquisition system is portable). In addition, the Arizona TPG maintains another six WIM sites, plus two AVC sites. These WIM sites are equipped with either bending-plate or piezo-electric sensors and were supplied by either PAT or IRD. The AVC systems come from PAT and they are of the double loop plus axle sensor technology.

The on-site WIM calibration method used is a variation of the method prescribed by the LTPP directive TDP-11 (April 1998).[5] It involves successive passes of two 5-axle semi-trailer (3S-2) test trucks. Typically, these trucks have flat-bed trailers and similar suspension systems in their corresponding axles. The trucks are loaded near their maximum GVW of 80 kips and their axle loads are measured using a static weigh scale.

Initially, 10 runs are performed at a given speed, which is selected depending on the speed limit at a WIM site. For these runs, errors are calculated as the percent difference between the static load and the WIM measurements for each of the:

- Steering axle.
- First tandem axle .
- Second tandem axle.
- GVW.

The statistics calculated are the average and the standard deviation of the percent errors for each of these four groups of measurements. A WIM system must yield average errors lower than a prescribed level in each of these four groups of measurements in order to pass. These levels of average error are set at +-5 percent for the bending plate systems and at a slightly higher value for the piezo systems. If during this process, consistent trends emerge in the average errors, calibration adjustments are made to the WIM system. Once the calibration is completed and if the maximum average errors are not exceeded, additional runs are performed using the same two trucks running at various speeds, to verify that the average WIM errors remain within the prescribed range. Otherwise, the particular WIM site is "shut-down" and no further data is collected from it until it can be fixed. This calibration process takes about 2-3 hours per WIM site to complete.

The statewide WIM data is post-processed at the office for quality assurance using the methodology developed by Minnesota DOT (TRR 1364, 1994).[(4)] For this purpose, the consistent properties of the steering axle load of 3-S2 trucks is used, rather than the consistent properties in the distribution of their GVW. In addition, the WIM data collected for the LTPP sites is processed through the software package developed by Chaparral Inc, which encompasses a wider range of QA tests than the Minnesota DOT method.

The on-site calibration of AVC systems is done through visual inspection without a rigorous analysis of observed versus recorded vehicle classification data. No post-processing of the AVC data is carried out for QA purposes.

## Recommended Improvements

A number of recommendations are made for improving and expediting the ADOT WIM and AVC calibration procedures. These include considering the effect of pavement roughness and vehicle speed on WIM error analysis and using a video recorder for AVC calibration, respectively.

### *Improved WIM Calibration Method*

It is well documented that the variation in dynamic axle loads increases with speed and roughness, hence affecting the magnitude of the WIM errors observed at a given site. Experimental evidence (Papagiannakis et al., 1990)[(6)] has produced relationships that can be used to calculate the expected coefficient of variation (CV percent) of dynamic axle loads as a function of pavement roughness (R in terms of International Roughness Index (IRI) m/km)) and vehicle speed (V in m/km). These relationships are plotted on figures 5.3 through 5.5 in terms of the CV of dynamic load versus the vehicle speed for three levels of pavement roughness (i.e., smooth, medium and high roughness). The two suspension types referred to in these figures are a rubber-sprung walking beam and an independent air-ride, which represent extremes in dynamic behavior (i.e., a leaf spring would exhibit a dynamic load CV between the two shown). It should be evident that using test trucks with air-ride suspensions would reduce the dynamic load variation and expedite the calibration process.

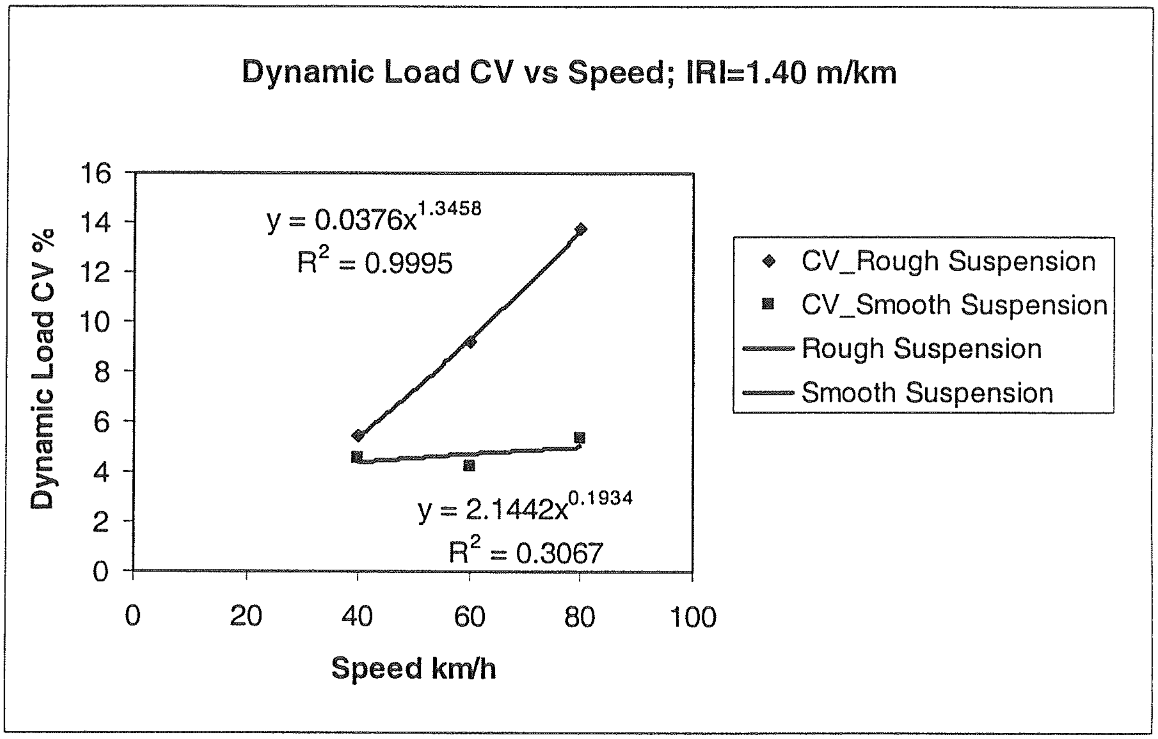



Figure 5.3. Dynamic load vs. vehicle speed; IRI=1.40 m/km.

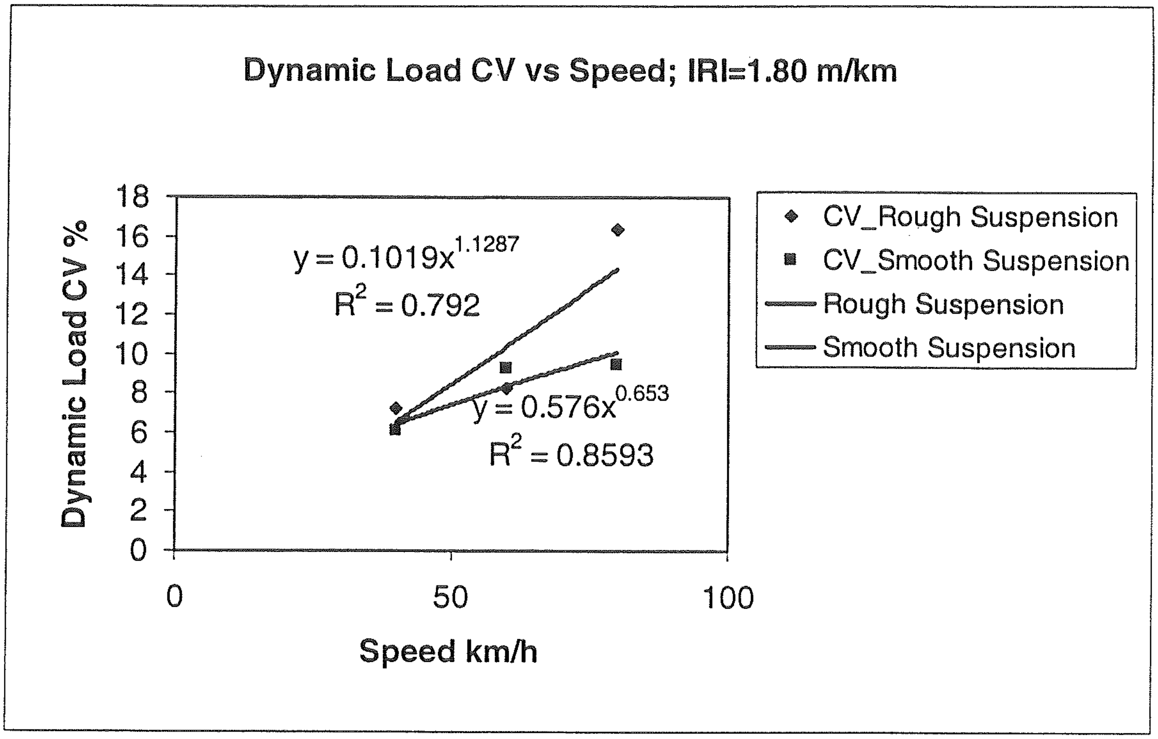



Figure 5.4. Dynamic load vs. vehicle speed; IRI=1.80 m/km.

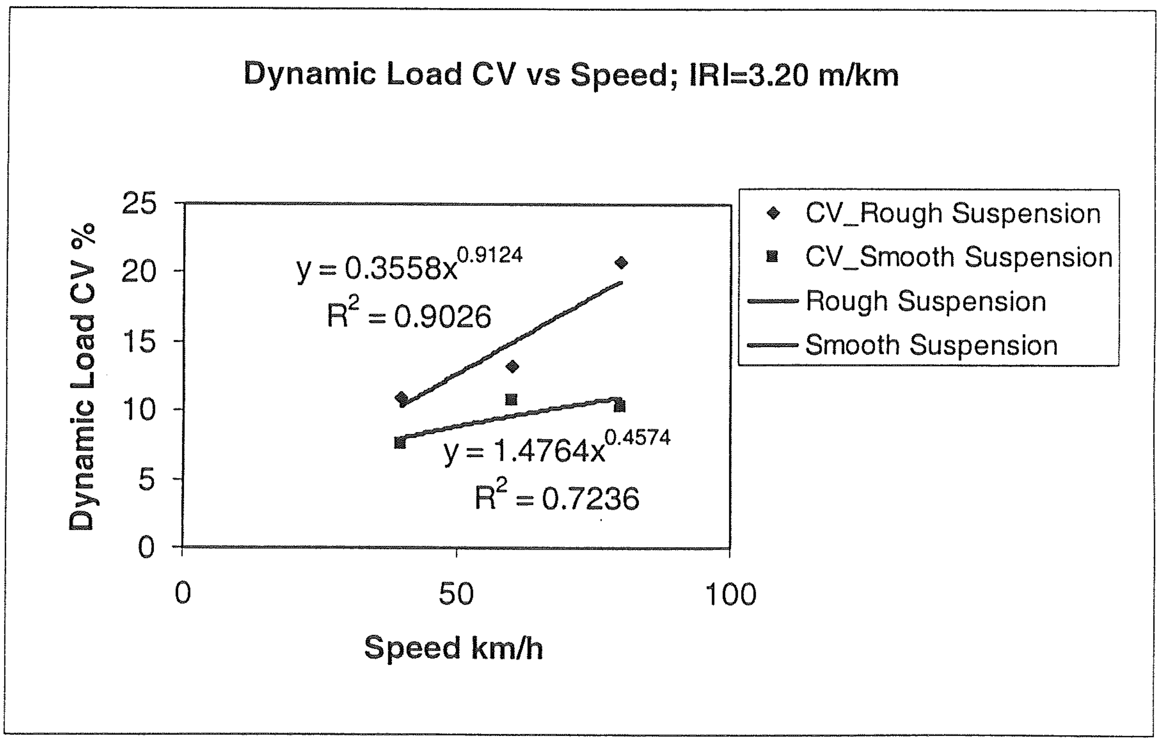



Figure 5.5. Dynamic load vs. vehicle speed; IRI=3.20 m/km.

Another experimental observation is that replicate test truck passes (i.e., same truck and speed) generate repetitive dynamic axle loads along the road. Hence, the magnitude of the dynamic axle loads applied on a WIM sensor from successive replicate truck passes are equal. This allows reducing the number of test truck passes for achieving an initial WIM calibration. To take advantage of this properties, it is suggested to carry out an initial analysis of the results by axle or axle group (i.e., tandems or triples) rather than by averaging the errors. This procedure is explained below.

These findings allow the following calibration approach (after Papagiannakis et. al, 1996).[7]

1. Calculate the anticipated range in the WIM measurements for each axle/axle group as the mean (i.e., static) load +- 2 standard deviations (i.e., calculated as the static load value multiplied by the CV obtained from figures 1 through 3 for the roughness at the site and the speeds of the test vehicles). This can be easily done at the office for all the speeds expected to of the test trucks at the site, given its IRI roughness.

2. Perform one run of each test truck and compare the WIM measurements of each axle/axle group and each vehicle to their anticipated range. There are four distinct possibilities:

   a. If all measurements fall outside the anticipated range and they are all either higher or lower than this range, adjust system calibration calculated as:

$$calibration\ \ factor\ \ adjustment = \frac{\sum static_i}{\sum WIM_i}$$

   It would be desirable to carry out this adjustment prior to continuing with subsequent test runs.

   b. If all measurements fall outside the anticipated range and some are above, while other below, there are major problems with the WIM system, either software (e.g., integration algorithms of piezo signals) or hardware (e.g., damaged strain gauges of bending plates. These problems are not likely to be solved through calibration adjustments and will require a technician's intervention.

   c. If all measurements fall within their anticipated ranges, no calibration adjustments are necessary prior to carrying a subsequent test run by repeating step 2.

   d. If some measurements are outside their expected range, while others are inside, a judgement call must be made whether actions corresponding to either (a) or (c) are to be taken.

3. Once the desirable number of runs is carried out and condition (2c) is satisfied for all runs and all speeds, it should be ensured that the requirements of the TDP 11 Protocol are met, that is average WIM errors are lower than the prescribed value percent for each axle group (i.e., steering, first tandem and second tandem) for all test speeds.

In summary, this approach allows expedient (i.e., several test runs) determination of whether a WIM calibration problem exists and whether the problem can be solved via calibration factor adjustments or there is a hardware/software problem present.

*Improved WIM Data QA Method for Non-LTPP Sites*

In improving the WIM data QA for non-LTPP sites, it is advised to use the properties of the traffic stream to determine likely problems with the data. The simplest approach is to use the steering axle load of the three-S2 trucks as an indicator of WIM data quality. This is one of the tests used by the Minnesota DOT approach and does not take into account problems with the vehicle classifying algorithms of WIM systems. It has nevertheless been used successfully as a QA criterion (Ott et al., 1996)[8] and it is used by a number of WIM manufacturers as a means of auto-calibrating WIM systems. In establishing mean and standard deviation values for the steering axles of three-S2 trucks, it is advised to collect a small data sample at static weigh scales (e.g., 10-20 trucks per season). Suggested static load locations are the major ports of entry at the four boundaries of the State. It is understood that the ports of entry truck inspection stations run independently of ADOT. However, it would take a small effort to convince them to print and retain the small sample size required.

*Improved AVC Calibration Method*

As described next, AVC data collection should complement the WIM data collection for the purpose of predicting AADT volumes and accumulated ESALs. For this purpose, it is essential that AVCs are properly calibrated. It is recommended to use a video camera for recording the vehicle classification of the traffic stream, instead of relying on visual observations. This can be done using a household-grade video camera set on a tripod on the side of the road. The clock on the camera can be synchronized with the clock on the AVC system. Even recording over a short period of time (e.g., while visiting an AVC site) would allow a far more accurate calibration of the AVCs than as compared with visual observation. The data should be post-processed at the office by at least two observers and the manual classification procedure compared to the AVC to decide on its accuracy.

## SURVEY OF OTHER AGENCIES

For comparative purposes, a number of State Highway Agencies were surveyed to determine how they calculated ESALs. The survey was submitted to 15 agencies and 11 responded. The following questions were included in the survey:

1. *Does your State use ESAL computations for pavement design and rehabilitation?*

   *Yes:____*
   *No:_____*

2. *What type of types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example?)*

   a.) *Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?*

3. *Do you break down ESALs by vehicle classification*

4. *Do you apply average ESAL factors to the vehicles in each classification? What are they?*

5. *Do you use growth factors to expand ESALs to design years?*

6. *Do you use WIM data? If not, what do you use for load data?*

7. *Are there links between Pavement Management System (PMS) data and the ESAL tables?*

   a.) *Are your growth factors for PMS the same for ESAL growth factors?*

8. *How much confidence do you have in the values you use for pavement design and rehab?*

*Survey States comments if any:*

The complete responses to these surveys can be found in appendix C, but the results have been summarized in table 5.8.

Every agency that responded said that they did use ESAL computations. However, in reviewing table 5.8, that is about the only thing they all had in common. On the whole, most States use WIM data as a method of determining or confirming ESAL values for different vehicle types, and use different ESAL values for different locations. The level of confidence in the resulting values ranged from fair to high. The project team found the methodology employed by Kentucky of particular interest. As mentioned previously, the detailed response from each agency can be found in appendix C.

Table 5.8. Summary of agency responses to ESAL survey.

| | Washington | Kansas | Oklahoma | Idaho | Oregon | South Dakota | Montana | Wyoming | Utah | Nebraska | Kentucky |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Question 1 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Question 2 | * | * | * | * | * | * | Static scale data | * | Axle weights from WIM | * | * |
| Question 2a | Different | Different | * | Different | Same | Different | Same | Same | Different | Different | Different |
| Question 3 | Y | Y | N | N | Y | Y | Y | Y | Y | Y | N |
| Question 4 | Y | Y | Y | N | Y | N | Y | Y | Y | Y | Y |
| Question 5 | Y | N | N | Y | Y | Y | Y | Y | N (for volumes, not ESALs) | Y | Y |
| Question 6 | Y and N | Y | N | Y | N | Y | N (but will be changing) | Y | Y | Y | Y |
| Question 7 | Y | N | N | * | Y | N | N | Y | Y | * | N |
| Question 7a | Y | * | N | * | Y | * | * | N | * | * | * |
| Question 8 | High--ESAL (60-75%--traffic) | Fairly good | High | Good | Fairly good | Depends on proximity to WIM site | Average to high | Fair | High on major routes, lower on other routes | Good | High |

*No comments provided.

# CHAPTER 6: PREPARE NEW ESAL DESIGN TABLES

This chapter describes the format of the new ESAL tables, including the relevant analyses. A complete Users Manual can be found in appendix D.

## DATA INPUTS

Three electronic files provided by the Arizona TPG were implemented into the ESAL design tables. Information from these files was supplemented by data collected at the LTPP and TPG AVC and WIM sites. The first file was *TR9397C.xls.*, which contains detailed segment location information, the number of lanes for each segment and the AADT and percent commercial vehicle values for each segment from 1993 through 1997. The second file was *Vcls9704.xls*, which contains classification station location data and the break down of the percent of each vehicle class 1-13 for each station to be applied to the 1997 data. The third file was *trfc7497.xls*, which contains the segment location information and the AADT value for each segment dating back to 1974.

The LTPP WIM data was extracted from the Western Regional Information Management System (RIMS) for all years through 1997. A number of investigations into this data were performed as described in chapter 5, including: comparing WIM data from adjacent systems near Phoenix; determining average ESAL factors per vehicle, per segment, and per pavement type; and calculating growth factors for ESALs.

Data was submitted from the four TPG functional WIM sites in Arizona for the years of 1997 and 1998 (except for site 9003, S.R. 95 MP 115EB, for which only 1998 data is available). All four sites are equipped with IRD piezo cable systems. This data was processed using the traffic software developed in the LTPP Program following the same methodologies used to process the data collected at LTPP sites.

As the WIM sensors were in the LTPP test lane, the above data only applied to the test lane. Truck classification as a percentage of total trucks was calculated and then, truck type as a percentage of total traffic was calculated for the test lane using the provided data.

As previously discussed, tables 5.3 and 5.4 show the AVC/WIM systems that were contained in each classification station. In instances where the relationship was 1:1, the TPG values for percent trucks in vehicle classes 4-13 (from *Vcls9704.xls*) were replaced with the values from the AVC/WIM systems. For the classification stations within which multiple AVC/WIM systems were located, the AVC/WIM data was averaged and then replaced the data from *Vcls9704.xls*.

ESAL values for each station were determined in similar fashion. Stations within which WIM systems were located had either the average values of all systems or the distinct values from the one system applied to determine the ESALs per vehicle class 4-

13. For classification stations in which no WIM systems were located, the average values for flexible and rigid pavements (tables 5.5 and 5.6) were utilized.

A table was developed listing the types of data collected at the various segments designated in the existing ESAL table. Particular attention was paid to those segments that contained a WIM system. The factor group for each segment containing a WIM system was determined.

## KEY ASSUMPTIONS

The goal in the development of the ADOT ESAL tables is to report the most accurate forecast of the traffic and axle loading on the ADOT roadway network. There are, however, limitations due to the type of traffic data collection and limited traffic data collection locations. The following are assumptions that the NCE team made during the development of the new ADOT ESAL tables.

### Directional Split

An assumption concerning ADOT traffic data is the directional split of traffic. The assumption is that there is a 50/50 split in traffic (i.e., that the same number of vehicles are traveling in one direction as the other). If this is not the case, then an alteration to the ESAL table spreadsheet can be made to accommodate site-specific information. However, no data that could be used to determine the directional split was provided to the NCE team.

### Necessary Pavement Structure Assumptions

The LTPP WIM data utilizes the site-specific pavement structure for calculating the average ESALs per vehicle type. The ESAL values can vary depending on differences in the pavement type and structural section of each ADOT segment. This difference can be observed for the same axle weight but for different pavement types, (i.e., flexible and rigid pavement) and terminal serviceabilities, as shown in figure 6.1.

It is clear from figure 6.1 that the thickness of the pavement structure has a small effect on the ESAL calculation regardless of pavement type, and using a terminal serviceability of 3.0 instead of 2.5 has a similarly small effect. However, pavement type (portland cement concrete (PCC) or asphalt concrete (AC)) has a significant impact on ESAL calculation. The new ESAL table provides ESAL values for both PCC and AC pavements based on the average ESAL per vehicle class calculated using the 1993 through 1997 LTPP WIM data. In the new ESAL table, ESAL values for both AC and PCC type pavements are provided for each segment based on the recommendation of the TAC.

The TAC requested that the project team investigate the impact of a condition of terminal serviceability of 3.0 instead of 2.5. This was performed and it was determined that at the legal load limits, there is very little difference. As loading increases past the legal limit, the ESALs are slightly less for the calculation based on 3.0 for both rigid and flexible pavements. The relationship is not linear and increases with load (see figures 6.2 and 6.3).

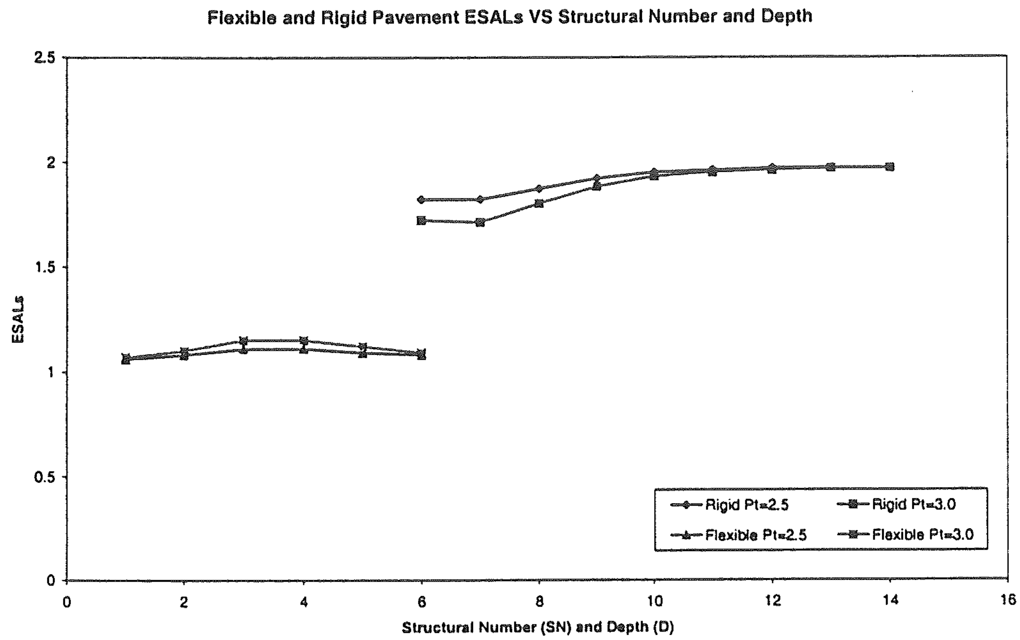



Figure 6.1

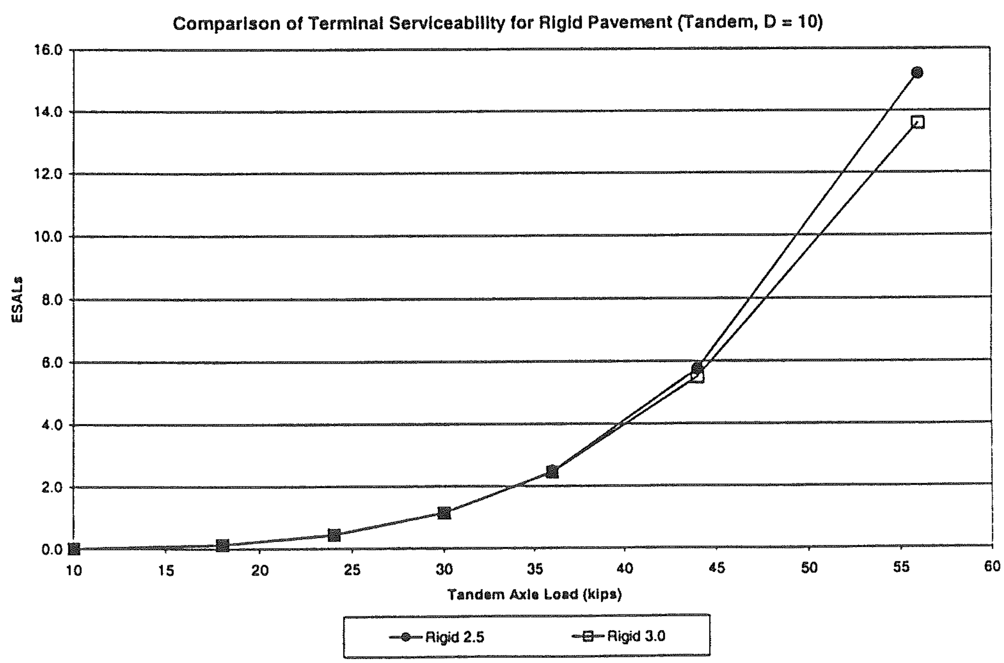



Figure 6.2

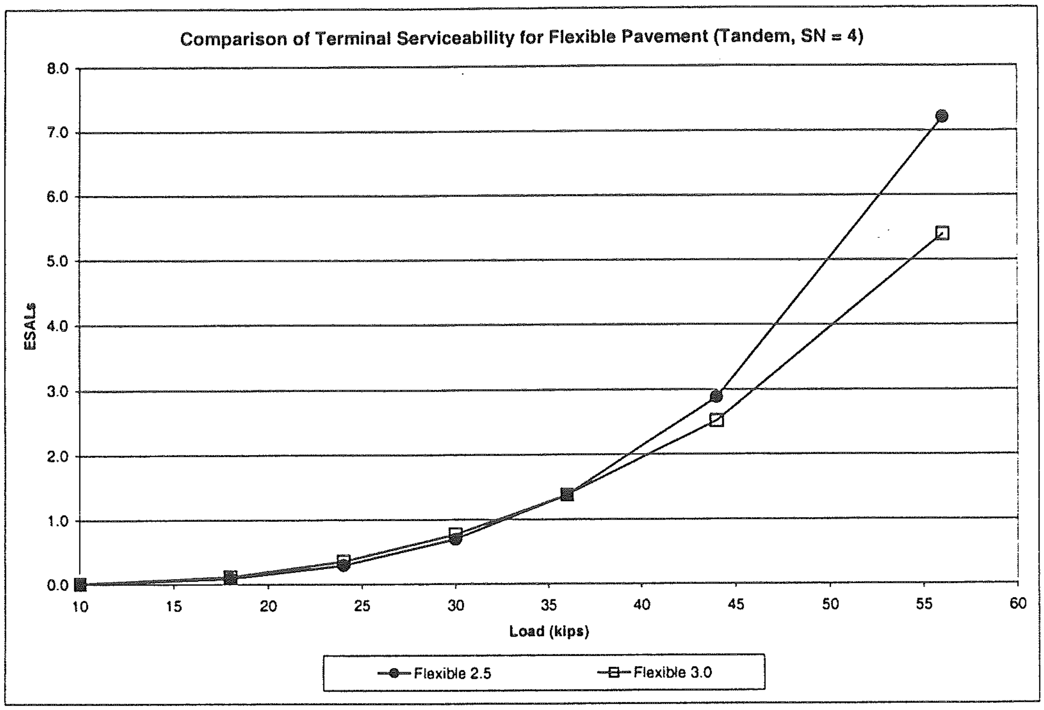



Figure 6.3.

# ESAL TABLES

## Proposed Format for the New ADOT ESAL Tables

Three independent tables were developed for use by ADOT. The new ESAL tables each contain 14 sub-tables in total. The only difference between each table is the set of values used for the ESAL per vehicle class.

- *Average_ESAL_Table.xls* uses either the measured or the averaged ESAL values for classes 4-13 as described in the Data Inputs section.
- *ESAL_Table_One_Std_Dev.xls* uses the measured or averaged values, plus one standard deviation of the averages for each vehicle class.
- *ESAL_Table_Two_Std_Dev.xls* uses the measured or averaged values, plus two standard deviations of the averages for each vehicle class.

Some tables represent calculations and others represent the input location of ADOT TPG and WIM data. This format of table interaction will allow the ESAL tables to be used for years to come, and allow easy access of information necessary for traffic engineering, traffic planning, and pavement design. Appendix F contains a stand-alone document that should be used to navigate through the spreadsheets. The following is a brief description of important elements in the new ESAL table.

*Site Information*

This data (primarily taken from *TR9397C.xls*) contains the segment by segment location, AADT and percent commercial vehicle information.

*Cumulative One-way Flexible KESALs*

This worksheet contains the cumulative thousands of ESALs (KESALs) for each segment assuming that the pavement is flexible. These values are determined by adding the previous year's KESAL total to the KESAL data for a particular year. Cumulative values are calculated through the year 2020. This worksheet is different for the three tables.

*Cumulative One-way Rigid KESALs*

This worksheet contains the cumulative thousands of ESALs (KESALs) for each segment assuming that the pavement is rigid. These values are determined by adding the previous year's KESAL total to the KESAL data for a particular year. Cumulative values are calculated through the year 2020. This worksheet is different for the three tables.

*AADT 1974-2020*

This worksheet contains the AADT values provided by the TPG from 1974 through 1997 (from *trfc7497.xls*). The average percent growth factor is calculated using the methodology described in chapter 5, and in instances where the percent growth is less than 2 percent, it is adjusted to be 2 percent. Using this growth factor, the AADTs from 1998 to 2020 for each segment are calculated. No limit as to maximum growth factor was utilized.

*Capacity*

This worksheet contains a simple logic check as to whether each segment has reached its capacity based on the following assumptions:

Using the 1994 Highway Capacity Manual, the capacity for each segment was calculated. Because capacity is primarily an issue in urban areas, the assumptions were based on urban conditions. Following the equation:

capacity = 2200 vehicles per lane per hour/.08 = 27,500 vehicles per lane per day

As the number of lanes for each segment is known, the capacity was determined for each segment for each year through 2020 (this is contained in the worksheet Total Theoretical Capacity). If a segment is under capacity for a given year, the capacity worksheet will contain the word "pass." If it is at or over capacity, it will contain the word "fail." After discussing the issue of capacity with the TAC, this method was adopted so that capacity issues could be identified but future calculations are based on the assumption that additional lanes will be constructed to handle the additional traffic.

*Rigid KESAL One-way*

This worksheet contains the calculation of rigid KESALs for each segment for each year beginning with 1997. This calculation is described below.

*Rigid ESALs*

This worksheet contains the ESAL factors for vehicle classes 4-13 for each segment, assuming that the pavement is rigid.

*Flexible KESAL One-way*

This worksheet contains the calculation of flexible KESALs for each year beginning with 1997. This calculation is described below, and includes, as instructed by the TAC, a multiplier of 1.1 for the ESALs per vehicle for classes 9-13. This multiplier is a safety factor to account for potential increases in tire pressure and vehicle weights.

*Flexible ESALs*

This worksheet contains the ESAL factors for vehicle classes 4-13 for each segment, assuming that the pavement is flexible.

*Standard Deviation of ESALs per Class*

This worksheet contains the average, plus one and plus two standard deviation values for flexible and rigid pavements. These values are the same as given in tables 5.5 and 5.6.

*AADT Percent Growth for All Years*

This worksheet contains the percent growth from year-to-year for each segment beginning in 1974 and continuing through 2020.

*Number of Lanes*

This worksheet contains the number of lanes in each segment. This value is given for each year between 1997 and 2020 to allow ADOT to evaluate the construction of additional lanes in future years.

*Percent of Each Vehicle Type*

This worksheet contains the percentage of each vehicle class 4-13 for each segment as determined in the most recent year this data was measured (1997).

*ESAL Calculation*

The site specific AADT is the basis or calculating ESALs for the ADOT ESAL table. To this, the nearest classification site/WIM site data available is applied to calculate yearly ESALs. The calculation of the values for rigid ESALs reported in the ESAL tables are done in the following manner using equation 1.

(equation 1)

Yearly $ESAL_{seg}$ = 0.5 * ($AADT_{seg}$) * (365) * (% Trucks)*[(% VC4)*(ESAL4) + (%VC5) * (ESAL5) + ........ + (% VC13) * (ESAL13)]

The definitions of the variables for equation 1 are as follows:

$ESAL_{seg}$: Total yearly one-way ESALs for all lanes for a network segment.

$AADT_{seg}$: Average Annual Daily Traffic collected by ADOT for the total two-way traffic for all lanes for a single network segment.

% Trucks: Percentage of trucks in the traffic system.

%VC(#): This is the percent of vehicle class (4-13) in the truck lane determined from collected WIM data.

ESAL(#): This is the average ESAL of vehicle class (4-13) in the truck lane determined from collected WIM data.

In order to calculate the flexible ESAL values, an additional factor of 1.1 is used as a multiplier within the brackets for vehicle classes 9-13 as shown in equation 2. This 1.1 multiplier was suggested by ADOT TAC as a safety factor to account for potential increases in tire pressure and vehicle weights. The KESAL values are determined by dividing the $ESAL_{seg}$ value by 1000.

(equation 2)

Yearly $ESAL_{seg}$ = 0.5 * ($AADT_{seg}$) * (365) * (% Trucks)*[(% VC4)*(ESAL4) + (%VC5) * (ESAL5) + ........ + 1.1 * (% VC9) * (ESAL9) + 1.1 * (% VC10) * (ESAL10) + ........ + 1.1 *(% VC13) * (ESAL13)]

## COMPARISON OF CURRENT AND NEW ESAL TABLES

As a test of the new ESAL table, the 1997 and 2017 AADT values and cumulative ESALs were compared with the same values from the existing ADOT ESAL table. This comparison was carried out for 20 segments, the 10 with the highest AADT values and the 10 with the lowest AADT values. Table 6.1 contains the results of the AADT comparison and tables 6.2 and 6.3 contain the results of the cumulative ESAL comparison for flexible and rigid pavements, respectively.

Table 6.1. AADT comparison between current and new ESAL tables.

| Order | Segment | Existing ESAL Table AADT, 1997 | New ESAL Table AADT, 1997 | Existing ESAL Table AADT, 2017 | New ESAL Table AADT, 2017 | % Difference in Reported 1997 AADT | % Difference in Reported 2017 AADT |
|---|---|---|---|---|---|---|---|
| 1L | 719 | 264 | 74 | 317 | 104 | 72.0 | 67.2 |
| 2L | 873 | 166 | 95 | 226 | 717 | 42.8 | -217.3 |
| 3L | 874 | 188 | 105 | 256 | 2575 | 44.1 | -905.9 |
| 4L | 1160 | 212 | 125 | 254 | 980 | 41.0 | -285.8 |
| 5L | 528 | 139 | 129 | 167 | 190 | 7.2 | -13.8 |
| 6L | 882 | 160 | 161 | 218 | 225 | -0.6 | -3.2 |
| 7L | 762 | 186 | 172 | 223 | 430 | 7.5 | -92.8 |
| 8L | 819 | 260 | 175 | 426 | 245 | 32.7 | 42.5 |
| 9L | 799 | 254 | 227 | 305 | 344 | 10.6 | -12.8 |
| 10L | 798 | 223 | 246 | 267 | 318 | -10.3 | -19.1 |
| 1H | 68 | 205186 | 208643 | 400000 | 292100 | -1.7 | 27.0 |
| 2H | 72 | 153672 | 209066 | 276610 | 589642 | -36.0 | -113.2 |
| 3H | 66 | 192487 | 209166 | 400000 | 367014 | -8.7 | 8.2 |
| 4H | 76 | 212000 | 210332 | 381600 | 294465 | 0.8 | 22.8 |
| 5H | 73 | 189426 | 214944 | 340967 | 426763 | -13.5 | -25.2 |
| 6H | 74 | 192197 | 217255 | 345955 | 430377 | -13.0 | -24.4 |
| 7H | 67 | 192487 | 218411 | 400000 | 455807 | -13.5 | -14.0 |
| 8H | 1004 | 189384 | 221336 | 340891 | 540334 | -16.9 | -58.5 |
| 9H | 75 | 195396 | 223033 | 351713 | 441675 | -14.1 | -25.6 |
| 10H | 69 | 202260 | 231123 | 400000 | 984575 | -14.3 | -146.1 |

Table 6.2. Cumulative ESAL comparison between current and new ESAL tables for flexible pavements.

| Order | Segment | New ESAL Flex Average + 2 StDev ESAL, 2017 | % Diff. in Reported 1997 Flexible ESALs | % Diff. in Forecasted 1997 Average + 1 StDev Flexible ESALs | % Diff. in Forecasted 1997 Average + 2 StDev Flexible ESALs | % Diff. in Forecasted 2017 Average Flexible ESALs | % Diff. in Forecasted 2017 Average + 1 StDev Flexible ESALs | % Differ. in Forecasted 2017 Average + 2 StDev Flexible ESALs |
|---|---|---|---|---|---|---|---|---|
| 1L | 719 | 15 | 99.1 | 98.3 | 95.7 | 99.2 | 98.5 | 97.9 |
| 2L | 873 | 485 | 60.0 | 20.0 | 0.0 | -23.5 | -104.7 | -185.3 |
| 3L | 874 | 1600 | 50.0 | 33.3 | 0.0 | -261.5 | -497.4 | -733.3 |
| 4L | 1160 | 428 | 71.4 | 57.1 | 28.6 | 14.2 | -43.9 | -101.9 |
| 5L | 528 | 68 | 50.0 | 0.0 | -50.0 | 60.6 | 32.4 | 4.2 |
| 6L | 882 | 231 | 0.0 | -75.0 | -125.0 | 8.3 | -51.4 | -111.9 |
| 7L | 762 | 663 | -133.3 | -333.3 | -500.0 | -174.7 | -372.7 | -569.7 |
| 8L | 819 | 89 | 80.0 | 40.0 | 20.0 | 76.6 | 60.1 | 43.7 |
| 9L | 799 | 325 | -50.0 | -125.0 | -225.0 | -2.9 | -70.1 | -137.2 |
| 10L | 798 | 352 | -50.0 | -150.0 | -250.0 | -27.5 | -110.8 | -193.3 |
| 1H | 68 | 191815 | 24.8 | -26.1 | -76.9 | 38.9 | -2.5 | -43.8 |
| 2H | 72 | 305953 | -0.6 | -68.6 | -136.6 | -30.2 | -118.2 | -206.3 |
| 3H | 66 | 220712 | 19.6 | -34.7 | -89.0 | 25.0 | -25.7 | -76.4 |
| 4H | 76 | 193368 | 26.6 | -23.0 | -72.6 | 40.3 | 0.0 | -40.3 |
| 5H | 73 | 245812 | 16.1 | -40.7 | -97.4 | 15.1 | -42.2 | -99.6 |
| 6H | 74 | 248028 | 16.4 | -40.1 | -96.6 | 15.6 | -41.5 | -98.5 |
| 7H | 67 | 258266 | 16.1 | -40.6 | -97.4 | 12.2 | -47.1 | -106.4 |
| 8H | 1004 | 291765 | 13.5 | -44.9 | -103.3 | -0.8 | -68.9 | -137.0 |
| 9H | 75 | 254623 | 15.6 | -41.5 | -98.6 | 14.8 | -42.8 | -100.4 |
| 10H | 69 | 465686 | 15.5 | -41.7 | -98.8 | -50.6 | -152.4 | -254.2 |

Table 6.3. Cumulative ESAL comparison between current and new ESAL tables for rigid pavements.

| Order | Segment | Existing ESAL Rigid ESAL, 1997 | New ESAL Rigid Average ESAL, 1997 | New ESAL Rigid Average + 1 StDev ESAL, 1997 | New ESAL Rigid Average + 2 StDev ESAL, 1997 | Existing ESAL Rigid ESAL, 2017 | New ESAL Rigid Average ESAL, 2017 | New ESAL Rigid Average + 1 StDev ESAL, 2017 | New ESAL Rigid Average + 2 StDev ESAL, 2017 | % Diff. in Reported 1997 Rigid ESALs | % Diff. in Forecasted 1997 Average + 1 StDev Rigid ESALs | % Diff. in Forecasted 1997 Average + 2 StDev Rigid ESALs | % Diff. in Forecasted 2017 Average Rigid ESALs | % Diff. in Forecasted 2017 Average + 1 StDev Rigid ESALs | % Diff. in Forecasted 2017 Average + 2 StDev Rigid ESALs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1L | 719 | 26 | 0.3 | 0.4 | 1 | 798 | 8 | 11 | 15 | 98.8 | 98.5 | 96.2 | 99.0 | 98.6 | 98.1 |
| 2L | 873 | 6 | 3 | 4 | 5 | 190 | 270 | 369 | 467 | 50.0 | 33.3 | 16.7 | -42.1 | -94.2 | -145.8 |
| 3L | 874 | 7 | 3 | 5 | 6 | 215 | 893 | 1217 | 1540 | 57.1 | 28.6 | 14.3 | -315.3 | -466.0 | -616.3 |
| 4L | 1160 | 8 | 3 | 3 | 4 | 238 | 232 | 317 | 402 | 62.5 | 62.5 | 50.0 | 2.5 | -33.2 | -68.9 |
| 5L | 528 | 3 | 1 | 2 | 2 | 80 | 34 | 48 | 63 | 66.7 | 33.3 | 33.3 | 57.5 | 40.0 | 21.3 |
| 6L | 882 | 4 | 5 | 7 | 9 | 122 | 129 | 175 | 222 | -25.0 | -75.0 | -125.0 | -5.7 | -43.4 | -82.0 |
| 7L | 762 | 4 | 9 | 13 | 17 | 111 | 334 | 479 | 623 | -125.0 | -225.0 | -325.0 | -200.9 | -331.5 | -461.3 |
| 8L | 819 | 6 | 2 | 3 | 3 | 177 | 45 | 64 | 82 | 66.7 | 50.0 | 50.0 | 74.6 | 63.8 | 53.7 |
| 9L | 799 | 5 | 7 | 10 | 12 | 153 | 181 | 247 | 313 | -40.0 | -100.0 | -140.0 | -18.3 | -61.4 | -104.6 |
| 10L | 798 | 4 | 8 | 11 | 13 | 134 | 197 | 268 | 339 | -100.0 | -175.0 | -225.0 | -47.0 | -100.0 | -153.0 |
| 1H | 68 | 4819 | 4176 | 5766 | 7357 | 149400 | 105231 | 145316 | 185400 | 13.3 | -19.7 | -52.7 | 29.6 | 2.7 | -24.1 |
| 2H | 72 | 3609 | 4184 | 5778 | 7372 | 111892 | 167848 | 231785 | 295722 | -15.9 | -60.1 | -104.3 | -50.0 | -107.2 | -164.3 |
| 3H | 66 | 4521 | 4186 | 5781 | 7376 | 140154 | 121084 | 167208 | 213331 | 7.4 | -27.9 | -63.1 | 13.6 | -19.3 | -52.2 |
| 4H | 76 | 4979 | 4210 | 5813 | 7417 | 154361 | 106083 | 146492 | 186901 | 15.4 | -16.8 | -49.0 | 31.3 | 5.1 | -21.1 |
| 5H | 73 | 4449 | 4302 | 5941 | 7579 | 137925 | 134854 | 186223 | 237592 | 3.3 | -33.5 | -70.4 | 2.2 | -35.0 | -72.3 |
| 6H | 74 | 4514 | 4348 | 6005 | 7661 | 139942 | 136100 | 187943 | 239786 | 3.7 | -33.0 | -69.7 | 2.7 | -34.3 | -71.3 |
| 7H | 67 | 4521 | 4371 | 6036 | 7702 | 140154 | 141687 | 195658 | 249630 | 3.3 | -33.5 | -70.4 | -1.1 | -39.6 | -78.1 |
| 8H | 1004 | 4448 | 4430 | 6117 | 7805 | 137894 | 160065 | 221037 | 282009 | 0.4 | -37.5 | -75.5 | -16.1 | -60.3 | -104.5 |
| 9H | 75 | 4589 | 4464 | 6164 | 7865 | 142272 | 139688 | 192898 | 246109 | 2.7 | -34.3 | -71.4 | 1.8 | -35.6 | -73.0 |
| 10H | 69 | 4751 | 4626 | 6388 | 8150 | 147269 | 255478 | 352796 | 450113 | 2.6 | -34.5 | -71.5 | -73.5 | -139.6 | -205.6 |

As shown in table 6.1, there is a noticeable difference in the 1997 AADT values for the existing ADOT ESAL table and the new ESAL table. This can be attributed to the fact that the existing and new ESAL tables use two different sources of AADT data. The existing ESAL table's 1997 AADT values are forecasted based on 1991 (or earlier) AADT values and growth rates. The AADT values for the new ESAL table are from an electronic version of the *Traffic on the Arizona State Highway System 1997* provided by the Arizona Department of Transportation. This difference is substantial and is amplified further when projecting values for the 2017 comparison. As expected, values are much more similar at high AADT values than at low AADT values. As mentioned previously, the forecasted AADTs are not limited by capacity and there is no maximum growth rate. Segment 874, for example, has a growth rate of 117.6 percent with a very low AADT. High variability in year-to-year growth rate for segments with very low AADT is expected.

As shown in tables 6.2 and 6.3, the cumulative ESALs comparison results mirror that of the AADT comparison. It is important to note that the values are quite similar at higher ESALs for the average ESAL table and that adding plus one and plus two standard deviations adds to the final ESAL values an additional 38 percent and 76 percent, respectively. For the low volume roads, even when the table is off by 300 percent, that only works out to be 600 ESALs (or 30 ESALs/year), which is not a significant difference.

Based upon this investigation, it is the opinion of the NCE team that the approach outlined for the new ESAL table is a valid one and does not go against the experience and engineering judgement used in the development of the current ESAL table. This comparison; however, brings out the importance of more frequent update of the ESAL table in the future to incorporate new gathered data as it becomes available.

## DEVELOPMENT OF ONE VALUE FOR ALL VEHICLES

At the request of the TAC, the project team was asked to provide a single ESAL value for all trucks. Some city or county agencies (that only have the capability to collect volume counts) come to ADOT asking for a single ESAL factor. To calculate this value, the average ESALs per vehicle class 4-13 was determined based on all WIM data collected in Arizona. Then, the average vehicle percentages per class was determined. These two values were multiplied together and then summed as shown in table 6.4.

The resulting value of 1.08 is the average ESALs per commercial vehicle. As discussed in chapter 4, in the existing ESAL table a value of 1.4 was used, which included some safety factors for increases in tire pressure and vehicle weights. It is up to ADOT to determine what value they would give to any agency, but the project team recommends using a value of 1.2, which will provide a 10 percent safety factor.

Table 6.4. Determination of a single ESAL value.

| Vehicle Class | Average ESAL per Class | Average % Class | ESALS x Average % Class |
|---|---|---|---|
| 4 | 0.87 | 4.8 | 0.04 |
| 5 | 0.21 | 21.8 | 0.04 |
| 6 | 0.82 | 10.4 | 0.09 |
| 7 | 1.64 | 2.4 | 0.04 |
| 8 | 0.61 | 16.1 | 0.10 |
| 9 | 1.71 | 36.1 | 0.62 |
| 10 | 1.31 | 2.0 | 0.03 |
| 11 | 1.86 | 5.1 | 0.09 |
| 12 | 0.97 | 0.6 | 0.01 |
| 13 | 3.73 | 0.5 | 0.02 |
| | | 100 | 1.08 |

# CHAPTER 7: ASSESSMENT OF WIM AND AVC DATA NEEDS

## EXISTING SYSTEMS

The current WIM and AVC systems installed in Arizona have been described in chapter 3 and chapter 5 (see figures 3.1 and 3.2).

## EQUIPMENT COST

The following estimated costs for the purchase, installation and maintenance of AVC and WIM equipment are for one travel lane. Installation costs are based upon a contracted bid for a turn-key operation. These estimated costs do not take into consideration associated factors such as roadway maintenance, repair, and traffic delays.

There are many variables that may effect the cost of installing, maintaining and calibrating AVC and/or WIM system. Probably the biggest variable will be the cost of obtaining power and telephone service to the site. The estimated costs for these services are based upon power and telephone service being within 20 feet of the site with an estimated total cost of $14,000. Other variables that affect costs are; site selection, site location, drainage, soil conditions, pavement conditions, in-roadway equipment configuration, full freeway limits, contractor installation costs, traffic control requirements, power and telephone line locations availability, equipment calibration, available manpower usage and construction equipment usage. The actual costs will very for each specific application, so these estimated costs should be used for relative comparisons only.

These estimated costs are based upon information provided by California DOT, Colorado DOT, Nevada DOT and from a presentation of WIM Technology – Economics and Performance presented at NATMEC 1998 by Andrew J. Pratt (see the estimated cost worksheets presented later in this section).

Estimated single lane installation and maintenance cost for AVC and WIM:

Permanent Automatic Vehicle Classifiers (AVC) type 2 Piezoelectric installation cost per lane is $18,280, in addition:

- Telephone and power costs are estimated at $14,000.
- Per year maintenance cost for permanent AVC per lane is $2,000.
- Life expectancy for in-roadway sensor is estimated at 4 years.

Permanent WIM type 1 Piezoelectric installation cost per lane is $25,750, in addition:

- Telephone and Power costs are estimated at $14,000.
- Per year maintenance cost for permanent Piezoelectric WIM per lane is $5,600.
- Life expectancy for in-roadway sensor is estimated at 4 years.

Permanent WIM, Bending Plate, constructed in a concrete pad installation cost per lane is $87,730, in addition:

- Per year maintenance cost for permanent Bending Plate WIM per lane is $5,600.
- Life expectancy for in-roadway Bending Plate WIM installation is estimated at 10 years.

**Cost Worksheets**

1) AVC Piezoelectric:

These estimated installation costs for AVC are for two inductive loops and one type 2 piezoelectric sensor in one lane of travel for both directions with roadside pull boxes and conduit connection to a roadside control cabinet with power and phone line connections and AVC classification equipment. No portable roadway or AVC classification equipment were considered for this estimate. Permanent AVC equipment can be removed from the cabinet and used at different locations where permanent in-roadway equipment exists for short period classification and a portable operation. The estimated maintenance costs do not include traffic data computations.

| | Equipment and Installation By Private Contract |
|---|---|
| a. Control cabinets and mounts | $3,300 |
| b. Pull boxes | 710 |
| c. Detector loops | 2,100 |
| d. Power service | 7,000 |
| e. Telephone service | 7,000 |
| f. Mobilization | 3,400 |
| g. Traffic control | 2,900 |
| h. Conduit | 3,350 |
| i. Piezo type 2 cable | 3,400 |
| j. AVC equipment | 3,400 |

Two-lane estimated costs = $36,860. The estimate costs for one lane is $18,430.

Estimated maintenance costs per year per lane = $2,000. The life expectancy of AVC in-roadway equipment is estimated at 4 years.

2) WIM Cost Estimates:

Estimated costs are for in-roadway sensors: A. Piezoelectric, B. Bending Plate WIM. No portable WIM on-roadway or WIM portable equipment were considered for this estimate.

A. Piezoelectric WIM:

The Piezoelectric WIM was assumed to consist of two class 1 piezoelectric sensors, two inductive loops and one temperature sensor for one lane of traffic being monitored for both direction with roadside pull boxes and conduit connection to a roadside control cabinet with power and phone line connections.

| | Equipment and Installation By Private Contract |
|---|---|
| a. Control cabinets and mounts | $6,500 |
| b. Pull boxes | 1,100 |
| c. Detector loops | 2,100 |
| d. Power service | 7,000 |
| e. Telephone service | 7,000 |
| f. Mobilization | 3,400 |
| g. Traffic control | 2,900 |
| h. Conduit | 3,400 |
| i. Piezo type 1 cable | 8,100 |
| j. WIM equipment | 10,000 (Includes calibration acceptance testing). |

Estimated costs for two lanes = $51,500. The estimate for Piezoelectric for one lane is $25,750.

Estimated maintenance cost per year per lane is $5,600 (includes one calibration session). The life expectancy of WIM piezoelectric in-roadway equipment is estimated at 4 years.

B. Bending Plate:

The Bending Plate WIM sensors was assumed to be installed in a construction 100- by 12- by 1-ft concrete pad in a asphalt roadway. The in-roadway sensor was assumed to consist of one bending plate frame with two bending plates with sensors, two inductive loops, and one off scale sensor installed in one lane of traffic. Also, roadside pull boxes and conduit connection to a roadside control cabinet with power and phone line connections were assumed to be available.

One lane installation costs estimates:

| | Equipment and Installation By Private Contract |
|---|---|
| a. Control cabinets and mounts | $6,500 |
| b. Pull boxes | 1,100 |
| c. Detector loops | 2,100 |
| d. Power service | 7,000 |
| e. Telephone service | 7,000 |
| f. Mobilization | 3,400 |
| g. Traffic control | 6,000 |
| h. Conduit | 3,500 |
| i. Bending plate frame and plates | 14,100 |
| j. WIM equipment | 15,000 (Includes calibration acceptance testing). |
| k. Construction concrete pad | 21,900 |

Estimated costs per lane = $87,600. For two lanes, installation is $175,200.

Estimated yearly maintenance cost per lane is $5,600 (includes one calibration session). The life expectancy for the Bending Plate installed in a concrete pad is estimated at 10 years.

**Recommendations**

In deciding future investment in WIM/AVC operation, there are two considerations :

- Maintaining the WIM/AVC sites available.
- Adding additional WIM/AVC sites to the ones already operating.

To address the first consideration, the operational condition (i.e., calibration status) of the available WIM/AVC sites needs to be evaluated.

For the WIM systems at LTPP sites, the calibration status is routinely ascertained through the QA process implemented by the Chaparral software. The WIM systems at LTPP sites are very close together, especially on I-10 and I-19, for the purpose of yielding network-wide traffic data samples. Furthermore, it may possible to obtain national funding for rehabilitating some of these sites. As a result, it is recommended not to expend State funding towards rehabilitating any of the WIM systems at the LTPP sites.

For the WIM systems at other than LTPP sites, a simpler method can be followed for ascertaining calibration status. This can be done by testing the mean values of the steering axle load of three-S2 trucks against the range established from either static weigh data as already suggested under "WIM System Calibration" or, from WIM data, provided that it is obtained from an independently calibrated WIM system (e.g., WIM system at LTPP site).

For the AVC systems, at LTTP or other sites, there is a need to improve the "visual" calibration method currently used. For this purpose it is recommended to use video technology as the ground truth. Currently there are no video systems capable of classifying traffic based on the FHWA 13-bin classification scheme. However, this can have the simple form of a household-grade video-camera on the side of the road followed by manual counts from several independent observers. The advantage of a video system is that it is portable and can be moved between AVC locations to cover the entire State.

To address the second consideration, an evaluation of the truck traffic levels across the State needs was undertaken. Operating on the assumption that the greatest need is in areas of the highest AADTs where there is currently no AVC/WIM equipment the list compiled in table 7.1 was developed. In addition to the AADT factor, the other major factor was selecting classification sites that currently have no AVC/WIM systems located in their limits.

Some substitute locations for classification sites located above are: segment 76, for classification site 136; segment 102, for classification site 64; segment 79, for classification site 69.

In discussions with the TPG, seven ATRs were purchased and installed that had the capacity to collect classification data, but due to equipment and software problems (not to mention the constant pounding of thousands of vehicles per day) there is only one (on I-10 near Benson) that is currently capable of collecting vehicle classification information. ADOT should investigate the cost of getting these ATRs to collect classification data as was originally intended, and if there is a need to replace existing ATRs, ADOT should do so with equipment that can collect classification data.

Table 7.1. Recommended locations for AVC/WIM installations.

| Classification | Traffic Segment | Route | 1997 AADT |
|---|---|---|---|
| 136 | 1184* | I-10 | 218,881 |
| 148 | 833 | U-60 | 156,008 |
| 74 | 107* | I-10 | 108,332 |
| 143 | 1104 | SL-202 | 124,060 |
| 64 | 97* | I-10 | 37,495 |
| 69 | 1001 | I-10 | 102,850 |
| 144 | 610* | S-77 | 46,000 |
| 68 | 569 | S-87 | 49,624 |
| 39 | 628 | S-89 | 37,696 |
| 107 | 419 | SB-40 | 34,000 |

*Existing ATR within this segment.

Before acting on these recommended installations, ADOT should revisit the assignment of particular traffic segments to the various classification sites. Additional weight should be given to sites containing AVC/WIM systems. If these assignments (segmentation) are revised, perhaps there would not be as strong a need for some of the installations (for example, recommendations for four installations in I-10 are in table 6.4, when there are already five existing systems on I-10 related to the LTPP program).

# CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

Arizona DOT does a fine job collecting as much traffic information as their budget allows. As funding becomes available, the following recommendations would be worth pursuing:

- Increase the frequency with which classification counts are taken (annually would be ideal).
- Increase the duration of the classification counts.
- Have all counts be collected with automated equipment and use manual classification (in association with video cameras) as a method of calibration.
- Install new AVC/WIM equipment at key locations.
- Instrument all lanes at AVC/WIM locations to allow accurate counts of percent trucks and AADT.
- Convert the ESAL tables from Excel spreadsheets to an interactive database.

Other issues that should not wait for increased funding are:

- Revisit the traffic segments assigned to classification sites to place more segments in classification sites with AVC/WIM systems.
- Calibrate of the TPG AVC/WIM equipment.

## SUMMARY

This study resulted in the development of ESAL design tables that:

- Calculate annual ESALs for flexible and rigid pavements.
- Predict annual growth and assesses the reasonableness of the prediction.
- Are interactive so that a manual change of one parameter will cause the final ESAL calculation for that segment to be revised.
- Provide information regarding the capacity of each segment, with the ability to update these values in the future if additional lanes are constructed.
- Update ESAL values based on WIM data collected throughout Arizona.
- Provide a safety factor of +1 and +2 standard deviations for these ESAL values.

In addition, the following information is also provided:

- Insight into the types of data collected by ADOT.
- Formal documentation of how AADT values are calculated.
- Recommendations on AVC/WIM calibration.

- Recommendations on additional AVC/WIM installations.
- Determination of a single ESAL value for all trucks to provide other agencies in Arizona.
- Information from 11 State highway agencies on how they determine and utilize ESALs.
- Cost information on installation and maintenance of different types of AC and WIM systems.

The electronic files containing the three Excel spreadsheets (for three different ESAL calculation methodologies) is provided to ADOT on a compact disk.

## REFERENCES


1. Conformity Analysis for the Fiscal Year 1999-2003 MAG Transportation Improvement Program and the MAG Long Range Transportation Plan Summary and 1997 Update with 1998 Addendum, Maricopa Association of Governments, September 1998.

2. ADOT, Traffic on the Arizona State Highway System 1997, Arizona Department of Transportation, Data Collection Team.

3. AASHTO, Guide for the Design of Pavement Structures, 1993.

4. Dahlin, C., "Proposed Method for Calibration Weigh-in-Motion Systems and for Monitoring that Calibration Over Time," TRB Research Record 1364, 1992.

5. Protocol for Calibrating Traffic Data Collection Equipment, LTPP Directive TDP-11, United States Department of Transportation, April 1998.

6. A.T. Papagiannakis, J.H.F. Woodrooffe, R.C.G. Haas and P. LeBlanc (1990), "Impact of Roughness-Induced Dynamic Load on Flexible Pavement Performance," ASTM Special Technical Publication, No. 1031, American Society of Testing of Materials, Philadelphia, PA.

7. A.T.Papagiannakis, K.Senn, and H.Hong (1996), "Two Alternative Methods for WIM System Evaluation/Calibration," Transportation Research Record, No. 536 pp. 1-11. Washington, D.C.

8. Ott, W. and A.T.Papagiannakis (1996), "A WIM QA Method Based on Analysis of the Variation of Three-S2 Steering Axle Loads," Transportation Research Record, No.1536 pp., 12-18, Washington, D.C.

# APPENDIX A: MINUTES FROM KICK-OFF MEETING

# APPENDIX A: MINUTES FROM KICK-OFF MEETING

## KICK-OFF MEETING MINUTES

Arizona Department of Transportation
Development of New Pavement Design Equivalent Single Axle Load (ESAL)
Contract No.: T9813A0003

Note: Italicized items involve submission of data from ADOT to NCE; tasks from the work plan are referred to by number in these minutes.

**<u>December 2, 1998</u>**

Meeting called to order by Estomih Kombe at 1:15 p.m.

The meeting agenda is included as attachment 1.

Those attending the meeting are listed in attachment 2.

Following the introductions, the project objectives were briefly discussed.

Next, a discussion of the work plan was begun.

Opening remarks (Sirous Alavi):

- Discussion of ESAL table
  - The ESAL table is one of the key deliverables and we need as much information as possible on the existing table used by ADOT.
  - *George Way will send both a hardcopy and electronic version of the existing ADOT ESAL table.*
  - *Bob Pike will send the ADT file his group creates (uncertain whether it is an electronic file or hardcopy).*
  - George Way asked NCE to investigate how other agencies do things.

Task A

1. No discussion
2. No discussion

Task B

- *John Eisenberg and George Way adapted the AASHTO ESAL calculation method for ADOT, George Way to provide this documentation.*

1. *Bob Pike will work with us to provide and explain this information.*
2. ADOT collects the FHWA 13 classes on manual and automated surveys and then places them into the appropriate bins on the ESAL table.

- George Way expressed the opinion that we should be focusing on how to make WIM data work.

3. The planning group has only two AVC units and neither has produced any usable data; planning group WIM data was briefly discussed as well (more in task D).

   - *George Way has looked at a lot of the data provided by NCE in 1997 and will provide us with the "interesting" trends (and questionable trends) he has noticed in some of the traffic data.*
   - *Estomih Kombe will help to investigate issues arising from WIM data submitted to us:*
     - Questionable data will be investigated by us.
     - Nonsensical data will be ignored.

4. No seasonal effects currently used in percent trucks estimations.

   - Truck information is tied to ADT (i.e., number of trucks increases as ADT increases, but the percentage remains constant).

5. There has been an historical under-estimation on traffic data for urban routes.

   - Linear regression was used to determine growth factors on the current ESAL table.
   - *Bob Pike and George Way to give us data concerning how growth factors are/were calculated.*
   - A system-wide forecast may be available for the greater Phoenix area from the Maricopa Association of Governments (MAG)--*Bob Pike to provide us with a contact.*
   - There was a significant discussion related to unrestricted traffic growth vs. restricted (i.e., sections reaching capacity) traffic growth.
     - Sirous Alavi stated that we would not be generating new growth rates from scratch but would investigate the methods currently used by ADOT and other forecasting methods in place in Arizona to propose the most appropriate methods for forecasting traffic growth.
     - Sirous Alavi identified three major sources of information wherein data exists that would aid in this effort.
       - *ADOT--George Way, Bob Pike and Estomih Kombe to provide.*
       - *Other Arizona traffic studies--Bob Pike to investigate potential sources and provide contacts or information as it is found.*
       - LTPP data--we have.
     - Larry Scofield questioned our methods for developing growth information, but upon further discussion it was determined that we were talking about the same thing and the confusion was in the semantics (growth rates would be developed but that they would be reliant upon the best available data and not on "new" forecasting models).

- It was determined that an additional column be added to the table to show a segment that has reached capacity and this capacity value would be used to determine the ESALs for that segment.
- ~~*Bob Pike to provide information regarding ADT capacity values.*~~
- It was determined that the vast majority of ADOT's highway network is not operating at capacity currently and will most likely not reach capacity in the next 20 years.
- George Way spoke of how part of this task is to develop methodology to allow for a more "continuous" updating of the ESAL tables in the future--we agree with the understanding that "continuous" doesn't imply daily, weekly or even monthly, but rather whenever dependable annual ADT values can be provided.

Task C

1. This task was discussed thoroughly as part of the Task B discussion

Task D

1. Estomih Kombe and Bob Pike stated that the planning group WIM data could easily be converted into the file format that would enable processing using the LTPP software.
2. No discussion
3. *Bob Pike to provide vehicle volume and classification data.*
4. It was learned that weigh stations in Arizona are not collecting weight or classification data. The possibility of collecting this type of information at key weigh stations was discussed, but no request for this information was made.
5. As previously mentioned, Bob Pike stated that seasonal effects are not currently assigned to truck percentages anywhere in Arizona (ADT values have seasonality).
6. The planning group's AVC on I-40 is gone and the one on I-8 is down with no plans to get working any time soon; all working WIM systems were calibrated.
   - Three systems calibrated fine and one had questionable values (the other two systems are down at this time).
   - *Estomih Kombe will be providing data from three WIM sites soon and from the one remaining site following his trip.*

Task E

1. No discussion

Task F

1. *Estomih Kombe and/or Bob Pike to prodcue a list of weigh scales within Arizona*
   - Potential classification data collection from weigh stations was again discussed but not requested.

2. No discussion

Task G

1. No discussion.

Task H

1. No discussion.

Task I

1. No discussion.

The NCE wish/question list was reviewed. This list is included in the attached agenda and the following list shows the persons responsible for the numbered items and whether the question was resolved during the meeting. Please note that there is some overlap between information requested on this list and information requested in the work plan discussion above.

1. Estomih Kombe provided the TAC list.
2. *Bob Pike to provide planning group traffic count data.*
3. *Bob Pike to provide planning group classification data.*
4. *Bob Pike and Estomih Kombe to provide planning group WIM data .*
5. *Estomih Kombe, Bob Pike and George Way to provide other appropriate data (i.e., WIM studies, AASHTO ESAL modification, corridor forecasts, etc.).*
6. Estomih Kombe provided a current list of WIM and AVC sites (*there still is a need to know whether any are located in pavements that will be requiring major rehabilitations in the near future*).
7. *Estomih Kombe, George Way and Bob Pike to provide information regarding current data collection, analysis and forecasting procedures.*
8. *Estomih Kombe, Bob Pike, George Way and Larry Scofield to provide available traffic forecasting models utilized by ADOT or commonly used in Arizona.*
9. *Estomih Kombe, Bob Pike, George Way and Larry Scofield to provide any supplemental sources of data (i.e., weigh scale data, Research Notes, etc.).*
10. *Bob Pike and George Way to provide current procedures for developing the ESAL design table.*
11. *George Way to provide all relevant literature and reports from the 1986 ADOT ESAL study (and related work based on the study).*
12. Estomih Kombe answered questions regarding ADOT's reporting requirements and stated that monthly reports should be brief summaries of work performed by task and should be sent to himself only (the quarterly reports will be sent to all TAC members).
13. Estomih Kombe gave ADOT's consent for ADOT LTPP data to be used in the study. The completed consent form will be sent to the LTPP TSSC.

14. The need to set up a meeting to discuss work completed through Task D and previous to beginning Task E was reviewed. It was decided that the TAC will review the work completed on Tasks B, C and D and a meeting will only take place if the project manager and the TAC deem it necessary.
15. NCE asked for a one-month no cost extension (letter requesting extension to be Fed-Ex'd to Estomih Kombe on 12/3/98).

ADOT did not have any major requests or questions that were not addressed during the course of the meeting.

The meeting was adjourned at 4:30 p.m.

# APPENDIX B: ANALYSES FOR ESAL TABLE

## APPENDIX B: ANALYSES FOR ESAL TABLE

## CONVERTING ONE LANE CLASSIFICATION DATA TO ALL LANES

An area that was investigated was the distribution of ESALs across traffic lanes. This is the result of heavy vehicles traveling on the innermost lanes unless otherwise directed to travel in the left-hand lanes. Furthermore, it is difficult to determine what percentage of heavy vehicles will travel in each lane. Therefore, the recommendations from the 1993 AASHTO Guide were followed. The percent of design ESALs for the design lane are found in table b.1 below.

Table B.1. Percent of total ESALs in the design lane (AASHTO 1993).

| Total No. of Lanes | No. of Lanes in Each Direction | Percent of 18-kip ESALs in Design Lane | Percent of 18-kip ESALs in Design Lane |
|---|---|---|---|
| 2 | 1 | 100 | 100 |
| 3 | 1/2 | NRBA | 100* |
| 4 | 2 | 80 - 100 | 80 |
| 6 | 3 | 60 - 80 | 60 |
| 7 | 3/4 | NRBA | 60* |
| 8 | 4 | 50 - 75 | 50 |
| 9 | 4/5 | NRBA | 50* |
| 10 | 5 | NRBA | 50* |

Note: NRBA is the abbreviation for No Recommendation By AASHTO.
*Represents values recommended by the NCE team.

From the above table for the percent of total ESALs in the design lane, the percent of ESALs in the adjoining lanes will be 100 percent minus the percent of ESALs in the design lane (truck lane).

The term AADT represents the average annual daily traffic for all lanes and directions of a traffic segment. It was decided by the NCE team to report ESALs in the same manner. (i.e., total applied ESALs for all lanes and directions.) However, the LTPP WIM data is generally only gathered for the truck lane in one direction of travel. The collected WIM data must then be expanded to represent all lanes.

The ESAL data is expanded based upon the information in table B.2. This is accomplished by determining the cumulative recommend percentage distribution of ESALs across multilane traffic segments. To achieve the number of ESALs for a traffic segment, the AADT is multiplied by 365 (days in a year) then by the percent trucks in the truck lane from collected data and finally by a factor referred to as the Lane Distribution Factors (LDF). The LDF is used to account for the percent of vehicles in lane(s) adjacent to the truck lane. The following table contains the LDFs for different lane configurations.

Table B.2. Lane distribution factors for ADOT ESAL table.

| No. of Lanes in Each Direction | Total No. of Lanes | Lane Distribution Factor (LDF) |
|---|---|---|
| 1 | 2 | 1.000 |
| 1/2 | 3 | 1.000 |
| 2 | 4 | 0.625 |
| 3 | 6 | 0.555 |
| 3/4 | 7 | 0.476 |
| 4 | 8 | 0.500 |
| 4/5 | 9 | 0.444 |
| 5 | 10 | 0.400 |

The LDF factor will be used for each segment based upon the number of lanes in the segment. The LDF's use is further explained in the following section concerning the ESAL calculation.

## ESAL CALCULATION

In order to account for lane distribution factor, the ESAL calculation would be as shown below.

Yearly $ESAL_{seg}$ = (0.5) * ($AADT_{seg}$)* (365) * (% Trucks)*(LDF) * [(% VC4)*(ESAL4) +
(%VC5) * (ESAL5) + ........ + (% VC13) * (ESAL13)]

The definitions of the variables for equation 1 are as follows:

$ESAL_{seg}$: Total yearly one-way ESALs for all lanes for a network segment.
$AADT_{seg}$: Average Annual Daily Traffic collected by ADOT for the total two-way traffic for all lanes for a single network segment.
% Trucks: Percentage of trucks in the truck lane for one direction, or the average of the truck lane percentage for both directions.
LDF: Lane Distribution Factor (LDF) is the cumulative distribution of ESALs across all lanes in one direction.
%VC(#): This is the percent of vehicle class (4-13) in the truck lane determined from collected WIM data.
ESAL(#): This is the average ESAL of vehicle class (4-13) in the truck lane determined from collected WIM data.

However, the project team was not confident in this methodology (based on resulting outcome) and decided to use the percent commercial vehicles values provided by the Traffic Planning Group instead of using the lane distribution factor.

Figure B.1. FHWA Vehicle Classifications for LTPP sites 041006 and 041007 on 2/25/96.

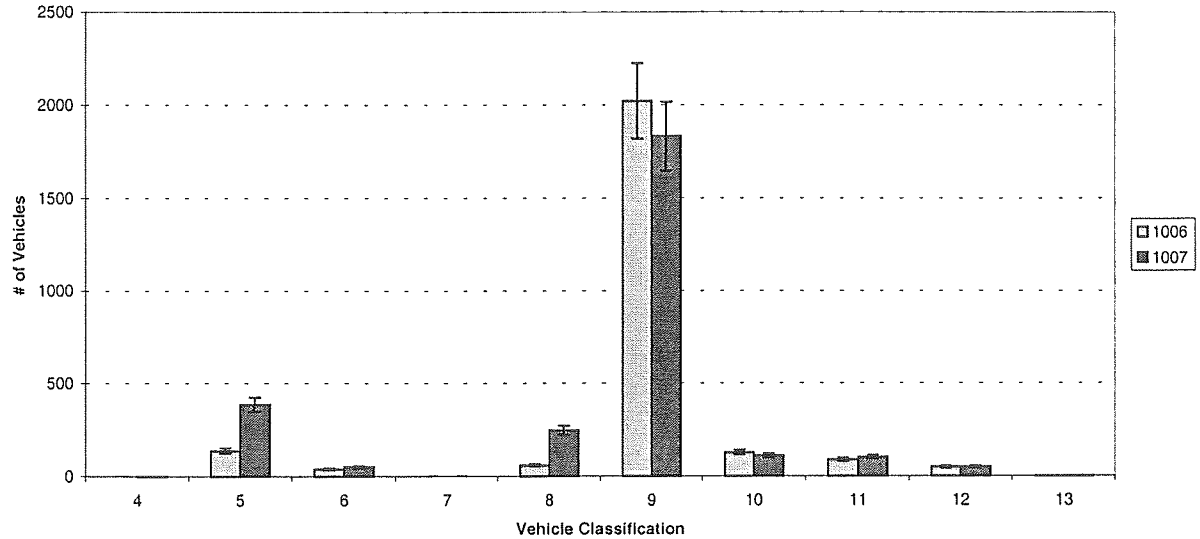



Figure B.2. FHWA Vehicle Classifications for LTPP sites 041006 and 041007 on 3/14/96.

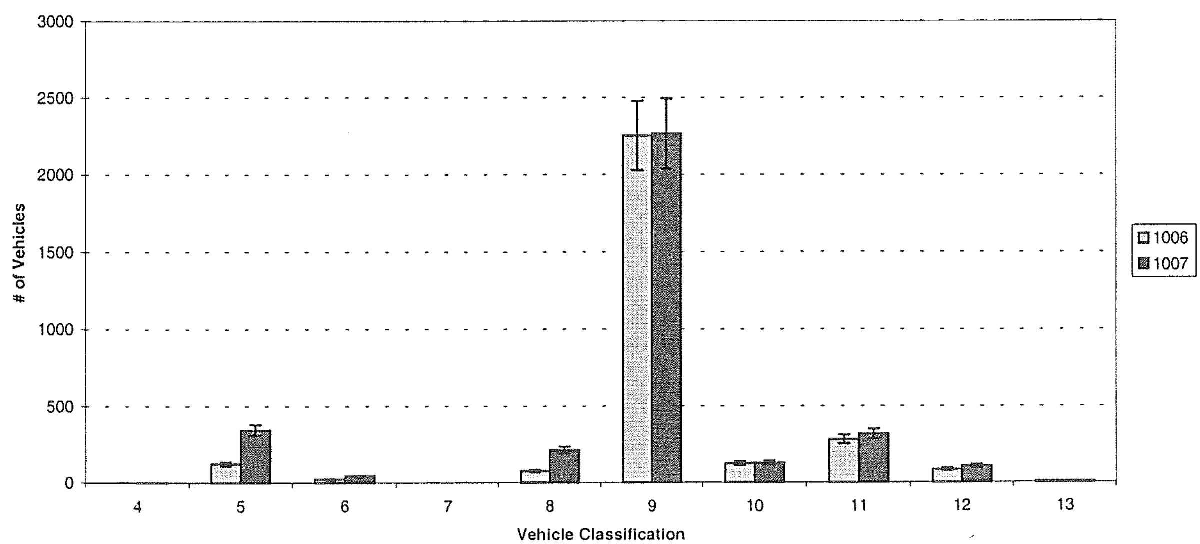


Figure B.3. FHWA Vehicle Classifications for LTPP sites 041006 and 041007 on 7/5/96.

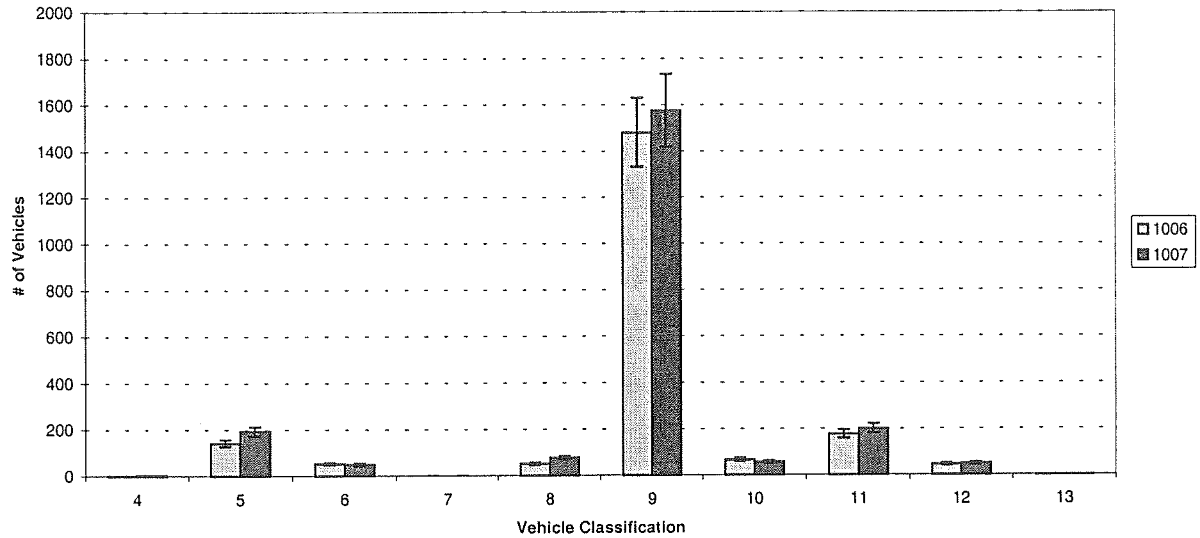



Figure B.4. FHWA Vehicle Classifications for LTPP sites 041006 and 041007 on 7/20/96.

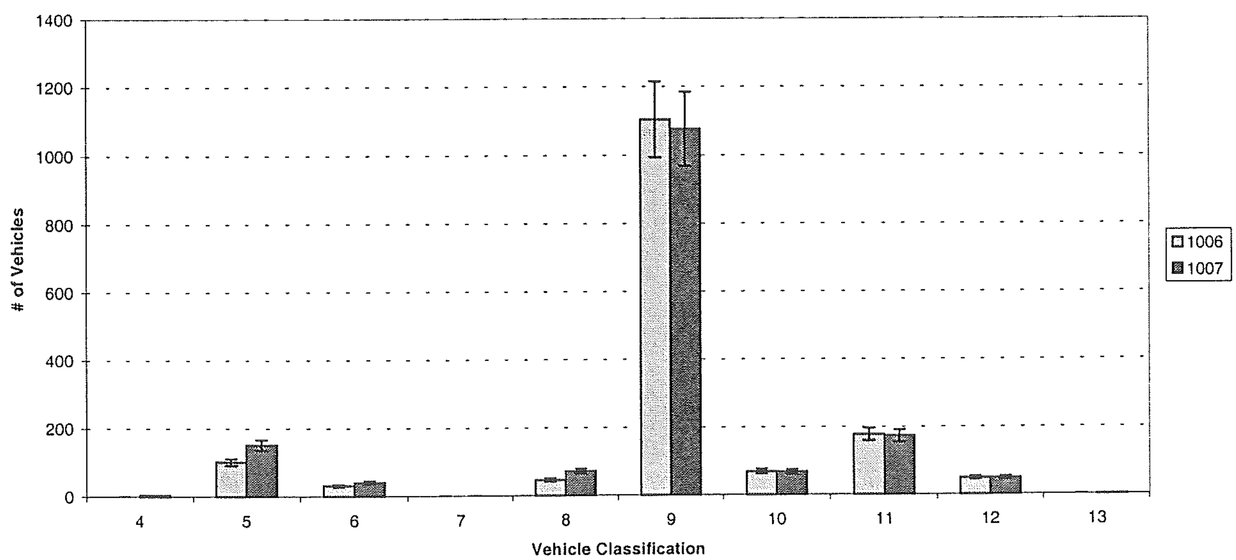
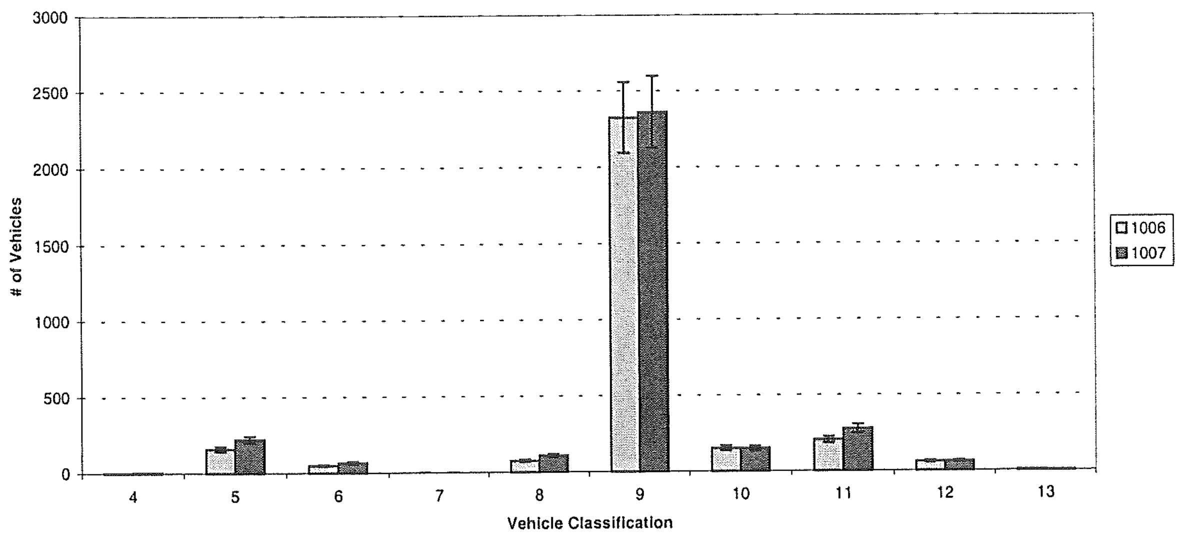


Figure B.5. FHWA Vehicle Classifications for LTPP sites 041006 and 041007 on 8/5/96.



# APPENDIX C: RESPONSES TO AGENCY SURVEYS

# KENTUCKY TRANSPORTATION CABINET

# FAX TRANSMITTAL

KYTC
DIVISION OF MULTIMODAL PROGRAMS
3RD FLOOR, NEW STATE OFFICE BLDG.
125 HOLMES STREET
FRANKFORT, KENTUCKY 40622
TELEPHONE NO. (502) 564- 7686

| | |
|---|---|
| DATE: 3/25/99 | TOTAL PAGES TRANSMITTED: 7 *(Including this cover sheet)* |
| TIME: | |
| | |
| TO: Earl Laird | FROM: Rob Bostrom |
| FAX TRANSMITTAL NO: | |
| 775-882-4565 | |
| | |
| | |
| | FAX PHONE: (502) 564-4422 |

If total number of pages indicated are not received, please contact 3rd Floor at (502) 564- 7686.
*(Telephone Number)* *(FAX Operator)*

## MESSAGE:

Earl,
(1) Response to survey emailed. ✓
(2) Requested examples / tables:
A. Default ESAL table
B Standard ESAL worksheet w/ methodology.
C. Simplified ESAL output
[uses default source data, default growth rates]

Rev. 10-12-94

Rob Bostrom

KENTUCKY RESPONSE TO NCE QUESTIONNAIRES

# Survey Response
# ESALs Used in Pavement Design

Our state can be identified in respect to answers on this survey.

1. Yes.
2. We have one ESAL value for all trucks. Two examples will be faxed. Note that we have a more complex (standard) methodology for Pavement Design that involves additional data collection, data smoothing and a high level of effort. We also have a simplified computer program that is used for determining ESALs when calculating Superpave mix design parameters.
   a. We use different ESAL values based on load information when the load information is available. Usually we use unit EAL values and the vehicle classification information (axles/truck) is different from site to site. We are faxing our default ESAL tables that contain data for six aggregated Classes.
3. We do not break down ESALs by vehicle classification.
4. We do apply average ESAL factors when site specific information is not available.
5. We use growth factors for all of the key prediction parameters separately. We use growth factors for volume, truck percentages, axles per truck and ESALs per axle.
6. We do use WIM data. The WIM data is preprocessed when our annual ESAL tables are produced by the Kentucky Transportation Center (the Cabinet's research partner). These ESAL values are then used when computing site specific ESAL forecasts for design purposes.
7. There are no links between the HPMS data and the ESAL tables. The growth factors for HPMS at this time are generic functional class factors while our ESAL growth factors are computed on a site specific basis (except when using the simplified method).
8. We have a high level of confidence in our pavement design/rehab ESAL values. We have invested a lot of research resources in developing/refining our ESAL prediction process and we think it does a good job. We also have a good traffic data collection program that supports the traffic forecasting function. The one deficiency that we have is that we would like to have more vehicle classification data. We currently have classification data at less than 7% of all state highway segments.

Subj: **RE: Survey ESAL Used in Pavement Design**
Date: 3/26/99 12:33:00 PM Pacific Standard Time
From: RBOSTROM@mail.kytc.state.ky.us (Bostrom, Rob (KYTC))
To: ETLAIRD@aol.com
CC: JROSS@mail.kytc.state.ky.us (Ross, Jerry (KYTC))

File: Survey Response.doc (34816 bytes)
DL Time (32000 bps): < 1 minute

Earl,

I enjoyed chatting with you the other day. In response to your survey, answers are listed on the attached document. I am faxing a copy of:

* Default 1997 ESAL values by functional class
* A sample ESAL calculation from an actual project using our standard methods that we use for pavement design.
* A sample ESAL calculation using a simplified method that we are using for Superpave mix designs.

<<Survey Response.doc>>

If you have any questions or need additional documentation, don't hestitate to call or e-mail.

Rob Bostrom
Transportation Engineering Specialist
Division of Multimodal Programs
Kentucky Transportation Cabinet
125 Holmes Street
Frankfort, KY 40622
Ph: 502-564-7686
> ---------
> From: ETLAIRD@aol.com[SMTP:ETLAIRD@aol.com]
> Sent: Wednesday, March 24, 1999 12:20 PM
> To: RBOSTROM@mail.kytc.state.ky.us
> Subject: Survey ESAL Used in Pavement Design
>
> EARL T. LAIRD
> T P & R CONSULTANT
> Transportation Planning and Research
> 529 Bonanza Dr., Carson City, NV. 89706
> (775)882-4755 Fax (775)882-4565
> E-mail: etlaird@aol.com
>
> March 24, 1999
>
> Survey of States using ESALS for pavement design and rehabilitation. ESAL
> Data information being collected for an ESAL Research Contract between
> Arizona
> DOT and Nichols Consulting Engineers in Reno, Nevada:
>
> Survey State of: Kentucky; Mr. Rob Bostrom;
> Transportation Engineering Specialist; (502) 564-7183
>
> Please check One: Surveyed State (Does __) or (Does Not __) wish to be
> identified on how the state answered any of the survey questions. Only
> identify the state as a participant in the survey.

>
> Question No. 1: Does your state use ESAL computations for
> pavement design and rehabilitation?
> Yes:___
> No:___ If No what do you use?
>
> Q No. 2: What type or types of data do you use to come up with
>
> the ESAL table values (i.e.; one ESAL value for all trucks; ESAL
> values per truck class; etc.)? Will you fax us the first
> page of your
> ESAL table for an
> example.
>
> a. Do you use a single ESAL table for all design locations within your
> state
> or is a different ESAL value computed for different locations based upon
> load
> information for that location?
>
> Q NO. 3: Do you break down ESALS by vehicle classification?
>
> Q No. 4: Do you apply average ESAL factors to the vehicles in
> each classification? What are they?
>
> Q No. 5: Do you use Growth factors to expand ESAL's to design
> years?
>
> Q No. 6: Do you use WIM data? If No what do you use for load
> data?
>
> Q No. 7: Are there links between HPMS data and the ESAL tables?
> a. Are your growth factors for HPMS the same for ESAL
> growth factors?
>
> Q No. 8: How much confidence do you have in the values you use
> for pavement design and rehab?
>.
> Survey States comments if any:
>
> Thank you for participating in this ESAL pavement design and
> rehabilitation
> survey. If you have any questions on this survey you may contact Earl
> Laird
> at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D.,
> P.E.;
> Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No.
> (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe;
> Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az
>
> Thank you again for your anticipated help.
>
> Earl T. Laird.
>

---------------

A

## Aggregated 1997 ESALs - Three-year Averages with Smoothed Growth Rates

*6-26-98/nrb*

| Agg. class | FCs | T% | GR | A/T | GR | EALs/A | GR | A/CT | GR | EALs/CA | GR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 1 | 28.653 | 1.000 | 4.493 | 0.092 | 0.217 | 1.000 | 4.778 | 0.000 | 0.880 | 1.989 |
| II | 2,6 | 11.635 | 1.000 | 3.490 | 0.535 | 0.251 | 1.000 | 4.956 | 0.000 | 2.639 | 2.000 |
| III | 7,8,9 | 7.770 | 1.000 | 2.936 | 0.983 | 0.219 | 0.000 | 4.595 | 0.000 | 1.235 | 0.000 |
| IV | 11 | 13.406 | 1.000 | 4.076 | 1 | 0.183 | 0.000 | | | | |
| V | 12,14 | 6.262 | 1.000 | 3.042 | 0.398 | 0.209 | 0.556 | 4.590 | 0.000 | 1.048 | 0.000 |
| VI | 16,17,19 | 5.238 | 1.000 | 2.772 | 0.946 | 0.171 | 0.000 | 4.083 | 0.000 | 0.594 | 0.000 |

Note: Negative growth rates were rounded to 0%, a maximum growth rate of 1% was used for T% and A/T, and a maximum growth rate of 2% was used for EALs/A.

B

# FORECAST OF EQUIVALENT SINGLE AXLE LOAD ACCUMULATIONS

## ROUTE ID:

| | |
|---|---|
| County | Boone |
| Road Name | KY 536 |
| Functional Class | 16 - Urban Minor Arterial |
| Project Numbers | |
| Project Limits | East of US 25 |
| Segment Limits | Same as Project Limits |

| | |
|---|---|
| Date | 3/26/99 |
| Name | R. Bostrom |

| | |
|---|---|
| TC 10-1 No. | 61653 |
| Route No. | KY 536 |
| Item No. | 6-101.00 |
| Beg. MP | |
| End MP | |
| T.F. No. | 98.227 |
| Number of Lanes | 2 |
| 1 or 2 way | 2 |

## REFERENCES:

| | |
|---|---|
| Previous Forecasts | |
| Volume | OKI TMs |
| Truck Percent | Estimate by Dennis Merrill |
| ESAL Information | State Default |

| | |
|---|---|
| Present Year | 1998 |
| Construction Year | 2002 |
| Median Year | 2012 |
| Design Year | 2022 |

## TRAFFIC PARAMETERS:

| | Present Year | Annual Change | Construction Year | Median Year | Design Year |
|---|---|---|---|---|---|
| Volume (AADT) | 5560 | 1.68% | 5940 | 7020 | 8300 |
| Percent Trucks (%T) | 10.00% | 1.00% | 10.4% | 11.5% | 12.7% |
| Percent Trucks Hauling Coal (%CT) | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| *Non-Coal Trucks:* | | | | | |
| Axles/Truck (A/T) | 2.772 | 1.00% | 2.885 | 3.186 | 3.520 |
| ESALs/Axle (ESAL/A) | 0.171 | 0.00% | 0.171 | 0.171 | 0.171 |
| *Coal Trucks:* | | | | | |
| Axles/Truck (A/CT) | 0 | 0.00% | 0.000 | 0.000 | 0.000 |
| ESALs/Axle (ESAL/CA) | 0 | 0.00% | 0.000 | 0.000 | 0.000 |

## ESAL CALCULATIONS:

Total Median Year Daily ESALs

(AADT x (1-%T) x .005)+(AADT x %T x (A/T) x (ESAL/A))+(AADT x (%T) x (%CT) x (A/CT) x (ESAL/CA)) = **470.733**

Design ESALs in Critical Lane

Median Daily ESALs x 365 x 20 x Lane Adj. = **1,718,000**

Version 1.2, 7/22/97

KY536_ESALs.XLS

# CALCULATIONS

## ESAL Calculations:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4-Tired Vehicles = | 7020 | x | 88.5% | x | 0.005 | | | | | = | 31.065 |
| Non-Coal Trucks = | 7020 | x | 11.5% | x | 3.186 | x | 0.171 | | | = | 439.668 |
| Coal Trucks = | 7020 | x | 11.5% | x | 0.00% | x | 0.000 | x | 0.000 | = | 0 |
| Median Year Daily ESALs = | 31.065 | + | 439.668 | + | 0 | | | | | = | 470.733 |
| Design ESALs = | 470.733 | x | 365 | x | 20 | x | 0.500 | | | = | 1,718,000 |

## Lane Distribution Factors:

| | |
|---|---|
| 1 lane, 1 way | 1.000 |
| 2 or 3 lane, 2 way | 0.500 |
| 4 or 5 lane, 2 way | 0.483 |
| 4 lane, 1 way | 0.350 |
| 5 lane, 1 way | 0.300 |
| 6 lane, 2 way | 0.413 |
| 6 lane, 1 way | 0.250 |
| > 6 lane, 2 way | 0.351 |
| > 6 lane, 1 way | 0.600 |

Segment: Same as Project Limits

# TRAFFIC FORECAST METHODOLOGY

## FORECAST INFORMATION

Forecast Number: 98.227 Forecaster: R. Bostrom

County: Boone Route: KY 536

Description: East of US 25

Item #: 6-101.00 Project #:

Requester: District 6 Priority: High Date: 11/9/98

Construction Year: 2002 Design Year: 2022

Data Requested: [X] ADTs [X] DHVs [X] PHFs [X] T% [X] EALs [X] TMs

## BACKGROUND INFORMATION

Previous Forecasts:

Volume Source: OKI TMs

Classification Source: State Default

Coal Truck Source: DNA

Special Counts-
Date Requested: 12/4/98
Date Received: 12/28/98
Number Requested:

General Comments: None

Special Methods Used: ☐ Turns ☐ Manual Gravity ☐ Traffic Model ☐ Field Trip

Version 1.2, 7/22/97

KY536_ESALs.XLS

## METHODOLOGY - GROWTH RATE & K FACTOR

Growth Rate: 1.68% Source: OKI TMs

County Area: Entire Source: KY State Data Center

| YEAR | TYPE | POPULATION | | | ANNUAL GROWTH RATE | |
|---|---|---|---|---|---|---|
| 1990 | Census | 43438 | | | - | |
| 1995 | Moderate Growth Est. | 45939 | | | 1.13% | |
| 1995 | High Growth Est. | 48092 | | | 2.06% | |
| 2020 | Moderate Growth Est. | 53114 | | | 0.67% | |
| 2020 | High Growth Est. | 60670 | | | 1.12% | |

TLA GROWTH:

| Station | Growth Rate | Notes |
|---|---|---|
| 7 | 1.58% | |
| 52 | 1.70% | |
| | | |
| | | |
| | | |
| Average: | 1.64% | |

Growth From Previous Forecast: None Forecast #: DNA

Are any new developments planned or special conditions present in this area? ☐ Yes ☐ No

Source of this information: Field Trip

Describe development / special conditions: Wal-Mart

Land Use in Area: Mostly farm land

Comments: None

K Factor: 8.50% Source: OKI TMs

Related ATR: None Location: DNA K Factor: DNA

Peak Hour Factor: 0.9 Source:

Version 1.2, 7/22/97 KY536_ESALs.XLS

# Forecasted ESALs

County Kenton

**Data type**

A = actual data E = estimated data I = insufficient data

| County | Station | Rt. Prefix | Rt. # | Rt. Suffix | Milepoints Start | Milepoints End | AADT | %T | Data type | A/T | Data type | ESAL/A | FC | Lanes | Daily # of coal trucks | Data type | A/CT | Data type | ESAL/CA | Lane Dist. | Years | Forecasted ESALs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 59 | 59086 | KY | 536 | na | 0 | 0.268 | 2020 | 7.770 | E | 2.936 | E | 0.219 | 7 | 2 | 0 | E | 4.595 | E | 1.235 | 0.500 | 20 | 588,051 |
| 59 | 59L22 | KY | 536 | na | 0 | 1.895 | 5810 | 5.238 | E | 2.772 | E | 0.171 | 16 | 2 | 0 | E | 4.083 | E | 0.594 | 0.500 | 20 | 900,762 |
| 59 | 59L23 | KY | 536 | na | 1.895 | 3.305 | 4200 | 5.238 | E | 2.772 | E | 0.171 | 16 | 2 | 0 | E | 4.083 | E | 0.594 | 0.500 | 20 | 651,153 |
| 59 | 59L25 | KY | 536 | na | 3.305 | 4.476 | 3720 | 5.238 | E | 2.772 | E | 0.171 | 16 | 2 | 0 | E | 4.083 | E | 0.594 | 0.500 | 20 | 576,736 |
| 59 | 59L26 | KY | 536 | na | 4.476 | 6.092 | 2890 | 5.238 | E | 2.772 | E | 0.171 | 16 | 2 | 0 | E | 4.083 | E | 0.594 | 0.500 | 20 | 448,055 |
| 59 | 59065 | KY | 536 | na | 6.092 | 7.386 | 1550 | 7.770 | E | 2.936 | E | 0.219 | 7 | 2 | 0 | E | 4.595 | E | 1.235 | 0.500 | 20 | 451,227 |
| 59 | 59257 | KY | 536 | na | 7.386 | 9.284 | 1110 | 7.770 | E | 2.936 | E | 0.219 | 7 | 2 | 0 | E | 4.595 | E | 1.235 | 0.500 | 20 | 323,137 |
| 59 | 59250 | KY | 536 | na | 9.284 | 10.249 | 1330 | 7.770 | E | 2.936 | E | 0.219 | 7 | 2 | 0 | E | 4.595 | E | 1.235 | 0.500 | 20 | 387,182 |
| 59 | 59086 | KY | 536 | na | 10.249 | 10.474 | 2020 | 7.770 | E | 2.936 | E | 0.219 | 7 | 2 | 0 | E | 4.595 | E | 1.235 | 0.500 | 20 | 588,051 |

Friday, March 26, 1999

Subj: **Survey ESAL Used in Pavement Design**
Date: 3/24/99
To: [redacted]

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 24, 1999

Survey of States using ESALS for pavement design and rehabilitation. ESAL Data information being collected for an ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: [redacted]
Transportation Engineering Specialist; (502) 564-7183

Please check One: Surveyed State (Does __) or (Does Not __) wish to be identified on how the state answered any of the survey questions. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes:___
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values (i.e.; one ESAL value for all trucks; ESAL values per truck class; etc.)? Will you fax us the first page of your ESAL table for an example.

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

Q NO. 3: Do you break down ESALS by vehicle classification?

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design years?

Q No. 6: Do you use WIM data? If No what do you use for load data?

Q No. 7: Are there links between HPMS data and the ESAL tables?
a. Are your growth factors for HPMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe;

Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again for your anticipated help.

Earl T. Laird.

Hi Rob Bostrom,

Thank you for the quick and very informative reply to the questionnaire on ESAL use in pavement design. Of the 10 states I have received back questionnaires, I must tell you that your state and Kansas, thus far (and you know this is not a contest), has the most aggressive ESAL tables. You have ESAL for trucks, growth factors for future years, use vehicle class data at design sites, etc.. Very, very nice ESAL reporting tables. This old traffic guy like to see traffic reports tables that show the user we know how to collect traffic data and how to report same. Very good reporting.

Thanks again for your states input.

Earl T. (:>))

NEBRASKA DOT

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 16, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Nebraska DOT: Mr. Jerome Miller ; Asst. Transportation Planning Engineer; (402) 479-4670 Fax: (402) 479-3884

Please check One: Surveyed State (Does X ) or (Does Not __) wish to be identified on how the state answered any of the survey questions. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes: X
No: __ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location? DIFFERENT

Q NO. 3: Do you break down ESALS by vehicle classification? YES

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they? SEE ATTACHED SHEET

Q No. 5: Do you use Growth factors to expand ESAL's to design years? YES

Q No. 6: Do you use WIM data? If No what do you use for load data? YES

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab? GOOD CONFIDENCE

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,
Earl T. Laird.

DATE : 06/16/98
STATE : NE
PERIOD : 1997

NEBRASKA DEPARTMENT OF ROADS
TRANSPORTATION PLANNING DIVISION

# W-4 TABLE EQUIVALENCY FACTORS

## By Direction



FUNCTIONAL CLASS(ES) : 02
AVERAGING METHOD : Hour of Day
AXLE GROUPING METHOD: Vehicle Size & Weight
STATION CODE(S) : 31030 (31030), 31070 (31070), 31110 (31110), 31150 (31150), 35650 (35650)

| SUMMARY ESAL DESIGN FACTORS | 3 SU 2-AX 4-TR | 4 BUS | 5 SU 2-AX 6-TR | 6 SU 3-AX | 7 SU 4-AX OR MORE | 8 STT 4-AX OR LESS | 9 STT 5-AX | 10 STT 6-AX OR MORE | 11 MTT 5-AX OR LESS | 12 MTT 6-AX | 13 MTT 7-AX OR MORE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *RIGID PAVEMENT P=* 2.50 *D=* 228 mm | | | | | | | | | | | |
| ESALSs PER VEHICLE | 0.0000 | 0.3217 | 0.1593 | 0.3918 | 0.8451 | 0.9096 | 1.6278 | 1.8730 | 2.0122 | 3.1856 | 0.0000 |
| PERCENT DISTRIBUTION USING AVERAGE DAILY COUNT | 0.00 | 0.23 | 2.70 | 1.86 | 0.54 | 5.53 | 77.86 | 10.50 | 0.52 | 0.22 | 0.00 |
| *FLEXIBLE PAVEMENT P=* 2.50 *SN=* 127 mm | | | | | | | | | | | |
| ESALSs PER VEHICLE | 0.0000 | 0.2687 | 0.1605 | 0.2351 | 0.6965 | 0.7347 | 0.9872 | 1.1111 | 2.0317 | 2.7270 | 0.0000 |
| PERCENT DISTRIBUTION USING AVERAGE DAILY COUNT | 0.00 | 0.31 | 4.31 | 1.76 | 0.70 | 7.07 | 74.79 | 9.86 | 0.84 | 0.30 | 0.00 |
| *TRAFFIC VOLUME* | | | | | | | | | | | |
| AVERAGE VEHICLES WEIGHED | 0 | 3 | 51 | 17 | 1 | 13 | 165 | 18 | 1 | - | 0 |
| AVERAGE VEHICLES COUNTED | 457 | 3 | 72 | 20 | 3 | 26 | 201 | 24 | 1 | - | 0 |
| PERCENT DISTRIBUTION OF AVERAGE DAILY COUNT BY TRUCK TYPE | | | 20.66 | 5.78 | 0.78 | 7.40 | 58.16 | 6.82 | 0.32 | 0.09 | 0.00 |

### 20 YEAR ESAL ESTIMATES

ADT = 1000

Values in millions

FLEXIBLE PAVEMENTS GROWTH RATES

| PERCENT TRUCKS | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 2 | 0.11 | 0.14 | 0.17 | 0.19 | 0.23 | 0.29 |
| 4 | 0.22 | 0.27 | 0.33 | 0.38 | 0.46 | 0.57 |
| 6 | 0.34 | 0.41 | 0.50 | 0.57 | 0.69 | 0.86 |
| 8 | 0.45 | 0.54 | 0.67 | 0.76 | 0.93 | 1.14 |
| 10 | 0.56 | 0.68 | 0.83 | 0.94 | 1.16 | 1.43 |
| 15 | 0.84 | 1.02 | 1.25 | 1.42 | 1.74 | 2.14 |
| 20 | 1.12 | 1.36 | 1.66 | 1.89 | 2.32 | 2.86 |
| 25 | 1.40 | 1.70 | 2.08 | 2.36 | 2.90 | 3.57 |
| 30 | 1.68 | 2.04 | 2.50 | 2.83 | 3.47 | 4.29 |
| 35 | 1.96 | 2.38 | 2.91 | 3.30 | 4.05 | 5.00 |
| 40 | 2.24 | 2.72 | 3.33 | 3.78 | 4.63 | 5.72 |
| 45 | 2.51 | 3.06 | 3.74 | 4.25 | 5.21 | 6.43 |
| 50 | 2.79 | 3.39 | 4.16 | 4.72 | 5.79 | 7.15 |

RIGID PAVEMENTS GROWTH RATES

| PERCENT TRUCKS | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 2 | 0.18 | 0.22 | 0.26 | 0.30 | 0.37 | 0.45 |
| 4 | 0.35 | 0.43 | 0.53 | 0.60 | 0.73 | 0.91 |
| 6 | 0.53 | 0.65 | 0.79 | 0.90 | 1.10 | 1.36 |
| 8 | 0.71 | 0.86 | 1.06 | 1.20 | 1.47 | 1.81 |
| 10 | 0.89 | 1.08 | 1.32 | 1.50 | 1.84 | 2.27 |
| 15 | 1.33 | 1.61 | 1.98 | 2.24 | 2.75 | 3.40 |
| 20 | 1.77 | 2.15 | 2.64 | 2.99 | 3.67 | 4.53 |
| 25 | 2.21 | 2.69 | 3.30 | 3.74 | 4.59 | 5.66 |
| 30 | 2.66 | 3.23 | 3.96 | 4.49 | 5.51 | 6.80 |
| 35 | 3.10 | 3.77 | 4.62 | 5.24 | 6.42 | 7.93 |
| 40 | 3.54 | 4.30 | 5.27 | 5.99 | 7.34 | 9.06 |
| 45 | 3.99 | 4.84 | 5.93 | 6.73 | 8.26 | 10.19 |
| 50 | 4.43 | 5.38 | 6.59 | 7.48 | 9.18 | 11.33 |

97F

# FUNCTIONAL CLASSIFICATION 02 (1997)
# FLEXIBLE

Project No.: F-1-1(111)
Control No.: 12345
Location: Widget City
Date: 36238

| | % | EQV | 12330<br>ADT | 12<br>% HT | ESAL |
|---|---|---|---|---|---|
| **Single Unit Trucks** | | | | | |
| 2 axle, 6-tire | 20.66 | 0.1605 | 12330 | 12 | 49.06 |
| 3 axle | 5.78 | 0.2351 | 12330 | 12 | 20.11 |
| 4 axle, or more | 0.78 | 0.6965 | 12330 | 12 | 8.04 |
| **Single Trailer Trucks** | | | | | |
| 4 axle, or less | 7.4 | 0.7347 | 12330 | 12 | 80.44 |
| 5 axle | 58.16 | 0.9872 | 12330 | 12 | 849.52 |
| 6 axle, or more | 6.82 | 1.1111 | 12330 | 12 | 112.12 |
| **Multi-Trailer Trucks** | | | | | |
| 5 axle, or less | 0.32 | 2.0317 | 12330 | 12 | 9.62 |
| 6 axle | 0.09 | 2.727 | 12330 | 12 | 3.63 |
| 7 axle, or more | 0 | 0 | 12330 | 12 | 0.00 |
| | | | | | ======== |
| | | | | Total | 1132.54 |
| | | | Total x 365 | | 413377.24 |

| | | |
|---|---|---|
| 1993 Total EASL | 391507 | using 1993 Esal Info |
| 1994 Total EASL | 376198 | " 1994 " " |
| 1995 Total EASL | 358767 | " 1995 " " |
| 1996 Total EASL | 411481 | " 1996 " " |
| 1997 Total EASL | 413377 | " 1997 " " |
| Average EASL | 390266 | USING 5-YR AVG OF ESAL INFO |

~~future ADT 0 present ADT 0 years between 0 growth factor #DIV/0! 18-kip ESAL #DIV/0!~~

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Transportation Planning and Research
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E-mail: ETLAIRD@AOL.COM

FAX COVER SHEET
Number of pages including this cover sheet 2

TO: Jerome Miller FAX NUMBER: (402) 479-3884
Asst. Transportation Planning Engineer

FROM: Earl Laird FAX NUMBER: (775) 882-4565

DATE: March 18 1999 TIME: 8:15 AM

SUBJECT: State Survey of ESAL Use For Pavement Design and Rehabilitation

REMARKS:
Hello Mr. Miller:

Per our phone conservation this A.M., attached is the small questionnaire dealing with your state's use of ESALS data in the design and rehabilitation of pavements. As I explained to you, the ESAL survey is part of a contract Nichols Consulting Engineers of Reno has with Arizona DOT dealing with ESAL design and its use in pavement design and rehab.

If you have any questions please call me at (775) 882-4755.

You may fax your answers to me at Fax No. (775) 882-4565.

Thanks for your anticipated help
1
Earl T. Laird (:>))

# FACSIMILE COVER SHEET
# NEBRASKA DEPARTMENT OF ROADS

**TRANSMIT TO**

DATE 4-1-99
FAX # (775) 882-4565
NAME EARL T. LAIRD
COMPANY J. P. & R. CONSULTANT
DIVISION
SECTION
ROOM
CITY
STATE
PHONE ( ) -
PAGES SENT 5 (INCLUDING THIS PAGE)

**TRANSMITTED FROM**

FAX # (402)-479-3884
[redacted] J.C. MILLER
[redacted] ASST. PLN ENGR.
TRANSPORTATION PLANNING DIVISION
LINCOLN, NEBRASKA
(402) 479-[redacted] 4670
DOR5005@VMHOST.CDP.STATE.NE.US

NOTE:

**EARL T. LAIRD**
**T P & R CONSULTANT**
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 16, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Nebraska DOT; Mr. Jerome Miller; Asst. Transportation Planning Engineer; (402) 479-4670 Fax: (402) 479-3884

Please check One: Surveyed State (Does __) or (Does Not __) wish to be identified on how the state answered any of the survey questions. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes:___
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

Q NO. 3: Do you break down ESALS by vehicle classification?

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design years?

Q No. 6: Do you use WIM data? If No what do you use for load data?

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,
Earl T. Laird.

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FAX COVER SHEET
Number of pages including this cover sheet 2

TO: Jerome Miller FAX NUMBER: (402) 479-3884
Asst. Transportation Planning Engineer

FROM: Earl Laird ETL FAX NUMBER: (775) 882-4565

DATE: March 18, 1999 TIME: 8:15 AM

SUBJECT: State Survey of ESAL Use For Pavement Design and Rehabilitation

==============================================================

REMARKS:
Hello Mr. Miller:

Per our phone conservation this A.M., attached is the small questionnaire dealing with your state's use of ESALS data in the design and rehabilitation of pavements. As I explained to you, the ESAL survey is part of a contract Nichols Consulting Engineers of Reno has with Arizona DOT dealing with ESAL design and its use in pavement design and rehab.

If you have any questions please call me at (775) 882-4755.

You may fax your answers to me at Fax No. (775) 882-4565.

Thanks for your anticipated help.
1
Earl T. Laird (:>))

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FAX COVER SHEET
Number of pages including this cover sheet 2

TO: Jerome Miller FAX NUMBER: (402) 479-3884
Asst. Planning Engineer

FROM: Earl Laird FAX NUMBER: (775) 882-4565

DATE: April 1, 1999 TIME: 11:05 AM

SUBJECT: Thanks For State Survey of ESAL Use In Design and Rehabilitation

==============================================================

REMARKS:
Hi J.C. Miller:

Thank you for your prompt and very comprehensive answer to the survey of Nebraska's use of ESAL's in pavement design and rehabilitation.

I, an old retired planning traffic person, was very pleased to see that your division is collecting traffic classification and weight data and using individual truck and bus class data in developing ESAL for site specific design locations. I respect traffic personnel who collect site specific or site related traffic data and take the time to present this data to the user in a comprehensive report form that will answers site specific design questions that the designer may have. If the design administrator uses or does not use the data, it is there for their decision making needs. Of 11 states (15 states surveyed) three states, and your state is one, are using classification and weight data that are site specific or site related to the site location under design. The other 8 states are using a combination of: 1. An all truck statewide average ESAL; 2. A 3 bin truck (single, semi, and truck and trailer) statewide ESAL average; 3. A four bin truck (same as #2 only busses added) statewide ESAL value; or 4. Class 4 through 13 vehicle class statewide average ESAL value and applying these statewide ESAL values to vehicle classification of: 1. A state average; 2. Highway functional class; or 3. Site specific or related vehicle classification count.

Which of the above works? This is what the Arizona DOT research project is trying to answer. What way is best?

My personal view of this average one table, less computation, basic approach is: it's the easy way out. There are exceptions to all rules and I feel, without knowledge being gained from this research project, one should take the time to assure the ESAL values fit the location under design. Roadway construction and maintenance is very expensive and during the design stage of the project is not the time to take the easy way out. Knowing what traffic loads are there now is easy, to a degree, projecting these loads into the future is the hard part and needs lots of crystal ball work. I have provided a lot of design traffic data over the years and had the privilege of seeing my 20 and 30 year projections come true and some that were a long ways off. Most of those that were a long way off are in areas of unexpected fast traffic growth, unexpected land use changes, and truck commodity carrying changes. Win some lose some.

In a couple states, the design divisions are using statewide ESAL values developed, and supposedly verified with WIM data, from old loadometer static weight W-Tables and applied to new vehicle classification data. I am from the old loadometer days and moved my state (Nevada) into WIM data collection in the late 70's. I know that many trucks never came into our loadometer sites for weighing thus our ESAL values were low. Sadly, I see by the average ESAL values being used by the above states, the ESAL values appear to me to be low and when compared to your and other state ESAL values are low.

You are doing what appears to this old planning traffic guy, one good job. If you take this to your boss, you will get a pay raise. Yah, right! APRIL FOOL!

Thanks again for your help.

Earl T. Laird (:>))

From: <ETLAIRD@aol.com>
To: <GKUHL@dot.state.ut.us>
Date: Tue, Mar 23, 1999 8:58 AM
Subject: Survey ESAL Use For Design

UTAH DOT

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 22, 1999

Survey of States using ESALS for pavement design and rehabilitation. ESAL Data information being collected for an ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Utah DOT; Mr. Gary Kuhl; Planning Division Engineer; (801) 964-4552

Please check One: Surveyed State (Does X) or (Does Not __) wish to be identified on how the state answered any of the survey questions. Only identify the state as a participant in the survey. — that's fine

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes: X
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.) — Axle weights from W.I.M. equipment

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location? — varies by functional class

Q NO. 3: Do you break down ESALS by vehicle classification? yes

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they? yes

Q No. 5: Do you use Growth factors to expand ESAL's to design years? for volumes, not factors

Q No. 6: Do you use WIM data? If No what do you use for load data? yes

Q No. 7: Are there links between HPMS data and the ESAL tables? yes - for vehicle class breakdown
a. Are your growth factors for HPMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use
higher on major routes with good truck data
lower on other routes with limited data

# Project Traffic Report

**PROJECT DESCRIPTION:** So. of Silver Creek Interchange ( North bd. traffic)

**STATE ROUTE:** S.R.- 40

**BEG. M.P.:** 0.50 **END M.P.:** 1.00 **LENGTH:**

**PROJECT SCOPE:** Reconstruction **REGION:** 2

**Rigid or Flexible:** Rigid **DIRECTIONAL FACTOR:** 1.00

**CONSTRUCTION YEAR:** 2000 **FUNCTIONAL CLASS** 2

**DESIGN PERIOD:** 20 yrs **D** = 9.00

**DESIGN HOUR VOLUME %:** 13 **NUMBER OF LANES:** 2

**BASE YEAR AADT** = 12,000
**FINAL YEAR AADT** = 17,440

**ESAL's RATE CLASS 5-7** = 0.01 ESAL'S/VEH-YR
**ESAL's RATE CLASS 8-13** = 0.03 ESAL'S/VEH-YR

**F** = 1.00

| VEHICLE CLASS | BASE YEAR AADT | FINAL YEAR AADT | ANNUAL GROWTH RATE % | TRUCK FACTOR ESALS/VE | % OF LOAD | DESIGN ESAL'S X 1,000 |
|---|---|---|---|---|---|---|
| 1&2 MT. CYC. & CARS | 8,620 | 12,360 | 1.8 | 0.0002 | 0.1 | 15.0 |
| 3 2 AXLE/4 TIRE VEH. | 2,280 | 3,320 | 1.9 | 0.0300 | 2.9 | 600.4 |
| 4 BUSES | 60 | 110 | 3.1 | 0.8800 | 2.5 | 521.9 |
| **SINGLE UNIT TRUCKS** | | | | | | |
| 5 2 AXLE/6 TIRES | 150 | 245 | 2.5 | 0.2065 | 2.1 | 427.9 |
| 6 3 AXLES | 75 | 120 | 2.4 | 0.5211 | 2.1 | 429.0 |
| 7 4 AXLES (OR MORE) | 35 | 60 | 2.7 | 0.0414 | 0.2 | 47.2 |
| **SINGLE TRAILER TRUCKS** | | | | | | |
| 8 4 AXLE (OR LESS) | 45 | 75 | 2.6 | 0.4847 | 1.6 | 332.1 |
| 9 5 AXLE (3S2) | 400 | 660 | 2.5 | 2.9648 | 58.7 | 12219.7 |
| 10 6 AXLE (OR MORE) | 65 | 105 | 2.4 | 1.4470 | 5.0 | 1051.0 |
| **MULTI-TRAILER TRUCKS** | | | | | | |
| 11 5 AXLE (OR LESS) | 65 | 90 | 1.6 | 1.3290 | 4.4 | 906.1 |
| 12 6 AXLE | 25 | 35 | 1.7 | 1.0085 | 1.4 | 281.5 |
| 13 7 AXLE (OR MORE) | 180 | 260 | 1.9 | 2.2342 | 19.2 | 3987.8 |
| **TOTAL (TRUCKS):** | 1,100 | 1,760 | | | 100.0 | 20,820 |
| **PERCENT TRUCKS:** | 9.17% | 10.09% | | | | |
| **WEIGHTED TRUCK FACTOR:** | 1.7635 | 1.7575 | | | | |
| **TOTAL (CARS/PICKUPS):** | 10,900 | 15,680 | | | | |
| **PERCENT CARS/PICKUPS:** | 90.83% | 89.91% | | | | |
| **WEIGHTED CAR/PICKUP FACTOR:** | 0.0064 | 0.0065 | | | | |

SAMPLE REPORT

**DESIGN LANE ESAL'S** = 20,819,864

**DESIGN LANE ESAL'S/DAY** = 2,852

**VEHICLE DATA SOURCES:** Counts made in area
**DATA COLLECTION DATES:** 1996
**ESAL FUNCTIONAL CLASS:**
**ESAL COLLECTION DATES:** 1997-98

23-Mar-99

FUNCTIONAL CLASS

| Axle Class | 1 | | 2 | | 6 | | 7 | | 8 | | 9 | | 11 | | 12 | | 14 | | 16 | | 17 | | 19 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rigid | Flex | Rigid | Flex | Rigid | Flex | Rigid | Flex | Rigid | Flex | Rigid | Flex | Rigid | Flex | Rigid | Flex | Rigid | Flex | Rigid | Flex | Rigid | Flex | Rigid | Fl |
| 3 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0026 | 0.0026 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | [illegible] |
| 4 | 0.5973 | 0.4315 | 0.4825 | 0.3327 | 0.0156 | 0.0186 | 0.0489 | 0.0520 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6822 | 0.5021 | 0.0000 | 0.0000 | 0.1850 | 0.1604 | 0.5403 | 0.4424 | 0.0000 | 0.0000 | 0.0000 | [illegible] |
| 5 | 0.5064 | 0.4716 | 0.2066 | 0.1996 | 0.3061 | 0.2898 | 0.3103 | 0.2798 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3827 | 0.3529 | 0.0000 | 0.0000 | 0.1993 | 0.1812 | 0.8035 | 0.7393 | 0.0000 | 0.0000 | 0.0000 | [illegible] |
| 6 | 0.8061 | 0.5259 | 0.5211 | 0.3486 | 0.4437 | 0.3172 | 0.6826 | 0.5204 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.4316 | 1.0389 | 0.0000 | 0.0000 | 1.6884 | 1.0722 | 1.5896 | 1.1136 | 0.0000 | 0.0000 | 0.0000 | [illegible] |
| 7 | 0.0388 | 0.0386 | 0.0414 | 0.0431 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7126 | 0.4919 | 0.0000 | 0.0000 | 0.8384 | 0.6205 | 0.5828 | 0.3485 | 0.0000 | 0.0000 | 0.0000 | [illegible] |
| 8 | 0.9673 | 0.7836 | 0.4847 | 0.3809 | 0.5591 | 0.5016 | 0.8547 | 0.6276 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9871 | 0.6323 | 0.0000 | 0.0000 | 0.6136 | 0.4834 | 1.6810 | 1.3867 | 0.0000 | 0.0000 | 0.0000 | [illegible] |
| 9 | 4.8749 | 2.8744 | 2.9548 | 1.7798 | 2.7212 | 1.6410 | 1.6930 | 1.0079 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.8934 | 1.6884 | 0.0000 | 0.0000 | 3.0104 | 1.8133 | 4.2476 | 2.6028 | 0.0000 | 0.0000 | 0.0000 | [illegible] |
| 10 | 3.6364 | 2.1457 | 1.4470 | 0.8289 | 0.0342 | 0.0360 | 0.0238 | 0.0185 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.9179 | 1.6844 | 0.0000 | 0.0000 | 1.7633 | 1.2264 | 3.4718 | 2.1155 | 0.0000 | 0.0000 | 0.0000 | [illegible] |
| 11 | 4.0969 | 3.3987 | 1.3290 | 1.2482 | 1.4394 | 1.2700 | 0.7015 | 0.7197 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.3295 | 1.9882 | 0.0000 | 0.0000 | 2.4675 | 2.2975 | 0.3105 | 0.3074 | 0.0000 | 0.0000 | 0.0000 | [illegible] |
| 12 | 3.5131 | 2.7883 | 1.0085 | 0.6695 | 0.1890 | 0.1813 | 0.0145 | 0.0150 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.2456 | 1.8715 | 0.0000 | 0.0000 | 1.6821 | 1.5490 | 0.2632 | 0.2760 | 0.0000 | 0.0000 | 0.0000 | [illegible] |
| 13 | 5.2436 | 3.6042 | 2.2342 | 1.3596 | 2.6832 | 1.7199 | 0.8221 | 0.6400 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.6508 | 2.5203 | 0.0000 | 0.0000 | 3.1270 | 1.9288 | 5.2762 | 3.3584 | 0.0000 | 0.0000 | 0.0000 | [illegible] |

ESAL FACTOR TABLE

23-Mar-99

Subj: **Survey ESAL Use For Design**
Date: 3/23/99
To: GKUHL@dot.state.ut.us

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March ~~22~~ 23, 1999

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Survey State of: Utah DOT; Mr. Gary Kuhl; Planning Division Engineer;
(801) 964-4552

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No:___ If No what do you use?

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a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

Q NO. 3: Do you break down ESALS by vehicle classification?

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design years?

Q No. 6: Do you use WIM data? If No what do you use for load data?

Q No. 7: Are there links between HPMS data and the ESAL tables?
a. Are your growth factors for HPMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird.

[redacted]

UTAH

Yes, thank you, I did receive you faxed ESAL data tables.

After the Arizona ESAL research study is completed (in approximately 9 months), it is planned that the accumulated answers provided by the participating states, in how ESAL data is used in pavement design, will be distributed to all participating states (approximately 15 States).

Thank you for the prompt and very informative ESAL information.

Earl T. (:>))

Subj: **Re: Survey ESAL Use For Design**
Date: 3/24/99 6:49:35 AM Pacific Standard Time
From: srcopo1.gkuhl@dot.state.ut.us (Gary Kuhl)
To: ETLAIRD@aol.com

I faxed you some info yesterday. Could you let me kow if you didn't get it.

Also, can I get a copy of your study when you get it put together. I'd like to see what others are using for their ESAL factors.

----------------------- Headers -----------------------
Return-Path: <srcopo1.gkuhl@dot.state.ut.us>
Received: from rly-yd01.mx.aol.com (rly-yd01.mail.aol.com [172.18.150.1]) by air-yd05.mx.aol.com (v58.13) with SMTP; Wed, 24 Mar 1999 09:49:35 -0500
Received: from email.state.ut.us (email.state.ut.us [168.180.96.41])
by rly-yd01.mx.aol.com (8.8.8/8.8.5/AOL-4.0.0)
with SMTP id JAA27912 for <ETLAIRD@aol.com>;
Wed, 24 Mar 1999 09:49:33 -0500 (EST)
Received: from STATE-DOMAIN-Message_Server by email.state.ut.us
with Novell_GroupWise; Wed, 24 Mar 1999 07:44:02 -0700
Message-Id: <s6f897c2.020@email.state.ut.us>
X-Mailer: Novell GroupWise 5.5
X-GWFix: Yes
Date: Wed, 24 Mar 1999 07:46:33 -0700
From: "Gary Kuhl" <srcopo1.gkuhl@dot.state.ut.us>
To: <ETLAIRD@aol.com>
Subject: Re: Survey ESAL Use For Design
Mime-Version: 1.0
Content-Type: text/plain; charset=US-ASCII
Content-Transfer-Encoding: quoted-printable
Content-Disposition: inline

Survey of States using ESALS for pavement design and rehabilitation. ESAL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: **Wyoming DOT; Ms. Vicki Bonds; Materials Engineer; (307) 777-4359**

Please check One: Surveyed State (Does X) or (Does Not __) wish to be identified on how the state answered any of the survey questioned. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes: X
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.) **Faxed**

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location? **Single ESAL table for statewide.**

Q NO. 3: Do you break down ESALS by vehicle classification? **Yes**

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they? **Yes, 13 FHWA class.**

Q No. 5: Do you use Growth factors to expand ESAL's to design years? **Yes. We update ESAL's yearly and project future.**

Q No. 6: Do you use WIM data? If No what do you use for load data? **Yes**

Q No. 7: Are there links between PMS data and the ESAL tables? **Yes, updated annually.**
a. Are your growth factors for PMS the same for ESAL growth factors? **No**

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab? **A fair amount of confidence, however WYDOT is considering incorporating the AASHTO recommendations.**

Survey States comments if any: **We would appreciate a copy of the resultant report.**

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az
Thank you again,

Earl T. Laird.

NATURE SAVER™ FAX MEMO 01616

| | |
|---|---|
| To Earl Laird | Date 3-23-99 # of pages ▶ |
| Co./Dept. TP & R | From Dave Birge |
| Phone # 775-882-4755 | Co. WYDOT |
| Fax # 775-882-4565 | Phone # 307-777-4190 |
| | Fax # 307-777-3857 |

WYOMING DOT

HSED SURVEY BACK

STATEWIDE FACTORS
FLEXIBLE P=2.5 SN=5.0

1994

| | # TRUCKS | ESAL | 94FACTOR |
|---|---|---|---|
| PU | 532 | 2.9588 | 0.00556165 |
| BUSSES | 815 | 361.0378 | 0.44299117 |
| 2D-6 | 2902 | 578.4832 | 0.19933949 |
| 3AXSUT | 1294 | 436.9886 | 0.33770371 |
| 4AXSUT | 5 | 2.5853 | 0.51706 |
| CAT-08 | 2296 | 1015.993 | 0.44250566 |
| CAT-09 | 88805 | 112823.7 | 1.27046563 |
| CAT-10 | 2536 | 2025.123 | 0.79855008 |
| CAT-11 | 8264 | 15238.27 | 1.84393393 |
| CAT-12 | 300 | 266.6518 | 0.88883933 |
| CAT-13 | 4434 | 4021.163 | 0.90689287 |
| TOTAL | 112183 | 136772.955 | 1.21919502 |

1995

| | # TRUCKS | ESAL | 95FACTOR |
|---|---|---|---|
| PU | 637 | 35.0201 | 0.05497661 |
| BUSSES | 1145 | 542.8636 | 0.47411668 |
| 2D-6 | 7955 | 1000.1029 | 0.12572004 |
| 3AXSUT | 2180 | 948.5803 | 0.43512858 |
| 4AXSUT | 12 | 13.3779 | 1.114825 |
| CAT-08 | 2677 | 1261.4318 | 0.47121098 |
| CAT-09 | 105940 | 143146.873 | 1.35120703 |
| CAT-10 | 3428 | 3321.672 | 0.9689825 |
| CAT-11 | 8118 | 15423.5847 | 1.89992421 |
| CAT-12 | 556 | 567.7007 | 1.02104442 |
| CAT-13 | 5600 | 5505.8295 | 0.98318384 |
| TOTAL | 138248 | 171767.037 | 1.24245585 |

1996

| | # TRUCKS | ESAL | 96FACTOR |
|---|---|---|---|
| PU | 674 | 25.2295 | 0.03743249 |
| BUSSES | 1364 | 703.0242 | 0.51541364 |
| 2D-6 | 9461 | 1428.632 | 0.15100222 |
| 3AXSUT | 2722 | 1107.31 | 0.40680015 |
| 4AXSUT | 42 | 84.414 | 2.00985714 |
| CAT-08 | 3820 | 1497.316 | 0.39196754 |
| CAT-09 | 124841 | 158512.759 | 1.26971715 |
| CAT-10 | 5009 | 4830.658 | 0.96439569 |
| CAT-11 | 6622 | 11583.81 | 1.74929175 |
| CAT-12 | 831 | 672.8226 | 0.80965415 |
| CAT-13 | 6614 | 7114.7584 | 1.07571188 |
| TOTAL | 162000 | 187560.734 | 1.15778231 |

16 YEAR ACCUM. 78,80-94

| | # TRUCKS | ESAL | FACTOR |
|---|---|---|---|
| PU | 21043 | 100.3878 | 0.0047706 |
| BUSSES | 2005 | 891.3819 | 0.4445795 |
| 2D-6 | 29016 | 8106.7933 | 0.27939045 |
| 3AXSUT | 11616 | 7371.0266 | 0.63455808 |
| 4AXSUT | 228 | 887.5601 | 3.89280746 |
| CAT-08 | 11923 | 5141.0072 | 0.43118403 |
| CAT-09 | 271278 | 344142.317 | 1.26859649 |
| CAT-10 | 8478 | 13159.3732 | 1.55217896 |
| CAT-11 | 23980 | 44754.4987 | 1.86632605 |
| CAT-12 | 1915 | 1680.8963 | 0.87775264 |
| CAT-13 | 13603 | 16039.7409 | 1.17913261 |
| TOTAL | 395085 | 442274.963 | 1.11944261 |

17 YEAR ACCUM. 78,80-95

| | # TRUCKS | ESAL | FACTOR |
|---|---|---|---|
| PU | 21680 | 135.4079 | 0.00624575 |
| BUSSES | 3150 | 1434.2455 | 0.45531603 |
| 2D-6 | 36971 | 9106.8962 | 0.2463254 |
| 3AXSUT | 13796 | 8319.6069 | 0.60304486 |
| 4AXSUT | 240 | 900.938 | 3.75390833 |
| CAT-08 | 14600 | 6402.439 | 0.43852322 |
| CAT-09 | 377218 | 487289.19 | 1.29179729 |
| CAT-10 | 11906 | 16481.0452 | 1.38426383 |
| CAT-11 | 32098 | 60178.0834 | 1.87482346 |
| CAT-12 | 2471 | 2248.597 | 0.90999474 |
| CAT-13 | 19203 | 21545.5704 | 1.12198981 |
| TOTAL | 533333 | 614042.02 | 1.15132951 |

18 YEAR ACCUM. 78,80-96

| | # TRUCKS | ESAL | FACTOR |
|---|---|---|---|
| PU | 22354 | 160.6374 | 0.00718607 |
| BUSSES | 4514 | 2137.2697 | 0.47347579 |
| 2D-6 | 46432 | 10535.5282 | 0.22690231 |
| 3AXSUT | 16518 | 9426.9169 | 0.57070571 |
| 4AXSUT | 282 | 985.352 | 3.49415603 |
| CAT-08 | 18420 | 7899.755 | 0.42886835 |
| CAT-09 | 502059 | 645801.95 | 1.28630689 |
| CAT-10 | 16915 | 21311.7032 | 1.25992925 |
| CAT-11 | 38720 | 71761.8934 | 1.85335468 |
| CAT-12 | 3302 | 2921.4196 | 0.88474246 |
| CAT-13 | 25817 | 28660.3288 | 1.11013397 |
| TOTAL | 695333 | 801602.754 | 1.15283289 |

STATEWIDE FACTORS
FLEXIBLE P=2.5 SN=5.0

1997

| | # TRUCKS | ESAL | 97FACTOR |
|---|---|---|---|
| PU | 1381 | 11.0286 | 0.00798595 |
| BUSSES | 1631 | 707.5185 | 0.4337943 |
| 2D-6 | 6858 | 1484.2546 | 0.21642674 |
| 3AXSUT | 3357 | 1186.5053 | 0.35344215 |
| 4AXSUT | 40 | 40.2348 | 1.00587 |
| CAT-08 | 3547 | 1437.673 | 0.40532083 |
| CAT-09 | 120771 | 142633.166 | 1.18102165 |
| CAT-10 | 4481 | 4244.9726 | 0.94732707 |
| CAT-11 | 5481 | 8679.1072 | 1.58348973 |
| CAT-12 | 1004 | 959.2201 | 0.95539851 |
| CAT-13 | 8295 | 8906.7876 | 1.07375378 |
| TOTAL | 156846 | 170290.468 | 1.08571764 |

19 YEAR ACCUM. 78,80-97

| | # TRUCKS | ESAL | FACTOR |
|---|---|---|---|
| PU | 23735 | 171.666 | 0.00723261 |
| BUSSES | 6145 | 2844.7882 | 0.46294356 |
| 2D-6 | 53290 | 12019.7828 | 0.22555419 |
| 3AXSUT | 19875 | 10613.4222 | 0.53400866 |
| 4AXSUT | 322 | 1025.5868 | 3.18505217 |
| CAT-08 | 21967 | 9337.428 | 0.42506614 |
| CAT-09 | 622830 | 788435.116 | 1.26589136 |
| CAT-10 | 21396 | 25556.6758 | 1.19446045 |
| CAT-11 | 44201 | 80441.0006 | 1.81989097 |
| CAT-12 | 4306 | 3880.6397 | 0.90121684 |
| CAT-13 | 34112 | 37567.1164 | 1.10128742 |
| TOTAL | 852179 | 971893.222 | 1.14048014 |

Subj: **ESAL's Use For Pavement Design**
Date: 3/18/99
To: vbonds@missc.state.wy.us

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 16, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Wyoming DOT; Ms. Vicky Bonds; Materials Engineer;
(307) 777-4070

Please check One: Surveyed State (Does __ ) or (Does Not __) wish to be identified on how the state answered any of the survey questioned. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes:___
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

Q NO. 3: Do you break down ESALS by vehicle classification?

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design years?

Q No. 6: Do you use WIM data? If No what do you use for load data?

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird.

Subj: [redacted]
Date: 3/25/99
To: VBONDS@missc.state.wy.us

Hi Vicki Bonds:

Thank you for the return of the ESAL questionnaire and the information you provided on the use of ESAL's' in pavement design by Wyoming DOT. Dave Berge did fax to me, earlier, the ESAL tables used by Wyoming DOT. Please thank Dave for his help and again thank you for your prompt attention to the questionnaire.

Thanks again for the help.

Earl T. Laird (:>))

## Tompkins, James

**From:** ETLAIRD@aol.com
**Sent:** Thursday, March 18, 1999 3:47 PM
**To:** jtompkins@state.mt.us
**Subject:** Survey ESAL Use In Pavement Design

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 16, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Montana DOT; Mr. James Tompkins; Surface Design Engineer; (406) 444-6295 Fax: (406) 444-6204

Please check One: Surveyed State (Does __ ) or (Does Not __) wish to be identified on how the state answered any of the survey questioned. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes: X
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.) Static Scale data - Near future will use WIM

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location? Single ESAL Table

Q NO. 3: Do you break down ESALS by vehicle classification? yes

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they? yes

Q No. 5: Do you use Growth factors to expand ESAL's to design years? yes

Q No. 6: Do you use WIM data? If No what do you use for load data? Static Scale — Will use WIM in the near future

Q No. 7: Are there links between PMS data and the ESAL tables? NO
a. Are your growth factors for PMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab? AVERAGE TO HIGH

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

# RIGID PAVEMENT

18 KIP EALs
Equivalent Load Factors

## INTERSTATE

N = sample size

| Type | 1986 | N | 1987 | N | 1988 | N | 1989 | N | 1990 | N | 1991 | N | 1992 | N | 1993 | N | 1994 | N | 1995 | N | 1996 | N | 1997 | N | AVG. | Total N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2A-6T | 0.324 | 860 | 0.298 | 1031 | 0.258 | 861 | 0.269 | 1074 | 0.203 | 1180 | 0.239 | 968 | 0.229 | 1010 | 0.320 | 637 | 0.431 | 376 | 0.394 | 414 | 0.825 | 492 | 0.448 | 248 | 0.311 | 9151 |
| 3A-SU | 0.458 | 554 | 0.536 | 351 | 0.609 | 363 | 0.615 | 392 | 0.529 | 446 | 0.598 | 328 | 0.564 | 443 | 0.724 | 319 | 0.709 | 261 | 0.542 | 271 | 0.776 | 348 | 0.742 | 194 | 0.600 | 4270 |
| 4A-SU | 2.143 | 21 | 2.412 | 17 | 1.870 | 23 | 1.667 | 27 | 1.654 | 26 | 1.909 | 22 | 2.920 | 25 | 1.741 | 27 | 1.565 | 23 | 1.160 | 25 | 3.063 | 16 | 1.939 | 33 | 1.954 | 285 |
| 2-S-1 | 0.742 | 124 | 0.695 | 203 | 0.603 | 151 | 0.850 | 133 | 0.555 | 155 | 0.455 | 156 | 0.554 | 130 | 0.777 | 94 | 0.975 | 40 | 0.673 | 52 | 0.487 | 76 | 0.822 | 45 | 0.653 | 1359 |
| 2-S-2 | 0.871 | 263 | 0.589 | 353 | 0.732 | 250 | 0.554 | 258 | 0.475 | 261 | 0.515 | 235 | 0.513 | 234 | 0.625 | 176 | 0.551 | 89 | 0.894 | 94 | 1.462 | 119 | 0.981 | 53 | 0.670 | 2385 |
| 3-S-2 | 2.372 | 7898 | 2.335 | 10058 | 2.319 | 8046 | 2.314 | 8967 | 2.294 | 9626 | 2.283 | 10076 | 2.211 | 10350 | 2.360 | 9974 | 2.325 | 5914 | 2.238 | 7542 | 2.238 | 9223 | 2.194 | 4148 | 2.293 | 101822 |
| 3-S-3 | 2.150 | 240 | 1.743 | 257 | 2.215 | 205 | 2.205 | 215 | 2.279 | 244 | 1.929 | 323 | 1.902 | 338 | 1.992 | 361 | 2.020 | 353 | 2.053 | 473 | 2.090 | 667 | 1.541 | 444 | 1.989 | 4120 |
| 2-1 | 0.143 | 7 | 0.214 | 14 | 0.222 | 18 | 0.143 | 7 | 0.348 | 23 | 0.182 | 22 | 0.100 | 20 | 0.154 | 13 | 0.000 | 6 | 0.700 | 10 | 0.286 | 7 | 0.800 | 5 | 0.250 | 152 |
| 2-2 | 0.346 | 26 | 0.310 | 42 | 0.417 | 24 | 0.282 | 71 | 0.313 | 67 | 0.265 | 49 | 0.300 | 50 | 0.279 | 43 | 0.683 | 41 | 0.289 | 38 | 0.229 | 48 | 0.136 | 22 | 0.319 | 521 |
| 3-2 | 1.939 | 132 | 1.619 | 118 | 1.509 | 116 | 1.237 | 93 | 1.350 | 103 | 0.933 | 119 | 0.983 | 115 | 1.091 | 88 | 1.844 | 77 | 1.469 | 96 | 1.230 | 87 | 1.302 | 53 | 1.383 | 1197 |
| 3-3 | 2.053 | 38 | 1.548 | 31 | 0.864 | 22 | 1.167 | 18 | 1.870 | 23 | 1.176 | 17 | 1.708 | 24 | 1.667 | 21 | 0.375 | 8 | 1.929 | 14 | 1.526 | 19 | 1.356 | 45 | 1.518 | 280 |
| 2-S-1-2 | 2.345 | 542 | 2.088 | 628 | 1.988 | 402 | 2.020 | 512 | 2.022 | 538 | 2.031 | 582 | 1.978 | 541 | 1.960 | 376 | 1.990 | 205 | 1.341 | 135 | 2.182 | 88 | 1.547 | 53 | 2.033 | 4602 |
| 3-S-1-2 | 1.500 | 126 | 1.589 | 151 | 1.426 | 148 | 1.146 | 164 | 1.224 | 134 | 1.217 | 217 | 1.230 | 235 | 1.329 | 164 | 2.000 | 93 | 1.071 | 126 | 1.601 | 138 | 1.127 | 63 | 1.351 | 1759 |
| 3-S-2-2 | 2.274 | 503 | 2.305 | 574 | 2.527 | 545 | 2.360 | 583 | 2.327 | 727 | 2.333 | 664 | 2.573 | 726 | 2.616 | 554 | 2.791 | 388 | 2.397 | 365 | 2.590 | 536 | 2.611 | 239 | 2.459 | 6404 |
| 3-S-2-3 | 1.939 | 198 | 2.121 | 206 | 2.392 | 189 | 2.221 | 240 | 2.075 | 295 | 2.281 | 281 | 2.480 | 306 | 2.157 | 344 | 2.086 | 198 | 2.286 | 203 | 3.204 | 235 | 2.452 | 84 | 2.302 | 2779 |
| 7 AX. TRIP. | ERR | 0 | 2.942 | 86 | 2.733 | 131 | 2.879 | 141 | 2.737 | 179 | 2.631 | 198 | 2.699 | 186 | 2.872 | 133 | 2.485 | 68 | 1.754 | 61 | 2.340 | 53 | 0.946 | 37 | 2.629 | 1273 |

Class 1 & 2 = 0.001
Class 3 = 0.007
Class 4 = 0.257

02/04/98 FILE NAME = EAL_R_I.WK4

### RIGID PAVEMENT

18 KIP EALs
Equivalent Load Factors

## INTERSTATE

N = sample size

| Type | 1986 | N | 1987 | N | 1988 | N | 1989 | N | 1990 | N | 1991 | N | 1992 | N | 1993 | N | 1994 | N | 1995 | N | 1996 | N | 1997 | N | AVG | Total N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.324 | 860 | 0.298 | 1031 | 0.258 | 861 | 0.269 | 1074 | 0.203 | 1180 | 0.239 | 968 | 0.229 | 1010 | 0.320 | 637 | 0.431 | 376 | 0.394 | 414 | 0.825 | 492 | 0.448 | 248 | 0.311 | 9151 |
| 6 | 0.458 | 554 | 0.536 | 351 | 0.609 | 363 | 0.615 | 392 | 0.529 | 446 | 0.598 | 328 | 0.564 | 443 | 0.724 | 319 | 0.709 | 261 | 0.542 | 271 | 0.776 | 348 | 0.742 | 194 | 0.600 | 4270 |
| 7 | 2.143 | 21 | 2.412 | 17 | 1.870 | 23 | 1.667 | 27 | 1.654 | 26 | 1.909 | 22 | 2.920 | 25 | 1.741 | 27 | 1.565 | 23 | 1.160 | 25 | 3.063 | 16 | 1.939 | 33 | 1.954 | 285 |
| 8 | 0.788 | 420 | 0.596 | 612 | 0.650 | 443 | 0.591 | 469 | 0.472 | 506 | 0.452 | 462 | 0.482 | 434 | 0.604 | 326 | 0.659 | 176 | 0.706 | 194 | 0.896 | 250 | 0.768 | 125 | 0.609 | 4417 |
| 9 | 2.365 | 8030 | 2.327 | 10176 | 2.308 | 8162 | 2.303 | 9060 | 2.284 | 9729 | 2.267 | 10195 | 2.198 | 10465 | 2.349 | 10062 | 2.319 | 5991 | 2.228 | 7638 | 2.229 | 9310 | 2.182 | 4201 | 2.283 | 103019 |
| 10 | 2.137 | 278 | 1.722 | 288 | 2.084 | 227 | 2.124 | 233 | 2.243 | 267 | 1.891 | 340 | 1.890 | 362 | 1.974 | 382 | 1.983 | 361 | 2.049 | 487 | 2.074 | 686 | 1.524 | 489 | 1.959 | 4400 |
| 11 | 2.345 | 542 | 2.088 | 628 | 1.988 | 402 | 2.020 | 512 | 2.022 | 538 | 2.031 | 582 | 1.978 | 541 | 1.960 | 376 | 1.990 | 205 | 1.341 | 135 | 2.182 | 88 | 1.547 | 53 | 2.033 | 4602 |
| 12 | 1.500 | 126 | 1.589 | 151 | 1.426 | 148 | 1.146 | 164 | 1.224 | 134 | 1.217 | 217 | 1.230 | 235 | 1.329 | 164 | 2.000 | 93 | 1.071 | 126 | 1.601 | 138 | 1.127 | 63 | 1.351 | 1759 |
| 13 | 2.180 | 701 | 2.324 | 866 | 2.528 | 865 | 2.401 | 964 | 2.326 | 1201 | 2.372 | 1143 | 2.569 | 1218 | 2.496 | 1031 | 2.546 | 654 | 2.299 | 629 | 2.749 | 824 | 2.403 | 360 | 2.438 | 10456 |

Class 1 & 2 = 0.001
Class 3 = 0.007
Class 4 = 0.257

02/04/98

S:\K\WORK\Eal_r_i.123

# FLEXIBLE PAVEMENT

18 KIP EALs
Equivalent Load Factors

## INTERSTATE

N = sample size

| | 1986 | N | 1987 | N | 1988 | N | 1989 | N | 1990 | N | 1991 | N | 1992 | N | 1993 | N | 1994 | N | 1995 | N | 1996 | N | 1997 | N | AVG. | Total N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2A-6T | 0.337 | 860 | 0.316 | 1031 | 0.281 | 861 | 0.284 | 1074 | 0.225 | 1180 | 0.263 | 968 | 0.252 | 1010 | 0.336 | 637 | 0.452 | 376 | 0.413 | 414 | 0.803 | 492 | 0.464 | 248 | 0.328 | 9151 |
| 3A-SU | 0.356 | 554 | 0.405 | 351 | 0.457 | 363 | 0.462 | 392 | 0.404 | 446 | 0.451 | 328 | 0.433 | 443 | 0.561 | 319 | 0.548 | 261 | 0.417 | 271 | 0.601 | 348 | 0.572 | 194 | 0.459 | 4270 |
| 4A-SU | 1.571 | 21 | 1.882 | 17 | 1.348 | 23 | 1.407 | 27 | 1.192 | 26 | 1.455 | 22 | 2.000 | 25 | 1.407 | 27 | 1.391 | 23 | 1.080 | 25 | 2.313 | 16 | 1.667 | 33 | 1.530 | 285 |
| 2-S-1 | 0.766 | 124 | 0.714 | 203 | 0.662 | 151 | 0.865 | 133 | 0.619 | 155 | 0.455 | 156 | 0.615 | 130 | 0.819 | 94 | 0.975 | 40 | 0.731 | 52 | 0.553 | 76 | 0.867 | 45 | 0.689 | 1359 |
| 2-S-2 | 0.829 | 263 | 0.578 | 353 | 0.716 | 250 | 0.523 | 258 | 0.467 | 261 | 0.506 | 235 | 0.517 | 234 | 0.614 | 176 | 0.528 | 89 | 0.819 | 94 | 1.303 | 119 | 0.925 | 53 | 0.643 | 2385 |
| 3-S-2 | 1.494 | 7898 | 1.476 | 10058 | 1.461 | 8046 | 1.463 | 8967 | 1.458 | 9626 | 1.459 | 10076 | 1.419 | 10350 | 1.497 | 9974 | 1.480 | 5914 | 1.429 | 7542 | 1.453 | 9223 | 1.403 | 4148 | 1.460 | 101822 |
| 3-S-3 | 1.483 | 240 | 1.230 | 257 | 1.537 | 205 | 1.535 | 215 | 1.582 | 244 | 1.362 | 323 | 1.364 | 338 | 1.427 | 361 | 1.433 | 353 | 1.469 | 473 | 1.520 | 667 | 1.110 | 444 | 1.414 | 4120 |
| 2-1 | 0.143 | 7 | 0.357 | 14 | 0.222 | 18 | 0.143 | 7 | 0.348 | 23 | 0.227 | 22 | 0.150 | 20 | 0.231 | 13 | 0.000 | 6 | 0.600 | 10 | 0.429 | 7 | 0.800 | 5 | 0.283 | 152 |
| 2-2 | 0.308 | 26 | 0.333 | 42 | 0.417 | 24 | 0.282 | 71 | 0.299 | 67 | 0.245 | 49 | 0.280 | 50 | 0.256 | 43 | 0.585 | 41 | 0.263 | 38 | 0.208 | 48 | 0.136 | 22 | 0.299 | 521 |
| 3-2 | 1.652 | 132 | 1.381 | 118 | 1.293 | 116 | 1.086 | 93 | 1.155 | 103 | 0.824 | 119 | 0.861 | 115 | 1.023 | 88 | 1.571 | 77 | 1.240 | 96 | 1.046 | 87 | 1.094 | 53 | 1.192 | 1197 |
| 3-3 | 1.658 | 38 | 1.129 | 31 | 0.682 | 22 | 0.833 | 18 | 1.261 | 23 | 0.882 | 17 | 1.208 | 24 | 1.143 | 21 | 0.375 | 8 | 1.286 | 14 | 1.158 | 19 | 1.067 | 45 | 1.129 | 280 |
| 2-S-1-2 | 2.424 | 542 | 2.194 | 628 | 2.092 | 402 | 2.129 | 512 | 2.132 | 538 | 2.148 | 582 | 2.098 | 541 | 2.088 | 376 | 2.117 | 205 | 1.474 | 135 | 2.239 | 88 | 1.660 | 53 | 2.142 | 4602 |
| 3-S-1-2 | 1.444 | 126 | 1.556 | 151 | 1.372 | 148 | 1.140 | 164 | 1.209 | 134 | 1.212 | 217 | 1.234 | 235 | 1.305 | 164 | 1.903 | 93 | 1.087 | 126 | 1.558 | 138 | 1.143 | 63 | 1.329 | 1759 |
| 3-S-2-2 | 1.718 | 503 | 1.730 | 574 | 1.884 | 545 | 1.765 | 583 | 1.761 | 727 | 1.759 | 664 | 1.927 | 726 | 1.960 | 554 | 2.134 | 388 | 1.819 | 365 | 1.993 | 536 | 1.996 | 239 | 1.856 | 6404 |
| 3-S-2-3 | 1.323 | 198 | 1.451 | 206 | 1.651 | 189 | 1.529 | 240 | 1.427 | 295 | 1.584 | 281 | 1.699 | 306 | 1.494 | 344 | 1.465 | 198 | 1.591 | 203 | 2.213 | 235 | 1.690 | 84 | 1.589 | 2779 |
| 7 AX. TRIP. | ERR | 0 | 3.116 | 86 | 2.916 | 131 | 3.050 | 141 | 2.899 | 179 | 2.803 | 198 | 2.882 | 186 | 2.955 | 133 | 2.691 | 68 | 1.738 | 61 | 2.528 | 53 | 1.054 | 37 | 2.785 | 1273 |

Class 1 & 2 = 0.001
Class 3 = 0.007
Class 4 = 0.257

02/06/98 FILE NAME = EAL_F_I.WK4


FLEXIBLE PAVEMENT

18 KIP EALs
Equivalent Load Factors

INTERSTATE

N = sample size


| Type | 1986 | N | 1987 | N | 1988 | N | 1989 | N | 1990 | N | 1991 | N | 1992 | N | 1993 | N | 1994 | N | 1995 | N | 1996 | N | 1997 | N | AVG. | Total N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.337 | 860 | 0.316 | 1031 | 0.281 | 861 | 0.284 | 1074 | 0.225 | 1180 | 0.263 | 968 | 0.252 | 1010 | 0.336 | 637 | 0.452 | 376 | 0.413 | 414 | 0.803 | 492 | 0.464 | 248 | 0.328 | 9151 |
| 6 | 0.356 | 554 | 0.405 | 351 | 0.457 | 363 | 0.462 | 392 | 0.404 | 446 | 0.451 | 328 | 0.433 | 443 | 0.561 | 319 | 0.548 | 261 | 0.417 | 271 | 0.601 | 348 | 0.572 | 194 | 0.459 | 4270 |
| 7 | 1.571 | 21 | 1.882 | 17 | 1.348 | 23 | 1.407 | 27 | 1.192 | 26 | 1.455 | 22 | 2.000 | 25 | 1.407 | 27 | 1.391 | 23 | 1.080 | 25 | 2.313 | 16 | 1.667 | 33 | 1.530 | 285 |
| 8 | 0.767 | 420 | 0.601 | 612 | 0.661 | 443 | 0.578 | 469 | 0.486 | 506 | 0.448 | 462 | 0.502 | 434 | 0.610 | 326 | 0.625 | 176 | 0.675 | 194 | 0.840 | 250 | 0.760 | 125 | 0.604 | 4417 |
| 9 | 1.497 | 8030 | 1.475 | 10176 | 1.459 | 8162 | 1.459 | 9060 | 1.455 | 9729 | 1.452 | 10195 | 1.413 | 10465 | 1.493 | 10062 | 1.481 | 5991 | 1.427 | 7638 | 1.449 | 9310 | 1.399 | 4201 | 1.456 | 103019 |
| 10 | 1.507 | 278 | 1.219 | 288 | 1.454 | 227 | 1.481 | 233 | 1.554 | 267 | 1.338 | 340 | 1.354 | 362 | 1.411 | 382 | 1.410 | 361 | 1.464 | 487 | 1.510 | 686 | 1.106 | 489 | 1.396 | 4400 |
| 11 | 2.424 | 542 | 2.194 | 628 | 2.092 | 402 | 2.129 | 512 | 2.132 | 538 | 2.148 | 582 | 2.098 | 541 | 2.088 | 376 | 2.117 | 205 | 1.474 | 135 | 2.239 | 88 | 1.660 | 53 | 2.142 | 4602 |
| 12 | 1.444 | 126 | 1.556 | 151 | 1.372 | 148 | 1.140 | 164 | 1.209 | 134 | 1.212 | 217 | 1.234 | 235 | 1.305 | 164 | 1.903 | 93 | 1.087 | 126 | 1.558 | 138 | 1.143 | 63 | 1.329 | 1759 |
| 13 | 1.606 | 701 | 1.801 | 866 | 1.990 | 865 | 1.894 | 964 | 1.848 | 1201 | 1.897 | 1143 | 2.016 | 1218 | 1.933 | 1031 | 1.989 | 654 | 1.738 | 629 | 2.090 | 824 | 1.828 | 360 | 1.898 | 10456 |


Class 1 & 2 = 0.001
Class 3 = 0.007
Class 4 = 0.257


02/06/98

3.

# RIGID PAVEMENT

18 KIP EALs
Equivalent Load Factors

## PRIMARY

N = sample size

| | 1986 | N | 1987 | N | 1988 | N | 1989 | N | 1990 | N | 1991 | N | 1992 | N | 1993 | N | 1994 | N | 1995 | N | 1996 | N | 1997 | N | AVG. | Total N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2A-6T | 0.374 | 745 | 0.335 | 1405 | 0.354 | 1247 | 0.360 | 892 | 0.358 | 1135 | 0.307 | 1663 | 0.316 | 1533 | 0.346 | 1254 | 0.433 | 725 | 0.416 | 735 | 0.384 | 1095 | 0.479 | 721 | 0.360 | 13150 |
| 3A-SU | 1.024 | 291 | 0.710 | 639 | 0.754 | 686 | 0.861 | 459 | 1.043 | 601 | 0.400 | 743 | 0.744 | 731 | 0.886 | 535 | 0.733 | 329 | 0.750 | 332 | 0.890 | 500 | 0.680 | 334 | 0.772 | 6180 |
| 4A-SU | 1.714 | 21 | 1.875 | 16 | 1.273 | 22 | 5.500 | 10 | 1.182 | 22 | 2.205 | 39 | 1.800 | 50 | 2.116 | 43 | 1.067 | 45 | 1.821 | 39 | 1.670 | 115 | 1.900 | 50 | 1.797 | 472 |
| 2-S-1 | 0.790 | 62 | 0.695 | 95 | 0.546 | 97 | 0.500 | 66 | 0.476 | 82 | 0.508 | 130 | 0.407 | 123 | 0.446 | 92 | 0.429 | 63 | 0.357 | 84 | 0.378 | 119 | 0.355 | 76 | 0.483 | 1089 |
| 2-S-2 | 1.354 | 79 | 0.570 | 165 | 0.445 | 146 | 0.266 | 94 | 0.390 | 123 | 0.349 | 149 | 0.397 | 151 | 0.763 | 139 | 0.481 | 106 | 0.333 | 63 | 0.542 | 72 | 0.479 | 48 | 0.518 | 1335 |
| 3-S-2 | 2.731 | 2516 | 2.420 | 3619 | 2.291 | 3184 | 2.376 | 2586 | 2.458 | 3236 | 2.264 | 4272 | 2.134 | 3622 | 2.061 | 2757 | 2.015 | 2322 | 1.942 | 2427 | 2.119 | 3348 | 1.988 | 2370 | 2.242 | 36259 |
| 3-S-3 | 2.924 | 314 | 2.390 | 344 | 2.574 | 230 | 2.478 | 253 | 2.723 | 300 | 2.297 | 374 | 1.963 | 294 | 1.810 | 179 | 2.124 | 218 | 1.908 | 239 | 1.832 | 417 | 2.018 | 272 | 2.262 | 3434 |
| 2-1 | 0.500 | 6 | 0.826 | 23 | 0.684 | 19 | 0.462 | 13 | 0.286 | 14 | 0.138 | 29 | 0.114 | 35 | 0.261 | 23 | 0.071 | 14 | 0.091 | 11 | 0.250 | 12 | 0.474 | 19 | 0.335 | 218 |
| 2-2 | 0.067 | 15 | 0.370 | 46 | 0.277 | 47 | 0.209 | 43 | 0.308 | 39 | 0.298 | 94 | 0.211 | 114 | 0.169 | 65 | 0.106 | 123 | 0.115 | 87 | 0.321 | 84 | 0.296 | 54 | 0.223 | 811 |
| 3-2 | 2.360 | 189 | 2.633 | 422 | 3.314 | 563 | 3.311 | 489 | 3.191 | 351 | 2.894 | 622 | 3.166 | 679 | 2.803 | 320 | 1.394 | 104 | 3.320 | 322 | 2.921 | 354 | 1.753 | 154 | 2.961 | 4569 |
| 3-3 | 2.897 | 29 | 2.250 | 24 | 2.421 | 19 | 1.182 | 11 | 2.500 | 18 | 1.725 | 51 | 1.083 | 24 | 1.783 | 23 | 0.917 | 12 | 1.214 | 14 | 1.063 | 16 | 0.550 | 20 | 1.736 | 261 |
| 2-S-1-2 | 1.120 | 25 | 1.120 | 50 | 1.174 | 23 | 1.818 | 11 | 1.045 | 22 | 1.156 | 64 | 1.481 | 54 | 1.244 | 41 | 0.867 | 15 | 1.500 | 14 | 1.111 | 18 | 0.563 | 16 | 1.195 | 353 |
| 3-S-1-2 | 1.714 | 21 | 2.175 | 40 | 1.278 | 36 | 1.560 | 25 | 1.958 | 24 | 1.396 | 53 | 1.500 | 50 | 1.507 | 69 | 0.703 | 37 | 0.731 | 26 | 1.889 | 27 | 0.750 | 16 | 1.453 | 424 |
| 3-S-2-2 | 2.524 | 164 | 2.129 | 348 | 2.833 | 509 | 2.491 | 222 | 2.413 | 269 | 2.259 | 665 | 2.310 | 432 | 2.378 | 384 | 2.000 | 285 | 2.348 | 293 | 2.423 | 456 | 2.404 | 371 | 2.380 | 4398 |
| 3-S-2-3 | 2.359 | 39 | 2.465 | 99 | 2.038 | 105 | 2.805 | 82 | 2.211 | 114 | 2.286 | 220 | 2.475 | 198 | 2.954 | 151 | 2.232 | 151 | 2.483 | 118 | 2.755 | 159 | 2.215 | 93 | 2.449 | 1529 |

Class 1 & 2 = 0.001
Class 3 = 0.007
Class 4 = 0.257

02/04/98 FILE NAME = EAL_R_P.WK4

# RIGID PAVEMENT

18 KIP EALs
Equivalent Load Factors

## PRIMARY

N = sample size

| Type | 1986 | N | 1987 | N | 1988 | N | 1989 | N | 1990 | N | 1991 | N | 1992 | N | 1993 | N | 1994 | N | 1995 | N | 1996 | N | 1997 | N | AVG. | Total N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.374 | 745 | 0.335 | 1405 | 0.354 | 1247 | 0.360 | 892 | 0.358 | 1135 | 0.307 | 1663 | 0.316 | 1533 | 0.346 | 1254 | 0.433 | 725 | 0.416 | 735 | 0.384 | 1095 | 0.479 | 721 | 0.360 | 13150 |
| 6 | 1.024 | 291 | 0.710 | 639 | 0.754 | 686 | 0.861 | 459 | 1.043 | 601 | 0.400 | 743 | 0.744 | 731 | 0.886 | 535 | 0.733 | 329 | 0.750 | 332 | 0.890 | 500 | 0.680 | 334 | 0.772 | 6180 |
| 7 | 1.714 | 21 | 1.875 | 16 | 1.273 | 22 | 5.500 | 10 | 1.182 | 22 | 2.205 | 39 | 1.800 | 50 | 2.116 | 43 | 1.067 | 45 | 1.821 | 39 | 1.670 | 115 | 1.900 | 50 | 1.797 | 472 |
| 8 | 0.988 | 162 | 0.596 | 329 | 0.466 | 309 | 0.338 | 216 | 0.399 | 258 | 0.373 | 402 | 0.326 | 423 | 0.514 | 319 | 0.301 | 306 | 0.253 | 245 | 0.397 | 287 | 0.381 | 197 | 0.426 | 3453 |
| 9 | 2.705 | 2705 | 2.442 | 4041 | 2.445 | 3747 | 2.525 | 3075 | 2.530 | 3587 | 2.344 | 4894 | 2.297 | 4301 | 2.138 | 3077 | 1.988 | 2426 | 2.104 | 2749 | 2.196 | 3702 | 1.973 | 2524 | 2.323 | 40828 |
| 10 | 2.921 | 343 | 2.380 | 368 | 2.562 | 249 | 2.424 | 264 | 2.711 | 318 | 2.228 | 425 | 1.896 | 318 | 1.807 | 202 | 2.061 | 230 | 1.870 | 253 | 1.804 | 433 | 1.918 | 292 | 2.225 | 3695 |
| 11 | 1.120 | 25 | 1.120 | 50 | 1.174 | 23 | 1.818 | 11 | 1.045 | 22 | 1.156 | 64 | 1.481 | 54 | 1.244 | 41 | 0.867 | 15 | 1.500 | 14 | 1.111 | 18 | 0.563 | 16 | 1.195 | 353 |
| 12 | 1.714 | 21 | 2.175 | 40 | 1.278 | 36 | 1.560 | 25 | 1.958 | 24 | 1.396 | 53 | 1.500 | 50 | 1.507 | 69 | 0.703 | 37 | 0.731 | 26 | 1.889 | 27 | 0.750 | 16 | 1.453 | 424 |
| 13 | 2.493 | 203 | 2.204 | 447 | 2.697 | 614 | 2.576 | 304 | 2.352 | 383 | 2.266 | 885 | 2.362 | 630 | 2.540 | 535 | 2.080 | 436 | 2.387 | 411 | 2.509 | 615 | 2.366 | 464 | 2.398 | 5927 |

Class 1 & 2 = 0.001
Class 3 = 0.007
Class 4 = 0.257

02/04/98

# FLEXIBLE PAVEMENT

18 KIP EALs
Equivalent Load Factors

## PRIMARY

N = sample size

| | 1986 | N | 1987 | N | 1988 | N | 1989 | N | 1990 | N | 1991 | N | 1992 | N | 1993 | N | 1994 | N | 1995 | N | 1996 | N | 1997 | N | AVG. | Total N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2A-6T | 0.393 | 745 | 0.351 | 1405 | 0.373 | 1247 | 0.379 | 892 | 0.382 | 1135 | 0.331 | 1663 | 0.336 | 1533 | 0.365 | 1254 | 0.446 | 725 | 0.435 | 735 | 0.405 | 1095 | 0.491 | 721 | 0.379 | 13150 |
| 3A-SU | 0.735 | 291 | 0.527 | 639 | 0.560 | 686 | 0.636 | 459 | 0.757 | 601 | 0.655 | 743 | 0.550 | 731 | 0.637 | 535 | 0.562 | 329 | 0.551 | 332 | 0.664 | 500 | 0.515 | 334 | 0.612 | 6180 |
| 4A-SU | 1.429 | 21 | 1.313 | 16 | 1.045 | 22 | 4.200 | 10 | 1.000 | 22 | 1.564 | 39 | 1.400 | 50 | 1.674 | 43 | 0.956 | 45 | 1.410 | 39 | 1.365 | 115 | 1.520 | 50 | 1.424 | 472 |
| 2-S-1 | 0.790 | 62 | 0.716 | 95 | 0.598 | 97 | 0.530 | 66 | 0.524 | 82 | 0.562 | 130 | 0.480 | 123 | 0.500 | 92 | 0.476 | 63 | 0.417 | 84 | 0.437 | 119 | 0.408 | 76 | 0.532 | 1089 |
| 2-S-2 | 1.241 | 79 | 0.545 | 165 | 0.445 | 146 | 0.255 | 94 | 0.390 | 123 | 0.342 | 149 | 0.377 | 151 | 0.669 | 139 | 0.453 | 106 | 0.317 | 63 | 0.514 | 72 | 0.479 | 48 | 0.490 | 1335 |
| 3-S-2 | 1.679 | 2516 | 1.504 | 3819 | 1.434 | 3184 | 1.486 | 2586 | 1.535 | 3236 | 1.424 | 4272 | 1.359 | 3622 | 1.333 | 2757 | 1.297 | 2322 | 1.256 | 2427 | 1.347 | 3348 | 1.296 | 2370 | 1.417 | 36259 |
| 3-S-3 | 1.968 | 314 | 1.640 | 344 | 1.752 | 230 | 1.688 | 253 | 1.873 | 300 | 1.586 | 374 | 1.398 | 294 | 1.313 | 179 | 1.541 | 218 | 1.427 | 239 | 1.333 | 417 | 1.463 | 272 | 1.585 | 3434 |
| 2-1 | 0.500 | 6 | 0.826 | 23 | 0.684 | 19 | 0.462 | 13 | 0.429 | 14 | 0.138 | 29 | 0.143 | 35 | 0.261 | 23 | 0.143 | 14 | 0.182 | 11 | 0.333 | 12 | 0.421 | 19 | 0.358 | 218 |
| 2-2 | 0.133 | 15 | 0.348 | 46 | 0.255 | 47 | 0.186 | 43 | 0.308 | 39 | 0.277 | 94 | 0.219 | 114 | 0.169 | 65 | 0.098 | 123 | 0.103 | 87 | 0.310 | 84 | 0.278 | 54 | 0.215 | 811 |
| 3-2 | 1.910 | 189 | 2.102 | 422 | 2.622 | 563 | 2.626 | 489 | 2.527 | 351 | 2.314 | 622 | 2.521 | 679 | 2.253 | 320 | 1.183 | 104 | 2.640 | 322 | 2.328 | 354 | 1.455 | 154 | 2.361 | 4569 |
| 3-3 | 1.966 | 29 | 1.708 | 24 | 2.000 | 19 | 0.909 | 11 | 1.667 | 18 | 1.255 | 51 | 0.875 | 24 | 1.261 | 23 | 0.667 | 12 | 0.857 | 14 | 0.750 | 16 | 0.450 | 20 | 1.268 | 261 |
| 2-S-1-2 | 1.240 | 25 | 1.220 | 50 | 1.217 | 23 | 1.818 | 11 | 1.182 | 22 | 1.281 | 64 | 1.593 | 54 | 1.415 | 41 | 0.867 | 15 | 1.643 | 14 | 1.222 | 18 | 0.688 | 16 | 1.306 | 353 |
| 3-S-1-2 | 1.619 | 21 | 1.975 | 40 | 1.194 | 36 | 1.440 | 25 | 1.833 | 24 | 1.302 | 53 | 1.400 | 50 | 1.449 | 69 | 0.730 | 37 | 0.692 | 26 | 1.852 | 27 | 0.688 | 16 | 1.370 | 424 |
| 3-S-2-2 | 1.835 | 164 | 1.818 | 348 | 2.187 | 509 | 1.842 | 222 | 1.803 | 269 | 1.770 | 665 | 1.734 | 432 | 1.773 | 384 | 1.502 | 285 | 1.741 | 293 | 1.807 | 456 | 1.790 | 371 | 1.797 | 4398 |
| 3-S-2-3 | 1.615 | 39 | 1.636 | 99 | 1.410 | 105 | 1.951 | 82 | 1.518 | 114 | 1.591 | 220 | 1.687 | 198 | 1.974 | 151 | 1.523 | 151 | 1.695 | 118 | 1.849 | 159 | 1.495 | 93 | 1.668 | 1529 |

Class 1 & 2 = 0.001
Class 3 = 0.007
Class 4 = 0.257

02/04/98 FILE NAME = EAL_F_P.WK4

### FLEXIBLE PAVEMENT

18 KIP EALs
Equivalent Load Factors

PRIMARY

N = sample size

| Type | 1986 | N | 1987 | N | 1988 | N | 1989 | N | 1990 | N | 1991 | N | 1992 | N | 1993 | N | 1994 | N | 1995 | N | 1996 | N | 1997 | N | AVG. | Total N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.393 | 745 | 0.351 | 1405 | 0.373 | 1247 | 0.379 | 892 | 0.382 | 1135 | 0.331 | 1663 | 0.336 | 1533 | 0.365 | 1254 | 0.446 | 725 | 0.435 | 735 | 0.405 | 1095 | 0.491 | 721 | 0.379 | 13150 |
| 6 | 0.735 | 291 | 0.527 | 639 | 0.560 | 686 | 0.636 | 459 | 0.757 | 601 | 0.655 | 743 | 0.550 | 731 | 0.637 | 535 | 0.562 | 329 | 0.551 | 332 | 0.664 | 500 | 0.515 | 334 | 0.612 | 6180 |
| 7 | 1.429 | 21 | 1.313 | 16 | 1.045 | 22 | 4.200 | 10 | 1.000 | 22 | 1.564 | 39 | 1.400 | 50 | 1.674 | 43 | 0.956 | 45 | 1.410 | 39 | 1.365 | 115 | 1.520 | 50 | 1.424 | 472 |
| 8 | 0.938 | 162 | 0.587 | 329 | 0.479 | 309 | 0.338 | 216 | 0.422 | 258 | 0.383 | 402 | 0.345 | 423 | 0.489 | 319 | 0.301 | 308 | 0.269 | 245 | 0.415 | 287 | 0.391 | 197 | 0.430 | 3453 |
| 9 | 1.695 | 2705 | 1.566 | 4041 | 1.612 | 3747 | 1.667 | 3075 | 1.632 | 3587 | 1.537 | 4894 | 1.542 | 4301 | 1.429 | 3077 | 1.292 | 2426 | 1.418 | 2749 | 1.441 | 3702 | 1.305 | 2524 | 1.522 | 40828 |
| 10 | 1.968 | 343 | 1.644 | 368 | 1.771 | 249 | 1.655 | 264 | 1.862 | 318 | 1.546 | 425 | 1.358 | 318 | 1.307 | 202 | 1.496 | 230 | 1.395 | 253 | 1.312 | 433 | 1.394 | 292 | 1.563 | 3695 |
| 11 | 1.240 | 25 | 1.220 | 50 | 1.217 | 23 | 1.818 | 11 | 1.182 | 22 | 1.281 | 64 | 1.593 | 54 | 1.415 | 41 | 0.867 | 15 | 1.643 | 14 | 1.222 | 18 | 0.688 | 16 | 1.306 | 353 |
| 12 | 1.619 | 21 | 1.975 | 40 | 1.194 | 36 | 1.440 | 25 | 1.833 | 24 | 1.302 | 53 | 1.400 | 50 | 1.449 | 69 | 0.730 | 37 | 0.692 | 26 | 1.852 | 27 | 0.688 | 16 | 1.370 | 424 |
| 13 | 1.793 | 203 | 1.622 | 447 | 2.054 | 614 | 1.872 | 304 | 1.718 | 383 | 1.725 | 885 | 1.719 | 630 | 1.830 | 535 | 1.509 | 436 | 1.727 | 411 | 1.818 | 615 | 1.731 | 464 | 1.764 | 5927 |

Class 1 & 2 = 0.001
Class 3 = 0.007
Class 4 = 0.257

02/04/98

Subj: **RE: Survey ESAL Use In Pavement Design**
Date: 3/19/99 12:32:24 PM Pacific Standard Time
From: jtompkins@state.mt.us (Tompkins, James)
To: ETLAIRD@aol.com ('ETLAIRD@aol.com')

Jim

-----Original Message-----
From: ETLAIRD@aol.com [mailto:ETLAIRD@aol.com]
Sent: Thursday, March 18, 1999 3:47 PM
To: jtompkins@state.mt.us
Subject: Survey ESAL Use In Pavement Design

MONTANA REPLY 3/19/99 ETL

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 16, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona
DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Montana DOT; Mr. James Tompkins; Surface Design Engineer;
(406) 444-6295 Fax: (406) 444-6204

Please check One: Surveyed State (Does X ) or (Does Not __) wish to be identified on how the state answered any of the survey questioned. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes:X
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with

the ESAL table values? (Will you fax us the first page of your ESAL table for an example.)Static scale data, in the near future we will use WIM.

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load
information for that location? Simple Esal table.

Q NO. 3: Do you break down ESALS by vehicle classification? Yes

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they? Yes

Q No. 5: Do you use Growth factors to expand ESAL's to design
years? Yes

Q No. 6: Do you use WIM data? If No what do you use for load
data? Will use WIM in the near future. Presently use static
scale.

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL
growth factors? NO.

Q No. 8: How much confidence do you have in the values you use
for pavement design and rehab? Average to High.

Survey States comments if any: Earl, I am mailing some Esal
charts that Dan Bisom furnished, as I had his section answer some
of the questions that pertained to them.

Thank you for participating in this ESAL pavement design and rehabilitation
survey. If you have any questions on this survey you may contact Earl Laird
at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.;
Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No.
(775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe;
Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird.

---------------- Headers ----------------
Return-Path: <jtompkins@state.mt.us>
Received: from rly-yd02.mx.aol.com (rly-yd02.mail.aol.com [172.18.150.2]) by air-yd01.mail.aol.com (v58.13) with SMTP; Fri, 19 Mar 1999 15:32:24 -0500
Received: from doaisd01001.state.mt.us (doaisd01001.state.mt.us [161.7.104.182])
by rly-yd02.mx.aol.com (8.8.8/8.8.5/AOL-4.0.0)
with ESMTP id PAA02670 for <ETLAIRD@aol.com>;
Fri, 19 Mar 1999 15:32:23 -0500 (EST)
Received: by doaisd01001.state.mt.us with Internet Mail Service (5.5.2407.0)
id <HB7DYAFD>; Fri, 19 Mar 1999 13:32:22 -0700
Message-ID: <018C4C169A5CD211B84808002BB29C64BB2BE4@doaisd02003.mdt.state.mt.us>
From: "Tompkins, James" <jtompkins@state.mt.us>
To: "'ETLAIRD@aol.com'" <ETLAIRD@aol.com>
Subject: RE: Survey ESAL Use In Pavement Design
Date: Fri, 19 Mar 1999 13:32:17 -0700
MIME-Version: 1.0
X-Mailer: Internet Mail Service (5.5.2407.0)
Content-Type: text/plain;
charset="iso-8859-1"

Subj: **Survey ESAL Use In Pavement Design**
Date: 3/18/99
To: jtompkins@state.mt.us

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 16, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Montana DOT; Mr James Tompkins; Surface Design Engineer;
(406) 444-6295 Fax: (406) 444-6204

Please check One: Surveyed State (Does __ ) or (Does Not __) wish to be identified on how the state answered any of the survey questioned. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes:___
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

Q NO. 3: Do you break down ESALS by vehicle classification?

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design years?

Q No. 6: Do you use WIM data? If No what do you use for load data?

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird.

Subj: **Re: Thanks For Survey Reply**
Date: 3/24/99
To: jtompkins@state.mt.us

MONTANA

Hi Jim,

Thank you for the prompt and informative reply to the Arizona ESAL research questionnaire. You informed me that you would mail the sample ESAL table you received from Dan Bison and I am looking for it in the mail.

Thanks again,

Earl T. (:>))

Subj: **Re: Thanks for Mailing Survey ESAL**
Date: 3/29/99
To: jtompkins@state.mt.us

MONTANA

Hi Jim,

I received the ESAL tables and Survey in the mail on Saturday. Thank you for mailing them.

Thanks again and have a nice bright summer.

Earl T. (:>))

EARL T. LAIRD
T P & R CONSULTANT
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529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

South Dakota Reply

March 23, 1999

Survey of States using ESALS for pavement design and rehabilitation. ESAL Data information being collected for an ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: South Dakota; Mr. David Huff; Planning Traffic Division; (605) 773-3358 Fax: (605) 773-4713

Please check One: Surveyed State (Does __) or (Does Not __) Wish to be identified on how the state answered any of the survey questions. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes: X
No: ___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.) WIM data (SEE ATTACHED FAX)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location? Different for locations

Q NO. 3: Do you break down ESALS by vehicle classification? Average ESAL / 13 vehicle classes

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they? NO - based on WIM

Q No. 5: Do you use Growth factors to expand ESAL's to design years? Yes

Q No. 6: Do you use WIM data? If No what do you use for load data? Yes

Q No. 7: Are there links between HPMS data and the ESAL tables? Not necessarily
a. Are your growth factors for HPMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab? It depends how close location is to WIM installation

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird.

South Dakota

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775) 882-4755 Fax (775) 882-4565
E-mail: ETLAIRD@AOL.COM

FAX COVER SHEET
Number of pages including this cover sheet 2

TO: David Huff FAX NUMBER: (605) 773-4713
Planning Traffic Division

FROM: Earl Laird FAX NUMBER: (775) 882-4565

DATE: March 23, 1999 TIME: 7:45 PM

SUBJECT: Thank You For State Survey of ESAL Use For Design

REMARKS:
Hello David ~~Huff~~. Huft

Thank you for the quick fax response and very informative reply to the questionnaire on the use of ESAL's in pavement design.

Would you have an example of an ESAL table that you would send to your design or material divisions that provides the ESAL values they may need for pavement design? This would be very helpful in showing Arizona DOT how ESAL data are reported to interested divisions needing the data. My fax number is (775) 882-5465.

Thanks again for the help,

Earl T. Laird (:>))

Earl - ESAL values are computed upon request of Materials & Surfacing to our Data Inventory Office. No "tables" are reported. Instead, Data Inventory estimates the total number of ESALs that are expected to be applied to a highway pavement during its design period. Rigid and flexible estimates are provided.

If I'm missing something in your request, please call me at 605/773-3358. I think it might be more productive to speak in person. Dave

**EARL T. LAIRD**
**T P & R CONSULTANT**
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 23, 1999

Survey of States using ESALS for pavement design and rehabilitation. ESAL Data information being collected for an ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: South Dakota; Mr. David Huff; Planning Traffic Division; (605) 773-3358 Fax: (605) 773-4713

Please check One: Surveyed State (Does __) or (Does Not __) wish to be identified on how the state answered any of the survey questions. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes:___
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

Q NO. 3: Do you break down ESALS by vehicle classification?

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design years?

Q No. 6: Do you use WIM data? If No what do you use for load data?

Q No. 7: Are there links between HPMS data and the ESAL tables?
a. Are your growth factors for HPMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435, e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird.

EARL T. LAIRD
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(775) 882-4755 Fax (775) 882-4565
E-mail: ETLAIRD@AOL.COM

FAX COVER SHEET
Number of pages including this cover sheet 2

TO: David Huff FAX NUMBER: (605) 773-4713
Planning Traffic Division

FROM: Earl Laird ETL FAX NUMBER: (775) 882-4565

DATE: March 23, 1999 TIME: 7:45 PM

SUBJECT: State Survey of ESAL Use For Pavement Design and Rehabilitation

==========================================================

REMARKS:
Hello David Huff:

Per my phone message, attached is the small questionnaire dealing with South Dakota's use of ESAL data in the design and rehabilitation of pavements. As I explained to you, the ESAL survey is part of a contract Nichols Consulting Engineers of Reno, Nevada has with Arizona DOT dealing with ESAL design and its use in pavement design and rehab.

If you have any questions please call me at (775) 882-4755.

You may fax your answers to me at Fax No. (775) 882-4565, or e-mail to the above e-mail address.

Thanks for your anticipated help.

Earl T. Laird (:>)) Earl T. Laird

EARL T. LAIRD
T P & R CONSULTANT
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529 Bonanza Dr., Carson City, NV. 89706
(775) 882-4755 Fax (775) 882-4565
E-mail: ETLAIRD@AOL.COM

FAX COVER SHEET
Number of pages including this cover sheet 2

TO: David Huff FAX NUMBER: (605) 773-4713
Planning Traffic Division

FROM: Earl Laird FAX NUMBER: (775) 882-4565

DATE: March 23, 1999 TIME: 7:45 PM

SUBJECT: Thank You For State Survey of ESAL Use For Design

==========================================================

REMARKS:

Hello David Huff:

Thank you for the quick fax response and very informative reply to the questionnaire on the use of ESAL's in pavement design.

Would you have an example of an ESAL table that you would send to your design or material divisions that provides the ESAL values they may need for pavement design? This would be very helpful in showing Arizona DOT how ESAL data are reported to interested divisions needing the data. My fax number is (775) 882-5465.

Thanks again for the help,

Earl T. Laird (:>))

WASHINGTON STATE DOT
REPLY TO SURVEY.

Subj: **FW: ESAL Use Survey**
Date: 3/15/99 4:37:16 PM Pacific Standard Time
From: PIERCEL@WSDOT.WA.GOV (Pierce, Linda M)
To: ETLAIRD@aol.com ('ETLAIRD@aol.com')

See comments in text below.

>----------
>From: ETLAIRD@aol.com[SMTP:ETLAIRD@aol.com]
>Sent: Monday, March 15, 1999 3:50 PM
>To: Pierce, Linda M
>Cc: sirous@nce.reno.nv.us
>Subject: ESAL Use Survey
>
>EARL T. LAIRD
>T P & R CONSULTANT
>Transportation Planning and Research
>529 Bonanza Dr., Carson City, NV. 89706
>(775)882-4755 Fax (775)882-4565
>E-mail: etlaird@aol.com
>
>March 15, 1999
>
>Survey of States using ESALS for pavement design and rehabilitation. ESAL
>Data information being collected for a ESAL Research Contract between Arizona
>DOT and Nichols Consulting Engineers in Reno, Nevada:
>
>Survey State of: Washington DOT; Ms. Linda Pierce; Material and Testing
>(360)709-5470
>
>Please check One: Surveyed State (Does X ) or (Does Not __) wish to be
>identified on how the state answered any of the survey questioned. Only
>identify the state as a participant in the survey.
>
>Question No. 1: Does your state use ESAL computations for
> pavement design and rehabilitation?
> Yes: X
> No:___ If No what do you use?
>
>Q No. 2: What type or types of data do you use to come up with
> the ESAL table values? (Will you fax us the first page
of your ESAL table for an example.) WSDOT has determined
ESAL/truck factors. The original factors were developed based on
Washington loadometer tables and later verified using WIM. ESAL table
>is not available.
>
>a. Do you use a single ESAL table for all design locations within your state
>or is a different ESAL value computed for different locations based upon load
information for that location? ESAL factors developed based on type of
>truck.
>
Q NO. 3: Do you break down ESALS by vehicle classification? Yes,
FHWA vehicle class 4, 5, 6, 7 - 0.40 ESAL/vehicle
FHWA vehicle class 8, 9, 10 - 1.00 ESAL/vehicle
>FHWA vehicle class 11, 12, 13 - 1.75 ESAL/vehicle
>
>Q No. 4: Do you apply average ESAL factors to the vehicles in
> each classification? What are they? See above.

>
>Q No. 5: Do you use Growth factors to expand ESAL's to design
years? Yes, we apply a 1.6 percent growth factor to our ESAL
>calculation.
>
>Q No. 6: Do you use WIM data? If No what do you use for load
> data? See answer to No. 2 above.
>
>Q No. 7: Are there links between PMS data and the ESAL tables?
> a. Are your growth factors for PMS the same for ESAL
growth factors? Our PMS contains the ESAL calculations for
>each section of state highway. The growth factors are the same.
>
>Q No. 8: How much confidence do you have in the values you use
for pavement design and rehab? Complete confidence in the
ESAL/vehicle values, I have about 60 - 75 percent confidence in the
>actual traffic counts that are supplied to us.
>
>Survey States comments if any:
>
>Thank you for participating in this ESAL pavement design and rehabilitation
>survey. If you have any questions on this survey you may contact Earl Laird
>at above telephone or e-mail. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal
>Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or
>e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT;
>telephone (602)407-3435; e-mail ekombe@dot.state.az
>
>Thank you again,
>
>Earl T. Laird.
>

------------------- Headers -------------------------
Return-Path: <PIERCEL@WSDOT.WA.GOV>
Received: from rly-yd02.mx.aol.com (rly-yd02.mail.aol.com [172.18.150.2]) by air-yd01.mail.aol.com (v56.26) with SMTP; Mon, 15 Mar 1999 19:37:16 1900
Received: from mail1.wsdot.wa.gov (mail1.wsdot.wa.gov [164.110.100.178])
by rly-yd02.mx.aol.com (8.8.8/8.8.5/AOL-4.0.0)
with ESMTP id TAA21806 for <ETLAIRD@aol.com>;
Mon, 15 Mar 1999 19:37:15 -0500 (EST)
Received: from magnolia.WSDOT.WA.GOV (magnolia.wsdot.wa.gov [164.110.102.213]) by mail1.wsdot.wa.gov (8.7.5/8.7.5.96328) with SMTP id RAA01348 for <ETLAIRD@aol.com>; Mon, 15 Mar 1999 17:00:59 -0800 (PST)
Received: by magnolia.WSDOT.WA.GOV with SMTP (Microsoft Exchange Server Internet Mail Connector Version 4.0.996.39)
id <01BE6F02.1E1C6E30@magnolia.WSDOT.WA.GOV>; Mon, 15 Mar 1999 16:37:29 -0800
Message-ID: <c=US%a=_%p=WA.GOV%l=CEDAR-990316003712Z-54210@magnolia.WSDOT.WA.GOV>
From: "Pierce, Linda M" <PIERCEL@WSDOT.WA.GOV>
To: "'ETLAIRD@aol.com'" <ETLAIRD@aol.com>
Subject: FW: ESAL Use Survey
Date: Mon, 15 Mar 1999 16:37:12 -0800
X-Mailer: Microsoft Exchange Server Internet Mail Connector Version 4.0.996.39
MIME-Version: 1.0
Content-Type: text/plain; charset="us-ascii"
Content-Transfer-Encoding: 7bit

KANSAS
ESAL DATA

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 19, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Kansas DOT; Mr. Garrett Olson ; OR Alan Spicer
Field Data Collection Engineer: (785) 296-3470
(785) 296-~~6361~~ 6357 Fax: (785) 296-8168

Please check One: Surveyed State (Does X) or (Does Not __) wish to be identified on how the state answered any of the survey questions. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes: X
No: __ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.) See next 2 pages — truck weight data by vehicle classification

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location? See sample from traffic forecast

Q NO. 3: Do you break down ESALS by vehicle classification? Yes (modified to 9 groups)

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? Yes What are they? Grouped by Functional Classification

Q No. 5: Do you use Growth factors to expand ESAL's to design years? No

Q No. 6: Do you use WIM data? Yes If No what do you use for load data? Yes 30 sites per year

Q No. 7: Are there links between PMS data and the ESAL tables? NO
a. Are your growth factors for PMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab? Fairly confident.

Survey States comments if any: We have been collecting all truck data since 1995 in metric - we do not have "metric esal tables" to use.

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator: Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe: Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,
Earl T. Laird. [signature]

English Units

# STATE OF KANSAS
## EIGHTEEN KIP EQUIVALENTS RATE PER 1000 VEHICLES OF VEHICLES WEIGHED DURING THE YEARS 1992, 93, 94,

08/17/95

number of sites → (15) RURAL PRINCIPAL ARTERIAL - INTERSTATE

RIGID PAVEMENT - P=2.0

| | Single Unit Trucks: 2 AXLE 4 TIRE | Single Unit Trucks: 2 AXLE 6 TIRE | Single Unit Trucks: 3 AXLE OR MORE | Single Trailer Trucks: 4 AXLE OR LESS | Single Trailer Trucks: 5 AXLE OR MORE | Multi-Trailer Trucks: 5 AXLE OR LESS | Multi-Trailer Trucks: 6 AXLE OR MORE |
|---|---|---|---|---|---|---|---|
| D= 6" | 2 | 140 | 681 | 614 | 1891 | 1611 | 1839 |
| D= 7" | 2 | 136 | 671 | 605 | 1878 | 1590 | 1818 |
| D= 8" | 2 | 135 | 675 | 601 | 1897 | 1578 | 1809 |
| D= 9" | 2 | 135 | 682 | 600 | 1904 | 1574 | 1837 |
| D=10" | 2 | 135 | 689 | 600 | 1915 | 1573 | 1807 |
| D=11" | 2 | 135 | 693 | 630 | 1921 | 1574 | 1898 |

RIGID PAVEMENT - P=2.5

| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
|---|---|---|---|---|---|---|---|
| D= 6" | 2 | 144 | 665 | 633 | 1853 | 1659 | 1884 |
| D= 7" | 2 | 136 | 643 | 612 | 1825 | 1611 | 1834 |
| D= 8" | 2 | 133 | 648 | 602 | 1848 | 1582 | 1513 |
| D= 9" | 2 | 132 | 664 | 599 | 1860 | 1572 | 1805 |
| D=10" | 2 | 133 | 678 | 599 | 1901 | 1570 | 1806 |
| D=11" | 2 | 133 | 687 | 600 | 1914 | 1571 | 1807 |

FLEXIBLE PAVEMENT - P=2.0

| | Single Unit Trucks: 2 AXLE 4 TIRE | Single Unit Trucks: 2 AXLE 6 TIRE | Single Unit Trucks: 3 AXLE OR MORE | Single Trailer Trucks: 4 AXLE OR LESS | Single Trailer Trucks: 5 AXLE OR MORE | Multi-Trailer Trucks: 5 AXLE OR LESS | Multi-Trailer Trucks: 6 AXLE OR MORE |
|---|---|---|---|---|---|---|---|
| SN=1 | 2 | 138 | 437 | 530 | 1101 | 1527 | 1396 |
| SN=2 | 2 | 143 | 444 | 549 | 1128 | 1576 | 1454 |
| SN=3 | 2 | 143 | 446 | 560 | 1149 | 1607 | 1495 |
| SN=4 | 2 | 137 | 436 | 547 | 1134 | 1583 | 1468 |
| SN=5 | 2 | 133 | 431 | 536 | 1116 | 1555 | 1433 |
| SN=6 | 2 | 132 | 430 | 530 | 1105 | 1541 | 1413 |

FLEXIBLE PAVEMENT - P=2.5

| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
|---|---|---|---|---|---|---|---|
| SN=1 | 3 | 141 | 439 | 538 | 1109 | 1549 | 1418 |
| SN=2 | 4 | 155 | 463 | 585 | 1177 | 1645 | 1546 |
| SN=3 | 3 | 157 | 470 | 614 | 1234 | 1725 | 1652 |
| SN=4 | 2 | 142 | 446 | 581 | 1195 | 1666 | 1582 |
| SN=5 | 2 | 131 | 431 | 550 | 1165 | 1593 | 1490 |
| SN=6 | 2 | 128 | 447 | 558 | 1167 | 1556 | 1509 |

15 RURAL PRINCIPAL ARTERIAL - OTHER

RIGID PAVEMENT - P=2.0

| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
|---|---|---|---|---|---|---|---|
| D= 6" | 3 | 183 | 834 | 1161 | 2469 | 2068 | 2756 |
| D= 7" | 3 | 180 | 816 | 1142 | 2441 | 2053 | 2728 |
| D= 8" | 3 | 180 | 816 | 1142 | 2459 | 2048 | 2734 |
| D= 9" | 3 | 181 | 827 | 1154 | 2490 | 2049 | 2753 |
| D=10" | 3 | 182 | 839 | 1156 | 2515 | 2050 | 2772 |
| D=11" | 3 | 183 | 849 | 1175 | 2532 | 2052 | 2789 |

RIGID PAVEMENT - P=2.5

| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
|---|---|---|---|---|---|---|---|
| D= 6" | 3 | 183 | 803 | 1135 | 2375 | 2094 | 2696 |
| D= 7" | 3 | 177 | 763 | 1093 | 2317 | 2058 | 2636 |
| D= 8" | 3 | 176 | 763 | 1093 | 2352 | 2046 | 2648 |
| D= 9" | 3 | 178 | 783 | 1116 | 2418 | 2046 | 2686 |
| D=10" | 3 | 190 | 808 | 1141 | 2471 | 2048 | 2726 |
| D=11" | 3 | 182 | 829 | 1161 | 2506 | 2051 | 2758 |

FLEXIBLE PAVEMENT - P=2.0

| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
|---|---|---|---|---|---|---|---|
| SN=1 | 3 | 186 | 583 | 1066 | 1490 | 2031 | 2433 |
| SN=2 | 3 | 189 | 587 | 1068 | 1503 | 2067 | 2432 |
| SN=3 | 3 | 186 | 574 | 1044 | 1504 | 2081 | 2398 |
| SN=4 | 3 | 180 | 555 | 1010 | 1481 | 2057 | 2350 |
| SN=5 | 2 | 178 | 551 | 1005 | 1471 | 2041 | 2351 |
| SN=6 | 2 | 179 | 557 | 1018 | 1471 | 2037 | 2375 |

FLEXIBLE PAVEMENT - P=2.5

| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
|---|---|---|---|---|---|---|---|
| SN=1 | 3 | 189 | 586 | 1069 | 1493 | 2052 | 2438 |
| SN=2 | 5 | 197 | 595 | 1078 | 1533 | 2115 | 2449 |
| SN=3 | 4 | 192 | 574 | 1035 | 1545 | 2152 | 2381 |
| SN=4 | 3 | 178 | 532 | 963 | 1493 | 2096 | 2277 |
| SN=5 | 3 | 172 | 520 | 946 | 1461 | 2051 | 2268 |
| SN=6 | 2 | 174 | 542 | 980 | 1488 | 2037 | 2348 |

S T A T E   O F   K A N S A S — 08/17/95

EIGHTEEN KIP EQUIVALENTS RATE PER 1000 VEHICLES
OF VEHICLES WEIGHED DURING THE YEARS 1992, 93, 94.

## 01 RURAL MINOR COLLECTOR

RIGID PAVEMENT - P=2.0

| | SINGLE UNIT TRUCKS | | | SINGLE TRAILER TRUCKS | | MULTI-TRAILER TRUCKS | |
|---|---|---|---|---|---|---|---|
| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
| D= 6" | 36 | 649 | 1096 | | | | |
| D= 7" | 34 | 636 | 997 | | | | |
| D= 8" | 33 | 639 | 993 | | | | |
| D= 9" | 33 | 650 | 994 | | | | |
| D=10" | 33 | 659 | 994 | | | | |
| D=11" | 33 | 665 | 993 | | | | |

RIGID PAVEMENT - P=2.5

| | SINGLE UNIT TRUCKS | | | SINGLE TRAILER TRUCKS | | MULTI-TRAILER TRUCKS | |
|---|---|---|---|---|---|---|---|
| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
| D= 6" | 40 | 624 | 1020 | | | | |
| D= 7" | 36 | 597 | 1000 | | | | |
| D= 8" | 34 | 602 | 993 | | | | |
| D= 9" | 33 | 624 | 993 | | | | |
| D=10" | 33 | 644 | 994 | | | | |
| D=11" | 33 | 656 | 994 | | | | |

FLEXIBLE PAVEMENT - P=2.0

| | SINGLE UNIT TRUCKS | | | SINGLE TRAILER TRUCKS | | MULTI-TRAILER TRUCKS | |
|---|---|---|---|---|---|---|---|
| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
| SN=1 | 31 | 684 | 773 | | | | |
| SN=2 | 36 | 679 | 795 | | | | |
| SN=3 | 37 | 650 | 806 | | | | |
| SN=4 | 34 | 620 | 789 | | | | |
| SN=5 | 31 | 622 | 776 | | | | |
| SN=6 | 30 | 639 | 772 | | | | |

FLEXIBLE PAVEMENT - P=2.5

| | SINGLE UNIT TRUCKS | | | SINGLE TRAILER TRUCKS | | MULTI-TRAILER TRUCKS | |
|---|---|---|---|---|---|---|---|
| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
| SN=1 | 33 | 687 | 761 | | | | |
| SN=2 | 45 | 679 | 834 | | | | |
| SN=3 | 52 | 618 | 871 | | | | |
| SN=4 | 42 | 557 | 825 | | | | |
| SN=5 | 35 | 555 | 788 | | | | |
| SN=6 | 32 | 670 | 774 | | | | |

## 15 URBAN PRINCIPAL ARTERIAL - INTERSTATE

RIGID PAVEMENT - P=2.0

| | SINGLE UNIT TRUCKS | | | SINGLE TRAILER TRUCKS | | MULTI-TRAILER TRUCKS | |
|---|---|---|---|---|---|---|---|
| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
| D= 6" | 2 | 207 | 1209 | 732 | 2252 | 2317 | 3036 |
| D= 7" | 2 | 203 | 1192 | 722 | 2231 | 2300 | 3013 |
| D= 8" | 2 | 202 | 1198 | 716 | 2249 | 2297 | 3020 |
| D= 9" | 2 | 202 | 1211 | 719 | 2273 | 2300 | 3033 |
| D=10" | 2 | 203 | 1223 | 719 | 2292 | 2303 | 3044 |
| D=11" | 2 | 203 | 1231 | 726 | 2303 | 2306 | 3051 |

RIGID PAVEMENT - P=2.5

| | SINGLE UNIT TRUCKS | | | SINGLE TRAILER TRUCKS | | MULTI-TRAILER TRUCKS | |
|---|---|---|---|---|---|---|---|
| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
| D= 6" | 3 | 212 | 1172 | 748 | 2181 | 2336 | 3017 |
| D= 7" | 2 | 204 | 1137 | 725 | 2139 | 2296 | 2966 |
| D= 8" | 2 | 201 | 1147 | 716 | 2172 | 2288 | 2976 |
| D= 9" | 2 | 201 | 1175 | 716 | 2226 | 2293 | 3005 |
| D=10" | 2 | 202 | 1200 | 718 | 2265 | 2300 | 3028 |
| D=11" | 2 | 203 | 1217 | 719 | 2288 | 2303 | 3042 |

FLEXIBLE PAVEMENT - P=2.0

| | SINGLE UNIT TRUCKS | | | SINGLE TRAILER TRUCKS | | MULTI-TRAILER TRUCKS | |
|---|---|---|---|---|---|---|---|
| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
| SN=1 | 2 | 201 | 768 | 647 | 1325 | 2291 | 2375 |
| SN=2 | 2 | 209 | 779 | 667 | 1346 | 2323 | 2415 |
| SN=3 | 2 | 210 | 780 | 676 | 1357 | 2332 | 2436 |
| SN=4 | 2 | 204 | 765 | 662 | 1339 | 2303 | 2404 |
| SN=5 | 2 | 200 | 758 | 650 | 1325 | 2268 | 2380 |
| SN=6 | 2 | 199 | 757 | 646 | 1319 | 2289 | 2373 |

FLEXIBLE PAVEMENT - P=2.5

| | SINGLE UNIT TRUCKS | | | SINGLE TRAILER TRUCKS | | MULTI-TRAILER TRUCKS | |
|---|---|---|---|---|---|---|---|
| | 2 AXLE 4 TIRE | 2 AXLE 6 TIRE | 3 AXLE OR MORE | 4 AXLE OR LESS | 5 AXLE OR MORE | 5 AXLE OR LESS | 6 AXLE OR MORE |
| SN=1 | 3 | 205 | 772 | 655 | 1330 | 2310 | 2392 |
| SN=2 | 4 | 223 | 800 | 703 | 1386 | 2369 | 2480 |
| SN=3 | 3 | 228 | 809 | 730 | 1422 | 2395 | 2539 |
| SN=4 | 2 | 212 | 774 | 692 | 1377 | 2328 | 2462 |
| SN=5 | 2 | 201 | 753 | 661 | 1337 | 2286 | 2397 |
| SN=6 | 2 | 198 | 770 | 666 | 1370 | 2280 | 2399 |

# EQUIVALENT SINGLE AXLE LOADS (ESAL) ANALYSIS

## K-4 Oakland Expressway Just North of US-40

4-89 K-7316-01

Sample of ESAL traffic forecast

| | | % DIST. | 18 KIP ADL ON RIGID PVMNT.* | | 18 KIP ADL ON FLEX. PVMNT.* | |
|---|---|---|---|---|---|---|
| YR 2000 TRAFFIC = | 12700 | 7.0% TRUCKS | D=260mm (10in.) | D=280mm (11in.) | SN=5 | SN=6 |
| AUTO | 8852 | 69.7 | 2.66 | 2.66 | 2.66 | 2.66 |
| LT. TRUCK | 2959 | 23.3 | 5.92 | 5.92 | 5.92 | 5.92 |
| 2 AXLE-6 TIRE | 114 | 0.9 | 21.15 | 21.37 | 20.23 | 20.36 |
| 3 AXLE TANDEM | 38 | 0.3 | 30.18 | 30.78 | 19.16 | 20.00 |
| 4 AXLE 1 TRAILER | 241 | 1.9 | 176.15 | 177.11 | 156.36 | 159.74 |
| 5 AXLE 1 TRAILER | 495 | 3.9 | 1022.30 | 1031.71 | 611.70 | 623.58 |
| 5 AXLE 2 TRAILER | 0 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 AXLE 2 TRAILER | 0 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| TOTALS | 12700 | 100.0 | 1258.34 | 1269.58 | 816.03 | 832.24 |

| | | % DIST. | 18 KIP ADL ON RIGID PVMNT.* | | 18 KIP ADL ON FLEX. PVMNT.* | |
|---|---|---|---|---|---|---|
| YR 2010 TRAFFIC = | 16800 | 7.0% TRUCKS | D=260mm (10in.) | D=280mm (11in.) | SN=5 | SN=6 |
| AUTO | 11710 | 69.7 | 3.51 | 3.51 | 3.51 | 3.51 |
| LT. TRUCK | 3914 | 23.3 | 7.83 | 7.83 | 7.83 | 7.83 |
| 2 AXLE-6 TIRE | 151 | 0.9 | 27.97 | 28.27 | 26.76 | 26.91 |
| 3 AXLE TANDEM | 50 | 0.3 | 39.92 | 40.72 | 25.35 | 26.46 |
| 4 AXLE 1 TRAILER | 319 | 1.9 | 233.02 | 234.29 | 206.84 | 211.31 |
| 5 AXLE 1 TRAILER | 655 | 3.9 | 1352.33 | 1364.78 | 809.17 | 824.90 |
| 5 AXLE 2 TRAILER | 0 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 AXLE 2 TRAILER | 0 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| TOTALS | 16800 | 100.0 | 1664.58 | 1679.41 | 1078.47 | 1100.92 |

| 10 YEAR ACCUMULATED ESAL'S | |
|---|---|
| RIGID PAVEMENT: | |
| D=260mm: | 5,334,333 |
| D=280mm: | 5,381,871 |
| FLEXIBLE PAVEMENT: | |
| SN=5 : | 3,459,280 |
| SN=6 : | 3,528,031 |

| | | % DIST. | 18 KIP ADL ON RIGID PVMNT.* | | 18 KIP ADL ON FLEX. PVMNT.* | |
|---|---|---|---|---|---|---|
| YR 2020 TRAFFIC = | 20900 | 7.0% TRUCKS | D=260mm (10in.) | D=280mm (11in.) | SN=5 | SN=6 |
| AUTO | 14567 | 69.7 | 4.37 | 4.37 | 4.37 | 4.37 |
| LT. TRUCK | 4870 | 23.3 | 9.74 | 9.74 | 9.74 | 9.74 |
| 2 AXLE-6 TIRE | 188 | 0.9 | 34.80 | 35.17 | 33.28 | 33.48 |
| 3 AXLE TANDEM | 63 | 0.3 | 49.66 | 50.66 | 31.54 | 32.92 |
| 4 AXLE 1 TRAILER | 397 | 1.9 | 289.88 | 291.47 | 257.32 | 262.88 |
| 5 AXLE 1 TRAILER | 815 | 3.9 | 1682.37 | 1697.85 | 1006.65 | 1026.21 |
| 5 AXLE 2 TRAILER | 0 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 AXLE 2 TRAILER | 0 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| TOTALS | 20900 | 100.0 | 2070.82 | 2089.27 | 1342.91 | 1369.60 |

| 20 YEAR ACCUMULATED ESAL'S | |
|---|---|
| RIGID PAVEMENT: | |
| D=260mm: | 12,151,[illegible] |
| D=280mm: | 12,259,720 |
| FLEXIBLE PAVEMENT: | |
| SN=6 : | 7,880,123 |
| SN=6 : | 8,036,734 |

* USING TERMINAL SERVICEABILITY OF 2.5 / FACILITY TYPE RURAL
USING 1992, 1993, & 1994 KANSAS TRUCK WEIGHT DATA

03-Mar-99

Kansas Department of Transportation

**KDOT**

Bureau of Transportation Planning,
Docking State Office Building, Room 830
915 Harrison
Topeka, Kansas 66612-1568

# FAX

Date: 3-22-99
Number of pages including cover sheet: 5

To: EARL LAIRD
TP&R CONSULTANT
Phone: (775) 882-4755
Fax phone: (775) 882-4565
CC:

From: ALAN SPICER
TRAFFIC AND FIELD OPERATIONS ENGINEER
KANSAS DOT
Phone: 785-296-3470
Fax phone: 785-296-8168
spicer@ksdot.org

REMARKS: ☐ Urgent ☐ For your review ☐ Reply ASAP ☐ Please comment

Earl-
If you have questions about our answers or our data - feel free to give Garry or me a call. Good-luck
-Alan

**If assistance is needed, please contact Phyllis Bailey or Rachel Quinlan at (785) 296-3841**

**EARL T. LAIRD**
**T P & R CONSULTANT**
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 19, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Kansas DOT; Mr. Garrett Olson ; Field Data Collection Engineer; (785) 296-6351 Fax: (785) 296-8168

Please check One: Surveyed State (Does __) or (Does Not __) wish to be identified on how the state answered any of the survey questions. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes:___
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

Q NO. 3: Do you break down ESALS by vehicle classification?

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design years?

Q No. 6: Do you use WIM data? If No what do you use for load data?

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,
Earl T. Laird.

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775) 882-4755 Fax (775) 882-4565
E-mail: ETLAIRD@AOL.COM

FAX COVER SHEET
Number of pages including this cover sheet 2

TO: Garrett Olson FAX NUMBER: (785) 296-8168
Field Data Collection Engineer

FROM: Earl Laird FAX NUMBER: (775) 882-4565

DATE: March 19, 1999 TIME: 8:30 AM

SUBJECT: State Survey of ESAL Use For Pavement Design and Rehabilitation

==================================================================

REMARKS:
Hello Garrett Olson:

Per our phone conservation this A.M., attached is the small questionnaire dealing with your state's use of ESALS data in the design and rehabilitation of pavements. As I explained to you, the ESAL survey is part of a contract Nichols Consulting Engineers of Reno has with Arizona DOT dealing with ESAL design and its use in pavement design and rehab.

If you have any questions please call me at (775) 882-4755.

You may fax your answers to me at Fax No. (775) 882-4565.

Thanks for your anticipated help.
1
Earl T. Laird (:>))

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 16, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Oklahoma DOT; Mr. Daryl Johnson; Traffic Analyst; (405) 521-2575 Fax: (405) 521-6917

Please check One: Surveyed State (Does __) or (Does Not __) wish to be identified on how the state answered any of the survey questions. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes: ✓
No: __ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.) LEGAL LIMIT TYPE 9 (80 K)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

Q NO. 3: Do you break down ESALS by vehicle classification? NO

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they? → RIGID - 4.066 ESAL/T; FLEX - 2.378

Q No. 5: Do you use Growth factors to expand ESAL's to design years? NO

Q No. 6: Do you use WIM data? If No what do you use for load data? NO

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL growth factors? NO, NO ESTIMATE TRAFFIC GROWTH, ASSUME ESAL/T3 SAME

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab? HIGH, CONSERVATIVE APPLICATION (SAFETY #1)

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird. [signature]

03/19/99 FRI 10:02 [TX/RX NO 7333]

**EARL T. LAIRD**
**T P & R CONSULTANT**
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 16, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Oklahoma DOT; Mr. Daryl Johnson; Traffic Analyst; (405) 521-2575 Fax: (405) 521-6917

Please check One: Surveyed State (Does __) or (Does Not __) wish to be identified on how the state answered any of the survey questions. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes:___
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

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Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design years?

Q No. 6: Do you use WIM data? If No what do you use for load data?

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird.

EARL T. LAIRD
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(775) 882-4755 Fax (775) 882-4565
E-mail: ETLAIRD@AOL.COM

FAX COVER SHEET
Number of pages including this cover sheet 2

TO: Daryl Johnson FAX NUMBER: (405) 521-6917
Planning Traffic Analyst

FROM: Earl Laird ETL FAX NUMBER: (775) 882-4565

DATE: March 18, 1999 TIME: 8:00 AM

SUBJECT: State Survey of ESAL Use For Pavement Design and Rehabilitation

================================================================

REMARKS:
Hello Daryl Johnson:

Per our phone conservation this A.M., attached is the small questionnaire dealing with your state's use of ESALS data in the design and rehabilitation of pavements. As I explained to you, the ESAL survey is part of a contract Nichols Consulting Engineers of Reno has with Arizona DOT dealing with ESAL design and its use in pavement design and rehab.

If you have any questions please call me at (775) 882-4755.

You may fax your answers to me at Fax No. (775) 882-4565.

Thanks for your anticipated help.
1
Earl T. Laird (:>))

OKLAHOMA DEPARTMENT OF TRANSPORTATION

**Date:** 3-19-99

**To:** MR. EARL T. LAIRD

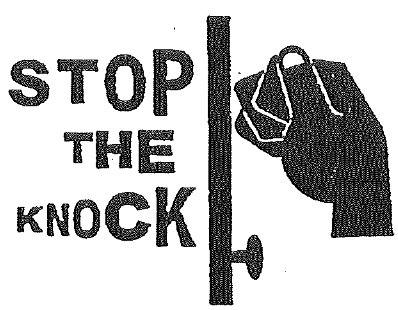
**Fax #:** 775 882 — 4565

**From:** DARYL JOHNSON

**Fax #:** **(405) 521-6917**

**Subject:** ESAL QUESTIONAIRE

**Number of Pages Including Cover Sheet:** 2




**Please remind drivers to:**

- Not drink and drive
- Watch speed limits
- Wear passenger restraints

Subj: **RE: Survey ESAL Use In Pavement Design**
Date: 3/22/99 10:16:47 AM Pacific Standard Time
From: SFugit@itd.state.id.us (Scott Fugit)
To: ETLAIRD@aol.com ('ETLAIRD@aol.com')

IDAHO DOT
RESPONSES
WITH FAX ESAL TABLE

Earl
Here's Idaho's responses. I hope this helps. Let me know if you have any other questions. I will have the ESAL report fax going out to you sometime today. I would appreciate a copy of your results when your done. Thanks Earl. Good luck.

Scott W. Fugit
Traffic Survey and Analysis Section
Idaho Transportation Department
ph: 208-334-8207
fx: 208-334-4432
email: sfugit@itd.state.id.us

Question #1. Yes

Question #2. We use volume, some basic classification breakdown (commercial versus non-commercial) and WIM data to establish and update ESAL tables. Yes, I would be glad to fax you a sample of the ESAL table used by ITD.

Question #3. No. The ADT estimates are shown for passenger cars and commercial vehicles on the ESAL Report, but all of the actual ESAL numbers are combined for all vehicles.

Question #4. ESAL's are not specified for separate vehicle classifications.

Question #5. Yes. We use a straight 20 year design life linear growth estimate for ESALs.

Question #6. Yes. WIM data is used to do periodic updates of the ESAL tables on which estimates are based.

Question #7. I am assuming by PMS your referring to HPMS. With that in mind the answer is no, not directly. Some of the same classification data used for HPMS submissions are also used to contribute to figuring the commercial/non-commercial breakdown on the ESAL report, but there is no direct connection. The HPMS and ESAL growth factors are different.

Question #8. We have good confidence that our ESAL report provides our clients with good ESAL estimates – but they could be even better. We are attempting to update the ESAL table more often to provide more detailed ESAL information based on the most recent data available.

-----Original Message-----
From: ETLAIRD@aol.com [mailto:ETLAIRD@aol.com]
Sent: Thursday, March 18, 1999 10:58 AM
To: SFUGIT@itd.state.id.us
Subject: Survey ESAL Use In Pavement Design

EARL T. LAIRD
T P & R CONSULTANT

·Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 16, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona
DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Idaho Dept. of Highways; Mr. Scott W. Fugit; Traffic Survey;
(406) 444-6295 Fax: (208) 334-8207

Please check One: Surveyed State (Does __ ) or (Does Not __) wish to be identified on how the state answered any of the survey questioned. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for
pavement design and rehabilitation?
Yes:___
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with

the ESAL table values? (Will you fax us the first page
of your ESAL table for an example.)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load
information for that location?

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Q No. 4: Do you apply average ESAL factors to the vehicles in
each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design
years?

Q No. 6: Do you use WIM data? If No what do you use for load
data?

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL

growth factors?

Q No. 8: How much confidence do you have in the values you use
for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird.

---------------- Headers ----------------------
Return-Path: <SFugit@itd.state.id.us>
Received: from rly-zb01.mx.aol.com (rly-zb01.mail.aol.com [172.31.41.1]) by air-zb02.mail.aol.com (v58.13) with SMTP; Mon, 22 Mar 1999 13:16:46 -0500
Received: from hqissv09.itd.state.id.us (hqissv09.itd.state.id.us [164.165.237.9])
by rly-zb01.mx.aol.com (8.8.8/8.8.5/AOL-4.0.0)
with ESMTP id NAA16658 for <ETLAIRD@aol.com>;
Mon, 22 Mar 1999 13:16:43 -0500 (EST)
Received: by HQISSV09 with Internet Mail Service (5.5.2232.9)
id <FZCHKF0P>; Mon, 22 Mar 1999 11:16:29 -0700
Message-ID: <7C3F7CD4E21FD1119F73006097DBB254E9F377@HQISSV10.itd.state.id.us>
From: Scott Fugit <SFugit@itd.state.id.us>
To: "'ETLAIRD@aol.com'" <ETLAIRD@aol.com>
Subject: RE: Survey ESAL Use In Pavement Design
Date: Mon, 22 Mar 1999 11:16:25 -0700
MIME-Version: 1.0
X-Mailer: Internet Mail Service (5.5.2232.9)
Content-Type: text/plain;
charset="iso-8859-1"

PROJECTED COMMERCIAL AND 18,000 EQUIVALENT SINGLE AXLE LOADINGS (ESALS)

10:08 MONDAY, MARCH 15, 1999 1

ROUTE NUMBER : SH 75 SEGMENT CODE : 002230 BEGINNING MILEPOINT : 202.439 ENDING MILEPOINT : 202.476
TRUCK DENSITY = 1 : LIGHT LAST YEAR WITH DATA : 1997 CUMULATING ESALS UP TO 2020 STARTING TO CUMULATE IN 2000

| YEAR | PASSENGER CAR ADT | PICKUP ADT | COMMERCIAL ADT | RIGID PAVEMENT ESAL (IN THOUSANDS) ESALS:BOTH DIRECTIONS YEAR VALUE | CUMULATIVE | 50% DIRECTION OF TRAVEL YEAR VALUE | CUMULATIVE | FLEXIBLE PAVEMENT ESAL (IN THOUSANDS) ESALS:BOTH DIRECTIONS YEAR VALUE | CUMULATIVE | 50% DIRECTION OF TRAVEL YEAR VALUE | CUMULATIVE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1997 | 620 | 0 | 80 | | | | | | | | |
| 2000 | 650 | 0 | 90 | 13 | 13 | 7 | 7 | 10 | 10 | 5 | 5 |
| 2001 | 660 | 0 | 90 | 14 | 27 | 7 | 13 | 10 | 20 | 5 | 10 |
| 2002 | 670 | 0 | 90 | 14 | 41 | 7 | 20 | 11 | 31 | 5 | 15 |
| 2003 | 680 | 0 | 90 | 14 | 55 | 7 | 27 | 11 | 42 | 5 | 21 |
| 2004 | 690 | 0 | 90 | 14 | 69 | 7 | 35 | 11 | 53 | 6 | 26 |
| 2005 | 690 | 0 | 100 | 15 | 84 | 7 | 42 | 11 | 64 | 6 | 32 |
| 2006 | 700 | 0 | 100 | 15 | 99 | 8 | 50 | 11 | 76 | 6 | 38 |
| 2007 | 710 | 0 | 100 | 15 | 114 | 8 | 57 | 12 | 87 | 6 | 44 |
| 2008 | 720 | 0 | 100 | 16 | 130 | 8 | 65 | 12 | 99 | 6 | 50 |
| 2009 | 730 | 0 | 100 | 16 | 146 | 8 | 73 | 12 | 111 | 6 | 56 |
| 2010 | 740 | 0 | 110 | 16 | 162 | 8 | 81 | 12 | 124 | 6 | 62 |
| 2011 | 750 | 0 | 110 | 17 | 179 | 8 | 90 | 13 | 137 | 6 | 68 |
| 2012 | 760 | 0 | 110 | 17 | 196 | 8 | 98 | 13 | 149 | 6 | 75 |
| 2013 | 770 | 0 | 110 | 17 | 213 | 9 | 107 | 13 | 163 | 7 | 81 |
| 2014 | 780 | 0 | 110 | 18 | 231 | 9 | 115 | 13 | 176 | 7 | 88 |
| 2015 | 790 | 0 | 120 | 18 | 249 | 9 | 124 | 14 | 190 | 7 | 95 |
| 2016 | 800 | 0 | 120 | 18 | 267 | 9 | 133 | 14 | 203 | 7 | 102 |
| 2017 | 810 | 0 | 120 | 18 | 285 | 9 | 143 | 14 | 218 | 7 | 109 |
| 2018 | 820 | 0 | 120 | 19 | 304 | 9 | 152 | 14 | 232 | 7 | 116 |
| 2019 | 820 | 0 | 120 | 19 | 323 | 10 | 162 | 15 | 246 | 7 | 123 |
| 2020 | 830 | 0 | 130 | 19 | 342 | 10 | 171 | 15 | 261 | 7 | 131 |

IDAHO

# FAX

## From The Idaho Transportation Department
## Traffic Survey and Analysis Section

To: Earl Laird
Of: TP&R Consulting
Phone: 775-882-4755
Fax: 775-882-4565
Number of pages: 2 including cover page

From: Scott Fugit
Ph: (208)334-8207
Fax: (208)334-4432
Date: 22 March, 1999
Email: sfugit@itd.state.id.us

Subject: ITD's Projected ESAL Loadings Report

Earl

In conjunction with question #2 on your ESAL survey, attached please find a copy of ITD's Projected ESAL Loadings Report. If you have any questions, or I can be of any further service, please don't hesitate to contact me. Good luck.

Scott

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 16, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Idaho Dept. of Highways; Mr. Scott W. Fugit; Traffic Survey;
(406) 444-6295 Fax: (208) 334-8207

Please check One: Surveyed State (Does __ ) or (Does Not __) wish to be identified on how the state answered any of the survey questioned. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes:___
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

Q NO. 3: Do you break down ESALS by vehicle classification?

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design years?

Q No. 6: Do you use WIM data? If No what do you use for load data?

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone, e-mail or Fax Number. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird.

OREGON DOT
REPLY

HIGHLITE IN YELLOW

Subj: **RE: Survey ESAL Use For Design**
Date: 3/16/99 7:04:19 AM Pacific Standard Time
From: Jeffrey.L.GOWER@odot.state.or.us
To: ETLAIRD@aol.com

My response to your questionnaire is below, my comments are in bold print to help you identify them. Hope this information is helpful.

> -----Original Message-----
> From: ETLAIRD@aol.com [SMTP:ETLAIRD@aol.com]
> Sent: Monday, March 15, 1999 5:04 PM
> To: GOWER Jeffrey L
> Subject: Survey ESAL Use For Design
>
> EARL T. LAIRD
> T P & R CONSULTANT
> Transportation Planning and Research
> 529 Bonanza Dr., Carson City, NV. 89706
> (775)882-4755 Fax (775)882-4565
> E-mail: etlaird@aol.com
>
> March 15, 1999
>
> Survey of States using ESALS for pavement design and rehabilitation. EASL
> Data information being collected for a ESAL Research Contract between
> Arizona
> DOT and Nichols Consulting Engineers in Reno, Nevada:
>
> Survey State of: **Oregon DOT; Mr. Jeffrey L. Gower; Pavement Design;**
> **(503)986-3123**
>
> Please check One: Surveyed State (Does _X_ ) or (Does Not __) wish to be
> identified on how the state answered any of the survey questioned. Only
> identify the state as a participant in the survey.
>
> Question No. 1: Does your state use ESAL computations for
> pavement design and rehabilitation?
> Yes:_X__
> No:___ If No what do you use?
>
> Q No. 2: What type or types of data do you use to come up with
>
> the ESAL table values? (Will you fax us the first page
> of your ESAL table for an example.)
>
> a. Do you use a single ESAL table for all design locations within your
> state
> or is a different ESAL value computed for different locations based upon
> load
> information for that location?**Single table**
>
> Q NO. 3: Do you break down ESALS by vehicle classification?**Yes**
>
> Q No. 4: Do you apply average ESAL factors to the vehicles in
> each classification? What are they?**Yes, See table at end.**
>
> Q No. 5: Do you use Growth factors to expand ESAL's to design
> years?**YES**

>
> Q No. 6: Do you use WIM data? If No what do you use for load
> data?Only for vehicle counts.
>
> Q No. 7: Are there links between PMS data and the ESAL tables?Yes
> a. Are your growth factors for PMS the same for ESAL
> growth factors?Yes
>
> Q No. 8: How much confidence do you have in the values you use
> for pavement design and rehab?They are only as reasonable as the
> vehicle count information. Average axle weight information is probably
> conservative if anything.
>
> Survey States comments if any:
>
> Truck ESAL Table
>

| | |
|---|---|
| > Two Axle Truck: | 0.27 ESALS per Truck |
| > Three Axle Truck: | 0.60 ESALS per Truck |
| > Four Axle Truck: | 0.88 ESALS per Truck |
| > Five or more Axles: | 1.78 ESALS per Truck |
| > Buses: | 1.98 ESALS per Truck |

>
> Thank you for participating in this ESAL pavement design and
> rehabilitation
> survey. If you have any questions on this survey you may contact Earl
> Laird
> at above telephone or e-mail. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal
> Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955
> or
> e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT;
> telephone (602)407-3435; e-mail ekombe@dot.state.az
>
> Thank you again,
>
> Earl T. Laird.

———— Headers ————

Return-Path: <Jeffrey.L.GOWER@odot.state.or.us>
Received: from rly-zb01.mx.aol.com (rly-zb01.mail.aol.com [172.31.41.1]) by air-zb02.mail.aol.com (v56.26) with SMTP; Tue, 16 Mar 1999 10:04:18 -0500
Received: from odot.state.or.us (goofy.odot.state.or.us [167.131.11.233] (may be forged))
by rly-zb01.mx.aol.com (8.8.8/8.8.5/AOL-4.0.0)
with ESMTP id KAA04513 for <ETLAIRD@aol.com>;
Tue, 16 Mar 1999 10:04:16 -0500 (EST)
From: Jeffrey.L.GOWER@odot.state.or.us
Received: by exsalem1.isb.odot.state.or.us with Internet Mail Service (5.5.2232.9)
id <HBS3PVTJ>; Tue, 16 Mar 1999 07:04:16 -0800
Message-ID: <BF03ED27D2C2D111AEA500A0C95DC7900141072B@EXSALEM3.highway.odot.state.or.us>
To: ETLAIRD@aol.com
Subject: RE: Survey ESAL Use For Design
Date: Tue, 16 Mar 1999 07:04:14 -0800
MIME-Version: 1.0
X-Mailer: Internet Mail Service (5.5.2232.9)
Content-Type: text/plain

EARL T. LAIRD
T P & R CONSULTANT
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775)882-4755 Fax (775)882-4565
E-mail: etlaird@aol.com

March 15, 1999

Survey of States using ESALS for pavement design and rehabilitation. EASL Data information being collected for a ESAL Research Contract between Arizona DOT and Nichols Consulting Engineers in Reno, Nevada:

Survey State of: Oregon DOT; Mr. Jeffrey L. Gower; Pavement Design;
(503)986-3123

Please check One: Surveyed State (Does __ ) or (Does Not __) wish to be identified on how the state answered any of the survey questioned. Only identify the state as a participant in the survey.

Question No. 1: Does your state use ESAL computations for pavement design and rehabilitation?
Yes:___
No:___ If No what do you use?

Q No. 2: What type or types of data do you use to come up with the ESAL table values? (Will you fax us the first page of your ESAL table for an example.)

a. Do you use a single ESAL table for all design locations within your state or is a different ESAL value computed for different locations based upon load information for that location?

Q NO. 3: Do you break down ESALS by vehicle classification?

Q No. 4: Do you apply average ESAL factors to the vehicles in each classification? What are they?

Q No. 5: Do you use Growth factors to expand ESAL's to design years?

Q No. 6: Do you use WIM data? If No what do you use for load data?

Q No. 7: Are there links between PMS data and the ESAL tables?
a. Are your growth factors for PMS the same for ESAL growth factors?

Q No. 8: How much confidence do you have in the values you use for pavement design and rehab?

Survey States comments if any:

Thank you for participating in this ESAL pavement design and rehabilitation survey. If you have any questions on this survey you may contact Earl Laird at above telephone or e-mail. Or: Dr. Sirous Alavi, Ph.D., P.E.; Principal Investigator; Nichols Consulting Engineers, Chtd., Phone No. (775)329-4955 or e-mail sirous@nce.reno.nv.us; or, Dr. Estomih M. Kombe; Arizona DOT; telephone (602)407-3435; e-mail ekombe@dot.state.az

Thank you again,

Earl T. Laird.

**EARL T. LAIRD**
**T P & R CONSULTANT**
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775) 882-4755 Fax (775) 882-4565
E-mail: ETLAIRD@AOL.COM

KANSAS
THANKS

**FAX COVER SHEET**
Number of pages including this cover sheet 2

**TO:** Garrett Olson **FAX NUMBER:** (785) 296-8168
Field Data Collection Engineer

**FROM:** Earl Laird ELT **FAX NUMBER:** (775) 882-4565

**DATE:** March 24, 1999 **TIME:** 4:50 PM

**SUBJECT:** State Survey of ESAL Use For Pavement Design and Rehabilitation

==========================================================

**REMARKS:**
Hello Garrett Olson:

Thank you for the quick and very informative reply to the questionnaire on ESAL use in pavement design. Of the 8 states I have received back questionnaires, I must tell you that your state, thus far and I know this is not a contest, has the most aggressive ESAL tables. You have ESAL by truck class, by functional class, by pavement depth and future years, etc.. Very, very nice ESAL reporting. This old traffic guy like to see traffic reports that show the user we know how to collect traffic data and how to report same. Very good reporting. Why collect the data unless you are going to put it in a report form that the user can and should use. Thanks for showing it can be done.

Thanks again for your states input.

Earl T. (:>)) EarlT

OKLAHOMA THANKS

**EARL T. LAIRD**
**T P & R CONSULTANT**
Transportation Planning and Research
529 Bonanza Dr., Carson City, NV. 89706
(775) 882-4755 Fax (775) 882-4565
E-mail: ETLAIRD@AOL.COM

**FAX COVER SHEET**

Number of pages including this cover sheet 2

**TO:** Daryl Johnson **FAX NUMBER:** (405) 521-6917
Planning Traffic Analyst

**FROM:** Earl Laird ETL **FAX NUMBER:** (775) 882-4565

**DATE:** March 24, 1999 **TIME:** 4:30 PM

**SUBJECT:** Thanks for State Survey of ESAL Use For Pavement Design and Rehabilitation

**REMARKS:**

Hello Daryl Johnson:

Thank you for the quick and very informative reply to the questionnaire on the use of ESAL's in pavement design.

Thanks again,

Earl T. (:>)) ETL

# APPENDIX D: NEW ESAL TABLE USER'S MANUAL

## APPENDIX D: NEW ESAL TABLE USER'S MANUAL

The following serves as reference documentation for all of the electronic files included in the new ADOT ESAL Tables. Electronic copies of three files are included, as listed below:

- Average_ESAL_Table.xls
- OneStdDev_ESAL_Table.xls
- TwoStdDev_ESAL_Table.xls

There are 14 worksheets in each of the three Microsoft Excel spreadsheets. These worksheets are defined on the following pages. The definitions follow a consistent format of identifying the worksheet name at the top of each table, and then describing the contents of each column within the worksheet. Ten worksheets are the same for all three files. The only difference between each file is the value used in the ESAL calculation. The Average_ESAL_Table file uses either the measured or the system average values for ESALs per vehicle class, while the OneStdDev_ESAL_Table and TwoStdDev_ESAL_Table files use the measured or average ESAL values plus one and plus two standard deviations, respectively. These standard deviations are calculated using the differences in average ESALs per each vehicle class for all WIM systems.

All three files are over 20 Megabytes in size as they contain a large amount of information and they are also set up to recalculate the final KESAL values based on changes made to any of the worksheets. The following is a list of activities that a user may want to perform (referenced by **worksheet name** and *column name*):

- Create a new segment.
  - **All worksheets** (except **Stdev ESALs per Class**), *SEGMENT* (or *SECTID*): if additional traffic sections are created, the site information would need to be created in **Site Info** and then the *SEGMENT* (or *SECTID*), as well as *ATR* and *class* columns would need to be updated in the other worksheets. For worksheets where equations are present, simply paste the equation from an adjacent row into the new segment's row.

- Reset KESALs to Zero following a reconstruction or overlay.
  - **Cum.One-way Flex + 10 percent, Cum One-way Rigid**, *KESAL Yr*: in each of the two spreadsheets, enter "0" for the year in which the reconstruction or overlay took place for the segment. The KESAL values will remain cumulative from that point on.

- Modify a segment's percent growth.
  - **AADT 1974-2020**, *Forecasting Percent Growth*: if the user would like to modify the growth factor for any segment, enter the revised factor in this column. The forecasted AADT values will automatically be recalculated as will the KESAL values.

- Limit the maximum AADT for a segment
  - **AADT 1974-2020**, *AADT Yr*: if the user would like to limit the maximum AADT for a particular segment, enter the value into the year in which maximum capacity will be reached and then copy that value for future years. Each file contains the worksheet **Capacity** that indicates--by pass or fail--whether a section is under capacity for each year. Each file also has the worksheet **Total Theoretical Capacity** that contains the actual AADT value that is assumed to be the maximum capacity.

- Adjust the maximum AADT for a segment.
  - **Number of Lanes**, *# Lanes Yr*: if there is going to be additional lanes constructed for a segment, enter the new number of lanes in the year where construction will be completed and then copy that value into future years.
  - **Total Theoretical Capacity**, *Year Yr*: these values are all calculated based on the assumption that 27,500 vehicles per lane per day is the maximum capacity and multiplying this value by the number of lanes. If the user wishes to modify the maximum capacity per lane, then the equation should be modified and copied to all related cells. Another method would be to replace the equation with a new value (i.e., replace the calculated 110,000 vehicles per day with 125,000).

- Adjust the ESALs per vehicle class.
  - **Rigid ESALs, Flexible ESALs**, *ESALcls**: the user can replace the value for either rigid or flexible pavements (or both) for any segment. The final KESAL values will be recalculated automatically.

- Adjust the percentage of each vehicle class.
  - **Percent Vehicle Type Table**, percent *Cls* *: the user can replace the percentage of any vehicle class for any segment (note: there is no check to confirm the percentages add up to 100 percent). The final KESAL values will be recalculated automatically.

These instructions were provided assuming the user was using the Average_ESAL_Table File. They can be applied to the other two files by changing the following: **Cum.One-way Flex +10 percent** to **Cum 1way Flex 10 percent 1 stdev** or **Cum 1way Flex 10 percent 2 stdev**, **Cum One-Way Rigid** to **Cum One-Way Rigid 1 stdev** or **Cum One-Way Rigid 2 stdev**. All other referenced tables are the same for all three files.

Worksheets in Average_ESAL_Table

| Site Info (ADOT % Trucks)--from *TR9397C.xls* | |
|---|---|
| Column | Description |
| SECTID | The segment number as designated by ADOT (ADOT uses segment and SECTID interchangeably) |
| RTE_L | The route type (i.e., I = interstate, U = U.S. highway, S = state highway) |
| RTE_N | The route number |
| BMP | The beginning milepost of the segment |
| STARTING | A description of the beginning location of the segment in terms of nearest exit/interchange |
| EMP | The ending milepost of the segment |
| ENDING | A description of the ending location of the segment in terms of nearest exit/interchange |
| ORDER | A counting function that begins with 1 and increases by 1 for each segment |
| SEC_LEN | The length of the segment (in miles) |
| ATR | The Automatic Traffic Recorder assosicated with each segment |
| CLASS | The classification station associated with each segment |
| SECTION | The segment number as designated by ADOT |
| LANES | The total number of lanes (in both directions) within the segment |
| AADT93 | The AADT for each segment as reported by ADOT for 1993 |
| PCCV93 | The percent commercial vehciles for each segment as reported by ADOT for 1993 |
| AADT94 | The AADT for each segment as reported by ADOT for 1994 |
| PCCV94 | The percent commercial vehciles for each segment as reported by ADOT for 1994 |
| AADT95 | The AADT for each segment as reported by ADOT for 1995 |
| PCCV95 | The percent commercial vehciles for each segment as reported by ADOT for 1995 |
| AADT96 | The AADT for each segment as reported by ADOT for 1996 |
| PCCV96 | The percent commercial vehciles for each segment as reported by ADOT for 1996 |
| AADT97 | The AADT for each segment as reported by ADOT for 1997 |
| PCCV97 | The percent commercial vehciles for each segment as reported by ADOT for 1997 |
| EST_DATE | The year the traffic segment was established |
| CNTFRQ | The frequency with which traffic counts are performed at each segment |
| STATUS | The status of the most recent traffic count for each segment |
| LASTCNT | The year of the last traffic count for each segment |
| NEXTCNT | The year of the next traffic count for each segment |
| MISSCNT | Whether the traffic count was successfully collected (FALSE) or not (TRUE) at each segment |
| REMARKS | Comments by ADOT regarding each segment |

| Cum.One-way Flex + 10% | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | The total one-way KESALs for each segment in 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 1998 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 1999 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2000 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2001 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2002 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2003 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2004 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2005 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2006 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2007 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2008 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2009 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2010 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2011 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2012 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2013 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2014 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2015 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2016 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2017 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2018 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2019 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |
| KESAL 2020 | The total one-way KESALs for each segment since 1997 assuming a flexible pavement and adding a 10% factor of safety for vechicle classes 9-13 |

Worksheets in Average_ESAL_Table

| Cum One-way Rigid | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | Total one-way KESALs for each segment based on a rigid pavement for 1997 |
| KESAL 1998 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 1999 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2000 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2001 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2002 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2003 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2004 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2005 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2006 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2007 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2008 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2009 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2010 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2011 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2012 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2013 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2014 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2015 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2016 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2017 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2018 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2019 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |
| KESAL 2020 | Total one-way KESALs for each segment based on a rigid pavement since 1997 |

Worksheets in Average_ESAL_Table

| AADT 1974-2020--1974-1997 data from *trfc7497.xls* | |
|---|---|
| Column | Description |
| ORDER | A counting function that begins with 1 and increases by 1 for each segment |
| Segment | The segment number as designated by ADOT |
| RTE_L | The route type (i.e., I = interstate, U = U.S. highway, S = state highway) |
| RTE_N | The route number |
| BMP | The beginning milepost of the segment |
| EMP | The ending milepost of the segment |
| SEC_LEN | The length of the segment (in miles) |
| ATR | The Automatic Traffic Recorder assosicated with each segment |
| CLASS | The classification station associated with each segment |
| Segment | The segment number as designated by ADOT |
| PCCV97 | The percent commercial vehicles for each segment as reported by ADOT in 1997 |
| 1974 | The measured AADT for each segment for 1974 |
| 1975 | The measured AADT for each segment for 1975 |
| 1976 | The measured AADT for each segment for 1976 |
| 1977 | The measured AADT for each segment for 1977 |
| 1978 | The measured AADT for each segment for 1978 |
| 1979 | The measured AADT for each segment for 1979 |
| 1980 | The measured AADT for each segment for 1980 |
| 1981 | The measured AADT for each segment for 1981 |
| 1982 | The measured AADT for each segment for 1982 |
| 1983 | The measured AADT for each segment for 1983 |
| 1984 | The measured AADT for each segment for 1984 |
| 1985 | The measured AADT for each segment for 1985 |
| 1986 | The measured AADT for each segment for 1986 |
| 1987 | The measured AADT for each segment for 1987 |
| 1988 | The measured AADT for each segment for 1988 |
| 1989 | The measured AADT for each segment for 1989 |
| 1990 | The measured AADT for each segment for 1990 |
| 1991 | The measured AADT for each segment for 1991 |
| 1992 | The measured AADT for each segment for 1992 |
| 1993 | The measured AADT for each segment for 1993 |
| 1994 | The measured AADT for each segment for 1994 |
| 1995 | The measured AADT for each segment for 1995 |
| 1996 | The measured AADT for each segment for 1996 |
| 1997 | The measured AADT for each segment for 1997 |
| Avg. % Growth | The average % growth for each segment based on the average of the annual growth factors from 1992 to 1997; this value is calculated using Macro 1 |
| Forecasting % Growth | The % growth used in projecting AADT for future years; this differs from the Avg. % Growth where the Avg. % Growth is less than 2% (Forecasting % Growth is never less than 2%) |
| 1996 | The measured AADT for each segment for 1996; this value is repeated but not counted twice |
| 1997 | The measured AADT for each segment for 1997; this value is repeated but not counted twice |
| 1998 | The forecasted AADT for each segment for 1998 |
| 1999 | The forecasted AADT for each segment for 1999 |
| 2000 | The forecasted AADT for each segment for 2000 |
| 2001 | The forecasted AADT for each segment for 2001 |
| 2002 | The forecasted AADT for each segment for 2002 |
| 2003 | The forecasted AADT for each segment for 2003 |
| 2004 | The forecasted AADT for each segment for 2004 |

Worksheets in Average_ESAL_Table

| | |
|---|---|
| 2005 | The forecasted AADT for each segment for 2005 |
| 2006 | The forecasted AADT for each segment for 2006 |
| 2007 | The forecasted AADT for each segment for 2007 |
| 2008 | The forecasted AADT for each segment for 2008 |
| 2009 | The forecasted AADT for each segment for 2009 |
| 2010 | The forecasted AADT for each segment for 2010 |
| 2011 | The forecasted AADT for each segment for 2011 |
| 2012 | The forecasted AADT for each segment for 2012 |
| 2013 | The forecasted AADT for each segment for 2013 |
| 2014 | The forecasted AADT for each segment for 2014 |
| 2015 | The forecasted AADT for each segment for 2015 |
| 2016 | The forecasted AADT for each segment for 2016 |
| 2017 | The forecasted AADT for each segment for 2017 |
| 2018 | The forecasted AADT for each segment for 2018 |
| 2019 | The forecasted AADT for each segment for 2019 |
| 2020 | The forecasted AADT for each segment for 2020 |

Worksheets in Average_ESAL_Table

| Capacity | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| Year 1997 | Indication of whether each segment exceeds capacity in 1997 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 1998 | Indication of whether each segment exceeds capacity in 1998 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 1999 | Indication of whether each segment exceeds capacity in 1999 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2000 | Indication of whether each segment exceeds capacity in 2000 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2001 | Indication of whether each segment exceeds capacity in 2001 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2002 | Indication of whether each segment exceeds capacity in 2002 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2003 | Indication of whether each segment exceeds capacity in 2003 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2004 | Indication of whether each segment exceeds capacity in 2004 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2005 | Indication of whether each segment exceeds capacity in 2005 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2006 | Indication of whether each segment exceeds capacity in 2006 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2007 | Indication of whether each segment exceeds capacity in 2007 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2008 | Indication of whether each segment exceeds capacity in 2008 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2009 | Indication of whether each segment exceeds capacity in 2009 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2010 | Indication of whether each segment exceeds capacity in 2010 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2011 | Indication of whether each segment exceeds capacity in 2011 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2012 | Indication of whether each segment exceeds capacity in 2012 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2013 | Indication of whether each segment exceeds capacity in 2013 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2014 | Indication of whether each segment exceeds capacity in 2014 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2015 | Indication of whether each segment exceeds capacity in 2015 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2016 | Indication of whether each segment exceeds capacity in 2016 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2017 | Indication of whether each segment exceeds capacity in 2017 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2018 | Indication of whether each segment exceeds capacity in 2018 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2019 | Indication of whether each segment exceeds capacity in 2019 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2020 | Indication of whether each segment exceeds capacity in 2020 ("Pass" means under capacity, "Fail" means over capacity) |

| Rigid KESAL One-Way | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | One-way KESALs assuming a rigid pavement for 1997 |
| KESAL 1998 | One-way KESALs assuming a rigid pavement for 1998 |
| KESAL 1999 | One-way KESALs assuming a rigid pavement for 1999 |
| KESAL 2000 | One-way KESALs assuming a rigid pavement for 2000 |
| KESAL 2001 | One-way KESALs assuming a rigid pavement for 2001 |
| KESAL 2002 | One-way KESALs assuming a rigid pavement for 2002 |
| KESAL 2003 | One-way KESALs assuming a rigid pavement for 2003 |
| KESAL 2004 | One-way KESALs assuming a rigid pavement for 2004 |
| KESAL 2005 | One-way KESALs assuming a rigid pavement for 2005 |
| KESAL 2006 | One-way KESALs assuming a rigid pavement for 2006 |
| KESAL 2007 | One-way KESALs assuming a rigid pavement for 2007 |
| KESAL 2008 | One-way KESALs assuming a rigid pavement for 2008 |
| KESAL 2009 | One-way KESALs assuming a rigid pavement for 2009 |
| KESAL 2010 | One-way KESALs assuming a rigid pavement for 2010 |
| KESAL 2011 | One-way KESALs assuming a rigid pavement for 2011 |
| KESAL 2012 | One-way KESALs assuming a rigid pavement for 2012 |
| KESAL 2013 | One-way KESALs assuming a rigid pavement for 2013 |
| KESAL 2014 | One-way KESALs assuming a rigid pavement for 2014 |
| KESAL 2015 | One-way KESALs assuming a rigid pavement for 2015 |
| KESAL 2016 | One-way KESALs assuming a rigid pavement for 2016 |
| KESAL 2017 | One-way KESALs assuming a rigid pavement for 2017 |
| KESAL 2018 | One-way KESALs assuming a rigid pavement for 2018 |
| KESAL 2019 | One-way KESALs assuming a rigid pavement for 2019 |
| KESAL 2020 | One-way KESALs assuming a rigid pavement for 2020 |

Worksheets in Average_ESAL_Table

| Rigid ESALs | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| Class | The classification station number associated with each segment |
| ESALcls4 | The rigid ESALs per vehicle class 4 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 4 vehicles is applied. |
| ESALcls5 | The rigid ESALs per vehicle class 5 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 5 vehicles is applied. |
| ESALcls6 | The rigid ESALs per vehicle class 6 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 6 vehicles is applied. |
| ESALcls7 | The rigid ESALs per vehicle class 7 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 7 vehicles is applied. |
| ESALcls8 | The rigid ESALs per vehicle class 8 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 8 vehicles is applied. |
| ESALcls9 | The rigid ESALs per vehicle class 9 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 9 vehicles is applied. |
| ESALcls10 | The rigid ESALs per vehicle class 10 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 10 vehicles is applied. |
| ESALcls11 | The rigid ESALs per vehicle class 11 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 11 vehicles is applied. |
| ESALcls12 | The rigid ESALs per vehicle class 12 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 12 vehicles is applied. |
| ESALcls13 | The rigid ESALs per vehicle class 13 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 13 vehicles is applied. |

Worksheets in Average_ESAL_Table

| 10% added Flex. KESAL One-Way | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | Total one-way KESALs for each segment for 1997 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 1998 | Total one-way KESALs for each segment for 1998 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 1999 | Total one-way KESALs for each segment for 1999 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2000 | Total one-way KESALs for each segment for 2000 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2001 | Total one-way KESALs for each segment for 2001 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2002 | Total one-way KESALs for each segment for 2002 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2003 | Total one-way KESALs for each segment for 2003 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2004 | Total one-way KESALs for each segment for 2004 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2005 | Total one-way KESALs for each segment for 2005 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2006 | Total one-way KESALs for each segment for 2006 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2007 | Total one-way KESALs for each segment for 2007 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2008 | Total one-way KESALs for each segment for 2008 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2009 | Total one-way KESALs for each segment for 2009 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2010 | Total one-way KESALs for each segment for 2010 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2011 | Total one-way KESALs for each segment for 2011 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2012 | Total one-way KESALs for each segment for 2012 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2013 | Total one-way KESALs for each segment for 2013 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2014 | Total one-way KESALs for each segment for 2014 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2015 | Total one-way KESALs for each segment for 2015 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2016 | Total one-way KESALs for each segment for 2016 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2017 | Total one-way KESALs for each segment for 2017 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2018 | Total one-way KESALs for each segment for 2018 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2019 | Total one-way KESALs for each segment for 2019 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |
| KESAL 2020 | Total one-way KESALs for each segment for 2020 based on a flexible pavement and including a 10% factor of safety for vehicle classes 9-13. |

Worksheets in Average_ESAL_Table

| Flexible ESALs | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| Class | The classification station number associated with each segment |
| ESALcls4 | The flexible ESALs per vehicle class 4 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 4 vehicles is applied. |
| ESALcls5 | The flexible ESALs per vehicle class 5 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 5 vehicles is applied. |
| ESALcls6 | The flexible ESALs per vehicle class 6 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 6 vehicles is applied. |
| ESALcls7 | The flexible ESALs per vehicle class 7 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 7 vehicles is applied. |
| ESALcls8 | The flexible ESALs per vehicle class 8 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 8 vehicles is applied. |
| ESALcls9 | The flexible ESALs per vehicle class 9 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 9 vehicles is applied. |
| ESALcls10 | The flexible ESALs per vehicle class 10 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 10 vehicles is applied. |
| ESALcls11 | The flexible ESALs per vehicle class 11 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 11 vehicles is applied. |
| ESALcls12 | The flexible ESALs per vehicle class 12 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 12 vehicles is applied. |
| ESALcls13 | The flexible ESALs per vehicle class 13 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 13 vehicles is applied. |

| Stdev ESALs per Cls | |
|---|---|
| Column | Description |
| Column 1 | This table contains the mean, plus one standard deviation and plus two standard deviations for ESALs per vehicle class for both rigid and flexible pavements |
| Class 4 | These values for vechilce class 4 |
| Class 5 | These values for vechilce class 5 |
| Class 6 | These values for vechilce class 6 |
| Class 7 | These values for vechilce class 7 |
| Class 8 | These values for vechilce class 8 |
| Class 9 | These values for vechilce class 9 |
| Class 10 | These values for vechilce class 10 |
| Class 11 | These values for vechilce class 11 |
| Class 12 | These values for vechilce class 12 |
| Class 13 | These values for vechilce class 13 |

| AADT Percent Growth All Years | |
|---|---|
| Column | Description |
| Segment | The segment number as designated by ADOT |
| % Growth 1974 | The percent growth in AADT for each segment for 1974 |
| % Growth 1975 | The percent growth in AADT for each segment for 1975 |
| % Growth 1976 | The percent growth in AADT for each segment for 1976 |
| % Growth 1977 | The percent growth in AADT for each segment for 1977 |
| % Growth 1978 | The percent growth in AADT for each segment for 1978 |
| % Growth 1979 | The percent growth in AADT for each segment for 1979 |
| % Growth 1980 | The percent growth in AADT for each segment for 1980 |
| % Growth 1981 | The percent growth in AADT for each segment for 1981 |
| % Growth 1982 | The percent growth in AADT for each segment for 1982 |
| % Growth 1983 | The percent growth in AADT for each segment for 1983 |
| % Growth 1984 | The percent growth in AADT for each segment for 1984 |
| % Growth 1985 | The percent growth in AADT for each segment for 1985 |
| % Growth 1986 | The percent growth in AADT for each segment for 1986 |
| % Growth 1987 | The percent growth in AADT for each segment for 1987 |
| % Growth 1988 | The percent growth in AADT for each segment for 1988 |
| % Growth 1989 | The percent growth in AADT for each segment for 1989 |
| % Growth 1990 | The percent growth in AADT for each segment for 1990 |
| % Growth 1991 | The percent growth in AADT for each segment for 1991 |
| % Growth 1992 | The percent growth in AADT for each segment for 1992 |
| % Growth 1993 | The percent growth in AADT for each segment for 1993 |
| % Growth 1994 | The percent growth in AADT for each segment for 1994 |
| % Growth 1995 | The percent growth in AADT for each segment for 1995 |
| % Growth 1996 | The percent growth in AADT for each segment for 1996 |
| % Growth 1997 | The percent growth in AADT for each segment for 1997 |
| % Growth 1998 | The percent growth in AADT for each segment for 1998 |
| % Growth 1999 | The percent growth in AADT for each segment for 1999 |
| % Growth 2000 | The percent growth in AADT for each segment for 2000 |
| % Growth 2001 | The percent growth in AADT for each segment for 2001 |
| % Growth 2002 | The percent growth in AADT for each segment for 2002 |
| % Growth 2003 | The percent growth in AADT for each segment for 2003 |
| % Growth 2004 | The percent growth in AADT for each segment for 2004 |
| % Growth 2005 | The percent growth in AADT for each segment for 2005 |
| % Growth 2006 | The percent growth in AADT for each segment for 2006 |
| % Growth 2007 | The percent growth in AADT for each segment for 2007 |
| % Growth 2008 | The percent growth in AADT for each segment for 2008 |
| % Growth 2009 | The percent growth in AADT for each segment for 2009 |
| % Growth 2010 | The percent growth in AADT for each segment for 2010 |
| % Growth 2011 | The percent growth in AADT for each segment for 2011 |
| % Growth 2012 | The percent growth in AADT for each segment for 2012 |
| % Growth 2013 | The percent growth in AADT for each segment for 2013 |
| % Growth 2014 | The percent growth in AADT for each segment for 2014 |
| % Growth 2015 | The percent growth in AADT for each segment for 2015 |
| % Growth 2016 | The percent growth in AADT for each segment for 2016 |
| % Growth 2017 | The percent growth in AADT for each segment for 2017 |
| % Growth 2018 | The percent growth in AADT for each segment for 2018 |
| % Growth 2019 | The percent growth in AADT for each segment for 2019 |
| % Growth 2020 | The percent growth in AADT for each segment for 2020 |

Worksheets in Average_ESAL_Table

| Number of Lanes | |
|---|---|
| Column | Description |
| SECTID | The segment number as designated by ADOT (ADOT uses segment and SECTID interchangeably) |
| LANES | Value taken from *TR9397C.xls* |
| # Lanes 1993 | The number of lanes for each segment in 1993 |
| # Lanes 1994 | The number of lanes for each segment in 1994 |
| # Lanes 1995 | The number of lanes for each segment in 1995 |
| # Lanes 1996 | The number of lanes for each segment in 1996 |
| # Lanes 1997 | The number of lanes for each segment in 1997 |
| # Lanes 1998 | The number of lanes for each segment in 1998 |
| # Lanes 1999 | The number of lanes for each segment in 1999 |
| # Lanes 2000 | The number of lanes for each segment in 2000 |
| # Lanes 2001 | The number of lanes for each segment in 2001 |
| # Lanes 2002 | The number of lanes for each segment in 2002 |
| # Lanes 2003 | The number of lanes for each segment in 2003 |
| # Lanes 2004 | The number of lanes for each segment in 2004 |
| # Lanes 2005 | The number of lanes for each segment in 2005 |
| # Lanes 2006 | The number of lanes for each segment in 2006 |
| # Lanes 2007 | The number of lanes for each segment in 2007 |
| # Lanes 2008 | The number of lanes for each segment in 2008 |
| # Lanes 2009 | The number of lanes for each segment in 2009 |
| # Lanes 2010 | The number of lanes for each segment in 2010 |
| # Lanes 2011 | The number of lanes for each segment in 2011 |
| # Lanes 2012 | The number of lanes for each segment in 2012 |
| # Lanes 2013 | The number of lanes for each segment in 2013 |
| # Lanes 2014 | The number of lanes for each segment in 2014 |
| # Lanes 2015 | The number of lanes for each segment in 2015 |
| # Lanes 2016 | The number of lanes for each segment in 2016 |
| # Lanes 2017 | The number of lanes for each segment in 2017 |
| # Lanes 2018 | The number of lanes for each segment in 2018 |
| # Lanes 2019 | The number of lanes for each segment in 2019 |
| # Lanes 2020 | The number of lanes for each segment in 2020 |

Worksheets in Average_ESAL_Table

| Total Theoretical Capacity | |
|---|---|
| Column | Description |
| SECTID | The segment number as designated by ADOT (ADOT uses segment and SECTID interchangeably) |
| Year 1997 | The total theoretical capacity for all lanes for each segment for 1997 |
| Year 1998 | The total theoretical capacity for all lanes for each segment for 1998 |
| Year 1999 | The total theoretical capacity for all lanes for each segment for 1999 |
| Year 2000 | The total theoretical capacity for all lanes for each segment for 2000 |
| Year 2001 | The total theoretical capacity for all lanes for each segment for 2001 |
| Year 2002 | The total theoretical capacity for all lanes for each segment for 2002 |
| Year 2003 | The total theoretical capacity for all lanes for each segment for 2003 |
| Year 2004 | The total theoretical capacity for all lanes for each segment for 2004 |
| Year 2005 | The total theoretical capacity for all lanes for each segment for 2005 |
| Year 2006 | The total theoretical capacity for all lanes for each segment for 2006 |
| Year 2007 | The total theoretical capacity for all lanes for each segment for 2007 |
| Year 2008 | The total theoretical capacity for all lanes for each segment for 2008 |
| Year 2009 | The total theoretical capacity for all lanes for each segment for 2009 |
| Year 2010 | The total theoretical capacity for all lanes for each segment for 2010 |
| Year 2011 | The total theoretical capacity for all lanes for each segment for 2011 |
| Year 2012 | The total theoretical capacity for all lanes for each segment for 2012 |
| Year 2013 | The total theoretical capacity for all lanes for each segment for 2013 |
| Year 2014 | The total theoretical capacity for all lanes for each segment for 2014 |
| Year 2015 | The total theoretical capacity for all lanes for each segment for 2015 |
| Year 2016 | The total theoretical capacity for all lanes for each segment for 2016 |
| Year 2017 | The total theoretical capacity for all lanes for each segment for 2017 |
| Year 2018 | The total theoretical capacity for all lanes for each segment for 2018 |
| Year 2019 | The total theoretical capacity for all lanes for each segment for 2019 |
| Year 2020 | The total theoretical capacity for all lanes for each segment for 2020 |

| % Vehicle Type Table | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| % Cls 4 | The percentage of FHWA class 4 vehicles for each segment |
| % Cls 5 | The percentage of FHWA class 5 vehicles for each segment |
| % Cls 6 | The percentage of FHWA class 6 vehicles for each segment |
| % Cls 7 | The percentage of FHWA class 7 vehicles for each segment |
| % Cls 8 | The percentage of FHWA class 8 vehicles for each segment |
| % Cls 9 | The percentage of FHWA class 9 vehicles for each segment |
| % Cls 10 | The percentage of FHWA class 10 vehicles for each segment |
| % Cls 11 | The percentage of FHWA class 11 vehicles for each segment |
| % Cls 12 | The percentage of FHWA class 12 vehicles for each segment |
| % Cls 13 | The percentage of FHWA class 13 vehicles for each segment |
| Year | Year when calculations of vehicle class percentages was performed for each segment |

Worksheets in OneStdDev_ESAL_Table

| Site Info (ADOT % Trucks)--from *TR9397C.xls* | |
|---|---|
| Column | Description |
| SECTID | The segment number as designated by ADOT (ADOT uses segment and SECTID interchangeably) |
| RTE_L | The route type (i.e., I = interstate, U = U.S. highway, S = state highway) |
| RTE_N | The route number |
| BMP | The beginning milepost of the segment |
| STARTING | A description of the beginning location of the segment in terms of nearest exit/interchange |
| EMP | The ending milepost of the segment |
| ENDING | A description of the ending location of the segment in terms of nearest exit/interchange |
| ORDER | A counting function that begins with 1 and increases by 1 for each segment |
| SEC_LEN | The length of the segment (in miles) |
| ATR | The Automatic Traffic Recorder assosicated with each segment |
| CLASS | The classification station associated with each segment |
| SECTION | The segment number as designated by ADOT |
| LANES | The total number of lanes (in both directions) within the segment |
| AADT93 | The AADT for each segment as reported by ADOT for 1993 |
| PCCV93 | The percent commercial vehciles for each segment as reported by ADOT for 1993 |
| AADT94 | The AADT for each segment as reported by ADOT for 1994 |
| PCCV94 | The percent commercial vehciles for each segment as reported by ADOT for 1994 |
| AADT95 | The AADT for each segment as reported by ADOT for 1995 |
| PCCV95 | The percent commercial vehciles for each segment as reported by ADOT for 1995 |
| AADT96 | The AADT for each segment as reported by ADOT for 1996 |
| PCCV96 | The percent commercial vehciles for each segment as reported by ADOT for 1996 |
| AADT97 | The AADT for each segment as reported by ADOT for 1997 |
| PCCV97 | The percent commercial vehciles for each segment as reported by ADOT for 1997 |
| EST_DATE | The year the traffic segment was established |
| CNTFRQ | The frequency with which traffic counts are performed at each segment |
| STATUS | The status of the most recent traffic count for each segment |
| LASTCNT | The year of the last traffic count for each segment |
| NEXTCNT | The year of the next traffic count for each segment |
| MISSCNT | Whether the traffic count was successfully collected (FALSE) or not (TRUE) at each segment |
| REMARKS | Comments by ADOT regarding each segment |

Worksheets in OneStdDev_ESAL_Table

| Cum 1way Flex 10% 1 stdev | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | The total number of one-way KESALs for each segment for 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 1998 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 1999 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2000 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2001 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2002 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2003 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2004 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2005 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2006 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2007 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2008 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2009 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2010 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2011 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2012 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |

Worksheets in OneStdDev_ESAL_Table

| | |
|---|---|
| KESAL 2013 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2014 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2015 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2016 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2017 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2018 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2019 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2020 | The total number of KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |

Worksheets in OneStdDev_ESAL_Table

| Cum One-way Rigid 1 stdev | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | Total one-way KESALs for 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 1998 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 1999 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2000 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2001 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2002 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2003 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2004 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2005 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2006 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2007 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2008 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2009 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2010 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2011 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2012 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2013 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2014 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2015 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2016 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2017 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2018 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2019 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2020 | Total one-way KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |

Worksheets in OneStdDev_ESAL_Table

| AADT 1974-2020--1974-1997 data from *trfc7497.xls* | |
|---|---|
| Column | Description |
| ORDER | A counting function that begins with 1 and increases by 1 for each segment |
| Segment | The segment number as designated by ADOT |
| RTE_L | The route type (i.e., I = interstate, U = U.S. highway, S = state highway) |
| RTE_N | The route number |
| BMP | The beginning milepost of the segment |
| EMP | The ending milepost of the segment |
| SEC_LEN | The length of the segment (in miles) |
| ATR | The Automatic Traffic Recorder assosicated with each segment |
| CLASS | The classification station associated with each segment |
| Segment | The segment number as designated by ADOT |
| PCCV97 | The percent commercial vehicles for each segment as reported by ADOT in 1997 |
| 1974 | The measured AADT for each segment for 1974 |
| 1975 | The measured AADT for each segment for 1975 |
| 1976 | The measured AADT for each segment for 1976 |
| 1977 | The measured AADT for each segment for 1977 |
| 1978 | The measured AADT for each segment for 1978 |
| 1979 | The measured AADT for each segment for 1979 |
| 1980 | The measured AADT for each segment for 1980 |
| 1981 | The measured AADT for each segment for 1981 |
| 1982 | The measured AADT for each segment for 1982 |
| 1983 | The measured AADT for each segment for 1983 |
| 1984 | The measured AADT for each segment for 1984 |
| 1985 | The measured AADT for each segment for 1985 |
| 1986 | The measured AADT for each segment for 1986 |
| 1987 | The measured AADT for each segment for 1987 |
| 1988 | The measured AADT for each segment for 1988 |
| 1989 | The measured AADT for each segment for 1989 |
| 1990 | The measured AADT for each segment for 1990 |
| 1991 | The measured AADT for each segment for 1991 |
| 1992 | The measured AADT for each segment for 1992 |
| 1993 | The measured AADT for each segment for 1993 |
| 1994 | The measured AADT for each segment for 1994 |
| 1995 | The measured AADT for each segment for 1995 |
| 1996 | The measured AADT for each segment for 1996 |
| 1997 | The measured AADT for each segment for 1997 |
| Avg. % Growth | The average % growth for each segment based on the average of the annual growth factors from 1992 to 1997; this value is calculated using Macro 1 |
| Forecasting % Growth | The % growth used in projecting AADT for future years; this differs from the Avg. % Growth where the Avg. % Growth is less than 2% (Forecasting % Growth is never less than 2%) |
| 1996 | The measured AADT for each segment for 1996; this value is repeated but not counted twice |
| 1997 | The measured AADT for each segment for 1997; this value is repeated but not counted twice |
| 1998 | The forecasted AADT for each segment for 1998 |
| 1999 | The forecasted AADT for each segment for 1999 |
| 2000 | The forecasted AADT for each segment for 2000 |
| 2001 | The forecasted AADT for each segment for 2001 |
| 2002 | The forecasted AADT for each segment for 2002 |
| 2003 | The forecasted AADT for each segment for 2003 |
| 2004 | The forecasted AADT for each segment for 2004 |

Worksheets in OneStdDev_ESAL_Table

| | |
|---|---|
| 2005 | The forecasted AADT for each segment for 2005 |
| 2006 | The forecasted AADT for each segment for 2006 |
| 2007 | The forecasted AADT for each segment for 2007 |
| 2008 | The forecasted AADT for each segment for 2008 |
| 2009 | The forecasted AADT for each segment for 2009 |
| 2010 | The forecasted AADT for each segment for 2010 |
| 2011 | The forecasted AADT for each segment for 2011 |
| 2012 | The forecasted AADT for each segment for 2012 |
| 2013 | The forecasted AADT for each segment for 2013 |
| 2014 | The forecasted AADT for each segment for 2014 |
| 2015 | The forecasted AADT for each segment for 2015 |
| 2016 | The forecasted AADT for each segment for 2016 |
| 2017 | The forecasted AADT for each segment for 2017 |
| 2018 | The forecasted AADT for each segment for 2018 |
| 2019 | The forecasted AADT for each segment for 2019 |
| 2020 | The forecasted AADT for each segment for 2020 |

Worksheets in OneStdDev_ESAL_Table

| Capacity | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| Year 1997 | Indication of whether each segment exceeds capacity in 1997 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 1998 | Indication of whether each segment exceeds capacity in 1998 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 1999 | Indication of whether each segment exceeds capacity in 1999 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2000 | Indication of whether each segment exceeds capacity in 2000 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2001 | Indication of whether each segment exceeds capacity in 2001 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2002 | Indication of whether each segment exceeds capacity in 2002 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2003 | Indication of whether each segment exceeds capacity in 2003 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2004 | Indication of whether each segment exceeds capacity in 2004 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2005 | Indication of whether each segment exceeds capacity in 2005 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2006 | Indication of whether each segment exceeds capacity in 2006 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2007 | Indication of whether each segment exceeds capacity in 2007 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2008 | Indication of whether each segment exceeds capacity in 2008 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2009 | Indication of whether each segment exceeds capacity in 2009 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2010 | Indication of whether each segment exceeds capacity in 2010 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2011 | Indication of whether each segment exceeds capacity in 2011 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2012 | Indication of whether each segment exceeds capacity in 2012 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2013 | Indication of whether each segment exceeds capacity in 2013 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2014 | Indication of whether each segment exceeds capacity in 2014 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2015 | Indication of whether each segment exceeds capacity in 2015 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2016 | Indication of whether each segment exceeds capacity in 2016 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2017 | Indication of whether each segment exceeds capacity in 2017 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2018 | Indication of whether each segment exceeds capacity in 2018 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2019 | Indication of whether each segment exceeds capacity in 2019 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2020 | Indication of whether each segment exceeds capacity in 2020 ("Pass" means under capacity, "Fail" means over capacity) |

Worksheets in OneStdDev_ESAL_Table

| Rigid 1 stdev | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | Total KESALs for 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 1998 | Total KESALs for 1998 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 1999 | Total KESALs for 1999 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2000 | Total KESALs for 2000 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2001 | Total KESALs for 2001 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2002 | Total KESALs for 2002 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2003 | Total KESALs for 2003 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2004 | Total KESALs for 2004 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2005 | Total KESALs for 2005 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2006 | Total KESALs for 2006 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2007 | Total KESALs for 2007 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2008 | Total KESALs for 2008 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2009 | Total KESALs for 2009 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2010 | Total KESALs for 2010 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2011 | Total KESALs for 2011 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2012 | Total KESALs for 2012 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2013 | Total KESALs for 2013 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2014 | Total KESALs for 2014 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2015 | Total KESALs for 2015 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2016 | Total KESALs for 2016 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2017 | Total KESALs for 2017 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2018 | Total KESALs for 2018 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2019 | Total KESALs for 2019 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |
| KESAL 2020 | Total KESALs for 2020 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by one standard deviation |

Worksheets in OneStdDev_ESAL_Table

| Rigid ESALs | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| Class | The classification station number associated with each segment |
| ESALcls4 | The rigid ESALs per vehicle class 4 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 4 vehicles is applied. |
| ESALcls5 | The rigid ESALs per vehicle class 5 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 5 vehicles is applied. |
| ESALcls6 | The rigid ESALs per vehicle class 6 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 6 vehicles is applied. |
| ESALcls7 | The rigid ESALs per vehicle class 7 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 7 vehicles is applied. |
| ESALcls8 | The rigid ESALs per vehicle class 8 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 8 vehicles is applied. |
| ESALcls9 | The rigid ESALs per vehicle class 9 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 9 vehicles is applied. |
| ESALcls10 | The rigid ESALs per vehicle class 10 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 10 vehicles is applied. |
| ESALcls11 | The rigid ESALs per vehicle class 11 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 11 vehicles is applied. |
| ESALcls12 | The rigid ESALs per vehicle class 12 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 12 vehicles is applied. |
| ESALcls13 | The rigid ESALs per vehicle class 13 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 13 vehicles is applied. |

Worksheets in OneStdDev_ESAL_Table

| Flex 1 stdev 10% | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | The total KESALs for each segment for 1997 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 1998 | The total KESALs for each segment for 1998 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 1999 | The total KESALs for each segment for 1999 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2000 | The total KESALs for each segment for 2000 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2001 | The total KESALs for each segment for 2001 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2002 | The total KESALs for each segment for 2002 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2003 | The total KESALs for each segment for 2003 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2004 | The total KESALs for each segment for 2004 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2005 | The total KESALs for each segment for 2005 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2006 | The total KESALs for each segment for 2006 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2007 | The total KESALs for each segment for 2007 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2008 | The total KESALs for each segment for 2008 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2009 | The total KESALs for each segment for 2009 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2010 | The total KESALs for each segment for 2010 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2011 | The total KESALs for each segment for 2011 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2012 | The total KESALs for each segment for 2012 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |

Worksheets in OneStdDev_ESAL_Table

| | |
|---|---|
| KESAL 2013 | The total KESALs for each segment for 2013 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2014 | The total KESALs for each segment for 2014 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2015 | The total KESALs for each segment for 2015 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2016 | The total KESALs for each segment for 2016 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2017 | The total KESALs for each segment for 2017 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2018 | The total KESALs for each segment for 2018 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2019 | The total KESALs for each segment for 2019 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |
| KESAL 2020 | The total KESALs for each segment for 2020 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by one standard deviation |

Worksheets in OneStdDev_ESAL_Table

| Flexible ESALs | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| Class | The classification station number associated with each segment |
| ESALcls4 | The flexible ESALs per vehicle class 4 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 4 vehicles is applied. |
| ESALcls5 | The flexible ESALs per vehicle class 5 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 5 vehicles is applied. |
| ESALcls6 | The flexible ESALs per vehicle class 6 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 6 vehicles is applied. |
| ESALcls7 | The flexible ESALs per vehicle class 7 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 7 vehicles is applied. |
| ESALcls8 | The flexible ESALs per vehicle class 8 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 8 vehicles is applied. |
| ESALcls9 | The flexible ESALs per vehicle class 9 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 9 vehicles is applied. |
| ESALcls10 | The flexible ESALs per vehicle class 10 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 10 vehicles is applied. |
| ESALcls11 | The flexible ESALs per vehicle class 11 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 11 vehicles is applied. |
| ESALcls12 | The flexible ESALs per vehicle class 12 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 12 vehicles is applied. |
| ESALcls13 | The flexible ESALs per vehicle class 13 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 13 vehicles is applied. |

| Stdev ESALs per Cls | |
|---|---|
| Column | Description |
| Column 1 | This table contains the mean, plus one standard deviation and plus two standard deviations for ESALs per vehicle class for both rigid and flexible pavements |
| Class 4 | These values for vechilce class 4 |
| Class 5 | These values for vechilce class 5 |
| Class 6 | These values for vechilce class 6 |
| Class 7 | These values for vechilce class 7 |
| Class 8 | These values for vechilce class 8 |
| Class 9 | These values for vechilce class 9 |
| Class 10 | These values for vechilce class 10 |
| Class 11 | These values for vechilce class 11 |
| Class 12 | These values for vechilce class 12 |
| Class 13 | These values for vechilce class 13 |

Worksheets in OneStdDev_ESAL_Table

| AADT Percent Growth All Years | |
|---|---|
| Column | Description |
| Segment | The segment number as designated by ADOT |
| % Growth 1974 | The percent growth in AADT for each segment for 1974 |
| % Growth 1975 | The percent growth in AADT for each segment for 1975 |
| % Growth 1976 | The percent growth in AADT for each segment for 1976 |
| % Growth 1977 | The percent growth in AADT for each segment for 1977 |
| % Growth 1978 | The percent growth in AADT for each segment for 1978 |
| % Growth 1979 | The percent growth in AADT for each segment for 1979 |
| % Growth 1980 | The percent growth in AADT for each segment for 1980 |
| % Growth 1981 | The percent growth in AADT for each segment for 1981 |
| % Growth 1982 | The percent growth in AADT for each segment for 1982 |
| % Growth 1983 | The percent growth in AADT for each segment for 1983 |
| % Growth 1984 | The percent growth in AADT for each segment for 1984 |
| % Growth 1985 | The percent growth in AADT for each segment for 1985 |
| % Growth 1986 | The percent growth in AADT for each segment for 1986 |
| % Growth 1987 | The percent growth in AADT for each segment for 1987 |
| % Growth 1988 | The percent growth in AADT for each segment for 1988 |
| % Growth 1989 | The percent growth in AADT for each segment for 1989 |
| % Growth 1990 | The percent growth in AADT for each segment for 1990 |
| % Growth 1991 | The percent growth in AADT for each segment for 1991 |
| % Growth 1992 | The percent growth in AADT for each segment for 1992 |
| % Growth 1993 | The percent growth in AADT for each segment for 1993 |
| % Growth 1994 | The percent growth in AADT for each segment for 1994 |
| % Growth 1995 | The percent growth in AADT for each segment for 1995 |
| % Growth 1996 | The percent growth in AADT for each segment for 1996 |
| % Growth 1997 | The percent growth in AADT for each segment for 1997 |
| % Growth 1998 | The percent growth in AADT for each segment for 1998 |
| % Growth 1999 | The percent growth in AADT for each segment for 1999 |
| % Growth 2000 | The percent growth in AADT for each segment for 2000 |
| % Growth 2001 | The percent growth in AADT for each segment for 2001 |
| % Growth 2002 | The percent growth in AADT for each segment for 2002 |
| % Growth 2003 | The percent growth in AADT for each segment for 2003 |
| % Growth 2004 | The percent growth in AADT for each segment for 2004 |
| % Growth 2005 | The percent growth in AADT for each segment for 2005 |
| % Growth 2006 | The percent growth in AADT for each segment for 2006 |
| % Growth 2007 | The percent growth in AADT for each segment for 2007 |
| % Growth 2008 | The percent growth in AADT for each segment for 2008 |
| % Growth 2009 | The percent growth in AADT for each segment for 2009 |
| % Growth 2010 | The percent growth in AADT for each segment for 2010 |
| % Growth 2011 | The percent growth in AADT for each segment for 2011 |
| % Growth 2012 | The percent growth in AADT for each segment for 2012 |
| % Growth 2013 | The percent growth in AADT for each segment for 2013 |
| % Growth 2014 | The percent growth in AADT for each segment for 2014 |
| % Growth 2015 | The percent growth in AADT for each segment for 2015 |
| % Growth 2016 | The percent growth in AADT for each segment for 2016 |
| % Growth 2017 | The percent growth in AADT for each segment for 2017 |
| % Growth 2018 | The percent growth in AADT for each segment for 2018 |
| % Growth 2019 | The percent growth in AADT for each segment for 2019 |
| % Growth 2020 | The percent growth in AADT for each segment for 2020 |

Worksheets in OneStdDev_ESAL_Table

| Number of Lanes | |
|---|---|
| Column | Description |
| SECTID | The segment number as designated by ADOT (ADOT uses segment and SECTID interchangeably) |
| LANES | Value taken from *TR9397C.xls* |
| # Lanes 1993 | The number of lanes for each segment in 1993 |
| # Lanes 1994 | The number of lanes for each segment in 1994 |
| # Lanes 1995 | The number of lanes for each segment in 1995 |
| # Lanes 1996 | The number of lanes for each segment in 1996 |
| # Lanes 1997 | The number of lanes for each segment in 1997 |
| # Lanes 1998 | The number of lanes for each segment in 1998 |
| # Lanes 1999 | The number of lanes for each segment in 1999 |
| # Lanes 2000 | The number of lanes for each segment in 2000 |
| # Lanes 2001 | The number of lanes for each segment in 2001 |
| # Lanes 2002 | The number of lanes for each segment in 2002 |
| # Lanes 2003 | The number of lanes for each segment in 2003 |
| # Lanes 2004 | The number of lanes for each segment in 2004 |
| # Lanes 2005 | The number of lanes for each segment in 2005 |
| # Lanes 2006 | The number of lanes for each segment in 2006 |
| # Lanes 2007 | The number of lanes for each segment in 2007 |
| # Lanes 2008 | The number of lanes for each segment in 2008 |
| # Lanes 2009 | The number of lanes for each segment in 2009 |
| # Lanes 2010 | The number of lanes for each segment in 2010 |
| # Lanes 2011 | The number of lanes for each segment in 2011 |
| # Lanes 2012 | The number of lanes for each segment in 2012 |
| # Lanes 2013 | The number of lanes for each segment in 2013 |
| # Lanes 2014 | The number of lanes for each segment in 2014 |
| # Lanes 2015 | The number of lanes for each segment in 2015 |
| # Lanes 2016 | The number of lanes for each segment in 2016 |
| # Lanes 2017 | The number of lanes for each segment in 2017 |
| # Lanes 2018 | The number of lanes for each segment in 2018 |
| # Lanes 2019 | The number of lanes for each segment in 2019 |
| # Lanes 2020 | The number of lanes for each segment in 2020 |

Worksheets in OneStdDev_ESAL_Table

| Total Theoretical Capacity | |
|---|---|
| Column | Description |
| SECTID | The segment number as designated by ADOT (ADOT uses segment and SECTID interchangeably) |
| Year 1997 | The total theoretical capacity for all lanes for each segment for 1997 |
| Year 1998 | The total theoretical capacity for all lanes for each segment for 1998 |
| Year 1999 | The total theoretical capacity for all lanes for each segment for 1999 |
| Year 2000 | The total theoretical capacity for all lanes for each segment for 2000 |
| Year 2001 | The total theoretical capacity for all lanes for each segment for 2001 |
| Year 2002 | The total theoretical capacity for all lanes for each segment for 2002 |
| Year 2003 | The total theoretical capacity for all lanes for each segment for 2003 |
| Year 2004 | The total theoretical capacity for all lanes for each segment for 2004 |
| Year 2005 | The total theoretical capacity for all lanes for each segment for 2005 |
| Year 2006 | The total theoretical capacity for all lanes for each segment for 2006 |
| Year 2007 | The total theoretical capacity for all lanes for each segment for 2007 |
| Year 2008 | The total theoretical capacity for all lanes for each segment for 2008 |
| Year 2009 | The total theoretical capacity for all lanes for each segment for 2009 |
| Year 2010 | The total theoretical capacity for all lanes for each segment for 2010 |
| Year 2011 | The total theoretical capacity for all lanes for each segment for 2011 |
| Year 2012 | The total theoretical capacity for all lanes for each segment for 2012 |
| Year 2013 | The total theoretical capacity for all lanes for each segment for 2013 |
| Year 2014 | The total theoretical capacity for all lanes for each segment for 2014 |
| Year 2015 | The total theoretical capacity for all lanes for each segment for 2015 |
| Year 2016 | The total theoretical capacity for all lanes for each segment for 2016 |
| Year 2017 | The total theoretical capacity for all lanes for each segment for 2017 |
| Year 2018 | The total theoretical capacity for all lanes for each segment for 2018 |
| Year 2019 | The total theoretical capacity for all lanes for each segment for 2019 |
| Year 2020 | The total theoretical capacity for all lanes for each segment for 2020 |

| % Vehicle Type Table | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| % Cls 4 | The percentage of FHWA class 4 vehicles for each segment |
| % Cls 5 | The percentage of FHWA class 5 vehicles for each segment |
| % Cls 6 | The percentage of FHWA class 6 vehicles for each segment |
| % Cls 7 | The percentage of FHWA class 7 vehicles for each segment |
| % Cls 8 | The percentage of FHWA class 8 vehicles for each segment |
| % Cls 9 | The percentage of FHWA class 9 vehicles for each segment |
| % Cls 10 | The percentage of FHWA class 10 vehicles for each segment |
| % Cls 11 | The percentage of FHWA class 11 vehicles for each segment |
| % Cls 12 | The percentage of FHWA class 12 vehicles for each segment |
| % Cls 13 | The percentage of FHWA class 13 vehicles for each segment |
| Year | Year when calculations of vehicle class percentages was performed for each segment |

Worksheets in TwoStdDev_ESAL_Table

| Site Info (ADOT % Trucks)--from *TR9397C.xls* | |
|---|---|
| Column | Description |
| SECTID | The segment number as designated by ADOT (ADOT uses segment and SECTID interchangeably) |
| RTE_L | The route type (i.e., I = interstate, U = U.S. highway, S = state highway) |
| RTE_N | The route number |
| BMP | The beginning milepost of the segment |
| STARTING | A description of the beginning location of the segment in terms of nearest exit/interchange |
| EMP | The ending milepost of the segment |
| ENDING | A description of the ending location of the segment in terms of nearest exit/interchange |
| ORDER | A counting function that begins with 1 and increases by 1 for each segment |
| SEC_LEN | The length of the segment (in miles) |
| ATR | The Automatic Traffic Recorder assosicated with each segment |
| CLASS | The classification station associated with each segment |
| SECTION | The segment number as designated by ADOT |
| LANES | The total number of lanes (in both directions) within the segment |
| AADT93 | The AADT for each segment as reported by ADOT for 1993 |
| PCCV93 | The percent commercial vehciles for each segment as reported by ADOT for 1993 |
| AADT94 | The AADT for each segment as reported by ADOT for 1994 |
| PCCV94 | The percent commercial vehciles for each segment as reported by ADOT for 1994 |
| AADT95 | The AADT for each segment as reported by ADOT for 1995 |
| PCCV95 | The percent commercial vehciles for each segment as reported by ADOT for 1995 |
| AADT96 | The AADT for each segment as reported by ADOT for 1996 |
| PCCV96 | The percent commercial vehciles for each segment as reported by ADOT for 1996 |
| AADT97 | The AADT for each segment as reported by ADOT for 1997 |
| PCCV97 | The percent commercial vehciles for each segment as reported by ADOT for 1997 |
| EST_DATE | The year the traffic segment was established |
| CNTFRQ | The frequency with which traffic counts are performed at each segment |
| STATUS | The status of the most recent traffic count for each segment |
| LASTCNT | The year of the last traffic count for each segment |
| NEXTCNT | The year of the next traffic count for each segment |
| MISSCNT | Whether the traffic count was successfully collected (FALSE) or not (TRUE) at each segment |
| REMARKS | Comments by ADOT regarding each segment |

Worksheets in TwoStdDev_ESAL_Table

| Cum 1way Flex 10% 2 stdev | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | The total number of one-way KESALs for each segment for 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 1998 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 1999 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2000 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2001 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2002 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2003 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2004 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2005 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2006 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2007 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2008 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2009 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2010 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2011 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2012 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |

Worksheets in TwoStdDev_ESAL_Table

| | |
|---|---|
| KESAL 2013 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2014 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2015 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2016 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2017 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2018 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2019 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2020 | The total number of one-way KESALs for each segment since 1997 assuming a flexible pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |

Worksheets in TwoStdDev_ESAL_Table

| Cum One-way Rigid 2 stdev | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | Total KESALs for 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 1998 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 1999 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2000 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2001 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2002 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2003 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2004 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2005 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2006 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2007 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2008 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2009 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2010 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2011 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2012 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2013 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2014 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2015 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2016 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2017 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2018 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2019 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2020 | Total KESALs since 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |

Worksheets in TwoStdDev_ESAL_Table

| AADT 1974-2020--1974-1997 data from *trfc7497.xls* | |
|---|---|
| Column | Description |
| ORDER | A counting function that begins with 1 and increases by 1 for each segment |
| Segment | The segment number as designated by ADOT |
| RTE_L | The route type (i.e., I = interstate, U = U.S. highway, S = state highway) |
| RTE_N | The route number |
| BMP | The beginning milepost of the segment |
| EMP | The ending milepost of the segment |
| SEC_LEN | The length of the segment (in miles) |
| ATR | The Automatic Traffic Recorder assosicated with each segment |
| CLASS | The classification station associated with each segment |
| Segment | The segment number as designated by ADOT |
| PCCV97 | The percent commercial vehicles for each segment as reported by ADOT in 1997 |
| 1974 | The measured AADT for each segment for 1974 |
| 1975 | The measured AADT for each segment for 1975 |
| 1976 | The measured AADT for each segment for 1976 |
| 1977 | The measured AADT for each segment for 1977 |
| 1978 | The measured AADT for each segment for 1978 |
| 1979 | The measured AADT for each segment for 1979 |
| 1980 | The measured AADT for each segment for 1980 |
| 1981 | The measured AADT for each segment for 1981 |
| 1982 | The measured AADT for each segment for 1982 |
| 1983 | The measured AADT for each segment for 1983 |
| 1984 | The measured AADT for each segment for 1984 |
| 1985 | The measured AADT for each segment for 1985 |
| 1986 | The measured AADT for each segment for 1986 |
| 1987 | The measured AADT for each segment for 1987 |
| 1988 | The measured AADT for each segment for 1988 |
| 1989 | The measured AADT for each segment for 1989 |
| 1990 | The measured AADT for each segment for 1990 |
| 1991 | The measured AADT for each segment for 1991 |
| 1992 | The measured AADT for each segment for 1992 |
| 1993 | The measured AADT for each segment for 1993 |
| 1994 | The measured AADT for each segment for 1994 |
| 1995 | The measured AADT for each segment for 1995 |
| 1996 | The measured AADT for each segment for 1996 |
| 1997 | The measured AADT for each segment for 1997 |
| Avg. % Growth | The average % growth for each segment based on the average of the annual growth factors from 1992 to 1997; this value is calculated using Macro 1 |
| Forecasting % Growth | The % growth used in projecting AADT for future years; this differs from the Avg. % Growth where the Avg. % Growth is less than 2% (Forecasting % Growth is never less than 2%) |
| 1996 | The measured AADT for each segment for 1996; this value is repeated but not counted twice |
| 1997 | The measured AADT for each segment for 1997; this value is repeated but not counted twice |
| 1998 | The forecasted AADT for each segment for 1998 |
| 1999 | The forecasted AADT for each segment for 1999 |
| 2000 | The forecasted AADT for each segment for 2000 |
| 2001 | The forecasted AADT for each segment for 2001 |
| 2002 | The forecasted AADT for each segment for 2002 |
| 2003 | The forecasted AADT for each segment for 2003 |
| 2004 | The forecasted AADT for each segment for 2004 |

Worksheets in TwoStdDev_ESAL_Table

| | |
|---|---|
| 2005 | The forecasted AADT for each segment for 2005 |
| 2006 | The forecasted AADT for each segment for 2006 |
| 2007 | The forecasted AADT for each segment for 2007 |
| 2008 | The forecasted AADT for each segment for 2008 |
| 2009 | The forecasted AADT for each segment for 2009 |
| 2010 | The forecasted AADT for each segment for 2010 |
| 2011 | The forecasted AADT for each segment for 2011 |
| 2012 | The forecasted AADT for each segment for 2012 |
| 2013 | The forecasted AADT for each segment for 2013 |
| 2014 | The forecasted AADT for each segment for 2014 |
| 2015 | The forecasted AADT for each segment for 2015 |
| 2016 | The forecasted AADT for each segment for 2016 |
| 2017 | The forecasted AADT for each segment for 2017 |
| 2018 | The forecasted AADT for each segment for 2018 |
| 2019 | The forecasted AADT for each segment for 2019 |
| 2020 | The forecasted AADT for each segment for 2020 |

Worksheets in TwoStdDev_ESAL_Table

| Capacity | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| Year 1997 | Indication of whether each segment exceeds capacity in 1997 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 1998 | Indication of whether each segment exceeds capacity in 1998 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 1999 | Indication of whether each segment exceeds capacity in 1999 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2000 | Indication of whether each segment exceeds capacity in 2000 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2001 | Indication of whether each segment exceeds capacity in 2001 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2002 | Indication of whether each segment exceeds capacity in 2002 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2003 | Indication of whether each segment exceeds capacity in 2003 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2004 | Indication of whether each segment exceeds capacity in 2004 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2005 | Indication of whether each segment exceeds capacity in 2005 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2006 | Indication of whether each segment exceeds capacity in 2006 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2007 | Indication of whether each segment exceeds capacity in 2007 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2008 | Indication of whether each segment exceeds capacity in 2008 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2009 | Indication of whether each segment exceeds capacity in 2009 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2010 | Indication of whether each segment exceeds capacity in 2010 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2011 | Indication of whether each segment exceeds capacity in 2011 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2012 | Indication of whether each segment exceeds capacity in 2012 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2013 | Indication of whether each segment exceeds capacity in 2013 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2014 | Indication of whether each segment exceeds capacity in 2014 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2015 | Indication of whether each segment exceeds capacity in 2015 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2016 | Indication of whether each segment exceeds capacity in 2016 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2017 | Indication of whether each segment exceeds capacity in 2017 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2018 | Indication of whether each segment exceeds capacity in 2018 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2019 | Indication of whether each segment exceeds capacity in 2019 ("Pass" means under capacity, "Fail" means over capacity) |
| Year 2020 | Indication of whether each segment exceeds capacity in 2020 ("Pass" means under capacity, "Fail" means over capacity) |

Worksheets in TwoStdDev_ESAL_Table

| Rigid 2 stdev | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | Total KESALs for 1997 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 1998 | Total KESALs for 1998 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 1999 | Total KESALs for 1999 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2000 | Total KESALs for 2000 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2001 | Total KESALs for 2001 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2002 | Total KESALs for 2002 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2003 | Total KESALs for 2003 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2004 | Total KESALs for 2004 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2005 | Total KESALs for 2005 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2006 | Total KESALs for 2006 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2007 | Total KESALs for 2007 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2008 | Total KESALs for 2008 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2009 | Total KESALs for 2009 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2010 | Total KESALs for 2010 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2011 | Total KESALs for 2011 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2012 | Total KESALs for 2012 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2013 | Total KESALs for 2013 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2014 | Total KESALs for 2014 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2015 | Total KESALs for 2015 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2016 | Total KESALs for 2016 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2017 | Total KESALs for 2017 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2018 | Total KESALs for 2018 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2019 | Total KESALs for 2019 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |
| KESAL 2020 | Total KESALs for 2020 for each segment based on a rigid pavement and adjusting the ESALs per vehicle class upwards by two standard deviations |

Worksheets in TwoStdDev_ESAL_Table

| Rigid ESALs | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| Class | The classification station number associated with each segment |
| ESALcls4 | The rigid ESALs per vehicle class 4 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 4 vehicles is applied. |
| ESALcls5 | The rigid ESALs per vehicle class 5 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 5 vehicles is applied. |
| ESALcls6 | The rigid ESALs per vehicle class 6 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 6 vehicles is applied. |
| ESALcls7 | The rigid ESALs per vehicle class 7 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 7 vehicles is applied. |
| ESALcls8 | The rigid ESALs per vehicle class 8 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 8 vehicles is applied. |
| ESALcls9 | The rigid ESALs per vehicle class 9 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 9 vehicles is applied. |
| ESALcls10 | The rigid ESALs per vehicle class 10 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 10 vehicles is applied. |
| ESALcls11 | The rigid ESALs per vehicle class 11 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 11 vehicles is applied. |
| ESALcls12 | The rigid ESALs per vehicle class 12 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 12 vehicles is applied. |
| ESALcls13 | The rigid ESALs per vehicle class 13 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 13 vehicles is applied. |

Worksheets in TwoStdDev_ESAL_Table

| Flex 2 stdev 10% | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| KESAL 1997 | The total KESALs for each segment for 1997 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 1998 | The total KESALs for each segment for 1998 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 1999 | The total KESALs for each segment for 1999 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2000 | The total KESALs for each segment for 2000 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2001 | The total KESALs for each segment for 2001 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2002 | The total KESALs for each segment for 2002 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2003 | The total KESALs for each segment for 2003 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2004 | The total KESALs for each segment for 2004 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2005 | The total KESALs for each segment for 2005 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2006 | The total KESALs for each segment for 2006 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2007 | The total KESALs for each segment for 2007 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2008 | The total KESALs for each segment for 2008 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2009 | The total KESALs for each segment for 2009 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2010 | The total KESALs for each segment for 2010 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2011 | The total KESALs for each segment for 2011 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2012 | The total KESALs for each segment for 2012 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |

Worksheets in TwoStdDev_ESAL_Table

| | |
|---|---|
| KESAL 2013 | The total KESALs for each segment for 2013 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2014 | The total KESALs for each segment for 2014 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2015 | The total KESALs for each segment for 2015 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2016 | The total KESALs for each segment for 2016 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2017 | The total KESALs for each segment for 2017 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2018 | The total KESALs for each segment for 2018 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2019 | The total KESALs for each segment for 2019 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |
| KESAL 2020 | The total KESALs for each segment for 2020 assuming a flexible pavement, adding a 10% factor of safety for vechicle classes 9-13 and adjusting the ESALs per vehcile class upwards by two standard deviations |

Worksheets in TwoStdDev_ESAL_Table

| Flexible ESALs | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| Class | The classification station number associated with each segment |
| ESALcls4 | The flexible ESALs per vehicle class 4 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 4 vehicles is applied. |
| ESALcls5 | The flexible ESALs per vehicle class 5 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 5 vehicles is applied. |
| ESALcls6 | The flexible ESALs per vehicle class 6 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 6 vehicles is applied. |
| ESALcls7 | The flexible ESALs per vehicle class 7 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 7 vehicles is applied. |
| ESALcls8 | The flexible ESALs per vehicle class 8 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 8 vehicles is applied. |
| ESALcls9 | The flexible ESALs per vehicle class 9 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 9 vehicles is applied. |
| ESALcls10 | The flexible ESALs per vehicle class 10 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 10 vehicles is applied. |
| ESALcls11 | The flexible ESALs per vehicle class 11 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 11 vehicles is applied. |
| ESALcls12 | The flexible ESALs per vehicle class 12 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 12 vehicles is applied. |
| ESALcls13 | The flexible ESALs per vehicle class 13 for each segment. Segments that have a WIM located within their class station have the measured value applied. Otherwise the average value for ADOT WIM systems for class 13 vehicles is applied. |

| Stdev ESALs per Cls | |
|---|---|
| Column | Description |
| Column 1 | This table contains the mean, plus one standard deviation and plus two standard deviations for ESALs per vehicle class for both rigid and flexible pavements |
| Class 4 | These values for vechilce class 4 |
| Class 5 | These values for vechilce class 5 |
| Class 6 | These values for vechilce class 6 |
| Class 7 | These values for vechilce class 7 |
| Class 8 | These values for vechilce class 8 |
| Class 9 | These values for vechilce class 9 |
| Class 10 | These values for vechilce class 10 |
| Class 11 | These values for vechilce class 11 |
| Class 12 | These values for vechilce class 12 |
| Class 13 | These values for vechilce class 13 |

| AADT Percent Growth All Years | |
|---|---|
| Column | Description |
| Segment | The segment number as designated by ADOT |
| % Growth 1974 | The percent growth in AADT for each segment for 1974 |
| % Growth 1975 | The percent growth in AADT for each segment for 1975 |
| % Growth 1976 | The percent growth in AADT for each segment for 1976 |
| % Growth 1977 | The percent growth in AADT for each segment for 1977 |
| % Growth 1978 | The percent growth in AADT for each segment for 1978 |
| % Growth 1979 | The percent growth in AADT for each segment for 1979 |
| % Growth 1980 | The percent growth in AADT for each segment for 1980 |
| % Growth 1981 | The percent growth in AADT for each segment for 1981 |
| % Growth 1982 | The percent growth in AADT for each segment for 1982 |
| % Growth 1983 | The percent growth in AADT for each segment for 1983 |
| % Growth 1984 | The percent growth in AADT for each segment for 1984 |
| % Growth 1985 | The percent growth in AADT for each segment for 1985 |
| % Growth 1986 | The percent growth in AADT for each segment for 1986 |
| % Growth 1987 | The percent growth in AADT for each segment for 1987 |
| % Growth 1988 | The percent growth in AADT for each segment for 1988 |
| % Growth 1989 | The percent growth in AADT for each segment for 1989 |
| % Growth 1990 | The percent growth in AADT for each segment for 1990 |
| % Growth 1991 | The percent growth in AADT for each segment for 1991 |
| % Growth 1992 | The percent growth in AADT for each segment for 1992 |
| % Growth 1993 | The percent growth in AADT for each segment for 1993 |
| % Growth 1994 | The percent growth in AADT for each segment for 1994 |
| % Growth 1995 | The percent growth in AADT for each segment for 1995 |
| % Growth 1996 | The percent growth in AADT for each segment for 1996 |
| % Growth 1997 | The percent growth in AADT for each segment for 1997 |
| % Growth 1998 | The percent growth in AADT for each segment for 1998 |
| % Growth 1999 | The percent growth in AADT for each segment for 1999 |
| % Growth 2000 | The percent growth in AADT for each segment for 2000 |
| % Growth 2001 | The percent growth in AADT for each segment for 2001 |
| % Growth 2002 | The percent growth in AADT for each segment for 2002 |
| % Growth 2003 | The percent growth in AADT for each segment for 2003 |
| % Growth 2004 | The percent growth in AADT for each segment for 2004 |
| % Growth 2005 | The percent growth in AADT for each segment for 2005 |
| % Growth 2006 | The percent growth in AADT for each segment for 2006 |
| % Growth 2007 | The percent growth in AADT for each segment for 2007 |
| % Growth 2008 | The percent growth in AADT for each segment for 2008 |
| % Growth 2009 | The percent growth in AADT for each segment for 2009 |
| % Growth 2010 | The percent growth in AADT for each segment for 2010 |
| % Growth 2011 | The percent growth in AADT for each segment for 2011 |
| % Growth 2012 | The percent growth in AADT for each segment for 2012 |
| % Growth 2013 | The percent growth in AADT for each segment for 2013 |
| % Growth 2014 | The percent growth in AADT for each segment for 2014 |
| % Growth 2015 | The percent growth in AADT for each segment for 2015 |
| % Growth 2016 | The percent growth in AADT for each segment for 2016 |
| % Growth 2017 | The percent growth in AADT for each segment for 2017 |
| % Growth 2018 | The percent growth in AADT for each segment for 2018 |
| % Growth 2019 | The percent growth in AADT for each segment for 2019 |
| % Growth 2020 | The percent growth in AADT for each segment for 2020 |

Worksheets in TwoStdDev_ESAL_Table

| Number of Lanes | |
|---|---|
| Column | Description |
| SECTID | The segment number as designated by ADOT (ADOT uses segment and SECTID interchangeably) |
| LANES | Value taken from *TR9397C.xls* |
| # Lanes 1993 | The number of lanes for each segment in 1993 |
| # Lanes 1994 | The number of lanes for each segment in 1994 |
| # Lanes 1995 | The number of lanes for each segment in 1995 |
| # Lanes 1996 | The number of lanes for each segment in 1996 |
| # Lanes 1997 | The number of lanes for each segment in 1997 |
| # Lanes 1998 | The number of lanes for each segment in 1998 |
| # Lanes 1999 | The number of lanes for each segment in 1999 |
| # Lanes 2000 | The number of lanes for each segment in 2000 |
| # Lanes 2001 | The number of lanes for each segment in 2001 |
| # Lanes 2002 | The number of lanes for each segment in 2002 |
| # Lanes 2003 | The number of lanes for each segment in 2003 |
| # Lanes 2004 | The number of lanes for each segment in 2004 |
| # Lanes 2005 | The number of lanes for each segment in 2005 |
| # Lanes 2006 | The number of lanes for each segment in 2006 |
| # Lanes 2007 | The number of lanes for each segment in 2007 |
| # Lanes 2008 | The number of lanes for each segment in 2008 |
| # Lanes 2009 | The number of lanes for each segment in 2009 |
| # Lanes 2010 | The number of lanes for each segment in 2010 |
| # Lanes 2011 | The number of lanes for each segment in 2011 |
| # Lanes 2012 | The number of lanes for each segment in 2012 |
| # Lanes 2013 | The number of lanes for each segment in 2013 |
| # Lanes 2014 | The number of lanes for each segment in 2014 |
| # Lanes 2015 | The number of lanes for each segment in 2015 |
| # Lanes 2016 | The number of lanes for each segment in 2016 |
| # Lanes 2017 | The number of lanes for each segment in 2017 |
| # Lanes 2018 | The number of lanes for each segment in 2018 |
| # Lanes 2019 | The number of lanes for each segment in 2019 |
| # Lanes 2020 | The number of lanes for each segment in 2020 |

Worksheets in TwoStdDev_ESAL_Table

| Total Theoretical Capacity | |
|---|---|
| Column | Description |
| SECTID | The segment number as designated by ADOT (ADOT uses segment and SECTID interchangeably) |
| Year 1997 | The total theoretical capacity for all lanes for each segment for 1997 |
| Year 1998 | The total theoretical capacity for all lanes for each segment for 1998 |
| Year 1999 | The total theoretical capacity for all lanes for each segment for 1999 |
| Year 2000 | The total theoretical capacity for all lanes for each segment for 2000 |
| Year 2001 | The total theoretical capacity for all lanes for each segment for 2001 |
| Year 2002 | The total theoretical capacity for all lanes for each segment for 2002 |
| Year 2003 | The total theoretical capacity for all lanes for each segment for 2003 |
| Year 2004 | The total theoretical capacity for all lanes for each segment for 2004 |
| Year 2005 | The total theoretical capacity for all lanes for each segment for 2005 |
| Year 2006 | The total theoretical capacity for all lanes for each segment for 2006 |
| Year 2007 | The total theoretical capacity for all lanes for each segment for 2007 |
| Year 2008 | The total theoretical capacity for all lanes for each segment for 2008 |
| Year 2009 | The total theoretical capacity for all lanes for each segment for 2009 |
| Year 2010 | The total theoretical capacity for all lanes for each segment for 2010 |
| Year 2011 | The total theoretical capacity for all lanes for each segment for 2011 |
| Year 2012 | The total theoretical capacity for all lanes for each segment for 2012 |
| Year 2013 | The total theoretical capacity for all lanes for each segment for 2013 |
| Year 2014 | The total theoretical capacity for all lanes for each segment for 2014 |
| Year 2015 | The total theoretical capacity for all lanes for each segment for 2015 |
| Year 2016 | The total theoretical capacity for all lanes for each segment for 2016 |
| Year 2017 | The total theoretical capacity for all lanes for each segment for 2017 |
| Year 2018 | The total theoretical capacity for all lanes for each segment for 2018 |
| Year 2019 | The total theoretical capacity for all lanes for each segment for 2019 |
| Year 2020 | The total theoretical capacity for all lanes for each segment for 2020 |

| % Vehicle Type Table | |
|---|---|
| Column | Description |
| SEGMENT | The segment number as designated by ADOT |
| ATR | The Automatic Traffic Recorder number associated with each segment |
| CLASS | The classification station number associated with each segment |
| % Cls 4 | The percentage of FHWA class 4 vehicles for each segment |
| % Cls 5 | The percentage of FHWA class 5 vehicles for each segment |
| % Cls 6 | The percentage of FHWA class 6 vehicles for each segment |
| % Cls 7 | The percentage of FHWA class 7 vehicles for each segment |
| % Cls 8 | The percentage of FHWA class 8 vehicles for each segment |
| % Cls 9 | The percentage of FHWA class 9 vehicles for each segment |
| % Cls 10 | The percentage of FHWA class 10 vehicles for each segment |
| % Cls 11 | The percentage of FHWA class 11 vehicles for each segment |
| % Cls 12 | The percentage of FHWA class 12 vehicles for each segment |
| % Cls 13 | The percentage of FHWA class 13 vehicles for each segment |
| Year | Year when calculations of vehicle class percentages was performed for each segment |