Improved LRFD/LRFR Specifications for Permit and Fatigue Load Trucks

Requested by
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The Caltrans Division of Research and Innovation (DRI) receives and evaluates numerous research problem statements for funding every year. DRI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field.

Executive Summary

Background
Bridge design and evaluation are moving toward the American Association of State Highway and Transportation Officials (AASHTO) load and resistance factor design/load and resistance factor rating (LRFD/LRFR) specifications using calibrated truck load models and associated load factors. Current code has load factors determined by national data, some of which is quite old and doesn't reflect current traffic and load patterns. Additionally, loads vary greatly from site to site across the country, and California is unique in many aspects of the distribution of truck loading on its highway systems.

Caltrans is embarking on a project to produce a revised permit vehicle and load factors for LRFD/LRFR based on California weigh-in-motion (WIM) data and permit routing policies. To aid in this effort, we identified and reviewed research reports from national and state sources in which state-of-the-art WIM data were applied to bridge design and evaluation, and were used in calibrating reliability-based load and resistance factors. We looked particularly for states that have gone through similar processes with special interest in the incorporation of side-by-side occurrences of truck traffic and detailed calibrations of the load factors.

Summary of Findings
We gathered and reviewed information from national and state sources regarding the use of WIM truck data for the calibration of load factors in the LRFD/LRFR code.

National Research

- *NCHRP Report W135: Protocols for Collecting and Using Traffic Data in Bridge Design* is a key document for the Caltrans project. It provides the results of NCHRP Project 12-76 whose primary goal was the development of procedures and protocols for calibrating load factors using WIM data.
- *NCHRP Report 575*: *Legal Truck Loads and AASHTO Legal Loads for Posting* gives the results of multiple presence studies, especially side-by-side occurrences. It also includes a discussion of issues related to the quality of WIM data.

State Research

- *Recommendations for Michigan Specific Load and Resistance Factor Design Loads and Load and Resistance Factor Rating Procedures* details the calibration effort recently completed in Michigan.

- *Calibration of LRFR Live Load Factors Using Weigh-in-Motion Data* summarizes the calibration effort in Oregon. A recalibration was completed this past year. The documentation is currently unpublished but is attached as Appendix A.
- We interviewed the engineers responsible for both of these projects.

Other Research

- We found four recently published journal articles that focus on using WIM data in site-specific LRFD/LRFR calibration (Oregon, New York and West Virginia) and studying multiple presence statistics (New Jersey).

Research in Progress

- NCHRP Project 12-78, *Evaluation of Load Rating by Load and Resistance Factor Rating*, is under way and expected to be completed in early March 2010. This project will provide refinements to the LRFR methods in the *AASHTO Manual for Bridge Evaluation* and an explanation of the difference between the new LRFR requirements and the established load factor rating (LFR) requirements.

Gaps in Findings

Each locality must generate its own calibrations according to local truck traffic and load conditions, so no "out-of-the-box" solution exists to determine the necessary load factors for permitting and design in California. However, detailed protocols and procedures have been researched, and both Michigan and Oregon have recently completed local calibrations as well as published results and methodology.

Next Steps

As Caltrans articulates and executes the project to calibrate the LRFD/LRFR live load factors, the department might consider:

- Consulting the protocols and methodology presented in *NCHRP Report W135: Protocols for Collecting and Using Traffic Data in Bridge Design*.
- Consulting researchers working on NCHRP Project 12-78, *Evaluation of Load Rating by Load and Resistance Factor Rating,* who are drafting recommended refinements to the *AASHTO Manual for Bridge Evaluation* as part of their project.
- Consulting directly with engineers in Michigan and Oregon who recently completed large-scale calibrations using WIM data and studied side-by-side occurrences explicitly.

Contacts

During the course of this Preliminary Investigation, we spoke with the following individuals:

Michigan DOT
Rebecca Curtis, Bridge Load Rating Engineer, (517) 322-1186, curtisre@michigan.gov

Oregon State University
Christopher Higgins, Professor of Structural Engineering, (541) 737-8869, chris.higgins@oregonstate.edu

National Research

Below we highlight reports issued by NCHRP that address WIM data application to bridge design and evaluation, particularly using WIM data for calibration of load and resistance factors.

Protocols for Collecting and Using Traffic Data in Bridge Design, *NCHRP Report W135*, July 2008.
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w135.pdf
Abstract: "This report documents and presents the results of a study to develop a set of protocols and methodologies for using available recent truck traffic data to develop and calibrate live load models for LRFD bridge design. The HL-93, a combination of the HS20 truck and lane loads, was developed using 1975 truck data from the Ontario Ministry of Transportation to project a 75-year live-load occurrence. Because truck traffic volume and weight have increased and truck configurations have become more complex, the 1975 Ontario data do not represent present U.S traffic loadings. The goal of this project, therefore, was to develop a set of protocols and methodologies for using available recent truck traffic data collected at different U.S. sites and recommend a step-by-step procedure that can be followed to obtain live load models for LRFD bridge design. The protocols are geared to address the collection, processing and use of national WIM data to develop and calibrate vehicular loads for LRFD superstructure design, fatigue design, deck design and design for overload permits. These protocols are appropriate for national use or data specific to a state or local jurisdiction where the truck weight regulations and/or traffic conditions may be significantly different from national standards. The study also gives practical examples of implementing these protocols with recent national WIM data drawn from states/sites around the country with different traffic exposures, load spectra, and truck configurations."

This document is among the most pertinent to the project at hand as it provides a detailed protocol for the exact task that Caltrans is embarking upon addressing: collection, processing and use of WIM data to develop and calibrate vehicular loads. Though the researchers provide an example of calibration using national WIM data, they intend the protocol to be flexible enough for use in specific state or local jurisdictions to perform site-specific calibrations. Recommendations and highlights from the report include:

- Researchers detail a 13-step protocol for using WIM data to calibrate load factors. (See below.)
- WIM data should include headway, truck weights, axle weights and axle configurations from collection sites that are hidden from the view of truck drivers (not from weigh stations).
- WIM data must be high quality. They recommend one year's worth of recent, continuously collected data, emphasizing that it is much better to collect limited amounts of well-calibrated data than large amounts of poorly calibrated data. (See pages 35 to 40.)
- Multiple presence statistics are very important for regulating the maximum lifetime loading event.
- Reliable multiple presence statistics require large quantities of continuous WIM data with refined time stamps.
- Two methods of reliability-based calibration of load factors are presented: Method I is simple and appropriate for data sets and truck routes with small variations. Method II is more complicated, but factors in site-to-site variations.
- Researchers propose a detailed process to develop vehicular load models (page 29 and Appendix D).
- Researchers include a detailed demonstration of the use of their 13-step protocol to calibrate load factors using traffic data (page 89). The focus is on the "use of WIM data to develop and calibrate vehicular loads for LRFD superstructure design, fatigue design, deck design and design overload permits."

Below is a summary of the calibration protocol. A detailed presentation (with analysis) of each step is given on pages 41 to 88; a detailed summary of each step is given on pages 139 to 143.

STEP 1	DEFINE WIM DATA REQUIREMENTS FOR LIVE LOAD MODELING
STEP 2	SELECTION OF WIM SITES FOR COLLECTING TRAFFIC DATA FOR BRIDGE DESIGN
STEP 3	QUANTITIES OF WIM DATA REQUIRED FOR LOAD MODELING
STEP 4	WIM CALIBRATION & VERIFICATION TESTS
STEP 5	PROTOCOLS FOR DATA SCRUBBING, DATA QUALITY CHECKS & STATISTICAL ADEQUACY OF TRAFFIC DATA
STEP 6	GENERALIZED MULTIPLE-PRESENCE STATISTICS FOR TRUCKS AS A FUNCTION OF TRAFFIC VOLUME

STEP 7	PROTOCOLS FOR WIM DATA ANALYSIS FOR ONE-LANE LOAD EFFECTS FOR SUPERSTRUCTURE DESIGN
STEP 8	PROTOCOLS FOR WIM DATA ANALYSIS FOR TWO-LANE LOAD EFFECTS FOR SUPERSTRUCTURE DESIGN
STEP 9	ASSEMBLE AXLE LOAD HISTOGRAMS FOR DECK DESIGN
STEP 10	FILTERING OF WIM SENSOR ERRORS/WIM SCATTER FROM WIM HISTOGRAMS
STEP 11	ACCUMULATED FATIGUE DAMAGE AND EFFECTIVE GROSS WEIGHT FROM WIM DATA
STEP 12	LIFETIME MAXIMUM LOAD EFFECT L_{max} FOR SUPERSTRUCTURE DESIGN
STEP 13	DEVELOP AND CALIBRATE VEHICULAR LOAD MODELS FOR BRIDGE DESIGN

Appendix B of the report compiles approximately 40 references from a detailed literature review of approximately 250 abstracts, research papers, journal articles, conference papers and reports that apply to the calibration of load factors using WIM data. We have included it at the end of this document for reference.

Legal Truck Loads and AASHTO Legal Loads for Posting, *NCHRP Report 575*, 2007.
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_575.pdf
The report focuses on the development of recommended revisions to the legal loads for posting as depicted in the *Manual for Condition Evaluation of Bridges* and the *Guide Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges*. The report includes:

- Detailed presentation of WIM data analysis (starting on page 30) utilizing both old WIM data and describing the collection of new WIM data.
- Detailed side-by-side multiple presence analysis (starting on page 35) using data gathered from Idaho, Michigan and Ohio.
    - In general, researchers found the multiple presence rate quite low compared to past assumptions.
    - For modeling purposes (page 63) in LRFD calibrations, they recommend utilizing a multiple presence rate of 1/15 for 5,000 ADTT; 1 percent for 1,000 ADTT; and 0.001 for 100 ADTT. (The current rate used in the code is 1/15.)

Bridge Rating Practices and Policies for Overweight Vehicles, *NCHRP Synthesis Report 359*, 2006.
http://gulliver.trb.org/publications/nchrp/nchrp_syn_359.pdf
This report gathers information on state bridge rating systems, bridge evaluation practices and permit policies as they relate to overweight and oversize vehicles. Along with a literature search, information was gathered by survey of transportation agencies at the state level in the United States and their counterparts in Canada, and supplemented with telephone interviews conducted with targeted organizations and individuals. One of the main goals of the report is to document and examine variations in bridge rating for oversize/overweight vehicles and look for ways to improve uniformity between jurisdictions.

Calibration of Load Factors for LRFR Bridge Evaluation, *NCHRP Report 454*, 2001.
http://gulliver.trb.org/publications/nchrp/nchrp_rpt_454.pdf
The report presents a consistent approach to calibrate live load factors for the proposed *AASHTO Evaluation Manual*. The aim was "to achieve uniform target reliability indexes over a range of applications, including design load rating, legal load rating, posting and permit vehicle analysis." The document focuses primarily on the calibration process itself. Section 6.4 describes the use of WIM data for load factor calibration and includes a brief discussion of WIM data requirements.

State Research

Below we highlight reports issued by Michigan and Oregon that describe the load factor calibrations in which they used WIM data. We also interviewed engineers from both of these studies who were primarily responsible for the calibration of the live load factors used in the LRFD/LRFR calculations in their respective states. Summary notes from those interviews are given below.

Michigan

Recommendations for Michigan Specific Load and Resistance Factor Design Loads and Load and Resistance Factor Rating Procedures, *MDOT Research Report R-1511*, April 2008.
http://www.michigan.gov/documents/mdot/MDOT_Research_Report_R1511_233374_7.pdf
Excerpt from the report: "The Load and Resistance Factor Rating (LRFR) code for load rating bridges and Load and Resistance Factor Design (LRFD) code for designing bridges are based on factors calibrated from structural load and resistance statistics to achieve a more uniform level of reliability for all bridges. The live load factors in the LRFR code are based on load data thought to be representative of heavy truck traffic nationwide. However, the code allows for recalibrating live load factors for a jurisdiction if weigh-in-motion data are available. The Michigan Department of Transportation anticipates implementing customized live load factors based on the analysis described in this report. Additional clarifications are made regarding gross vehicle weight to use for determining the live load factor and loading configurations for use with the LRFR code.

"The revised LRFD live load factors and other LRFR recommendations are compared to the HL-93 loading and recommendations are made to meet the operational needs of the Michigan Department of Transportation."

Highlights include:

- Researchers generated a new truck (HL-93-mod) for using in LRFD to ensure that bridges designed to LRFD will still meet the operational needs within the state.
- As a result of their multiple presence analysis, they use a 1/30 side-by-side probability in the load factor calculation. This is half the standard value of 1/15 in the current code. The side-by-side study is detailed on page 10.

LRFD Load Calibration for State of Michigan Trunkline Bridges, *MDOT Research Report RC-1466*, August 2006.
http://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC1466_200613_7.pdf
Abstract: This report presents the process and results of a research effort to calibrate the live load factor for the load and resistance factor (LRFD) design of bridges on Michigan's trunkline roadways. Initially, the AASHTO LRFD Bridge Code was reviewed, which included investigation into the design code's background documentation (NCHRP Report 368). Weigh-in-motion (WIM) data were procured for more than 100 million trucks at sensor locations throughout the state of Michigan, including those gathered by other researchers earlier. The WIM data were divided by functional classification and numerically run over influence lines for 72 different critical load effects present on 20 randomly selected bridges, and then projected to create the statistical distribution of the 75-year maximum. Several projection techniques were investigated for comparison. Projection using the Gumbel approach presented herein was found to be the most theoretically accurate for the data set. However, taking into account the practical approach used in the calibration of the AASHTO LRFD Bridge Code, a more empirical and consistent approach was selected for application. Based on the findings presented herein and those of the Phase I portion of this study, the live load factor was calibrated using an approach that was as consistent as possible with that used for the AASHTO LRFD Bridge Code calibration. A reliability index β of 3.5 was used as the structural safety target in both calibrations. Based on the calibration results herein, it is recommended that the live load factor should be increased by a factor of 1.2 for the Metro Region in Michigan to cover observed heavy truck loads. For other regions in the state, this additional factor is not needed. The cost impact of this recommended change was also studied and documented in this report, and was estimated at a 4.5 percent cost increase for the Metro Region only."

Highlights from this study include:

- Five years of WIM data used.
- Twenty bridges included all constructed or reconstructed after 1990.
- Researchers recommended an increase in the live load factor by 1.2 for bridges in the metro Detroit region to maintain a reliability index of 3.5 throughout the state.
- Researchers estimate a 4.5 percent cost increase to construction to achieve the higher bridge capacity.

Author Interview
We spoke with Rebecca Curtis, bridge load rating engineer, in the Construction and Technology Division of the Michigan Department of Transportation.

The calibration in Michigan was prompted by the fact that bridge designs using new HL-93 truck resulted in bridges that would not allow current legal loads. According to Curtis, among the lessons learned were:

- The LRFR/LRFD code itself is underdeveloped and unfinished, particularly on the rating side. This is true of both the code and the computer programs used to do the calculations. Researchers had numerous concerns regarding consistency within the code itself. Several NCHRP projects bear on the matter—12-76 (completed) and 12-78 (ongoing)—and are worth consulting.
- There are problems with the definition of long spans and their correct loading.
- Good WIM data is essential for a sound calibration.
- The side-by-side event assumption "is huge" in the LRFD/LRFR code, and the accuracy of much WIM data is limited for side-by-side presence.
    - Michigan had very accurate side-by-side data on one of its most heavily traveled highways that showed the multiple presence frequency was about half the value in the code, which resulted in a significantly lower live load factor in their calculation.

The calibration took about five months to complete, though it was squeezed into other work being done. Importantly, the WIM data had already been collected.

Curtis knows that Oregon used WIM data in its load factor calibration and that others are interested in doing so, but did not know of other states that have done such calibrations.

Recommendations:

- Get good quality WIM data.
- Use a person involved with load rating, not just load design, when doing the calibration. Permit and overloading are very important issues, and a load rating engineer will have the necessary expertise to understand how and why things have changed and provide an engineering justification for any revision of load/permitting regulations.
- Be sure to understand how any modification of the live load factors will affect other operations within the DOT.

Oregon

Calibration of LRFR Live Load Factors Using Weigh-in-Motion Data, *Oregon DOT Project SPR 635,* June 2006.
http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/LiveLoadFactors.pdf
Abstract: "The Load and Resistance Factor Rating (LRFR) code for load rating bridges is based on factors calibrated from structural load and resistance statistics to achieve a more uniform level of reliability for all bridges. The liveload factors in the LRFR code are based on load data thought to be representative of heavy truck traffic nationwide. However, the code allows for recalibrating liveload factors for a jurisdiction if weigh-in-motion data of sufficient quality and quantity are available. The Oregon Department of Transportation is implementing customized liveload factors based on the analysis described in this report. The relatively low liveload factors obtained in the Oregon calibration are a logical outcome of the regulatory and enforcement environment in Oregon."

Highlights include:

- A detailed example of the calculation of live load factors (page 11).
- Significant findings regarding seasonal variation, directional variation, traffic volume variation, overweight vehicle avoidance, large axle loads, interstate vs. noninterstate traffic and data time-window variation (pages 15 to 18).
- A sensitivity analysis and discussion based upon the variation in the WIM data (pages 18 to 21).
- A detailed presentation of the method of quality control checks used for processing the WIM data and the load factor calculations (pages 21 to 24).
- A pertinent report attached as an appendix: *Calibration of Route-Specific LRFR Live Load Factors Using I-5 Weigh-in-Motion Data,* by Bala Sivakumar. The report details a route-specific calibration and includes special analysis of multiple presence statistics.

Author Interview
We spoke with Christopher Higgins, professor of structural engineering at Oregon State University.

The study in Oregon was prompted by a problem with rating bridges: approximately 1,800 concrete bridges (primarily 1950s era) would have failed federal standards if load factors were left with the default calibration. Researchers needed to be able to look more carefully at the reserve capacity of the bridges and more carefully understand the live loads that they would be encountering, hence the recalibration.

Researchers worked with Bala Sivakumar (investigator on the NCHRP 17-76 project) to use site-specific WIM data for a statewide load factor calibration. The initial calibration took about two years and was completed in 2006. They performed a recalibration this year with more recent WIM data (attached as Appendix A) in about six months using a graduate student for much of the work.

Higgins said that the calibration makes sense for rating (LRFR) but not for design (LRFD). He was called by (he thinks) the Port of Long Beach about one year ago to be consulted about a site-specific calibration of load factors for bridges there. He hasn't heard anything since and doesn't know of anyone else embarking on load factor calibrations using WIM data.

Important factors and lessons learned in doing the calibration:

- "The most important factor is the quality of the data."
    - Need overall high-quality WIM data.
    - Need calibration and validation of the scales.
    - Must maintain consistent kinds, styles and quality of WIM stations whose data is included.
    - Must examine data manually in addition to using software checks to ensure overall integrity.
- Be careful about construction routes as they skew the results.
- Rogue trucks had a large effect on calibrating the WIM data itself. The big question in examining the data was classifying over-legal trucks and deciding whether they were permitted or rogue.
- Grade of the roadway on the bridge makes a significant difference in the effect of side-by-side events.

Unexpected findings:

- The size of the data window needed for accumulating enough statistics to obtain a steady state varied significantly by site and took some time to determine.
- Some seasonal, weather and economic effects (agricultural vehicles) affected the data, depending on the site.

Other Research

Below we highlight pertinent recent research appearing in transportation and engineering journals.

Multiple Presence Statistics for Bridge Live Load Based on Weigh-in-Motion Data, Mayrai Gindy and Hani H. Nassif, *Transportation Research Record*: Journal of the Transportation Research Board, Vol. 2028, 2007, pages 125-135.
Abstract: http://dx.doi.org/10.3141/2028-14
This research describes a study that determined truck load spectra for bridges in New Jersey with emphasis on multiple truck presence statistics. Researchers analyzed truck weight data collected by the New Jersey Department of Transportation from 25 WIM sites throughout the state between 1993 and 2003 (with some gaps). The sites encompassed a variety of site-specific conditions, including truck volume, road and area type, and number of lanes. For each truck, the recorded parameters included the time of passage, speed, travel lane, number of axles, and axle loads and spacings. Of particular interest were the frequency and correlation among trucks simultaneously occurring on a bridge either as following, side by side or staggered. Researchers observed that truck volume and bridge span length have a significant effect on the frequency of multiple truck presence, whereas area and road type have only a slight effect. They also observed that the rate of increase in the percent occurrence of following loading events is lower for bridge span lengths of up to 100 feet (30 m) as compared with longer spans, whereas for staggered loading patterns the opposite is true. The frequency of side-by-side trucks was found to remain relatively constant with respect to span length.

State-Specific LRFR Live Load Factors Using Weigh-in-Motion Data, Jordan Pelphrey, Christopher Higgins, Bala Sivakumar, Richard L. Groff, Bert H. Hartman, Joseph P. Charbonneau, Jonathan W. Rooper, Bruce V. Johnson, *Journal of Bridge Engineering,* Vol. 13, No. 4, 2008, pages 339-350.
Abstract: http://dx.doi.org/10.1061/(ASCE)1084-0702(2008)13:4(339)
In Oregon, truck WIM data was used to develop live load factors for use on state-owned bridges. The factors were calibrated using the same statistical methods that were used in the original development of LRFR. This procedure maintains the nationally accepted structural reliability index for evaluation, even though the resulting state-specific live load factors were smaller than the national standard. This paper describes the jurisdictional and enforcement characteristics in the state, the modifications used to described the alongside truck population based on the unique truck permitting conditions in the state, the WIM data filtering, sorting and quality control as well as the calibration process and the computed live load factors.

Enhancement of Bridge Live Loads Using Weigh-in-Motion Data, Bala Sivakumar, Firas I. Sheikh Ibrahim, *Bridge Structures, Assessment, Design and Construction,,* Vol. 3, No. 3/4, 2007, pages 193-204.
Abstract: http://www.ingentaconnect.com/content/tandf/nbst/2007/00000003/f0020003/art00005
This paper reviews the evolution of U.S. bridge design live loads and discusses the possible enhancement of bridge live loads and load factors using WIM data. The paper presents recent investigations for evaluating the design live loads for the state of New York, and calibrating the live load factors used in rating for the state of Oregon using WIM data. The New York investigation indicates that truck loads at two studied sites may be significantly heavier than the AASHTO-specified loads. It also indicates that WIM-enhanced site-specific fatigue design loading is significantly heavier than the AASHTO LRFD fatigue design truck. In the Oregon investigation, state-specific WIM data resulted in a significant reduction in the live load factor for legal and permit trucks for the entire state of Oregon, which is attributable to the state's regulatory and enforcement environment.

Enhancement of Bridge Live Loads Based on West Virginia Weigh-in-Motion Data, Samir N. Shoukry, Gergis W. William, Mourad Y. Riad, Yan Luo, *Bridge Structures, Assessment, Design and Construction,* Vol. 4, No. 3/4, 2008, pages 121-133.
Abstract: http://dx.doi.org/10.1080/15732480802642501
This paper presents the development of two WIM systems in West Virginia to provide site-specific traffic data that can be employed for bridge design and evaluation. The paper discusses the traffic spectra measured in both sites to evaluate the design of live load trucks and discusses the possible enhancement of bridge live loads using the WIM data. The data indicated that the current truck loads are heavier than the AASHTO-specified loads. A fatigue design truck model has been developed based on the WIM data. The WIM enhanced fatigue design truck loading was found to be 31 percent heavier than the HL-93 AASHTO design truck. The data can also be used by bridge engineers and researchers to build a nationwide traffic spectra that would yield a new live load model in future AASHTO editions.

Research in Progress

Evaluation of Load Rating by Load and Resistance Factor Rating, *NCHRP Project 12-78*.
http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=1629
This is an active project that builds on the results of NCHRP Project 12-46 (*NCHRP Report 454*), offers refinements to the LRFR methods in the *AASHTO Manual for Bridge Evaluation*, and provides an explanation of the difference between the new LRFR requirements and the established load factor rating (LFR) requirements. The results of this research are expected to provide guidance and clarification to current rating code. The expected completion data is March 2, 2010.

OREGON SPECIFIC TRUCK LIVE LOAD FACTORS FOR RATING STATE-OWNED BRIDGES - 2008

Recalculation of live load truck factors using 2008 weigh-in-motion data for rating Oregon state owned bridges

Submitted to:
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This report outlines the recalculation of Oregon specific live load truck factors for rating state owned bridges. The calculation is done by performing statistical analysis to 2008 data collected from Oregon weigh-in-motion sites. Results from the 2008 calculation are then compared to the factors established in 2006.

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INTRODUCTION and BACKGROUND

The Oregon Department of Transportation uses Oregon-specific live load factors for Load and Resistance Factor Rating (LRFR) of state-owned bridges. This approach is addressed in the commentary Article C6.4.4.2.3 of the LRFR Specifications (LRFR 2008). The Oregon factors were developed using weigh-in motion (WIM) data following the overall methodology described in the LRFR Specification and as developed in NCHRP Project No. 12-46 (Moses 2001). The methods were adapted to account for the unique characteristics of truck loads and permitting regulations in Oregon and include permitted trucks in the along-side truck population. The Oregon live load factors were calculated using the same statistical methods that were used in the original development of the LRFR and this procedure maintains the nationally accepted structural reliability index for evaluation, even though the resulting state-specific live load factors were smaller than the national standard. The original calibration was performed using WIM data from 2005 for four sites which included state and interstate routes, considered seasonal variations, and different WIM data collection windows. The jurisdictional and enforcement characteristics in the state, the modifications used to described the alongside truck population based on the unique truck permitting conditions in the state, the WIM data filtering, sorting, quality control, calibration process, and the live load factor computations are described by Pelphrey and Higgins (2006) and Pelphrey et al. (2008). The policy implementation of the Oregon-specific live load factors is described by Groff (2006), and the current factors used in rating practice are shown in Table 1. As a part of the policy implementation, regular maintenance of the factors is prescribed using newly available WIM data to ensure the factors remain contemporary.

Table 1: Current ODOT LL Factors (T6-5 and 6-6A Groff 2006)

Current ODOT Factors	ADTT		
	≥ 5000	1500	≤ 500
Legal Loads	1.40	1.35	1.30
CTP-3	1.45	1.40	1.30
CTP-2A, CTP-2B	1.35	1.35	1.25
STP-3	1.25	1.20	1.10
STP-4A	1.40	1.35	1.25
STP-4B	1.00	1.00	1.00
STP- 5A*	1.10	1.05	1.00
STP-5B*	1.05	1.05	1.00
STP-5C*	1.00	1.00	1.00
STP-5BW	1.00	1.00	1.00
* notes truck designations per (Groff 2006)			

This report describes the recalculation of Oregon live load factors for rating Oregon state-owned bridges using WIM data from 2008. The 2008 live load factors for load rating Oregon bridges were calculated following the procedure described by Pelphrey and Higgins (2006). These new factors were calculated for the same four sites; I-5 Woodburn, US-97 Bend, OR-58 Lowell, I-84 Emigrant Hill. Data were taken from four months in 2008; January, March, June and October that represent the seasons of winter, spring, summer and fall, respectively.

Since the original 2006 calibration of the live load factors, some aspects have changed that required updates to the software. The original WIM data format mixed substantial text headers with the numerical data while the current format is almost exclusively numeric using comma separated variables (CSV). As a result, the original data processing programs were updated to read the new format. Additionally, some of the ODOT weight tables have changed and the resulting table classifications of different truck configurations are affected. These changes as well as the procedures and findings of the 2008 calculation of live load factors for rating state-owned bridges are detailed below.

UPDATES REQUIRED SINCE 2005 CALIBRATION

Verification of Calibration Procedures

The procedure for calibrating the truck live load factors have already been established by ODOT as described by Groff (2006) in the ODOT LRFR Policy Report: Live load factors for Use in Load and Resistance Factor Rating (LRFR) of Oregon's State-Owned Bridges (referenced here as "ODOT Policy Report"). To ensure that the methods could be faithfully reproduced several years later with new personnel, raw WIM data used in the original 2006 calibration were reprocessed and the load factors were recalculated. Data from I5 Woodburn Northbound in April of 2005 were used in this verification process. Following the established methods and using the programs developed and reported in the ODOT Policy Report, the 2005 load factors were accurately reproduced.

Effects of Changes to Load Tables

Since the ODOT Policy Report was issued, the ODOT issued permit weight tables (PWT) have been updated. The current tables are shown in Appendix A. The changes between the 2005 and current tables resulted in a decrease in the number of "Table X" trucks and an increase in the "Table 4", and

"Table 5" trucks. To determine the impact altering the PWTs on the LRFR live load factors, the current PWTs and the 2005 PWTs were used to sort a set of WIM data from I5 Woodburn Northbound in April 2005 (data used in the original calibration). Results from this analysis are presented below in Table 2 and Table 3. As seen in Table 2, most of the vehicles that were previously classified as "Table X" are now classified under one of the five permit weight tables. Altering the truck PWTs caused very small changes in "Table 4", but "Table 5" and "Table X" truck populations were significantly altered. The changes observed for classification of the heavier trucks did not alter the alongside truck population and thus, the live load factors remained unchanged as seen below in Table 3. Based on this analysis, the recent changes to the ODOT Permit Weight Tables did not affect the live load factors.

Table 2: 05' vs. 08' Permit Weight Table Comparison

GVW Statistical Data I5 Woodburn April 05										
Data Classification	Sorted with 2005 Permit Weight Tables					Sorted with 2008 Permit Weight Tables				
	Tot. No Records	No. of Top 20%	Mean (Kips)	Std. Dev (Kips)	COV (%)	Tot. No Records	No. of Top 20%	Mean (Kips)	Std. Dev (Kips)	COV (%)
Table 1 (all)	136363	27273	73.60	2.58	3.5%	136363	27273	73.60	2.58	3.5%
Table 1 (3S2)	49232	9846	74.04	2.05	2.8%	49232	9846	74.04	2.05	2.8%
Table 2 with	13675	2735	101.43	1.72	1.7%	13675	2735	101.43	1.72	1.7%
Table 1 and 2	150038	30008	83.05	9.81	11.8%	150038	30008	83.05	9.81	11.8%
Table 3 No CTP	1226	245	114.53	16.28	14.2%	1226	245	114.53	16.28	14.2%
Table 4	57	11	177.85	18.82	10.6%	58	12	177.85	18.82	10.6%
Table 5	1	0	134.10	#DIV/0!	#DIV/0!	22	4	106.72	29.41	27.6%
Table X	25	5	137.10	24.16	17.6%	3	1	100.90	NA	NA

Table 3: Permit Weight Table Comparison of Live Load Factors

Type	γL		%Change
	05 Tables	**08 Tables**	
Oregon Legal Loads	1.39	1.39	0%
CTP-3	1.42	1.42	0%
CTP-2A, CTP-2B	1.36	1.36	0%
STP-3	1.21	1.21	0%
STP-4A	1.35	1.35	0%
STP-4B	0.98	0.98	0%
STP-5A	1.08	1.08	0%
STP-5B	1.04	1.04	0%
STP-5C	0.85	0.85	0%
STP-5BW	0.94	0.94	0%

Additional Sorting Procedures Required for New WIM Data Format

As stated previously, the original 2005 WIM data format mixed substantial text headers with the numerical data as seen in Figure 1 while the current format uses a CSV format as seen in Figure 2. This change to the data format required additional steps to be performed prior to executing the cleaning and sorting process outlined in the ODOT Policy Report. Several executable files were produced during the 2005 calibration process to aid in the cleaning and sorting process: Wingnut12.exe, Liger9.exe, Tablesorter9.exe, and 3S2_Nubs2b.exe. To run these executables with the new data format, the read statements had to be updated. In addition, there were a number of hard returns that were embedded in the raw WIM data that had to be removed prior to initiating the cleaning and sorting process. Once these were removed the data was processed without difficulty. The new read statements were verified to properly read the raw data and the resulting outputs retained the data fidelity.

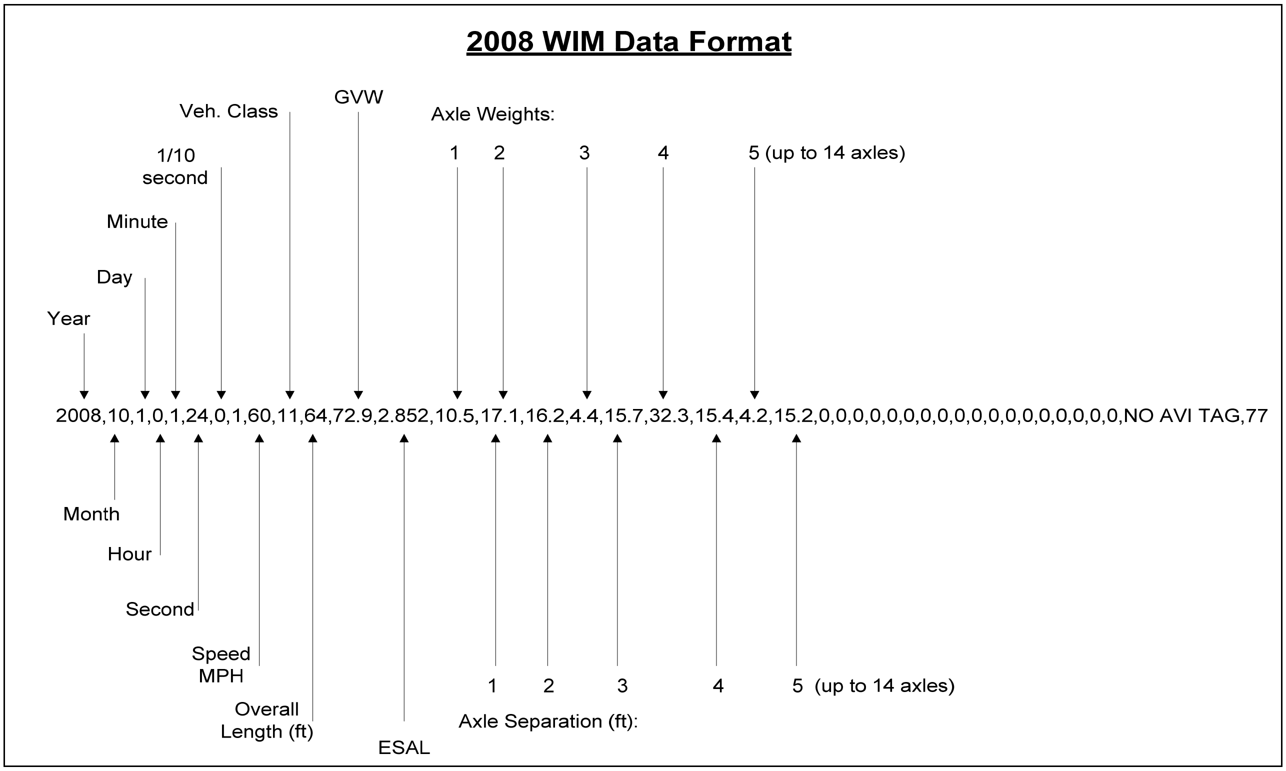
One last change that was made to the new WIM data structure is that 14 axles are now recorded whereas the 2005 data had only 13 axles. The data arrays were updated in all the programs to account for the additional axle recorded in the data fields.

Once the above changes were made, the 2008 WIM data were cleaned, filtered, and processed according to the procedures described in the ODOT Policy Report. Checks were made to ensure trucks were properly classified and the data fidelity was retained.

Figure 1: Prior WIM Data Format from 2005

```
(6688) LANE #1  CLASS 12  GVW 49.9 kips  LENGTH 67 ft
ESAL 0.774 SPEED 58 mph  MAX GVW 80.0 kips Tue Jan 01 00:01:07.44 2008
 AXLE    SEPARATION     LEFT WT     RIGHT WT     TOTAL WT    ALLOWABLE
            (ft)        (kips)       (kips)       (kips)       (kips)
   1                     5.3          5.8         11.1         13.2
   2        12.8         6.9          6.7         13.7         20.0
   3        21.4         4.9          4.2          9.1         20.0
   4         8.5         4.0          3.9          7.9         20.0
   5        22.6         4.5          3.5          8.0         20.0
[OFF]
     TAG_H:000545746924
(6689) LANE #1  CLASS 11  GVW 71.5 kips  LENGTH 68 ft
ESAL 2.613 SPEED 51 mph  MAX GVW 80.0 kips Tue Jan 01 00:01:21.08 2008
 AXLE    SEPARATION     LEFT WT     RIGHT WT     TOTAL WT    ALLOWABLE
            (ft)        (kips)       (kips)       (kips)       (kips)
   1                     5.6          5.6         11.2         13.2
   2        17.4         8.8          7.8         16.6         17.0
   3         4.4         7.2          8.1         15.3         17.0
   4        32.1         7.3          6.6         13.9         17.0
   5         4.2         7.8          6.8         14.5         17.0
[OFF]
```

Figure 2: 2008 WIM Data Format



It should be noted that the CSV format has reduced the formatting errors present in the prior format. Thus Wingnut12.exe may no longer detect any data format errors.

2008 LRFR TRUCK FACTOR METHODOLOGY and RESULTS

The ODOT Policy Report described the procedures used for sorting and analyzing WIM data to produce the state specific live load factors and after the above changes were made, these procedures were followed to process the 2008 WIM data. As the methods are covered in detail in the original Report, only a brief overview of the process is included here.

WIM Site Selection, Seasons, and Data Collection Windows

The same four sites used in the 2005 calibration were used in the present calculations. The selected stations are; I-5 Northbound at Woodburn, US-97 Northbound at Bend, OR-58 Westbound at Lowell, and I-84 Westbound at Emigrant Hill. To account for possible seasonal variations, data for each site were obtained for four different times of the year. January, March, June, and October were selected to represent the four different seasons of winter, spring, summer, and fall respectively. These were similar to those selected in the 2005 calibration.

The length of time required for continuous data collection at a site was shown in the 2005 calibration process to be of less importance, with data quality being more paramount. Although not established in prior reports, a period of two weeks with continuous WIM data was chosen to be a minimum length of time for data collection. In the present calculations, WIM data were available for a minimum of two weeks and when more data were available, up to a full month was included in the results. The details for the WIM data set used in the present calculations are show in Table 4.

Table 4: Evaluation Time Frame

Location	Raw data time frame			
	Winter	Spring	Summer	Fall
I-5 Northbound at Woodburn	1/1/2008 through 1/31/2008	3/1/2008 through 3/31/2008	6/7/2008 through 6/30/2008	10/1/2008 through 10/31/2008
US-97 Northbound at Bend	1/1/2008 through 1/31/2008	3/1/2008 through 3/31/2008	6/9/2008 through 6/30/2008	10/1/2008 through 10/31/2008
OR-58 Westbound at Lowell	1/1/2008 through 1/31/2008	3/1/2008 through 3/31/2008	6/1/2008 through 6/30/2008	10/1/2008 through 10/31/2008
I-84 Westbound at Emigrant Hill	1/1/2008 through 1/31/2008	3/1/2008 through 3/27/2008	6/1/2008 through 6/30/2008	10/1/2008 through 10/31/2008

<u>Sorting Process</u>

Raw data retrieved from the four WIM stations was processed according to the procedures outlined in ODOT Policy Report. Upon removing the invalid records, the remaining data was classified according to the five ODOT permit weight tables (see Appendix A). In addition to sorting the trucks by weight table, the trucks identified as the alongside truck were grouped into a separate table. The alongside truck population is classified as all trucks in the following:

- Legal trucks (Weight Table 1)
- Extended Weight Table 2 (105500 lbs maximum)
- 98,000-lb CTP vehicles from Weight Table 3

According to the ODOT Policy Report, the above list best describes the Oregon alongside truck population.

Average Daily Truck Traffic

For each of the four locations, ADTT values were determined in the 2005 calibration. The measured ADTT using the 2008 data were also determined and compared to the 2005 ADTT as seen in Table 5. The highlighted cells in Table 5 indicate the 2008 data show larger ADTT values for particular months than the average used in 2005. However, averages of the ADTT over the four months considered at all sites were below the 2005 averages. In the current work the original 2005 ADTT values were retained for the subsequent load factor calculations.

Table 5: Observed 2008 ADTT and comparison ADTT from 2005 WIM data.

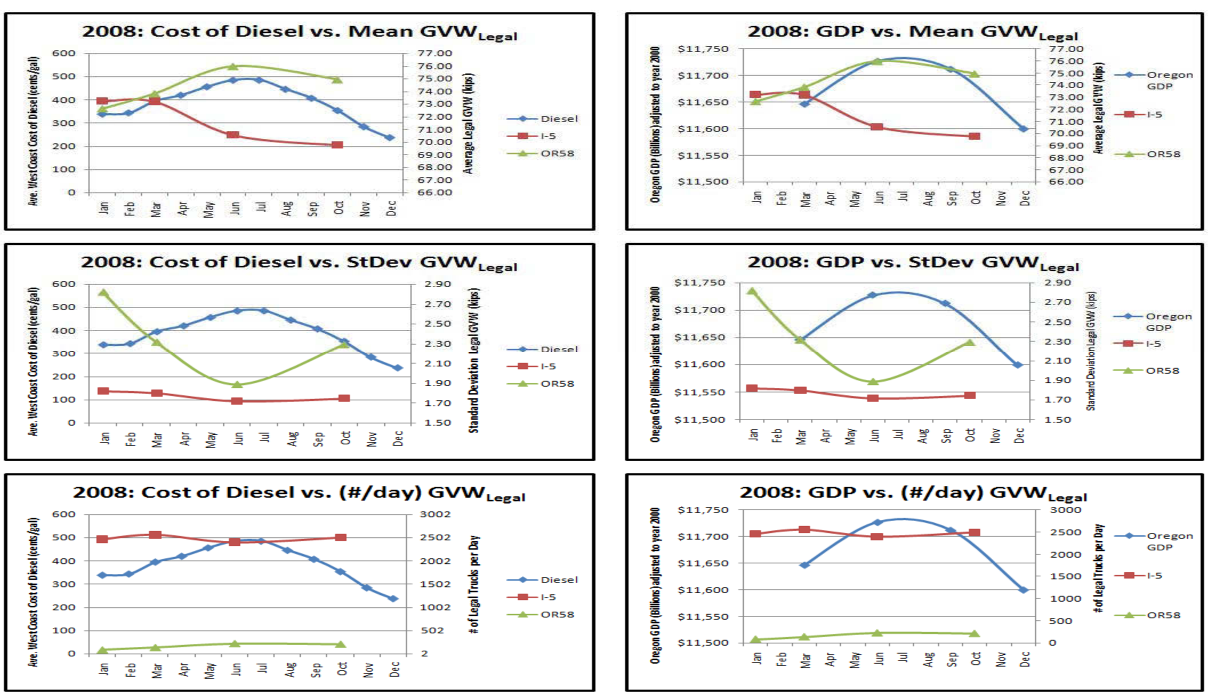
2008 Recorded ADTT from WIM data				
Location	Lowell	Woodburn	Bend	Emigrant Hill
Winter	227	4616	396	976
Spring	306	4850	505	1743
Summer	493	4776	678	1761
Fall	453	4821	619	1743
Average	370	4766	550	1556
2005 ADTT	**581**	**5550**	**607**	**1786**

Oregon Truck Population Statistics

This section provides the statistical results from the 2008 WIM data that were subsequently used to calculate the live load factors. The live load factors were calculated based on the top 20% of the WIM truck data and use the following statistical parameters: mean gross vehicle weight (GVW_{mean}), standard deviation of the gross vehicle weight (GVW_{stdev}), total number of trucks, number of permitted trucks, probability of side by side events, and evaluation period. Statistical data is presented in two forms; one that presents results that are based on averages of the data over the entire year (from the 4 months selected), while the other retains the seasonal variation in the statistical data. Data averaged over the entire year is meant to show broad changes in the truck population and is shown in Table 7: The results show that the Emigrant Hill, Bend, and Lowell locations tended to follow similar trends, but Woodburn was somewhat different. In general the volume of truck traffic has decreased relative to the 2005 Calibration Report. While the truck volume has decreased, the mean GVW of the top twenty percent of the population generally increased, except for Woodburn which showed a 3% reduction in the GVW_{mean}. Lowell showed the most significant changes in that the number of trucks was reduced significantly (down 50%) and the truck weight increased by the largest margin. Another feature of note is that the three lower volume locations had a significant increase in the percentage of permitted trucks, while the Woodburn location showed a significant decrease. Changes in the number of permitted trucks in the population results in changes to the single trip permit (STP) live load factors.

Detailed statistical summaries are included in APPENDIX B and show the statistical results for each location for each season. The 2008 data showed similar variation associated with seasonal changes as was seen in 2005. However, high fuel prices through the middle of the year and then the downturn in the economy accelerating at the end of 2008 also may have influenced the results. In an attempt to quantify this effect the Legal truck population was compared to economic parameters; the results of this comparison is presented in Figure 3. I-5 and OR-58 are plotted vs. two economic parameters; average cost of diesel for the west coast during 2008[1] and gross domestic product (GDP) for Oregon in 2008[2]. The GDP and the cost of diesel follow similar trends, both of which peaked in the summer and then decreased through the end of the year. Statistics for OR-58 at Lowell are considered to represent general statistical trends for I-84 Emigrant Hill and US-97 Bend.

Figure 3: Economic parameters considered with respect to legal truck populations at WIM sites.



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[1] Information regarding Diesel cost is from US Energy Information Administration. 3 23, 2009. http://tonto.eia.doe.gov/dnav/pet/hist/ddr006M.htm (accessed 3 29, 2009).
[2] Information regarding the GDP for Oregon is from the Office of Economic Analysis. 2008. http://www.oregon.gov/DAS/OEA/economic.shtml (access 3 29, 2009)

Table 6: 2008 WIM Statistical Data

GVW Statistical Data for I5 Woodburn NB 2008 Annual Average					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	126743	25349	71.91	2.70	4%
Table 1 (3S2 to 80k)	72843	14569	71.68	1.77	2%
Table 2 with CTP (all)	11724	2345	97.36	1.89	2%
Table 1 and 2 with CTP	138466	27693	80.17	8.94	11%
Table 3 No CTP	787	158	109.26	14.60	13%
Table 4	110	22	150.61	16.30	11%
Table 5	7	2	144.30	#DIV/0!	#DIV/0!
Table X	5	1	131.00	#DIV/0!	#DIV/0!

ADTT Verification	
Total Trucks	139375
Total Time (days)	29
Recorded ADTT	4766
Suggested ADTT	5550
Total Permit Trucks	909
Permits/day	31

Permits per 1000 Trucks	6.5

GVW Statistical Data for I5 Woodburn NB 2005 Annual Average					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	134852	26970	73.93	2.58	4%
Table 1 (3S2 to 80k)	53997	10799	74.58	2.01	3%
Table 2 with CTP (all)	14130	2826	101.74	1.71	2%
Table 1 and 2 with CTP	148982	29797	83.37	9.70	12%
Table 3 No CTP	1947	389	91.04	17.40	19%
Table 4	71	14	118.34	24.36	21%
Table 5	5	1	135.04	16.60	13%
Table X	38	7	143.75	25.25	18%

ADTT Verification	
Total Trucks	151042
Total Time (days)	31
Recorded ADTT	4957
Suggested ADTT	5550
Total Permit Trucks	2060
Permits/day	68

Permits per 1000 Trucks	13.6

GVW Statistical Data for I5 Woodburn NB % Change					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-6%	-6%	-3%	5%	7%
Table 1 (3S2 to 80k)	35%	35%	-4%	-12%	-18%
Table 2 with CTP (all)	-17%	-17%	-4%	11%	-3%
Table 1 and 2 with CTP	-7%	-7%	-4%	-8%	-5%
Table 3 No CTP	-60%	-60%	20%	-16%	-31%
Table 4	55%	56%	27%	-33%	-47%
Table 5	35%	50%	7%	#DIV/0!	#DIV/0!
Table X	-86%	-86%	-9%	#DIV/0!	#DIV/0!

ADTT Verification	
Total Trucks	-8%
Total Time (days)	-4%
Recorded ADTT	-4%
Suggested ADTT	0%
Total Permit Trucks	-56%
Permits/day	-54%

Permits per 1000 Trucks	-52%

GVW Statistical Data for US-97 Bend NB 2008 Annual Average					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	13372	2674	75.94	1.98	3%
Table 1 (3S2 to 80k)	6696	1339	77.97	1.09	1%
Table 2 with CTP (all)	1696	339	96.36	4.40	5%
Table 1 and 2 with CTP	15067	3013	81.68	7.35	9%
Table 3 No CTP	401	80	109.97	11.04	10%
Table 4	13	3	169.94	8.75	5%
Table 5	6	1	139.01	#DIV/0!	#DIV/0!
Table X	2	0	#DIV/0!	#DIV/0!	#DIV/0!

ADTT Verification	
Total Trucks	15489
Total Time (days)	29
Recorded ADTT	550
Suggested ADTT	607
Total Permit Trucks	422
Permits/day	15

Permits per 1000 Trucks	27.2

GVW Statistical Data for US-97 Bend NB 2005 Annual Average					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	14493	2899	75	2	0
Table 1 (3S2 to 80k)	7346	1469	77	1	0
Table 2 with CTP (all)	1267	253	99	3	0
Table 1 and 2 with CTP	15760	3152	80	7	0
Table 3 No CTP	363	73	86	18	0
Table 4	10	2	123	22	0
Table 5	2	0	103	3	0
Table X	11	4	113	14	0

ADTT Verification	
Total Trucks	16145
Total Time (days)	30
Recorded ADTT	538
Suggested ADTT	607
Total Permit Trucks	385
Permits/day	13

Permits per 1000 Trucks	23.8

GVW Statistical Data for US-97 Bend % Change					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-8%	-8%	1%	-2%	-2%
Table 1 (3S2 to 80k)	-9%	-9%	1%	-7%	-8%
Table 2 with CTP (all)	34%	34%	-3%	70%	81%
Table 1 and 2 with CTP	-4%	-4%	2%	0%	-2%
Table 3 No CTP	11%	11%	28%	-38%	-52%
Table 4	33%	33%	38%	-61%	-71%
Table 5	260%	260%	35%	#DIV/0!	#DIV/0!
Table X	-86%	-92%	#DIV/0!	#DIV/0!	#DIV/0!

ADTT Verification	
Total Trucks	-4%
Total Time (days)	-4%
Recorded ADTT	2%
Suggested ADTT	0%
Total Permit Trucks	10%
Permits/day	18%

Permits per 1000 Trucks	14%

GVW Statistical Data for OR-58 Lowell 2008 Annual Average					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	9533	1907	73.54	2.59	4%
Table 1 (3S2)	5027	1005	74.35	2.33	5%
Table 2 with CTP (all)	1363	273	98.20	2.17	2%
Table 1 and 2 with CTP	10894	2179	84.26	8.04	10%
Table 3 No CTP	385	77	106.86	5.33	5%
Table 4	38	8	143.10	23.83	16%
Table 5	5	1	154.23	#DIV/0!	#DIV/0!
Table X	3	1	145.35	#DIV/0!	#DIV/0!

ADTT Verification	
Total Trucks	11325
Total Time (days)	31
Recorded ADTT	370
Suggested ADTT	581
Total Permit Trucks	430
Permits/day	15

Permits per 1000 Trucks	38

GVW Statistical Data for Lowell WB Annual Average 2005					
Data	Tot. No. of	No. of	Mean	Std Dev	COV
Classification	Records	Top 20%	(kips)	(kips)	(%)
Table 1 (all)	20653	4131	68.21	4.26	6%
Table 1 (3S2 to 80k)	10614	2123	66.13	3.12	5%
Table 2 with CTP (all)	832	166	92.08	2.42	3%
Table 1 and 2 with CTP	21485	4297	72.08	7.58	11%
Table 3 No CTP	38	8	95.53	20.43	21%
Table 4	7	1	125.93	22.65	17%
Table 5	1	0	61.60	0.00	0%
Table X	4	1	70.60	#DIV/0!	#DIV/0!

ADTT Verification	
Total Trucks	21546
Total Time (days)	30
Recorded ADTT	718
Suggested ADTT	581
Total Permit Trucks	61
Permits/day	2

Permits per 1000 Trucks	3

GVW Statistical Data for Lowell WB % Change					
Data	Tot. No. of	No. of	Mean	Std Dev	COV
Classification	Records	Top 20%	(kips)	(kips)	(%)
Table 1 (all)	-54%	-54%	8%	-39%	-44%
Table 1 (3S2 to 80k)	-53%	-53%	12%	-25%	0%
Table 2 with CTP (all)	64%	64%	7%	-10%	-20%
Table 1 and 2 with CTP	-49%	-49%	17%	6%	-10%
Table 3 No CTP	919%	919%	12%	-74%	-77%
Table 4	467%	467%	14%	5%	-6%
Table 5	800%	800%	150%	#DIV/0!	#DIV/0!
Table X	-31%	-45%	106%	#DIV/0!	#DIV/0!

ADTT Verification	
Total Trucks	-47%
Total Time (days)	3%
Recorded ADTT	-49%
Suggested ADTT	0%
Total Permit Trucks	602%
Permits/day	638%

Permits per 1000 Trucks	1236%

GVW Statistical Data for I-84 E.Hill 2008 Annual Average					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	36558	7312	74.50	2.14	3%
Table 1 (3S2 to 80k)	25610	5122	76.40	1.66	2%
Table 2 with CTP (all)	6383	1277	97.24	3.87	4%
Table 1 and 2 with CTP	42940	8588	81.97	7.53	9%
Table 3 No CTP	2981	596	113.68	5.02	4%
Table 4	64	13	149.28	15.31	10%
Table 5	18	4	118.63	8.07	6%
Table X	29	6	123.09	13.66	10%

ADTT Verification	
Total Trucks	46032
Total Time (days)	30
Recorded ADTT	1556
Suggested ADTT	1786
Total Permit Trucks	3092
Permits/day	105

Permits per 1000 Trucks	67.2

GVW Statistical Data for I-84 E.Hill 2005 Annual Average					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	43550	8710	70.18	4.02	6%
Table 1 (3S2 to 80k)	28633	5727	68.38	2.29	3%
Table 2 with CTP (all)	4314	863	96.75	2.63	3%
Table 1 and 2 with CTP	47864	9573	78.00	9.13	12%
Table 3 No CTP	1012	202	93.90	18.27	20%
Table 4	22	4	77.33	10.41	10%
Table 5	1	0	40.28	9.72	6%
Table X	22	4	83.51	4.99	4%

ADTT Verification	
Total Trucks	48920
Total Time (days)	30
Recorded ADTT	1631
Suggested ADTT	1786
Total Permit Trucks	1056
Permits/day	35

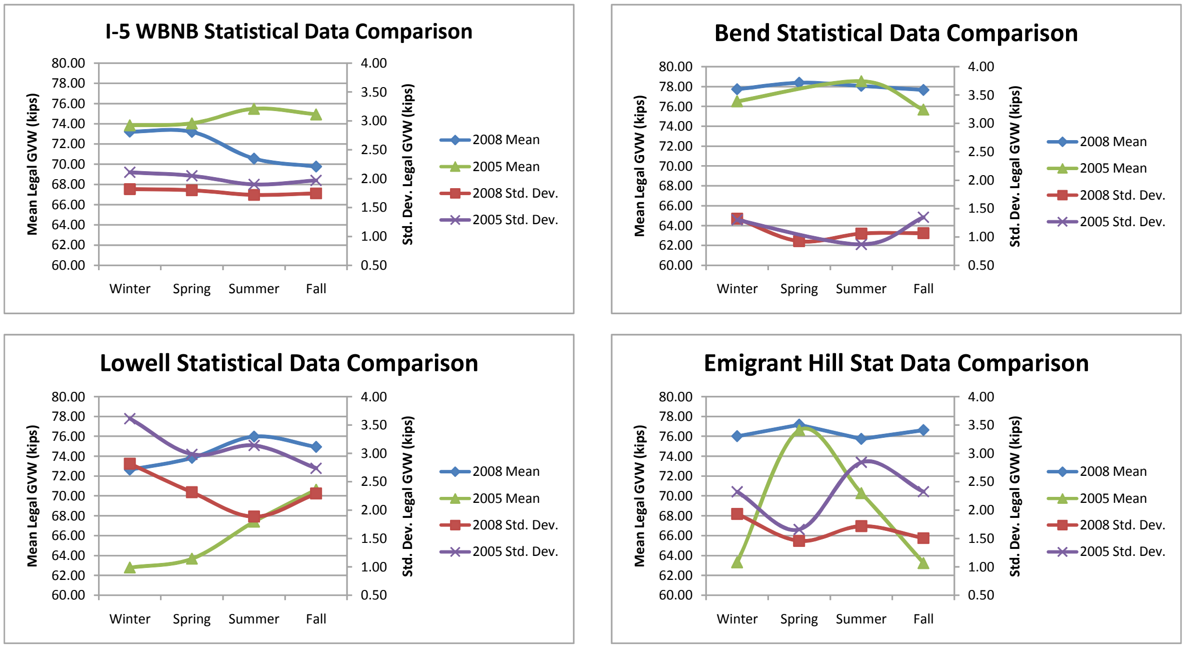
Permits per 1000 Trucks	21.6

GVW Statistical Data for I-84 E.Hill % Change					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-16%	-16%	6%	-47%	-51%
Table 1 (3S2 to 80k)	-11%	-11%	12%	-28%	-36%
Table 2 with CTP (all)	48%	48%	1%	47%	48%
Table 1 and 2 with CTP	-10%	-10%	5%	-18%	-22%
Table 3 No CTP	195%	195%	21%	-73%	-78%
Table 4	192%	192%	93%	47%	6%
Table 5	3550%	3550%	195%	-17%	4%
Table X	33%	34%	47%	174%	154%

ADTT Verification	
Total Trucks	-6%
Total Time (days)	-1%
Recorded ADTT	-5%
Suggested ADTT	0%
Total Permit Trucks	193%
Permits/day	200%

Permits per 1000 Trucks	211%

Figure 4: Statistical comparison GVW of legal truck populations at four WIM sites considered.



The observed changes in the truck population, regardless of cause, resulted in changes of the live load factors as shown in the subsequent section.

Live Load Factors

LRFR live load factors for state-owned bridges were calculated from the statistical data show in Appendix B following the procedure outlined in the ODOT Policy Report. The maximum value for each site at any season during 2008 is shown in Table 8. Comparison results from the 2005 calibration are shown in Table 9 and the factors currently used by ODOT can be referred back to Table 1. As seen in these tables, the live load factors for locations with ADTT greater than 5000 decreased, while the low ADTT volume sites saw an increase in truck live load factors. The intermediate ADTT value site remained about the same. The low volume site was controlled by Lowell and the resulting live load factors are now larger than those now used in ODOT practice for the legal loads, CTP-3, CTP-2A and CTP-2B, as well as STP-3, STP-4A and STP-5A. Detailed plots showing live load factor for each site, rating vehicle, and seasonal variation are included in Appendix C.

Table 7: 2008 Truck live load factors for different ADTT with controlling WIM site and month.

UPPERBOUND 2008	ADTT			
	≥ 5000	1500	≤ 500	≤ 500*
Legal Loads	**1.36** WBNB Jan	**1.34** EHill Jun-Oct	**1.34** Lowell Mar	**1.33** Lowell Mar
CTP-3	**1.39** WBNB Jan	**1.34** EHill Jun-Oct	**1.32** Lowell Mar	**1.30** Lowell Mar
CTP-2A, CTP-2B	**1.33** WBNB Jan	**1.28** EHill Jun-Oct	**1.26** Lowell Mar	**1.25** Lowell Mar
STP-3	**1.19** WBNB Jan	**1.19** EHill Oct	**1.15** Lowell Jun-Oct	**1.15** Lowell Jun-Oct
STP-4A	**1.33** WBNB Jan	**1.33** EHill Oct	**1.28** Lowell Jun-Oct	**1.28** Lowell Jun-Oct
STP-4B	**0.96** WBNB Jan	**0.96** EHill Jun-Oct	**0.94** Lowell Oct	**0.94** Lowell Oct
STP-5A	**1.06** WBNB Jan	**1.06** EHill Jun-Oct	**1.03** Lowell Jun-Oct	**1.03** Lowell Jun-Oct
STP-5B	**1.02** WBNB Jan	**1.02** EHill Jun-Oct	**0.99** Lowell Mar-Jun-Oct	**0.99** Lowell Mar-Jun-Oct
STP-5C	**0.84** WBNB Jan	**0.84** EHill Jun-Oct	**0.82** Bend Jan Lowell Mar-Jun-Oct	**0.82** Bend Jan Lowell Mar-Jun-Oct
STP-5BW	**0.92** WBNB Jan	**0.93** EHill Oct	**0.90** Lowell Jun-Oct	**0.90** Lowell Jun-Oct

Note: WBNB=Woodburn NB and EHill=Emigrant Hill.
* indicates calculations performed using average annual recorded 2008 WIM ADTT for Lowell (ADTT = 370)

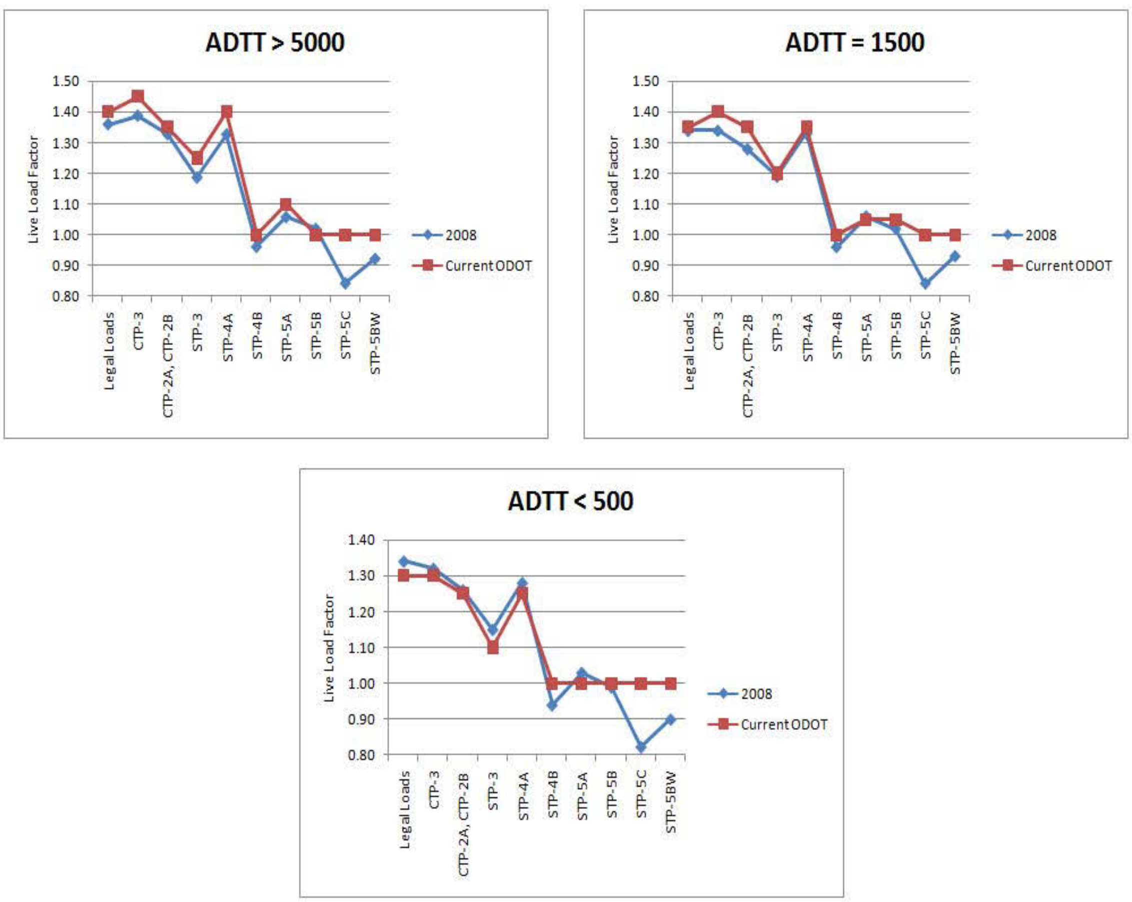
Table 8: Truck live load factors from 2005 WIM data.

UPPERBOUND 2005	ADTT		
	≥ 5000	1500	≤ 500
Legal Loads	1.40	1.34	1.30
CTP-3	1.43	1.39	1.29
CTP-2A, CTP-2B	1.36	1.33	1.24
STP-3	1.23	1.18	1.11
STP-4A	1.38	1.32	1.24
STP-4B	0.99	0.96	0.91
STP-5A	1.09	1.06	1.00
STP-5B	1.05	1.02	0.97
STP-5C	0.86	0.84	0.81
STP-5BW	0.95	0.92	0.88

Table 9: Percent change in truck live load factor for high, moderate, and low volume sites.

UPPERBOUND % Change	ADTT		
	≥ 5000	1500	≤ 500
Legal Loads	-3%	0%	3%
CTP-3	-3%	-4%	2%
CTP-2A, CTP-2B	-2%	-4%	2%
STP-3	-4%	1%	4%
STP-4A	-4%	1%	3%
STP-4B	-3%	0%	3%
STP-5A	-3%	0%	3%
STP-5B	-3%	0%	2%
STP-5C	-2%	0%	2%
STP-5BW	-3%	1%	2%

Figure 5: Live load factor comparisons for high, moderate, and low volume sites.



As seen in Table 7, compared to 2005 results in Table 8, the Lowell site produced higher live load factors for almost all truck types. Referencing Table 5, the WIM recorded average ADTT is substantially less than the corresponding 2005 values. The Lowell live load factors were recalculated using a WIM measured average ADTT value of 370 (the recorded average for 2008). The resulting change in live load factors are shown in the far right column of Table 7 and were slightly smaller.

The same approach to rounding live load factors established by Groff (2006) was applied to the low volume site. Table 10 shows the resulting live load factors if the Lowell ADTT = 581, while Table 11 shows the resulting live load factors if the Lowell ADTT = 370.

Table 10: Rounded Live Load Factor Comparison w/ Lowell ADTT = 581

ADTT ≤ 500 w/ Lowell ADTT = 581	ODOT Current	Actual 2008	Rounded 08	% Change
Legal Loads	1.30	1.34	1.35	4%
CTP-3	1.30	1.32	1.35	4%
CTP-2A, CTP-2B	1.25	1.26	1.30	4%
STP-3	1.10	1.15	1.15	5%
STP-4A	1.25	1.28	1.30	4%
STP-4B	1.00	0.94	1.00	0%
STP- 5A	1.00	1.03	1.05	5%
STP-5B	1.00	0.99	1.00	0%
STP-5C	1.00	0.82	1.00	0%
STP-5BW	1.00	0.90	1.00	0%

Table 11: Rounded Live Load Factor Comparison w/ Lowell ADTT = 370

ADTT ≤ 500 w/ Lowell ADTT = 370	ODOT Current	Actual 2008	Rounded 08	% Change
Legal Loads	1.30	1.32	1.35	4%
CTP-3	1.30	1.30	1.30	0%
CTP-2A, CTP-2B	1.25	1.25	1.25	0%
STP-3	1.10	1.15	1.15	5%
STP-4A	1.25	1.28	1.30	4%
STP-4B	1.00	0.94	1.00	0%
STP- 5A	1.00	1.03	1.05	5%
STP-5B	1.00	0.99	1.00	0%
STP-5C	1.00	0.82	1.00	0%
STP-5BW	1.00	0.90	1.00	0%

Conclusion and Recommendations

Based on recalculation of the Oregon-specific live load factors, using 2008 WIM data, for four sites, and four months in different seasons, and compared with prior 2005 results, the following conclusions and recommendations are presented:

- WIM records for I5 at Woodburn in 2008 compared to 2005, showed fewer trucks with lighter legal loads, resulting in smaller truck live load factors for the high volume location.
- WIM records for I84 at Emigrant Hill in 2008 compared to 2005, showed less seasonal variation but similar peak effects, resulting in similar live load factors for the intermediate volume site.
- WIM records for US97 at Bend in 2008 compared to 2005, showed little change with respect to 2005 values.
- WIM records for OR58 at Lowell in 2008 compared to 2005, showed significantly fewer trucks (nearly 50%). At the same time, the mean gross vehicle weights increased by the largest margin, which resulted in higher live load factors. Lowell controlled the low volume sites live load factor selection in all cases.
- If Lowell is taken to represent sites with ADTT < 500 then the low volume site live load factors should be increased, unless there is a unique operational rationale (construction routing for example) to account for the observed changes. As was shown in Table 10 and Table 11, the selection of the ADTT value for this site should be taken into consideration when choosing the final live load factors.
- Based on the economic conditions and diesel fuel price variation, 2008 may be an atypical year with respect to the truck populations in Oregon.
- Given the changes observed at the low volume site, it is recommended that the live load factors be recalculated when the economic and/or diesel fuel pricing conditions change, regardless of the time increment since the last calculation. Thresholds for these changes are not known at this time. Recalculation is also recommended if policy changes would in turn alter the truck population characteristics.
- WIM data should continue to be collected and archived by ODOT to facilitate future data analysis.

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APPENDIX A: Permit Weight Tables

Figure 6: Permit Weight Table 1

OREGON DEPARTMENT OF TRANSPORTATION
MOTOR CARRIER TRANSPORTATION DIVISION
TRANSPORTATION PERMIT UNIT
550 CAPITOL ST NE
SALEM OREGON 97301-2530

Permit Weight Table 1

The following exceptions apply to the table of weights shown below:

Exception 1: Two consecutive tandem axles may weigh up to 34,000 pounds each if:

Minimum Axle Spacing Required	Interstate Highways	Non-Interstate Highways
30 feet or more	Permit Required	No Permit Required
36 feet or more	No Permit Required	No Permit Required

Exception 2: A group of four axles consisting of a set of tandem axles and two axles spaced nine feet or more apart may have a loaded weight of more than 65,500 pounds and up to 70,000 pounds if:

Minimum Axle Spacing Required	Interstate Highways	Non-Interstate Highways
35 feet or more	Permit Required	No Permit Required

- Minimum axle spacing is the distance between the frst and last axle of any group shown above.

Wheelbase In Feet*	Number of Axles: 2	3	4	5	6	7 Or More	Wheelbase In Feet*	Number of Axles: 2	3	4	5	6	7 Or More
4	34,000	34,000	34,000	34,000	34,000	34,000	31	40,000	59,000	62,500	67,500	72,500	78,000
5	34,000	34,000	34,000	34,000	34,000	34,000	32	40,000	60,000	63,500	68,000	73,000	78,500
6	34,000	34,000	34,000	34,000	34,000	34,000	33	40,000	60,000	64,000	68,500	74,000	79,000
7	34,000	34,000	34,000	34,000	34,000	34,000	34	40,000	60,000	64,500	69,000	74,500	80,000
8 & less	34,000	34,000	34,000	34,000	34,000	34,000	35	40,000	60,000	65,500	70,000	75,000	80,000
Over 8	38,000	42,000	42,000	42,000	42,000	42,000	36	40,000	60,000	66,000	70,500	75,500	80,000
9	39,000	42,500	42,500	42,500	42,500	42,500	37	40,000	60,000	66,500	71,000	76,000	80,000
10	40,000	43,500	43,500	43,500	43,500	43,500	38	40,000	60,000	67,500	71,500	77,000	80,000
11	40,000	44,000	44,000	44,000	44,000	44,000	39	40,000	60,000	68,000	72,500	77,500	80,000
12	40,000	45,000	50,000	50,000	50,000	50,000	40	40,000	60,000	68,500	73,000	78,000	80,000
13	40,000	45,500	50,500	50,500	50,500	50,500	41	40,000	60,000	69,500	73,500	78,500	80,000
14	40,000	46,500	51,500	51,500	51,500	51,500	42	40,000	60,000	70,000	74,000	79,000	80,000
15	40,000	47,000	52,000	52,000	52,000	52,000	43	40,000	60,000	70,500	75,000	80,000	80,000
16	40,000	48,000	52,500	58,000	58,000	58,000	44	40,000	60,000	71,500	75,500	80,000	80,000
17	40,000	48,500	53,500	58,500	58,500	58,500	45	40,000	60,000	72,000	76,000	80,000	80,000
18	40,000	49,500	54,000	59,000	59,000	59,000	46	40,000	60,000	72,500	76,500	80,000	80,000
19	40,000	50,000	54,500	60,000	60,000	60,000	47	40,000	60,000	73,500	77,500	80,000	80,000
20	40,000	51,000	55,500	60,500	66,000	66,000	48	40,000	60,000	74,000	78,000	80,000	80,000
21	40,000	51,500	56,000	61,000	66,500	66,500	49	40,000	60,000	74,500	78,500	80,000	80,000
22	40,000	52,500	56,500	61,500	67,000	67,000	50	40,000	60,000	75,500	79,000	80,000	80,000
23	40,000	53,000	57,500	62,500	68,000	68,000	51	40,000	60,000	76,000	80,000	80,000	80,000
24	40,000	54,000	58,000	63,000	68,500	74,000	52	40,000	60,000	76,500	80,000	80,000	80,000
25	40,000	54,500	58,500	63,500	69,000	74,500	53	40,000	60,000	77,500	80,000	80,000	80,000
26	40,000	55,500	59,500	64,000	69,500	75,000	54	40,000	60,000	78,000	80,000	80,000	80,000
27	40,000	56,000	60,000	65,000	70,000	75,500	55	40,000	60,000	78,500	80,000	80,000	80,000
28	40,000	57,000	60,500	65,500	71,000	76,500	56	40,000	60,000	79,500	80,000	80,000	80,000
29	40,000	57,500	61,500	66,000	71,500	77,000	57 or more	40,000	60,000	80,000	80,000	80,000	80,000
30	40,000	58,500	62,000	66,500	72,000	77,500							

The loaded weight of any group of axles, vehicle, or combination of vehicles shall not exceed that specified in the table of weights shown above or any of the following:

- The manufacturer's side wall tire rating but not to exceed 600 pounds per inch of tire width.
- 600 pounds per inch of tire width.
- 20,000 pounds on any one axle, including any one axle of a group of axles.
- 34,000 pounds on any tandem axle.
- The sum of the permittable axle, tandem axle, or group of axle weights shown above, whichever is less.

Note exceptions 1 and 2 above.

* *Distance measured to the nearest foot; when exactly 1/2 foot or more, round up to the next larger number.*

Figure 7: Permit Weight Table 2

OREGON DEPARTMENT OF TRANSPORTATION
MOTOR CARRIER TRANSPORTATION DIVISION
550 CAPITOL ST NE
SALEM OR 97301-2530

PERMIT WEIGHT TABLE 2

WHEELBASE	5 Axles	6 Axles	7 Axles	8 or More Axles
47	77500	81000	81000	81000
48	78000	82000	82000	82000
49	78500	83000	83000	83000
50	79000	84000	84000	84000
51	80000	84500	85000	85000
52	80500	85000	86000	86000
53	81000	86000	87000	87000
54	81500	86500	88000	91000
55	82500	87000	89000	92000
56	83000	87500	90000	93000
57	83500	88000	91000	94000
58	84000	89000	92000	95000
59	85000	89500	93000	96000
60	85500	90000	94000	97000
61	86000	90500	95000	98000
62	87000	91000	96000	99000
63	87500	92000	97000	100000
64	88000	92500	97500	101000
65	88500	93000	98000	102000
66	89000	93500	98500	103000
67	90000	94000	99000	104000
68	90000	95000	99500	105000
69	90000	95500	100000	105500
70	90000	96000	101000	105500
71	90000	96500	101500	105500
72	90000	96500	102000	105500
73	90000	96500	102500	105500
74	90000	96500	103000	105500
75	90000	96500	104000	105500
76	90000	96500	104500	105500
77	90000	96500	105000	105500
78	90000	96500	105500	105500

See Weight Table 1, if using less than five axles or 47 feet wheelbase.

735-8111(2-00) • DISTANCE MEASURED TO THE NEAREST FOOT. WHEN EXACTLY 1/2 FOOT OR MORE, ROUND UP TO THE NEXT LARGER NUMBER • STK # 300558

Figure 8: Permit Weight Table 3 (1/2)

OREGON DEPARTMENT OF TRANSPORTATION
MOTOR CARRIER TRANSPORTATION DIVISION
TRANSPORTATION PERMIT UNIT
550 CAPITOL ST NE
SALEM OREGON 97301-2530

Permit Weight Table 3

WHEEL BASE	2 Axles	3 Axles	4 Axles	5 Axles	6 Axles	7 Axles	8 Axles	9 Axles	10 Axles	11 Axles or more
4	43,000									
5	43,000									
6	43,000									
7	43,000									
8	43,000									
OVER 8' (BUT LESS THAN 8'6")										
	43,000	48,000								
9	43,000	49,000								
10	43,000	50,000								
11	43,000	51,000								
12	43,000	52,000								
13	43,000	53,000								
14	43,000	54,000								
15	43,000	55,000								
16	43,000	56,000								
17	43,000	57,000								
18	43,000	58,000								
19	43,000	64,500	70,800							
20	43,000	64,500	72,000							
21	43,000	64,500	73,200							
22	43,000	64,500	74,400							
23	43,000	64,500	75,600							
24	43,000	64,500	76,800							
25	43,000	64,500	78,000							
26	43,000	64,500	79,200							
27	43,000	64,500	80,400							
28	43,000	64,500	81,600							
29	43,000	64,500	82,800							
30	43,000	64,500	84,000							
31	43,000	64,500	85,200							
32	43,000	64,500	86,000	86,400						
33	43,000	64,500	86,000	87,600						
34	43,000	64,500	86,000	88,800						
35	43,000	64,500	86,000	90,000						
36	43,000	64,500	86,000	91,200						
37	43,000	64,500	86,000	92,400						
38	43,000	64,500	86,000	93,600						
39	43,000	64,500	86,000	94,800						
40	43,000	64,500	86,000	96,000						
41	43,000	64,500	86,000	97,200						
42	43,000	64,500	86,000	98,400						
43	43,000	64,500	86,000	99,600						
44	43,000	64,500	86,000	100,800						
45	43,000	64,500	86,000	102,000						
46	43,000	64,500	86,000	103,200						
47	43,000	64,500	86,000	104,400						
48	43,000	64,500	86,000	105,600						
49	43,000	64,500	86,000	106,800						
50	43,000	64,500	86,000	107,500	108,000					
51	43,000	64,500	86,000	107,500	109,200					
52	43,000	64,500	86,000	107,500	110,400					
53	43,000	64,500	86,000	107,500	111,600					
54	43,000	64,500	86,000	107,500	112,800					
55	43,000	64,500	86,000	107,500	114,000					
56	43,000	64,500	86,000	107,500	115,200					
57	43,000	64,500	86,000	107,500	116,400					
58	43,000	64,500	86,000	107,500	117,600					
59	43,000	64,500	86,000	107,500	118,800					
60	43,000	64,500	86,000	107,500	120,000					
61	43,000	64,500	86,000	107,500	121,200					
62	43,000	64,500	86,000	107,500	122,400					
63	43,000	64,500	86,000	107,500	123,600					
64	43,000	64,500	86,000	107,500	124,800					
65	43,000	64,500	86,000	107,500	126,000					
66	43,000	64,500	86,000	107,500	127,200					
67	43,000	64,500	86,000	107,500	128,400					
68	43,000	64,500	86,000	107,500	129,000	129,600				
69	43,000	64,500	86,000	107,500	129,000	130,800				
70	43,000	64,500	86,000	107,500	129,000	132,000				
71	43,000	64,500	86,000	107,500	129,000	133,200				
72	43,000	64,500	86,000	107,500	129,000	134,400				
73	43,000	64,500	86,000	107,500	129,000	135,600				
74	43,000	64,500	86,000	107,500	129,000	136,800				
75	43,000	64,500	86,000	107,500	129,000	138,000				

The loaded weight of a group of axles, vehicles, or combination of vehicles shall not exceed that specified in this permit weight table or any of the following:

*The manufacturer's side wall tire rating but not to exceed **600** pounds per inch of tire width;*
***21,500** pounds per single axle;*
***43,000** pounds per tandem axle;*
The weight shown on the permit; and
The sum of the permittable axle, tandem axle, or group axle weight, whichever is less;
Or except as described in OAR 734-082-0010 (2)

Formulas applied:

1,000 times (the wheelbase in feet plus 40) when wheelbase is 18 feet or less.
1,200 times (the wheelbase in feet plus 40) when wheelbase is more than 18 feet.

Distance measured to the nearest foot; when exactly 1/2 foot or more, round up to the next larger number.

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Figure 9: Permit Weight Table 3 (2/2)

WHEEL BASE	2 Axles	3 Axles	4 Axles	5 Axles	6 Axles	7 Axles	8 Axles	9 Axles	10 Axles	11 Axles or more
76	43,000	64,500	86,000	107,500	129,000	139,200				
77	43,000	64,500	86,000	107,500	129,000	140,400				
78	43,000	64,500	86,000	107,500	129,000	141,600				
79	43,000	64,500	86,000	107,500	129,000	142,800				
80	43,000	64,500	86,000	107,500	129,000	144,000				
81	43,000	64,500	86,000	107,500	129,000	145,200				
82	43,000	64,500	86,000	107,500	129,000	146,400				
83	43,000	64,500	86,000	107,500	129,000	147,600				
84	43,000	64,500	86,000	107,500	129,000	148,800				
85	43,000	64,500	86,000	107,500	129,000	150,000				
86	43,000	64,500	86,000	107,500	129,000	150,500	151,200			
87	43,000	64,500	86,000	107,500	129,000	150,500	152,400			
88	43,000	64,500	86,000	107,500	129,000	150,500	153,600			
89	43,000	64,500	86,000	107,500	129,000	150,500	154,800			
90	43,000	64,500	86,000	107,500	129,000	150,500	156,000			
91	43,000	64,500	86,000	107,500	129,000	150,500	157,200			
92	43,000	64,500	86,000	107,500	129,000	150,500	158,400			
93	43,000	64,500	86,000	107,500	129,000	150,500	159,600			
94	43,000	64,500	86,000	107,500	129,000	150,500	150,800			
95	43,000	64,500	86,000	107,500	129,000	150,500	152,000			
96	43,000	64,500	86,000	107,500	129,000	150,500	153,200			
97	43,000	64,500	86,000	107,500	129,000	150,500	154,400			
98	43,000	64,500	86,000	107,500	129,000	150,500	155,600			
99	43,000	64,500	86,000	107,500	129,000	150,500	156,800			
100	43,000	64,500	86,000	107,500	129,000	150,500	158,000			
101	43,000	64,500	86,000	107,500	129,000	150,500	159,200			
102	43,000	64,500	86,000	107,500	129,000	150,500	170,400			
103	43,000	64,500	86,000	107,500	129,000	150,500	171,600			
104	43,000	64,500	86,000	107,500	129,000	150,500	172,000	172,800		
105	43,000	64,500	86,000	107,500	129,000	150,500	172,000	174,000		
106	43,000	64,500	86,000	107,500	129,000	150,500	172,000	175,200		
107	43,000	64,500	86,000	107,500	129,000	150,500	172,000	176,400		
108	43,000	64,500	86,000	107,500	129,000	150,500	172,000	177,600		
109	43,000	64,500	86,000	107,500	129,000	150,500	172,000	178,800		
110	43,000	64,500	86,000	107,500	129,000	150,500	172,000	180,000		
111	43,000	64,500	86,000	107,500	129,000	150,500	172,000	181,200		
112	43,000	64,500	86,000	107,500	129,000	150,500	172,000	182,400		
113	43,000	64,500	86,000	107,500	129,000	150,500	172,000	183,600		
114	43,000	64,500	86,000	107,500	129,000	150,500	172,000	184,800		
115	43,000	64,500	86,000	107,500	129,000	150,500	172,000	186,000		
116	43,000	64,500	86,000	107,500	129,000	150,500	172,000	187,200		
117	43,000	64,500	86,000	107,500	129,000	150,500	172,000	188,400		
118	43,000	64,500	86,000	107,500	129,000	150,500	172,000	189,600		
119	43,000	64,500	86,000	107,500	129,000	150,500	172,000	190,800		
120	43,000	64,500	86,000	107,500	129,000	150,500	172,000	192,000		
121	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,200		
122	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	194,400	
123	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	195,600	
124	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	196,800	
125	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	198,000	
126	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	199,200	
127	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	200,400	
128	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	201,600	
129	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	202,800	
130	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	204,000	
131	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	205,200	
132	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	206,400	
133	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	207,600	
134	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	208,800	
135	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	210,000	
136	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	211,200	
137	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	212,400	
138	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	213,600	
139	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	214,800	
140	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	216,000
141	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	217,200
142	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	218,400
143	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	219,600
144	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	220,800
145	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	222,000
146	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	223,200
147	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	224,400
148	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	225,600
149	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	226,800
150	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	228,000

Distance measured to the nearest foot; when exactly 1/2 foot or more, round up to the next larger number.

PERMIT WEIGHT TABLE 3 - PAGE 2

Figure 10: Permit Weight Table 4 (1/2)

OREGON DEPARTMENT OF TRANSPORTATION
MOTOR CARRIER TRANSPORTATION DIVISION
TRANSPORTATION PERMIT UNIT
550 CAPITOL ST NE
SALEM OREGON 97301-2530

Permit Weight Table 4

WHEEL BASE	2 Axles	3 Axles	4 Axles	5 Axles	6 Axles	7 Axles	8 Axles	9 Axles	10 Axles	11 Axles	12 Axles	13 Axles	14 Axles	15 Axles or more
4	43,000													
5	43,000													
6	43,000													
7	43,000													
8	43,000													
OVER 8' (BUT LESS THAN 8'6")														
	43,000	57,600												
9	43,000	58,800												
10	43,000	64,500	65,000											
11	43,000	64,500	68,200											
12	43,000	64,500	70,400											
13	43,000	64,500	72,600											
14	43,000	64,500	74,800											
15	43,000	64,500	77,000											
16	43,000	64,500	79,200											
17	43,000	64,500	81,400											
18	43,000	64,500	83,600											
19	43,000	64,500	85,800											
20	43,000	64,500	86,000	88,000										
21	43,000	64,500	86,000	90,200										
22	43,000	64,500	86,000	92,400										
23	43,000	64,500	86,000	94,600										
24	43,000	64,500	86,000	96,800										
25	43,000	64,500	86,000	99,000										
26	43,000	64,500	86,000	101,200										
27	43,000	64,500	86,000	103,400										
28	43,000	64,500	86,000	105,600										
29	43,000	64,500	86,000	107,500	107,800									
30	43,000	64,500	86,000	107,500	110,000									
31	43,000	64,500	86,000	107,500	113,600									
32	43,000	64,500	86,000	107,500	115,200									
33	43,000	64,500	86,000	107,500	116,800									
34	43,000	64,500	86,000	107,500	118,400									
35	43,000	64,500	86,000	107,500	120,000									
36	43,000	64,500	86,000	107,500	121,600									
37	43,000	64,500	86,000	107,500	123,200									
38	43,000	64,500	86,000	107,500	124,800									
39	43,000	64,500	86,000	107,500	126,400									
40	43,000	64,500	86,000	107,500	128,000									
41	43,000	64,500	86,000	107,500	129,000	129,600								
42	43,000	64,500	86,000	107,500	129,000	131,200								
43	43,000	64,500	86,000	107,500	129,000	132,800								
44	43,000	64,500	86,000	107,500	129,000	134,400								
45	43,000	64,500	86,000	107,500	129,000	136,000								
46	43,000	64,500	86,000	107,500	129,000	137,600								
47	43,000	64,500	86,000	107,500	129,000	139,200								
48	43,000	64,500	86,000	107,500	129,000	140,800								
49	43,000	64,500	86,000	107,500	129,000	142,400								
50	43,000	64,500	86,000	107,500	129,000	144,000								
51	43,000	64,500	86,000	107,500	129,000	145,600								
52	43,000	64,500	86,000	107,500	129,000	147,200								
53	43,000	64,500	86,000	107,500	129,000	148,800								
54	43,000	64,500	86,000	107,500	129,000	150,400								
55	43,000	64,500	86,000	107,500	129,000	150,500	152,000							
56	43,000	64,500	86,000	107,500	129,000	150,500	153,600							
57	43,000	64,500	86,000	107,500	129,000	150,500	155,200							
58	43,000	64,500	86,000	107,500	129,000	150,500	156,800							
59	43,000	64,500	86,000	107,500	129,000	150,500	158,400							
60	43,000	64,500	86,000	107,500	129,000	150,500	160,000							
61	43,000	64,500	86,000	107,500	129,000	150,500	161,600							
62	43,000	64,500	86,000	107,500	129,000	150,500	163,200							
63	43,000	64,500	86,000	107,500	129,000	150,500	164,800							
64	43,000	64,500	86,000	107,500	129,000	150,500	166,400							
65	43,000	64,500	86,000	107,500	129,000	150,500	168,000							
66	43,000	64,500	86,000	107,500	129,000	150,500	169,600							
67	43,000	64,500	86,000	107,500	129,000	150,500	171,200							
68	43,000	64,500	86,000	107,500	129,000	150,500	172,000	172,800						
69	43,000	64,500	86,000	107,500	129,000	150,500	172,000	174,400						
70	43,000	64,500	86,000	107,500	129,000	150,500	172,000	176,000						
71	43,000	64,500	86,000	107,500	129,000	150,500	172,000	177,600						
72	43,000	64,500	86,000	107,500	129,000	150,500	172,000	179,200						
73	43,000	64,500	86,000	107,500	129,000	150,500	172,000	180,800						
74	43,000	64,500	86,000	107,500	129,000	150,500	172,000	182,400						
75	43,000	64,500	86,000	107,500	129,000	150,500	172,000	184,000						

The loaded weight of a group of axles, vehicles, or combination of vehicles shall not exceed that specified in this permit weight table or any of the following:

*The manufacturer's side wall tire rating but not to exceed **600** pounds per inch of tire width;*
***21,500** pounds per single axle;*
***43,000** pounds per tandem axle;*
The weight shown on the permit; and
The sum of the permittable axle, tandem axle, or group axle weight, whichever is less;
Or except as described in OAR 734-082-0010 (2)

For weights beyond 15 axles and 150 feet of wheelbase, apply the following formula:

1,600 times (the wheelbase in feet plus 40) when wheelbase is more than 30 feet

Distance measured to the nearest foot; when exactly 1/2 foot or more, round up to the next larger number.

FORM 735-8113 (7-06) STK# 300360

Figure 11: Permit Weight Table 4 (2/2)

WHEEL BASE	2 Axles	3 Axles	4 Axles	5 Axles	6 Axles	7 Axles	8 Axles	9 Axles	10 Axles	11 Axles	12 Axles	13 Axles	14 Axles	15 Axles or more
76	43,000	64,500	86,000	107,500	129,000	150,500	172,000	185,600						
77	43,000	64,500	86,000	107,500	129,000	150,500	172,000	187,200						
78	43,000	64,500	86,000	107,500	129,000	150,500	172,000	188,800						
79	43,000	64,500	86,000	107,500	129,000	150,500	172,000	190,400						
80	43,000	64,500	86,000	107,500	129,000	150,500	172,000	192,000						
81	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	193,600					
82	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	195,200					
83	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	196,800					
84	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	198,400					
85	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	200,000					
86	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	201,600					
87	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	203,200					
88	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	204,800					
89	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	206,400					
90	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	208,000					
91	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	209,600					
92	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	211,200					
93	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	212,800					
94	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	214,400					
95	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	216,000				
96	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	217,600				
97	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	219,200				
98	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	220,800				
99	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	222,400				
100	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	224,000				
101	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	225,600				
102	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	227,200				
103	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	228,800				
104	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	230,400				
105	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	232,000				
106	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	233,600				
107	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	235,200				
108	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	236,800			
109	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	238,400			
110	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	240,000			
111	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	241,600			
112	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	243,200			
113	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	244,800			
114	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	246,400			
115	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	248,000			
116	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	249,600			
117	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	251,200			
118	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	252,800			
119	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	254,400			
120	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	256,000			
121	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	257,600			
122	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	259,200		
123	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	260,800		
124	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	262,400		
125	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	264,000		
126	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	265,600		
127	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	267,200		
128	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	268,800		
129	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	270,400		
130	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	272,000		
131	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	273,600		
132	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	275,200		
133	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	276,800		
134	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	278,400		
135	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	280,000	
136	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	281,600	
137	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	283,200	
138	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	284,800	
139	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	286,400	
140	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	288,000	
141	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	289,600	
142	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	291,200	
143	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	292,800	
144	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	294,400	
145	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	296,000	
146	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	297,600	
147	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	299,200	
148	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	300,800	
149	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	301,000	302,400
150	43,000	64,500	86,000	107,500	129,000	150,500	172,000	193,500	215,000	236,500	258,000	279,500	301,000	304,000

Distance measured to the nearest foot; when exactly 1/2 foot or more, round up to the next larger number.

PERMIT WEIGHT TABLE 4 – PAGE 2

Figure 12: Permit Weight Table 5 (1/2)

OREGON DEPARTMENT OF TRANSPORTATION
MOTOR CARRIER TRANSPORTATION DIVISION
TRANSPORTATION PERMIT UNIT
550 CAPITOL ST NE
SALEM OREGON 97301-2530

Permit Weight Table 5

WHEEL BASE	2 Axles	3 Axles	4 Axles	5 Axles	6 Axles	7 Axles	8 Axles	9 Axles	10 Axles	11 Axles	12 Axles	13 Axles or more
4	48,000											
5	48,000											
6	48,000											
7	48,000											
8	48,000											
OVER 8' (BUT LESS THAN 8'6")												
	48,000	57,600										
9	48,000	58,800										
10	48,000	65,000										
11	48,000	68,200										
12	48,000	70,400										
13	48,000	72,000	72,600									
14	48,000	72,000	74,800									
15	48,000	72,000	77,000									
16	48,000	72,000	79,200									
17	48,000	72,000	81,400									
18	48,000	72,000	83,600									
19	48,000	72,000	85,800									
20	48,000	72,000	88,000									
21	48,000	72,000	90,200									
22	48,000	72,000	92,400									
23	48,000	72,000	94,600									
24	48,000	72,000	96,000	96,800								
25	48,000	72,000	96,000	99,000								
26	48,000	72,000	96,000	101,200								
27	48,000	72,000	96,000	103,400								
28	48,000	72,000	96,000	105,600								
29	48,000	72,000	96,000	107,800								
30	48,000	72,000	96,000	110,000								
31	48,000	72,000	96,000	113,600								
32	48,000	72,000	96,000	115,200								
33	48,000	72,000	96,000	116,800								
34	48,000	72,000	96,000	118,400								
35	48,000	72,000	96,000	120,000								
36	48,000	72,000	96,000	120,000	121,600							
37	48,000	72,000	96,000	120,000	123,200							
38	48,000	72,000	96,000	120,000	124,800							
39	48,000	72,000	96,000	120,000	126,400							
40	48,000	72,000	96,000	120,000	128,000							
41	48,000	72,000	96,000	120,000	129,600							
42	48,000	72,000	96,000	120,000	131,200							
43	48,000	72,000	96,000	120,000	132,800							
44	48,000	72,000	96,000	120,000	134,400							
45	48,000	72,000	96,000	120,000	136,000							
46	48,000	72,000	96,000	120,000	137,600							
47	48,000	72,000	96,000	120,000	139,200							
48	48,000	72,000	96,000	120,000	140,800							
49	48,000	72,000	96,000	120,000	142,400							
50	48,000	72,000	96,000	120,000	144,000							
51	48,000	72,000	96,000	120,000	144,000	145,600						
52	48,000	72,000	96,000	120,000	144,000	147,200						
53	48,000	72,000	96,000	120,000	144,000	148,800						
54	48,000	72,000	96,000	120,000	144,000	150,400						
55	48,000	72,000	96,000	120,000	144,000	152,000						
56	48,000	72,000	96,000	120,000	144,000	153,600						
57	48,000	72,000	96,000	120,000	144,000	155,200						
58	48,000	72,000	96,000	120,000	144,000	156,800						
59	48,000	72,000	96,000	120,000	144,000	158,400						
60	48,000	72,000	96,000	120,000	144,000	160,000						
61	48,000	72,000	96,000	120,000	144,000	161,600						
62	48,000	72,000	96,000	120,000	144,000	163,200						
63	48,000	72,000	96,000	120,000	144,000	164,800						
64	48,000	72,000	96,000	120,000	144,000	166,400						
65	48,000	72,000	96,000	120,000	144,000	168,000						
66	48,000	72,000	96,000	120,000	144,000	168,000	169,600					
67	48,000	72,000	96,000	120,000	144,000	168,000	171,200					
68	48,000	72,000	96,000	120,000	144,000	168,000	172,800					
69	48,000	72,000	96,000	120,000	144,000	168,000	174,400					
70	48,000	72,000	96,000	120,000	144,000	168,000	176,000					
71	48,000	72,000	96,000	120,000	144,000	168,000	177,600					
72	48,000	72,000	96,000	120,000	144,000	168,000	179,200					
73	48,000	72,000	96,000	120,000	144,000	168,000	180,800					
74	48,000	72,000	96,000	120,000	144,000	168,000	182,400					
75	48,000	72,000	96,000	120,000	144,000	168,000	184,000					

The loaded weight of a group of axles, vehicle, or combination of vehicles shall not exceed that specified in this permit weight table or any of the following:

Subject to special routing and analysis by the Department of Transportation, single trip permits may be issued for combinations of vehicles having a steering axle followed by four or more consecutive tandem axles, provided the weight does not exceed:

The manufacturer's side wall tire rating or

600 pounds per inch of tire width, whichever is less;

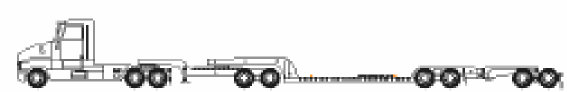
24,000 pounds per single axle;

48,000 pounds per tandem axle;

The weight shown on the permit; and

The sum of the permittable axle, tandem axle, or group axle weight, whichever is less;

Or except as described in OAR 734-082-0010 (2)



EXAMPLE (AS STATED ABOVE)

For weights beyond 15 axles and 150 feet of wheelbase, apply the following formula:

1,600 times (the wheelbase in feet plus 40) when wheelbase is more than 30 feet.

Distance measured to the nearest foot; when exactly 1/2 foot or more, round up to the next larger number.

FORM 735-8114 (7-06) STK# 300591

Figure 13: Permit Weight Table (2/2)

WHEEL BASE	2 Axles	3 Axles	4 Axles	5 Axles	6 Axles	7 Axles	8 Axles	9 Axles	10 Axles	11 Axles	12 Axles	13 Axles or more
76	48,000	72,000	96,000	120,000	144,000	168,000	185,600					
77	48,000	72,000	96,000	120,000	144,000	168,000	187,200					
78	48,000	72,000	96,000	120,000	144,000	168,000	188,800					
79	48,000	72,000	96,000	120,000	144,000	168,000	190,400					
80	48,000	72,000	96,000	120,000	144,000	168,000	192,000					
81	48,000	72,000	96,000	120,000	144,000	168,000	192,000	193,600				
82	48,000	72,000	96,000	120,000	144,000	168,000	192,000	195,200				
83	48,000	72,000	96,000	120,000	144,000	168,000	192,000	196,800				
84	48,000	72,000	96,000	120,000	144,000	168,000	192,000	198,400				
85	48,000	72,000	96,000	120,000	144,000	168,000	192,000	200,000				
86	48,000	72,000	96,000	120,000	144,000	168,000	192,000	201,600				
87	48,000	72,000	96,000	120,000	144,000	168,000	192,000	203,200				
88	48,000	72,000	96,000	120,000	144,000	168,000	192,000	204,800				
89	48,000	72,000	96,000	120,000	144,000	168,000	192,000	206,400				
90	48,000	72,000	96,000	120,000	144,000	168,000	192,000	208,000				
91	48,000	72,000	96,000	120,000	144,000	168,000	192,000	209,600				
92	48,000	72,000	96,000	120,000	144,000	168,000	192,000	211,200				
93	48,000	72,000	96,000	120,000	144,000	168,000	192,000	212,800				
94	48,000	72,000	96,000	120,000	144,000	168,000	192,000	214,400				
95	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000				
96	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	217,600			
97	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	219,200			
98	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	220,800			
99	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	222,400			
100	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	224,000			
101	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	225,600			
102	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	227,200			
103	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	228,800			
104	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	230,400			
105	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	232,000			
106	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	233,600			
107	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	235,200			
108	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	236,800			
109	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	238,400			
110	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000			
111	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	241,600		
112	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	243,200		
113	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	244,800		
114	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	246,400		
115	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	248,000		
116	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	249,600		
117	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	251,200		
118	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	252,800		
119	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	254,400		
120	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	256,000		
121	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	257,600		
122	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	259,200		
123	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	260,800		
124	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	262,400		
125	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000		
126	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	265,600	
127	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	267,200	
128	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	268,800	
129	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	270,400	
130	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	272,000	
131	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	273,600	
132	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	275,200	
133	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	276,800	
134	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	278,400	
135	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	280,000	
136	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	281,600	
137	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	283,200	
138	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	284,800	
139	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	286,400	
140	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	
141	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	289,600
142	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	291,200
143	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	292,800
144	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	294,400
145	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	296,000
146	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	297,600
147	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	299,200
148	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	300,800
149	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	302,400
150	48,000	72,000	96,000	120,000	144,000	168,000	192,000	216,000	240,000	264,000	288,000	304,000

Distance measured to the nearest foot; when exactly 1/2 foot or more, round up to the next larger number.

PERMIT WEIGHT TABLE 5 – PAGE 2

APPENDIX B: Statistical Data

Table 12: Lowell GVW Statistical Data 2008

GVW Statistical Data for OR-58 Lowell January					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	5611	1122.2	72.81	3.18	4.36%
Table 1 (3S2)	2606	521.2	72.64	2.82	10.34%
Table 2 with CTP (all)	1164	232.8	97.14	2.03	2.09%
Table 1 and 2 with CTP	6775	1355	87.74	6.83	7.78%
Table 3 No CTP	237	47.4	102.43	2.29	2.24%
Table 4	18	3.6	149.45	30.09	20.14%
Table 5	1	0.2	158.00	#DIV/0!	#DIV/0!
Table X	2	0.4	138.80	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	7033				
Total Time (days)	31				
Recorded ADTT	227				
Suggested ADTT	581				
Total Permit Trucks	258				
Permits/day	9				

GVW Statistical Data for Lowell WB WIM Record - January 2005					
Data	Tot. No. of	No. of	Mean	Std Dev	COV
Classification	Records	Top 20%	(kips)	(kips)	(%)
Table 1 (all)	15157	3031	66.56	5.06	8%
Table 1 (3S2 to 80k)	7373	1475	62.79	3.61	6%
Table 2 with CTP (all)	473	95	89.00	2.96	3%
Table 1 and 2 with CTP	15630	3126	70.02	7.45	11%
Table 3 No CTP	26	5	96.00	19.41	20%
Table 4	3	1	129.03	37.82	29%
Table 5	0	0			
Table X	0	0	0.00	0.00	0.00%
ADTT Verification					
Total Trucks	15659				
Total Time (days)	30				
Recorded ADTT	522				
Suggested ADTT	581				
Total Permit Trucks	29				
Permits/day	1				

% Change GVW Statistical Data for Lowell WB January					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-63%	-63%	9%	-37%	-43%
Table 1 (3S2)	-65%	-65%	16%	-22%	80%
Table 2 with CTP (all)	146%	146%	9%	-31%	-37%
Table 1 and 2 with CTP	-57%	-57%	25%	-8%	-27%
Table 3 No CTP	812%	812%	7%	-88%	-89%
Table 4	500%	500%	16%	-20%	-31%
Table 5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	23343%				
Total Time (days)	-94%				
Recorded ADTT	-61%				
Suggested ADTT	1903%				
Total Permit Trucks	25700%				
Permits/day	#REF!				

GVW Statistical Data for OR-58 Lowell March 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	7965	1593	73.31	2.53	3.46%
Table 1 (3S2)	4253	850.6	73.84	2.32	3.14%
Table 2 with CTP (all)	1257	251.4	97.66	2.29	2.34%
Table 1 and 2 with CTP	9222	1844.4	85.25	8.40	9.85%
Table 3 No CTP	236	47.2	105.99	2.47	2.33%
Table 4	19	3.8	133.00	4.24	3.19%
Table 5	4	0.8	139.80	#DIV/0!	#DIV/0!
Table X	1	0.2	95.30	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	9482				
Total Time (days)	31				
Recorded ADTT	306				
Suggested ADTT	581				
Total Permit Trucks	260				
Permits/day	9				

GVW Statistical Data for Lowell WB WIM Record - April 2005					
Data	Tot. No. of	No. of	Mean	Std Dev	COV
Classification	Records	Top 20%	(kips)	(kips)	(%)
Table 1 (all)	17455	3491	66.94	4.71	7%
Table 1 (3S2 to 80k)	9103	1821	63.69	2.99	5%
Table 2 with CTP (all)	436	87	88.46	2.01	2%
Table 1 and 2 with CTP	17891	3578	69.57	6.89	10%
Table 3 No CTP	14	3	85.77	17.02	20%
Table 4	3	1	108.60	4.20	4%
Table 5	0	0			
Table X	0	0	0.00	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	17957				
Total Time (days)	30				
Recorded ADTT	599				
Suggested ADTT	581				
Total Permit Trucks	66				
Permits/day	2				

% Change GVW Statistical Data for Lowell WB March					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-54%	-54%	10%	-46%	-51%
Table 1 (3S2)	-53%	-53%	16%	-22%	-33%
Table 2 with CTP (all)	188%	188%	10%	14%	3%
Table 1 and 2 with CTP	-48%	-48%	23%	22%	-1%
Table 3 No CTP	1586%	1586%	24%	-86%	-88%
Table 4	533%	533%	22%	1%	-18%
Table 5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	31507%				
Total Time (days)	-95%				
Recorded ADTT	-47%				
Suggested ADTT	780%				
Total Permit Trucks	12900%				
Permits/day	#REF!				

GVW Statistical Data for Lowell June 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	12503	2500.6	74.34	2.22	2.99%
Table 1 (3S2)	6716	1343.2	75.99	1.89	2.48%
Table 2 with CTP (all)	1593	318.6	98.93	2.18	2.20%
Table 1 and 2 with CTP	14096	2819.2	82.04	8.34	10.17%
Table 3 No CTP	581	116.2	108.70	7.73	7.11%
Table 4	79	15.8	139.45	31.34	22.47%
Table 5	7	1.4	195.50	20.22	10.34%
Table X	6	1.2	204.00	3.96	1.94%
ADTT Verification					
Total Trucks	14769				
Total Time (days)	30				
Recorded ADTT	493				
Suggested ADTT	581				
Total Permit Trucks	673				
Permits/day	23				

GVW Statistical Data for Lowell WB WIM Record - June 2005					
Data	Tot. No. of	No. of	Mean	Std Dev	COV
Classification	Records	Top 20%	(kips)	(kips)	(%)
Table 1 (all)	24765	4953	68.71	3.95	6%
Table 1 (3S2 to 80k)	12842	2568	67.41	3.14	5%
Table 2 with CTP (all)	999	200	94.86	2.29	2%
Table 1 and 2 with CTP	25764	5153	72.91	7.99	11%
Table 3 No CTP	50	10	102.67	22.87	22%
Table 4	12	2	127.71	26.31	21%
Table 5	1	0	138.10		
Table X	3	1	114.60	0.00	0.00%
ADTT Verification					
Total Trucks	25830				
Total Time (days)	30				
Recorded ADTT	861				
Suggested ADTT	581				
Total Permit Trucks	66				
Permits/day	2				

% Change GVW Statistical Data for Lowell WB June					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-50%	-50%	8%	-44%	-48%
Table 1 (3S2)	-48%	-48%	13%	-40%	-47%
Table 2 with CTP (all)	59%	59%	4%	-5%	-9%
Table 1 and 2 with CTP	-45%	-45%	13%	4%	-7%
Table 3 No CTP	1062%	1062%	6%	-66%	-68%
Table 4	558%	558%	9%	19%	9%
Table 5	600%	600%	42%	#DIV/0!	#DIV/0!
Table X	#DIV/0!	20%	78%	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	49130%				
Total Time (days)	-97%				
Recorded ADTT	-15%				
Suggested ADTT	780%				
Total Permit Trucks	33550%				
Permits/day	#REF!				

GVW Statistical Data for Lowell October 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	12051	2410.2	73.71	2.44	3.31%
Table 1 (3S2)	6533	1306.6	74.95	2.29	3.06%
Table 2 with CTP (all)	1438	287.6	99.07	2.18	2.20%
Table 1 and 2 with CTP	13484	2696.8	81.99	8.59	10.47%
Table 3 No CTP	485	97	110.31	8.83	8.00%
Table 4	37	7.4	150.49	29.65	19.71%
Table 5	6	1.2	123.60	2.97	2.40%
Table X	2	0.4	143.30	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	14014				
Total Time (days)	31				
Recorded ADTT	453				
Suggested ADTT	581				
Total Permit Trucks	530				
Permits/day	18				

GVW Statistical Data for Lowell October 05					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	25235	5047	70.62	3.33	5.00%
Table 1 (3S2)	13138	2628	70.64	2.74	4.00%
Table 2 with CTP (all)	1419	284	95.99	2.40	3.00%
Table 1 and 2 with CTP	26654	5331	75.84	7.99	11.00%
Table 3 No CTP	61	12	97.70	22.41	23.00%
Table 4	9	2	138.38	22.28	16.00%
Table 5	1	0	108.30		
Table X	13	3	167.80	18.35	10.94%
ADTT Verification					
Total Trucks	26738				
Total Time (days)	30				
Recorded ADTT	891				
Suggested ADTT	581				
Total Permit Trucks	84				
Permits/day	3				

% Change GVW Statistical Data for Lowell WB October					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-52%	-52%	4%	-27%	-34%
Table 1 (3S2)	-50%	-50%	6%	-16%	-24%
Table 2 with CTP (all)	1%	1%	3%	-9%	-27%
Table 1 and 2 with CTP	-49%	-49%	8%	7%	-5%
Table 3 No CTP	695%	695%	13%	-61%	-65%
Table 4	311%	311%	9%	33%	23%
Table 5	500%	500%	14%	#DIV/0!	#DIV/0!
Table X	-85%	-87%	-15%	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	-48%				
Total Time (days)	3%				
Recorded ADTT	-49%				
Suggested ADTT	0%				
Total Permit Trucks	531%				
Permits/day	500%				

Table 13: Woodburn GVW Statistical data 2008

GVW Statistical Data for I5 Woodburn NB January 2008					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	128382	25677	73.21	2.39	3.26%
Table 1 (3S2 to 80k)	76543	15309	73.22	1.82	2.48%
Table 2 with CTP (all)	13348	2670	99.38	1.85	1.86%
Table 1 and 2 with CTP	141730	28346	82.30	9.19	11.16%
Table 3 No CTP	1123	225	108.18	11.94	11.04%
Table 4	219	44	140.54	18.90	13.45%
Table 5	12	3	164.37	13.26	8.07%
Table X	10	2	125.35	38.68	30.86%
ADTT Verification					
Total Trucks	143094				
Total Time (days)	31				
Recorded ADTT	4616				
Suggested ADTT	5550				
Total Permit Trucks	1364				
Permits/day	44				

GVW Statistical Data for I5 Woodburn NB January 2005					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	124062	24812	73.66	2.55	3.00%
Table 1 (3S2 to 80k)	44167	8833	73.85	2.11	3.00%
Table 2 with CTP (all)	13652	2730	101.49	1.72	2.00%
Table 1 and 2 with CTP	137714	27543	83.85	9.84	12.00%
Table 3 No CTP	1311	262	89.29	17.75	20.00%
Table 4	44	9	118.09	21.46	18.00%
Table 5	1	0	152.30		
Table X	32	6	145.89	23.98	16.44%
ADTT Verification					
Total Trucks	139102				
Total Time (days)	31				
Recorded ADTT	4487				
Suggested ADTT	5550				
Total Permit Trucks	1388				
Permits/day	45				

% Change GVW Statistical Data for I5 Woodburn NB June					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	3%	3%	-1%	-6%	9%
Table 1 (3S2)	73%	73%	-1%	-14%	-17%
Table 2 with CTP (all)	-2%	-2%	-2%	8%	-7%
Table 1 and 2 with CTP	3%	3%	-2%	-7%	-7%
Table 3 No CTP	-14%	-14%	21%	-33%	-45%
Table 4	398%	400%	19%	-12%	-25%
Table 5	1100%	1400%	8%	#DIV/0!	#DIV/0!
Table X	-69%	-69%	-14%	61%	88%
ADTT Verification					
Total Trucks	3%				
Total Time (days)	0%				
Recorded ADTT	3%				
Suggested ADTT	0%				
Total Permit Trucks	-2%				
Permits/day	-2%				

GVW Statistical Data for I-5 Woodburn NB March 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	136073	27214.6	73.09	2.42	3.31%
Table 1 (3S2)	79470	15894	73.19	1.80	2.46%
Table 2 with CTP (all)	13165	2633	99.39	1.96	1.97%
Table 1 and 2 with CTP	149238	29847.6	81.61	9.11	11.16%
Table 3 No CTP	1009	201.8	106.61	8.37	7.85%
Table 4	74	14.8	143.40	12.57	8.77%
Table 5	8	1.6	122.25	36.13	29.56%
Table X	6	1.2	108.45	19.30	17.80%
ADTT Verification					
Total Trucks	150335				
Total Time (days)	31				
Recorded ADTT	4850				
Suggested ADTT	5550				
Total Permit Trucks	1097				
Permits/day	36				

GVW Statistical Data for I-5 Woodburn NB April 05					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	136363	27273	73.60	2.58	4.00%
Table 1 (3S2)	49232	9846	74.04	2.05	3.00%
Table 2 with CTP (all)	13675	2735	101.43	1.72	2.00%
Table 1 and 2 with CTP	150038	30008	83.05	9.81	12.00%
Table 3 No CTP	1226	245	90.40	19.01	21.00%
Table 4	57	11	127.66	30.47	24.00%
Table 5	1	0	134.10		
Table X	25	5	137.10	24.16	17.62%
ADTT Verification					
Total Trucks	151347				
Total Time (days)	31				
Recorded ADTT	4882				
Suggested ADTT	5550				
Total Permit Trucks	1309				
Permits/day	44				

% Change GVW Statistical Data for I5 Woodburn NB April					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	0%	0%	-1%	-6%	-17%
Table 1 (3S2)	61%	61%	-1%	-12%	-18%
Table 2 with CTP (all)	-4%	-4%	-2%	14%	-1%
Table 1 and 2 with CTP	-1%	-1%	-2%	-7%	-7%
Table 3 No CTP	-18%	-18%	18%	-56%	-63%
Table 4	30%	30%	12%	-59%	-63%
Table 5	700%	700%	-9%	#DIV/0!	#DIV/0!
Table X	-76%	-76%	-21%	-20%	1%
ADTT Verification					
Total Trucks	-1%				
Total Time (days)	0%				
Recorded ADTT	-1%				
Suggested ADTT	0%				
Total Permit Trucks	-16%				
Permits/day	-18%				

GVW Statistical Data for I5 Woodburn NB June 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	106078	21216	70.94	2.89	4.08%
Table 1 (3S2)	57707	11541	70.55	1.72	2.43%
Table 2 with CTP (all)	7903	1581	95.48	2.08	2.18%
Table 1 and 2 with CTP	113981	22796	77.78	8.48	10.90%
Table 3 No CTP	572	114	107.79	17.15	15.92%
Table 4	65	13	164.83	22.48	13.64%
Table 5	3	1	179.70	#DIV/0!	#DIV/0!
Table X	1	0	146.70	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	114622				
Total Time (days)	24				
Recorded ADTT	4776				
Suggested ADTT	5550				
Total Permit Trucks	641				
Permits/day	27				

GVW Statistical Data for I5 Woodburn NB June 05					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	143018	28604	74.41	2.54	3.00%
Table 1 (3S2)	58455	11691	75.48	1.90	3.00%
Table 2 with CTP (all)	15622	3124	102.18	1.67	2.00%
Table 1 and 2 with CTP	158640	31728	83.72	9.61	11.00%
Table 3 No CTP	2775	555	92.00	16.53	18.00%
Table 4	89	18	115.03	20.98	18.00%
Table 5	4	1	127.38	36.94	29.00%
Table X	47	9	145.30	21.37	14.71%
ADTT Verification					
Total Trucks	161555				
Total Time (days)	30				
Recorded ADTT	5385.1667				
Suggested ADTT	5550				
Total Permit Trucks	2915				
Permits/day	97				

% Change GVW Statistical Data for I5 Woodburn NB June					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-26%	-26%	-5%	14%	36%
Table 1 (3S2)	-1%	-1%	-7%	-10%	-19%
Table 2 with CTP (all)	-49%	-49%	-7%	24%	9%
Table 1 and 2 with CTP	-28%	-28%	-7%	-12%	-1%
Table 3 No CTP	-79%	-79%	17%	4%	-12%
Table 4	-27%	-27%	43%	7%	-24%
Table 5	-25%	-25%	41%	#DIV/0!	#DIV/0!
Table X	-98%	-98%	1%	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	-29%				
Total Time (days)	-20%				
Recorded ADTT	-11%				
Suggested ADTT	0%				
Total Permit Trucks	-78%				
Permits/day	-72%				

GVW Statistical Data for I5 Woodburn NB October 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	136437	27287.4	70.40	3.10	4.40%
Table 1 (3S2)	77653	15530.6	69.76	1.74	2.50%
Table 2 with CTP (all)	12478	2495.6	95.19	1.69	1.78%
Table 1 and 2 with CTP	148915	29783	78.97	8.99	11.39%
Table 3 No CTP	445	89	114.47	20.91	18.27%
Table 4	82	16.4	153.66	11.25	7.32%
Table 5	4	0.8	110.90	#DIV/0!	#DIV/0!
Table X	4	0.8	143.50	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	149450				
Total Time (days)	31				
Recorded ADTT	4821				
Suggested ADTT	5550				
Total Permit Trucks	535				
Permits/day	18				

GVW Statistical Data for I5 Woodburn NB October 05					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	135964	27193	74.03	2.64	4.00%
Table 1 (3S2)	64133	12827	74.93	1.97	3.00%
Table 2 with CTP (all)	13572	2714	101.87	1.74	2.00%
Table 1 and 2 with CTP	149536	29907	82.87	9.53	12.00%
Table 3 No CTP	2476	495	92.46	16.30	18.00%
Table 4	93	19	112.59	24.51	22.00%
Table 5	14	3	126.38	29.46	23.00%
Table X	46	9	146.72	31.49	21.46%
ADTT Verification					
Total Trucks	152165				
Total Time (days)	30				
Recorded ADTT	5072				
Suggested ADTT	5550				
Total Permit Trucks	2629				
Permits/day	85				

% Change GVW Statistical Data for I5 Woodburn NB October					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	0%	0%	-5%	17%	10%
Table 1 (3S2)	21%	21%	-7%	-12%	-17%
Table 2 with CTP (all)	-8%	-8%	-7%	-3%	-11%
Table 1 and 2 with CTP	0%	0%	-5%	-6%	-5%
Table 3 No CTP	-82%	-82%	24%	28%	1%
Table 4	-12%	-12%	36%	-54%	-67%
Table 5	-71%	-71%	-12%	#DIV/0!	#DIV/0!
Table X	-91%	-91%	-2%	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	-2%				
Total Time (days)	3%				
Recorded ADTT	-5%				
Suggested ADTT	0%				
Total Permit Trucks	-80%				
Permits/day	-79%				

Table 14: Bend GVW Statistical Data 2008

GVW Statistical Data for US-97 Bend January 2008					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	end	(%)
Table 1 (all)	10654	2130.8	75.99	1.95	2.57%
Table 1 (3S2 to 80k)	5865	1173	77.74	1.32	1.70%
Table 2 with CTP (all)	1270	254	102.00	1.85	1.81%
Table 1 and 2 with CTP	11924	2384.8	82.65	8.44	10.21%
Table 3 No CTP	322	64.4	109.56	13.14	12.00%
Table 4	7	1.4	164.45	0.92	0.56%
Table 5	7	1.4	74.15	13.08	17.64%
Table X	0	0	#DIV/0!	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	12260				
Total Time (days)	31				
Recorded ADTT	396				
Suggested ADTT	607				
Total Permit Trucks	336				
Permits/day	11				

GVW Statistical Data for US-97 Bend December 2005					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	9776	1955.2	75.59	1.78	2%
Table 1 (3S2 to 80k)	5305	1061	76.52	1.30	2%
Table 2 with CTP (all)	596	119.2	101.12	1.40	1%
Table 1 and 2 with CTP	10372	2074.4	80.21	8.02	10%
Table 3 No CTP	213	42.6	85.26	18.47	22%
Table 4	9	1.8	110.48	11.19	10%
Table 5	0	0			
Table X	1	0	75.30	0.00	0.00%
ADTT Verification					
Total Trucks	10595				
Total Time (days)	31				
Recorded ADTT	342				
Suggested ADTT	607				
Total Permit Trucks	223				
Permits/day	7				

% Change GVW Statistical Data for US-97 Bend Winter					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	9%	9%	1%	9%	9%
Table 1 (3S2 to 80k)	11%	11%	2%	2%	0%
Table 2 with CTP (all)	113%	113%	1%	32%	31%
Table 1 and 2 with CTP	15%	15%	3%	5%	2%
Table 3 No CTP	51%	51%	29%	-29%	-45%
Table 4	-22%	-22%	49%	-92%	-94%
Table 5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table X	-100%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	16%				
Total Time (days)	0%				
Recorded ADTT	16%				
Suggested ADTT	0%				
Total Permit Trucks	51%				
Permits/day	57%				

GVW Statistical Data for US-97 Bend March 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	12766	2553.2	76.46	1.83	2.39%
Table 1 (3S2)	6776	1355.2	78.39	0.93	1.18%
Table 2 with CTP (all)	2260	452	97.28	5.22	5.36%
Table 1 and 2 with CTP	15026	3005.2	82.38	6.81	8.27%
Table 3 No CTP	599	119.8	107.84	5.01	4.65%
Table 4	8	1.6	179.10	5.09	2.84%
Table 5	7	1.4	183.10	6.65	3.63%
Table X	1	0.2	65.60	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	15641				
Total Time (days)	31				
Recorded ADTT	505				
Suggested ADTT	607				
Total Permit Trucks	615				
Permits/day	20				

GVW Statistical Data for US-97 Bend April 05					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)					
Table 1 (3S2)					
Table 2 with CTP (all)					
Table 1 and 2 with CTP					
Table 3 No CTP					
Table 4					
Table 5					
Table X					
ADTT Verification					
Total Trucks					
Total Time (days)					
Recorded ADTT					
Suggested ADTT					
Total Permit Trucks					
Permits/day					

% Change GVW Statistical Data for US-97 Bend Spring					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table 1 (3S2 to 80k)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table 2 with CTP (all)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table 1 and 2 with CTP	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table 3 No CTP	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table 4	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table 5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	#DIV/0!				
Total Time (days)	#DIV/0!				
Recorded ADTT	#DIV/0!				
Suggested ADTT	#DIV/0!				
Total Permit Trucks	#DIV/0!				
Permits/day	#DIV/0!				

GVW Statistical Data for US-97 Bend June 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	12914	2582.8	75.32	2.39	3.18%
Table 1 (3S2)	5604	1120.8	78.08	1.06	1.36%
Table 2 with CTP (all)	1637	327.4	85.19	7.97	9.36%
Table 1 and 2 with CTP	14551	2910.2	80.82	6.75	8.35%
Table 3 No CTP	317	63.4	110.24	11.02	10.00%
Table 4	17	3.4	155.80	15.58	10.00%
Table 5	7	1.4	103.60	14.70	14.19%
Table X	3	0.6	190.80	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	14895				
Total Time (days)	22				
Recorded ADTT	678				
Suggested ADTT	607				
Total Permit Trucks	344				
Permits/day	16				

GVW Statistical Data for US-97 Bend June 05					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	15676	3135	76.17	2.32	3%
Table 1 (3S2)	7605	1521	78.54	0.87	1%
Table 2 with CTP (all)	2379	476	97.20	4.84	5%
Table 1 and 2 with CTP	18055	3611	81.76	6.46	8%
Table 3 No CTP	688	138	88.40	16.38	19%
Table 4	9	2	125.68	26.15	21%
Table 5	1	0	176.00	0.00	0%
Table X	20	9	157.48	33.55	21.30%
ADTT Verification					
Total Trucks	18773				
Total Time (days)	30				
Recorded ADTT	626				
Suggested ADTT	607				
Total Permit Trucks	718				
Permits/day	24				

% Change GVW Statistical Data for US-97 Bend Summer					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-18%	-18%	-1%	3%	4%
Table 1 (3S2 to 80k)	-26%	-26%	-1%	22%	23%
Table 2 with CTP (all)	-31%	-31%	-12%	65%	88%
Table 1 and 2 with CTP	-19%	-19%	-1%	5%	6%
Table 3 No CTP	-54%	-54%	25%	-33%	-46%
Table 4	89%	89%	24%	-40%	-52%
Table 5	600%	600%	-41%	#DIV/0!	#DIV/0!
Table X	-85%	-93%	21%	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	-21%				
Total Time (days)	-27%				
Recorded ADTT	8%				
Suggested ADTT	0%				
Total Permit Trucks	-52%				
Permits/day	-33%				

GVW Statistical Data for US-97 Bend October 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	17152	3430.4	76.00	1.74	2.29%
Table 1 (3S2)	8539	1707.8	77.67	1.07	1.37%
Table 2 with CTP (all)	1616	323.2	100.99	2.57	2.54%
Table 1 and 2 with CTP	18768	3753.6	80.87	7.40	9.16%
Table 3 No CTP	366	73.2	112.23	14.99	13.36%
Table 4	21	4.2	180.40	13.40	7.43%
Table 5	3	0.6	195.20	#DIV/0!	#DIV/0!
Table X	2	0.4	130.50	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	19160				
Total Time (days)	31				
Recorded ADTT	619				
Suggested ADTT	607				
Total Permit Trucks	392				
Permits/day	13				

GVW Statistical Data for US-97 Bend October 05					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	18028	3606	74.74	1.93	3%
Table 1 (3S2)	9129	1826	75.68	1.35	2%
Table 2 with CTP (all)	825	165	100.03	1.54	2%
Table 1 and 2 with CTP	18853	3771	78.79	7.57	10%
Table 3 No CTP	187	37	83.83	18.93	23%
Table 4	12	2	132.63	29.23	22%
Table 5	4	1	133.35	8.73	7%
Table X	11	2	105.50	8.77	8.31%
ADTT Verification					
Total Trucks	19067				
Total Time (days)	30				
Recorded ADTT	636				
Suggested ADTT	607				
Total Permit Trucks	214				
Permits/day	7				

% Change GVW Statistical Data for US-97 Bend Fall					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-5%	-5%	2%	-10%	-11%
Table 1 (3S2 to 80k)	-6%	-6%	3%	-21%	-23%
Table 2 with CTP (all)	96%	96%	1%	67%	65%
Table 1 and 2 with CTP	0%	0%	3%	-2%	-5%
Table 3 No CTP	96%	96%	34%	-21%	-41%
Table 4	75%	75%	36%	-54%	-66%
Table 5	-25%	-25%	46%	#DIV/0!	#DIV/0!
Table X	-82%	-80%	24%	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	0%				
Total Time (days)	#NAME?				
Recorded ADTT	-3%				
Suggested ADTT	0%				
Total Permit Trucks	83%				
Permits/day	86%				

Table 15: Emigrant Hill GVW Statistical Data 2008

GVW Statistical Data for I-84 E.Hill January 2008					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	end	(%)
Table 1 (all)	24955	4991	74.41	2.38	3.20%
Table 1 (3S2 to 80k)	17588	3517.6	76.03	1.93	2.54%
Table 2 with CTP (all)	3507	701.4	94.30	4.56	4.84%
Table 1 and 2 with CTP	28462	5692.4	80.44	6.19	7.69%
Table 3 No CTP	1715	343	112.07	5.31	4.74%
Table 4	32	6.4	140.24	21.28	15.17%
Table 5	11	2.2	105.40	1.40	1.33%
Table X	33	6.6	119.64	10.29	8.60%
ADTT Verification					
Total Trucks	30253				
Total Time (days)	31				
Recorded ADTT	976				
Suggested ADTT	1786				
Total Permit Trucks	1791				
Permits/day	58				

GVW Statistical Data for I-84 E.Hill November 2005					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	43416	8683	67.37	5.32	8%
Table 1 (3S2 to 80k)	26657	5331	63.32	2.33	4%
Table 2 with CTP (all)	2238	448	94.24	2.16	2%
Table 1 and 2 with CTP	45654	9131	73.18	9.33	13%
Table 3 No CTP	58	12	86.30	19.41	22%
Table 4	2	0	87.15	7.99	9%
Table 5	0	0			
Table X	0	0	0.00	0.00	0.00%
ADTT Verification					
Total Trucks	45714				
Total Time (days)	30				
Recorded ADTT	1524				
Suggested ADTT	1786				
Total Permit Trucks	60				
Permits/day	2				

% Change GVW Statistical Data for I-84 E.Hill Winter					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-43%	-43%	10%	-55%	-60%
Table 1 (3S2 to 80k)	-34%	-34%	20%	-17%	-31%
Table 2 with CTP (all)	57%	57%	0%	111%	111%
Table 1 and 2 with CTP	-38%	-38%	10%	-34%	-40%
Table 3 No CTP	2857%	2857%	30%	-73%	-79%
Table 4	1500%	1500%	61%	166%	66%
Table 5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	-34%				
Total Time (days)	3%				
Recorded ADTT	-36%				
Suggested ADTT	0%				
Total Permit Trucks	2885%				
Permits/day	2800%				

GVW Statistical Data for I-84 E.Hill March 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	36031	7206.2	74.74	2.18	2.92%
Table 1 (3S2)	25652	5130.4	77.18	1.46	1.89%
Table 2 with CTP (all)	7485	1497	95.22	4.94	5.19%
Table 1 and 2 with CTP	43516	8703.2	82.00	6.82	8.32%
Table 3 No CTP	3398	679.6	114.03	4.01	3.51%
Table 4	72	14.4	130.75	10.13	7.75%
Table 5	24	4.8	117.34	3.04	2.59%
Table X	33	6.6	112.46	5.59	4.97%
ADTT Verification					
Total Trucks	47043				
Total Time (days)	27				
Recorded ADTT	1743				
Suggested ADTT	1786				
Total Permit Trucks	3527				
Permits/day	131				

GVW Statistical Data for I-84 E.Hill April 05					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	37249	7450	75.32	2.03	3%
Table 1 (3S2)	28021	5604	76.64	1.66	2%
Table 2 with CTP (all)	7121	1424	98.92	3.54	4%
Table 1 and 2 with CTP	44370	8874	83.87	7.82	9%
Table 3 No CTP	3489	698	98.49	13.81	14%
Table 4	73	15	115.65	23.35	20%
Table 5	2	0	161.10	38.89	24%
Table X	77	15	121.14	16.42	13.55%
ADTT Verification					
Total Trucks	48011				
Total Time (days)	30				
Recorded ADTT	1600				
Suggested ADTT	1786				
Total Permit Trucks	3641				
Permits/day	121				

% Change GVW Statistical Data for I-84 E.Hill Spring					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-3%	-3%	-1%	7%	8%
Table 1 (3S2 to 80k)	-8%	-8%	1%	-12%	-13%
Table 2 with CTP (all)	5%	5%	-4%	40%	45%
Table 1 and 2 with CTP	-2%	-2%	-2%	-13%	-11%
Table 3 No CTP	-3%	-3%	16%	-71%	-75%
Table 4	-1%	-1%	13%	-57%	-62%
Table 5	1100%	1100%	-27%	-92%	-89%
Table X	-57%	-56%	-7%	-66%	-63%
ADTT Verification					
Total Trucks	-2%				
Total Time (days)	-10%				
Recorded ADTT	9%				
Suggested ADTT	0%				
Total Permit Trucks	-3%				
Permits/day	8%				

GVW Statistical Data for I-84 E.Hill June 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	43609	8721.8	74.18	2.02	2.72%
Table 1 (3S2)	29875	5975	75.75	1.72	2.27%
Table 2 with CTP (all)	6359	1271.8	100.02	2.89	2.89%
Table 1 and 2 with CTP	49968	9993.6	81.92	8.65	10.55%
Table 3 No CTP	2771	554.2	114.21	4.95	4.33%
Table 4	51	10.2	163.61	10.86	6.64%
Table 5	19	3.8	111.68	7.55	6.76%
Table X	9	1.8	147.90	29.42	19.89%
ADTT Verification					
Total Trucks	52818				
Total Time (days)	30				
Recorded ADTT	1761				
Suggested ADTT	1786				
Total Permit Trucks	2850				
Permits/day	95				

GVW Statistical Data for I-84 E.Hill May 05					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	45109	9022	70.87	3.24	5%
Table 1 (3S2)	30429	6086	70.30	2.85	4%
Table 2 with CTP (all)	4802	960	98.86	2.47	2%
Table 1 and 2 with CTP	49911	9982	80.48	9.48	12%
Table 3 No CTP	461	92	100.28	17.34	17%
Table 4	13	3	106.53	10.32	10%
Table 5	0	0	0.00	0.00	0%
Table X	8	2	122.10	3.54	2.90%
ADTT Verification					
Total Trucks	50393				
Total Time (days)	30				
Recorded ADTT	1680				
Suggested ADTT	1786				
Total Permit Trucks	482				
Permits/day	16				

% Change GVW Statistical Data for I-84 E.Hill Summer					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-3%	-3%	5%	-38%	-41%
Table 1 (3S2 to 80k)	-2%	-2%	8%	-40%	-44%
Table 2 with CTP (all)	32%	32%	1%	17%	15%
Table 1 and 2 with CTP	0%	0%	2%	-9%	-10%
Table 3 No CTP	501%	501%	14%	-71%	-75%
Table 4	292%	292%	54%	5%	-31%
Table 5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table X	13%	-10%	21%	731%	586%
ADTT Verification					
Total Trucks	5%				
Total Time (days)	0%				
Recorded ADTT	5%				
Suggested ADTT	0%				
Total Permit Trucks	491%				
Permits/day	494%				

GVW Statistical Data for I-84 E.Hill October 08					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	41638	8327.6	74.67	1.99	2.66%
Table 1 (3S2)	29325	5865	76.64	1.51	1.97%
Table 2 with CTP (all)	8181	1636.2	99.43	3.09	3.11%
Table 1 and 2 with CTP	49814	9962.8	83.52	8.44	10.11%
Table 3 No CTP	4041	808.2	114.41	5.81	5.08%
Table 4	102	20.4	162.53	18.96	11.67%
Table 5	19	3.8	140.10	20.27	14.47%
Table X	39	7.8	112.38	9.35	8.32%
ADTT Verification					
Total Trucks	54015				
Total Time (days)	31				
Recorded ADTT	1743				
Suggested ADTT	1786				
Total Permit Trucks	4201				
Permits/day	136				

GVW Statistical Data for I-84 E.Hill October 05					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	48426	9685	67.16	5.48	8%
Table 1 (3S2)	29423	5885	63.25	2.33	4%
Table 2 with CTP (all)	3094	619	94.99	2.35	2%
Table 1 and 2 with CTP	51520	10304	74.46	9.92	13%
Table 3 No CTP	39	8	90.52	22.51	25%
Table 4	0	0	0.00	0.00	0%
Table 5	0	0	0.00	0.00	0%
Table X	1	0	90.80	0.00	0.00%
ADTT Verification					
Total Trucks	51560				
Total Time (days)	30				
Recorded ADTT	1719				
Suggested ADTT	1786				
Total Permit Trucks	40				
Permits/day	1				

% Change GVW Statistical Data for I-84 E.Hill Fall					
Data	Tot. No	No. of	Mean	Std. Dev	COV
Classification	Records	Top 20%	(Kips)	(Kips)	(%)
Table 1 (all)	-14%	-14%	11%	-64%	-67%
Table 1 (3S2 to 80k)	0%	0%	21%	-35%	-47%
Table 2 with CTP (all)	164%	164%	5%	32%	26%
Table 1 and 2 with CTP	-3%	-3%	12%	-15%	-24%
Table 3 No CTP	10262%	10262%	26%	-74%	-80%
Table 4	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table 5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Table X	3800%	#DIV/0!	24%	#DIV/0!	#DIV/0!
ADTT Verification					
Total Trucks	5%				
Total Time (days)	3%				
Recorded ADTT	1%				
Suggested ADTT	0%				
Total Permit Trucks	10403%				
Permits/day	13500%				

APPENDIX C: Truck Live Load Factors

Table 16: Woodburn Truck LL Factors

Woodburn Truck LL Factors	January 08	January 05	% Change	March 08	April 05	% Change	June 08	June 05	% Change	October 08	October 05	% Change
Legal Loads	1.36	1.40	-2.9%	1.35	1.39	-2.9%	1.29	1.40	-7.9%	1.31	1.39	-5.8%
CTP-3	1.39	1.42	-2.3%	1.38	1.42	-2.8%	1.33	1.41	-5.5%	1.36	1.41	-3.5%
CTP-2A, CTP-2B	1.33	1.36	-2.4%	1.32	1.36	-2.9%	1.28	1.35	-5.5%	1.30	1.34	-3.0%
STP-3	1.19	1.21	-1.9%	1.18	1.21	-2.5%	1.13	1.22	-7.0%	1.15	1.21	-5.0%
STP-4A	1.33	1.36	-2.4%	1.31	1.35	-3.0%	1.26	1.37	-7.8%	1.28	1.36	-5.9%
STP-4B	0.96	0.98	-1.9%	0.95	0.98	-3.1%	0.93	0.99	-6.3%	0.93	0.98	-5.1%
STP-5A	1.06	1.08	-2.1%	1.05	1.08	-2.8%	1.02	1.09	-6.8%	1.02	1.08	-5.6%
STP-5B	1.02	1.04	-2.0%	1.01	1.04	-2.9%	0.98	1.05	-6.6%	0.99	1.04	-4.8%
STP-5C	0.84	0.85	-1.0%	0.84	0.85	-1.2%	0.82	0.86	-4.9%	0.82	0.85	-3.5%
STP-5BW	0.92	0.94	-1.9%	0.92	0.94	-2.1%	0.89	0.94	-5.2%	0.90	0.94	-4.3%

Table 17: Emigrant Hill Truck LL Factors

Emigrant Hill Truck LL Factors	January 08	January 05	% Change	March 08	April 05	% Change	June 08	June 05	% Change	October 08	October 05	% Change
Legal Loads	1.27	1.23	3.3%	1.29	1.33	-3.0%	1.34	1.34	0.0%	1.34	1.25	7.2%
CTP-3	1.23	1.31	-6.2%	1.26	1.31	-3.8%	1.34	1.36	-1.8%	1.34	1.34	0.0%
CTP-2A, CTP-2B	1.18	1.26	-6.3%	1.21	1.26	-4.0%	1.28	1.30	-1.6%	1.28	1.29	-0.8%
STP-3	1.09	1.07	2.0%	1.13	1.17	-3.4%	1.18	1.16	2.1%	1.19	1.06	12.3%
STP-4A	1.21	1.18	2.7%	1.26	1.31	-3.8%	1.32	1.30	1.9%	1.33	1.18	12.7%
STP-4B	0.90	0.88	2.2%	0.92	0.95	-3.2%	0.96	0.95	1.0%	0.96	0.88	9.1%
STP-5A	0.98	0.96	2.3%	1.01	1.05	-3.8%	1.06	1.04	1.5%	1.06	0.96	10.4%
STP-5B	0.95	0.93	2.0%	0.98	1.01	-3.0%	1.02	1.00	1.8%	1.02	0.93	9.7%
STP-5C	0.80	0.79	1.0%	0.82	0.83	-1.2%	0.84	0.83	1.3%	0.84	0.78	7.7%
STP-5BW	0.87	0.85	1.9%	0.89	0.91	-2.2%	0.92	0.91	1.2%	0.93	0.85	9.4%

Table 18: Bend Truck LL Factors

Bend Truck LL Factors	January 08	January 05	% Change	March 08	April 05	% Change	June 08	June 05	% Change	October 08	October 05	% Change
Legal Loads	1.32	1.29	2.3%	1.28	NA	NA	1.26	1.26	0.0%	1.28	1.26	1.6%
CTP-3	1.30	1.28	1.9%	1.24	NA	NA	1.23	1.23	0.2%	1.26	1.25	0.8%
CTP-2A, CTP-2B	1.25	1.22	2.4%	1.19	NA	NA	1.18	1.18	0.3%	1.21	1.20	0.8%
STP-3	1.13	1.10	3.2%	1.10	NA	NA	1.09	1.09	-0.1%	1.10	1.08	1.9%
STP-4A	1.26	1.23	2.8%	1.22	NA	NA	1.21	1.21	-0.2%	1.23	1.20	2.5%
STP-4B	0.93	0.91	1.9%	0.91	NA	NA	0.90	0.90	-0.3%	0.91	0.89	2.2%
STP-5A	1.02	0.99	2.7%	0.99	NA	NA	0.98	0.98	-0.1%	0.99	0.98	1.0%
STP-5B	0.98	0.96	2.2%	0.96	NA	NA	0.95	0.95	-0.3%	0.96	0.94	2.1%
STP-5C	0.82	0.80	2.2%	0.80	NA	NA	0.80	0.80	-0.5%	0.80	0.79	1.3%
STP-5BW	0.89	0.87	2.5%	0.87	NA	NA	0.86	0.87	-0.7%	0.87	0.86	1.2%

Table 19: Lowell Truck LL Factors

Lowell Truck LL Factors	January 08	January 05	% Change	March 08	April 05	% Change	June 08	June 05	% Change	October 08	October 05	% Change
Legal Loads	1.32	1.17	12.8%	1.34	1.14	17.5%	1.32	1.22	8.2%	1.33	1.25	6.4%
CTP-3	1.27	1.20	6.0%	1.32	1.17	12.8%	1.30	1.23	5.5%	1.30	1.25	4.0%
CTP-2A, CTP-2B	1.22	1.15	6.1%	1.26	1.13	11.5%	1.24	1.18	5.4%	1.25	1.20	4.2%
STP-3	1.11	1.00	11.1%	1.14	0.98	16.3%	1.15	1.04	10.2%	1.15	1.06	8.5%
STP-4A	1.24	1.10	12.3%	1.27	1.08	17.6%	1.28	1.15	11.1%	1.28	1.18	8.5%
STP-4B	0.91	0.84	8.6%	0.93	0.83	12.0%	0.93	0.86	8.7%	0.94	0.88	6.8%
STP-5A	1.00	0.91	9.6%	1.02	0.90	13.3%	1.03	0.94	9.1%	1.03	0.96	7.3%
STP-5B	0.96	0.88	9.5%	0.99	0.87	13.8%	0.99	0.91	8.7%	0.99	0.93	6.5%
STP-5C	0.81	0.75	7.6%	0.82	0.75	9.3%	0.82	0.77	6.9%	0.82	0.78	5.1%
STP-5BW	0.88	0.81	8.3%	0.89	0.80	11.3%	0.90	0.83	8.2%	0.90	0.85	5.9%

Figure 14: Woodburn Live Load Truck Factor Comparison

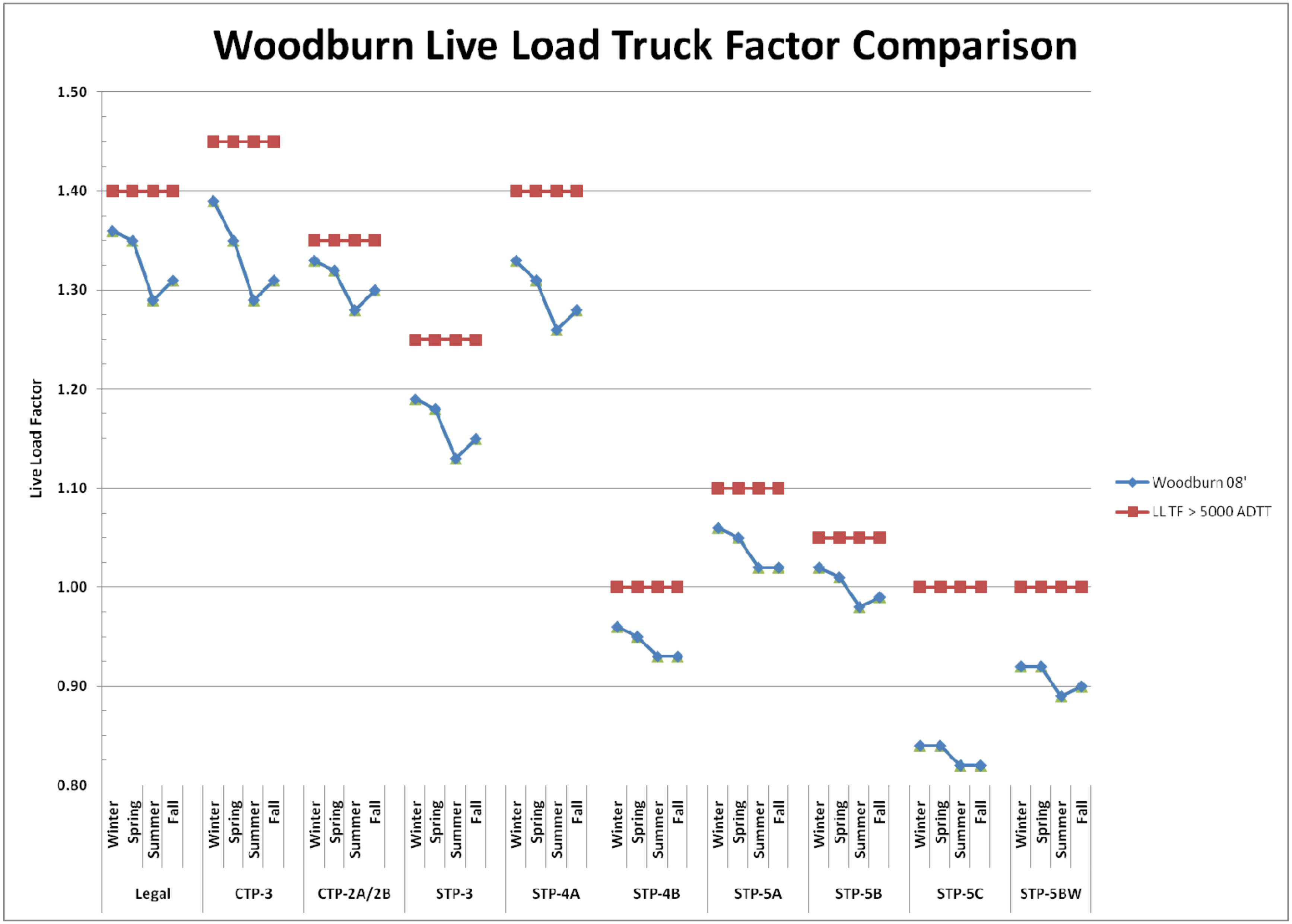


Figure 15: Emigrant Hill Live Load Truck Factor Comparison

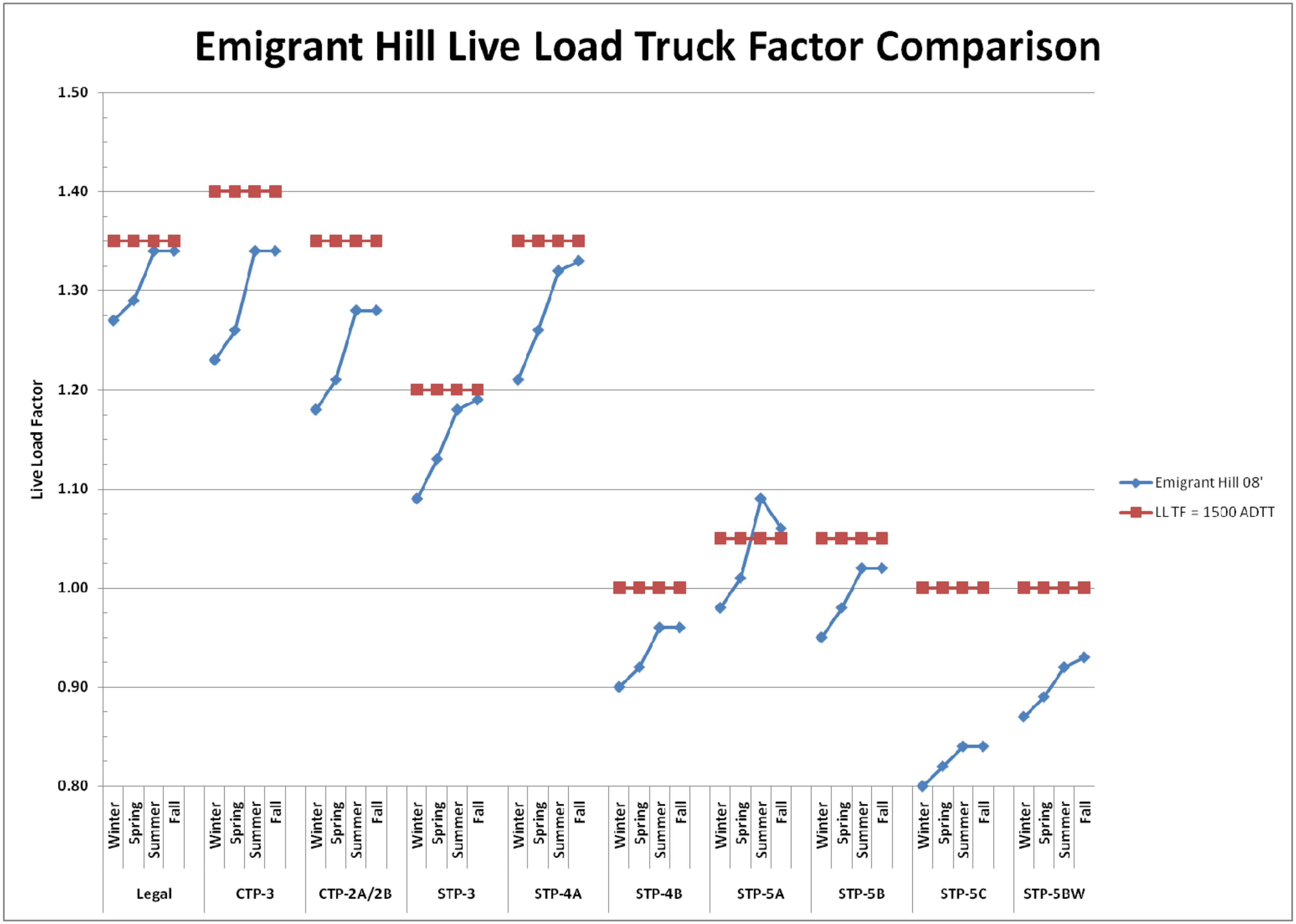


Figure 16: Bend Live Load Truck Factor Comparison

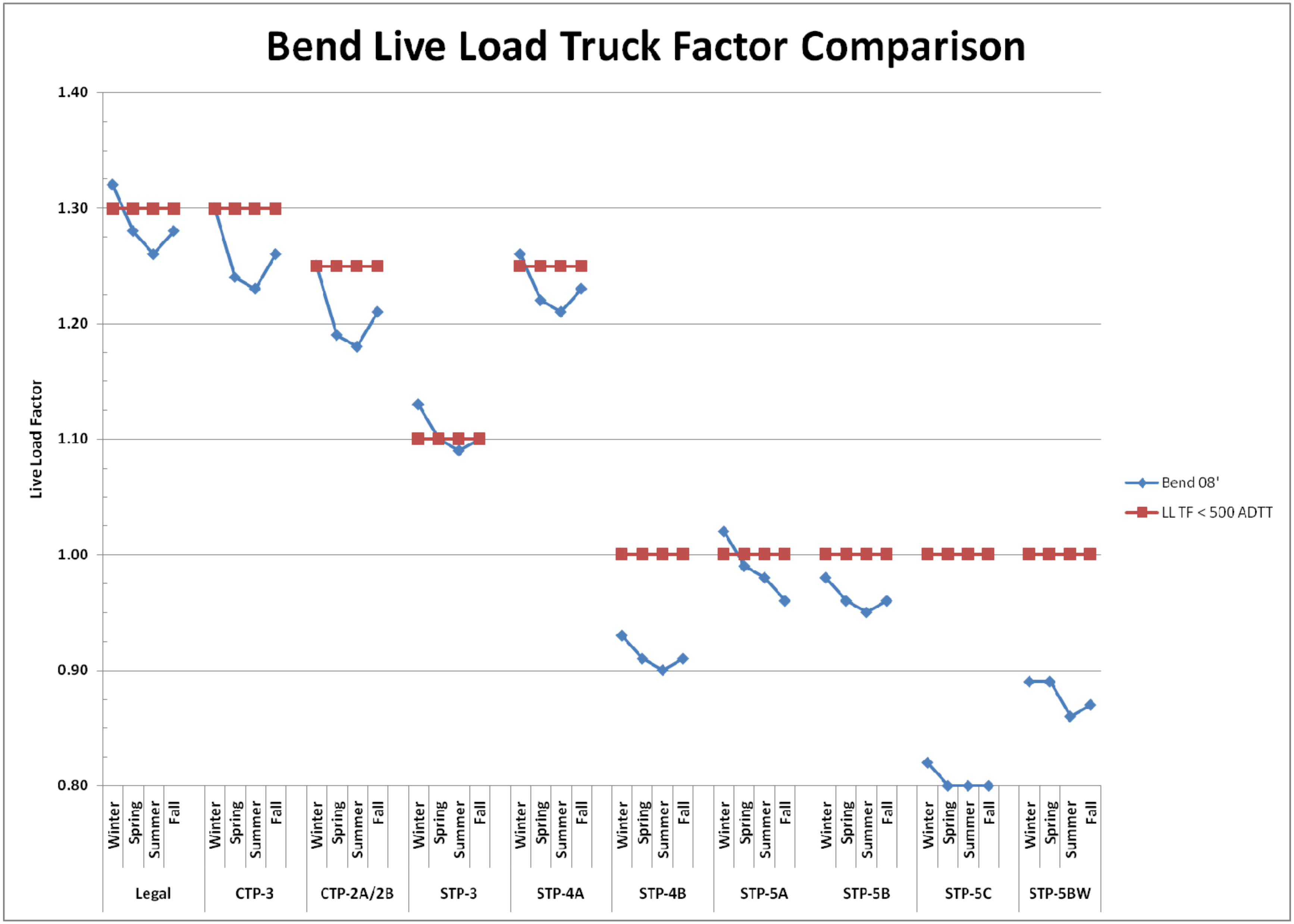
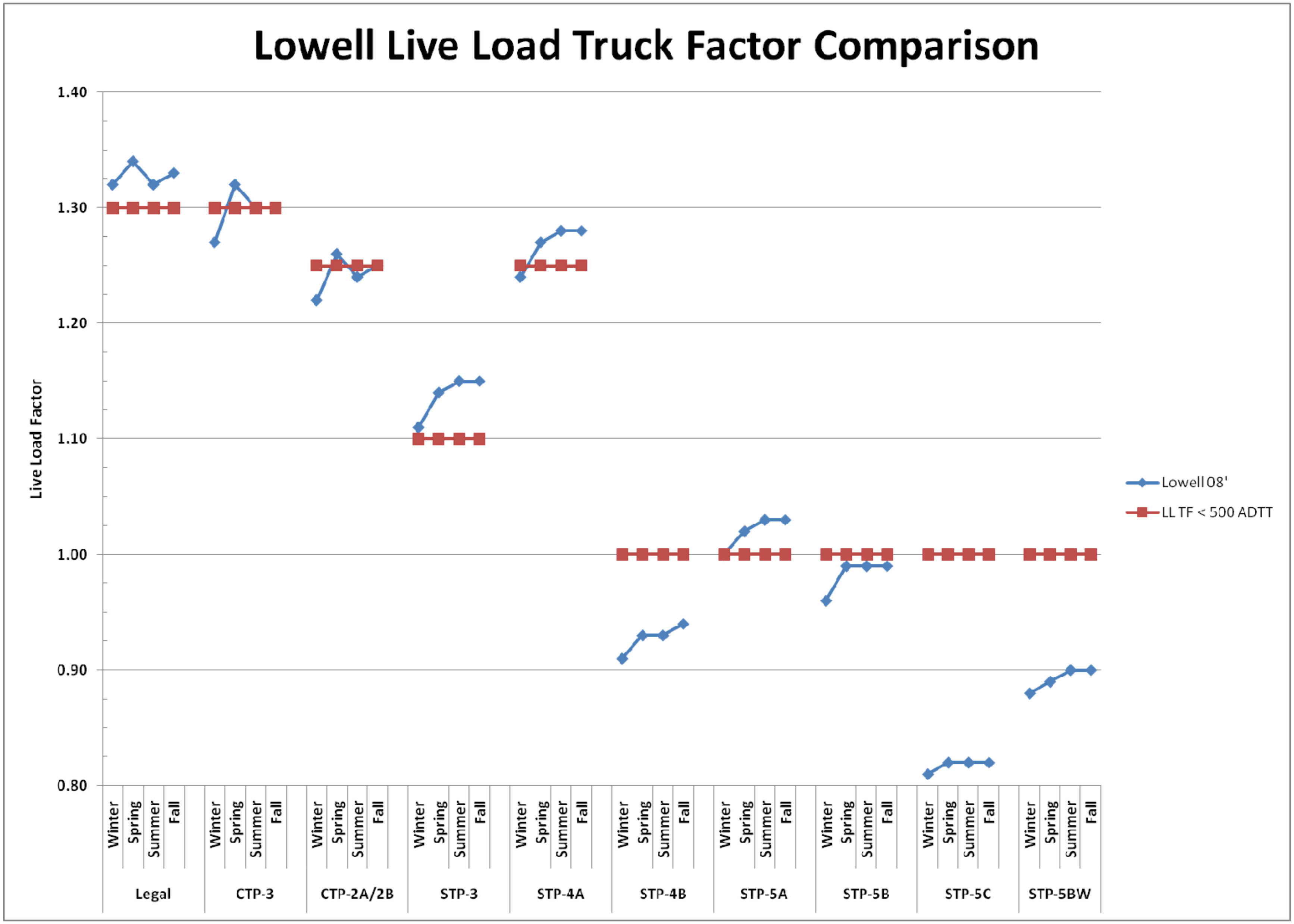


Figure 17: Lowell Live Load Truck Factor Comparison



APPENDIX B

Main Features of Selected Studies for Collecting and Using Traffic Data in Bridge Design

The technical literature search resulted in the compilation of a reference list consisting of approximately 250 abstracts, research papers, journal articles, conference papers, and reports with applicability to the project research. Of the examined material, approximately 70 applicable documents were selected for further evaluation and possible summary preparation. A tabulated summary (given below) of approximately 40 documents was prepared from the reviewed material. Contained in each document summary is a brief study description, the study findings (if any), and recommendations for further research suggested by the authors (if any).

Reference	Study Description	Findings	Recommendations
Lui, Cornell and Imbsen *Analysis of Bridge Truck Loads* (1998)	Presents statistical analysis of truck loading variables including gross vehicle weight (GVW) data collected at several weigh-in-motion (WIM) sites on roadways of various functional classifications in Florida and Wisconsin. Discusses the application of WIM data and truck loading statistical analysis to site-specific load model development for bridge evaluation.	The upper tail of Florida GVW probability distribution data collected during this study is similar to the results of previous studies. The upper tail of collected Wisconsin GVW probability distribution data reveals two abnormalities in the data collected at several WIM sites: 1). Vehicles weighing in excess of 100 Kips, more than the 80 Kips legal limit, 2). Overloaded trucks weighing between 120 and 150 Kips.	Two distinct aspects of the site-specific load model for bridge rating are important: 1). Realistic assessment of the load level, 2). Uncertainty reduction associated with loads. To manage an aging infrastructure with limited available resources, site-specific load model development for bridge evaluation must critically assess the uncertainties of the random variables that make up the model.
Moses, Ghosn and Snyder *Application of Load Spectra to Bridge Rating* (1984)	Presents methods of acquiring and applying live load spectrum data at a bridge site for evaluation purposes. A reliability based model is described that can calibrate appropriate load factors, predict maximum expected truck loading, and incorporate the measured statistics of girder distribution and impact.	AASHTO girder distribution factors are generally conservative compared to measured values from WIM data when trucks are occupying two lanes. Design specification moments used in evaluation have a greater uncertainty than a measured load spectrum determined at the site.	Reduced load factors for permit loads may be warranted for permit loads if the loading is carefully controlled. Load and resistance factors in rating calculations need to differ from factors applied to design because of exposure period and available performance data.

Reference	Study Description	Findings	Recommendations
Miao and Chan *Bridge Live Load Models from WIM Data* (2002)	Hong Kong based study presents a new methodology for deriving highway bridge live load models for short span bridges using WIM data. Two methods are presented to obtain extreme daily bending moments using WIM data: 1). The lane loading model is derived based upon the equivalent base length concept, 2). The truck loading model is developed based upon a statistical approach. The developed lane and truck loadings are compared with other loading models adopted locally and overseas.	The developed Hong Kong Bridge Design Load (HKBDL) (per lane) was found to be best represented by the following: 1). For a span of 0 to 5 m – a single axle load of 15.0 t, 2). For a span of 5 to 23.5 m – a single axle load of 8.0 t plus a uniformly distributed load, 3). For a span greater than or equal to 23.5 m – a uniformly distributed load over 23.5 m. After studying five possible truck models, the developed HKBDL (standard truck) was determined to be best represented by a six axle vehicle with a total length of 14.0 m. Axle loads vary from 7.5 t to 11.0 t and axle spacings vary from 1.3 m to 4.0 m. The proposed design loadings for Hong Kong, developed assuming a probability of 0.98 of the heaviest vehicle in Hong Kong, induce forces that are less than the design loading standards of many other countries.	Additional work is necessary to consider shear effects and effects on continuous spans. Load factors need to be studied for various combinations of loadings.
Heywood and Nowak *Bridge Live Load Models*(1989)	Australian study presents the analysis of WIM data. The data is statistically analyzed and normalized by the National Association of Australian State Road Authorities (NAASRA) T44 design loading, and the results of analysis are compared to current Load and Resistance Factor Design (LRFD) loading limit states.	The ratio of ultimate limit state (ULS) to serviceability limit state (SLS) moments based on statistically analyzed WIM data is approximately constant for each distribution considered, however it varies from 1.1 to 1.4 for all of the distributions studied. The ratio of the largest ULS (recurrence interval distribution) to the smallest SLS (normal distribution) moments	Develop a new bridge design live load in place of the T44 loading in order to provide a more uniform prediction of the effects of traffic loads on a variety of bridge spans. Consider revising the recurrence interval for the serviceability limit state so that this condition does not control the bridge design.

Reference	Study Description	Findings	Recommendations
		results in a value of 1.6. Similarly, the shear value varies from 1.4 to 1.5. Both the moment and shear values are less than the ultimate load factor of 2.0 that was proposed for the NAASRA Bridge Design Code.	
Nowak and Hong *Bridge Live-Load Models* (1991)	Presents a statistical procedure for calculation of live-load moments and shears for highway girder bridges of various span lengths with one and two lane configurations and using truck survey data collected by the Ontario Ministry of Transportation. The maximum load effects for time periods from one day to 75 years are produced from extrapolations and simulations.	The maximum moment and shear for single lane bridges up to approximately 100 feet long result form the application of a single truck. The study shows that two trucks following each other produce the maximum moment and shear for longer single lane bridges. The simulation results indicate that that two side-by-side perfectly correlated truck or lane loads, depending upon bridge length, is the governing two lane bridge live load model.	None.
Nowak and Szerszen *Bridge Load and Resistance Models* (1998)	As a part of the development of rational codes (the AASHTO LRFD Bridge Design Specifications, Ontario Highway Bridge Design Code, and Eurocode) for the design of bridges and evaluation of existing structures, presents a procedure for statistically calculating the live-load moments and shears for highway girder bridges using truck survey data collected by the Ontario Ministry of Transportation. Resulting bias factors for live load from the analysis are presented with the corresponding changes to the design live loads for the national	The maximum moment and shear for single lane bridges up to approximately 30 to 40 m feet long result form the application of a single truck. The study shows that two fully correlated trucks following each other produce the maximum moment and shear for longer single lane bridges. The simulation results indicate that that two side-by-side perfectly correlated truck or lane loads, depending upon bridge length, is the governing two lane bridge live load model for interior girders. One truck may govern in some cases for exterior girders.	None.

Reference	Study Description	Findings	Recommendations
	design codes.	The live load bias factors for moment and shear were found to be non-uniform for the span lengths investigated, necessitating a change in the live load model to produce a uniform factor. Current code girder distribution factors (GDF) were found to be inaccurate; long spans and large girder spacings result in conservative values, and short spans with small spacings result in non-conservative values.	
Moses *Calibration of Load Factors for Load and Resistance Factor Evaluation* (1999)	Outlines the derivations of the live load factors in the proposed AASHTO Condition Evaluation Manual using truck weight spectra. The use of site specific traffic data is addressed.	Live load factor calibration, using similar data from the LRFD code development, was necessary to allow greater flexibility for evaluation as compared to design (varying site traffic and permits, and amount of site traffic data retrieved).	None.
Nowak and Grouni *Calibration of the Ontario Highway Bridge Design Code 1991 Edition* (1994)	Describes the calculation of load and resistance factors for the Ontario Highway Bridge Design Code (OHBDC) 1991 edition, including the development of load and resistance models utilizing available truck surveys from Ontario, the selection of the reliability analysis method, and the calculation of reliability indices for bridge design and evaluation.	An analysis of the reliability indices for girder bridge types designed per the OHBDC (1983) revealed that they are generally lower than the desired target for shorter spans. Therefore, the existing design truck tandem axle load was increased from 140 kN to 160 kN. For the evaluation of existing bridges, the time dependent load model results in shears and moments that are 3% to 5% lower than those used for design and lower reliability indices are generally used as compared to design.	The following are the results of this study: 1). For design, the live load was modified and the tandem axle load was increased to 160 kN. 2). Modified load and resistance factors should be used for the evaluation of existing bridges depending upon the frequency of inspection, if the components have single or multiple paths, and if the components are primary or secondary members.
Nowak *Development of Bridge Load*	Using truck surveys, weigh-in-motion measurements, and other	The values of live load moments and shear from truck survey data (number	Based upon the results of the two lane model simulation, the girder

Reference	Study Description	Findings	Recommendations
Model for LRFD Code (1993)	observations, this paper describes the development of the LRFD load model for static live load.	of axles and axle spacing, and axle loads and gross vehicle weight) are determined by extrapolation for a wide range of simple and continuous spans. Both one and two lane conditions are considered for time periods of 1 day to 75 years. For the one lane condition, the maximum lane moment or shear is caused by one truck, or two or more trucks following each other, depending upon span length. For the two lane condition, distribution of truck load to the girders is very important. Simulations reveal that for interior girders, the case of two fully correlated side-by-side trucks governs.	distribution factors specified by AASHTO (1992) are generally too conservative, particularly for larger girder spacing. The proposed LRFD live load is recommended as the following: 1). The superposition of an HS20 vehicle and a uniform load of 640 lb/ft. 2). For shorter spans a tandem is specified. 3). For negative moments, use two HS20 vehicles, however reduce the total effect by 10 percent.
Agarwal and Cheung *Development of Loading-Truck Model and Live-Load Factor for the Canadian Standards Association CSA-S6 Code* (1987)	Presents the methodology utilized to develop the CS-*W* loading design truck and uniform live load factor for the Canadian Standards Association CSA-S6 code. Truck survey data was collected in seven Canadian provinces and used in the development of the design load model and live load factor.	Using survey data from Newfoundland, Ontario, and Alberta, the study found that for spans up to 20m, the proposed CS-600 design truck requires a higher load factor, reflecting a deficiency in the live load model for short spans. The design load was revised to ensure a uniform live load factor. Using survey data from Nova Scotia, Quebec, Saskatchewan, and British Columbia, the study found that each province demonstrated live load factors of similar magnitude.	For all types of live-load effects and ranges of span lengths a uniform live-load factor of 1.60 should be adopted. The CS-600 loading should be adopted as the standard bridge design load for Canadian interprovincial truck routes. A load level different from the CS-600 loading may be adopted by provincial and local authorities.
Nowak and Nassif *Live Load Models Based on WIM Data*	Michigan bridge WIM study compares measurements taken on three instrumented US route and Interstate	Weigh station data greatly underestimates the gross vehicle weights of overloaded truck traffic in Michigan. Truck weigh	None.

Reference	Study Description	Findings	Recommendations
(1992)	bridges to weigh station data.	station data is biased to less heavy vehicles due to trucker avoidance of the stationary scales. The study found that the gross weights collected at weigh stations were generally within the legal limits, however bridge WIM data shows that the structures are actually being significantly overloaded.	
Heywood *A Multiple Presence Load Model for Bridges* (1992)	Australian study investigates the use of WIM data to simulate multi-lane traffic crossing short span multiple lane bridges. Two lane bridges with spans less than 30 m long are simulated in this study, as this model is representative of the majority of Australian bridges.	The multiple presence simulation models indicate that for low traffic volumes the serviceability recurrence interval is significantly less than the proposed AASHTO value considering that the ultimate limit state is far less sensitive to changing traffic volume.	None.
Jaeger and Bakht *Multiple Presence Reduction Factors for Bridges* (1987)	Paper reviews the multiple presence reduction factors specified in the AASHTO and Ontario codes and provides an alternate method for establishing these factors for short and medium span bridges in relation to traffic volume using truck survey data. Factors for design and evaluation are proposed.	The multiple presence reduction factors by the proposed method using traffic density and truck weight distribution data are not significantly different from those of the AASHTO and Ontario codes.	Traffic density should be one of the deciding factors in choosing a multiple presence reduction factor value for design and evaluation. The reduction factors used in evaluation should also consider the expected remaining bridge life, the number of loaded lanes, and the time interval for vehicle to cross the middle third of the bridge, using the procedure presented in the paper.
Fu and Hag-Elsafi *New Safety-Based Checking Procedure for Overloads on Highway Bridges* (1996)	Using WIM data from United States sites and NYSDOT overload permit data, this paper presents an evaluation method for nondivisible overload permit checking using the LRFD concept of uniform bridge safety.	The paper proposes live load factors to be used in the checking procedure for annual and trip permits for overloaded trucks.	Incorporation of this bridge evaluation method for overweight trucks into code may be considered.
Fujino and Ito	Utilizing data from	The study shows that the	A revised design load is

Reference	Study Description	Findings	Recommendations
Probabilistic Analysis of Traffic Live Loading on Highway Bridges (1979)	surveys of traffic loads carried out on several Japanese highways, this paper summarizes the statistical analysis using computer simulation for the appraisal of the current design load and the development of a new design load.	current design load provides a safety reserve that is not constant for bridges of different span lengths, with a greater safety level provided for longer spans.	proposed, however the authors suggest analysis of continuous span bridges and further investigation of traffic flow on bridges.
Ghosn and Moses *Reliability Calibration of Bridge Design Code* (1986)	This study is the reliability calibration of the AASHTO bridge design code. The study incorporates two important concepts in bridge design load modeling: 1). The use of WIM to provide data on bridge loading and response for short and medium span bridges. 2). The use of reliability-based design to provide uniform reliability through a combined selection of nominal design loads and corresponding safety margins.	The reliability-based calibration of the AASHTO bridge design code revealed the following: 1). The AASHTO code provides high levels of reliability, but does not provide uniform reliability levels for all span lengths. 2). New safety factors and design loads are proposed to achieve uniform reliabilities or safety indices. 3). The target safety index was derived from average AASHTO performance. 4). The derived partial safety factors achieved more uniform safety indices. 5). Different live load factors are desirable for different loading intensities. 6). This approach to load modeling can be applied to bridge evaluation.	None.
Ghosn and Frangopol *Site-Specific Live Load Models for Bridge Evaluation* (1996)	Study focuses on the use of WIM to define site-specific bridge loads, and the differences in safety that result from applying site-specific values to evaluation rather than the national average (design loads).	For the bridge evaluation example presented, a safety index of 4.07 resulted from the use of the method presented in the Nowak (1993) model for design. Repeated with site-specific WIM data from two independent sites, the example resulted in safety indices of 3.69 and 3.03, displaying that the use of site-specific	The use of average live load data in the assessment of existing bridge reliability may not be representative of actual site conditions and actual site loading from WIM data should be utilized.

Reference	Study Description	Findings	Recommendations
		load data provides results that are different than those obtained from typical data.	
Laman and Nowak *Site-Specific Truck Loads on Bridges and Roads* (1997)	This study uses bridge WIM data to determine and compare site-specific bridge live loads at several locations on Interstate highways, state highways, US highways, and surface streets in Michigan. Weigh station data and truck citation data is utilized to verify the recorded truck loads by WIM.	The study shows that truck loads are strongly site specific and depends on factors such as traffic volume, local industry, and law enforcement effort. A negative correlation was found between law enforcement effort and the occurrence of overloaded trucks as overloaded trucks were found on roadways not controlled by truck weigh stations.	Additional truck data is needed to determine the site-specific load spectra for bridges. Rather than utilizing truck weigh station data, which is biased due to avoidance, unbiased WIM data is needed to determine accurate statistics for site-specific bridge live load models.
Nowak and Ferrand *Truck Load Models for Bridges* (2004)	Michigan bridge WIM study reviews some of the practical procedures used for field measurement of truck weights and uses this data to simulate site-specific truck loads.	The results of the WIM measurements show that truck traffic is strongly site specific and varies within a geographic area based on the number of trucks, gross vehicle weight, and axle weight. The study found that the shapes of the moment and shear distributions are almost identical, simplifying the bridge evaluation procedure since the same live load factors can be used for both moment and shear. Using the collected WIM data, maximum lane moments and shears were computed and compared to the AASHTO LRFD 1998 moments and shears. The maximum lane moments and shears due to the measured trucks vary between 0.6 and 2.0 times the AASHTO values.	None.
Frangopol, Goble and Tan *Truck Loading Data for a Probabilistic*	Study consists of a major bridge testing and analysis program for the FHWA. Thirty-five bridges in thirteen states	The study classified approximately 160,000 truck occurrences. Of these occurrences, approximately 6,881 fell	The data will be employed in the development of improved live load models for bridge design and

Reference	Study Description	Findings	Recommendations
Bridge Live Load Model (1992)	were tested using WIM.	into the multiple presence category, defined as a front axle-to-front axle spacing between vehicles of less than 120 feet. Side-by-side multiple presence was separated from same-line multiple presence. 5,516 side-by-side and 1,365 same-line multiple presence situations were recorded.	evaluation.
Fu and Hag-Elsafi *Vehicular Overloads: Load Model, Bridge Safety, and Permit Checking* (2000)	This study develops a live load model for truck traffic including overloads. The model is used to assess bridge safety subject to overloads and is designed to incorporate site-specific WIM data.	The paper proposes live load factors to be used in the checking procedure for annual and trip permits for overloaded trucks, consistent with the average bridge safety by the AASHTO code.	Consideration may be given to incorporating this bridge evaluation method for overloaded trucks into code.
Ghosn, Moses and Gabriel *Truck Data for Bridge Load Modeling* (1990)	Utilizing WIM data collected at several steel multi-girder Interstate bridges in Ohio, this study applies a simulation program that estimates the probabilistic distribution of maximum moment response of bridges. The study uses the model to develop a reliability-based truck weight formula that regulates the weight of trucks on US bridges. The developed truck weight formula is applicable to simply supported steel bridges designed for AASHTO's WSD HS20 loading and will have a .25 safety index for a 50 year life.	In the calculation of the truck weight formula, H, the random variable that gives the overload factor due to the presence of closely spaced vehicles, was found to be sensitive to only very large changes in truck volumes.	None.
Nyman *Calibration of Bridge Fatigue Design Model* (1985)	This study consists of a structural reliability evaluation of the current AASHTO fatigue specification for steel bridges using field data obtained from a bridge-mounted WIM system. A fatigue life failure model	The study has determined the following: 1). The proposed fatigue vehicle model is more representative of the current truck traffic at sites examined in the US. 2). The current AASHTO code appears to lead to	The proposed revisions to the current specification include: 1). Replacement of the current AASHTO fatigue design load model with Pavia's vehicle. 2). Modification of the allowable stress ranges to

Reference	Study Description	Findings	Recommendations
	is formulated in terms of a fatigue failure function.	safety indices that vary with the different stress categories. 3). Truck traffic including weight and volume vary too much from site to site to be covered by only two categories as currently done.	give a more uniform safety index for all stress categories. 3). Specification of different load factors for a range of volumes and loadometer values. 4). Refinement of the failure function variables to provide a more accurate safety index. The relationship between truck headway and volume also needs to be determined.
Caprani, Grave, O'Brien and O'Connor *Critical Loading Events for the Assessment of Medium Span Bridges* (2002)	Using WIM data from a French site, this study is the Monte-Carlo simulation of free-flowing traffic across bridges to determine the critical loading events and extreme load effects (bending moment and shear force).	The study shows that the two-truck event is the most important free-flowing event for short to medium span bridges with two opposing lanes of traffic. For longer spans, events involving three or more trucks can be significant.	Both two and three truck events should be modeled in the assessment of site-specific bridge loading for structure lengths up to 50 m and in free flowing situations.
Laman and Nowak *Fatigue-Load Models for Girder Bridges* (1996)	This paper focuses on the development of a new fatigue-load model for steel girder bridges using WIM data from five bridges. The data from the five structures consists of site-specific truck parameters and component-specific stress spectra.	The study findings indicate that the magnitude and frequency of truck loading are site-specific and component-specific. The results also reveal a significant variation in stress spectrum between girders. Generally, the girder that is located nearest to the left wheel track of vehicles traveling in the right lane experiences the highest stresses in the stress spectra and decreases as a function of the distance from this location. It was found that a vehicle that dominates the distribution of vehicle types does not necessarily dominate the fatigue damage of the particular component. Rather, a vehicle that dominates the distribution of the lane	A single truck model for fatigue loading is not recommended as the most accurate approach as a result of the site-specific nature of the distribution of vehicle types by axle. The paper recommends the use of an equivalent three axle fatigue truck with varying axle weight and spacings for sites with traffic consisting of two to nine axle trucks. Similarly, for sites with ten and eleven axle trucks, a four axle truck is recommended as an equivalent fatigue vehicle.

Reference	Study Description	Findings	Recommendations
		moments will likely dominate the fatigue analysis.	
Au, Lam, Agarwal and Tharmabala *Bridge Evaluation by Mean Load Method per the Canadian Highway Bridge Design Code* (2005)	This paper summarizes bridge evaluation by the Canadian Highway Bridge Design code (CHBDC) mean load method. The mean load method does not require the use of load or resistance factors. Instead, the uncertainties associated with the loads and resistances are considered by using default statistical parameters. The code also allows the use of parameters that are derived from collected site-specific WIM data. The paper compares the results of a steel box girder bridge evaluation using the mean load method default parameters, WIM derived parameters, and the LRFD method.	A comparison of the evaluation results shows that the LRFD method and the mean load method using the default statistical parameters provide similar results, with the mean load method offering a slightly higher live load capacity factor. The mean load method using live load statistics based on WIM data, provides the highest load carrying capacity. This is a result of the conservative statistical parameters provided in the CHBDC.	Mean load method evaluation results using WIM data may not be conclusive if the bridge's most critical traffic loading periods are missed during field data collection. The season and measurement periods require thoughtful selection to capture the most critical live loading on the bridge.
van de Lindt, Fu, Zhou and Pablo *Locality of Truck Loads and Adequacy of Bridge Design Load* (2005)	This paper investigates the differences in live loading conditions between the national average as utilized in the AASHTO LRFD code and twenty site-specific Detroit, Michigan girder bridge locations. Resulting reliability indices are compared. WIM data is used to characterize the truck load effect in the bridges' primary members for moment and shear at critical cross sections.	This study established the following: 1). In general, the local truck loading may vary significantly from the state or national average, resulting in inconsistent risk levels for highway bridges. 2). Based upon the study findings of the twenty subject bridges, the current Michigan HS25 design load does not consistently achieve a reliability index of 3.5 for the design-minimum strength of bridges in the Detroit area.	This WIM data used in this study did not include headroom information. Further study incorporating WIM data with headroom information should be performed to advance the study topic. Site-specific live load analyses are necessary, particularly for trunkline roadways with high ADTTs, in order to achieve a more uniform reliability index. Consideration should be given to performing a feasibility study at the national level.
Cohen, Fu, Dekelbab and Moses	Using WIM and truck survey data, this study presents a qualitative	This study has established the following: 1). The modeling is based	None.

Reference	Study Description	Findings	Recommendations
Predicting Truck Load Spectra Under Weight Limit Changes and its Application to Steel Bridge Fatigue Assessment (2003)	method of predicting truck load spectra as a result of changing truck weight limits. This study utilizes historical and present truck weight data and can be used to estimate the impact of weight changes on bridges.	on freight transportation behavior, and it is flexible for both national and local changes. 2). Using measured truck data from Arkansas and Idaho, the paper shows that the proposed method can capture effects of truck weight-limit change on TWHs and on resulting steel bridge fatigue. 3). This method can be used to estimate possible impacts to bridges as a result of truck weight-limit changes, in developing rational policies for freight transportation.	
Moses *Probabilistic Load Modeling for Bridge Fatigue Studies* (1982)	The author presents a reliability model to provide consistent levels of fatigue safety for steel girder bridges. Discussions of shortcomings with truck data collection systems are offered.	Since the fatigue model is considerably influenced by the heavy end of the weight spectra, a WIM system was developed as part of this study to collect truck data. It was found that weigh stations and temporary weigh scales are avoided by overloaded trucks, resulting in biased data. The study found that pavement weigh scales provide erroneous static truck weights due to adjacent pavement roughness and that their proposed bridge WIM system offers more accurate data.	The paper recommends that following for future consideration: 1). The allowable stress range for fatigue should be made a continuous function of truck volume instead of discrete volume categories. 2). The nominal loading should coincide with a representative vehicle with expected dimensions and axle load percentages instead of a variable wheelbase vehicle. 3). Safety indices for non-redundant structures should be based on risk models that integrate load probability occurrences over a range of damage. Models should be developed to produce consistent safety for redundant and non-redundant behavior. 4). Future tests should involve multi-lane measurements to monitor vehicle combinations.
Wang, Liu, Hwang and	Using data from a Florida WIM station, this study	This study has found the following:	None.

Reference	Study Description	Findings	Recommendations
Shahawy *Truck Loading and Fatigue Damage Analysis for Girder Bridges Based on Weigh-in-Motion Data* (2005)	synthesizes the truck traffic data and establishes the live-load spectra, and performs a fatigue damage analysis for six typical steel multi-girder bridge models that were generated for this project.	1). Flexural stress and shear vary with bridge span length. 2). Truck loading on the bridges does not necessarily increase with GVW, but rather with axle weight. Tandem axles significantly exceed the loading of an HS20-44 vehicle. 3). The average impact factors are generally less than the values specified in AASHTO (1996). 4). The AASHTO fatigue truck and the actual truck-traffic flow based on with measurements have close effects.	
Grundy and Boully *Fatigue Design in the New Australian Bridge Design Code* (2004)	This paper presents an overview of the work performed in developing the fatigue provisions for the new Australian Bridge Design Code AS5100. Calibration of the fatigue loading model against Culway WIM data is described. The projected growth in traffic volume and magnitude of vehicle and axle mass is incorporated in the fatigue loading model.	The following was noted: 1). Span has a great effect on the fatigue damage per truck. For short steel bridges, fatigue can become the governing limit state for structures on heavily traveled roadways. For longer spans, fatigue is not as great an issue due to the effect of dead load. 2). Multiple presence of trucks in the same or adjacent lanes occurs infrequently per the WIM data.	None.
Jamera et al *FHWA Study Tour for European Traffic-Monitoring Programs and Technologies* (1997)	This FHWA-sponsored study is a scanning tour of the Netherlands, Switzerland, Germany, France, and the United Kingdom. The tour was conducted in order to learn how European countries perform traffic monitoring and if and how these concepts can be applied in the United States. Several areas of specific interest regarding WIM system and data collection were reviewed	The study found the following: 1). Fewer and less detailed data are collected on trucks than in the US. 2). Standardization of data collection equipment is common. The Europeans are working to coordinate WIM research and development to produce better, more reliable WIM equipment (DIVINE, COST 323, and WAVE projects). 3). WIM systems require	The study recommends that there are two areas in which US transportation experts should pay attention to European WIM systems and activities: 1). The Europeans employ limited classification schemes, allowing the use of less sophisticated and less costly collection equipment. An analysis of cost savings versus loss of detailed

Reference	Study Description	Findings	Recommendations
	and summarized.	calibration at least twice a year. 4). Only France and the United Kingdom have extensive WIM system installations.	information requires analysis. 2). The COST and WAVE WIM tests should be monitored by US researchers to eliminate duplicate efforts in this county.
O'Brien and Caprani *Headway Modelling for Traffic Load Assessment of Short to Medium Span Bridges* (2005)	The assumed headways of successive trucks on bridges have a great impact on the critical loading events from which the characteristic effects are derived. This paper presents a new approach that uses measured headway statistical distributions generated from French WIM data.	The following has been established from this study: 1). Headways of less than 1.5 sec. were found to be insensitive to traffic flow and are influenced by driver behavior. Headways between 1.5 sec. And 4.0 sec. were found to be considerably influenced by traffic flow. 2). Assumptions related to headways and gaps have a great impact on load effects and characteristic values.	The authors recommend a statistical (HeDS) approach for site-specific assessment of bridge loading.
van de Lindt, Fu, Pablo and Zhou *Investigation of the Adequacy of Current Design Loads in the State of Michigan* (2002)	This report presents the process and results of a research effort to examine the adequacy of current vehicle loads used to design bridges in the State of Michigan. The target reliability index used in the AASHTO LRFD code was utilized in the study as the criterion for evaluating the adequacy. Reliability indices were calculated for twenty different bridges selected from the Michigan inventory of new bridges. Existing WIM data was processed to statistically characterize the truck load effect.	The following conclusions were made by the report: 1). The reliability indices were found to vary among bridge types. 2). The 50^{th} and 90^{th} percentile of traffic volume do not noticeably influence the reliability indices. 3). The current design load, HS25, could be modified to achieve, on average, a reliability index of 3.5, which was used as a target index for the AASHTO LRFD code. 4). The deck design load of HS20 is adequate for reinforced concrete decks.	The authors recommend that a new design load level be considered for bridge beam design in the Detroit Metro Region.
Nichols and Bullock *Quality Control Procedures for Weigh-in-Motion Data*	This study consists of the development of a quality control program for the Indiana Department of Transportation to improve the accuracy of	The study found the following: 1). The WIM applications at static weigh stations were effective for identifying safety	The study recommended the following: 1). The drive tandem axle spacing metric should be applied to all WIM systems to monitor the

Reference	Study Description	Findings	Recommendations
(2004)	the data produced from their WIM sites. The quality control program is based on the Six Sigma quality control program DMAIC performance improvement model and provides a mechanism for assessing the accuracy of vehicle classification, weight, speed, and axle spacing data and monitoring it over time.	violations, but ineffective for identifying overweight vehicles. Virtual weigh stations in Indiana were found to be approximately 55 times more effective than the static weigh stations for overweight truck identification. 2). Robust metrics for speed and axle spacing accuracy, weight accuracy, and sensor error rates are necessary in a quality control program that can be continuously monitored using statistical process control procedures. 3). Data mining of these metrics revealed variations in the data caused by incorrect calibration, sensor failure, temperature, and precipitation.	speed calibration and prioritize maintenance on a lane basis. 2). The bending plate and single load cell WIM systems should be configured to log the left and right wheel data to compute the left-right residual metric. Use the left-right residual for detecting weight calibration drift and to prioritize maintenance on a lane basis. 3). The error proportion metric should be applied to all WIM systems to identify lanes that experience high error rates to prioritize maintenance on a lane basis. 4). The WIM data should be continuously monitored for errors and drifts to establish and maintain accurate data. 5). The WIM system algorithms should consider variations in the climate to account for temperature and precipitation or flag data that is collected during days of climatic anomalies when the accuracy is questionable. 6). To apply the recommended quality control procedures, the WIM data must be uploaded to a relational database that supports free-form queries. Analysis cubes are recommended for data mining. 7). A test bed should be constructed of various types of WIM sensor for long-term evaluation of performance, accuracy, and maintenance costs for

Reference	Study Description	Findings	Recommendations
			each type. Installation of equipment to collect continuous climate data would allow further exploration of the climatic impacts on the WIM sensors.
Hwang and Koh *Simulation of Bridge Live Load Effects* (2000)	The current design load in Korea, which is not based on any research or actual data, was adopted in 1978. This paper presents the research for the new live load model for the reliability-based design code that is based on collected bridge WIM data and video recording. The new model is compared to the design live load model from several countries.	The study has determined the following: 1). The new live load model should consist of a combination of truck load and distributed load with a varying magnitude based on span length. 2). Weight distributions differ for each WIM site and direction, highlighting the importance of accurate data for the live load model. 3). The maximum moment ratio is variable based on span length. A single truck controls for shorter span lengths and two fully correlated trucks govern for longer spans.	The paper suggests that additional data should be collected to better represent truck load effects.
O'Connor and O'Brien *Traffic Load Modelling and Factors Influencing the Accuracy of Predicted Extremes* (2005)	This paper describes traffic simulation (direct and Monte Carlo method) using European WIM statistics for the assessment of existing bridges. The implications of the accuracy of the recorded data and the duration of recording and of the sensitivity of the extreme to the method of prediction are investigated. Traffic evolution with time is also explored.	The paper offers the following findings: 1). The accuracy of the extreme load effects by Monte Carlo simulation increases with increasing span length in inverse proportion to the variance in the extreme. 2). A comparison of extrapolation techniques shows the importance of appropriate selection of an extreme value distribution. 3). The accuracy of WIM data is more critical for shorter span lengths. The effects of increasing inaccuracy were seen to attenuate with span. 4). The time-dependent and seasonal analyses do not provide any clear	None.

Reference	Study Description	Findings	Recommendations
		proof of a seasonal trend. 5). When considering future growth, it is found that the factor that could have major influence on predicted extremes in the future is a change allowable gross vehicle weight. 6). The sensitivity of characteristic extremes to the duration of recording and the amount of available data is a function of the effect and span under consideration.	
Lu, Harvey, Le, Lea, Quinley, Redo and Avis *Truck Traffic Analysis Using Weigh-In-Motion (WIM) Data in California* (2002)	This report is based on truck traffic data collected from all of the WIM stations on the California State highway network. Two objectives of the study were to determine truck traffic volume and load growth trends using regression methods and to check the possibility of extrapolating available truck traffic data to sites where WIM stations are not installed.	The report concluded the following: 1). Axle load spectra are heavier at night than during the daytime, possibly due to more efficient operation without car traffic or avoidance due to closure of more weigh stations. 2). Axle load spectra shows little seasonal variation. 3). Axle load spectra are much higher at rural WIM stations compared to urban stations, likely due to the presence of more long-haul trucking at rural WIM stations, and more short-haul, less-than-full-load trucking in urban areas. 4). The proportion of larger truck types, which would more typically be used for long-haul trucking, increases at night. 5). The analysis of six representative WIM sites shows that GVW generally did not grow across the six sites. Although the number of trucks using the highways increased, the trucks were	The following recommendations were made: 1). Further research should be conducted to improve methods of estimation for locations that are not equipped with WIM systems. 2) Several recommendations were made regarding improvement to the capability of the WIM data collection system including regular quality assurance checks and maintenance at all WIM stations.

Reference	Study Description	Findings	Recommendations
		generally not carrying heavier loads. 6). Axle load spectra can generally be extrapolated for steering and single axles to adjacent sites.	
O'Brien and Znidaric *Report of Work Package 1.2 – Bridge WIM Systems (B-WIM)* (2001)	This work package 1.2 report is part of the Weigh-in-motion of Road Vehicles for Europe (WAVE) study and focuses on bridge WIM systems. The objectives of the study are to understand the dynamics of a truck crossing event, to develop a bridge WIM system, to develop new approaches and algorithms, to investigate the possibility of systems that are free of axle detectors, and to test the accuracy of bridge WIM systems.	The study has shown that major difficulties observed with bridge WIM systems in the past can be avoided when using new and updated algorithms and more powerful computers and data-acquisition systems. The study results indicate that bridge WIM systems have an accuracy comparable to other types of WIM systems. Several advantages of the bridge WIM system include portability, durability, and the lack of influence of the pavement on the weighing accuracy. One issue that has not been addressed by this study is the multiple presence of more than one heavy vehicle on the bridge at the time of weighing.	The further development of free of axle detector systems is necessary as there are many potential improvements in accuracy and in the range of bridge types to which it can be applied.
Chotickai and Bowman *Truck Models for Improved Fatigue Life Predictions of Steel Bridges* (2006)	This paper presents the development of a new fatigue model based on WIM data collected from three different sites in Indiana. The recorded truck traffic was simulated over analytical bridge models to investigate moment range responses of bridge structures under truck traffic loadings. The bridge models include simple and two equally continuous spans. Based on Miner's hypothesis, fatigue damage accumulations were computed for details at	Based on the analysis of the WIM database, the paper shows that the effective fatigue stress range is site-specific and can be significantly different from the gross weight specified for the AASHTO fatigue truck. The simulation results indicate that the use of the studied fatigue trucks in a fatigue evaluation of bridge structures subjected to different truck traffic loadings can result in a considerable underestimation or overestimation of the extent of the actual	The paper recommends the use of the newly developed fatigue trucks. The three-axle fatigue truck can be used to represent truck traffic on typical highways with a majority of the fatigue damage dominated by two- to five-axle trucks. The new four-axle truck can better estimate the fatigue damage on heavy duty highways with more than 10% of the truck traffic dominated by eight- to eleven-axle trucks.

Reference	Study Description	Findings	Recommendations
	various locations on the bridge models and compared with the damage predicted for the AASHTO fatigue truck, a modified AASHTO fatigue truck with an equivalent gross weight, and other fatigue truck models.	fatigue damage when compared to the damage predicted using the WIM database.	
Tallin and Petreshock *Modeling Fatigue Loads for Steel Bridges* (1990)	Using WIM data from seven states, histograms of truck GVW are analyzed. These histograms are modeled by two bimodal distributions. Fatigue lifetimes for AASHTO categories A, B, C, and E details are calculated from these distribution of GVW models by approximating the Miner's stress as a linear function of the *m*th root of the *m*th expected moment of the GVW. The lifetimes based on the two models are compared with each other and with the results obtained by assuming a single lognormal distribution.	The study results show that the fatigue lifetimes for AASHTO categories A, B, C, and E details estimated using the bimodal distributions differ little from each other but are significantly shorter than the lifetimes estimated from the single lognormal distribution. It was also noted that there are large differences between the estimated lifetimes of different AASHTO fatigue categories.	None.