TRANSPORTATION DEPARTMENT

RESEARCH REPORT

A Procedure to Calculate the Economic Benefit of Increased Pavement Life that Results from Port-of-Entry Operations

FINAL REPORT
ITD-RP110A

to:

Idaho Transportation Department
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by

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Abstract

A calculation procedure has been developed to determine the economic benefit of increased pavement life that results from operation of a port of entry. It uses Weigh-in-Motion data and the AASHTO ESAL tables to evaluate the percentage of overloaded trucks and their equivalent ratio. These values are used to calculate a reduction of pavement life. The cost of reduced pavement life is based on construction and rehabilitation costs of a typical asphalt highway section with an assumed life of 36 years.

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AC	Annual Cost
ADTT	Average Daily Truck Traffic
E	Equivalents
ESAL	Equivalent Single Axle Load
ITD	Idaho Transportation Department
LEE	Legal Equivalents
LNW	Legal Net Freight Weight
O-D	Origin Destination
OE	Overload Equivalents
OL	Percent of Trucks Overloaded
ONW	Overloaded Net Freight Weight
PC	Present Cost
P/F	Present Value given Future Value
POE	Port of Entry
P_t	Pavement Servicibility Index
SN	Structural Number
WIM	Weight in Motion
3S2	5 axle tractor, single trailer - 2 tandems, 1 single

Introduction

Ports of entry (POE's) are operated in the State of Idaho to 1) issue permits and collect fees, 2) reduce the number of overloaded trucks and thereby reduce damage to pavement and bridges, and 3) perform other associated tasks, such as regulation of hazardous wastes. Efficient economic management of these ports requires that their costs and benefits be estimated. The objective of this project is to develop a method to quantify the economic benefit to the State of Idaho that results from prevention of premature pavement failure. The results for a specific site can be combined with other economic benefits (such as permits and licenses) and costs (personnel and facilities) to help determine the economic viability of a port of entry.

This report begins with a discussion of other economic studies of ports of entry, the relationships between port operation and truck overloading, and the limitations of weigh - in - motion equipment. The procedure is next described and illustrated with examples. The method is then applied to the Bliss, Lewiston, Moyie Junction, and Marsing ports of entry. A sensitivity analysis is performed to determine how much the results change if two key inputs are changed.

Literature Review

Only a few publications have attempted to quantify benefits of increased pavement life due to ports of entry. Barros (8) estimated the cost of overweight trucks to New Jersey highways. He assumed that approximately 20% of the trucks were overloaded, based on portable scale results in New Jersey and on weights obtained from strain gages on a bridge on I 80 in nearby Pennsylvania. Remaining pavement life was calculated from existing highway conditions and a statewide average truck fleet. Wyatt and Hassan (63) estimated that $1.8 million (1982 Canadian dollars) in pavement damages to the southern Saskatchewan provincial highways system was due to overloaded trucks.

Nielsen (38) calculated the cost of reduced pavement life in order to recommend fines for overloaded vehicles. He assumed an average truck trip length, an average cost per equivalent single axle load (ESAL) per mile of roadway, and a 3 to 1 factor of actual to apprehended overload violators.

Related studies include Abdel Halim and Saccomanno (1), who compared increased pavement costs and transportation costs under 2 different load limits. They determined that increased operating costs associated with decreases in pavement serviceability and increased repair costs are not offset by gains in efficiency arising from higher axle load limits.

A key component of this study is the estimation of the effect of ports of entry on truck weights. However, little information relating weigh station operation with weight violation rates has been published. Wyatt and Hassan (62) investigated the relationship between enforcement effort and weight compliance at permanent and mobile weigh stations in Saskatchewan. They report that at permanent weigh stations, zero enforcement results in violation rates that exceed 15% for all types of loaded trucks. The violation rate is reduced to about 3% when the probability of apprehension exceeds 10%. For mobile weigh cars, zero enforcement corresponds to violation rates of about 30%, with the violation rate reducing to 9% as inspections increase. In both situations, once low violation rates are achieved, additional enforcement effort results in little improvement. These results are expressed as a percentage of loaded trucks, and were obtained from violation rate records (static weighing), number of loaded trucks checked, and average percent time the scale is open.

Similar data were taken for short haul trucks, using weigh - in - motion (WIM) equipment. Under normal enforcement (approximately 20 hours per week in the case cited), 31.2% of 3S2 trucks, (26% of all trucks) exceeded legal gross vehicle weights. Under zero enforcement 34.5% of 3S2 trucks (33.2% of all trucks) exceeded legal weight limits. These violation rates are expressed as a percentage of loaded trucks.

In the last few years, weigh - in - motion (WIM) equipment has been deployed in the State of Idaho. This equipment uses stress - strain relationships to weigh trucks without requiring them to stop. Data from WIM sites are used in this study. Shannon and Stanly (43) investigated the accuracy of the PAT weigh - in - motion systems used by the Idaho Transportation Department (ITD). While they found that it was not accurate enough to replace static axle weighing for enforcement purposes, they found good agreement between WIM total gross weight and static weights. With the exception of the front axle, the R^2 coefficient of determination between WIM axle weights and static axle weights ranged from 0.7 to 0.95. Their results indicate that WIM is acceptable for planning purposes, if its limitations are kept in mind.

Users of WIM data are cautioned that a truck of legal static weight may register as an illegal truck on WIM equipment due to normal weight redistribution at speed, and normal truck vibrations. (Hamrick, J. L., unpublished)

The State of Idaho uses a number of criteria to determine if a truck is legally loaded. These include the following maximum legal weights:

Single axle	20,000 lbs.	
Tandem axle	34,000 lbs.	(Federal interstate system)
	37,800 lbs.	(If total gross weight does not exceed 79,000 lbs. allowed on non-interstate system)
Total Weight	80,000 lbs.	(With out permit on interstate highways)

For purposes of this study, a legal truck is defined as one that weighs less than 80,000 lbs. gross.

Methods

Our procedure employs the following steps: 1) after the port has been identified, the road segments under its influence are identified. Since some trucks on each segment do not route through the port, the percentage of trucks influenced by the port is estimated for each segment. 2) For each road segment, the percent reduction in pavement life due to overloaded trucks is calculated from the percentage of overloaded trucks, axle equivalents and net weights of legal and overloaded trucks, and the percentage of trucks that are influenced by the port. This calculation is performed for port open and port closed conditions. The percentage of overloaded trucks and their equivalents are estimated from 1989 WIM data. 3) The cost of building and repairing the road system under decreased lifetimes is calculated for port open and port closed conditions. The difference between these values is the economic benefit that results from operation of the port of entry, assuming that the port is either always open or always closed. For this study, the port open condition assumes that the POE is open 24 hours per day, 365 days per year. The port closed condition assumes that the POE is closed 365 days per year. In real time, the Idaho Transportation Department does not normally operate the ports on a 24 hours per day schedule.

<u>Selecting the road segments that are influenced by the port</u>

The preferable method for selecting road segments would consist of an origin - destination study of trucks coming to and going away from the port of entry (POE) being analyzed. An origin - destination study would have the benefit of providing both an estimate of the number of trucks on each road segment that are influenced by the POE, as well as the range that the road segment system should extend outward from the port.

An origin - destination study was available only for the Marsing port of entry, and was used in conjunction with a geographic zone of influence to select the road segments to be included in the analysis. The origin - destination study was conducted over a 1 week long period in October, 1989 near the Marsing POE. Each truck's origin, destination by state and county, and principal route was recorded. Using these data, it was possible to identify the road segments for each truck passing through the POE (influenced trucks). The road segments were broken up at county lines and highway intersections. Trucks traveling on any portion of a particular road segment were considered to travel the entire length of that segment. To calibrate the influenced truck volumes resulting from the origin -destination study to ITD's ADTT volumes, all influenced volumes were adjusted by the ratio of the POE road segment origin - destination volume to ITD's ADTT volume.

An origin - destination study was not available for the remaining three sites. Therefore, a geographic zone of influence was identified for the Bliss, Lewiston, and Moyie Junction ports of entry. That is, road segments were divided between the subject POE and neighboring POE's. Figures 1, 2, 3 and 4 illustrate the road systems used in the Bliss, Lewiston, Moyie Junction and Marsing analysis respectively. As long as the zone of influence is not too extensive, and since every road in the state would not be assigned to a POE, the results of each analyses should be conservative, since the influence of each POE likely extends past the selected road systems.

Determining Influenced Truck Volumes on Road Segments

When origin - destination data is not available for a road segment, the influenced truck traffic on that segment must be calculated using an alternate method. For each of the road segments considered in the analysis, the average daily truck traffic (ADTT) for 1989 was collected from the Idaho Transportation Department's (ITD's) MACS/ROSE data base. Weighted averages of ADTT are calculated for each road segment, but point ADTT data are used for calculating turning volumes at intersections.

All of the truck traffic on the POE road segment is assumed to be influenced by the port when it is open, or 100% influence (i.e. segment A in Figure 5). At each branch in the road system leading away from the POE, the influence of the POE on the truck traffic on a given road segment decreases due to the turning traffic. Traffic that travels on road segments in a POE zone, but never passes through the POE is considered uninfluenced traffic.

The number of influenced and uninfluenced trucks on each road segment is estimated using turning movement calculations. On Figure 5, the trucks that follow AC or AB are influenced by the POE, while the trucks that follow BC bypass the POE, and are uninfluenced by it.

To compute the volume of trucks that follow any of the three possible routes at a three way intersection, the ADTT for all three segments must be known at the intersection. Equations 1, 2, and 3 are used to compute the turning volumes illustrated in Figure 5.

$$AB = \frac{ADTT_a + ADTT_b - ADTT_c}{2} \tag{1}$$

$$AC = \frac{ADTT_a + ADTT_c - ADTT_b}{2} \tag{2}$$

$$BC = \frac{ADTT_b + ADTT_c - ADTT_a}{2} \tag{3}$$

For the situation illustrated in Figure 5, the truck traffic on segment C consists of AC influenced trucks, and BC uninfluenced trucks. Segment B has AB influenced trucks and BC uninfluenced trucks. Segment A has all influenced trucks.

The influenced truck traffic is found for each road segment by computing the turning volume at each intersection, working outward from the POE. The number of influenced trucks on a road segment is determined by multiplying the number of influenced trucks at the intersection by the percent of trucks that turn onto the road segment being analyzed. The following example illustrates the procedure used to compute the number of influenced trucks on each segment for the POE shown in Figure 6.

Influenced Traffic on Segment 1

No traffic leaves segment 1 until the intersection, therefore all trucks on segment 1 are influenced by the POE. On segment 1, 2180 trucks are influenced by the POE.

Influenced Traffic on Segment 2

$\frac{2180 + 90 - 2180}{2} = 45$ trucks on segment 2 influenced by POE

Influenced Traffic on Segment 15

$2180 - 45 = 2135$ trucks on segment 15 influenced by POE or 97.94% of the total.

Influenced Traffic on Segment 3

$\frac{2180 + 120 - 2180}{2} = 60$ trucks on segment 3 from segment 15.

That is:

$\frac{60}{2180} \times 100\% = 2.75\%$ of all trucks on segment 15 turn on to segment 3

There are

$0.0275 * 0.9749 * 2180 = 59$ trucks on segment 3 influenced by the POE.

Influenced Traffic on Segment 16

2135 - 59 = 2076 trucks on segment 16 influenced by the POE or 95.2% of the trucks.

This method does not account for the possibility of trucks leaving and entering the system between intersections, which would decrease the percentage of influenced trucks. However, this method also ignores trucks that go through the subject POE influence zone and then travel in other POE zones without encountering another POE. This category of truck movement should properly be counted as a benefit of the subject POE. In this sense, our method can be considered a pessimistic estimate of both the influenced road system and benefit of the subject POE.

One way of dealing with this "under-accounting" is to accredit any truck travelling in the subject POE zone (that routes through only one POE) as being influenced by the subject POE, regardless of which POE it came through. This obviously mis-applies benefits among POEs. However, if done consistently over the state, the correct state-wide benefit would be accounted for. This additional benefit will be calculated later for the Bliss POE and included separately.

Calculating Percent Loss of Life

The percent loss of pavement life is calculated from the axle equivalents of legal (LEE) and overloaded (OE) trucks, the percent of overweight trucks in the traffic stream (OL), and the net (freight) weight of legal (LNW) and overloaded

(ONW) trucks. The difference in net weights must be included so that equal amounts of freight are carried regardless of the percent of overloaded trucks. Equation 4 was developed in this research to calculate the percent loss of pavement service life.

$$\%\ Years\ Lost = \left(1 - \left(\frac{LEE}{LNW}\right) \times \right.$$

$$\left.\left(\left(1-OL\right) \times LNW + OL \times ONW\right) / \left(\left(1 - OL\right) \times LEE + OL \times OE\right)\right) \times 100\% \quad (4)$$

This equation estimates the proportional loss of pavement life due to overloaded trucks.

Equivalents and Percent Overloads

Equivalents are a measure of pavement fatigue from truck axle loads. Percent overloads for this study are the percent of total trucks with a gross weight greater than 80,000 lbs. Only axle weights of trucks with a gross weight greater than 80,000 lbs are used to calculate OE.

For this study, AASHTO ESAL tables are used to calculate equivalents. Calculating equivalents from AASHTO tables requires knowledge of the truck axle weights, the terminal serviceability index P_t, and the structural number (SN) for asphalt concrete or thickness for portland cement concrete.

The predominant pavement material throughout the study area is asphalt concrete. A 3S2 analysis truck (5 axle tractor - single trailer truck, 1 steering axle and two tandem axles) is used to compute the legal equivalents since the majority of trucks on Idaho highways are of this type. The legal equivalent is computed from the AASHTO tables as follows:

Steering Axle-12 kip = 1 axle * 0.19 equiv. = 0.19 equiv.

Tandem Axles-34 kip = 2 axles * 1.09 equiv. = 2.18 equiv.

Total Equivalents = 0.19 + 2.18 = 2.37 equiv. (legal)

It is preferable to conduct a long term, site specific survey to obtain an actual percent of overloaded trucks and equivalents. Since this is not available, axle weights are obtained from WIM data available at locations throughout the state for port open and closed conditions. Figure 7 shows the WIM site locations for 1989. OL and equivalents were calculated at selected interstate and secondary WIM sites, for both port open and port closed conditions. The OL and equivalent values applied to the sample study areas are based on averages from these WIM sites.

Figure 8 illustrates the calculation procedure used to estimate average equivalents (E) for a group of tandem axles. Adding the average equivalents for the front axle and the other tandem results in an average equivalent for the group of trucks. A summary of the equivalent and overload calculations is included in Appendix B.

The axle load data available at each WIM site indicates that the average overload equivalent on interstate and secondary highways for influenced and uninfluenced trucks is approximately 3.80, and is only weakly related to percent of overloaded trucks. See Figure 9 for the relationship between percent overload and equivalents. Although the percent of overloaded trucks is not closely related to the equivalent for overloaded trucks, the percent that a truck is overloaded is well correlated to the overload equivalent. Figures 10 and 11 illustrate this relationship for both interstate and non interstate roads.

WIM data from 1989 is used to estimate the percent overloads on interstate and secondary highways for influenced and uninfluenced truck traffic. Again, a long term survey at the site would be preferable. The OL values used in the benefit calculation are shown in Table 1. The percentages given in Table 1 are rounded averages of the WIM data from Figure 12. For convenience, the data from Wyatt and Hassan (62) for all truck types is shown next to the values used in the benefit calculation. Unlike the U of I values, the Saskatchewan data is expressed as a percentage of loaded trucks as opposed to total trucks, and uses static weighing.

Due to the small size of the "secondary open" data set, and since secondary ports are frequently closed, it is assumed that 10% OL is a reasonable figure if the port was normally open. The Saskatchewan data indicates a 3 to 1 ratio of percent of overloaded trucks for closed and open ports.

The 1989 WIM data used to estimate axle equivalents (E) and percent overloads (OL) was taken during periods of approximately one week or less for each WIM site. Data collected during a relatively short time span may be influenced by short term local or seasonal events. A more accurate estimate would be possible from a larger data set collected over a longer time span, preferably from several times throughout the year. The Wyatt and Hassan data was collected over longer periods.

Calculate Percent Loss of Life for Continuous POE Operation

If the port was operating continuously, truck traffic on road segments within the study area would consist of both influenced and uninfluenced trucks due to turning traffic that is not influenced by the port. To account for the difference in percent overloads of influenced and uninfluenced trucks, the percent loss of service life is computed for both port open and port closed condition for each road segment using equation 4. Then a weighted average percent loss of service life is found using the number of influenced and uninfluenced trucks on each road segment. The weighted average percent loss of service life is used to compute a reduced life for the condition of continuous POE operation. The following example illustrates the procedure used to compute the weighted average loss of life.

Given the following conditions:

Influenced traffic, loss of pavement life = 4.06%

Uninfluenced traffic, loss of pavement life = 11.27%

POE influenced ADTT = 1530

POE uninfluenced ADTT = 710

then:

$$\textit{Wtd. Avg. Loss of Life} = \frac{4.06\% \times 1530 + 11.27\% \times 710}{1530 + 710} = 6.35\%$$

Calculate Percent Loss of Life for POE not Operating

If the port did not exist or is not operating, it is assumed that all truck traffic in the study area would be uninfluenced. The percent loss of life would be 11.27% in this case.

Computing Reduced Life

The Idaho Transportation Department uses a pavement design life of 20 years, but maintains roads on a 36 year replacement schedule with maintenance and repairs scheduled at 12 and 24 years after initial construction. For this study, it is assumed that a reduction in pavement service life would reduce the 36 year scheduled life-time, as well as the 12 and 24 year maintenance schedule.

The reduced service life was computed as illustrated in Equation 5.

$$\textit{Reduced Life} = 36 - 36 \times \%\ \textit{Yrs. Lost} \tag{5}$$

Calculating present cost per mile with reduced life

The Idaho Transportation department uses the following cost estimate for a 4 lane asphalt concrete highway. The initial cost per mile is $868,600. The 12 and 24 year maintenance are $168,200 and $401,100, respectively. The cost of a 2 lane road is one-half of these costs. ITD uses a 4 percent interest rate to evaluate its projects.

For this study, it is assumed that truck traffic on interstate and 4 lane highways travels in the outside lanes. The inside lanes do not experience any loss of pavement life due to overloaded trucks. Therefore, all road segments, interstate or secondary, are considered to be 2 lanes wide for allocating costs attributable to pavement damage from overloaded trucks.

A cash flow diagram for a 2 lane road is illustrated in Figure 13. The diagram is for a 1 mile long road segment.

The present cost of 2 lane road segments per mile is determined using Equation 6 for both port operating and not operating conditions.

$$PC = \$434,300 + \$84,100 \times (P/F,\ 4\%, \frac{Reduced\ Life}{3}) + \$200,550 \times (P/F,\ 4\%,\ \frac{Reduced\ Life}{3} \times 2) \qquad (6)$$

The annual cost of each 2 lane road segment per mile in the study area is found using Equation 7 for both port operating and not operating conditions.

$$AC = PC\ of\ Segment \times (A/P,\ 4\%,\ Reduced\ Life) \qquad (7)$$

Total Annual Pavement Costs of Study Area

The total annual cost of all of the road segments in the study area is determined by multiplying the annual cost per mile of each road segment by its length (in miles), and summing the costs of each road segment. The difference between the total annual cost for port operating and not operating is the benefit derived from operating the port.

Bliss Results

Example calculations for the Bliss port of entry are shown in Figures 14 and 15. They show the spreadsheets and procedures used to calculate the annual benefit. The following truck related values were used in the Bliss analysis: legal truck equivalent ratio of 2.37, overloaded truck equivalent ratio of 3.8, legal truck net freight weight of 51,400 lb, overloaded truck net freight weight of 58,400 lb, and an empty truck weight of 30,000 lb.

In Figure 14 the difference between net weights of legal and overloaded trucks is <u>ignored</u>. Under these conditions, and with the POE open continuously, the net benefit of the POE is $5,304,567 - $5,063,012 = $241,555.

In Figure 15 the difference between net weights of legal and overloaded trucks is <u>included</u>. With the POE open continuously, and if the difference in net weights is included, the AC is $4,987,627. With no port operation, the AC is $5,163,017. Under the assumptions employed, it shows that full time operation of the port results in an annual benefit of $5,163,017 - $4,987,627 = $175,390. The length of the road system included in the Bliss example analysis is 159.2 miles long. The annual benefit of full time operation of the port per mile is $1,102. This represents the <u>minimum</u> benefit of the Bliss POE under the given assumptions, since the calculation does not include benefits of the Bliss POE that occur outside of the Bliss zone which are not included in the benefits of other POEs.

The annual cost (AC) of building and repairing the roadways in the Bliss area would be $4,756,300 with no overloaded trucks. The benefit if all overloading could be stopped is $5,163,017 - $4,756,300 = $406,717. This represents the maximum benefit possible.

If it is assumed that all of the trucks and roads in the Bliss zone are influenced by the Bliss POE (100% influence), but overloading (OL) is only reduced to 10%, then the annual benefit is $366,850.

If instead, it is assumed that 90% of the trucks on Highway 30 (segment 2040) are influenced by the Bliss POE (instead of 32%), and the percent influence on each segment remains as originally calculated in Figure 14, and OL is 10%, then the annual benefit is $296,797. While the port influence calculations show that most (68%) of the trucks on Highway 30 are not influenced by the Bliss POE, these trucks have a very high probability of routing through adjacent POEs. Since the adjacent POEs would not have their beneficial influence on Highway 30 attributed to their zone, it is reasonable to apply this benefit to the Bliss POE. Consistency requires that any benefits from the Bliss POE that are felt in other zones (and the truck only travels through the Bliss POE) should be accredited to those POEs, and not the Bliss POE. This would be a consistent way to apply this otherwise ignored benefit. It also results in the correct total state-wide benefit. This is the recommended method for calculating the correct benefit amount.

Lewiston Results

Example calculations for the Lewiston port of entry are shown in Figures 16 and 17. The figures illustrate the procedures used to calculate the annual benefit of the port with respect to pavement life. The following truck related values were used in the Lewiston analysis: legal truck equivalent ratio of 2.37, overloaded truck equivalent ratio of 3.8, legal truck net freight weight of 51,400 lb, overloaded truck net freight weight of 58,400 lb, and an empty truck weight of 30,000 lb.

In Figure 16 the difference between net weights of legal and overloaded trucks is ignored. Under these conditions, and with the POE operated continuously, the net benefit of the Lewiston POE is $8,822,356 - $8,250,525 = $271,831.

In Figure 17 the difference between net weights of legal and overloaded trucks is included. With the POE open continuously, and if the difference in net weights is included, the AC is $8,098,904. With no port operation, the AC is $8,294,942. Under the assumptions employed, it shows that full time operation of the port results in an annual benefit of $8,294,942 - $8,098,904 = $196,038. The length of the road system included in the Lewiston example analysis is 255.7 miles long. The annual benefit of full time operation of the Lewiston port per mile is $767. This represents the minimum benefit of the Lewiston POE under the given assumptions, since the calculation does not include benefits of the Lewiston POE that occur outside of the Lewiston zone which are not included in the benefits of other POEs.

The annual cost (AC) of building and repairing the roadways in the Lewiston area would be $7,641,400 with no overloaded trucks. The benefit if all overloading could be stopped is $8,294,942 - $7,641,400 = $653,542. This represents the <u>maximum</u> benefit possible.

Moyie Junction Results

Example calculations for the Moyie Junction port of entry are shown in Figures 18 and 19. The figures illustrate the procedures used to calculate the annual benefit of the port with respect to pavement life. The following truck related values were used in the Moyie Junction analysis: legal truck equivalent ratio of 2.37, overloaded truck equivalent ratio of 3.8, legal truck net freight weight of 51,400 lb, overloaded truck net freight weight of 58,400 lb, and an empty truck weight of 30,000 lb.

In Figure 18 the difference between the net weights of legal and overloaded trucks is ignored. Under these conditions, and with the POE operated continuously, the net benefit of the Moyie POE is $2,059,995 - $1,922,883 = $137,112.

In Figure 19 the difference between net weights of legal and overloaded trucks is included. With the POE open continuously, and if the difference in net weights is included, the AC is $1,904,911. With no port operation, the AC is $2,005,075. Under the assumptions employed, it shows that full time operation of the port results in an annual benefit of $2,005,075 - $1,904,911 = $100,164. The length of the road system included in the Moyie example analysis is 61.8 miles long. The annual benefit of full time operation of the Moyie port per mile is $1621. This represents the minimum benefit of the Moyie POE under the given assumptions, since the calculation does not include benefits of the Moyie POE that occur outside of the Moyie zone which are not included in the benefits of other POEs.

The annual cost (AC) of building and repairing the roadways in the Moyie area would be $1,847,100 with no overloaded trucks. The benefit if all overloading could be stopped is $2,005,075 - $1,847,100 = $157,975. This represents the <u>maximum</u> benefit possible.

Marsing Results

Example calculations for the Marsing port of entry are shown in Figures 20 and 21. The figures illustrate the procedures used to calculate the annual benefit of the port with respect to pavement life. The following truck related values were used in the Marsing analysis: legal truck equivalent ratio of 2.37, overloaded truck equivalent ratio of 3.8, legal truck net freight weight of 51,400 lb, overloaded truck net freight weight of 58,400 lb, and an empty truck weight of 30,000 lb.

In Figure 20 the difference between the net weights of legal and overloaded trucks is ignored. Under these conditions, and with the POE operated continuously, the net benefit of the Marsing POE is \$11,143,043 - \$10,988,715 = \$154,328.

In Figure 21 the difference between net weights of legal and overloaded trucks is included. With the POE open continuously, and if the difference in net weights is included, the AC is \$10,726,997. With no port operation, the AC is \$10,845,697. Under the assumptions employed, it shows that full time operation of the port results in an annual benefit of \$10,845,697 - \$10,726,997 = \$118,700. The length of the road system included in the Marsing example analysis is 334.3 miles long. The annual benefit of full time operation of the Marsing port per mile is \$355. This represents the minimum benefit of the Marsing POE under the given assumptions, since the calculation does not include benefits of the Marsing POE that occur outside of the Marsing zone which are not included in the benefits of other POEs.

The annual cost (AC) of building and repairing the roadways in the Marsing area would be $9,991,000 with no overloaded trucks. The benefit if all overloading could be stopped is $10,845,697 - $9,991,000 = $854,692. This represents the <u>maximum</u> benefit possible.

Sensitivity Analysis of OL and Equivalent Ratio

Due to the uncertainties of OL and ER, these variables were allowed to vary in order to check the sensitivity of the results. ER is the ratio of overloaded equivalents (OE) to legal equivalents (LEE). Figures 22 and 23 show the results of the sensitivity analysis for the Bliss study area. If the assumed percentage of overloaded trucks is reduced by 50%, the annual benefit is $118,300, or $743 per mile, which is a reduction of 51%. If the assumed equivalent ratio is increased by 20%, the annual benefit is increased to $375,074, or $2350 per mile, which is an increase of 56%. OL and ER have a strong effect on the results. The results confirm that care should be used when estimating them.

Conclusion

A calculation procedure has been developed to determine the economic benefit due to increased pavement life that results from operation of a port of entry. It uses WIM data and the AASHTO ESAL tables to evaluate the percentage of overloaded trucks and their equivalents. These values are used to calculate a reduction of pavement service life. The cost of reduced pavement life is based on construction and rehabilitation costs of a typical asphalt highway section and an assumed life of 36 years.

The procedure has been applied to the Bliss, Lewiston, Moyie Junction, and Marsing POEs. The annual benefit of the Bliss POE is $1102 per mile. Lewiston POE has an annual benefit of $767 per mile. The annual benefit of the Moyie Junction POE is $1621 per mile. Marsing POE has an annual benefit of $355 per mile of highway. The benefits of each port differ because of varying total truck volumes, influenced truck volumes, and the total length of road segments in each study area. These benefits are unique to the conditions used to analyze each of the ports studied. Any changes to the conditions used to analyze these ports will result in different benefits.

Appendix A

Figures and Tables

Table 1 - OL VALUES

	POE	Used[1] % O.L.	Saskatchewan[2] % O.L.
Interstate	Open	10	3
Roads	Closed	30	18.6
Secondary	Open	10	9
Roads	Closed	30	30

1 percent of all trucks, WIM

2 percent of loaded trucks, static weights

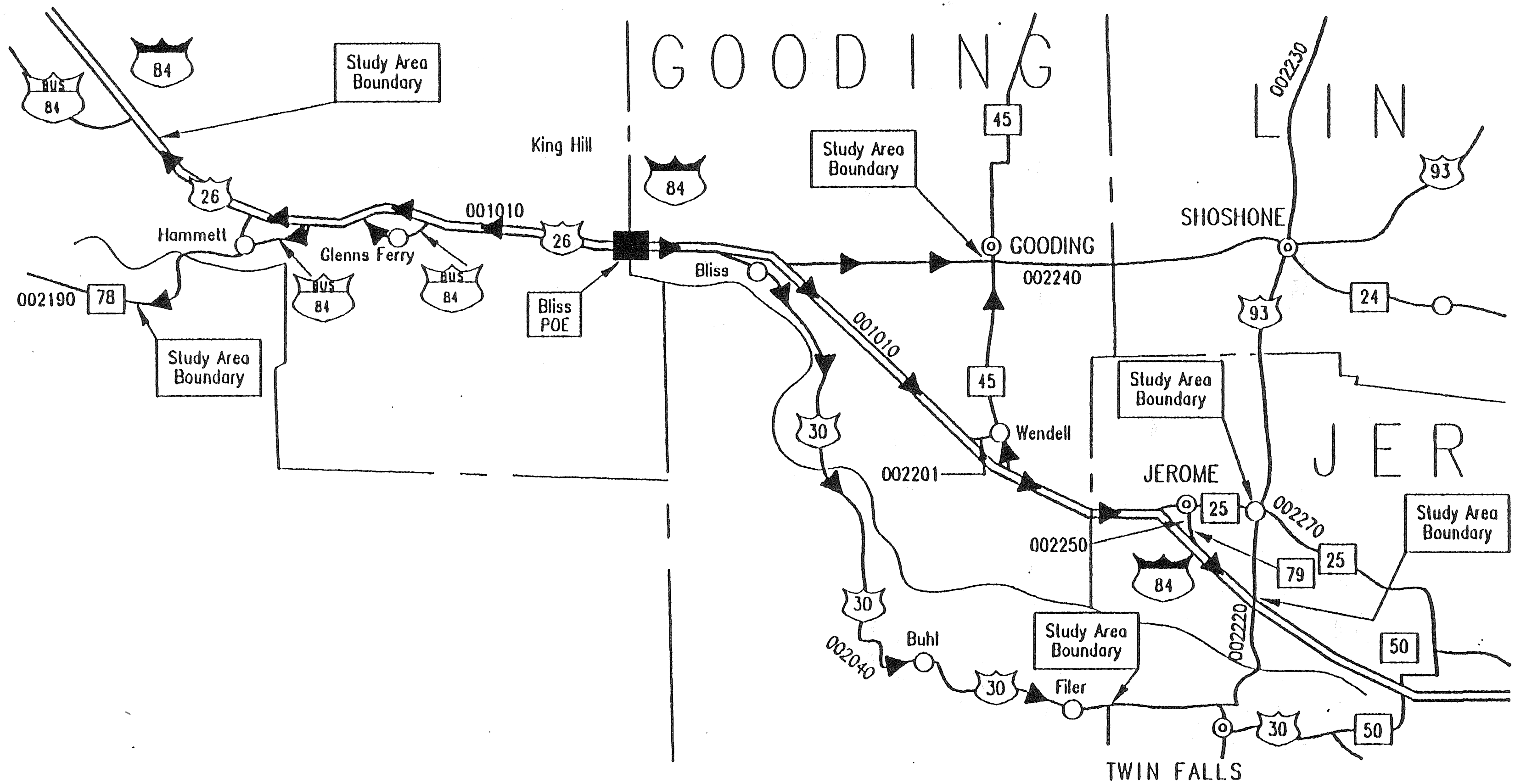


Figure 1. Bliss POE and surrounding road system.

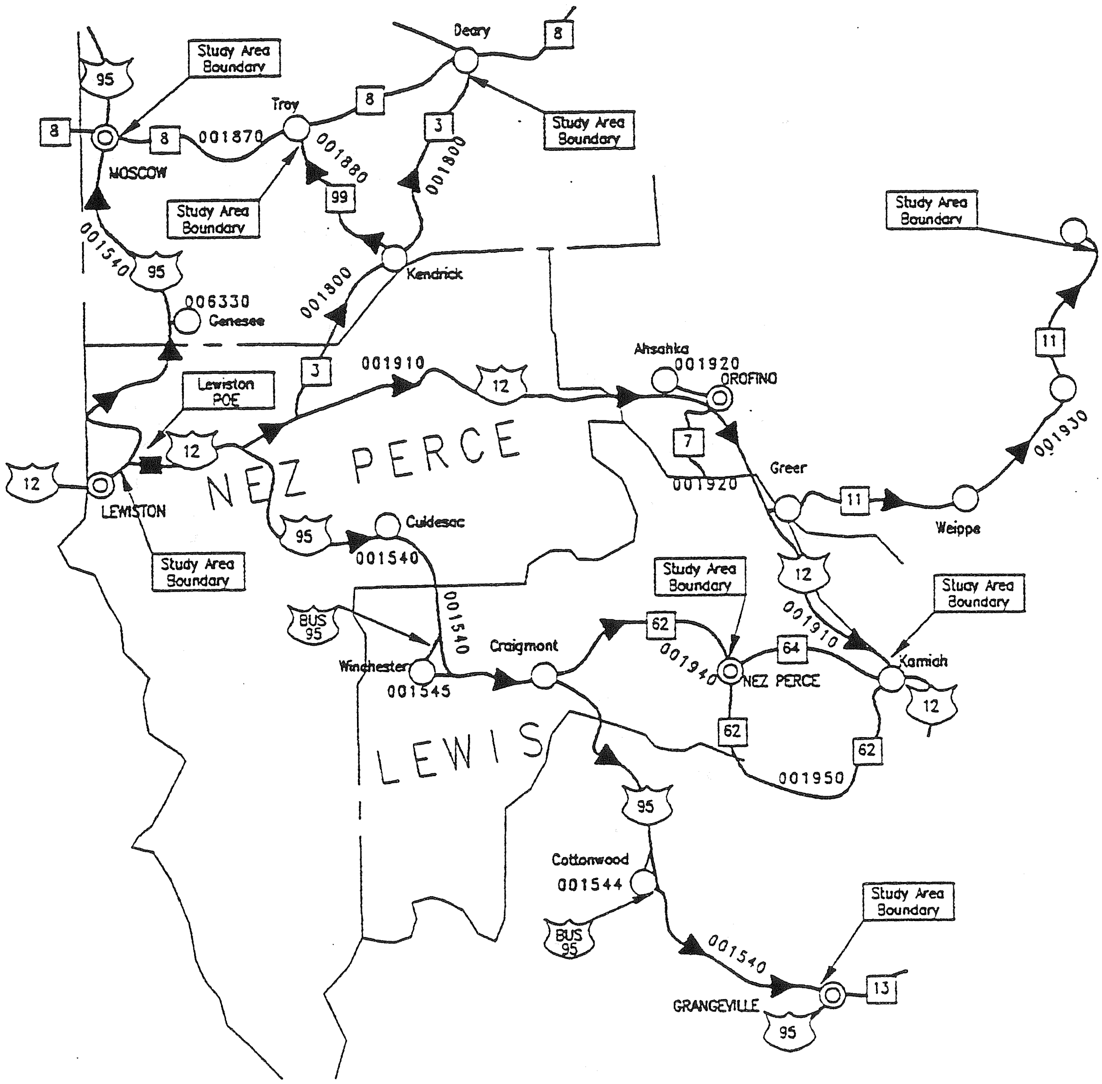


Figure 2. Lewiston POE and surrounding road system.

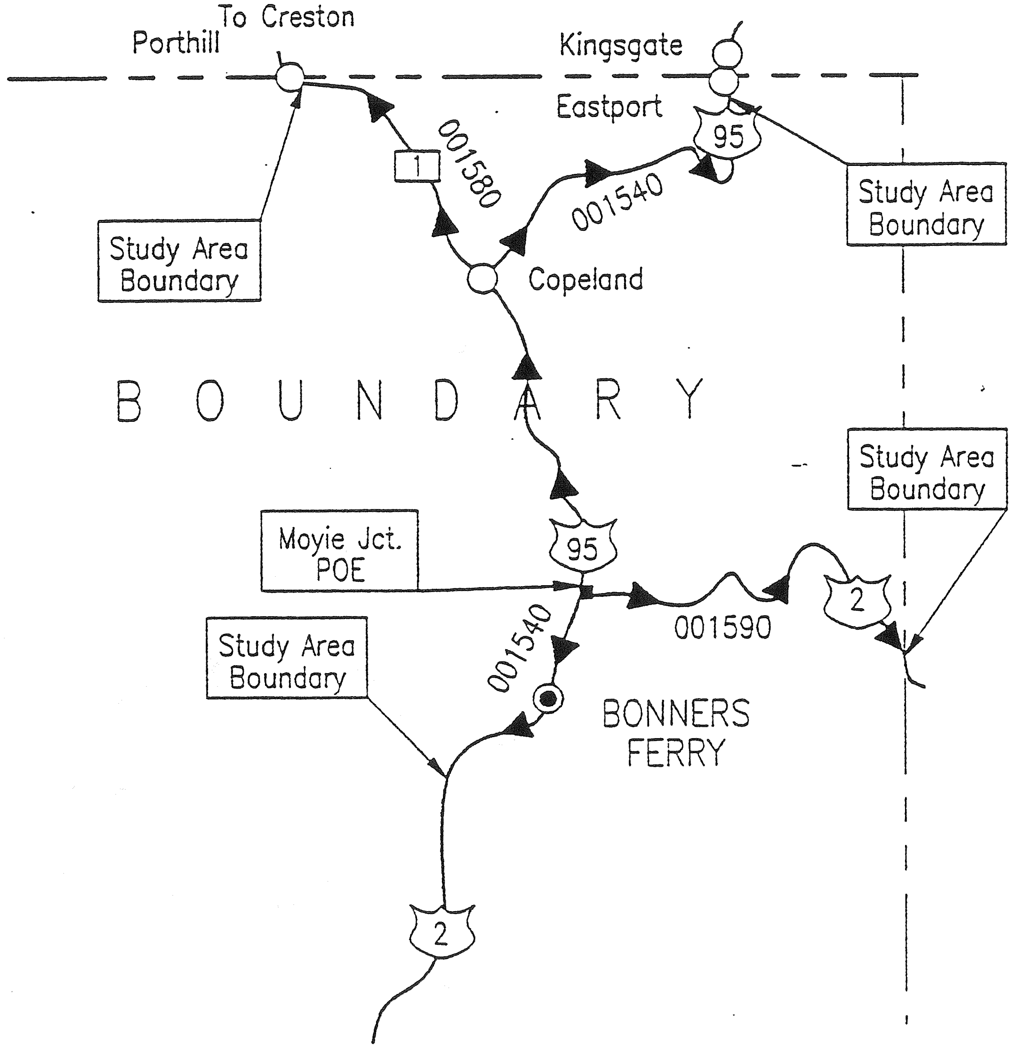


Figure 3. Moyie Junction POE and surrounding road system.

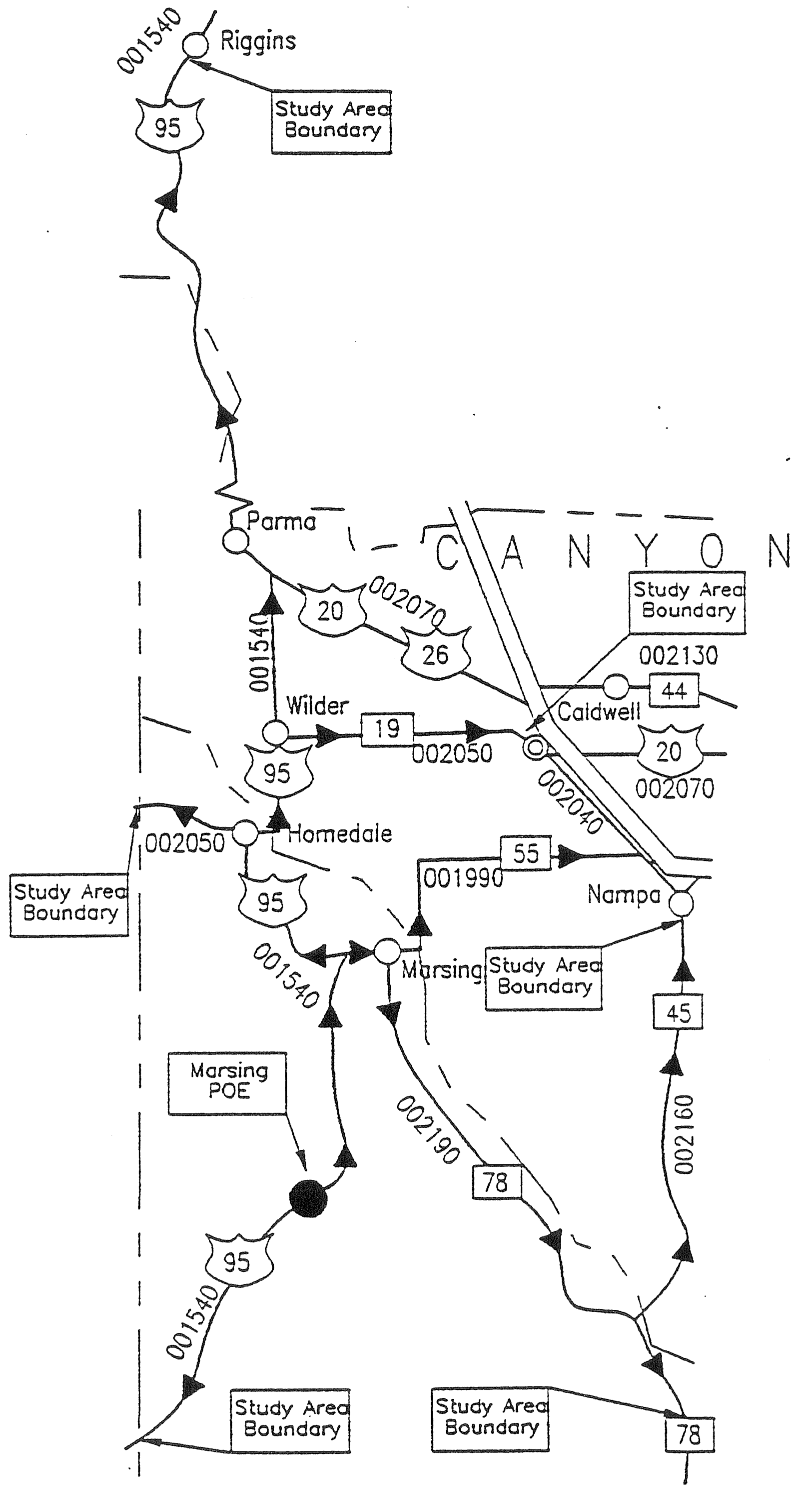


Figure 4. Marsing POE and surrounding road system.

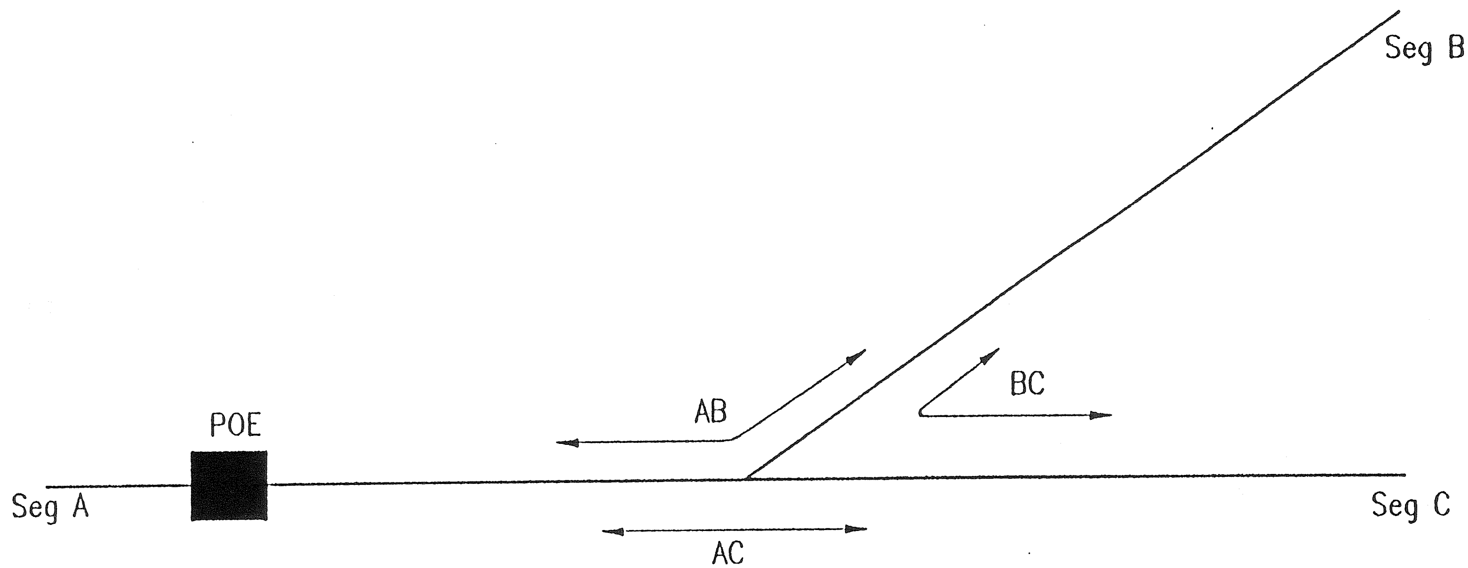
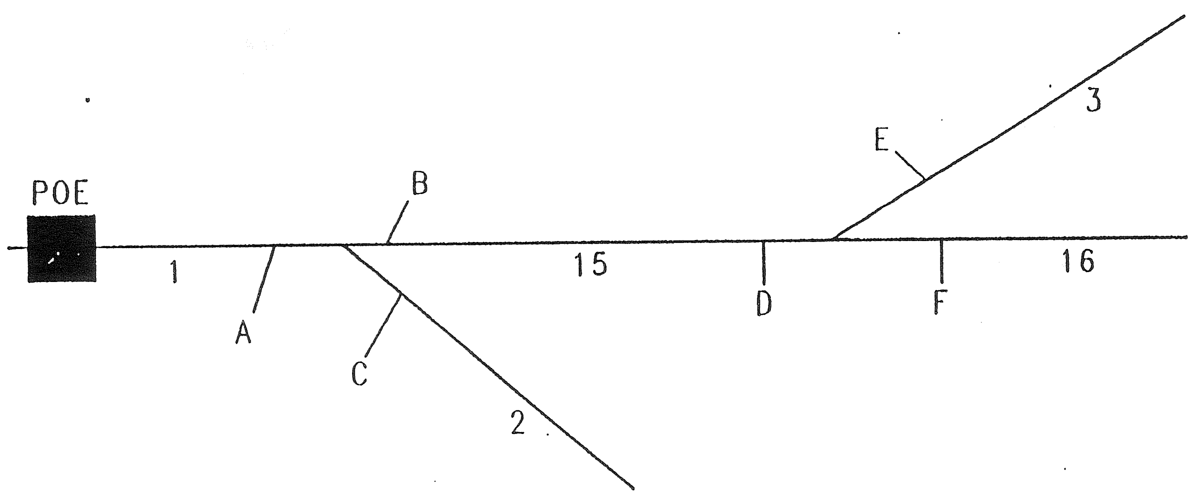


Figure 5. Road diagram used to calculate percent influence.



$ADTT_A = 2180$
$ADTT_B = 2180$
$ADTT_C = 90$
$ADTT_D = 2180$
$ADTT_E = 120$
$ADTT_F = 2180$

Figure 6. Road diagram to calculate percent influence for multiple branches.

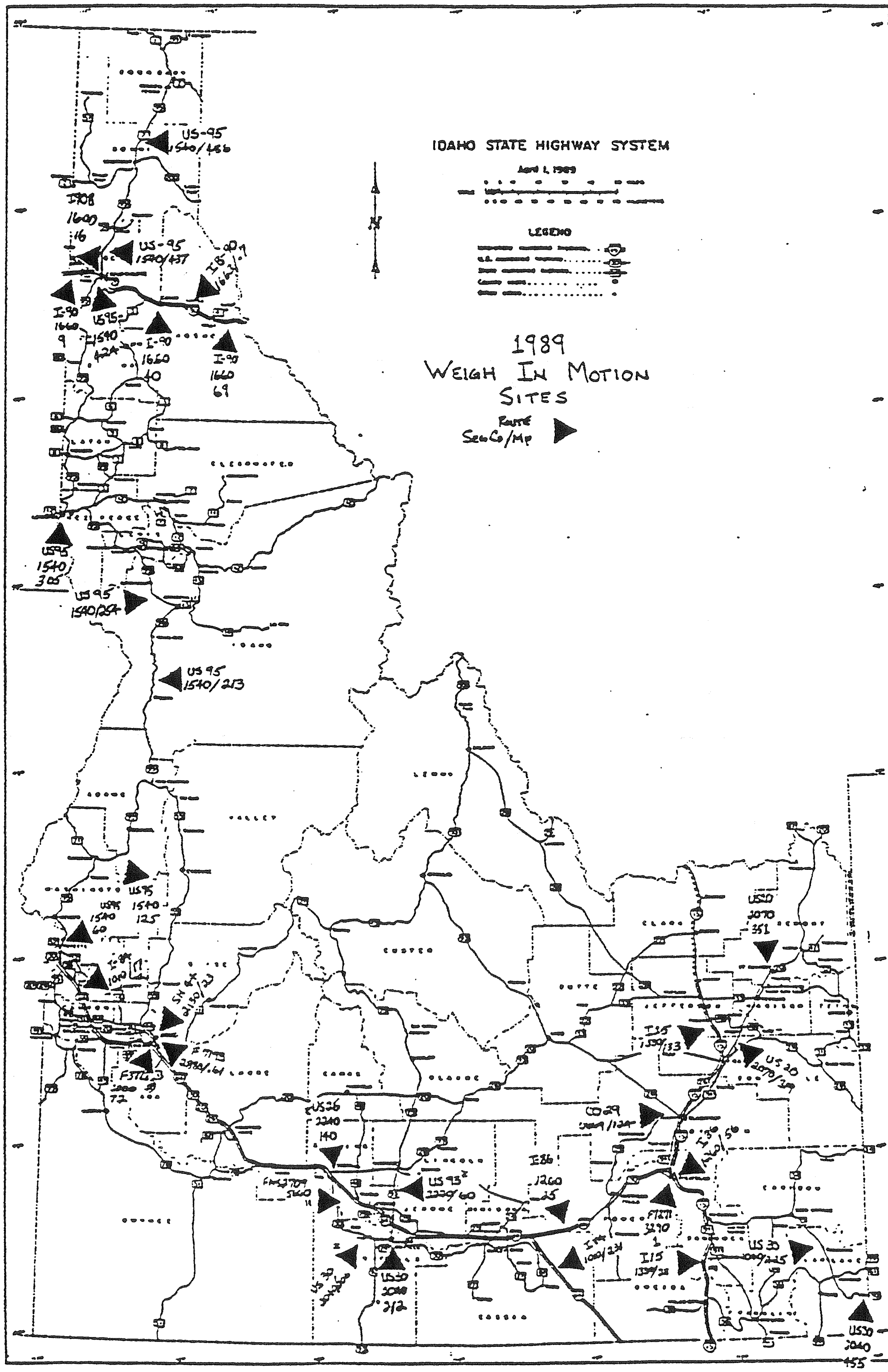


Figure 7. WIM sites in Idaho.

1989 WIM Data for 3S2 Trucks with GVW >= 80000 lb
All Trucks, Asphalt Concrete
Tandem 1

Axle Load	# of Tandems	Equiv. / Axle, SN=5	Sum of Equiv.
20000	0	0.121	0
24000	0	0.180	0
28000	0	0.364	0
32000	0	0.658	0
36000	2	1.090	2
40000	32	1.700	54
44000	25	2.510	63
48000	8	3.550	28
52000	0	4.860	0
56000	0	6.470	0
60000	0	8.400	0
Sum =	67		148

Average Equivalent = 148 / 67 = 2.2

Figure 8. Example calculation of average equivalent for one tandem axle (Pt = 2.5 and SN = 5).

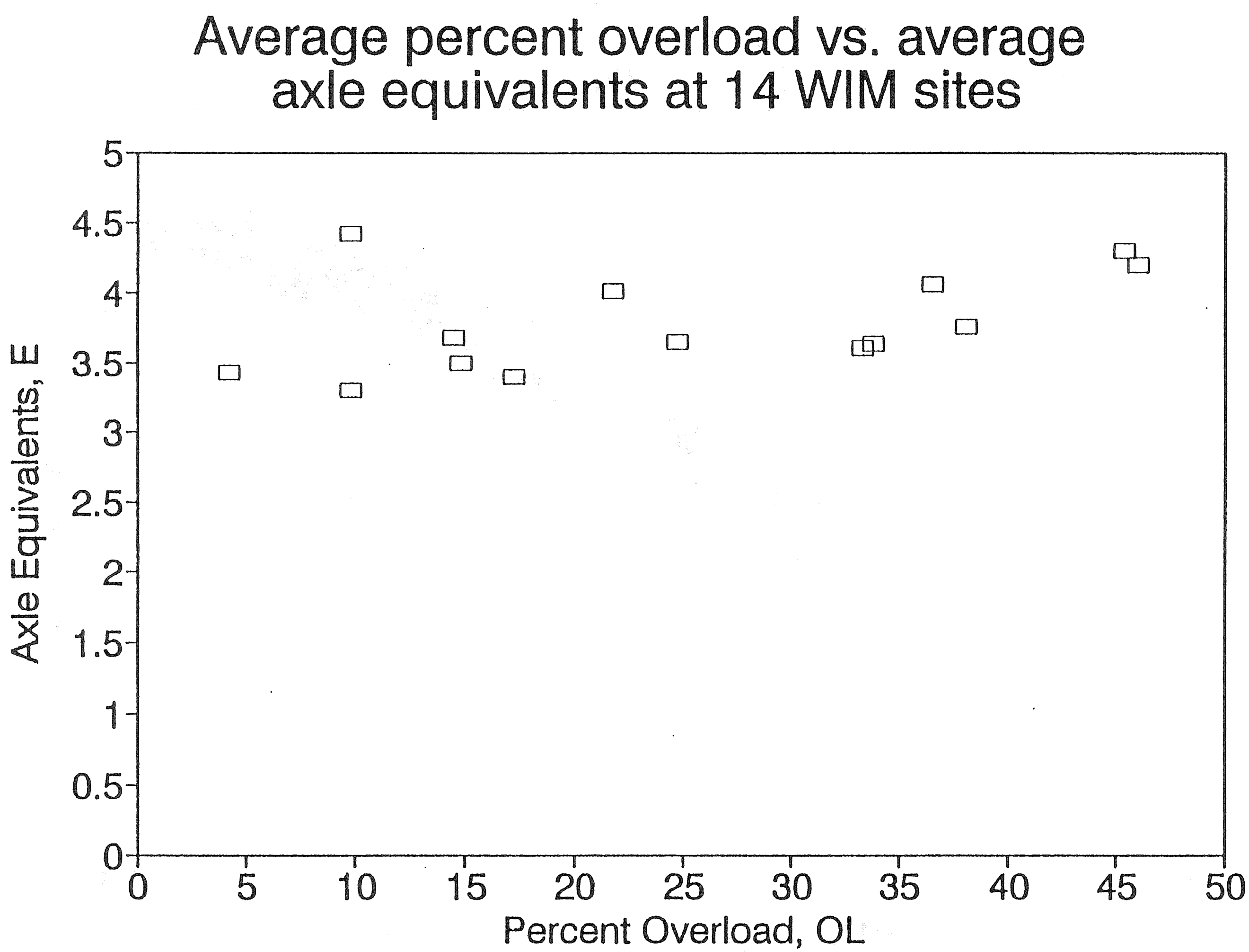


Figure 9. OL (percent of total trucks) vs. E of overloaded trucks for selected WIM sites.

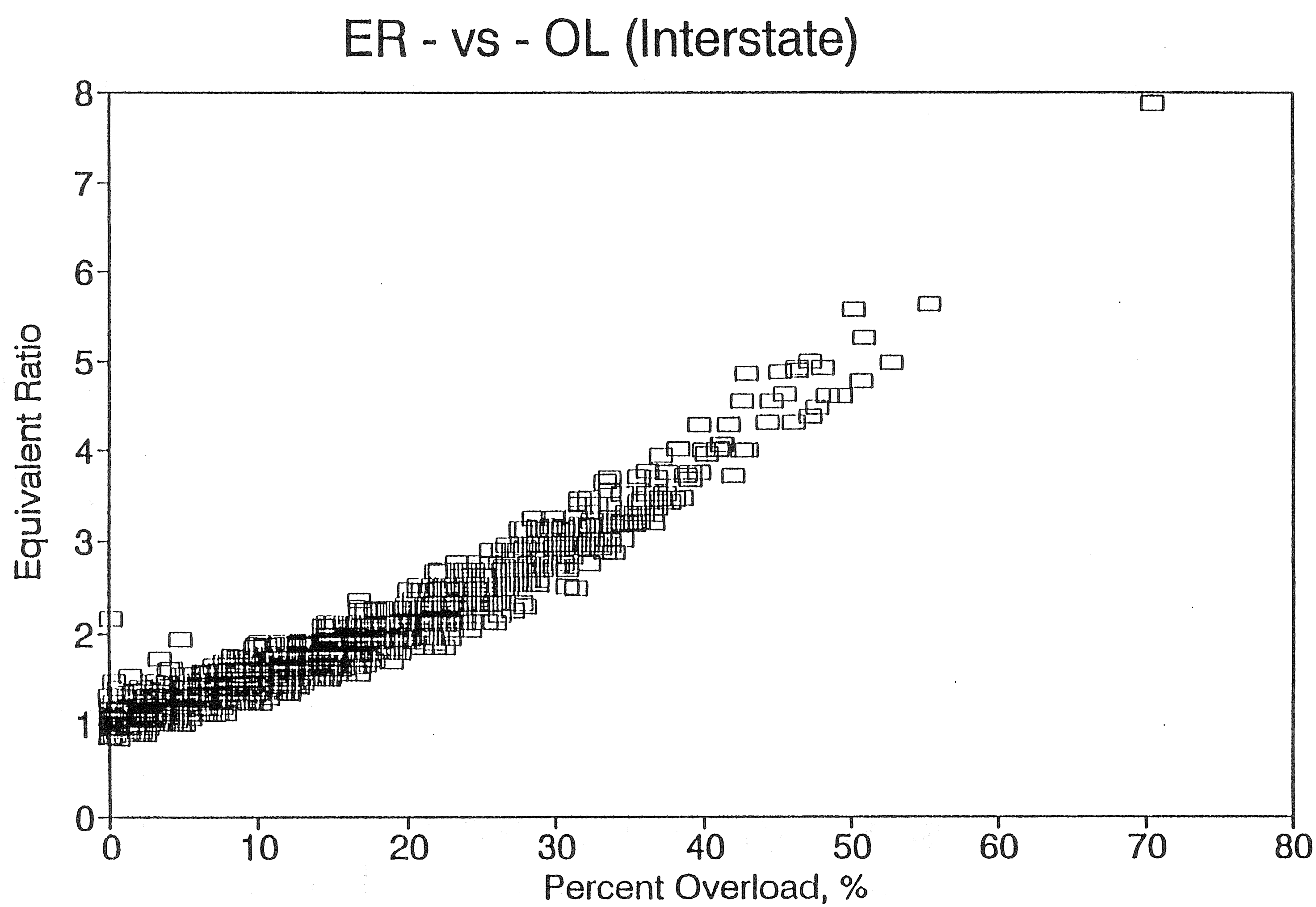


Figure 10. Percent Overloaded (single truck) vs. Equivalent Ratio for interstate roads.

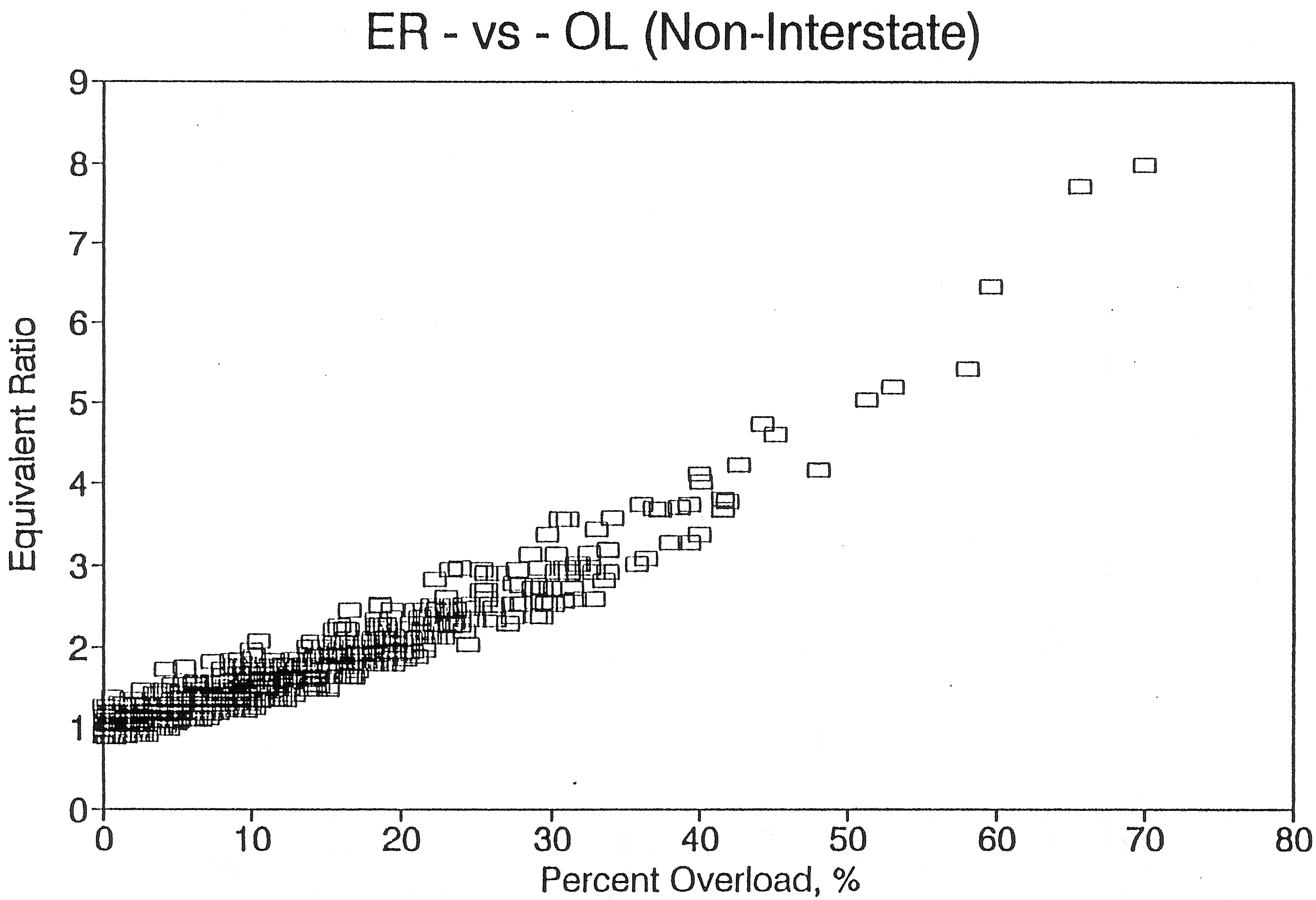


Figure 11. Percent Overloaded (single truck) vs. Equivalent Ratio for non interstate roads.

Interstate Roads - POE Open

Location	Total # of Trucks Weighed	Percent Overload	Weighted ER
Buhl-Hollister	267	9	3.26
Cotteral	903	19.9	3.75
Lewiston	630	6.8	4.42
Average		11.9	3.81

Interstate Roads - POE Closed

Location	Total # of Trucks Weighed	Percent Overload	Weighted ER
Buhl-Hollister	28	17.9	3.5
Cotteral	1499	46.5	4.26
Average		32.2	3.88

Secondary Roads - POE Open

Location	Total # of Trucks Weighed	Percent Overload	Weighted ER
Samuels	104	26.7	3.66

Secondary Roads - POE Closed

Location	Total # of Trucks Weighed	Percent Overload	Weighted ER
Samuels	387	20.4	4.13
Ashton	176	38.1	3.76
Council	172	17.4	3.91
Payette	278	24.8	3.65
Cottonwood	151	33.8	3.64
Average		26.9	3.82

Figure 12. OL and E for open and closed POEs

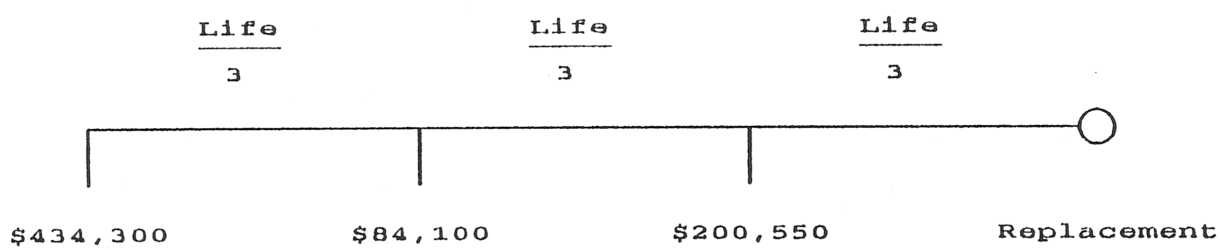


Figure 13. Cash flow diagram for pavement construction and repair.

PAVEMENT LIFE ECONOMIC ANALYSIS FOR ROAD SYSTEM NEAR BLISS POE
Ignoring net freight weights.
Structural Number = 5

	COSTS	
Initial Cost =	$868,600 / mile, 4 lanes,	$434,300 / mile, 2 lanes
12 yr Cost =	$168,200 / mile, 4 lanes,	$84,100 / mile, 2 lanes
24 yr Cost =	$401,100 / mile, 4 lanes,	$200,550 / mile, 2 lanes

Interest Rate = 4 %

Equiv. of Legal Truck = 2.37

	Trucks Influenced by POE			Trucks Not Influenced by POE		
	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.
Interstate	10	3.8	1.603	30	3.8	1.603
Rural	10	3.8	1.603	30	3.8	1.603

						100% POE OPERATION (OL = 10%)					NO POE OPERATION (OL = 30%)				(OL = ZERO)
SEGMENT CODE	SEGMENT LENGTH	TOTAL ADTT	INFL. ADTT	UN-INFL. ADTT	% INFL.	INFL. LOSS OF LIFE %	UNINFL. LOSS OF LIFE %	WTD AVG LOSS OF LIFE %	REDUCE LIFE	TOTAL A. C.	% LOSS OF LIFE	REDUCED LIFE	TOTAL A. C.	DIFFERENCE of A. C.	NO O.L. A. C.
1010	3.16	2180	2180	0	100.0	5.69	15.33	5.69	34.0	$98,035	15.33	30.5	$105,322	$7,287	$94,436
2040	42.65	140	45	95	32.1	5.69	15.33	12.23	31.6	$1,387,299	15.33	30.5	$1,421,415	$34,116	$1,274,491
2240	8.40	120	60	60	50.0	5.69	15.33	10.51	32.2	$269,730	15.33	30.5	$279,970	$10,240	$251,031
2201	1.87	220	100	120	45.5	5.69	15.33	10.95	32.1	$60,244	15.33	30.5	$62,327	$2,083	$55,884
2200	0.14	300	140	160	46.7	5.69	15.33	10.83	32.1	$4,506	15.33	30.5	$4,666	$160	$4,184
2200	10.86	380	180	200	47.4	5.69	15.33	10.76	32.1	$349,446	15.33	30.5	$362,028	$12,582	$324,607
1010	6.03	2240	1530	710	68.3	5.69	15.33	8.75	32.9	$191,111	15.33	30.5	$200,945	$9,834	$180,175
2270	1.50	340	120	220	35.3	5.69	15.33	11.93	31.7	$48,617	15.33	30.5	$49,928	$1,311	$44,767
2250	2.56	300	100	200	33.3	5.69	15.33	12.12	31.6	$83,333	15.33	30.5	$85,458	$2,124	$76,624
2270	3.84	140	130	10	92.9	5.69	15.33	6.38	33.7	$119,824	15.33	30.5	$128,120	$8,295	$114,877
1010	12.71	2180	2180	0	100.0	5.69	15.33	5.69	34.0	$394,220	15.33	30.5	$423,521	$29,301	$379,744
1030	3.18	50	20	30	40.0	5.69	15.33	11.47	31.9	$102,787	15.33	30.5	$105,922	$3,135	$94,973
2190	1.60	50	30	20	60.0	5.69	15.33	9.55	32.6	$51,141	15.33	30.5	$53,461	$2,320	$47,935
2190	14.38	50	30	20	60.0	5.69	15.33	9.55	32.6	$458,484	15.33	30.5	$479,282	$20,798	$429,741
1010	3.33	2180	2140	40	98.2	5.69	15.33	5.87	33.9	$103,528	15.33	30.5	$111,088	$7,560	$99,606
1010	14.67	2180	2080	100	95.4	5.69	15.33	6.13	33.8	$456,417	15.33	30.5	$488,848	$32,431	$438,318
1010	7.94	2180	1830	350	83.9	5.69	15.33	7.24	33.4	$248,839	15.33	30.5	$264,472	$15,632	$237,135
1010	1.87	2180	1970	210	90.4	5.69	15.33	6.62	33.6	$58,389	15.33	30.5	$62,327	$3,938	$55,884
1010	1.86	2180	1670	510	76.6	5.69	15.33	7.95	33.1	$58,780	15.33	30.5	$62,160	$3,380	$55,735
1010	3.20	2180	2110	70	96.8	5.69	15.33	6.00	33.8	$99,488	15.33	30.5	$106,655	$7,167	$95,631
1010	5.60	2180	2090	90	95.9	5.69	15.33	6.09	33.8	$174,304	15.33	30.5	$186,747	$12,443	$167,444
1010	3.20	2180	2120	60	97.2	5.69	15.33	5.96	33.9	$99,458	15.33	30.5	$106,655	$7,197	$95,631
1010	2.60	2180	2150	30	98.6	5.69	15.33	5.82	33.9	$80,736	15.33	30.5	$86,657	$5,922	$77,700
1040	1.41	70	30	40	42.9	5.69	15.33	11.20	32.0	$45,445	15.33	30.5	$46,928	$1,483	$42,078
1050	0.59	70	40	30	57.1	5.69	15.33	9.82	32.5	$18,849	15.33	30.5	$19,665	$815	$17,632
TOTALS	159.2	miles								$5,063,012			$5,304,567	$241,554	$4,756,262

Figure 14. Cost calculation for Bliss POE, ignoring net freight weights.

PAVEMENT LIFE ECONOMIC ANALYSIS FOR ROAD SYSTEM NEAR BLISS POE
Including net freight weights.
Structural Number = 5

	COSTS	
Initial Cost =	$868,600 / mile, 4 lanes,	$434,300 / mile, 2 lanes
12 yr Cost =	$168,200 / mile, 4 lanes,	$84,100 / mile, 2 lanes
24 yr Cost =	$401,100 / mile, 4 lanes,	$200,550 / mile, 2 lanes

Interest Rate = 4 %

Equiv. of Legal Truck = 2.37

	Trucks Influenced by POE			Trucks Not Influenced by POE		
	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.
Interstate	10	3.8	1.603	30	3.8	1.603
Rural	10	3.8	1.603	30	3.8	1.603

						100% POE OPERATION (OL = 10%)					NO POE OPERATION (OL = 30%)				(OL = ZERO)
SEGMENT CODE	SEGMENT LENGTH	TOTAL ADTT	INFL. ADTT	UN-INFL. ADTT	% INFL.	INFL. LOSS OF LIFE %	UNINFL. LOSS OF LIFE %	WTD AVG LOSS OF LIFE %	REDUCE LIFE	TOTAL A. C.	% LOSS OF LIFE	REDUCED LIFE	TOTAL A. C.	DIFFERENCE of A. C.	NO O.L. A. C.
1010	3.16	2180	2180	0	100.0	4.41	11.87	4.41	34.4	$97,185	11.87	31.7	$102,512	$5,326	$94,436
2040	42.65	140	45	95	32.1	4.41	11.87	9.47	32.6	$1,359,001	11.87	31.7	$1,383,485	$24,484	$1,274,491
2240	8.40	120	60	60	50.0	4.41	11.87	8.14	33.1	$265,113	11.87	31.7	$272,499	$7,386	$251,031
2201	1.87	220	100	120	45.5	4.41	11.87	8.48	32.9	$59,163	11.87	31.7	$60,664	$1,501	$55,884
2200	0.14	300	140	160	46.7	4.41	11.87	8.39	33.0	$4,426	11.87	31.7	$4,542	$115	$4,184
2200	10.86	380	180	200	47.4	4.41	11.87	8.34	33.0	$343,299	11.87	31.7	$352,367	$9,069	$324,607
1010	6.03	2240	1530	710	68.3	4.41	11.87	6.77	33.6	$188,454	11.87	31.7	$195,583	$7,129	$180,175
2270	1.50	340	120	220	35.3	4.41	11.87	9.24	32.7	$47,654	11.87	31.7	$48,596	$942	$44,767
2250	2.56	300	100	200	33.3	4.41	11.87	9.38	32.6	$81,652	11.87	31.7	$83,177	$1,525	$76,624
2270	3.84	140	130	10	92.9	4.41	11.87	4.94	34.2	$118,649	11.87	31.7	$124,701	$6,052	$114,877
1010	12.71	2180	2180	0	100.0	4.41	11.87	4.41	34.4	$390,802	11.87	31.7	$412,220	$21,418	$379,744
1030	3.18	50	20	30	40.0	4.41	11.87	8.89	32.8	$100,841	11.87	31.7	$103,096	$2,255	$94,973
2190	1.60	50	30	20	60.0	4.41	11.87	7.39	33.3	$50,356	11.87	31.7	$52,034	$1,678	$47,935
2190	14.38	50	30	20	60.0	4.41	11.87	7.39	33.3	$451,450	11.87	31.7	$466,493	$15,043	$429,741
1010	3.33	2180	2140	40	98.2	4.41	11.87	4.55	34.4	$102,601	11.87	31.7	$108,124	$5,523	$99,606
1010	14.67	2180	2080	100	95.4	4.41	11.87	4.75	34.3	$452,125	11.87	31.7	$475,803	$23,678	$438,318
1010	7.94	2180	1830	350	83.9	4.41	11.87	5.61	34.0	$246,035	11.87	31.7	$257,414	$11,379	$237,135
1010	1.87	2180	1970	210	90.4	4.41	11.87	5.13	34.2	$57,792	11.87	31.7	$60,664	$2,871	$55,884
1010	1.86	2180	1670	510	76.6	4.41	11.87	6.16	33.8	$58,045	11.87	31.7	$60,501	$2,456	$55,735
1010	3.20	2180	2110	70	96.8	4.41	11.87	4.65	34.3	$98,575	11.87	31.7	$103,809	$5,234	$95,631
1010	5.60	2180	2090	90	95.9	4.41	11.87	4.72	34.3	$172,678	11.87	31.7	$181,763	$9,085	$167,444
1010	3.20	2180	2120	60	97.2	4.41	11.87	4.62	34.3	$98,552	11.87	31.7	$103,809	$5,257	$95,631
1010	2.60	2180	2150	30	98.6	4.41	11.87	4.51	34.4	$80,018	11.87	31.7	$84,345	$4,327	$77,700
1040	1.41	70	30	40	42.9	4.41	11.87	8.67	32.9	$44,608	11.87	31.7	$45,676	$1,068	$42,078
1050	0.59	70	40	30	57.1	4.41	11.87	7.61	33.3	$18,551	11.87	31.7	$19,140	$589	$17,632
TOTALS	159.2	miles								$4,987,627			$5,163,017	$175,390	$4,756,262

Figure 15. Cost calculation for Bliss POE, including net freight weights.

PAVEMENT LIFE ECONOMIC ANALYSIS FOR ROAD SYSTEM NEAR LEWISTON POE
Ignoring net freight weight.
Structural Number = 5

	COSTS		
Initial Cost =	$868,600 / mile, 4 lanes,	$434,300 / mile, 2 lanes
12 yr Cost =	$168,200 / mile, 4 lanes,	$84,100 / mile, 2 lanes
24 yr Cost =	$401,100 / mile, 4 lanes,	$200,550 / mile, 2 lanes

Interest Rate = 4 %

Equiv. of Legal Truck = 2.37

	Trucks Influenced by POE			Trucks Not Influenced by POE		
	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.
Interstate	10	3.8	1.603	30	3.8	1.603
Rural	10	3.8	1.603	30	3.8	1.603

						100% POE OPERATION (OL = 10%)					NO POE OPERATION (OL = 30%)				(OL = ZERO)
SEGMENT CODE	SEGMENT LENGTH	TOTAL ADTT	INFL. ADTT	UN-INFL. ADTT	% INFL.	INFL. LOSS OF LIFE %	UNINFL. LOSS OF LIFE %	WTD AVG LOSS OF LIFE %	REDUCE LIFE	TOTAL A. C.	% LOSS OF LIFE	REDUCED LIFE	TOTAL A. C.	DIFFERENCE of A. C.	NO O.L. A. C.
1540	7.53	750	750	0	100.0	5.69	15.33	5.69	34.0	$233,672	15.33	30.5	$251,040	$17,368	$225,091
1540	31.59	420	170	250	40.5	5.69	15.33	11.43	31.9	$1,021,306	15.33	30.5	$1,052,821	$31,515	$943,996
1540	32.80	280	140	140	50.0	5.69	15.33	10.51	32.2	$1,053,233	15.33	30.5	$1,093,217	$39,984	$980,217
1940	15.41	90	10	80	11.1	5.69	15.33	14.26	30.9	$509,244	15.33	30.5	$513,612	$4,368	$460,523
1910	4.25	690	510	180	73.9	5.69	15.33	8.20	33.0	$134,165	15.33	30.5	$141,618	$7,453	$126,980
1910	32.42	560	320	240	57.1	5.69	15.33	9.82	32.5	$1,035,687	15.33	30.5	$1,080,485	$44,798	$968,801
1800	12.80	250	120	130	48.0	5.69	15.33	10.70	32.1	$411,607	15.33	30.5	$426,621	$15,014	$382,524
1800	16.20	290	100	190	34.5	5.69	15.33	12.01	31.7	$526,077	15.33	30.5	$539,942	$13,865	$484,131
1880	11.86	90	20	70	22.2	5.69	15.33	13.19	31.3	$388,655	15.33	30.5	$395,291	$6,636	$354,432
1540	0.58	750	750	0	100.0	5.69	15.33	5.69	34.0	$17,994	15.33	30.5	$19,331	$1,337	$17,333
1540	32.50	1000	490	510	49.0	5.69	15.33	10.61	32.2	$1,044,347	15.33	30.5	$1,083,218	$38,870	$971,251
1910	15.22	420	220	200	52.4	5.69	15.33	10.28	32.3	$487,927	15.33	30.5	$507,312	$19,386	$454,874
1930	42.54	170	50	120	29.4	5.69	15.33	12.49	31.5	$1,386,611	15.33	30.5	$1,417,849	$31,238	$1,271,293
TOTALS	255.7	miles								$8,250,525			$8,522,356	$271,831	$7,641,446

Figure 16. Cost calculation for Lewiston POE, ignoring net freight weights.

PAVEMENT LIFE ECONOMIC ANALYSIS FOR ROAD SYSTEM NEAR LEWISTON POE

Including net freight weight.

Structural Number = 5

	COSTS	
Initial Cost =	$868,600 / mile, 4 lanes,	$434,300 / mile, 2 lanes
12 yr Cost =	$168,200 / mile, 4 lanes,	$84,100 / mile, 2 lanes
24 yr Cost =	$401,100 / mile, 4 lanes,	$200,550 / mile, 2 lanes

Interest Rate = 4 %

Equiv. of Legal Truck = 2.37

	Trucks Influenced by POE			Trucks Not Influenced by POE		
	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.
Interstate	10	3.8	1.603	30	3.8	1.603
Rural	10	3.8	1.603	30	3.8	1.603

						100% POE OPERATION (OL = 10%)					NO POE OPERATION (OL = 30%)				(OL = ZERO)
SEGMENT CODE	SEGMENT LENGTH	TOTAL ADTT	INFL. ADTT	UN-INFL. ADTT	% INFL.	INFL. LOSS OF LIFE %	UNINFL. LOSS OF LIFE %	WTD AVG LOSS OF LIFE %	REDUCE LIFE	TOTAL A. C.	% LOSS OF LIFE	REDUCED LIFE	TOTAL A. C.	DIFFERENCE of A. C.	NO O.L. A. C.
1540	7.53	750	750	0	100.0	4.41	11.87	4.41	34.4	$231,646	11.87	31.7	$244,341	$12,695	$225,091
1540	31.59	420	170	250	40.5	4.41	11.87	8.85	32.8	$1,002,056	11.87	31.7	$1,024,727	$22,671	$943,996
1540	32.80	280	140	140	50.0	4.41	11.87	8.14	33.1	$1,035,204	11.87	31.7	$1,064,045	$28,840	$980,217
1940	15.41	90	10	80	11.1	4.41	11.87	11.04	32.0	$496,791	11.87	31.7	$499,906	$3,116	$460,523
1910	4.25	690	510	180	73.9	4.41	11.87	6.36	33.7	$132,428	11.87	31.7	$137,839	$5,411	$126,980
1910	32.42	560	320	240	57.1	4.41	11.87	7.61	33.3	$1,019,276	11.87	31.7	$1,051,652	$32,376	$968,801
1800	12.80	250	120	130	48.0	4.41	11.87	8.29	33.0	$404,414	11.87	31.7	$415,237	$10,823	$382,524
1800	16.20	290	100	190	34.5	4.41	11.87	9.30	32.7	$515,577	11.87	31.7	$525,534	$9,957	$484,131
1880	11.86	90	20	70	22.2	4.41	11.87	10.21	32.3	$379,994	11.87	31.7	$384,743	$4,749	$354,432
1540	0.58	750	750	0	100.0	4.41	11.87	4.41	34.4	$17,838	11.87	31.7	$18,815	$978	$17,333
1540	32.50	1000	490	510	49.0	4.41	11.87	8.21	33.0	$1,026,283	11.87	31.7	$1,054,313	$28,029	$971,251
1910	15.22	420	220	200	52.4	4.41	11.87	7.96	33.1	$479,783	11.87	31.7	$493,775	$13,992	$454,874
1930	42.54	170	50	120	29.4	4.41	11.87	9.68	32.5	$1,357,613	11.87	31.7	$1,380,014	$22,401	$1,271,293
TOTALS	255.7	miles								$8,098,904			$8,294,942	$196,038	$7,641,446

Figure 17. Cost calculation for Lewiston POE, including net freight weights.

PAVEMENT LIFE ECONOMIC ANALYSIS FOR ROAD SYSTEM NEAR MOYIE POE
Ignoring net freight weight.
Structural Number = 5

	COSTS	
Initial Cost =	$868,600 / mile, 4 lanes,	$434,300 / mile, 2 lanes
12 yr Cost =	$168,200 / mile, 4 lanes,	$84,100 / mile, 2 lanes
24 yr Cost =	$401,100 / mile, 4 lanes,	$200,550 / mile, 2 lanes

Interest Rate = 4 %

Equiv. of Legal Truck = 2.37

	Trucks Influenced by POE			Trucks Not Influenced by POE		
	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.
Interstate	10	3.8	1.603	30	3.8	1.603
Rural	10	3.8	1.603	30	3.8	1.603

						100% POE OPERATION (OL = 10%)					NO POE OPERATION (OL = 30%)				(OL = ZERO)
SEGMENT CODE	SEGMENT LENGTH	TOTAL ADTT	INFL. ADTT	UN-INFL. ADTT	% INFL.	INFL. LOSS OF LIFE %	UNINFL. LOSS OF LIFE %	WTD AVG LOSS OF LIFE %	REDUCE LIFE	TOTAL A. C.	% LOSS OF LIFE	REDUCED LIFE	TOTAL A. C.	DIFFERENCE of A. C.	NO O.L. A. C.
1590	15.83	190	190	0	100.0	5.69	15.33	5.69	34.0	$491,233	15.33	30.5	$527,730	$36,497	$473,194
1540	8.00	660	660	0	100.0	5.69	15.33	5.69	34.0	$248,192	15.33	30.5	$266,632	$18,440	$239,077
1540	12.00	370	370	0	100.0	5.69	15.33	5.69	34.0	$372,287	15.33	30.5	$399,947	$27,660	$358,616
1540	14.79	210	200	10	95.2	5.69	15.33	6.15	33.8	$460,267	15.33	30.5	$492,902	$32,634	$441,964
1580	11.19	60	50	10	83.3	5.69	15.33	7.30	33.4	$350,904	15.33	30.5	$372,784	$21,880	$334,260
TOTALS	61.8	miles								$1,922,883			$2,059,995	$137,112	$1,847,111

Figure 18. Cost calculation for Moyie Junction POE, ignoring net freight weights.

PAVEMENT LIFE ECONOMIC ANALYSIS FOR ROAD SYSTEM NEAR MOYIE POE
Including net freight weight.
Structural Number = 5

	COSTS	
Initial Cost =	$868,600 / mile, 4 lanes,	$434,300 / mile, 2 lanes
12 yr Cost =	$168,200 / mile, 4 lanes,	$84,100 / mile, 2 lanes
24 yr Cost =	$401,100 / mile, 4 lanes,	$200,550 / mile, 2 lanes
Interest Rate =	4 %	
Equiv. of Legal Truck =	2.37	

	Trucks Influenced by POE			Trucks Not Influenced by POE		
	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.
Interstate	10	3.8	1.603	30	3.8	1.603
Rural	10	3.8	1.603	30	3.8	1.603

						100% POE OPERATION (OL = 10%)					NO POE OPERATION (OL = 30%)				(OL = ZERO)
SEGMENT CODE	SEGMENT LENGTH	TOTAL ADTT	INFL. ADTT	UN-INFL. ADTT	% INFL.	INFL. LOSS OF LIFE %	UNINFL. LOSS OF LIFE %	WTD AVG LOSS OF LIFE %	REDUCE LIFE	TOTAL A. C.	% LOSS OF LIFE	REDUCED LIFE	TOTAL A. C.	DIFFERENCE of A. C.	NO O.L. A. C.
1590	15.83	190	190	0	100.0	4.41	11.87	4.41	34.4	$486,973	11.87	31.7	$513,661	$26,688	$473,194
1540	8.00	660	660	0	100.0	4.41	11.87	4.41	34.4	$246,039	11.87	31.7	$259,523	$13,484	$239,077
1540	12.00	370	370	0	100.0	4.41	11.87	4.41	34.4	$369,058	11.87	31.7	$389,285	$20,226	$358,616
1540	14.79	210	200	10	95.2	4.41	11.87	4.77	34.3	$455,926	11.87	31.7	$479,761	$23,835	$441,964
1580	11.19	60	50	10	83.3	4.41	11.87	5.65	34.0	$346,914	11.87	31.7	$362,846	$15,931	$334,260
TOTALS	61.8	miles								$1,904,911			$2,005,075	$100,165	$1,847,111

Figure 19. Cost calculation for Moyie Junction POE, including net freight weights.

PAVEMENT LIFE ECONOMIC ANALYSIS FOR ROAD SYSTEM NEAR MARSING POE
Ignoring net freight weights.
Structural Number = 5

	COSTS	
Initial Cost =	$868,600 / mile, 4 lanes,	$434,300 / mile, 2 lanes
12 yr Cost =	$168,200 / mile, 4 lanes,	$84,100 / mile, 2 lanes
24 yr Cost =	$401,100 / mile, 4 lanes,	$200,550 / mile, 2 lanes

Interest Rate = 4 %

Equiv. of Legal Truck = 2.37

	Trucks Influenced by POE			Trucks Not Influenced by POE		
	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.
Interstate	10	3.8	1.603	30	3.8	1.603
Rural	10	3.8	1.603	30	3.8	1.603

						100% POE OPERATION (OL = 10%)					NO POE OPERATION (OL = 30%)				(OL = ZERO)
SEGMENT CODE	SEGMENT LENGTH	TOTAL ADTT	INFL. ADTT	UN-INFL. ADTT	% INFL.	INFL. LOSS OF LIFE %	UNINFL. LOSS OF LIFE %	WTD AVG LOSS OF LIFE %	REDUCE LIFE	TOTAL A.C.	% LOSS OF LIFE	REDUCED LIFE	TOTAL A.C.	DIFFERENCE of A.C.	NO O.L. A.C.
2050	4.83	80	10	70	12.5	5.69	15.33	14.12	30.9	$159,343	15.33	30.5	$160,883	$1,540	$144,253
2050	10.85	360	60	300	16.7	5.69	15.33	13.72	31.1	$356,874	15.33	30.5	$361,461	$4,588	$324,099
2190	19.78	80	20	60	25.0	5.69	15.33	12.92	31.3	$646,678	15.33	30.5	$659,096	$12,418	$590,969
2160	17.91	150	10	140	6.7	5.69	15.33	14.68	30.7	$593,860	15.33	30.5	$596,936	$3,076	$535,234
2190	10.00	120	10	110	8.3	5.69	15.33	14.52	30.8	$331,157	15.33	30.5	$333,298	$2,140	$298,847
1540	18.43	210	23	193	8.1	5.69	15.33	14.55	30.8	$610,434	15.33	30.5	$614,268	$3,833	$550,774
1540	58.78	260	23	243	6.5	5.69	15.33	14.70	30.7	$1,949,221	15.33	30.5	$1,959,124	$9,903	$1,756,620
1540	46.97	290	24	272	6.2	5.69	15.33	14.73	30.7	$1,557,983	15.33	30.5	$1,565,499	$7,517	$1,403,682
1540	20.18	380	62	326	14.2	5.69	15.33	13.96	31.0	$665,292	15.33	30.5	$672,595	$7,303	$603,072
1540	19.27	430	191	254	40.9	5.69	15.33	11.38	31.9	$622,826	15.33	30.5	$642,265	$19,439	$575,877
1540	34.78	290	290	0	100.0	5.69	15.33	5.69	34.0	$1,079,013	15.33	30.5	$1,159,210	$80,197	$1,039,388
1010	22.78	2659	58	2604	2.1	5.69	15.33	15.13	30.6	$758,019	15.33	30.5	$759,252	$1,234	$680,772
1010	17.18	2715	16	2703	0.4	5.69	15.33	15.28	30.5	$572,395	15.33	30.5	$572,606	$210	$513,418
1010	32.6	3443	40	3406	1.1	5.69	15.33	15.22	30.5	$1,085,619	15.33	30.5	$1,086,551	$931	$974,240
TOTALS	334.3	miles								$10,988,715			$11,143,043	$154,328	$9,991,247

Figure 20. Cost calculation for Marsing POE, ignoring net freight weights.

PAVEMENT LIFE ECONOMIC ANALYSIS FOR ROAD SYSTEM NEAR MARSING POE
Including net freight weights.
Structural Number = 5

	COSTS	
Initial Cost =	$868,600 / mile, 4 lanes,	$434,300 / mile, 2 lanes
12 yr Cost =	$168,200 / mile, 4 lanes,	$84,100 / mile, 2 lanes
24 yr Cost =	$401,100 / mile, 4 lanes,	$200,550 / mile, 2 lanes

Interest Rate = 4 %

Equiv. of Legal Truck = 2.37

	Trucks Influenced by POE			Trucks Not Influenced by POE		
	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.	% of Tot O.L.	Equiv. of O.L. Truck	ER of O.L.
Interstate	10	3.8	1.603	30	3.8	1.603
Rural	10	3.8	1.603	30	3.8	1.603

						100% POE OPERATION (OL = 10%)					NO POE OPERATION (OL = 30%)				(OL = ZERO)
SEGMENT CODE	SEGMENT LENGTH	TOTAL ADTT	INFL. ADTT	UN-INFL. ADTT	% INFL.	INFL. LOSS OF LIFE %	UNINFL. LOSS OF LIFE %	WTD AVG LOSS OF LIFE %	REDUCE LIFE	TOTAL A. C.	% LOSS OF LIFE	REDUCED LIFE	TOTAL A. C.	DIFFERENCE of A. C.	NO O.L. A. C.
2050	4.83	80	10	70	12.5	4.41	11.87	10.94	32.1	$155,493	11.87	31.7	$156,590	$1,097	$144,253
2050	10.85	360	60	300	16.7	4.41	11.87	10.63	32.2	$348,543	11.87	31.7	$351,816	$3,273	$324,099
2190	19.78	80	20	60	25.0	4.41	11.87	10.01	32.4	$632,623	11.87	31.7	$641,509	$8,886	$590,969
2160	17.91	150	10	140	6.7	4.41	11.87	11.37	31.9	$578,826	11.87	31.7	$581,007	$2,181	$535,234
2190	10.00	120	10	110	8.3	4.41	11.87	11.25	32.0	$322,884	11.87	31.7	$324,404	$1,520	$298,847
1540	18.43	210	23	193	11.0	4.41	11.87	11.05	32.0	$594,203	11.87	31.7	$597,876	$3,673	$550,774
1540	58.78	260	23	243	8.8	4.41	11.87	11.21	32.0	$1,897,365	11.87	31.7	$1,906,846	$9,481	$1,756,620
1540	46.97	290	24	272	8.3	4.41	11.87	11.25	31.9	$1,516,634	11.87	31.7	$1,523,725	$7,091	$1,403,682
1540	20.18	380	62	326	16.3	4.41	11.87	10.65	32.2	$648,684	11.87	31.7	$654,647	$5,963	$603,072
1540	19.27	430	191	254	44.4	4.41	11.87	8.56	32.9	$610,001	11.87	31.7	$625,126	$15,125	$575,877
1540	34.78	290	290	0	100.0	4.41	11.87	4.41	34.4	$1,069,654	11.87	31.7	$1,128,277	$58,622	$1,039,388
1010	22.78	2659	58	2604	2.2	4.41	11.87	11.71	31.8	$738,081	11.87	31.7	$738,992	$911	$680,772
1010	17.18	2715	16	2703	0.6	4.41	11.87	11.83	31.7	$557,140	11.87	31.7	$557,326	$186	$513,418
1010	32.6	3443	40	3406	1.2	4.41	11.87	11.78	31.8	$1,056,861	11.87	31.7	$1,057,557	$695	$974,240
TOTALS	334.3	miles								$10,726,992			$10,845,697	$118,705	$9,991,247

Figure 21. Cost calculation for Marsing POE, including net freight weights.

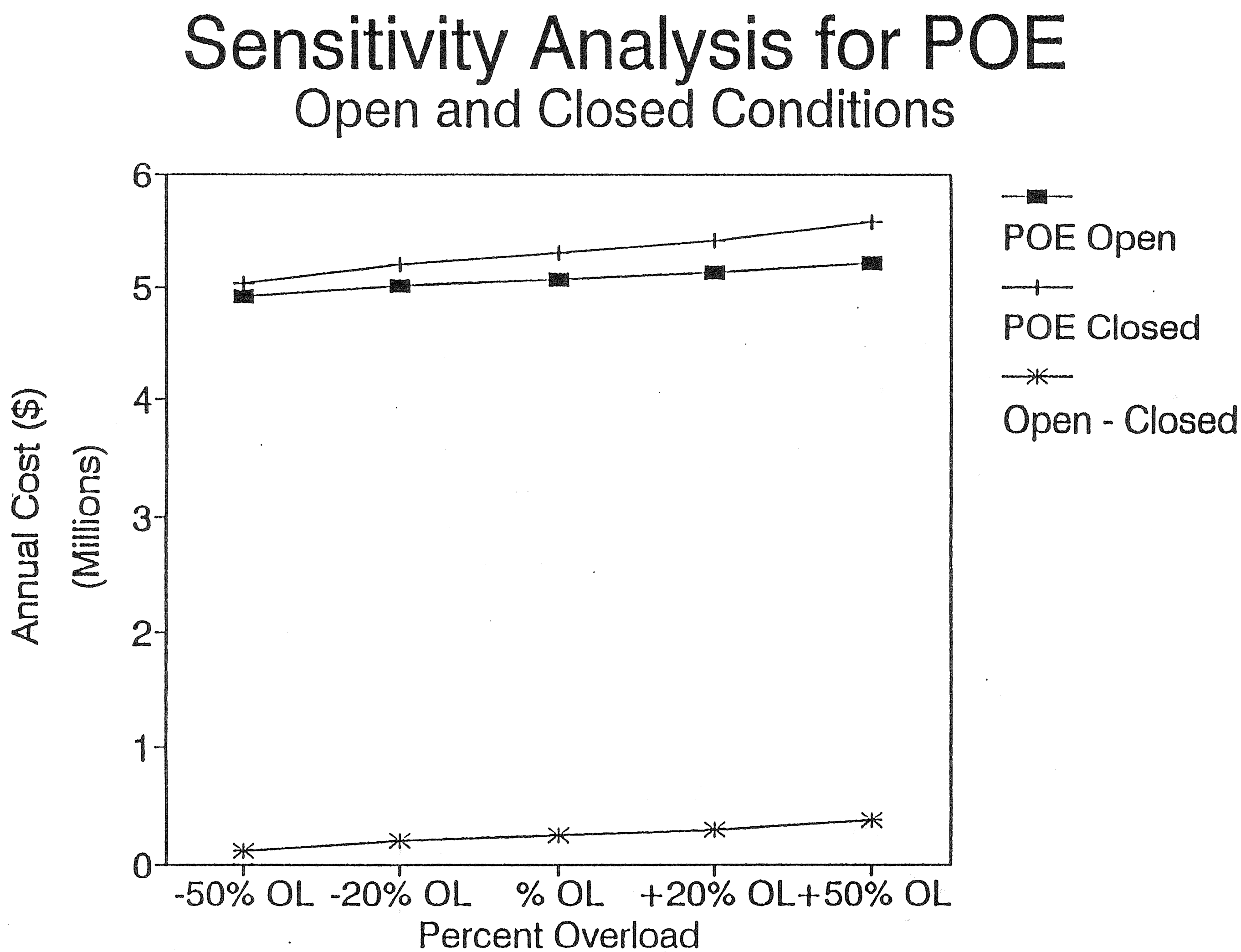


Figure 22. Sensitivity analysis for OL for Bliss POE.

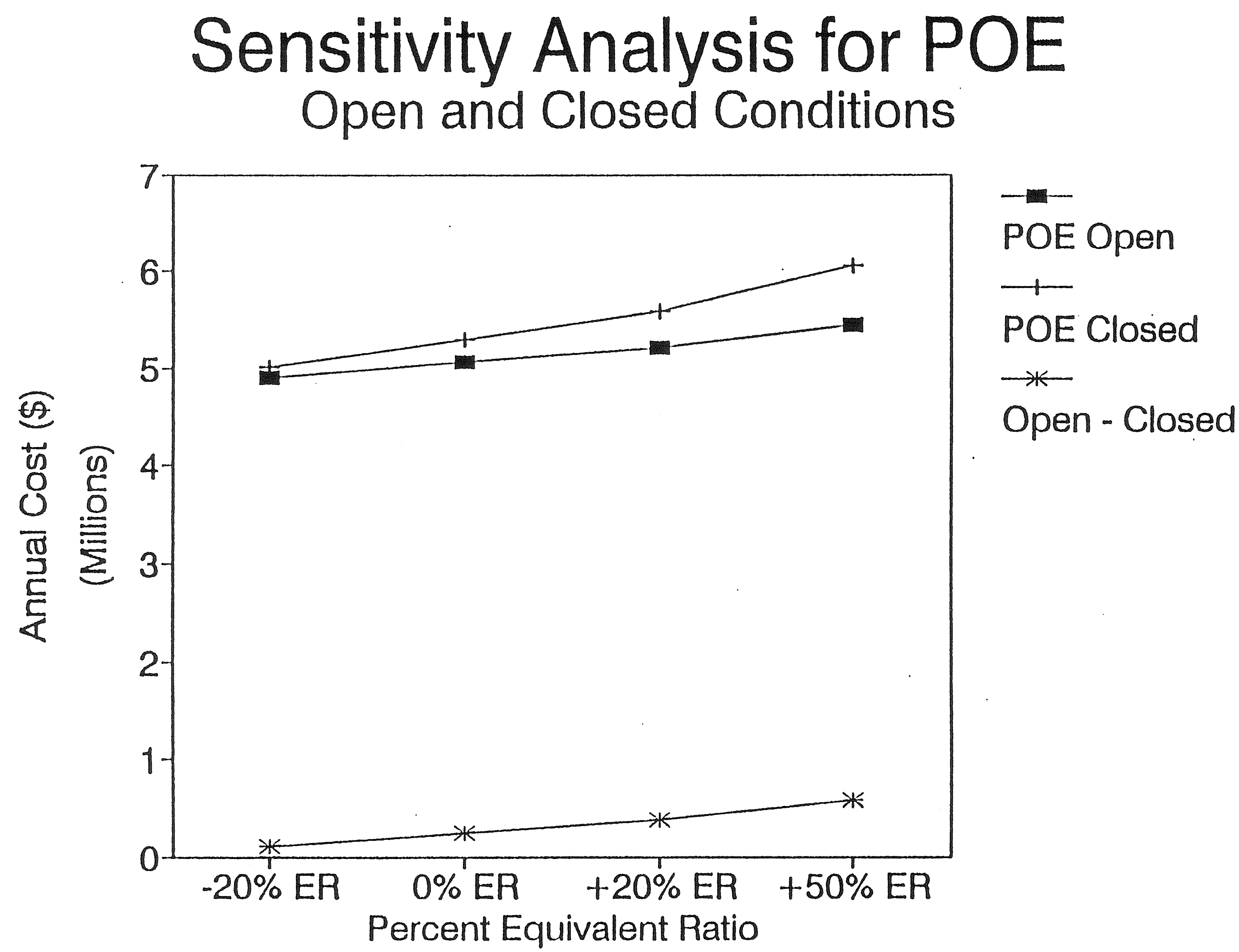


Figure 23. Sensitivity analysis for ER for Bliss POE.

Appendix B

Summary of ER and OL data

WIM DATA ON ROAD SEGMENT 2070 (HWY-20) AT MP 351

ALL TRUCKS

NUMBER
SAMPLED = 176

PERCENT
LEGAL = 61.9

OVERLIMIT TRUCKS

NUMBER
SAMPLED = 67

PERCENT
OVERLIMIT = 38.1

TOTAL AVERAGE EQUIVALENT = 3.76

WIM DATA ON ROAD SEGMENT 2130 (HWY-44) AT MP 23

ALL TRUCKS

NUMBER
SAMPLED = 15

PERCENT
LEGAL = 66.7

OVERLIMIT TRUCKS

NUMBER
SAMPLED = 5

PERCENT
OVERLIMIT = 33.3

TOTAL AVERAGE EQUIVALENT = 3.61

WIM DATA ON ROAD SEGMENT 1540 (HWY-95) AT MP 437

ALL TRUCKS

NUMBER
SAMPLED = 318

PERCENT
LEGAL = 93.7

OVERLIMIT TRUCKS

NUMBER
SAMPLED = 20

PERCENT
OVERLIMIT = 6.3

TOTAL AVERAGE EQUIVALENT = 1.51

WIM DATA ON ROAD SEGMENT 1540 (HWY-95) AT MP 254

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 151	NUMBER SAMPLED = 51
PERCENT LEGAL = 66.2	PERCENT OVERLIMIT = 33.8

TOTAL AVERAGE EQUIVALENT = 3.64

WIM DATA ON ROAD SEGMENT 2040 (HWY-30) AT MP 206

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 295	NUMBER SAMPLED = 29
PERCENT LEGAL = 90.2	PERCENT OVERLIMIT = 9.8

TOTAL AVERAGE EQUIVALENT = 3.3

WIM DATA ON ROAD SEGMENT 1540 (HWY-95) AT MP 305

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 630	NUMBER SAMPLED = 43
PERCENT LEGAL = 93.2	PERCENT OVERLIMIT = 6.8

TOTAL AVERAGE EQUIVALENT = 4.42

WIM DATA ON ROAD SEGMENT 1540 (HWY-95) AT MP 486

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 491	NUMBER SAMPLED = 107
PERCENT LEGAL = 78.2	PERCENT OVERLIMIT = 21.8

TOTAL AVERAGE EQUIVALENT = 4.01

WIM DATA ON ROAD SEGMENT 1540 (HWY-95) AT MP 213

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 118	NUMBER SAMPLED = 5
PERCENT LEGAL = 95.8	PERCENT OVERLIMIT = 4.2

TOTAL AVERAGE EQUIVALENT = 3.43

WIM DATA ON ROAD SEGMENT 1540 (HWY-95) AT MP 60

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 278	NUMBER SAMPLED = 69
PERCENT LEGAL = 75.2	PERCENT OVERLIMIT = 24.8

TOTAL AVERAGE EQUIVALENT = 3.65

WIM DATA ON ROAD SEGMENT 1540 (HWY-95) AT MP 125

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 172	NUMBER SAMPLED = 30
PERCENT LEGAL = 82.6	PERCENT OVERLIMIT = 17.4

TOTAL AVERAGE EQUIVALENT = 3.91

WIM DATA ON ROAD SEGMENT 2040 (HWY-30) AT MP 206

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 295	NUMBER SAMPLED = 29
PERCENT LEGAL = 90.2	PERCENT OVERLIMIT = 9.8

TOTAL AVERAGE EQUIVALENT = 3.3

WIM DATA ON ROAD SEGMENT 2040 (HWY-30) AT MP 212

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 111	NUMBER SAMPLED = 32
PERCENT LEGAL = 71.2	PERCENT OVERLIMIT = 28.8

TOTAL AVERAGE EQUIVALENT = 6.6

WIM DATA ON ROAD SEGMENT 1600 (HWY-I90B) AT MP 1

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 1088	NUMBER SAMPLED = 158
PERCENT LEGAL = 85.5	PERCENT OVERLIMIT = 14.5

TOTAL AVERAGE EQUIVALENT = 3.68

WIM DATA ON ROAD SEGMENT 1660 (HWY-I90) AT MP 38

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 913	NUMBER SAMPLED = 135
PERCENT LEGAL = 85.2	PERCENT OVERLIMIT = 14.8

TOTAL AVERAGE EQUIVALENT = 3.5

WIM DATA ON ROAD SEGMENT 1660 (HWY-I90) AT MP 69

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 1218	NUMBER SAMPLED = 210
PERCENT LEGAL = 82.8	PERCENT OVERLIMIT = 17.2

TOTAL AVERAGE EQUIVALENT = 3.4

WIM DATA ON ROAD SEGMENT 1260 (HWY-I86) AT MP 56

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 887	NUMBER SAMPLED = 408
PERCENT LEGAL = 54	PERCENT OVERLIMIT = 46

TOTAL AVERAGE EQUIVALENT = 4.2

WIM DATA ON ROAD SEGMENT 1330 (HWY-I15) AT MP 13

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 975	NUMBER SAMPLED = 348
PERCENT LEGAL = 64.3	PERCENT OVERLIMIT = 35.7

TOTAL AVERAGE EQUIVALENT = 3.7

WIM DATA ON ROAD SEGMENT 1330 (HWY-I15) AT MP 28

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 672	NUMBER SAMPLED = 305
PERCENT LEGAL = 54.6	PERCENT OVERLIMIT = 45.4

TOTAL AVERAGE EQUIVALENT = 4.3

WIM DATA ON ROAD SEGMENT 1660 (HWY-I90) AT MP 9

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 1025	NUMBER SAMPLED = 434
PERCENT LEGAL = 57.7	PERCENT OVERLIMIT = 42.3

TOTAL AVERAGE EQUIVALENT = 3.7

WIM DATA ON ROAD SEGMENT 1010 (HWY-I84) AT MP 23

ALL TRUCKS	*OVERLIMIT TRUCKS*
NUMBER SAMPLED = 2402	NUMBER SAMPLED = 877
PERCENT LEGAL = 63.5	PERCENT OVERLIMIT = 36.5

TOTAL AVERAGE EQUIVALENT = 4.06

Appendix C

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