OREGON DEPARTMENT OF TRANSPORTATION
ECONOMIC AND BRIDGE OPTIONS

ECONOMIC AND TRANSPORTATION MODELING AND ANALYSIS OF BRIDGE OPTIONS

TECHNICAL REPORT

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20 DAYS IN MARCH...OR THE "RIDDLE EFFECT"

For 20 days in March 2001, the Oregon communities of Canyonville and Riddle experienced a surge in truck traffic unlike anything they had ever seen before. Ford's Bridge, an I-5 bridge several miles away, was closed for emergency repairs. Truck detours ran right through the main streets of these two towns of fewer than 1,500 people, a half-hour drive south of Roseburg.

The streets and bridges of these communities were not built to handle such a volume of large trucks. Some of the streets were too narrow, some of the corners too sharp and some of the bridges were too weak to accommodate the heavy trucks. The results were safety concerns and infrastructure damage to city facilities.

The detours had a negative effect on commerce in the region. Hayes Oil of Medford continued hauling 80 truckloads of gas and oil per week using the detour routes. Depending on which detour they took, Hayes added 100-200 miles per trip. Terrain Tamers split their 25 loads of wood chips per day into smaller loads, increasing shipping costs $150 per load.

No serious crashes were reported, but residents expressed serious concerns for their safety and that of their children. "I think the trucks are going through town way too fast," resident Korenia Franklin told the local newspaper. "We have kids everywhere at lunch hour. I think that this is extremely dangerous. There's too much traffic." School buses were rerouted, parking was restricted and detour signs went up.

The Oregon Department of Transportation (ODOT) put the project on a fast track, made repairs to the bridge that are expected to last 3-5 years and got the trucks back on I-5 for the short term. With funding from the Oregon Transportation Investment Act, ODOT began construction of a permanent replacement bridge in August 2002.

This same situation has occurred in Mt. Vernon, Juntura and other rural communities in the last two years. By the year 2010, ODOT expects that, at the current level of investment, 30 percent of bridges will be posted with reduced weight limits.

This means that the situation described above will happen more and more frequently, affecting local businesses and degrading community livability. As the frequency increases, the dollars available to address the problems are used up faster. The emergency bridge postings are likely to restrict trucks at 64,000 pounds and last longer than the three-week closure that occurred at the Ford's bridge.

EXECUTIVE SUMMARY

Abstract: When it was determined that Oregon's bridges were failing, the Oregon Department of Transportation (ODOT) used its state-of-the-art integrated economic, land use and transport model to analyze the effects of different courses of action on the Oregon transportation system, its economy, local roads and communities. This model was developed by ODOT as part of the Oregon Modeling Implementation Program (OMIP) started in 1995. To complement the inter-city focus of the statewide model, additional analysis focused on the safety and livability of increased truck traffic in local communities and in sensitive environmental areas. This technical report provides background on the Oregon economy and how goods and services are transported, the national context, the statewide model and how it works, and modeling results. It documents the decision-making process within the context of implementing the model for this significant public investment decision.

ODOT recently identified a growing number of structural deficiencies in Oregon bridges. In the absence of sufficient funding to repair or replace these bridges, many of these bridges will be subject to weight restrictions. These weight-restricted bridges could reduce freight mobility on major roadways, potentially disrupting local and regional livability and the Oregon economy.

To address this issue, ODOT established the Economic & Bridge Options Team (EBOT). This team developed several investment strategies to address bridge improvements, ranging from no new investment, the repair or replacement of certain bridges, to fixing all bridges. Using the statewide model and supplementary information, the ODOT Transportation Planning Analysis Unit (TPAU) assessed the possible ramifications of these investment strategies to highway users, Oregon communities and the Oregon economy. Modeling information was combined with information from Motor Carrier Division, Bridge Section and others to develop a recommended investment strategy to address the bridge problem.

The interstates I-5 and I-84 support commerce throughout Oregon. The Portland metropolitan area and the Willamette Valley represent the economic heart of the state and rely heavily on the interstate system for movement of goods and services. Their connection to ports and markets within Oregon, with neighboring states, and overseas is vital to the state's economic health. The backbone of that connection is the interstate system. Two-thirds of the state's economic benefit can be derived by connecting I-84 and I-5 to Portland. The Interstate and U.S. highway systems in Oregon not only facilitate trade within Oregon, but also are an integral part of the North American trade network. Therefore, restoration of I-5 and I-84 as unrestricted freight routes must be the ultimate goal of a bridge replacement strategy.

At the same time, it is imperative that other areas of the state continue to have unrestricted access for movement of goods and services. Deteriorating bridges in these areas, far from the interstate highways, are a serious threat because businesses in rural and coastal Oregon tend to rely more on goods typically shipped in heavy trucks, such as wood and agricultural products. Such heavy commodities and remote area businesses already demand high transportation costs. Any increased cost brought about by truck detours or load limits will erode what is in many cases a slim profit margin. Heavy loads that cannot be divided into smaller loads are essentially "landlocked" if they

cannot cross load-restricted bridges. Given the nature of the heavy goods moved in rural Oregon and the importance of these goods to the local economy, it is critical to maintain key freight routes across the state.

Modeling results show that Oregon's bridge problem has the potential to cost the state economy as much as $123 billion in lost production and 88,000 lost jobs over the next 25 years. In addition to the potential economic cost, the bridge problem poses a threat to the livability and safety of many communities throughout Oregon. Weight limits lead to truck detours, which put trucks on city streets and other roadways that often have inadequate maintenance funding and were not built for these loads. In addition to safety concerns with increased traffic detours through local communities, deterioration of local bridges could impede the response time of emergency personnel to reach citizens and forest fires. As bridges continue to age and crack, communities will increasingly experience these impacts. Without significant investment, 30 percent of Oregon's bridges are expected to be weight-limited, with associated heavy truck detours, by 2010.

Expenditures to repair or replace components of the transportation infrastructure serve two purposes. An investment in state and local bridges maintains accessibility, avoiding loss of jobs and productivity growth in the long term. Money spent on bridges throughout Oregon will also sustain family-wage construction jobs in the near-term. These jobs, in turn, generate income that is spent on goods and services and income taxes for the Oregon General Fund. This issue was important to the Governor and the 2003 Oregon Legislature, facing one of the highest unemployment rates in the nation.

The bridge improvement strategy must balance these issues in a timely manner. Because half of the critical bridges are on the interstate system, the time and the cost (over $1 billion) required to address them make them problematic as a first step.

In January 2003, ODOT submitted a report to the Oregon Transportation Commission (OTC), outlining a recommended 10-year $2 billion bridge investment strategy. The strategy restores heavy haul access to a skeletal freight system extending to all parts of the state. It strategically restores detour routes for the major interstate routes first to accommodate heavy truck traffic during the 10-year construction period and unexpected emergency bridge failures. The statewide model provided information to support the dialogue of tradeoffs, particularly state versus regional economic impacts under various investment scenarios. This discussion of tradeoffs framed the ODOT recommendation to the OTC and ultimately shaped state legislature funding discussions.

This technical report provides a detailed discussion of the modeling and analysis process and results to complement the Economic and Bridge Options Report: A Report to the Oregon Transportation Commission prepared January 15, 2003. It provides technical documentation as well as a "case study" of the use of Oregon's statewide model in an important transportation investment decision-making process. This report discusses:

- State and regional economy and importance of heavy goods production
- Characteristics of freight movement in Oregon, with an emphasis on heavy truck movements and the shipment of heavy commodities
- Parameters included in the statewide model
- Approach to modeling and analysis of the bridge problem, including the range of options considered

- Economic, community and environmental impacts of the bridge investment options
- The implementation environment, including the ODOT recommendation, how the state-wide model supported decision-making
- Lessons learned

Appendixes to this report provide background on:

- The history and condition of Oregon bridges (Appendix A)
- How the statewide model works and provides a new way to think about complex issues (Appendix B)
- The Oregon multi-modal transportation system, including the potential for diversion of heavy commodity flows to non-truck modes (Appendix C)
- Typical goods transported in different truck weight categories (Appendix D)
- Bridge study and statewide model committees (Appendix E)
- Results of a Local Community Bridge Survey assessing the local economic importance of cracked city and county bridges (Appendix F)

BACKGROUND

During a 2001 routine biennial bridge inspection, cracks noted on several bridges in previous inspections had grown. In fact, some cracks had progressed to the point that the functionality of some bridges was at risk, forcing ODOT to immediately impose weight restrictions. As ODOT looked into this accelerated cracking, most of the bridges of concern were found to be of a reinforced concrete deck girder (RCDG) design built in the 1950s and 1960s. For more detailed information on the condition of Oregon bridges, see Appendix A.

When all of the state-owned RCDG bridges were evaluated, nearly 500 were found to have varying degrees of crack problems. An investigation of RCDG bridges owned by cities and counties showed that medium to high density cracks had developed on over 100 of these bridges. Figure 1 shows the location of state-owned bridges and Figure 2 shows locally-owned bridges across Oregon that have crack problems. The figures highlight the large concentration of cracked bridges on the interstates, particularly I-5 south of Eugene.

Defining the Problem

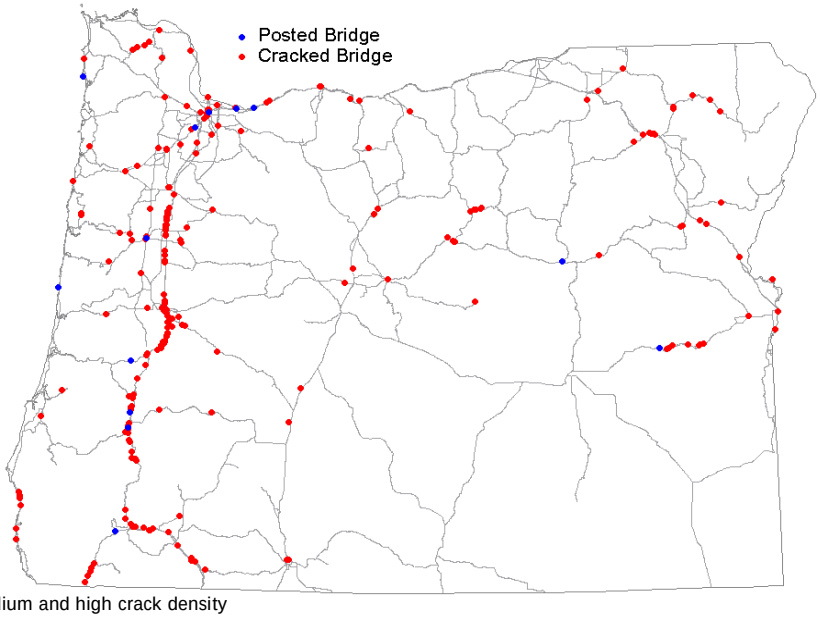
A Bridge Strategy Task Force was convened in June 2002, composed of ODOT staff, national bridge experts and a representative of the trucking industry. The Task Force confirmed the bridge problem. Its recommendations for a major bridge rebuilding program included the following:

- The nature of the cracking makes replacement more economical than repairs.
- Because of the magnitude of the problem, efficient investment requires keeping corridors open for freight. This requires shifting from a “worst-first” to a “corridor” strategy of investment.
- Major freight routes should be kept open to minimize economic impacts throughout the state.
- Interstates I-5 and I-84 should be fixed first. This provides one east-west and north-south route on the Oregon’s Strategic Highway Network (STRAHNET), a national security network of highways. Earlier draft versions identified starting with US 97, an alternate north-south route, to avoid the high cost of damaged bridges on I-5.

Based on the Bridge Task Force report, ODOT embarked on multiple fast-track efforts:

- Contract with Oregon State University for technical data on bridge deterioration.
- Conduct detailed bridge inspections to identify and quantify bridge deficiencies.
- Define affected or needed internal ODOT modifications to manage the future bridge investment program.
- Initiate conversation with the public, legislators and the governor.
- Begin work with constituents - cities, counties, trucking community.

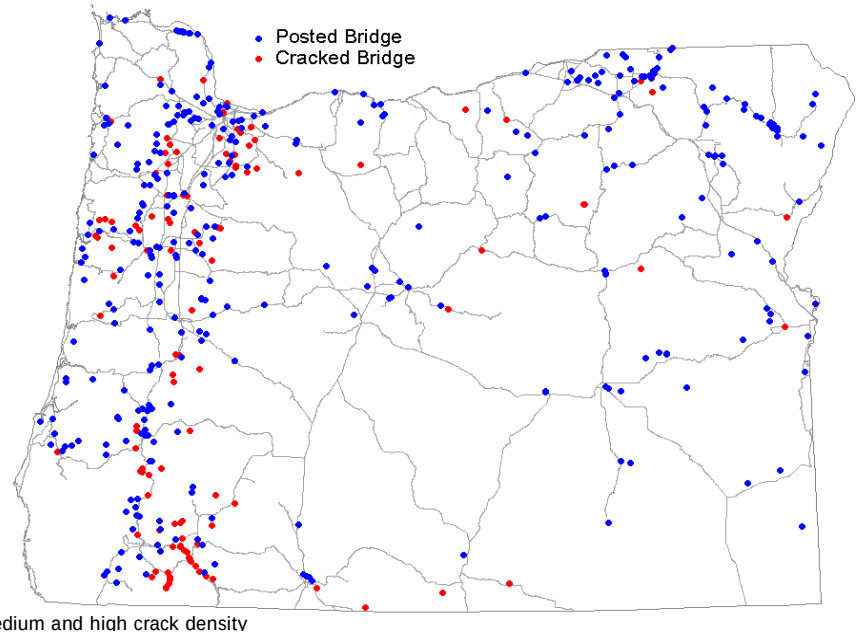
An Economic & Bridge Options Team (EBOT) was formed to coordinate these efforts (see Appendix E). The EBOT developed an investment strategy in cooperation with stakeholder groups to form a recommendation the ODOT and OTC discussion with the Governor and the 2003 Legislature for staging and funding bridge improvements.



* Medium and high crack density

Source: ODOT Bridge Section, September 2002

Figure 1: Weight limited and cracked State-owned bridges



* Medium and high crack density

Source: ODOT Bridge Section, September 2002

Figure 2: Weight limited and cracked locally-owned bridges

Recognizing that the location and timing of bridge investment influences how and where the Oregon economy grows or shifts, the strategy considered both bridge investment costs and the resulting economic costs. Economic costs were defined by an economic analysis using ODOT's statewide model. This state-of-the-art integrated economic, land use and transport model was developed by ODOT as part of the Oregon Modeling Integration Program (OMIP) started in 1995. The key modeling objectives were to analyze the effects of different courses of action on the Oregon transportation system, its economy, and local roads and communities. To complement the intercity focus of the statewide model, additional analysis targeted the safety and livability issues of increased truck traffic in local communities and in sensitive environmental areas.

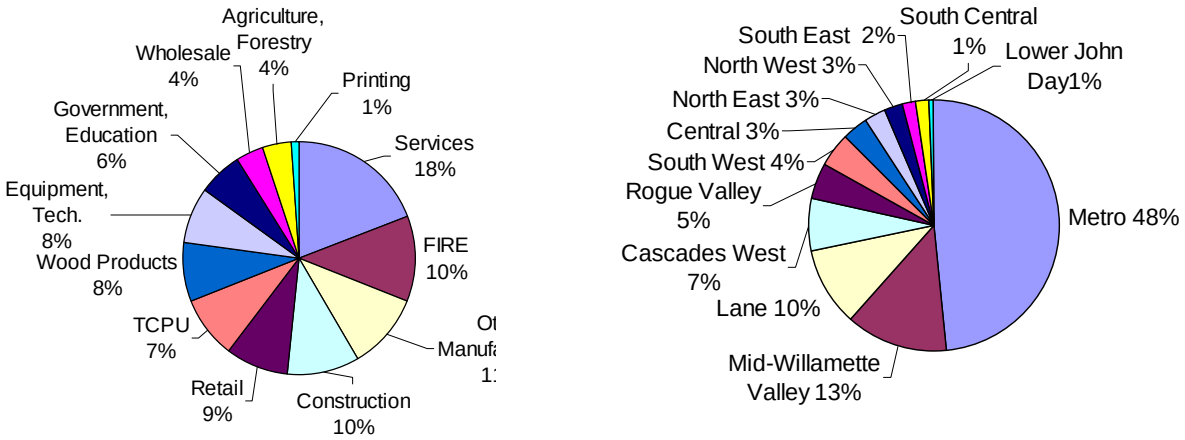
The Oregon Economy

The overall economy of Oregon can be expressed in terms of the production of goods and services (in dollars). The Portland metropolitan area and the Willamette Valley drive the Oregon economy. Almost half of total 2000 production in Oregon occurred in the Portland metropolitan area (Figure 3). The mid- and lower-Willamette Valley (Lane County) areas have over a quarter of total state production[1], with the remainder distributed throughout the rest of the state. Portland serves as an end market and access point to overseas markets for much of the rest of the state's production. Services make up the largest industry sector, about one-third of total production dollars. For analysis with the integrated statewide model, counties with similar characteristics were combined as follows:

Oregon region[2]	*Counties*
Portland Metro	Clackamas, Multnomah, Hood River
Mid-Willamette Valley	Marion, Polk, Yamhill
Lane	Lane
Cascades West	Benton, Lincoln, Linn
Rogue Valley	Jackson, Josephine
South West	Coos, Curry, Douglas
Central Oregon	Crook, Deschutes, Jefferson
North East	Baker, Morrow, Umatilla, Union, Wallowa
North West	Clatsop, Columbia, Tillamook, Washington
South East	Grant, Harney, Malheur
South Central	Klamath, Lake
Lower John Day	Gilliam, Sherman, Wasco, Wheeler

Looking at the entire Oregon economy, the Portland metro area and the Willamette Valley produce the greatest share of goods that are normally transported in heavy trucks over 80,000 pounds (Figure 4). This is the legal weight allowed on Oregon roads without special permit and the likely initial weight restriction for deteriorating bridges. These trucks would be most impacted by initial bridge restrictions.[3]

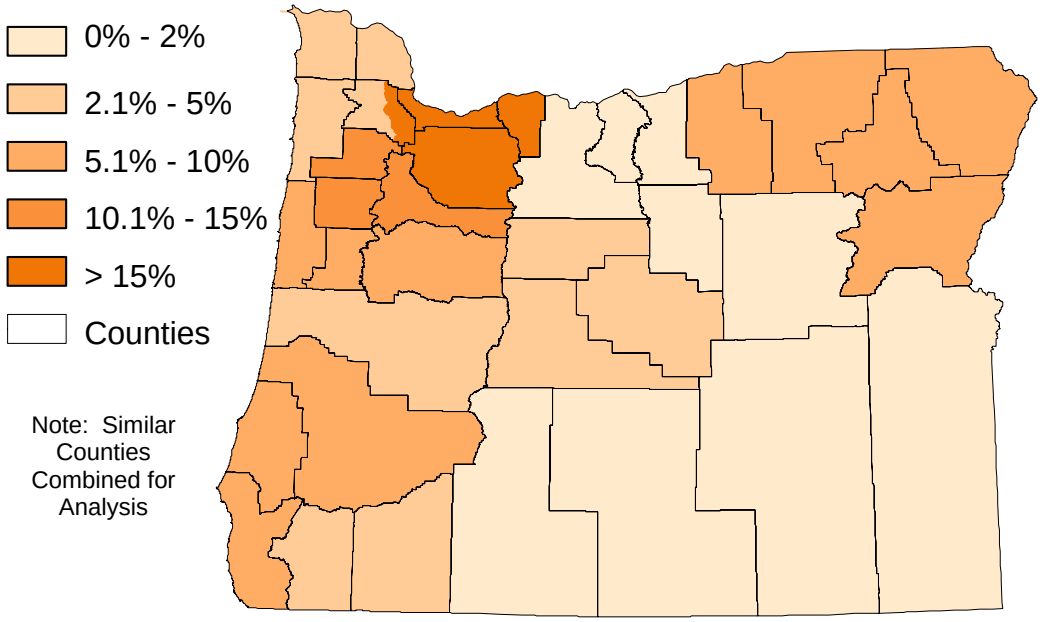
1. Total State Production as tabulated by the model is similar but larger than Gross State Product (GSP) as recorded by the U.S. Bureau of Economic Analysis (BEA) and others. GSP includes only the value-added portion of goods sold to other industries with the state (not final demand). By contrast, state production as tabulated in the model includes the total value of the inter-industry sale.
2. These sub-state regions are consistent with state transportation funding districts or Area Commissions on Transportation (ACTs), except Washington County is included in the North West ACT and is not part of Metro.



Source: 2000 Oregon statewide model, calibrated to 1997 Office of Economic Analysis forecasts.

Figure 3: Production of goods and services in Oregon

The Portland metropolitan area and the Mid-Willamette Valley have diversified economies. These areas produce the bulk of heavy goods in the state and this diversity helps weather the impact from restrictions in heavy goods transport. Conversely, heavy goods are a significant part of the local economy of many other areas (Northeast, Northwest, Rogue Valley and Southeast), even

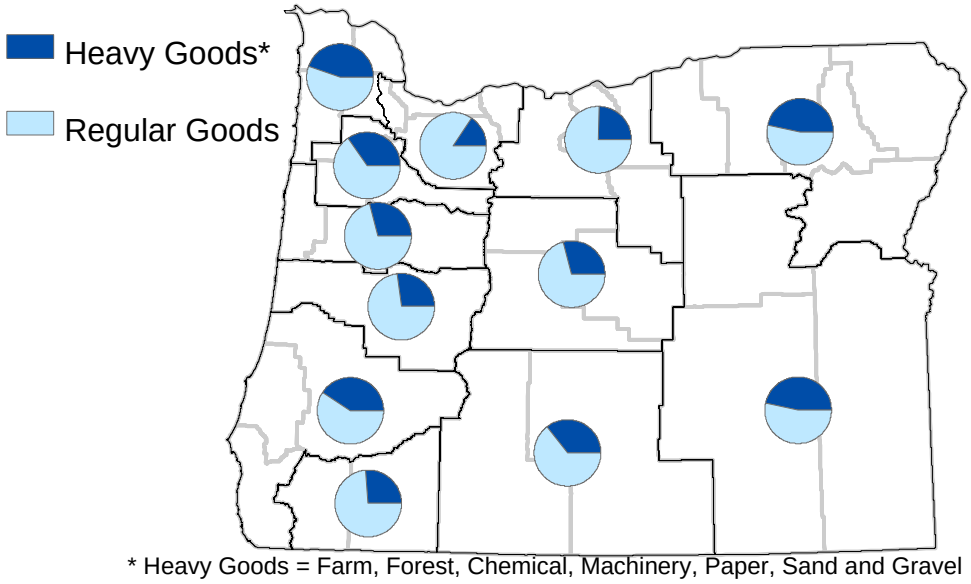


* Heavy Goods = Farm, Forest, Chemical, Machinery, Paper, Sand and Gravel

Source: 1999 IMPLAN economic production by county.

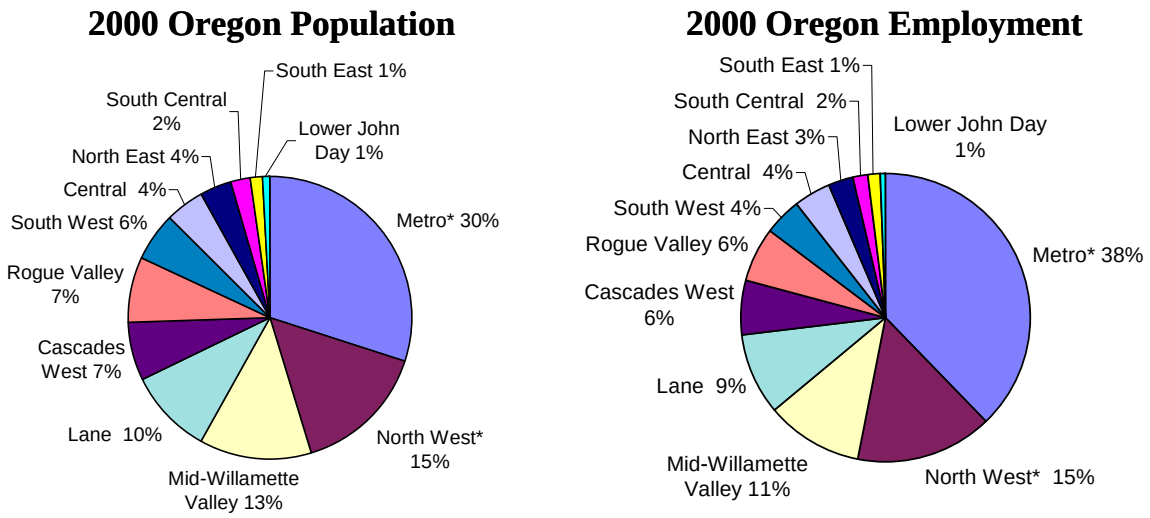
Figure 4: Location of production of heavy goods in the Oregon economy

3. Gross weight is a simplification of ORS 818.020 ODOT load restrictions regulations, which are also contingent upon the truck configuration and axle weights.



Source: 1999 IMPLAN economic production by county.

Figure 5: Location of production of heavy goods as part of local economies



* Northwest includes all of Washington county (13 and 12 percent of state population and employment, respectively).

Source: 1997 Office of Economic Analysis forecasts.

Figure 6: 2000 employment and population in Oregon

though this production does not represent a large share statewide (Figure 5). As a result, these rural economies would be affected much more by restrictions in the transport of heavy goods.

Oregon Employment

Figure 6 shows the distribution of the 1,600,000 employees in Oregon in 2000 by different areas of the state. Population generally matches the employment trend.

The Oregon Highway Network

Oregon relies heavily on its transportation system to move products to national and international markets. Modeling focused on truck freight transport over Oregon highways. A brief assessment of Oregon's multi-modal transportation system and the potential for off-loading freight onto non-truck modes was made and is summarized in Appendix C.

The major truck corridors in Oregon are shown in Figures 7 and 8. The key north-south and east-west highways for moving freight in Oregon are I-5, I-205, I-405 and I-84. These are the only Oregon highways that exceed 3,000 trucks daily. About 10,600 trucks cross the Interstate (I-5) Bridge in Portland and 7,800 cross the Glenn Jackson (I-205) Bridge into Washington each day.

Other non-interstate highways important to freight include US 97 through central Oregon, highways over the Cascade Mountains to central and eastern Oregon, highways between the Oregon coast and I-5, and highways within Oregon's metropolitan areas (Bend, Corvallis, Eugene-Springfield, Medford-Ashland, Portland and Salem). US 97 was the preferred north-south truck route at

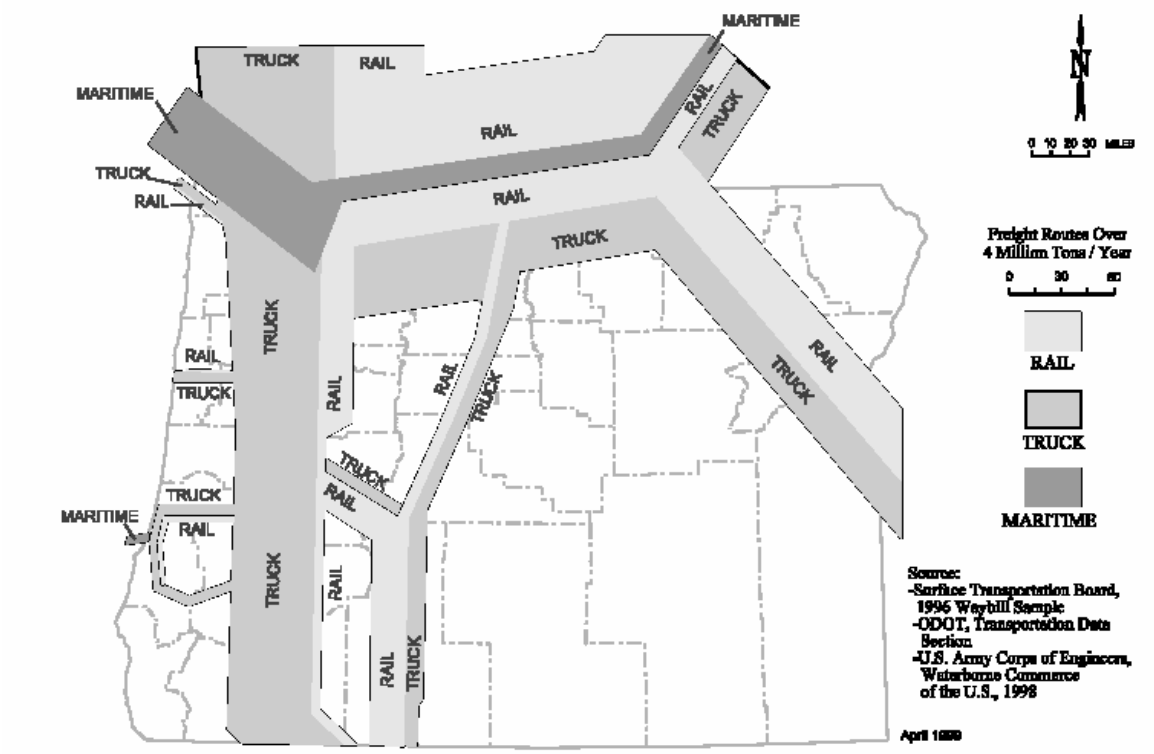
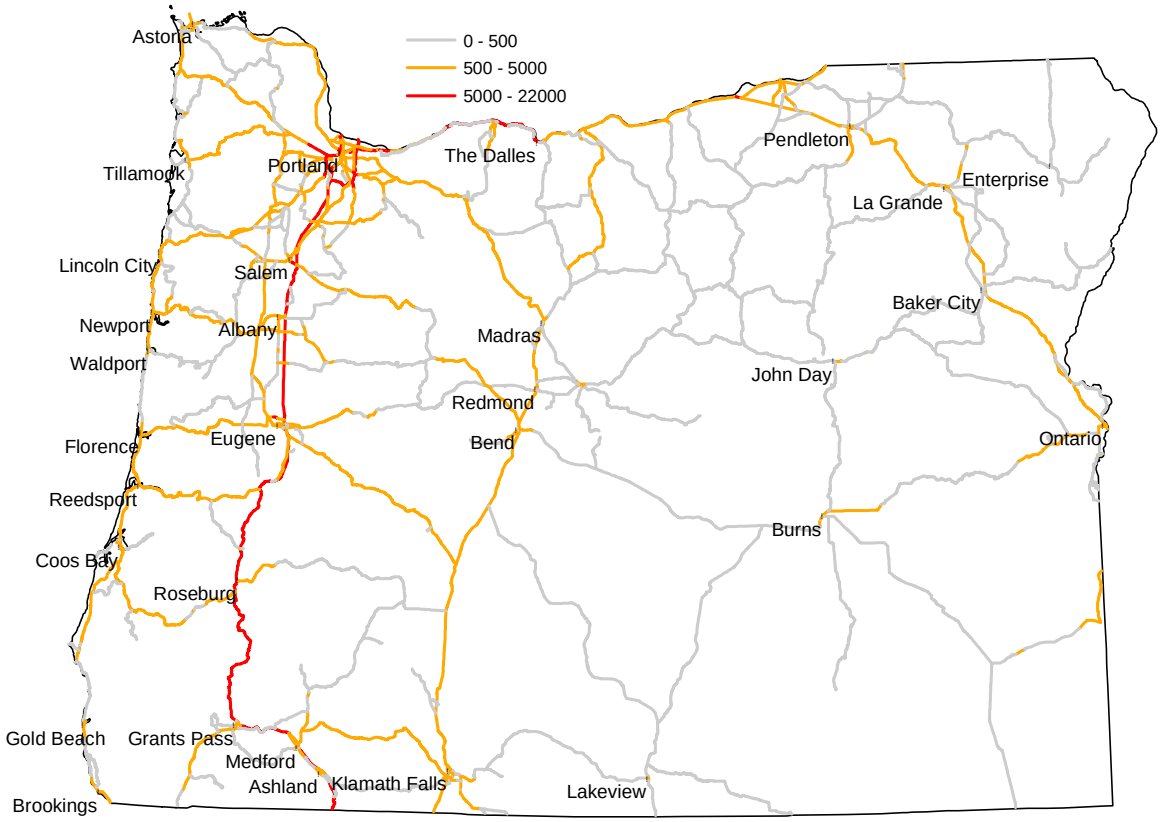


Figure 7: Major Oregon freight corridors (millions of 1996 tons shipped)



Source: ODOT Transportation Monitoring Unit.

Figure 8: 2001 Oregon truck average daily traffic (ADT) on Oregon freight roadways

one time, due to the high grades on southern I-5. Truck percentages of total traffic today range from less than 10 percent on major routes in Oregon's metropolitan areas to more than 45 percent on portions of I-84 where it meets the Idaho border in Baker and Malheur Counties.

In Oregon, trucks move more tons of freight than all other modes combined (Figure 9). Trucks transport roughly 70 percent of total tons and ton value originating in Oregon. Goods shipped by

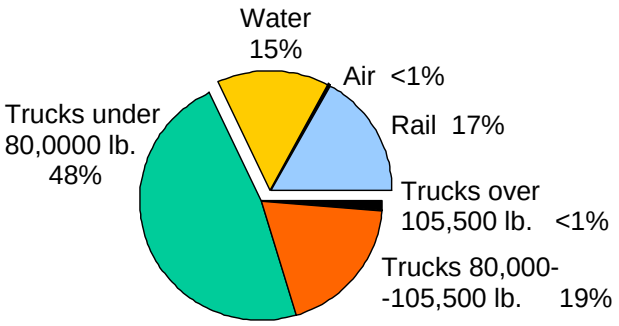
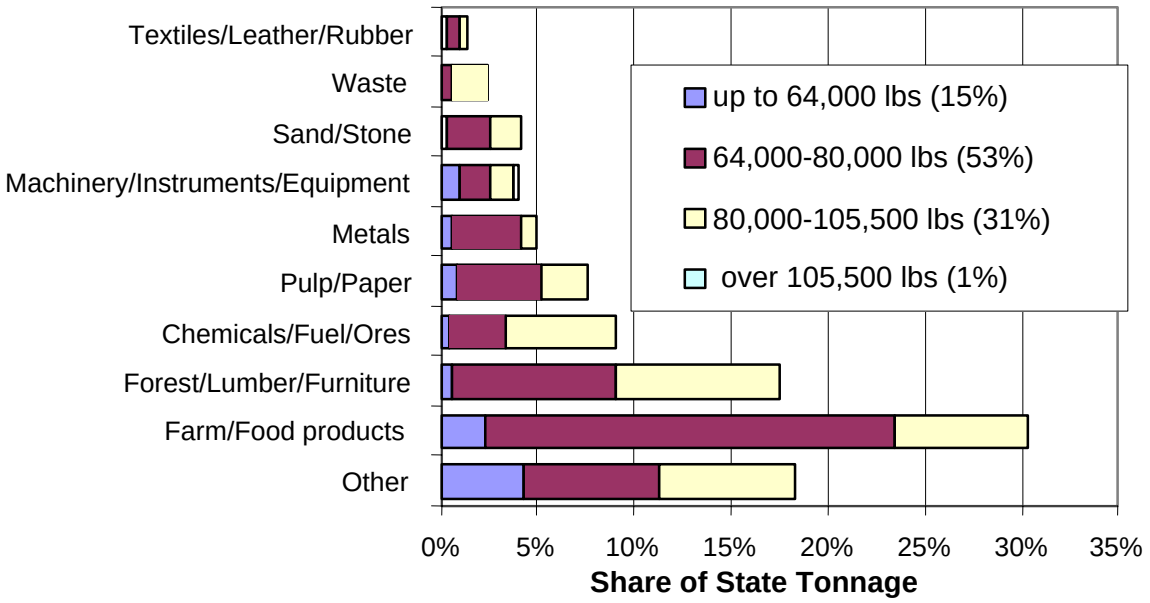


Figure 9: Oregon freight flows in tons, by mode and truck weight

air, although less than one percent of total tonnage, include significant high value goods with a high rate of growth.

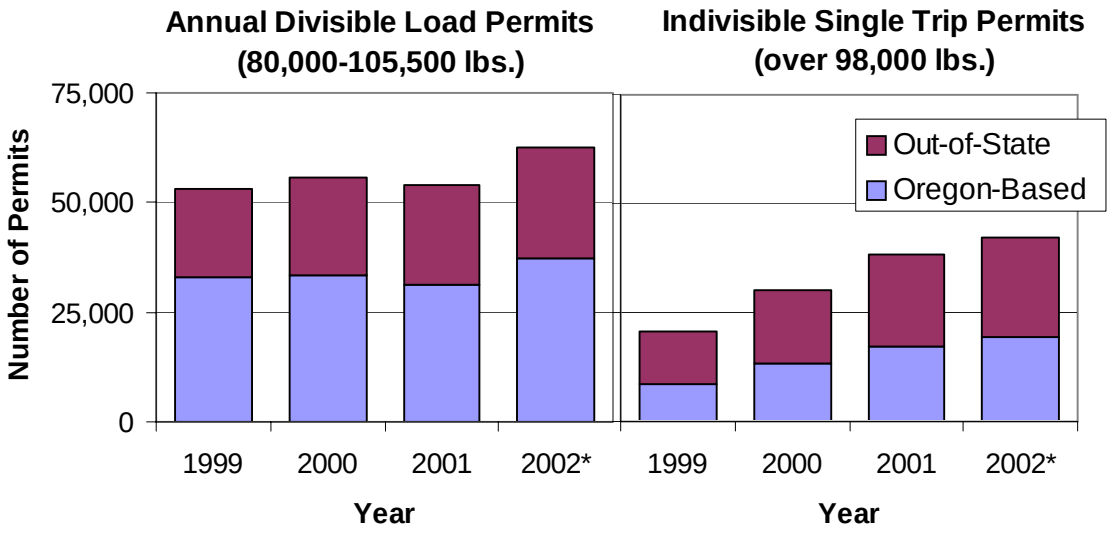
The bulk of state truck tons (85 percent) are moved in trucks over 64,000 pounds (Figure 10). Roughly 30 percent of truck tons are moved in trucks over 80,000 pounds which equates to 15-20 percent of truck trips. Heavy commodities typically transported in trucks that exceed 80,000 pounds include products such as lumber, agriculture and food products, fuel, sand and stone, and heavy equipment. Trucks over 105,500 pounds make up less than one percent of all truck trips but most carry non-divisible loads that cannot be redistributed into lighter trucks (e.g., industrial process equipment, bridge beams and construction equipment). To provide a perspective on the types of goods that will be affected by different bridge weight restrictions, goods typically transported in trucks of varying weights are summarized in Appendix D.

A 1997 Oregon Freight Truck Commodity Flow Survey found that about 26 percent of all truck tons on Oregon roads and 10 percent of all heavy truck tons (over 80,000 pounds) are "through" trips with both origin and destination outside the state. The majority of heavy truck permits in the last several years were issued to Oregon-based trucking companies (Figure 11).



Sources: ODOT Special Weighings Truck data, 1997 Oregon Commodity Flow Survey

Figure 10: Typical truck weights for transporting industry commodities



* 2002 extrapolated from January-September data.
Source: ODOT Motor Carrier Transportation Division, October 2002.

Figure 11: Heavy truck permits issued from 1999-2002

MODELING PARAMETERS

Several parameters were established to allow the Oregon statewide model to estimate the effects of restricting truck use of deteriorating bridges, the location of these restrictions, and impacts of these restrictions on the overall Oregon economy. The modeled economic impacts include the effects of bridge weight restrictions on transportation costs and the consequent effects on the location of Oregon businesses. The model was run in five-year increments. Although most model runs extended to 2025, the most recent runs include the effects of bridge construction spending and generation of construction revenues over a longer time horizon (to 2050).

Modeled Transportation Network

The roadways in the modeled transportation network were grouped into four categories for the bridge analysis (Figure 12).

The road network included in the Oregon statewide model is indicated in Figure 13. The intercity road network encompasses all roadways with a functional classification of rural minor arterial and above. Air and rail freight is not included. Bridges that are currently weight restricted are shown in black in Figure 13. Additional bridges that have identified cracks are included on each roadway segment according to the color of the roadway. The “other highway” group is included to show roadway connections for cracked bridges on roads outside the modeled network.

Although some local road links are added to include key bridges and communities, local roads are not fully represented in the model. To account for this, weight limited bridges within urban growth boundaries are considered to have a reasonable detour if a short alternate route exists on principal arterials and minor arterials. Because such detours are likely to be long-term in nature, alternates on major and minor collectors are not allowed.

In general, the transportation network includes no substantial increase in highway capacity or other transportation policies or services (e.g., public transportation). Future networks are primarily based on existing funded improvements. Ongoing repair/replacement projects as specified in the Statewide Transportation Improvement Program (STIP), including projects in the Oregon Transportation Investment Acts (OTIA I and II), are assumed. No scheduled bridge improvements are included beyond the OTIA and STIP time frames. Although non-cracked bridges are also aging and will need repair or replacement eventually, deterioration rates and the costs and economic impacts of these effects are not modeled.

In addition to cracked bridge load restrictions, heavy trucks are likely to be restricted on other routes due to physical conditions. Because of the many possible heavy truck configurations, no additional restrictions are imposed. Instead, the growth of truck vehicle miles traveled on roadway segments unsuitable for truck travel is assessed from model output.

I - 5 / I - 84	⇨	**Interstate bridges**
Freight Routes	⇨	**As defined by the Oregon Highway Plan**
Key State and Local Routes	⇨	**Significant Economic Routes**
Regional and District & Other Local Routes	⇨	**Other bridges**

Figure 12: Four major groups of Oregon freight roadways

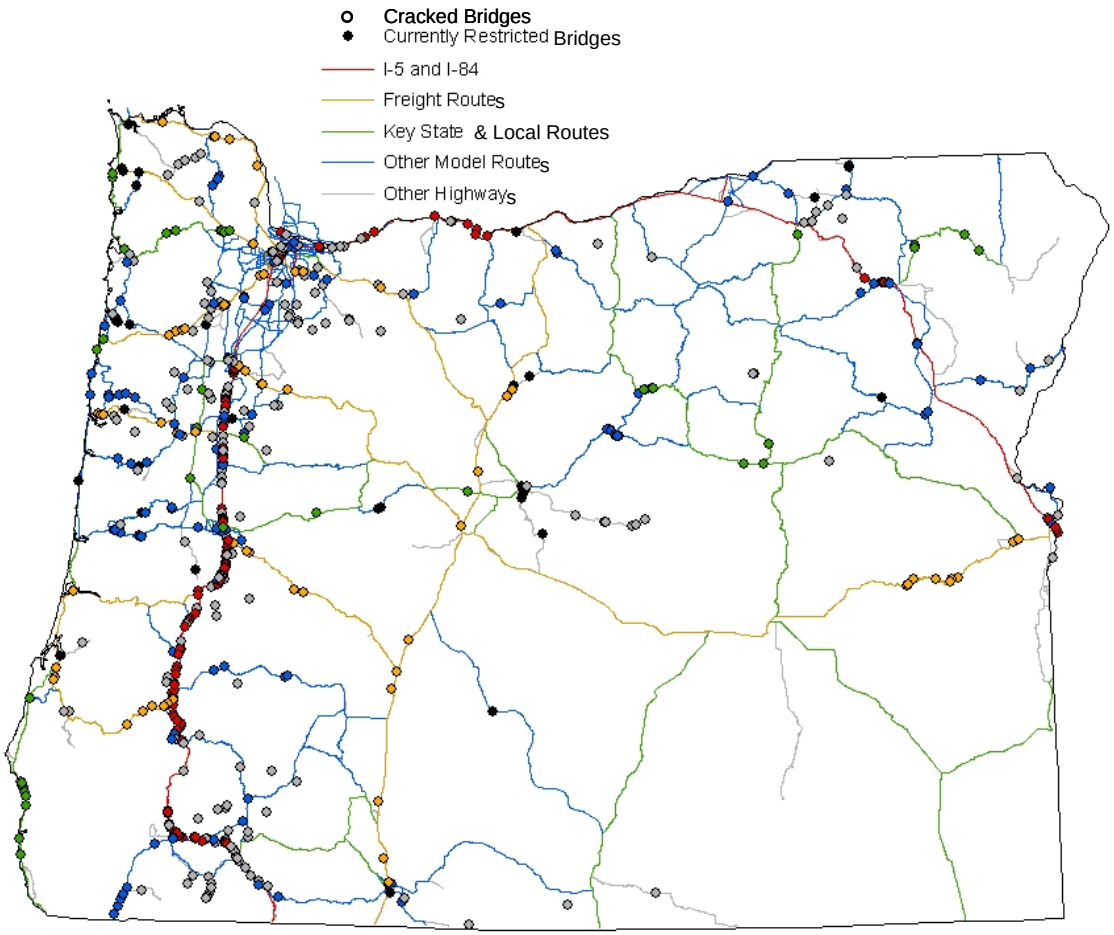


Figure 13: Oregon statewide model roadway network

Bridge Deterioration

The expected bridge deterioration rate of cracked bridges is a necessary model input to define the future year when each bridge restriction will begin. Bridge deterioration depends on a number of factors. Further deterioration expected from the Oregon bridge-cracking phenomenon is the subject of an ODOT-sponsored research program at Oregon State University (OSU) (see Appendix A). In the absence of results from the OSU research, the ODOT Bridge Section estimated deterioration rates of one to 15 years given current bridge condition of crack stage and crack width (Table 1).

Table 1: Estimated cracked bridge deterioration rates
(Anticipated years before 80,000 pound load limit)

Maximum crack width	Crack stage		
	Stage 1: Crack near bents	Stage 2: Cracks in 1/3 span	Stage 3: Cracks throughout
> 0.025”	5 years	3 years	1 year
≤ 0.025”	10 years	7 years	4 years
Hairline (≤ 0.013”)	15 years	10 years	8 years

Source: Data estimated for modeling purposes only. ODOT Bridge Section, July 2002.

Table 1 does not account for posting bridges below 80,000 pounds that is likely if additional investment does not occur. Bridge replacements are estimated to last 50 years, while a repair is estimated to last 10 years before it is again restricted to 80,000 pounds. A system of link types was created to restrict trucks over certain weight limits on routes with deteriorating bridges.

Industry and Truck Parameters

The modeling approach requires that heavy trucks (over 80,000 pounds) shift to other routes to avoid posted bridge limits or to lighten their loads to avoid these restrictions. In the long-term, industry is allowed to shift operations elsewhere either in or out of the state. The choice among these alternatives is based on the overall costs of each location for each industry sector.

In the Oregon statewide model, monetary trade flows are converted into transport flows (e.g., daily tons of freight). The transport model takes the transportation flows, assigns them to paths and computes transportation costs. The model is configured to distinguish between heavy (transported in trucks over 80,000 pounds) and regular goods (in trucks 80,000 pounds or less) produced by industries.

Heavy goods as a share of total goods production is estimated for 8 of 12 industry sectors in the model that transport commodities within the state (Table 2). This represents the share of that industry’s goods currently transported in trucks that exceed 80,000 pounds. Commodity shares (by SIC code) in various truck weights are estimated from Oregon Commodity Flow Survey and Special Weighings data collected at statewide truck weigh stations. Each commodity is linked to its producing industry using 1999 IMPLAN data. The highest rates of heavy goods occur in three industry sectors: Lumber/Paper pulp (43 percent), Transport/Communications/Utilities (65 percent), and Wholesale (65 percent).

Table 2: Estimated industry production by truck weight class

Industry sector	Code	Total goods (MTons/Year)	% shipped by truck weight	
			64,000-80,000 lbs.	>80,000 lbs.[a]
Farms, forests, fisheries	AGFF	6,150	60	34
Construction, mining	CONS	2,360	49	44
Food processing, non-metallic minerals, metals, other	OMFG	2,100	61	27
Lumber & wood products, pulp & paper	WOOD	6,000	47	48
Printing & publishing	PRNT	1,500	52	14
Machinery & equipment, high tech, transport equipment	TECH	250	42	32
Transport, communications & utilities	TCPU	10	22	74
Wholesale	WLSE	180	22	74
Retail	RETL	0	0	0
Finance, insurance & real estate	FIRE	0	0	0
Business, personal, and health services, amusements, lodging, other organizations	SERV	0	0	0
Government, education	GOVT	0	0	0

a. Heavy commodities primarily consist of farm and forest products in AGFF, construction materials and petroleum in CONS, stone and metal products in OMFG, forest products, lumber and paper pulp in WOOD, paper and printed matter in PRNT, heavy machinery in TECH, and waste and scrap material in TCPU and WLSE.

Source: 1997 Oregon Freight Truck Commodity Flow Survey and 1999 IMPLAN production data by industry.

In the model, heavy goods are required to ship in full or partially full heavy trucks, while all other goods are transported in regular trucks. Only full heavy trucks (over 80,000 pounds) are restricted from traveling on network links with posted bridge restrictions. A partially full heavy truck (alternative truck) is unaffected by bridge load restrictions but operates at a higher cost than regular trucks (Table 3). Freight trips are assigned to combinations of truck operators (heavy truck or alternate truck) and available routes based on relative costs.

A similar process was used to model 64,000 pound bridge restrictions. In this case, industry goods were split into three groups: those typically transported in trucks over 80,000 pounds, trucks 64,000 pounds to 80,000 pounds, and trucks less than 64,000 pounds. The assumed share of goods transported in these truck weights by industry is also shown in Table 3.

For these model runs, trucks were allowed to lighten their loads down to 64,000 pounds to avoid bridge restrictions. This required a modified set of truck cost parameters as shown in Table 4.[4]

Increased production costs resulting from heavy truck restrictions produce proportional increases in the price of goods. At five-year intervals, the model adjusts statewide exports of affected goods proportionally, assuming that market demand for these goods reacts to the change in price. The model assumes that if bridge limitations result in a one percent increase in consumption costs for those outside of Oregon to buy Oregon goods, they will buy one percent less with a resulting

4. Due to different truck parameters, 64,000 pound run output was scaled relative to 80,000 pound runs.

Table 3: Truck operating cost parameters

Truck parameter	Regular (80,000 lbs. or less)	Alternate (heavy truck limited to 80,000 lbs.)	Heavy (over 80,000 lbs.)
Average payload (non-empty)	14.4 tons	18 tons	26.4 tons
% returned loaded	83.2	83.2	83.2
Minimum fuel consumption	0.165 gal/mi.	0.1734 gal/mi.	0.183 gal/mi.
Maximum fuel consumption	0.183 gal/mi.	0.193 gal/mi.	0.203 gal/mi.
Fuel cost	$1.18/gal	$1.18/gal	$1.18/gal
Time cost	$19/hr	$19/hr	$19/hr
Mileage cost[a]	$1.56/mi	$1.67/mi	$1.67/mi
Load/reload cost	$40/trip	$40/trip	$40/trip

a. Average costs per mile of oil, tires, maintenance, flat and weight mile taxes, equipment rents, insurance, depreciation, and other miscellaneous expenses, in 2000 dollars.

Sources: ODOT truck weight data, American Trucking Association fuel consumption/cost data, and other ODOT sources.

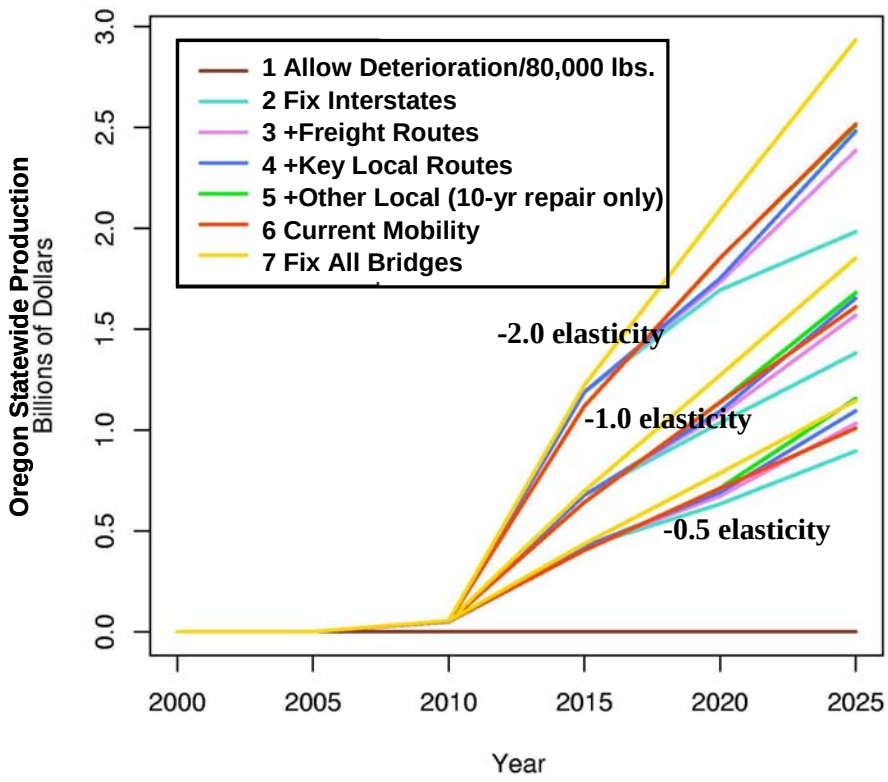
Table 4: Truck model parameters for 64,000 pound bridge restrictions

Truck Parameter	Small (64,000 lbs. or less)	Alternate	Medium (64,000 lbs.-80,000 lbs.)	Heavy (over 80,000 lbs.)
		Medium/Heavy Trucks lightened to ≤64,000 lbs.	Heavy Trucks lightened to 64,000-80,000 lb	
Average payload (non-empty)	6.4 tons	14.4 tons	21.3 tons	28.4 tons
% returned loaded	83.2	83.2	83.2	83.2
Min. fuel consumption	0.165 gal/mi.	0.165 gal/mi.	0.173 gal/mi.	0.183 gal/mi.
Max. fuel consumption	0.183 gal/mi.	0.183 gal/mi.	0.193 gal/mi.	0.203 gal/mi.
Fuel cost	$1.18/gal	$1.18/gal	$1.18/gal	$1.18/gal
Time cost	$19/hr	$19/hr	$19/hr	$19/hr
Mileage cost[a]	$1.56/mi	$1.56/mi	$1.63/mi	$1.67/mi
Load/reload cost	$40/trip	$40/trip	$40/trip	$40/trip

a. Average costs per mile of oil, tires, maintenance, flat and weight mile taxes, equipment rents, insurance, depreciation, and other miscellaneous expenses, in 2000 dollars.

Sources: ODOT truck weight data, American Trucking Association fuel consumption/cost data, and other ODOT sources.

decrease in Oregon production. The impact on industry revenues is expected to cause subsequent changes to the number of employees needed, which in turn affects state population levels as some households migrate to follow the jobs. For certain industries, the net effect might translate to a decline in revenues and employment over time while other industries may experience a slower rate of growth.



Note: Production in 2000 real dollars.

Figure 14: Sensitivity of future statewide production to elasticity value

Since little dynamic information is available to define how industry responds to changing prices, different elasticity values were run for sensitivity testing. Figure 14 shows the results of using elasticity values other than the chosen -1.0 in various bridge analysis alternatives (see Figure 18 for scenario definition). A doubling of the elasticity (-2.0) means the size of the state's economy is more sensitive to changing prices (including the cost of bridge detours), which increases the difference between the "Fix All Bridges" scenario and the "Allow Deterioration/80,000 pounds" scenario. Conversely, cutting the elasticity in half (-0.5) reduces sensitivity to price, reducing the difference between the "Fix All Bridges" scenario and the "Allow Deterioration" scenario by about a third. Although the absolute total state production values change, the relative ordering of the alternatives is typically maintained regardless of the chosen elasticity value.

In addition to trips generated by local economic activity, the model includes a significant number of "through" truck trips on state roadways (origin and destination outside of Oregon). Although these trips have little direct economic impact to the state, they contribute to the traffic that must be accommodated in detours. Table 5 presents through truck data assumed for 1990 at various state border locations.

Data in Table 5 is based on truck surveys taken at Oregon Ports of Entry. The model forecasts future through trips using the annual growth factors shown in Table 6.

Table 5: 1990 through truck trips

Road segment	1990 through truck trips						
	I-5 CA	US 97 CA	I-5 WA	US 97 WA	I-82 WA	I-84 ID	Total
I-5 CA	-	-	3,603	19	277	42	3,941
US 97 CA	-	-	1,051	31	223	25	1,330
I-5 WA	1,323	522	-	32	324	322	2,523
US 97 WA	39	46	81	-	-	1	167
I-82 WA	187	207	414	3	-	881	1,692
I-84 ID	47	17	162	-	74	-	300
Total	1,596	792	5,311	85	898	1,271	9,953

Source: 1997 Oregon Commodity Flow Truck Survey, processed for statewide model, scaled back to 1990 volumes using growth rates of Table 6.

Table 6: Annual growth of through truck trips

Border highway	Through truck annual growth rate (%)					
	I-5 CA	US 97 CA	I-5 WA	US 97 WA	I-82 WA	I-84 ID
I-5 CA	0.6	3.0	2.4	3.2	2.6	3.3
US 97 CA	3.0	5.3	4.8	5.5	5.0	5.7
I-5 WA	2.4	4.8	4.3	5.0	4.5	5.1
US 97 WA	3.2	5.5	5.0	5.7	5.2	5.9
I-82 WA	2.6	5.0	4.5	5.2	4.6	5.3
I-84 ID	3.3	5.7	5.1	5.9	5.3	6.0

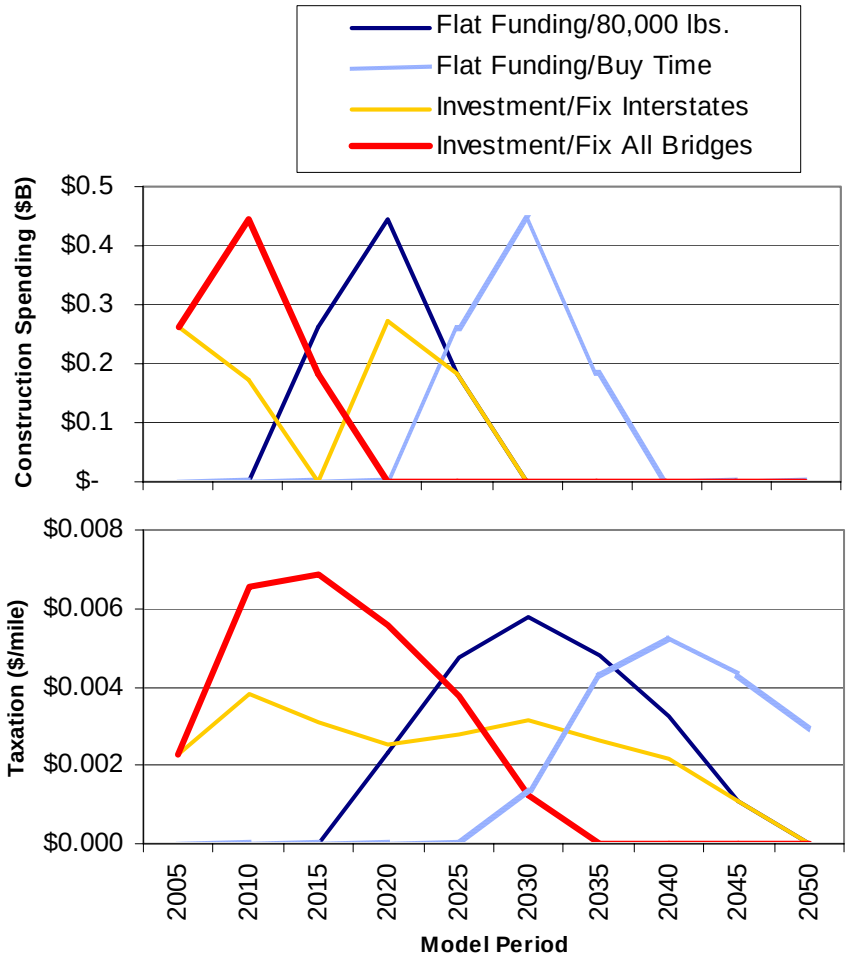
Source: 1991-2000 growth in truck Automatic Traffic Recorder (ATR) counts on state border roads.

Construction Spending and Taxation

Separate model runs assessed the net impact of the construction spending stimulus afforded by bridge investment, and the vehicle-based taxation required to generate these funds. These runs are a variation of the 80,000 lb. model runs with the addition of construction spending and taxation, and are extended to 50 years in order to account for the full life cycle effect of early investment.

Construction spending assumes that all cracked bridges are replaced by 2050 under all scenarios. This $4.7 billion investment (in 2002 dollars) was added to statewide construction production levels and allocated by the model to various regions of the state based on previous year construction activity. The construction schedule varies by scenario, as shown in Figure 15. Full investment occurs in 2005-2014 in the Invest/Fix All option. This investment is deferred 15 years with the Flat Funding/80,000 pounds option, and an additional 10 years with the Flat Funding/Buy Time option. The original Option 1 Invest/Fix Interstates, approximates ODOT's recommended option. Its spending schedule assumes a $2 billion investment in the 2005-2009 time frame, with remaining bridge investment in the 2025-2029 time frame.

Taxation provides the revenues for bridge investment. Taxation is modeled as a mileage-based vehicle tax incurred at existing cost allocation ratios (e.g., vehicle weight groups).[5] Tax rates per



Notes: Constant 2000 dollars. See "Two Courses of Action" section for description of scenarios.

Figure 15: Construction spending and taxation schedules

mile (average for each 5-year period), also shown in Figure 15, begin with the construction period and extend for 20 years. Thus, the funds spent in each five-year construction period result from bonding future tax revenues, assuming a 20-year bond maturity, one-fifth of the total bond amount sold in each year, at a 6 percent interest rate, 2 percent cost of underwriting and fees, and a 3 percent real discount rate. The per-mile taxation to meet the resulting bond payments was calculated using the following formula:

$$[(\text{5 year bond payments}) \times (\text{cost allocation \%})_i] / [(\text{5 year VMT})_i \times (\text{scaling factor})_i]$$

where i = vehicle weight groups: <26,000 lb, 26,0000-80,000 lb, >80,0000 lbs

5. Highway Cost Allocation Studies (HCAS) are conducted every two years in Oregon to estimate the costs associated with vehicles by weight. The periodic review identifies the equitable amount each vehicle group should pay in highway user taxes to maintain, operate, and improve Oregon's public roadways.

A scaling factor to match vehicle miles traveled by group from the 2002 Cost Allocation Study was used to account for local (intrazonal) trips not fully accounted for in the statewide model. Figure 15 shows the average taxation rates of each vehicle weight group.

Non-Divisible Freight Demand

A separate modeling step addresses the impact of bridge restrictions for heavy non-divisible loads. In order to evaluate the effects on these shipments, a separate model run was made for each course of action, assuming the origins-destinations from actual permit data and assigning a route on the network consistent with that action's bridge load limitations. Because these trips cannot shift to lighter loads, output indicators of these runs include the availability of routes and associated detour lengths necessary to avoid restricted bridges.

In fiscal year 2001-2002, 26,000 single trip permits were issued by ODOT for non-divisible loads over 98,000 pounds. These permits represent approximately 70-100 truck trips per day, less than one percent of statewide truck trips. A preliminary review of permits indicates that these trips are largely for transporting heavy equipment, construction equipment and other construction materials (e.g., bridge beams).

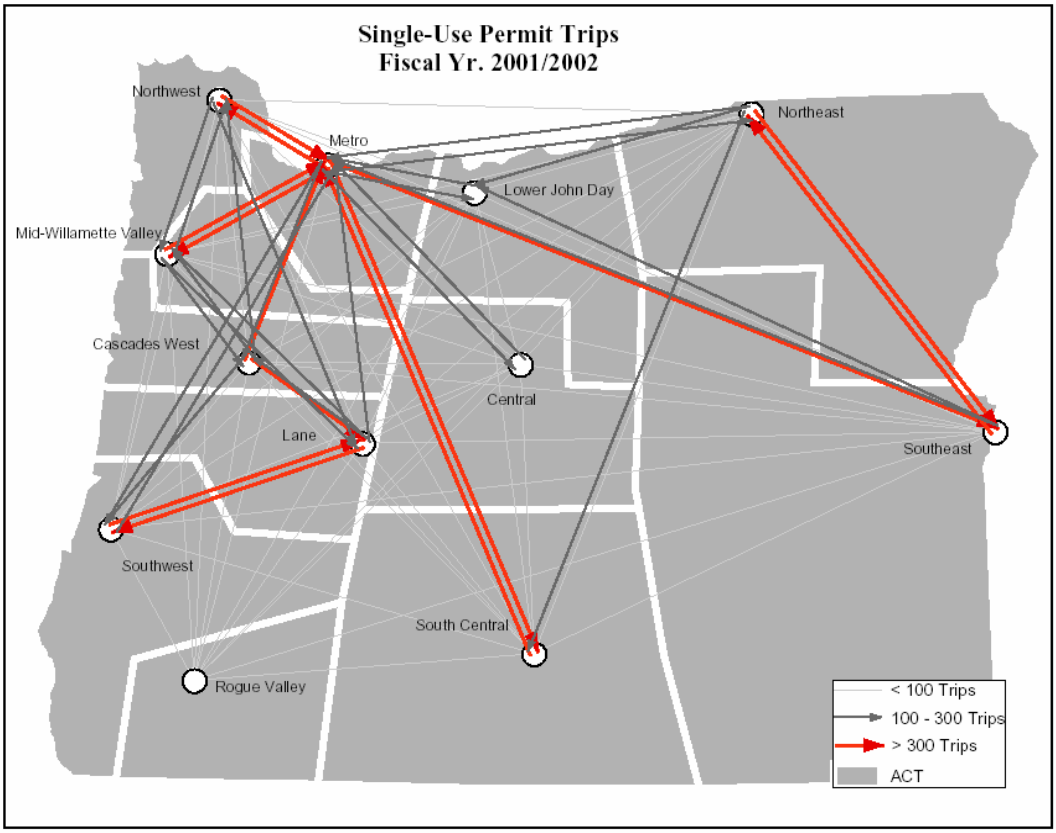
A 20 percent cross-sectional sample of this data set was modeled with outputs scaled up to represent annual trips. The ODOT Motor Carrier permit database was designed to support the permit program only and does not include information on routes or bridges used. Thus, the data were not conducive to geocoding or cross-referencing with highway and bridge databases. Original paper copies of permit applications were used to prepare data used in the model runs. Despite difficulties in manually coding this data from the permit records, the sample is reasonably representative of the full data set in terms of truck weights and origin-destination pairs. The geographic pattern of the FY 2001-2002 trip sample scaled up to represent full annual activity is shown in Figure 16. Over one-third of the trips are either to or from the Portland metropolitan area.

The non-divisible trips from the single trip permits are assumed to be "heavy trucks" restricted from traversing network links restricted to heavy trucks, as in the other model runs.

Parameters Common to All Scenarios

The following parameters are common to all bridge model applications:

- *Geographic Activity Zones:* All activities in the model area (Oregon and Clark County, Washington) are grouped into a set of 122 zones. Over half of these zones are located in whole or in large part in the Willamette Valley. An additional 25 zones represent areas external to Oregon and Clark County.
- *Growth of Urban Land Supply:* A 1990 base year inventory of available land for development and the amount of new land added in each five-year increment is an important input to the statewide model. Two land use categories are modeled - residential and commercial/industrial land. Because Oregon law requires that a 20-year supply of land is maintained within urban growth boundaries, the model zones additional land in each five-year interval to maintain the required supply.



ACT	Northwest	Metro	Northeast	South Central	Rogue Valley	Lower John Day	Central	Mid-Willamette Vlly	Cascades West	Southwest	Southeast	Lane	Total Trips	Percent Total Trips
FROM \ TO														
Northwest	1,253	593	13	13	0	0	20	180	80	33	33	173	2,391	9.19
Metro	560	3,591	267	466	87	273	220	413	240	146	513	300	7,076	27.20
Northeast	20	126	906	140	7	173	80	20	20	0	326	7	1,825	7.01
South Central	0	340	93	460	93	67	60	27	20	40	40	47	1,287	4.95
Rogue Valley	0	87	20	53	673	20	13	7	7	93	20	47	1,040	4.00
Lower John Day	0	126	67	40	7	140	13	47	7	0	47	0	494	1.90
Central	7	140	67	93	7	60	580	53	13	7	7	60	1,094	4.20
Mid-Willamette Vlly.	120	346	27	13	27	53	20	580	253	93	7	133	1,672	6.43
Cascades West	126	346	27	93	67	0	7	280	1,099	133	33	360	2,571	9.88
Southwest	13	100	20	40	93	7	7	67	47	1,972	13	320	2,699	10.37
Southeast	60	293	340	53	27	186	33	27	0	20	346	27	1,412	5.43
Lane	40	146	33	60	33	13	53	107	253	313	53	1,352	2,456	9.44
													26,017	100.00

Note: ACTs are Area Commissions on Transportation boundaries as defined by ODOT.
Source: Full statewide origin-destination activity scaled from 20 percent sample of ODOT FY2001-02 single trip permit databases.

Figure 16: Indivisible single trip permit data

- *Economic and Population Growth:* Forecasts of changes in economic (final) demand are derived from employment and population forecasts developed by the Office of Economic Analysis (OEA). Without restrictions (e.g., bridge load limits) the state grows according to the OEA forecasts with regional allocation affected by transportation and land costs. For the bridge application, the model was augmented to allow the overall level of statewide economic activity to vary in response to the costs of producing goods in Oregon.
- *Trade Relationships:* The IMPLAN-based input-output model describes trade relationships in the model area. Although amounts of (final and intermediate) production are changed in response to economic growth, each sector's technology (the amount that each sector consumes from each other as a proportion of its total production) does not change.
- *Shadow Prices:* The relative differences among zones in public service quality, aesthetics and other factors that affect location choices (shadow prices) are assumed not to change. Although the relative attractiveness of places may change as a result of public or private actions, there is no way to assess how such actions would change the equivalent shadow prices
- *Model Calibration Parameters:* Various model calibration parameters do not change. Parameters like the monetary value people place on time they spend traveling are very important in modeling travel and location choices. Such parameters used in the model are derived and calibrated from existing data.

Model Calibration

The statewide model was calibrated and validated in previous efforts using data from 1990 and 1995. Additional calibration was specific to the bridge analysis. This included data from the following sources:

- IMPLAN economic model
- Oregon commodity flow and special truck weight surveys
- Oregon household travel surveys
- Highway and local road inventories
- County assessment records
- Land sales records
- Metro (Regional Land Inventory System) data
- Statewide zoning
- 1990 Census

The calibration of the model is a highly iterative process because of the interrelated nature of the model components. During initial development of the model, three major cycles of calibration and testing were involved with numerous iterations within each cycle. These included:

- Initial base year (1990) calibration
- Initial 1990-1995 calibration and validation
- Recalibration and validation during the bridge analysis and previous model applications

The initial base year calibration focused on determining the correct set of parameters for replicating the distribution of activities, passenger trip generation and truck freight trip generation. The

goal for calibration of activity distribution was to match measured production by zone. This was done using a reasonably close match between resulting model prices with relatively small shadow prices with no observable bias.

After calibration of the base year was completed, model parameters were adjusted as necessary to replicate observed changes that occurred in the 1990 to 1995 time increment. Global increments of final production, including inputs and model results, were compared to target values. The primary criteria for evaluation of the model were:

- Closely match the actual increments of change in households and employment by sector for each zone
- Match target passenger trips by sub-state area within 20 percent
- Match the expected change in passenger trips by sub-state area within 20 percent
- Match 1995 truck and auto average weekday counts along major intercity corridors within 20 percent

During each application of the model, including the bridge study, model outputs are evaluated for reasonableness with regards to the particular issue under study. For example, in the Willamette Valley Futures study, efforts were made to validate that land prices responded to supply constraints and travel patterns responded to congestion. In the bridge analysis, efforts were made to fine-tune truck operating costs and truck movements. This included replicating the statewide share of trucks of various weights (e.g. over 80,000 pounds) on roadways as observed in the Oregon Commodity Flow Survey and Special Weighings data. The paths of various weight trucks and the distribution of trip lengths by truck weight were also checked for reasonableness.

MODELING RESULTS

Several series of model runs were conducted as broad questions and different approaches to the bridge problem were defined and then modified based on model findings. Each set of model runs provided information on the effects to the statewide economy, population and employment, regional economic ramifications and business response of different bridge restrictions and investment strategies.

Model Limitations

The statewide model is an ideal framework for quantifying the economic impacts of bridge restrictions. The model was reviewed by international and local peers during development and application, ensuring that the model reflects the best available data and understanding of state transportation, land use and economic issues (see Appendix E).

Since models are simplified representations of reality, significant effort was undertaken to supplement the results of this model with other information as much as possible. Some considerations include:

- Modeling bridge restrictions at 80,000 pounds does not account for further bridge deterioration if no additional investment is made. Modeling a restriction of 64,000 pounds has significantly greater impacts. Anecdotal evidence of bridge failures shows that weight restrictions can fall as low as 26,000 pounds with speeds across bridges often limited to as low as 10 mph.
- Bridge deterioration is a key assumption in the model. The best information available to the ODOT Bridge Section was used in estimating bridge deterioration rates until the OSU research results are available in summer 2003.
- The model's economic response to bridge restrictions in the model makes use of the best understanding of the State's economy. Key model data are based on nationally recognized sources of economic relationships (e.g., IMPLAN input-output tables with specific Oregon parameters) and current/forecast state data. Leading economists set model parameters based on this data. These were subject to review by the Oregon Department of Economic & Community Development and the Oregon Office of Economic Analysis. However, the model can only account for rational industry behavior given changes in freight costs. Perceptions of the bridge problem could further impact state business development and tourism.
- The model quantifies the economic impacts within the state. Restricting transport within Oregon will also have regional and international impacts.
- The model results highlight the significant increase in diverted truck traffic on local roads under bridge weight restrictions. It should be noted that the model results do not tabulate the increased maintenance and preservation that would likely be needed under these conditions.

- In response to bridge restrictions and associated increases in shipping goods by truck, business is likely to consider the use of alternate modes. To further address non-trucking freight modes, potential for model shift was assessed by state freight experts (see Appendix C).
- Proprietary data issues require an aggregate rather than business-level modeling of the economy. This level of information is important to assess the small number of trucks with non-divisible loads over 98,000 pounds. To supplement the model results, opinions were also solicited from key industries and shippers.[6]
- Because of the long-term intercity-nature of the model, results were coordinated with cities and counties to ensure that local bridges do not block access to the larger freight network and that short-term bridge detours minimize local impacts (see Appendix F).
- Analysis was completed using available data and bound by the existing model framework. This required sector and commodity aggregation and a fixed "heavy" share of goods produced by each industry. The statewide economy, although allowed to respond to increased in-state costs, did so with a long lag time. In the construction tax and spend runs, construction spending was injected at the statewide level and allocated locally based on previous year construction activity.

Initial Modeling Process

Following the June 2002 Bridge Task Force Report, the OTC asked that six investment options be explored. Each option has a different time frame for repair and replacement of identified bridges. The options address the level of additional investment assumed within the next 15 years. However, most cracked bridges will be well beyond their design life at this point, requiring replacement even if temporary repairs are made earlier. Within an option, each of the major highway groupings is assigned a level of bridge restoration as shown in Figure 17.

The level of restoration and the assumed timing of investment for bridges on each highway group defines these initial investment options. The options are shown in Figure 18 and are described below.

Option 1: No funding increase, restrict bridges to 80,000 pounds as they deteriorate

This option uses existing monies to address bridge deficiencies, understanding that eventually most cracked bridges will be posted to a minimum of 80,000 pounds.

Option 2: Fix Bridges on Interstates 5 and 84

Option 2 includes a multi-year investment to systematically repair or replace some at-risk bridges:

- Replace cracked bridges on I-5 and I-84 by 2010.
- Repair bridges on freight routes and key state and local routes by 2015. These are assumed to extend the life of the bridge for ten years.
- Restrict other regional, district and local routes as bridges deteriorate.

6. ODOT Economic & Bridge Options Report, Appendix H.

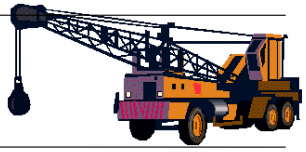
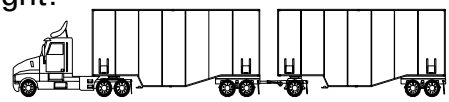
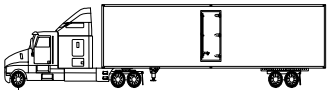
No Restrictions	No restrictions 
Limited	Maximum weight: 105,500 lbs. 10 year fix 
Restricted	Maximum weight: 80,000 lbs. 
Current Levels	**Bridges maintained at today's level of restrictions**

Figure 17: Levels of bridge restoration

Option ▸	**1**	**2**	**3**	**4**	**5**	**6**
Level of Restriction ▸	**30%**	**25%**	**20%**	**10%**	**5%**	**0%**
Route ▾	**No Investment Change**				**Today's Level of Restriction**	**No Restrictions**
I-5 and I-84	**Restricted**	**No Restrictions**	**No Restrictions**	**No Restrictions**	**No Restrictions**	**No Restrictions**
Freight Routes	**Restricted**	**Limited**	**No Restrictions**	**No Restrictions**	**No Restrictions**	**No Restrictions**
Key State & Local	**Restricted**	**Limited**	**Limited**	**No Restrictions**	**No Restrictions**	**No Restrictions**
Reg, Dist, & Local	**Restricted**	**Restricted**	**Restricted**	**Restricted**	**No Restrictions**	**No Restrictions**

Figure 18: Elements of initial investment options

Option 3: Fix Bridges on Interstates 5 and 84 and Major Freight Routes

- Option 3 represents a greater investment than Option 2 by replacing key freight routes instead of repairing them. It includes a multi-year investment that will:
- Replace all failing bridges on I-5 and I-84 by 2010 and freight routes by 2015.
- Repair other key state/local routes in that time frame, pushing off bridge posting by 10 years.
- Restrict other regional, district and local routes as bridges deteriorate.

Option 4: Fix I-5 and I-84, Key Freight Routes, Key State and Local Routes

This option includes the same multi-year investment as in the previous options to systematically replace at risk bridges, but now replaces rather than repairs bridges on key state and local routes:

- Replace failing bridges on I-5 and I-84 by 2010.
- Replace bridges on freight and key state/local routes by 2015.
- Restrict other regional, district and local routes as bridges deteriorate.

Option 5: Current bridge restrictions remain but no new bridges are restricted

Option 5 replaces all the bridges necessary to maintain today's level of transport mobility:

- Replace bridges on the interstates, freight routes, key state and local bridges, and region/district/local bridges. Only the few currently restricted bridges remain restricted.
- The interstate bridges are replaced by 2010, and others replaced by 2015.

Option 6: Replace all bridges

- All bridges are replaced to accommodate all loads by 2015.
- No bridges are restricted and current restrictions are lifted.
- No additional replacements of cracked bridges are needed after 2015.
- This option will not address the restoration of historic and coastal bridges.

The modeling analysis looks at changes from 2000 through 2025 to provide comparisons among the options. The information presented for these options is intended to provide decision-makers with tradeoffs that can be expected relative to the investments made. The options vary in their assumptions about which, if any, bridges will be fixed soon (next 15 years). The investment choices range from full accessibility throughout the state at the highest cost (Option 6: Replace All Bridges) to improvement of only the major corridors serving the majority of business in the state at the expense of regional growth (Option 2: Fix Interstates).

The overall and regional production of goods and services is a key economic measure of the bridge options. Other supporting model outputs, including industry costs and increased truck traffic on unsuitable roads, in communities and in environmentally sensitive areas are also assessed.

Figure 19 identifies production across the state under each option and for a selected set of industry sectors. This information is presented as change relative to Option 5, which represents how production is allocated if current transportation mobility is retained. Industries such as agriculture, wood products, construction, and mining/aggregate are impacted by bridge restrictions because of

their reliance on heavy truck transport. Other sectors that move goods in triple trailers are also impacted if required to detour or redistribute goods to lighter weight trucks. The service sector that supports these industries will be indirectly impacted by the options. In some sectors, such as the technology sector, there is little change to production whether bridges are restricted or not. Although the technology industry uses highways to transport products, it produces lightweight products that are typically less impacted by 80,000 lb. weight restrictions.

Figure 19 shows that the Option 1 restriction of 30 percent of the state's bridges leads to reduced growth in production in the interior of the state and accelerated growth near state borders. This reflects the relative advantage of border areas that can trade with neighboring states with minimum travel on Oregon roads. High transport costs also contribute to a centralization of the state's economy, giving advantage to larger metropolitan areas that provide local availability for many goods. The increase in transportation costs provides an incentive to consider alternate modes, which are less cost effective or as flexible as transporting by truck.

As the interstates are opened up in Option 2, production is restored along these corridors. Production along I-5 and I-84 represents over 75 percent of the overall state economy. The opening of interstate and repaired freight routes provides viable detours for heavy trucks, limiting the shift to lighter trucks and increasing the heavy truck average distance. However, more remote areas of the state do not share this unfettered accessibility. Despite short-term bridge repairs on freight routes that provide some relief, regional and district road bridges remain restricted to heavy trucks leading to a dampening of regional economic growth.

Option 3 represents a longer-term investment in freight route accessibility. It opens up several areas of the state, particularly in central and southeast Oregon that were only repaired in Option 2 (10-year fix). A reduced need for detours keeps trucks on state freight routes, minimizing impacts on local roads, within communities and in sensitive environmental areas.

However, it is not until freight routes and key state and local routes are opened up in Options 4 -6 that production growth returns to the central area of the state. Option 4 replaces key state and local bridges instead of the 10-year repair assumed in Options 2 and 3. As a result, both economic production statewide and transportation costs improve slightly over Option 3. Growth occurs over a longer period in the same locations highlighted in Option 3. For the most part, heavy trucks are now able to continue normal operations in the state. Impact on local roads, communities and the environment is roughly equivalent to that of Option 3.

In Option 5, representing current mobility, the majority of bridges in the state are improved allowing the state to capture nearly all opportunities for increased population growth and economic production. All regions of the state share in this growth. Because Option 5 extends today's low transport costs, business has less incentive to purchase goods locally, increasing average truck trip lengths. Continued economic growth throughout the state and the decentralization of this growth because of a more efficient transportation network leads to more overall truck trips on all road types, including local roads.

Option 6 provides the maximum mobility for Oregon business and commerce and provides the maximum increase in population and employment. However, with low transport costs, business tends to buy goods from farther away, resulting in a decentralized economy and the highest

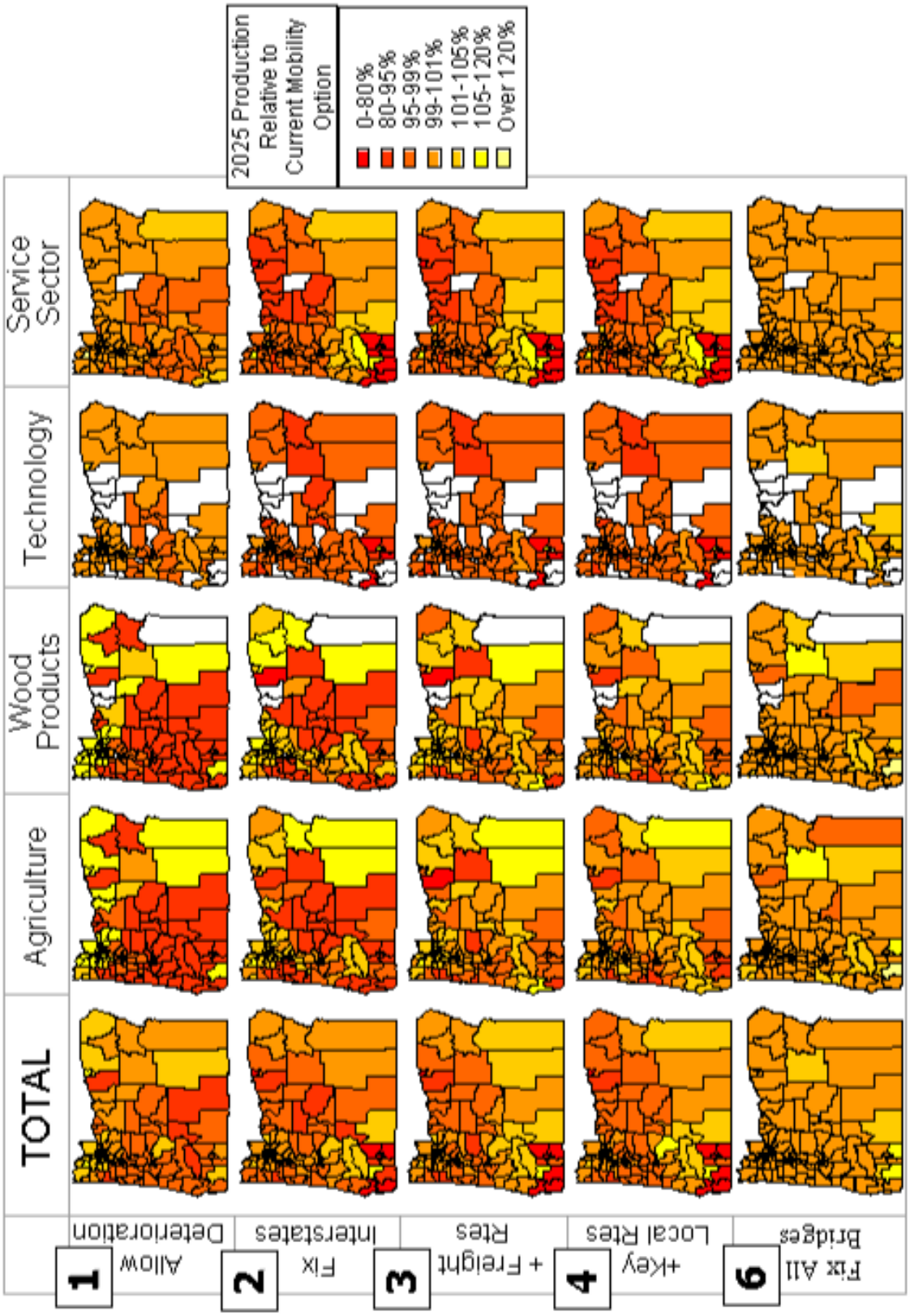


Figure 19: 2025 production relative to current levels

amount of truck miles traveled of any option. Low transport costs also provide little incentive to use alternate freight modes.

Two Courses of Action

Analyzing the initial six options highlighted the fundamental choice facing the state: continue today's level of funding (flat funding) and manage bridge deterioration as much as possible, or invest in a long-term strategic program of bridge improvement. Because bridges are nearing their life expectancy, the decision becomes whether to invest now or later. Additional model runs were made to address the range of choices within the flat funding and investment courses of action.

Course of Action 1: Flat Funding

Actions that could be taken at today's level of bridge investment ($70 million a year) must be considered before additional monies are invested in the Oregon transport infrastructure. The following two actions were modeled.

Allow bridges to be used until they have to be restricted. Today's level of investment is continued to keep the at-risk bridges operating as long as possible. Replacement investments are deferred as long as possible, relying on weight restrictions, emergency bridge repair or replacement as bridges fail. Bridges are initially restricted to 80,000 pounds, affecting 20 percent of statewide truck trips. Without additional investment, further deterioration is expected, resulting in a more severe restriction to 64,000 pounds or less (affecting 80 percent of truck trips). Restricting to 64,000 pounds is a reasonable scenario as the number of restricted bridges increases and emergency funds are insufficient for quick repair response.

Buy Time by proactively restricting all Oregon bridges to preserve the life of the bridges. In an effort to prolong the life of Oregon bridges, all bridges are immediately weight-limited to 80,000 pounds, the maximum weight allowed without special permits. Lower weight limits occur as necessary to protect public safety and to maintain the integrity of the bridge.

Course of Action 2: Increase Investment in Oregon Bridges

Expanding the investment in Oregon bridges has many possible variations. The effect of specific strategies varies significantly depending on the approach, location of investment, and amount of funding available.

Fix All Bridges Immediately. A program to expediently replace deficient bridges is instituted immediately and progress until all deficient bridges are replaced or repaired. Addressing all cracked bridges is estimated to cost $4.7 billion if constructed today.

Staged Investment (Recommended). A less-costly strategic investment in freight corridors begins immediately. Initial investment begins with detour routes (US 97 and US 20) to ensure that freight movement occurs as unimpeded as possible while bridges on the interstates are addressed. The initial stage of this strategy can be implemented by reallocating existing funds.

Results of the Two Courses of Action

As shown in Figure 19, bridge load limits affect how much the Oregon economy grows and where this growth occurs. In response to bridge restrictions, industry can detour or divide heavy loads into trucks that meet the 80,000 lb. or 64,000 lb. restrictions (and ultimately retool their fleet). Either choice increases costs but continues to allow transport of goods. In the longer term, industry can also relocate or leave the state to avoid restricted bridges and this possibility is more likely to happen where bridges are restricted proactively. Proactively restricting all bridges may maximize investment in public infrastructure but at a cost of future growth of the economy. This is particularly true for remote rural areas of the state where heavy goods are a significant part of the local economy and where more restricted bridges are crossed in delivering goods to markets.

ODOT's budget for bridge construction, maintenance and repair was $70 million in 2001. It is estimated that $4.7 billion in 2002 dollars will be required to bring all Oregon bridges to a level that accommodates loads of 105,500 pounds (99 percent of truck tonnage).

Statewide Results

Table 7 shows the change in statewide production relative to the total investment in Oregon bridges under the various courses of action. This table identifies the investment required for each course of action assuming a reasonable projection of 20-year bonding schedule, rates, and fees and the ultimate replacement of all bridges by 2035. It also shows that nearly $14 billion in total statewide production potential is lost over the 2000-2025 period (constant 2003 dollars) when 30 percent of the state's bridges are restricted to 80,000 pounds. This increases significantly to $123 billion when bridges further deteriorate and loads are restricted to 64,000 pounds. This lost production potential is significant, accounting for up to four percent of the total Oregon economy by 2025.

Investing now to maintain and improve today's level of mobility allows a greater statewide growth in production of goods and services than the flat funding courses of action. The recommended strategy represents a realistic compromise. It reaps most of the economic gain from fixing all bridges at significantly less cost.

The model estimates that employment opportunities lost in Oregon by 2025 could be as much as 88,000 jobs as a result of decreased mobility from bridge restrictions (Table 7). This is equivalent to the doubling of unemployment during the 2000-2002 recession where unemployment increased from roughly 4 to 8 percent. These lost growth opportunities are expected to increase over time as the economy is dampened by a growing number of bridge restrictions. In contrast, increased investment continues employment growth throughout the state. The recommended investment strategy retains most of this employment growth with significantly less investment.

Regional Results

Lost opportunities at a statewide level from weight-restricted bridges are significant. Even more significant is the regional variation that occurs under the different courses of action. Different investment decisions influence the economic potential of the various areas of the state due to transport costs and mobility variations. Figure 20 shows the anticipated production growth of select areas of the state and industry sectors under the various courses of action. Employment and

Table 7: Effect of bridge investments on Oregon economy and employment

Economic measure	Flat Funding			Invest	
	64,000 lbs.	80,000 lbs.	Buy Time	Fix All Bridges	Recom-mended
Bridge investment (millions of 2003 dollars)					
Long Term Bridge Investment (2005-2060)[a]	3,100	3,100	2,200	4,900	3,600
Economic effects (millions of 2003 dollars)					
2025 Statewide Economic Output[b]	342,400	354,700	354,100	357,100	356,800
2000-2025 Cumulative Statewide Production3	5,129,70	5,238,300	5,234,900	5,252,400	5,248,700
Gained Oregon Economic Potential (2000-2025)[c]	0	108,600	105,200	122,700	119,000
Lost Oregon Economic Potential (2000-2025)3	-122,700	-14,100	-17,500	0	-3,700
Economic effects — 2025 employment					
2025 Statewide Employment	2,191,400	2,263,100	2,260,500	2,279,200	2,275,800
Gain in Employment by 2025	0	71,700	69,100	87,800	84,400
Loss in Employment by 2025	-87,800	-16,100	-18,700	0	-3,400

a. Present value of bond payment schedule to fix all bridges. Flat funding defers investment until 2020 and Pro-active Restrictions to 2030. Bond schedule assumes 6 percent interest, standard 2 percent for underwriting and fees, 20 year maturity, and a mid-range 3 percent real discount rate.
b. Adjusted only for inflation, assumed at 3 percent per year.
c. Present value of 25 year cumulative state production. Model output originally estimated in 1990 dollars, brought to present value with 3 percent real discount rate, then to 2003 dollars assuming 3 percent inflation rate.

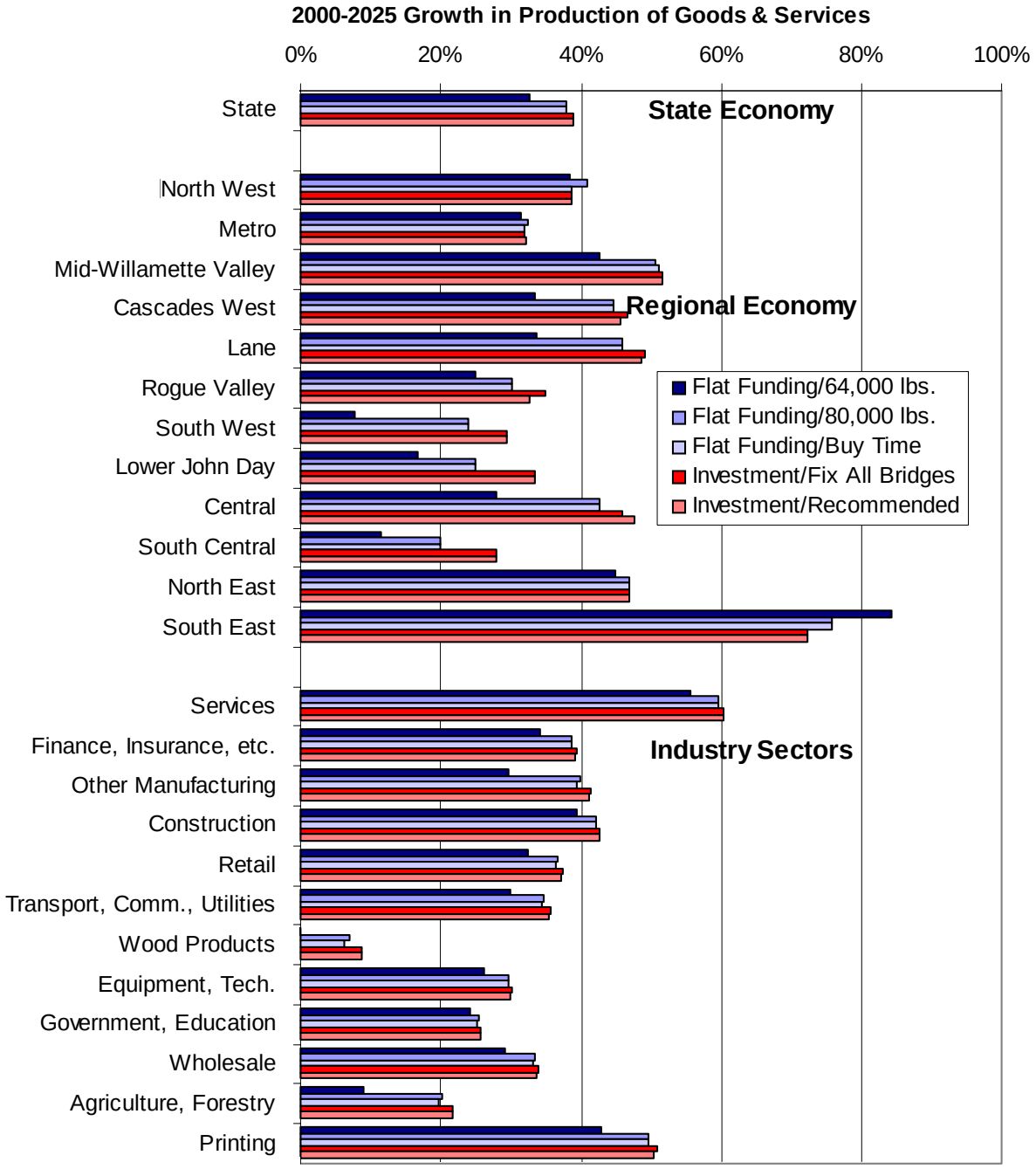
Note: Economic production does not represent the benefits of bridge investment. Production is the value of goods and services produced, not profit, and excludes other user benefits (e.g., operating cost savings). Additional economic potential is expected from near-term construction activity and increased statewide production beyond 2025.

population redistribution is expected to follow these regional trends. Figure 20 shows that a 64,000 lb. restriction on 30 percent of the state's bridges will have significant impact to all areas of the state. Business incurs significant cost to detour or lighten loads to meet these restrictions.

A restrictive transport system favors areas at the borders with unrestricted access to neighboring states. For example, when bridges throughout Oregon are restricted, border cities (Longview, Portland, The Dalles, Ontario) experience growth in production because of direct access to Washington and Idaho markets without detouring around Oregon weight-restricted bridges.

Larger urban areas (Portland Metro, Mid-Willamette Valley) also benefit from flat funding options because they have the advantage of offering more goods within a short distance. This is valuable when mobility is restricted. Central Oregon (South Central, Lower John Day, Central) is significantly disadvantaged with restricted bridges because it greatly reduces accessibility to other states and other parts of Oregon. The high number of cracked bridges in the Rogue Valley and South West areas dampens economic growth under all flat funding courses of action.

Investment provides an unrestricted transport system and avoids the redistribution of economic growth experienced by flat funding. It continues existing growth patterns. Statewide growth relies on the ability to move heavy goods on the interstate system. For the central and remote parts of



Notes: Does not include inflation. High growth rates may reflect a small base employment (South East) while small growth rates may reflect a large base employment (Metro).

Figure 20: Growth in production from 2000 to 2025

the state, unrestricted freight routes and local roadways provide important access to move goods that tend to be “landlocked” when bridges are restricted. Although not a big part of the overall state economy, the health of these areas is dependent upon heavy goods industries and access to key markets in and beyond Portland.

The recommended course of action efficiently invests in selected key freight routes across the state, providing a high-level of mobility at limited cost. The growth rates of the recommended strategy are nearly as high as if all bridges are fixed. The recommended strategy initially opens central freight routes (US 97 and US 20) before tackling costly interstate corridors. As a result, the Central area of the state shows stronger economic growth, while areas in the I-5 corridor south of Portland (Land and Cascades West) incur some dampening of growth in 2025.

Transportation costs relate to the ease in moving both regular and heavy goods around the state. When bridges are restricted to an 80,000 lb. load limit, businesses that primarily make or use heavy goods in their production processes will have to find other ways to transport their products. They can break the product into lighter loads, find alternative routes, find alternative transportation modes or find alternative business locations. Depending on enforcement capabilities, some weight restrictions may simply be ignored, especially for transport of resource products that have no alternative routes (farm products). As bridges continue to deteriorate, the more severe restriction of 64,000 pounds will impact a significantly larger share of freight movement.

Bridge restriction effects contribute to an increase in transport costs. Consistent with regional production findings, Southwest, Central and rural Oregon will incur the highest transportation costs depending on the number of restricted bridges on their routes. In the most severe flat funding courses of action, transportation costs are expected to increase up to 10 percent, averaging 6 percent across all industries statewide. This falls to an average of 2 percent when restrictions are limited to 80,000 pounds.

Bridge restrictions increase costs due to the need to transport in lighter loads or to use detours. A region with fewer bridge restrictions can have lower transportation costs relative to other parts of the state, leading to regional economic advantages. This is especially the case for border areas and the larger urban areas. Southwest, Central and rural Oregon will incur the highest transportation costs depending on the number of restricted bridges on their routes.

As shown in Figure 20, specific industries will bear more of these costs. Most impacted are wood products and agriculture/forestry industries, expanding to manufacturing, printing and other sectors when 64,000 lb. restrictions are imposed. Overall, the model results show that heavy goods industries and the regions that rely economically on them, which already have the highest transportation rates, will see the largest transport cost increases under bridge restrictions.

The investment courses of action open bridges to heavy freight, tempering increases in transport costs. Both investment strategies more equitably share costs across state areas and industries. The recommended strategy results in industry costs and production growth rates that are similar to the action of fixing all bridges.

Community and Environment Results

The number of truck miles on Oregon roadways increase when heavy loads are broken down to avert bridge restrictions. Detours around restricted bridges also increase miles of truck travel. In addition to economic impacts, bridge restrictions will increase truck travel on unsuitable roads and will threaten community livability and environmental quality.

To evaluate these effects, a post-processing analysis was made of the model's output on specific roadway links of interest. This analysis employed a data integration process to tie various community, roadway and environmental data to specific road network links. This data included information from Oregon's Integrated Transportation Information System (ITIS), Oregon's Congestion Management System (CMS), the Oregon Highway Plan (OHP), Environmental Protection Agency non-attainment areas, state and national locations of threatened and endangered species, and Motor Carrier division route restrictions. The majority of the data used came from ITIS, processed to create the OHP and CMS datasets in compliance with the national HPMS data format (e.g., road curvatures). For each category, the analysis identified the 2000-2025 increase in truck VMT on those selected links and compared these results across scenarios (Figure 21).

The community and environmental category definitions used in Figure 21 are drawn from various ODOT data sources as defined below.

Cities/Livability:

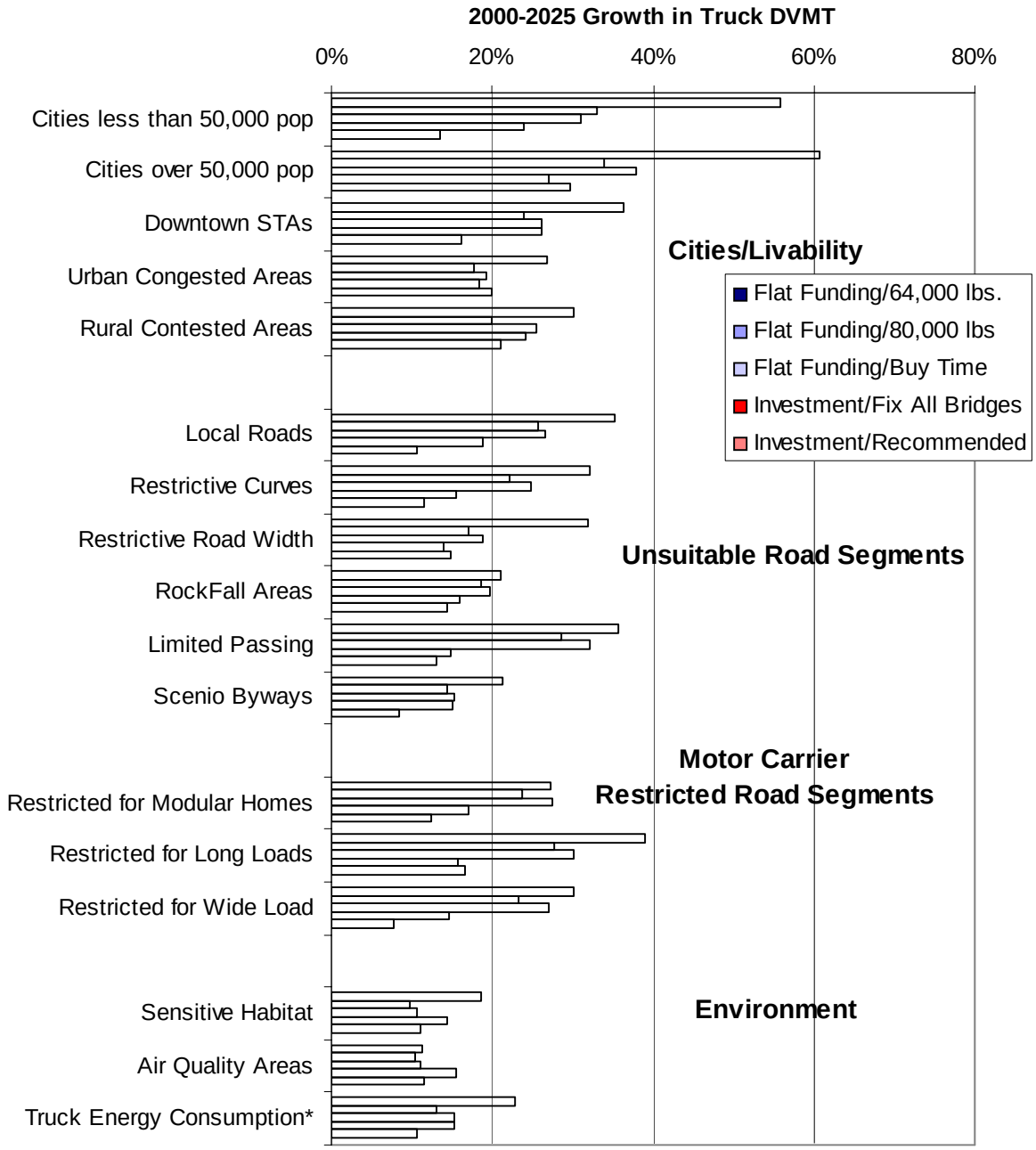
- Cities - local roads in cities above/below 50,000 population.
- STAs - local roads in designated Special Transportation Areas, typically within downtowns.
- Congestion - existing urban/rural congested roadway segments, based on 1999 Oregon Highway Plan mobility standards.
- Scenic Byways - 1999 Oregon Highway Plan designated Scenic Byways.
- Limited Passing - two-lane road segments in rolling/mountainous terrain with no passing.

Unsuitable Road Segments for Trucks:

- Local Roads - urban/rural local roads typically not designed to handle repeated heavy loads.
- Restrictive Curves - curves with a horizontal alignment that is uncomfortable and/or unsafe when traveled at the prevailing speed limit (HPMS data).
- Restrictive Road Width - roadway segments with lanes less than 11 feet and/or shoulder widths less than 6 feet.
- Rockfall Areas - road segments with rockfall/slide danger.

Road Segments Restricted for Oversize Vehicles per ODOT Motor Carrier Division Route Maps:

- Restricted for Modular Homes - restricted road segments for trailer coaches/modular buildings (Route Map 6).
- Restricted for Long Loads - restricted road segments for long trucks (Route Map 7).
- Restricted for Wide Loads - restricted road segments for trucks over 14 feet wide (Route Map 9).



DVMT = daily vehicle miles traveled

Figure 21: Growth in truck traffic from 2000 to 2025

Environment:

- Sensitive Habitat - roadways in locations of observed federal/state threatened and endangered species.
- Air Quality Areas - roadways in designated federal air quality non-attainment or maintenance areas.
- Truck Energy Consumption - truck transportation energy usage.

The analysis identified increased truck traffic on local roads in large and small communities. The growth of truck traffic in cities is significantly greater than that on all local roads for all courses of action. The highest growth in truck traffic by far occurs when bridges are restricted to 64,000 pounds, reflecting the detours and the increase in lightly loaded trucks required under this option. Weight restrictions on local bridges mean that these bridges are not available for detours so overall impacts could be larger than modeled. Communities may also be affected by the inability of local businesses to access the state highway system because of restrictions on local bridges. To minimize undesired impacts, detour routes and industry accessibility need to be coordinated with local communities.

With investment, truck traffic is kept on state freight routes and/or requires fewer trucks to transport the same goods, leading to significantly less impact on local community roads. This occurs despite increased shipping demands with the larger overall economy under these options. Because the recommended investment strategy does not fix all bridges, more truck detours are required with the associated community impacts.

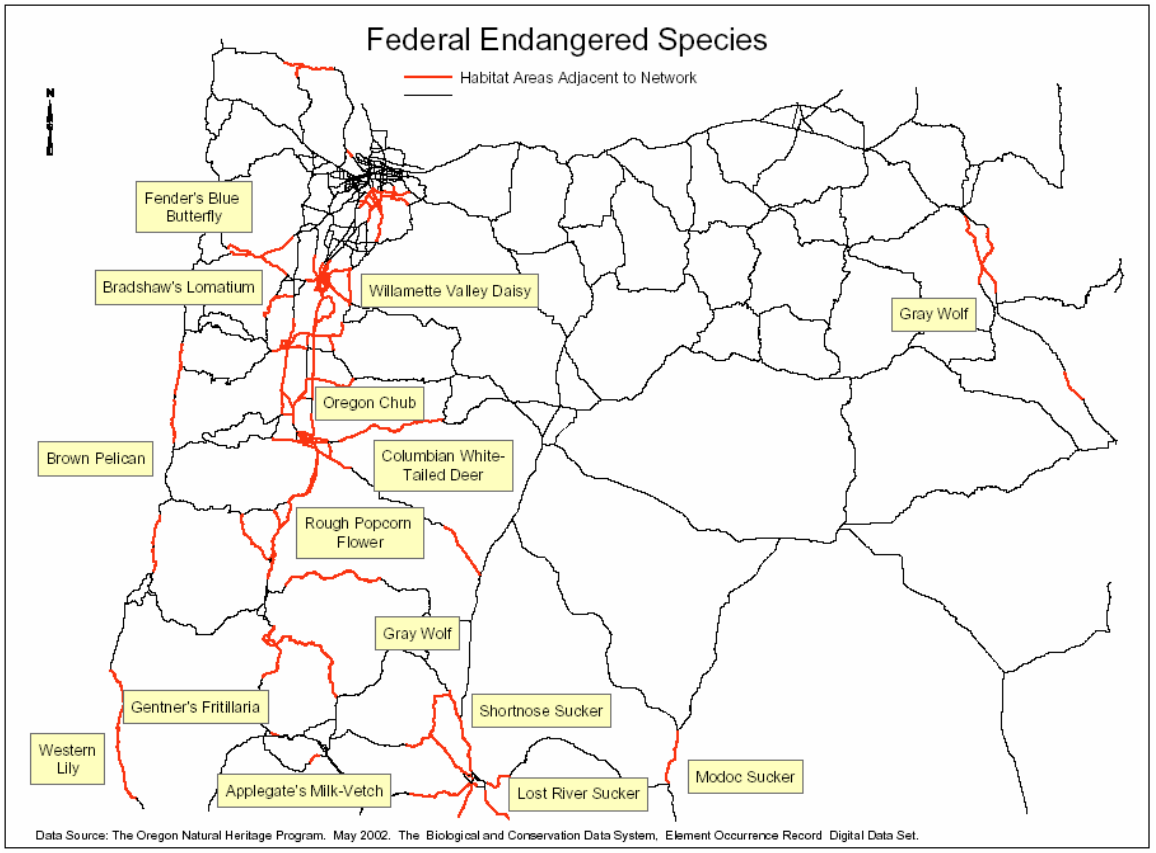
Many roads have restrictive geometry, limited passing, congestion spots and other safety considerations. Scenic roadways are intended to provide an aesthetic opportunity for travelers to enjoy the beauty of Oregon. Increased truck travel on these roadways can increase safety concerns, road maintenance costs and congestion, and can reduce the aesthetic experience of scenic roadways. The analysis shows that the flat funding course of action increases truck traffic on almost all of these unsuitable road sections. Imposing proactive restrictions immediately on all bridges typically has a larger impact than restricting bridges gradually as they deteriorate. Increased travel on local roads is likely to require a significant increase in maintenance costs that are not included in the model's economic results.

Investment allows truck traffic to avoid unsuitable road segments. The low shipping costs that result when all bridges are fixed leads to longer trip lengths in the production and consumption of goods. As a result, this option often has a higher amount of truck traffic than the more restricted recommended investment strategy.

ODOT Motor Carrier Division maintains route maps that identify roadway segments restricted to oversized vehicles, typically due to physical road and corridor conditions. The large increase in truck traffic on these routes means that many detours found in the model will not be available to these oversized vehicles. Either investment course of action significantly reduces truck traffic on these road segments.

Oregon has several air quality non-attainment and maintenance areas: Portland, Salem, Eugene, Grants Pass/Medford, Klamath Falls, Lakeview, Oakridge and LaGrande/Island City. Air quality is directly related to increases in the number of vehicles and vehicle miles traveled within the non-attainment area.

Federal and state designated threatened or endangered species have been observed in almost all areas of the state, so all courses of action have some level of impact. Impacts are also directly related to increases in the number of vehicles and vehicle miles traveled. General habitats for federal endangered species are shown in Figure 22.



ODOT Transportation Planning & Analysis Unit 09/2002

Note: This product is for informational purposes and may not be suitable for legal, engineering or surveying purposes. This information or data is provided with the understanding that conclusions from such information are the responsibility of the user.

Figure 22: Location of selected Federal Endangered Species

Some species exhibit road aversion, with their densities decreasing near roads (e.g., elk, black bear, white-tailed deer). Certain bird species avoid roads or the forest edges associated with roads. Some species refuse to cross barriers as wide as a road, fragmenting populations. If not mitigated, higher traffic volumes on remote roads can increase road kills. Habitat can also be polluted beginning with road construction and continuing with higher traffic volumes and road maintenance. Increased noise inhibits wildlife communication and increases animal stress.

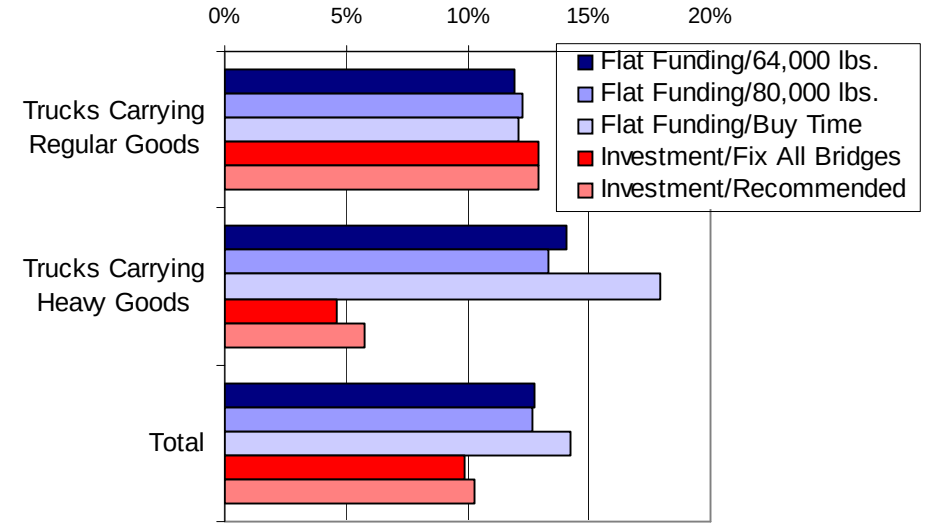
Vehicle pollutants, such as heavy metals, emissions, lead contamination from gas and tires, can also affect wildlife health. Lead in particular increases with traffic and moves up the food chain. Earthworms have been found to accumulate heavy metals in concentrations high enough to kill earthworm-eating animals. Salt and chemicals used in maintenance, such as de-icing and dust control, can also impact habitat health. Bridges over streams typically alter the stream and restrict passage of fish. Erosion caused by roads and bridges both during and after construction can lead to increased sedimentation, especially troubling for Salmon spawning grounds.

Surprisingly, a fix all bridges investment rivals the most restrictive flat funding course of action for the largest impact to habitat and air quality areas. The fix all bridges course of action results in

the largest overall economy and increased decentralization (because of low transportation costs) placing more trucks on all roadways. Energy use, closely tied to VMT, is largest under the most severe flat funding strategy with significantly more trucks and detour truck miles. Overall, the recommended strategy has one of the lowest impacts in all environmental categories.

Transportation Results

Transportation impacts are defined by changes in the amount of product transported, total amount of heavy truck traffic, and average trip length. Figures 23 and 24 show transportation impacts for heavy and regular weight commodity groups (not truck weight groups). These figures compile many interacting factors including increased detour trip lengths, congestion incentives to buy locally, and increased number of lighter trucks to carry the same goods.



Note: Does not include intrazonal trips.

Figure 23: Growth in daily truck trips from 2000 to 2025

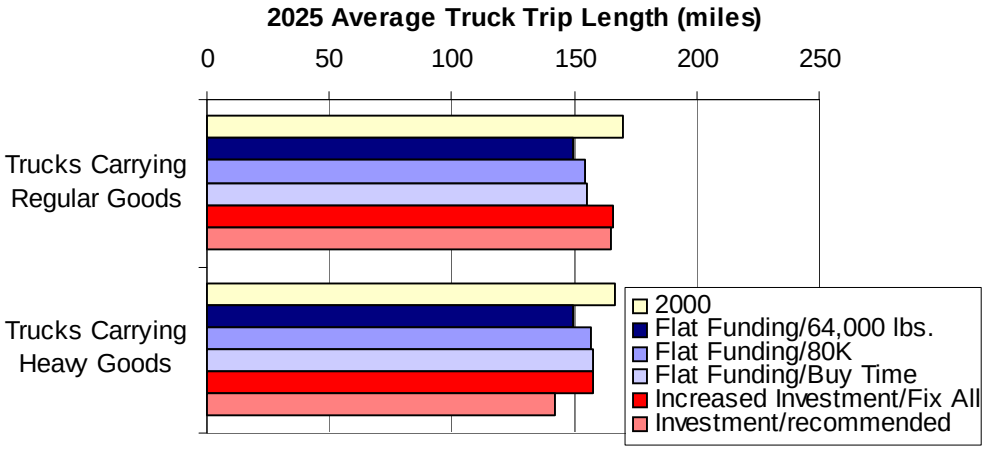
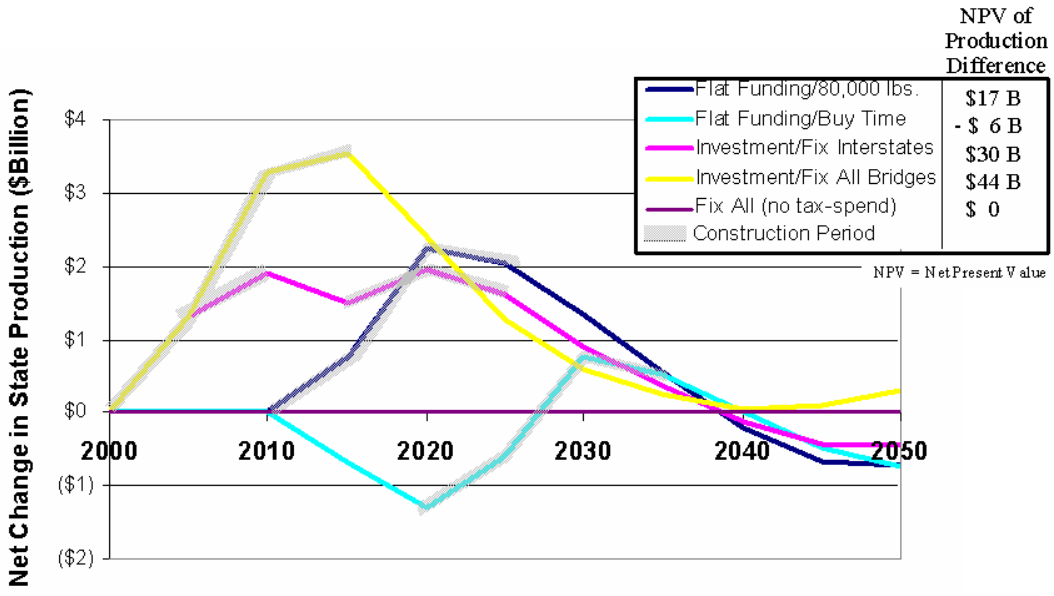


Figure 24: 2025 average truck trip length



Note: Compared to Investment/Fix All Bridges base case, without taxation.

Figure 25: Economic impact of construction spending and revenue generation

Increased bridge weight restrictions result in more truck trips to carry heavy goods that are typically shipped in trucks over 80,000 pounds (Figure 23). This results primarily because these industries distribute their heavy goods to lighter trucks. This trend is most pronounced when all bridges are restricted to 80,000 pounds. Restrictions below 80,000 pounds will further increase the number of truck trips for all goods, and is likely as bridges deteriorate under both flat funding courses of action. There is less change in the trips required to ship regular (non-heavy) goods. These goods typically ship in less than 80,000 pounds and would only be impacted by the 64,000 lb. restriction or a change in the overall size of the economy.

When transport costs are low, business tends to buy goods from farther away. This results in a decentralized economy and longer trips (Figure 24). The average distance to ship heavy goods is expected to grow when bridges are restricted because of detours to avoid the restricted bridges. This is countered by a shift to lighter trucks not subject to detours and shorter trips when transport costs are high.

Construction Spending and Taxation Results

Expenditures to repair or replace components of the transportation infrastructure serve two purposes. The investment in state and local bridges maintains accessibility, avoiding loss of jobs and productivity growth in the long term. Additionally, the dollars spent on construction of bridges throughout Oregon will sustain family wage jobs in the near-term. These jobs, in turn, generate income that is spent on goods and services and income taxes for the Oregon General Fund. Countering this bridge investment economic stimulus is the increase in travel costs due to taxation, required to generate the bridge investment revenue, which has a damping effect on the economy. The statewide model was used to assess the net economic effect of bridge construction activity and the taxation measures to generate these construction funds.

Figure 25 shows the net effect of these actions on statewide production. Bridge construction periods are also noted. The results are plotted relative to the Investment/Fix All Bridges course of action assessed earlier without construction spending or taxation effects.

As shown in Figure 25, investment provides a near-term economic stimulus, amounting to nearly $4 billion in additional statewide production under the Fix All course of action and nearly $2 billion under the Fix Interstates (comparable to the recommended strategy). Once the construction period ends, this economic stimulus is dampened by the 20-year taxation necessary to generate these funds. The Flat Funding/Buy Time course of action proactively restricts all bridges, limiting freight mobility and leading to a decline in overall near-term production. This decline is reversed when all bridges are replaced by 2035. In the Flat Funding/80,000 pounds course of action, bridge investment is begun before sufficient bridge deterioration is allowed to occur (2010+).

By 2050, most of the courses of action arrive at a similar statewide production level, approximately $1 billion lower than the baseline option that assumes no taxation. It is unclear why the early surge of the Fix All investment results in the larger 2050 statewide production. Perhaps the other courses of action will show similar results beyond the modeling timeline or the higher VMT of the Fix All leads to over-taxation in this alternative.

The net present value (NPV) of each course of action exceeds the untaxed base case in all but the Buy Time course of action. Early investment avoids the impacts of bridge weight restrictions on the economy and the construction stimulus, in present value terms, exceeds the 20-year taxation that follows.

This analysis is valuable to a state that is advocating economic stimulus in the face of the 2000-2003 recession. The analysis and long-term view gives a more dynamic understanding than economic multipliers typically applied to construction expenditures. The model can also be used to assess the economic effects of variations in taxation schemes (e.g., cost allocations among user groups).

Impacts on Non-Divisible Truck Loads

The 26,000 non-divisible single trip permits issued in fiscal year 2001-2002 represent about 70-100 truck trips per day, or one percent of statewide truck trips. These trips are important as they include transport of unique goods, including construction equipment and bridge beams. Without investment, the bulk of these heavy trips in 2025 (up to 90 percent) will need to cross at least one restricted bridge. Only after the interstate and freight routes are fixed does the level of trips blocked by bridge restrictions decline to a reasonable level (9 percent). In reality, many of these trips will be granted the right to use restricted bridges on a single-time basis only.[7] This is evidenced in the one percent of trips the model found to be blocked by bridge restrictions in 2000.

If all bridges are restricted immediately (Post All), 90 percent of the non-divisible trips are blocked and almost no detours are available (Figure 26). When restrictions occur more gradually (Flat Funding), bridge restrictions impact 63 percent of the trips by 2025. The widespread nature of the bridge restrictions blocks 60 percent of the non-divisible trips and allow three percent to

7. Single-trip permits are issued through ODOT's Motor Carrier Transportation Division. Permits over 304,000 pounds (above Weight Table 5) require specific engineering analysis from ODOT Bridge staff.

detour. Opening the interstates to heavy loads (Fix Interstates) cuts the blocked trips in half and triples the number of detoured trips. When the Oregon freight routes (Interstates/Freight) are also opened, the blocked trips drop to less than 10 percent with seven percent detoured. This approximates the impact of the recommended investment strategy. However, since the recommended strategy provides statewide coverage without opening all freight routes, it will likely incur more detours.

Of the unblocked single permit truck trips, most retain their optimum route rather than being detoured around bridges. When detours are used, Figure 27 shows that they generally add less than 20 miles to the trip, but can add up to 200 miles.

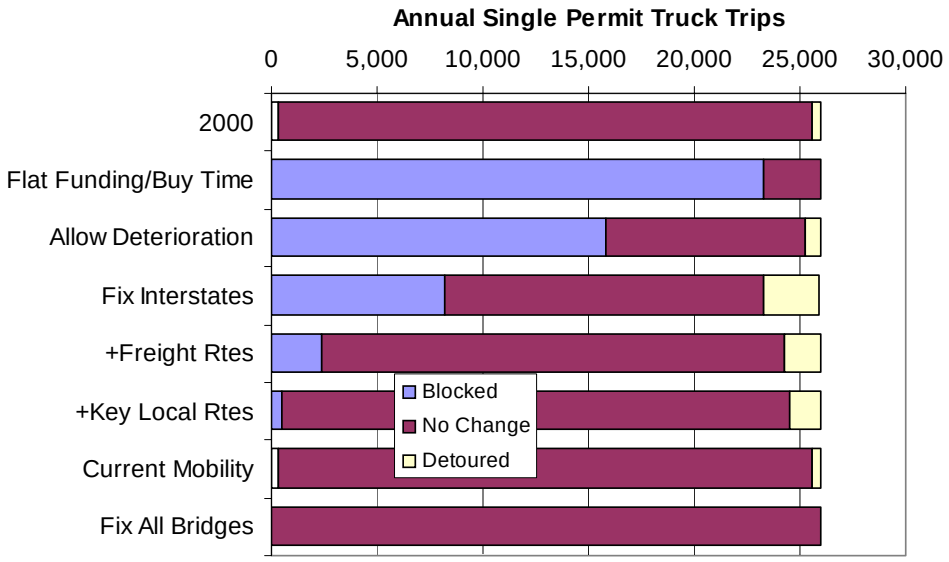


Figure 26: Annual single permit truck trips impacted by bridge restrictions

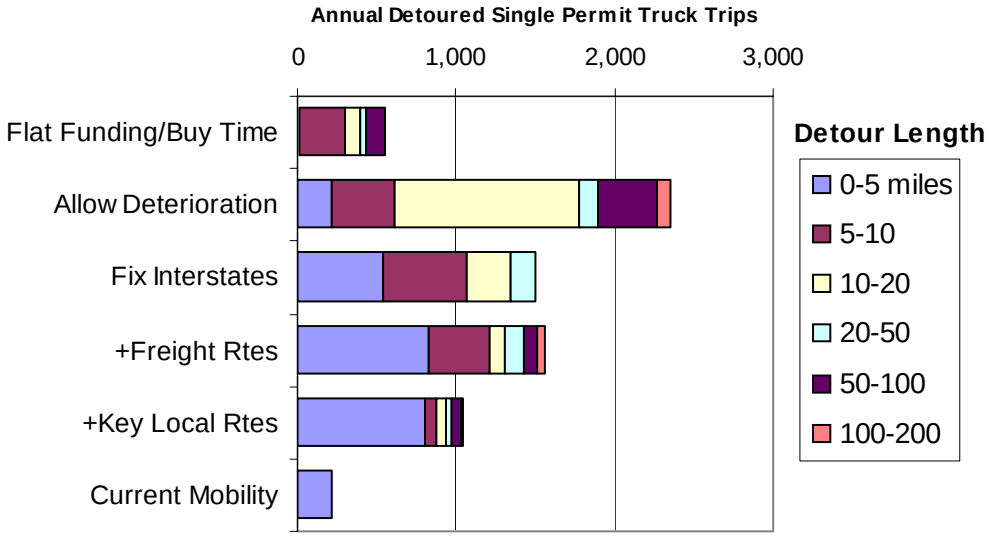


Figure 27: Annual single permit truck trips length of detours

IMPLEMENTATION

In determining how and in what order to address the significant bridge cracking problem, the EBOT considered the findings of the economic modeling process, the number of problem bridges on each road corridor, the cost to address each deficient bridge, and the needs of heavy freight haulers. EBOT members worked with the owners and users of the system, including counties, cities, the Federal Highway Administration, Oregon Truckers Association, American Automotive Association and others. The process of developing a recommendation to the OTC involved many discussions on impacts and tradeoffs among the courses of action.

ODOT Recommendations

The OTC, the Governor and the Oregon Legislature have placed increasing priority on the bridge program and have shifted funds in that direction over the last four biennia. The 2003-2005 bridge budget request is well over a 100 percent increase above the 1997-1999 Biennium. The percentage of the ODOT Highway Fund budget allocated to the bridge program has more than doubled in the same period. Although there are other priority areas, this component of the ODOT budget increased more in percentage terms than any other major element of the budget, maximizing the level of support for bridges within current revenues.

ODOT and its local city and county partners estimate that it will take approximately $4.7 billion to replace or repair all state and local problem bridges in the state. The magnitude of the problem is such that efforts by the OTC and ODOT to redirect existing resources to the bridge problem are insufficient to make a significant impact on what needs to be done to forestall economic impacts to state and local economies caused by inadequate bridges.

Many bridges in Oregon will not be funded under this recommendation. Funds will be needed for short-term repairs to address emergencies that arise on other bridges. This will ensure that bridges can accommodate traffic until funding for more permanent repairs is available. For purposes of this analysis and per the recommendation of the Bridge Task Force, planned repairs will occur if they will last 10 years and will support loads of at least 105,500 pounds. However, emergency repairs are likely to be less stringent. In some cases, these repairs may only be able to accommodate 80,000 lb. loads. These emergency funds will be used on an as-needed basis until they are depleted. Any excess emergency funds will be applied to planned investments in subsequent stages.

The following recommendations were formulated through this process. These recommendations were used to begin the discussion with the OTC, the Governor, the Legislature and the Oregon public in early 2003 to define a strategy to fund and resolve the bridge issues.

Recommendation 1

Put an investment package into place immediately to begin a strategic repair and replacement program for Oregon bridges. The following priorities should guide this investment:

- Fix the interstate freight routes to keep heavy trucks on the interstate and off local roads and streets.
- Fix important freight routes that need only minor amounts of improvements.
- Fix economically critical city and county bridges as they connect directly to each recommended stage.
- Develop a funding strategy that will allow sufficient funds to be available to address emergency repairs or replacement of bridges that have an impact on economic vitality while the corridor work progresses.

Recommendation 2

Implement the strategic investment plan in stages that build on each other over the next 10 years. This will minimize impacts to state and local economies and to users, while maximizing results at lowest cost. Funding for bridge emergencies will play a key role in keeping Oregon's economy moving. However, there may be some routes that are less important to the economy that will see load-restricted bridges for the duration of this strategy in order to maximize resources for more important routes. The amount needed for emergency spending is identified for each stage and will decline as restoration of all bridges in each corridor is complete.

Recommendation 3

Numerous strategic and operational changes will also be necessary within ODOT to meet the challenge of maintaining the transportation infrastructure over the next 10 years. This will include reallocating staff to manage and implement this program, pursuing additional funding for future stages, and investment in technology and data storage/retrieval systems to increase efficiency and effectiveness.

Recommended Staging

Recommended stages include the bridge repairs and replacements and emergency bridge funding summarized in Table 8. The stages are also shown graphically in Figure 28.

Table 8: Recommended stages for bridge repair/replacement

Stage	State Bridges			Local Bridges			Total Cost ($ million)
	# bridges repaired	# bridges replaced	Cost ($ million)	# bridges repaired	# bridges replaced	Cost ($ million)	
1	4	21	73.4	0	24	27.3	100.6
2	19	78	428.1	0	41	55.6	483.8
3	35	53	298.7	0	23	37.9	336.6
4	15	60	311.6	0	14	69.1	380.7
5	11	57	303.9	0	24	86.4	390.3
Other	2	6	7.9	0	0	0	7.9
Total	86	275	1,423.6	0	126	276.3	1,699.9
Emergency funding if all stages are constructed							300.0

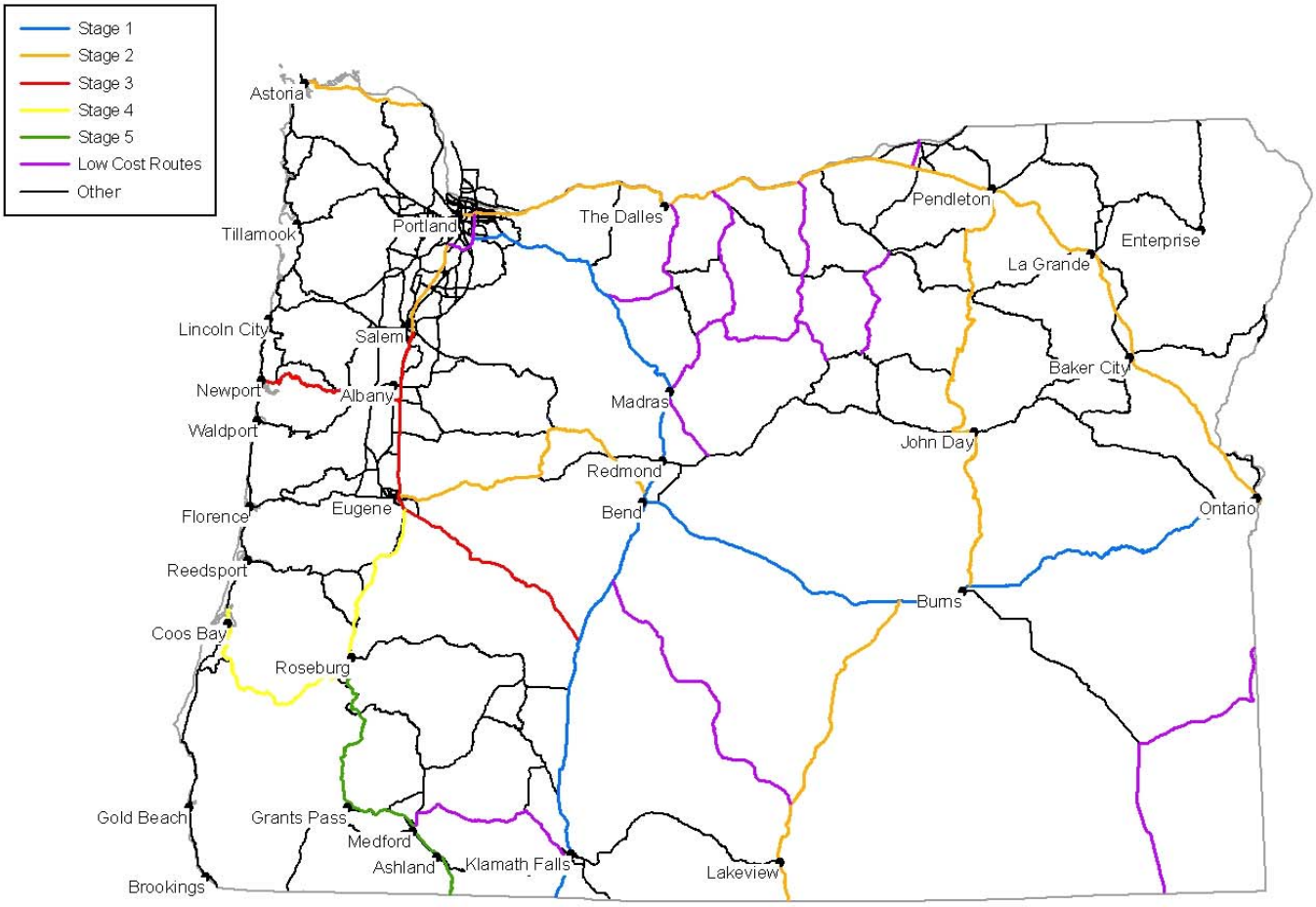


Figure 28: Recommended stages of bridge improvements

The cost to address the state and local problem of cracked bridges is estimated at $4.7 billion. This recommendation is a less costly 10-year program to correct the deficiencies on the most important freight routes and the local bridges that support these routes. The amount needed for emergency spending is identified for each stage and declines as more stages are funded, leaving fewer bridges at risk. The recommended plan does not include repairs and replacements required beyond the 10 years of the program. Additionally other bridges in the state that are not cracking will still exhibit the wear and tear caused by age and significant use. Additional funds will be required in the long term to address the entire state and local bridge needs.

- *Stage 1:* Stage 1 creates unrestricted north-south and east-west freight routes for heavy loads while interstate highway bridges are under construction and/or remain weight-limited. The number of state and local bridges addressed in this stage is relatively low. However, this stage can be completed with current ODOT revenue by redirecting resources and using innovative financing options. All subsequent stages will require new revenue. This provides the maximum freight mobility as quickly as possible at least cost.
- *Stage 2:* Stage 2 is the first to begin directly addressing the interstates, which are the backbone of the Oregon economy and serve national defense purposes. It completely fixes I-84 and addresses I-5/I-205 south to Salem. In addition, it improves Highway 395, an impor-

tant north-south route for industries in eastern Oregon. This stage also provides heavy haul access to the Port of Astoria.

- *Stage 3:* Stage 3 continues work on I-5 to the Highway 58 connection just south of Eugene. It also addresses key connector routes from I-5 to central Oregon and heavy haul access to the coastal Port of Newport.
- *Stage 4:* Stage 4 continues working south on I-5 to Highway 42 south of Roseburg. This stage provides heavy haul access to the Port of Coos Bay.
- *Stage 5:* Stage 5 completes I-5 from Roseburg to the California border.
- *Individual Low-Cost Routes:* In addition to the bridges on the staged routes described above, selected bridges that return high value at low cost will be improved concurrent with Stage 1. These bridges open corridors in timber and agriculture production areas with benefits to the local and state economy.

Tradeoff Considerations

The recommended investment strategy is the culmination of a process that included many participants and substantial amounts of information from a variety of sources. Participants in the development of the recommendation are listed in Appendix E.

Alternative east-west and north-south routes that can be improved quickly and at least cost serve as detour routes for subsequent stages of the work to restore the interstate system, such as using Highway 97 as a detour route for south I-5. These subsequent stages address the bridges on I-84 and begin the I-5 work from north to south. As the work progresses southward on I-5, lateral routes are fixed that will reconnect the coastal ports and Central Oregon with the Willamette Valley.

Figure 29 identifies the relative importance of network roadways in connecting Oregon activity centers. A unitary origin-destination matrix (connecting all origins and destinations with one trip) was loaded onto the network. The results show the links required to connect all zones via the optimal path. Links that are used multiple times are more important to connectivity. Additional model runs were used to identify routes that truck traffic will use to reach the coast and internal Oregon (US 97) if portions of I-5 are blocked, as assumed in the recommended strategy stages. Relative truck volumes indicate the desirability of alternate routes to meet the economic transactions (e.g., port activities) embodied in the model. Near-term results from 2005 are used, so business is unable to relocate to better serve these needs. These rough order-of-magnitude findings were helpful in arriving at ways to reach key economic centers with both low bridge investment and low economic impact.

Interstates are Top Priority

The earlier Bridge Task Force Report recommended improving all interstate (I-5, I-84, I-205) bridges as a first priority in recognition of the state and national importance of these freight routes. Seventy-five percent of state production lies along the interstate corridors, which are also an important component of the national freight system. The top priority to repair interstate bridges was reaffirmed by the OTC. The EBOT agreed with this assessment and looked at strategies to

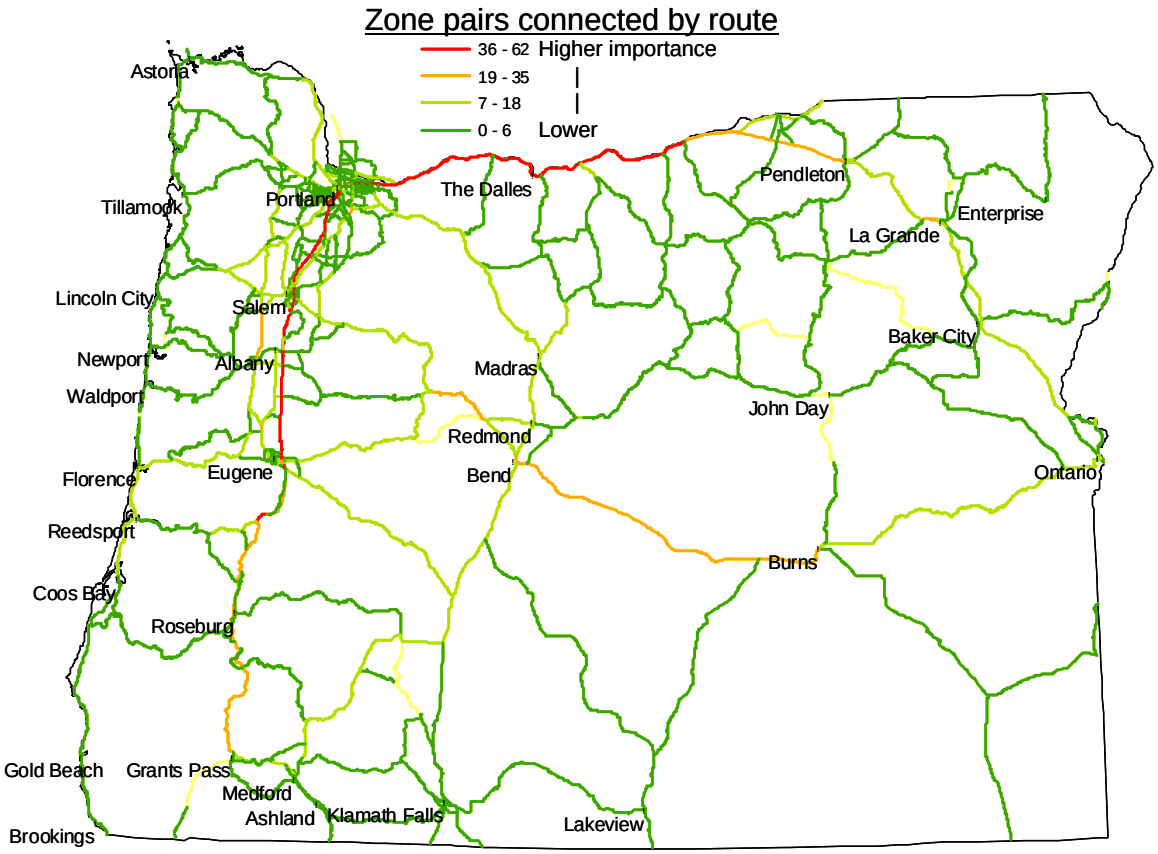


Figure 29: Route importance to connectivity

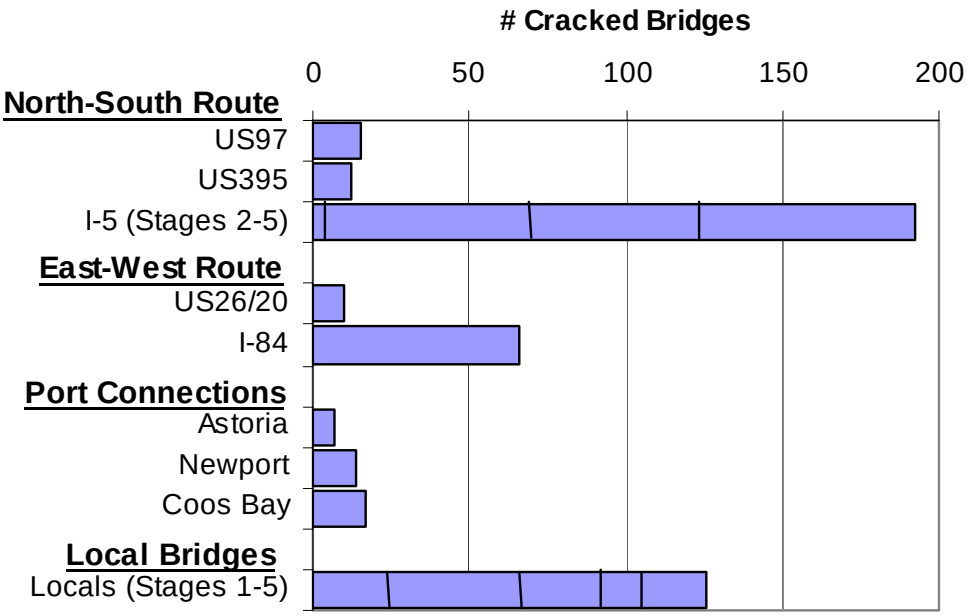


Figure 30: Number of cracked bridges by route

improve the interstate system as quickly as possible. An important part of the recommended strategy is to improve interstate bridges while maintaining critical freight movement throughout the state and minimizing impacts to local communities and local economies.

Prudently Set the Stage for Long-Term Construction on the Interstate System

As shown in Figure 30, the interstate routes are the most expensive way to restore east-west and north-south access across the state. The estimated cost to restore all 271 of the bridges on the interstate system is $1.2 billion. Almost half of this cost is incurred on I-5 south of Eugene.

Replacing and repairing this many bridges on the interstate system means years of construction with associated delays and truck detours through local communities. Even with extraordinary care to keep traffic moving, there will be unavoidable delays throughout construction. Addressing multiple bridges at the same time will reduce the duration of construction but will increase traffic disruption.

Disruptions from planned construction projects will likely be compounded by disruptions from unplanned bridge failures. Delays in addressing bridges on interstate and key freight routes will increase the likelihood of emergency repairs and their associated traffic delays and community detours. The large number of bridges along southern I-5 makes it particularly vulnerable.

To avoid the impacts described in the Preface (the “Riddle effect”), the EBOT looked for low-cost alternative routes that could be completed quickly at low cost. The projects included in Stage 1 can be completed within the existing ODOT budget and provide a heavy haul detour route to accommodate both north-south and east-west traffic. These projects will enable uninterrupted freight flows while planned and unplanned disruptions occur on the interstates and elsewhere.

Stage Investment to Access Important Oregon Economic Centers

It is unlikely that the total amount needed to repair all cracked bridges on the state highway system will be available immediately. Therefore, a 10-year $2 billion phased approach was taken to prioritize projects that build on each other and begin to repair Oregon bridges while keeping freight moving to all areas of the state. It is recognized that since this is an expensive long-term program, difficult tradeoffs will be necessary. These tradeoffs will affect the overall Oregon economy and the location and timing of investment will affect regions of the state differently.

It is logical to assume that simply improving I-5 and I-84 bridges addresses the most important freight corridors in Oregon and therefore is where money should be invested immediately. It is true that the interstate corridors carry the bulk of the Oregon economy. However, improving only the interstate system essentially “land locks” the rest of Oregon since cracked bridges on other state and local roads block access to the interstate system. If trucks cannot use these off-interstate roads because of restricted bridges, the economy in regions removed from the interstate corridors will be depressed. Central and coastal areas will be most severely impacted.

Oregon businesses have a significant level of trade outside the state but all Oregon traffic requires some level of local distribution. The EBOT was concerned that fixing the interstate routes first would give in-state distribution secondary priority to out-of-state needs for through traffic. In many cases, local economies will be severely impacted by isolation caused by bridge restrictions.

Providing a reasonable detour to I-5 and I-84 first not only addresses maintaining major freight routes and through traffic statewide but it also maintains access to central Oregon. The statewide model indicated that an initial investment in US 97 before I-5 could boost central Oregon economies, with traffic naturally shifting back to I-5 when reconstruction is complete. The Rouge Valley economy connects to US 97 via the Lake of the Woods Highway (OR 140) under Stage 1 and I-5 will continue to be open, barring bridge emergencies. Although the Rogue Valley economy in southwestern Oregon will still suffer initially, the model shows a recovery when southern I-5 is tackled within the recommended 10-year period.

Once major detours are established relatively quickly and inexpensively in Stage 1, EBOT recommends that investment shift to the formidable task of the interstates. The entire I-84 corridor is improved in Stage 2 and I-5 is addressed starting in Portland and moving south. Each stage moves successively south on I-5. The Roseburg to the California border segment was recommended for a later stage as it includes nearly half the bridges to be repaired or replaced on the interstate system.

As investment on I-5 moves south, those state and local roads important to connect ports and other areas of economic importance are improved as well. For example, as the I-5 section from Portland to Salem is improved in Stage 2, access to the Port of Astoria is improved at the same time. In Stage 3, as I-5 is improved from Salem to Eugene, the Port of Newport and Central Oregon are connected with the Willamette Valley. Stage 4 improves I-5 from Eugene to Roseburg and connects the Port of Coos Bay with the Willamette Valley.

Several bridges not included in Stages 1-5 will provide substantial accessibility benefits for minimal cost. For $7.9 million, eight bridges can be restored that open several entire corridors in the Portland area and central and eastern Oregon. Because this limited investment quickly opens entire corridors with benefit to the local and state economy, it is included concurrent with Stage 1.

Funds for Emergency Repairs and Remaining Bridges

It is estimated that without investment, 30 percent of the bridges in Oregon will be weight restricted by 2010 and an increasing number of bridges will require emergency repairs. Deferred investment on bridges not included or in later stages of the recommended strategy makes them susceptible to unanticipated bridge failures. Emergency repairs, such as those required at Sauvies Island in the Portland area and the Coles Bridge in John Day Valley, will become more and more common as bridges approach the end of their useful life. EBOT recommends a contingency fund be made available to allow ODOT to quickly respond to bridge emergencies. This fund is anticipated to decrease as planned investments restore more bridges, particularly on key freight routes across the state. Investment will also be necessary beyond the 10-year recommendation for those cracked bridges not addressed in the near term.

Local Connections are Critical

Addressing the cracked bridges on Oregon’s interstate system is critical. Addressing major state freight corridors are just as critical to sustain business in all areas of the state. These freight routes in turn are accessed via local roads and bridges that serve businesses of local and regional importance. If local bridges are not part of the overall bridge improvement strategy, major Oregon businesses may be unable to access markets, and local and regional economies will be severely impacted. At this time, the focus has been on identifying the interstate and state freight routes that

are most critical to the state and regional economy of Oregon. As this strategy is refined and projects within each stage are better defined, the local bridges needed to support key local economies will be identified as well.

The Funding Discussion

When the cracked bridge problem was first identified, ODOT responded to the “crisis” with alarm. After the initial model runs (restricting trucks over 80,000 pounds), it was clear that Oregon does not face a statewide “crisis” at this time. It likely will not face a crisis provided that adequate funding is applied to repair or replace cracked bridges over the next ten years. This more carefully considered premise was taken to the Governor and the Legislature - that significant investment in Oregon bridges is required to maintain the flow of goods and services throughout Oregon. If this basic investment is not forthcoming, bridges will be weight limited over time and the resulting impacts on Oregon jobs and the economy will be substantial. The number of small Oregon towns facing safety and livability concerns as heavy trucks are detoured around emergency load-limited bridge restrictions will increase in frequency if the bridge problem is not addressed.

ODOT started the discussion with the Oregon public, the press and lawmakers as soon as bridge inspections revealed systemic cracking. Regular press briefings kept the issue in front of the public and lawmakers throughout the studies and modeling activities. Each time a bridge was weight-limited, the posting and subsequent heavy truck detours through small communities was documented for the public. By the time the Economic & Bridge Options Report was submitted to the OTC, detailing economic and job loss, there was a high level of public awareness of the issue and general acceptance that something must be done. Working closely with the news media from initial identification throughout the problem-solving discussion and final Legislative action was important.

It was a challenge at the beginning for users to understand the statewide model. The model and its findings needed to be communicated to a wide audience with varied interests and technical skills, including the ODOT Bridge Section, truckers, elected officials and other model users. The importance of reasonable input assumptions was not always clear. For example it was not until bridges were restricted to 64,000 pounds that a statewide crisis became evident. This caused many to assume that the model was not providing useful information, when it was the input assumptions that were driving the results. As discussions continued and additional model runs were made at different truck weights, it became clear that the model produced reasonable and logical results that were useful in understanding the complex interplay between transportation investment and the economy.

ODOT senior management gave many presentations and had many discussions with the Governor and members of the 2003 Legislature about increased bridge funding. The theme of the discussions was job loss and impacts on the Oregon economy. The numbers generated by the model were quantified in local terms to increase understanding, e.g., potential job losses were compared to employment levels at Intel, Oregon’s largest employer, or to the State’s recent downturn in the employment rate. The model’s quantitative findings on the impact on local and regional economies from bridge restrictions was of great importance to Legislators as they considered the impacts to their constituents. The emphasis on developing a fully repaired detour route as the first

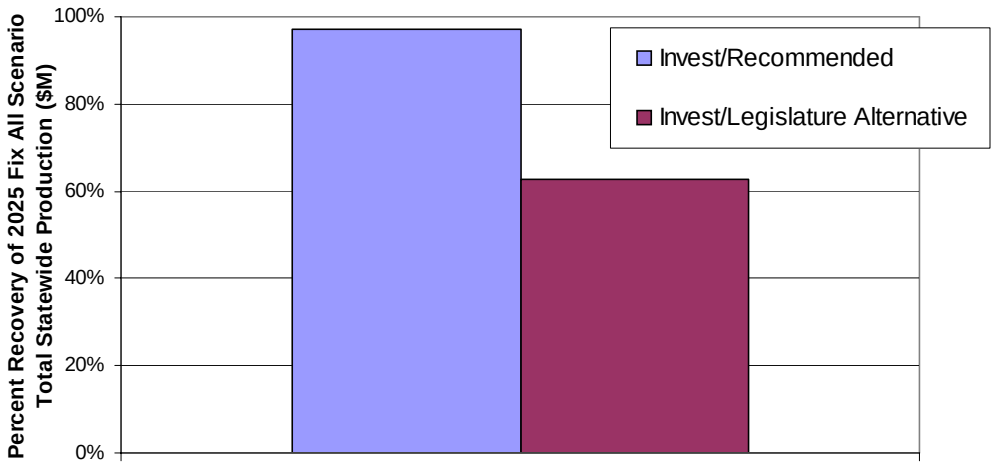


Figure 31: House Bill 2041 funding estimated results

stage, before tackling the more expensive and greater number of bridges on the interstates, was supported by quantitative model results that documented the economic benefit to the more remote regions of the state. The discussion ranged from specific details - “when will my bridge be rebuilt?” - to policy level discussions on how a bridge improvement program will stimulate a depressed overall Oregon economy and job market. The model was useful in providing objective data to inform these high-level “what if” discussions.

After the Legislative discussion began, an additional model run was completed to assess the impact of a lower funding level proposed by the Republican House legislators. This model run used the proactive bridge posting solution (Flat Funding/Buy Time) but assumed that less funding for investment and emergency repairs resulted in more severe bridge restriction of 64,000 pounds, rather than the 80,000 pounds assumed in the earlier run. The results shown in Figure 31 are compared to the recommended alternative. The previous model runs found that the recommended staging plan recovered 95 percent of the benefit of fixing all the bridges (i.e., measured relative to the 2025 total production of the Investment/Fix All scenario). The Legislature’s lower funding scenario, with its more severe weight limitations, recovered only 65 percent of the potential losses. These findings convinced legislators of the need to fully fund the recommended staging plan.

The model runs in the initial report sufficiently bounded the alternatives and addressed most questions posed by legislators. The time required for additional model runs generally precluded use of the model during negotiation in the Legislative session, as answers were needed in hours not days. The impact on the heaviest indivisible trucks (Weight Table 5 loads over 304,000 pounds) became an issue and many permutations of options were proposed. Because of the time required to set up and run the model, it was not used in these discussions. Given more time, information on how the Oregon economy affects the larger Pacific Northwest economy also would have been useful.

The value of the model as a decision-making tool was not readily apparent to many early in the process. At the end of the process, however, the model and the information it produced were considered critical to the success in obtaining funding for Oregon bridges. It was felt that the model

took away an excuse to vote “no” by providing scientific information that gave credibility to the funding proposal and allowed ODOT to aggressively direct the process. Once the assumptions were made clear, no one disputed the problems with Oregon bridges or the economic impacts. From then on, the discussions primarily revolved around what projects would be included in what stages. Staging was adjusted to address specific OTC and Legislative concerns for their districts and local economies.

The headline of the impacts of bridge restrictions on jobs and the Oregon economy grabbed and held the attention of the Governor and the Legislature. It was recognized that many of the products that heavy trucks transport, such as construction materials to new building sites, not only create new jobs, but also are essential to economic development. From this discussion, the amount of income tax generated by the new jobs became the focus.

In July 2003, after much discussion and debate, House Bill 2041 was passed and signed into law to provide $2.5 billion to fix hundreds of cracked bridges across the state. The staging approved by HB 2041 is show in Figure 32.

The bill provides the largest infusion of new money in Oregon’s road system in decades. It increases driving-related fees for private autos and commercial truckers - from registration and title fees to the cost of the driver’s license test. Part of the money will be bonded to raise the $2.5 billion over the next ten years.

At the next Legislative session, HB 2041 requires ODOT to quantify how many jobs are actually created and how much is added to the economy from the $2.5 billion investment. Clearly-defined

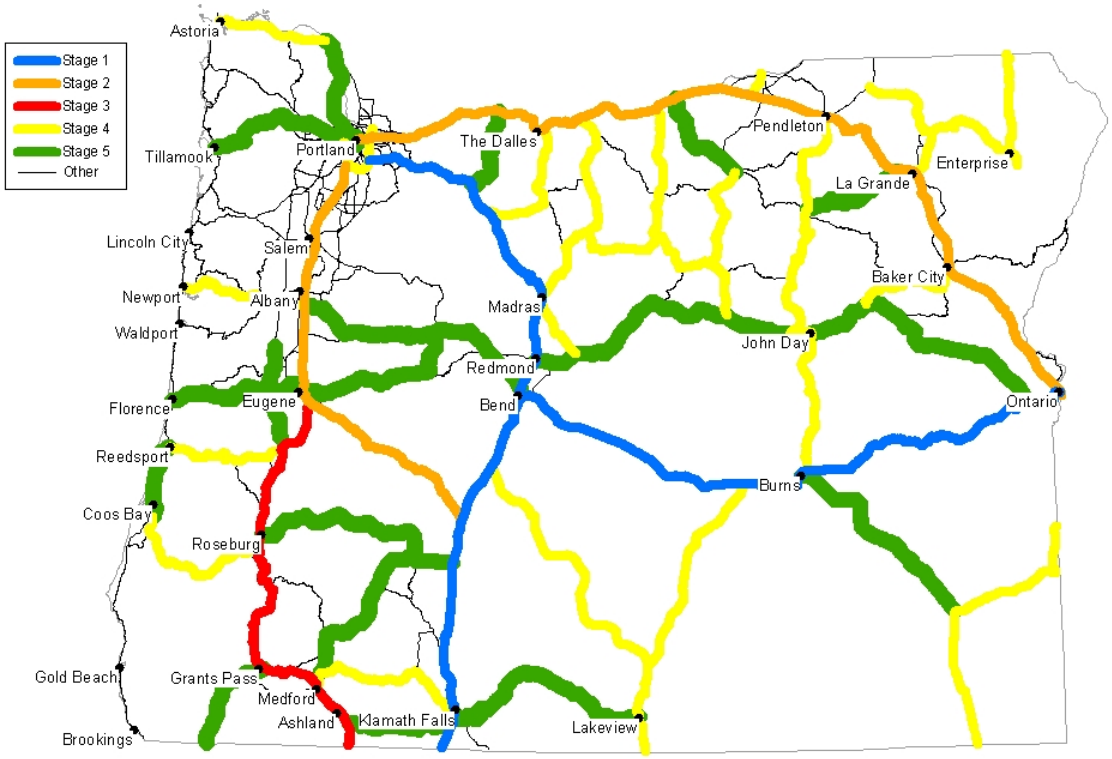


Figure 32: House Bill 2041 approved staging

program goals and objectives and performance measures are being discussed and the Oregon statewide model will be of significant help in defining and formulating this information and preparing reports for the next Legislature.

Although HB 2041 was a success, there are several remaining issues:

- The question of how long bridges can safely function once cracks become apparent will be important to identify options for maintaining the flow of commerce as more bridges deteriorate over time. This engineering analysis is being conducted for ODOT by Oregon State University.
- To implement HB 2041, ODOT will need to prioritize the actual bridge projects within and among the recommended stages that will be simultaneously underway under multiple contractors. Additionally, some bridge improvements will face challenges concerning capacity expansion and environmental sensitivities, which may take more time. The statewide model will be used to support these decisions by providing economic impact of various project prioritizations as well as the state/regional impact of corridor improvements.
- HB 2041 provides new revenue. However, it also reduces several on-going programs within ODOT. It will be important to document the results of the decrease in these maintenance and modernization areas as well as the benefits from the $2.5 billion investment passed by the 2003 Legislature.
- Alternate modes are an important part of a sustainable freight system, as noted by Oregon representatives. At a minimum, it is important to maintain alternate freight modes to avoid transferring additional demands to the highway system during the bridge construction phase.
- Finally, despite the significant funding provided by HB 2041, this only begins to address the problem of bridges and highway infrastructure in general in Oregon. There remains at least a $3.2 billion need to address the remaining cracked bridges and likely increased maintenance on detour routes. This is in addition to costs to address the remaining aging highway and bridge infrastructure throughout the state. The ongoing need for maintaining and upgrading transportation infrastructure, given over a decade of under-investment, will continue to be an important discussion. It is expected that the Oregon statewide model will continue to be a useful tool to inform many of these discussions.

FINAL STAGING PLAN

In September 2003, the OTC formally approved the Economic & Bridge Options Report. The following staging plan was adopted to reflect the discussions among the OTC, ODOT and the Legislature. Several stages will be worked on concurrently. The total number of bridges and estimated costs for the approved staging plan are included in Table 9. The final Economic & Bridge Options Report is available on the ODOT website at https://www.oregon.gov/ODOT/Planning/Pages/ Technical-Tools.aspx.

- *Stage 1:* Stage 1 creates unrestricted north-south and east-west freight routes that will serve as alternate routes when work begins on the interstates. The number of state and local bridges addressed in this stage is relatively low. This provides the maximum freight mobility as quickly as possible at least cost.
- *Stage 2:* This stage is the first to begin directly addressing the interstates. It completely fixes I-84 and addresses I-5 from the I-205 interchange to Eugene. In addition, it improves improve Highway 58, an important alternative route for the southern portion of I-5.
- *Stage 3:* Complete work on I-5.
- *Stage 4:* Improve connections between Astoria, Newport, and Coos Bay and I-5. Fix US 395 and finish work on US 97. Fix other segments in central and eastern Oregon. Fixing Highway 42 from Roseburg to Coos Bay and Highway 38 from I-5 to Highway 101 provides heavy haul access to the Port of Coos Bay.
- *Stage 5:* Fix Highway 26 connection between Eugene and US 97 and Highway 126 connection between Eugene and Florence. Fix US 199 and US 126 between Prineville and Ontario. Complete connection between Portland and Astoria.

Table 9: OTC approved bridge repair/replacement staging plan

Stage	State Bridges			Local Bridges[a]	Total Cost ($ million)
	# bridges repaired	# bridges replaced	Cost ($ million)	Cost ($ million)	
1	5	18	60.7	27.3	88.0
2	35	83	495.8	55.6	551.4
3	15	89	481.8	37.9	519.7
4	21	56	193.9	69.1	263.0
5	10	33	104.9	86.4	191.3
Total	87	279	1337.2	276.3	1613.4

a. To be determined by local government and ODOT based on HB 2041.

LESSONS LEARNED

With each application of the statewide model, an assessment of the benefits of the effort and issues encountered are documented. This guides the continued development of the Oregon modeling tools and helps decision-makers evaluate better ways to apply this integrated tool for future policy issues.

For the bridge analysis, the integrated statewide model provided valuable perspective to the decision process. The issue of cracked bridges in Oregon is larger than the Bridge Section of ODOT and larger than ODOT itself. The need to ensure freight mobility given the magnitude of bridge work versus a minimum cost 'worst first' solution changed ODOT's philosophy to a corridor perspective. The impacts of weight-limited bridges and how repairs and replacements are staged have economic ramifications at the statewide, regional and local levels. The overall environment and livability of Oregon is also affected by the bridge strategy selected.

The statewide model provided an opportunity for integrated strategic policy solutions that considered stimulation of jobs and economic development, impacts on communities and overall livability, and sustainable growth. The model quantified the range of economic, community, environmental, and transportation impacts of different courses of action, including statewide and substate economic impacts for specific industries and regions.

The current bridge problem is not a "crisis" and solutions can be enacted to avoid the worst impacts. However, the statewide model was valuable in defining what would constitute a crisis and what the impacts of such a crisis would be.

Throughout the modeling effort, several lessons were learned that will improve implementation on future projects. These include:

- New tools take time to be accepted in a large agency like ODOT. Because the initial modeling results did not fit with preconceived conclusions on the nature of the problem and therefore the best solutions, it was not automatically embraced by the EBOT. In-depth discussions on the model results and how they could help frame the discussions and recommendations were necessary to use the model most effectively on the project.
- It is important to build and maintain relationships between technical staff and management. Well-established relationships between modeling staff and senior ODOT management made management more willing to take a chance on a process that did not support their initial preconceived ideas.
- Interest and support of modeling from "outsiders" is helpful. The statewide model was used to address several previous large-scale policy questions. Those who had used the modeling tool in the past were supportive and advocated for its use on this project. It is helpful to have advocacy from others external to the process that are perceived as unbiased and those that may better understand non-traditional model outputs (e.g., economic measures).

- The model is best used to help define the problem and develop options, rather than reinforce preconceived solutions. The value of the model is that it allows consideration of economic, transportation and land use issues in an integrated manner. It can be used to develop “What If?” scenarios and to look at how different actions affect one another, immediately and in the long-term. In fact, the model is best used iteratively. Most decision-makers are accustomed to asking linear questions of a model - “If I invest in these bridges, what happens?” However, the question should evolve just as much as the solution. As technical analysis proceeds, the results should identify whether additional or different questions should be asked (e.g., “How do we provide accessibility to remote regions that rely economically on heavy goods transport?” or “How do we use the bridge program as an opportunity for economic development in depressed regions of the state?”). In the bridge study, an iterative process helped decision-makers understand the complexity of the bridge issue and what truly constituted a crisis.
- The credibility of the model and modeling results is critical. Recognized modeling and economic experts participated on the OMSC subcommittee to make recommendations on model input and to review reasonableness of model results. The peer review provided by this subcommittee gave the results credibility within ODOT, with other state agencies and with stakeholder groups.
- Good interpretation and visualization of model results is important. A significant amount of data was generated from the many model runs. In order to focus the discussion, it was important to identify and effectively present the data deemed most useful to the decision-making process. Although transportation metrics are now well understood, identifying effective economic performance measures is more challenging. If the user of the information cannot understand the information, it is of little value. In the bridge study, the same information was presented in a variety of ways - maps, graphs, histograms, tables, text - to be responsive to the many different ways people comprehend complex information. This is especially important given the limited time to produce and present the information and the variety of audiences that will make opinions and decisions based on the information.
- It is challenging to balance the time required to run the model and interpret results and the expectations of decision-makers for fast turnaround. Education about the time and resources required to set up and validate the model for numerous runs, the length of time required to run the model as well as digest and analyze the results, is necessary to maintain integrity in the process. It is clear, however, that there will always be a gap between decision-makers’ need for immediate feedback and the technical desire for additional time for analysis. It is important to have this discussion at the outset of the project so that schedules can be negotiated as much as possible.
- The model is one of many inputs to the decision-making process. It is not appropriate to rely on model results alone any more than only cost should define the solutions. The bridge study was valuable because it considered the economic and transportation results from the model, along with bridge repair/replacement costs, Motor Carrier information on suitable detour routes, information on city/county bridges and needs, trucking industry needs, and other anecdotal information.

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APPENDIX A: CONDITION OF OREGON BRIDGES

The condition of Oregon's bridges provides insight into the magnitude of the problem facing the state. More detailed information is included in the Economic & Bridge Options Report to the Oregon Transportation Commission.

Historical Investment in Oregon Bridges

Oregon has almost 6,500 bridges. Of these, 2,680 are state-owned bridges managed by ODOT and 3,800 are local bridges owned by cities and counties. Almost half the state-owned bridges and a third of local bridges were built prior to 1960 (Figure A-1).

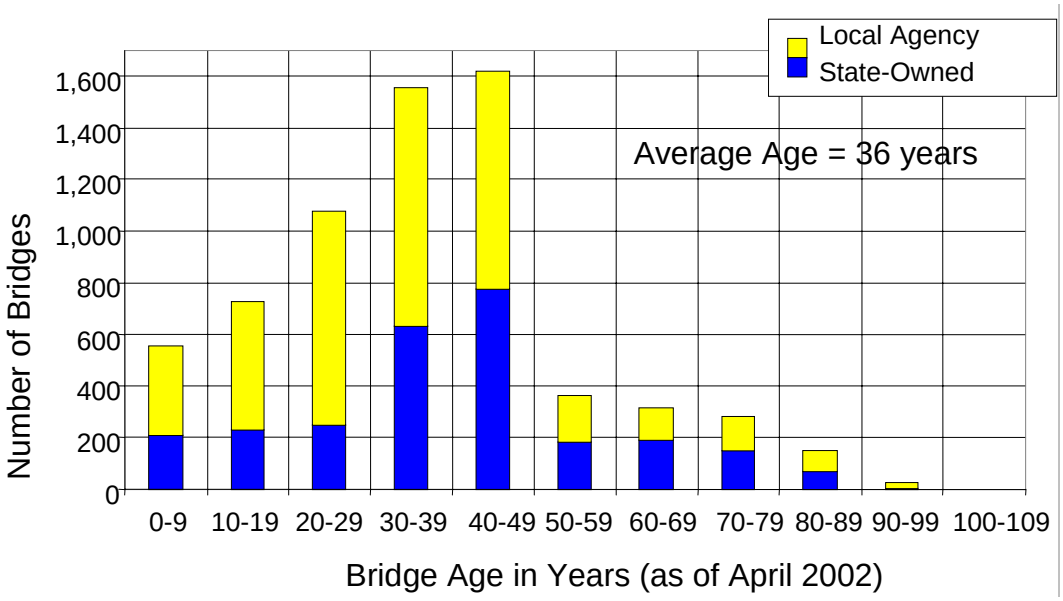
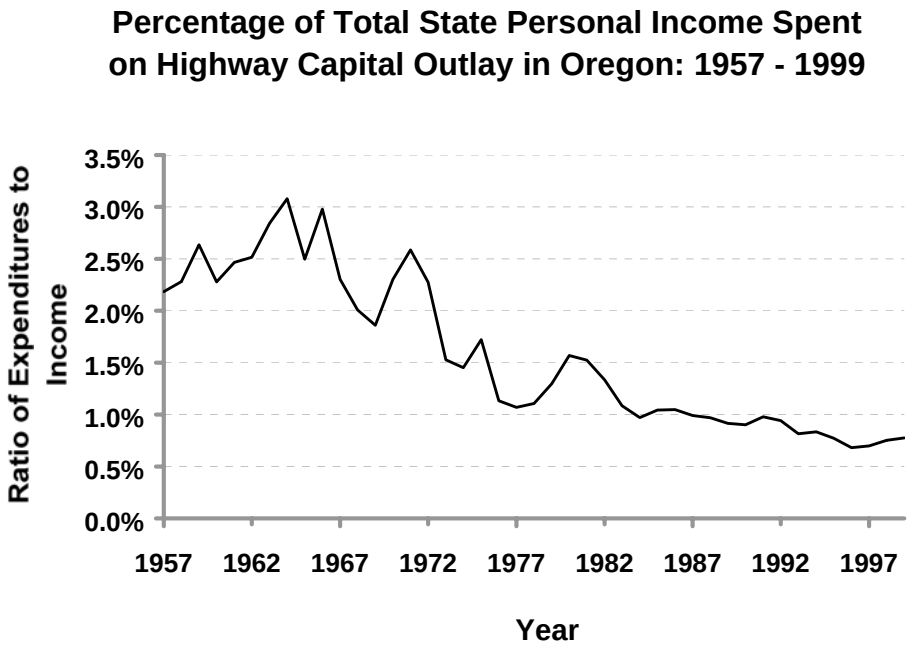


Figure A-1: Year of construction of Oregon bridges

The 1950s and 1960s witnessed the construction of the Interstate Highway System as well as many state and local roads. During the 1960s, an annual average of 2.5 percent of total state personal income was spent on highway capital outlay.[1] With the completion of that major road and bridge building effort, the focus turned to preservation and maintenance of the system which required less capital outlay. By the 1990s the annual average of total state personal income spent on the highway system dropped to 0.8 percent (Figure A-2).

1. "Capital outlays are those costs associated with highway improvements, including land acquisition and other right-of-way costs, preliminary and construction engineering, construction and reconstruction, resurfacing, rehabilitation, and restoration costs of roadway and structure; system preservation activities; and installation of traffic service facilities such as guard rails, fencing, signs, and signals." *Highway Statistics* 1999, p. IV-5.



Sources: Personal Income - US Bureau of Economic Analysis; Capital Expenditures - *Highway Statistics Summary to 1995*, Table HF-202C, *Highway Statistics* reports for years 1996-1999, Table HF2.

Figure A-2: Percentage of total state personal income spent on highway capital outlay in Oregon 1957-1999

Condition of Oregon Bridges

According to the Federal Highway Administration, there was a downward trend in the deficient bridge deck area until 2000, both nationally and in Oregon. With the onset of the bridge-cracking problem in Oregon, the trend has reversed and shows a dramatic increase in deficient bridge deck area in Oregon.

The 1999 Oregon Highway Plan identified 1,553 major bridge replacements and rehabilitation projects needed over the coming 20 years to maintain the bridges at 1997 condition levels. In 1997 there were no bridge postings on major routes and no critical emergency repairs. The cost to maintain 1997 condition levels was estimated at $83 million per year for the 20-year period 1998-2017. The actual investment directed to bridge projects was much less and will be $70 million in 2003.

During a 2001 routine biennial bridge inspection, cracks that were identified on several bridges in previous inspections had grown. In fact, the cracks had progressed to the point that functionality of some of the bridges was at risk. ODOT immediately placed load restrictions on these at-risk bridges. As ODOT looked into this accelerated cracking, most of the bridges of concern were found to be RCDG bridges built in the 1950s. When all of the 555 state-owned RCDG bridges were evaluated, 487 were found to have varying degrees of crack problems:

- 178 had randomly dispersed low-density cracks, not an urgent concern but could get worse.

- 180 had medium density cracks, mostly near supports. They need frequent monitoring and must either be restricted or replaced in the near future.
- 129 had widely dispersed high-density cracks. They also need frequent monitoring and must either be restricted or replaced in the near future.

An investigation of the additional 300 RCDG bridges owned by cities and counties showed that a medium to high density of cracks had developed on 122 of these bridges.

The bridge cracking phenomenon cannot be explained by any one factor. Several contributing factors include:

- Bridges are reaching their 50-year service life.
- Design and construction standards were different than those used today.
- Oregon used standard AASHTO design with limited shear reinforcement.
- Design of older bridges did not anticipate increased volumes, truck weights and speeds.
- Rough bridge approach pavement conditions can increase the effective truck weight up to 50 percent.
- Bridge deck pavement overlays increase dead load weight.
- Reduced investment has been made in bridge maintenance, repair and construction.
- Improved bridge inspection methods and coordination in the 1990s.

In general, bridges degrade over time at a very slow rate. A typical service life for a bridge is somewhere between 50-100 years. ODOT experience has indicated, however, that a bridge loses its ability to carry loading very rapidly toward the end of its service life. The rate of degradation is influenced by many factors including the loading demand placed upon it, the amount of maintenance the bridge has received over the years, the quality of construction and the effect of the environment. At this point, there are more questions than answers regarding the degradation rate of bridges. ODOT has contracted with Oregon State University (OSU) to research the degradation of Oregon's bridges relative to the cracking that has recently been identified. OSU researchers are scheduled to complete this project in July 2003.

Every community in Oregon is vulnerable to the bridge crisis because every community depends on the flow of freight over the state's 6,500 bridges. Most businesses depend directly or indirectly on heavy trucks to supply them with materials and to take their products to market. Likewise, citizens depend on the trucking industry to supply local stores with food and other products at reasonable prices.

In the past few years, the decline in the condition of Oregon's bridges has accelerated:

- In 1997, there were 42 bridges with load restrictions, but none required emergency repairs to avoid economic damage.
- In 2000, ODOT had 49 bridges with load restrictions, 35 more under evaluation, and 13 emergency repairs.
- In 2001, ODOT had 68 bridges with load restrictions, conducted 18 emergency repairs, and had 555 bridges under evaluation for cracking.
- By the year 2010, ODOT expects that 30 percent of state bridges will have weight restrictions and corresponding truck detours.

APPENDIX B: THE OREGON STATEWIDE MODEL

Analysis of the bridge investment strategies relies primarily on an integrated statewide transport-land use model. This model was developed by ODOT as part of the Oregon Model Implementation Program. The integrated statewide transportation modeling concept was introduced by ODOT in 1995. The intent is for Oregon cities, counties, metropolitan planning organizations and state agencies to work together in using state-of-the-art transportation modeling tools to aid decision-making and policy development.

Background

The Oregon statewide model used for this analysis is a complex set of computer programs and data that describes the relationships between Oregon's economy, land use patterns, and transportation flows. It is one of the most advanced models of its kind in the United States, integrating these elements across an entire state. It was developed as an analytical tool to help policy makers better understand these complex relationships.

The statewide model simulates land use and travel behavior mathematically and relies on various data, such as business sector exports and transportation operator characteristics. This statewide model complements regionally focused Metropolitan Planning Organization (MPO) models. Figure B-1 represents the fundamental model interactions, highlighting the interdependence of the economy, land use, and transport.

Figure B-1: Schematic Representation of the Statewide Model

The core of the model is an input-output economic model of commodities by standard industrial code in dollars. The amounts correspond to the production and consumption of goods and services. As the model distributes these goods and services regionally, it looks for available land or locations that minimize costs for the production (industry) and consumption (households) of goods and services. This is the land use or land allocation portion of the model.

After the production and consumption of activities are located, the model generates the travel required for production and consumption of these goods and services. This travel is translated into vehicle and freight trips on the transportation system. These trips are assigned to travel the system via the least cost available path. As the number of vehicles and roadway congestion rise so does the cost of using the roadways. The model reiterates until there is little change in transport route choices. At this point the model advances to the next time period, where travel costs to obtain goods for production and reach markets for consumption influence purchase decisions and business locations. The model continues operating in this iterative fashion until it reaches a predetermined forecast year. Policies can be introduced at any point for testing.

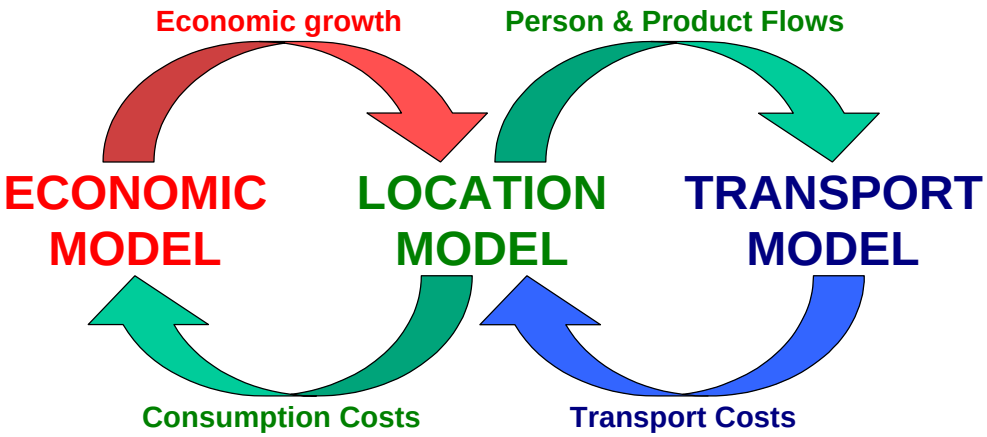


Figure B-2: Statewide model components

How the Model Works

The Oregon Statewide Model is a set of computer programs that are run in a linked fashion to simulate changes in the distribution of activities (industry and household) and travel over time. It is implemented in the TRANUS modeling package with some functions being carried out in Excel spreadsheets. The three primary elements of the Statewide Model are an economic model, location model and a transport model. The economic model determines the growth of the state's economy. The location model allocates production growth among zones and simultaneously determines the amount of trade occurring between zones by economic sector. The transport model converts the trade flows into trips, calculates trip generation by trip type, apportions the trips among modes, and assigns the trips to the road and transit networks. Figure B-2 shows how these models are linked through the economy.

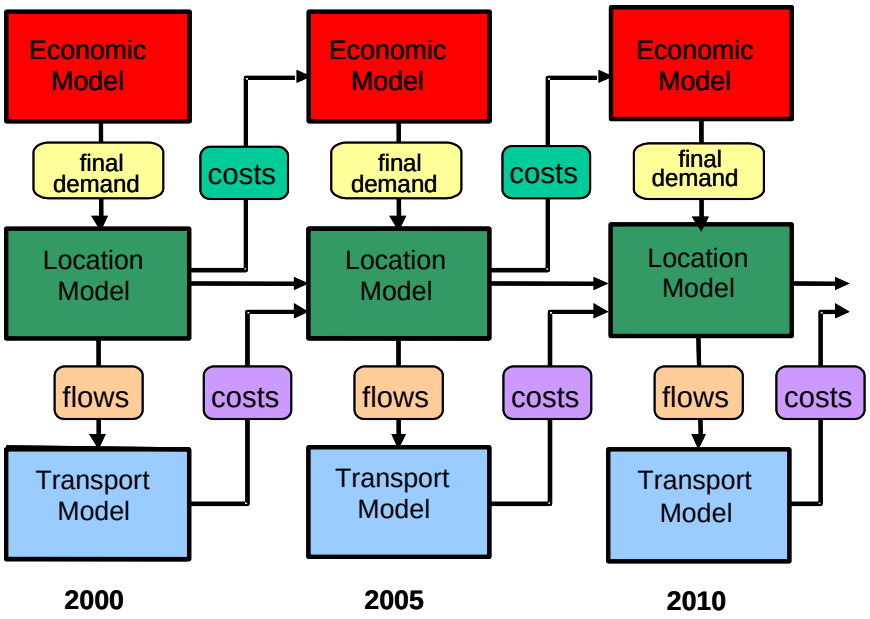


Figure B-3: Sequence of economic, location, and transport modeling

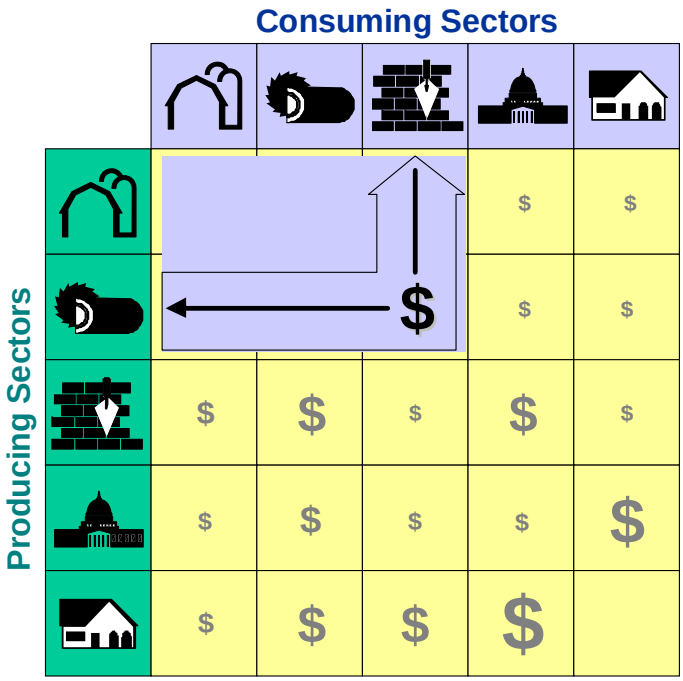


Figure B-4: Schematic representation of input-output model of the economy

Figure B-3 shows how these programs are linked to simulate changes over time. For each time period, the economic model passes final demand to the location model. The location model determines the location of activities and transactions, while the transport model converts the transactions into transportation flows (tons). It simultaneously determines the travel costs between zones. The resulting travel costs are then passed to the location model for the following time period, while consumption cost of goods faced by external zones impact overall next period state growth within the economic model.

The economic model incorporates a model of the study area economy. It is like an economic input-output (I-O) model that includes a spatial dimension embodied in the location model. I-O models represent the trading relationships between sectors of the economy. Each sector of the economy produces goods and services that are consumed by other sectors of the economy. Products flow in one direction, dollars in the opposite direction. This is illustrated in Figure B-4.

Some of the goods and services that are produced are purchased by other economic sectors for use in their production processes and are called intermediate production. Other goods and services are exported from the area or are sold to private individuals or government. These are not used to produce other goods or services and are called final production. Every increase in final goods production induces a chain of intermediate goods production. For example, the production of houses by a construction company requires the production of lumber by a sawmill, which requires the production of saws and other machinery. I-O models track these production and consumption relationships and allow induced demand to be calculated from changes in final demand. The Statewide Model is based on an I-O model produced by IMPLAN. This is a system of software and data sets

originally developed by the U.S. Forest Service for policy analysis and now maintained by the Minnesota IMPLAN Group, Inc.

The economic model simulates the growth of the economy based on increments in exports. Baseline increments are assumed in each five-year period, to replicate Office of Economic Analysis (OEA) state employment forecasts under nominal conditions. However, actions that impact the cost of producing goods in Oregon, such as bridge restrictions on trucking costs, can affect the demand for exports with subsequent impacts to the economic production and demand for labor within Oregon. Specifically, the model assumes that if bridge limitations result in a one percent increase in consumption costs for those outside of Oregon to buy Oregon goods (external zones), they will buy one percent less with a resulting decrease in Oregon production (i.e., unitary elasticity in the demand for exports with changes in external consumption costs). Economic model final demand and production growth increments by industry sector is passed to the location model to be used in the next 5-year period.

The statewide model adds a spatial dimension to the I-O model. In addition to calculating total induced production for the model area, it determines where the induced production is most likely to occur. This is done through a chain of computations that consider cost of producing and consuming the goods and services in different zones. Production/consumption costs are in turn affected by land prices and transportation costs. The chain starts with forecasts of the growth of final production for all goods and services by each economic sector for the analysis period (five-year increment).

These forecasts were derived from population and employment forecasts developed by OEA. The process of forecasting final demand started with the extrapolation of recent changes in employment by economic sector. The results were modified based on national economic trends, such as the growth of service industries relative to other industries, and state employment forecasts. Then, final demand was incrementally increased while monitoring resulting modeled population increases to arrive at a total population forecast that is consistent with the long-range OEA forecast. It should be noted that although the resulting population forecast in the base model matches that of the OEA closely, the forecast of employment is high. That is to be expected because the economic model is static and therefore does not anticipate changes in labor productivity. The OEA forecasts, on the other hand, are based on trends that implicitly account for increasing labor productivity. This difference is not significant, however, because the study's purpose is to compare the relative effects of policy alternatives, not to forecast future conditions.

The forecasted increments of final demand are then allocated to zones based on the proportions of the total sector production in each zone and the price of production in each zone. The model component that does this was calibrated from 1990 and 1995 economic data. After the growth of final demand is allocated by zone, the statewide model computes induced production and allocates that to zones based on the cost of production in each zone. The zonal production costs depend on the cost of consuming intermediate production from other zones, which depends on transportation costs. It also depends on the cost of consuming land in the zone that depends, in turn, on supply of land in the zone and the aggregate demand for using it. The model cycles through numerous iterations of calculating induced production by economic sector, allocating the production among zones, determining if land constraints exist, and adjusting prices. This goes on until the change in prices from one cycle to the next is very small.

The results of the location model are the allocation of annual production in dollars by economic sector to each zone. Annual production in dollars is converted to employees based on current labor productivity rates by sector ($/employee) and households ($/household). The location model also produces a set of annual dollar flows of goods and services by zone and by economic sector. These monetary flows are converted by another program into transportation flows (e.g., daily tons of freight).

The transportation model takes the transportation flows, assigns them to paths and computes transportation costs. It does this through several steps. First, a set of possible pathways between each pair of zones must be determined for each type of trip and each mode of travel. The model identifies several distinct pathways for each combination of zones, trip type and mode. As pathways are determined, the cost of traveling each of them is computed. The cost includes the amount and value of travel time (including driver wages), distance-related costs (including tolls, weight-mile taxes, vehicle maintenance) and transfer costs. Next, the model calculates the number of trips of each type to convey each transportation flow. This trip generation component of the transportation model considers trip generation as a function of the cost of travel (elastic trip generation). For example, a business located in a more remote location may make fewer trips to transport the same amount of goods to market than will a business located in a more accessible area. In this way, the model considers how increased costs due to congestion can suppress trip making and how new facilities that reduce travel costs can induce trip making.

Following trip generation, trips are split among modes and assigned to the pathways determined previously. In the statewide model, the modal structure is simplified, consisting only of passenger and truck freight modes. Once mode splits are determined, trips are assigned to pathways based on the relative costs of traveling by each of the paths. The resulting assignment of trips is then evaluated to determine levels of congestion and how congestion affects travel costs. This results in a recalculation of travel costs for each of the paths. The program then cycles back to the trip generation step to refigure trip generation rates based on the recalculated travel costs, then to mode split again, then trip assignment and back to recalculation of travel costs. This cycle is repeated over and over until there is very little change in trip assignments from one cycle to the next.

The results of the transportation analysis are tables of trips and costs between zones by mode and type. Another program converts these tables into interzonal costs that the activity model uses for the next five-year period of analysis.

A convenient way to summarize the overall structure of the statewide model is provided in Figure B-5. This figure depicts the interaction among the major model elements. The top box represents the economic flow in the model, primarily based on IMPLAN Input-Output data. The 12 industry sectors and 3 household income groups are identified as both consumers (rows) and producers (columns) in the Oregon economy. These economic flows are based on fixed demand coefficients, each of which is indicated by an “f.” The demand coefficients, or technical coefficients, are derived from the Input-Output matrix of monetary transactions representing the Oregon economy. Land is also consumed (column), but its demand is modeled as elastic (“e”).

ECONOMIC FLOWS (Z-Z)

CONSUMING SECTORS	PRODUCING SECTORS (Note Re-Orientation)																		
	Industries												Households			Land			
	AGFF	CONS	OMFG	WOOD	PRNT	TECH	TCPU	WLSE	RETL	FIRE	SERV	GOVT	HH Low	HH Mid	HH High	IND	COM	UrbRES	RurRES
Industries																			
AG FOREST FISH	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f				
CONSTRUCTION	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e			
OTHER MFG	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e			
WOOD	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e			
PRINT	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e			
TECH	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e	e		
TRANS COM PU	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e	e		
WHOLESALE	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e	e		
RETAIL	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e		
FIN INSUR RE	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e		
SERVICES	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e		
GOVERMENT	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e		
Households																			
HH LOW INCOME	f	f	f	f	f	f	f	f	f	f	f	f						e	e
HH MID INCOME	f	f	f	f	f	f	f	f	f	f	f	f						e	e
HH HIGH INCOME	f	f	f	f	f	f	f	f	f	f	f	f						e	e

TRANSPORT FLOWS (Z-Z)

TRANSPORT CATEGORIES	Industries												Households			MODES		
	AGFF	CONS	OMFG	WOOD	PRNT	TECH	TCPU	WLSE	RETL	FIRE	SERV	GOVT	HH Low	HH Mid	HH High	Person	Truck	Hvy Truck
Commute Low													1			1		
Commute Mid														2		1		
Commute High															3	1		
Recreation	4								4		4	4				1		
HomeBased Other									5	5	5	5				1		
NonHB Other									6	6	6	6				1		
NonHB Work	7	7	7	7	7	7	7	7	7	7	7	7				1		
Visitor Business																		
Visitor Other																		
Commodities	8	8	8	8	8	8	8	8									2	
Hvy Commodities	9	9	9	9	9	9	9	9									2	3

Demand coefficients:	Transport flows:
e = elastic	1-3 = Work commute
f = fixed	4-7 = Non-commuter
	8-10 = Freight

Figure B-5: Statewide model structure

The arrows leading to the lower box represent the translation of economic flows into transport flows through a land use-transport interface. The economic flows contributing to each transport demand category are indicated by the numbers in the Transport Flows matrix of Figure B-5. Transport categories 1-3 are commuter flows that travel between households and industry. Non-commuter flows are represented by transport categories 4-7, related primarily to the service, retail and government sectors. Freight demands, category 8-10, are dominated by activity in the remaining sectors. The lower right box represents the transport modes within the model. Arrows leading to it represent the accommodation of people or freight in particular vehicles.

The Next Generation of the Oregon Statewide Model

The experience gained with the Oregon statewide model is positive. Oregon's modeling tools engage technical staff and policy-makers in a collaborative and comprehensive approach to define and solve the complex policy issues faced today. Clearly, the integrated models are plausible and

can provide policy-makers and planners with timely and useful information about the interactions between the economy, land use, transportation and the environment.

This project evaluated the economic costs of deteriorating Oregon bridges and generated an economically viable phased bridge rebuilding plan. Other policies that have been tested by the Oregon statewide model include:

- Evaluated the growth and livability impacts of various transport and land use visions for the populous Oregon Willamette Valley (Willamette Valley Livability Forum)
- Economic and transportation evaluation of a new Interstate highway in rural eastern Oregon (House Bill 3090)
- Analyzed induced demand from a proposed urban bypass roadway (Newberg-Dundee Bypass)

Capitalizing on the promising aspects of the first generation models, a second generation model is being developed. The principal components are shown in this graphic. Modeling requirements were thoroughly reviewed and a new model specification developed. This underwent extensive revision through the peer review process. The resulting design brought the parallel tracks of the first generation model into a single unified development effort.

The second generation model includes several innovative model elements, as shown in Figure B-6:

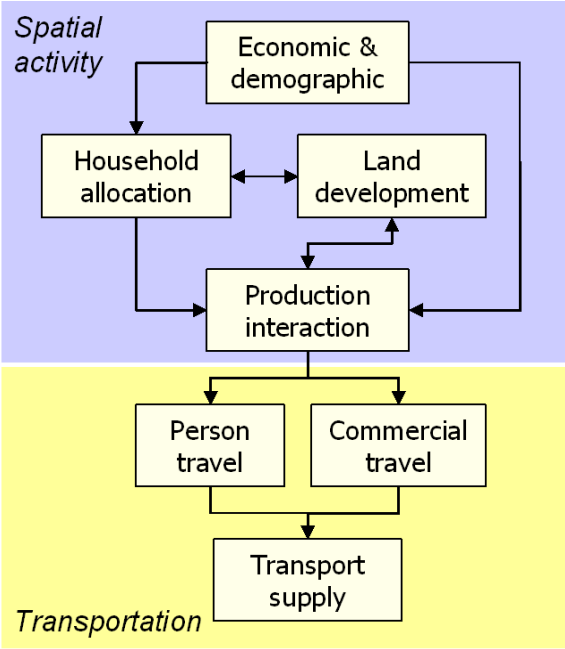


Figure B-6: Second generation statewide model structure

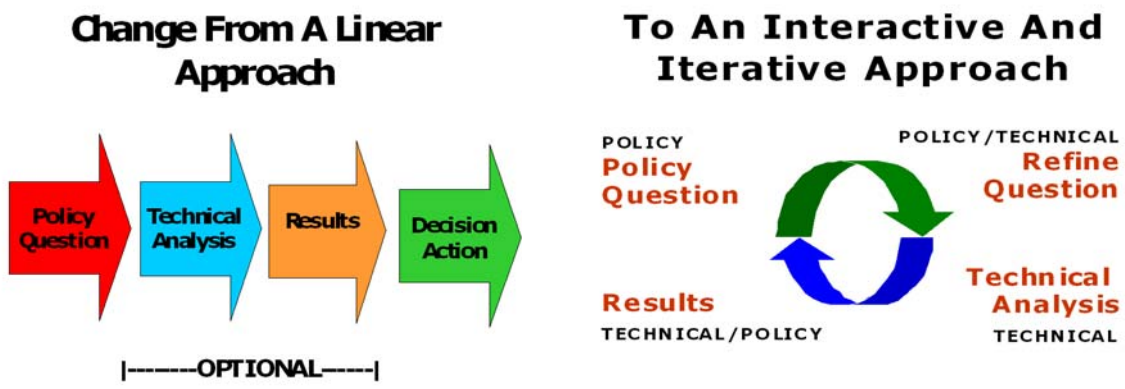
- Operates at varying scales depending on what is being measured, using MPO traffic analysis zones within the urban areas and larger zones outside, aggregated trade regions for the economic model, and land use at a 30-meter grid cell level.
- Fully integrated economic, land use and transportation model elements.
- Fully dynamic.
- Uses hybrid equilibrium (for economic and transportation markets) and disequilibrium (for activity and location markets) formulation.
- Uses activity-based travel models.
- Data required for the model is affordable, both in terms of time and money.
- A modular, component-based modeling system using object-oriented programming is under development. Second generation models will be developed in an open source environment, enabling others to use and contribute to the development of the software.

The Oregon statewide models use the strength of geographical information systems (GIS) to analyze land use and transportation data and to display information in easily understood maps and graphics. Models developed at the statewide and urban levels are being integrated to allow analy-

sis of the entire state transportation system in a multi-modal, coordinated, and standardized process.

A New Way of Thinking and Decision-Making

Modeling tools inform a comprehensive approach to decision-making. Historically, decisions tended to be made in a linear fashion. Technical analysis and recommendations were available but often simply substantiated decisions instead of helping to develop or inform decisions. Oregon's modeling tools and the Oregon modeling program engage technical staff and policy-makers in a collaborative and holistic approach to define and solve the complex policy issues faced today.



The Oregon Modeling Improvement Program: An Overview, June 2002 provides background on development of the Oregon modeling program and an overview of other applications of the statewide model. This report and additional information on the Oregon modeling program is available at https://www.oregon.gov/ODOT/Planning/Pages/OMIP.aspx.

APPENDIX C: THE OREGON MULTI-MODAL TRANSPORTATION SYSTEM

Oregon has a broad transportation network of highway, railroad, waterway and pipeline facilities. Characteristics of heavy commodities dictate the most efficient and cost-effective mode of. As more Oregon bridges are weight-restricted, other methods to transport heavy goods may become more attractive and an assessment of potential for modal shifts was made.

Oregon Freight

Freight is shipped by rail, barge and truck within and through Oregon. Figure C-1 conceptually shows the historic (1996) levels of freight tonnage shipped on various modes.

Table C-1 identifies percent of tonnage for key heavy commodities that are shipped in trucks exceeding 80,000 lbs. These commodities were chosen because over 30 percent of shipments are made in heavy truckloads or because the commodity represents more than five percent of total heavy truck tonnage.

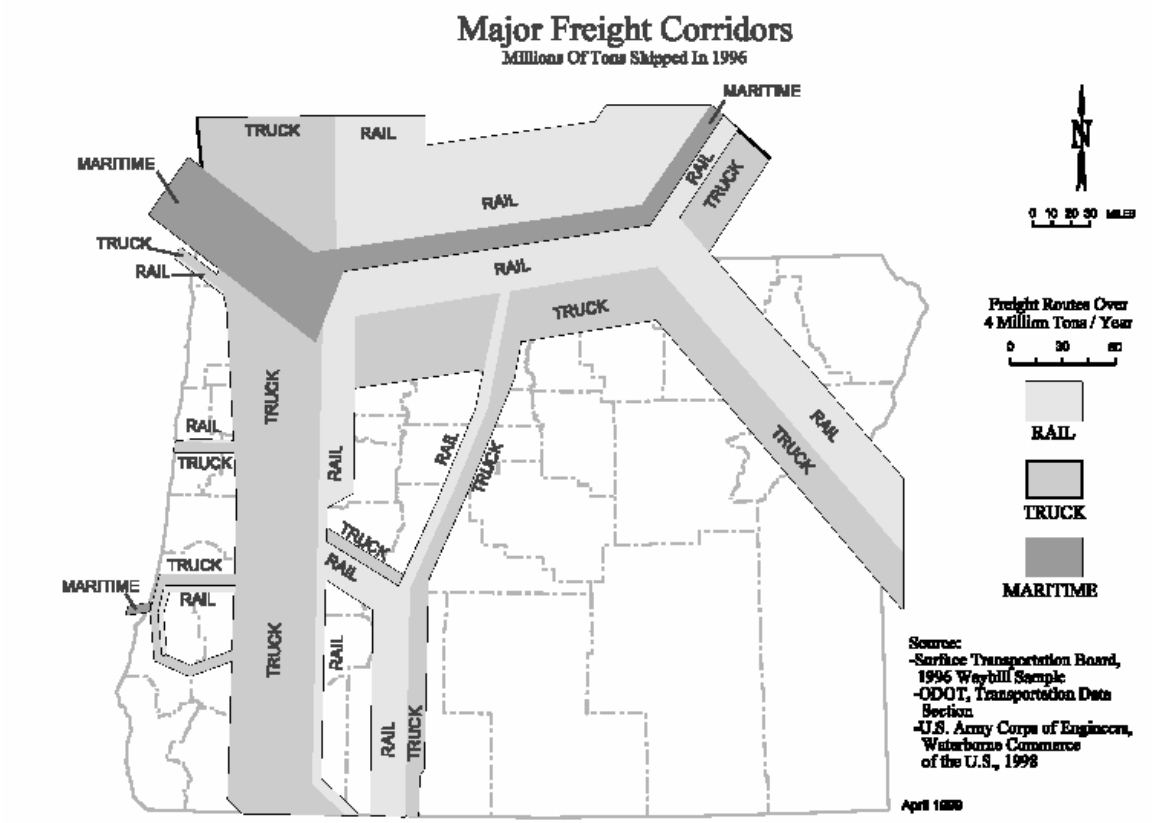


Figure C-1: Major Oregon freight corridors (millions of tons shipped in 1996)

Table C-1: Percentage of key commodities shipped in trucks over 80,000 pounds gross weight

Commodity		% carried in trucks weighing >80,000 lbs.
STCC	Description	
8	Forest products	47
24	Lumber or wood products, excluding furniture	41
1	Farm products	17
20	Food or kindred products	19
13	Crude petroleum, natural gas or gasoline	91
29	Petroleum or coal products	63
28	Chemicals or allied products	33
32	Clay, concrete, glass or stone products	31
14	Non-metallic ores or minerals, excluding fuels	60
26	Pulp, paper or allied products	25
35	Machinery, excluding electrical	37
40	Waste or scrap materials not identified by producing industry	65
48	Waste hazardous materials or waste hazardous substances	65
	Other	28

Source: 1997 Oregon Commodity Flow Surcey (intercept survey).
Note: Commodities in >105,500 pound trucks may be overstated, due to payload calculation from gross weight and mean empty weight by truck class. Only indivisible loads are allowed in trucks exceeding 105,500 pounds.

The preferred methods of shipment varies for each of the the commodities shown in Table C-1, as discussed in the following sections.

Agricultural and Food Products

Almost all agricultural products leave the farm on trucks. These trucks typically travel fairly short distances to a processing plant or to a warehouse, grain elevator or freight terminal. From those locations, agricultural and food products move on by truck, rail, barge, ship or airplane. Food processing plants are located both near the farms and in cities, depending on the type of processing and the perishable nature of the crop. Processed food products are distributed around the world, and processed food products from around the world are shipped to distribution centers and retailers located where people live. Load weights vary greatly by product and destination.

Forest Products, Lumber, and Wood Chips

Logs are transported from forests to mills on log trucks. Logs also are moved from mill to mill on log trucks, as logs are bought, sold, and traded between mills. Log trucks are poorly suited to carrying anything other than logs and typically return empty. About 30 percent of loaded log trucks weigh over 80,000 pounds.

Lumber, panel products, wood chips and bark are shipped from mills by truck or rail to warehouses, freight terminals and end users. Lumber and panels typically travel on flatbed trucks or

specialized rail cars, whereas chips and bark travel in trucks with specialized trailers. Almost all full chip trucks weigh over 80,000 pounds.

Fuel and Chemicals

Oregon produces no petroleum products. Fuels arrive in Oregon by pipeline or tanker ship and are carried from the terminal by tanker truck. Natural gas travels exclusively in pipes, while propane is shipped by rail and tanker trucks for rural delivery. Chemicals are shipped by all modes. Bulk chemicals usually travel first by rail to a distribution center and are then transported by truck to their final destinations. Fertilizers probably account for the largest portion of chemicals hauled by heavy trucks.

Machinery

This category of commodities includes construction equipment and machinery, engines, generators, pumps, industrial machinery and equipment, conveyors, hoists, cranes and farm equipment. Most machinery is brought into Oregon from elsewhere and delivered to where it is needed. Construction equipment is regularly transferred from one site to another, and heavy construction equipment accounts for a large proportion of the non-divisible loads over 98,000 pounds.

Pulp and Paper

Pulp and integrated paper mills receive logs from the forest as well as logs, wood chips and bark from lumber and panel mills. Logs always travel on log trucks, and chips and bark are carried in specialized trailers. About 30 percent of loaded log trucks weigh over 80,000 pounds, and almost all full truck loads of wood chips weigh over 80,000 pounds. Bark is used as fuel by pulp and paper mills to produce steam and electricity.

Some mills produce only pulp, which must be transported to a paper mill or exported. Pulp usually leaves the mill by truck or rail and is often dried before shipping long distances. Other mills, called integrated mills, produce pulp and paper on the same site. Paper mills ship paper on rail or trucks, depending on the destination and size of the shipment.

Sand, Gravel and Other Minerals

Sand and gravel have one of the lowest value-to-weight ratios of any commodity. For this reason, they typically are obtained from the nearest source and hauled the shortest distance possible. Sources are abundant throughout Oregon. Sand and gravel usually are carried in either dump trucks or specialized trailers that load from the top and unload from the bottom. About 70 percent of loaded sand and gravel trucks weigh over 80,000 pounds.

Other than sand and gravel, little other mining takes place in Oregon. When the aluminum smelters are operating, they receive large quantities of alumina that is unloaded from ships or barges directly into the smelters. Rare metals are processed in Albany from ores and concentrates received at the Port of Portland. Steel mills in Oregon use scrap, rather than ore, to produce steel.

Waste

Waste is produced primarily in metropolitan areas and is hauled to landfill sites. Waste is collected at transfer stations and reloaded onto heavier trucks. Waste from the Portland area is hauled by truck to Arlington in Gilliam County. Other major landfills are located near Eugene and Corvallis. A waste-burning facility is located near Salem.

Truck Transport Regulations

Restricting bridges to 80,000 lbs. will primarily affect Oregon-based trucking companies. A 1997 Oregon Freight Truck Commodity Flow Survey found that about 26 percent of all truck tons on Oregon roads and 10 percent of all heavy truck tons (over 80,000 lbs.) are “through” trips with both origin and destination outside the state.

ORS 818.020 establishes the maximum allowable weight limitations for a vehicle or combination of vehicles operating in Oregon. Basically, a vehicle or vehicle combination exceeds the maximum allowable weight whenever its gross weight exceeds 80,000 pounds, any of its wheels exceeds 10,000 pounds, any of its axles exceed 20,000 pounds, or any of its tandem axles exceed 34,000 pounds.

ORS 818.200 grants any road authority the ability to issue a variance permit if it determines that the public interest is served to allow a vehicle or combination of vehicles to move over the highway or street under the jurisdiction of the road authority without violation of the maximum allowable weights established under ORS 818.020. Annual or single trip permits allow trucks to operate in excess of 80,000 lbs. gross or in excess of legal axle load limits. For a nominal fee, the ODOT Motor Carrier Transportation Division issues annual permits to allow loads between 80,000 and 105,500 lbs. to operate on roads within the state.[1]

Indivisible loads[2] over 98,000 lbs. must obtain a single trip permit. Approximately 26,000 single trip permits were issued in FY2000-01. Figure C-2 shows the number of single trip permits issued by weight in FY2000-01. The majority of heavy truck permits in the last several years were issued to Oregon-based trucking companies (Figure C-3).

The Highway System

Oregon roads are part of a larger freight transportation system. The key north-south and east-west highways for moving freight are I-5 and I-84. These are the only two Oregon highways that exceed 3,000 trucks daily and provide an important link in the national freight system. I-5 is part of a main international route extending from Mexico and Canada (Figure C-4).

The Interstate and U.S. highway system in Oregon not only facilitates trade within Oregon, but also is an integral part of the North American trade network. The Port of Portland is the largest grain export port on the West Coast, and the second largest in the country. Most of this traffic

1. Permit fees are administrative fees only and seek to recover the administrative cost of issuing the permit. Infrastructure costs resulting from the operation of heavier vehicles are recovered through weight mile tax or Road Use Assessment Fee (RUAF). Approximately 93,200 annual permits were issued in FY01-02.
2. An indivisible load is one that cannot be broken down into smaller units (i.e., steel bridge beams).

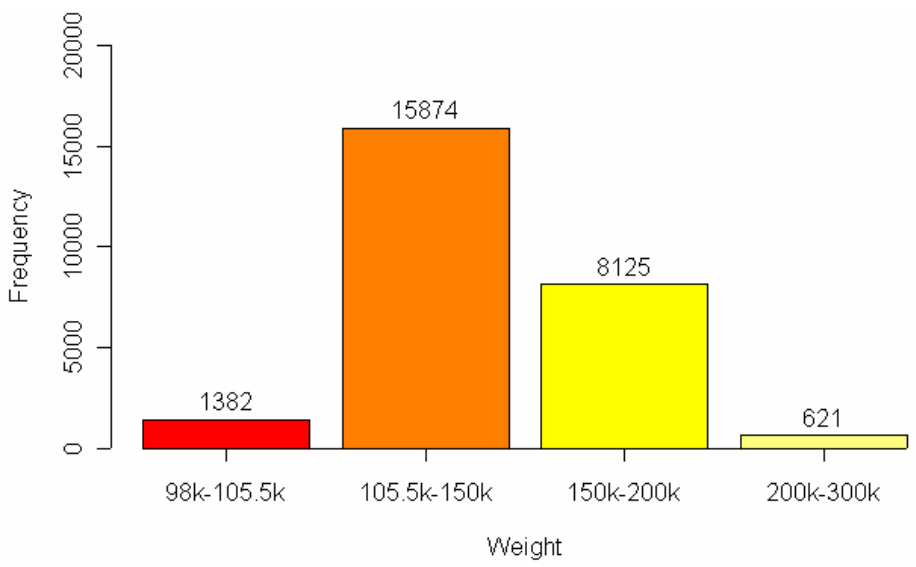
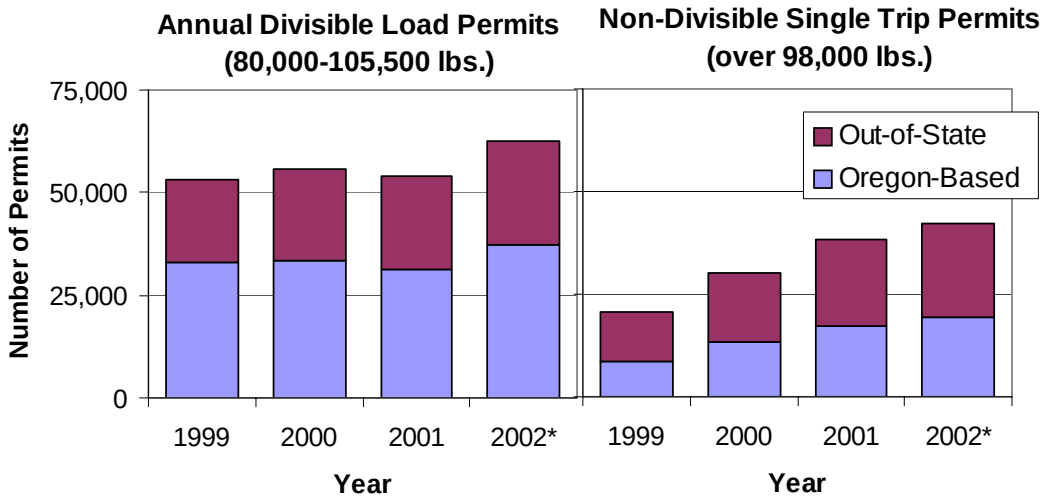


Figure C-2: FY00-01 single trip permit data truck weight distribution

arrives at the Port via rail and marine modes of transport, and would be relatively unaffected by bridge restrictions. However, the handling of other traffic, including containers, is an important part of the Port's financial portfolio. Any disruption of the highway system serving the Portland region would disrupt these flows, most of which arrive by truck. The majority of these flows use I-84, as shown in Figure C-5.



* 2002 extrapolated from January-September data.
Source: ODOT Motor Carrier Transportation Division, October 2002.

Figure C-3: Heavy truck permis issued from 1999 through 2002

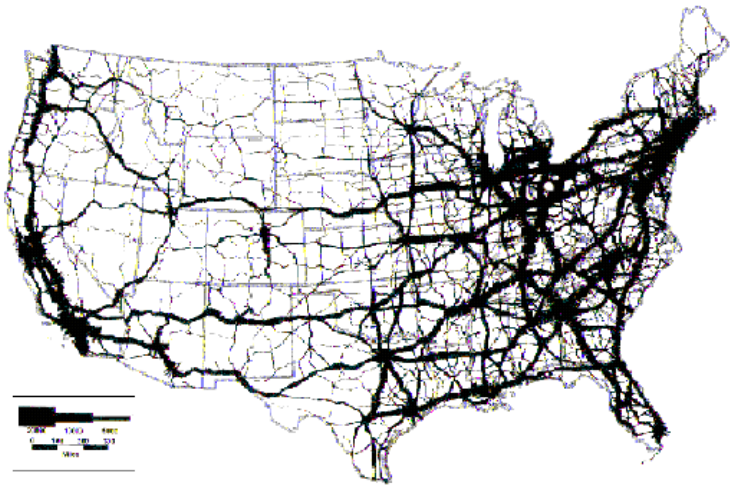


Figure C-4: Truck flows on the National Highway System

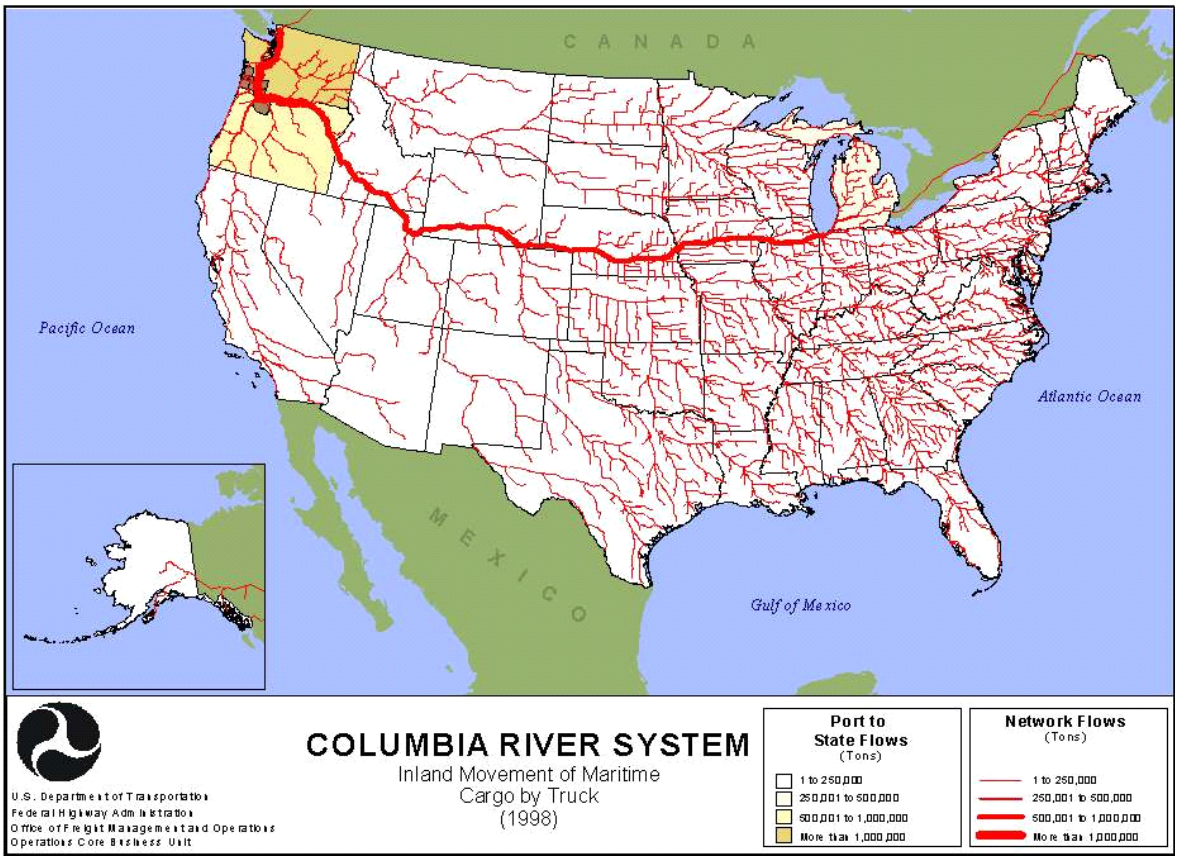


Figure C-5: Distribution of truck flows serving the Port of Portland

The West Coast marine ports are highly competitive. Any decrease in accessibility or reliability in reaching the Port will adversely affect the Port's ability to compete, either as a distribution hub or as a marketplace adding and capturing value from foreign trade. The "ripple effect" on the Oregon economy that such a loss of market share would trigger would be substantial.

Oregon's highway network is also key to the economies of most of the Western states. A great deal of freight moves north and south along I-5 between major metropolitan areas and competing ports. Export traffic does not always leave the country through the nearest port. In many instances

cargo is trucked considerable distance to connect it with the right marine shipping company. Most shipping lines only call in one or two West Coast ports, where their traffic is consolidated from across the country. Excellent connectivity to the Ports of Seattle, Tacoma and Vancouver (British Columbia) affords Oregon access to all major shipping lines. Any disruption of these flows will harm Oregon far more than it will Washington or British Columbia, which will continue to enjoy a considerable market share between them. Figures C-6 and C-7 show the geographic distribution of flows from the marine ports in the Puget Sound region, as well as truck flows across the western Washington-British Columbia border.

The Railroad System

Two major railroads, 18 short-line railroads and 2 terminal railroads operate on 2,500 miles of rail line in Oregon (Figure C-8). The two Class I railroads, Union Pacific (UP) and Burlington Northern/Santa Fe (BNSF), operate on just under half of the state's rail mileage. Short line railroads operate on the bulk of the remaining total rail mileage.

Freight rail tends to focus on heavy bulk commodities (Table C-2). Although historically dominated by wood, lumber, and farm products, other commodities such as chemicals, pulp/paper, food products, and mixed shipments have increased and now encompass two thirds of rail tonnage. Farm products and chemicals from other northwest states and northern Great Plains states are the leading products shipped to Oregon by rail. Lumber and wood lead rail export to other states, primarily California and the Midwest states.

Portland is an important hub for commodities moved by rail. Over half of Oregon's rail tonnage originates or terminates in Multnomah County. The state's largest truck-rail intermodal yards are located in Portland, and along the UP and BNSF railroads in the Willamette Valley. Grain is brought in by truck and shipped out by rail at seven large (>500,000 bushel capacity) elevators in northeastern Oregon, Ontario, Klamath Falls and in the Willamette Valley.

Over a third of all state rail tonnage is traffic passing through Oregon, much through the Port of Portland. Less than five percent of total tonnage operates within the state, often by short line railroads (half of current 2,400 system miles).

Congestion and inadequate rail infrastructure contribute to lost or delayed freight shipments, increased truck traffic and motor vehicle congestion. Rail-related congestion is greatest in Portland where the UP and BNSF operate intermodal yards, switching yards and other facilities. Oregon's short-line railroads generally experience the greatest physical condition deficiencies and shortages of rail cars. Rail service has suffered in the recent past from service disruptions due to a wave of major railroad consolidations.

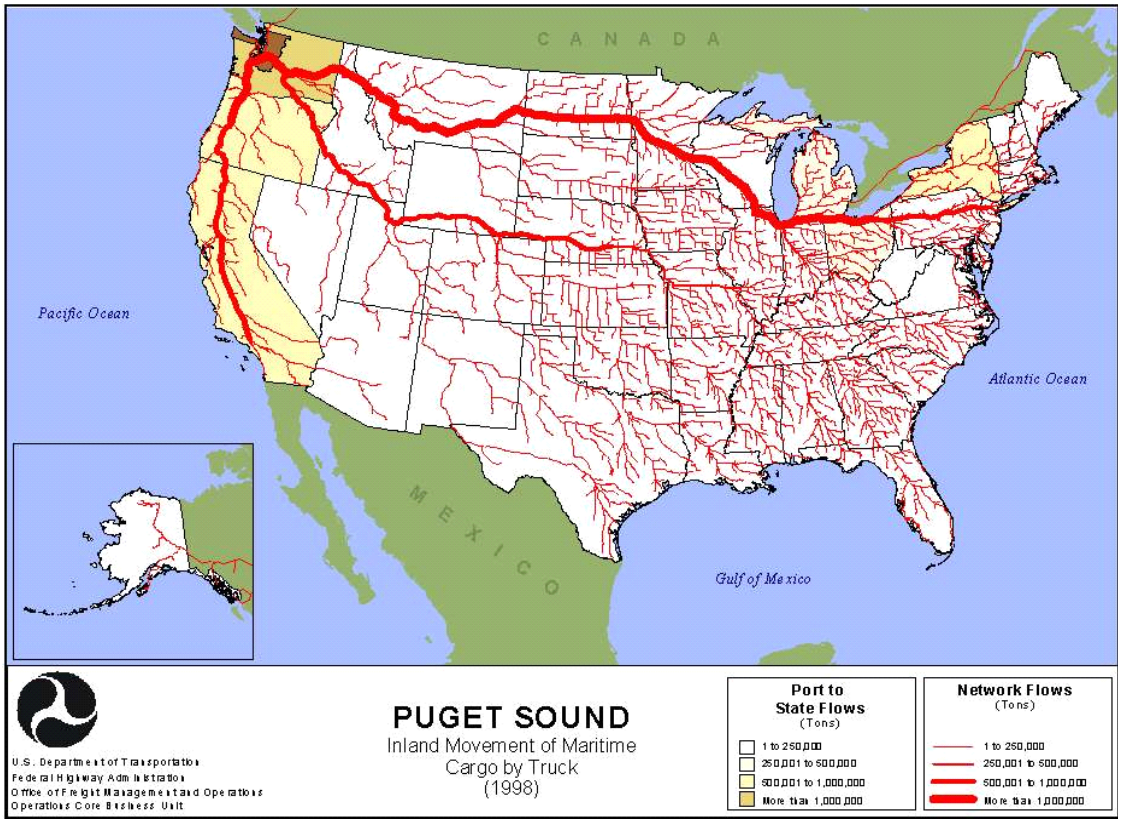


Figure C-6: Distribution of truck flows serving Puget Sound marine ports

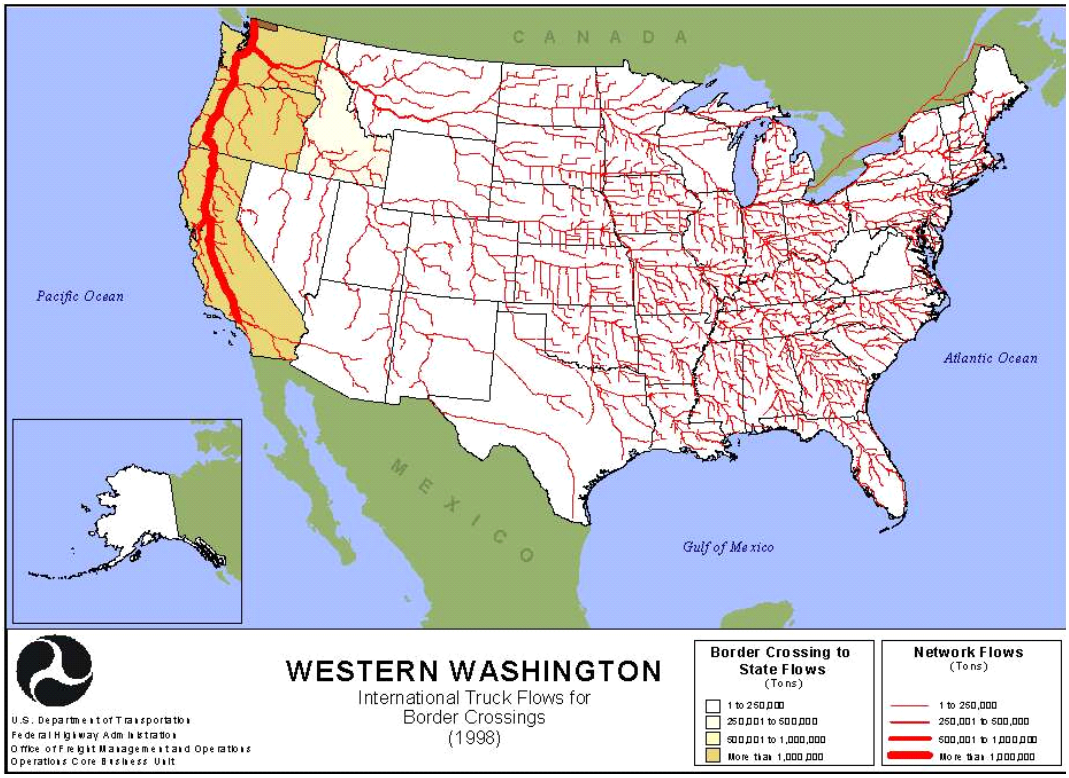


Figure C-7: Distribution of truck flows crossing the Western Washington-British Columbia border

Table C-2: 1999 Oregon rail freight tonnage by commodity

Commodity		Tons (thousands)					% of total
Description	STCC	Originating	Terminating	Intrastate	Through	Total	
Farm products	01	531.8	4,078.8	341.0	4,971.4	9,923.0	15.6
Lumber or wood products	24	6,893.1	1,730.1	123.8	4,521.4	13,268.4	20.9
Chemicals or allied products	28	316.9	4,478.0	118.8	1,855.5	6,769.2	10.7
Misc. mixed shipments	46	1,759.7	2,205.7	0.0	2,517.8	6,483.0	10.2
Pulp, paper or allied products	26	2,600.5	872.7	229.5	1,643.1	5,345.8	8.4
Food or kindred products	20	541.1	1,704.9	52.5	2,014.7	4,313.2	6.8
All others		3,377.2	8,259.3	807.8	4,914.5	17,358.8	27.4
Total		16,020.3	23,329.3	1,673.4	22,438.4	63,461.4	100.0

Source: STB rail waybill sample compiled by Wilbur Smith Associates.

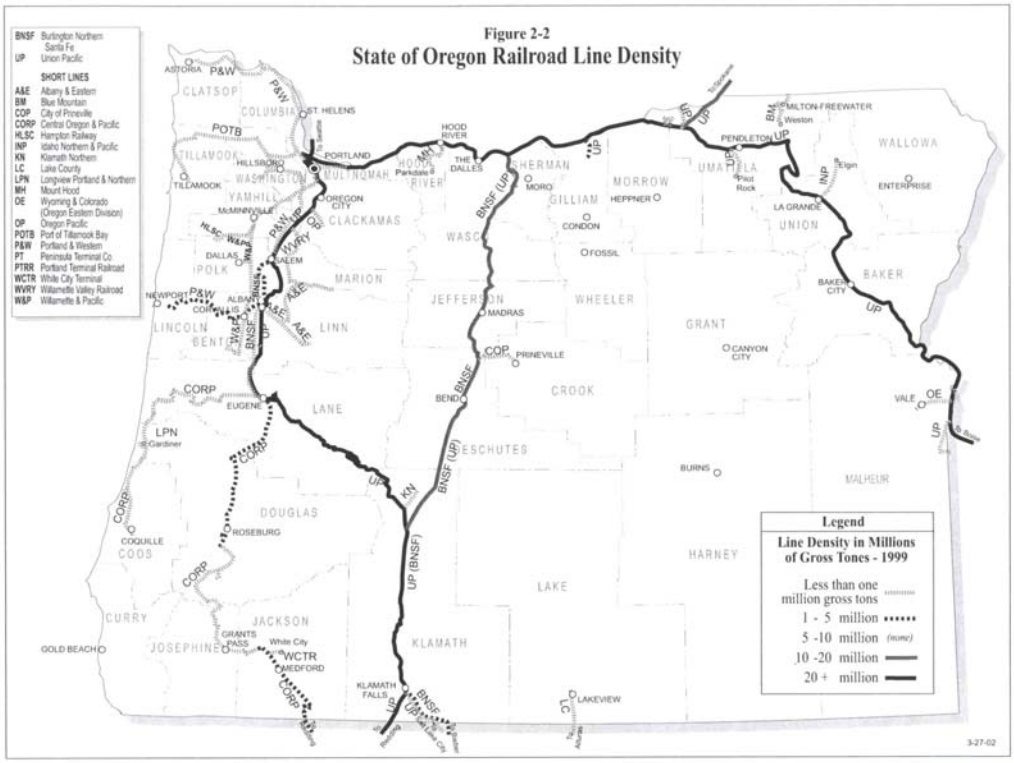


Figure C-8: Location of State of Oregon railroad lines

Planned public investment in Oregon's High Speed Rail Corridor from Eugene to Vancouver, BC will benefit both passenger and rail freight traffic. However, freight railroads are often concerned about the ability to maintain capacity and run times when trackage is shared with faster, higher priority passenger service. Increased rail traffic may increase pressure to improve safety at high-traffic at-grade rail crossings.

UP and BNSF feel rail has the potential to capture significant truck traffic from I-5. Critical elements to increase competitiveness include increasing tunnel clearances (20 tunnels in Lane

County and 4 in California), reducing Seattle to Los Angeles rail transit time, and increasing the capacity of the railroad bridge over the Columbia River in Portland. Key investments to bolster shortline railroads include rehabilitation of track and bridges to accommodate the increase in maximum railcar weights (286,000 lbs.) which facilitate linkage with Class I operations.

Waterways

Inland waterway traffic, focused primarily east-west along the Columbia River, has historically served to connect eastern Oregon and Washington agricultural interests to the rest of the world. Barge travel emphasizes low-value bulk commodities in addition to higher value commodities such as autos and transportation equipment. Commodities shipped by water along the Columbia are largely heavy commodities, including grain, petroleum, sand/gravel, chemicals, and paper pulp. The Port of Portland ranks 1st nationally in the export of wheat, which represents 36 percent of Port of Portland marine tonnage. Petroleum products account for another 20 percent. Tonnages have been increasing slightly on the Columbia River above Portland.

The Columbia-Snake River system extends from the mouth of the Columbia at Astoria eastward 465 miles to Lewiston, ID. Much of the material moved by barge is transloaded to/from ships, primarily in Portland. The Port of Morrow at Boardman moves the most freight of Oregon's shallow draft ports. Shallow-water terminals along the Columbia are also located at The Dalles, Biggs, Arlington, and Umatilla. Low clearance on Portland area bridges slow barge traffic and impact important I-5 and rail line flows when movable spans are raised to allow barges to pass.

Ongoing studies on the Columbia River are evaluating dredging to increase navigable depth south of Portland. Drawdown has been considered for salmon restoration north of Portland and would reduce navigable depth. Some studies have shown that drawdowns would weaken soils, which could lead to damage for bridges and other transportation structures on these soils (Lund Consulting Study 1999).

The Willamette River served an historically important freight role between Portland and Eugene. There has been some interest in exploring the feasibility of dredging to reopen the Willamette section above Newberg to commercial navigation for barge shipment, specifically for agricultural products and aggregates. Willamette River actions are hindered by concerns about jeopardizing threatened salmon runs and by the 2000 Environmental Protection Agency designation of the Portland Harbor as a federal superfund site due to accumulation of hazardous materials on the river bottom.

Various studies note that should river navigation be eliminated or reduced, heavy commodity freight demands on highway and rail lines along I-84 would increase significantly. The OR Economic & Community Development Department with IRZ Consulting and Pacific Northwest Project (1999) estimated impacts of closing the Columbia River above John Day Dam for barge traffic. The study estimated that this would add more than 54,000 trucks on the interstate highways with $12.8 million in increased interstate highway maintenance costs, not including bridge improvements and maintenance of county and city roads.

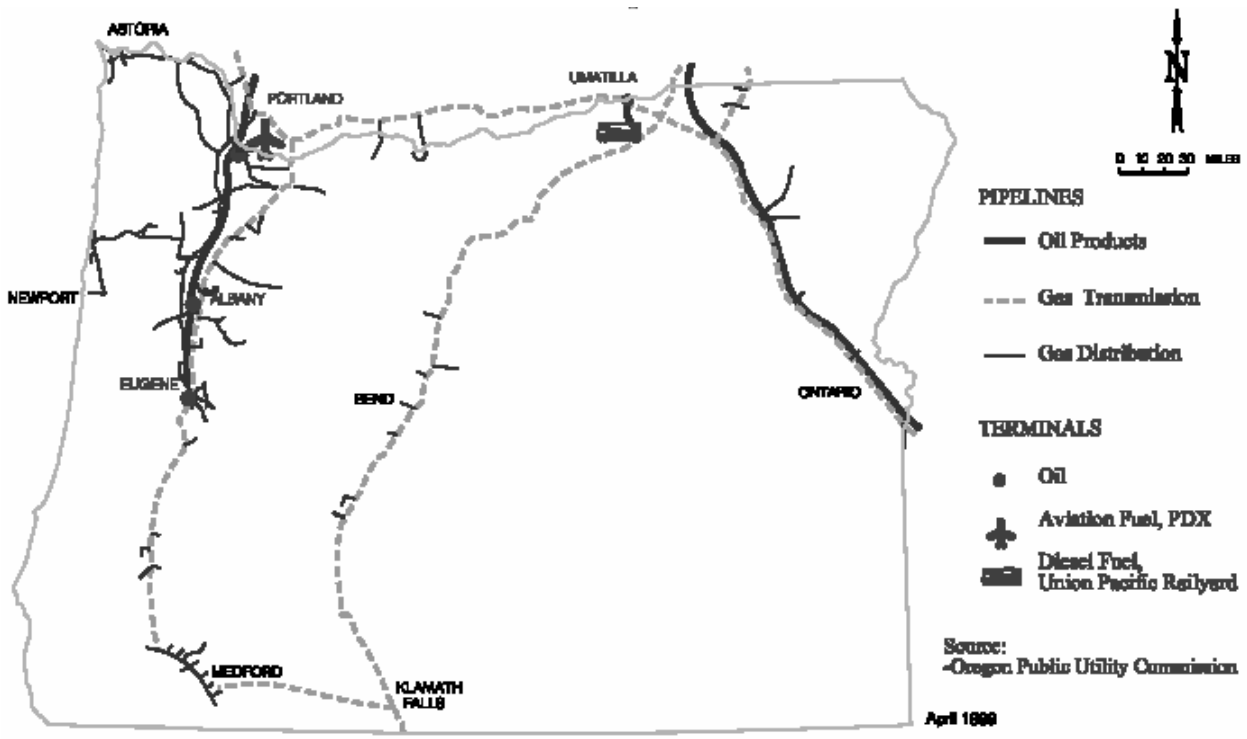


Figure C-9: Oregon oil and natural gas pipelines and terminals

Pipelines

Oregon's oil and natural gas pipelines generally extend in a north-south direction to serve major areas of population in Oregon and to connect areas of production to the north with areas of consumption to the south, especially in California (Figure C-9). Natural gas is only moved by pipeline, transferring to other modes as petroleum. Pipeline capacity restrictions between Puget Sound and Portland will affect the future ability to meet petroleum needs in Oregon, including jet fuel

delivery by pipeline to the Portland Airport. A Cross-Cascade Pipeline is proposed between the Puget Sound and the Tri-City area in Central Washington to address this need. This project may also reduce barge shipments of petroleum to Umatilla, which may need to be supplied more expensively by other modes, including truck. Oil pipeline-truck terminals are located in Portland, Eugene, and Salem.

In some instances, there is potential to offload the transport of heavy commodities to non-truck modes, such as rail or barge. Given the amount of goods moved by trucks and the need for flexibility in routes and scheduling, however, investment in non-truck modes will not solve the bridge problem. Higher costs for trucking companies often mean higher costs for shippers and ultimately consumers.

Potential for Modal Shift

With significant investment, rail and barge could play an increasing role in the movement of heavy commodities. However, investment in these modes alone will not completely solve the

bridge problem. Diversion to non-truck modes is primarily based on competitive costs and services offered by alternate modes. In any case, it is important to maintain alternate modes to avoid transferring additional freight demands to the highway/trucking mode.

Table C-3 provides an overview of the service requirements of various commodities, while Table C-4 illustrates the service attributes of various modes. Trucks have the greatest mobility among freight modes. Heavy commodities of high value that rely on “just-in-time” deliveries require frequent, reliable and fast service and are best served by truck. Heavy commodities are unlikely to travel as air cargo, which is more likely to carry lighter high-value, time-sensitive goods and in smaller volumes. Rail, barges and pipeline move commodities that require low-cost, low-speed and low-damage service. Such commodities are typically raw materials or other bulky, low-value products clustered in the agricultural, forestry, mining, and construction sectors.

Table C-3: Transportation service requirements by sector and commodity

Sector	Commodity	Transportation Service Requirements
Agriculture, Forestry, & Fisheries	Grain	Low cost, low speed, low damage
	Fruits and vegetables	Frequent and reliable service
	Livestock	Low cost, low speed, low damage
	Forestry products	Low cost, low speed, low damage
	Fish products	Frequent and reliable service
Mining	Crude petroleum	Low cost, low speed, low damage
	Natural gas	Regular movements
	Sand and gravel	Low cost, low speed, low damage
Construction	Construction material	Low cost, low speed, low damage
Manufacturing	Food products	Frequent, reliable, fast service
	Frozen foods	Frequent, reliable, fast service
	Wood products	Frequent, reliable, fast service
	Paper products	Frequent, reliable, fast service
	Printing and publishing	Frequent, fast service
	Chemicals and allied products	Frequent, reliable, fast service
	Rubber and plastics	Frequent, reliable, fast service
	Industrial machinery & equipment	Frequent, reliable, fast and innovative service
	Electronic and electrical equipment	Frequent, reliable, fast and innovative service
	Motor vehicles	Frequent, reliable service
	Professional & scientific instruments	Frequent, reliable, fast and innovative service
Wholesale	Motor Vehicles	Frequent, reliable service
	Chemicals and Allied Products	Frequent, reliable service
	Groceries and Food	Frequent, reliable, fast and innovative service
	Paper Products	Frequent, reliable, fast and innovative service
	Lumber and Construction Material	Frequent, reliable, fast and innovative service
Retail		Frequent, reliable, fast and innovative service
Services		Frequent, reliable, fast and innovative service

Source: Louis Berger International, Inc., Economic Trends and Multimodal Transportation Requirements, 1999

Table C-4: Characteristics of freight transportation modes

Mode	Cargo Value	Cargo Volume	Service	Distance Traveled
Truck	Moderate to high	Loads of less than 50,000 pounds per vehicle. Higher weights with state permits.	Single driver can go 500 miles/day. Team or relay driving can go further. On-time performance for most carriers is 90% or better.	Varies by carrier type. 2/3 of tonnage moves less than 100 mi. Interstate carriers average more than 400 miles.
Rail	Moderate to low	Multiple carloads. No weight restrictions.	Dedicated service can move goods cross-country by third morning. More normal times: 4-7 days. Short-line hauls often require less time. On-time performance varies from 60 % to 85 % or better.	Average length of haul is 670-800 miles. Short-line carriers have shorter average length of haul.
Air	High	Small. Most are less than 100 lbs.	Service normally is overnight or second day.	Average distance is more than 1,300 mi.
Ship	Moderate to low	Bulk, container and general freight shipments.	Bulk service is slower than container (which averages 7-10 days trans-Pacific and trans-Atlantic.	Average distance is more than 2,300 mi. for international shipments and less within the U.S.
Barge	Moderate to low	Bulk and container shipments.	Varies according to system segment. Competitive with rail on large dimension and bulk shipments.	Average distances vary by system segment.
Pipe-line	Low	Bulk shipments	Flow rates vary with consumer demand.	Average distance is 825 miles for crude oil and 375 miles for finished products.
Inter-modal	Moderate to high	Containers by truck, rail, air or water. Trailers by truck and rail. Also other types of connections such as air/truck, water/rail, water/truck, water/pipeline, pipeline/truck.	Matches top end of rail-third morning for cross-country. On-time performance equal to or better than rail but not as good as truck.	Distances normally range from 700 to 1,500 miles or more.

Source: Based on U.S Department of Transportation, U.S. Freight: Economy in Motion, 1998.

According to the Oregon Transportation Plan, inter-modal truck-rail has been the largest growth sector of long-haul transportation, due to various economic reasons as well as a truck driver shortage. Between 1992 and 1999, inter-modal traffic grew from 8 to 12 percent of total inbound and outbound rail tonnage. Factors which have driven this growth include a large international container port (Port of Portland), a base of export commodities which can be containerized (e.g., lumber and paper), and a large metropolitan area (Portland). These factors assume deepening of the Columbia River channel and not breaching Snake River dams.

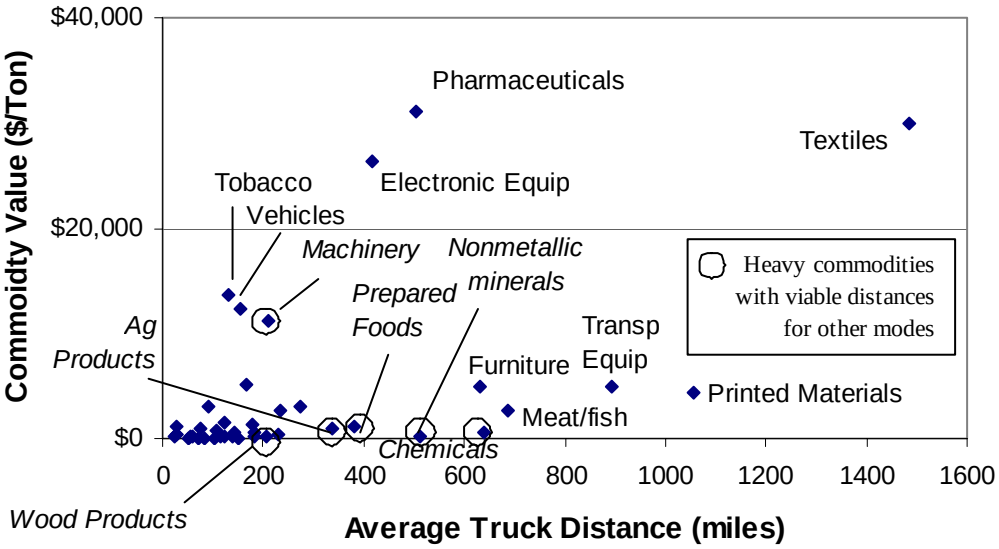
Average truck trip lengths for most commodities in the United States are less than 250 miles.[3] In contrast, most rail shipments travel more than 750 miles and, in the case of Oregon, this is probably closer to 1,000 miles. Large rail carriers are generally not interested in small lot shipments that travel short distances.[4] Some of this market is served by short-line railroads, smaller rail compa-

3. Ed Immel, ODOT Rail Planner, September 2002.

nies that generally operate within a limited service area. Oregon short-line railroads serve about 60 percent of the facilities that normally use rail service. Their cost and price structure is significantly lower than large carriers and they are more willing to carry small volumes of traffic. This is especially true if the haul remains on their line and does not have to be transferred to a large carrier.

Figure C-10 shows a plot of the average truck distance by tonnage value of various commodities in the United States. Average truck trip lengths for most commodities are less than 250 miles. In contrast, most rail shipments travel more than 750 miles and, in the case of Oregon, this is probably closer to 1,000 miles. Large rail carriers are generally not interested in small lot shipments that travel short distances. Some of this market is served by short-line railroads, smaller rail companies that generally operate within a limited service area. Short-line railroads in Oregon serve about 60 percent of the facilities that normally use rail service. Their cost and price structure is significantly lower than large carriers and they are more willing to carry small volumes of traffic. This is especially true if the haul remains on their line and does not have to be transferred to a large carrier.

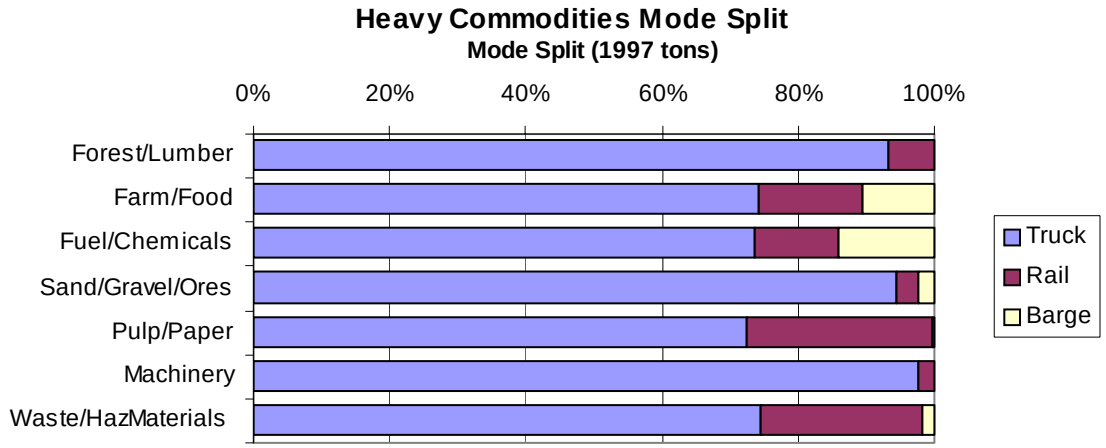
While economies of scale favor the use of trucks for shorter distances, there are exceptions. The heavy commodities with the most potential for other modes include: nonmetallic minerals, chemicals, machinery, prepared foods, and agricultural products. Wood products and machinery average slightly less than 200 miles, but isolated longer trips may be viable by other modes. Heavy transportation equipment shipments largely serve local needs within Oregon and adjacent states (ID, WA). Roughly half of chemicals, non-metallic ores, machinery and prepared foods truck trips are intrastate. Only a third of the truck trips made to haul agricultural products, wood products,



Source: Table 6, 1997 Commodity Flow Survey.

Figure C-10: Average truck distance and value by commodity (Oregon)

4. Recent WSDOT rail office study found medium truck and rail are competitive at 250 miles.



Source: 1997 Commodity Flow Survey.

Figure C-11: Heavy commodites mode split (Oregon)

and chemicals are within the state, with a significant share shipped to and from non-adjacent states. The average distance for trucks hauling petroleum products is less than 150 miles, serving a distribution role within the state (two-thirds of the surveyed trips were intrastate).

Although there are many large trucking firms that operate in and pass through Oregon, many trucks are owner-operated. Large firms can put load on rail and pick it up for local delivery at its destination. Most small firms or individual truck owners do not have this network available to them and stay with the truck from load to unload. To capture truck traffic, railroads need to provide second-day delivery to Los Angeles, which is possible for shipments from Portland, but not from Seattle. The time of day of deliveries is also an important consideration, i.e., midday deliveries are too late to serve most markets.

Currently, both rail and barge are best suited for the transport of heavy commodities such as low-value bulk goods. Figure C-11 gives an estimate of current modal shares in the United States for seven heavy commodities.

The potential for offloading these heavy commodities to alternate modes varies considerably by commodity:

- *Forest and Lumber Products:* Wood chips is a major commodity that continues to move by rail. It has moved in greater quantities in the past and some of the modal shift away from rail has been to trucks in the greater-than-80,000 lbs. weight classes. Over the years, a number of paper mills have removed their rail car unloading facilities. The mills at Newberg and Wauna cannot unload wood chips. The Blue Heron mill at Oregon City still has their rail unloading facility intact but has not used it for several years. Wood chip cars are normally either dumped from the end or are rolled over and there is a substantial capital cost involved to retool since most truck facilities cannot be used for rail cars.

  A corresponding problem is that some lumber mills do not have the ability to load rail cars. Capital costs are considerably less to make provision to load than to unload cars. Most of Oregon's mills are located on short-line railroads that are more likely to be

aggressive in going after the business than larger carriers. The Portland & Western Railroad and the Central Oregon & Pacific Railroad have combined resources to move sizeable quantities of logs from St. Helens to Roseburg and wood chips between their two railroads and have indicated they have sufficient capacity to expand this operation. These movements would not be economical for the large railroads.

- *Farm and Food Products:* Shippers and receivers of farm and food products will use the railroads when they have to move a large quantity a long distance. The railroad's fixed costs work against short haul movements; however, short-haul rail shipments of grain between the Willamette Valley and the Port of Portland have occurred in the past and could probably resume under the right economic circumstances. Barge already moves a substantial amount of product on the Columbia-Snake River system.
- *Fuel and Chemicals:* Petroleum fuels were once commonly carried by railroads, but trucking has gradually gained a much larger share of this commodity market. Today most bulk terminals in the Portland area cannot load a tank car and most of the outlying receiving tracks have been removed. It is possible to return some of this to rail, but investments would be required to improve loading and unloading facilities. Rail movement of propane to rural points in the state is still a common practice. Propane comes mostly from Canada and cannot be trucked economically to Oregon. This is also true of many chemicals that are produced far from Oregon and then are reloaded to trucks for local distribution.
- *Sand, Gravel and Minerals:* The transport of aggregates by rail requires a special set of circumstances. The only significant transport of aggregates by rail is between Portland and Salem in which a producer was required to invest in his own train. A local short-line railroad already served a number of the firm's distribution sites and there was no need to interchange the traffic with a major carrier. It is doubtful that similar circumstances exist anywhere else in the state, and getting the product from the distribution site to the job site must be done by truck. The only other large non-highway transport of aggregates is from the Dallesport area to Portland by barge.
- *Pulp and Paper:* The pulp and paper industry is a major user of rail, receiving inbound chemicals and outbound finished product. One of the major trucking firms has capitalized on this by using "Road-Railer" technology to move paper products from the Portland area to Los Angeles.[5] This operation required a special set of circumstances to be successful.
- *Machinery:* Movement of this commodity is related primarily to construction or farming activity. As such, it is not constant or predictable and has little potential for transfer to non-truck modes.
- *Waste and Hazardous Materials:* Several municipalities in Washington send their solid waste by rail and barge to landfills in Oregon and southern Washington. To date, all of Oregon's solid waste is moved by truck. This transport decision is made primarily on pricing so it is possible that rail or barge may be more competitive in the future.

5. "Road Railers" use modified highway trailers that are raised slightly and a set of rail wheels inserted underneath. They are then formed into solid trains of 70 to 90 trailers.

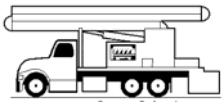
APPENDIX D: TRUCK WEIGHTS AND TYPICAL TRUCK CONTENTS

Different regulations are based on truck weights. When bridges begin to fail, they are usually restricted to lower weights to maintain public safety and to keep the bridge operational until bridge repair or replacement can be completed. The report speaks to load limiting bridges to 80,000 pounds as an initial effort to prolong the life of bridges. The next truck weight category is 64,0000 to 80,000 pounds. To help the reader understand what these truck weights mean in practical terms, this Appendix shows the typical contents for different truck weights. This information is presented for loads that cannot be broken into smaller loads (indivisible) and loads that can be lightened by distribution among more trucks (divisible).

46,000 LBS. GROSS WEIGHT OR LESS

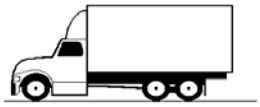
INDIVISIBLE LOADS

- Fire Trucks
- Small Self-propelled Cranes
- Small Self-propelled Drill Rigs
- Tow Trucks



DIVISIBLE LOADS

- School Buses or other Passenger Buses
- Local Delivery Trucks (furniture, appliances, soft drinks)
- Utility/Parts Trucks (glass repair, plumbing)
- Printed Matter (newspapers, magazines, periodicals, advertising supplements)
- Light Wood Products (millwork, specialty wood, lumber, firewood, fencing)
- Residential Household Items (mattresses, ladders, storm doors, carpet, pillows)
- Small Equipment (bobcat, auto parts)
- Some Grocery (chips, cookies, fruit, fish)
- Hazardous Commodities/Waste (chemicals, paint, garden supplies, compressed gases)
- Light Construction Materials (tools, parts, scaffolding, styrofoam, vinyl flooring, plumbing fixtures/supplies)
- Bulky Furniture and Appliances (office products, chairs, refrigerators, bath tubs, storm doors, store fixtures, hospital fixtures/supplies, stereos, video machines)



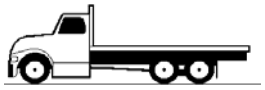
46,000-64,000 LBS. GROSS WEIGHT

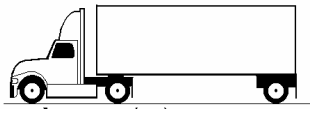
INDIVISIBLE LOADS

- Manufactured Homes
- Equipment (small forklift, rototiller, tractors/combines, military supplies)

DIVISIBLE LOADS

- Mail/Parcel Packages
- Clothing/Textile Products
- Household Goods
- Hardware and Lumber Products
- Furniture
- Small Sand and Gravel Loads
- Metals/Metal Products
- Light Machinery/Electronics (computers, computer parts, office machines)
- Light Grocery (bread, chips, cookies, health products, cigarettes, toilet paper, diapers)
- Light Farm Products (flowers, nursery, mulch)
- Hazardous Commodities/Waste (chemicals, paint, garden supplies, compressed gases)





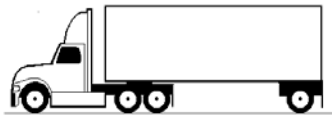
64,000-80,000 LBS. GROSS WEIGHT

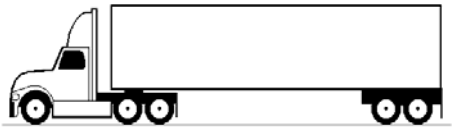
INDIVISIBLE LOADS

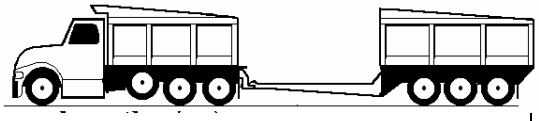
- Manufactured Homes
- Equipment (small forklift, rototiller, tractors/combines, military supplies)

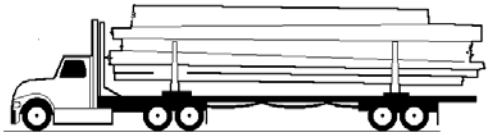
DIVISIBLE LOADS

- Grocery (produce, meat, canned/bottled goods, frozen foods, cheese, coffee, beer/wine/juice, pet food, cleaning products)
- Larger Mail/Parcel Packages Loads
- Farm Products (fruit/vegetables, flowers, grass seed, livestock, nursery, fertilizers)
- Hazardous Commodities/Waste (chemicals, paint, garden supplies, compressed gases)
- Bulk Textiles (fabric bolts, some apparel)
- Department Store Merchandise
- Bulk Paper Products (cardboard boxes, newsprint, newspaper, books, catalogs)
- Raw logs/lumber (particle board, poles, siding)
- Sand and Gravel
- Construction Materials (tin, wire, roofing, cable, metal plates, poles, stone, gravel, glass, concrete forms, siding, rubber, PVC pipes, asphalt)
- Transportation (autos, airplane parts, boats)



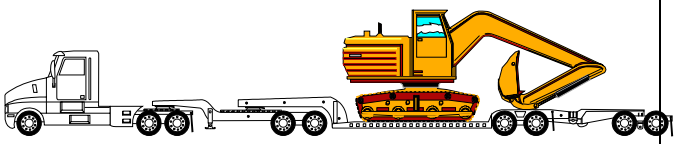




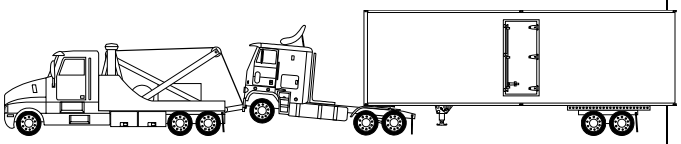


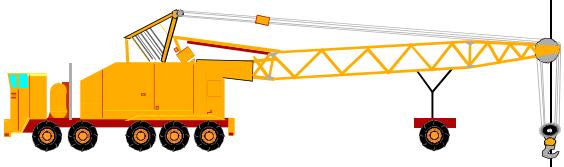
OVER 80,000 LBS. GROSS WEIGHT*

INDIVISIBLE LOADS

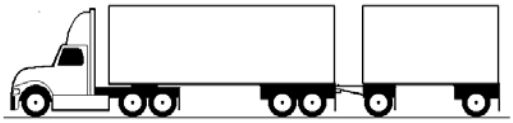


- Bridge Sections, Beams
- Buildings
- Log Loader
- Railroad Equipment (boxcars)
- Boats, Planes, Helicopters, Army Tanks
- Self-propelled Cranes
- Self-propelled Drill Rigs
- Transformers
- Tanks
- Heat Exchanger
- Tow Trucks Towing Vehicle Combinations (considered indivisible when over 98,000 lbs.)
- Construction Equipment (excavators, conveyors, yarders, rock crusher, stump grinder, backhoe)

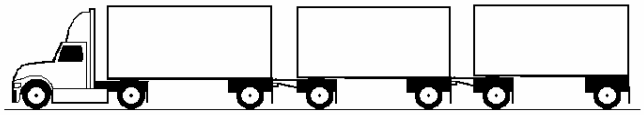




DIVISIBLE LOADS



- Gas and Petroleum Products
- Hazardous Commodities/Waste (chemicals, acids, ammonia, ash, sludge/biosolids, urea, caustic soda, lime)
- Larger Mail/Parcel Packages
- Bulk Lumber/Heavier Forest Products (plywood, pulp, sawdust, veneer, bark, woodchips)



- Construction Materials/Metals (I-beams, rebar, joists, brick, trusses, cement trucks, sand, roofing material, concrete, pavers)
- Heavy Grocery Items (flour, milk, oils, ice cream, heavier produce, cardboard)
- Heavy Farm Products (hay, potatoes, melons, peaches, livestock, feed, grain/wheat)

* Gross Weight limited to 105,500 pounds for indivisible loads.

APPENDIX E: BRIDGE STUDY AND STATEWIDE MODEL OVERSIGHT COMMITTEES

To be credible, the analytical integrity and data consistency of model development and analysis must be maintained at all levels. Technical peer review groups regularly review model development and application. A committee of modeling and economic experts was convened to ensure reasonableness of model input and results for the bridge analysis. Discussions on modeling results with a number of groups resulted in additional or modified model runs as the problem and possible solutions were further refined.

International Peer Review Panel

An internationally prominent Peer Review Panel maintains a key role in the Oregon Statewide modeling program. This panel meets regularly to review progress on model development and to recommend improvements and modifications. Their invaluable contributions have shaped the modeling work program and heavily influenced the design of the models. A statement of support for use of the statewide model for the bridge study is included at the end of this appendix.

The Peer Review Panel includes recognized experts from the U.S., England and Germany:

Julie K.P. Dunbar, Dunbar Transportation Consulting, Bloomington, IL
Kimberly M. Fisher, Transportation Research Board, Washington, DC
Robert Gorman, Federal Highway Administration, Washington, DC
Frank S. Koppelman, Ph.D., Northwestern University, Evanston, IL
Keith Lawton, Portland Metro, Portland, OR
Gordon A. Shunk, Ph.D., Texas Transportation Institute, Arlington, TX
David Simmonds, Ph.D., David Simmonds Consultancy, Cambridge, UK
Michael Wegener, University of Dortmund, Dortmund, Germany

Oregon Modeling Steering Committee

The Oregon Modeling Implementation Program was established in 1995. Its purpose was to have Oregon cities, counties, metropolitan planning organizations (MPOs) and state agencies working together using state-of-the-art transportation modeling tools. To oversee travel modeling in Oregon, an Oregon Modeling Steering Committee (OMSC) was established at the outset of the program. A statement of support for using the statewide model for the bridge analysis is included at the end of this appendix.

Membership in this consortium includes representatives of local, state, and federal agencies, including:

Federal Highway Administration (FHWA)
Governor’s Community Solutions Office (CSO)
Oregon Department of Transportation (ODOT)
Oregon Department of Land Conservation and Development (DL CD)

Oregon Department of Housing and Community Services (OHCS)
Oregon Economic and Community Development Department (OECDD)
Oregon Department of Environmental Quality (DEQ)
Oregon Department of Administrative Services-Office of Economic Analysis (OEA)
Portland Metro (Metro)
Mid-Willamette Valley Council of Governments (MWVCOG)
Lane Council of Governments (LCOG)
Rogue Valley Council of Governments (RVCOG)
Southwest Washington Regional Transportation Council (RTC)

OMSC Bridge Study Peer Review

Through specialized subcommittees, the OMSC provides oversight of statewide model applications on significant projects. A subcommittee composed of the following individuals provided ongoing review and insight for the bridge study:

William Upton, ODOT, Chair
Carl Batten, ECONorthwest
Richard Bjelland, OHCS
Gregg Dal Ponte, ODOT Motor Carrier Division
Kim Hoovestal, FHWA
David Kavanaugh, OECD
Rebecca Knudson, ODOT Policy
Keith Lawton, Portland Metro

ODOT Economic & Bridge Options Team

A team of senior ODOT managers, key constituents and supporting staff provided direction to data development and analysis for the bridge study. This team was responsible for evaluating modeling results and integrating these results with other important information to develop the recommendation to the Oregon Transportation Commission. Members include:

Bruce Warner, Director
Paul Mather, Region 3 Manager, Chair and Project Manager
Jenny Carmichael, Assistant Project Manager
Matt Garrett, Chief of Staff
John Rosenberger, Executive Deputy Director for Highways
Patrick Cooney, Deputy Director, Communications
Gregg Dal Ponte, Deputy Director, Motor Carrier Division
Craig Greenleaf, Deputy Director, Transportation Development
Thomas Lulay, Deputy Director, Oregon Transportation Investment Act
Michael Wolfe, Deputy Director, Project Delivery
Mark Hirota, State Bridge Engineer
Catherine Nelson, Technical Services Manager
Doug Tindall, State Maintenance Engineer
William Upton, Transportation Modeling Program Manager
Jon Oshel, Association of Oregon Counties

Calvin Lee, League of Oregon Cities
Tara Weidner, Parsons Brinckerhoff Quade & Douglas
Michal Wert, MW Consulting

Stakeholder Groups

Several stakeholder groups participated with ODOT staff to review modeling results and other information and to develop its recommendations. A wide range of perspectives was sought because the bridge problem affects many parts of the state infrastructure and economy. Stakeholders included American Automobile Association (AAA) and the Oregon Trucking Association (OTA). Local bridges are also at risk and the Association of Oregon Counties (AOC) and the League of Oregon Cities (LOC) were partners in providing local bridge information and in developing this recommendation. FHWA provided suggestions and information from other parts of the country that are also beginning to experience this problem.

To gather the perspective of freight carriers, ODOT conducted interviews with a representative sample of motor, marine, pipeline and rail freight carriers. Manufacturers of large indivisible loads were also interviewed to determine concerns and how they would likely respond to bridge restrictions. Copies of these interviews are included in the Economic & Bridge Options Report.

Meetings were held with representatives of the trucking industry to discuss priority corridors for bridge replacement. The following “principles of prioritization” were recommended, understanding that specifics may change with new information:

- Keep a north-south and east-west “backbone” open to 105,500 lb. loads at all times.
- Fully restore this backbone in the quickest and cheapest manner. This may require improvement of detour corridors first.
- Once the backbone is in place, focus on reaching population centers and on bridges that have no good detour routes.
- Consider truck height, length, width, and weight when designating detours.
- Coordinate multiple bridge construction and maintenance work to minimize construction disruption.
- Prepare a long-range plan for all bridge construction to allow business to do long-term planning.

Within ODOT, region staff, as well as the Bridge Section, Planning Section, and Office of Project Delivery were key to the process. Agency employees throughout the state have hands-on knowledge of highway system operations and relationships with the local interests who depend on the bridges.

OREGON MODELING IMPROVEMENT PROGRAM PEER REVIEW PANEL
APPRAISAL OF MODEL VALIDATION

Integrated land use-transport models are ideally suited for examining the widely acknowledged but often poorly quantified relationships between these important and complex realms. The impetus for the Transportation and Land Use Model Integration Program (TLUMIP) was a list of policy and investment issues facing the Oregon Department of Transportation. Many of these issues were associated with interdisciplinary topics such as growth management, sustainable development, modal tradeoffs and their economic consequences, and of course the synergy between land development and travel behavior. None of these issues can be studied or usefully analyzed using only traditional travel demand forecasting models.

The first generation TLUMIP statewide model was built upon a proven foundation. Aggregate models of the type developed in Oregon had been successfully applied elsewhere around the world, although almost none at the geographic scale attempted in Oregon. They have been successful at addressing many complex issues involving economic, land use, and transportation elements. The Bridge Limitation Study currently being studied by the Department is an excellent example of the complex, dynamic issues that can be usefully studied with such models. We commend the Department for their foresight in applying the model in such settings.

The Department has asked us to address the issue of model validation, and the practical implications for interpreting the modeling results. This was a topic of earnest discussion early on in our review of the TLUMIP work plan. A considerable amount of experience has been gained in the calibration and validation of traditional urban travel demand forecasting models, including the most relevant criteria for assessing their validity. Comparable experience with integrated land use-transportation models, which are considerably more complex with respect to the interactions they portray, has not yet been gained. Several objective criteria for model validation were decided upon, and the first generation models were rigorously assessed in terms of them. We found that the models met or exceeded the validation targets, suggesting that the models were robust and ready for trial and implementation. Indeed, this last phase of validation-assessment of model performance in real-world applications-is an important indicator of the model's validity.

The modeling process outlined in the Bridge Report is a well thought out and relevant application of the model. The results presented in the Appendix of the report suggest that the model is providing intuitively sensible results that are consistent with its validation. The decisions made by the Department should of course incorporate information from other sources as well. The evidence suggests that the TLUMIP models are providing useful results that should inform decision-makers about the issues at stake.

Julie K. P. Dunbar, P.E., Dunbar Consulting Group
Frank S. Koppelman, Ph.D., Northwestern University
Gordon Shunk, Ph.D., P.E., Texas Transportation Institute
David Simmonds, Ph.D., David Simmonds Consultancy (Cambridge, U.K.)
Dr. Michael Wegener, The University of Dortmund (Germany)

January 10, 2003

OREGON MODELING STEERING COMMITTEE
ASSESSMENT OF STATEWIDE MODEL APPLICATION

The Oregon Modeling Improvement Program (OMIP) was developed to consider the broad changes that are required in how we work together to make decisions, the number of interactions that must be considered in this decision-making process, and the tools necessary to provide solid information for efficient and effective decision-making. OMIP brings together local, state and federal agencies, and private interests who have expertise with and/or will use the modeling products.

The Oregon Modeling Steering Committee (OMSC) is an integral part of the OMIP and provides a high level of cooperation among metropolitan planning organizations, state agencies and the federal government. This results in broad problem-identification and problem-solving collaboration. The data and analysis tools available to decision-makers are uniform statewide and supported by the federal government as a result of this collaboration. Development and application of the statewide model is a significant part of the OMIP and OMSC has provided continued oversight for implementation of the model. For complex projects, a subcommittee of the OMSC is generally established as a technical resource and to review parameters and results for reasonableness and accuracy.

The OMSC was instrumental in providing technical review and recommendations for the first application of the statewide model for the Willamette Valley Livability Forum (WVLF) Alternative Transportation Futures Project in 1999-2000. This type of high-level policy analysis was a good first application of the statewide model for the OMSC to understand how it works, to evaluate parameters used in the model, and to analyze reasonableness of results. The ability to include economic considerations in transportation decision-making was an important element of this project. This was a successful application of the model and was recognized by the WVLF as a significant decision-making tool for assessing complex policy choices.

Since then, the statewide model has been applied to other projects. Two examples include evaluating the feasibility of diverting traffic from I-5 in the Willamette Valley to Central and Eastern Oregon and to encourage growth in those areas. It was also used to evaluate induced growth pressures on rural Yamhill County as part of the Newberg-Dundee Bypass Environmental Impact Statement. For both projects, the statewide model provided information that is not available through standard modeling procedures.

The current Oregon bridge problem is the type of issue that the statewide model was developed to address. The ability to evaluate the economic and transportation results of different funding strategies and improvement packages, when combined with other traditional engineering analyses allows decision-makers to make informed decisions on this important infrastructure issue. The application of the statewide model to the bridge project provides information on economics and transportation that would not be possible given current methods of economic analysis and standard modeling tools. The results of this analysis are sensible and provide information to help decision-makers make informed choices for significant expenditure of public funds.

Keith Lawton, OMSC Chair
Portland Metro, 600 NE Grand, Portland, OR 97232-2799

January 30, 2003

(503) 797-1764

APPENDIX F: LOCAL COMMUNITY BRIDGE SURVEY

Along with state-owned bridges, city and county bridges are also exhibiting cracking and deterioration. These local bridges are important connections to economic centers throughout Oregon. In addition, many local roads and bridges will be used as detour routes if bridges on state routes fail or must be weight restricted. A survey of local bridges and their importance for safety and to local economies was undertaken in the summer of 2002. This appendix summarizes the results of that survey.

In July 2002, ODOT provided the cities and the counties with lists from ODOT's Bridge Management System. The lists indicated that 59 city and 364 county bridges were load limited or had moderate to severe concrete cracking (or both). These worn out bridges are located in 27 cities and 31 counties throughout the state.

In July/August 2002, surveys were sent to all of the cities and counties with bridges on the ODOT lists (Attachment 1). The surveys asked for information on each bridge on ODOT's lists. All of the surveys were returned providing information on 100 percent of the bridges. The survey instrument and distribution letter is included at the end of this appendix.

The survey data was analyzed and combined with the ODOT Bridge Management System information for detour routes. This analysis is summarized in Tables F-1 and F-2. Table F-1 identifies information regarding heavy (over 80,000 pounds) trucks on 88 bridges identified as economically important. Table F-2 lists 120 bridges that were identified as important to serve communities and/or residential areas for safety and emergency response. Bridges of economic importance would be impacted at restrictions of 80,000 pounds while safety bridges would primarily be impacted under more severe restrictions.

The impact of restrictions on these local bridges is not addressed directly in the statewide modeling results. However, this information was combined with modeled truck VMT to provide information on probable effects of different courses of action to cities and counties throughout the state.

Table F-1: Heavy trucks on local bridges of economic importance, by area

Area	"Economic" Bridges[a]		Average daily traffic (ADT)[b]		Average detour (mi)[b]	Economic value ($M/yr) for heavy trucks[c]	
	Total	%posted	All veh	Truck		Payload	Detours[d]
North West Oregon	2	100%	100	8	100	7	14
Portland Metro	3	33%	2,000	10	16	13	4
North East	20	90%	270	10	65	91	128
South Central Oregon	3	33%	490	7	20	9	3
Rogue Valley	15	7%	3,010	9	63	62	80
Lower John Day	2	100%	60	3	74	2	2
Central Oregon	3	67%	90	12	12	16	9
Mid-Willamette Valley	12	58%	5,180	12	41	62	63
Cascades West	7	43%	130	6	65	20	30
South West	8	38%	2,120	14	69	49	72
South East	4	25%	210	13	51	22	20
Lane	9	44%	2,300	9	79	35	57
All "Economic" Bridges	88	66%	1,170	9	58	388	482

a. Includes Cracked Hardship A/B bridges per 2002 City/County Bridge Survey; excludes bridges with committed funding.
b. Truck ADT and detour length per ODOT Bridge Management System; 24% of trucks were greater than 80,000 pounds, per Special Weighings data.
c. Value assumes $5,000/truck (25 tons/heavy truck, $200/heavy commodity ton).
d. Detour cost applies only to trucks over 80,000 pounds, at an average cost of $1.67/mile.

Table F-2: Local bridges important for safety reasons, by area

Area	"Safety" bridges[a]	Posted	Average daily traffic (ADT)[b]		Average detour (mi)[b]
			All veh	Truck	
North West Oregon	9	78%	670	8	44
Portland Metro	22	64%	1,250	7	58
North East	15	93%	70	6	47
South Central Oregon	2	100%	1,320	6	81
Rogue Valley	13	46%	5,690	10	48
Lower John Day	5	40%	70	6	44
Central Oregon	3	100%	380	2	42
Mid-Willamette Valley	11	82%	370	3	59
Cascades West	18	56%	300	8	43
South West	10	60%	3,400	11	40
South East	8	88%	50	10	65
Lane	4	25%	520	13	63
All "Safety" Bridges total	120	68%	1,320	8	51

a. Includes Cracked Hardship (C/D) bridges without detour and "lifeline" bridges per 2002 Bridge Survey; excludes bridges with committed funding.
b. Truck ADT and detour length per ODOT Bridge Management System.

Survey of City and County Bridges

The Association of Oregon Counties sent the following email to all cities and counties in July 2002.

> We are working with ODOT to develop a finance package for Oregon bridges. This package is to include local agency bridges, as well as the ODOT bridges. It appears the effort will focus on bridges with severe concrete cracking (State 2 & 3) and bridges with load postings. Over 400 County and City bridges have either severe cracking and/or load postings.
>
> We need to develop an estimate of the cost to replace these bridges. We also need to develop a system to prioritize the bridges for a multi-phase funding package.
>
> Attached is a memo explaining the details I need. Also attached is a spreadsheet I would like you to download, enter the data on, and then return to me by E-Mail.
>
> My next meeting with ODOT on this issue is August 5th. I would like to have at least of rough picture of our needs by then. I need time to analyze the responses you give me.
>
> Please return the completed spreadsheet to me by JULY 29TH. If you need time to give me a better answer, send me your best guess by July 29th, but tell me you will be sending updated information latter. I will update my data sheets when I get your updated information.
>
> I know this is a very short time frame. However, if we want to be a part of the Bridge Finance Initiative we must get at least rough numbers and priorities on the table very quickly.
>
> Thanks for your help.

July 2002 Survey

We are working with ODOT to develop a finance package for Oregon bridges. This package is to include local agency bridges, as well as the ODOT bridges. It appears the effort will focus on bridges with severe concrete cracking (State 2 & 3) and bridges with load postings. We need to develop an estimate of the cost to replace these bridges. We also need to develop a system to prioritize the bridges for a multi-phase funding package.

We have developed a method of calculating the cost for bridge replacements based on the information we can gather from the National Bridge Inventory System (NBIS) data sheets. It is mostly based on a cost per square foot. We have compared our estimates with the costs of recent STIP and OTIA projects. On a system basis, our estimating method matches actual costs fairly well. Individual bridges vary quite a bit. The number may appear high at first but it includes all project costs, including design, R/W, road approaches, detours and contingencies. We assumed that there will be some federal money, so all federal standards and procedures will be needed.

The estimates for the bridges in the attached spreadsheet will not be used to program funds for individual bridges. However, if the estimate for one of the bridges on your list is considerably lower than your anticipated costs for some special reason we need to know. PLEASE REVIEW THE LIST OF BRIDGES TO CONFIRM THAT THE ESTIMATED COST IS NOT WAY TOO LOW. If so, please tell us why. *[NOTE: The highlighted bridges on your list, if any, are bridges already programmed for funding by OTIA or HBRR. For these bridges I put the programmed amount in the estimate cell]*

As part of the prioritization process, we are trying to determine the impact to the community's economy (area of the county) caused by a bridge closure. For purposes of the following questions:

- Industry means any major source of community revenue/employment such as a farm, timber, manufacturing, commercial or tourism.
- Hardship is to be a determination of the impact on the TOTAL community economy. The following would be an example related to a lumber mill:
  A. If a bridge load posting caused the closure of the only lumber mill in town it would be "Industry would close or cease to exist."
  B. If there were two other lumber mills in town it would be a "Significant hardship."
  C. If there were another route to the mill, even if longer over a poorer road, it would be "Some Hardship."
  D. If there was another route, with less than a 20-minute delay, on good roads, it would be "Little Hardship"

Please answer each of the following questions for each bridge on the attached spread sheet"

1. Is there a feasible detour for trucks that is less than 20 minutes?
   Yes_____ No_____

2. Is the bridge a primary access to emergency facilities (Lifeline Route)?
   Yes_____ No_____

3. If the bridge were posted, what would be the hardship to the local industry?
   A. Industry would close or cease to exist.
   B. Significant hardship.
   C. Some hardship.
   D. Little effect.

My next meeting with ODOT on this issue is August 5th. I would like to have at least of rough picture of our needs by then. I need time to analyze the responses you give me.

PLEASE RETURN THE COMPLETED SPREAD SHEET TO ME BY July 29th. If you need time to give me a better answer, send me your best guess by August 1st, but tell me you will be sending updated information latter. I will update my data sheets when I get your updated information.

I know this is a very short time frame. However, if we want to be a part of the Bridge Finance Initiative we must get at least rough numbers and priorities on the table very quickly.

Thanks for your help.

Jon Oshel
County Road Program Manager
Association of Oregon Counties
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