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New Techniques for Estimating Impacts of Rail Line Abandonment on Highways in Washington

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SFTA Research Report # 7

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SFTA Research Reports:
Background and Purpose

This is the seventh of a series of reports prepared from the Strategic Freight Transportation Analysis (SFTA) study. SFTA is a six year comprehensive research and implementation analysis that will provide information (data and direction) for local, state and national investments and decisions designed to achieve the goal of seamless transportation.

The overall SFTA scope includes the following goals and objectives:

- Improving knowledge about freight corridors.
- Assessing the operations of roadways, rail systems, ports and barges – freight choke points.
- Analyze modal cost structures and competitive mode shares.
- Assess potential economic development opportunities.
- Conduct case studies of public/private transportation costs.
- Evaluate the opportunity for public/private partnerships.

The five specific work tasks identified for SFTA are:

- Work Task 1 - Scoping of Full Project
- Work Task 2 - Statewide Origin and Destination Truck Survey
- Work Task 3 - Shortline Railroad Economic Analysis
- Work Task 4 - Strategic Resources Access Road Network (Critical State and Local Integrated Network)
- Work Task 5 - Adaptive Research Management

For additional information about the SFTA or this report, please contact Eric Jessup or Ken Casavant at the following address:

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Or go to the following Web Address:

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DISCLAIMER

PREVIOUS SFTA REPORTS NOW AVAILABLE

1. Casavant, Kenneth L. and Eric L. Jessup. "SFTA Full Scope of Work." SFTA Research Report Number 1. December 2002.

2. Clark, Michael L., Eric L. Jessup and Kenneth L. Casavant. "Freight Truck Origin and Destination Study: Methods, Procedures and Data Dictionary." SFTA Research Report Number 2. December 2002.

3. Casavant, Kenneth L. and Eric L. Jessup. "Value of Modal Competition for Transportation of Washington Fresh Fruits and Vegetables." SFTA Research Report Number 3. December 2002.

4. Ripplinger, Toby, Kenneth L. Casavant and Eric L. Jessup. "Transportation Usage of the Washington Wine Industry." SFTA Research Report Number 4. May 2003.

5. Clark, Michael L., Eric L. Jessup and Kenneth L. Casavant. "Dynamics of Wheat and Barley Shipments on Haul Roads to and from Grain Warehouses in Washington State." SFTA Research Report Number 5. September 2003.

6. Casavant, Kenneth L., Eric L. Jessup, and Joe Poire. "An Assessment of the Current Situation of the Palouse River and Coulee City Railroad and the Future Role of the Port of Whitman County." SFTA Research Report Number 6. September 2003.

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INTRODUCTION

This working paper is part of the Strategic Freight Transportation Analysis (SFTA) being conducted by Washington State University. The overall purpose of SFTA is to "strategically maximize the efficiencies and benefits available from Washington's multimodal transportation system in moving freight." Two of the six objectives of SFTA relate to pavement cost impacts resulting from changes in freight traffic patterns. This working paper describes pavement cost models commonly used in transportation investment decisions and public planning. In addition, the paper describes how these models are used to estimate the potential impacts of railroad abandonment in eastern Washington.

Scope of the Problem

More than 1,500 miles of Class I branch line and short-line railroad are operated in the state of Washington, including 1,158 miles of local, regional, switching, and terminal rail line. Approximately 15 million tons of freight are originated or terminated on these lines each year.[1] Most of these shipments consist of Lumber and Wood Products, Petroleum or Coal Products, Farm Products, Chemicals, Food and Kindred Products, and Pulp, Paper and Allied Products.[2]

For the State as a whole, the annual branch-line traffic is equivalent to nearly 600,000 truck loads. Without branch lines, this traffic would move by truck. Many of these additional trucks would travel over local arterial and collector highways. These roads are not designed to the same standards as interstate or principal arterial highways. Additional truck traffic on these roads would accelerate pavement deterioration and shorten the interval between resurfacing events.

Case Study

The Palouse River and Coulee City Railroad (PCC) currently operates 372 miles of light-density lines in eastern Washington. The PCC has raised the possibility that these lines may be targeted for abandonment in the next five years. This system makes a good case study of incremental highway investment needs associated with traffic that is shifted from rail lines to trucks.

The purpose of this paper is to describe the potential highway impacts that would result if the contents of the 10,700 annual carloads handled on the PCC system are moved in trucks to river ports or inland terminals and the analytical models and data used in the study. Although many of the techniques described in this paper have been used in previous studies in Washington State, two new techniques are described in the report:

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1 Estimated from the Rail Carload Waybill Sample and railroad traffic density maps.

2 Rail Carload Waybill Sample.

- An incremental pavement thickness method
- An environmental analysis procedure that isolates load-related and non-load (environmental) effects

OVERVIEW OF PCC RAIL NETWORK

The PCC network (Figure 1) consists of four sets of lines or subsystems:

- The Cheney-to-Coulee City line
- The Marshall-to-Pullman line
- The northern division of the Blue Mountain Railroad (BLMR North)
- The southern division of the Blue Mountain Railroad (BLMR South)

Figure 1 PCC Railroad Network in Eastern Washington Courtesy of PCC Railroad

The Cheney-to-Coulee City line was sold to PCC by BNSF in 1996. It connects to the BNSF's Spokane-Pasco mainline at Cheney. From Cheney, the line runs through Medical Lake and Hite on its way to Reardan. From Reardan westward, the line parallels US-2, running through Davenport, Creston, Wilbur, and Hartline before terminating in Coulee City.

In 2000, 1,946 carloads were originated from stations on the Marshall-to-Pullman line. From north-to-south, the stations on this line include: Spangle, Plaza, Rosalia, McCoy, Flaig, Oakesdale, Belmont, Eden, Palouse, and Fallon. A branch of this line -- the WI&M (Washington Idaho and Montana) subdivision -- extends into Idaho.

The northern division of the BLMR connects with the Union Pacific (UP) at Hooper Junction. From Hooper Junction, the railroad runs east for 79 miles, passing through Winona, Colfax, and Pullman on its way to Moscow, Idaho. A branch of this line runs northeast from Winona to Thornton, a distance of 31 miles. This branch includes stations at St. John, Willada, Mockonema, and Endicott.

In 2000, the northern BLMR lines generated 3,447 carloads of traffic. Most of this traffic was grain. However, some shipments of farm machinery, fertilizer, and coal moved over the line.

The BLMR South division of the PCC operates more than 80 miles of railroad. It connects with the UP at Zanger Junction, near Wallula. From Zanger Junction, the line extends 27.5 miles to Walla Walla. A branch runs from Dayton through Walla Walla to Weston, Oregon. However, this line is operated only as far as Milton Freewater, Oregon. Most of the traffic originated from stations in Washington comes from shippers located in Dayton and Walla Walla. Seneca Foods in Dayton is a shipper of canned vegetables. Agri Pak and Americold ship food products from Walla Walla.

If the PCC rail lines are abandoned, elevators now shipping by rail will truck grain to river ports, where it will be transferred to barge for downriver movement. Food manufacturers will truck products to the Tri Cities for subsequent re-shipment by rail to markets in the eastern United States. In either case, these agricultural industries will experience higher shipping costs after abandonment than they experience today.

POTENTIALLY AFFECTED HIGHWAYS

Shipper telephone surveys and interviews were conducted in eastern Washington in late 2001 and 2002. Shippers were asked about the types of trucks they use, their trucking costs, and the river ports to which they would deliver grain if the PCC rail lines are abandoned. Using this information, a highway network model was developed. Routes were defined connecting each elevator and food processor to one or more river ports. The highway distance was computed from each station to the closest river port or to the river port specified by the shipper. In most cases, the preferred river port is the one nearest to the shipper.

Most of the 10,700 rail cars moving over the PCC in eastern Washington are transporting grain. Abandonment of these lines would result in more than 29,000 additional truck trips in eastern

Washington each year. Most of these incremental trips would be generated from the Cheney-to-Coulee City line and the BLMR North. Each of these subsystems would generate in excess of 10,000 new heavy truck trips per year. In the most likely post-abandonment scenario, these trucks would be destined for the river ports of Windust, Central Ferry, and Pasco. The average loaded trip distance would be at least 75 miles.

As many as 645 miles of highway in eastern Washington will be impacted if the PCC rail lines are abandoned. State Routes 17, 21, 23, 26, 27, 28, 124, 127, 231, 263, and 272 will be affected as well as portions of US-2, US-12, US-195, and US-395. More than 300 of the 645 impacted miles are classified as minor arterial or collector highway. About 355 of these miles are asphalt-concrete (AC) pavements. Another 272 miles consist of bituminous surface treatments. Many of these BST routes are low-volume, low-ESAL highways.

TRUCK CONFIGURATIONS AND AXLE LOADS

If the PCC lines are abandoned, several types of heavy trucks will be used to move the commodities now moving by rail. Grain will be hauled in Rocky Mountain Doubles. When fully loaded, a Rocky Mountain Double (RMD) weighs 105,500 pounds. The payload of a grain-hauling RMD is 72,000 pounds or 36 tons, based on a midpoint tare weight of 33,500 pounds.

If the PCC lines are abandoned, manufactured and processed goods would be transported in 5-axle tractor-semitrailer trucks. Because of the tandem-axle exception to Bridge Formula B, most of these trucks would be loaded to 80,000 pounds. Chemical and petroleum products would move in specialized tanker trailers. Farm equipment or machinery traffic would move on flatbed trailers.

The effects of different axle types and weights are accounted for by converting the axle weights to equivalent single-axle loads or ESALs. An ESAL represents the impact of a certain type of axle and load in comparison to the impact of an 18,000-pound single axle. In this study, an ESAL factor is computed for each truck/commodity combination and for each affected highway segment using equations developed by the American Association of State Highway and Transportation Officials (AASHTO). Separate equations are used for single and tandem axles and flexible and rigid pavements.

If the PCC lines are abandoned, the annual equivalent single-axle loads will more than triple on 33 miles of BST pavement. Annual ESALs will more than double on another 46 miles of BST pavement. Approximately 80 percent (or 219 miles) of all affected BST miles will experience at least a 10 percent increase in annual ESALs. Over half of the 355 miles of potentially-impacted asphalt-concrete pavements will experience more than a 5 percent increase in annual ESALs. Altogether, nearly 7 million annual ESAL-miles will be added to the state highway system each year. A primary objective of this working paper is to forecast the effects of these ESALs.

PAVEMENT COST ANALYSIS PROCEDURES

The primary analysis method used in this study is the incremental overlay thickness method. This method is an abstract representation of the pavement rehabilitation process using overlays. It is based on the American Association of State Highway and Transportation Officials pavement rehabilitation method and uses the AASHTO pavement design equations. These procedures are described in Chapter 7 of Volume 2 of the 1995 WSDOT Pavement Guide, published by the Washington State Department of Transportation. The objective of this method is to determine the additional overlay thickness needed to provide the enhanced structural capacity necessary to accommodate the new truck traffic.

INCREMENTAL OVERLAY THICKNESS METHOD

The incremental thickness method of estimating highway costs uses the AASHTO pavement design equations. A similar approach was used in the Transportation Research Board's Special Report 225: Truck Weight Limits. The relationship between structural (SN) and ESALs is simulated for a range of potential designs. The value of SN in the AASHTO pavement design equation is increased in very small increments. This simulation creates a set of "observations" of structural numbers and corresponding ESALs. The log of ESALs is then regressed against the log of SN to determine the slope coefficients.

Table 1 shows a set of slope coefficients or elasticities for structural classes of pavements. A coefficient in Table 1 represents the percentage change in structural number corresponding to a one percent change in ESALs. The use of multiple coefficients allows economies of pavement thickness to be reflected in the incremental cost estimates. For example, the slope coefficient for light-duty flexible pavements is .178. This means that when a one percent increase in ESALs occurs on a light-duty flexible pavement the structural number must be increased by .178 percent to maintain the same performance period. In comparison, a one percent increase in ESALs on a heavy flexible pavement section means that the structural number must be increased by .142 percent to maintain the same performance curve. The structural capacity of rigid or concrete pavements is represented by the slab thickness (D).

Table 1. Elasticity of Pavement Structural Number with ESALs

Structural Class	Flexible Pavement		Rigid Pavement	
	SN Range	Slope Coefficient	D Range	Slope Coefficient
Heavy	4.6 – 6.0	0.142	9.1 – 14.0	0.149
Medium	3.1 – 4.5	0.167	7.1 – 9.0	0.166
Light	1.0 – 3.0	0.178	5.0 – 7.0	0.195

In order to implement this procedure, the current (design) ESALs and the current (design) structural number must be known for each impacted highway segment. Both inputs are derived from the Washington State Pavement Management System (WSPMS). The incremental cost procedure is then implemented as follows:

1. The percent increase in ESALs for an impacted segment is computed by dividing the ESALs generated from the potential abandonment by the existing ESALs and multiplying by 100.
2. The percent increase in structural number is computed from the appropriate slope coefficient in Table 1.
3. The numerical increase in structural number is computed by multiplying the design (current) SN by the percent increase divided by 100.
4. The incremental overlay thickness is computed by dividing the increase in structural number by .44 - the layer coefficient for new asphalt concrete.
5. The cost per inch for the type of impacted highway is computed from paving costs provided by the WSDOT Eastern Region office.
6. The incremental cost is computed by multiplying the cost per inch by the incremental inches of overlay thickness needed for the additional traffic.

It is assumed that the incremental thickness is added at the time the pavement is scheduled for preservation resurfacing and that thickness can be finely adjusted - i.e., it is possible to increase the normal overlay thickness by fractions of an inch. Moreover, the effects of environmental factors are reflected already in WSDOT's pavement preservation program. The only effect attributed to incremental truck traffic is the additional thickness required at the time the pavement is resurfaced.

ANALYSIS OF BST ROUTES

Special procedures are used to analyze BST routes. Because of large percentage increases in ESALs after abandonment, many BST routes will require structural overlays instead of surface treatments. In the incremental method, these segments are converted to AC pavements assuming a standard overlay thickness of 1.8 inches. These conversions represent short-run solutions only. The conversion costs may be analogous to the "tip of the iceberg." In the long-run, many of these BST segments may have to be reconstructed to ACP route standards. The pavement reconstruction cost involved in such a conversion would be 2 to 3 times the cost of a standard overlay. Moreover, the route would have to be brought up to current design standards as specified in the WSDOT Design Manual. The full cost of a BST-to-ACP route conversion would be $1 million per mile instead of the $193,000 per mile used for rural two-lane highways in this study.

AVERAGE/MARGINAL COST METHOD

Pavement costs are estimated using a second independent method. This method was developed originally by Federal Highway Administration in the 1982 Highway Cost Allocation Study for allocating pavement preservation (3R) costs among vehicle classes. FHWA referred to this method as a "marginal cost" approach. Technically, this is true only if certain assumptions are met.

In the average/marginal cost approach, structural capacity is defined as the maximum number of axle loads that a pavement can accommodate before it is rehabilitated. Structurally, the life of a pavement is measured in equivalent single axle loads or ESALs. When a pavement reaches its terminal serviceability level, it is restored or rehabilitated through resurfacing. For a given functional class of highway, marginal pavement cost is assumed to be the same as average cost. However, marginal costs may vary greatly among functional classes.

The portion of resurfacing cost that is unaffected by truck traffic is excluded from the marginal cost calculation. In a multi-year study, the relative shares of pavement rehabilitation costs attributable to environmental (non-load) and traffic (load-related) factors were estimated by FHWA using the National Pavement Cost Model (NAPCOM). For flexible pavements, NAPCOM analyzes traffic-related PSR loss (roughness), fatigue cracking, rutting, loss of skid resistance, expansive clay-related PSR loss, and thermal-related cracking. The first four distresses are load-related. However, the last two distresses are non-load or environmental distresses.

The non-load shares of pavement rehabilitation cost in Washington State were derived from FHWA's cost allocation spreadsheet. As described in the main report, the estimated contribution of non-load factors to pavement rehabilitation cost is less than 4 percent for Rural Interstate highways in Washington. However, the non-load contribution increases to 12.5 percent for Rural Other Principal Arterial highways and 16.7 percent for Rural Minor Arterial highways. The highest non-load cost responsibility is nearly 30 percent for Rural Major Collector highways. The increasing non-load cost responsibility for lower highway classes is primarily the result of PSR loss due to expansive clay soils.

After the contribution of environment to pavement rehabilitation cost has been isolated, the residual cost is traffic-related. The marginal pavement cost of a truck trip within a given functional class is estimated through a multi-step process:

1. The ESAL life is computed from AASHTO equations using the structural number of the segment as computed from WSPMS layer data.
2. The load-related share of pavement rehabilitation cost is estimated from the average rehabilitation cost per lane-mile for the functional class of highway (Table 2).[3]
3. An average (marginal) cost per ESAL is computed by dividing the load share of rehabilitation cost by the ESAL life.
4. The axle loads of a truck or a particular class of trucks are converted into ESALs.
5. For divided highways, the ESALs are converted to design-lane ESALs using a lane distribution factor.
6. The design-lane ESAL factor is multiplied by the cost per ESAL to yield a cost per vehicle-mile of travel (VMT).

3 The resurfacing costs shown in Table 2 implicitly reflect differences in the typical overlay thickness required for different classes of highways with different traffic loads. Because of higher ESAL loads, a thicker overlay may be needed on a rural interstate highway than on a rural principal arterial highway than on a minor arterial or collector road. Moreover, lanes and shoulders may not be as wide on minor arterial and collector highways as on principal arterial roads. For these reasons, the average resurfacing cost per lane mile decreases with the functional class of highway in the average cost approach.

Table 2. 2000 Resurfacing Costs per Lane Mile Adjusted for Washington State Construction Costs

	Thousands of Dollars per Lane Mile		
	Terrain		
Functional Class	Flat	Rolling	Mountainous
Rural Interstate	$165	$165	$204
Rural Other Principal Arterial	$103	$103	$151
Rural Minor Arterial	$86	$92	$145
Rural Major Collector	$49	$57	$72

Source: 1997 FHWA costs indexed to 2000 levels using FHWA Construction Price Indexes for pavement surfacing in rural and urban areas and then adjusted by the Washington State cost factor.

Table 3 illustrates the results of these calculations using the mean structural number of each functional class. The estimated Rural Interstate cost of 13 cents is very close to the FHWA marginal cost of 12.7 cents per truck-mile shown in the 1997 Highway Cost Allocation Study. Although there are no benchmarks for the other unit costs, their relationships to the Rural Interstate cost seem reasonable in light of the ESAL lives shown in Table 3.

Table 3. Average Costs per ESAL and VMT for an 80,000-Pound 5-Axle Truck Traveling on Rural Highways in Eastern Washington

Functional Class	SN	ESAL Life	Cost per ESAL	Cost per VMT
Interstate	5.3	5,167,630	$0.06	$0.13
Other Principal Arterial	4.2	1,406,861	$0.13	$0.30
Minor Arterial	3.0	325,217	$0.47	$1.16
Major Collector	2.5	173,078	$0.46	$1.14

The relationship between Minor Arterial and Major Collector highways may appear unusual. However, the cost per ESAL reflects differences in ESAL life and resurfacing cost. The average resurfacing cost per lane-mile of a Minor Arterial highway is 176 percent greater than the average resurfacing cost of a Minor Collector highway. However, the ESAL life of a Minor Arterial highway is 188 percent greater than the average resurfacing cost of a Minor Collector highway. For these reasons, the average cost per ESAL varies only slightly between the two functional classes. However, it is important to note that average functional class costs are not used in the highway impact analysis. Instead, impact costs are estimated for each highway segment based on its actual structural number. Functional class costs are used for purposes of illustration.

RESULTS OF CASE STUDY

The incremental thickness and marginal cost methods yield virtually identical results. Table 4 shows the results of the incremental thickness method for a 10-year period for the prime impact scenario: transshipment from stations located on the PCC to the river ports of Windust, Central Ferry, and Pasco. The estimates shown in Table 4 are based on future resurfacing events for each potentially-impacted WSPMS segment. Resurfacing is assumed to occur in the year the pavement is due, as shown in the WSPMS database. Column 3 of Table 4 shows the present value of these future costs based on the federal discount rate of 4.33 percent.

Table 4. 10-Year Incremental Pavement Cost Resulting from Potential Abandonment of PCC Railroad Lines

Main Scenario: Transshipment via River Ports		
	Thousands of Dollars	
Rail Subsystem	**Future Cost**	**Present Value**
BLMR North	$ 6,222	$ 5,619
BLMR South	$ 3,549	$ 3,071
Cheney-Coulee City	$ 31,890	$ 29,735
Marshall-Pullman	$ 5,965	$ 5,412
Total: PCC System	$ 47,627	$ 43,838

The highway impact analysis considers the incremental user fees that would be generated from the additional truck traffic if the PCC lines are abandoned. These user fees include motor fuel tax revenues, vehicle registration fees, excise taxes, and heavy vehicle use fees. The present value of these revenues is $5.5 million over a 10-year period. When truck revenues are considered, the net present value of resurfacing cost drops to $38.3 million. However, these costs do not fully capture all potential effects. Not only will WSDOT need to place thicker-than-normal overlays on impacted segments, the due years for these segments may be moved forward in time as a result of accelerated pavement deterioration.

BUILD-SOONER COST

The incremental thickness method assumes that WSDOT resurfaces the pavement in the due year and restores the lost structural capacity resulting from normal traffic and environmental deterioration. In actuality, large increases in truck traffic on BST or low-capacity segments may shift the due date forward in time. This phenomenon is called "Build-Sooner Cost." WSDOT must place the preservation overlay earlier than planned. Because of the time value of money, there is a cost associated with earlier resurfacing, even if the paving depth and cost are the same.

Build-sooner cost is illustrated in the appendix. Analytically, this effect this modeled using pavement deterioration equations from the Highway Economic Requirements System (HERS). The HERS deterioration functions were derived originally from AASHTO road test equations. In this study, the current Pavement Structural Condition (PSC) rating used by WSDOT is converted to the Present Serviceability Rating (PSR) used by Federal Highway Administration. For each impacted segment, the decline in PSR due to ESALs is simulated on an annual basis until it reaches 3.0 (which is comparable to a PSC value of 50). Deterioration rates are simulated with and without the incremental traffic. The difference in due years is the "build-sooner" interval. The difference in present value is estimated using the applicable federal discount rate of 4.33 percent. At this discount rate, approximately $1.1 million in build-sooner cost is estimated for the potentially-impacted highways.

Build-sooner costs are an attempt to quantify the time-related effects of accelerated pavement preservation. However, they ignore budgetary constraints and political realities. They assume WSDOT has unlimited budget and can respond immediately to the shortened resurfacing intervals by moving the impacted segments forward in the preservation improvement program.

Theoretically, it is possible for WSDOT to move an impacted highway forward in the pavement preservation program. In practice, this is extremely difficult to do. Approximately 23 percent of state highway miles are past due for resurfacing. Moving impacted segments forward in the resurfacing program means that other projects must be delayed, downgraded, or foregone.

In the most likely scenario, many of the impacted segments will become "past due" - i.e., the PSC will drop below 50 before WSDOT can apply preservation overlays. These segments will be rehabilitated in the due year as planned. However, the normal preservation cost will be greater.

PAST-DUE COST

The past-due cost estimates presented in this report assume the pavement receives a preservation overlay in the future year for which it is predicted in the WSPMS. However, by the time the due year is reached, the pavement will be past due because of incremental traffic. In other words, the pavement has deteriorated faster that expected. Therefore, it should have been resurfaced earlier to achieve the optimal overlay cost. However, with a fixed preservation budget and a queue of past-due projects, the impacted segment could not be moved forward in time.

The build-sooner cost of a pavement reflects normal resurfacing cost incurred at an earlier time. In contrast, past-due cost reflects a normal resurfacing interval, but a more deteriorated pavement at the end of the interval. According to historic data, the paving cost of a project that is less than 3 years past due is 25 percent greater than the paving cost of the same project when it is due. Moreover, the paving cost of a project that is 3-to-6 years past due is 50 percent greater than the timely cost of the same project.

With no rail-line abandonment, past due highway miles are projected to increase significantly in the future because of funding constraints.[4] If the PCC rail network is abandoned, past-due paving costs are projected to increase by an additional $14.7 million during the next 10 years.

Past due costs are distinct from the incremental costs computed with the incremental thickness method.[5] In the latter instance, incremental thickness is needed to increase the structural capacity of the pavement in light of the permanent increase in heavy truck traffic. In the first instance, the thicker overlay is needed to restore the pavement to its design structural capacity given the greater severity of fatigue cracking and other distresses that have developed during the current resurfacing interval.

CONCLUSION

Analytical Techniques

Two new analytical techniques are described in this paper. A new environmental analysis procedure has been developed that improves the average cost approach used in earlier studies. An incremental thickness method has been developed that simulates the overlay thickness approach used in pavement rehabilitation. The revised average cost and incremental thickness methods yield similar forecasts of future highway impacts in the eastern Washington case study. Either of these procedures would be useful in future studies.

Projected Increase in Highway Cost for Eastern Washington Case Study

Abandonment of the Palouse River and Coulee City Railroad would increase heavy truck traffic in eastern Washington by more than 29,000 trips per year. This additional traffic would have two effects: (1) it would shorten the time interval before a resurfacing improvement is needed and (2) it would affect the thickness of the overlay, and thus the resurfacing cost at the time the improvement is made.

In the current preservation cycle, WSDOT would incur build-sooner or past-due costs because of accelerated deterioration of pavements. These costs could range from $1.1 to $14.7 million over

4 The WSDOT Eastern Region projects that past-due miles could increase from 13% to approximately 35% of highway miles as a result of budget constraints faced in the pavement preservation program.

5 It is important to note that past-due and build-sooner costs cannot be added together. One cost or the other will be incurred during the present resurfacing interval.

the next 10 years, depending on the ability of WSDOT to find supplemental highway funds to move the impacted segments forward in the pavement preservation program.

These costs reflect only the restoration of pavements to their normal structural capacity. However, additional structural capacity will be needed to prevent them from experiencing accelerated rates of deterioration in future periods. The logical time to add this capacity is at the scheduled time for a preservation overlay. If this occurs, the additional cost (in addition to the past-due or build-sooner cost in the current resurfacing period) will be the cost of additional pavement thickness needed to provide the increased structural number necessary to accommodate the permanent increase in truck traffic.

Over a 10-year period, the estimated present value of this additional pavement thickness cost is $43.8 million. However, the incremental pavement cost is offset partially by incremental truck user fees of $5.5 million. Thus, the estimated net present value of this cost is $38.3 million. However, if the present value of potential past-due cost is considered, the total pavement cost resulting from the abandonment of PCC rail lines in eastern Washington may exceed $50 million.

Other Highway Costs

In addition to pavement rehabilitation costs, other types of highway impacts could result from changes in freight traffic including:

- Higher routine maintenance costs (such as patching and spot maintenance)
- Capacity-related impacts resulting from a higher percentage of trucks on high-traffic highways
- Safety-related impacts from additional truck travel on rural two-lane highways
- Increased energy consumption and emission of air pollutants as a result of shifting traffic from railroads to trucks

Analytical techniques exist to measure some of these effects. It may be appropriate to include capacity, safety, and air quality effects in rail-line impact studies in other areas of the State.

DICTIONARY OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt concrete
ACP	Asphalt-concrete pavement
BLMR	Blue Mountain Railroad
BST	Bituminous surface treatment
ESAL	Equivalent single axle load
FHWA	Federal Highway Administration
HERS	Highway Economic Requirements System
NAPCOM	National Pavement Cost Model
PCC	Palouse River and Coulee City Railroad
PSC	Pavement Structural Condition (scaled from 0 to 100)
PSR	Present Serviceability Rating (scaled from 0 to 5)
WSDOT	Washington State Department of Transportation
WSPMS	Washington State Pavement Management System

APPENDIX

The purpose of this appendix is to illustrate the effects of accelerated pavement deterioration and resulting build-sooner and past-due costs. Figure 2 shows a resurfacing life-cycle for a hypothetical flexible pavement. This hypothetical pavement is on a 12-year preservation cycle. It is expected to be resurfaced every 12 years.

After the pavement is resurfaced, it shows no signs of distress or wear. Thus, it is given a PSC rating of 100 (Figure 2). Over time, the PSC drops to 50, at which time a normal preservation overlay is applied to the pavement. In this example, the normal overlay is assumed to be 1.8 inches deep. The normal preservation overlay restores the lost structural capacity of the pavement and adds any structural capacity needed to accommodate normal traffic growth. For example, the thickness of the preservation overlay may reflect a normal truck growth rate of 1 percent per year.

In this example, rail-line abandonment suddenly adds thousands of new trucks to the highway in the third year of the current resurfacing cycle. This traffic was not anticipated when the pavement was resurfaced. Under this new traffic load, the pavement deteriorates much faster than expected. The PSC drops to 50 in Year 9 of the current preservation cycle. The due year is now 3 years earlier than expected.

In this example, the hypothetical pavement is a two-lane rural highway in eastern Washington. The average preservation cost for such a highway is $208,000 per mile. If the project is moved forward to Year 9, WSDOT must spend $208,000 three years earlier than expected. Because of the time value of money, there is a cost associated with earlier resurfacing, even though the paving depth and cost are the same. This time-related cost is computed by comparing the present value of $208,000 nine years into the future to its present value 12 years from now.

In this study, the federal discount rate of 4.33 percent is used to make present value comparisons. Using this rate, the present value of $208,000 in Year 12 is $125,000. In comparison, the present value of $208,000 in Year 9 is $142,000. The difference in present value ($17,000) is the build-sooner cost resulting from abandonment during the first resurfacing interval.

As depicted in Figure 2, the build-sooner effect will continue unless additional structure is built into the pavement when it is resurfaced. Since the pavement is now on a 9-year cycle instead of a 12-year cycle, it will be due for resurfacing again in Year 18 instead of in Year 24. The present value of $208,000 in Year 24 is $75,000 as compared to its present value of $97,000 in Year 18. The difference in present value ($22,000) is the build-sooner cost associated with the abandonment in the second resurfacing interval. The difference in due years increases until, in the fourth resurfacing cycle, the pavement has been moved forward one full interval (12 years). In this example, a total of $78,000 in build-sooner cost is incurred over 4 resurfacing cycles.

The build-sooner cost calculation assumes that WSDOT's budget is perfectly elastic and can be adjusted immediately to accommodate the earlier due date. This may be an unrealistic assumption. Instead, the impacted pavement may be resurfaced in Year 12 as scheduled.

As Figure 2 shows, the rate of pavement deterioration accelerates with the accumulation of distresses. After Year 9, the PSC drops rapidly from its due value of 50. The paving cost of a project that is 3-to-6 years past due is 50 percent greater than the normal (optimal) paving cost. The paving portion of the preservation cost for this hypothetical rural highway is $193,000 per mile. Thus, the paving cost of the project will be $96,500 greater in Year 12 than in Year 9. The present value of this additional cost is $58,000.

It is important to understand that the additional past-due cost only restores the pavement to its design structural capacity, given the greater severity of fatigue cracking and other distresses that have developed during the current resurfacing interval. It does not provide the structural capacity needed to return the pavement to its 12-year resurfacing cycle given the permanent increase in truck traffic. If additional structure is not added, the pavement will continue its accelerated rate of deterioration in future periods. The logical time to add this capacity is at the scheduled time for a preservation overlay. The cost of this additional structure is reflected in the incremental thickness costs described in the report.

Figure 2: Illustration of Build-Sooner and Past-Due Costs

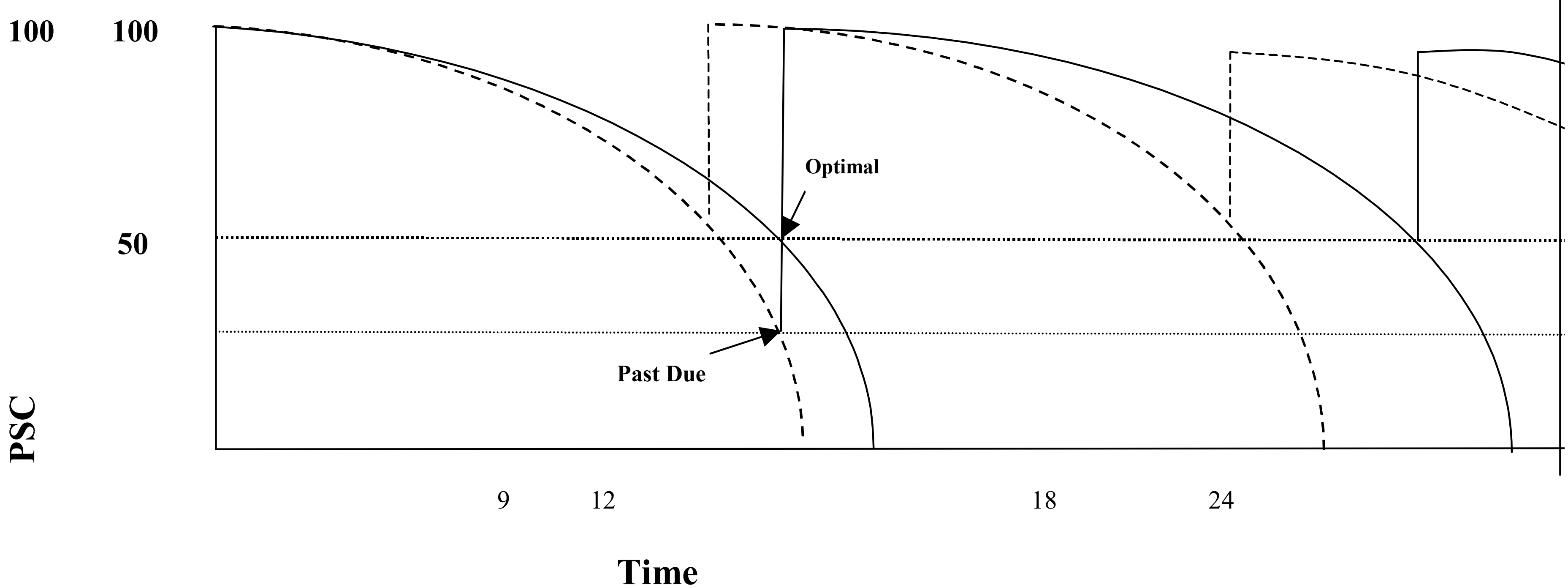

Figure 2 Illustration of Build-Sooner and Past-Due Costs