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16. Abstract
The current study makes a preliminary assessment of the impact of increasing the gross vehicle weight (GVW) from current legal limits to 100,000 pounds (lbs) on vehicles hauling sugarcane, rice, timber, and cotton. Sample sections of road in each area of the state where the commodities are hauled were identified, the amount of each commodity hauled on the road estimated, and the effect of increasing the GVW evaluated for each section of road using pavement design models.

Design data was secured from the Louisiana Department of Transportation and Development computer database and project files to determine the pavement design parameters and traffic estimates for each road. The number of vehicles hauling the 1998 harvest payload was estimated, the projected increase in the production of each commodity was based on government statistics, and rehabilitations were designed using the 1986 AASHTO Design Guide for a 20 year analysis period. Net present worth (NPW) was calculated for each GVW scenario for each roadway.

Comparisons of NPW between the weight scenarios showed that increases in GVW have more effect on Louisiana state and US highways than on interstate highways. Any elevation in GVW over current limits increases the cost of overlays and decreases the length of the time before an overlay is required. The cost increase due to raising the GVW is substantial. Fee structures need to be modified by the legislature to pay for these costs through the current registration and overweight permit fee structure or some new tax such as a ton-mile tax.

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PRELIMINARY ASSESSMENT OF PAVEMENT DAMAGE DUE TO HEAVIER LOADS ON LOUISIANA HIGHWAYS

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LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
LOUISIANA TRANSPORTATION RESEARCH CENTER

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ABSTRACT

The current study makes a preliminary assessment of the impact of increasing the gross vehicle weight (GVW) from current legal limits to 100,000 pounds (lbs) on vehicles hauling sugar cane, rice, timber, and cotton. Sections of road were chosen in each area of the state where commodities are produced, the amount of each commodity hauled estimated, and the effects of increasing the GVW evaluated for each section of road using pavement design models.

Design data was secured from the Louisiana Department of Transportation and Development (DOTD) computer data base and project files to determine the pavement design parameters and traffic estimates for each road. The number of vehicles hauling the 1998 harvest payload was estimated, the projected increase in the production of each commodity was based on government statistics, and rehabilitations were designed using the 1986 AASHTO Design Guide for a 20 year analysis period. Net present worth (NPW) was calculated for each GVW scenario for each roadway.

Comparisons of NPW between the weight scenarios showed that increases in GVW have more effect on state and U.S. than on interstate highways. Any increase in GVW over current limits increases the cost of overlays and decreases the length of time before an overlay is required. The cost increase due to increasing the GVW is substantial. Fee structures need to be modified by the legislature to pay for these costs through the current registration and overweight permit fee structure or some new tax such as a ton-mile tax.

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IMPLEMENTATION STATEMENT

The results from this preliminary study are sufficient to provide an indication of the potential impact of increasing the gross vehicle weight on vehicles carrying selected commodities on Louisiana highways. The results clearly demonstrate that the costs are substantial and that the Louisiana Department of Transportation and Development should request that the legislature adjust the current registration and fee structure to pay for the costs occasioned by these heavier vehicles and that only the heavier vehicles bear the burden of these costs. One other way to have the permitted vehicles pay is through the institution of a ton-mile tax, as has been done by some other states.

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Overview

The 1998 Transportation Equity Act for the 21st Century (TEA 21) allows heavier loads for sugarcane haul on Louisiana highways. Though not stated, this is assumed to refer to interstate highways. These same, heavier loads are currently being applied to state and parish roads that are traveled by vehicles going from the interstate to the processing plants. TEA 21 further provides Federal funding to enable Louisiana to study the effects of increasing the allowable permitted loads for transporting sugar cane. Gross vehicle weight (GVW) on interstate routes has typically been restricted to 80,000 lbs for five axle semi-trailer (LA type 6) vehicles with a maximum tandem axle weight of 32,000 lbs. Permitted loads on the type 6 vehicle during harvest season have since 1997 been allowed for up to 83,400 lbs GVW and 35,200 lbs on tandem axles. TEA 21 now extends the GVW to 100,000 lbs with tandem axle weights increasing to 48,000 lbs. Since this legislation opens the door to heavier loads on sugarcane, it is also necessary to evaluate the effect of increasing the GVW on all special harvest permit vehicles using Louisiana highways.

To complete such an evaluation there are two parts which must ultimately be considered:

a) An assessment of the additional damage caused by these heavier loads and the resultant maintenance and rehabilitation costs incurred because these trucks are operating at higher loads, and

b) An assessment of the additional road user costs that should be assessed against the vehicles producing the damage if equity is desired. An equity analysis involves, first, determining the cost incurred by the road authority in providing roadways which accommodate a particular group of vehicles and, second, determining the user fees paid by that group of vehicles as they operate on the roadways. Equity occurs when each group of vehicles, with similar characteristics, pays a percentage of the total cost incurred to provide the roadways that is equal to that group's percentage of total contributed revenues from the various road user taxes paid, i.e., cost responsibility divided by user fees paid equals 1.0.

Cost Allocation Studies

Studies which address the two previously mentioned assessments are generally called cost allocation studies. During the last several years a number of cost allocation studies have been conducted at both the state and federal levels. The most recent federal study was completed in August 1997 [*1*]. National Cooperative Highway Research Program (NCHRP) Project 20-24(7)A on alternative approaches to the taxation of heavy vehicles reported that a number of states have conduced studies on either taxation or cost allocation in the last few years [*2*]. Table 1 contains a list of these state studies with a brief description of the topics included in each.

The primary objective of the 1997 federal highway cost allocation study (HCAS) was to analyze the highway related costs attributed to different classes of highway vehicles, passenger vehicles, single unit trucks, and combination trucks, as a basis for evaluating the equity and efficiency of the existent federal highway user charges. The principal basis for equity evaluations is to compare the responsibility of different vehicle classes for highway program costs paid from the federal highway trust fund (HTF) to the fees paid into the HTF by the different vehicle classes. To evaluate the cost portion of the equity issue, the 1997 federal study uses the overall cost-occasioned approach from the 1982 federal HCAS for allocating transportation agency costs. Agency costs included construction of new pavements; pavement reconstruction, rehabilitation and resurfacing (3R); construction of new bridges; system enhancements including safety, transportation system management, intelligent transportation system, transit, environment, bicycle and pedestrian facilities, etc.; and other special project costs attributable to vehicle classes such as weigh stations for trucks. These costs were compared to the fees paid into the HTF from fuel taxes, vehicle excise taxes, tire taxes, and a heavy vehicle use tax (HVUT). The 1997 federal tax rates are shown in table 2[*1*].

Table 1

States and topics covered in case studies of heavy vehicle taxation cost allocation [*2*]

Arizona:	"The Weight-distance Tax in Arizona" Highway revenues review study Highway cost allocation study (1991) Diesel fuel tax evasion and countermeasures Evaluation of tax options study
Arkansas:	Fuel tax evasion and countermeasures study
California:	Highway cost allocation studies (1987 and 1996) Congestion pricing programs
Kentucky:	"Report of Commission on Tax Policy" Highway cost allocation studies (1988 and 1992)
Maine:	Highway cost allocation studies (1982 and 1989) Diesel fuel tax evasion and countermeasures Northern New England ITS/commercial vehicle operations study
Minnesota:	Congestion pricing implementation study Public-private partnerships of a toll-financed freeway "Transportation and Economic Development in the Upper Midwest" (symposium on pricing and ITS program) "State Advisory Council on Major Transportation Projects" (pricing and a formal evaluation of tax alternatives)
Oregon:	"Long-range Transportation Finance Issues and Opportunities" (public discussion paper for the Transportation Commission) "Oregon Weight-Mile Tax Study" "Diesel Fuel Fee Non-Compliance"
S. Carolina:	"Trucking Quality Team Report" (study of ways to reduce compliance burden)
Virginia:	"Report of the Governor's Task Force on Fuel Tax Evasion" Weigh station avoidance study

Table 2

1997 Federal highway related tax rates [*1*]

Tax Type		Federal Tax Rate Under Current Law in 1997
Fuel Tax	Gasoline	18.3 cents per gallon
	Diesel	24.3 cents per gallon
	Gasohol: 10 percent Gasohol made with Ethanol	12.9 cents per gallon
	LPG (Propane)	18.3 cents per gallon
	CNG	4.3 cents per gallon
	LNG	18.3 cents per gallon
	Ethanol	11.3 cents per gallon
	Methanol	11.3 cents per gallon
Vehicle Excise Tax	Heavy Trucks > 26,000 pounds	12 percent of retail sales for new vehicles (trucks, tractors, and trailers)
Tire Tax	Tire Weight: from 40 to 70 pounds	15 cents per pound in excess of 40 pounds
	Tire Weight: from 70 to 90 pounds	$4.50 plus 30 cents per pound over 70 pounds
	Tire Weight: over 90 pounds	$10.50 plus 50 cents per pound over 90 pounds
HVUT[1]	Annual tax on Motor Vehicle registered 55,000 pounds gross weight or more.	$100 plus $22 per 1,000 pounds over 55,000 with an annual cap of $550

[1] Heavy Vehicle Use Tax

The underlying philosophy of the cost-occasioned approach is that each vehicle class or user should pay the costs that it creates or "occasions" as a result of its presence in the traffic stream. The highway agency costs considered in the 1997 federal HCAS are those paid from highway user charges. Equity in this case is defined as each vehicle class paying user charges proportional to its share of highway agency costs. In both the 1997 federal HCAS and the 1997 comprehensive truck size and weight study, data on user charges paid by vehicle classes are presented in several ways and these reports can be referenced for additional data [*1*],[*3*]. In this report, the data will be presented using the total costs incurred by each vehicle class and also using 3R costs incurred by each vehicle class. Data presented on a total cost basis gives a comparison among the various users for the general case, and data presented using 3R is specifically related to the category of costs that will be increased for Louisiana roads when GVW and axle loads are increased without a change in the number of axles on trailers which carry the loads.

Table 3 shows the projected federal user fees paid by each vehicle class for the year 2000. Notice that automobiles (auto) and pickup trucks (LT4) pay almost 64 percent of the total federal revenue into the highway trust fund. The single unit three axle truck (SU3) and combination, five axle truck with tandem axles(CS5T) together pay about 20.5 percent of the total federal user revenues. All other single unit trucks, buses, and combination trucks pay the remaining 15.5 percent of the federal user revenues. Figure 1 shows the various vehicle classes used in the 1997 federal HCAS along with the acronym used to identify each vehicle type.

Table 3

Federal highway user fee payments by vehicle class projected for the year 2000 ($, millions) [*1*]

Vehicle Class	Fuel Tax	HVUT	Tire Tax	Vehicle Excise Tax	Total	Vehicle Share Paid (Percent)
AUTO	$11,576	$0	$0	$0	$11,576	42.60
LT4	5,811	0	0	0	5,811	21.39
SU2	1,879	1	32	0	1,912	7.04
SU3	337	47	41	0	425	1.56
SU4+	124	43	30	63	260	0.96
CS3	77	5	5	0	87	0.32
CS4	278	65	24	0	367	1.35
CS5T	2,753	527	223	1,647	5,150	18.95
CS5S	98	19	8	58	183	0.67
CS6	220	52	33	164	470	1.73
CS7+	21	5	3	19	47	0.17
CT3&4	34	3	4	116	158	0.58
CT5	60	25	8	72	165	0.61
CT6+	17	6	3	17	43	0.16
DS5	165	28	14	113	320	1.18
DS6	24	4	2	18	48	0.18
DS7	23	4	2	24	54	0.20
DS8+	28	5	3	32	68	0.25
TPL	5	1	0	5	10	0.04
BUS	19	0	1	0	20	0.07
TOTAL	$23,547	$841	$439	$2,347	$27,174	100.0
NOTES: Sums may not total due to rounding.						

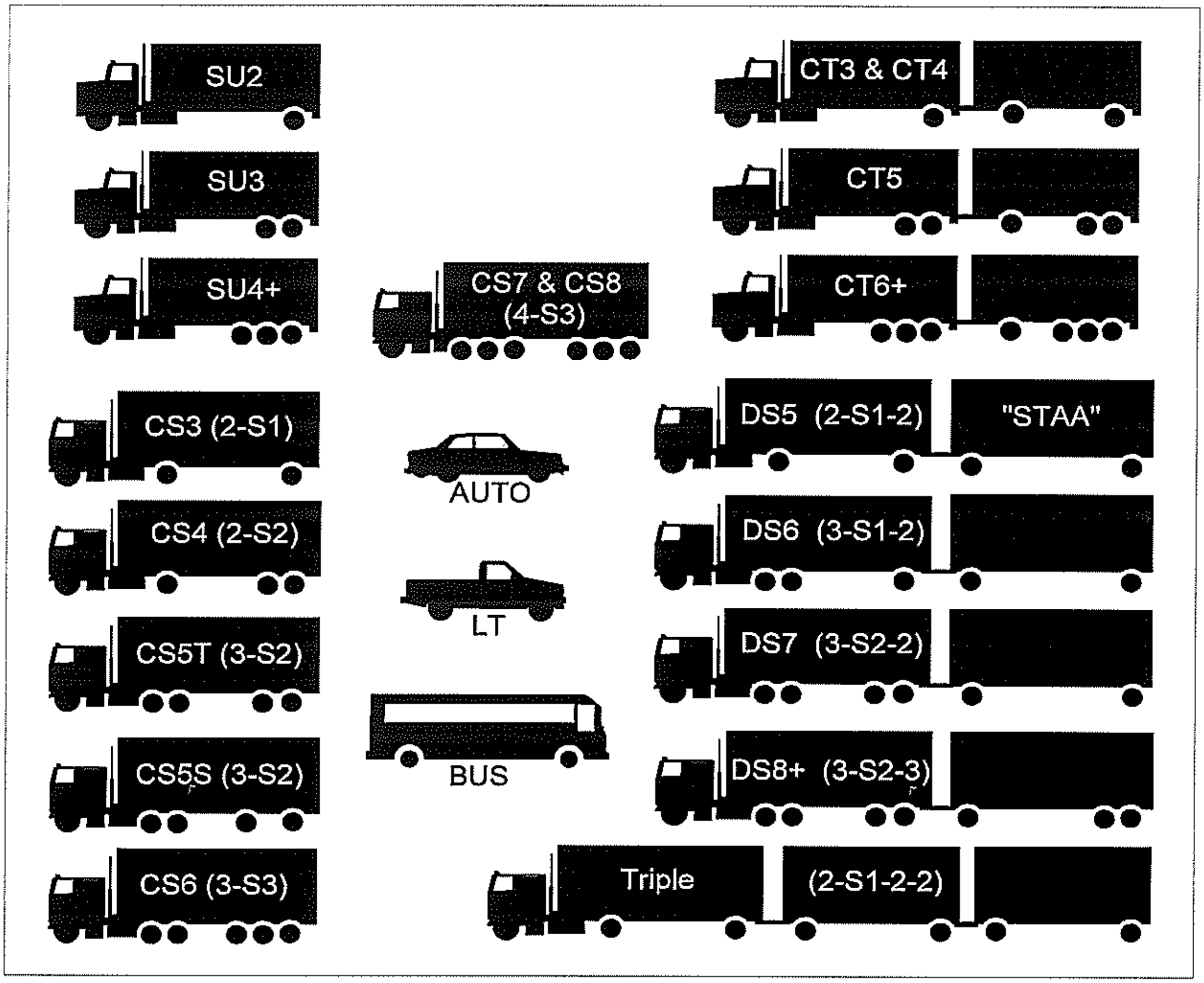

Figure 1

Sketch of each vehicle class used in the 1997 federal highway cost allocation study [*1*]

The total estimated federal program highway cost responsibility projected for the year 2000 are shown in table 4 for vehicle classes and weight ranges. Notice that all the single unit trucks are combined into three weight ranges and the combination trucks are combined into six weight ranges. This combining into weight ranges has been done because it is the axle weights which damage highways, and the pavement cost responsibility was evaluated using these weight ranges for each vehicle type and the individual trucks combined over each weight range to produce table 4.

In table 4 the cost responsibility in the heavier weight categories for any vehicle class are lower when estimated on a registered weight basis because some of the travel of these vehicles is at lower weights than the registered weights.

The operating weight data is generated from the actual weights measured in the field on different functional highway classes. Notice in table 4 that the cost responsibility increases dramatically as the axle weights increase for both single unit and combination trucks. Notice also that the largest cost increase occurs for the last weight increment. For single unit trucks, moving from the 25,001 - 50,000 lbs axle weight range to more than 50,000 lbs the cost responsibility increases from 4.38 ¢/mile to 14.60 ¢/mile, a 230 percent increase. For combination trucks, moving from 75,001 - 80,000 lbs to 80,001 - 100,000 lbs increases the cost responsibility from 7.08 ¢/mile to 12.50 ¢/mile, a 76 percent increase.

Table 4

Comparison of federal cost responsibility on both registered weight and operating weight bases for the year 2000 [1]

Vehicle Class/ Registered Weight	Cost Responsibility (cents per mile)	
	Registered Weight Basis	Operating Weight Basis
Autos	0.65	0.65
Pickups and Vans	0.65	0.65
Buses	2.57	2.57
All Passenger Vehicles	0.66	0.66
Single Unit Trucks		
<25,000 pounds	1.75	1.81
25,001 - 50,000 pounds	4.38	6.26
>50,000 pounds	14.60	37.25
All Single Unit Trucks	3.51	3.51
Combination Trucks		
<50,000 pounds	2.78	2.42
50,001 - 70,000 pounds	4.25	5.50
70,001 - 75,000 pounds	6.25	9.50
75,001 - 80,000 pounds	7.08	12.36
80,001 - 100,000 pounds	12.50	20.57
>100,001 pounds	16.60	48.96
All Combinations	6.90	6.90
All Levels of Government Cost Allocation	5.48	5.48

Table 5 shows an excerpt from the tables in the 1997 federal HCAS for the two vehicles of interest in this study. The SU3 corresponds to the cotton module truck and the CS5 corresponds to the vehicle that hauls sugarcane, rice, and timber. Notice for the CS5 vehicle that when the vehicle weight increases from 80,000 lbs to 100,000 lbs that the cost responsibility increases from 7.2 to 14.2 ¢/mile, an increase of 97 percent.

Table 5

Federal cost responsibility on a registered weight basis for selected vehicles (cents per mile) for the year 2000 [*1*]

Registered Weight (Thousands of pounds)	Vehicle Class	
	SU3[1]	CS5[2]
0 - 10		
20	1.7[3]	
30	1.9	
40	2.8	
50	5.1	2.8
60	13.2	3.7
70	25.8	5.7
80	32.5	7.2
90		12.9
100		14.2
110		15.4

[1] SU3 is the truck that hauls cotton modules

[2] CS5 is the truck that hauls sugarcane, rice, and timber

[3] Cost in ¢/mile

Table 6 includes a breakout of the federal cost responsibility for pavement 3R costs for these same two vehicles that were included in table 5. Notice that the data in table 6 were based on an operating weight basis while those in table 5 were based on a registered weight basis. However it is easy to see that a majority of the total federal cost responsibility for these two vehicles is made up of pavement 3R costs especially for weights above 50,000 lbs. For example, the SU3 vehicle at a weight of 50,000 lbs incurs 5.1 ¢/mile total cost responsibility and 4.81 ¢/mile is made up of pavement 3R costs. For the CS5 vehicle at a weight of 80,000, the total cost responsibility is 7.2 ¢/mile and 6.37 ¢/mile is made up of 3R costs. One may conclude then that pavement 3R costs make up the major portion of costs incurred by these two vehicles and all other costs may be ignored with little error.

Table 6
Federal cost responsibility on an operating weight basis for pavement 3R costs for selected vehicle classes (cents per mile) for the year 2000 [*7*]

Operating Weight (Thousands of pounds)	Vehicle Class	
	SU3	CS5
0 - 10		
20	0.69[1]	0.64
30	0.86	0.75
40	1.62	0.89
50	4.81	1.19
60	12.03	1.86
70	31.70	3.55
80		6.37
90		11.01
100		19.96
110		36.53

[1] Cost in ¢/mile

Now let us consider the issue of equity in the 1997 federal HCAS. Equity occurs when the total highway user fees paid by a vehicle class equals the total cost responsibility or when the ratio of user fees paid to total cost responsibility is 1.0. Table 7 contains the calculated equity ratios for vehicle classes with trucks divided into registered weight ranges. Notice that automobiles pay their way; that pickups pay 40 percent more than their fair share; buses pay only 10 percent of the costs they incur; and that when lightly loaded both single unit and combination trucks pay more than their fair share of the costs. However when single unit trucks weigh more than 25,000 lbs and when combination trucks weigh more than 75,000 lbs, the equity ratios are less than one which means that vehicles operating at these weights have a portion of the costs they incur subsidized by other vehicles. Notice also that as the weights for these trucks increase the equity ratio decreases, i.e., they pay less of their fair share of the costs as their weights increase.

Equity ratios for the SU3 and CS5 trucks of special interest in this study are given in table 8. Along with the equity ratios are the percent of vehicle miles traveled (VMT) at each weight range. Notice that for the SU3, 77 percent of the miles traveled are at weights in the decades of the 50,000 and 60,000 lbs where the equity ratios are 0.8 and 0.5, respectively. For the CS5, 91 percent of the miles traveled are in the decade of 80,000 lbs weight where the equity ratio is 0.90.

Table 7

Calculated equity ratios for the 1997 federal HCAS for various vehicle classes for the year 2000 [*1*]

Vehicle Class/Registered Weight	2000 Forecast Period		
	User Fees Paid, %	Cost Incurred, %	Equity Ratio
Automobiles	42.6[1]	43.8[2]	1.0
Pickups/Vans	21.4	15.4	1.4
All Personal Use Vehicles	64.0	59.2	1.1
Buses	0.1	0.7	0.1
Single Unit Trucks			
≤ 25,000 pounds	5.5	3.6	1.5
25,001 - 50,000 pounds	2.2	3.1	0.7
> 50,000 pounds	1.8	4.0	0.5
All Single Units	9.6	10.7	0.9
Combination Trucks			
≤ 50,000 pounds	1.1	0.7	1.6
50,001 - 70,000 pounds	1.9	1.7	1.1
70,001 - 75,000 pounds	1.4	1.4	1.0
75,001 - 80,000 pounds	20.3	22.5	0.9
80,001 - 100,000 pounds	1.0	1.8	0.6
> 100,001 pounds	0.7	1.4	0.5
All Combinations	26.4	29.4	0.9
All Trucks	35.9	40.1	0.9
All Vehicles	100.0	100.0	1.00

[1] Percent of total federal user fees paid into the HTF by vehicle class

[2] Percent of total federal cost responsibility incurred by vehicle class

Table 8

Equity ratios for the 1997 federal HCAS for selected truck classes based on registered weights for the year 2000 [*1*]

Registered Weight (000)	SU3		5-axle Tractor Semitrailer (CS5)	
	Equity Ratio	Percent of VMT[1]	Equity Ratio	% of VMT
0-10				
20	2.0	<1		
30	1.9	5		
40	1.4	8		
50	0.8	40	1.9	1
60	0.5	37	1.6	2
70	0.3	8	1.1	3
80	0.2	<1	0.9	91
90			0.5	2
100			0.5	1
110				
120				
130				
140				
150				
Overall	0.6	100	0.9	100

[1] VMT = vehicle miles of travel

So one may conclude from the results of the 1997 federal HCAS presented for federal taxes paid by vehicle classes that trucks overall appear to be paying fees that are consistent with the costs they incur on those highways which receive some federal funds from the HTF. Let us now consider the cost responsibility incurred by these same vehicles at other governmental levels. Table 9 shows that at the federal level trucks have a cost responsibility of about 40 percent but at the state and local levels only about 25 percent of the total cost responsibility. This lower cost responsibility results primarily from the difference for which the road is used at the state and local levels when compared to the purpose at the federal level. Many state and local roads serve primarily a land use function while the interstate and U.S. highway systems serve primarily to carry traffic.

Table 9

Estimated cost responsibility for the year 2000 incurred by vehicle classes for each level of government [*1*]

Vehicle Class/Registered Weight	Cost Responsibility ($ Millions)			
	Federal	State	Local	Total
Autos	12,405	35,988	15,791	64,184
Pickups and Vans	4,770	13,678	6,328	24,777
Buses	221	383	268	871
All Passenger Vehicles	17,396	50,049	22,387	89,832
Single Unit Trucks				
≤ 25,000 pounds	1,074	1,755	886	3,715
25,001 - 50,000 pounds	981	1,867	1,349	4,197
≤ 50,000 pounds	1,098	1,929	1,212	4,239
All Single Unit Trucks	3,153	5,551	3,447	12,151
Combination Trucks				
≤ 50,000 pounds	222	325	149	696
50,001 - 70,000 pounds	528	722	306	1,555
70,001 - 75,000 pounds	408	517	178	1,103
75,001 - 80,000 pounds	6,329	8,353	2,950	17,632
≥ 80,000 pounds	778	1,125	450	2,353
All Combinations	8,264	11,042	4,032	23,338
All Trucks	11,417	16,593	7,479	35,490
All Vehicles	28,813	66,642	29,866	125,322

However, it must be noted that when trucks operate on roads primarily designed for access to land, the pavement costs can be substantial. Data in tables 10 and 11 were taken from the 1997 federal comprehensive truck size and weight study and show the pavement costs occasioned by the SU3 (single unit three axle truck) and CS5 (semitrailer five axle truck) operating at the GVW indicated in the tables[*3*]. Notice that as these vehicles move from the interstate and primary arterial (principal state and U.S.) routes onto the major and minor collectors and local roads that the costs generated by the presence of these vehicles increases dramatically. This increase occurs because these lower volume roads do not have sufficient layer thicknesses to carry a very large number of applications of the loads imposed by these vehicles without requiring substantial maintenance or rehabilitation costs.

For example, the roadway cost of one SU3 vehicle operating at 54,000 lbs on a local road is more than 60 times the cost for that same vehicle to travel on an interstate highway based on the different bases included in both tables 10 and 11. For a CS5 vehicle operating at 80,000 lbs, the cost on a local road is more than 75 times the cost for the same vehicle to operate on an interstate highway. These data emphasize the fact that roads traveled by harvest vehicles going from the field where farm products or timber are produced to gins, sugar mills, rice driers, or saw mills often travel over local, low volume roads. As a result, any substantial number of these loads, especially at high GVWs, can significantly shorten the life of a typical low volume road and require major rehabilitation after only a few years of carrying heavily loaded vehicles.

Table 10

Unit pavement costs in $ per 1000 miles traveled for selected truck classes on rural highways [*3*]

Truck Configurations		
Truck Type	Single Unit	Semitrailer
Axles	Three	Five
GVW (pounds)	54,000	80,000
$/1,000 miles		
Functional Class		
Interstate	0.09	0.05
Prin. Art.	0.17	0.12
Min. Art.	0.37	0.29
Maj. Col.	1.38	0.90
Min. Col.	2.27	1.49
Locals	5.90	3.87

Table 11

Unit pavement cost in $ per payload-mile for selected truck classes on rural highways [3]

Truck Configurations		
Truck Type	Single Unit	Semitrailer
Axles	Three	Five
GVW (pounds)	54,000	80,000
Tare Weight	22,600	30,490
Payload Weight	31,400	49,510
$/1,000 ton-miles		
Functional Class		
Interstate	0.006	0.002
Prin. Art.	0.011	0.005
Min. Art.	0.024	0.012
Maj. Col.	0.088	0.036
Min. Col.	0.145	0.060
Locals	0.376	0.156

Louisiana Weight Regulations

The current regulations controlling operation of trucks on Louisiana highways are described in the 1997 Louisiana Regulations for Trucks, Vehicles and Loads prepared by the weights and standards division of the Louisiana Department of Transportation and Development (DOTD)[*4*]. Several sections of these regulations are excerpted to indicate how the current legislation is interpreted and applied. The current legal limitations on weights for vehicles and axles in Louisiana are noted below [*4*].

LEGAL LIMITATIONS

Weights. The maximum legal axle weights on interstate highways are:

SINGLE AXLES	20,000 POUNDS
TANDEM AXLES	34,000 POUNDS
TRIDUM AXLES	42,000 POUNDS
QUADRUM AXLES	50,000 POUNDS

Axle variances of 2,000 pounds for single axles and 3,000 pounds for tandem, tridum, and quadrum axles are allowed on non-interstate highways. Therefore, the maximum legal weights on non-interstate highways are:

SINGLE AXLES	22,000 POUNDS
TANDEM AXLES	37,000 POUNDS
TRIDUM AXLES	45,000 POUNDS
QUADRUM AXLES	53,000 POUNDS

There is one exception: Weight limits for vehicles with tandem axles carrying forest products in their natural state shall be 40,000 pounds.

The maximum legal weight on a tire is:

650 POUNDS PER INCH OF TIRE WIDTH

The sum of the legal axle weights on a vehicle or combination of vehicles is its legal gross weight. But regardless of the number and type of axles, the maximum legal gross weight of any vehicle or combination of vehicles (except a combination with a tridum or quadrum axle) is:

80,000 POUNDS

Regardless of the number and type of axles, the maximum legal gross weight of any combination of vehicles which has a tridum or quadrum axle is:

83,400 POUNDS	INTERSTATE HIGHWAYS
88,000 POUNDS	NON-INTERSTATE HIGHWAYS

PERMITS

Vehicles may not exceed their licensed gross weight. Maximum licensed gross weight is equal to the maximum legal gross weight.

Vehicles may exceed these legal weight limitations only if a permit is acquired to allow such an overload. Louisiana regulations allow a host of these permits for various vehicles but the three permits used by vehicles included in this study are the agronomic/horticultural permit, the cotton module permit, and the harvest season or natural forest products permit. Each of these permits is described below.

The agronomic permit applies to products which are edible by humans and include sugarcane, grains, rice, and other commodities. This permit allows vehicles with a minimum of 18 wheels to carry up to 100,000 lbs GVW. The Louisiana type 6 vehicle is the vehicle which hauls sugarcane and rice which are included in this study. The regulations for the agronomic permit are quoted below [*4*].

Agronomic/Horticultural ($100.00 per year). These permits are for truck combinations hauling agronomic or horticultural crops in their natural state, have a minimum of eighteen (18) wheels, are legal in size, and exceed axle group or gross vehicle weights. The permits are valid for one (1) year and allow travel on any state-maintained highway, except the interstate system.

On non-interstate highways the maximum weights are:	
Gross Vehicle Weight	100,000 pounds
Steering Axle	12,000 pounds
Tandem Axles	48,000 pounds
+ Note:	This permit shall not supersede any lesser weight limit POSTED on a bridge or highway.

Vehicles traveling with a valid Agronomic/Horticultural Permit are not prohibited from traveling at night, during moderate rain, or on holidays. These permits are issued on computer generated forms from the Truck Permit Office.

Notice that travel under this permit is restricted to non-interstate highways. If one of these vehicles travels on the interstate it must comply with the lower interstate weight restrictions under the legal limitations quoted earlier. It should be noted that the TEA 21 federal legislation now allows sugarcane haulers to carry up to 100,000 lbs on the interstate highways.

During the last several years the transportation of cotton from the field to the gin has moved from two axle cotton trailers to module trucks. The cotton is poured from the cotton picker into a module compress and a rectangular cotton module containing from 12 to 15 bales is hydraulically compressed, covered and placed on the ground awaiting transport from the field to the gin. The vehicle used to transport the cotton module to the gin is a cotton module truck, a specially designed vehicle which picks up the module and loads it into a three axle single unit truck (LA type 2 truck). The permit restrictions on the cotton module truck are discussed below [*4*].

Cotton Module: ($50.00 Per Year). These permits are for three (3) axle vehicles that haul cotton modules and exceed the legal limitations on axle, axle group, or gross vehicle weights. They are valid for one (1) year and may travel on any state maintained highway, except the interstate system.

On non-interstate highways, the Cotton Module Permit maximum weights are:	
Gross Vehicle Weight	68,000 pounds
Single Axle	20,000 pounds
Tandem Axles	48,000 pounds
+ Note:	This permit shall not supersede any lesser weight limit POSTED on a bridge or highway.

Vehicles with a Cotton Module Permit are not prohibited from traveling at night, during moderate rain, or on holidays. These permits are issued on computer generated permit forms from the Truck Permit Office.

Notice that the cotton module truck is restricted from using the interstate system. The reason for the restriction is the size of the vehicle.

Timber hauling trucks are typically pole trucks (LA type 6) which generally operate under the harvest season or natural forest product permit described below [*4*].

Harvest Season or Natural Forest Products: ($10.00 per year). These permits are for vehicles that exceed the legal limitations on weight or size which haul farm or forest products in their natural state, grass sod, seed cotton modules or cotton from the field to the gin or from the gin to the mill.

On non-interstate highways the maximum weights are:

Gross Vehicle Weight	86,600 pounds
Single Axle	22,000 pounds
Tandem Axles	37,000 pounds

There is one exception: Weight limits for a vehicle with tandem axles carrying forest products in their natural state shall be 40,000 pounds.

On Interstate highways the maximum weights are:

Gross Vehicle Weight	83,400 pounds
Single Axle	20,000 pounds
Tandem Axles	35,200 pounds

These permits are valid for one (1) year, expiring each year on December 31, and are obtained by mail or in person only. They shall not supersede any lesser weight limit POSTED on a bridge or highway. Vehicles with valid permits are not prohibited from traveling at night, during moderate rain, or on holidays. Harvest Season or Natural Forest Product Permits are issued on computer generated forms from the Truck Permit Office.

The information contained in these special permit sections presented above is summarized in table 12 as it relates to this study. Notice in table 12 that provisions of both Louisiana and federal law are cited since the weights on the interstate system are controlled by legislation at the federal level.

Table 12

1998 Louisiana and federal statutes on vehicle weights for selected commodities

Commodity Hauled Under Permit	Permit Type	Road Permit Applies to	Max. GVW, lbs	Axle Weight Restrictions		
				Steering Axle, lbs	Single Axle, lbs	Tandem Axle, lbs
Sugarcane	TEA 21	I H	100,000	--	--	48,000
	Agron./ Hortic.	non-I H	100,000	12,000	--	48,000
Rice	Legal Limit	I H	83,400	--	22,000	37,000
	Agron./ Hortic.	non-I H	100,000	12,000	--	48,000
Cotton	Cotton Module	I H	not	allowed	on I H	systems
		non-I H	68,000	--	20,000	48,000
Timber	Natural Forest Products	I H	83,400	--	20,000	35,200
		non-I H	86,600	--	22,000	40,000

Commodities Selected for Study

Since this is a preliminary study, neither time nor funds were sufficient to include all agricultural commodities produced in Louisiana but rather four commodities were selected (sugarcane, rice, cotton and timber) which represent all areas of the state. Production data on the crops of cotton, rice, and sugarcane were secured from reports by the Louisiana State University (LSU) Agricultural Center in Baton Rouge [*5*]. Data on timber was secured from the Louisiana Department of Agriculture and Forestry, Office of Forestry, Baton Rouge.

Pavement Rehabilitation Design Considerations

Traffic loads are considered in pavement design using factors called load equivalence factors (LEFs). These LEFs were developed in the late 1950's by engineers analyzing data from the American Association of State Highway Officials (AASHO) road test. Results from the AASHO road test were used to develop the first nationally accepted procedures for designing highway pavements. Part of that design procedure included the development and use of LEF. These equivalence factors were based on observed performance to the road by loads of different magnitude and configuration (single load axles with dual tires and tandem axles with dual tires). The American Association of State Highway and Transportation Officials (AASHTO) defines load equivalence factors as representing the ratio of the number of repetitions of any axle load and axle configuration necessary to cause the same reduction in present serviceability index (PSI) as one application of an 18,000 lb single axle load [*6*].

These LEFs have been the basis for evaluating traffic since their introduction and continue to be the way to convert loads on different axle configurations and different amounts of load to a standard axle load. In the design procedure the standard axle load is the 18,000 lbs single axle with dual tires at each end of the axle. All other configurations and weights are converted into this equivalent single axle load (ESAL). Conversion of other axle loads into ESALs is accomplished by multiplying the number of axles of a particular type and weight times an appropriate load equivalency factor. An example of load equivalence factors and how they vary with the axle type and load is contained in table 13. These data were taken from appendix D of the 1996 American Association of State Highway and Transportation Officials (AASHTO) Guide for pavement structures [*6*].

Remembering that these LEFs were based on observed pavement performance and damage, one can conclude that a single axle load of 30,000 lbs does five times the damage to this eight inch concrete slab as that from a single axle load of 20,000 lbs (7.79/1.55 = 5.0), and a tandem axle load of 40,000 lbs does more than three times the damage to this eight inch concrete slab as that from a tandem axle load of 30,000 lbs (3.55/1.13 = 3.1). Notice also that as the single axle loads increase above 20,000 lbs the LEFs increase dramatically. The same trend occurs for tandem axle loads above 30,000 lbs. The principal reason for this occurrence is that when an eight inch concrete slab is subjected to such heavy loads, it is over stressed, may bend excessively, and the concrete may even crack under loading with the result that the pavement will fail prematurely and require extensive maintenance and rehabilitation.

Table 13

An example of axle load equivalency factors for an eight inch thick concrete pavement

Load on Axle (Thousands of pounds)	Axle Load Equivalency Factor[1]	
	Single Axle LEF	Tandem Axle LEF
10	0.084	0.013
20	1.55	0.211
30	7.79	1.13
40	25.7	3.55
50	68.2	8.55
60	--	18.1
70	--	35.0
80	--	62.9

[1] Terminal PSI = 2.5

OBJECTIVE

The principal objective of this study is to provide a preliminary assessment of the effect of increasing the GVW, on Louisiana type 2 and type 6 vehicles as allowed by special permits, on pavement costs to rehabilitate the damaged interstate, U.S. and state highways in the state. The special permits include provisions of both TEA 21 and Louisiana regulations on vehicles and weights.

SCOPE

Since this is a preliminary study, the scope is limited to four commodities hauled on Louisiana highways: sugarcane, cotton, rice and timber. A sample of roads which are used to transport these commodities from the harvest field to the first processing location were selected. Generally, one road section was selected for each commodity to represent each of the interstate, U.S., and Louisiana state highway systems, where available. The selected roads also were required to have data on original design or the last major rehabilitation on the DOTD main frame computer in order for the data acquisition to be accomplished during this two-month preliminary study. Since the pavement design office of the DOTD only started to retain design data on pavement projects contracted during the last ten years, a considerable amount of time was spent locating suitable sections for which data was available on both the main frame computer (project data) and in the pavement design office. Road sections were generally selected from a single parish except for sugarcane.

METHODOLOGY

A research methodology has been adopted to accomplish the objectives of the project. First, an outline of the steps in the research procedure will be presented. Second, each step of the methodology will be discussed in more detail in subsequent paragraphs.

Steps in the research procedure are as discussed below:

1. Identify the key commodities which operate under harvest permits, determine what the harvest permit loads are and the harvest permit fees.

2. Review Louisiana agricultural statistics to identify parishes with high production of the identified commodities.

3. Call the state or industry organization which represents each commodity and get help in identifying a parish whose roads are heavily used to transport the commodity from the field to the first processing plant.

4. Using DOTD mainframe computer resources, identify candidate sections of road for which construction data are available and easily accessible. Review project files in the pavement design office to determine if design data is available. The accessibility requirement is necessary because of the limited time available for this study (November and December 1998).

5. Discuss candidate sections with industry representatives and select one interstate, one U.S. highway, and one Louisiana highway section for inclusion in the study. Some parishes do not have interstate highways so that only U.S. and Louisiana highways are included.

6. Secure pavement design data from DOTD to have information on design of the latest major rehabilitation on each roadway. The data includes traffic, materials, subgrade, and other required data for an assessment of the effects of increasing vehicle weight on rehabilitation costs.

7. For each roadway determine how many pounds of each study commodity is hauled over the road on the way from the field to the first processing point. This data will be developed with the help of industry personnel who work with each commodity.

8. Using the data from item 5, estimate the time when the existing pavement will carry all the design traffic for each weight scenario. The weight scenarios to be investigated are:

   A. Scenario 1 for both state and interstate highways operating without permits - this scenario is to develop base line data to which other scenario results can be compared.

      1. 80,000 lbs GVW on type 6 vehicles with nine inch tires on the steering axle with single axle maximum of 22,000 and tandem axle maximum of 37,000 lbs [*4*].

      2. 49,000 lbs GVW on type 2 vehicles with nine inch tires on the steering axle with tandem axle maximum of 37,000 lbs [*4*].

   B. Scenario 2 for state highways

      1. For agronomic/horticultural permits: 100,000 lbs GVW on type 6 vehicles with maximum weights of 12,000 lbs on the steering axle and 48,000 lbs on tandem axles [*4*].

      2. For cotton module permits: 68,000 lbs GVW on type 2 vehicles with maximum weights of 20,000 lbs on single axles and 48,000 lbs on tandem axles [*4*].

      3. Natural forest products: 86,600 lbs GVW for type 6 vehicles with maximum weights of 22,000 lbs on single axles and 37,000 lbs on tandem axles [*4*].

C. Scenario 2 for interstate highways

1. For agronomic/horticultural permits: the same as for state highways in scenario 2 [TEA 21].

2. For cotton module permits: These vehicles are over length and are not allowed to travel on interstate highways.

3. Natural forest products: 83,400 lbs GVW for type 6 vehicles with maximum weights of 20,000 lbs on single axles and 35,200 lbs on tandem axles [*4*].

D. Scenario 3 for all highways

1. For agronomic/horticultural and natural forest products: 100,000 lbs GVW on type 6 vehicles with maximum weights of 12,000 lbs on steering axles and 48,000 lbs on tandem axles.

2. For cotton module permits: These vehicles are over length and are not allowed to travel on interstate highways. For state highways use the 68,000 lbs GVW on type 2 vehicles with maximum weights of 12,000 lbs on the steering axle and 48,000 lbs on tandem axles.

9. For each weight scenario, determine the empty weight of the type 2 and type 6 trucks so that the average payload per truck can be determined (Payload = GVW - empty weight). The number of trucks required to carry the commodity is the total weight of commodity hauled over the road divided by the average payload. This number of trucks is appropriately added into the traffic estimates for each scenario.

10. At the time that the design traffic has been served, redesign an overlay for each roadway assuming that each weight scenario continues during the next design period. Repeat this procedure for the length of the analysis period and generate a project cost stream which includes the periodic rehabilitations.

11. Calculate the net present worth of the rehabilitation costs for each project using an interest rate provided by the DOTD.

12. Compare the cost differential for the weight scenarios and develop cost differential tables for comparisons between the weight scenarios.

Step one involved selecting a group of commodities that represent the major products which utilize the special weight permits of concern to the DOTD. After discussion with representatives of the department, sugarcane, rice, cotton, and timber were selected. These commodities represent major crops and are also widely spread across Louisiana.

Step two involved a review of statistics for each crop to determine where the crops were produced, and the location of the first processing points for each commodity. High production parishes were identified, parish maps were secured and the first processing points marked on the maps, whether they were sugar mills, rice driers, gins, saw mills, or pulp and paper plants. Figures 2 and 3 show the parishes involved in producing the major quantities rice, cotton and sugarcane (figure 2) and timber (figure 3).

Step three involved identifying the industry group which represented the first processing points. These groups and contact person at each group are:

1) American Sugarcane League - contact: Mr Charlie Melancon @ (504) 448-3707

2) Louisiana Farm Bureau - contact: Mr. Blake Fontenot @ (800) 835-7423

3) Louisiana Cotton Ginners Association - contact: Mr. David Ruppenicker @ (318) 322-2999

4) Louisiana Forestry Association - contact: Mr. Buck Vanderstein @ (318) 443-2558

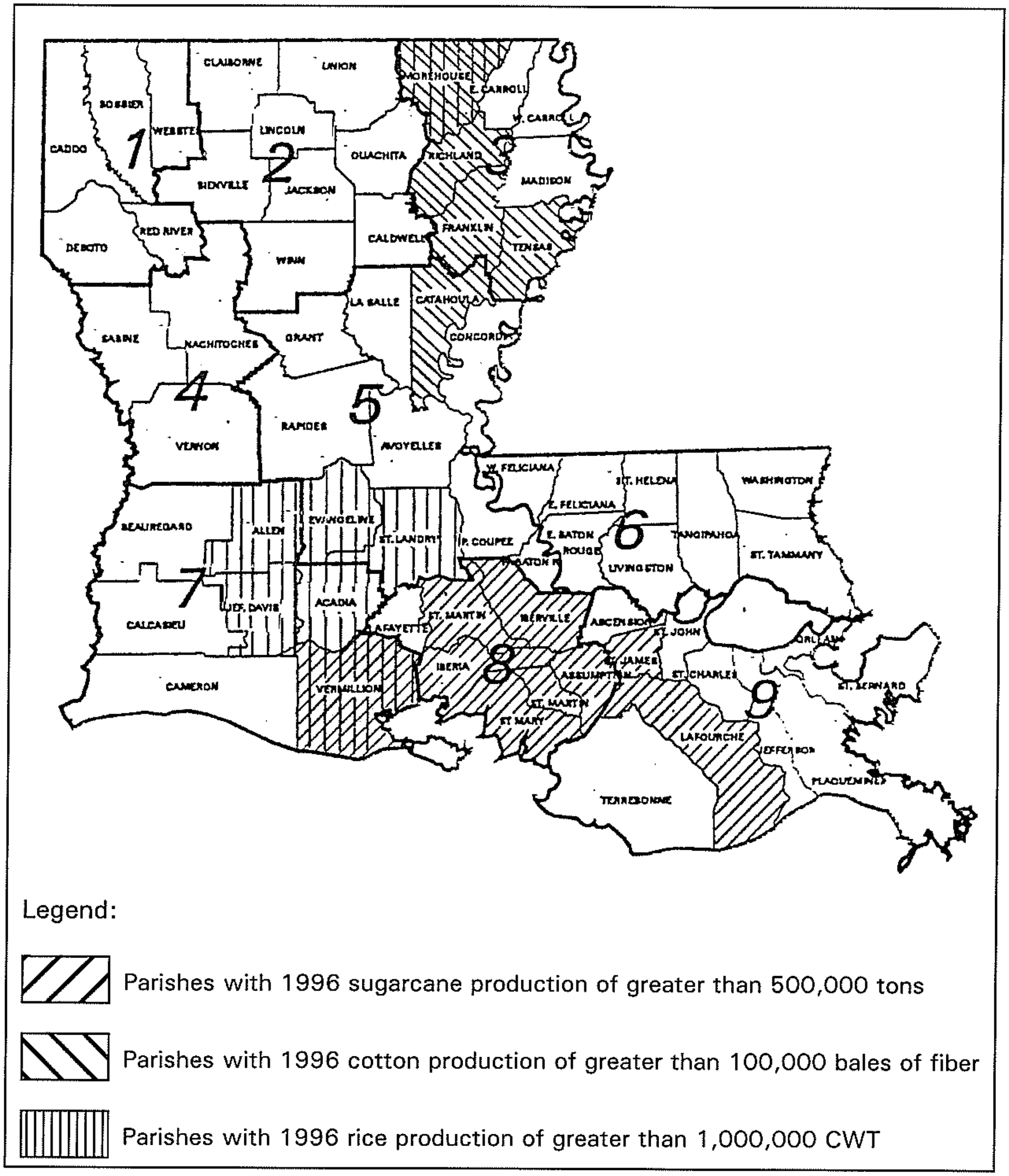

Figure 2

Major parishes involved in the production of sugarcane, cotton, and rice in 1996 [5]

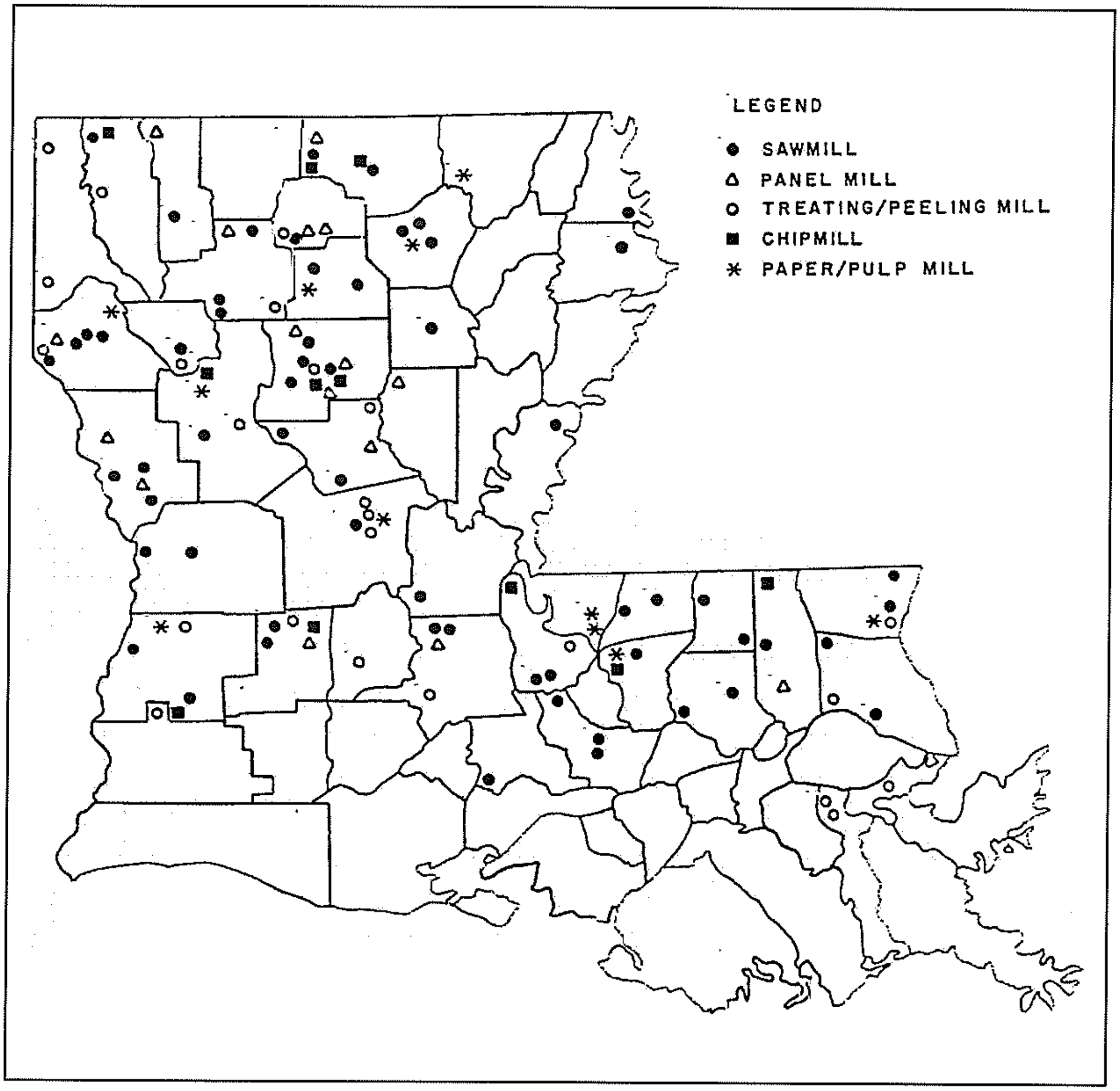

Figure 3

Primary wood-using plants in Louisiana, 1991

The industry groups were contacted and enlisted to help identify parishes and/or routes which are heavily used by trucks transporting commodities from the field, where harvested, to the first processing points. This was done for all groups except sugarcane. The Louisiana Transportation Research Center (LTRC) already had a project underway which had identified the sites chosen for use in this study. The unique knowledge of this group of people was instrumental in identifying a group of roadways of all types which were good candidates for inclusion in the study.

Step four involved taking the list of candidate roadways to a point where project records could be accessed on the DOTD mainframe computer. Roadway projects were reviewed until some were found which had been rehabilitated within the last ten years. Project numbers and control sections were identified and then the pavement design files were checked to ensure that pavement design data was available. Then for the candidate roads with all data available, we consulted with the industry contact person again, except for roads carrying sugarcane, before making final roadway selections.

Step five involved discussing the candidate roadways for which both project construction and pavement design data were available with industry representatives, except for roads carrying sugarcane, to select a set of roadways which had substantial commodity traffic. These discussions led to the selection of the roadways listed in table 14. Notice that there are no interstate highways included in either Tensas or Acadia parishes. There are no interstate highways in Tensas parish and even if there were the cotton module truck is prohibited from operating on the interstate system. I-10 runs across Acadia parish but the principal rice movements from the field to the rice drier are north and south while I-10 runs east and west.

Table 14

Roadways included in the preliminary analysis

Commodity	Parish	Roadway and description	Project No./Date
Sugarcane	Iberia	US 90 Between its junctions with LA 83 and LA 85	424-04-0023/1994
	Lafourche	LA 308 Between its junction with LA 3199 and Theriot bridge	407-04-0032/1996
	Lafayette	I-10 Between its junctions with US 167 and La 182 just north of Lafayette	450-05-0046/1996
Rice	Acadia	US 90 Between its junctions with LA 1111 and LA 13 in Crowley, LA	003-10-0010/1986
	Acadia	LA 13 North of its junction with LA 92 to 6.45 miles north of the Vermillion Parish line	057-02-0025/1994
	Acadia	LA 35 North of I-10 to its junction with LA 365	207-07-0019/1986
Cotton	Tensas	US 65 Between its junctions with LA 128 and LA 607	020-04-0034/1997
	Tensas	LA 128 Between its junctions with LA 573 and US 65	036-06-0012/1998
Timber	De Soto	I-49 Section just south of its junction with US 84	455-07-0008/1988
	De Soto	LA 509 From Red River parish line west to the International Paper plant near Clear Lake	105-02-0016/1996
	De Soto	US 84 West from its junction with LA 3248 to its junction with LA 509	021-03-0028/1998

Step six involved securing pavement design data from the DOTD pavement design office on the most recent rehabilitation on each project included in table 14. An example of the pavement information, traffic and design data are included in tables 15 through 18 for US 80 over which sugar cane is hauled.

Table 15
Project information on US 90 obtained from LA DOTD mainframe

```
                   *** PROJECT INFORMATION - PART 1 ***                TOPS11
RECORD DISPLAYED                                        STATUS: C COMPLETE
CONTROL SECT: 407 04  LENGTH:  14.890  LAST JOB: 0036   CANCEL: _ _ __
PROJECT      : 407 04 0032 FEDERAL #:
R/W UTIL PROJ: __ _ ___
ENGR PROJECT : __ _ ___
ONST PROJECT: __ _ ___
LEAD PROJECT:              # OTHER PROJECTS:    GOAL/SETASIDE:
ASSIGN FOR  : BURST/SEC. 11          DATE: 04 30 1996  BEG LOG MI:  0.000
DISTRICT: 02 PARISH: 29 LAFOURCHE    LENGTH:  3.100    END LOG MI:  3.100
ROUTES  : LA 308   : _____  TYPE: 05 ASPH OVLY ASPH PV : _
PROJECT NAME  : JCT. LA 3199 - THERIOT CANAL BRIDGE
LIMITS: BEGIN : 1996 - 1997 OVERLAY PROGRAM
        END   :
PROJ ENGR: ANGELETTE, KEITH J.  DIST/GANG: 02 282    WORK CAT: 300 __ __
DATES: BID : 02 25 1998     EST COST:          629,927  FINC SOURCE: ST
       CTR : 03 30 1998  CONTRACT AMT:         731,517  SYS CODE ST: 4 FED: 0
       W.O.: 04 14 1998                                 PLANS?     : PLANS
       F.I.: 09 30 1998 APPROVED COST:         730,111  FUNCT CLASS: 107 RURAL
       ACCP: 10 08 1998    FINAL COST:         682,031  CAP OUTLAY : B07
       F.E.:            CONTRACTOR: T. L. JAMES & CO., INC.
ACTION: I  A=ADD, U=UPDATE, D=DELETE, I=INQUIRE, C=CANCEL
F1 HELP    2 NEXT SCREEN   3 EXIT       4 REQ FILE    5 LIST        6 REPT
F7 BACK    8 NEXT RECORD   9 CTL SEC   10 XREF PAR   11 FED NUM    12 JOINT
```

Table 16
US 90 traffic data prepared by LA DOTD

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
PLANNING DIVISION
DATA COLLECTION AND ANALYSIS SECTION
P. O. BOX 94245
BATON ROUGE, LOUISIANA 70804-9245
(504) 358-9137

TRAFFIC ASSIGNMENT

DATE:	24-Oct-96
PROJECT NO.	407-04-0032
NAME:	Jct. La. 3199 - Theriot Canal Br.
DESCRIPTION:	Along La. 308 From Jct. La. 3199 to Theriot Canal Br.
ROUTE:	La. 308
FUNCTIONAL CLASS:	Rural Major Collector
PARISH:	Lafourche

1997 ADT =	4,900	ANN. GROWTH	1.0%
2005 ADT =	5,300		

D =	55%
K =	10%
T =	10%

AXLE DISTRIBUTION

VEHICLE TYPE	PERCENT	1997 ADT	2005 ADT	MEDIAN YEAR
1 MOTORCYCLES	0.50%	12	13	13
2 PASSENGER CARS	59.10%	1448	1566	1507
3 2A-4T SINGLE UNIT	30.00%	735	795	765
4 BUSES	0.50%	12	13	13
5 2A-6T SINGLE UNIT	4.40%	108	117	112
6 3A SINGLE UNIT	1.30%	32	34	33
7 4A SINGLE UNIT	0.00%	0	0	0
8 4A SINGLE TRAILER	0.40%	10	11	10
9 5A SINGLE TRAILER	2.60%	64	69	66
10 6A SINGLE TRAILER	0.50%	12	13	13
11 5A MULTI-TRAILER	0.20%	5	5	5
12 6A MULTI-TRAILER	0.20%	5	5	5
13 7A MULTI-TRAILER	0.30%	7	8	8
TOTALS		2,450	2,650	2,550

The above traffic data is an estimate based on data available at the time of preparation.

SUBMIT TO:	Geneva P. Grille	DISTRICT:	02
COPY TO:	J.B. Esnard	SECTION:	67
	James Bell	SECTION:	24
PREPARED BY:	Dan Broussard / John Spragio		

Table 17
DARW in output prepared by LA DOTD for US 90

1993 AASHTO Pavement Design

DARWin(tm) Pavement Design System

A Proprietary AASHTOWARE(tm)
Computer Software Product

Flexible Structural Design Module

SPN 407-04-0032, LA 308 (JCT LA 3199 - THERIOT CANAL BRIDGE), LAFOURCHE PARISH.

Flexible Structural Design Module Data

18-kip ESALs Over Initial Performance Period:	508,081
Initial Serviceability:	4
Terminal Serviceability:	2
Reliability Level (%):	85
Overall Standard Deviation:	.47
Roadbed Soil Resilient Modulus (PSI):	9,000
Stage Construction:	1

Calculated Design Structural Number: 2.75

Specified Layer Design

Layer	Material Description	Struct. Coef. (Ai)	Drain. Coef. (Mi)	Thickness (Di) (in)	Width (ft)	Calculated SN
1	Wearing Course, Type 8F AC	.44	1	1.5	-	.66
2	Binder Course, Type 8F AC	.44	1	2	-	.88
3	Existing AC Pavemant	.18	.9	3	-	.49
4	CSB	.1	.9	8	-	.72
Total	-	-	-	14.50	-	2.75

Table 18
Pavement design traffic data for US 90

Rigorous ESAL Calculation

Performance Period (years): 8
Two-Way Daily Traffic (ADT): 4,900
Number of Lanes In Design Direction: 1
Percent of All Trucks In Design Lane (%): 100
Percent Trucks In Design Direction (%): 50

Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/truck)	Annual % Growth in Truck Factor	Accumulated 18K ESALs over Performance Period
1	.5	1	.0004	0	15
2	59.1	1	.0004	0	1,753
3	30	1	.0143	0	31,808
4	.5	1	.1694	0	6,280
5	4.4	1	.1694	0	55,265
6	1.3	1	.3836	0	36,975
7	0	1	.3836	0	0
8	.4	1	.8523	0	25,278
9	2.6	1	1.045	0	201,453
10	.5	1	1.45	0	53,755
11	.2	1	1.84	0	27,285
12	.2	1	1.84	0	27,285
13	.3	1	1.84	0	40,928
Total	100.00	-	-	-	508,081

Step seven involved determining the quantity of each commodity that was hauled over a particular road. Much of this data was secured by industry representatives who contacted each business that received a particular commodity from the field to ascertain which way the drivers traveled from the field to their business. Project staff contacted all the cotton gins in Tensas parish to determine how much cotton was transported over the LA 128 and US 65 sections. The data collected in this step represents the total payload carried in the trucks traveling over the selected roadways. The number of trucks required to carry the total payload is calculated by dividing total payload by the available payload per truck under each of the weight scenarios.

Step eight involves determining the weight scenarios to be investigated in the study. The base scenario is assumed to be that in which all vehicles operate according to the legal loading with variance in weights on axles but with no special permits. Scenario 1 provides a basic picture of how the pavements will perform without special overweight permits for agricultural products. Scenario 2 included the special overweight permits allowed by current Louisiana legislation plus the TEA 21 provision for sugarcane and rice but not timber.

Discussion with timber specialists indicated that they prefer the current 86,600 GVW to 100,000 GVW as provided under the agronomic/horticultural permit because of safety and operational considerations. However, scenario 3 extends the GVW up to 100,000 lbs. for timber haulers. Each of the vehicle and axle weights for the vehicles involved in the three weight scenarios is included in table 19 for both state (U.S. and Louisiana systems) and interstate highways (I H).

Table 19

Vehicle loads for each weight scenario and commodity

Rice and Sugarcane	Highway Type	LA type 6 vehicle			
		Steering Axle, lbs	Tandem Axle, lbs	Tandem Axle, lbs	GVW with variance
Scenario 1	State	12,000	37,000	37,000	86,000
	I H	12,000	34,000	34,000	80,000
Scenario 2	State	12,000	44,000	44,000	100,000
	I H	12,000	44,000	44,000	100,000
Scenario 3	State	12,000	44,000	44,000	100,000
	I H	12,000	44,000	44,000	100,000
Timber					
Scenario 1	State	12,000	37,000	37,000	86,000
	I H	12,000	34,000	34,000	80,000
Scenario 2	State	12,600	37,000	37,000	86,600
	I H	12,000	35,700	35,700	83,400
Scenario 3	State	12,000	44,000	44,000	100,000
	I H	12,000	44,000	44,000	100,000

Cotton		LA type 2 vehicle[1]		
		Steering	Tandem	GVW with variance
Scenario 1	State	12,000	37,000	49,000
Scenario 2	State	12,000	48,000	68,000
Scenario 3	State	12,000	48,000	68,000

[1] Cotton module trucks may not travel on the I H system

For each weight scenario the amount of payload per truck is determined in step nine. The payload per truck is calculated by subtracting the empty weight of the truck from the sum of the axle weights for the vehicle shown in table 19 and recorded in table 20. Using the total commodity hauled from step seven and the average payload per truck, the number of vehicle-trips required to carry the total weight of commodity can be calculated for each commodity. The average empty weight of the type 6 vehicles are:

Rice hauler - 28,500 lbs

Sugarcane hauler - 37,300 lbs

Timber pole truck - 26,600 lbs

The average empty weight of a cotton module truck is 34,000 lbs. The payloads under each of the weight scenarios for the LA type 6 and type 2 vehicles are given in table 20.

Trucks carrying rice, cotton, and sugarcane generally are operated in September through December of each year and are assumed to not be included in the traffic volume surveys conducted for pavement design. Therefore the number of these vehicles required to carry each commodity are simply added to the traffic projections included in the pavement design. Since timber operations generally occur during all months of the year, these vehicles are assumed to be included in the traffic projections. Therefore the number of trucks required to carry the timber under scenario 2 are assumed to be included in the pavement design traffic volume estimates. The scenario 2 number of timber trucks required to carry the total payload will be removed from the traffic stream for scenarios 1 and 3, a new number of trucks with different payloads (and axle loads)will be added back in to complete the traffic estimates for scenarios 1 and 3.

Table 20

Payloads for each commodity under each weight scenario

Commodity	Weight Scenario	Highway Type	Sum of axle loads, lbs	Vehicle empty weight, lbs	Payload/ truck, lbs
Rice	1	State	86,000	28,500	57,500
		I H	80,000	28,500	51,500
	2	State	100,000	28,500	71,500
		I H	100,000	28,500	71,500
	3	State	100,000	28,500	71,500
		I H	100,000	28,500	71,500
Timber	1	State	86,000	26,600	59,400
		I H	80,000	26,600	53,400
	2	State	86,600	26,600	60,000
		I H	83,400	26,600	56,800
	3	State	100,000	26,600	73,400
		I H	100,000	26,600	73,400
Sugar Cane	1	State	86,000	37,300	48,700
		I H	80,000	37,300	42,700
	2	State	100,000	37,300	62,700
		I H	100,000	37,300	62,700
	3	State	100,000	37,300	62,700
		I H	100,000	37,300	62,700
Cotton	1	State	49,000	34,000	15,000
	2	State	60,000	34,000	26,000
	3	State	60,000	34,000	26,000

Step ten involves taking the pavement design traffic in ESALs, construction date of the most recent rehabilitation, and traffic growth rate to estimate how much of the design traffic has been carried up to the end of 1998. The difference between the design traffic and that carried to the end of 1998 will be applied using the three weight scenarios presented earlier to estimate a date when the total design traffic has been carried by the road and a rehabilitation is needed. Traffic for the new rehabilitation will be developed by projecting the previous traffic to estimate the non commodity traffic. Commodity traffic will be calculated by projecting the future crop quantities using historical data. Annual commodity harvests will be converted into the number of truck trips for each scenario as described in step nine. Therefore there will be three traffic estimates worked out for each roadway for each rehabilitation that occurs during an analysis period of 20 years. A cost stream will be generated for each scenario for each project representing the rehabilitation costs which are incurred during the project analysis period.

Step eleven involves computing the net present worth of the rehabilitation costs for each project for each of the three different weight scenarios. The interest rate to be used in these calculations is 5.0 percent.

Step twelve will involve making comparisons between the three different weight scenarios. Of particular interest will be the comparisons between scenarios 1 and 2 which will indicate the pavement costs associated with moving from the no permit weights (scenario 1) to the current permits on non interstate (state) highways (scenario 2). A second comparison of special interest will be that between pavement costs associated with moving from scenario 1 to scenario 3 which allows up to 100,000 lbs on all systems for the type 6 vehicle.

DISCUSSION OF RESULTS

Introduction

As discussed in the methodology, road sections over which each of the commodities were transported were identified and pavement design data secured from DOTD project files. These data were used along with commodity estimates transported over each road to predict the effect of the additional ESALs on 1) the time to the next overlay and 2) the amount of overlay required. These data were used to generate a DOTD cost stream for each weight scenario. Net present worth was calculated for each scenario and differences between the net present worths provided a basis for comparing the effects of the different weight scenarios on pavement costs.

To demonstrate how these calculations were performed, the pavement section on US 90 over which sugarcane was transported is presented next.

Example Analysis on US 90

The section on US 90 over which sugarcane was transported is identified in table 14.

Calculate 1998 production of sugarcane transported over US 90.

- Mill 1 = 41,000 tons
- Mill 2 = 1,300,000 tons
- Mill 3 = 251,800 tons
- Mill 4 = 190,000 tons
- Mill 5 = 140,000 tons
- Mill 6 = 20,700 tons

Total = 1,943,500 tons = 3,887,000,000 lbs

Evaluate Scenario 1: GVW = 86,000 lbs.

Evaluate US 90 serving current traffic in the first performance period. For the following axle configuration, ESALs are obtained from tables D4 and D5 of AASHTO [*6*] with SN = 4.59:

Steering axle (12,000 lbs)	= 0.213
Tandem axle (37,000 lbs)	= 1.530
Tandem axle (37,000 lbs)	= 1.530
ESALs for each truck	= 3.273 ESALs

Maximum payload per truck = GVW - tare weight of truck

= 86,000 - 37,300 = 48,700 lbs

Number of trucks required to carry the 1998 sugarcane harvest:

$$= \frac{3,887,000,000}{48,700} = 79,815$$

Total number of ESALs = 79,815 x 3.273 = 261,235 (for the 1998 harvest season)

Note that the data above is calculated for the 1998 harvest. Since the base for the traffic analysis was 1999, the number of ESALs from sugarcane needs to be estimated for the harvest year 1999. A five percent growth rate for sugarcane is projected based on data from Zapata [*5*].

Total ESALs in 1999 = $(1 + 0.05)^1 \times 261{,}235 = 274{,}297$

For an eight year performance period (1999-2006), the total ESALs from sugarcane trucks are

$$\frac{(1+0.05)^8-1}{0.05} x\,274{,}297 = 2{,}619{,}289$$

Total traffic carried by US 90 between 1999 - 2006 for the standard eight year overlay performance period is

ESALs = other traffic[1] + sugarcane truck traffic

= 1,858,123 + 2,619,289 = 4,477,412 ESALs

[1]Other traffic ESALs are contained in table 21. This total traffic was used as the basis for determining the thickness of the overlay to be constructed by DOTD at the end of 1998.

Table 21
ESAL calculation for US 90 for other non sugarcane traffic beginning in 1999 for scenario 1

Commodity:	Sugarcane	
Location:	US 90	
Func. Class:	02 (Other Rural Principal Arterial)	
Performance Period:	8	Years
ADT/ADTT:	11,447	(1999)
Directional Distribution (%)	50	
Lane Distribution (%)	80	

Class	% ADT	ADT per Class	% Annual Growth	Avg. Initial Truck Factor (ESAL/Truck	% Annual Growth in Truck Factor	Accummulated 18K ESALs
1	0.52	60	1	0.0005	0	36
2	68.36	7,825	1	0.0005	0	4,733
3	16.42	1,880	1	0.0188	0	42,747
4	0.46	53	1	0.1932	0	12,307
5	2.13	244	1	0.1932	0	56,985
6	1.22	140	1	0.4092	0	69,130
7	0.03	3	1	0.4092	0	1,700
8	1.23	141	1	0.8814	0	150,124
9	8.8	1,007	1	1.1	0	1,340,441
10	0.49	56	1	1.45	0	98,387
11	0.18	21	1	1.84	0	45,863
12	0.02	2	1	1.84	0	5,096
13	0.12	14	1	1.84	0	30,575
Total	100	11,445			**Total**	1,858,123

Design overlay for second performance period. To calculate the thickness of overlay for the period of 2007 - 2014 (scenario 1), the AASHTO method for overlay design was used [*6*]. According to the AASHTO method, the thickness of overlay for this second performance period (2007-2014) with the total traffic noted in table 22 can be calculated as follows:

a. Flexible overlay over flexible pavement:

$$h_{ol} = \frac{SN_{ol}}{a_{ol}} = \frac{SN_y - F_{RL} SN_{xeff}}{a_{ol}}$$

b. Flexible overlay over rigid pavement, using visual condition factor method:

$$h_{ol} = \frac{SN_{ol}}{a_{ol}} = \frac{SN_y - F_{RL}(a_{2r} D_o + SN_{xeff-rp})}{a_{ol}}$$

Where:

h_{ol}	=	overlay thickness, inches
SN_{ol}	=	required structural number of overlay
SN_y	=	total structural number required to support the overlay traffic over existing subgrade conditions
a_{ol}	=	structural layer coefficient of HMA overlay
F_{RL}	=	remaining life factor; 0.6 was used in the analysis as a conservative estimate
SN_{xeff}	=	total effective structural number of existing pavement structure above the subgrade prior to overlay
a_{2r}	=	structural layer coefficient of existing cracked PCC pavement layer
D_o	=	existing PCC layer thickness, inches
$SN_{xeff-rp}$	=	effective structural capacity of all of the remaining pavement layers above the subgrade except for the existing PCC layer

Table 22

ESAL calculation for US 90 for traffic beginning in 2007 for scenario 1 with an overlay in 2007

Commodity:	Sugar cane	
Location:	US 90	
Func. Class:	02 (Other Rural Principal Arterial)	
Performance Period:	8	Years
ADT/ADTT:	12,395	(2007)
Directional Distribution (%)	50	
Lane Distribution (%)	80	

Class	% ADT	ADT per Class	% Annual Growth	Avg. Initial Truck Factor (ESAL/Truck)	% Annual Growth in Truck Factor	Accummulated 18K ESALs
1	0.52	64	1	0.0005	0	39
2	68.36	8,473	1	0.0005	0	5,125
3	16.42	2,035	1	0.0188	0	46,287
4	0.46	57	1	0.1932	0	13,326
5	2.13	264	1	0.1932	0	61,704
6	1.22	151	1	0.4092	0	74,855
S.Cane Truck		405,261	5			3,869,881
7	0.03	4	1	0.4092	0	1,841
8	1.23	152	1	0.8814	0	162,557
9	8.8	1,091	1	1.1	0	1,451,451
10	0.49	61	1	1.45	0	106,535
11	0.18	22	1	1.84	0	49,661
12	0.02	2	1	1.84	0	5,518
13	0.12	15	1	1.84	0	33,107
Total	100				**Total**	5,881,887

To automate the calculation, an MS Excel 97 macro was written and the output is presented in table 23 for scenario 1 during the second performance period (2007-2014).

As can be seen from table 23, the required overlay thickness in 2007 for US 90 is 5.31 inches.

Table 23
Overlay design for US 90 for scenario 1 during the second performance period (2007-2014)

Commodity: Sugarcane
Route: US 90

Existing Pavement

Layers	Thickness, in.	"ai"	mi	SN
Surface	5	0.33	1	1.65
PCC	9	0.2	0.9	
Subbase	3.5	0.07	0.9	0.2205
			$SN_{xeff\text{-}rp}$	1.8705

Overlay Material and Design Data

Asphalt Modulus, psi	0
"a"	0.44
Roadbed Modulus, psi	9,000
Future Traffic	5,881,887
Reliability (%)	95
Overall Std. Deviation (So)	0.47
Initial PSI (po2)	4.3
PSI at End of Overlay (pt2)	2.5
Future SN	4.54
Overlay Thickness, in.	**5.31**

Design overlay for third performance period. To complete the analysis of this study, data for the third performance period (2015-2022) was projected. The total traffic for this period is 7,896,289 ESALs as noted in table 24. Using a similar analysis, the thickness of the overlay is computed to be 5.31 inches as noted in table 25.

Table 24

ESAL calculation for US 90 for scenario 1 during the third performance period (2015 - 2022)

Commodity:	Sugar cane	
Location:	US 90	
Func. Class:	02 (Other Rural Principal Arterial)	
Performance Period:	8	Years
ADT/ADTT:	13,422	(2015)
Directional Distribution (%)	50	
Lane Distribution (%)	80	

Class	% ADT	ADT per Class	% Annual Growth	Avg. Initial Truck Factor (ESAL/Truck	% Annual Growth in Truck Factor	Accummulated 18K ESALs
1	0.52	70	1	0.0005	0	42
2	68.36	9,175	1	0.0005	0	5,550
3	16.42	2,204	1	0.0188	0	50,122
4	0.46	62	1	0.1932	0	14,430
5	2.13	286	1	0.1932	0	66,817
6	1.22	164	1	0.4092	0	81,058
Cane Truck		598,755	5			5,717,577
7	0.03	4	1	0.4092	0	1,993
8	1.23	165	1	0.8814	0	176,026
9	8.8	1,181	1	1.1	0	1,571,713
10	0.49	66	1	1.45	0	115,362
11	0.18	24	1	1.84	0	53,776
12	0.02	3	1	1.84	0	5,975
13	0.12	16	1	1.84	0	35,851
Total	100				**Total**	7,896,289

Table 25
Overlay design for US 90 for scenario 1 during the third performance period (2015-2022)

Commodity: Sugarcane
Route: US 90

Existing Pavement

Layers	Thickness, in.	"ai"	mi	SN
Surface	6	0.33	1	1.98
PCC	9	0.2	0.9	
Subbase	3.5	0.07	0.9	0.2205
			$SN_{xeff-rp}$	2.2005

Overlay Material and Design Data

Asphalt Modulus, psi	0
"a"	0.44
Roadbed Modulus, psi	9,000
Future Traffic	7,896,289
Reliability (%)	95
Overall Std. Deviation (So)	0.47
Initial PSI (po2)	4.3
PSI at End of Overlay (pt2)	2.5
Future SN	4.74
Overlay Thickness, in.	**5.31**

Evaluate Scenario 2: GVW = 100,000 lbs.

Evaluate US 90 serving current traffic in the first performance period. For the following axle configuration, ESALs are obtained from tables D4 and D5 of AASHTO with SN = 4.59 [*6*]:

Steering axle (12,000 lbs)	= 0.213
Tandem axle (44,000 lbs)	= 2.940
Tandem axle (44,000 lbs)	= 2.940
ESALs for each truck	= 6.093 ESALs

Maximum payload per truck = GVW - tare weight of truck

= 100,000 - 37,300 = 62,700 lb

Number of trucks required to carry the 1998 sugarcane harvest:

$$= \frac{3{,}887{,}000{,}000}{62{,}700} = 61{,}994$$

Total number of ESALs = 61,994 x 6.093 = 377,727 (for the 1998 harvest)

The GVW = 100,000 lbs is designed to be applied starting in 1999. Therefore, the total number of ESALs of sugarcane truck in 1999 harvest season is:

$$(1+0.05)^1 \times 377{,}727 = 396{,}614 \text{ ESALs}$$

To determine the number of years required to reach the 4,477,412 ESALs design load for the existing pavement, an MS Excel spreadsheet simulation was performed with the result shown in table 26. As can be seen from table 26 that it takes 6.52 years for the traffic ESALs to equal the end of the first performance period. Based on the above simulation, the design traffic for the current overlay under scenario II loading was all served by mid 2005, ending the first performance period.

Table 26

Simulation to determine the number of years required by scenario 2 to reach 4,477,412 ESALs, i.e., the end of the first performance period

Commodity:	Sugarcane	
Location:	US 90	
Func. Class:	02 (Other Rural Principal Arterial)	
Number of years required:	**6.52**	Years
ADT/ADTT:	11,447	(1999)
Directional Distribution (%)	50	
Lane Distribution (%)	80	

Class	% ADT	ADT per Class	% Annual Growth	Avg. Initial Truck Factor (ESAL/Truck)	% Annual Growth in Truck Factor	Accummulated 18K ESALs
1	0.52	60	1	0.0005	0	29
2	68.36	7,825	1	0.0005	0	3,829
3	16.42	1,880	1	0.0188	0	34,580
4	0.46	53	1	0.1932	0	9,955
5	2.13	244	1	0.1932	0	46,098
6	1.22	140	1	0.4092	0	55,923
Cane Truck		396,614	5			2,970,877
7	0.03	3	1	0.4092	0	1,375
8	1.23	141	1	0.8814	0	121,443
9	8.8	1,007	1	1.1	0	1,084,348
10	0.49	56	1	1.45	0	79,590
11	0.18	21	1	1.84	0	37,101
12	0.02	2	1	1.84	0	4,122
13	0.12	14	1	1.84	0	24,734
Total	100	408,059			**Total**	4,474,004

Design analysis for the second performance period. The total amount of traffic to be served during the next DOTD standard overlay performance period of eight years (2005-2013) is 6,299,876 ESALs as noted in table 27. The required overlay thickness is 5.41 inches as noted in table 28.

Table 27
ESAL calculation for US 90 for scenario 2 during the second performance period (2005 - 2013)

Commodity:	Sugar cane	
Location:	US 90	
Func. Class:	02 (Other Rural Principal Arterial)	
Performance Period:	8	Years
ADT/ADTT:	12,151	(2005)
Directional Distribution (%)	50	
Lane Distribution (%)	80	

Class	% ADT	ADT per Class	% Annual Growth	Avg. Initial Truck Factor (ESAL/Truck)	% Annual Growth in Truck Factor	Accummulated 18K ESALs
1	0.52	63	1	0.0005	0	38
2	68.36	8,306	1	0.0005	0	5,024
3	16.42	1,995	1	0.0188	0	45,376
4	0.46	56	1	0.1932	0	13,063
5	2.13	259	1	0.1932	0	60,489
6	1.22	148	1	0.4092	0	73,382
Cane Truck		531,500	5			4,327,477 *
7	0.03	4	1	0.4092	0	1,804
8	1.23	149	1	0.8814	0	159,357
9	8.8	1,069	1	1.1	0	1,422,879
10	0.49	60	1	1.45	0	104,438
11	0.18	22	1	1.84	0	48,684
12	0.02	2	1	1.84	0	5,409
13	0.12	15	1	1.84	0	32,456
Total	100				Total	6,299,876

*Since the performance period was between mid 2005 and mid 2013, the sugar cane traffic in year 2013 was excluded from this performance period.

Table 28

Overlay design for US 90 for scenario 2 during the second performance period (2005-2013)

Commodity: Sugarcane
Route: US 90

Existing Pavement

Layers	Thickness, in.	"ai"	mi	SN
Surface	5	0.33	1	1.65
PCC	9	0.2	0.9	
Subbase	3.5	0.07	0.9	0.2205
			$SN_{xeff\text{-}rp}$	1.8705

Overlay Material and Design Data

Asphalt Modulus, psi	0
"a"	0.44
Roadbed Modulus, psi	9,000
Future Traffic	6,299,876
Reliability (%)	95
Overall Std. Deviation (So)	0.47
Initial PSI (po2)	4.3
PSI at End of Overlay (pt2)	2.5
Future SN	4.58
Overlay Thickness, in.	**5.41**

Design analysis for the third performance period. For the third performance period (2013-2021) of scenario 2, using a similar analysis method, the total traffic is 8,529,518 ESALs as noted in table 29 and the overlay thickness is 5.43 inches as noted in table 30.

Table 29

ESAL calculation for US 90 for scenario 2 during the third performance period (2013 - 2021)

Commodity:	Sugar cane	
Location:	US 90	
Func. Class:	02 (Other Rural Principal Arterial)	
Performance Period:	8	Years
ADT/ADTT:	13,158	(2013)
Directional Distribution (%)	50	
Lane Distribution (%)	80	

Class	% ADT	ADT per Class	% Annual Growth	Avg. Initial Truck Factor (ESAL/Truck)	% Annual Growth in Truck Factor	Accummulated 18K ESALs
1	0.52	68	1	0.0005	0	41
2	68.36	8,995	1	0.0005	0	5,441
3	16.42	2,161	1	0.0188	0	49,136
4	0.46	61	1	0.1932	0	14,146
5	2.13	280	1	0.1932	0	65,502
6	1.22	161	1	0.4092	0	79,463
Cane Truck		785,268	5			6,393,659 *
7	0.03	4	1	0.4092	0	1,954
8	1.23	162	1	0.8814	0	172,563
9	8.8	1,158	1	1.1	0	1,540,798
10	0.49	64	1	1.45	0	113,093
11	0.18	24	1	1.84	0	52,718
12	0.02	3	1	1.84	0	5,858
13	0.12	16	1	1.84	0	35,145
Total	100				**Total**	8,529,518

*Since the performance period was between mid 2013 and mid 2021, the sugar cane traffic in year 2021 was excluded from this performance period.

Table 30
Overlay design for US 90 for scenario 2 during the third performance period (2013-2021)

Commodity:	Sugarcane
Route:	US 90

Existing Pavement

Layers	Thickness, in.	"ai"	mi	SN
Surface	6	0.33	1	1.98
PCC	9	0.2	0.9	
Subbase	3.5	0.07	0.9	0.2205
			$SN_{xeff\text{-}rp}$	2.2005

Overlay Material and Design Data

Asphalt Modulus, psi	0
"a"	0.44
Roadbed Modulus, psi	9,000
Future Traffic	8,529,518
Reliability (%)	95
Overall Std. Deviation (So)	0.47
Initial PSI (po2)	4.3
PSI at End of Overlay (pt2)	2.5
Future SN	4.79
Overlay Thickness, in.	**5.43**

Evaluate Scenario 3: GVW = 100,000 lbs.

Scenario 3 is identical to scenario 2 for sugarcane loadings.

Cost Stream Analysis

The cost difference between the three scenarios is calculated as follows:

$$\Delta_{1-2} = PW_2 - PW_1 \qquad \text{and} \qquad \Delta_{2-3} = PW_3 - PW_2$$

where:

$$PW_1 = OverlayCost_{1,1}(\frac{1}{(1+i_{1,1})^{n1,1}}) + OverlayCost_{1,2}(\frac{1}{(1+i_{1,2})^{n1,2}})$$

$$PW_2 = OverlayCost_{2,1}(\frac{1}{(1+i_{2,1})^{n2,1}}) + OverlayCost_{2,2}(\frac{1}{(1+i_{2,2})^{n2,2}})$$

$$PW_3 = OverlayCost_{3,1}(\frac{1}{(1+i_{3,1})^{n3,1}}) + OverlayCost_{3,2}(\frac{1}{(1+i_{3,2})^{n3,2}})$$

Information obtained from the Monroe district office indicated that a typical compacted in-place cost for HMA surface and binder courses for several recent projects is about

$44/Megagram = $14,784/in/12 ft lane

Therefore,

$$PW_1 = 5.31x\$14{,}784(\frac{1}{(1+0.05)^8}) + 5.31x\$14{,}784(\frac{1}{(1+0.05)^{16}})$$
$$= \$89{,}097.09 / 12 ft.\ lane\ mile$$

$$PW_2 = 5.41x\$14{,}784(\frac{1}{(1+0.05)^{6.52}}) + 5.43x\$14{,}784(\frac{1}{(1+0.05)^{14.52}})$$
$$= \$97{,}717.88 / 12 ft.\ lane\ mile$$

$$PW_3 = PW_2$$

Thus,

$$\Delta_{1-2} = \$97{,}717.88 - \$89{,}097.09$$
$$= \$8{,}620.78 / 12 ft.\ lane\ mile$$

$$\Delta_{2-3} = \$97{,}717.88 - \$97{,}717.88$$
$$= \$0.00$$

Using the same methodology as described above, the cost stream calculations for other roads were developed and are shown in tables 31 through 41.

Table 31

Summary of analysis cost stream and comparisons of weight scenarios for US 90 carrying sugarcane

Commodity:	Sugarcane
Route:	US 90
Total 1998 Payload Carried over the ro	3,887,000,000
Vehicle Tare Weight, lb.:	37,300
Growth Rate:	5% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Tota Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	86,000	48,700	79,815	3.273	261,235
2	100,000	62,700	61,994	6.093	377,727
3	100,000	62,700	61,994	6.093	377,727

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness,	Time to Next Overlay, Yea	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	4,477,412	7.00	8.00	Jan 1999	$103,488.00	$103,488.00
2	5,881,887	5.31	8.00	Jan 2007	$78,503.04	$53,133.95
3	7,896,289	5.31	8.00	Jan 2015	$78,503.04	$35,963.15

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness,	Time to Next Overlay, Yea	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	4,477,412	7.00	6.52	Jan 1999	$103,488.00	$103,488.00
2	6,299,876	5.41	8.00	Jun 2005	$79,981.44	$58,188.21
3	8,529,518	5.43	8.00	Jun 2013	$80,277.12	$39,529.67

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness,	Time to Next Overlay, Yea	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	4,477,412	7.00	6.52	Jan 1999	$103,488.00	$103,488.00
2	6,299,876	5.41	8.00	Jun 2005	$79,981.44	$58,188.21
3	8,529,518	5.43	8.00	Jun 2013	$80,277.12	$39,529.67

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$89,097.09	$8,620.78	$0.00	$8,620.78
2	$97,717.88			
3	$97,717.88			

[1]The cost is in dollar/12 ft.lane mile

[2]PW is in dollar/12 ft.lane mile

Table 32

Summary of analysis cost stream and comparisons of weight scenarios for LA 308 carrying sugarcane

Commodity:	Sugarcane
Route:	LA 308
Total 1998 Payload carried over the road, lb.:	304,000,000
Vehicle Tare Weight, lb.:	37,300
Growth Rate:	5% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Total Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	86,000	48,700	6,243	3.285	20,506
2	100,000	62,700	4,848	6.595	31,976
3	100,000	62,700	4,848	6.595	31,976

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	703,547	3.50	8	Jan 1999	$51,744.00	$51,744.00
2	761,841	3.33	8	Jan 2007	$49,230.72	$33,321.29
3	908,673	3.07	16	Jan 2015	$45,386.88	$20,792.25

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	703,547	3.5	7	Jan 1999	$51,744.00	$51,744.00
2	993,471	3.61	8	Jan 2006	$53,370.24	$37,929.23
3	1,103,255	3.28	8	Jan 2014	$48,491.52	$23,325.25

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	703,547	3.5	7	Jan 1999	$51,744.00	$51,744.00
2	993,471	3.61	8	Jan 2006	$53,370.24	$37,929.23
3	1,103,255	3.28	8	Jan 2014	$48,491.52	$23,325.25

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$54,113.54	$7,140.94	$0.00	$7,140.94
2	$61,254.48			
3	$61,254.48			

[1]The cost is in dollar/12 ft.lane mile

[2]PW is in dollar/12 ft.lane mile

Table 33

Summary of analysis cost stream and comparisons of weight scenarios for I-10 carrying sugarcane

Commodity:	Sugarcane
Route:	I-10
Total 1998 Payload Carried Over Road, lb.:	600,200,000
Vehicle Tare Weight, lb.:	37,300
Growth Rate:	5% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Total Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	80,000	42,700	14,057	2.367	33,271
2	100,000	62,700	9,572	6.317	60,470
3	100,000	62,700	9,572	6.317	60,470

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	16,918,311	6	10	Jun 1999	$88,704.00	$88,704.00
2	18,870,662	7.11	10	Jun 2009	$105,114.24	$64,531.03
3	21,087,225	6.19	10	Jun 2019	$91,512.96	$34,490.27

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	16,348,376	6	9.806	Jun 1999	$88,704.00	$88,704.00
2	20,504,068	7.26	10	Apr 2009	$107,331.84	$66,519.09
3	22,402,156	6.3	10	Apr 2019	$93,139.20	$35,437.02

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	16,348,376	6	9.806	Jun 1999	$88,704.00	$88,704.00
2	20,504,068	7.26	10	Apr 2009	$107,331.84	$66,519.09
3	22,402,156	6.3	10	Apr 2019	$93,139.20	$35,437.02

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$99,021.30	$2,934.82	$0.00	$2,934.82
2	$101,956.12			
3	$101,956.12			

[1]The cost is in dollar/12 ft.lane mile

[2]PW is in dollar/12 ft.lane mile

Table 34

Summary of analysis cost stream and comparisons of weight scenarios for US 65 carrying cotton

Commodity:	Cotton
Route:	US 65
Total 1998 Payload Carried Over Road, lb.:	28,738,500
Vehicle Tare Weight, lb.:	34,000
Growth Rate:	1% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Total Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	49,000	42,700	1,916	1.759	3,370
2	54,250	20,250	1,419	2.744	3,894
3	100,000	20,250	1,419	2.744	3,894

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	681,139	3.50	8	Jan 1998	$51,744.00	$51,744.00
2	795,586	4.57	8	Jan 2006	$67,562.88	$45,729.22
3	929,548	3.59	8	Jan 2014	$53,074.56	$24,314.07

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	681,139	3.50	7.9	Jan 1998	$51,744.00	$51,744.00
2	800,282	4.6	8	Jan 2006	$68,006.40	$46,254.54
3	934,643	3.6	8	Jan 2014	$53,222.40	$24,501.04

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	681,139	3.50	7.9	Jan 1998	$51,744.00	$51,744.00
2	800,282	4.6	8	Jan 2006	$68,006.40	$46,254.54
3	934,643	3.6	8	Jan 2014	$53,222.40	$24,501.04

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$70,043.28	$712.30	$0.00	$712.30
2	$70,755.58			
3	$70,755.58			

[1]The cost is in dollar/12 ft.lane mile

[2]PW is in dollar/12 ft.lane mile

Table 35

Summary of analysis cost stream and comparisons of weight scenarios for LA 128 carrying cotton

Commodity:	Cotton
Route:	LA 128
Total 1998 Payload Carried Over Road, lb.:	16,549,500
Vehicle Tare Weight, lb.:	34,000
Growth Rate:	1% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Total Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	49,000	42,700	1,103	1.746	1,926
2	54,250	20,250	817	2.881	2,354
3	54,250	20,250	817	2.881	2,354

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	51,493	4.00	8	Jan 2000	$59,136.00	$59,136.00
2	55,740	2.89	8	Jan 2008	$42,725.76	$28,918.48
3	60,332	2.24	8	Jan 2016	$33,116.16	$15,170.89

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	51,493	4.00	7.5	Jan 2000	$59,136.00	$59,136.00
2	73,988	3.11	8	Jun 2007	$45,978.24	$31,888.39
3	75,868	2.42	8	Jun 2015	$35,777.28	$16,794.74

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	51,493	4.00	7.5	Jan 2000	$59,136.00	$59,136.00
2	73,988	3.11	8	Jun 2007	$45,978.24	$31,888.39
3	75,868	2.42	8	Jun 2015	$35,777.28	$16,794.74

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$44,089.37	$4,593.76	$0.00	$4,593.76
2	$48,683.13			
3	$48,683.13			

[1]The cost is in dollar/12 ft.lane mile

[2]PW is in dollar/12 ft.lane mile

Table 36
Summary of analysis cost stream and comparisons of weight scenarios for US 90 carrying rice

Commodity:	Rice
Route:	US 90
Total 1998 Payload Carried Over Road, lb.:	1,000,000,000
Vehicle Tare Weight, lb.:	28,500
Growth Rate:	0% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Total Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	86,000	57,500	17,392	3.273	57,046
2	100,000	71,500	13,986	2.744	83,538
3	100,000	71,500	13,986	2.744	83,538

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	1,932,545	4.00	8	Jan 2000	$59,136.00	$59,136.00
2	2,054,694	4.98	8	Jan 2008	$73,624.32	$49,831.84
3	2,186,988	4.16	8	Jan 2016	$61,501.44	$28,174.52

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	1,932,545	4.00	7.23	Jan 2000	$59,136.00	$59,136.00
2	2,249,107	5.1	8	Apr 2007	$75,398.40	$52,986.29
3	2,379,981	4.28	8	Apr 2015	$63,275.52	$30,096.96

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	1,932,545	4.00	7.23	Jan 2000	$59,136.00	$59,136.00
2	2,249,107	5.1	8	Apr 2007	$75,398.40	$52,986.29
3	2,379,981	4.28	8	Apr 2015	$63,275.52	$30,096.96

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$78,006.36	$5,076.90	$0.00	$5,076.90
2	$83,083.25			
3	$83,083.25			

[1]The cost is in dollar/12 ft.lane mile

[2]PW is in dollar/12 ft.lane mile

Table 37
Summary of analysis cost stream and comparisons of weight scenarios for LA 13 carrying rice

Commodity:	Rice
Route:	LA 13
Total 1998 Payload Carried Over Road, lb.:	650,000,000
Vehicle Tare Weight, lb.:	28,500
Growth Rate:	0% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Total Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	86,000	57,500	11,304	3.296	37,258
2	100,000	71,500	9,091	6.606	60,055
3	100,000	71,500	9,091	6.606	60,055

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	1,576,629	3.50	8	Jun 1996	$51,744.00	$51,744.00
2	1,682,558	4.94	8	Jun 2004	$73,032.96	$49,431.58
3	1,797,315	5.02	8	Jun 2012	$74,215.68	$33,999.06

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	1,576,629	3.50	7.42	Jun 1996	$51,744.00	$51,744.00
2	1,864,934	5.07	8	Jan 2004	$74,954.88	$52,188.56
3	1,979,691	5.14	8	Jan 2012	$75,989.76	$35,810.97

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Next Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	1,576,629	3.50	7.42	Jun 1996	$51,744.00	$51,744.00
2	1,864,934	5.07	8	Jan 2004	$74,954.88	$52,188.56
3	1,979,691	5.14	8	Jan 2012	$75,989.76	$35,810.97

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$83,430.64	$4,568.89	$0.00	$4,568.89
2	$87,999.53			
3	$87,999.53			

[1]The cost is in dollar/12 ft.lane mile
[2]PW is in dollar/12 ft.lane mile

Table 38

Summary of analysis cost stream and comparisons of weight scenarios for LA 35 carrying rice

Commodity:	Rice
Route:	LA 35
Total 1998 Payload Carried Over Road, lb.:	185,000,000
Vehicle Tare Weight, lb.:	28,500
Growth Rate:	0% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Total Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	86,000	57,500	3,217	3.313	10,658
2	100,000	71,500	2,587	6.783	17,548
3	100,000	71,500	2,587	6.783	17,548

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	563,564	3.00	8	Jan 2000	$44,352.00	$44,352.00
2	603,073	4.41	8	Jan 2008	$65,197.44	$44,128.19
3	645,831	3.31	8	Jan 2016	$48,935.04	$22,417.71

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	563,564	3.00	7.35	Jan 2000	$44,352.00	$44,352.00
2	649,565	4.49	8	May 2007	$66,380.16	$46,376.39
3	691,889	3.38	8	May 2015	$49,969.92	$23,629.41

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	563,564	3.00	7.35	Jan 2000	$44,352.00	$44,352.00
2	649,565	4.49	8	May 2007	$66,380.16	$46,376.39
3	691,889	3.38	8	May 2015	$49,969.92	$23,629.41

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$66,545.90	$3,459.90	$0.00	$3,459.90
2	$70,005.80			
3	$70,005.80			

[1]The cost is in dollar/12 ft.lane mile

[2]PW is in dollar/12 ft.lane mile

Table 39

Summary of analysis cost stream and comparisons of weight scenarios for I-49 carrying timber

Commodity:	Timber
Route:	I-49
Total 1998 Payload Carried Over Road, lb.:	396,000,000
Vehicle Tare Weight, lb.:	26,640
Growth Rate:	0% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Total Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	80,000	53,360	7,421	2.367	17,566
2	83,400	56,760	6,977	2.907	20,282
3	100,000	73,360	5,398	6.317	34,099

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	13,290,919	6.00	20	Jun 1987	$88,704.00	$88,704.00
2	9,483,737	6.96	10	Jun 2007	$102,896.64	$38,780.66
3	12,094,294	6.51	10	Jun 2017	$96,243.84	$22,268.65

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	13,290,919	6.00	20	Jun 1987	$88,704.00	$88,704.00
2	9,505,580	6.96	10	Jun 2007	$102,896.64	$38,780.66
3	12,116,138	6.52	10	Jun 2017	$96,391.68	$22,302.86

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	13,290,919	6.00	19.836	Jun 1987	$88,704.00	$88,704.00
2	9,653,182	6.99	10	Apr 2007	$103,340.16	$39,260.71
3	12,263,740	6.54	10	Apr 2017	$96,687.36	$22,551.00

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$61,049.32	$34.21	$728.19	$762.40
2	$61,083.52			
3	$61,811.71			

[1]The cost is in dollar/12 ft.lane mile

[2]PW is in dollar/12 ft.lane mile

Table 40

Summary of analysis cost stream and comparisons of weight scenarios for LA 509 carrying timber

Commodity:	Timber
Route:	LA 509
Total 1998 Payload Carried Over Road, lb.:	1,080,000,000
Vehicle Tare Weight, lb.:	26,640
Growth Rate:	0% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Total Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	86,000	59,360	18,194	3.299	60,022
2	86,600	59,960	18,012	3.404	61,313
3	100,000	73,360	14,722	6.629	97,592

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	1,276,090	4.50	20	Jan 1999	$66,528.00	$66,528.00
2	519,418	3.55	8	Jan 2019	$52,483.20	$19,780.37
3	525,897	2.62	8	Jan 2027	$38,734.08	$9,880.82

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	1,276,090	4.50	19.43	Jan 1999	$66,528.00	$66,528.00
2	534,001	3.58	8	Jun 2018	$52,926.72	$20,510.06
3	540,344	2.65	8	Jun 2026	$39,177.60	$10,275.79

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	1,276,090	4.50	12.75	Jan 1999	$66,528.00	$66,528.00
2	9,653,182	4.02	8	Sept 2011	$59,431.68	$31,904.68
3	12,263,740	3.09	8	Sept 2019	$45,682.56	$16,598.64

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$29,661.18	$1,124.67	$17,717.47	$18,842.14
2	$30,785.85			
3	$48,503.32			

[1]The cost is in dollar/12 ft.lane mile

[2]PW is in dollar/12 ft.lane mile

Table 41
Summary of analysis cost stream and comparisons of weight scenarios for US 84 carrying timber

Commodity:	Timber
Route:	US 84
Total 1998 Payload Carried Over Road, lb.:	550,000,000
Vehicle Tare Weight, lb.:	26,640
Growth Rate:	0% / year

Weight Scenario	GVW, lb	Payload/ Vehicle, lb	No. Of trucks to Carry Total Payload, lbs	ESALs per Truck	No. Of ESALs to Carry Total '98 Payload
1	86,000	59,360	9,265	3.290	30,481
2	86,600	59,960	9,173	4.198	38,508
3	100,000	73,360	7,497	6.126	45,927

Scenario 1

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	744,310	4.50	8	Jun 1998	$66,528.00	$66,528.00
2	786,653	4.58	8	Jun 2006	$67,710.72	$45,829.28
3	832,471	3.75	8	Jun 2014	$55,440.00	$25,397.70

Scenario 2

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	744,310	4.50	7.5	Jun 1998	$66,528.00	$66,528.00
2	843,949	4.67	8	Jan 2006	$69,041.28	$47,883.85
3	889,767	3.83	8	Jan 2014	$56,622.72	$26,580.10

Scenario 3

Performance Period	Traffic Projected	Overlay Thickness, in.	Time to Next Overlay, Years	Date of Overlay	Cost @ Time of Overlay[1]	NPW[2]
1	744,310	4.50	7	Jun 1998	$66,528.00	$66,528.00
2	910,088	4.76	8	Jun 2005	$70,371.84	$50,011.95
3	955,432	3.92	8	Jun 2013	$57,953.28	$27,876.52

Cost Stream

Scenario	ΣNPW	ΔPW_{1-2}	ΔPW_{2-3}	ΔPW_{1-3}
1	$71,226.98	$3,236.97	$3,424.52	$6,661.49
2	$74,463.95			
3	$77,888.47			

[1]The cost is in dollar/12 ft.lane mile
[2]PW is in dollar/12 ft.lane mile

Comparisons among weight scenarios

To simplify the assimilation of the data contained in the cost stream data of tables 31 through 41, a series of summary bar charts have been prepared to compare the costs of implementing the various weight scenarios. Figure 4 shows the difference in net present worth (NPW) between scenarios 1 and 2 for roads carrying sugarcane. This difference represents an increase from scenario 1 to scenario 2. Note that the percentage (PCT) shown is based on the difference in ESALs between scenarios 1 and 2. The NPW cost difference between scenarios 1 and 2 was about $2,900/12 ft lane mile for I-10; $8,600/12 ft lane mile for US 90; and $7,100/12 ft lane mile for LA 308. Bar charts presenting NPW and PCT differences for cotton are given in figure 5. Figure 6 compares scenarios 1 and 2 for rice. Figure 7 shows the difference in NPW and PCT between scenarios 1 and 2 and between scenarios 2 and 3 for timber. These differences represent an increase from scenario 1 to scenario 2 and from scenario 2 to scenario 3. Notice that the increase in cost from scenario1 to scenario 2 ranges from a low of $34/12 ft lane for I-49 hauling timber to $8,600/12 ft lane for US 90 hauling sugarcane. The cost difference between scenarios1 and 2 varies generally from lows on the interstate system to highs on the U.S. and Louisiana system roads.

One should also note that Figures 4 through 7 contain the percent increase in ESALs between the two weight scenarios as a result of the trucks hauling the identified commodity as a percentage of the total ESALs. As can be seen from the figures, as the percentage of ESALs increase for a given road, the NPW of roadway costs increases. An exception for LA 509 hauling timber occurs because only timber trucks use that road and it is designed for those trucks. Consequently, when the load limit is raised from 86,000 lbs GVW to 86,600 lbs GVW (scenario 1 to 2) the increase in weight is marginal, therefore, the effect on cost is marginal. However, when moving from 86,600 lbs GVW to 100,000 lbs GVW (from scenario 2 to 3) the increase in weight is more substantial and the costs reflect this effect. The cost data from figures 4 through 7 are summarized in table 42.

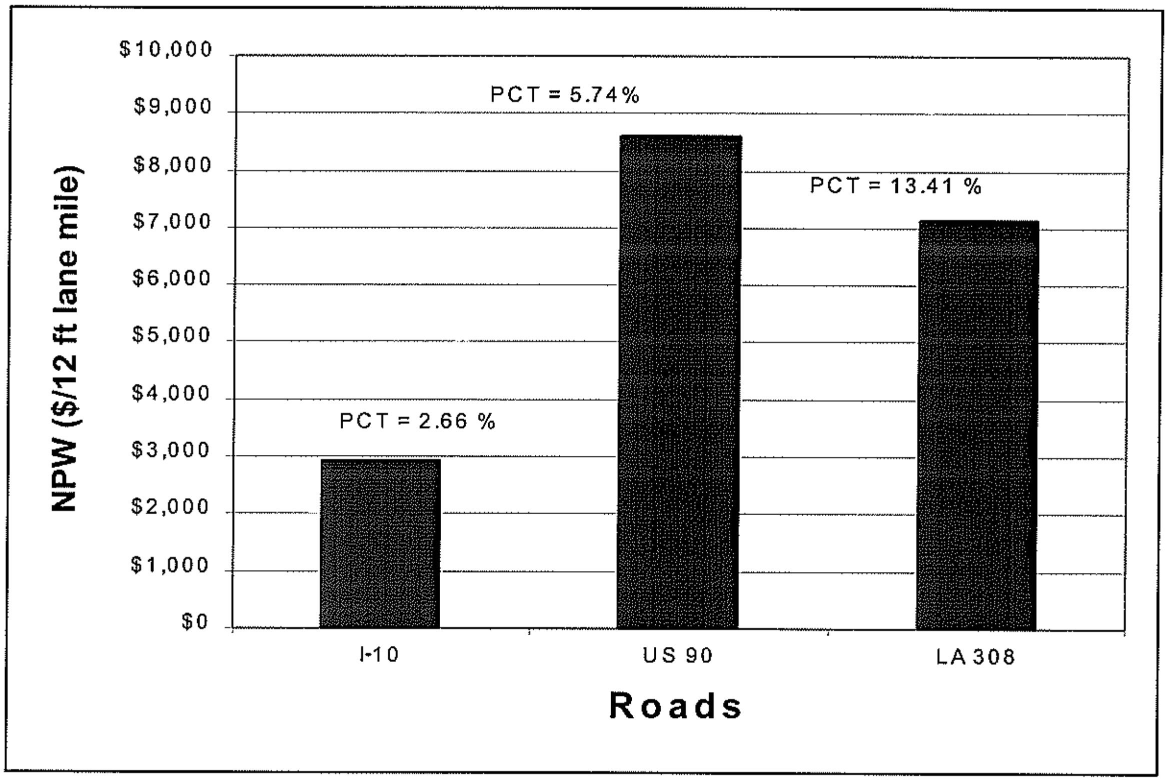

Figure 4
Difference in net present worth (NPW) between scenarios 1 and 2 for roads carrying sugarcane

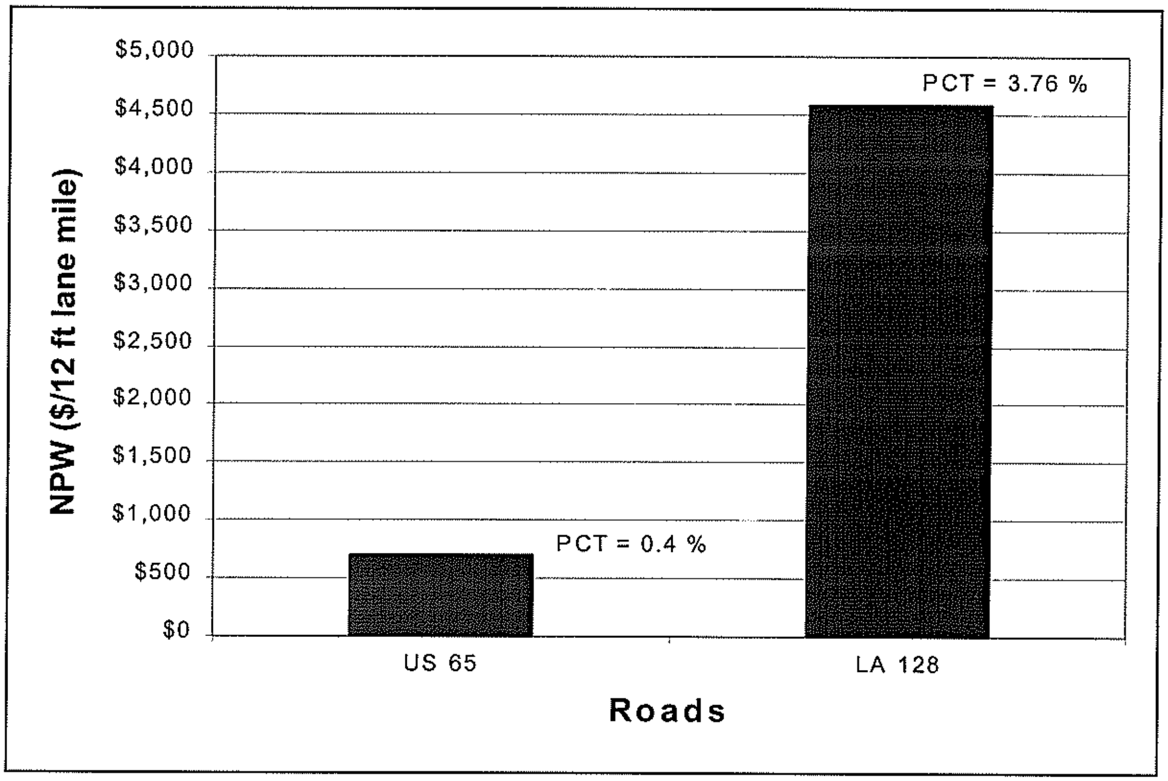

Figure 5

Difference in net present worth (NPW) between scenarios 1 and 2 for roads carrying cotton

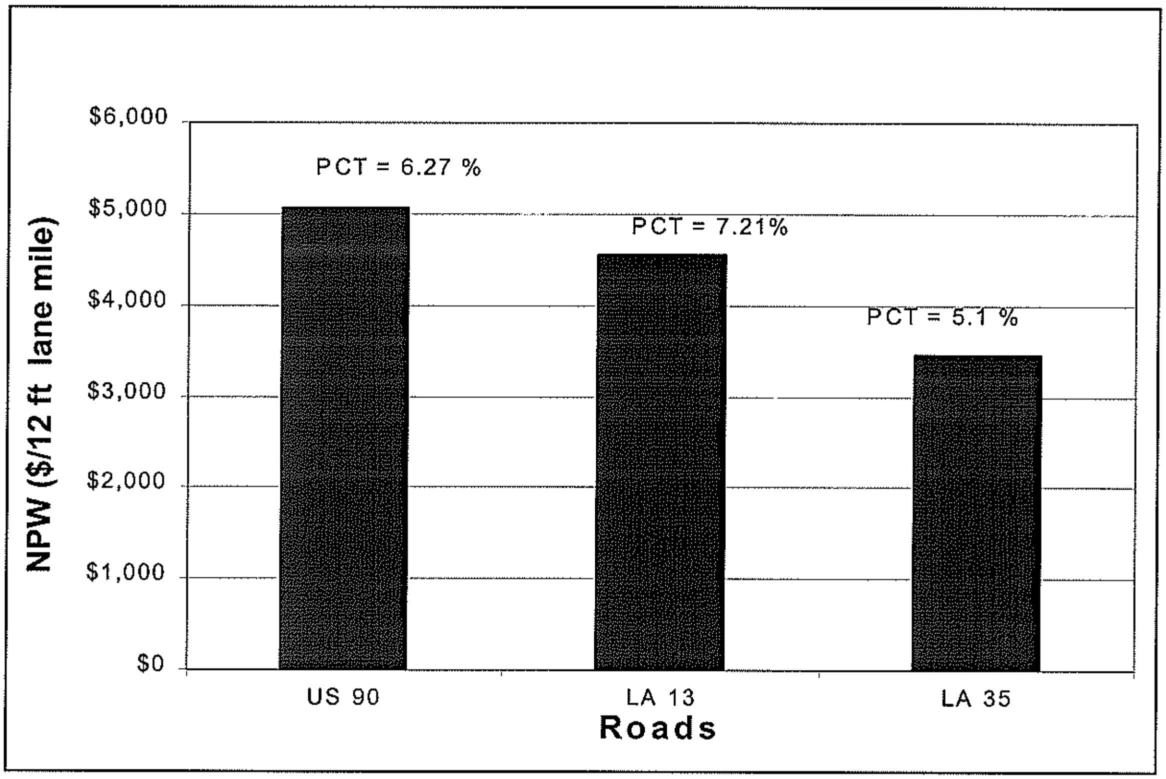

Figure 6
Difference in net present worth (NPW) between scenarios 1 and 2 for roads carrying rice

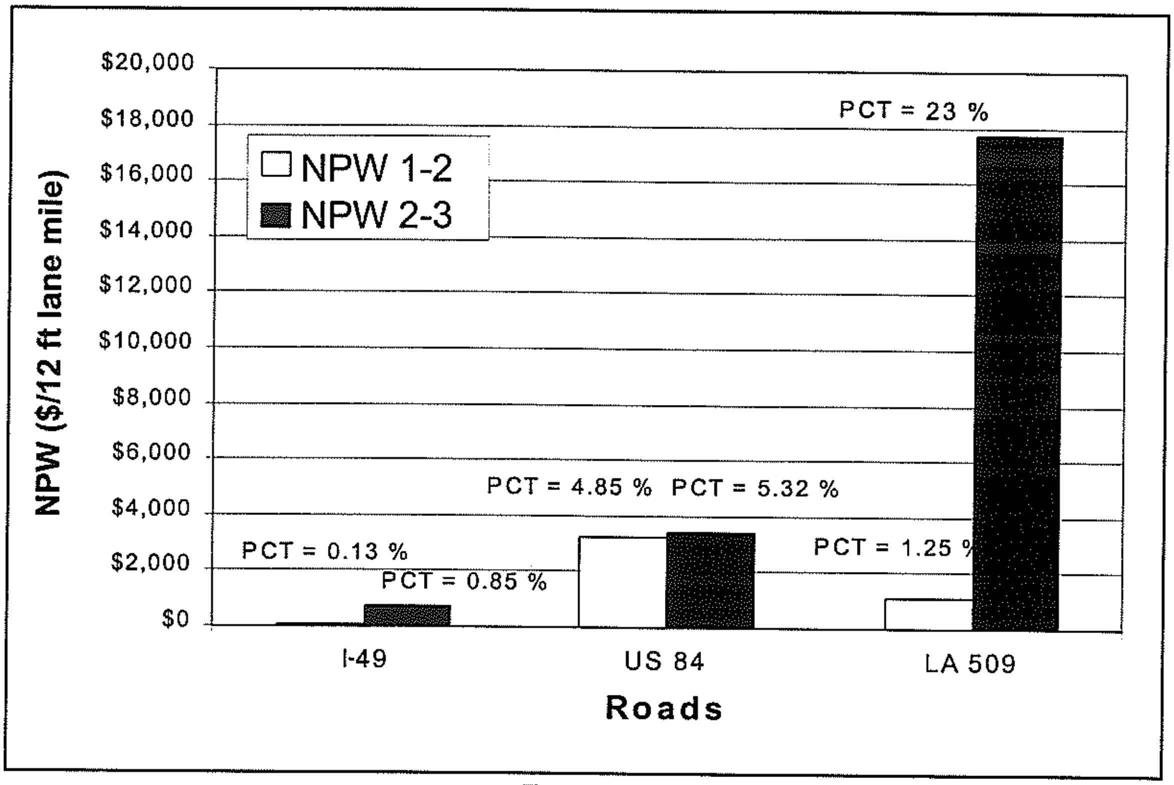

Figure 7
Difference in net present worth (NPW) between scenarios 1 and 2 and scenarios 2 and 3 for roads carrying timber

Table 42

Summary of comparisons of differences in NPW for roads carrying commodities under different weight scenarios

Weight Scenario Comparison	Commodity	Differences in NPW for roads on different systems ($/12 ft lane mile)		
		Interstate	U.S.	State
1-2[1]	Cotton	Not included	$712.30	$4,593.76
	Rice	Not included	$5,076.90	$4,568.89 and $3,459.90
	Timber	$34.21	$3,236.97	$1,124.67
	Sugarcane	$2,934.82	$8,620.78	$7,140.94
2-3[2]	Cotton	Not included	$0.00	$0.00
	Rice	Not included	$0.00	$0.00
	Timber	$728.19	$3,424.52	$17,717.47
	Sugarcane	$0.00	$0.00	$0.00
1-3[3]	Cotton	Not included	$712.30	$4,593.76
	Rice	Not included	$5,076.90	$4,568.89 and $3,459.90
	Timber	$762.40	$6,661.49	$18,842.14
	Sugarcane	$2,934.82	$8,620.78	$7,140.94

[1]From no overweight permits to current overweight permits including sugarcane at 100,000 lbs on Interstate

[2]Timber from 86,400 GVW to 100,000 lbs GVW

[3]From no overweight permits to 100,000 lbs GVW

Notice also in figures 4 through 7 that as the percent ESALs from a commodity increase, the costs increase as well. This trend occurs for all roadways on all systems. Generally, the number of ESALs for design of an interstate roadway is very large. Therefore, a fairly substantial increase in ESALs generated by one commodity at a higher GVW does not cause a very large increase in the percentage ESALs very much and does not generate a very large cost, see figure 4 for sugarcane and figure 7 for timber where the cost increases range from $34.23/12 ft lane mile to $2,934.82/12 ft lane mile for scenario 1 to 2. On the U.S. routes the cost increase generated by higher GVWs are generally higher than for the interstate roads, see figure 5 for cotton and figure 4 for sugarcane where the cost increases range from $712.30/12 ft lane mile to $8,620.28/12 ft lane mile for scenario 1 to 2. On the Louisiana state routes the increase in ESALs varies dramatically and so does the associated NPW cost of moving from scenario 1 to 2. The NPW costs vary from about $1,100/12 ft lane mile on La 509 carrying timber to $7,100/12 ft lane mile on LA 308 carrying sugarcane for moving from scenario 1 to 2.

To estimate the effect of these weight changes on roads in the whole state of Louisiana, one could estimate the number of lane miles of roads with similar traffic to that carried by each of the roads summarized in table 42, multiply the number of lane miles times the cost in table 42 for the weight scenario, and add them together to produce an estimate of the total highway costs produced under these two weight change scenarios. Due to the shortage of time in this contract, such an estimate was not included in this analysis.

It should be noted that the predictions of remaining service life of pavements subjected to heavier GVW was based solely on pavement design models. Engineers who observe pavement performance know that increasing in GVW often is accompanied by rapid changes in pavement distress especially rutting and fatigue cracking in hot mix asphalt (HMA) pavements and HMA overlays on portland cement concrete (PCC) pavements. Consideration of changes in distress development were not included in this study but is an important consideration when attempting to assess the impact of increasing GVW on service provided by roadways in the state of Louisiana.

CONCLUSIONS

The following conclusions can be drawn from this study:

1. Increasing the gross vehicle weight on vehicles transporting commodities on a system of roads that were designed for vehicles operating at a lower GVW decreases the service life of the road in a manner proportional to the ratio of ESALs produced by vehicles under the new GVW divided by the number of ESALs remaining in the design period. The greater the increase in GVW for trucks with the same number of axles, the shorter the remaining service life of the pavements.

2. The larger the total number of ESALs that a road is designed to carry, the less the effect of increasing the GVW on vehicles carrying a single commodity. One ramification of this conclusion is that the effects of increasing GVW on the interstate for a single commodity should be lower than would be the effect on either US or Louisiana highways. Data tabulated in table 42 bear out this conclusion. It should be noted that this conclusion also holds true for an increase in GVW for all commodities but the magnitude of the reduction in service life and increase in costs would be substantially higher.

3. The cost to road users of increasing the gross vehicle weight on vehicles carrying a few select commodities is substantial. The cost increases shown in table 42 are due solely to increases in GVW, not to the transport of more tons of a commodity. As a result, the responsibility for the increase in rehabilitation costs are directly attributable to the operation of the vehicles carrying the heavier loads. The total magnitude of these costs for the whole state of Louisiana have not been estimated.

4. The costs developed in this report are developed only from design parameters, i.e., no distress factors have been included such as rutting or cracking induced by heavier GVWs. It is possible and, indeed, probable that the performance periods based on design considerations would be shortened substantially and the costs of rehabilitation increased substantially if the pavement layers are overstressed by these heavier axle loads so that premature rutting or cracking occurs.

RECOMMENDATIONS

Based on the results from this study and the highway pavement costs which will have to be paid by the DOTD as a consequence of allowing permitted overweight vehicles on Louisiana highways, it is recommended that the Louisiana legislature consider doing one of the following:

1. Roll back all gross vehicle weights to the legal limit and issue overweight permits only on an individual trip basis,

2. Continue to issue harvest permits but increase the registration and permit fees enough to pay for all the projected roadway damage induced by these overweight vehicles. One alternative to increasing the registration and permit fees is to institute a ton-mile tax to pay for the roadway damage, or

3. Continue to issue harvest permits at the current fee levels but require that all vehicles add enough tires and axles to reduce the damage to the pavement structure to that produced by vehicles loaded to the legal load limits.

The Louisiana DOTD should monitor the performance of a selected group of roadways being subjected to these heavier GVWs in order to determine whether the distress developed is more severe that the pavement design models estimate. The DOTD should also consider developing performance models to predict rutting and fatigue cracking for roads being subjected to these heavier permitted loads.

LIST OF ACRONYMS/ABBREVIATIONS/SYMBOLS

TEA 21	1998 Transportation Equity Act
HCAS	Highway Cost Allocation Study
NCHRP	National Cooperative Highway Research Program
STAA	Surface Transportation Assistance Act
TS&W	Truck Size and Weight
DOT	Department of Transportation
3R	Reconstruction, Resurfacing, and Rehabilitation
HCA	Highway Cost Allocation
ESAL	Equivalent Single Axle Load
VMT	Vehicle Miles of Travel
HTF	Highway Trust Fund
HVUT	Heavy Vehicle Use Tax
GVW	Gross Vehicle Weight
DOTD	Department of Transportation and Development of Louisiana
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
LEF	Load Equivalency Factor
HPMS	Highway Performance Monitoring System

M&R	Maintenance and Rehabilitation
VOC	Vehicle Operating Costs
PSI	Pavement Serviceability Index
AADT	Annual Average Daily Traffic
HUR	Highway User Revenue
CNG	Compressed Natural Gas
AUTO	Automobiles and Motorcycles
LT4	Light Trucks with 2-Axles and 4 Tires (Pickup Trucks, Vans, Minivans, etc.)
SU2	Single Unit, 2-Axle, 6 Tire Trucks (Includes SU2 Pulling a Utility Trailer)
SU3	Single Unit, 3-Axle Trucks (Includes SU3 Pulling a Utility Trailer)
SU4+	Single Unit Trucks with 4- or More Axles (Includes SU4+ Pulling a Utility Trailer)
CS3	Tractor-Semitrailer Combinations with 3-Axle
CS4	Tractor-Semitrailer Combinations with 4-Axle
CS5T	Tractor-Semitrailer Combinations with 5-Axles, Two Rear Tandem Axles
CS5S	Tractor-Semitrailer Combinations with 5-Axles, Two Split (>8 feet) Rear Axles
CS6	Tractor-Semitrailer Combinations with 6-Axles

CS7+	Tractor-Semitrailer Combinations with 7- or more Axles
CT34	Truck-Trailers Combinations with 3- or 4-Axles
CT5	Truck-Trailers Combinations with 5-Axles
CT6+	Truck-Trailers Combinations with 6- or more Axles
DS5	Tractor-Double Semitrailer Combinations with 5-Axles
DS6	Tractor-Double Semitrailer Combinations with 6-Axles
DS7	Tractor-Double Semitrailer Combinations with 7-Axles
DS8+	Tractor-Double Semitrailer Combinations with 8- or more Axles
TRPL	Tractor-Triple Semitrailer or Truck-Double Semitrailer Combinations
BUS	Buses (all types)
LTRC	Louisiana Transportation Research Center

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