

Wisconsin State Highway System: Needs and Resources 2011-2020

Final Report
May 13, 2011

Prepared for the
Wisconsin Policy Research Institute
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Executive Summary

Wisconsin has about 114,800 miles of roads, of which about 11,800 constitute the State Highway System. This study assesses the condition and 10-year needs of Wisconsin's State Highway System. It estimates the costs of addressing deficiencies, adding new or expanded facilities, bringing the system up to prudent standards, and maintenance and administration. The report then estimates the resources likely to be available from federal, state and local governments, and the likely gap between resources and needs. It does not cover the needs of localities (counties, towns, municipalities) or needs of other modes, which also have substantial needs that may exceed their resources.

Wisconsin's recent population growth has been slower than the national average, but the state is expected to grow modestly, about 5%, over the next decade. Vehicle registrations and motor vehicle travel are expected to grow at similar but slowing rates. However, given the likely increases in fuel efficiency, motor fuel use is likely to fall, reducing state motor fuel taxes.

Wisconsin's State Highway System is similar in overall condition to the US average, but the higher road classes (Interstates, urban freeways and other principal arterials) are in better shape than minor arterials and collectors. Progress has been made in improving the system, and many elements are in better shape than in the past. However, significant portions of the system are in need of repair, replacement, expansion or modernization. About 57% of pavements are judged to potentially require treatment, 52% of bridges need repair, 333 miles need congestion-related widening, and 809 miles of new roads and expansions have also been identified.

The total estimated prudent need for the Wisconsin State Highway System over ten years is about \$28.56 B. This estimate would address most but not all of the repair needs and allow for some system expansion. Highway rehabilitation needs are estimated at about \$9.25 B, of which pavement repair, \$8.18 B is the largest part. The need for capacity-related widening and new roads totals about \$13.93 B. Maintenance and other improvements total about \$3.57 B, and administration totals about \$1.81 B. If the proposed widening of I 43 and I 94 in Milwaukee were subtracted, prudent needs would total about \$28.15 B.

Fiscal resources likely to be available over the same period are estimated at about \$18.63 B. This includes about \$5.82 B in federal funds, \$11.58 B in state funds and services, \$43 M in local contributions, and \$1.19 B in bonding. These estimates are summarized in the following table.

Table ES 1: Summary of Resources and Needs, Wisconsin State Highway System, 2011-2020

Resources, \$M, 2011-20		Needs, \$M, 2011-20	
		Highway Rehabilitation	\$9,249
Federal Funds	\$5,816	<i>Pavement Repair</i>	<i>\$8,175</i>
State Funds and Services	\$11,582	<i>Bridge Repair</i>	<i>\$678</i>
Local Funds	\$43	<i>Narrow Lanes</i>	<i>\$362</i>
Bonding/Debt Service	\$1,189	<i>Narrow Shoulders</i>	<i>\$34</i>
		Capacity and Expansion	\$13,931
		<i>New Roads and Expansions</i>	<i>\$7,776</i>
		<i>Capacity-related Widening</i>	<i>\$6,154*</i>

Resources, \$M, 2011-20		Needs, \$M, 2011-20	
		Maintenance and Other	\$3,570
		<i>Physical Maintenance/Ops</i>	<i>\$1,574</i>
		<i>Roadside Maintenance</i>	<i>\$685</i>
		<i>Winter Operations</i>	<i>\$662</i>
		<i>Signals and Lighting</i>	<i>\$335</i>
		<i>Other Needs</i>	<i>\$314</i>
		Administration	\$1,811
Total	\$18,630	Total	\$28,560*
		<i>*Total less I 43 Mitchell-Silver Spring and I 94 Marquette-Zoo, Milwaukee</i>	<i>\$28,147*</i>
Gap \$9,930		Gap/year \$993 M	
<i>Gap* \$9,517</i>		<i>Gap*/year \$952 M</i>	

The estimated gap between likely resources and prudent needs is about \$9.93 B, or about \$993 M/year on average. (If I 43 and I 94 in Milwaukee were not widened, the gap between resources and revenues would be about \$952/year). Further, the analysis shows an increasing shortfall compared to earlier studies – i.e., a \$242 M per year gap estimated in 2000 and a \$589 M per year gap estimated in 2006. However, if fuel-related resources decline sharply this gap could be even greater. But even if all major new projects were deferred, or if all capacity-related widening were deferred, a gap of between \$2.1 B and \$3.8 B would still remain in meeting the needs for prudent pavement and bridge repairs, maintenance, signals, shoulders and other actions. In short, Wisconsin’s 10-year likely resources for the State Highway System appear to cover only about 65% of its 10-year prudent needs. Since the magnitude of the shortfall appears to be growing, serious attention by elected and appointed officials to this issue is timely.

The increasing trend in the magnitude of the shortfall should be cause for concern, and obviously a gap of this magnitude will be difficult to close. This report briefly discusses general options for bringing needs into line with resources. This report does not assess various specific mechanisms for addressing this issue, but by highlighting the magnitude of the problem it hopes to focus discussion on it.

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I. Introduction

A. Issues

The Wisconsin State Highway System, about 11,800 miles in length, is the state's primary transportation system for providing Wisconsin residents, businesses and visitors with access and mobility. The system is a key element in the state's economic progress and must be maintained adequately and expanded prudently. The Wisconsin Department of Transportation (WisDOT) has taken the lead in planning and implementing needed improvements. The 1994 TransLinks21 study documented the state's growth and the need for sound planning and needs estimation tied to traffic forecasts¹. In 2000 the 2020 State Highway Plan estimated 21-year needs for the system to be \$21.4 B, against projected revenues of \$15.3 B, for a projected gap of \$5.1 B or about \$242 M annually². A 2003 study³ estimated the cost of repairing and expanding the southeastern Wisconsin freeway system at about \$6.2 B in 2000 dollars, which would undoubtedly be higher today. In 2006 a review of system needs by the Wisconsin Legislature⁴ estimated an annual highway need of \$1,771.2 M versus annual revenues of \$ 1,182.3 M, for an annual gap of \$589 M. However since 2006 significant economic and technological changes have altered both needs and revenues. Although the system is in generally moderate shape compared with other states, maintenance and repair needs are increasing, congestion and safety remain issues, and revenue sources are flattening.

Table 1 shows comparative state highway system statistics for Wisconsin and neighboring states⁵. The system is slightly smaller than the average state, as is the budget. Wisconsin spends about the same, per mile of responsibility, as the US average. The state has considerably less funds to work with per mile of responsibility than either Michigan or Illinois but more than Minnesota or Iowa. And the state spends considerably less than its neighbors on road maintenance. The state's percentage of poor mileage is relatively high compared to the US averages, but is similar to that of surrounding states. Overall Wisconsin is rated 28th nationwide for system cost-effectiveness, better than its neighbors except Minnesota (25th).

Table 1: Highway Performance for Wisconsin and Nearby States

Item	Statistic (Rank), 2008					
	Wisconsin	Michigan	Minnesota	Iowa	Illinois	US Avg.
Miles Under State Control*	11,839(22)	9,688 (30)	12,905(19)	9,444 (31)	16,747(13)	16,312
Disbursements for State-Admin Roads, \$B	\$1.802(30)	\$2.218 (35)	\$1.669 (29)	\$0.878 (15)	\$5.538 (45)	\$2.378
Capital/Bridge Disbursements per mile	\$95,479 (35)	\$134,657 (37)	\$73,249 (25)	\$55,713 (18)	\$177,347 (45)	\$77,130
Maintenance Disbursements per mile	\$19,196 (21)	\$31,145 (37)	\$31,434 (38)	\$19,663 (23)	\$44,360 (41)	\$22,937
Rural Interstate Percent Poor, rank	44th	42 nd	45 th	38 th	1 st (tie)	1.93 %
Urban Interstate Percent Poor, rank	41st	38 th	5 th	43 rd	35 th	5.37%
Rural OPA Percent Poor, rank	23rd	14 th	13 th	46 th	40 th	0.53%
Bridges, Percent Deficient, rank	6th	28 th	3 rd	34 th	9 th	23.7 %
Urban Interstate Percent Congested**, rank	27th	47 th	49 th	19 th	25 th	48.6 %
Fatal Accident Rate, rank	14th	8 th	2 nd	28 th	9 th	1.25
Rural Princ. Arts Pct Narrow Lanes, rank	12th	37 th	27 th	17 th	36 th	9.6 %
Overall Cost-Effectiveness, rank	28th	35 th	25 th	31 st	40 th	--

Data source: FHWA, Highway Statistics, various tables, 2008

* State owned roads include the state highway system and other small systems (parks, etc)

** In this table, Wisconsin Urban Interstate congestion data is for 2006.

Given the accumulating evidence that the significant portions of the State Highway System are in need of repair or upgrade, attention to the road system is prudent. The Wisconsin Policy

Research Institute has recognized these issues and has commissioned an updated assessment of highway needs⁶ that can help the state set its transportation priorities.

The purpose of this report is to develop an overall assessment of the condition and major deficiencies in the Wisconsin State Highway System, and to estimate the cost to bring most deficiencies up to prudent standards over the next 10 years, through 2020. The report also looks at the resources likely to be available to accomplish this task. The ultimate goal of the analysis is assist decision makers in setting priorities for work and identifying options for financing system maintenance and improvements.

The report does not look at *local* road needs which may an equally important issue since the local road system is more extensive and likely in worse shape than the state system. Nor does it review needs for other modes including transit, pedestrian, bicycle, or other non-highway issues. These are important additional considerations that affect state highway funding, but they are beyond the study scope.

B. Method

The study uses state and federal highway and bridge data to estimate elements with various major deficiencies (pavement, bridge, congestion, safety, shoulders, lane width, signals, etc) and the cost to meet them. Costs of work were also obtained from current construction cost estimates, primarily the Wisconsin 4-year STIP⁷, and from other WisDOT information. Other needs (e.g. road maintenance, winter maintenance, signs and signals, rural road widenings and new corridors, and administration) are also reviewed. Revenue trends are used to make forecasts of revenue from various sources, adding possible federal actions. Comparing needs and revenues, estimates of the ‘gap’ are then made. The study does not review specific alternative revenue sources, and given limited resources for this analysis no section-based forecasts of need are made. However we do prepare summaries by region of the state and by county where the data permits. A summary of road statistics by county is provided in the appendix.

The analysis uses the most recently available information on road conditions, along with current estimates of unit cost and recommended work, to estimate total costs to repair and improve the system. The source of most of this information is data from the Wisconsin Department of Transportation and the long-range plans of the state’s urbanized areas. The Appendix to this report provides additional notes on the methods used and several supporting tables. More detailed information is available from the authors on request.

This analysis is not intended as a comprehensive section-by-section assessment of Wisconsin highway needs. Instead, it should be viewed as a high-level assessment, based on simplified methods intended to provide an overview of the prudent needs of the State Highway System and likely resources over the next decade. More detailed assessments of the system and individual projects are regularly performed to sharpen the cost and resource estimates.

II. Findings

A. State Demographic and Traffic Trends

Between 2000 and 2008 Wisconsin’s population grew modestly at 4.9%, about ½ the US rate. During that same time, licensed drivers increased about 8%, vehicle registrations increased about 14 %, and fuel use increased about 3%. But travel actually increased only 0.3%, perhaps reflecting a decline during the recession⁸. Forecasts of continued modest population growth put the 2020 estimated population at about 5.94 Million, about 11% above 2000. Given the increasing saturation of drivers’ licenses and travel, we forecast these statistics to move in parallel with population.

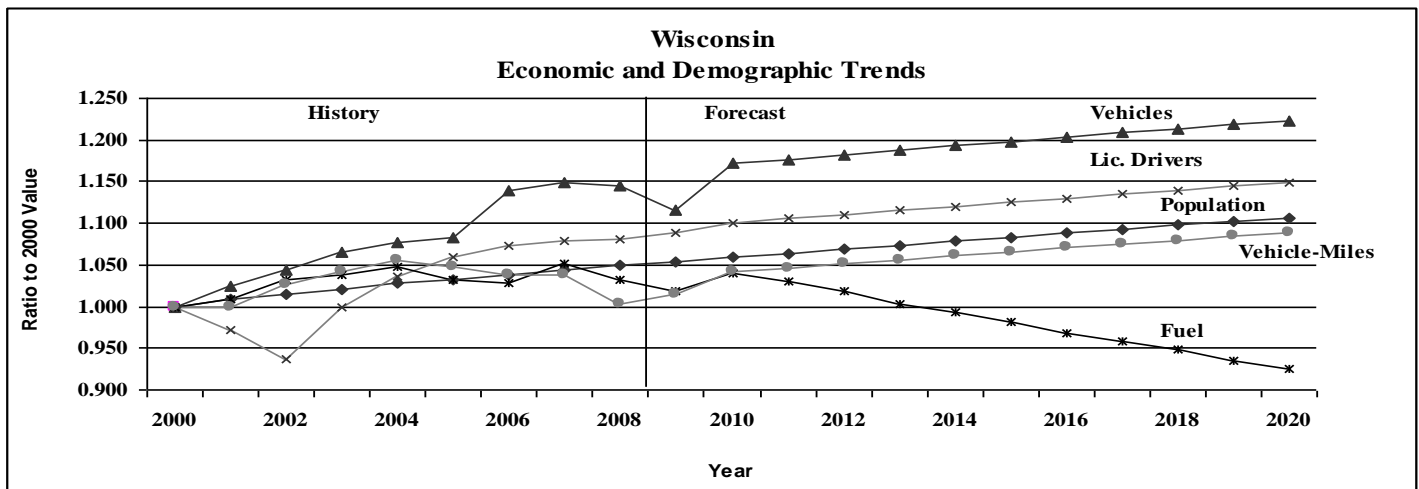
Table 2: Demographic and Travel Related Statistics for Wisconsin.

	Historical					Forecast						Percent Change		
	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020	2000-08	2008-20	2000-20
Population (M)	5.36	5.45	5.51	5.57	5.63	5.68	5.73	5.79	5.84	5.89	5.94	4.92	5.48	10.67
Employment (M)	2.85	2.84	2.81	2.87	2.88	2.72	2.81	2.88	2.94	3.00	3.07	0.84	6.59	7.49
Gross State Prod (\$B)	177.6	190.2	209.3	229.1	241.2							35.77		
Vehicle Registr (M)	4.37	4.56	4.71	4.97	5.00	5.11	5.16	5.21	5.25	5.30	5.34	14.51	6.87	22.37
Licensed Drivers (M)	3.77	3.53	3.91	4.05	4.08	4.15	4.19	4.22	4.26	4.30	4.33	8.10	6.31	14.92
Fuel Use (B gallons)	3.06	3.16	3.21	3.15	3.16	3.18	3.12	3.04	2.96	2.90	2.83	3.18	-10.31	-7.45
Vehicle-miles (B)	57.27	58.75	60.40	59.40	57.46	59.65	60.21	60.76	61.30	61.82	62.33	0.34	8.47	8.83

Source: Federal Highway Administration, Highway Statistics, 2000-08, and US Census 2010. Data submitted by the states. Forecasts by the Hartgen Group.

However recent federal legislation calling for more fuel efficient cars and trucks is likely to more than offset slowly rising travel, so fuel consumption is projected to decline by 2020, to about 8% less than in 2000. This means that fuel-based state revenues such as per-gallon gasoline and diesel tax revenues are also likely to decline, perhaps by as much as 8% from 2000 to 2020.

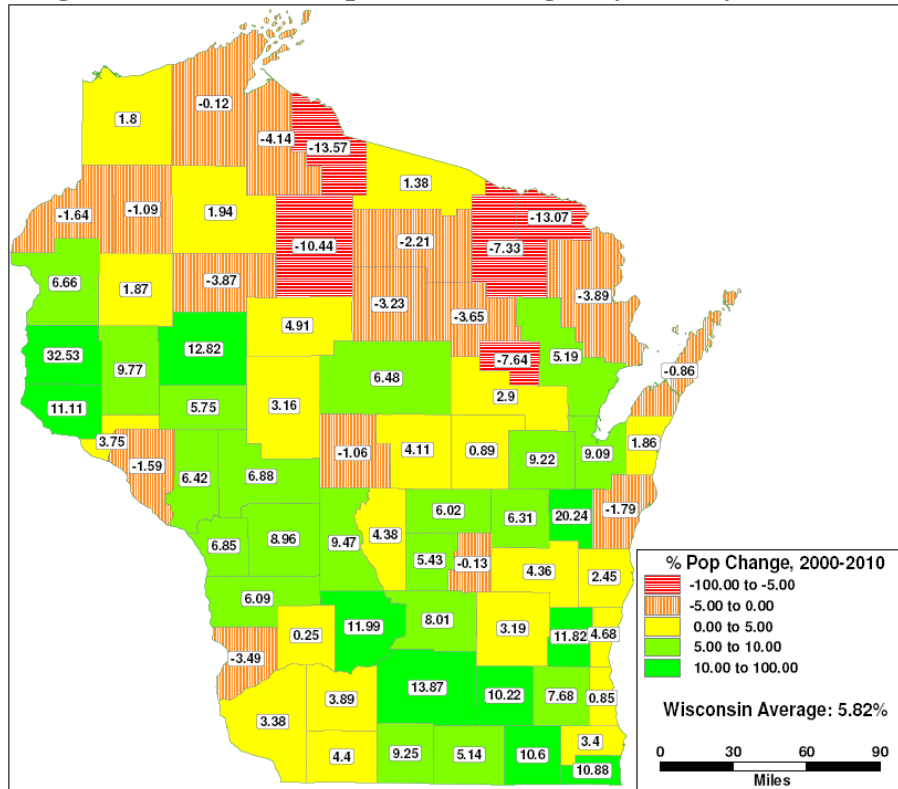
Figure 1: Economic and Demographic Trends, 2000-2020.



Population changes have not been uniform throughout the state. Typically urbanized areas have grown more rapidly while rural area populations have exhibited slower growth. Figure 2 shows generally faster growth rates in the metropolitan counties and their nearby

suburbs. Counties near to other major metropolitan areas (Chicago and Minneapolis) also exhibit stronger growth. The most rapidly growing counties are St Croix, Dane, Kenosha and Washington. Growth has been considerably slower in rural areas, with a number of counties showing declining populations and a few counties in northern Wisconsin declining by more than 5%.

Figure 2: Wisconsin Population Changes By County, 2000-2010



Source: US Census.

Table 3: Wisconsin Urbanized Area Traffic⁹ Growth, 2000-2008

Urbanized Area	Daily Vehicle-Miles of Travel (K)*		
	2000	2008	% Change
Milwaukee	31888	32353	1
Madison	6029	8093	34
Green Bay	4509	5113	13
Appleton	3916	4951	26
Duluth-Superior	2703	2907	8
Eau Claire	2136	2699	26
La Crosse	1875	2582	38
Racine	1763	1804	2
Kenosha	1735	2156	24
Wausau	1511	1947	29
Oshkosh	1149	1537	34
Sheboygan	1006	1091	8
Totals	60220	67233	12

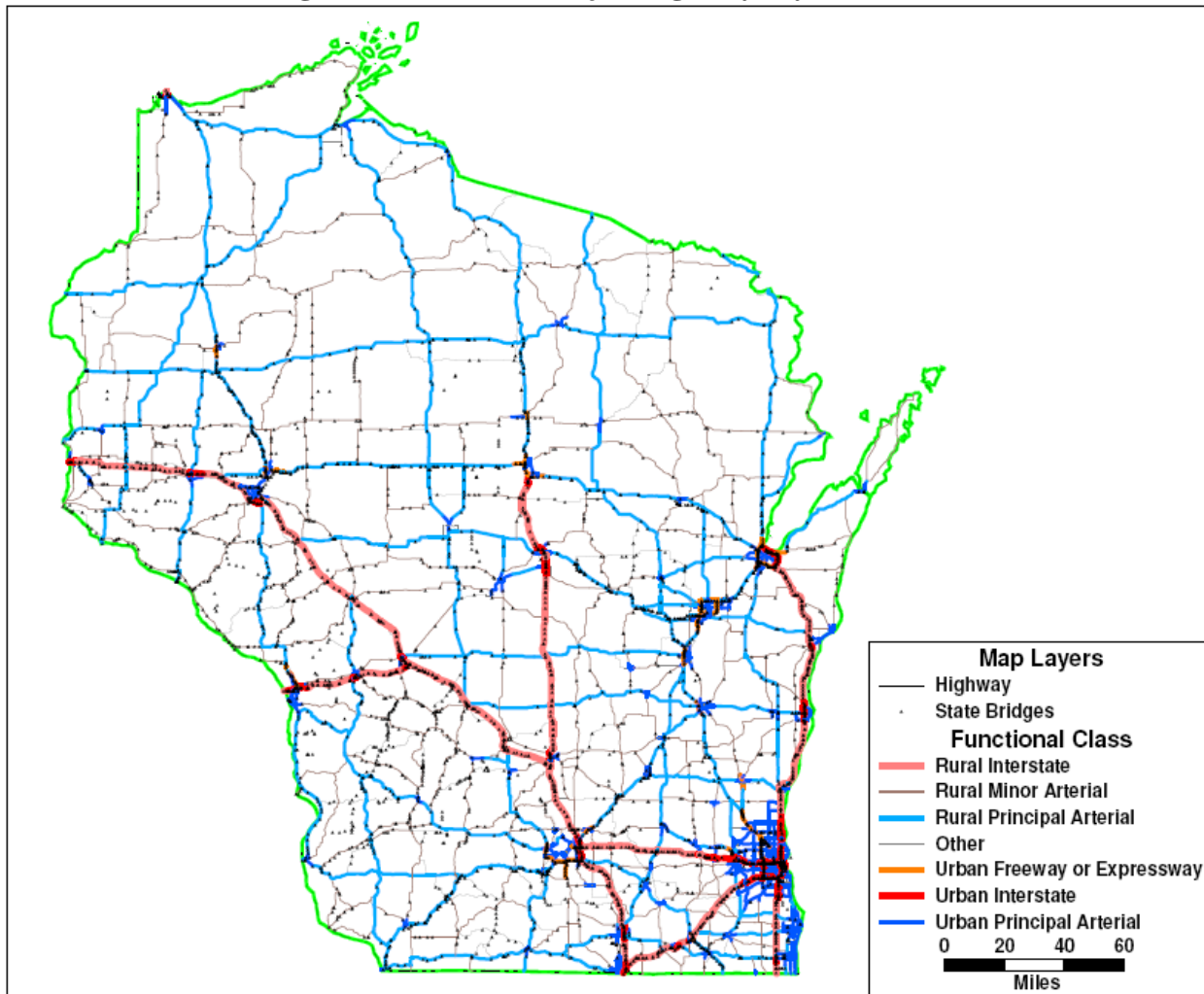
*Source: Federal Highway Administration, Highway Statistics, 2000 and 2008.

Comparing the metropolitan areas of the state, Table 3 shows that even within some slower-growing counties, metropolitan regions have exhibited more rapid growth but have also grown at varying rates. Milwaukee, the largest, has also shown the slowest growth. But several smaller regions (Madison, La Crosse and Oshkosh) have shown growth rates of over 30% between 2000 and 2008. These trends include expanding urbanized area borders, but they nevertheless indicate the shifting locations of population growth between the metropolitan counties.

B. Condition and Needs

Wisconsin has about 114,843 centerline miles of road, of which the Wisconsin State Highway System consists of about 11,770 centerline miles (14,412 ‘roadway’ miles¹⁰). Table 4 summarizes the state’s road mileage and the State Highway System. Although the Interstate System consists of only 743 centerline miles, it carries nearly half of the SHA system traffic, and about 18% of all state traffic¹¹.

Figure 3: Wisconsin Major Highways by Functional Class



Source: TransCAD Highway File and 2009 National Bridge Inventory.

Table 4: Wisconsin State Highway Agency Mileage

	Mileage by Jurisdiction	Centerline Miles	Percent
	State Highway Agency	11,770	10.24
	County	20,716	18.04
	Municipality	81,449	70.92
	Federal and other	908	0.80
	Total	114,843	100.00
State Highway Agency Mileage by Functional Class			
Urban or Rural	Functional Class	Centerline Miles	Percent
Rural	Rural Interstate	478	4.06
	Rural OPA	3,166	26.89
	Rural Minor Arterial	4,667	39.64
	Rural Major Collector	1,397	11.87
	Rural Minor Collector	15	0.13
	Rural Local	8	0.07
	TOTAL Rural	9,731	82.67
Urban	Urban Interstate	265	2.25
	Urban OFE	291	2.47
	Urban OPA	1,301	11.05
	Urban Minor Arterial	179	1.52
	Urban Collector	5	0.04
	Urban Local	-	0.00
	TOTAL Urban	2,041	17.33
Grand Total		11,772	100.00

Source: Federal Highway Administration, Highway Statistics, Table HM10 and HM1, 2008

1. Pavement Repairs

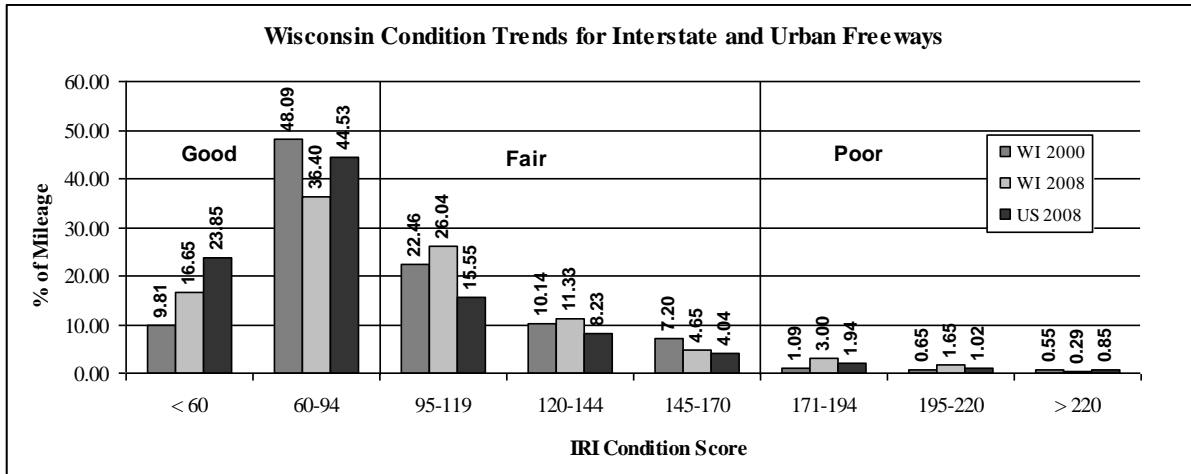
Road needs are determined by assessing the condition of each section of the state road system, then applying various repair actions at varying costs. This section reviews the needs for pavement repair and rehabilitation needs for the State Highway System, which is the 11,772 miles in the table above; needs for road expansions (widening) and for pavement maintenance are discussed in other sections. In this report we do not review the needs for local-jurisdiction roads.

Most states use a combination of methods to rate road condition. For the higher road classes (Interstates, expressways, and principal arterials) most states use the International Roughness Index (IRI), a measure of road surface “bumpiness” (vertical deviation) per unit length of road¹². The data is collected by special vehicles equipped with mechanical or electronic roughness meters. On this index, Interstates with more than 170 inches of roughness per mile are considered to be in “poor” condition¹³. The states also use other indices for rating distress and specifying repair needs. Wisconsin uses both the IRI method and a distress rating based on a 100-point scale. Although Wisconsin’s distress ratings are similar but not identical to that used by other states, the IRI method is generally used for the higher road systems by most states. Therefore comparisons of IRI condition data between the states are generally appropriate.

Using the national IRI data, the following three figures compare the condition of Wisconsin’s roads to the US averages, for 2000 and 2008, the latest year available. For the Interstates and urban freeways (Figure 4), the Wisconsin system is in better shape, on average,

than the US, and has been improving since 2000. Wisconsin’s percentage of mileage in good condition has been increasing and its percentage of mileage in poor condition decreasing since 2000. However, the percentage in fair condition is higher than that of the US, suggesting increasing pavement repair needs in the future.

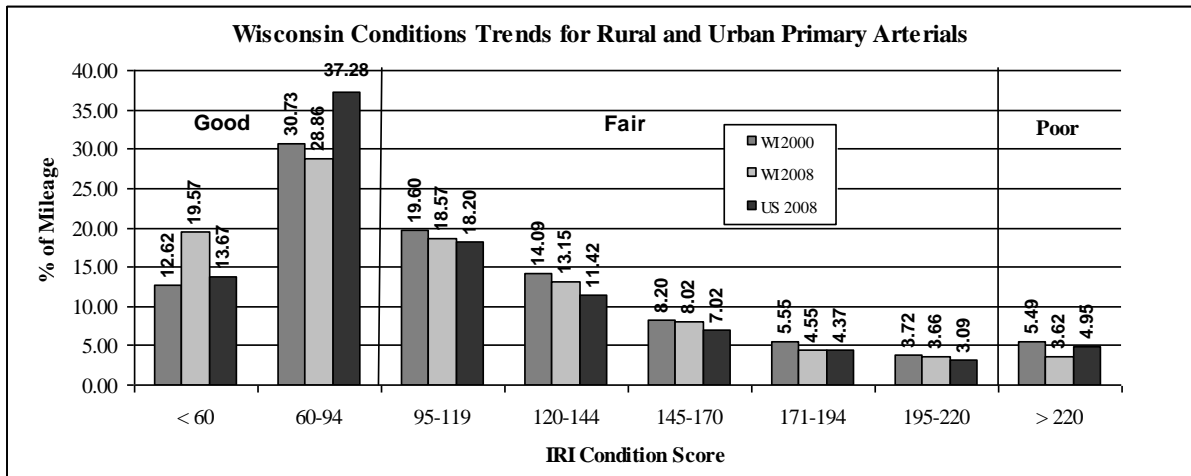
Figure 4: Wisconsin Road Condition Trends, Interstates and Urban Freeways



Source: Federal Highway Administration, Highway Statistics

For primary arterials, the data tell a similar story. For these roads (Figure 5) Wisconsin’s percentage of mileage in good condition has been improving and is higher than that of the US, and its percentage of roads in fair and poor condition is similar to that of the US average.

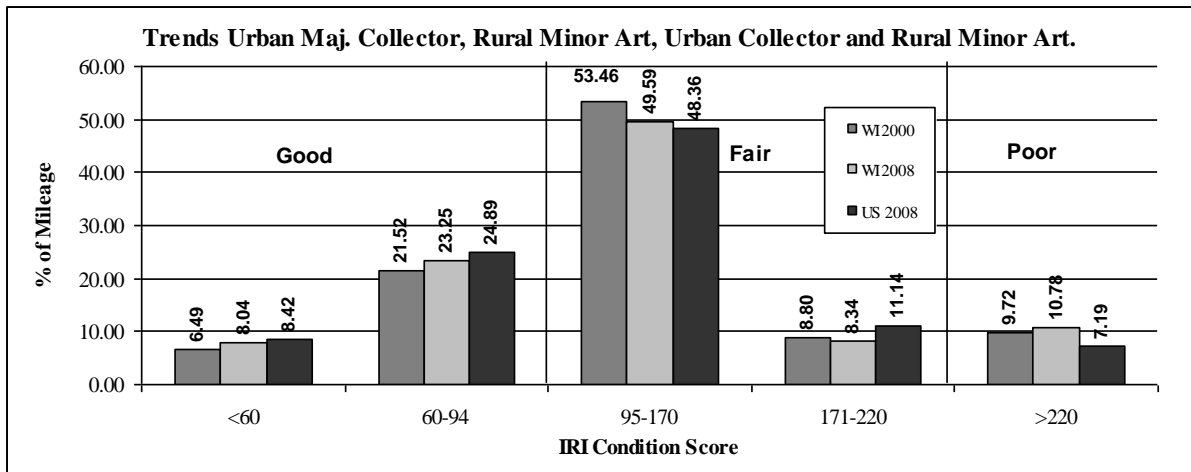
Figure 5: Wisconsin Road Condition Trends for Primary Arterials



Source: Federal Highway Administration, Highway Statistics

For lower-class roads, however, Wisconsin’s situation is not as positive. Although the state has been improving the condition of these roads, the improvement is not as dramatic as with the higher systems. Wisconsin’s lower-class roads are similar in condition to that of the US averages, and these roads are not in as good shape as higher-class roads (Figure 6).

Figure 6: Wisconsin Road Condition Trends: Collectors and Minor Arterials

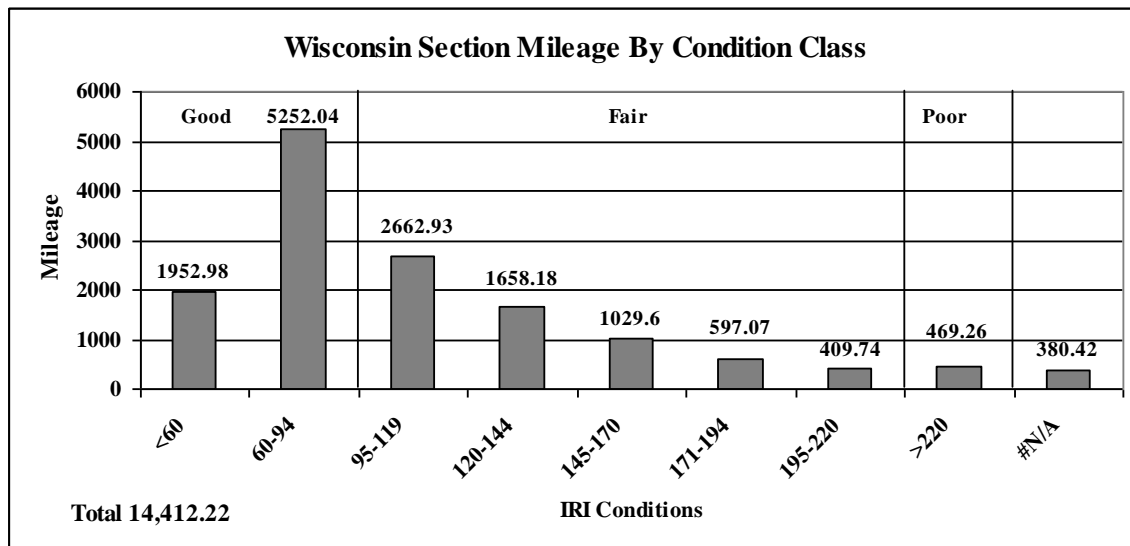


Source: Federal Highway Administration, Highway Statistics

Taken together, these graphics suggest that the state has made considerable progress in improving the condition of its major road systems but less progress in repairing the lower classes of roads. The current and planned extensive repair and freeway-arterial reconstruction work on the Milwaukee, Green Bay and Oshkosh-Appleton systems might widen this difference since it focuses largely on the higher road classes, and also includes expansions and new configurations for capacity.

More recent (2010) data for road condition, from the state’s Roadway Inventory File, is shown in Figure 7. According to this data, about 50% of the system is in good condition, and another 44% is in fair condition¹⁴.

Figure 7: Wisconsin State Highway System: Roadway Miles by Condition, 2010



Source: WisDOT, Road Inventory File for 2010, February 2011.

Wisconsin’s Roadway Inventory File contains both ratings of condition and potentially required pavement treatment¹⁵ for the next work to be performed, a significant advantage in planning road needs. Table 5 summarizes the mileage of each of 18 potentially required

pavement treatments, depending on pavement type, condition, traffic, pavement age and other factors. These work types are essentially an estimate of mileage needs for various pavement sections. **About 8,208 roadway miles out of 14,412 total roadway miles are judged to require some form of treatment.**

Table 5: Roadway Miles by Potentially Required Pavement Treatment

Work Effort Level	Potentially Required Pavement Treatment	2 Lanes ADT< 5K	2 Lanes ADT> 5K	4 Lanes ADT< 25k	4 Lanes ADT> 25k	6+ Lanes, Other	6+ Lane Expwy, Milw. Co	Grand Total Roadway Miles	Total Roadway Lane-Miles
	N/A	143.2	119.9	299.6	40.0	17.1	13.9	633.6	1176.0
1.1	Do Nothing	2810.9	933.8	1440.1	272.3	97.9	15.9	5570.9	11329.0
1.2	Crack Fill	865.1	253.6	122.1	76.1	5.3	5.1	1327.4	2678.9
1.3	Rut Fill	5.0	1.1					6.0	12.1
1.4	Seal Coat	230.9	42.8	4.3		2.1		280.1	564.4
1.5	Spot Repair (bituminous)	167.8	21.1	12.4		1.8		203.1	416.0
2.1	Surface Mill	1.7	3.5	0.5				5.7	11.1
2.2	Thin Overlay	1897.8	621.7	445.6	374.2	101.0	54.8	3495.0	7229.5
2.3	Thin Overlay over PCC	9.0	8.5	30.3	24.5	6.6		78.9	174.2
2.4	Thick Overlay	127.5	134.7	170.4	166.1	66.8	14.4	679.9	1462.9
3.1	Rubblize and Overlay	21.0	65.1	165.9	113.8	41.0	0.3	407.1	873.8
3.2	Partial Mill and Overlay	331.5	68.3	19.7			1.3	420.7	856.8
3.3	Cold Recycle	35.0	6.0	2.9	11.3			55.1	112.4
3.4	Full Depth Mill and Overlay	47.6	16.8	7.0		0.4		71.7	144.0
7.1	Repair	21.4	28.3	328.1	111.9	22.4		512.1	1069.1
7.2	Repair and Grind	2.5	10.2	18.4	2.9	4.6		38.6	96.1
7.3	Repair, Grind, and Thin Overlay	3.1	2.3	32.2	11.5	8.6		57.7	130.2
7.4	Repair, Patch, Crack/Seat and Thick Overlay	34.0	34.6	159.8	50.9	15.7		295.0	623.5
7.5	Base Repair <= 5%, Spot Repair, Patch, Thin Overlay	5.1	17.3	58.4	37.3	4.4		122.6	254.0
7.6	Base Repair > 5%, Spot Repair, Patch, Thin Overlay	6.4	27.8	71.9	36.1	9.0		151.2	330.9
	Grand Total	6766.1	2417.4	3389.4	1328.9	404.6	105.8	14412.2	29544.9
	Needing Treatment (Work Effort Levels 1.2-7.6)	3812.1	1363.7	1649.7	1016.7	289.6	76.0	8207.8	17039.9
	Pct Needing Work	56.3	56.4	48.7	76.5	71.6	71.8	57.0	56.3

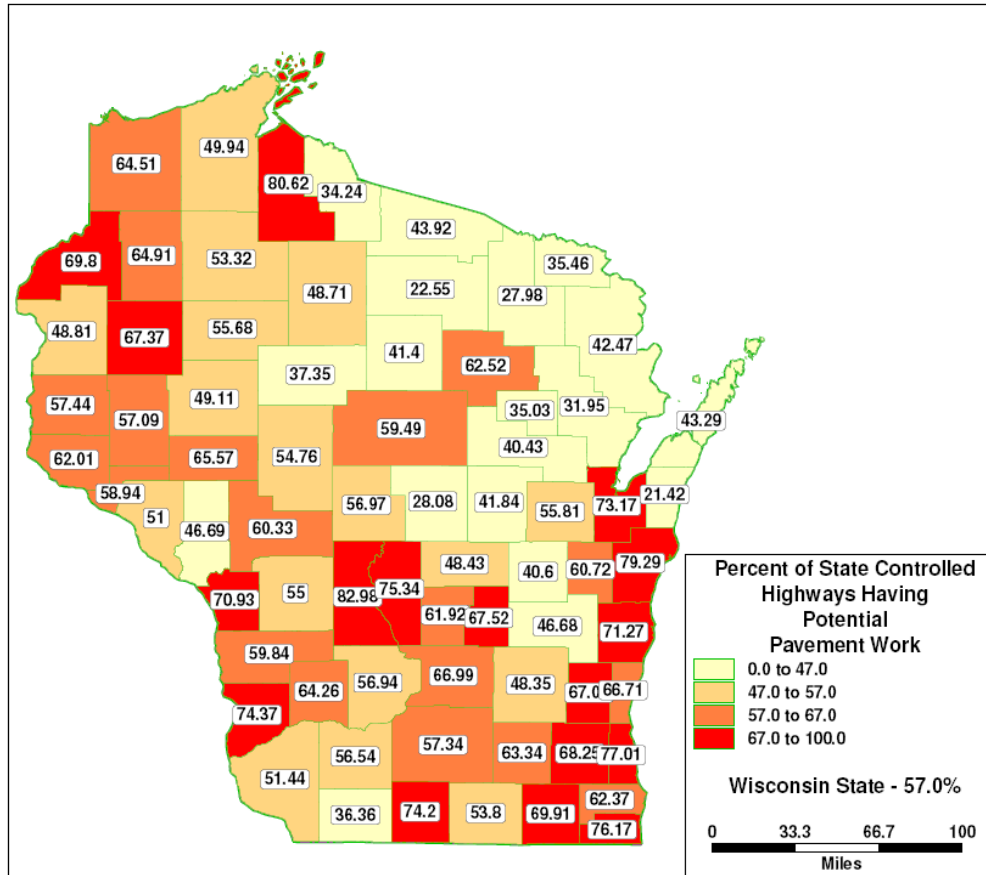
Source: Wisconsin Roadway Inventory File, WisDOT, February 2011. ADT=Average Daily Traffic.

Most of the mileage of potential required pavement treatment is for relatively light treatments such as cracking, patching and overlays. The greatest portion, about 3,495 roadway miles, is judged to need only thin overlays, and 1,327 miles are judged to need crack filling. Light treatments early in the life of pavements can be highly effective in prolonging pavement life and significantly reduce long-term costs. About 5,571 miles are judged to need no present treatment, and another 634 miles are not rated or were under construction when surveyed.

By region of the state, the percentage of roadway mileage needing treatment is shown in Figure 8. Pavement repair needs are widespread. The counties with the highest percentage of

mileage with potential work are Juneau (83%) and Ashland (81%), while those with the lowest percentage of mileage with potential work are Oneida (23%) and Kewaunee (21%). However, this figure does not show the type or likely cost of the potential work.

Figure 8: Percent of Roadway Miles with a Potentially Required Pavement Treatment



Source: Wisconsin Roadway Inventory File, WisDOT, February 2011.

A key issue in determining pavement needs is the ‘repair cycle’, the average time over which most state roads would receive at least one treatment. Over a decade most of the potential required pavement treatments would ideally be accomplished, but it is also likely that some work would not be completed. And some roads might need to be treated more than once per decade while others in good condition might not be treated at all (they would be maintained, however). A recent review of road repair cycles for the greater Milwaukee area¹⁶ found that concrete pavements lasted about 19 years before needing work, the first treatment (typically a milling and overlay) typically lasted another 10-15 years, and the second treatment (a lighter milling-resurfacing) lasted about 8-10 years. Asphalt pavements would typically last shorter periods of time and require more frequent treatment. **Our assessment assumes that on average, repair cycles for pavements will be about 13 years, implying that about 75% of the system could (ideally) be repaired during a 10-year period.** We also assume that no roads would be repaired more than once in a 10-year period. Both of these assumptions may be optimistic, particularly since light treatments often require ‘repeat’ work more frequently. A more comprehensive needs assessment of individual road sections, which is beyond the scope of this study, would explicitly include these factors¹⁷.

To estimate the cost of repair for various work types, we summarized the planned pavement work in the 2011-2014 Wisconsin STIP¹⁸. Typical unit (per mile) costs for various types of repair were determined and then these costs were interpolated for other work types based on complexity. Although each project is of course unique and has factors that raise or reduce costs, these average unit costs are viewed as sufficient for this high-level needs assessment. The Appendix to this report shows the cost tables for various treatments.

Total costs of repair are estimated by multiplying the unit repair costs by the percent repaired (assumed to be 75%) and the mileage needing work, adjusted for inflation. Also included was a factor to account for the difference average between basic letting (“LET”) costs versus total project costs. This factor (1.3245) provided by WisDOT¹⁹ would include engineering and right-of-way costs (likely to be modest for pavement repair work), contract change orders, mobilization and traffic control. To be conservative (slightly high in cost estimates) we did not adjust for roadway (as opposed to centerline) mileage, nor did we adjust for the likelihood that pavement treatments might not be applied to the entire length of road sections. Both adjustments, if applied, would lower our cost estimate.

Table 6 and Figure 9 show the results. **Over 10 years, the inflated cost to repair Wisconsin’s state highway pavements is about \$8.175 B.** About half of this work (51%) would be targeted to 4-lane roads, including rural interstates, and about 36% to 2-lane roads. The needs of 6+ lane roads are about 13% of the total.

Figure 9: Wisconsin SHS 2011-2020 Pavement Repair Needs, 75% Addressed

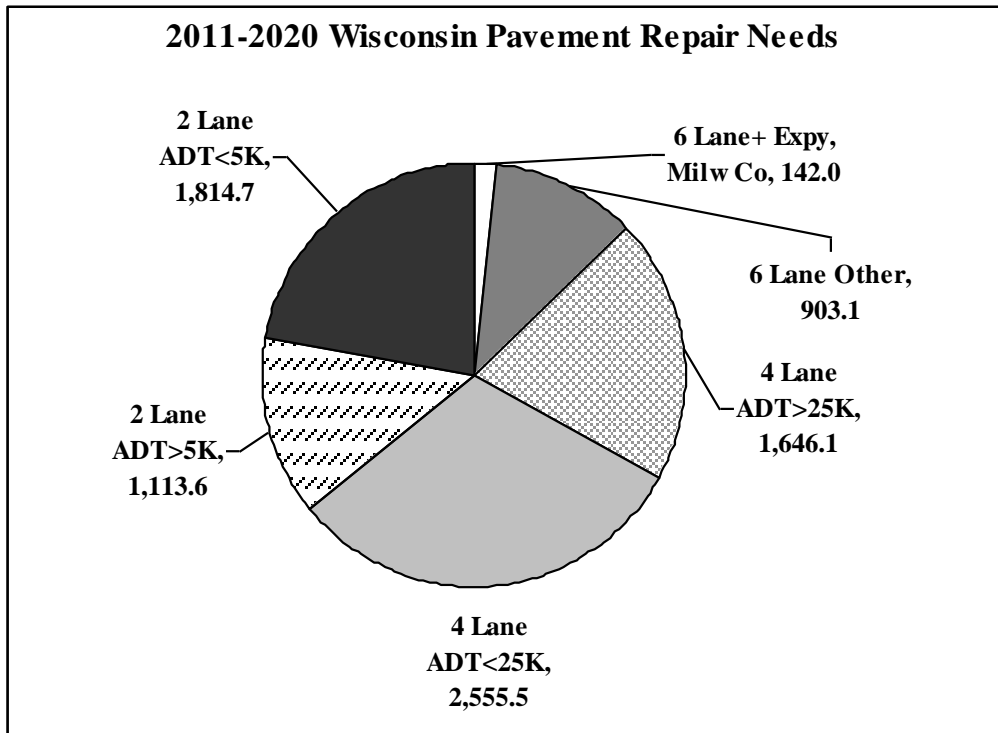


Table 6: Costs of Pavement Repair, 2011-2020, Wisconsin State Highway System

				POLICY	1.325 Tot\$/Let \$ Factor	2011-14		2015-20		Total 2011-20
Maintenance Road Class	Road- way Miles*	Rdwy Miles With Poten- tial Work*	% With Poten- tial Work	POLICY: % of Potential Work Completed	Base Cost, \$M	Road- way Miles Repaired	Inflated Cost, \$M	Road- way Miles Repaired	Inflated Cost, \$M	Total Inflated Cost, \$M
6 Lane+ Expwy, Milw Co	105.8	76.0	72	75	123.4	23	52.2	34	89.8	142.0
6 Lane Other	404.6	289.6	72	75	784.9	87	331.8	130	571.4	903.1
4 Lane ADT>25K	1,328.9	1,016.7	77	75	1,430.6	305	604.7	458	1,041.4	1,646.1
4 Lane ADT<25K	3,389.4	1,649.7	49	75	2,220.9	495	938.8	742	1,616.7	2,555.5
2 Lane ADT>5K	2,417.4	1,363.7	56	75	967.7	409	409.1	614	704.5	1,113.6
2 Lane ADT<5K	6,766.1	3,812.1	56	75	1,577.1	1,144	666.7	1,715	1,148.1	1,814.7
Total	14,412.2	8,207.8	57		\$ 7,104.6	2,462	\$ 3,003.2	3,693	\$ 5,171.8	\$ 8,175.1

*Source: Mileage from Wisconsin Roadway Inventory File, WisDOT, February 2011.

As noted, these estimates do not include additional 2nd-round pavement deterioration. And, also noted above, they do not include costs for widening existing lanes or adding new lanes, both of which are covered below.

2. Bridge Repairs

Wisconsin's highway bridges serve as key elements of the highway system, crossing features such as streams, trails, railroads, rivers, and other roads; as such, they are an integral part of the highway system and are critical to its functioning. Wisconsin has about 13,900 bridges, one of the larger inventories in the nation. Of these 4,885 are state-owned. This section reviews needs for repairing Wisconsin's state-owned bridges. Bridge maintenance needs are covered in a subsequent section, and new bridges are discussed in the section on new projects and expansions.

Unlike roads for which the states have many different rating procedures, bridges are rated uniformly nationwide. The federal government maintains the National Bridge Inventory²⁰ consisting of detailed information about each of the nation's 599,000 highway bridges. Each state regularly inspects each bridge for deficiencies in physical features and function, and reports its findings to the federal government. All states use the same data recording and rating methods which are based on rigorous training for field inspectors. The rating is based on observable distress symptoms for:

- *Bridge decks* (riding surface, roadway approaches, end joints, curbing and sidewalks),
- *Superstructures* (side rails, above-road piers and overhead truss), and
- *Substructures* (deck undercarriage, piers, footings, abutments and erosion protection).

For each component a 1-9 rating scale is used, where 4 or less is defined as "poor" condition. An overall rating based on a 100-point scale is also calculated, based on traffic, load carrying capacity, design, and condition. Bridges are rated "deficient" if they fail to meet either condition or functional adequacy. Since federal law requires that a bridge must be rated "deficient" in order

additional modest widening work to accommodate improved road geometry, engineering, mobilization and traffic control, but not inflation. We assumed that not all bridges would be repaired within the 10-year time frame. Nor do the estimates include costs for widening bridges to accommodate more traffic (capacity-based widening), or for modernizing older designs such as lift bridges.

Table 7 indicates that **about \$677.5 M would be needed over the next 10 years to prudently address Wisconsin's state-owned bridge repair needs.** Of this, about \$169 M would be targeted at bridges with poor-condition decks, with the remainder targeted at bridges in better shape to slow their deterioration. (If all bridge repair needs were addressed, the need would be about \$946 Million.)

Table 7: 10-Year Bridge Repair Needs, Wisconsin State-Owned Bridges

Condition Status	Deck Rating	# State-Owned Bridges	Bridges with Cost Est**	POLICY: Percent Repaired	Ave Cost Per Bridge, K\$	# Fixed	2010		2011-14		2015-20		2011-20
							# Fixed	Cost \$M Inflated	# Fixed	Costs (\$M) Inflated	# Fixed	Cost (\$M) Inflated	Total Cost (\$M) Inflated
NA/NR	N	607	12	20	7	121	11	0.1	44	0.3	66	0.6	0.9
Excellent	9	149	25	30	503*	45	4	2.0	16	8.6	24	14.9	23.5
Very Good	8	923	90	50	136	462	42	5.7	168	24.1	252	41.6	65.7
Good	7	1,665	163	60	117	999	91	10.7	363	45.1	545	77.6	122.7
Satisfactory	6	1,004	172	70	246	703	64	15.7	256	66.3	383	114.2	180.5
Fair	5	408	95	80	336	326	30	10.0	119	42.2	178	72.6	114.8
Poor	4	125	125	100	1,247	125	11	14.2	45	59.9	68	103.1	163.0
Serious	3	4	4	100	1,504	4	0	0.5	1	2.3	2	4.0	6.3
Critical	2	0	0			0	0	0.0	0	0.0	0	0.0	0.0
Im Failure	1	0	0			0	0	0.0	0	0.0	0	0.0	0.0
Failed	0	0	0			0	0	0.0	0	0.0	0	0.0	0.0
Totals		4,885	686	57	233	2,785	253	58.9	1,013	248.9	1,519	428.6	677.5

Source: NTAD 2009, National Bridge Inventory (NBI), Wisconsin portion.

* Almost 75% is for the bridges on Interstates and principal arterials which tend to be more expensive to repair.

** Bridges in Wisconsin's 2009 NBI that have estimated repair costs. These are typically bridges rated 'deficient'.

To account for higher future costs we inflated repair costs in future years at 2.8%/year. Further, recognizing that not all work could be done within the 10-year horizon, we have also reduced the estimate by limiting repairs to only a portion of the bridges in each condition category. We also subtracted out needed repairs for the 2010 calendar year, which have been partially done, but added inflation for repair work done beyond 2011. However, we do NOT include locally-owned bridges, or the needs for bridge widenings for capacity purposes or other reasons, nor do we include replacement costs for major bridge replacements such as the St. Croix Bridge at Stillwater; some of these are covered in the New Roads and Bridges section below.

3. Capacity-Related Widening.

Wisconsin's highways also have substantial congestion-related widening needs. Traffic engineers measure congestion by comparing the peak-hour traffic to a roadway's carrying capacity. For Interstates, the maximum flow rate of a modern lane of freeway is about 2,400 vehicles per hour, or about 25,000 vehicles per day using typical peak hour factors²³. So, a modern 4-lane freeway can carry about 100,000 vehicles a day maximum. Several 6-lane

facilities in the Milwaukee area carry traffic near 130,000 vehicles per day. As traffic on roads builds up, the volume-to-capacity ratio approaches 1.0 and traffic spreads out in time so roads are congested for longer periods. Typically, roads with volume/capacity ratios over 0.95 are considered to be severely or extremely congested and roads with volume/capacity ratios 0.80-0.95 are considered moderately congested.

Data on road congestion comes from several sources. Several private firms (e.g. INRIX) monitor real-time traffic congestion in major cities (including Milwaukee and Madison) using travel time reports from driver GPS devices²⁴. Using this data a recent study²⁵ put Milwaukee's 'US 45 southbound' (Zoo Freeway) at 26th among the nation's worst 50 commuter routes. All states including Wisconsin use the Federal Highway Capacity Manual²⁶ to calculate the rated capacities of their highways. For national comparisons, the states submit information annually to the federal government through a data reporting system known as the Highway Performance Monitoring System (HPMS)²⁷. This data is based on a sample of road sections in each state, monitored over time for condition, congestion, and other features. Wisconsin submits data to the federal government under this program. The data is summarized by the federal government and reported annually in Highway Statistics. However, the last published information for Wisconsin is for 2006.

WisDOT also calculates the HCM Level of Service (LOS) for each roadway section in the state Roadway Inventory File, and also converts the classification used in HPMS to a numeric classification noted in the table below (Table 8). This data is more recent, for 2010, and was the basis for our assessment.

Table 8: Wisconsin Traffic Congestion Levels of Service

Level of Service (Alpha Value, HCM)	Description of Congestion	WisDOT Level of Service (Numeric Value)
A	Not congested	1.01 - 2.00
B	Not congested	2.01 - 3.00
C	Minimal congestion	3.01 - 4.00
D	Moderate congestion	4.01 - 5.00
E	Severe congestion	5.01 - 6.00
F	Extreme congestion	6.01+

Source: WisDOT FDM, available at: <http://roadwaystandards.dot.wi.gov/standards/fdm/11-05.pdf>

Based on this numeric classification and the level of urbanization in which the facility is located, WisDOT has established LOS thresholds for various portions of the State Highway System:

Table 9: Acceptable Congestion Levels of Service

SHS Sub-System	Rural & Small Urban Areas	Urbanized Areas with Population > 50,000
C2020 Backbone Routes	LOS C (<= 4.0)	LOS C (<= 4.0)
C2020 Connector Routes and NHS Routes (not including NHS Backbone Routes)	LOS C (<= 4.0)	Mid LOS D (<= 4.5)
Other Principal Arterials	LOS D (<= 5.0)	Mid LOS E (<= 5.5)
Minor Arterials	LOS D (<= 5.0)	Mid LOS E (<= 5.5)
Collectors & Local Function Roads	LOS D (<= 5.0)	Mid LOS E (<= 5.5)

Source: WisDOT FDM, Table 3.1, Chapter 11, available at: <http://roadwaystandards.dot.wi.gov/standards/fdm/11-05.pdf>

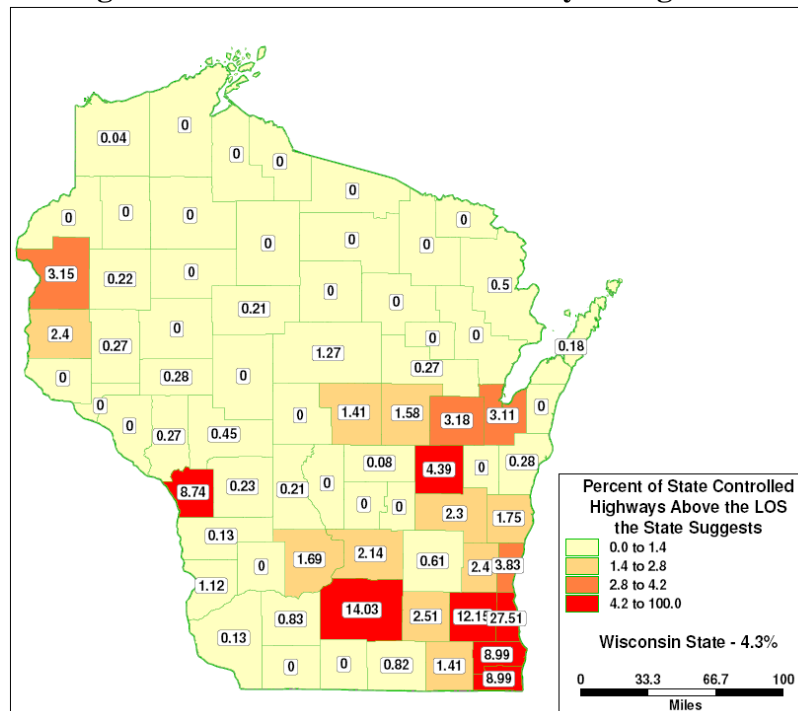
We have adapted these thresholds to the six road classes as follows. ‘Backbone’ routes operate at higher LOS’s, but urban routes are permitted more congestion. Therefore, 6-lane roads should be permitted to operate at “D” (LOS>4.0), but higher-volume 4-lane routes are allowed to carry more traffic (LOS>4.5). Lower-volume 4-lane and 2-lane roads are mostly rural. This translates into capacity criteria as shown in Table 10.

Table 10: Roadway Capacity Thresholds

Category	LOS Adequacy Threshold	Widen When LOS is
6+Lane Exp, Milw Co.	LOS C (<= 4.0)	D (> 4.0)
6+Lanes, Other	LOS C (<= 4.0)	D (> 4.0)
4L ADT> 25k	LOS D (<= 4.5)	D (> 4.5)
4L ADT< 25k	LOS C (<= 4.0)	D (> 4.0)
2L ADT>5K	LOS E (<= 5.5)	E (> 5.5)
2L ADT<5K	LOS D (<= 5.0)	D (> 5.0)

Following these criteria, most of Wisconsin’s State Highway System is only mildly congested. About 4.3% of the State Highway System exceeds the thresholds. However, the number is much higher for Milwaukee County 6+lane expressways (68%), and for other 6+lane roads throughout the state (27%). This is evident in Figure 11, which shows that capacity issues tend to be an urban problem with more roads needing widening in the areas in and around Milwaukee, Madison, La Crosse, Oshkosh, and Green Bay. The estimates using the above methodology may be low since they are based on a single uniform LOS threshold for each category, whereas in practice multiple thresholds apply. This increases the number of miles over capacity standards²⁸.

Figure 11: Percent of State Roadways Congested



Source: Wisconsin Roadway Inventory File, WisDOT, February 2011.

Of course, not all these roads could or should be widened, and there are other means to improve congestion²⁹. Actions such as improved traffic control, partial and directional treatments, bottleneck treatments, modal alternatives, and similar steps should be considered before major capacity-related widenings are undertaken. New technologies for traffic control are evolving that permit better use of real-time information, safer roads, and reduced delay. Some of these options are appropriate for higher-class roads such as freeways and major arterials, and others are appropriate for urban streets and other lower-class roads. Therefore, the proportion of roads that might be actually widened is likely to be higher for major facilities but lower for lower-class roads. Table 11 follows this approach by assuming that about 70% of congested 6+ lane facilities would be widened over a decade, but that only 50% of higher volume 2-lane and 4-lane roads, and 30% of lower volume 2-lane and 4-lane roads that are congested would be widened. In developing the cost estimates, we also adjusted for centerline-to-roadway mileage, total cost to letting cost, and inflation.

Following this strategy, Table 11 indicates that **about 333.4 roadway miles would need to be widened to meet a prudent widening policy, at a cost of about \$6.124 B.** This estimate is probably a low estimate of capacity-related widening needs, since it does not include work on moderately congested roads, modest traffic growth over time, higher costs of widening in other major urban areas (outside of Milwaukee County), and some related bridge and interchange work.

Table 11: Cost to Add Capacity to Roadways that Are Over the LOS Standard

								Tot\$/ Let\$ ratio	1.325**	1.057	Infl \$	1.213	Infl \$	
									2011-14		2015-20		2011-20	
Category	2010 Roadway Miles*	LOS Std*	Rdwy Miles Over LOS Std**	Pct Over Std	POLICY: Pct Widened	Rdwy Miles Widened	Cost to Widen per CL Mile, (\$M)	CLM /RM Ratio *	Total Base Year Cost (\$M)	Rdwy Miles Widened	Total Costs (\$M) Inflated	Rdwy Miles Widened	Total Costs (\$M) Infl	Grand Tot Infl Costs (\$M)
6+Lane Exp, Milw Co	106	D (>4.0)	72.2	68.2	70	50.5	75.0	0.50	2,511	20	1,061	30	1,828	2,889
Other 6+Lns	405	D (>4.0)	107.5	26.6	70	75.2	30.0	0.50	1,495	30	632	45	1,088	1,720
4L ADT> 25k	1,329	D (>4.5)	144.7	10.9	50	72.3	10.0	0.50	479	29	203	43	349	551
4L ADT< 25k	3,389	D (>4.0)	50.3	1.5	30	15.1	8.0	0.53	84	6	36	9	61	97
2L ADT>5K	2,417	E (>5.5)	240.5	9.9	50	120.3	5.0	0.98	779	48	329	72	567	897
2L ADT<5K	6,766	D (>5.0)	0.0	0.0	-	-	-	-	-	-	-	-	-	-
Total	14,412		615.1	4.3		333.4			\$ 5,349	133	\$ 2,261	200	\$3,894	\$ 6,154
I43 Mitchell Int-Silver Spring Int, + I94 Marquette Int-Zoo Int			-38			-38			- \$ 268			-38	-\$ 431	-\$ 431
Total - Above			577.1			295.4			\$ 5,081	\$ 133	\$ 2,261	162	\$ 3,463	\$ 5,724

*Sources: WisDOT Roadway Inventory File, Feb 2011. Unit cost data from analysis of Wisconsin 2011-14 STIP (see Appendix). LOS standards from WisDOT Facilities Design Manual. Centerline/Roadway ratio from RIF. (see Appendix)

** Provided by WisDOT, 4/26/11, Wolfgram to Lightbourn.

Two major proposed projects, I 43 (Mitchell-Silver Spring) and I 94 (Marquette-Zoo) are treated separately. These projects propose widenings that are very expensive and would probably impact the local areas. The incremental cost of widening for these two projects has been estimated at about \$268 M³⁰, or about \$431 M in future inflated dollars. Since no decision has been made regarding whether to widen these facilities, we show them as a separate alternative in Table 11. If these two projects were deleted, about \$5.724 B (\$431 M less) would be needed.

The decision to add capacity is a complex one balancing congestion, funding, safety, pavement condition, community impacts and many other factors. The benefits of increased roadway capacity are primarily higher travel speeds and reduced congestion-related delays, primarily in urban areas. Commuters also benefit from reduced accident rates and lower vehicle operating costs. Increased road capacity also increases accessibility and facilitates truck flows, thus improving local economies, and it can reduce air pollution through lower emissions rates. On the other hand, some widenings also create additional traffic (so-called induced traffic) which eats into travel time savings and air pollution gains, and may encourage development and sprawl. This report does not evaluate specific capacity improvements, but does attempt to estimate their impact on state highway needs.

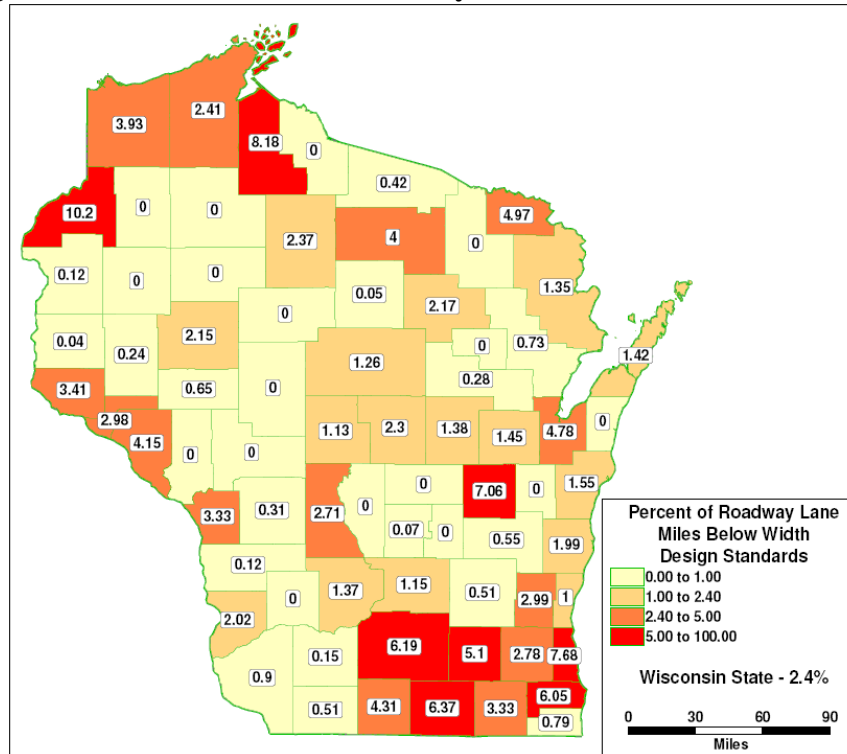
4. Narrow Lanes

Another important deficiency in highway systems is narrow lanes, that is, lanes less than standard design width. Many studies of road safety indicate that narrow lanes are a major factor in head-on vehicle collisions and sideswipes, in which the severity of the accident tends to be greater than in other accidents. They are also a major factor in roadway run-off accidents. Narrow lanes also contribute to lower driving speeds, thus reducing system efficiency and accessibility. They also contribute marginally to reduced capacity in cases where narrow lane width slows driving speeds and increases vehicle spacing in congested areas.

The WisDOT standard for lane width, as shown in the Facilities Development Manual (FDM), is 12 feet for the Interstate system³¹. Lane widths for the other portions of the State Highway System depend on functional class, traffic volume and speed. For arterials, the lane width standard is 12 feet (both urban³² and rural³³); for collectors and most local roads the lane width standard is 11 feet (for both urban and rural). In low-volume roads and subdivisions 10-foot lanes (20-foot pavement width) are permissible although the need for bikeways may increase widths somewhat. For our purposes, we have used the 12 foot guideline as a standard for all multi-lane highways, as well as the high volume 2-lane facilities. For the lower-volume 2-lane roads, we used the 11-foot guideline as the standard, recognizing that not all 2-lane roads need to be widened to 22 feet.

Analysis of the Wisconsin State Highway System indicates that **of Wisconsin's 29,545 roadway lane-miles, about 710 lane-miles (2.4%) have lane widths less than design standard (Figure 12)**. The map below indicates that the percentage of roadway lane-miles with narrow lanes is geographically dispersed, with the Southeast, Southwest and Northwest Regions having the highest percentages. Burnett County has the highest percent of narrow roadway lane-miles, 10.2%, followed by Ashland County (8.2%) and Milwaukee County (7.7%).

Figure 12: Percent of State Roadway Lane-Miles with Narrow Lanes



Source: Wisconsin Roadway Inventory File, WisDOT, February 2011.

However not all of these narrow lanes should or even could be widened, since some are limited by urban street geometry, terrain limitations, wetland avoidance, right-of-way limits or other factors. Therefore, the percentage of narrow lanes that might be prudently widened is less than 100% except for major freeways and arterials. Also the unit cost of lane widening is somewhat less than that of lane additions such as needed for capacity; we estimated these costs by reviewing 2011-14 STIP projects. **Prudent widening of existing lanes to meet design standards would cost about \$362 M over 10 years (Table 12).**

Table 12: Cost to Widen Narrow Lanes, \$M.

Category	2010 Roadway Miles	2010 Lane - Miles	Std Lane Width	Lane-Miles below Std	POLICY % Widened	Cost/LM to Widen (\$K)	LMs Widened	Total Base Cost, \$K	2011-14		2015-20		2011-20
									LMs Widened	Infl Cost, \$M	LMs Widened	Infl Cost, \$M	Infl Cost, Total \$M
6+Lane Exp, Milw Co	106	322	12 ft	0	100	950	0	0	0	0	0	0	0
6+Lanes, Other	405	1,244	12 ft	88	100	950	88	84.0	35	35.5	53	61.2	96.7
4 Lanes ADT> 25k	1,329	2,658	12 ft	24	75	808	18	14.6	7	6.2	11	10.6	16.8
4 Lanes ADT< 25k	3,389	7,138	12 ft	259	75	808	194	156.9	78	66.4	117	1143	180.6
2 Lanes ADT>5K	2,417	4,744	12 ft	157	50	475	78	37.3	31	15.8	47	27.1	429
2 Lanes ADT<5K	6,766	13,439	11 ft	182	25	475	45	21.6	18	9.1	27	15.7	24.8
Totals	14,412	29,545		710			425	\$ 314.4	170	\$ 132.9	255	\$ 228.8	\$ 361.8

Sources: Lane widths: WisDOT Roadway Inventory File, Feb 2011. Unit cost data: Wisconsin STIP analysis.

The benefits of lane width improvements on accident rates can be substantial. The Texas A&M Roadway Safety Design Workbook³⁴ indicates that for rural 2-lane arterials, improving lane width from 10 to 11 ft can reduce crash rates by about 12%. For urban arterials the effect is smaller, about 5%. Of course, these reductions would be applied only to those roads that have their lane widths widened, not to all of the system.

5. Narrow Shoulders

Adequate shoulders are another important highway system design feature. Adequate shoulders provide a margin of safety for vehicles that need to pull over to the roadside, as well as serve as extra area to reduce the chance and severity of run-off-pavement accidents. They also increase sight distance by ensuring that trees and other obstructions are set back from the pavement edge.

The design standard for shoulder width for the collectors, arterials and Interstates/freeways varies from 2 to 10 feet, depending on traffic, posted speed and road classification³⁵. Many of the state's narrow-shoulder roads have not been re-engineered to the current standards; they have always had narrow shoulders. If these roads were re-constructed, good engineering practice would be to try to bring them up to standards for both lane width and shoulder width. For most roads, except subdivisions or very low volume roads, a minimum of 6 feet would be the design standard, and most roads widened or improved would be provided with at least 6-foot shoulders.

To estimate the need for shoulder widening, we looked only at right-side road shoulders not constrained by curbs or retaining walls, guide rails or other roadside features³⁶. Table 13 summarizes the status of the Wisconsin state-owned highway system for shoulder widths. **About 4,828 miles, or 22.4% of the 21,596 miles of eligible right-shoulders in the State Highway System have narrow shoulders that are less than design standards.** Figure 13 shows that this problem occurs throughout the state, although the North Central and Southwest Regions seem to have more than their share. Eleven counties have greater than 35% of their roads with shoulders of less than design width. (Menominee County, the former Indian reservation, has almost 93% of shoulders below standard width but also significant first-growth forest protection.)

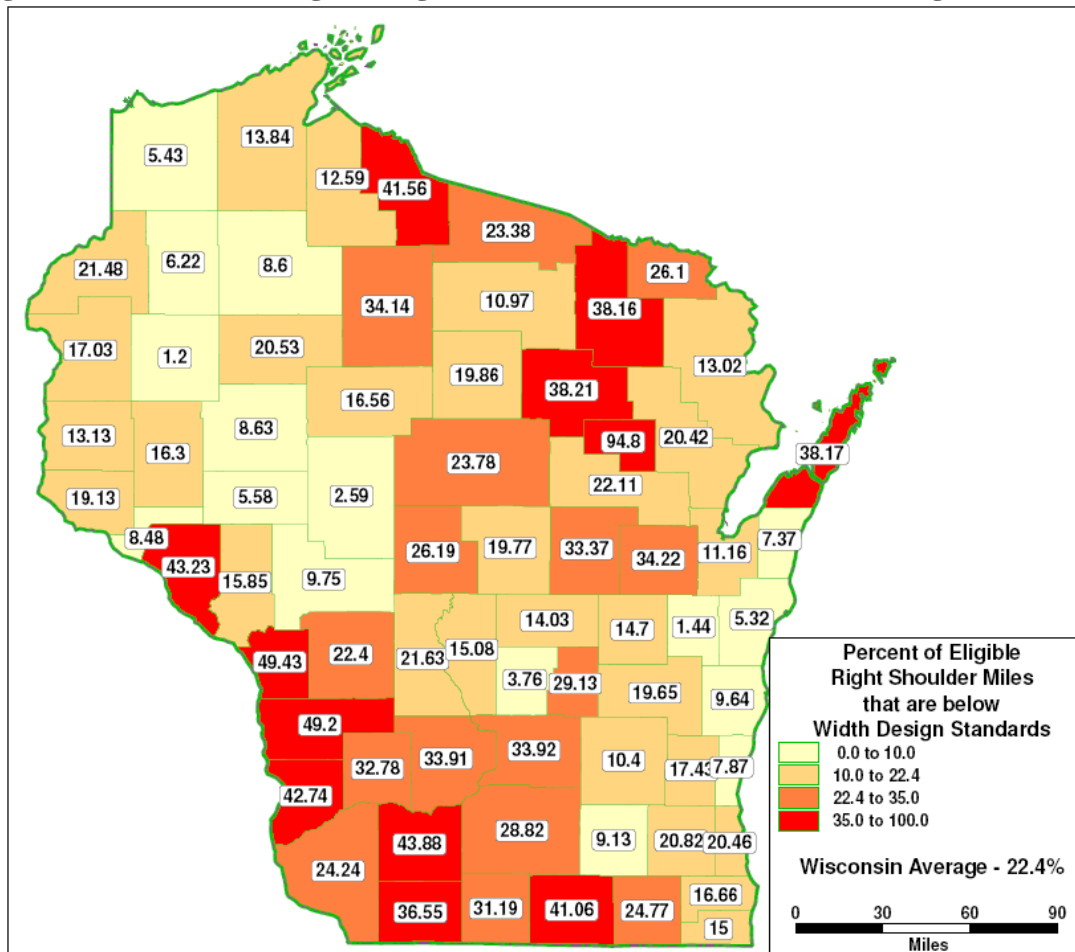
Cost estimates to widen the shoulders of roads are based on widening the current shoulder width out to design specifications for those shoulders that are currently below standard. Table 13 indicates that about 12,900 foot-miles of shoulder would need to be widened if *all* narrow shoulders were widened to design standards. However, not all of these could be widened due to geometric limitations or other factors. If about ½ of these were widened for major roads, and 25% for lower volume roads, with costs per foot-mile ranging from \$5,000 to \$10,000, **about \$34.2 M would be needed to bring ½ of the state's road shoulders up to minimum width standards.** This estimate is probably on the low side, since it does not include the cost of roadbed widening in hilly areas, which could be substantially more than the per-foot-mile estimates, or the cost of right-of-way, which would be needed if the shoulder widening encroached onto private property.

Table 13: Cost to Widen Narrow Shoulders, \$K

Category	2010 Eligible Right Shoulder Miles	Std Shoulder Width	Shoulder Miles below Std	Shoulder Ft-Miles Needed	POLICY	Pct Widened	Cost/ft-Mi to Widen (\$K)	Ft-Miles Widened	Tot Cost, \$M	2011-14		2015-20		2011-20
										Ft-Miles Widened	Infl Cost, \$M	Ft-Miles Widened	Infl Cost, \$M	Infl Cost, Total \$M
6+Lane Exp, Milw Co	98	10 ft	16	45	50	10.0	22	0.2	9	0.1	13	0.2	0.3	
6+Lanes, Oth	256	10 ft	27	90	50	10.0	45	0.4	18	0.2	27	0.3	0.5	
4L ADT> 25k	2,763	10 ft	71	207	50	10.0	103	1.0	41	0.4	62	0.8	1.2	
4L ADT< 25k	1,306	10 ft	290	1,086	50	10.0	543	5.4	217	2.3	326	3.9	6.2	
2L ADT>5K	4,093	8 ft	948	2,197	50	10.0	1,098	11.0	439	4.6	659	8.0	12.6	
2L ADT<5K	13,079	6 ft	3,476	9,297	25	5.0	2,324	11.6	930	4.9	1,395	8.5	13.4	
Totals	21,596		4,828	12,921			4,136	\$ 29.7	1,655	\$ 12.6	2,482	\$ 21.7	\$ 34.2	

Sources: Shoulder widths: WisDOT Roadway Inventory File, Feb 2011.

Figure 13: Percent of Eligible Right-Shoulder Miles Below Width Design Standards



Source: Wisconsin Roadway Inventory File, WisDOT, February 2011.

Although a formal cost-benefit assessment of a shoulder-widening initiative is beyond the scope of this review, it is believed that the initiative would be quite cost-effective, resulting in a reduction in frequency and severity of some accidents. A 1988 study reviewing data from seven states³⁷ found a 16 percent reduction in accident rates from adding a 2-ft paved shoulder and a 29 percent reduction for adding a 4-ft shoulder. The Texas A&M safety manual³⁸ notes that in rural areas, increasing shoulder width from 3 to 8 feet on 4-lane and high-volume 2-lane roads reduces accidents about 15%, and in urban areas, and widening shoulders from 2 to 4 feet on 4-lane arterials reduces accidents about 5.4% and on 2-lane arterials about 11.5%. The geometries and configurations of the individual highway sections may well prohibit shoulder expansion, and any reductions in accident frequency factors would, of course, have to be applied only to the sections treated. Still these reductions do show that the magnitude of the shoulder widening effect can be substantial, an effect that would be difficult to achieve in other ways for similar costs.

6. Physical Maintenance and Operations

Physical maintenance and roadway operations are also important regular activities. Numerous studies indicate that early regular maintenance of roads and bridges lengthens their service life and lowers overall costs by reducing later higher expenses. However, the vulnerability of maintenance costs to budget cuts sometimes makes them an easy short-term target, an action that can lead to significantly higher costs later.

Maintenance refers to activities that are intended to provide intermediate relief for road and bridge conditions but do not add to long-term life or system improvements. Typical activities under this category include light road treatments such as pothole filling and some crack sealing, shoulder maintenance, ditching, signs and vegetation, and snow and ice removal. Operations include activities related to traffic monitoring and management, lift bridge operations, management of signs, markings, signals and similar functions.

In its 2011-13 Biennial Budget Wisconsin identifies about \$200.2 M for “highway maintenance, repair, and traffic operations” for SFY 2012³⁹. However this includes funds for snow and ice removal, roadside maintenance, some signal maintenance, and some light road repairs. In our analysis we break out snow and ice removal, roadside maintenance, signal repairs, and higher-cost pavement repairs and treat them separately. Therefore our analysis of maintenance includes primarily light physical and bridge maintenance and traffic operations such as the traffic control center in Milwaukee, and is therefore somewhat lower in total cost than the state’s budget estimates.

In a departure from most (if not all) other states, Wisconsin uses *localities* to maintain state roads, even the higher-level roads such as the Interstate system. These arrangements are contracted by the state with individual localities, at about \$100 M annually, and are separate from the ‘grants to localities’ that the DOT also administers for local road assistance.

Table 14 estimates pavement and bridge maintenance and traffic operations costs for the coming decade. We used the state’s reported 2008 base year total, about \$140.5 M annually (which excludes snow and ice treatment) to estimate future needs. We also assumed a slower growth rate, 2% annually, than for major contracts, since these funds are largely under state budgetary control. Assuming a modest increase for 2011-14 (about 6%, on average) and a somewhat higher increase for 2015-20 (about 16%, on average) we estimate that **about \$1.574 B will be needed for pavement and bridge maintenance and traffic operations over the next decade**, excluding snow and ice, roadside, and signal replacements.

Table 14: Physical Maintenance and Operations, \$M

Expenditure Category	2000	2004	2008	2011-14	2015-20	Total, 2011-20
Physical Maintenance	93.2	95.5	66.7			
Other Maintenance Services	-	-	33.3			
Traffic Operations	21.9	42.2	40.5			
(Subtotal)	115.1	137.7	140.5	\$ 595.9	\$ 978.2	\$1,574.0
Snow and Ice Maintenance	32.8	40.3	86.7			

Source: 2000-08, FHWA Highway Statistics, Table SF4C, various years. Forecast: WisDOT budget statistics.

This assessment assumes no major changes in present maintenance and operations practices, such as might occur if the state were to expand its traffic operations center to cover the whole state or restructure its maintenance contract arrangements with localities by initiating private maintenance contracts.

7. Winter Maintenance

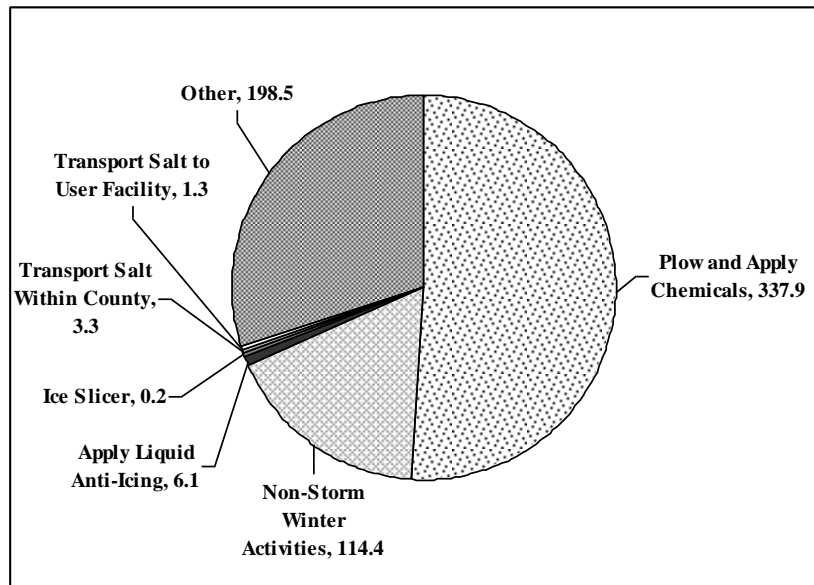
Regular pavement and bridge maintenance is covered in the discussion above. However, additional costs of winter-related maintenance are not covered there. The cost of winter maintenance obviously depends on the severity of a particular winter and the duration, nature, geographical location, and timing of the various storm events. Another important factor is the desired level of service, for instance the percentage of roads cleared to bare pavement 2 hours after a storm ends. The costs can vary widely as shown in Table 15 below. The winter of 2008 cost 88% more than the one in 2006.

Winter maintenance operations consist predominantly of the winter-specific activities noted in the table below, but also include activities such as public service announcements and Road Weather Information System (RWIS) monitoring. A review of the Compass Report and the Budget Report found these other activities to be about 30% of the total. The projections are based on the historical data which comes from these two reports. As evident in Figure 14, the majority of the cost (51%) is in the plowing and chemical application process.

Table 15: Historical and Projected Cost of Winter Operations, \$M

Activity Description	Historical (\$M)					Projected (\$M)		Total (\$M)
	2006	2007	2008	2009	2010	2011-14	2015-20	2011-20
Plow and Apply Chemicals	24.9	26.7	49.0	41.4	28.9	124.1	213.8	337.9
Non-Storm Winter Activities	7.7	8.4	10.3	10.1	9.8	42.0	72.4	114.4
Apply Liquid Anti-Icing	0.3	0.4	0.4	0.4	0.5	2.2	3.9	6.1
Ice Slicer	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.2
Transport Salt Within County	0.3	0.2	0.5	0.4	0.3	1.2	2.1	3.3
Transport Salt to User Facility	0.1	0.1	0.7	0.3	0.1	0.5	0.8	1.3
Other Costs	12.4	15.6	25.5	26.7	17.0	72.9	125.6	198.5
Totals	45.8	51.5	86.3	79.3	56.7	243.0	418.8	661.8

Sources: Base activities and costs: WisDOT winter cost budget estimates, February 2011. Other activities, WisDOT Compass Report 2009

Figure 14: Total Projected Costs of Winter Operations, 2011-2020.

Based on recent expenditures and historical trends, **this expenditure is estimated at about \$661.8 M over the next decade.** This estimate includes inflation.

8. Roadside Maintenance

The roadsides along highways also require regular systematic maintenance. The WisDOT annual Compass Report⁴⁰ classifies roadside maintenance into four categories (shoulders, drainage, roadside, and traffic and safety) and then addresses the percent of the system that is backlogged and how well the particular features of each category are maintained, both as an absolute grade and in relation to the grade that WisDOT seeks to maintain.

The *Shoulders* category includes the basic maintenance of the shoulders (but not their widening), the removal of hazardous debris, the build-up of drop-off areas, and repair of eroded areas. WisDOT has identified a significant backlog of shoulder projects, especially in the repair of cracking in paved shoulders and drop-off areas in unpaved shoulders – both of these features received an F grade in 2009. According to the Compass report, while progress has been achieved in reducing the backlog in hazardous debris removal and pothole repair, the state system has seen some slippage in cross-slope and shoulder cracking repair. Still, only one feature, shoulder cracking, did not meet target goals.

Table 16: Percent of Shoulder Maintenance Backlogged and Status of Features.

Shoulders Feature	Percent of the System Backlogged							Feature Grade		
	2005	2006	2007	2008	2009	Average	% Chg 05-09	Target Grade	2009 Grade	Status
Hazardous debris	12	13	9	9	8	10.2	-33.3	C	C	Met
Cracking (paved)	52	50	53	53	62	54.0	19.2	D	F	Below
Drop-off/build-up (paved)					4	4.0	NA	New	B	New
Potholes/raveling (paved)	7	5	6	6	6	6.0	-14.3	B	A	Over
Cross-slope (unpaved)	14	25	18	18	22	19.4	57.1	C	C	Met

Shoulders Feature	Percent of the System Backlogged							Feature Grade		
	2005	2006	2007	2008	2009	Average	% Chg 05-09	Target Grade	2009 Grade	Status
Drop-off/build-up (unpaved)	36	40	40	44	34	38.8	-5.6	F	F	Met
Erosion (unpaved)	3	3	1	2	3	2.4	0.0	A	A	Met
Average	20.7	22.7	21.2	22.0	19.9	21.3				

Source: WisDOT Compass Report 2009

The *Drainage* category includes basic maintenance and repair of the ditches, culverts, gutters, etc. that help move water off and away from the facility. There is a sizable backlog in several areas to include culverts, flumes, and under-drains and edge drains, and this backlog worsened from 2005 to 2009. Only one area, curb and gutter, saw improvement during this time period (and is rated above its target), while two, flumes and the storm sewer system, saw increases in the backlog of 89% or more. And these two are also rated below their targets.

Table 17: Percent of Drainage System Backlogged and Status of Features.

Drainage Feature	Percent of the System Backlogged							Feature Grade		
	2005	2006	2007	2008	2009	Avg	% Chg 05-09	Target Grade	2009 Grade	Status
Culverts	18	15	20	28	23	20.8	27.8	C	C	Met
Curb & gutter	7	8	8	5	5	6.6	-28.6	B	A	Over
Ditches	2	3	2	2	2	2.2	0.0	A	A	Met
Flumes	19	27	25	39	36	29.2	89.5	C	D	Below
Storm sewer system	9	9	11	16	19	12.8	111.1	B	C	Below
Under-drains/edge-drains	20	13	20	30	24	21.4	20.0	C	C	Met
Average	12.5	12.5	14.3	20.0	18.2	15.5				

Source: WisDOT Compass Report 2009

The *Roadsides* category includes basic maintenance and repair of fences, litter removal, control of noxious weeds and woody vegetation, and mowing. The problem areas in this category are litter removal, mowing and the control of noxious weeds, which have backlogs of 33% or more. The backlog in each category has been relatively consistent in recent years, and maintenance in each feature met or exceeded target goals.

Table 18: Percent of Roadsides System Backlogged and Status of Features.

Roadsides Feature	Percent of the System Backlogged							Feature Grade		
	2005	2006	2007	2008	2009	Avg	% Chg 05-09	Target Grade	2009 Grade	Status
Fences	2	3	2	1	3	2.2	50.0	C	A	Over
Litter	62	64	60	61	66	62.6	6.5	D	D	Met
Mowing	35	39	36	42	35	37.4	0.0	C	C	Met
Mowing for vision		2	2	3	5	3.0		B	B	Met
Noxious weeds	29	34	29	38	33	32.6	13.8	F	C	Over
Woody vegetation control	3	3	3	2	4	3.0	33.3	B	A	Over
Woody vegetation control for vision	1	1	2	1	0.4	1.1	-60.0	A	A	Met
Average	22.0	20.9	19.1	21.1	20.9	20.8				

Source: WisDOT Compass Report 2009

The *Traffic and Safety* category includes signage (but not signals), pavement markings, and protective barriers. On the whole, efforts in this category seem to be on target (only one area, centerline markings, was below the goal) and all areas have a C rating or above except one, the routine replacement of non-regulatory/warning signs. The backlog is high in this area, as well, at 55%. Gains have been realized in reducing the backlogs in several areas (emergency repair of non-regulatory/warning signs, the routine replacement of signs of all types, protective barriers, and delineators). Edge-line and special pavement markings have seen dramatic increases in backlogs.

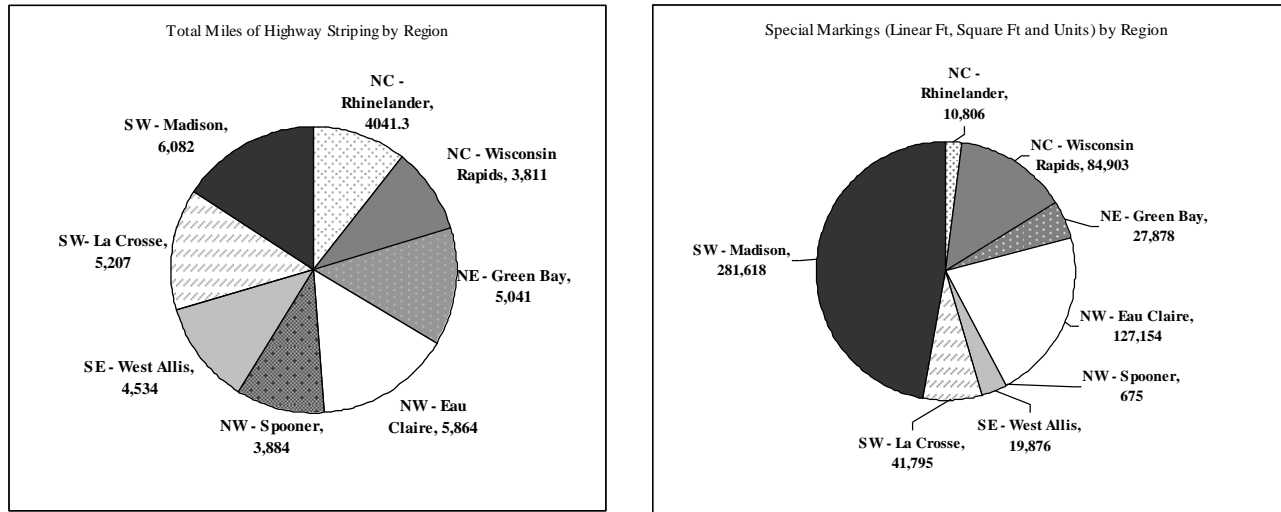
Table 19: Percent of Traffic/Safety System Backlogged and Status of Features.

Traffic/Safety Feature	Percent of the System Backlogged							Feature Grade		
	2005	2006	2007	2008	2009	Avg	% Chg 05-09	Target Grade	2009 Grade	Status
Centerline markings	5	4	3	3	7	4.4	40.0	B	C	Below
Delineators	24	21	21	26	20	22.4	-16.7	C	C	Met
Edge-line markings	5	6	4	4	12	6.2	140.0	C	C	Met
Detour/object marker/recreation/guide signs (emergency repair)	1	1	0.3	0.4	0.3	0.6	-70.0	A	A	Met
Detour/object marker/recreation/guide signs (routine replacement)	59	55	56	55	51	55.2	-13.6	F	D	Over
Protective barriers	4	4	5	3	3	3.8	-25.0	A	A	Met
Regulatory/warning signs (emergency)	1	1	1	1	1	1.0	0.0	A	A	Met
Regulatory/warning signs (routine replacement)	41	31	25	23	23	28.6	-43.9	C	C	Met
Special pavement markings	5	3	10	7	10	7.0	100.0	D	B	Over
Average	16.1	14.0	13.9	13.6	14.1	14.4				

Source: WisDOT Compass Report 2009

Centerline and special markings are broken out by WisDOT region in Figure 15 below. Interestingly, while highway striping seems to be distributed evenly throughout all regions, the special markings are overwhelmingly in the Southwest-Madison region.

Figure 15: Long-line Miles of Highway Striping and Special Markings, By Region



Source: WisDOT Long-line Painting and Special Pavement Markings data, February 2011.

Future costs for these activities are estimated using historical trends. Over the past several years these expenditures have averaged about \$50-\$60 M/year, with traffic and safety receiving the biggest portion of the roadside maintenance budget. **The projected cost for roadside maintenance for the next decade, including inflation, is \$684.5 M (Table 20).**

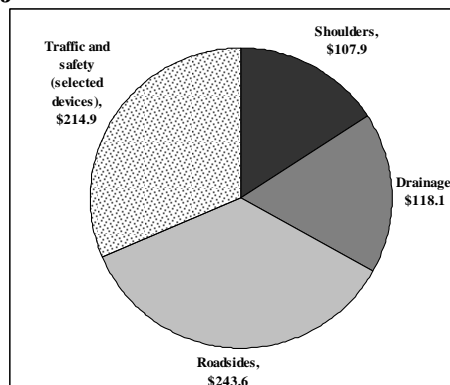
Table 20: Historical and Projected Cost of Roadside Maintenance, \$M.

	Historical					Forecast	Projected		
	2005	2006	2007	2008	2009	2010	2011-14	2015-20	2011-20
Shoulders	7.5	8.2	9.8	8.2	9.0	9.2	39.6	68.3	107.9
Drainage	5.7	5.1	7.2	8.0	9.8	10.1	43.4	74.7	118.1
Roadsides	20.2	21.9	24.0	19.4	20.3	20.9	89.4	154.1	243.6
Traffic and safety (selected devices)	15.8	16.4	17.2	17.3	17.9	18.4	78.9	136.0	214.9
Totals	49.2	51.6	58.2	52.9	57.0	\$ 58.6	\$ 251.3	\$ 433.1	\$ 684.5

Source: WisDOT Compass Report 2009

The largest share is for roadside maintenance, followed by traffic and safety activities (Figure 16).

Figure 16: Projected Roadside Maintenance Costs by Category



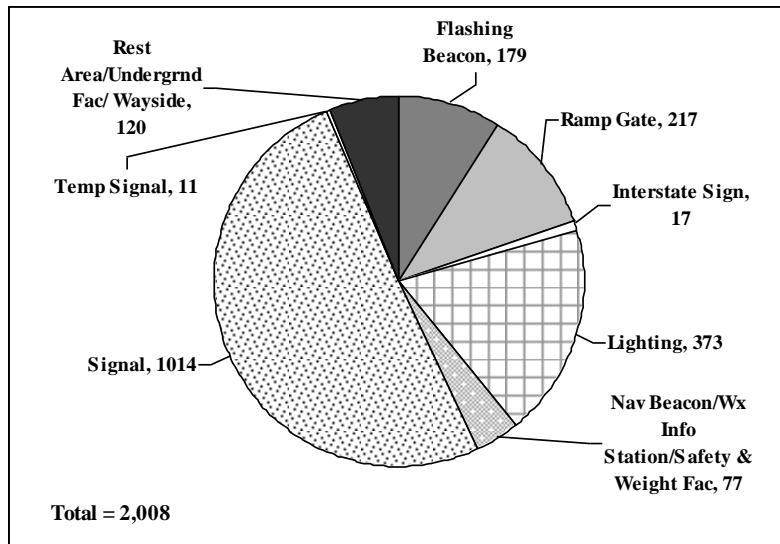
Source: WisDOT Compass Report, 2009

9. Signals and Lighting

Traffic signals and other lighted features are a critical element of the state highway system, providing for control and management of traffic and ensuring safe use of intersections and other roadway elements. Maintaining, upgrading and occasional replacement of these features are important activities in the safe and efficient use of the state highway system.

The Wisconsin State Highway System has about 1,014 traffic signal sites, and another 994 sites with other special signals or lighting. Figure 17 summarizes the types of signal sites and other lighted sites on the State Highway System. Of the 2,008 sites, about half (1014) are signals, and another 20% (373) are roadway lighting sites. The others are special lights, gates, beacons and service area lighting.

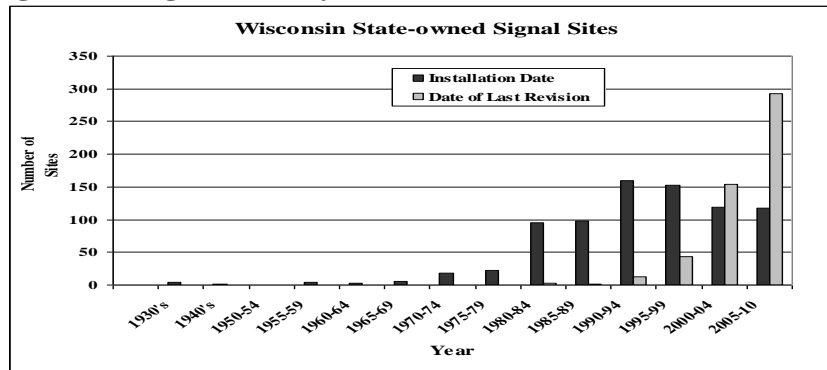
Figure 17: Lighted Sites, Wisconsin State Highway System



Source: WisDOT Signal Sites Library, February 2011.

The earliest installations of Wisconsin’s signals dates from the 1930’s (Figure 18) but most are much newer and many new signals have been installed in the 1990’s and after 2000, as traffic has risen and suburban growth around regions has necessitated additional traffic control. Almost all traffic signals have been revised, retimed or replaced since 1990, and about 57% of the state’s signal sites have been revised since 2005.

Figure 18: Signal Sites by Installation and Year of Last Revision



Source: WisDOT Signal Sites Inventory, February 2011.

Table 21: Signal and Other Lighted Sites: Needs, 2011-2020, \$M

Site Install Year	Sites	Pct	POLI CY	Ann Maint Cost per Site	POLI CY	Ave Sig Head GP per Site*	Repl Cost per Sig Head Group	Total Base Cost, \$M	2011-14		2015-20		Total Cost, \$M 2011-20
			% Maint per yr		% Repl in 10 yrs				Sites with Signals Replaced	Maint + Repl Cost, Infl, \$M	Sites with Signals Replaced	Maint + Repl Cost, Infl, \$M	
'30-49	5	0.6	100	2500	80	4	50000	\$ 0.9	2	\$ 0.4	2	\$ 0.7	\$ 1.1
1950's	4	0.5	100	2500	70	4	50000	\$ 0.7	1	\$ 0.3	2	\$ 0.5	\$ 0.8
1960's	9	1.1	100	2500	70	6	50000	\$ 2.1	3	\$ 0.9	4	\$ 1.5	\$ 2.4
1970's	41	5.1	100	3500	60	8	50000	\$ 11.3	10	\$ 4.8	15	\$ 8.2	\$ 13.0
1980's	193	24.1	100	5000	50	12	50000	\$ 67.6	39	\$ 28.6	58	\$ 49.3	\$ 77.9
1990's	312	39.0	85	5000	30	12	50000	\$ 69.4	37	\$ 29.4	56	\$ 50.7	\$ 80.0
2000-04	119	14.9	60	6000	10	16	50000	\$ 13.8	5	\$ 5.8	7	\$ 10.1	\$ 15.9
2005-10	117	14.6	60	6000	5	16	50000	\$ 8.9	2	\$ 3.8	4	\$ 6.5	\$ 10.3
No date	214	N/A	50	3500	50	8	50000	\$ 46.5	43	\$ 19.7	64	\$ 34.0	\$ 53.7
Subtotal	1,014	100						\$ 221.2	141	\$ 93.5	212	\$ 161.5	\$ 255.0
Other Sites	994	100	50	2000	30	4	50000	\$ 69.6	119	\$ 29.4	179	\$ 50.8	\$ 80.2
Total	2,008							\$ 290.8	260	\$ 122.9	390	\$ 212.3	\$ 335.3

Source: WisDOT Signal Site Inventory, February 2011. *Average 17.7 signal heads per intersection.

Table 21 summarizes the findings. **The estimated total 10-year need for prudent maintenance and replacement of signals and other lighted sites is about \$335 Million. Of this, about \$255 M is for signals.** These costs include an adjustment for inflation.

10. New Roads, Expansions, Major Bridges and Interchanges.

Repairs and maintenance for the existing road system are not the only Wisconsin road needs: as the population grows or standards change, new or expanded facilities are also needed. The STIP consolidates needs for the state's urban areas and for rural counties outside urbanized area boundaries, but only for 2011-14. The STIP also contains preliminary work for some (but not all) longer-range projects that are on the drawing boards for later years, beyond the end of the 2011-14 funding cycle.

To determine needs for major widenings and new road projects, we first reviewed the STIP for major bypasses, new roads, new bridges and similar actions. We also reviewed the long-range plans of the 14 urbanized areas and contacted each MPO to identify major projects in their plans that are beyond the STIP in time but are likely to be progressed in the next 10 years. We also reviewed the project lists of the Wisconsin Transportation Projects Commission and other sources for large statewide projects that might be initiated in the next 10 years. We also added several projects recently proposed or potentially on the list.

Most projects that involve expansion also need other improvements such as pavement repairs, bridge work, lane width, shoulder work, and other actions. Therefore, expansion projects should have their costs reduced somewhat to account for this 'overlap' work which we have

already considered above. In addition, not all major new or expansion projects are on the State Highway System (although most are) and some projects are not scheduled for action until after 2020, our 10-year horizon. Adjusting for these reductions is necessary for consistency. To account for these concerns, we reduced the estimated cost of these projects by 20-50%, depending on circumstances. However, we did not eliminate all projects since some are clearly new roads on new alignments or similar, and as such constitute system additions. The Appendix to this report contains the complete list of major projects for each region, and describes in detail the cost adjustments for these considerations.

Table 22 is a summary of these findings for each region and for other statewide projects. Including several recent announcements (most recently, the Governor's \$1.5 B proposal to upgrade 142 miles of US 41 to Interstate status⁴³), about 809 additional miles of major projects are planned for the 2011-20 time frame. Adjusting for overlap in work categories, state ownership and the 10-year horizon, **about \$2.278 B in the 2011-14 time period and about \$5.498 B in the 2015-20 time (about \$7.776 B total) is needed for the State's share of additional major projects over the next decade.**

Table 22: Major New and Expansion Needs, Wisconsin State Highway System, 2011-2020

Region	Total Length, 2011-20 Projects	2011-14 BASE YR Costs	2011-14 Cost Adjusted for Infl + Overlap	2015-20 BASE YR costs	2015-20 Cost Adjusted for Infl + Overlap	2011-20 Cost Adjusted for Infl + Overlap	2020+ BASE Yr Costs	2020+ Cost Adjusted for Infl + Overlap
Duluth-Superior	25.0	\$41.5	\$17.2	\$28.6	\$8.3	\$25.4	\$0.0	\$0.0
Beloit	1.5	\$5.0	\$1.3	\$10.0	\$2.9	\$4.2	\$0.0	\$0.0
Janesville	18.1	\$70.7	\$66.9	\$13.6	\$9.5	\$76.4	\$225.0	\$295.8
Dubuque IA	No major projects in Wisconsin							
Chippewa-Eau Claire	5.0	\$0.0	\$0.0	\$17.7	\$8.2	\$8.2	\$11.7	\$1.7
Wausau	6.2	\$20.4	\$13.3	\$9.6	\$9.4	\$22.8	\$4.1	\$5.0
La Crosse	18.6	\$129.6	\$91.8	\$133.8	\$117.5	\$209.3	\$0.0	\$0.0
Oshkosh	19.5	\$90.1	\$64.4	\$23.7	\$23.0	\$87.3	\$50.8	\$42.8
Fond du Lac	6.0	\$0.0	\$0.0	\$61.4	\$21.2	\$21.2	\$25.0	\$29.1
Appleton	19.5	\$31.0	\$19.4	\$0.0	\$0.0	\$19.4	\$150.0	\$188.8
Sheboygan	13.1	\$30.4	\$14.3	\$10.5	\$0.0	\$14.3	\$18.2	\$9.8
Madison	20.2	\$97.5	\$57.4	\$55.2	\$10.9	\$68.4	\$10.0	\$11.1
Green Bay	26.5	\$382.7	\$232.4	\$10.5	\$3.1	\$235.5	\$128.0	\$84.9
SE Wisc RPC	97.1	\$1,215.2	\$916.9	\$2,320.9	\$2,123.7	\$3,040.7	\$5,201.5	\$4,390.2
(Subtotal-MPOs)	276.3	\$2,114.1	\$1,495.4	\$2,695.5	\$2,337.8	\$3,833.1	\$5,824.3	\$5,059.2
State Transp Proj. Commission	317.1	\$1,206.8	\$782.2	\$350.6	\$287.9	\$1,070.1	\$0.0	\$0.0
(recd for adding 2011)	70.0	\$0.0	\$0.0	\$1,355.0	\$1,009.2	\$1,009.2	\$0.0	\$0.0
St Croix Br + US 41 Upgrade to Int'ste	146.0	\$0.0	\$0.0	\$1,800.0	\$1,863.9	\$1,863.9	\$0.0	\$0.0
	533.1	\$1,206.8	\$782.2	\$3,505.6	\$3,161.0	\$3,943.2	\$0.0	\$0.0
Grand Total	809.4	\$3,320.9	\$2,277.6	\$6,201.1	\$5,498.8	\$7,776.4	\$5,824.3	\$5,059.2

Source: MPO long range plans and Wisconsin State Transportation Projects Commission. Adjusted for overlap with other categories. See Appendix for complete list.

An additional \$5.059 B in identified needs are beyond the 10-year time frame of our study. This is likely to be a low estimate since several of the state's regional plans and the State

Transportation Projects Commission do not show details sufficient to quantify that longer-range need. As these plans are updated, the needs beyond 2020 will become more apparent.

11. Other Needs

In addition to needs for major projects, pavement and bridge repairs, capacity needs and other items, the State Highway System is also regularly improved in smaller but important ways. These improvements include upgrades of individual intersections to provide turning capacity, traffic signals, railroad grade crossing improvements, replacements of signalized intersections with roundabouts, pedestrian crossings and bicycle paths/greenways, and park-and-ride lots.

It is not feasible in this study to review all local and statewide plans for such actions, and for the years 2015-20 it is likely that all such actions have not yet been identified. Therefore, to estimate the needs related to these actions we reviewed the STIP for cases and examples of these projects. We adjusted costs for inflation, and for an assumed continuation of program activity.

Table 23 summarizes the findings. The largest portion of these needs is for intersection upgrades, usually adding turning lanes and improved signals. About \$76 M is targeted for this work in the 2011-14 STIP, at an average cost of about \$1.2 M per intersection. Looking forward, the total is estimated at about \$219.5 M over 2011-20.

Wisconsin has also been active in installing roundabouts as substitutes for signalized intersections. About 9 listed cases totaling \$15.2 M are in the current STIP, and if trends continue a total of \$43.7 M is likely to be spent on this activity in the next decade.

Table 23: Needs for Other Actions, \$M

	2011-14				2015-20		Total 2011-20
	Number of Cases	STIP Total Cost, \$M	STIP Ave Cost per Case, \$M	Inflated Total Cost, \$M	Number of Cases	Inflated Total Cost, \$M	Total for 2010-20
Intersection Upgrades	62	\$ 76.32	\$ 1.23	\$ 80.7	93	\$ 138.9	\$ 219.5
Roundabouts	9	\$ 15.20	\$ 1.69	\$ 16.1	14	\$ 27.7	\$ 43.7
Bike-Ped-Park/Ride	10	\$9.65	\$ 0.97	\$ 10.2	15	\$ 17.6	\$ 27.8
Intersection Signals	10	\$ 6.07	\$ 0.61	\$ 6.4	15	\$ 11.1	\$ 17.5
Railroad Xing Signals	13	\$ 2.02	\$ 0.16	\$ 2.1	20	\$ 3.7	\$ 5.8
Totals	104	\$ 109.27	\$ 1.05	\$ 115.5	156	\$ 198.8	\$ 314.3

Source: Wisconsin 2011-14 STIP.

Additional improvements for bicycle-pedestrian-park & ride actions are estimated to total about \$ 27.8 M, improved intersection signaling (without roadwork) about \$ 17.5 M, and railroad grade crossing signaling about \$ 5.8 M.

All total, **needs for these other actions that improve system quality are estimated to be about \$ 314 M over the next decade.**

11. Administration

In addition to specific repair and expansion costs, there are also needs for administration and planning of agency programs. Federal rules for reporting administrative expenditures indicate that the costs should be only the *non-project* agency administrative costs *related to the*

State Highway Program. The primary costs included are for general administration, non-project planning, general data gathering and research. Excluded are administrative costs for other functions such as motor vehicles or non-highway modes, engineering costs (which are mostly project specific) and maintenance costs.

We used the Highway Statistics tables from the Federal Highway Administration (specifically, Table SF4 and SF4C), to analyze administrative costs. This is data submitted by each state to FHWA and reflects each state's assessments of expenditures by category. Unfortunately the data is from 2008 at the latest. We used the 2% annual growth rate proposed in the 2011-13 Wisconsin State Budget to forecast these amounts; this leads to a 6% average growth for the period 2011-14, and a 16% average growth for the period 2015-20.

Table 24 summarizes the findings. Over the past decade, WisDOT reports that administrative costs have increased to about \$161.7 M in 2008, at that time about 7% of the budget. Some of that cost (about \$66 M) was paid from highway rehabilitation and maintenance programs⁴⁴. Going forward, **about \$1.811 B will be needed to administer the State Highway System over the next decade.**

Table 24: Administrative-Planning-Research Needs, 2011-2020, \$M

	2000	2004	2008	2011-14*	2015-20**	Total, 2011-20
Admin-Planning-Research	\$ 122.98	\$ 153.39	\$ 161.69	\$ 685.5	\$ 1,125.3	\$ 1,810.9

Source: WisDOT as reported In FHWA Highway Statistics, Table SF4 and SF 4C.

*Ave 6% growth over 2008 (2%/year) **Ave 16% growth over 2008 (2%/year)

This analysis assumes no major changes in the size of the department staff or its responsibilities, modest increases in agency administrative costs, but also no additional growth in these costs for possible increased activities. In other words, it assumes a somewhat leaner agency administrative function in the future.

12. Total Needs

Summarizing the separate sections above, Table 25 indicates that **the total need for the Wisconsin State Highway System over the next decade is estimated at about \$28.56 B.** As noted in the various sections, this need is not the maximum need, nor a cut-down estimate, but rather an estimate of what might prudently be accomplished applying design standards along with some limitations on work completed. If the incremental widening costs of two major Interstate widening projects in Milwaukee (about \$431 M) are excluded the estimate is about \$28.15 B.

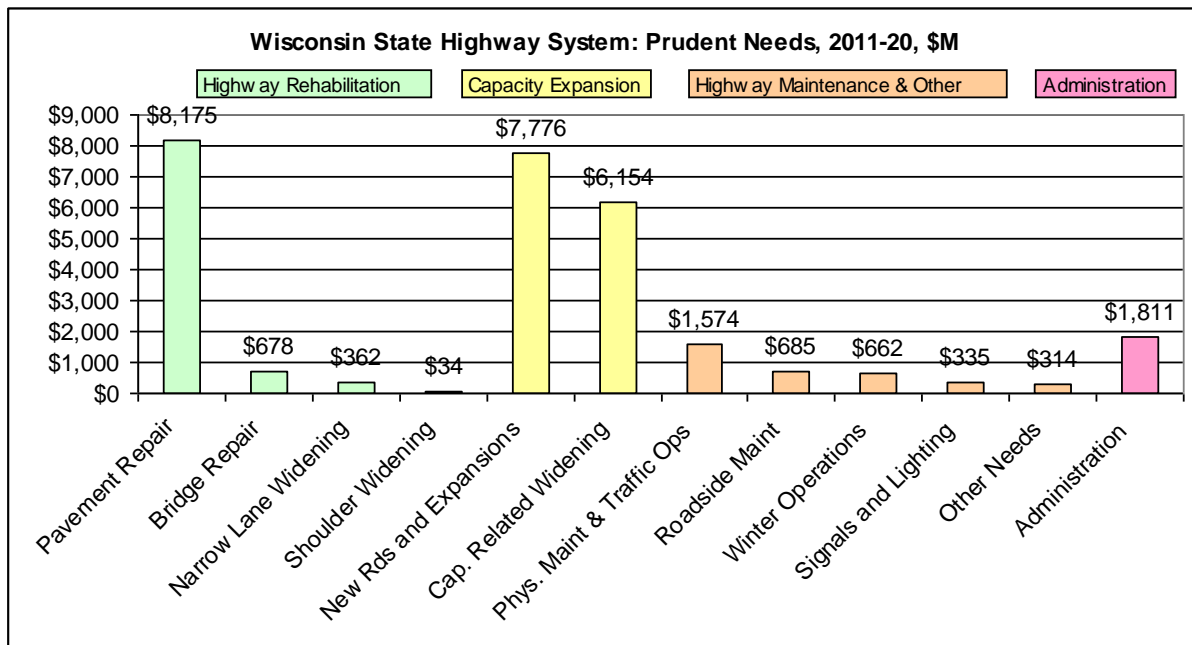
Table 25: Summary of Needs, Wisconsin State Highway System, 2011-2020

Category	Units	Unit Need Count	2011-14		2015-20		2011-2020	
			Units Addressed	Inflated Cost, \$M	Units Addressed	Inflated Cost, \$M	Units Addressed	Total Inflated Cost, \$M
Highway Rehabilitation								
Pavement Repair	Miles	8,208	2,462	\$3,003	3,693	\$5,172	6,156	\$ 8,175
Bridge Repair	Bridges	4,885	1,013	\$249	1,519	\$429	2,532	\$ 678
Narrow Lane Widening	Lane-Miles	710	170	\$133	255	\$229	425	\$ 362
Shoulder Widening	Foot-Miles	12,921	1,655	\$13	2,482	\$22	4,137	\$ 34
Subtotal		26,724	5,300	\$3,398	7,949	\$5,851	13,250	\$ 9,249

Capacity and Expansion								
New Roads/Expansions	Miles	809	485	\$2,278	324	\$5,499	809	\$ 7,776
Cap. Related Widening	Miles	615	133	\$2,261	200	\$3,894	333	\$ 6,154*
Subtotal		1,424	618	\$4,539	524	\$9,392	1,143	\$ 13,931
Maintenance and Other								
Phys. Maint & Ops				\$596		\$978		\$ 1,574
Roadside Maintenance				\$251		\$433		\$ 685
Winter Operations				\$243		\$419		\$ 662
Signals and Lighting	Sites	2,008	260	\$123	390	\$212	650	\$ 335
Other Needs	Cases	260	104	\$115	156	\$199	260	\$ 314
Subtotal		2,268	364	\$1,329	546	\$2,241	910	\$ 3,570
Administration				\$686		\$1,125		\$ 1,811
Total, Prudent Needs		30,416	6,283	\$9,951	9,020	\$18,609	15,303	\$ 28,560*
Total, Less I43 and I94, Milwaukee				\$ 9,951		\$ 18,178		\$ 28,147*

Highway rehabilitation needs total about \$9.25 B, of which the largest share is for pavement repair, \$8.18 B. Capacity needs and other expansions are estimated to need about \$13.93 B, of which new roads and expansions total about \$7.78 B and capacity needs total about \$6.15 B. Maintenance and other needs total about \$3.57 B, of which the largest amount is for physical maintenance. Administration totals about \$1.81 B, about 6.3% of the total. The three largest sub-categories of need are pavement repairs (\$8.2 B), major new projects (\$7.8 B) and capacity-related widening (\$6.2 B). These three categories are about 77% of all prudent needs. Figure 20 summarizes the needs in graphic form.

Figure 20: Summary of Needs, Wisconsin State Highway System, 2011-2020



C. Resources Available

In the above sections, we have developed an estimate of prudent repair and system expansion needs for the Wisconsin state-owned highway system over the next decade. In this section, we estimate the funds likely to be available, from all sources, to meet these needs.

1. Federal Funds

Although federal funds account for only about 1/3 of all State Highway System road expenditures nationally, all states rely extensively on the federal government to provide funds for repair and expansion of major roads. Most federal funds are distributed to the states annually using formulas developed by Congress periodically in major transportation funding initiatives (“authorizations”) that are funded annually (“appropriations”). The major funding categories and their allocation criteria are:

- *Interstate Maintenance;*
- *National Highway System;*
- *Surface Transportation Program;*
- *Highway Bridge Rehabilitation and Restoration;*
- *Congestion Mitigation and Air Quality.*

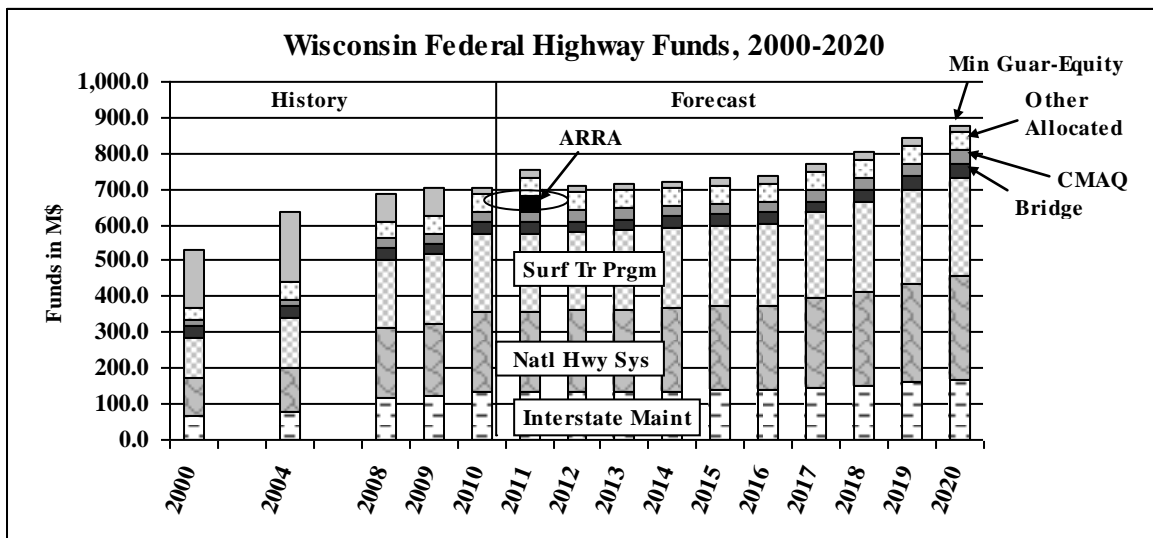
In addition to these major categories, states also receive funds for other purposes including high-priority projects and other allocations, and also receive adjustments for minimum funding and equity bonuses. A new category, ARRA⁴⁵ (Stimulus funds), provided additional funding for 2009 and 2010 but are scheduled to end in 2011, although some prior funds are still being spent. Considerable flexibility in funding decisions is also permitted so not all federal funds are spent on state-administered highways, and some are also spent for other modes. Wisconsin has traditionally been a ‘donor’ state, contributing more in federal highway dollars than it gets back, but in 2009 it was a ‘donee’ state, receiving about 4% more than it contributed (subtracting out general fund transfers)⁴⁶.

The current federal highway bill, known as SAFETY-LU, covered the federal fiscal years 2003-09 and expired on September 30, 2009. However, numerous factors have intervened to impede reauthorization. These include the current recession and improving fuel efficiency which have slowed revenues into the federal Trust Fund; no consensus about the future of the program and the appropriate federal role; and a reluctance to raise the federal gasoline and diesel tax rates, now 18.4 cents/gallon and 24.4 cents/gallon. As a result of these uncertainties, Congress has not yet addressed a comprehensive new highway funding program but has continued funding the current program through periodic continuation resolutions and several infusions of federal dollars. The last continuation, a 7-month extension to September 30, 2011, came on March 3, 2011. Although several national commissions⁴⁷ have studied the issue and have called for new sources of funding as well as a longer-term conversion to a per-mile tax, the new Congress with a more conservative inclination has yet to take action. The Obama Administration’s recent proposal for a \$556 B 6-year program and its earlier FFY12 \$50 B funding request has been met with considerable skepticism. Congress has signaled that future federal spending will be aligned with trust fund revenues from *existing* user fees, without further transfers from the General Fund⁴⁸. There is even a distinct possibility (perhaps even a probability) that federal highway dollars could *fall* if the economic recovery stalls or Congress cuts federal budgets sharply. The continuing FFY 2011 budget resolution passed by Congress on April 14, 2011⁴⁹ cut transportation funds for the remainder of FFY 2011, canceled some unused earmarks, and reduced transit and intercity rail funding. Another consideration is that Wisconsin’s share of the

federal total appears to be dropping slowly, from 2.26% in 2000 to 1.81% in 2008⁵⁰, as other states show faster growth in traffic, population and Highway Trust Fund contributions.

These considerations mean that forecasts of federal funds for Wisconsin are likely to show only modest growth. Table 26 reflects that by forecasting only a modest increase in federal funding for the State Highway System for 2011-14 and a slightly higher forecast for 2015-20. Figure 21 shows the forecast for federal funds. However, since this assessment is largely based on assumptions concerning how Congress is likely to deal with transportation issues in the next several months, it should be reviewed periodically.

Figure 21: Wisconsin Federal Highway Funds, 2000-2020



However, not all federal highway funds are spent on state-administered roads; some goes to local roads, to locally-owned bridges, and to other non-road projects. Reviewing the SFY 2009-10 State Budget, we estimate that about \$605 M in federal funds was spent on the State Highway System. However for SFY 2010-11, we estimate that that number is less, about \$534 M, and will remain at that level through SFY 2013-14. Beyond that, we have assumed a very small increase in federal funds, about 1%/year, through 2017, when (hopefully) yet another federal highway bill will permit a modest increase of 5%/year through 2020.

2. State and Local Funds

In addition to federal funds, each state also has its own highway-related revenues. Most states rely primarily on motor fuel taxes, vehicle registration fees bonds, tolls, bonds, direct appropriations and federal funds for most of their highway-related revenues. However, Wisconsin’s state fuel tax (30.9 cents/gallon) and vehicle registration fees are also used for other purposes (39% goes to local roads and streets, 8.3% to transit support, and 16.7% to general fund and non-highway uses⁵¹). Therefore, only about 35.9% of these sources go to the State Highway System. As a result, only about 34% of the State Highway System funding comes from user fees. Wisconsin has no toll roads, but does have a modest bonding program.

Forecasts of likely resources for the State Highway System are based on data from the Wisconsin State Budget for SFY 2011-13, as proposed in February 2011. Table 26 summarizes the key portions of the budget dealing with the State Highway System; the Appendix to this

report identifies the exact items⁵². According to the Budget, for SFY 2009-10 about \$1.371 B was spent for 'state highway facilities'. To that we added portions of the 2009-10 Budget dealing with general administration and operations (\$112 M), the 'safety and enforcement' (state police, truck weights, etc.) portions of motor vehicle and licensing functions (\$73M) and debt service (\$104 M). For SFY 2009-10 these resources totaled about \$1.661 B, and \$1.656 B in SFY 2010-11.

For future years the State Budget forecast for 2011-13 assumes modest growth in state highway system funding as the economy improves. Our view is not quite so optimistic, since slowing federal revenues, improving vehicle fuel efficiency, modest state population growth rates and (most recently) rising gasoline prices all suggest slow growth (or possible decline) in the primary revenue sources. But Wisconsin's state fuel taxes constitute only about 22% of its State Highway System funding⁵³, so even a 5% decline in fuel consumption between 2011 and 2020 would translate to about a 1% reduction in total program resources. This amount is below the accuracy of our other estimates. Therefore, we have elected instead to use the state's projection of state resources for 2012-13. Using the same procedures as above, this works out to \$1.757 for SFY2011-12 and for SFY 2012-13. Beyond that, we assume a modest rise, about 2%/year, through 2017-18, then a bit more rapidly to 2020. We assumed more modest growth or flat projections for general transportation operations, law enforcement and safety, and debt service. These forecasts may turn out to be optimistic: a recent WisDOT estimate forecasts a 2.4% decline in motor fuel revenues but a 2.0% increase in vehicle registration revenues, with the two together estimated at -1.2% between 2010 and 2020⁵⁴.

Consolidating these forecasts, we estimate that Wisconsin resources for the State Highway System are likely to grow modestly, from about \$1.656 B in SFY 2010-11 to about \$2.144 B in 2019-20. **Over the 10-year period 2011-2020, about \$18.63 B in resources is reasonably likely to be available.**

Table 26: Revenue Sources, Wisconsin State Highway System, 2011-2020

Million\$	Wisconsin State Budgets		2011-13 Wisconsin State Budget		Forecast							Sum for 2011-14	Sum for 2015-20	Sum for 2011-20
	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2010-11 thru 2013-14	2015-20	2011-20
Program														
Aids, Highway														
Federal funds	2	2	2	2										
State + Service funds	431	441	441	441										
Local funds	0	0	0	0										
Subtotal	432	443	443	443										
Local Transportation Assistance, Highway														
Federal funds	128	115	115	115										
State + Service funds	32	31	31	31										
Local funds	52	52	52	52										
Subtotal	212	199	199	199										
STATE HIGHWAY SYSTEM														
State Highway Facilities														
Federal funds	577	507	507	507	512	517	522	527	533	679	713	2032	3492	5524
State + Service funds	791	840	944	944	963	982	1001	1022	1042	1063	1084	3690	6194	9884
Local funds	4	4	4	4	4	4	4	4	4	4	4	16	23	39
Subtotal	1371	1351	1454	1454	1478	1503	1528	1553	1579	1746	1801	5738	9709	15447
General Transportation Operations														
Federal funds	14	14	14	14	15	15	15	15	15	19	20	58	99	157

State + Service funds	97	98	99	99	101	103	105	107	109	111	114	397	649	1045
Local funds	0	0	0	0	0	0	0	0	0	0	0	1	2	4
Subtotal	112	113	114	114	116	118	120	122	125	131	134	456	751	1206
Motor Vehicle Law Enforcement and Safety														
Federal funds	13	12	12	12	12	13	13	13	13	17	17	49	85	134
State + Service funds	60	61	62	62	63	64	66	67	68	70	71	248	406	654
Local funds	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	73	73	74	74	76	77	78	80	81	86	88	297	491	788
Debt Service (principle repayment plus interest)														
Subtotal	104	120	115	115	120	120	120	120	120	120	120	469	720	1189
STATE HIGHWAY SYSTEM TOTAL														
Federal funds	605	534	534	534	539	544	550	555	561	715	751	2140	3676	5816
State + Service funds	948	999	1104	1104	1127	1149	1172	1195	1219	1244	1269	4334	7248	11583
Local funds	4	4	4	4	4	4	4	4	4	4	4	17	26	43
Debt Service (all State money)	104	120	115	115	120	120	120	120	120	120	120	469	720	1189
Total	1661	1656	1757	1757	1790	1818	1846	1875	1905	2083	2144	6960	11670	18631
% Federal	36.4	32.2	30.4	30.4	30.1	29.9	29.8	29.6	29.4	34.3	35.0	30.7	31.5	31.2
% State	57.1	60.3	62.9	62.9	62.9	63.2	63.5	63.8	64.0	59.7	59.2	62.3	62.1	62.2
% Local	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
% Debt Service	6.3	7.2	6.5	6.5	6.7	6.6	6.5	6.4	6.3	5.8	5.6	6.7	6.2	6.4
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Wisconsin State Budget Request, 2011-13, Department of Transportation, February 2011. See Appendix for details.

This assessment of likely resources is dependent on several key factors that are uncertain. Noted above is the uncertainty of federal funding, which could be significantly lower than estimated if Congress determines that government-wide budget cuts are needed, or if Congress passes a more conservative highway bill. A second major uncertainty is the national trend in motor fuel use, which most analysts believe to be slowing (perhaps even declining) as vehicles become more efficient. A third factor is the ability of the state to get ahead of deterioration and complete necessary repairs on the southeastern Wisconsin road system on time and at predicted costs. All of these concerns would increase costs or lower revenues, widening the gap.

D. Gap between Resources and Needs

Estimation of the “gap” between resources likely to be available and prudent needs is of course an exercise based on a series of assumptions. There is no one estimate of the “gap” but many that depend on the underlying assumptions. Using the assumptions outlined in this report, Table 27 indicates that **over the next 10 years the gap between resources likely to be available and prudent needs is about \$9.93 B, or about \$993 M per year.** If the widenings of I 43 and I94 in Milwaukee are deleted, the gap would be about \$9.52 B, or about \$952 M per year.

Table 27: Comparison of Needs and Resources, \$M

Resources, \$M, 2011-20		Needs, \$M, 2011-20	
		Highway Rehabilitation	\$9,249
Federal Funds	\$5,816	<i>Pavement Repair</i>	\$8,175
State Funds and Services	\$11,582	<i>Bridge Repair</i>	\$678
Local Funds	\$43	<i>Narrow Lanes</i>	\$362
Bonding/Debt Service	\$1,189	<i>Narrow Shoulders</i>	\$34
		Capacity and Expansion	\$13,931
		<i>New Roads and Expansions</i>	\$7,776
		<i>Capacity-related Widening</i>	\$6,154*
		Maintenance and Other	\$3,570
		<i>Physical Maintenance/Ops</i>	\$1,574
		<i>Roadside Maintenance</i>	\$685
		<i>Winter Operations</i>	\$662
		<i>Signals and Lighting</i>	\$335
		<i>Other Needs</i>	\$314
		Administration	\$1,811
Total	\$18,630	Total	\$28,560*
		<i>*Total less I 43 Mitchell-Silver Spring and I 94 Marquette-Zoo, Milwaukee</i>	\$28,147*
Gap \$ 9,930		Gap/year \$ 993 M	
<i>Gap* \$ 9,517</i>		<i>Gap*/year \$ 952 M</i>	

Our estimate of the gap, averaging \$993 M per year, suggests an increasing shortfall compared to earlier studies – i.e. a \$242 M per year gap estimated in 2000 and a \$589 M per year gap estimated in 2006. If fuel-related resources decline sharply this gap could be even greater. Clearly this increasing trend should be cause for concern.

In summary the analysis finds that expected resources are likely to cover only about 65% of the prudent highway needs over the next 10 years. But even if all major new projects were deferred, or if all capacity-related widening were deferred, a gap of between \$2.1 B and \$3.8 B would still remain in meeting the needs for prudent pavement and bridge repairs, maintenance, signals, shoulders and other actions.

III. Discussion

This report finds that the prudent need for maintenance, repairs, expansions and related activities to support the Wisconsin State Highway System is about \$28.56 B over the next 10 years, compared with likely resources of about \$18.63 B. Therefore, the gap between likely resources and prudent needs is about \$9.93 B, or about \$829 M per year. The magnitude of the shortfall appears to be increasing.

This assessment does not consider local roads or other modes. These systems are also important not only because they support the State Highway System in providing access and mobility, but also because their sound condition is also a key element of quality of life. Review of the prudent needs and likely resources for these other systems should also be undertaken.

An additional consideration is that many of the assumptions made in this study have the effect of lessening need or raising resources and thus lowering the gap between resources and needs. We purposely did not consider all needs for the State Highway System, instead identifying *prudent* needs that might realistically be met over a decade. Had we included all needs for all repairs, the total would have been substantially higher. Similarly on the resources side, we considered the resources likely to be *realistically* available over the coming decade, assuming no major changes in state funding mechanisms and a cautious view of federal resources. This approach has the effect of perhaps over-estimating resources since some of these assumptions (particularly those regarding state fuel taxes and federal funds) may be optimistic. Therefore, it is possible that our assessment under-estimates the gap between resources and needs.

Closing a gap of this magnitude would be a significant challenge even with more resources, but given the state's present fiscal circumstances is even more daunting. It is beyond the scope of this study to evaluate or recommend specific means of dealing with this issue; indeed, a study of various approaches and their suitability for Wisconsin would be extensive in its own right. However, it is appropriate for us to make general observations regarding the basic options.

First among those are, of course, actions to *raise more revenue*. These include actions such as:

- *Use more of state road revenues for state roads.* One option of course is to use more of the state's road-user fees and registration fees for state-owned roads. But this would of course increase the pressure on funding other activities now funded with those revenues: local roads, transit, and other purposes. These needs of these systems are also substantial.
- *Increasing user fees* such as the state fuel tax rate and registration fees, with possibly dedication of increased revenues to state roads. These rates are comparable but in some cases higher than in other states. However, even significant increases in them might not raise enough revenue. Further, they directly impact people's pocketbooks and are likely to be unpopular. A newer idea, mileage-based fees, is also being widely discussed as a potential new (or replacement) form of user fee, but most analysts judge it infeasible for single states.
- *Bonding* is another option that might be attractive with current low interest rates. In recent years many states have increased bonding activities to take advantage of various federal programs such as GARVEE bonds and Build America Bonds, or lines of credit such as TIFIA. Wisconsin's bonding program is modest compared to many

states but bonding also passes debt to future generations that will have their own needs too.

- *Public-private-participation* and *tolls* as a revenue stream are also options. PPP initiatives have been used in many recent major road projects throughout the US, but they generally cover only major projects. Tolls do not increase revenues but merely allow for a mechanism to pay back an investment made by other means. They are also generally applied in unique situations where the benefits of tolling and their revenues clearly relate to specific projects.
- *Congestion pricing*, a form of tolling in which toll rates vary by congestion level, has also been tried in a few very large regions, but there is uncertainty about their applicability to other cities.
- *Increased federal funds* or other national resources are also a possibility, but we judge that major increases are unlikely in the current national fiscal environment, and there might be a significant decrease instead.
- *State infrastructure banks* or other mechanisms can improve the ability of localities to fund local road needs, thus reducing pressure on state resources.

Another basic approach is to *lower needs*. Although we have made what we consider a prudent estimate of needs by not addressing all needs, one might go further:

- *Restricting project selection*, for instance by increasing priority for projects that show higher user and non-user economic benefits of projects or create new jobs and economic activity. This would mean evaluating projects head-to-head across the state.
- *Raising the criteria for treatment*. For instance, tightening the criteria for road widening and allowing congestion to worsen above the current state standards would in effect delay some capacity-related widening. In response, drivers might shift times of travel, use ridesharing or transit, combine trip purposes or even change destinations. But this means lowering public expectations for when treatment is needed and what to do about it.
- *Lengthening repair cycles* is an option, but can result in greater costs later when more extensive work is required. Additionally, many of the state's higher-volume roads have conditions that already warrant action and cannot be delayed much longer.
- *Lowering demand* for road capacity and new roads through such actions as improved transit service, carpool and HOT lanes, flexible work hours, better traffic operations and controls and similar actions are also possible actions if undertaken in a cost-effective manner. But as traffic continues to grow they often provide only interim relief.
- *Privatizing maintenance and other functions* such as engineering can have some effect on costs, but are unlikely to be large enough in and of themselves to significantly reduce overall needs, and might not even reduce costs in the long run.
- *Implementing interim measures* such as partial widenings, one-side climbing or truck lanes, partial intersection treatments, bottleneck removals, better incident response and better traffic operations are also options that can be cost-effective as well as delay the need for major work.
- *Restricting access* for improved roads is a means of retaining the public's investment in road capacity longer.
- *Reducing maintenance* is also an option but usually results in greater needs later.

- *Stretching out new investments* for road expansions and widenings is another option, but this delays some improvements that could benefit the state's economy.
- *Shifting cost responsibility* to other governments or to the private sector is also an option, but does not reduce the total need and is judged less feasible.
- *Speeding up road improvements* through accelerated environmental review, design-build and other fast-track construction can also lower costs by reducing the effect of inflation and delivering user benefits faster.
- *Designing roads to last longer*, sometimes called 'European' construction, and performance-based contracting can lower costs over the longer term.
- *Innovative contracting*, such as using design-build, project performance warranties, construction incentives and penalties, and similar options are also ways of dealing with rising costs.

Some of these options also have geographic implications since their impacts would probably not be uniform throughout the state. This brief overview of various approaches is not intended to be definitive for Wisconsin, but merely touches on the most frequently mentioned approaches. Review of such options and their applicability to Wisconsin is a significant study in its own right.

This report identifies significant issues regarding the future of Wisconsin's State Highway System. It finds that Wisconsin's 10-year needs for the State Highway System significantly exceed its likely resources and that this shortfall appears to be growing. Therefore, serious attention by elected and appointed officials to this issue is timely.

Continuing efforts to accurately monitor and estimate future costs and revenues of highway services in Wisconsin are essential to assure that discussions about future transportation needs are based on solid information. This should include accurate estimates of revenue yields from various present and potential resources as well as assessment of standards and criteria for transportation investment. If this report increases discussion and assists with activities intended to address this issue, then the authors will have achieved their objective.

Appendices

County Data

The following table provides basic information on the condition of Wisconsin's State Highway System at the *county* level. The source of this information is the WisDOT Roadway Inventory File, the National Bridge Inventory, and the WisDOT Signal Site File.

Table C1: Wisconsin State Highway System County Statistics

WisDOT Region	Wisconsin County	Total Roadway Miles	Miles Needing Pavement Repair	Shoulder-Miles Needing Wider Shoulders	Lane-Miles Needing Lane Widening	Roadway Miles Needing Capacity Widening	Count of Signal and Light Sites	Count of Special Markings	State-owned Bridges Total	Count of Bridges with Est. Repair Cost
NC	ADAMS	92.8	70.0	27.2	0.0	0.0	7	73	7	0
NC	FLORENCE	67.9	24.1	34.7	6.7	0.0	0	7	8	0
NC	FOREST	152.6	42.7	114.2	0.0	0.0	2	10	11	0
NC	GREEN LAKE	70.2	47.4	37.0	0.0	0.0	4	53	10	0
NC	IRON	115.0	39.4	91.3	0.0	0.0	3	15	18	2
NC	LANGLADE	145.1	90.7	105.2	6.6	0.0	2	10	10	1
NC	LINCOLN	186.2	77.1	57.7	0.2	0.0	10	24	50	7
NC	MARATHON	376.7	224.1	116.3	9.7	4.8	52	316	143	14
NC	MARQUETTE	111.3	68.9	6.3	0.2	0.0	3	37	35	0
NC	MENOMINEE	40.7	14.3	75.4	0.0	0.0	0	0	3	0
NC	ONEIDA	181.9	41.0	33.7	15.5	0.0	32	101	14	2
NC	PORTAGE	231.8	65.1	57.7	10.8	3.3	17	271	78	1
NC	PRICE	155.6	75.8	103.8	7.5	0.0	4	16	20	3
NC	SHAWANO	237.9	96.2	75.6	1.4	0.7	5	21	19	2
NC	VILAS	136.1	59.8	59.8	1.2	0.0	11	34	11	0
NC	WAUPACA	237.7	99.5	124.2	6.6	3.8	9	238	62	11
NC	WAUSHARA	154.7	74.9	35.6	0.0	0.1	7	117	21	1
NC	WOOD	206.5	117.6	80.8	4.7	0.0	11	138	49	7
NC Total		2900.6	1328.4	1236.5	71.0	12.6	179	1481	569	51
NE	BROWN	291.4	213.2	33.3	29.4	9.1	111	222	217	12
NE	CALUMET	103.4	62.8	2.6	0.0	0.0	19	64	12	1
NE	DOOR	124.7	54.0	74.5	3.5	0.2	16	182	9	0
NE	FOND DU LAC	256.6	119.8	73.5	2.8	5.9	29	252	70	11
NE	KEWAUNEE	64.3	13.8	8.6	0.0	0.0	2	7	18	1
NE	MANITOWOC	206.0	163.3	14.0	6.4	0.6	44	229	89	9
NE	MARINETTE	178.9	76.0	38.8	4.9	0.9	12	34	26	2
NE	OCONTO	196.4	62.8	59.3	2.9	0.0	17	97	37	1
NE	OUTAGAMIE	226.9	126.6	107.1	6.8	7.2	100	371	79	6
NE	SHEBOYGAN	230.1	164.0	28.8	9.2	4.0	28	145	50	7
NE	WINNEBAGO	241.4	98.0	41.1	36.8	10.6	111	404	129	17
NE Total		2120.1	1154.2	481.6	102.8	38.5	489	2007	736	67
NW	ASHLAND	126.3	101.8	29.1	20.8	0.0	1	102	19	0
NW	BARRON	178.8	120.4	3.3	0.0	0.4	19	93	64	3
NW	BAYFIELD	155.7	77.8	42.1	7.5	0.0	5	19	34	0
NW	BUFFALO	148.3	75.7	123.0	12.3	0.0	4	29	71	12
NW	BURNETT	108.1	75.5	45.4	22.0	0.0	3	12	14	0
NW	CHIPPEWA	288.3	141.6	35.3	12.4	0.0	47	243	130	23
NW	CLARK	187.9	102.9	7.9	0.0	0.0	11	65	42	1
NW	DOUGLAS	217.6	140.4	16.0	17.2	0.1	25	169	62	1
NW	DUNN	240.6	137.3	64.8	1.2	0.6	15	151	88	9
NW	EAU CLAIRE	213.8	140.2	15.7	2.9	0.6	90	540	112	19
NW	JACKSON	230.4	139.0	35.0	0.0	1.0	6	82	73	8
NW	PEPIN	48.0	28.3	7.8	2.9	0.0	6	38	16	1
NW	PIERCE	165.0	102.3	61.1	11.3	0.0	20	111	56	5

NW	POLK	169.6	82.8	52.8	0.4	5.3	9	100	13	1
NW	RUSK	105.1	58.5	42.7	0.0	0.0	3	36	29	2
NW	SAWYER	162.3	86.6	27.4	0.0	0.0	5	26	79	8
NW	ST. CROIX	262.1	150.5	51.2	0.2	6.3	59	324	87	3
NW	TAYLOR	110.9	41.4	35.4	0.0	0.2	10	64	20	4
NW	TREMPEALEAU	182.3	85.1	53.2	0.0	0.5	9	95	74	7
NW	WASHBURN	175.5	113.9	16.6	0.0	0.0	8	42	20	1
NW Total		3476.5	2002.0	765.7	111.0	15.1	355	2341	1103	108
SE	KENOSHA	174.6	133.0	27.6	3.1	15.7	73	2	56	6
SE	MILWAUKEE	439.8	338.7	44.7	83.2	121.0	216	1	495	213
SE	OZAUKEE	130.9	87.3	10.3	2.6	5.0	34	6	50	2
SE	RACINE	220.0	137.2	43.3	29.1	19.8	77	11	47	5
SE	WALWORTH	295.2	206.4	99.9	19.7	4.2	23	4	115	9
SE	WASHINGTON	249.7	167.4	58.1	15.3	6.0	36	240	73	3
SE	WAUKESHA	368.2	251.3	81.7	22.0	44.7	177	33	170	37
SE Total		1878.5	1321.3	365.6	175.2	216.4	636	297	1006	275
SW	COLUMBIA	322.6	216.1	176.0	7.9	6.9	22	584	97	14
SW	CRAWFORD	182.3	135.6	145.2	7.5	2.1	8	10	64	11
SW	DANE	577.8	331.3	209.0	77.1	81.1	136	1245	284	55
SW	DODGE	275.8	133.4	45.6	2.8	1.7	16	520	63	10
SW	GRANT	282.5	145.3	116.0	5.0	0.4	4	36	66	10
SW	GREEN	133.0	98.7	71.9	11.5	0.0	2	174	28	1
SW	IOWA	202.4	114.4	144.8	0.6	1.7	7	204	56	3
SW	JEFFERSON	212.4	134.5	29.4	21.6	5.3	20	388	70	7
SW	JUNEAU	226.7	188.1	78.0	12.3	0.5	6	45	80	6
SW	LA CROSSE	210.1	149.1	122.0	14.4	18.4	32	26	103	15
SW	LAFAYETTE	138.6	50.4	88.4	1.4	0.0	1	98	41	2
SW	MONROE	292.6	160.9	102.9	1.8	0.7	13	95	154	10
SW	RICHLAND	157.2	101.0	96.6	0.0	0.0	7	32	76	4
SW	ROCK	314.7	169.3	178.8	41.9	2.6	30	487	115	25
SW	SAUK	255.3	145.4	135.8	7.1	4.3	41	684	100	10
SW	VERNON	214.7	128.5	199.5	0.5	0.3	3	59	74	2
SW Total		3998.7	2401.9	1940.0	213.6	125.7	348	4687	1471	185
	(blank)	37.8	0.0	38.8	36.4	0.0	1	0		
Grand Total		14412.2	8207.8	4828.2	709.9	408.3	2008	10813	4885	686

Technical Notes and Details

This brief technical appendix provides, in bullet form, additional information on the computation methods used in this report. Several additional key tables are also included.

Demographic and Travel Data

- Comparative highway statistics: source is Tables SF3, SF4, HM 61, and HM 42, Highway Statistics, 2008. Data are submitted annually by the States. Data include other state-administered systems, for instance toll roads, ferries, universities and parks, but these are a very small part of the total in Wisconsin.
- Economic and demographic data is from AASHTO Innovative Highway Financing website, various years, as reported in Highway Statistics. Sources are the State Highway Agencies.
- Urbanized area data: source is Highway Statistics, various years. Data for urbanized areas includes increased boundaries, as defined by the Census.

Pavement Repairs

- Mileage for pavements in various condition levels comes from WisDOT Roadway Inventory File (RIF), February 2011, representing 2010 conditions.
- For each road section, pavement roughness (IRI in ‘inches per mile’) is converted from IRI in ‘millimeters/kilometer’ reported in the RIF.
- Roadway file groupings are obtained from WisDOT 2009 Compass Report, using the 6 ‘Maintenance Road Groupings’, from the Compass Report. We use these road groupings throughout our work, since the study covers more than the SE Wisconsin area and many types of needs are being computed.
- For each roadway section in the RIF, the Maintenance Road Group is determined based on total ADT, as reported in the file, number of lanes (doubled for divided highways) and County (Milwaukee vs rest of state).
- Data are summed using pivot tables.
- For costs of road repairs we reviewed the 2011-14 STIP to determine average costs per mainline mile for various types of work. To obtain these we first calculated mid-point cost estimates (midway between ‘high’ and ‘low’ cost estimates in the STIP). We then identified only ‘mainline’ portions of projects since the STIP contains numerous contracts for the same location/job. We then computed average ‘mainline’ costs per centerline mile for projects for various types using pivot tables.
- These overall average costs (shown in **BOLD** in Table T1 below), range from a high of about \$73.4 Million/centerline mile for 6+ interstate reconstruction and expansion in Milwaukee County down to less than \$100,000/centerline mile for very light repairs. The remainder of Table T1 is then interpolated to other work types based on complexity and location.

Table T1. Unit Costs per Centerline Mile of Roadway Construction and Repair Activities, 2010 \$K

Order of Complexity	Potentially Required Pavement Treatment	STIP Concept Code	Unit Costs From STIP, \$K/center-line mile		
			Interstates	US-Numbered Highways	State-Numbered Highways
1.1	Do Nothing (annual maint work)	RDMTM	7 per yr	6 per yr	5 per yr
1.2	Crack Fill	RDMTM	150	75	75
1.3	Rut Fill	RDMTM	150	100	100
1.4	Seal Coat	RDMTM	267	256	247
1.5	Spot Repair (bituminous)	RDMTM	500	450	400
2.1	Surface Mill	RESURF	1000	900	800
2.2	Thin Overlay	RESURF	1164	750	862
2.3	Thin Overlay over PCC	RESURF	1500	800	900
2.4	Thick Overlay	RESURF	2000	850	900
3.1	Rubblize and Overlay	PVRPLA	2000	900	950
3.2	Partial Mill and Overlay	PVRPLA	2263	979	1034
3.3	Cold Recycle	PVRPLA	2500	1100	900
3.4	Full Depth Mill and Overlay	PVRPLA	2500	1200	900
7.1	Repair	RECOND	3000	1300	900
7.2	Repair and Grind	RECOND	3500	1400	900
7.3	Repair, Grind, and Thin Overlay	RECOND	4000	1575	927
7.4	Repair, Patch, Crack/Seat and Thick Overlay	RECOND	5000	2000	1500
7.5	Base Repair <= 5%, Spot Repair, Patch, Thin Overlay	RECNST	15000	3000	2000
7.6	Base Repair > 5%, Spot Repair, Patch, Thin Overlay	RECNST	19519	5222	3216
8.1	Reconstruct and expand	RECSTE	73442	30000	6639

- These costs are further disaggregated by traffic volume and region of the state as shown in Table T2 below.

Table T2. Unit Costs per Centerline Mile, 2010 \$K, by Treatment and Road Class

Order of Complexity	Potentially Required Pavement Treatment	Maintenance Road Class Letter Code and Description					
		2 Lane ADT<5K	2 Lane ADT>5K	4 Lane ADT<25K	4 Lane ADT>25K	6+Lane Other	6+Lane Expressway Milwaukee Co.
		F	E	D	C	B	A
1.1	Do Nothing (unit cost per mile per year)	3	5	6	7	10	10
1.2	Crack Fill	50	50	75	100	150	200
1.3	Rut Fill	100	100	100	150	200	200
1.4	Seal Coat	150	150	250	250	300	300
1.5	Spot Repair (bituminous)	300	400	400	500	500	600
2.1	Surface Mill	400	500	600	750	1000	1200
2.2	Thin Overlay	500	750	750	1000	1500	1500

Order of Complexity	Potentially Required Pavement Treatment	Maintenance Road Class Letter Code and Description					
		2 Lane ADT<5K	2 Lane ADT>5K	4 Lane ADT<25K	4 Lane ADT>25K	6+Lane Other	6+Lane Expressway Milwaukee Co.
		F	E	D	C	B	A
2.3	Thin Overlay over PCC	600	800	900	1000	2000	2000
2.4	Thick Overlay	600	800	1000	1100	2500	2500
3.1	Rubblize and Overlay	700	850	1100	1100	2500	2500
3.2	Partial Mill and Overlay	750	900	1100	1200	2500	3000
3.3	Cold Recycle	800	1000	1100	1500	2700	3000
3.4	Full Depth Mill and Overlay	800	1000	1100	1500	2700	3000
7.1	Repair	900	1000	1300	1750	3000	3500
7.2	Repair and Grind	900	1000	1400	1750	3500	4000
7.3	Repair, Grind, and Thin Overlay	1000	1000	1500	2000	4000	5000
7.4	Repair, Patch, Crack/Seal and Thick Overlay	1300	1500	2500	3000	6000	7000
7.5	Base Repair <= 5%, Spot Repair, Patch, Thin Overlay	1500	2500	3500	4000	1000	20000
7.6	Base Repair > 5%, Spot Repair, Patch, Thin Overlay	2000	3000	5000	5000	15000	25000
8.1	Reconstruct and expand	4000	5000	8000	10000	30000	75000

- After summaries were prepared we then expanded costs to account for non-mainline contracts, using the ratios of mainline letting contracts to all contracts for various work types. These typically average about 5-15% higher than the mainline contracts. We used the expansion factor provided by WisDOT, 1.3245⁵⁵.
- For forecasts, road cost summaries are then inflated by 1.0575 for the 2011-14 period, and by 1.213 for the 2015-20 period. This corresponds to an average of 2.8% annually, averaged over each time period.

Bridge Repairs

- Bridge condition data comes from the 2009 National Bridge Inventory, representing 2009 conditions (although some bridges would have been surveyed in 2008).
- For Wisconsin, 4,885 state owned bridges are extracted from the 13,800 bridges in the WI portion of the inventory.
- State-owned bridges are grouped by deck condition.
- For each bridge rated poor (rating = 4) or worse on deck condition, and for many other higher-rated bridges, the 'cost to repair' is a data item on the file. These are bridges typically rated 'deficient', for which costs to repair are needed for federal fund apportionment. We used Total Repair Cost (Item 96 in the file) which includes mobilization and approach work, as well as roadway and other costs. Bridge repair costs are then summed by deck condition using pivot tables.
- Average per-bridge repair costs are calculated for each deck condition level, and then multiplied by the percent to be repaired. This 'percent to be repaired' is higher than the percent of deficient bridges, since many bridges not rated deficient will also need work over the course of a decade.

- We did not expand bridge repair costs for additional costs such as engineering or contract adjustments. This is because federal guidelines call for the repair cost in Item 96 to include all costs in addition to those related to roadway and to bridge work, and in fact for most of the bridges in the Wisconsin file, total costs are about 10-15% higher than the sum of bridge and roadways costs. We therefore assumed that no additional expansion was needed.
- After summation, total costs are then inflated for the forecast years, using a factor of 1.0575 for the 2011-14 period and 1.213 for the 2015-20 period. This corresponds to an average of 2.8% annually, averaged over each time period.

Capacity-Related Widening

- Congestion data for roadway sections comes from WisDOT Roadway Inventory File (RIF), February 2011, representing 2010 conditions.
- We use the Level of Service (LOS) data field in the RIF, in conjunction with the thresholds noted in the WisDOT Facility Design Manual, to determine which links are in need of widening. However, this is a preliminary estimate based on just one congestion criterion.
- We sum the mileage of the links that need widening, and group them by Maintenance Road Group using pivot tables. Upon review of this analysis, WisDOT recommended slightly larger mileage for widening⁵⁶ based on additional criteria, so we used their revised numbers.
- Average costs per centerline mile to add capacity come from the various projects identified as Reconstruction and Expansion (RECSTE) projects in the 2011-14 STIP. We use costs as noted in Table T2 above.
- These costs are based on centerline miles, whereas ‘miles needing widening’ is based on roadways miles. We convert centerline miles to roadway miles using the ‘DIV or UNDIVIDE’ column in the WisDOT RIF, calculating the number of centerline miles from the roadway miles (centerline miles are half the roadway miles for divided highways, and the same as roadway miles for undivided highways and one-way facilities) and then determining the ratio of the two. The following table summarizes the data:

Table T3: Centerline/Roadway Mileage by Road Maintenance Group

Maintenance Group	1-lane	Divided	Undivided	Total	Centerline Miles	Centerline/Roadway Ratio
2L ADT<5K	63.41	55.2	6647.52	6766.13	6738.53	0.996
2L ADT>5K	40.91	107.66	2268.84	2417.41	2363.58	0.978
4L ADT< 25k	1.18	3209.30	178.89	3389.37	1784.72	0.527
4L ADT> 25k		1328.91		1328.91	664.46	0.500
6+Lane Expwy Milwaukee Co		105.79		105.79	52.89	0.500
6+Lanes, Other		404.61		404.61	202.31	0.500
Total	105.50	5211.47	9095.25	14412.22	11604.18	

- We used this ratio to convert centerline mile costs to roadway mile costs.
- We then expanded costs to account for non-mainline contracts, similar to Pavement Repairs above, using the expansion factor provided by WisDOT, 1.3245⁵⁷.

- Costs are then inflated for the forecast years, using a factor of 1.0575 for 2011-14 and 1.213 for 2015-20. This corresponds to an average of 2.8% annually, averaged over the time periods.

Narrow Lanes

- Lane width data for road segments comes from WisDOT Roadway Inventory File (RIF), February 2011, representing 2010 conditions.
- We use the 'Average Lane Width' data in the RIF file, in conjunction with the design standards in the WisDOT Facility Design Manual, to identify those road segments with lanes below standard width.
- We calculate the lane-miles needed to bring the lanes up to design width using 'Miles', 'Num Lanes', and links with a 'Narrow Lane Code', summing this data and grouping it by Maintenance Road Group, using pivot tables.
- Average costs per lane-mile to add capacity come from the Reconditioning (RECOND) costs in the STIP cost analysis, reduced proportionally by feet.
- We then expand costs to account for non-mainline contracts, similar to Pavement Repairs above, using the expansion factor calculated from the STIP analysis, 1.0259. We use this expansion factor rather than the one provided by WisDOT (1.3245⁵⁸) because these costs are relatively minor and have less external costs.
- Costs are then inflated for the forecast years, using a factor of 1.0575 for the 2011-14 time period and 1.213 for the 2015-20 time period. This corresponds to an average of 2.8% annually, averaged over the time periods.

Narrow Shoulders

- Shoulder width data for road segments comes from WisDOT Roadway Inventory File (RIF), February 2011, representing 2010 conditions.
- Using the shoulder types provided in the WisDOT RIF, we consider as eligible for widening only right-side shoulders of types 1-5. Left-side shoulders and shoulders with existing constraints (barriers, guard rails, curbs and gutters) are not considered.

Table T4. WisDOT Shoulder Types

Type	Definition
1	Not paved
2	PC concrete
3	Asphalt
4	Rumble strip - PC concrete
5	Rumble strip - Bituminous
6	Concrete barrier - s/f \leq 42" high
7	Concrete barrier - s/f $>$ 42" high
8	Concrete barrier - d/f \leq 42" high
9	Concrete barrier - d/f $>$ 42" high
10	Guard Rail
11	Cable Guard
12	Curb and Gutter
13	Continuous Left-turn Median (Left Shoulder)
15	Curb Only - NO GUTTER

- We use the Right Shoulder Width data in the RIF file, in conjunction with the design standards in the WisDOT Facility Design Manual, to determine which roadway have shoulders that are below standard.
- We calculate the eligible right-shoulder miles using the 'Miles', 'Div or Undiv', and 'Right Shoulder Type' columns. We sum this data, grouping it by county, using pivot tables.
- We calculate the eligible right-shoulder miles needing widening using the design standards, and the 'Right Shoulder Total Width' column. We sum this data, grouping it by county, using pivot tables.
- We calculate the foot-miles needed for each link to bring the right shoulder up to the design standard, and sum this data, grouping it by Maintenance Road Group, using pivot tables.
- We estimate average costs per foot-mile to add capacity using STIP data, data from the literature, and experience. Since these costs are relatively minor and have less external costs, we do not adjust for off-site or engineering costs.
- Costs are then inflated for the forecast years, using a factor of 1.0575 for the 2011-14 time period, and 1.213 for the 2015-20 time period. This corresponds to an average of 2.8% annually, averaged over the time periods.

Physical Maintenance and Operations

- Data on physical maintenance expenditures were obtained from FHWA Highway Statistics, Table SF4C, for Wisconsin 2000-08. This data was adjusted downward for winter maintenance. This data is submitted by the states to FHWA annually.
- For forecasting, an inflation of 1.06 was used for the 2011-14 time period, and 1.16 for the 2015-20 time period, assuming 2%/year) forecasts of growth of state expenditures.

Winter Maintenance

- Winter maintenance data comes from WisDOT 2009 Compass Report, January 2011, representing 2009 conditions, as well as a WisDOT Winterization Budget Report listing expenditures for selected winter operation items for 2006-2010.
- We use both data sources to determine the breakout of winter operations costs for 2010 and inflate this cost for each of the forecast years (2011-2010), using an average inflation factor of 2.8 % annually.
- We then aggregate the data into two forecast periods (2011-14 and 2015-20) to be in line with the other analyses.

Roadside Maintenance

- Roadside maintenance data comes from WisDOT 2009 Compass Report, January 2011, representing 2009 conditions.
- We use cost data for each of the four categories in Roadside Maintenance (shoulders, drainage, roadsides, traffic and safety (selected devices)) for 2010 and inflate this cost for each of the forecast years (2011-2010), using an average inflation factor of 2.8 % annually.
- We then aggregate the data into two forecast periods (2011-14 and 2015-20) to be in line with the other analyses.

Signals and Other Lighting

- WisDOT provided several key files documenting signals, the Roadway Lighting Inventory, containing data for about 2008 lighted sites (including signals), and a more detailed file containing data on signal head installations at each site. A separate paper listing was also obtained for signals showing their installation and revisited dates. In the files 1014 signal sites are identified (containing 16,211 signal heads for 915 sites).
- This data was summed using pivot tables and some hand tabulations.
- Each signal site contains several signal heads. A typical 4-leg rural intersection would have about 12-35 signal heads (green, yellow, red, turns, flashers, etc) arrayed facing each approach. Intersections on multi-lane roads typically have 35-60 signal heads.
- Estimates of the cost of signal replacement were obtained from separate email correspondence with WisDOT. These were extrapolated to estimate replacement costs at larger sites based on the number of signal heads per site. Older sites (those not recently visited) were assumed to have fewer signal heads per site.
- For forecasting, inflation factors of 1.057 and 1.213 were used for the periods 2011-14 and 2015-20, respectively (2.8% annually).

New Roads, Expansions, Major Bridges and Interchanges

- Preliminary lists of major capacity-adding and expansion projects were developed by reviewing the STIP for each MPO region.
- The long-range plans for each region were reviewed to identify potential projects beyond the STIP but are in the 2015-20 time period.
- Regional MPO staffs were contacted by phone to clarify the status of major projects and to identify recent changes from published long-range plans.
- Projects on the list of the Wisconsin Transportation Projects Review Board, including those recommended in October 2010, were added. Several projects were partially duplicated on the MPO lists; the costs for these were reduced accordingly. Two potential projects (the St. Croix bridge at Stillwater, and the Governor' recently announced (5/3/2011) proposed upgrade of US 41 to Interstate status) were added.
- After the draft project list was prepared, it was sent to MPOs and the state for review to ensure that no major projects have been overlooked. Some revisions were received, being primarily dates (typically further out in time) and costs (typically higher). Several projects completed in 2010 were removed.
- WisDOT comments suggested that some, perhaps all, such projects were essentially 'overlaps' with other work categories⁵⁹. Review of the list suggests that some projects are clearly on new alignments or are not otherwise accounted for. On the other hand, some projects are likely to have components (particularly capacity and pavement repair) that duplicate other needs. Therefore, to account for this possibility, the list was further refined as follows:

1. Costs for projects *partially* on the State Highway system were adjusted as follows:

Project not on SHS	0% SHS
County road with minor SHS	20% SHS
County road with one end on SHS	25% SHS

County road with both ends on SHS 50% SHS
 SEWRPC area: various arterials 80%-100% SHS

2. Reduce potential project costs to account for possible ‘overlap’ with other work categories, particularly capacity-related widening (covered in capacity widening) and reconstruction (would be covered in pavement repairs). The reduction to costs is as follows:

Reconstruction	50% of cost is ‘new’
Urban widenings	50% of cost is ‘new’
Urban widening+ interchange	60% of cost is ‘new’
Rural widenings	70% of cost is ‘new’
Upgraded interchange	70% of cost is ‘new’
Rural widen + partial expwy	80% of cost is ‘new’
Rural widen+ new bypass	80% of cost is ‘new’
Upgraded interchange	80% of cost is ‘new’
New interchange	100% of cost is ‘new’
Bypass (but no other work)	100% of cost is ‘new’
New facility on new align.	100% of cost is ‘new’
New bridge	100% of cost is ‘new’

3. All costs are updated for inflation, depending on the projected YOE (‘year-of-estimate’: year of completion) and the year of the Base Year cost estimate. The completion years are assumed to be the midpoint years (2013, 2017, and 2025). Inflation is assumed at 2.8%/year. The formulas for cost computation are:

$$\text{YOE Cost} = (\text{Base year cost}) * [1 + (0.028) * (\text{YOE year} - \text{Base year})]$$

$$\text{YOE Cost Adjusted for Overlap} = \text{YOE Cost} * (\% \text{ SHS}) * (\% \text{ new})$$

- The complete list, showing the reported ‘Base Year’ costs and the above adjustments, follows:

Table T5. New Roads, Expansions, Major Bridges and Interchanges, By Region

MPO area	Wisconsin County	Route or Name	From	To	Action Proposed	% St Hwy Sys	% NON-Overlap w. Other Work Category	Project Length	2011-14 BASE YR Cost	2011-14 YOE Cost, \$M, Adj for SHS & Non-Overlap	2015-20 BASE YR Cost	2015-20 YOE Cost, \$M, Adj for SHS & Non-Overlap	2020 + BASE YR Cost	2020 + YOE Cost, \$M, Adj for SHS & Non-Overlap
Duluth-Superior	Douglas	US 2	Bong Bridge		Rehabilitation	100	50	2	\$ 18.0	\$ 9.5	\$ -	\$ -	\$ -	\$ -
	Douglas	I-535	Blatnik Bridge ramps		Preservation	100	50	0.5	\$ 5.5	\$ 2.9	\$ -	\$ -	\$ -	\$ -
	Douglas	Tower Ave	Belknap	3rd St	Reduce 4L>2L		100	0.5	\$ 9.0	\$ -	\$ -	\$ -	\$ -	\$ -
	Douglas	US 2	US 53	CTH D	Recondition	100	50	5	\$ 9.0	\$ 4.8	\$ -	\$ -	\$ -	\$ -
	Douglas	CTH C	STH 35	MN line	Reconstruction	15	50	12	\$ -	\$ -	\$ 17.0	\$ 1.5	\$ -	\$ -
	Douglas	US 2	US 53	Belknap	Reconstruction	100	50	5	\$ -	\$ -	\$ 11.6	\$ 6.8	\$ -	\$ -
(TOTAL)								25	\$ 41.5	\$ 17.2	\$ 28.6	\$ 8.3	\$ -	\$ -
Beloit	Rock	Inman Ext	CTH G	Shopiere R	New 2-3L arterial	25	100	1.5	\$ 5.0	\$ 1.3	\$ 10.0	\$ 2.9	\$ -	\$ -
(TOTAL)								1.5	\$ 5.0	\$ 1.3	\$ 10.0	\$ 2.9	\$ -	\$ -
Janesville	Rock*	STH 26, ph2	CTH Y	Townline Rd	Widen 2L>4L	100	50	3.2	\$ 14.1	\$ 7.4	\$ -	\$ -	\$ -	\$ -
	Rock*	STH26, ph1	Townline Rd	CTH N	STH 59 interchange relocation	100	80	0.5	\$ 1.7	\$ 1.4	\$ -	\$ -	\$ -	\$ -
	Rock*	STH 26, ph3-4	Townline Rd	CTH N	New 4L arterial	100	100	4.4	\$ 34.8	\$ 36.7	\$ -	\$ -	\$ -	\$ -
	Rock*	STH 26, ph5	CTH N	S Fork Int	New 4L arterial	100	100	1.8	\$ 20.1	\$ 21.3	\$ -	\$ -	\$ -	\$ -
	Rock	US 14	STH 11	US 51	2L>4 and 6L	100	60	8.2	\$ -	\$ -	\$ 13.6	\$ 9.5	\$ -	\$ -
	Rock	US 14	Janesville	I-43 East	New 4L freeway/arterial	100	100	18	\$ -	\$ -	\$ -	\$ -	\$ 200.0	\$ 278.4
	Rock	Western Connector	STH 11	US 14	New 4L arterial	50	100	4	\$ -	\$ -	\$ -	\$ -	\$ 25.0	\$ 17.4
(TOTAL)								40.1	\$ 70.7	\$ 66.9	\$ 13.6	\$ 9.5	\$ 225.0	\$ 295.8
Dubuque IA	Grant								\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Chippewa-Eau Claire	Chippewa	CTH T	Alpine Road	Old STH 29	Expansion 2L > 4L	25	100	3.5	\$ -	\$ -	\$ 10.5	\$ 3.1	\$ -	\$ -
	Eau Claire	USH 12	Winchester W	Elco Road	Expansion/improvement interchanges	100	70	1.5	\$ -	\$ -	\$ 7.2	\$ 5.2	\$ -	\$ -
	Chippewa	CTH X	STH 29	CTH K	Expand 2L > 4L	25	50	4.5	\$ -	\$ -	\$ -	\$ -	\$ 11.7	\$ 1.7
(TOTAL)								9.5	\$ -	\$ -	\$ 17.7	\$ 8.2	\$ 11.7	\$ 1.7
Wausau	Marathon	US 51	Bridge St	Decatur	Repaving/ and replacement	100	50	2.2	\$ 10.9	\$ 6.5	\$ -	\$ -	\$ -	\$ -
	Marathon	I 39/US 51	Foxglove	Bus US 51	Recon+ bridge	100	60	1.5	\$ 9.5	\$ 6.8	\$ -	\$ -	\$ -	\$ -

MPO area	Wisconsin County	Route or Name	From	To	Action Proposed	% St Hwy Sys	% NON-Overlap w. Other Work Category	Project Length	2011-14 BASE YR Cost	2011-14 YOE Cost, \$M, Adj for SHS & Non-Overlap	2015-20 BASE YR Cost	2015-20 YOE Cost, \$M, Adj for SHS & Non-Overlap	2020 + BASE YR Cost	2020 + YOE Cost, \$M, Adj for SHS & Non-Overlap
					widen									
	Marathon	I 39/US 51	Maple Ridge Rd Int.		Reconstruction interchange	100	70	0.5	\$ -	\$ -	\$ 4.8	\$ 4.4	\$ -	\$ -
	Marathon	STH 29	Marathon City	Wausau	Freeway conversion	100	80	2	\$ -	\$ -	\$ 4.8	\$ 5.0	\$ -	\$ -
	Marathon	STH 29	Marathon City	Wausau	Freeway conversion	100	80	2	\$ -	\$ -	\$ -	\$ -	\$ 4.1	\$ 5.0
(TOTAL)								8.2	\$ 20.4	\$ 13.3	\$ 9.6	\$ 9.4	\$ 4.1	\$ 5.0
La Crosse	La Crosse	I 90, Dresbach Br	US 53	US 14/61 in MN	Bridge rehabilitation	100	70	3	\$ 65.9	\$ 44.8	\$ -	\$ -	\$ -	\$ -
	La Crosse	STH 35	US 14/16	South Co. Line	Widen 2L>4L	100	50	2	\$ 9.8	\$ 4.8	\$ -	\$ -	\$ -	\$ -
	La Crosse	STH 35	Poplar St	CTH OT	Reconstruction	100	50	3.5	\$ 9.3	\$ 4.5	\$ -	\$ -	\$ -	\$ -
	La Crosse*	US 53, La Crosse Corridor	STH 157	South Ave	Inters + imps (new roadway, widen-recon)	100	80	6.1	\$ 44.6	\$ 37.7	\$ 93.6	\$ 90.8	\$ -	\$ -
	La Crosse	I 90	USH 53/35	Theater Road	Widen 4L>6L	100	70	2	\$ -	\$ -	\$ 25.7	\$ 19.0	\$ -	\$ -
	La Crosse	STH 16	Landfill Road	Veterans Park	Widen 2L>4L	100	50	2	\$ -	\$ -	\$ 14.5	\$ 7.7	\$ -	\$ -
(TOTAL)								18.6	\$ 129.6	\$ 91.8	\$ 133.8	\$ 117.5	\$ -	\$ -
Oshkosh	Winnebago	US 41	STH 26	Metro Bound	Widen 4L>6L	100	70	14	\$ 71.6	\$ 54.3	\$ -	\$ -	\$ -	\$ -
	Winnebago	US 45	CTH G	CTH II	Reconstruction	100	50	4.5	\$ 18.5	\$ 10.0	\$ -	\$ -	\$ -	\$ -
	Winnebago	US 41	CTH T		New interchange	100	100	0.5	\$ -	\$ -	\$ 4.6	\$ 5.5	\$ -	\$ -
	Winnebago	US 44	Wisconsin St	Lift Bridge	Widen 2L>4L	100	70	0.5	\$ -	\$ -	\$ 19.1	\$ 17.5	\$ -	\$ -
	Winnebago	US 45	Jackson	Algoma	Reroute-widen	100	70	0.5	\$ -	\$ -	\$ -	\$ -	\$ 8.3	\$ 8.9
	Winnebago	STH 21	US 41	W. External	Upgrade to freeway	100	80	2	\$ -	\$ -	\$ -	\$ -	\$ 18.5	\$ 22.7
	Winnebago	CTH GG	CTH A	STH 26	Widen 2L>4L	25	50	3	\$ -	\$ -	\$ -	\$ -	\$ 12.5	\$ 2.4
	Winnebago	West Side arterial	STH 91	STH 21	New arterial	50	100	4	\$ -	\$ -	\$ -	\$ -	\$ 11.5	\$ 8.8
(TOTAL)								29	\$ 90.1	\$ 64.4	\$ 23.7	\$ 23.0	\$ 50.8	\$ 42.8
Fond du Lac	Fond du Lac	STH 23	Townline	USH 41	Widen 2L>4L	100	50	2	\$ -	\$ -	\$ 11.8	\$ 7.7	\$ -	\$ -
	Fond du Lac	STH 23	CTH K	Tower Rd	Widen 2L>4L	100	50	2	\$ -	\$ -	\$ 11.0	\$ 7.2	\$ -	\$ -
	Fond du Lac	Pioneer St	US 45	CTH OOO	Widen 2L>4L	25	50	2	\$ -	\$ -	\$ 38.6	\$ 6.3	\$ -	\$ -
	Fond du Lac	USH 151	9 Grade sep interchanges		Grade-separated interchanges	100	80	7	\$ -	\$ -	\$ -	\$ -	\$ 15.0	\$ 18.4

MPO area	Wisconsin County	Route or Name	From	To	Action Proposed	% St Hwy Sys	% NON-Overlap w. Other Work Category	Project Length	2011-14 BASE YR Cost	2011-14 YOE Cost, \$M, Adj for SHS & Non-Overlap	2015-20 BASE YR Cost	2015-20 YOE Cost, \$M, Adj for SHS & Non-Overlap	2020 + BASE YR Cost	2020 + YOE Cost, \$M, Adj for SHS & Non-Overlap
	Fond du Lac	USH 41	Townline Rd	Lost Arrow	Widen 4L>6L	100	70	9	\$ -	\$ -	\$ -	\$ -	\$ 10.0	\$ 10.7
(TOTAL)								22	\$ -	\$ -	\$ 61.4	\$ 21.2	\$ 25.0	\$ 29.1
Appleton	Outagamie	CTH CE (College Ave)	Fox River		Widen bridge 2L>4L	50	80	0.3	\$ 8.2	\$ 3.8	\$ -	\$ -	\$ -	\$ -
	Outagamie	STH 96	Rankin	CHT E	Reconstruction	100	50	1	\$ 5.0	\$ 2.7	\$ -	\$ -	\$ -	\$ -
	Outagamie	STH 96	STH 76	US 41	Reconstruction	100	50	3.2	\$ 7.8	\$ 4.4	\$ -	\$ -	\$ -	\$ -
	Winnebago	USH 41	STH 26	Breezewood	Reconst-widen 4L>6L	100	70	15	\$ 10.0	\$ 8.4	\$ -	\$ -	\$ -	\$ -
	Winnebago	US 10	LL BdM Bridge		New LL BdM bridge + interchanges	100	100	3	\$ -	\$ -	\$ -	\$ -	\$ 60.0	\$ 93.6
	Winnebago	USH 41/10/STH 441 Int			Reconstruction Interchange	100	70	1	\$ -	\$ -	\$ -	\$ -	\$ 30.0	\$ 32.8
	Calumet	USH 10	Appleton	UA boundary	Widen 2L>4L	100	50	6.5	\$ -	\$ -	\$ -	\$ -	\$ 10.0	\$ 7.8
	Outagamie	USH 41	STH 15	Brown Co line	Widen 4L>6L	100	70	6	\$ -	\$ -	\$ -	\$ -	\$ 40.0	\$ 43.7
	Outagamie	STH 15	Greenville	New London	Widen 2L>4L	100	70	16	\$ -	\$ -	\$ -	\$ -	\$ 10.0	\$ 10.9
(TOTAL)								52	\$ 31.0	\$ 19.4	\$ -	\$ -	\$ 150.0	\$ 188.8
Sheboygan	Sheboygan	CTH OK	CTH EE	Camelot	Widen 2L>3L		50	1	\$ 3.9	\$ -	\$ -	\$ -	\$ -	\$ -
	Sheboygan	STH 23	West Co. Line	CTH C	Reconstruction + Widen 2>4	100	50	7.5	\$ 24.0	\$ 12.7	\$ -	\$ -	\$ -	\$ -
	Sheboygan	I-43	Rowe Rd		New 1/4 'event' interchange	100	100	0.1	\$ 1.4	\$ 1.5	\$ -	\$ -	\$ -	\$ -
	Sheboygan	CTH O	I 43	Woodland	Widen 2L>3L	25	50	1.3	\$ 1.1	\$ 0.1	\$ -	\$ -	\$ -	\$ -
	Sheboygan	CTH OK	CTH EE	CTH V	Widen 2L>3L		50	1.8	\$ -	\$ -	\$ 6.9	\$ -	\$ -	\$ -
	Sheboygan	S. Taylor Dr	CTH EE	CTH OK	New 4L arterial		50	1.4	\$ -	\$ -	\$ 3.6	\$ -	\$ -	\$ -
	Sheboygan	STH 42	CTH Y	CTH A	Widen 2L>4L	100	50	2.8	\$ -	\$ -	\$ -	\$ -	\$ 6.6	\$ 4.6
	Sheboygan	CTH Y	CTH O	STH 42	Widen 2L>4L	25	50	3.1	\$ -	\$ -	\$ -	\$ -	\$ 6.2	\$ 1.1
	Sheboygan	I 43	CTH FF		New full interchange	100	100	0.2	\$ -	\$ -	\$ -	\$ -	\$ 3.0	\$ 4.2
	Sheboygan	18th St	CTH EE	CTH V	New 2L arterial		100	2.2	\$ -	\$ -	\$ -	\$ -	\$ 2.4	\$ -
(TOTAL)								21.4	\$ 30.4	\$ 14.3	\$ 10.5	\$ -	\$ 18.2	\$ 9.8
Madison	Dane	I 94	I 39/90	CTH N	Widen 4L>6L	100	50	4.4	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
	Dane	US 14	Lacy Rd		New interchange	100	100	0.5	\$ 7.5	\$ 7.9	\$ -	\$ -	\$ -	\$ -
	Dane	US 14	STH 138	vic. Rutland	Widen 2L>4L+ interchanges	100	60	5	\$ 6.5	\$ 4.1	\$ -	\$ -	\$ -	\$ -

MPO area	Wisconsin County	Route or Name	From	To	Action Proposed	% St Hwy Sys	% NON-Overlap w. Other Work Category	Project Length	2011-14 BASE YR Cost	2011-14 YOE Cost, \$M, Adj for SHS & Non-Overlap	2015-20 BASE YR Cost	2015-20 YOE Cost, \$M, Adj for SHS & Non-Overlap	2020 + BASE YR Cost	2020 + YOE Cost, \$M, Adj for SHS & Non-Overlap
	Dane	US 18 (Verona Rd)	US 14	CTH PD	Widen 4L>8L	100	50	1.6	\$ 17.0	\$ 9.0	\$ -	\$ -	\$ -	\$ -
	Dane	US 51	STH 19	CTH V	Widen 2L>4L	100	50	4.2	\$ 59.6	\$ 31.5	\$ -	\$ -	\$ -	\$ -
	Dane	US 41	Fish Hatchery Rd		Expansion/improve interchange	100	70	0.5	\$ 6.9	\$ 5.0	\$ -	\$ -	\$ -	\$ -
	Dane	CTH M	Cross Country	Mineral Pt R	Widen 2L>4L + interchange improvement		80	0.5	\$ -	\$ -	\$ 16.2	\$ -	\$ -	\$ -
	Dane	CTH S (Min Pt)	US 14	Pleasant View	Widen 4L>8L	25	50	2.5	\$ -	\$ -	\$ 10.7	\$ 1.6	\$ -	\$ -
	Dane	CTH S (Min Pt)	CTH M		Improve interchange	0	50	0.5	\$ -	\$ -	\$ 18.3	\$ -	\$ -	\$ -
	Dane	US 18 (Verona)	CTH PD		Upgrade interchange	100	80	0.5	\$ -	\$ -	\$ 10.0	\$ 9.3	\$ -	\$ -
	Dane	US 18/12	CTH AB		New interchange	100	80	0.5	\$ -	\$ -	\$ -	\$ -	\$ 10.0	\$ 11.1
(TOTAL)								20.7	\$ 97.5	\$ 57.4	\$ 55.2	\$ 10.9	\$ 10.0	\$ 11.1
Green Bay	Brown	US 41 (part*)	N Co line	S. Co line	Widen 4L>6L	100	50	12	\$ 283.5	\$ 149.7	\$ -	\$ -	\$ -	\$ -
	Brown	STH 29	CTH J	US 41	Freeway conversion	100	80	1.34	\$ 27.2	\$ 23.0	\$ -	\$ -	\$ -	\$ -
	Brown	STH 29	CTH J	CTH EB	Freeway conversion	100	80	1	\$ 31.5	\$ 26.6	\$ -	\$ -	\$ -	\$ -
	Brown	STH 96	Wrightstown	Fox River	New bridge	100	100	0.5	\$ 27.8	\$ 29.4	\$ -	\$ -	\$ -	\$ -
	Brown	STH 54	Oneida	Green Bay	Realignment study	100	100	6	\$ 0.6	\$ 0.6	\$ -	\$ -	\$ -	\$ -
	Brown	S Art (CTH GV)	STH 172	CTH X	New arterial	25	100	2.96	\$ 12.2	\$ 3.2	\$ -	\$ -	\$ -	\$ -
	Brown	S Art (CTH SB)	CTH X	STH 57	New arterial	25	100	2.66	\$ -	\$ -	\$ 10.5	\$ 3.1	\$ -	\$ -
	Brown	STH 29	CTH J	CTH U	Conversion to freeway	100	80	6	\$ -	\$ -	\$ -	\$ -	\$ 40.0	\$ 44.5
	Brown	STH 54	US 41	STH 172	Upgrade	100	70	8	\$ -	\$ -	\$ -	\$ -	\$ 20.0	\$ 19.5
	Brown	S Art (CTH SB)	STH 57	CTH EE	New arterial + bridge	25	100	2.4	\$ -	\$ -	\$ -	\$ -	\$ 60.0	\$ 20.9
	Brown	CTR EA	CTH JJ	CTH R	Widen		50	1.3	\$ -	\$ -	\$ -	\$ -	\$ 8.0	\$ -
(TOTAL)								44.16	\$ 382.7	\$ 232.4	\$ 10.5	\$ 3.1	\$ 128.0	\$ 84.9
SEWRPC	Milw-Rac-Kenosha	I 94	Howard/27th	IL St Line	Widen to 8 Lanes	100	70	32	\$1,150.2	\$ 867.2	\$ -	\$ -	\$ -	\$ -
Greater Milw Area	Milw-Rac-Kenosha	I 94	CTH P Interchange		Upgrade interchange	100	80	0.5	\$ 17.1	\$ 15.3	\$ -	\$ -	\$ -	\$ -
	Racine-Walworth	Burlington Bypass*	STH 83	STH 11	New arterial	100	100	4.9	\$ 15.6	\$ 16.5	\$ -	\$ -	\$ -	\$ -

MPO area	Wisconsin County	Route or Name	From	To	Action Proposed	% St Hwy Sys	% NON-Overlap w. Other Work Category	Project Length	2011-14 BASE YR Cost	2011-14 YOE Cost, \$M, Adj for SHS & Non-Overlap	2015-20 BASE YR Cost	2015-20 YOE Cost, \$M, Adj for SHS & Non-Overlap	2020 + BASE YR Cost	2020 + YOE Cost, \$M, Adj for SHS & Non-Overlap
	Racine	STH 32 (part)	Five Mile Rd	STH 31	Widen 2L>4L	100	50	1.3	\$ 4.3	\$ 2.4	\$ -	\$ -	\$ -	\$ -
	Waukesha	Waukesha West Bypass	I 94	STH 59	New bypass	50	100	5.1	\$ 28.0	\$ 15.6	\$ -	\$ -	\$ -	\$ -
	Milwaukee	I 94/894 (Zoo Interchange)	Burleigh/ Lincoln	124th/70th	Upgrade/reconstruct interchange	100	80	3	\$ -	\$ -	\$1,700.0	\$1,588.5	\$ -	\$ -
	Milwaukee	I 894	Hale Interchange		Upgrade Interchange	100	80	0.5	\$ -	\$ -	\$ 181.9	\$ 187.0	\$ -	\$ -
	Milwaukee	I 894	Zoo Interchange	Hale Interchange	Upgrade/widen	100	80	3.5	\$ -	\$ -	\$ 94.3	\$ 97.0	\$ -	\$ -
	Milwaukee	I 894	Hale Interchange	Mitchell Interchange	Upgrade/widen	100	80	4.5	\$ -	\$ -	\$ 147.0	\$ 155.7	\$ -	\$ -
	Milw-Racine	STH 38 (part)	Oakwood Rd	CTH K	Widen 2L>4L	100	50	6.1	\$ -	\$ -	\$ 25.3	\$ 15.5	\$ -	\$ -
	Milwaukee	US 45	Drexel Ave	60 the St	Widen 2L>4L	100	50	4.5	\$ -	\$ -	\$ 26.6	\$ 16.3	\$ -	\$ -
	Milwaukee	STH 242 (part)	College Ave	Drexel Ave	Widen 4L>6L	100	50	1	\$ -	\$ -	\$ 8.8	\$ 5.4	\$ -	\$ -
	Waukesha	Pilgrim Rd	US 18	Lisbon Rd	Widen 2L>4L	25	50	4.8	\$ -	\$ -	\$ 26.4	\$ 4.0	\$ -	\$ -
	Waukesha	Springdale/Towline Rd Extent	CTH JJ	Weyer	New arterial	50	100	4.7	\$ -	\$ -	\$ 25.7	\$ 15.7	\$ -	\$ -
	Waukesha	CTH Y	CTH L/Hickory Trail	College/Downing	Widen 2L>4L	0	50	6	\$ -	\$ -	\$ 21.9	\$ -	\$ -	\$ -
	Waukesha	STH 164	Howard Lane	CTH Q	Widen 2L>4L	100	50	3.5	\$ -	\$ -	\$ 13.7	\$ 8.4	\$ -	\$ -
	Waukesha	STH 190 (part)	Brookfield Rd	Calhoon Rd	Widen 2L>4L	100	50	1	\$ -	\$ -	\$ 8.8	\$ 5.4	\$ -	\$ -
	Waukesha	STH 83 (part)	CTH DE	US 18	Widen 2L>4L	100	50	1.8	\$ -	\$ -	\$ 7.0	\$ 4.3	\$ -	\$ -
	Waukesha	STH 83 (part)	Mariner Dr	STH 16	Widen 2L>4L	100	50	3.6	\$ -	\$ -	\$ 14.0	\$ 8.6	\$ -	\$ -
	Waukesha	STH 83	Bayview Rd	CTH X	Widen 2L>4L	100	50	4.8	\$ -	\$ -	\$ 19.5	\$ 11.9	\$ -	\$ -
	SEWRPC area	Various Freeways 5 Projects			Widen/reconstruction	100	50	60	\$ -	\$ -	\$ -	\$ -	\$1,627.2	\$1,118.2
	SEWRPC area	Various Freeways 9 Projects			Widen/reconstruction	100	50	31.6	\$ -	\$ -	\$ -	\$ -	\$1,523.2	\$1,292.0
	SEWRPC area	Various Freeways 8 Projects			Widen/reconstruction	100	50	127	\$ -	\$ -	\$ -	\$ -	\$1,761.1	\$1,773.1
	SEWRPC area	Various Arterials			Widen/reconstruction	80	50	19.3	\$ -	\$ -	\$ -	\$ -	\$ 119.3	\$ 70.3
	SEWRPC area	Various Arterials			Widen/reconstruction	90	50	27.9	\$ -	\$ -	\$ -	\$ -	\$ 138.1	\$ 105.1
	SEWRPC area	Various Arterials			Widen/reconstruction	100	50	7.8	\$ -	\$ -	\$ -	\$ -	\$ 32.6	\$ 31.7
Total for SEWRPC Area								370.7	\$1,215.2	\$ 916.9	\$2,320.9	\$2,123.7	\$5,201.5	\$4,390.2

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Sub total for MPOs								662.86	\$2,114.1	\$1,495.4	\$2,695.5	\$2,337.8	\$5,824.3	\$5,059.2	
Major State Highway Projects (per State Transportation Projects Board, Feb. 2011)															
Major Projects Report Listing															
	Portage-Wood	US 10	Marshfield	Stevens Point	New 4L + 5 bypasses	100	80	31	\$ 150.3	\$ 127.1	\$ -	\$ -	\$ -	\$ -	
	Portage-Waupaca	US 10	Stevens Point	Waupaca	Widen 2L>4L	100	70	21	\$ 2.9	\$ 2.1	\$ -	\$ -	\$ -	\$ -	
	Kenosha	STH 11, Burlington Byp**	STH 11 E of B	STH 11 W of B	New 4L divided bypass	100	80	11	\$ 6.4	\$ 5.4	\$ 20.0	\$ 19.4	\$ -	\$ -	
	Sauk	US 12, Ski HI Connector	I 90/94	Ski High Rd	New 4L bypass	100	80	13	\$ 52.4	\$ 44.3	\$ 73.6	\$ 71.4	\$ -	\$ -	
	Dane	US 12	Sauk City	Middleton	Widen 2L>4L+ upgrade interchanges	100	50	18	\$ 1.1	\$ 0.6	\$ -	\$ -	\$ -	\$ -	
	Vernon	US 14	Veroqua	Westby	Widen 2L>4L + 2 bypass	100	50	12.6	\$ 32.5	\$ 17.2	\$ 29.3	\$ 17.8	\$ -	\$ -	
	Jefferson-Waukesha	STH 16	Oconomowoc Bypass		New 4L expressway bypass	100	80	6.5	\$ -	\$ -	\$ 4.8	\$ 4.7	\$ -	\$ -	
	Crawford	US 18	Bridgeport	Prairie du Chien	Widen 2L>4L	100	50	4	\$ 4.6	\$ 2.4	\$ 9.5	\$ 5.8	\$ -	\$ -	
	Fond du Lac-Sheboygan	STH 23	Fond du Lac	Plymouth	Widen 2L>4L expressway	100	80	19	\$ 73.0	\$ 61.7	\$ 44.9	\$ 43.6	\$ -	\$ -	
	Jefferson-Dodge (less Janesville portion)**	STH 26	Janesville	Watertown	Widen 2L>4L + 3 bypass	100	80	44.1	\$ 206.1	\$ 83.0	\$ -	\$ -	\$ -	\$ -	
	Marathon	I 39/US 51 Wausau Corridor	Foxglove Rd	Bridge St, Wausau	Widen 4L>6L + interchange upgrade	100	60	7	\$ 8.3	\$ 5.3	\$ 7.2	\$ 5.2	\$ -	\$ -	
	Oconto-Marinette	US 41	Oconto	Peshigo	Widen 2L>4L divided + bypass	100	80	21.4	\$ 8.2	\$ 6.9	\$ 17.5	\$ 17.0	\$ -	\$ -	
	Brown-Winnebago	US 41 (part in Winnebago Co)	Green Bay	Little Chute	Reconstruction + interchange upgrade	100	60	31	\$ 644.0	\$ 408.6	\$ 123.0	\$ 89.5	\$ -	\$ -	
	Eau Claire-Chippewa	US 53, Eau Claire Bypass	Golf Rd Eau Claire	STR 29 Chippewa	New 4L frwy + interchanges	100	100	7.5	\$ 15.6	\$ 16.5	\$ -	\$ -	\$ -	\$ -	
	Door-Kewaunee	STH 57	Dyckesville	Sturgeon Bay	Widen 2L>4L	100	50	20	\$ 0.6	\$ 0.3	\$ 17.8	\$ 10.8	\$ -	\$ -	
	St Croix	STH 64	Houlton	Richmond	Widen 2L>4L +	100	80	13.1	\$ -	\$ -	\$ 2.6	\$ 2.5	\$ -	\$ -	

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					bypass									
	Oconto-Marinette	US 141	LeMere Rd, Oconto	6th Rd, Marinette	Widen 2L>4L expressway+3 bypass	100	80	16.4	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
	Fond du Lac	US 151, Fond du Lac Bypass	US 41 SW of Fond du Lac	STR 149 NE of Fond du Lac	New 4L bypass+ interchanges	100	100	7.8	\$ 0.7	\$ 0.7	\$ -	\$ -	\$ -	\$ -
	Fond du Lac	US 151	Waupun	Fond du Lac	Widen 2L>4L	100	50	12.7	\$ 0.1	\$ 0.1	\$ 0.4	\$ 0.2	\$ -	\$ -
(TOTAL)								317.1	\$1,206.8	\$ 782.2	\$ 350.6	\$ 287.9	\$ -	\$ -
		Recommended for adding 10-19-2010												
	Dane-Rock	I 39/90	IL State Line	US 12 E of Madison	Widen 4L>6L	100	50	45	\$ -	\$ -	\$ 715.0	\$ 433.6	\$ -	\$ -
	Winnebago	US 10/STH 441	Oneida St, Appleton	CTH CB W of App	Widen 4L>6L + new bridge	100	80	5	\$ -	\$ -	\$ 390.0	\$ 378.5	\$ -	\$ -
	Milwaukee-Racine	STH 38	Oakwood Rd, Milw C	CTH K, Racine C	Widen 2L>4L	100	50	9	\$ -	\$ -	\$ 125.0	\$ 75.8	\$ -	\$ -
	Outagamie	STH 15	STR 76, Greenville	New London	Widen 2L>4L + 1 bypass	100	80	11	\$ -	\$ -	\$ 125.0	\$ 121.3	\$ -	\$ -
(TOTAL)								70	\$ -	\$ -	\$1,355.0	\$1,009.2	\$ -	\$ -
		Potential Additional Projects												
	St Croix	STR 35, St Croix Bridge	STR 35 NE of Houlton	MN 36 Bayport	New bridge and bypass	100	100	4	\$ -	\$ -	\$ 300.0	\$ 363.9	\$ -	\$ -
	Milwaukee to Brown	US 41 (Press Release 5/9/11)	I94 Mitchell Int (Milw)	I 43 (Green Bay)	Upgrade to Interstate 41	100	100	142	\$ -	\$ -	\$1,500.0	\$1,500.0		\$ -
(TOTAL)								146	\$ -	\$ -	\$1,800.0	\$1,863.9		\$ -
Total, State Transportation Project Commission								533.1	\$1,206.8	\$ 782.2	\$3,505.6	\$3,161.0	\$ -	\$ -
Grand total for State and MPOs				Grand Total, MPOs and State				1196.0	\$3,320.9	\$2,277.6	\$6,201.1	\$5,498.8	\$5,824.3	\$5,059.2
*STPC and MPO joint project. Costs and mileage separated. **Reduced for MPO duplication.														

Other Needs

- Special summaries of the 2011-14 STIP were made to identify all projects in the following general classes:
 - Intersection upgrades.
 - Roundabouts.
 - Signal treatments (but no intersection upgrade)
 - Pedestrian, bike and greenway enhancements.
 - Railroad grade crossing signal upgrades.
- Within each group, projects were listed and average costs per project were estimated.
- Based on the current rate of activity, in the STIP, the same rate, in terms of projects per year were assume going forward, but at higher cost, for 2015-20.

Administrative Costs

- Administrative costs were obtained from WisDOT submittals to the FHWA, as reported in Table SF4 of Highway Statistics. These costs are about 7-8% of the highway program, in line with most other states.
- To forecast administrative costs, a growth rate of 2%/year was assumed.

Federal Funds

- Sources of information for federal funds come primarily from FHWA's Highway Statistics series, particularly Table SF3 and SF 4.
- Federal fund totals by funding category FHWA Highway Statistics, Table FA4, various years.
- For SFYs 2009/10 through 2013/14, data for federal funds come from details of the proposed Wisconsin 2011-13 State Budget. Federal funds in the State Highway System and federal funds for some other general and administrative categories, system operation and law enforcement/safety are also added in. The specific budget items included are noted in the table below.
- Forecasts of federal funds beyond 2013/14 are made by assuming a 1.0%/year growth rate for 2014-17, and a more rapid growth, 5%/year, to 2020.

Table T6. State Budget Categories Used For SHS Expenditure Estimates

TRANSPORTATION BUDGET SECTION AND ITEMS SELECTED	TRANSPORTATION BUDGET SECTION AND ITEMS SELECTED
(1) Aids	(3) State Highway Facilities (Continued)
(as) Transportation aids to counties, state funds	(eq) Highway maintenance, repair, and traffic operations, state funds
(at) Transportation aids to municipalities, state funds	(er) State-owned lift bridge operations and maintenance, state funds
(ex) Highway safety, local assistance, federal funds	(ev) Highway maintenance, repair, and traffic operations, local funds
(fq) Connecting highways aids, state funds	(ex) Highway maintenance, repair, and traffic operations, federal funds
(fs) Flood damage aids, state funds	(iq) Administration and planning, state funds
(ft) Lift bridge aids, state funds	(ir) Disadvantaged business mobilization assistance, state funds
(2) Local Transportation Assistance	(iv) Administration and planning, local funds
(aq) Accelerated local bridge improvement assistance, state funds	(ix) Administration and planning, federal funds
(av) Accelerated local bridge improvement assistance, local funds	(jh) Utility facilities within highway rights-of-way, state funds
(ax) Accelerated local bridge improvement assistance, federal funds	(jj) Damage claims
(eq) Highway and local bridge improvement assistance, state funds	(js) Telecommunications services, service funds
(ev) Loc. brdg. imprvmt. & trfc. marking enhncmnt. asst., loc. &	(4) General Transportation Operations

TRANSPORTATION BUDGET SECTION AND ITEMS SELECTED	TRANSPORTATION BUDGET SECTION AND ITEMS SELECTED
transfrd. fnds.	
(ex) Local bridge improvement assistance, federal funds	(aq) Departmental management and operations, state funds
(fb) Local roads for job preservation, state funds	(ar) Minor construction projects, state funds
(fr) Local roads improvement program, state funds	(at) Capital building projects, service funds
(ft) Local roads improvement program; discretionary grants, state funds	(av) Departmental management and operations, local funds
(fv) Local transportation facility improvement assistance, local funds	(ax) Departmental management and operations, federal funds
(fx) Local transportation facility improvement assistance, federal funds	(ch) Gifts and grants
(fz) Local roads for job preservation, federal funds	(dq) Demand management
(jq) Grant to village of Bellevue, state funds	(eq) Data processing services, service funds
(jr) Grant to village of Footville, state funds	(er) Fleet operations, service funds
(kv) Congestion mitigation and air quality improvement, local funds	(es) Other department services, operations, service funds
(kx) Congestion mitigation and air quality improvement, federal funds	(et) Equipment acquisition
(nv) Transportation enhancement activities, local funds	(ew) Operating budget supplements, state funds
(nx) Transportation enhancement activities, federal funds	(5) Motor Vehicle Services and Enforcement
(3) State Highway Facilities	(ci) Breath screening instruments, state funds
(bq) Major highway development, state funds	(dg) Escort, security and traffic enforcement services, state funds
(br) Major highway development, service funds	(dh) Traffic academy tuition payments, state funds
(bv) Major highway development, local funds	(di) Chemical testing training and services, state funds
(bx) Major highway development, federal funds	(dk) Public safety radio management, service funds
(ck) West Canal Street reconstruction and extension, service funds	(dL) Public safety radio management, state funds
(cq) State highway rehabilitation, state funds	(dq) Vehicle inspection, traffic enforcement and radio management, state funds
(cr) Southeast Wisconsin freeway rehabilitation, state funds	(dr) Transportation safety, state funds
(ct) Owner controlled insurance program, service funds	(dx) Vehicle inspection and traffic enforcement, federal funds
(cv) State highway rehabilitation, local funds	(dy) Transportation safety, federal funds
(cw) Southeast Wisconsin freeway rehabilitation, local funds	(6) Debt Services
(cx) State highway rehabilitation, federal funds	(af) Prin. rpmt. & int., transit, local rds, major hwy & rehab., state funds
(cy) Southeast Wisconsin freeway rehabilitation, federal funds	(aq) Prin. rpmt. & int., trans. facilities, major hwy & rehab., state funds
(dq) Major interstate bridge construction, state funds	(ar) Principal repayment and interest, buildings, state funds
(dv) Major interstate bridge construction, local funds	(au) Prin pmt & int, Marquette interch & I94 n-s corridor reconstr proj, state fds
(dx) Major interstate bridge construction, federal funds	

State and Local Funds

- State funds for the State Highway System are also drawn from the Wisconsin 2011-13 State Budget, Department of Transportation section.
- Funds for ‘state’ and ‘services’ are included for the SHS portion of the budget, and for other portions of the DOT budget that are related at the general administration, management and funding of the SHS. This includes a portion of administrative resources, and the law enforcement/safety portion of motor vehicle and licensing resources. The specific budget items included are noted in the table above.
- Resources for bonding and debt service (principal and interest payments) are also included.
- A small portion of SHS resources from local governments is also included.

Acknowledgements

This report was prepared by **Prof. David T. Hartgen**, Professor Emeritus of Transportation Studies at UNC Charlotte and President of The Hartgen Group, under contract to the Wisconsin Policy Research Institute. Prof. Hartgen was assisted by **M. Gregory Fields** and **Elizabeth San Jose**. The Hartgen Group gathered and consolidated information, analyzed the data and prepared the report. However, this report is also the product of the support and assistance of numerous individuals and agencies. **George Lightbourn** of the Wisconsin Policy Research Institute ensured a smooth and harmonious research environment. Representatives of the Wisconsin Department of Transportation led by **Mark Wolfgram** and **Joseph Nestler** were most cooperative in providing data and expertise to many sections, and comments on the draft report. MPO staff from Wisconsin's urbanized areas kindly reviewed material and provided input. We would also like to acknowledge **Prof. Edward Beimborn**, Prof. Emeritus of Civil Engineering at the University of Wisconsin-Milwaukee, for his input and comments on drafts of this report. Without the assistance of these individuals and organizations this study could not have been completed. The authors are grateful to all individuals and organizations for their assistance but of course retain full responsibility for the analysis and its interpretation. This study does not necessarily reflect the views of WPRI, the Wisconsin Department of Transportation, or the regional Metropolitan Planning Organizations.

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Endnotes:

- ¹ WisDOT, Impacts of Highway Facility Improvements on Travel and Regional Development, TransLinks21 project, Madison, WI, January 1994.
- ² Wisconsin Department of Transportation, Wisconsin State Highway Plan 2020, Summary Report, Madison WI, February 2000.
- ³ Southeastern Wisconsin Regional Planning Commission, Cost of Reconstructing the SEWRPC regional freeway system, Report No. 47, 2003.
- ⁴ Wisconsin Legislature, Joint Legislative Committee on Transportation Needs and Finance, Final Report, December 2006.
- ⁵ Hartgen D et al.. Comparative Performance of State Highway Systems, 1984-2008, Reason Foundation, September 30, 2010. Available at www.reason.org.
- ⁶ “Needs assessments” are transportation studies that estimate how much money and time it would take to bring a road (or other) system up to a given level of quality or standard. They are regularly done by the federal government, in the biennial reports to Congress, and occasionally by individual states.
- ⁷ WisDOT, State Transportation Improvement Program, 2011-14. January 2011.
- ⁸ Published VMT statistics for Wisconsin show an anomaly for 2008 local travel that has not been resolved. If corrected, VMT trends would likely be higher.
- ⁹ A ‘vehicle-mile of travel’ (VMT), defined as one vehicle traveling one mile, is a common measure of surface traffic activity.
- ¹⁰ Wisconsin’s data files list divided highways separately by direction, so ‘roadways’ are directional sections of pavement and hence total to slightly longer than centerline mileage.
- ¹¹ FHWA, Highway Statistics, Table VM 2, 2008
- ¹² FHWA, Highway Statistics, Table HM 64, 2000 and 2008.
- ¹³ The federal government has dropped the use of words such as “poor” in describing road condition. By prior research and convention, 170 inches/mile of roughness has been generally agreed as the cutoff for “poor” Interstate roads, and 220 inches/mile is the cutoff for “poor” other roads.
- ¹⁴ Based on “roadway” mileage which separates divided roads by direction.
- ¹⁵ ‘Potentially required pavement treatments’ are WisDOTs preliminary estimated pavement work types based on high-level assessment of road condition and traffic data. They are intended to estimate cost and work intensity for planning purposes, and do not necessarily reflect actual treatments developed when engineering design is completed and pavements are repaired.
- ¹⁶ Southeastern Wisconsin Regional Planning Commission, Freeway Reconstruction Plan for Southeastern Wisconsin, Report No. 47, 2003.
- ¹⁷ Some states use the federal HERS-ST model to prepare such estimates, and some use their own condition deterioration methods. Wisconsin uses a state-based deterioration model.
- ¹⁸ The State Transportation Improvement Program (STIP) is a federally-required document listing all projects involving federal funds for the short-range (4-6 Years) time frame. Many states use the STIP to list all projects, including those funded with only state or local funds as well.
- ¹⁹ Memo from Mark Wolfram, WisDOT Administrator to George Lightbourn, WPRI, “re: the draft report “Wisconsin State Highway System: Needs and Resources, 2011-2020”, April 26, 2011.
- ²⁰ USDOT, 2009 National Bridge Inventory for Wisconsin, available at www.fhwa.dot.gov.
- ²¹ Federal bridge repair funds are allocated to the states according to estimated cost to repair deficient bridges.
- ²² According to the *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation’s Bridges*, Item 96–Total Project Costs should include “*incidental costs not included in Items 94 [Bridge Improvement Costs] and 95 [Roadway Improvement Costs]*” and “*should include all costs normally associated with the proposed bridge improvement project.*” We assumed that this includes design engineering, right-of-way and potential change order costs, since many WisDOT bridges show total costs that are 10-15% higher than the sum of ‘roadway’ and ‘bridge’ costs.
- ²³ Transportation Research Board, Highway Capacity Manual, National Research Council, Washington, DC, 2000.
- ²⁴ Lomax T and Turner T, Urban Mobility Report, 2010, Texas Transportation Institute, Released December 2010, available at www.mobility.tamu.edu.
- ²⁵ Daily Beast, “50 Worst Commutes: America’s Highways to Hell”, March 8, 2011. www.thedailybeast.com .
- ²⁶ Highway Capacity Manual, op. cit.

- ²⁷ Federal Highway Administration, Highway Performance Monitoring System, Field Manual. Washington, DC, 1994.
- ²⁸ Memo from Mark Wolfgram to George Lightbourn, op. cit.
- ²⁹ For instance, new routes, bypasses, improved intersection treatments, coordinated traffic signals, ITS monitoring, better transit service, flex time and carpooling, etc.
- ³⁰ Yunker KR, "Preliminary draft, Appendix E, Evaluation of alternative freeway system improvements", Feb. 6, 2006. At www.milwaukeeerising.net/AppendixE.pdf.
- ³¹ WisDOT, Facilities Design Manual, available at: <http://roadwaystandards.dot.wi.gov/standards/fdm/11-44.pdf>.
- ³² WisDOT FDM, op. cit.
- ³³ WisDOT FDM, op. cit.
- ³⁴ Bonneson J and Pratt MP, Roadway Safety Design Workbook, Texas A and M University, July 2009.
- ³⁵ WisDOT FDM; urban road data available at: <http://roadwaystandards.dot.wi.gov/standards/fdm/11-20-001att.pdf>; rural road data available at: <http://roadwaystandards.dot.wi.gov/standards/fdm/11-15-001att.pdf>.
- ³⁶ Shoulder type codes 1-5, WisDOT Roadway Inventory file.
- ³⁷ Zeeger CV et al. Safety effects of cross-section design for two-lane roads. Record 1195, Transportation Research Board, Washington DC 20418, 1988.
- ³⁸ Bonneson and Pratt, op. cit.
- ³⁹ Wisconsin Department of Transportation, 2011-13 Biennial Budget Request, November 17, 2010, pages 234-243, sum for highway maintenance and repair, traffic operations, lift bridge operations, state, federal and local funds.
- ⁴⁰ WisDOT, Compass Report: Wisconsin State Highway 2009 Maintenance, Traffic and Operations Conditions, available at: https://trust.dot.state.wi.us/extntgtwy/dtid_bho/extranet/compass/reports/2009/Compass%20Report-2009-Final.pdf
- ⁴¹ National Traffic Operations Center (NTOC), 2007 National Traffic Signal Report Card, Federal Highway Administration, 2010.
- ⁴² Based on \$ 192,000 per intersection for replacement of a typical 4-leg intersection, per WisDOT correspondence, 3-15-2011.
- ⁴³ Wisconsin DOT press release, "Governor Walker announces plans to Convert US 41 to an Interstate Highway", Press Release, May 3, 2011., Madison, WI.
- ⁴⁴ Memo, Wolfgram to Lightbourn, op. cit.
- ⁴⁵ US Congress, American Reinvestment and Recovery Act, signed Feb. 13, 2009.
- ⁴⁶ Utt, Ronald, Federal highway program shortchanges more than half the states, Heritage Foundation, Web Memo #3228, April 18, 2011. This assessment subtracts out congressional transfers to the Highway Trust Fund from the General Fund. For Wisconsin, the cumulative 1959-2009 'donee/donor ratio' was 0.918, while the more recent 2009 ratio was 1.039.
- ⁴⁷ National Surface Transportation Policy and Revenue Study Commission, Transportation For Tomorrow, December 2007; and National surface Transportation Infrastructure Financing Commission, Paying Our Way, Final Report February 2009.
- ⁴⁸ Orski, K. House Transportation and Infrastructure Committee's 'Views and Estimates', Innovation Briefs, March 22, 2011. At www.innobriefs.org.
- ⁴⁹ According to the AASHTO Daily Briefing (April 15, 2011) "*The [2011] obligation limitation on the federal-aid highway program is frozen at its FY 2010 level of \$41.107 billion. State transportation departments will have their contract authority balances lowered by \$2.5 billion and states that have old unused earmarked highway funds from 1998 and prior years will see those canceled as well to the tune of \$630 million...Total Federal Highway Administration funding drops 2.2% from last fiscal year to this fiscal year, representing Congress' previous decision not to renew \$650 million in General Fund extra highway appropriations and \$293 million in General Fund highway earmarks made in FY 2010*"
- ⁵⁰ Federal Highway Administration, Highway Statistics, Table SF3, various years.
- ⁵¹ Federal Highway Administration, Highway Statistics, Tables MF 1, MF2, MV1 and MV2, 2008.
- ⁵² This summary includes only selected items in the Department of Transportation's budget; these items are identified in the Appendix.
- ⁵³ Federal Highway Administration, Highway Statistics, 2008, Table SF3.
- ⁵⁴ Memo from Mark Wolfgram to George Lightbourn, op cit, attached revenue forecast.
- ⁵⁵ Memo from Mark Wolfgram to George Lightbourn, op. cit.
- ⁵⁶ Memo from Mark Wolfgram to George Lightbourn, op. cit.
- ⁵⁷ Memo from Mark Wolfgram to George Lightbourn, op. cit.

⁵⁸ Memo from Mark Wolfram to George Lightbourn, op. cit.

⁵⁹ Memo from Mark Wolfram to George Lightbourn, op. cit.