2008
Pavement Condition
Executive Summary

EXECUTIVE SUMMARY

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Pavement Management Unit

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INTRODUCTION

This report is prepared annually by the Minnesota Department of Transportation (Mn/DOT) Pavement Management Unit to provide information concerning trunk highway pavement performance. It briefly discusses statewide performance trends and how they compare with established targets. In addition, comparisons are made between the eight Area Transportation Partnerships (ATP) used in statewide planning.

The two indices used to measure pavement performance in Mn/DOT's 20-year Transportation Plan are the Ride Quality Index (RQI), a measure of pavement smoothness, and Remaining Service Life (RSL), an estimate of the time until the pavement will reach the end of its design life and require major rehabilitation.

BACKGROUND

Mn/DOT's trunk highway system consists of approximately 12,000 centerline miles of pavement. This system consists of bituminous, concrete, and composite pavement with a wide range of condition, age, and performance. Each year, the Pavement Management Unit collects pavement roughness and digital image data on the entire trunk highway system, in both directions, and calculates surface distress quantities on approximately 60% of the system.

DATA COLLECTION

The pavement roughness and surface distress data (cracks, ruts, faults, etc.) are collected using a sophisticated digital inspection vehicle (shown to the right). This van films the pavement surface using four digital cameras, one looking straight ahead, one looking to the side and two looking straight down. The two down-looking cameras are used to evaluate the pavement surface distress. In addition to the cameras, the van is equipped with lasers that measure the longitudinal pavement profile, from which pavement roughness, rutting, and faulting are calculated.

Pavement condition data is used to monitor the performance of the system, to help in the selection of projects, and identify pavements that need future maintenance and/or rehabilitation. The van drives over every mile of trunk highway annually, in both directions.

Mn/DOT PAVEMENT CONDITION INDICES and MEASURES

Mn/DOT's pavement condition data is reduced to two indices for reporting the statewide pavement performance measures: Ride Quality Index (RQI) and Remaining Service Life (RSL). Each index captures a different aspect of the pavement's health and can be used to rank pavement sections and to predict future maintenance and rehabilitation needs. They are briefly described below.

RQI: Ride Quality Index

The RQI is Mn/DOT's ride or smoothness index. It uses a zero to five rating scale, rounded to the nearest tenth. The higher the RQI, the smoother the road is. The RQI is intended to represent the rating that a typical road user would give to the pavement's smoothness as felt while driving his/her vehicle. Most new construction projects have an initial RQI slightly over 4.0. Pavements are normally designed for a terminal RQI value of 2.5. When a road has reached its terminal RQI value it doesn't mean the road can't be driven on, but rather that it has deteriorated to the point where most people feel it is uncomfortable and a major rehabilitation is likely needed.

The RQI is calculated from the pavement's longitudinal profile, measured by the front mounted lasers on the digital inspection vehicle. A mathematical simulation, called the International Roughness Index (IRI), is then done to estimate the amount of vertical movement a standard vehicle would experience if driven down the road. The IRI is the roughness index used by every state DOT in the U.S. as well as most countries in the world. In the past, Mn/DOT has taken a rating panel of 30 to 40 people out in the field and driven them over hundreds of test sections to get their perception of the smoothness of various pavement sections. Following right behind them was the digital inspection vehicle. This provides us with a direct correlation between the IRI, as measured by the van, and the perceived roughness, as felt by the rating panel.

RSL: Remaining Service Life

The RSL is an estimate, in years, until the RQI will reach a value of 2.5, generally considered to be the end of a pavement's design life. Most pavements will need some type of major rehabilitation or reconstruction when the RQI has reached this value. The RSL is determined from pavement deterioration curves applied to the current data. A curve is fitted through the historical RQI data for each pavement section and the year the RQI will reach 2.5 is estimated. If there is inadequate historical data to make this calculation, default models, based on statewide pavement performance, are used. Rehabilitation activities with long service lives will add a considerable number of years to the RSL of a pavement. Short-term fixes, such as patching, may increase the pavement smoothness for a short time, but do not result in many additional years of RSL.

Each year, the RSL is calculated for all highway segments. From these values, a length-weighted Average Remaining Service Life (ARSL) is calculated for the entire trunk highway system as well as for each ATP. The ARSL provides a measure of whether the fixes being applied to the trunk highway system are mostly long-term or short-term.

PERFORMANCE CATEGORIES

Mn/DOT currently categorizes pavement condition, as measured by the RQI, into five equal categories as shown in Table 1. When reporting performance measures, the top two and bottom two categories are combined and will be referred to as "Good" and "Poor," respectively, for the remainder of this report.

Table 1. Ride Quality Index (RQI) Performance Categories

Descriptive Category	RQI Range	Performance Measure Category
Very Good	5.0 – 4.1	Good
Good	4.0 – 3.1	
Fair	3.0 – 2.1	
Poor	2.0 – 1.1	Poor
Very Poor	1.0 – 0.0	

PERFORMANCE TARGETS

Using the traffic functional class designation of each segment of highway, all pavements sections are assigned to one of two traffic functional groups, Principal Arterial (PA) or Non-Principal Arterial (NPA) when reporting statewide pavement performance measures. The Interstate system is considered to be part of the PA system. The current trunk highway system mileage is comprised of 53% PA and 47% NPA.

Performance targets have been established based on historical RQI values for both functional groups as shown in Table 2. The RQI targets are based on the percent of miles in the "Good" and "Poor" categories as described below.

Table 2. Ride Quality Index (RQI) Targets by Functional Group

Functional Group	Ride Quality Index (RQI)	
	"Good" RQI (RQI > 3.0)	"Poor" RQI (RQI <= 2.0)
Principal Arterial	70% or more	2% or less
Non-Principal Arterial	65% or more	3% or less

STATEWIDE HISTORICAL RQI TRENDS

Statewide, the smoothness of the PA system declined in 2008. While the PA system did have an increase in the "Good" category in 2008 it had a nearly identical increase in the "Poor" category. Since the cost of getting a road out of "Poor" condition is much more than the cost to keep one in "Good" condition, this is considered to be a slight overall decline.

Surprisingly, the 2008 condition of the NPA system was better than last year. The NPA system improved slightly in both the "Good" and "Poor" categories, which was unexpected given the amount of work the districts planned for 2008.

1999 - 2008 "Good" RQI Trend (Figure 2)

The percent of miles on the PA system in "Good" condition in 2008 was 67.0%, below the target of 70% or more. The percent of miles on the NPA system in "Good" condition was 60.2%, also below its target of 65% or more. This marks the 6th straight year the PA system has not met the "Good" RQI target and the 7th straight year the NPA system has not met the target. While

neither system met the target value, both had slightly more miles in "Good" condition compared with 2007. The PA system had an increase of 0.7% "Good" in 2008 while the NPA system had an increase of 1.1%.

The PA system in ATP-1, 2, 4, 6, and 8 improved in 2008 (more miles in "Good" condition), compared with 2007, ATP-3 and 7 remained the same, and Metro got worse (fewer miles in "Good" condition). On the NPA system, ATP-2, 3, 6, and Metro improved while ATP-1, 4, 7, and 8 got worse

The amount of pavement work planned from 2009 to 2012 in the State Transportation Improvement Program (STIP), including the pavement projects funded under the recently passed Chapter 152 legislation, is expected to maintain the number of miles in "Good" condition near their current levels. The percent of miles in "Good" condition on the PA system is expected to increase slightly from its current value of 67.0% to 68.0% in 2012. On the NPA system, the percent of miles in "Good" condition is expected to decrease from 60.2% in 2008 to 58.3% in 2012.

It should be noted that in the event the anticipated federal economic stimulus package actually comes to fruition, the estimates on future pavement conditions will need to be re-analyzed using a revised list of projects and will undoubtedly improve the overall pavement conditions.

1999 - 2008 "Poor" RQI Trend (Figure 3)

The percent of miles on the PA system in "Poor" condition in 2008 was 3.4%, above the target of 2% or less. The percent of miles on the NPA system in "Poor" condition was 5.9%, nearly twice the target amount of 3% or less. The "Poor" RQI targets on both the PA and NPA systems have not been met on a statewide basis since 2002. On the PA system, 2008 saw the largest increase in the amount of Poor roads since 2001. The NPA system actually had a decline in the amount of pavement in Poor condition in 2008, the first time that has happened since 2005. However, much of this decrease is due to extensive patching done by Mn/DOT maintenance forces during 2007 and 2008, and will provide only short term benefits. Although the patching will only provide short term benefits, it had enough immediate effect to keep the NPA Poor from increasing as predicted, and in some cases actually improved a section's RQI.

The PA system in ATP-2 improved in 2008 (fewer miles in "Poor" condition), compared with 2007. All other ATPs got worse and have more miles in "Poor" condition than they did in 2007, resulting in a statewide decline. The NPA system in ATP-1, 2, and Metro improved in 2008 while the other ATPs got worse. The improvements in ATP-1 and especially in ATP-2 were enough to yield the net improvement statewide.

Between now and 2012, the percent of miles in the "Poor" RQI category is expected to increase from 3.4% to 5.1%, on the PA system, and from 5.9% to 8.3% on the NPA system. This is approaching three times the target amount in each functional group. Once a pavement falls into the "Poor" category it normally will require major rehabilitation or reconstruction to restore any meaningful amount of service life. These types of repairs are very expensive, thus making it much harder to recover once the amount of miles in this condition gets very high.

RQI COMPARISON by ATP

In 2008, only ATP-2 met all four of the RQI targets. As was the case last year, ATP-1, 6, and Metro did not meet any of the RQI targets in 2008.

"Good" RQI Comparison (Figure 4)

For the third year in a row, ATP-2, 4 and 7 met the target of having at least 70% of the PA system in "Good" condition.

As was also the case last year, ATP-2, 3, and 7 met the target of having 65% or more of the NPA system in "Good" condition.

Similar to 2007, only ATP-2 and 7 met the "Good" RQI targets on both the PA and NPA system in 2008.

"Poor" RQI Comparison (Figure 5)

Only ATP-2 and 8 met the target of having 2% or less, of the PA system in "Poor" condition. Last year, ATP-3 also met this target. This continues the undesirable trend of a decreasing number of ATPs meeting the "Poor" targets.

ATP-2, 3, 4, and 8 met the target of having 3% or less, of the NPA system in "Poor" condition.

Only ATP-2 and 8 met the "Poor" RQI targets on both the PA and NPA system. Last year, only ATP-3 and 8 met both these targets.

RQI TARGET SUMMARY

The table below provides a visual picture of which ATPs met the pavement targets in 2008. It uses the following legend:

- Green = Met the target
- Red = Missed the Target
- Yellow = Missed the target, but was "close"

"Close" means within 1% of target for the "Poor" RQI category and within 5% for "Good".

Table 3. Overview of Ride Quality Index (RQI) Targets by ATP

ATP	Ride Quality Index (RQI) Targets Met in 2008			
	Good RQI (RQI > 3.0)		Poor RQI (RQI <= 2.0)	
	PA (target = 70% or more)	NPA (target = 65% or more)	PA (target = 2% or less)	NPA (target = 3% or less)
1	**62.1%**	**57.4%**	**3.7%**	**5.7%**
2	**85.5%**	**74.9%**	**0.6%**	**2.7%**
3	**65.8%**	**78.2%**	**2.2%**	**2.9%**
4	**76.5%**	**56.4%**	**3.1%**	**3.0%**
6	**56.8%**	**37.1%**	**9.5%**	**17.7%**
7	**73.9%**	**65.6%**	**2.7%**	**3.4%**
8	**65.3%**	**61.0%**	**1.3%**	**0.7%**
M	**61.1%**	**48.6%**	**3.3%**	**13.4%**

In 2007, 13 of the 32 (40.6%) RQI targets were met and shaded Green. In 2008, this has dropped to 12 of 32 (37.5%), another indication of the declining pavement condition on state highways.

AVERAGE REMAINING SERVICE LIFE (ARSL)

As mentioned earlier, the Remaining Service Life (RSL) is defined as the number of years until the RQI reaches a value of 2.5 or less. This is the point where most people begin to complain that a road's roughness is objectionable. In 2008, the pavement management software was modified so that historical RSL could be calculated for each pavement section on an annual basis. This allows for long-term trends to be viewed and the impacts of various funding scenarios to be studied in terms of years of life added to the system.

1999 - 2008 Average RSL Trend (Figure 6)

The 2008 ARSL was 9.4 years on the PA system and 7.7 years on the NPA system. These are both slightly lower than last year's averages of 9.7 and 8.2, respectively. The fact that the RSL of the NPA system is lower while the RQI is better reinforces the fact that the patching done by Mn/DOT forces only provides short term benefits and does not add much in terms of extended pavement life, although it does make the overall pavement smoothness better for a short time.

Average RSL Comparison (Figure 7)

By ATP, the ARSL ranges from 8.3 to 11.9 years on the PA system and from 5.2 to 11.3 years on the NPA system. ATP-2 has the highest ARSL on the PA system while ATP-3 has the highest ARSL on the NPA system. This was also the case last year.

ATP-6 continues to have the lowest ARSL on both the PA and NPA systems (8.3 and 5.2 years, respectively).

ACCURACY OF PREDICTED PAVEMENT CONDITIONS

Each year, a prediction of the following year's pavement condition is done using the pavement management system. This is done for several reasons, including reassuring management that the pavement management system is working correctly and that it can be relied on as a tool for predicting future needs, to give managers an idea of the impact different funding scenarios will have on the state's pavement conditions, and to alert the legislature of any worrisome trends that might be on the horizon.

The pavement sections not scheduled for any work in the 2009-2012 STIP use one of two types of deterioration curves to predict future condition. If there is enough historical data since the last rehabilitation was done on a section, a regression curve is fitted through the data. This curve is then used to predict the expected RQI for the section. If there is not enough historical data or if the regression through the historical data results in an unrealistic curve, then a default curve is used to predict the future RQI. Default curves were developed for all pavement fixes in the pavement management system in the mid-1980's and subsequently updated in 1992 and 2008. The curves are based on historical statewide performance.

For the pavement sections that are scheduled for work during the STIP, adjustments are made to the construction year to better predict the expected results. Since the pavement management van can't wait until all of the work is completed each year, some projects will not have begun, some will still be under construction, and some will be completed when the van is in the area collecting data. The following adjustments are made to the construction year in the STIP to try and estimate the status of construction projects when the van is in each district:

D-6, 7, and Metro:
The construction year for all pavement projects listed in the STIP is increased by one year. This is done because these three districts are normally tested early in the spring, when almost none of the construction projects slated for the year have begun. It won't be until the van returns the following year that the impact of this work is measured.

D-3 and 4:
No changes are made to the construction year for projects in the STIP since these two districts are normally tested late in the fall, when most of their pavement projects are completed for the year. Thus the van will likely be driving on the new, improved, surface and the impacts of the pavement work will be reflected.

D-1, 2, and 8:
Half of the projects in these districts have the construction year increased by one year. This is done because at the time the van is filming the pavements, some of their projects will be completed, some will be under construction, and others will not have begun. Since there is no way to predict which ones will be complete when the van is there and which ones will not, the projects are randomly chosen.

The table below compares the predicted 2008 pavement conditions with the actual conditions, using the method described above.

Table 4. Comparison of 2008 Predicted versus 2008 Actual RQI

Principal Arterial System			
RQI Category	**Actual 2007 Data**	**Predicted 2008 Data***	**Actual 2008 Data**
Good RQI (RQI > 3.0)	66.3%	65.4%	67.0%
Poor RQI (RQI <= 2.0)	2.6%	3.9%	3.4%
Non-Principal Arterial System			
RQI Category	**Actual 2007 Data**	**Predicted 2008 Data***	**Actual 2008 Data**
Good RQI (RQI > 3.0)	59.1%	56.4%	60.2%
Poor RQI (RQI <= 2.0)	6.5%	7.2%	5.9%

***Predictions based on the 2008-2011 STIP, with adjustments to construction year as described above. Source: *2007 Pavement Condition Executive Summary Report.*

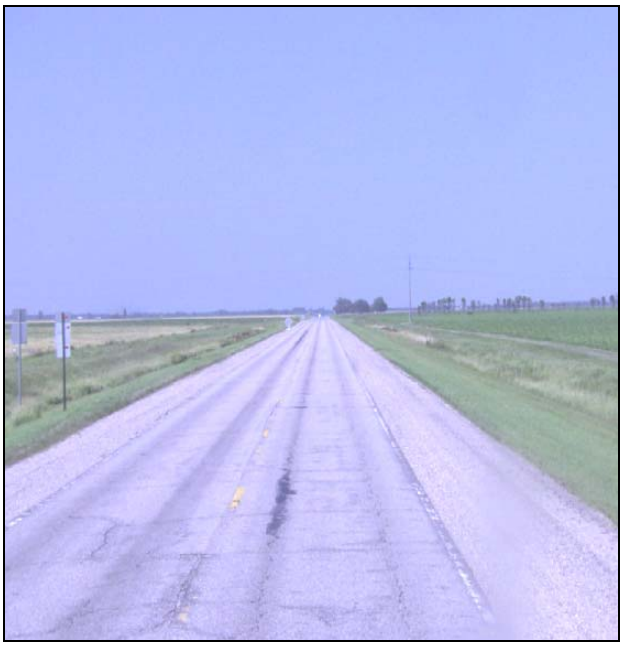
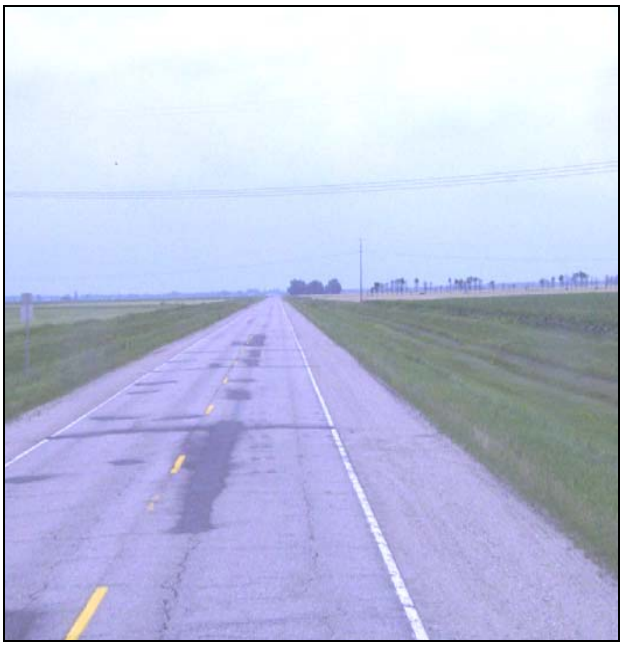
The actual 2008 condition of the PA system is very close to what was predicted. The percent in "Good" condition in 2008 was 1.6% higher than predicted and the percent in "Poor" condition was only 0.5% lower than predicted.

The NPA system, however, is much better than what was predicted, and in fact, better than the 2007 conditions. This is primarily due to extensive spot overlays and patching by maintenance forces on pavement segments that were predicted to decay into the Poor category during 2007 and 2008. There were 305 pavement segments (254 miles) that were predicted to fall into the Poor category during 2008. Each one was evaluated to see if the 2008 RQI did, in fact, drop to 2.0 or less. Thirty-eight percent (38%) of the sections fell into the Poor category as predicted. Those sections that did not fall into the Poor category were viewed using the video-log system to see if there was some kind of preservation or maintenance work done. Nearly 78% of the sections that did not fall into the Poor category as expected had some type of maintenance patching or other preservation work that was not anticipated. As such, they either didn't decay

as quickly as predicted or actually got smoother. Of the remaining sections that were predicted to decay into the Poor category in 2008, half decayed to an RQI of 2.1, just missing the predicted value and barely above the Poor category.

One example of a spot overlay is shown below on MN 108 at Reference Post (R.P.) 14 in District 4. The image on the left is from 2007. The image on the right is from 2008. As shown in the photos, a spot overlay was placed near the settlement at the bottom of the hill sometime between the 2007 and 2008 surveys. In addition, some type of ribbon paving was done near the centerline in the opposite direction, most likely to fill in a deteriorating longitudinal crack. This patching was done by Mn/DOT forces and not entered into the roadway history database, since it was not done under contract. As a result, the pavement management program predicted the RQI would fall from the 2007 value of 2.3 to a value of 2.0 in 2008, putting it in the "Poor" category. However, the patching kept the 2008 RQI at 2.3, preventing it from falling into the "Poor" category.

Another example of unaccounted maintenance work is shown in the next set of photos from MN 9 at R.P. 221, in District 2. The photo on the left is from 2007. The one on the right is from 2008. The road received patching in areas with deteriorated transverse and longitudinal cracking sometime between the 2007 and 2008 surveys. The 2007 RQI of 2.1 was expected to drop to 2.0 in 2008. As a result of the patching, the 2008 RQI actually increased to 2.5. This patching had a big impact on the 2008 RQI because it addressed a problem in the left wheel path, where the pavement roughness is measured.

One way to improve the accuracy of the predicted conditions would be to include areas like this where maintenance plans to do some type of patching. However, most of the time patching is a reactive activity based on the previous winter and spring breakup and the locations where patching will be done is not known ahead of time. Since the predicted condition is based on a given set of projects (the STIP) and performance trend data, any preservation or patching work done to the roadway and not entered into the pavement management system will result in less accurate predictions.

ADDITIONAL INFORMATION

Additional information about the condition and performance of the state highway system, including color coded maps showing the various indices, can be obtained from the Pavement Management Unit's website:

http://www.dot.state.mn.us/materials/pvmtmgmt.html

Or by contacting:

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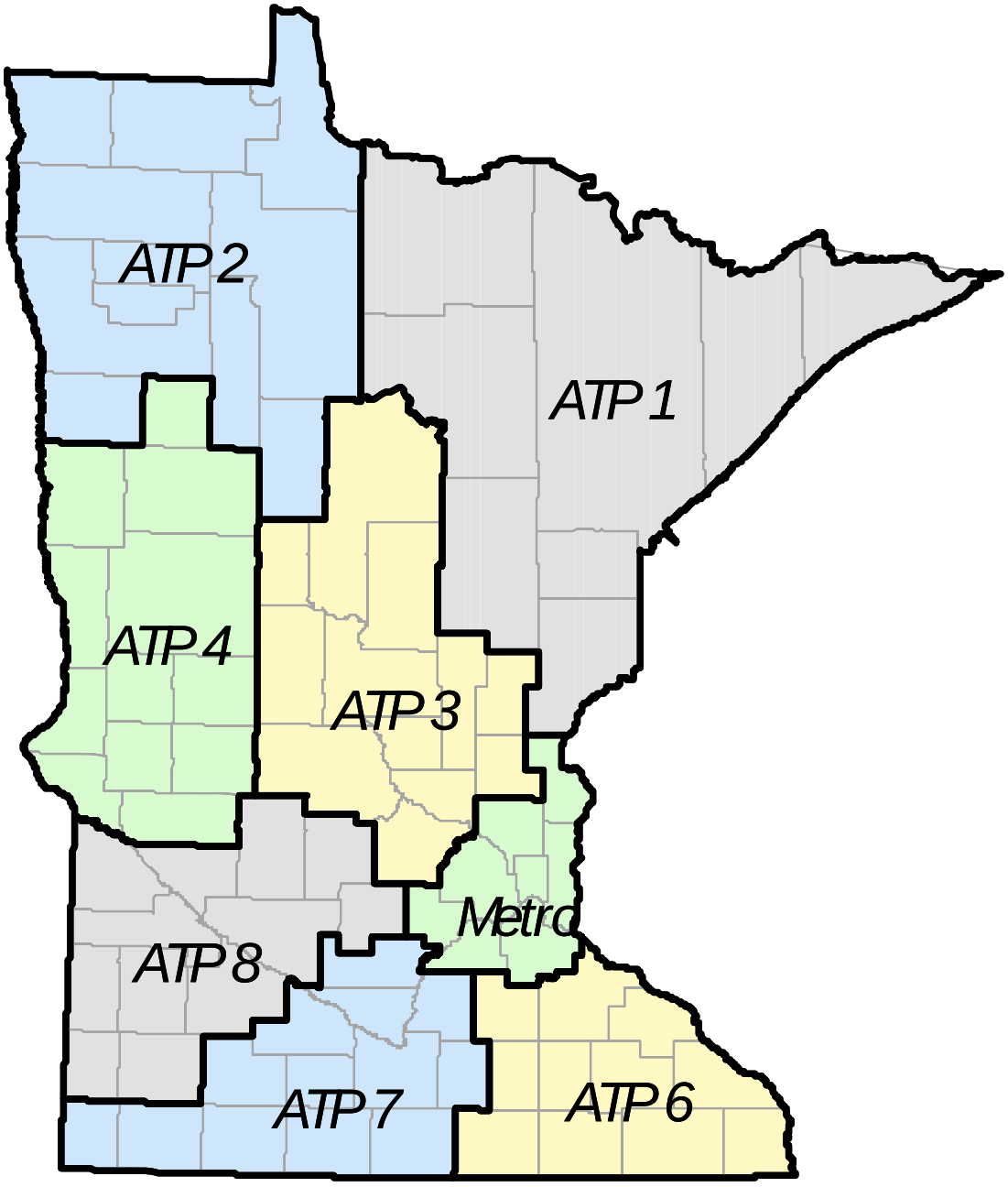
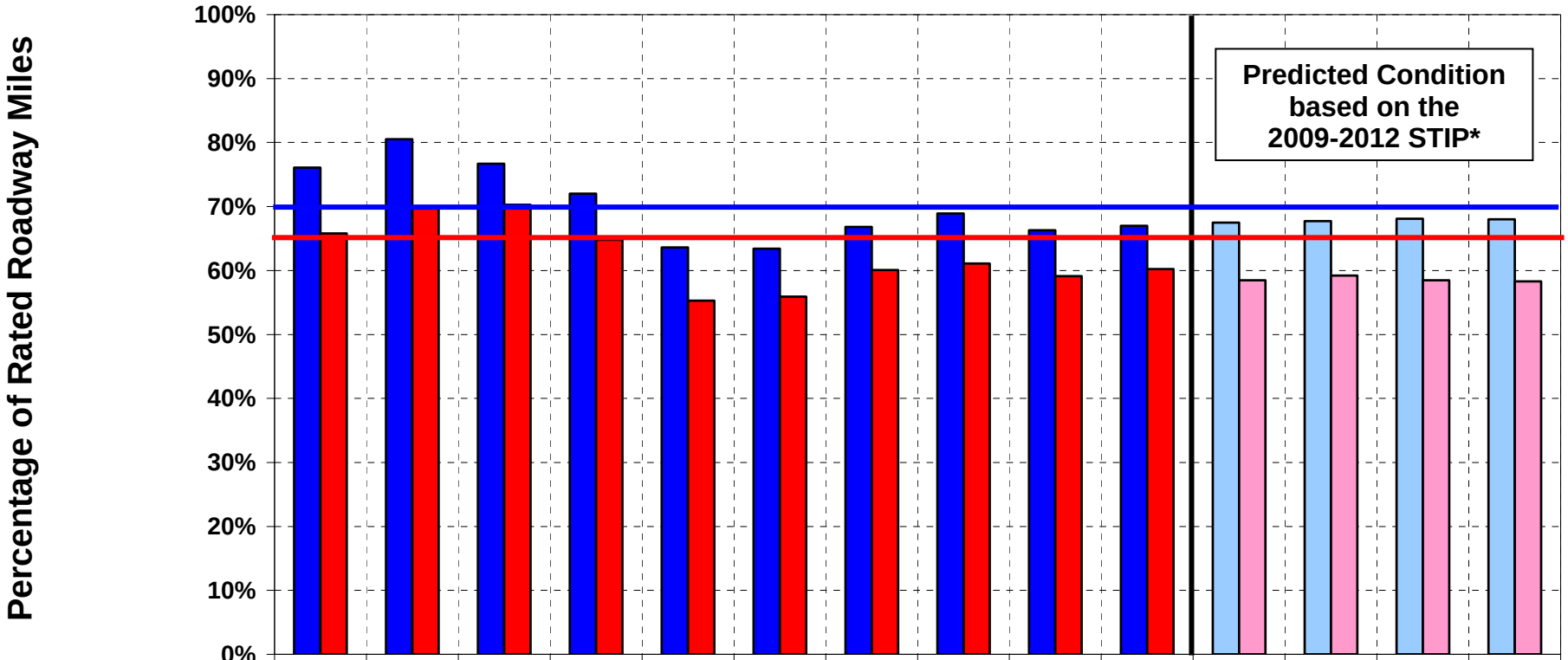


Figure 1. Mn/DOT's Area Transportation Partnership (ATP) Boundaries

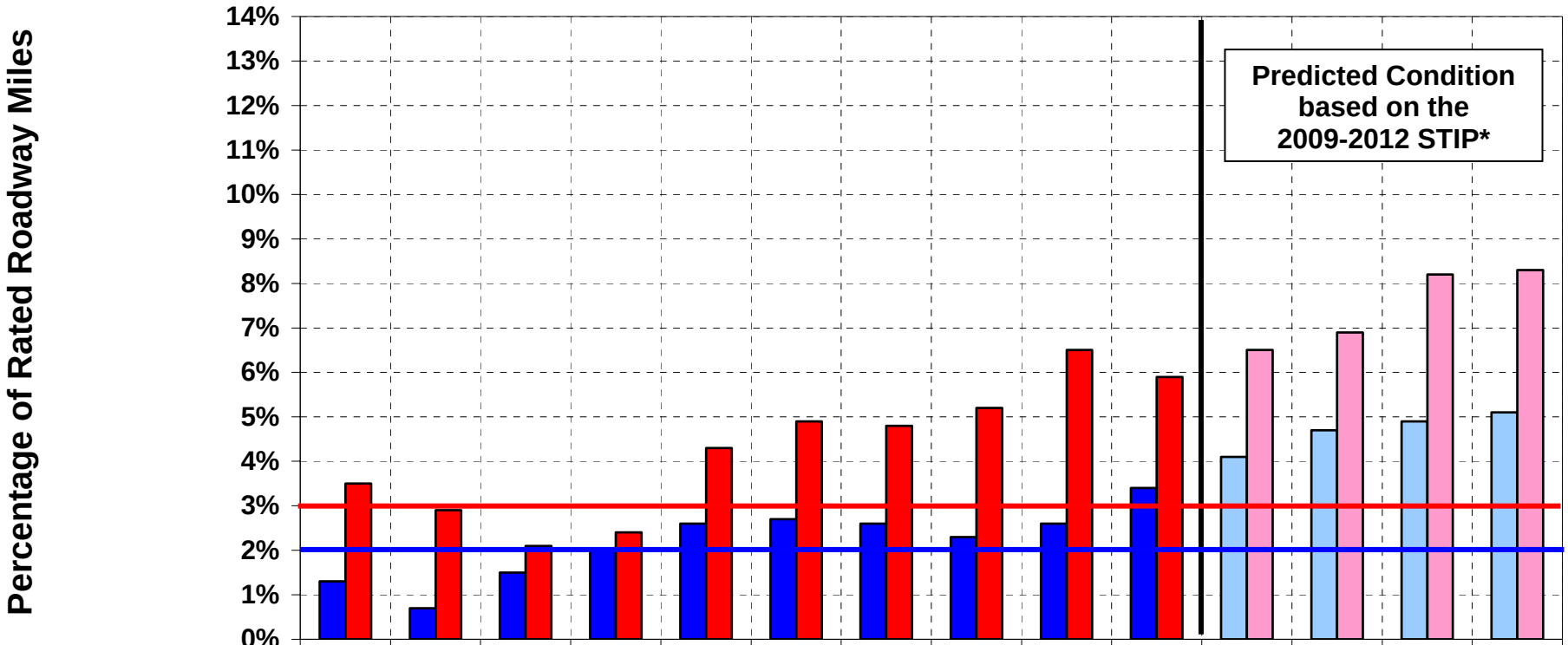
Figure 2
Statewide "Good" Ride Quality Index
(miles with an RQI greater than 3.0)
1999 - 2008



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Principal Art.	76.1%	80.5%	76.7%	72.0%	63.6%	63.4%	66.8%	68.9%	66.3%	67.0%	67.5%	67.7%	68.1%	68.0%
Non-Principal Art.	65.8%	69.7%	70.3%	64.8%	55.3%	55.9%	60.1%	61.1%	59.1%	60.2%	58.5%	59.2%	58.5%	58.3%

Principal Arterial Target = 70 percent or more
Non-Principal Arterial Target = 65 percent or more

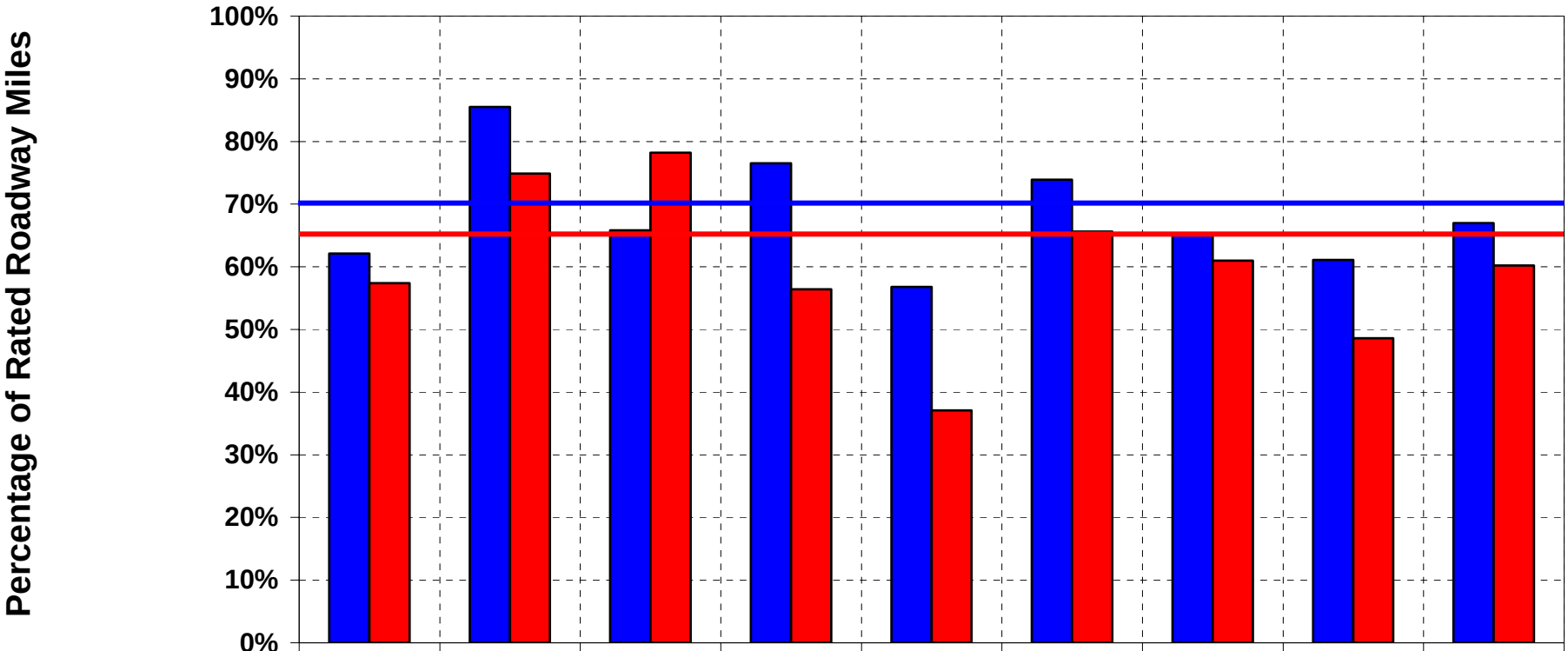
Figure 3
Statewide "Poor" Ride Quality Index
(miles with an RQI of 2.0 or less)
1999 - 2008



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Principal Art.	1.3%	0.7%	1.5%	2.0%	2.6%	2.7%	2.6%	2.3%	2.6%	3.4%	4.1%	4.7%	4.9%	5.1%
Non-Principal Art.	3.5%	2.9%	2.1%	2.4%	4.3%	4.9%	4.8%	5.2%	6.5%	5.9%	6.5%	6.9%	8.2%	8.3%

Principal Arterial Target = 2 percent or less
Non-Principal Arterial Target = 3 percent or less

Figure 4
"Good" Ride Quality Index
(miles with an RQI greater than 3.0)
Comparison of 2008 Data by ATP

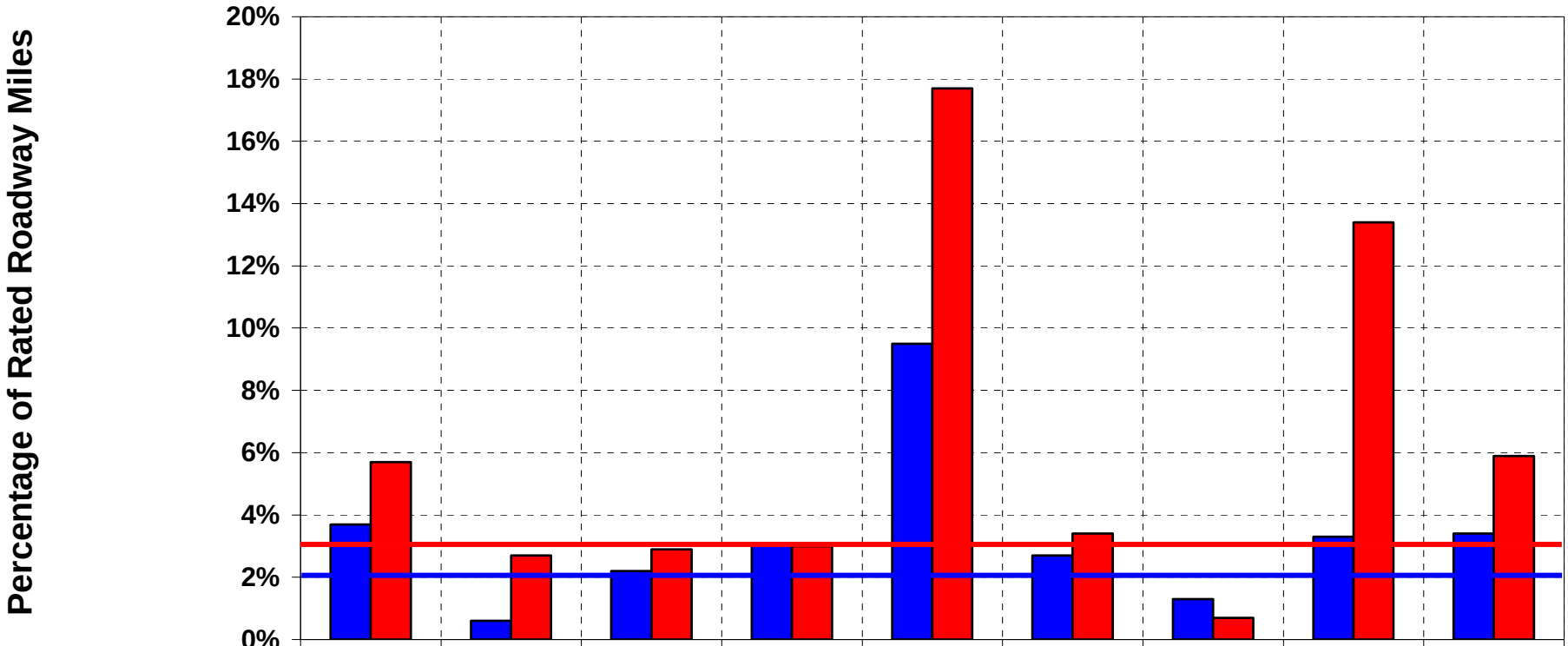


	ATP-1	ATP-2	ATP-3	ATP-4	ATP-6	ATP-7	ATP-8	Metro	State
Principal Art.	62.1% ▲	85.5% ▲	65.8%	76.5% ▲	56.8% ▲	73.9%	65.3% ▲	61.1% ▼	67.0% ▲
Non-Principal Art.	57.4% ▼	74.9% ▲	78.2% ▲	56.4% ▼	37.1% ▲	65.6% ▼	61.0% ▼	48.6% ▲	60.2% ▲

▲ = Better than 2007 ▼ = Worse than 2007 Blank = Same as 2007

Principal Arterial Target = 70 percent or more
Non-Principal Arterial Target = 65 percent or more

Figure 5
"Poor" Ride Quality Index
(miles with an RQI of 2.0 or less)
Comparison of 2008 Data by ATP

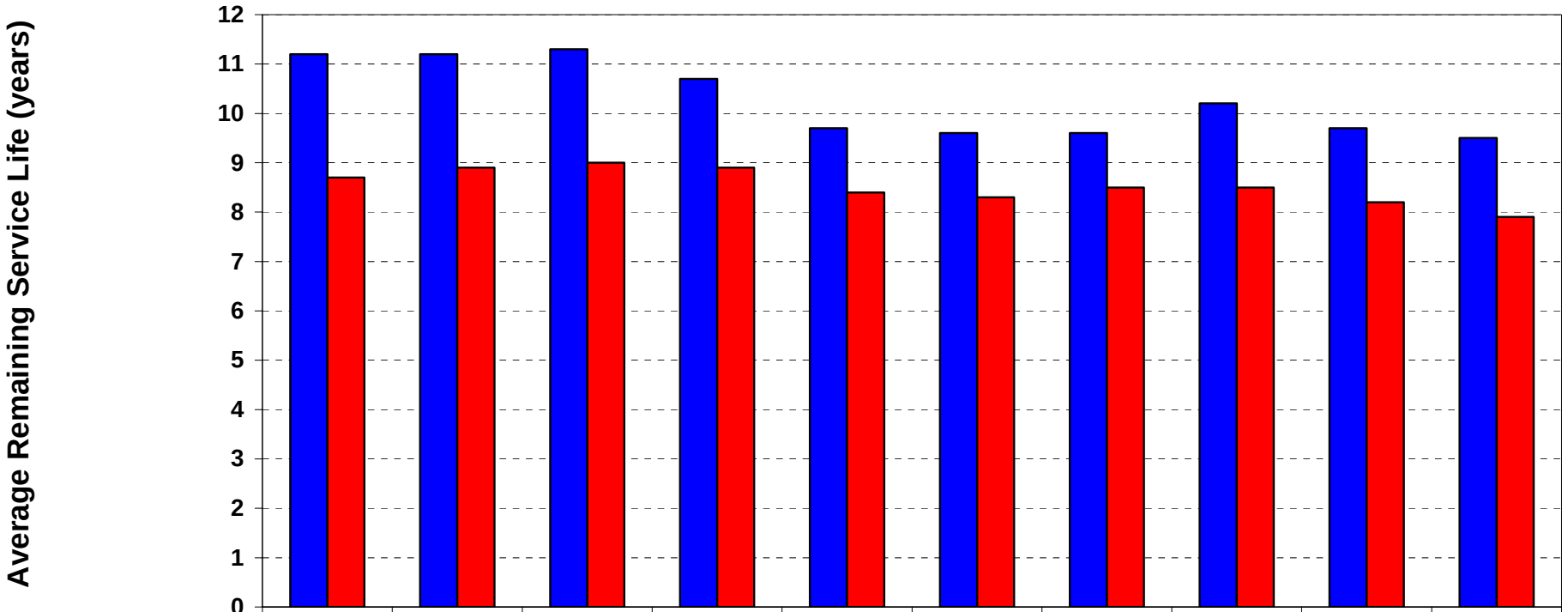


	ATP-1	ATP-2	ATP-3	ATP-4	ATP-6	ATP-7	ATP-8	Metro	State
Principal Art.	3.7% ▼	0.6% ▲	2.2% ▼	3.1% ▼	9.5% ▼	2.7% ▼	1.3% ▼	3.3% ▼	3.4% ▼
Non-Principal Art.	5.7% ▲	2.7% ▲	2.9% ▼	3.0% ▼	17.7% ▼	3.4% ▼	0.7% ▼	13.4% ▲	5.9% ▲

▲ = Better than 2007 ▼ = Worse than 2007 Blank = Same as 2007

Principal Arterial Target = 2 percent or less
Non-Principal Arterial Target = 3 percent or less

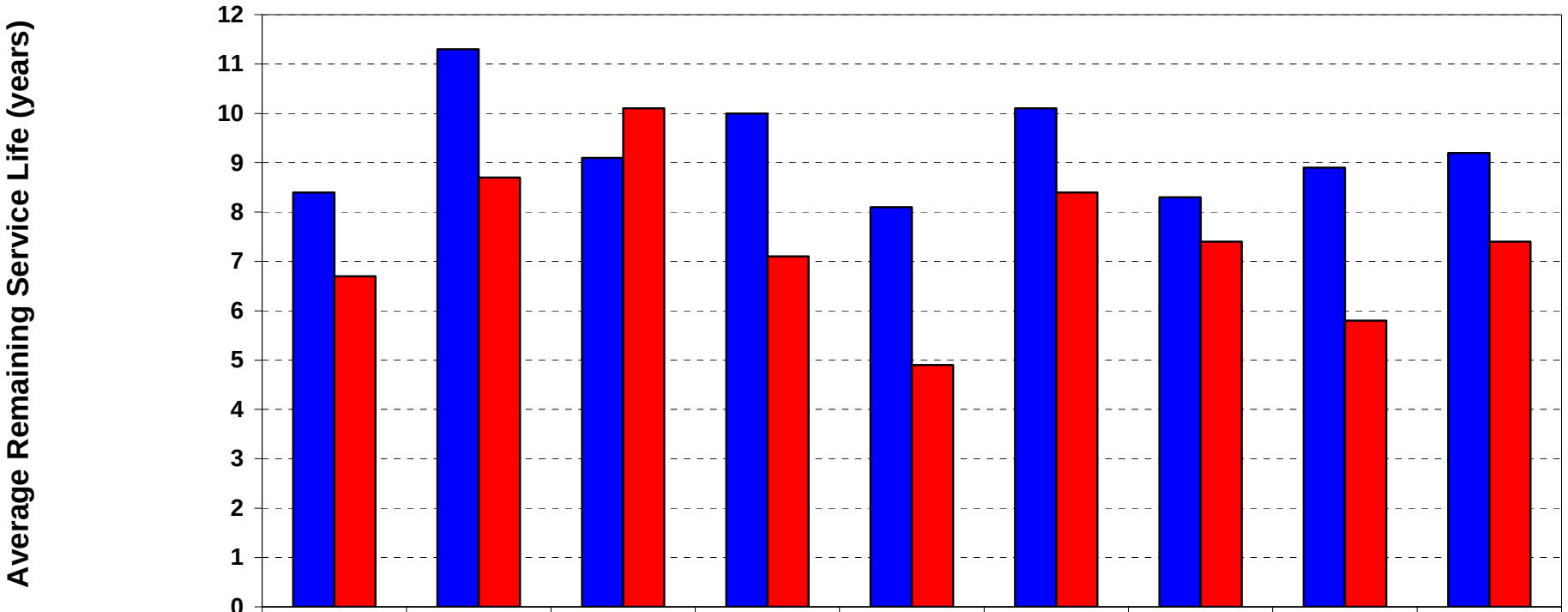
Figure 6
Statewide Average Remaining Service Life (ARSL)
(years until RQI reaches 2.5)
Statewide 1999 - 2008 Data



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Principal Art.	11.2	11.2	11.3	10.7	9.7	9.6	9.6	10.2	9.7	9.5
Non-Principal Art.	8.7	8.9	9.0	8.9	8.4	8.3	8.5	8.5	8.2	7.9

No official targets have been established for ARSL

Figure 7
Average Remaining Service Life (ARSL)
(Years until RQI reaches 2.5)
Comparison of 2008 Data by ATP



	ATP-1	ATP-2	ATP-3	ATP-4	ATP-6	ATP-7	ATP-8	Metro	State
Principal Art.	8.4	11.3	9.1	10.0	8.1	10.1	8.3	8.9	9.2
Non-Principal Art.	6.7	8.7	10.1	7.1	4.9	8.4	7.4	5.8	7.4

No official targets have been established for ARSL


MINNESOTA
DEPARTMENT OF TRANSPORTATION