2022 PAVEMENT CONDITION ANNUAL REPORT

DEPARTMENT OF TRANSPORTATION

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Pavement Management Unit

Office of Materials and Road Research

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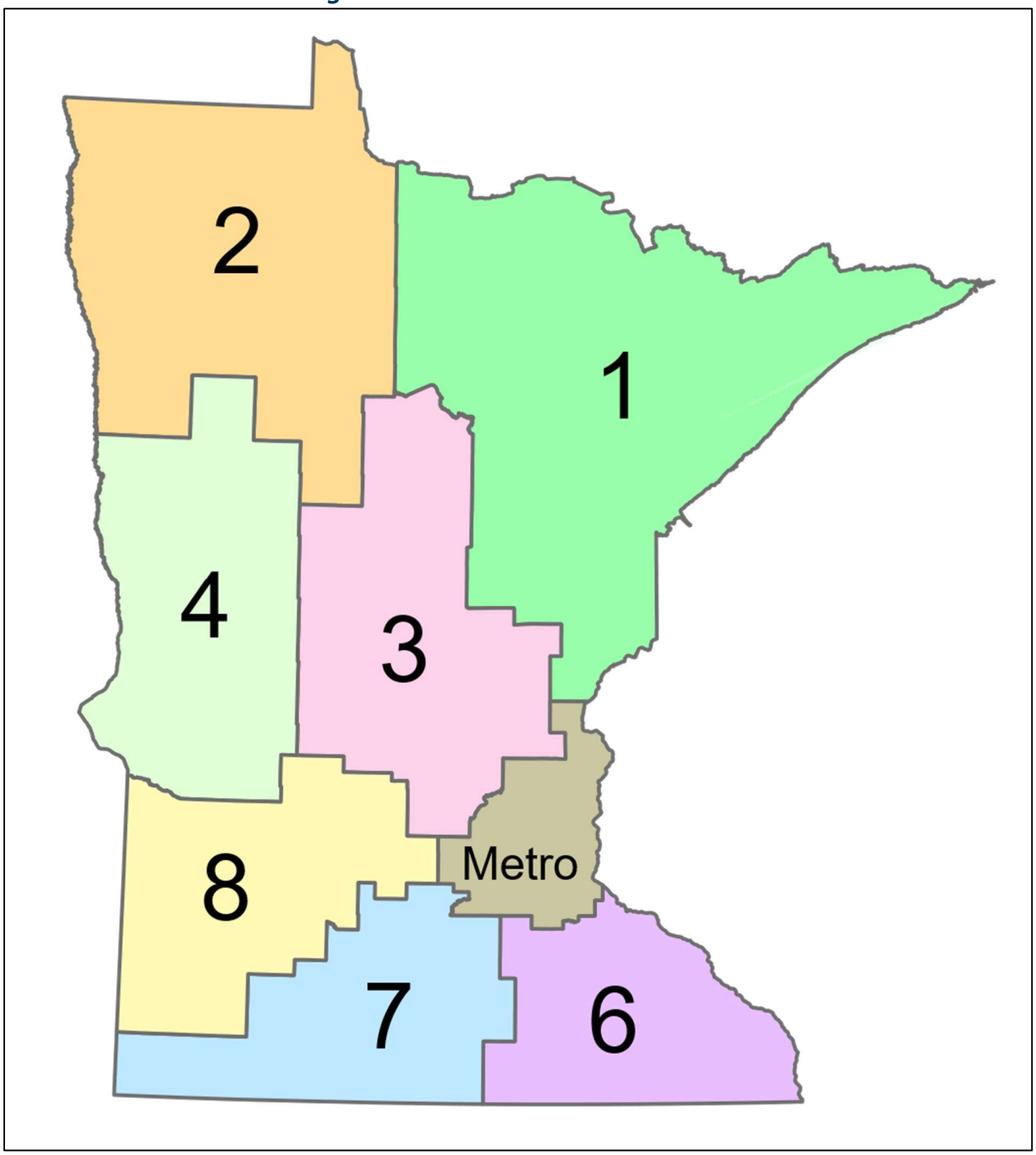
INTRODUCTION

This report is prepared annually by the Minnesota Department of Transportation (MnDOT) Pavement Management Unit to provide information concerning trunk highway pavement performance. It discusses statewide performance trends compared with established targets and compares performance between Area Transportation Partnerships (ATPs). Figure 1 displays MnDOT's eight ATPs.

Figure 1. MnDOT's ATP Boundaries



BACKGROUND

MnDOT's trunk highway system consists of approximately 12,000 centerline miles (14,271 rated roadway miles) of pavement. This system consists of bituminous, concrete, and composite pavement with a wide range of conditions, ages, 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 several different metrics related to pavement performance. Condition data has been collected on the trunk highway network since the late 1960s.

DATA COLLECTION

Pavement roughness and surface distress data is collected using a sophisticated digital inspection vehicle (shown in Figure 2). The vehicle is driven in the outer lane of all trunk highways annually, in both directions. It is equipped with two digital cameras: one facing straight ahead and one angling toward the right to collect right-of-way images. For pavement distress and rutting measurements, a 3D laser/camera system is used to produce images of the pavement surface, from which the type, severity, and amount of cracking can be determined. The vehicle is also equipped with laser height sensors that measure the longitudinal pavement profile, from which pavement roughness is calculated.

Figure 2. Network-Level Pavement Surface Data Collection Vehicle

Pavement condition data is used to monitor the performance of the system, to aid in project selection, and to identify future pavement maintenance or rehabilitation needs.

INDICES AND MEASURES

MnDOT's pavement condition data is reduced to several indices for reporting the statewide pavement performance measures in MnDOT's 20-year Transportation Plan: Ride Quality Index (RQI), Surface Rating (SR),

Pavement Quality Index (PQI), and Remaining Service Life (RSL). Each index captures a different aspect of a pavement's health. Collectively, the four indices are used to rank pavement sections and predict the need for future maintenance and rehabilitation. Each is briefly described below.

Ride Quality Index (RQI)

RQI is MnDOT's ride, or smoothness, index. It uses a 0.1 to 5.0 rating scale, rounded to the nearest tenth. A higher RQI represents a smoother road, while a lower RQI indicates a rougher ride. RQI attempts to quantify the range of smoothness ratings that typical drivers would use to evaluate ride. Most new construction projects have an initial RQI above 4.0. Pavements are normally designed for a terminal RQI value of 2.5. Roads that have reached a terminal RQI value can still be driven on but have deteriorated to a point where vehicle discomfort is felt by drivers and a major rehabilitation is likely needed.

RQI is calculated from a pavement's longitudinal profile, measured by height sensors that are situated a few inches above the ground behind the digital inspection vehicle's rear tires. These height sensors consist of a multitude of adjoining laser points that combine to form a four-inch, transverse line that extends down to the pavement surface. These line lasers, along with corresponding accelerometers, measure the distance between the floating reference height and the surface of the longitudinal profile being measured. From this data, a longitudinal elevation can be recorded as the vehicle travels down a road. Once collected, the data is run through a mathematical simulation to generate the International Roughness Index (IRI)—the amount of vertical movement a standard vehicle would experience on a particular pavement. IRI is the roughness index used by most countries and every state DOT in the U.S. While many states use IRI as their sole measure of roughness, MnDOT converts IRI to RQI to incorporate Minnesota drivers' attitudes toward pavement smoothness. The two indices are highly correlated.

Surface Rating (SR)

Pavement distresses are defects that are visible on the surface of a pavement. They are indicative of pavement deterioration such as cracks, patches, or ruts. The type and severity of a pavement distress can provide insight into future maintenance and/or rehabilitation needs.

MnDOT uses SR to quantify pavement distress. The distress identification procedure used to determine the SR is done using computer workstations in the Pavement Management Unit of the Office of Materials and Road Research, located in Maplewood, MN. Specialized software is used to examine and analyze digital images of the pavement captured by the vehicle's high-resolution cameras. The vehicle captures several images simultaneously: the pavement in front of the vehicle, to the right of the vehicle (i.e., the shoulder), and below the vehicle (downward-pointing images).

Since 2017, condition surveys have been done using an "AutoCrack" system. AutoCrack software looks at 3D images of the pavement surface and determines if any cracks or other distresses exist. If so, the software determines the location within the lane and classifies the distresses by type and severity, calculating length and/or width. Next, a second system, called "AutoClass," is used to convert the AutoCrack distress types and severities into MnDOT distress types and severities. Because the system is automated, continuous distress surveys covering 100% of the length of each section are performed. On undivided roadways, only the outside lane in the increasing direction (north or east) is rated for SR. On divided routes, the outside lane in both directions is rated.

The percentage of each distress in a section is determined and multiplied by a weighting factor to compute a weighted distress value. The weighting factor for a particular distress type increases as its severity level rises. In

addition, weighting factors are larger for distress types that indicate more serious roadway problems (such as alligator cracking or broken panels). Once a pavement section's individual weighted distress values are computed, they are combined to determine a corresponding SR. SR ranges from 0.1 to 4.0 and is rounded to the nearest tenth. A higher SR indicates a better condition. A road with no defects is rated at 4.0. A road in need of major rehabilitation or reconstruction will generally have an SR near or below 2.5.

Pavement Quality Index (PQI)

PQI is a composite index, equal to the square root of the product of RQI and SR. Because PQI is an amalgam of an index that measures pavement smoothness and another that quantifies pavement distress, it is a good indication of the overall condition of a pavement. Therefore, PQI is the index used to determine if Minnesota's state highway system is meeting performance thresholds established for the Government Accounting Standards Board, Standard 34 (GASB 34).

Remaining Service Life (RSL)

RSL is an estimate, in years, until an RQI will reach a value of 2.5, which is generally considered the end of a pavement's design life. Most pavements will need some type of major rehabilitation when their RQI is 2.5 or lower. RSL is determined from pavement deterioration curves. A regression curve is fit through the historical RQI data for each pavement section to provide an estimate of when its RQI will reach 2.5. If there is insufficient historical data to make this calculation, default models based on statewide pavement performance are used. Rehabilitation activities with long service lives add a considerable number of years to the RSL of a pavement. Short-term fixes, such as patching, temporarily increase a pavement's smoothness but do not result in many additional years of RSL.

Each year, RSL is calculated for all trunk highway segments. From these values, a length-weighted Average RSL (ARSL) is calculated for the entire trunk highway system and for each ATP. Service life is added when any maintenance or rehabilitation is performed on a pavement section. Service life is lost when the condition of a pavement section deteriorates due to aging. The ARSL of the trunk highway system increases when projects add more life to the system than the sum of the system's deterioration.

PERFORMANCE CATEGORIES

As shown in Table 1, MnDOT currently categorizes RQI pavement condition into five descriptive categories: "Very Good" (4.1 - 5.0), "Good" (3.1 - 4.0), "Fair" (2.1 - 3.0), "Poor" (1.1 - 2.0), and "Very Poor" (0.1 - 1.0). However, when reporting performance measures, the top two categories are combined and referred to as "Good" (3.1 - 5.0); likewise, the bottom two categories are combined and referred to as "Poor" (0.1 - 2.0). These two performance measure categories, which are highlighted in green and red in Table 1, respectively, will be used for the remainder of this report.

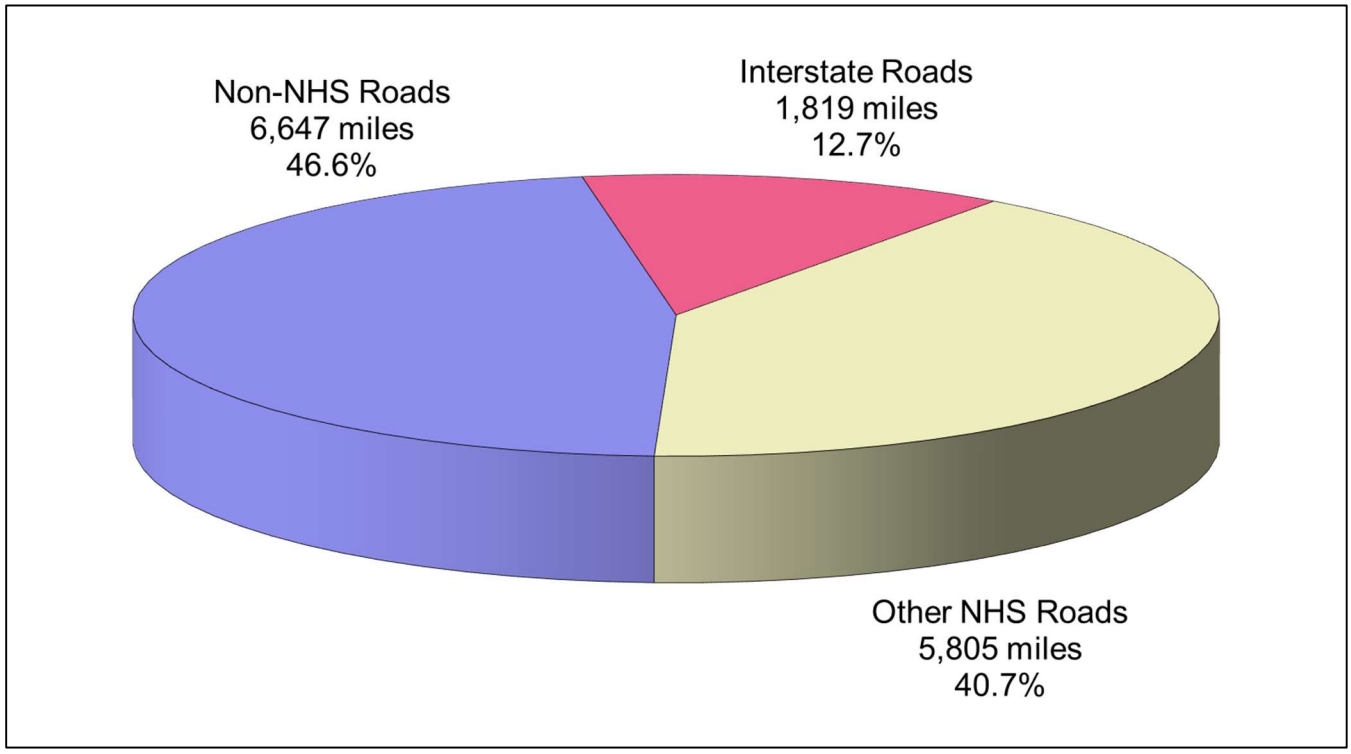
Table 1. RQI Performance Categories

Descriptive Category	RQI Range	Performance Measure Category
Very Good	4.1 – 5.0	**Good**
Good	3.1 – 4.0	
Fair	2.1 – 3.0	
Poor	1.1 – 2.0	**Poor**
Very Poor	0.1 – 1.0	

PERFORMANCE TARGETS

For reporting statewide pavement conditions, MnDOT divides its trunk highway system into three subsystems: "Interstate," "Other NHS," and "Non-NHS" roads. Minnesota's trunk highway system distribution is shown in Figure 3.

Figure 3. Distribution of Minnesota's Trunk Highway System



Interstates are highways that traverse more than one state. These roads, which comprise part of the National Highway System (NHS), account for 12.7 percent of Minnesota's trunk highway system. Other NHS roads, the non-interstate highways within Minnesota's NHS, constitute 40.7 percent of the trunk highway system. Lastly, Non-NHS roads make up the largest portion of Minnesota's trunk highway system: 46.6 percent. Every ATP contains Other NHS and Non-NHS roads, but some—namely, ATP-2 and ATP-8—do not have any Interstates.

Each subsystem has its own set of targets as shown in Table 2.

Table 2. RQI Targets by System

System	Good RQI Target	Poor RQI Target
Interstate	70 percent or more	2 percent or less
Other NHS	65 percent or more	4 percent or less
Non-NHS	60 percent or more	8 percent or less

MnDOT's targets for the Interstate system are 70 percent or more in Good condition and 2 percent or less in Poor condition. The targets for the Other NHS system are 65 percent or more in Good condition and 4 percent or less in Poor condition. Finally, the targets for the Non-NHS system are 60 percent or more in Good and 8 percent or less in Poor. Note: the Poor target for Non-NHS roads will officially decrease from 10 to 8 percent

later this year with the adoption of the Minnesota State Highway Investment Plan (MnSHIP). Since this policy change is imminent, the 8% target value will be used for this report.

Federal Highway Administration (FHWA) definitions of Good, Fair, and Poor are different than what is described above. Since this document is not intended to be the official document regarding MnDOT's pavement system to be submitted to the FHWA, FHWA measures and targets will not be discussed in this report. That information can be obtained from MnDOT's annual Highway Performance Monitoring System (HPMS) submittal.

Similarly, since forecasted pavement condition values are covered in MnDOT's annual State Transportation Improvement Program (STIP) and Capital Highway Investment Plan (CHIP) reports, this report will cover only present and past condition values.

RQI targets are based on the percentage of miles in MnDOT's Good and Poor categories. These are statewide targets. It is recognized that some ATPs will outperform the targets while others will not meet them. However, limiting the variation between ATPs' pavement conditions ensures the public does not encounter drastic differences in pavement performance while driving throughout the state.

STATEWIDE HISTORICAL RQI TRENDS

In 2022, the smoothness of the state highway system remained mostly unchanged, with 28 fewer miles in the Good category and 11 fewer miles in the Poor category, compared to 2021. The Interstate and Non-NHS systems experienced a small net improvement, whereas the Other NHS system worsened slightly.

Once a pavement falls into Poor condition, it normally will require major rehabilitation or reconstruction to restore a meaningful amount of service life. Because these types of repairs are expensive, the recovery of Poor pavements is constrained by limited budgetary resources. Nonetheless, even a small reduction in the number of Poor miles is an accomplishment.

2013-2022 Interstate RQI Trends (Figure 4)

Interstate Good improved between 2021 and 2022, rising from 91.3 to 92.0 percent. Over the same one-year period, Interstate Poor worsened slightly, increasing from 0.4 to 0.5 percent. Both the 2022 Interstate Good and Poor values met their Interstate RQI target.

2013-2022 Other NHS RQI Trends (Figure 5)

In 2022, Other NHS Good worsened from the previous year, dropping from 81.8 to 81.0 percent. Other NHS Poor remained unchanged at 0.6 percent. Both these values met their Other NHS RQI target.

2013-2022 Non-NHS RQI Trends (Figure 6)

Non-NHS Good and Poor both improved in 2022. Between 2021 and 2022, the proportion of Good pavement increased from 75.1 to 75.2 percent, while the proportion of Poor pavement decreased from 2.3 to 2.1 percent. In 2022, both the Good and Poor values met their Other NHS RQI target.

Although the overall smoothness of Minnesota's trunk highway system changed little between 2021 and 2022, significant improvements occurred between 2013 and 2022. During this ten-year period, the amount of Good pavement rose from 75.2 to 92.0 percent for Interstate, 71.0 to 81.0 percent for Other NHS, and 62.5 to 75.2

percent for Non-NHS. Between 2013 and 2022, the amount of Poor pavement decreased from 2.4 to 0.5 percent for Interstate, 2.9 to 0.6 percent for Other NHS, and 6.8 to 2.1 percent for Non-NHS.

RQI COMPARISON BY ATP

RQI values did not change much for any ATP between 2021 and 2022. Table 3 shows the change in Good and Poor miles for the Interstate, Other NHS, and Non-NHS systems between 2021 and 2022. Green cells in the table indicate an improved condition (i.e., fewer Poor or more Good miles), while red cells indicate a worse condition (i.e., fewer Good or more Poor miles). Of the 44 ATP comparisons in Table 3, 18 indicate a smoother overall condition, while 20 indicate a rougher overall condition. Six of the comparisons indicate no change in condition. While most ATPs experienced a mixture of smoothness condition changes on their trunk highway subsystems between 2021 and 2022, ATP-8 experienced only worsening conditions.

Table 3. ATP Comparison of Good and Poor RQI Miles in 2021 and 2022

ATP	Change in Miles Over One-Year Period					
	Interstate		Other NHS		Non-NHS	
	Good	Poor	Good	Poor	Good	Poor
1	6	0	-12	3	-1	-2
2	NA	NA	17	-3	-5	-3
3	2	0	1	1	15	-6
4	-8	0	-7	1	37	-9
6	-4	0	-5	0	-2	-3
7	15	0	11	2	-15	8
8	NA	NA	-26	1	-43	1
Metro	2	1	-14	-1	8	-3

2022 ATP Comparison of Interstate RQI (Table 3 and Figure 7)

In 2022, all ATPs met the Good target (70 percent or more) on the Interstate system. Values ranged from 88.1 percent (ATP-7) to 98.9 percent (ATP-3). Four ATPs—1, 3, 7, and Metro—had a small increase in the number of miles in Interstate Good in 2022 compared to 2021, while two ATPs—4 and 6—had a small decrease. Statewide, there were 14 more miles in Good condition on the Interstate system in 2022, compared to 2021.

All ATPs easily met the Poor target (2 percent or less) on the Interstate system in 2022. Values ranged from 0.0 percent (ATP-3, ATP-4, ATP-6, and ATP-7) to 1.4 percent (Metro). The quantity of Interstate Poor roads between 2021 and 2022 changed very little. The amount of Interstate Poor pavement remained the same for every ATP except Metro, which had an increase of 1 mile. Statewide, Interstate Poor pavement also increased by 1 mile.

2022 ATP Comparison of Other NHS RQI (Table 3 and Figure 8)

Every ATP surpassed the Good target (65 percent or more) on the Other NHS system in 2022. Values ranged from 71.4 percent (ATP-7) to 88.6 percent (ATP-3). Three ATPs—2, 3, and 7—had an increase in the number of miles in Interstate Good between 2021 and 2022, while five ATPs—1, 4, 6, 8, and Metro—had a decrease. Statewide, there were 36 fewer miles in Good condition on the Other NHS system in 2022, compared to 2021.

In 2022, all ATPs met the Poor target (4 percent or less) on the Other NHS system. Values ranged from 0.1 percent (ATP-6) to 1.2 percent (ATP-1). Between 2021 and 2022, ATP-2 and Metro had small reductions in the

number of Other NHS Poor miles, while the remaining ATPs had slight increases. Statewide, Other NHS pavement increased by 4 miles over the one-year period.

2022 ATP Comparison of Non-NHS RQI (Table 3 and Figure 9)

On the Non-NHS system, every ATP met the Good target (60 percent or more) in 2022. Values ranged from 59.3 percent (ATP-7) to 83.1 percent (ATP-6). Three ATPs—3, 4, and Metro—had an increase in Non-NHS Good miles between 2021 and 2022, while five ATPs—1, 2, 6, 7, and 8—had a decrease. ATP-4 had the largest increase (37 miles), while ATP-8 had the largest decrease (43 miles). Statewide, there were 5 fewer miles in Non-NHS Good.

In 2022, all ATPs met the Poor target (8 percent or less) on the Non-NHS system. Values ranged from 0.1 percent (ATP-4) to 5.9 percent (Metro). Between 2021 and 2022, six of the eight ATPs—1, 2, 3, 4, 6, and Metro—experienced reductions in the number of Non-NHS Poor miles. ATP-7 and ATP-8 had slight increases in the number of Poor miles. Statewide, Non-NHS Poor increased by 15 miles in 2022, compared to 2021.

AVERAGE RSL

RSL is defined as the number of years until a pavement's corresponding RQI reaches a value of 2.5 or lower. This is the point where most people begin to complain that a road's roughness is objectionable, and major rehabilitation is likely needed. ARSL is the average RSL for an ATP or the entire state.

2013-2022 ARSL Trends (Figure 10)

ARSL values did not change significantly between 2021 and 2022. In 2022, the ARSL was 20.2 years on the Interstate, 12.6 years on the Other NHS, and 10.4 years on the Non-NHS systems. The ARSL of the Interstate system decreased slightly from its all-time peak of 20.6 years in 2021. Despite the 0.4 drop, the 2022 Interstate ARSL value of 20.2 years was the second highest value ever, up 10.0 years from its 2013 value of 12.2 years. The ARSL of the Other NHS system decreased 0.2 years from its 2021 value of 12.8 years, which was an all-time high. Between 2021 and 2022, the Non-NHS ARSL increased by 0.1 years to reach its highest value ever: 10.4 years. This data is shown in Figure 10.

2022 ATP Comparison of ARSL (Figure 11)

By ATP, the ARSL of the Interstate system ranged from 17.3 years (ATP-7) to 23.8 years (ATP-6). The ARSL of the Other-NHS system ranged from 11.3 years (ATP-1) to 14.4 years (ATP-3), while the ARSL of the Non-NHS system ranged from 8.2 (Metro) to 11.9 (ATP-6). This data is shown in Figure 11.

GOVERNMENT ACCOUNTING STANDARDS BOARD, STATEMENT 34

The Government Accounting Standards Board (GASB), a private, nonprofit organization, was established in 1984 by the Financial Accounting Foundation. The Foundation oversees GASB, provides funding, and appoints the members of GASB's board. The Foundation has a similar relationship with GASB's sister organization, the private-sector, standard-setting Financial Accounting Standards Board. GASB's span of influence covers over 84,000 state, county, and other local governmental units. Also impacted by GASB's financial reporting standards are organizations such as public utilities, municipal hospitals, and state universities. GASB, which does not impact the federal government, establishes concepts and standards that guide the preparation of external financial reports. GASB establishes generally accepted accounting principles that are utilized by auditors charged with evaluating state and local government financial statements.

In June 1999, GASB established a new financial reporting standard that fundamentally changed the way state and local governments report their financial results. GASB Statement 34 (GASB 34), "Basic Financial Statements—and Management's Discussion and Analysis—for State and Local Governments," requires that major infrastructure assets acquired or having major additions or improvements in fiscal years beginning after June 15, 1980, be capitalized in financial statements. GASB 34 also states that the cost of using the assets must be reflected. The U.S. Department of Transportation's Office of Asset Management prepared a detailed report of GASB 34 in November 2000. This FHWA Primer can be accessed at: https://www.fhwa.dot.gov/infrastructure/asstmgmt/010019.pdf.

One of the primary purposes of GASB 34 is to check whether an agency is adequately maintaining the condition of its infrastructure and disclosing all future liabilities.

To determine and track the cost of agency assets, GASB 34 requires governments to report a depreciation expense or use an optional reporting method called "the modified approach." A government agency is permitted to use the modified approach if it meets or exceeds the following four requirements:

- Having a current inventory of eligible assets,
- Documenting the condition of those assets via a reproducible assessment procedure,
- Demonstrating that assets are being preserved at a level predetermined by the government, and
- Estimating the actual cost to maintain and preserve the assets.

With all the above requirements achieved, MnDOT has been authorized to use the modified approach. For the purposes of GASB 34, MnDOT established that the state trunk highway system will be maintained at the following levels:

- Principal Arterial System: Average PQI of 3.0 or higher
- Non-Principal Arterial System: Average PQI of 2.8 or higher

Figure 12 shows that MnDOT has surpassed these established GASB 34 levels during the ten-year reporting period. The Average PQI in 2022 was 3.6 and 3.4 for the Principal Arterial and Non-Principal Arterial systems, respectively—well above the minimum levels.

ADDITIONAL INFORMATION

Additional information about the condition of Minnesota's trunk highway system, including color-coded maps of the most recent indices, can be obtained from MnDOT's Pavement Management Unit's website: http://www.dot.state.mn.us/materials/pvmtmgmt.html.

Please direct any questions about the content of this report to:

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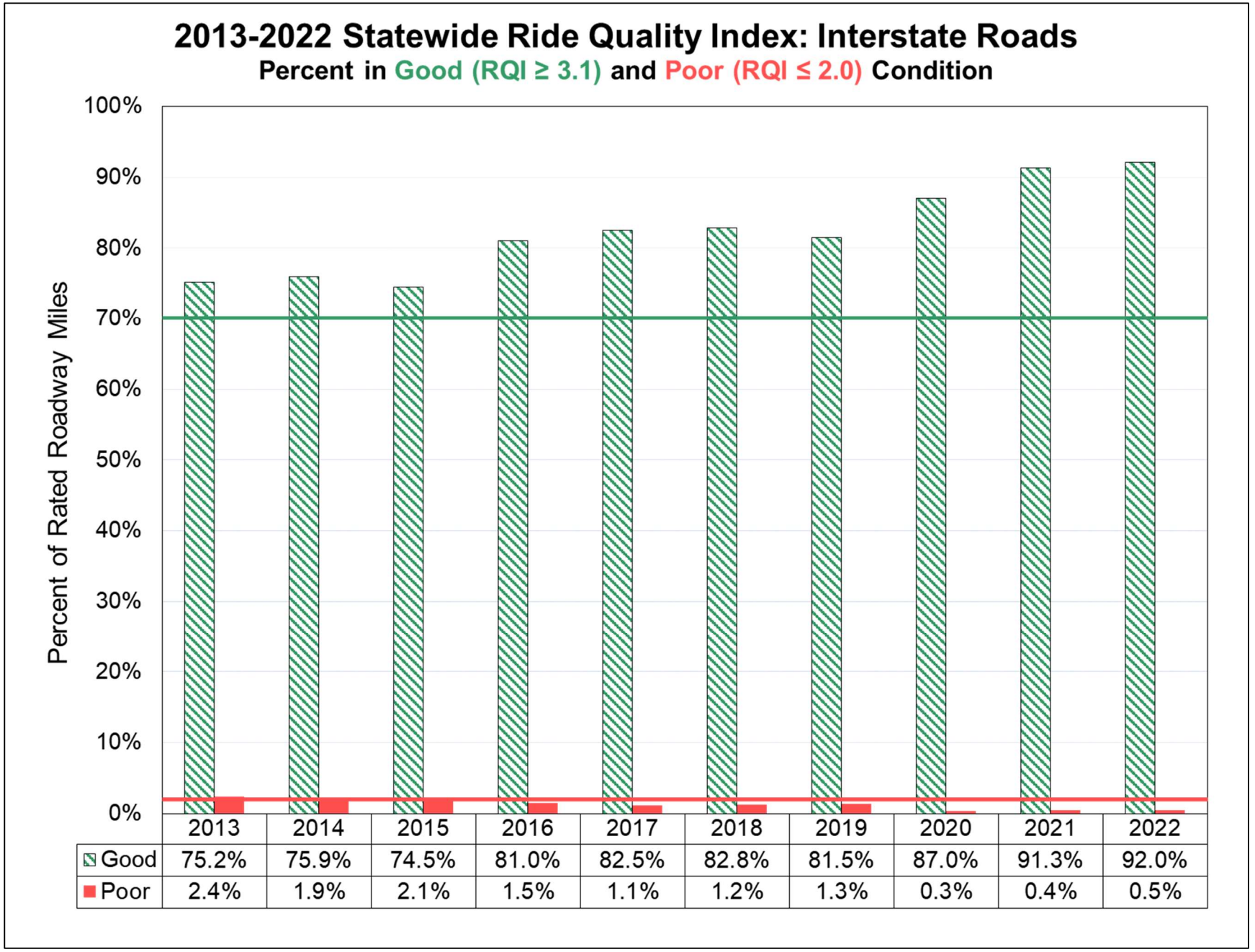
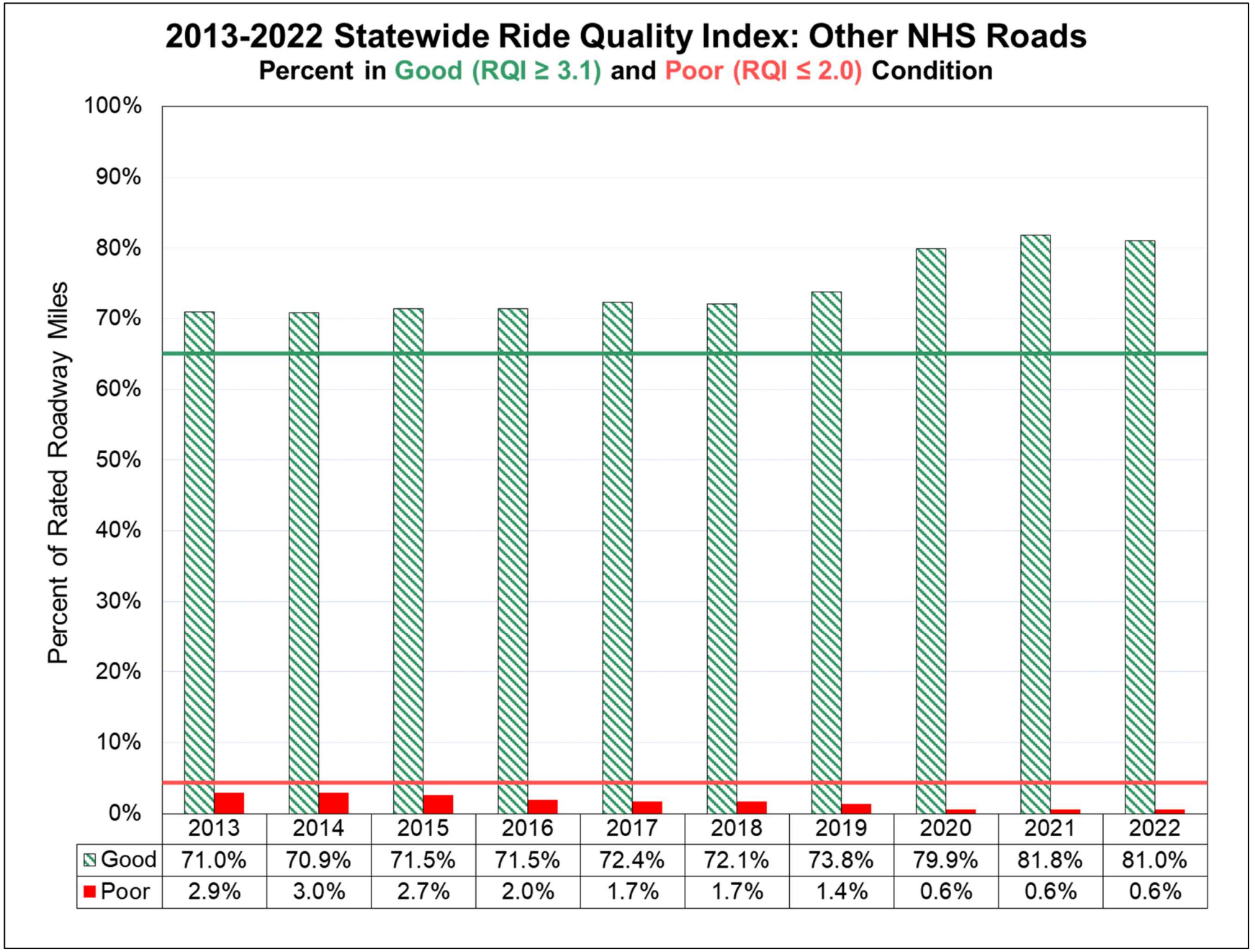
Figure 4. Ten-Year Statewide RQI for Interstate Roads



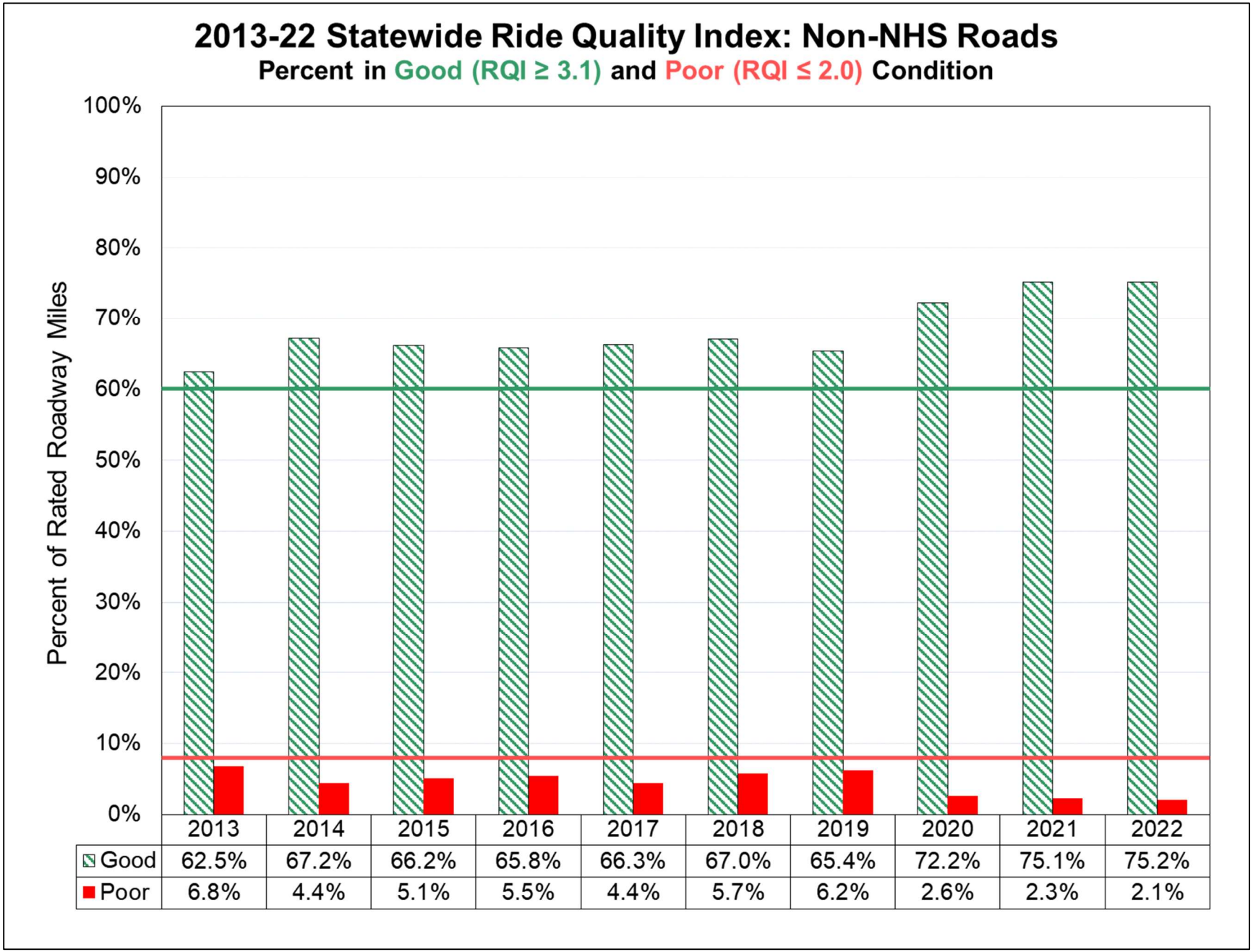
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Good	75.2%	75.9%	74.5%	81.0%	82.5%	82.8%	81.5%	87.0%	91.3%	92.0%
Poor	2.4%	1.9%	2.1%	1.5%	1.1%	1.2%	1.3%	0.3%	0.4%	0.5%

Figure 5. Ten-Year Statewide RQI for Other NHS Roads



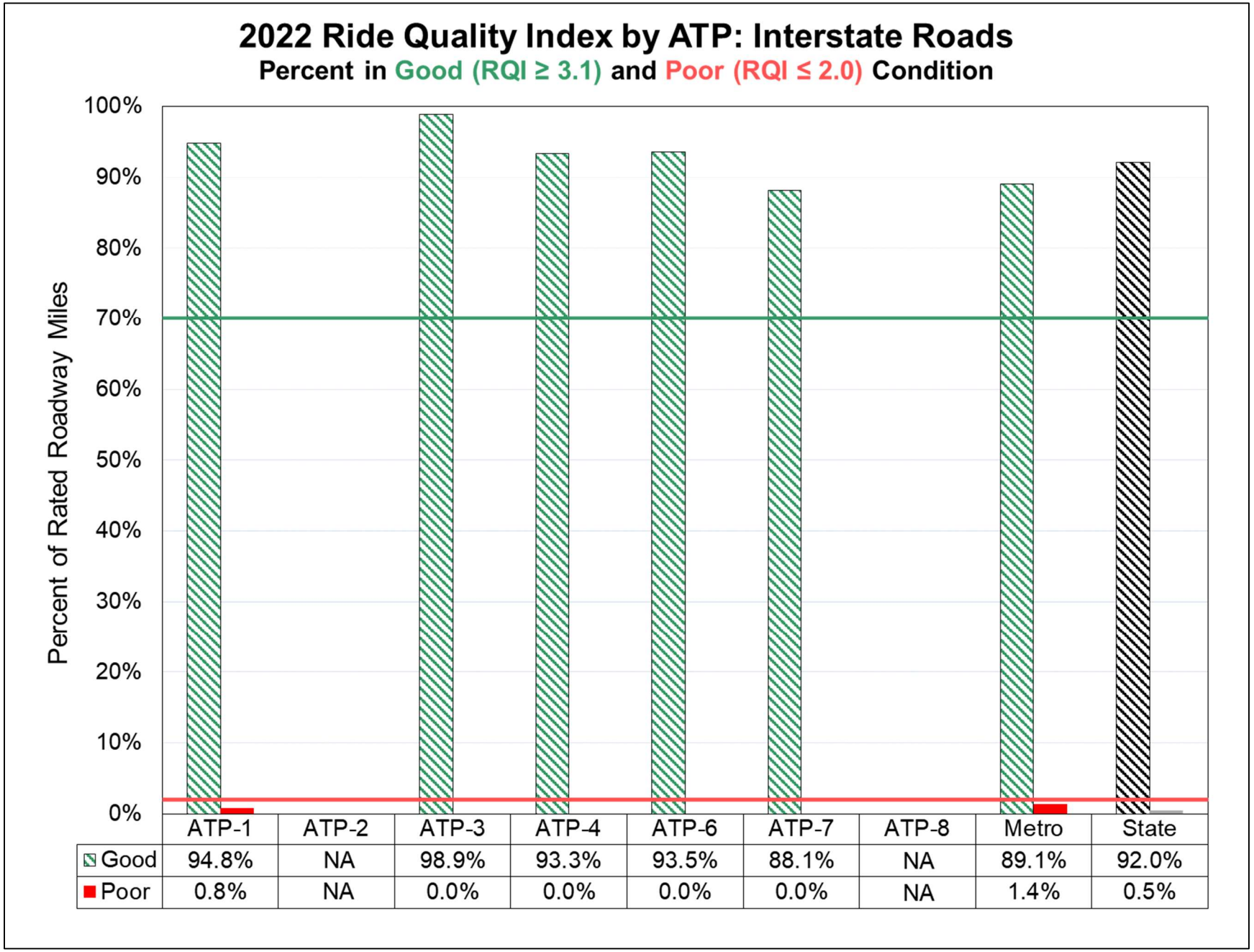
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Good	71.0%	70.9%	71.5%	71.5%	72.4%	72.1%	73.8%	79.9%	81.8%	81.0%
Poor	2.9%	3.0%	2.7%	2.0%	1.7%	1.7%	1.4%	0.6%	0.6%	0.6%

Figure 6. Ten-Year Statewide RQI for Non-NHS Roads



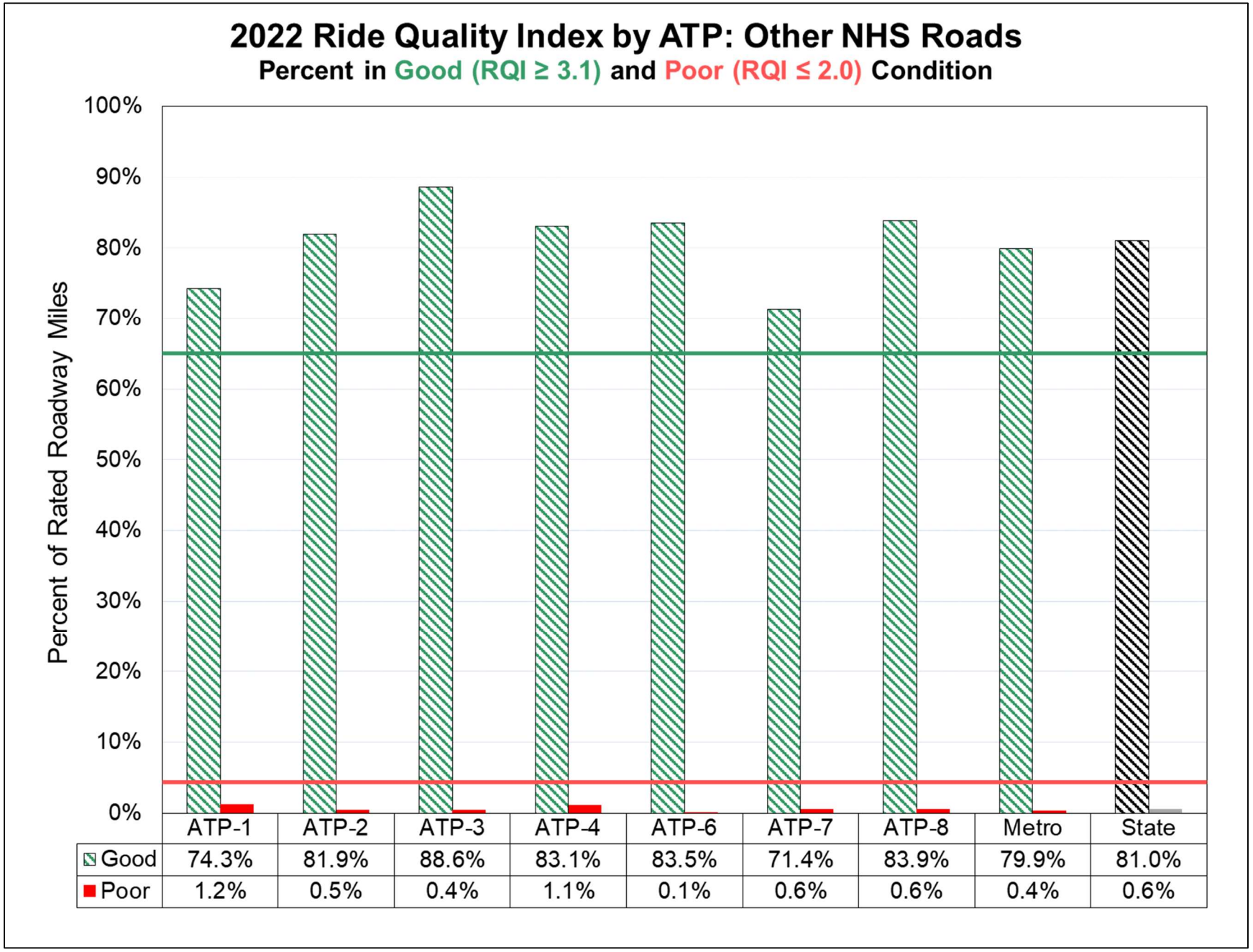
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Good	62.5%	67.2%	66.2%	65.8%	66.3%	67.0%	65.4%	72.2%	75.1%	75.2%
Poor	6.8%	4.4%	5.1%	5.5%	4.4%	5.7%	6.2%	2.6%	2.3%	2.1%

Figure 7. 2022 RQI by ATP for Interstate Roads



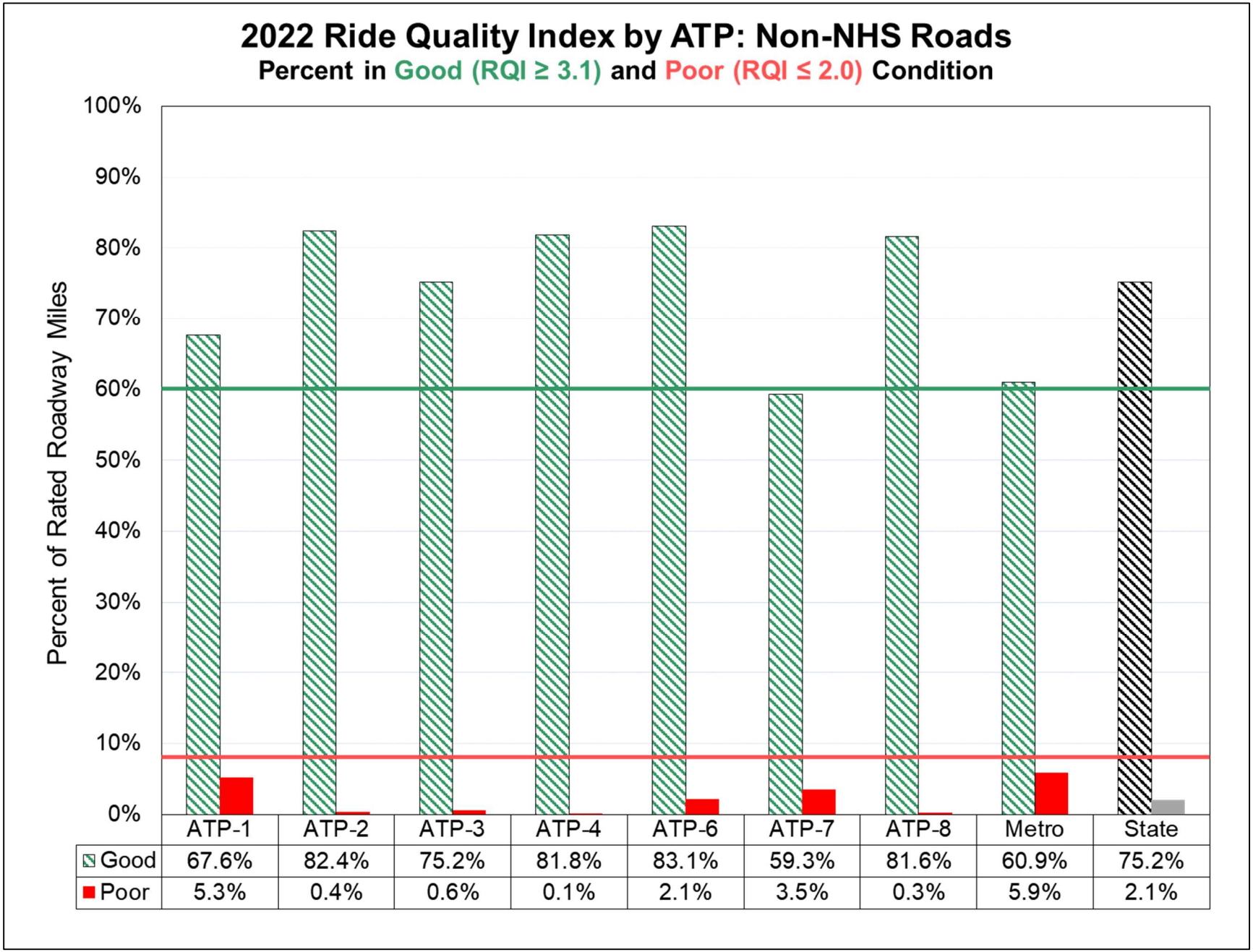
	ATP-1	ATP-2	ATP-3	ATP-4	ATP-6	ATP-7	ATP-8	Metro	State
Good	94.8%	NA	98.9%	93.3%	93.5%	88.1%	NA	89.1%	92.0%
Poor	0.8%	NA	0.0%	0.0%	0.0%	0.0%	NA	1.4%	0.5%

Figure 8. 2022 RQI by ATP for Other NHS Roads



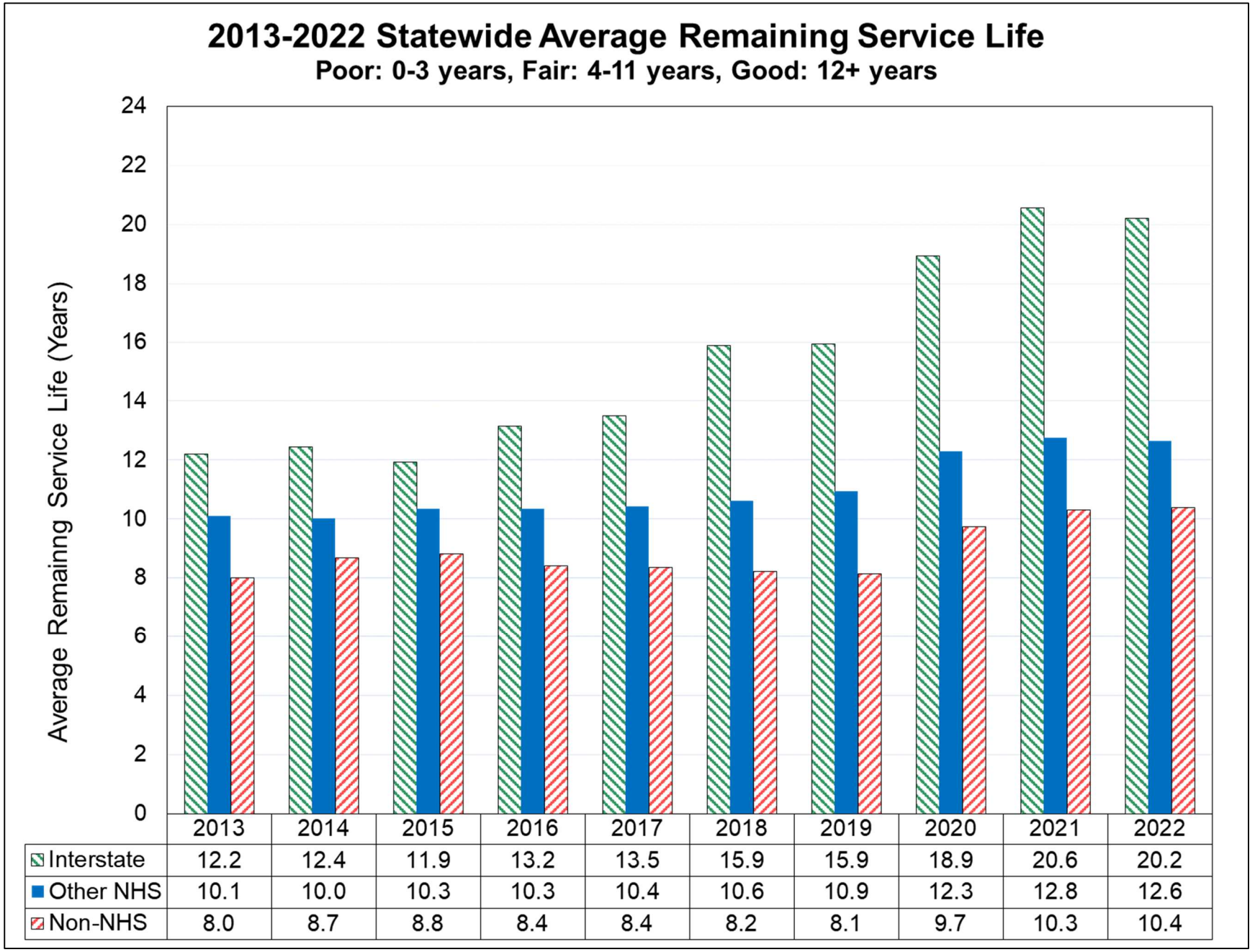
	ATP-1	ATP-2	ATP-3	ATP-4	ATP-6	ATP-7	ATP-8	Metro	State
Good	74.3%	81.9%	88.6%	83.1%	83.5%	71.4%	83.9%	79.9%	81.0%
Poor	1.2%	0.5%	0.4%	1.1%	0.1%	0.6%	0.6%	0.4%	0.6%

Figure 9. 2022 RQI by ATP for Non-NHS Roads



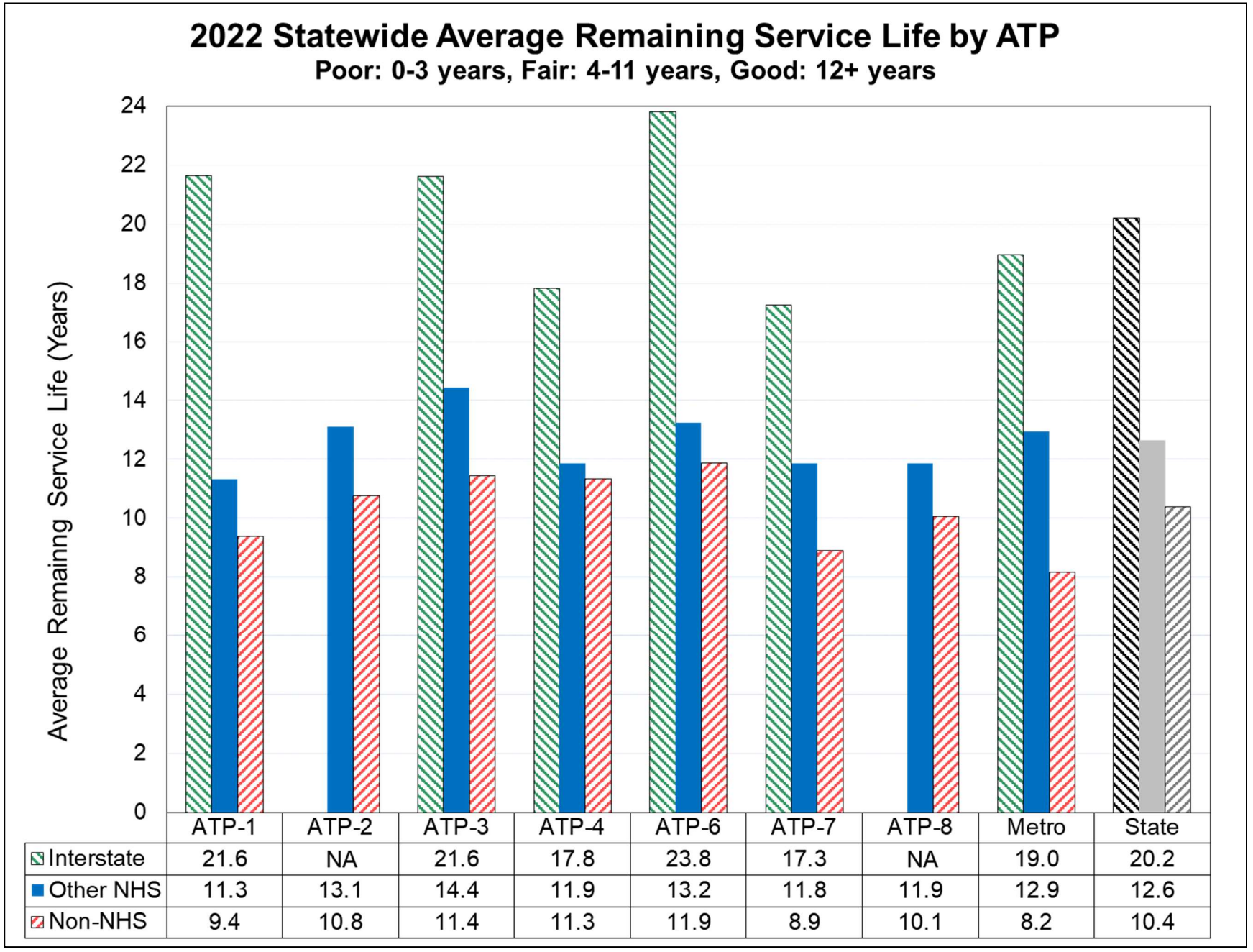
	ATP-1	ATP-2	ATP-3	ATP-4	ATP-6	ATP-7	ATP-8	Metro	State
Good	67.6%	82.4%	75.2%	81.8%	83.1%	59.3%	81.6%	60.9%	75.2%
Poor	5.3%	0.4%	0.6%	0.1%	2.1%	3.5%	0.3%	5.9%	2.1%

Figure 10. Ten-Year Statewide ARSL



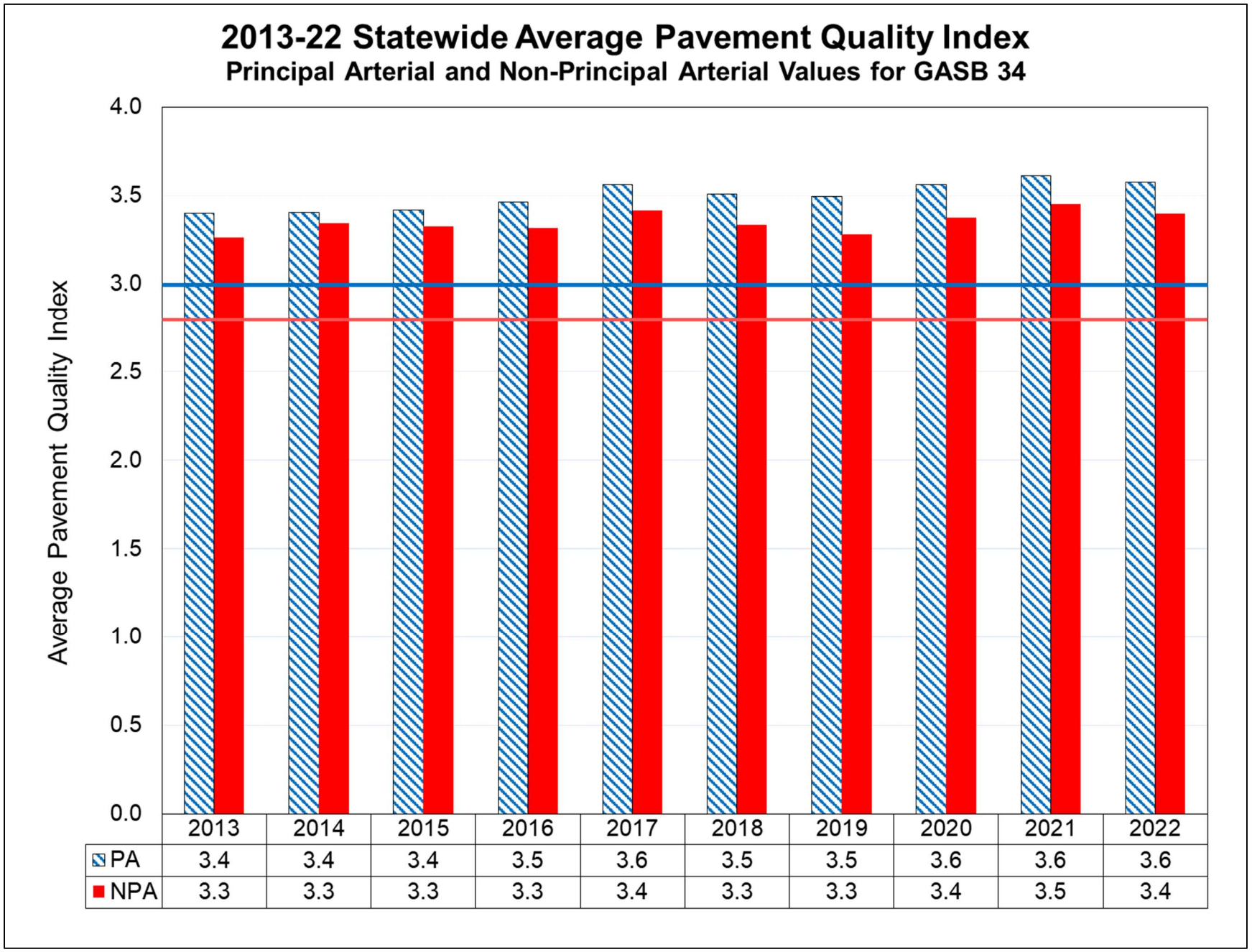
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Interstate	12.2	12.4	11.9	13.2	13.5	15.9	15.9	18.9	20.6	20.2
Other NHS	10.1	10.0	10.3	10.3	10.4	10.6	10.9	12.3	12.8	12.6
Non-NHS	8.0	8.7	8.8	8.4	8.4	8.2	8.1	9.7	10.3	10.4

Figure 11. 2022 ARSL by ATP



	ATP-1	ATP-2	ATP-3	ATP-4	ATP-6	ATP-7	ATP-8	Metro	State
Interstate	21.6	NA	21.6	17.8	23.8	17.3	NA	19.0	20.2
Other NHS	11.3	13.1	14.4	11.9	13.2	11.8	11.9	12.9	12.6
Non-NHS	9.4	10.8	11.4	11.3	11.9	8.9	10.1	8.2	10.4

Figure 12. Ten-Year Statewide Average PQI for GASB 34 Reporting



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
PA	3.4	3.4	3.4	3.5	3.6	3.5	3.5	3.6	3.6	3.6
NPA	3.3	3.3	3.3	3.3	3.4	3.3	3.3	3.4	3.5	3.4