COUNTY OF RIVERSIDE
TRANSPORTATION DEPARTMENT

PAVEMENT MANAGEMENT REPORT
2019

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EXECUTIVE SUMMARY

The Riverside County Transportation Department strives to provide a safe, efficient, and sustainable transportation system to its users. Having a pavement management system (PMS) is a crucial first step, which the County has implemented, to assist in determining pavement needs and priorities. A PMS further supplements in the decision-making on certain critical key points as far as understanding pavement life cycle and the implementation of cost-effective strategies for preventative maintenance, such as the use of pavement preservation treatments, to extend the service life of good roads.

In 2019, about 34 percent of the total maintained road miles throughout the County were identified to be in need of resurfacing or replacement. In order to reduce the percentage of AT RISK, POOR, and VERY POOR roads from 34 percent to 25 percent, it is estimated that it will cost at least $316 million.

The passing of SB1 by the State legislature in April 2017 established the Road Maintenance and Rehabilitation Program (RMRP) to fund road maintenance, rehabilitation, and critical safety needs on both the state highway and local streets and roads. SB1 provides the needed infusion of funds to augment existing budgets for roadway maintenance and rehabilitation projects based on local needs and priorities. With the passage of SB1, funding for road maintenance and rehabilitation is expected to be at least $200 million over the next five years.

The COVID-19 pandemic that started in March 2020 is expected to have a negative impact on gas tax and Measure A revenue, the two primary sources of revenue for pavement preservation. Revenue losses are expected to be about $7 million over the next 2 years, which is expected to have an impact on the County pavement management program.

SB1 FUNDING

SB1 funding will provide the needed funding to repair and replace pavement on roads identified as being poor and at risk. In order to provide a transportation system that is safe, cost-effective, sustainable, and efficient, environmental considerations and complete streets concepts will be incorporated into future SB1 paving projects. These considerations will include the following:

- Using materials that reduce the life cycle cost and minimize greenhouse gas (GHG) through recycling, such as in-place asphalt concrete pulverization, cold in-place recycling, and the use crumb rubber material (scrap tire) in asphalt concrete.
- Incorporating features resilient to climate change risks, such as flooding, by using Portland cement concrete (PCC) pavement in flood-prone areas.
- Incorporating complete streets elements to improve and increase mobility for pedestrians and bicyclists by installing curb ramps and sidewalk, and widening the roadway, where feasible and practicable.

CURRENT TOTAL MAINTAINED MILES

The County of Riverside Transportation Department is responsible for the operation and maintenance of 2,242 centerline miles of road, as of the end of fiscal year 2019. The table below shows the breakdown of the roadway network grouped by functional classification with the average network Pavement Condition Index (PCI).

Total Maintained Miles (Countywide)

FUNCTIONAL CLASSIFICATION[1]	CENTERLINE MILES[2]	LANE MILES[3]	PCI
Arterial	454	1023	69
Collector	617	1,257	70
Residential/Local	934	1,856	73
Gravel/Dirt[4]	237	470	-
TOTAL	2,242	4,606	
Average PCI[5] [FY 2019]	**72**		

[1)] Functional classification is the grouping of roads based on traffic and degree of land access they provide.
[2)] Centerline mile represents the total length of a road from its starting point to its end point regardless of the pavement width or the number of lanes.
[3)] Lane mile represents the total length and the lane count of a road from its starting point to its endpoint. Lane mile takes into account the number of lanes of a road maintained by the County.
[4)] PCI is not calculated for gravel and dirt roads. The PCI shown is calculated for paved roads only.
[5)] The average PCI in 2019 was 72 whereas the desirable goal is 80 or higher. Roads with a PCI less than 70 are considered to be at risk of failing.

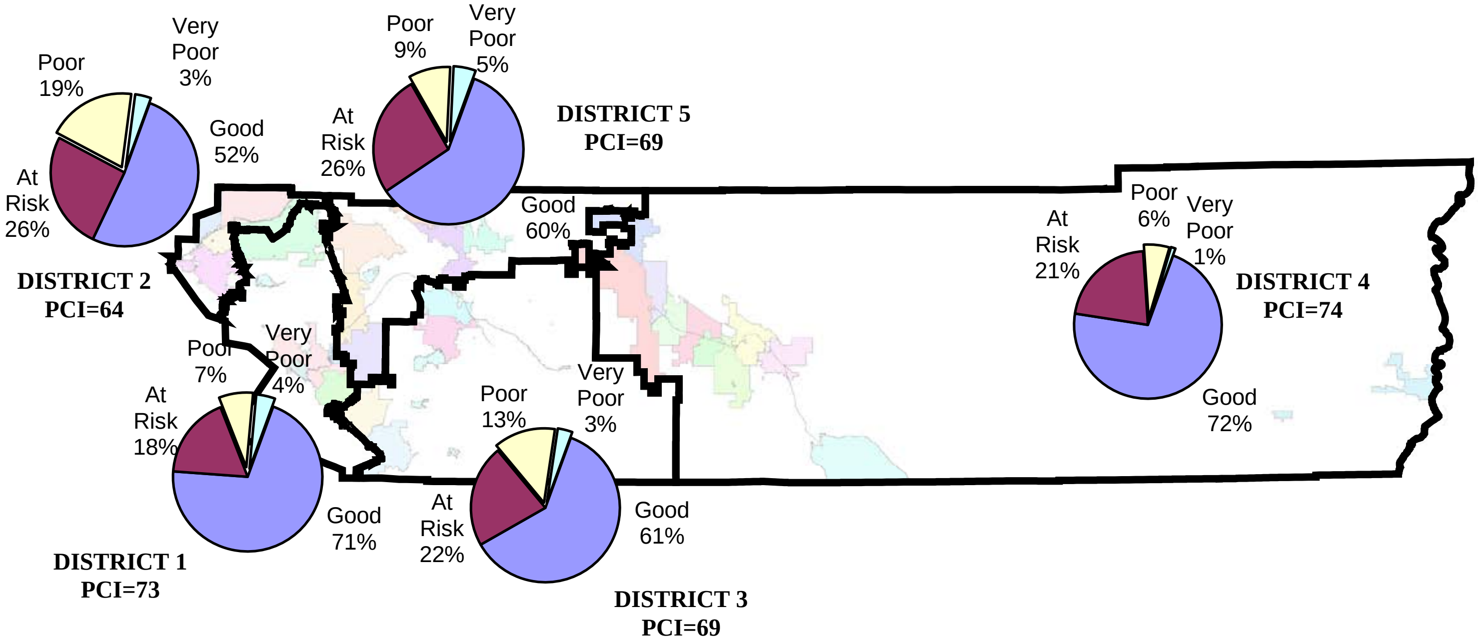
CURRENT ROAD NETWORK CONDITION

The table below shows existing pavement condition categorized by condition category and functional classification throughout the county. It illustrates the total percentage of distressed roads, which includes roads categorized as AT RISK, POOR, and VERY POOR.

Pavement Condition by Category (FY 2019) - Countywide

CLASSIFICATION	GOOD TO EXCELLENT PCI 70-100	AT RISK PCI 50-69	POOR PCI 25-49	VERY POOR PCI 0-24	TOTAL
ARTERIAL	16%	5%	3%	1%	25%
COLLECTOR	18%	5%	4%	1%	28%
RESIDENTIAL	32%	12%	2%	1%	47%
TOTAL	66%	22%	9%	3%	100%
DISTRESSED ROADS		34%			

CURRENT ROAD CONDITION BY DISTRICT (FY 2019)



SUSTAINABLE PAVEMENT PRACTICES

As part of the County's effort to reduce greenhouse gas emissions, the County has been able to:

- Use approximately 175,500 tons of reclaimed asphalt, which translate to a reduction of 878,000 pounds of carbon emission or the equivalent of 78 passenger cars removed from the County roads;
- Use about 480,000 scrap/used tires for pavement overlays and rehabilitation, resulting in less tires at the landfill, greater longevity of pavement life, and reduced pavement/tire noise from vehicles.

These amounts represent totals of recycling materials used by the County from 2005 to 2019.

CALIFORNIA STATEWIDE NEEDS ASSESSMENT

In 2008, the first California Statewide Needs Assessment report was published. This report provides a detailed analysis of California's local street and road system, its current condition, cost to repair, and funding shortfall. In April 2017, the Road Repair and Accountability Act (also known as SB1) passed which provides over $5 billion annually for transportation. The passage of SB1was a significant success for municipal governments statewide and injected a long awaited substantial infusion of funding to maintain the local street and road system. The 2018 "California Statewide Needs Assessment" report estimated that an additional $6.8 billion is needed annually for the next 10 years "….to bring local street and road pavement into a state of good repair." The average PCI in the State of California of all counties remained at 65 in the 2016 and 2018 assessment reports. The PCI ranges from a high of 79 in Orange County to a low of 37 in San Benito County; Riverside County had a PCI of 72.

SB1 is a critical funding source that will allow approximately $1.5 billion to cities and counties to arrest the deterioration that has occurred to local transportation infrastructure during the past decade or more. The next statewide needs assessment update will be in 2020. The "California Statewide Local Streets and Roads Needs Assessment 2018" can be found at www.savecaliforniastreets.org.

PROJECT LISTS FOR FISCAL YEAR 2019-20

Lists of projects for rehabilitation and pavement preservation including slurry seal and chip seal are available in the County's website at:

https://rctlma.org/Portals/7/documents/TIP/TIP%202019-20%20Annual%20Report_1.pdf?ver=2019-12-18-111001-090

INTRODUCTION

A Pavement Management Program (PMP) is a decision-making tool that assists the County in making cost-effective decisions related to the maintenance and rehabilitation of roadway pavements. It provides a process or system for rating pavement condition, establishing a consistent maintenance and repair schedule, and evaluating the effectiveness of maintenance treatment strategies. The PMP used by the County of Riverside Transportation Department is called "StreetSaver." This program was developed by the Metropolitan Transportation Commission (MTC), which is the transportation planning, coordinating, and financing agency for the nine San Francisco Bay Area counties - Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma. Other users of the PMP from outside the bay region are cities, counties, universities, and consulting firms in Southern California.

Pavement Condition Index

In the MTC StreetSaver software, the pavement condition assessment is based on collecting data to determine the type, amount, and severity of surface distress for each segment of pavement being managed. The distress data is used to calculate a Pavement Condition Index (PCI), which is based on a visual survey of the pavement and a numerical index between 0 and 100, with 0 being defined as failed roadway and 100 representing an excellent pavement (newly paved). Figure 1 shows the relationship between the PCI and pavement condition. Photos showing examples of pavement in excellent through very poor condition are shown in Figure 2A through 2F.

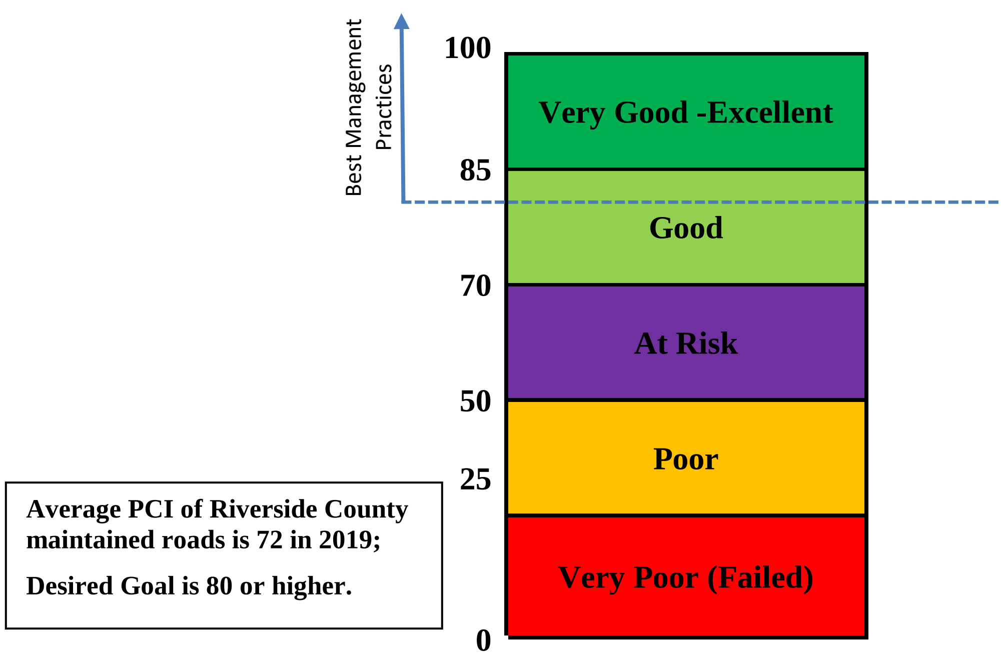


Figure 1. Relationship Between PCI and Pavement Condition

Figure 2A. PCI=98 (Excellent Condition)

Figure 2B. PCI=85 (Very Good Condition)

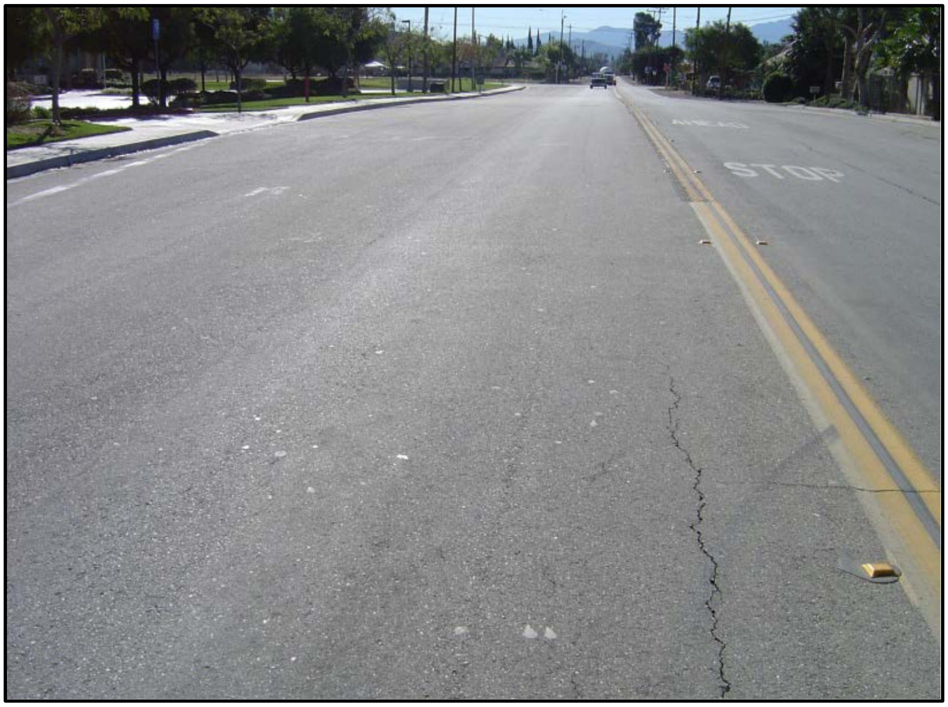


Figure 2C. PCI=78 (Good Condition)

Figure 2D. PCI=56 (At Risk Condition)

Figure 2E. PCI=30 (Poor Condition)

Figure 2F. PCI<10 (Very Poor Condition)

ROAD NETWORK

Road Condition

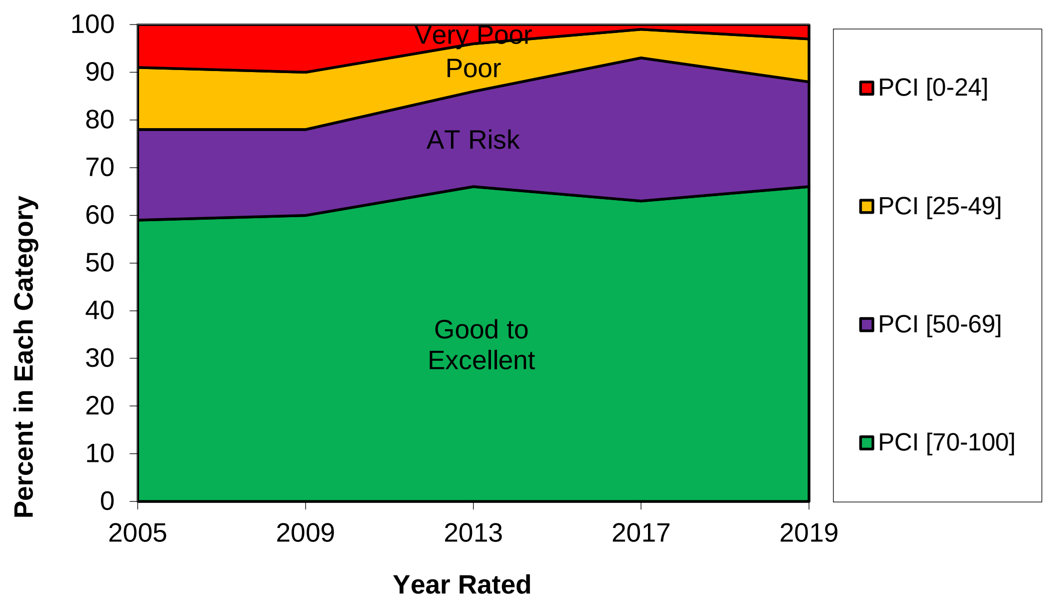
The percentage of mileage categorized by condition rating (good to excellent, at risk, poor, and very poor) over the last 15 years is summarized in Table 1. This table is also presented graphically showing the pavement condition trend in Figure 3 below.

Table 1. Condition Rating[1] (Countywide)

	GOOD TO EXCELLENT PCI 70-100	AT RISK PCI 50-69	POOR PCI 25-49	VERY POOR PCI 0-24	DISTRESSED ROADS[2]
FY 2019	66%	22%	9%	3%	34%
FY 2017	63%	30%	6%	1%	37%
FY 2013	66%	20%	10%	4%	34%
FY 2011	65%	17%	8%	10%	35%
FY 2009	60%	18%	12%	10%	40%
FY 2005	59%	19%	13%	9%	41%

1) Gravel or dirt roads are not included in the condition rating above.

2) Distressed roads include roads from the AT RISK, POOR, and VERY POOR categories. Over the last 15 years, the percentage of distressed roads has been gradually declining from 41% to 34%.

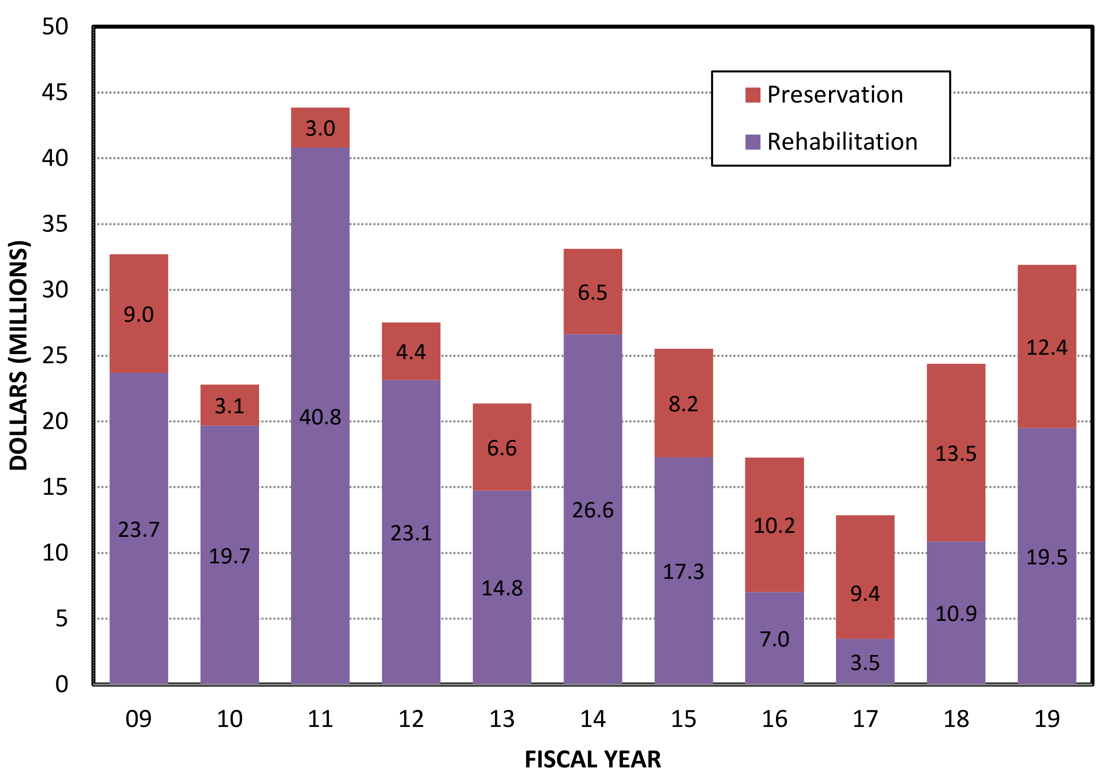


In 2009, Prop 1B, Transportation Bonds for Local Roads was introduced to fix distressed roads. The spikes on the POOR and VERY POOR categories above represent the repairs performed using Prop 1B funding.

Figure 3. Pavement Condition Trendline (Countywide)

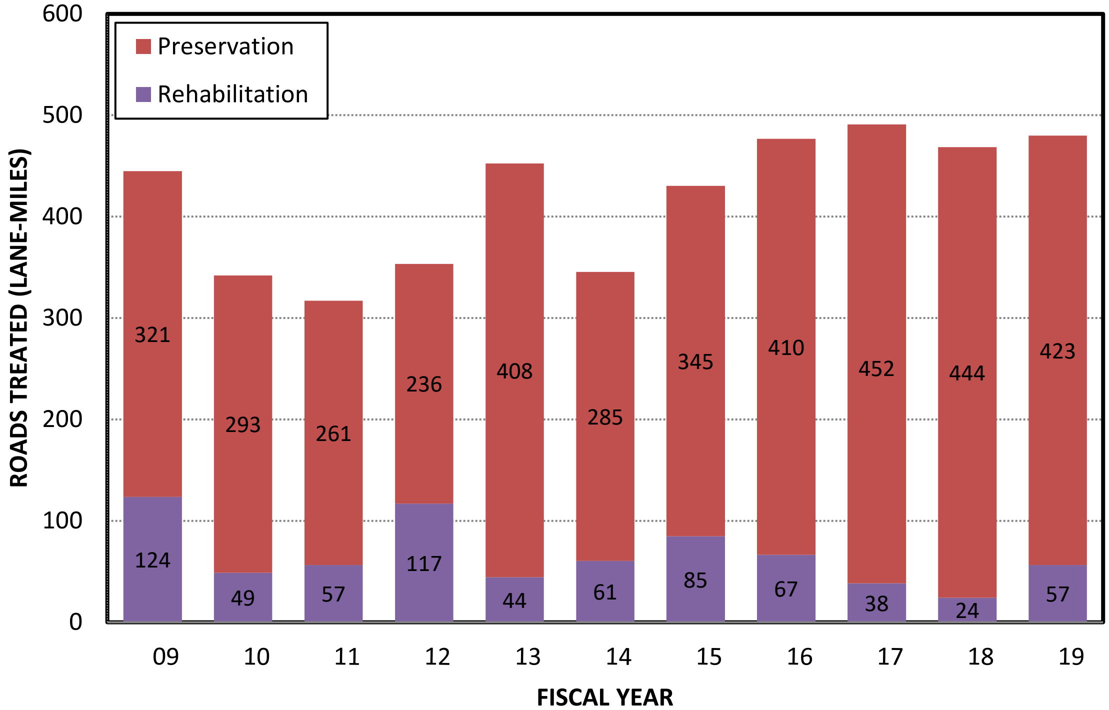
Funding History & Miles Treated by Treatment Type

Roadway rehabilitation funding varies from year to year. With the passage of SB1, the department will be able to plan for improvement projects into the future due to the certainty of gax tax revenue. Over the last 11 years, the transportation department has invested approximately $290 million in pavement preservation and rehabilitation. As funding declines, investment in preservation increases while costly rehabilitation decreases. Figure 4 and Figure 5 show the amount invested on preservation and rehabilitation and the associated total number of lane miles treated over the last 11 years.



Preservation includes Chip Seal, Slurry Seal, and Cape Seal.
Rehabilitation includes Overlays and Reconstruction. Spending spikes in 2009 & 2011 were caused by Prop 1B, Transportation Bonds for Local Roads.
Increase in expenditures starting in 2018 was the result of the passage of SB 1.

Figure 4. Funding History



Preservation includes Chip Seal, Slurry Seal, and Cape Seal.
Rehabilitation includes Overlays and Reconstruction.

Figure 5. Road Miles Treated History

Needs Assessment

In determining the pavement needs to maintain the network condition at an acceptable level, a goal must first be defined. The goal for Riverside County unincorporated roads is as follows:

- attain a PCI of 80 or higher where Best Management Practices (BMPs) can be implemented. These BMPs maximize the use of the most cost-effective pavement preservation treatments.

For this goal to be effective, it should be attainable within a specific timeframe. Two funding scenarios were analyzed to determine the impact of various funding levels in terms of the overall change in PCI. These scenarios are:

1. Impact based on current funding projections
2. Funding needed to maintain current PCI of 72

Impact based on Current Funding Projections

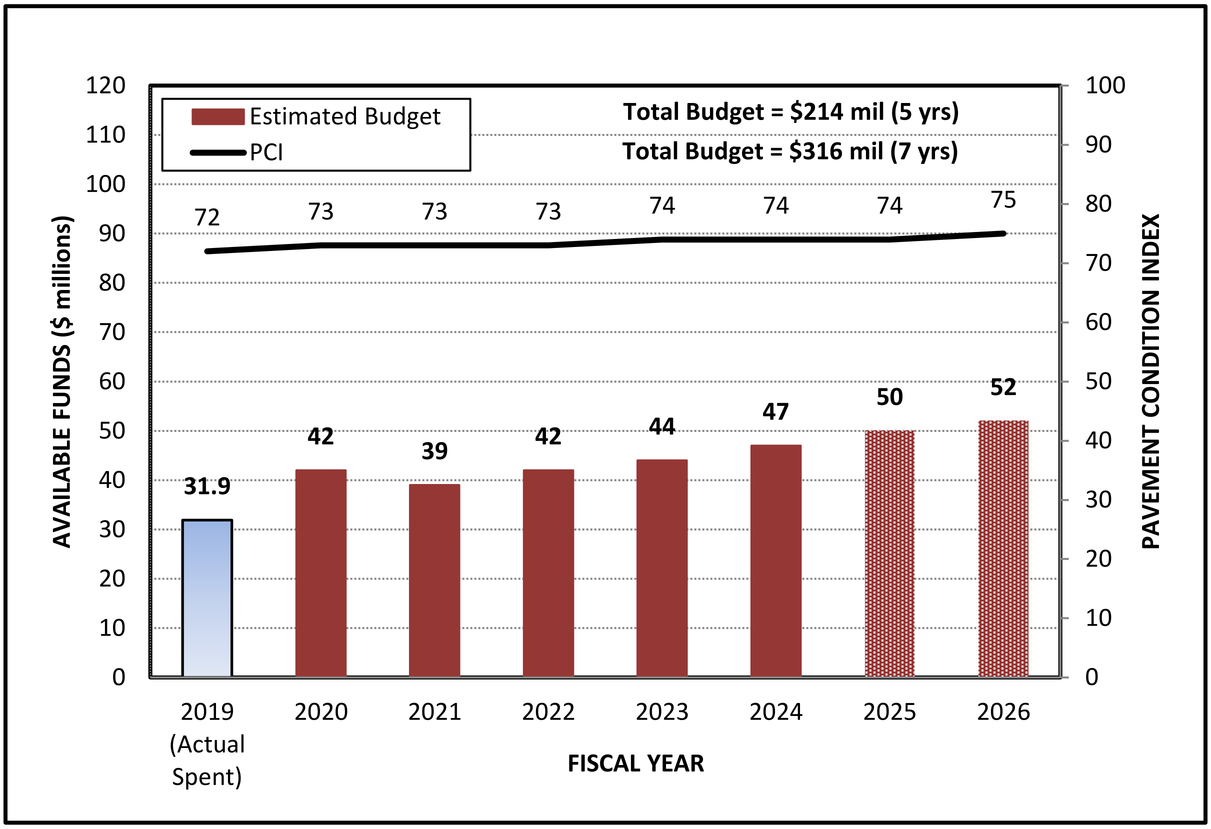


Figure 6. PCI based on Current Funding Projections

With the passage of SB1 in April 2017, the overall condition of the road network is expected to improve significantly. As can be seen in Figure 6, the PCI improves from 72 in 2019 to 74 in 2024. As shown in Table 1, page 5, approximately 34 percent of the total maintained road miles throughout the County were identified to be in need of resurfacing or replacement in FY 2019. In order to reduce the percentage of AT RISK, POOR, and VERY POOR roads from 34 percent to 25 percent, it is estimated that it will cost at least $316 million. In Figure 6 above, two additional years were added to project the PCI to 75 based on the anticipated SB1 funds for the year 2025 and 2026. At PCI of 75 in 2026, the AT RISK, POOR, and VERY POOR roads will decline to 25%.

Furthermore, it should be noted that the projected revenue is expected to decline approximately $7 million for FY 2020 and FY2021 due to the COVID-19 crisis. The impact of the outbreak has been severe, causing a tremendous reduction in travel and fuel use, and thereby decreasing the SB1 and Measure A revenues. As depicted in Figure 6, a reduction in revenue of about $1 million and $7 million is reflected in FY 2020 and FY 2021, respectively as a result of the outbreak.

Funding Needed to Maintain Current PCI of 72

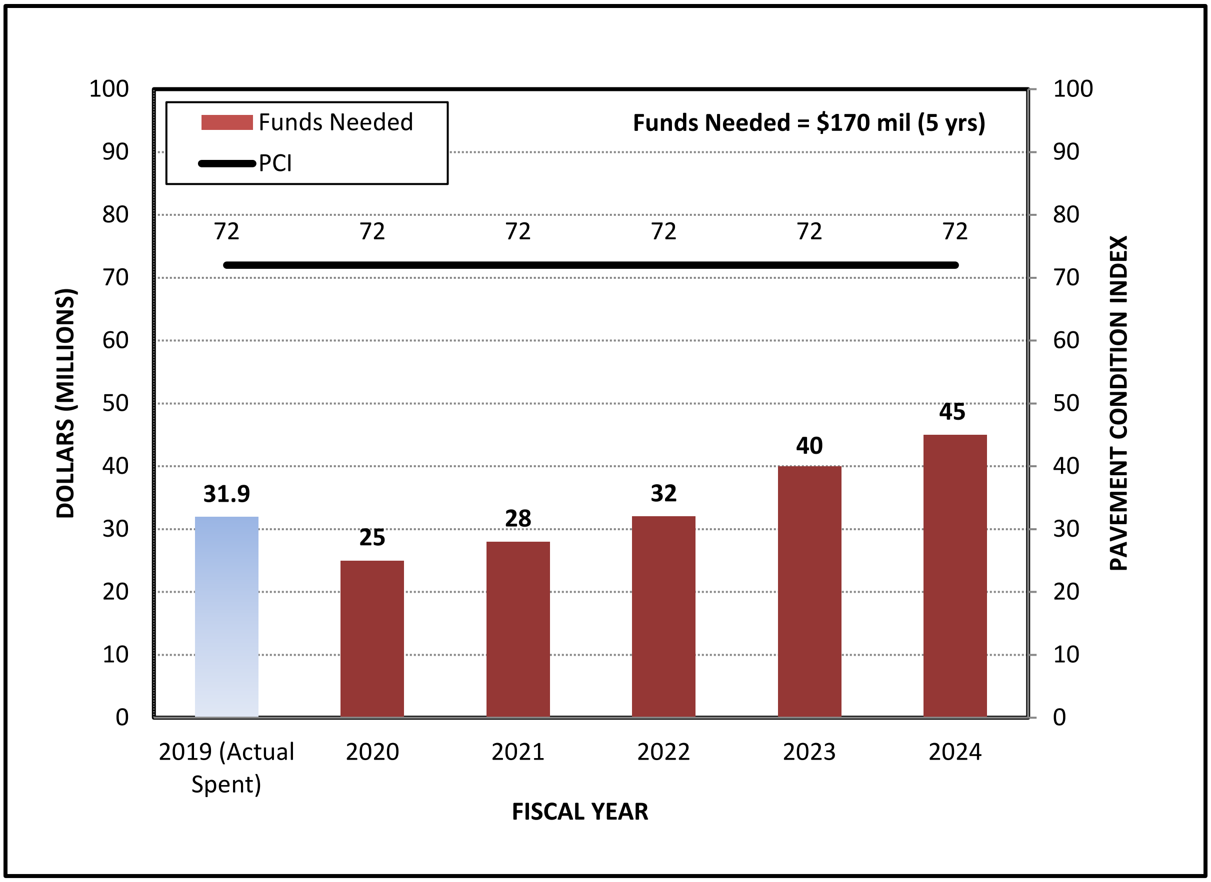


Figure 7. Funding Needed to Maintain Current PCI

Roadway Inventory and Condition

Riverside County maintains approximately 2,244 centerline miles of paved road as of the end of fiscal year 2019. Table 2 shows the breakdown of the countywide road network grouped by functional classification with the average network Pavement Condition Index (PCI).

Table 2. Total Maintained Miles (Countywide)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	PCI
Arterial	454	69
Collector	617	70
Residential/Local	934	73
Gravel/Dirt	237	-
TOTAL	2,244	
Average PCI [FY 2019]	**72**	

Historical PCI

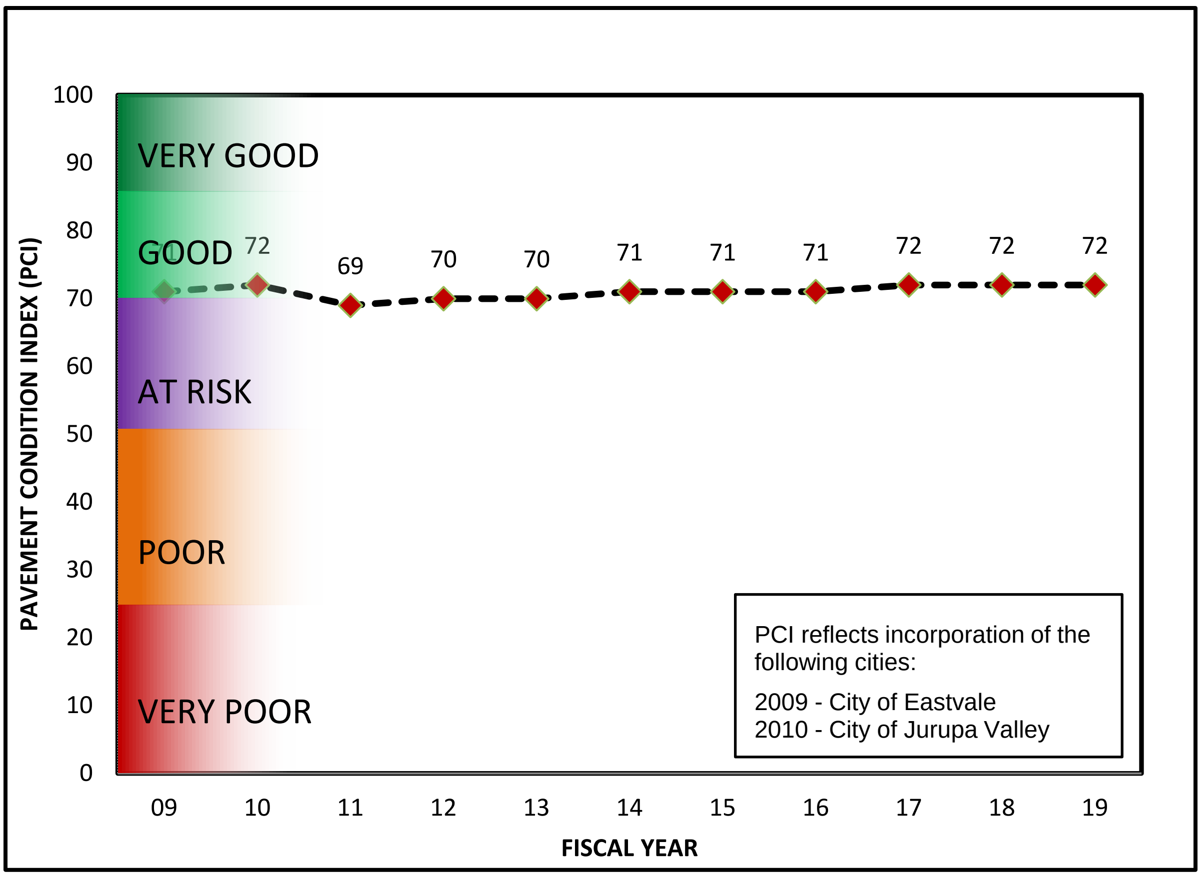


Figure 8. Pavement Condition Index Trend

Road Condition by Supervisorial District

Tables 3 through 7 depicts the total number of centerline miles in each Supervisorial District by the functional classification of road and the associated PCI.

Table 3. Total Miles (District 1)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	PCI
Arterial	117	66
Collector	85	68
Residential/Local	258	78
Gravel/Dirt	11	-
TOTAL	471	
Average PCI	**73**	

Table 4. Total Miles (District 2)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	PCI
Arterial	8	51
Collector	14	68
Residential/Local	44	67
Gravel/Dirt	7	-
TOTAL	73	
Average PCI	**64**	

Table 5. Total Miles (District 3)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	PCI
Arterial	118	69
Collector	150	66
Residential/Local	297	70
Gravel/Dirt	54	-
TOTAL	619	
Average PCI	**69**	

Table 6. Total Miles (District 4)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	PCI
Arterial	140	72
Collector	301	75
Residential/Local	211	75
Gravel/Dirt	143	-
TOTAL	795	
Average PCI	**74**	

Table 7. Total Miles (District 5)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	PCI
Arterial	70	69
Collector	66	64
Residential/Local	125	71
Gravel/Dirt	25	-
TOTAL	286	
Average PCI	**69**	

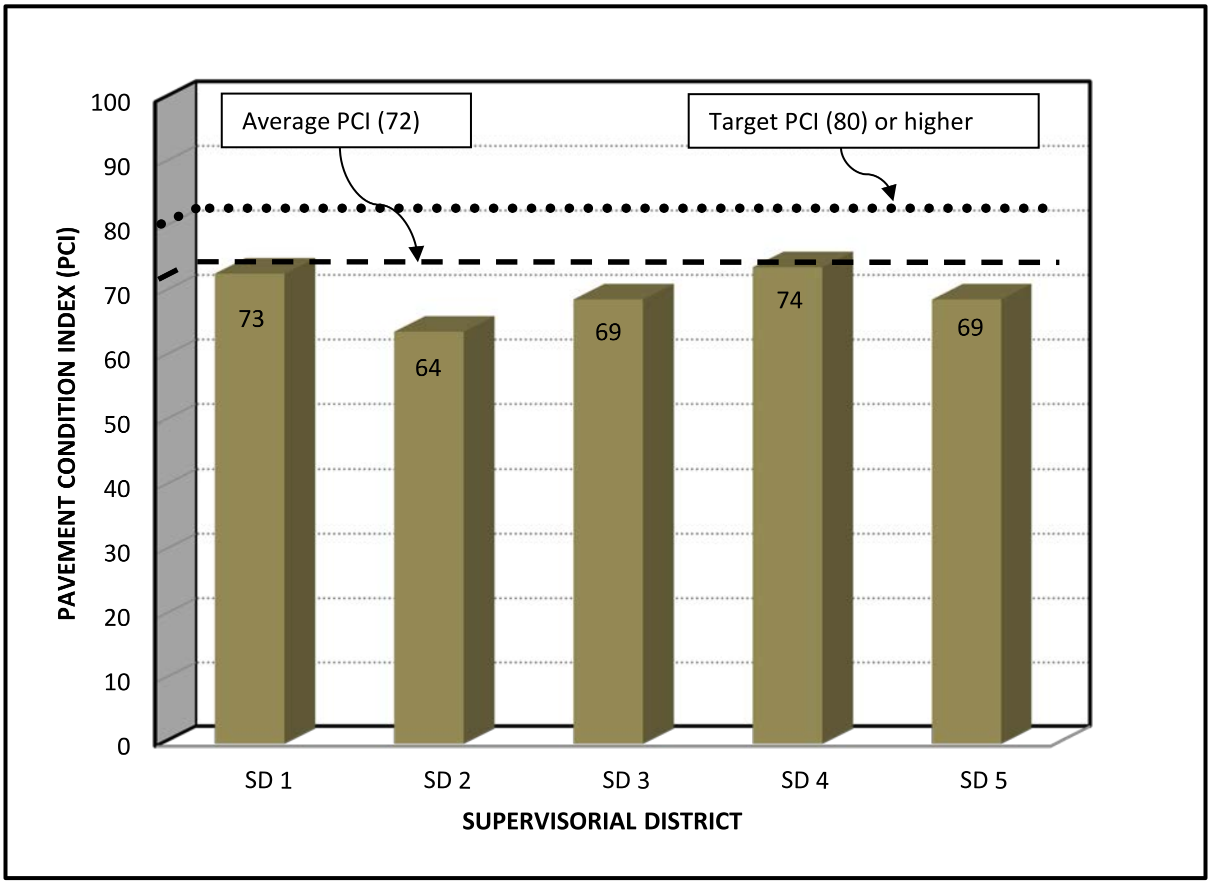


Figure 9. Pavement Condition Index by Supervisorial District

The Target PCI of 80 or higher, as shown in Figure 9, is based on a set goal that all pavements throughout the County road network system be in a condition where Best Management Practices (BMP) can occur. This means that the service life of roads can be extended by cost-effective pavement preservation treatments, such as, chip seal, slurry seal, cape seal, and thin overlay. Reaching and maintaining the target PCI of 80 offers other benefits (other than cost) such as reduced impact to the public in terms of:

- Construction delays
- Environmental noise, dust, energy usage and less greenhouse gas emissions

The average PCI of County roads is 72. As shown in Figure 1 (page 1), A PCI of 72 is approaching the "At Risk" category. The roadway network's life and deterioration accelerates rather rapidly once the PCI falls below 70, and if repairs are delayed by just a few years, the cost of repair could be as much as ten times more than a pavement preventative treatment. This will be discussed in further detail in the Pavement Preservation section of this report on page 14.

PAVEMENT PRESERVATION

As defined by the Federal Highway Administration (FHWA) Pavement Preservation Expert Task Group[1], "Pavement Preservation is a program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety, and meet motorist expectations." Pavement preservation represents a proactive approach in maintaining existing roadways to reduce costly, time-consuming rehabilitation and reconstruction and the associated traffic disruptions to the traveling public.

Pavement Life Cycle

A critical concept in overall pavement life is the timing of treatment actions being undertaken before the pavement falls to an unacceptable level of service. Pavement treatment actions can be effectively planned by monitoring the condition of the pavement network and forecasting future pavement performance. Pavement treatments include the preventive maintenance and preservation treatments, minor and major resurfacing, and reconstruction. These treatments are determined by pavement condition, location, and functional classification of the road, and designed to bring the pavement up to an acceptable condition and extend the service life of the pavement. The concept of pavement life cycle is based on pavement deterioration rates that accelerate as the pavement endures more damage. Figure 10 demonstrates this concept using a new pavement with a 20-yr design life in this example. In this figure, at 75 percent of pavement design life, the pavement condition drops by 40 percent. If left untreated or treatment is delayed, it only takes another 15 percent of pavement life for the pavement condition to decline another 40 percent, where it will cost 4 to 5 times as much in order to restore the pavement condition to a minimum acceptable level.

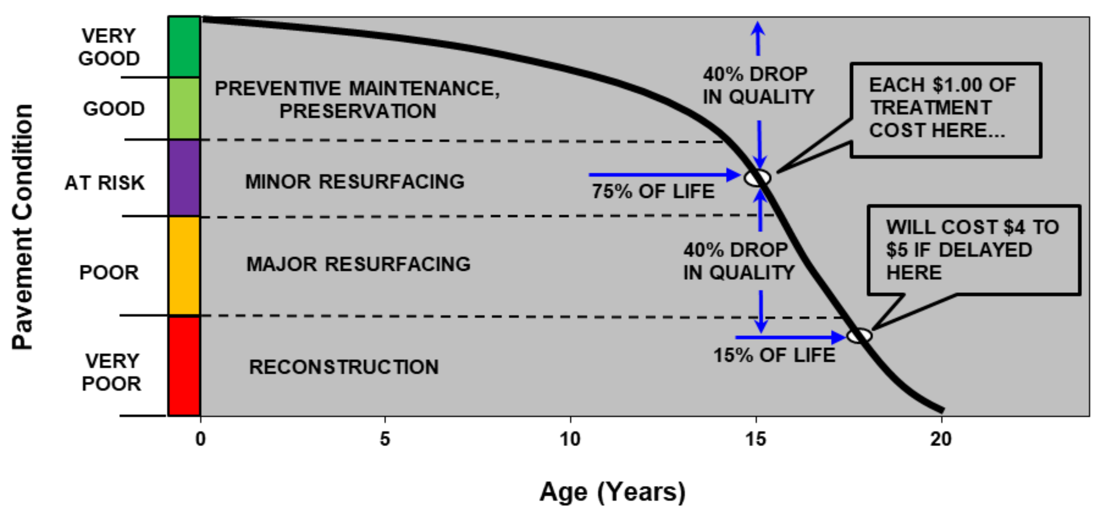


Figure 10. Increase of Treatment Cost as a Function of Pavement Deterioration

[1] Pavement Preservation definition can be found at http://www.fhwa.dot.gov/pavement/preservation/091205.cfm

Pavement Treatment Alternatives

An effective pavement preservation program will extend the life of pavements through preventive maintenance and preservation while they are still in relatively good condition to avoid the need for major reconstruction work. By applying a cost-effective treatment at the right time, the pavement is restored almost to its original condition. Figure 11 illustrates the concept of pavement preservation as it relates to enhancing pavement performance, extending pavement life, and ensuring taxpayer dollars are utilized wisely while providing improved safety and mobility to the public.

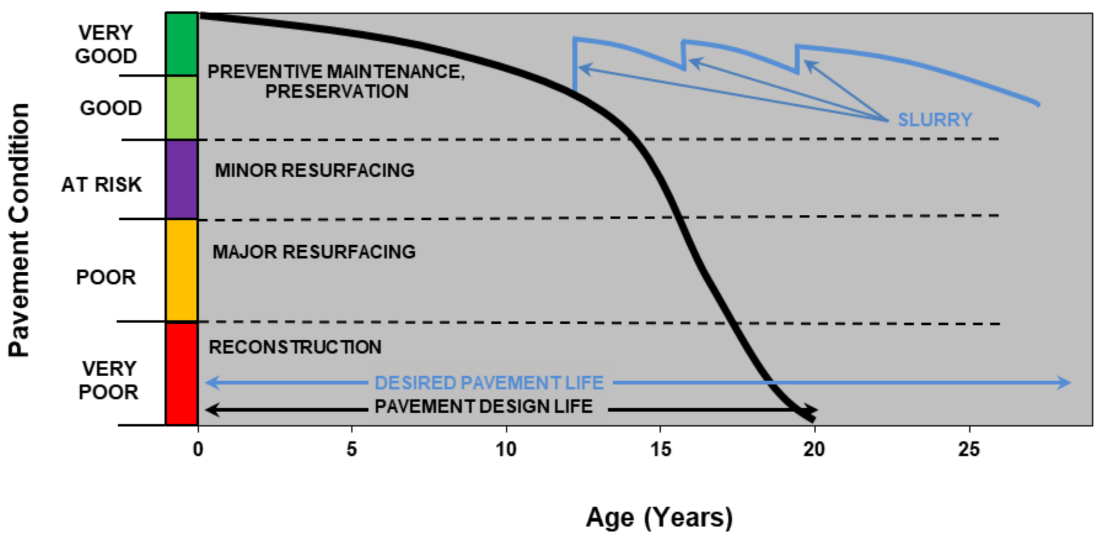


Figure 11. Treatment Zone Alternatives as a Function of Pavement Condition

As depicted in the figure above, the cumulative effect of systematic, successive preservation treatments results in the postponement of costly resurfacing and reconstruction. During the life of a pavement, the cumulative discount value of the series of pavement preservation treatments is substantially less than the discounted value of the more extensive, higher cost of reconstruction and generally more economical than the cost of major resurfacing.

The desired goal of the County is to extend the pavement life with the most effective treatment solution at a minimal cost.

PAVEMENT MANAGEMENT PROGRAM

Pavement Management Program – StreetSaver

A Pavement Management Program (PMP) is a tool that assists the County in making cost-effective decisions related to the maintenance and rehabilitation of roadway pavements. It provides a decision-making process or system for rating pavement condition, establishing a consistent maintenance and repair schedule, and evaluating the effectiveness of maintenance treatment strategies. A PMP is also an optimizing tool that facilitates the prioritization of current and future needs to make the best use of available funds. The goal of a pavement management program is to strategize cost effective treatments to pavement sections that will deliver the best performance for the funds allocated. Simply put, a pavement management program saves public funds. An example of StreetSaver results is shown in Figure 12.

In the absence of a PMP, jurisdictions that lack the tools to strategize how to spend limited funds are likely to choose the "Worst First" approach to repair their roads. A "Worst First" approach would use limited funds for costly reconstruction where few roads can be repaired. Long-term use of this strategy will result in poor performance and the ultimate decline of the overall quality of the pavement network.

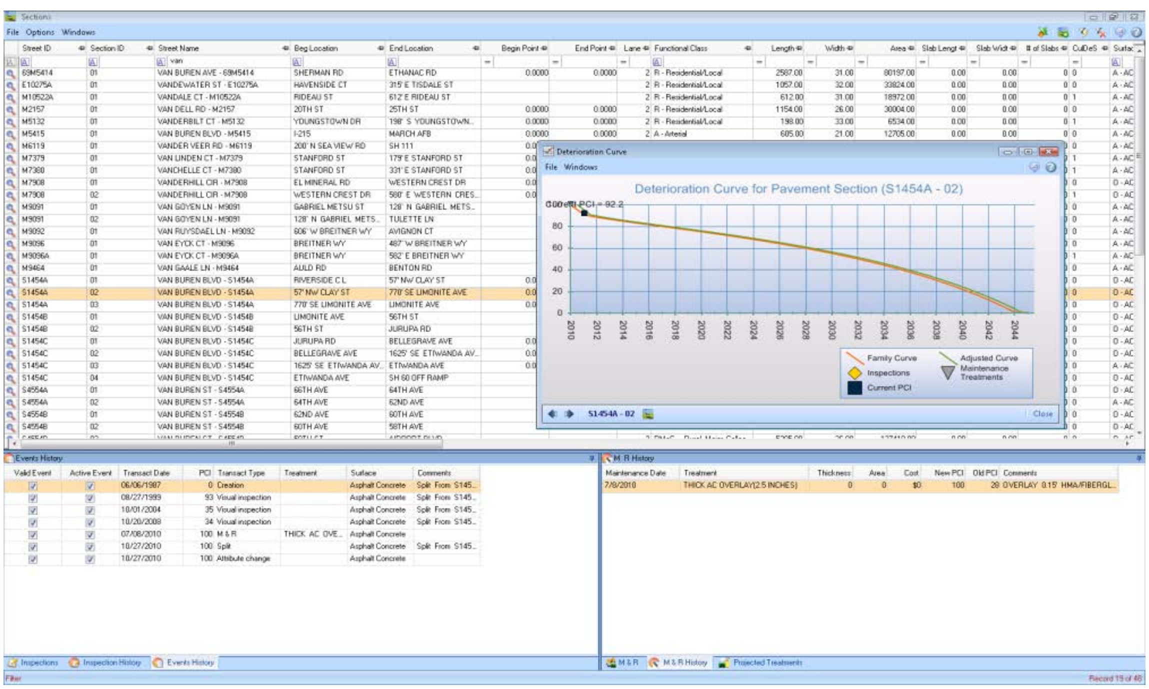


Figure 12. Pavement Management Program - StreetSaver

In 1998, the County began monitoring its roadway system using a PMP developed by the Metropolitan Transportation Commission (MTC), which is the transportation planning, coordinating, and financing agency for the nine-county San Francisco Bay area. It is widely used by cities and counties throughout the State of California and used by some jurisdictions nationwide and in other countries. In 2003, the MTC software was renamed StreetSaver.

Inspection of pavement condition is performed every year on one-fourth of the County's pavement network, which places all roads on a four-year inspection cycle. A field inspection or visual inspection survey is conducted by pavement raters (two-man crew) who walk each individual road segment evaluating the pavement for signs of distress. In early 2012, the County switched its data collection approach from paper inspection sheets to a hand-held computer device, as depicted in Figure 13. Not only does a hand-held device accelerate the collection of pavement distress data, but it also reduces paper usage - an environmentally friendly methodology.

Figure 13. Tablet device use in road inspection

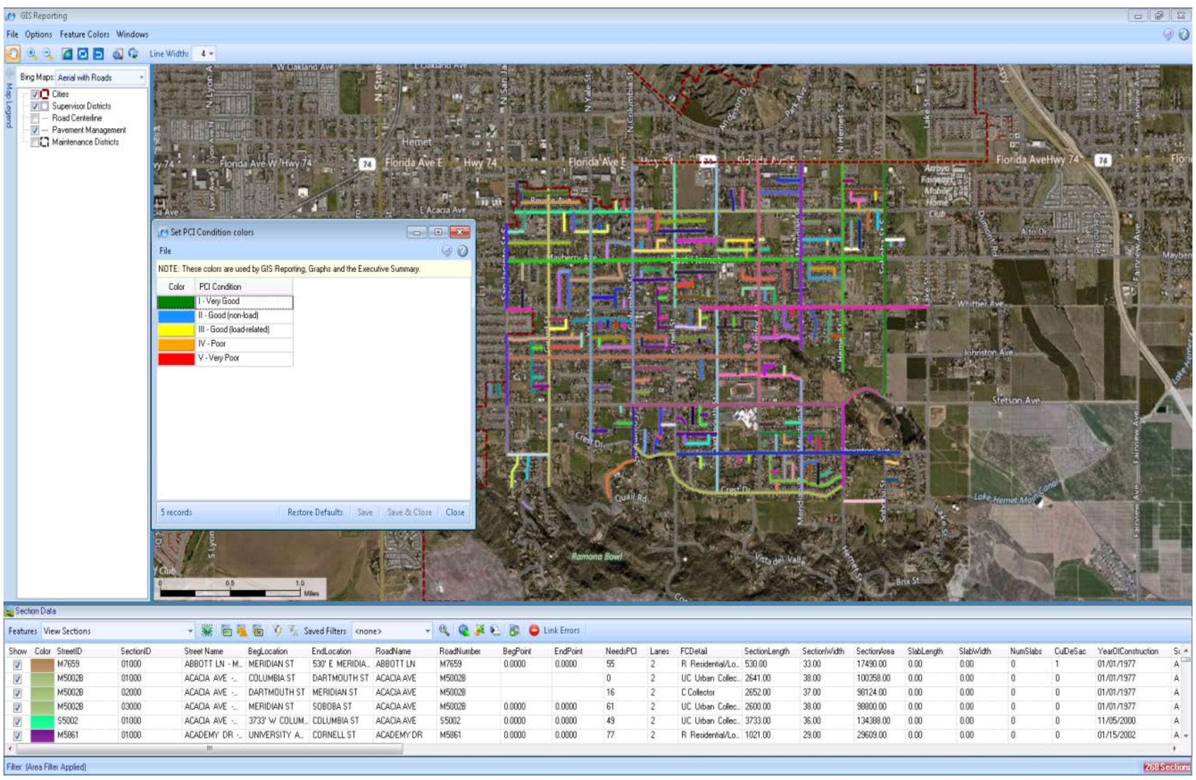


Figure 14. PMP result on GIS map

The integration of the PMP with Geographic Information Systems (GIS) has provided the County with a snapshot of the roadway network to better organize the road segments, and data collected and improves the decision-making in selecting roads to be included for treatment/repair in the annual Transportation Improvement Plan. An example of the PMP/GIS integration is shown in Figure 14.

Data Collection Technique and Equipment

The County invests millions of dollars each year in pavement maintenance activities. The Pavement Management Program (PMP) assists the County in determining the most cost effective strategy for investing in pavement rehabilitation. In addition to the PMP tool, the County has invested in advanced data collection equipment including a Ground Penetrating Radar (GPR) and a Falling Weight Deflectometer (FWD). Figure 15 depicts this advanced data collection equipment.

Figure 15. FWD and GPR Data Collection Equipment

The GPR is used to measure pavement layer thickness and detect groundwater and voids beneath the pavement. The FWD is used to evaluate the physical properties of the pavement structural condition. Data collected from this state of the art equipment in conjunction with visual inspection and the use of the StreetSaver PMP, provides the County pavement Engineer with adequate data to make informed decisions.

IMPLEMENTATION OF PAVEMENT PRESERVATION USING BEST MANAGEMENT PRACTICES

Riverside County implements pavement preservation treatments to preserve roads in good condition. In order to keep the good roads from deteriorating further, treatment strategies that can extend the life of roads at minimal costs are used. These treatment strategies include various seal coat treatments including; chip seals, scrub seals, slurry seals, and cape seals.

Seal Coat (Preventive) Treatment

A seal coat treatment follows the concept of preventive maintenance for preserving the pavement while it is still in good condition and prolonging its serviceable life. The following seal coat treatments are as described below in more detail.

Chip / Scrub Seal

A chip seal is a surface treatment applied to pavement with minimal surface distress to provide a new wearing surface, extend pavement life, and delay major rehabilitation or reconstruction. It is a process in which an asphalt emulsion is sprayed on the pavement then immediately covered by aggregate. Figure 16 illustrates the spreading of aggregate over the sprayed emulsion. When the asphalt emulsion is applied to the road surface in conjunction with a mechanized scrub broom (that forces the emulsion into the cracks), this process is called “scrub seal.”

Figure 16. Spreading of chip over emulsion

Slurry Seal / Micro-surfacing

A slurry seal is a maintenance treatment applied to pavement to improve the functional characteristics of the pavement surface. It is a mixture of asphalt emulsion, aggregates and mineral fillers, which is mixed and placed in a continuous basis using a truck mixer. A micro-surfacing is a maintenance treatment similar to slurry seal except it uses polymer modified and fast setting asphalt emulsion allowing thicker layers to be placed. The thick layer application allows to fill in ruts commonly found on roads with light to moderate truck traffic. Prior to application, any surface distresses, such as cracks, are filled and sealed. After thoroughly mixing the emulsion, aggregates and mineral fillers in the slurry truck's built-in pug mill, the slurry mixture is poured into a spreader box. As the truck moves forward, the slurry is extruded from the backside of the spreader box, see Figure 17. The box is capable of spreading the slurry over the width of a traffic lane in a single pass resulting in a uniform application. The slurry cures as the water evaporates and turns the freshly placed brown slurry into black slurry. Traffic can be returned once the slurry has cured, which is usually four to six hours.

Figure 17. Spreading of slurry

Cape Seal

Cape seal treatment consists of a bottom course of chip/scrub seal covered with a wearing course of slurry seal. In a cape seal application, covering a single layer of chip seal with slurry seal prevents the aggregate from the chip seal application from being dislodged especially for roads with curb and gutter.

Both pavement surface treatments are non-structural preventive maintenance applications that are classified as pavement preservation techniques. Such techniques can extend pavement life and improve safety.

RECYCLING MATERIALS

The County maximizes the recycling and reuse of materials in construction projects whenever feasible. These materials include reuse of existing pavements as well as other recycled materials such as scrap tires. Consideration is given whenever such materials meet the minimum engineering standards and are economically feasible. It should be noted that the use of recycled materials is made on a case-by-case basis based on material properties, past performance of the recycled material, benefit/cost analysis, and engineering judgment.

With high-volumes of industrial by-products, construction and demolition debris, and scrap tires being generated each year, hundreds of millions of waste materials are added to landfills and have a potential of being a threat to both the environment and public health and safety. Such materials can have beneficial uses, particularly in roadway construction. Pavement made with these materials can be stronger, more durable and less costly. Recycling and reusing these materials saves energy, conserves natural resources, and reduces greenhouse gas emissions (carbon footprint).

Over the last few years, the highway construction industry has developed more options and better techniques on building "green." This has provided public agencies with tools to protect the environment and reduce greenhouse gas. The use of Reclaimed Asphalt Pavement (RAP) in hot mix asphalt, base stabilization and subgrade treatment using the Full Depth Reclamation (FDR) process, and rehabilitation/maintenance of existing roadways using Cold-in-place Recycling (CIR) method, are some of the recycling technologies being practiced in the County.

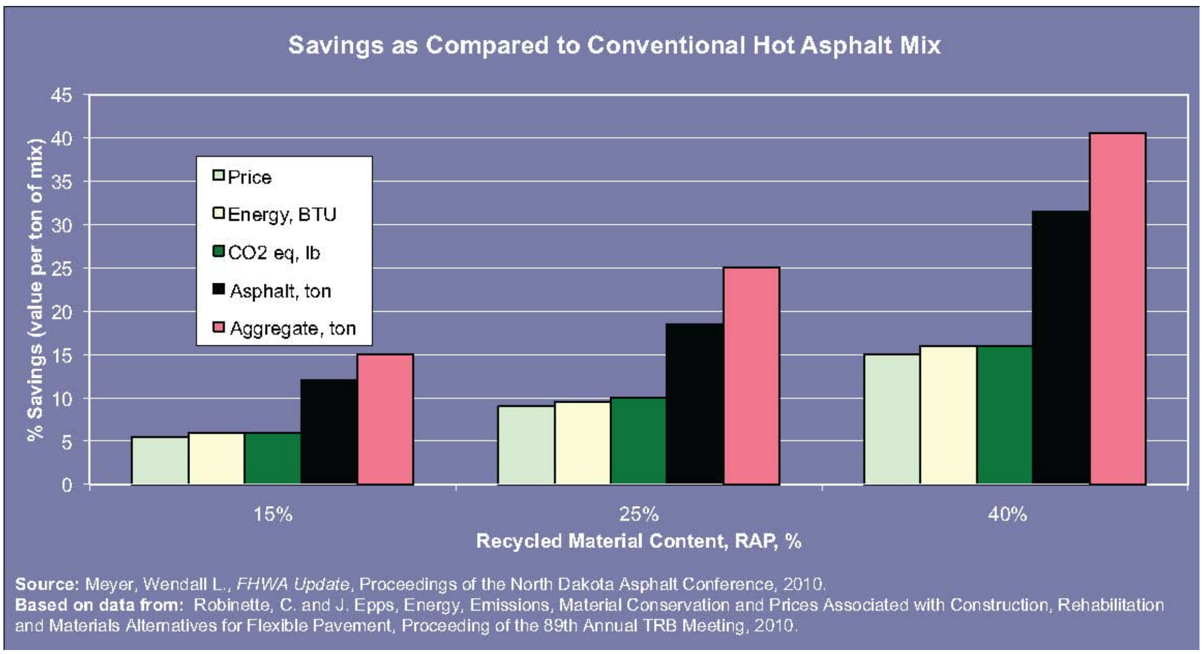
Reclaimed Asphalt Pavement

Reclaimed Asphalt Pavement (RAP) – removed/reprocessed asphalt concrete pavement – is a commonly recycled material incorporated in the production of new Hot-Mixed Asphalt (HMA). RAP can be generated from a number of different sources including cold milling, full-depth removal, and pulverize-in-place operations of existing pavements. The use of RAP in HMA is the most efficient use of this material as it provides a reduction in virgin asphalt binder and aggregate demand, thus conserving natural resources. RAP is also used as recycled aggregate base and helps reduce the pavement structural section due to its increased strength in comparison to conventional aggregate base.

In California, Caltrans goal is 40 percent RAP in HMA. In the recent report published by Caltrans in the "Specifications for the Use of Reclaimed Asphalt Pavement: A Status Report," dated 18 July 2016, up to 40 percent is allowed for the subsurface course in the asphalt pavement and only up to 25 percent for the surface course. On the same report, concerns have been raised regarding premature cracking in relatively new asphalt pavements as a result of using high content of RAP. Caltrans is currently working with the asphalt industry to address the issue of premature cracking in asphalt pavements containing up to 40% of RAP. The status report on the reclaimed asphalt pavement can be found at the following address: http://www.dot.ca.gov/legislative/reports-legislature.html

In Riverside County, the goal is 15% of RAP in HMA. The use of more than 15% RAP may potentially cause some long-term durability and premature cracking issues with the asphalt because of stability, swell, and moisture vapor susceptibility of the RAP in the asphalt mix. In light of this concern, the County will continue to allow up to 15% RAP until Caltrans and the asphalt industry come up with solutions to address durability and cracking.

From the chart illustrated in Figure 18, some environmental benefits and cost savings of using at least 15 percent RAP in conventional HMA will yield a reduction in asphalt by about 12%, a decrease of virgin aggregate by about 15%, and a reduction of greenhouse gas emissions at a rate of 5 pounds per ton of RAP used in the hot mix asphalt.



Price corresponds to materials, construction, rehabilitation, and maintenance costs based on Life Cycle Cost Analysis (LCCA) with environmental impact assessment. Energy (BTU) represents the requirements for construction materials processing and construction material production. CO2 eq (lb) is a measure of greenhouse emissions and it includes the production of raw materials, transportation, production and laydown of materials. Asphalt and Aggregate in tons are considered the natural resources. [Sources: Transportation Research Board and Federal Highway Administration (FHWA)].

Figure 18. Benefits and Cost Savings of using RAP

Since 2005, the County has used over 175,500 tons of RAP in its pavement rehabilitation and reconstruction projects. This translates to approximately 154 lane miles of recycled county maintained roads and a reduction of 878,000 pounds of carbon emissions or the equivalent of about 78 passenger cars removed from the County roads.

Full-Depth Reclamation (FDR)

Full-Depth Reclamation (FDR) involves the pulverization of the asphalt layers of the pavement and a portion of the underlying materials in-place four to ten inches deep to produce a stabilized material. The stabilized material is mixed with asphalt emulsion, then shaped and compacted in preparation for a new wearing surface such as hot mix asphalt. The wearing surface is placed within one to three days of completing the FDR material.

Cold In-Place Recycling (CIR)

Another method that involves the reuse of pavement material is Cold In-Place Recycling (CIR). Pavement is removed by cold planing to a depth of 3 to 4 inches leaving a small amount of pavement to support the equipment during the construction process. The material is crushed, sized and mixed with an asphalt emulsion and other additives. Then the material is placed and compacted. Within two to five days of placing the CIR material, a layer of hot mix asphalt is laid down. Typically, a 3-piece "train" is used consisting of a cold planing machine, a screening/crushing/mixing unit, and conventional laydown and rolling equipment. This "train" occupies only one lane, thus maximizing traffic flow.

Rubberized Asphalt Concrete (RAC)

Rubberized asphalt concrete (RAC) is a road paving material made by blending ground tire rubber with asphalt to produce a binder, which is then mixed with conventional aggregate materials. This mix is then placed and compacted into a road surface. Benefits of using RAC are as follows:

<u>Cost-effective</u>
In most applications, RAC can be used at a reduced thickness compared to conventional asphalt overlays--in some cases at half the thickness of conventional material--which can result in significant material reduction and cost savings.

<u>Durable, Safe and Quiet</u>

RAC is long lasting. It resists cracking, which can reduce maintenance costs. RAC provides better skid resistance, which can provide better traction. Moreover, RAC retains its darker color longer so that road markings are more clearly visible and can reduce road noise.

<u>Environmentally Friendly</u>

California produces more than 40 million waste tires annually, of which approximately 75 percent are diverted from landfill disposal. Over the past few years, California has used more than 10 million waste tires in RAC paving projects, diverting them from landfills or illegal disposal.

Use of RAC in Riverside County

The County of Riverside has been using RAC since 1995. The county typically uses a 2-inch thick overlay on all RAC resurfacing projects. A 2-inch thick RAC overlay uses over 1,200 scrap tires per lane mile. This means that for a one-mile section of a four-lane highway, over 4,800 scrap tires can be used in creating a safer, quieter, longer-lasting road. Since 2005, the County has used over 480,000 scrap tires in its pavement rehabilitation projects. This translates to at least 400 lane miles of rubber treated county maintained roadway.

Recycling Materials Usage Summary

A summary of the environmental benefits of recycling and reusing of roadway materials in road paving is as follows (as implemented by Riverside County) and as shown in Figure 19:

- 175,500 tons of RAP used in HMA which translate to a reduction of 878,000 pounds of carbon emissions.
- 480,000 scrap tires diverted from the landfill by substituting RAC in HMA.

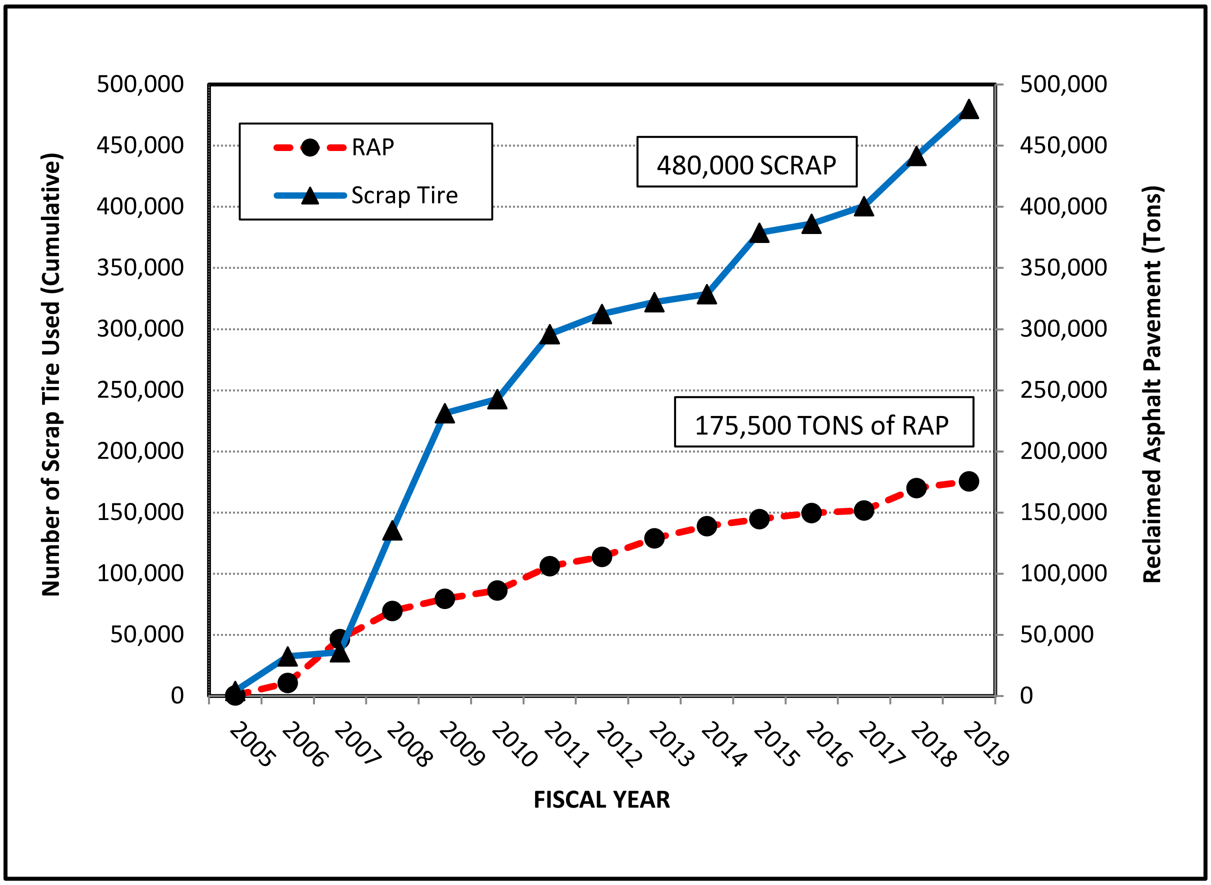


Figure 19. Benefits and Cost Savings of using RAP.