2020

REP14-20 - 2020 Pavement Management Report

Legistar

Public Works Department

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PAVEMENT MANAGEMENT

CITY OF COLUMBIA

PUBLIC WORKS DEPARTMENT

STREET DIVISION

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Executive Summary

Columbia's street infrastructure is critical to the operation of the City. The replacement cost of Columbia's 1389 lane miles of streets is estimated at more than $575 million. Over the years, traffic, weather, water, and aging of asphalt and concrete pavements all contribute to street deterioration.

The City of Columbia Pavement Management Plan proactively addresses street deterioration in the short-term, and improves the integrity and service life of Columbia streets over the long-term. The plan is grounded in the principle that preventative and rehabilitative street maintenance is more cost effective than reconstruction. The concept of preventive maintenance is the application of the right treatment, on the right road, at the right time[1] to save or delay future expenditures.

Current funding levels are better than historic levels, but are still approximately $2.3 million/year below what is necessary to maintain a high quality driving surface for all streets. This annual shortage is based on the current FY2020 budget for 1389 lane miles in comparison to budgets other agencies have historically had to successfully maintain their street networks. From our experience and what other professionals around the country recommend, a successful program will allocate approximately $0.67 per square yard for their entire paved street network per year. By doing so, this means that they can maintain about 1/10th of their system each year with some sort of preservation treatment. Due to our current funding, decisions regarding where to spend our maintenance money and on what streets are made with good data, technical resources and with the knowledge that some streets will continue to deteriorate. By keeping as many roads as possible in good shape, the impact of deferring maintenance on some roads can be somewhat managed. Due to the size of our network, funding for the Columbia Street Maintenance Program should be at $6.55 million/year. For FY2018 and FY2019 funding was at $4.275 and $4.355 million. The funding for the program for FY2020 is $4.226 million.

If funding stays the same, beginning possibly as soon as FY2021, some decisions will need to be made about potentially deferring more maintenance for local streets or having a lower expectation of our street conditions. This is because more major routes within Columbia will not be able to defer maintenance any longer; this will cause the pavement management plan to start transitioning from residential streets to free up funding to cover the higher cost of our collectors and arterials.

[1] FHWA, Asset Management: The Right Road at the Right Time, May 2015

Background

The basis for the pavement management plan has been developed and refined over the last seven years. The plan focuses on prevention of future deterioration once a road has been repaired to a good or excellent condition.

Historically, funding for street repair work focused on a chip seal program and asphalt overlay (with milling or without) for major streets and some minor streets, as funding allowed. Resources were low enough that very few streets were able to be maintained each year and many times a worst first selection method was used.

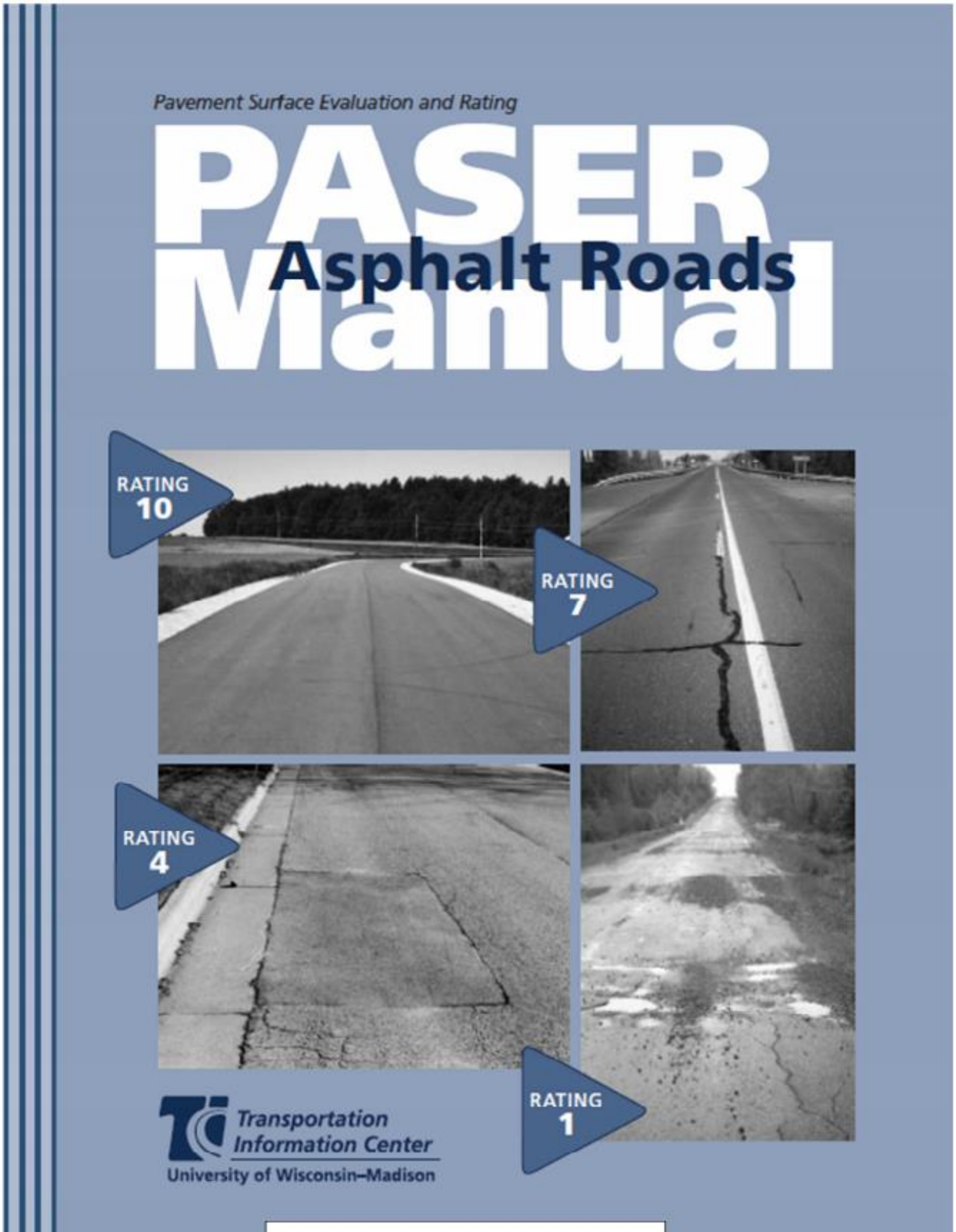
In 2012, the City began to increase funding for street maintenance with a commitment to focus on a more active, methodical preservation program that can be better represented graphically to the public. This effort has begun to create improved pavement conditions.

Between 2012 and 2015 funding increased and several major streets were brought to good condition or better. Implementation of the preservation program has allowed us to continue to improve major streets, but also to begin to catch more local streets at a stage where a mill & overlay will mitigate the need for a complete reconstruction. In FY 2017, a budget cut from General Fund sources was offset by one time use of Transportation Sales Tax funds leaving the program funded at $4.645 million. In FY 2018, another one time injection of funds and savings kept the program funded at $4.275 million. For FY2019, the program was funded at $4.355 million, which is slightly higher than funding for FY2020, which is $4.226 million. This leaves a deficient of $2.325 million needed to maintain 1/10th of our system each year.

To guide our process in a methodical manner, City of Columbia street maintenance staff updates the inventory and assessment of pavement conditions for City streets. Pavement condition is evaluated according to the Pavement Surface Evaluation and Rating (PASER) System. The PASER system is an industry standard and an efficient way to rate street segments. This method was originally developed by the University of Wisconsin Transportation Information Center[2]. There are other rating systems that can provide more detailed analysis and might be candidates for use in the future, but with the City's current resources the PASER

[2] Pavement Surface Evaluation and Rating (PASER) Manuals, University of Wisconsin-Madison Transportation Information Center, various manuals and publications dates

system provides us enough reliable data for decision making. The PASER system utilizes a 10 point scale, with 10 being a newly constructed road surface and 1 being total failure.



PASER Manual cover and example ratings

Rating system

Surface rating	*Visible distress**	*General condition/ treatment measures*
10 Excellent	None.	New construction.
9 Excellent	None.	Recent overlay. Like new.
8 Very Good	No longitudinal cracks except reflection of paving joints. Occasional transverse cracks, widely spaced (40' or greater). All cracks sealed or tight (open less than 1/4").	Recent sealcoat or new cold mix. Little or no maintenance required.
7 Good	Very slight or no raveling, surface shows some traffic wear. Longitudinal cracks (open 1/4") due to reflection or paving joints. Transverse cracks (open 1/4") spaced 10' or more apart, little or slight crack raveling. No patching or very few patches in excellent condition.	First signs of aging. Maintain with routine crack filling.
6 Good	Slight raveling (loss of fines) and traffic wear. Longitudinal cracks (open 1/4"–1/2"), some spaced less than 10'. First sign of block cracking. Sight to moderate flushing or polishing. Occasional patching in good condition.	Shows signs of aging. Sound structural condition. Could extend life with sealcoat.
5 Fair	Moderate to severe raveling (loss of fine and coarse aggregate). Longitudinal and transverse cracks (open 1/2") show first signs of slight raveling and secondary cracks. First signs of longitudinal cracks near pavement edge. Block cracking up to 50% of surface. Extensive to severe flushing or polishing. Some patching or edge wedging in good condition.	Surface aging. Sound structural condition. Needs sealcoat or thin non-structural overlay (less than 2")
4 Fair	Severe surface raveling. Multiple longitudinal and transverse cracking with slight raveling. Longitudinal cracking in wheel path. Block cracking (over 50% of surface). Patching in fair condition. Slight rutting or distortions (1/2" deep or less).	Significant aging and first signs of need for strengthening. Would benefit from a structural overlay (2" or more).
3 Poor	Closely spaced longitudinal and transverse cracks often showing raveling and crack erosion. Severe block cracking. Some alligator cracking (less than 25% of surface). Patches in fair to poor condition. Moderate rutting or distortion (1" or 2" deep). Occasional potholes.	Needs patching and repair prior to major overlay. Milling and removal of deterioration extends the life of overlay.
2 Very Poor	Alligator cracking (over 25% of surface). Severe distortions (over 2" deep) Extensive patching in poor condition. Potholes.	Severe deterioration. Needs reconstruction with extensive base repair. Pulverization of old pavement is effective.
1 Failed	Severe distress with extensive loss of surface integrity.	Failed. Needs total reconstruction.

** Individual pavements will not have all of the types of distress listed for any particular rating. They may have only one or two types.*

Source: PASER Manual Asphalt Roads Transportation Information Center, University of Wisconsin-Madison

I. Need for a Pavement Management Plan

A. Definition of Pavement Management System

The American Association of State Highway and Transportation Officials (AASHTO) defines pavement management as the effective and efficient directing of the various activities involved in providing and sustaining pavements in a condition acceptable to the traveling public at the least life cycle cost.[3]

B. Purpose of the Plan

The purpose of the City's Pavement Management Plan is to present a workable and affordable plan for improving the integrity and service life of City streets over the long term, while reducing the costs associated with deferred maintenance.

The key to effective pavement maintenance is applying the Right Treatment, at the Right Time, on the Right Roads. By not following this philosophy, the City will incur lower quality streets and the maintenance techniques will be more costly. This plan outlines when maintenance should be performed and what type of maintenance will give the best benefit to cost ratio.

This plan focuses on techniques used on our street network to ensure the long-term sustainability of the street infrastructure by using maintenance procedures such as seal coats, overlays, mill & overlays, and reconstruction. Day-to-Day maintenance activities are not addressed as part of this plan, however without additional funding our day-to-day maintenance of pothole repairs will decrease.

Our plan is based upon data gathered from street inspection reports performed by Public Works Street Division staff. A concentrated effort has been made to transition data gathering into a GIS centric approach to allow for better decision making, information sharing and transparency.

Not all aspects of our plan or data collection are complete and should be considered somewhat evolutionary. This is due to manpower limitations but also due to the fact that techniques and processes are constantly evolving in the pavement management industry. Also, some desired techniques for some roads do not fit within available funding constraints.

[3] Guidelines on Pavement Management, American Association of State Highway and Transportation Officials, 1985

C. Importance of Streets

The value of good streets should be considered an asset by the general public. Public attention is usually focused on streets that are in poor condition or when there is a major failure. Residents and visitors depend heavily on Columbia's streets. Our street network is vital to the local economy and for attracting new businesses. For example, the delivery of public safety services would be seriously compromised without a dependable street network. The ability to deliver goods to stores and for customers to seek out those goods is directly tied to a well-connected, well maintained system. This important network requires regular preventative maintenance and repair to continue to the serve the community

D. Magnitude of the Infrastructure

The City of Columbia's street network consists of over 1389 lane miles. A lane mile is a 12 foot wide strip of pavement one mile long. Lane miles provide a better representation of the amount of maintenance than centerline miles. One mile of a five lane facility with bicycle lanes on each side is six lane miles, but one centerline mile.

The number of City maintained lane miles continues to increase each year. Each new lane mile of roadway represents an added annual cost of maintenance for the life of the roadway. The estimated cost to build all 1389 lane miles today for the first time would cost over an estimated $1 billion. Since the cost of reconstruction is greater than first-time construction, to reconstruct all of the City owned roadways and associated drainage and other features would cost an estimated $1.3 billion.

The use of Columbia roadways is extensive and growing. According to census estimates, there were 123,180 people residing in the city during 2018, which represents greater than a 50% increase over the previous 20 years.[4] In addition to the City's population, many of the arterial roadways in the City carry residents from surrounding communities who come to Columbia for employment, business, travel, or shopping needs. Columbia remains a vibrant place for people to live, work and play. This means the total number of vehicles using Columbia's roadways is far greater than just the residents that reside within the City limit.

E. Cost of Foregoing Maintenance

Without a Pavement Management Plan, preventative and/or minor maintenance needs are often pre-empted by major repairs or re-construction needs. Roads that need preventative maintenance are typically in acceptable condition, which is why they are considered of lower priority in some communities than new construction or reconstruction of failed streets.

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[4] United States Census Bureau

Unfortunately, such an approach is much more expensive because it costs far more to rebuild a road after failure than it would have to rehabilitate the same road a few years earlier.

Studies have shown that the costs for street repair do not increase proportionately each year over the life of a street; rather, maintenance costs remain relatively low until the road's condition has deteriorated to below a good condition rating. Once this level has been reached, the cost of repairs rises sharply and will escalate as the pavement nears the end of its useful life. For an asphalt street, if an asphalt rejuvenator product, at a cost of $0.82 per square yard, is not applied within the first year then the next cost-effective product is a surface sealer. A surface sealer can be applied at $1.25 per square yard on 2-3 year old pavement. After an asphalt street continues to deteriorate the next cost-effective option is a chip seal at cost $1.30 per square yard on a 3-4 year old pavement. If these preventative maintenance techniques are not applied then a mill and overlay at a cost of $10 per square yard might be pursued when the pavement reaches 6 to 8 years old. Finally if nothing is done to the roadway the reconstruction cost would be $55 to $100 or more per square yard and need to be performed sometime as early as 10-15 years. Concrete streets can sometimes deteriorate more slowly earlier in their life cycle, but are more costly to maintain later on due to limited ways to preserve them and these methods cost significantly more.

The following graph illustrates how the quality of a road decreases rapidly after it deteriorates beyond the point of when preventative maintenance techniques can be used effectively. Depending on various factors, including; type of construction, quality and type of material used, traffic patterns and environmental factors, the life of a pavement may range from 15-30 years. For the first 50-75% of the roadway's life, the quality remains good and the costs of preventative maintenance are low. But once the condition of the pavement begins to drop, it drops rapidly and the cost to maintain it increases at an accelerated rate.

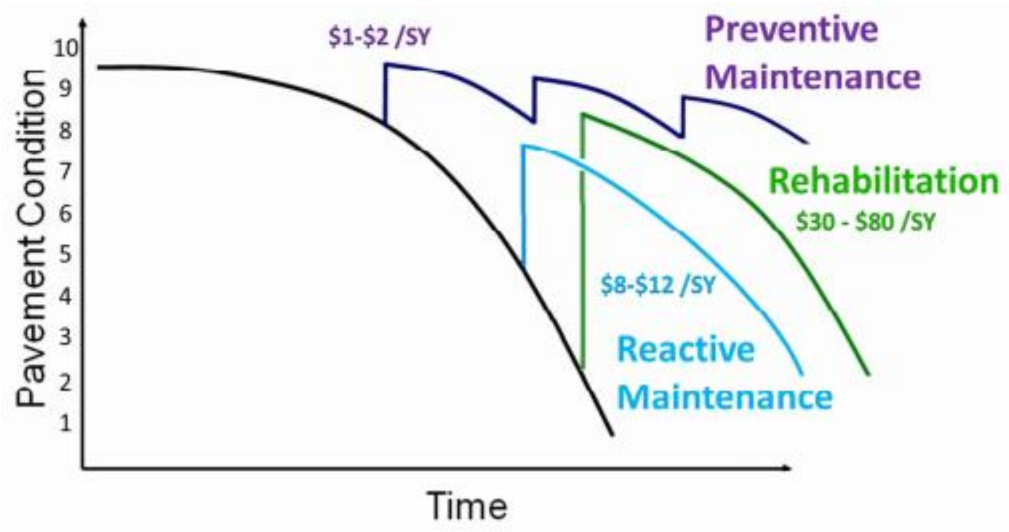

Figure 1: Pavement Maintenance options

The following is a comparison of two similar institutional locations showing the benefit of a pavement management plan over an ad-hoc system of repairing the worst roads.

The U.S. Army Corps of Engineers compared the maintenance practices at two Army Bases. One Base used a pavement management system to help determine optimum timing and the most cost-effective strategies for periodic maintenance actions. The other Base allocated its budget on the ad-hoc basis for which roads were in the worst condition. Both Bases had nearly identical budgets, but an evaluation of the pavement conditions on both (on a scale of 0 to 100, with 100 being excellent) found the first Base had an average condition rating of 75 compared with the second Base's average of 41.[5]

Poorly maintained roads not only result in higher costs; they can also result in higher automobile operating costs. These costs can occur due to poorly maintained pavements causing tire damage, more frequent front-end alignments, more frequent replacement of suspension systems components, more frequent traffic accidents, and increased travel times. Studies have shown that driving on rough, broken pavement can cost more than five times the amount in automobile maintenance than driving on smooth, newer pavement.[6]

Funding also determines the decision on which type of maintenance to pursue and on which streets.

[5] American Public Works Association, The Hole Story, p. 11
[6] University of Minnesota, The Per-Mile Costs of Operating Automobiles and Trucks, Final Report

Comparison of Potential Future Pavement Management Funding Scenarios

City staff used field inspection data to generate a list of prioritized repair needs defined by the maintenance activities required, based on PASER ratings and maintenance history. The following table compares the costs and outcomes of each of the funding scenarios. In Summary,

- **Scenario A (Adequate Funding Plan)** would provide funding for all critical seal coat and overlay work and some reconstruction, at a cost of $6.55 million in FY2020 with an additional funding of an anticipated $80,000 to $100,000 per year added after that. Historically, we have added about 18 lane miles to the system per year on average. The goal would be to increase funding based on the additional lane miles added the previous year. With this funding scenario, all 1389 lane miles in the system would get some type of maintenance every 10 years on average. This scenario results in an average PASER rating of 8 (Very Good) or better for most major routes and minor routes a rating of 7 (Good) for the long term. Local residential streets would have an average rating of 7 (Good) by fiscal year 2030. This scenario allows the City to maintain the streets that are in good shape and bring streets in poorer condition to a rating of good over time.
- **Scenario B (Add moderate funding to current funding level)** would add $265,000 per year to the existing funding level of $4.226 million per year. This scenario would allow us to somewhat keep pace and also delay how fast the funding gap grows between what we should spend and what we are spending for preventive maintenance. This scenario would delay deterioration of most roads, making them somewhat less costly to fix if this additional funding became available by 2023 (essentially keeping most roads already in good shape in good shape longer). This scenario results in an average PASER Rating of 6.5 (Good) by the year 2023. Much of the outcome after that would depend on advances in preservation techniques, additional maintenance responsibilities (added lane miles) and most importantly, any new additional funding. If no additional funding was available, after 2023 streets would begin to deteriorate and fall to an average overall PASER Rating of 4.5 (Fair) by fiscal year 2030, as deterioration would likely outpace maintenance funds. The amount 'we should be spending' will go up at a quicker pace once our 'average' rating falls below a PASER 6 (essentially it is not a matter of waiting a couple of years and then funding the program at $6.55 million per year).
- **Scenario C (Current Funding Level)** would maintain the City's current 2020 funding level for pavement maintenance, at $4.226 million per year, allowing for some critical overlays, seal coats and a very limited amount of reconstruction of existing streets. This scenario will likely result in an average PASER Rating of 4.5 (Fair) for major routes and 3.5 (Poor) for minor routes by fiscal year 2030. Local routes would average a 3.5 (Poor). Essentially we would continue to fall behind on maintenance of roads and the pace that we would fall behind will accelerate due to not being able to perform lower cost maintenance options sooner. Roads that have been recently brought to good shape would not be able to be kept at the same rating and will begin

to fail more rapidly. Concrete streets beginning to show signs of deterioration would accelerate towards very poor condition.

• **Scenario D (No Funding)** would defer essentially all pavement maintenance for ten years, with no annual cost for maintenance. This scenario would result in the average PASER rating of 2.5 (Very Poor, at the risk of failure) by fiscal year 2030.

Table 1: Comparison of Funding Scenarios

Comparison of Pavement Management Funding Scenarios				
	Scenario A	**Scenario B**	**Scenario C**	**Scenario D**
Plan	Adequate Funding	Current Funding with moderate increase over time	Current Funding with no increase in funding	No Funding
Maintenance Activities	All critical seal coat and overlay needs, most reconstruction needs met	Some overlay and seal coat, little reconstruction	Some overlay and seal coat, very little reconstruction	None
Annual Cost	$6.55 million initially, adding $80,000-$100,000 per year thereafter	$4.226 million initially, adding $265,000 per year thereafter	$4.226 million per year, no future	$0
Annual Number of Lane Miles Treated*	138	77 – increase incrementally over time initially, then decrease	77 initially, decreasing over time	None
Average PASER Rating (Condition) by Fiscal Year 2030	Majors: 8 (Very Good) Minors: 7 (Good) Locals: 7 (Good)	Majors: 5 (Fair) Minors: 3.5 (Poor) Locals: 4.5 (Fair) (Delays brunt of deterioration to 2023 with an average PASER of 6.5 at that time)	Majors: 4.5 (Fair) Minors: 3.5 (Poor) Locals: 3.5 (Poor) Average projected rating 5.5 in 2030	Major: 2 (Very Poor) Minor: 2 (Very Poor) Locals: 3 (Poor)

*Includes only: Chip Seal, Overlay, Mill & Overlay, Microsurface, Rejuvenators, and surface seals. Crack sealing, a vital part of the maintenance program, would be tracked separately.

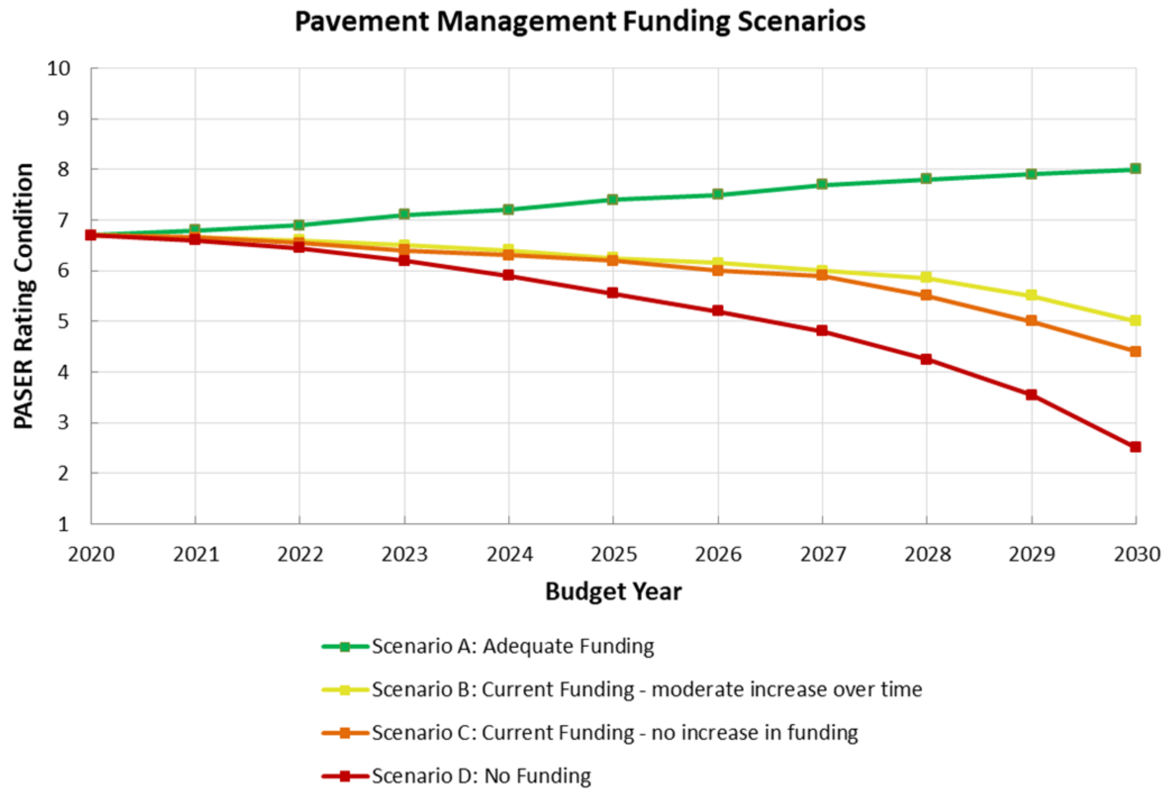

Figure 2: Graph of Funding Scenarios

All of these pavement management funding scenarios are flexible and can be modified as new funding or priorities are presented. The types of preservation chosen and the streets that are selected depends on the level of available funding. A choice of any one of the funded plans represents the absolute best use of funding for pavement management within the constraints of the available funding.

If the program continues on the current pace but without additional funding, by 2023 we will need to transition back to more preservation activity almost exclusively on those roads brought to good condition in the 2012 to 2018 time frame with less focus on local streets. We'll also be faced with tough choices for those streets that have base failure issues and concrete streets that begin to deteriorate. If that is the case, it would be better to let most of those failing roads continue to deteriorate and spend money more wisely on preserving more roads that are in better shape. That, however, is difficult from a public perception perspective.

In 2016, the City's concrete pavement specifications were updated to match current Missouri Department of Transportation (MoDOT) concrete pavement specifications. While this new specification will cause material cost for concrete pavement to increase slightly, this change will help prevent some of the issues our current concrete pavements are experiencing, this saving the City millions in long term maintenance cost. The future cost savings from this change may take several years to realize but it was essential to reduce the premature maintenance liability of our concrete pavements.

FY2020 funding is at about $0.43 per square yard of the entire system (approximately 9,778,500 square yards total). While there is no set national average for what ‘should be spent’, from our experience and what other professionals around the country recommend, about $0.67 per square yard allows for maintaining the system while minimizing the need for reconstruction. At current construction prices, this would provide for preventative maintenance on average for about 10% of the system each year. This equates to about $4,717 per lane mile (we are currently budgeting in FY2020 approximately $3,042 per lane mile).

Street rating data collection, programming street maintenance and providing data
In order to program improvements, all streets are inspected and rated every three years. This started in FY2016-2017, when residential streets transitioned from a 7 year cycle to a 3 year cycle to match the inspection cycles for major arterials and collectors. This increase in inspection frequency allowed for maintenance to be scheduled in a more timely manner, allowing for more streets to be maintained before their condition passed critical points in their life cycle.

Street data information has historically (20+ years) been maintained in a Hansen Software database. This system originally provided cutting edge information when, it was implemented. It still is a reliable source for internal operations personnel. However, it is not well suited to providing visual data for the public. In 2011, Public Works began transitioning street data information to a GIS based system that allowed for better visual information sharing with the public. Several underlying modifications in information sharing between Boone County and the City were needed prior to incorporating the information into the plan. Public Works staff worked with County and City GIS personnel to make the changes and is currently in the process of converting the Hansen database set to GIS. Utilizing GIS data allows for better coordination with utility and capital projects, reducing conflicts and minimizing street work being done prior to utility work.

Ratings for all arterials and collectors are now in the City’s GIS Pavement Management Database. The current average PASER rating for streets within the GIS system is 6.70; this is down from 6.97 last year and 7.5 the previous year. This large drop in such a short amount of time is because the higher PASER ratings were initially over-represented due to most streets being rated after maintenance was performed. This cuts down on data entry time, but doesn’t exactly reflect the actual overall rating of the street network. Over five hundred street segments that were rated in FY2019, were last rated five years ago. The estimated average PASER rating for FY2020 was expected to be approximately 6.75 (Good), which is very close to our actual overall average rating of 6.70 now that all street segments have been inspected on the new 3 year inspection cycle.

The current GIS map showing those rated segments and their ratings is attached. There are also maps of each Ward.

There are other pavement management rating systems. The bones of the PASER analysis relies on trained personnel's experience coupled with reference material. Training for rating is relatively straightforward and ratings can be performed by field personnel. This enhances buy-in from maintenance crews as they can continue to develop a better understanding of roadway conditions, how their maintenance work makes an impact long term and how proactive maintenance reduces costs. The PASER rating system offers a good balance between time up front and value of information. The PASER system also allows us to train seasonal employees, which includes part-time junior and senior level civil engineering students, this has allowed us to decrease the inspection periods from once every seven years to once every three years.

II. Example Street Resurfacing and Maintenance Techniques

A number of different maintenance techniques can be used on a roadway depending on condition and PASER rating. As a general rule, the following graph illustrates the types of maintenance activities correlated to the different PASER ratings for an asphalt street.

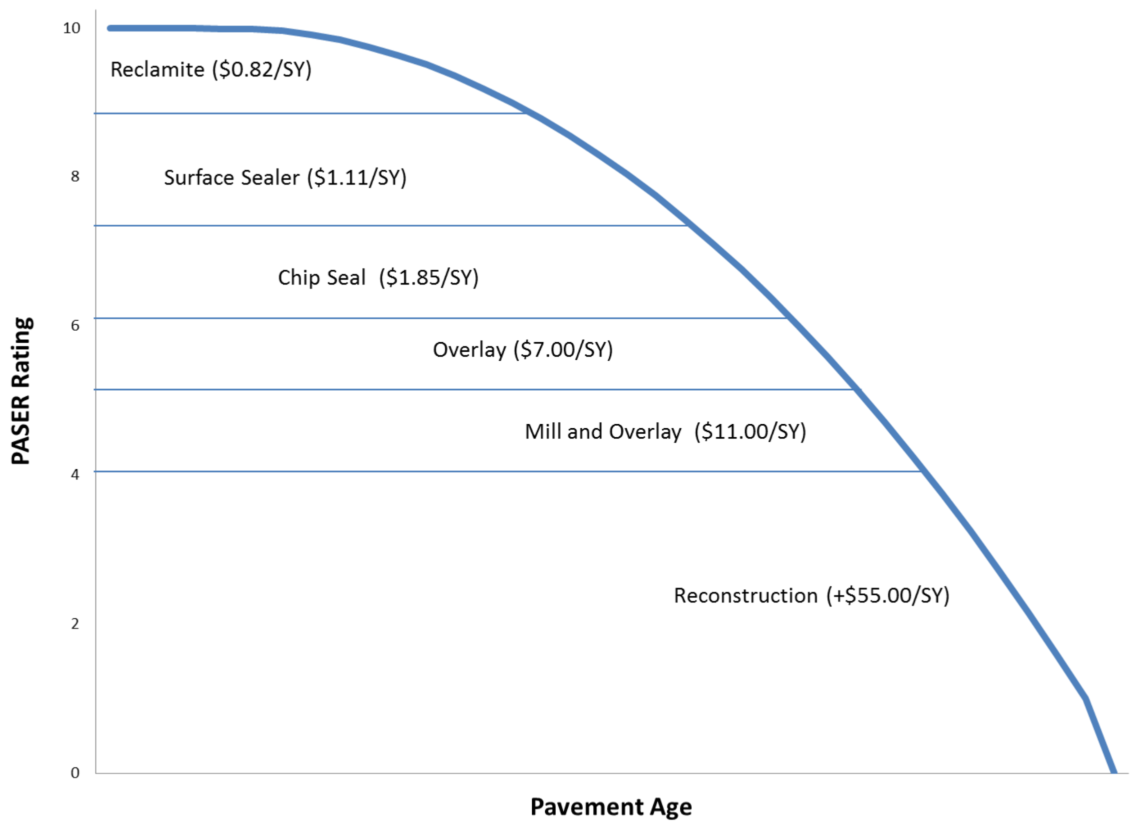

Figure 3: Pavement life cycle and maintenance cost of asphalt streets

Figure 3 shows the type and the average cost of each maintenance treatment used on asphalt streets. Streets with a PASER rating of 9 or higher are candidates for Reclamite or other rejuvenator type products. Rejuvenators are a maltene-based petroleum product that is applied to an existing asphalt surface which has the ability to absorb or penetrate into asphaltic concrete pavement and restore those reactive components (maltenes) that have been lost from the asphalt binder due to the natural process of oxidation.[7]

Once an asphalt roadway has dropped to a PASER rating of 7.5-8 the City uses a surface sealing product that seals up the roadway and blocks UV rays from further damaging the surface. Surface sealers are asphalt emulsions that are applied to an existing paved asphalt surface. These products are a mixture of asphalt emulsions, fine aggregates, recycled materials, polymers and catalysts.[8] These products help seal up surface cracks and prevent water and UV rays for damaging the street surface of the roadway. This is used if the street has deteriorated past the point of a Reclamite treatment but is slightly more expensive than the Reclamite.

[7] Nation Center for Pavement Preservation, Fog Seal Application of Rejuvenators & Sealer Coats, p 17
[8] Invia Pavement Technologies, Onyx Mastic Surface Treatment

Chip sealing is normally done in-house by City of Columbia crews and is performed when the condition rating of the street has dropped to a 6 or 7. Chip seal is a single bituminous surface treatment used as a wearing surface and water proofing course. It consists of a sprayed application of asphalt immediately covered by a single layer of uniform-sized aggregate.[9] A roller will then compact the aggregate into the asphalt, once the water has evaporated from the asphalt the chips will be locked into place by the asphalt. A sweeper is used once the process is completed to ensure any loose rocks are removed. This maintenance activity is currently one of the City's best values for extending the life of our asphalt streets. When chip sealing is done in house by our own crews we are able to treat many more miles of streets than we would if we contracted this out to a contractor. A chip seal can extend the life of an asphalt pavement by seven to ten years if the roadway has no structural issues. The sealant fills the small voids created from raveling and provides a seal to prevent water infiltration into the asphalt and base layers. Another benefit of a chip seal is an increase in the skid resistance of the pavement. This occurs because the cover aggregate increases the surface texture of the pavement.

In FY 2018, the City partnered with Boone County to hire a private contractor to chip seal City's streets. This contractor was hired because of our staffing shortages and lack of training of new employees were able to hire. In FY2019, staff had planned to split the chip sealing between in-house city crews and a private contractor, but was ultimatley able to perform all chip sealing with in-house city crews because of a reduction in staffing shortages, and also by reducing the total number of lanes miles. For FY2020, staff plans to perform all chip sealing with in-house city crews.

Once an asphalt pavement has reached a PASER rating of 5-6, an overlay is recommended. Like the chip seal, the City does most overlaying in-house with City crews in order to save money. This also allows us to fix problem areas that arise more quickly. Overlaying is much more expensive than any of the previous options but is much cheaper than a reconstruction. An overlay can bring the condition of a street back up to an 8-9. Once at this condition, we can then apply one of the previously mentioned treatment options to extend the life of the street.

Once a roadway reaches a rating of 4-5 an asphalt mill and overlay is our preferred method of rehabilitating the roadway. Depending on the thickness of the overlay, it may extend the life up

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[9] Asphalt Institute, The Asphalt Handbook 7th Edition, p 589-590

to 6 to 20 years.[10] This method requires a contractor to come in and mill up the top 1.5-2 inches of existing asphalt or concrete pavement and place down a new layer of asphalt on top of the milled roadway. An asphalt mill and overlay is one of the few maintenance activities that can be performed on concrete pavements other than remove and replace. This maintenance technique will bring the overall rating back up to an 8.5-9 if all structural issues with the pavement have been addressed prior to the milling of the street. These structural repairs, often called dig out repairs, are performed weeks or even months in advance of the mill and overlay. Dig out repairs can fix structural issues with the pavement by not only removing and replacing the pavement but also removing and replacing the base that supports the pavement. Dig out repairs are expensive and very time consuming.

Reconstruction is the final option if a street deteriorates below a 4 rating. Reconstruction is very expensive and time consuming. This method also causes more traffic problems for commuters more than any of the previous treatments because the street or parts of the street will have to be closed for days at a time during the reconstruction.

Staff is continually exploring other options for maintenance including concrete rehabilitation, full depth reclamation, hot-in-place asphalt recycling, and others. Many industry enchancements have occurred over the last 10 years and are continuing to be developed. Staff's current approach for considering new techniques is to explore a low dollar pilot project (less than $75,000) and evaluate the results, both in how disruptive the process is for traffic and how well the product worked.

Another critical maintenance technique is crack sealing. Crack sealing is a type of preventative maintenance in which heated and liquefied rubber asphalt is applied to fill surface cracks on streets. For the cost, crack sealing has probably the best pay off benefit of any maintenance technique when performed by our crews. It is very time consuming and the weather (hot or wet conditions) can impact when it can be applied. Because of these reasons, it is typically expensive if contracted out. Crack sealing can significantly delay deterioration where there is a pavement seam or crack (both concrete and asphalt streets). The City has two crack seal machines and crews that perform in-house cracking seal approximately 40% of the time during our annual maintenance schedule.

Our Pavement Management program is still evolving, and we will continue to utilize data and methodical analysis to dedicate the resources in the best manner possible to achieve our goals.

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[10] U.S. Department of Transportation, National Transportation Library, Pavement Management – A Manual for Communities, p 42

III. Historic Maintenance Trend

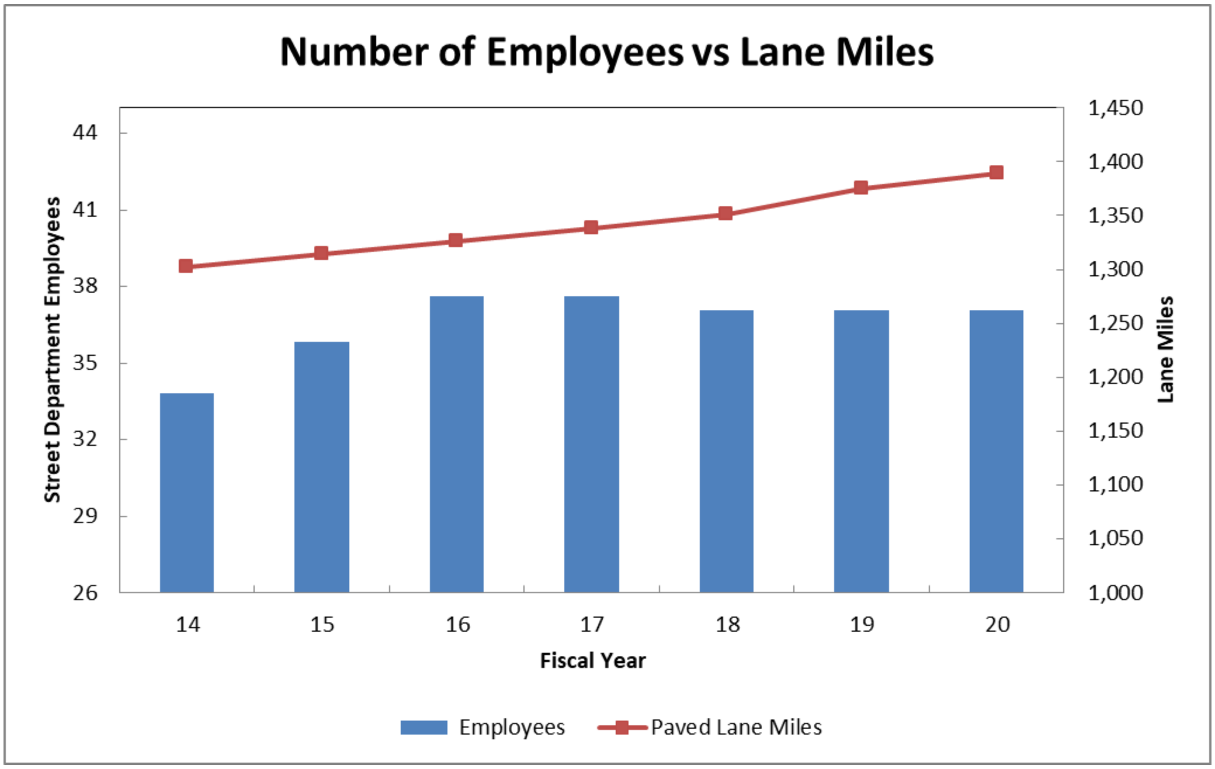

Figure 4: number of paved lane miles vs. number of street employees

As our street network continues to grow, the amount of maintenance required to maintain the system continues to increase. Annually, more lane miles of streets are added to the City's network than personnel. Figure 4 is a visual representation of how the number of lane miles have increased over the last 10 years compared to the number of full time street department employees. As this gap widens, more maintenance will have to be deferred or contracted out to private contractors. However, without additional funding to cover the additional cost of these contractual services, the maintenance will have to be deferred. Figure 5 below shows how the current gap between the number of lane miles in the City's street network and the street maintenance budget continues to grow.

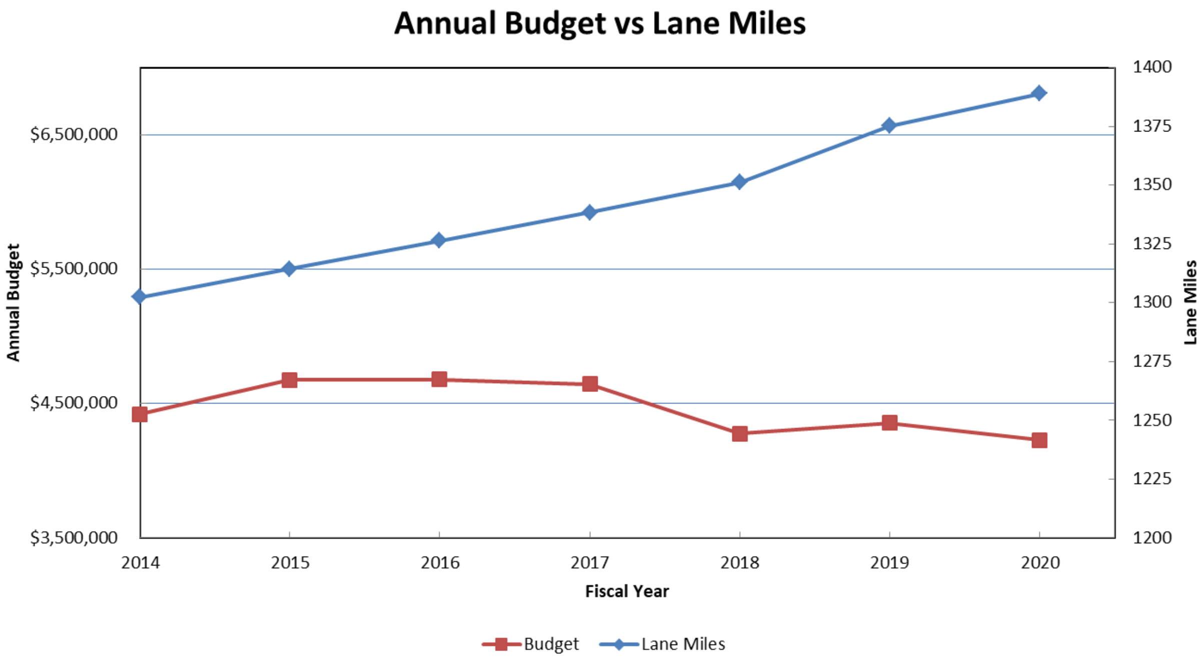

Figure 5: annual budget vs lane miles in the City's street network

I. Street Inventory and Condition Assessment Tool

A. Street Inventory Organization

1. Introduction

There are a number of different pavement management techniques and software to inventory a street network. Each system has it owns benefits, costs and level of complexity. The City of Columbia uses a GIS based database that we share with Boone County to utilize the same street segments. This system allows us to store information about the condition of a street segment along with that segment's maintenance history, physical characteristics, average daily traffic, road classifications, and future planned maintenance.

2. Road Classification

Arterial roadways are main thoroughfares. They serve more people than collectors or secondary roads do. As a result, they are likely to require more frequent maintenance, and also are often considered a higher priority. Many jurisdictions also set a higher standard of pavement condition for these roadways; for example, the average PASER rating goal for arterial roadways may be set higher than the average PASER rating goal for secondary roadways. Cost of repair per square foot may be greater as well, since the pavement is often designed to carry heavier loads than other roadways.

Collector roadways are intermediate streets. They collect vehicles from secondary roadways to funnel them to arterial roadways. They may feed into subdivisions to provide primary access to houses on other street, or they may serve as a primary connector between two major roads. They serve more people than secondary roads do, but less than arterials roadways. Maintenance needs and costs are therefore generally greater than for secondary roadways but less than for arterial roadways.

Secondary roadways are local, residential streets and alleys. They provide access to houses primarily on that street. Each roadway is used by a smaller number of people, but each of these roadways is used almost exclusively by Columbia residents. Since these are local users, residents receive 100% of the benefits of funding devoted to improvement of these roadways, compared to a smaller percent for arterial roadways. The pavement condition of these roadways may directly affect the value of the homes in the immediate neighborhood, when compared to other neighborhoods with different pavement conditions.

3. Street Segments

Each Street is broken into segments, which are generally defined by the name of the street and a unique object ID or segment number. End points generally extend from one cross street to the next street, bridge, or point, so segments vary in length according to the distance.

B. Determining Street Condition

As pavement deteriorate through its performance life cycle, it changes along the way. Its appearance and functionality diminish over time. This aging process begins immediately after construction even though these early changes are impossible to see. After a while, asphalt becomes noticeably more gray. This is a chemical oxidation process that is often referred to as aging or the age-hardening process. Chemical oxidation is intensified by the sun's ultraviolet rays. This chemical change in the asphalt binder makes the pavement more brittle and subject to wear and cracking. In addition to hardening, the asphalt also begins a process known as raveling. Raveling is the degradation of the binder that surround the aggregate and holds it in place. This could be best understood by comparing a very tight, smooth surface of new asphalt to a rough, deeply pitted surface of old asphalt. If preventative maintenance is not utilized, and the pavement is allowed to deteriorate past the point, the damage is irreversible.

Damage that leads to potholes in an asphalt pavement begins as the pavement starts to gray and light raveling occurs. At this point, fine hairline cracks usually are not noticeable but are prevalent in the pavement. As the raveling continues, the asphalt weakens and the fine hairline cracks spread and deepen within the asphalt. At this point, the asphalt is no longer impervious to water. As water enters the cracks, it begins to erode the sub-base, thereby weakening the very foundation of the asphalt. Asphalt is only as strong as the base it sits on, so it becomes susceptible to the weight of vehicles depressing the weak areas. The cracking then intensifies and begins a process known as alligator cracking. Alligator cracking gets its name because the cracks resemble the hide of an alligator's back. The cracks continue to worsen as more water enters and vehicles continue to compress the sub-base. If this continues, the pavement will reach imminent failure as mud pumps up through these cracks. This is the last stage of failure as the asphalt breaks in small pieces and starts to pop out and form pot holes or larger ruts.[11]

The majority of factors leading to the disrepair of asphalt can be prevented to proper maintenance. Seal coating and crack filling asphalt surfaces can prevent all factors stated above from occurring or stop the degradation for continuing. This is a small

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[11] City of Folsom, California. Pavement Management five year capital plan. May, 2005

expense as compared to no preventative maintenance and having to do costly patches and overlays, as well as complete removals and replacements.

Asphalt pavements are flexible and need regular traffic to maintain their surface resilience. As a result, lower traffic streets tend to age more quickly. Structural adequacy, representing the strength of the pavement and underlying foundation, tends to be more important factor for heavier traffic streets, and those that have more truck traffic.[12]

1. Surface Distress and Structural Adequacy

Asphalt's surface distress and structural adequacy can be measured by examining 12 criteria defining surface defects, surface deformations, cracking and patches and potholes. Definitions contained in the PASER Manual used by the City of Columbia street inspection staff are:[13]

Surface defects:

- Raveling is progressive loss of pavement material from the surface downward caused by; stripping of bituminous film from the aggregate, asphalt hardening due to aging, poor compaction especially in cold weather construction, or insufficient asphalt content.
- Flushing is excess asphalt on the surface caused by a poor initial asphalt mix design or by paving or sealcoating over a flushed surface.
- Polishing is a smooth slipper surface caused by traffic wearing off sharp edges of aggregates.

Surface deformations:

- Rutting is displacement of material creating channels in the wheelpaths. It is caused by traffic compaction or displacement of unstable material.
- Shoving or rippling is surfacing materials displaced crossways to the direction of traffic. In can develop into wash boarding when the asphalt mixture is unstable because of poor quality aggregate or improper mix design.

Cracking:

- Transverse cracks are often regularly spaced and approximately right angles to the center line. The cause is movement due to temperature changes and hardening of the asphalt with aging. Transverse cracks will initially be spaced about 50' but

[12] City of Longview, Texas. Establishing the level of Service of Our Streets. December 11, 2002
[13] Wisconsin Transportation Information Center, PASER MANUAL Asphalt Roads, 2002

additional cracking will occur as the asphalt ages until the spacing between transverse cracks is within several feet.

- Reflection cracks occur in overlays that reflect the crack pattern of the pavement underneath.
- Slippage cracks are crescent or rounded cracks in the direction of traffic caused by slippages between an overlay and an underlying pavement. Slippage cracks are most likely to occur at intersections where traffic is stopping and starting.
- Longitudinal cracks run in the direction of traffic, centerline or lane cracks are caused by inadequate bonding during construction. Longitudinal cracks in the wheel path indicate fatigue failure from heavy vehicle loads while cracks within one foot of the edge are caused by insufficient shoulder support, poor drainage, or frost action.
- Block cracking is interconnected cracks forming large blocks. Cracks usually intersect at nearly right angles and my range from one foot to approximately ten feet across. The closer spacing indicates more advanced aging cause by shrinking and hardening of asphalt over time.
- Alligator cracks are interconnected cracking forming small pieces ranging in size from about one inch to six inches. This is caused by failure of the surfacing due to traffic loading (fatigue) and very often is also due to inadequate base or subgrade support.

Potholes and patches

- Potholes are holes and loss of pavement material caused by traffic loading, fatigue and inadequate strength. Often combined with poor drainage.
- Patches are areas of repair that have been repaired with new asphalt material. This indicates a pavement defect or utility excavation which has been repaired. Patches with cracking, settlement or distortions indicate the underlying causes still remain.

Each of these criteria is measured by severity and density over the length of the street segment based on the percent of the street segment that is affected.

- None 0%
- Few <10%
- Intermittent 11-25%
- Frequent 26-50%
- Extensive >50%