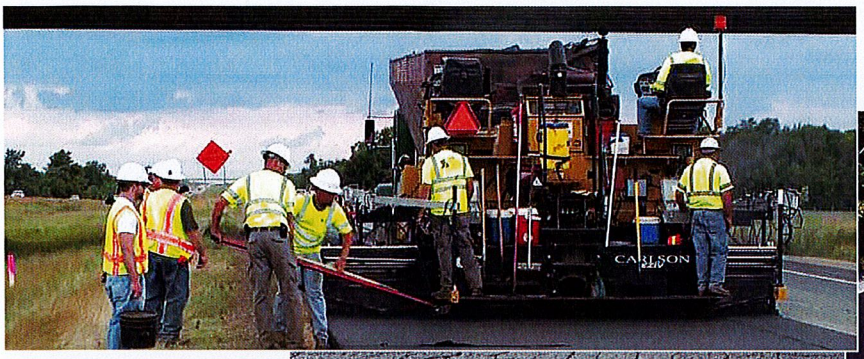
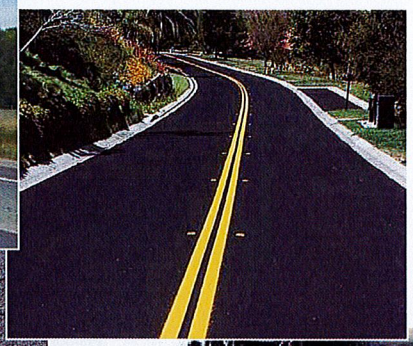
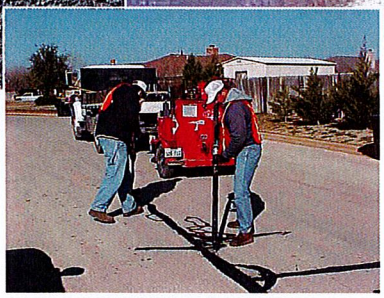
MUNICIPALITY OF MONROEVILLE
ENGINEERING DEPARTMENT

2022 Municipal Pavement Infrastructure Report
February 25, 2022







Monroeville
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Purpose

The purpose of this report is to explain to the reader how the Municipality of Monroeville's Engineering Department maintains the Municipality's pavement infrastructure by providing answers to the following questions:

- What pavement infrastructure do we have?
- How do we assess its condition?
- What is the current condition?
- How do we maintain it?

What pavement infrastructure do we have?

Within the Municipality's geographical limits there are roughly 193 miles of roadway. Portions of that roadway network are owned by the Pennsylvania Department of Transportation (PennDOT), the Pennsylvania Turnpike Commission, Allegheny County, the Municipality, and private parties.

The Municipality is responsible for maintaining only the Municipally-owned roadways and parking lots. The breakdown of this Municipally-owned pavement infrastructure is as follows:

- Municipal roads - Approximately 110 miles
- Municipal lots - 34 parking lots totaling roughly 6.3 equivalent road miles of pavement
- Total Municipal pavement infrastructure = roughly 116.3 equivalent miles of pavement

At today's construction costs this pavement infrastructure asset is worth roughly $230 million.

How do we assess its condition?

Obviously with such a high dollar value asset maintaining that asset to preserve its value is of utmost importance. In order to effectively maintain the infrastructure however we must first inventory and assess the condition of the pavement infrastructure. The remainder of this section will discuss the following:

- The pavement inventory system
- The condition assessment system

Pavement inventory system

The pavement inventory system was developed using the Engineering Department's Geographic Information System (GIS). In the GIS software the 116 equivalent miles of pavement are symbolized on a digital map with individual line segments representing the road or lot centerlines. These segments, normally spanning from intersection to intersection, break the system down into 948 segments each

averaging 633 feet in length. Each segment has pertinent information digitally affixed to it via a database such as name, cross streets, length, function, Ward, past resurfacing information, and condition.

Condition assessment system

The condition assessment is generally performed annually unless weather and/ or manpower preclude doing so. During the assessment the evaluator performs a windshield inspection of all Municipal roads and lots and rates each segment in accordance with the University of Wisconsin – Madison Transportation Information Center's PAvement Surface Evaluation & Rating (PASER) Manual.

The PASER rating system uses visual inspection cues to characterize four major categories of asphalt pavement distress:

- Surface Defects – Raveling, flushing, polishing
- Surface Deformation – Rutting, rippling, shoving, settling, frost heave
- Cracks – Transverse, reflection, slippage, longitudinal, block, alligator
- Patches and potholes

The PASER manual uses the observed distresses to assign a numerical rating to each segment spanning from a score of ten representing new construction to one representing failed pavement. The PASER numerical ratings and corresponding conditions are shown in Exhibit 1.

During the actual assessment the Engineering Inspector utilizes a vehicle-mounted GIS-enabled laptop to provide an instantaneous color-coded map of segment ratings facilitating fast and accurate data collection. As the segments are rated the information is immediately entered into the software in real-time.

Exhibit 1. PASER matrix illustrating numerical PASER rating and corresponding general condition.

PASER Rating	General Condition
10	Excellent
9	Excellent
8	Very Good
7	Good
6	Good
5	Fair
4	Fair
3	Poor
2	Very Poor
1	Failed

What is the current condition?

Now that we have discussed what pavement infrastructure we have and how we assess it we can delve into what that data tells us about the current condition of our system by discussing the following topics:

- The current condition of the pavement infrastructure
- Historical trends in pavement condition
- Factors affecting pavement condition

The current condition

By utilizing a numerical rating system the Engineering Department is able to statistically analyze the PASER ratings to provide an objective, quantifiable measure of the condition of the Municipality's roads and parking lots.

Based on the 2020 assessment the mean segment mileage-weighted PASER rating was 6.22 equating to a "good" rating for our overall pavement "health".

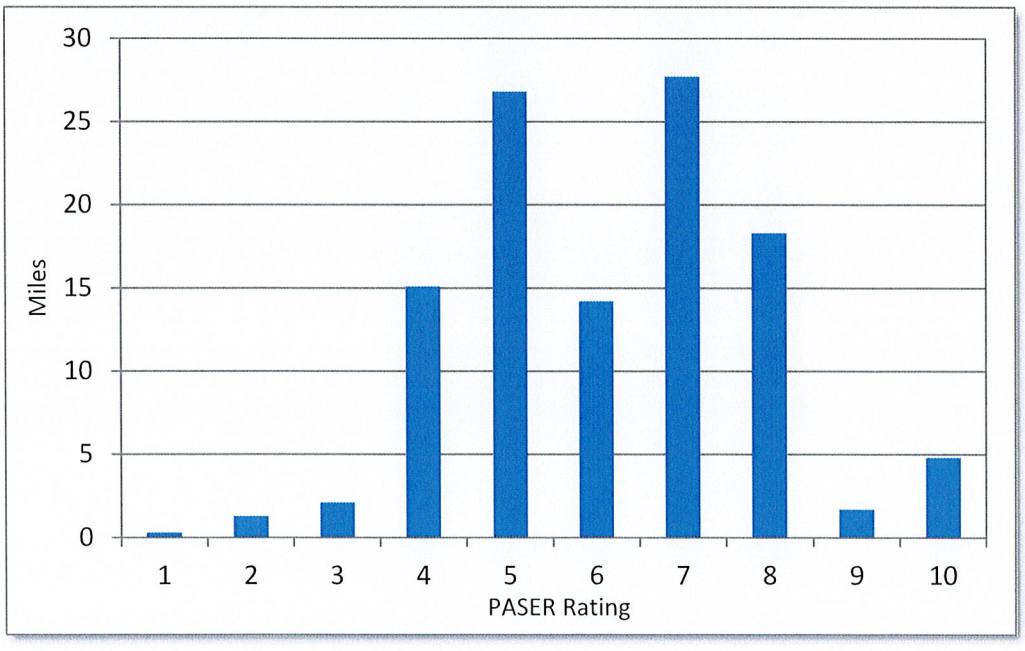
The total breakdown of the pavement infrastructure by PASER rating is shown below in tabular format in Exhibit 2 and in graphical format in Exhibit 3.

These Exhibits illustrate that the pavement condition follows somewhat of a bell-curve distribution, with few "excellent" or "failed" roads and most roads in "fair" to "good" condition.

Exhibit 2. Pavement infrastructure system classified by 2020 PASER rating in tabular format.

Paser Rating	Paser Condition	No. of Segments	Total Mileage
1	Failed	2	0.3
2	Very Poor	5	1.3
3	Poor	17	2.1
4	Fair	123	15.1
5	Fair	250	26.8
6	Good	131	14.2
7	Good	231	27.7
8	Very Good	128	18.3
9	Excellent	16	1.7
10	Excellent	41	4.8

Exhibit 3. Pavement infrastructure system classified by 2020 PASER rating in graphical format.



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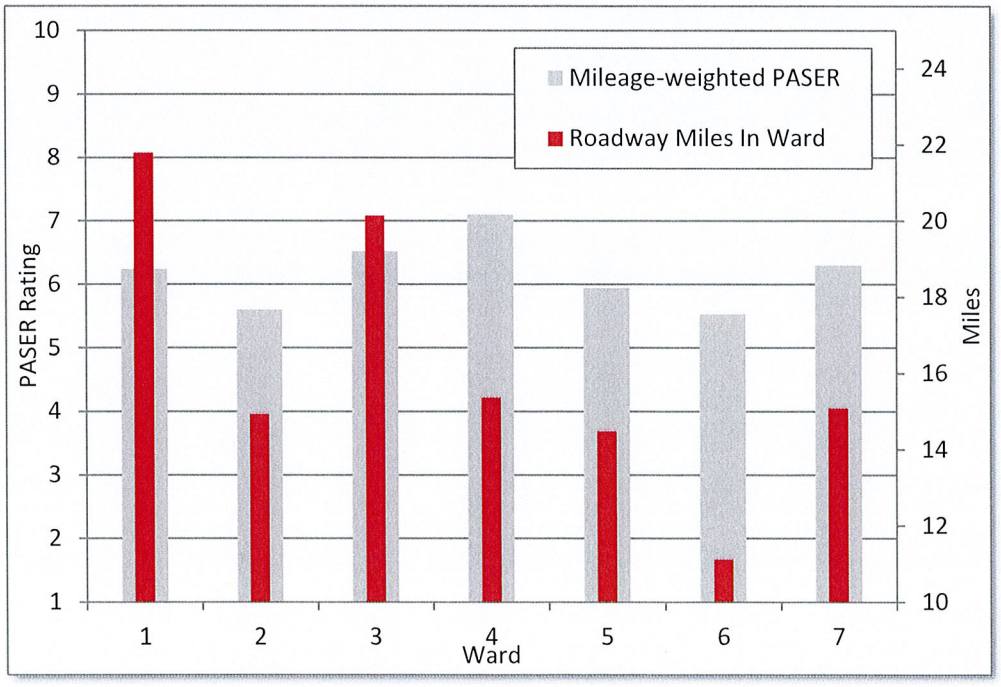
The GIS inventory system enables the Engineering Department to report pavement condition on a Ward-specific basis as well. Exhibit 4 below provides a tabular classification of the pavement infrastructure by Ward whereas Exhibit 5 provides a graphical representation of pavement condition by Ward.

The Exhibits clearly illustrate that the mileage of roads across the Wards varies greatly, with Ward 1 having nearly twice the mileage as Ward 6 for example. For this reason evenly distributing the allotted resurfacing budget equally across all Wards is not only illogical it would result in lower pavement condition in the Wards with greater mileage than those with less mileage. The Exhibits also show that the pavement condition is generally even across the Wards.

Exhibit 4. Tabular pavement system mileage and condition classified by Ward (2020 PASER).

Ward	Roadway Miles	Mileage-Weighted PASER Rating
1	21.8	6.24
2	14.94	5.60
3	20.15	6.52
4	15.37	7.10
5	14.48	5.94
6	11.12	5.53
7	15.09	6.30

Exhibit 5. Graphical pavement system mileage and condition classified by Ward (2020 PASER).



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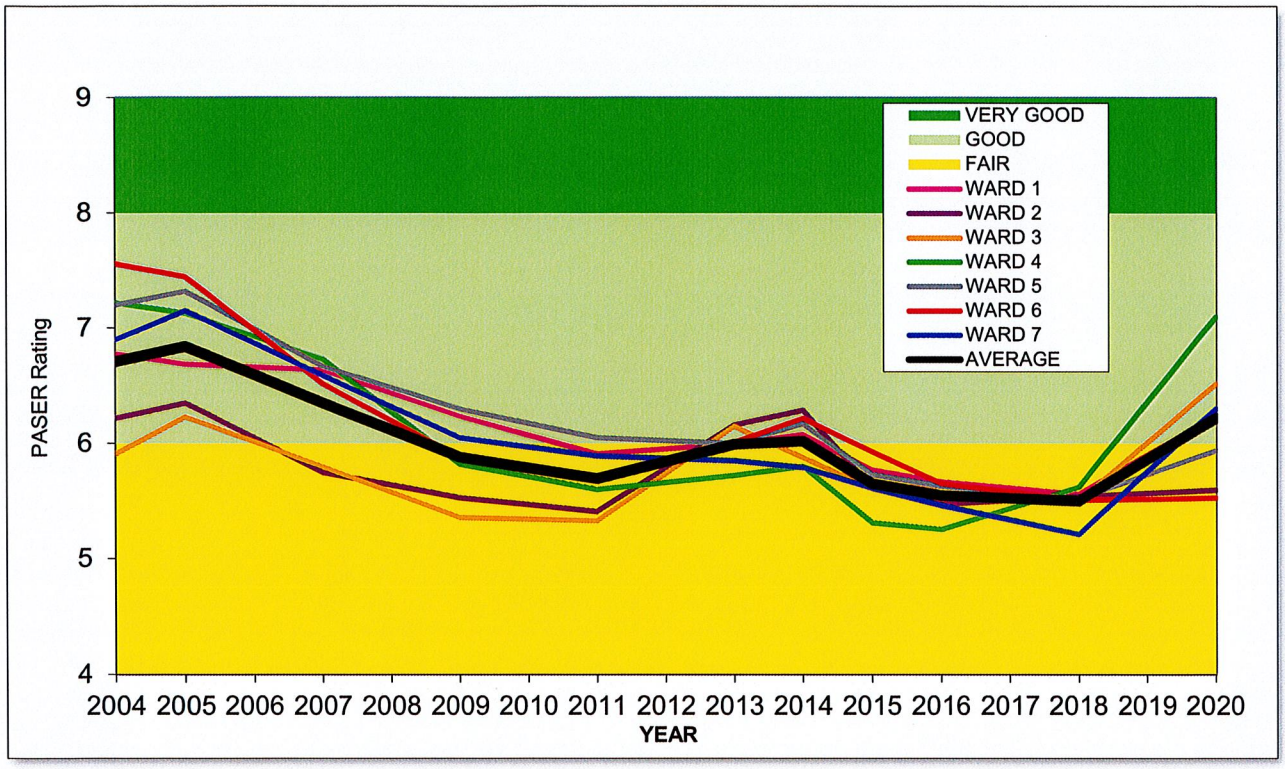
Historical trends in pavement condition

The mileage-weighted PASER rating provides an objective, quantifiable measure of the condition of the Municipality's pavement infrastructure which allows us to judge improvement (or deterioration) of the pavement infrastructure over time. Exhibit 6 below illustrates how the mileage-weighted PASER rating has changed over the last 18 years whereas Exhibit 7 does the same graphically.

Exhibit 6. Tabular mileage-weighted PASER rating between 2004 and 2020.

Assessment Year	Mileage-Weighted PASER Rating	PASER Condition
2004	6.71	Good
2005	6.84	Good
2006	6.60	Good
2007	6.35	Good
2008	6.12	Good
2009	5.88	Fair
2010	5.79	Fair
2011	5.69	Fair
2012	5.84	Fair
2013	5.99	Fair
2014	6.02	Good
2015	5.65	Fair
2016	5.55	Fair
2017	5.52	Fair
2018	5.50	Fair
2019	5.86	Fair
2020	6.22	Good

Exhibit 7. Graphical mileage-weighted PASER rating between 2004 and 2020



Exhibits 6 & 7 illustrate that over the last 18 years the overall mileage-weighted PASER rating had steadily decreased from 6.71 in 2004 to 5.50 in 2018 due to diminished funding, eroding buying power due to inflation of construction costs, and hesitancy to fully embrace a preventative maintenance philosophy. Since 2018 funding has increased and we have more fully embraced a preventative maintenance philosophy and in turn you see a rebounding overall road condition that we expect will continue trending in a positive direction in the 2022 assessment.

Factors affecting pavement condition

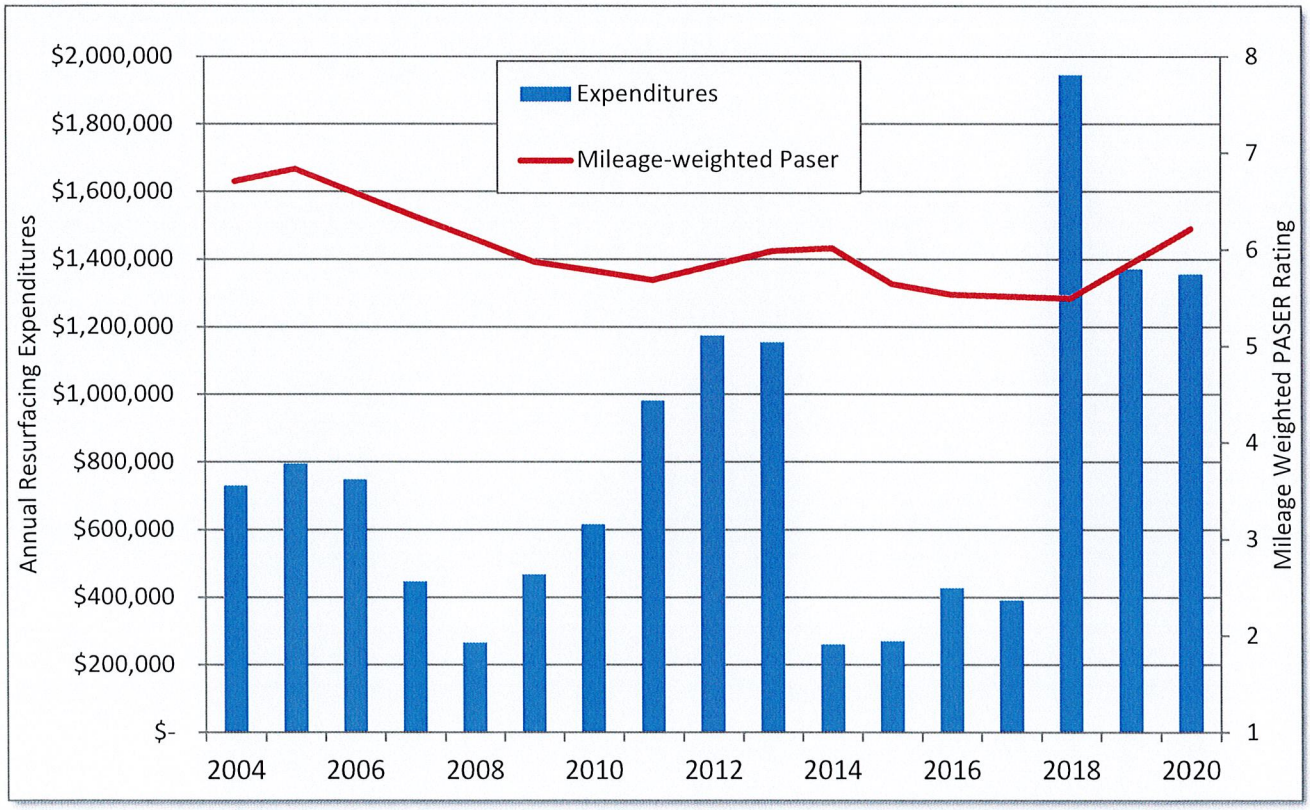
The condition of our pavement infrastructure is affected by a myriad of factors, including the following which will be discussed:

- Funding
- Pavement construction
- Modern asphalt materials
- Winter weather
- Preventive maintenance

Funding

The most important factor affecting pavement condition is funding for pavement maintenance. Over the last 18 years the budget expended for maintenance has vacillated greatly. Over that same period the cost to pave a road has more than doubled. Less funding compounded by less buying power resulted in less maintenance and subsequently the pavement system deteriorated at a faster pace than it could be maintained. Exhibit 8 below depicts funding over the last 18-years as well as pavement condition over the same period. Note how the drop in PASER rating from 2005 to 2011 shown in red on Exhibit 8 follows the funding "valley" shown in blue for the same period, and the decrease in funding between 2013 and 2018 is followed by a dip in PASER rating for that same period. The take-away from this visual is that pavement condition correlates with or "tracks" funding. It is also to understand that while you can defer maintenance you cannot escape it, you eventually have to "pay the piper" and generally it costs you more later to catch-up as the damage is more extensive and inflation has increased the cost.

Exhibit 8. Maintenance funding and pavement condition.



Based on the Municipality's observed average overlay lifespan of 15 years and today's construction costs the Municipality should be performing $1.65 million in paving each year (in today's dollars) in order to keep pace with deterioration. The cost to return all of the Municipal pavement to at least good condition (PASER's < 6) via mill and overlay is just over $9.7 million.

Pavement construction

The second factor affecting pavement condition is the construction of the pavement itself. Most of our pavements were built in different eras with different profiles and materials and therefore deteriorate at different rates. Pavements that have thinner profiles, poor drainage, or are built over soft soils crack and deteriorate quickly. Pavements that have thicker profiles, good drainage, and are built on stable soils last much longer. These factors make it impossible to manage each pavement the same or to put each pavement on a fixed repaving schedule. Because deterioration rates and mechanisms for each pavement are different the Engineering Department's condition assessments are an essential management tool.

Modern asphalt materials

Another factor that is affecting pavement condition is the modern asphalt used for paving. In 2006 PennDOT mandated that Municipalities use its new "Superpave" asphalt mix designs which have reduced fine aggregate ("sand") and binder ("tar") to minimize rutting on high-volume highways and interstates. On low-volume pavements like ours this material results in increased cold-weather cracking and increased permeability both of which are detrimental to pavement lifespan. Furthermore PennDOT and the asphalt industry in general have also been incorporating ever-increasing percentages of recycled asphalt materials into new asphalt meaning that 15% or more of our "new" asphalt is actually "old" asphalt. All of these factors are resulting in a higher rate of deterioration and we are finding that new overlays simply do not have the longevity they used to.

Winter weather

The third factor affecting pavement condition is winter weather which causes the majority of the deterioration our pavements experience via the mechanisms of frost heaving, freeze-thaw damage, thermal contraction cracking, and plow damage. The winters of 2009-2012 were especially wet consisting of warm spells coupled with rain and/or snowmelt followed by prolonged deep freezes. This phenomenon repeatedly produced dramatic frost heaving which resulted in widespread cracking in even new pavements. While the winter of 2012/2013 was rather mild, the record cold spells of the 2013/2014 winter cracked most of the roads that were paved the prior year. The winters of 2014-2016 were again mild but the prolonged cold spells the following winter produced heaving and cracking. The last couple winters 2019-2021 have been relatively mild, but this winter you undoubtedly noticed dramatic frost heaving on the roads over the prolonged freeze. The permeability of the Superpave asphalt contributes to this problem by allowing more water to enter the pavement and freeze.

Preventive maintenance

The final factor affecting pavement condition is preventive maintenance. Preventive maintenance aims to preserve roads and extend the lifespan between repaving in order to achieve a longer life-cycle at a reduced cost. The goal of preventive maintenance is to keep the pavement from slipping in condition via application of the appropriate maintenance method at the appropriate timing.

Exhibit 9 below illustrates this concept by showing how periodic preventive maintenance, shown in black, can temporarily improve pavement condition and increase the lifespan of a pavement by lengthening the deterioration curve versus pavement that receives no preventive maintenance (shown

in orange). Exhibit 9 also addresses the fact that a dollar spent on preventive maintenance is much more cost effective than repaving or reconstruction required further down on the deterioration curve.

Exhibit 9. Pavement deterioration curve depicting preventive maintenance (black) and lack of preventive maintenance (orange).

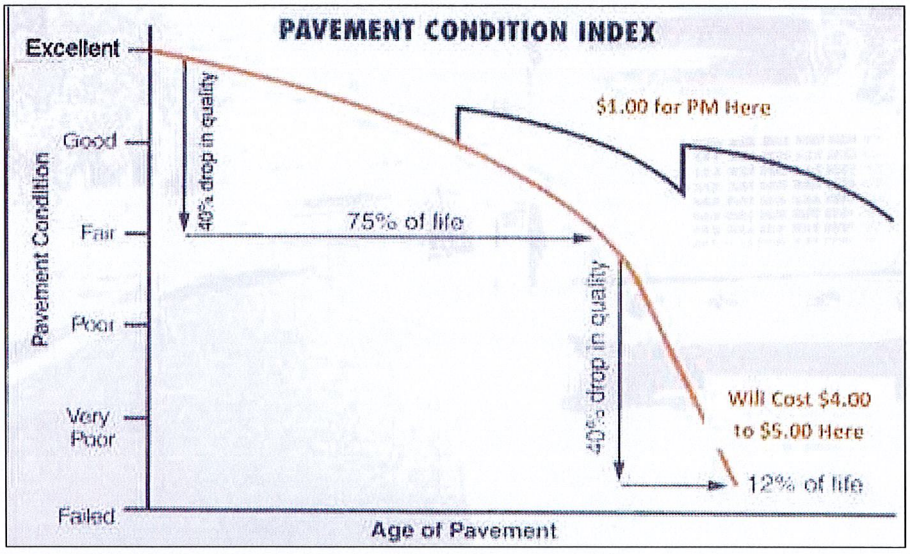


Image courtesy of www.missouripetroleum.com

We have been employing preventive maintenance in earnest since roughly 2014, although fully implementing preventive maintenance has been hampered by funding and perception. The old philosophy to pave a road or lot and then and ignore it for 20 years is analogous to building a new home but never painting, cleaning, or repairing it and then building a new one in 20 years. Preventive maintenance for pavement is like painting your house every few years, changing the oil in your car, or sealing your driveway. These things are common sense maintenance and are widely accepted as prudent, as preventive maintenance of pavement should be. The Municipality's use of preventive maintenance will be discussed more throughout the remainder of this report.

How do we maintain our pavement infrastructure?

The maintenance process begins with the Engineering Department's condition assessment discussed earlier in this report. In order to select candidates for maintenance the Engineering Department developed a custom prioritization formula which was amalgamated from several such formulas published by industry experts and academics. The Engineering Department's formula prioritizes segments based upon three factors:

- Roadway age (years since last paved)
- Functional category (collector, local throughway, cul-de-sac, dead end, alley, parking lot)
- PASER rating

These three factors are assigned a weighting to produce a theoretical priority rating from 1-100, with 1 being the highest priority and 100 being lowest. This system relies most on the pavement rating, as any such prioritization should, but gives preference to heavily trafficked roads over low volume ones and resurfacing of "older" roads over "newer" ones.

These scores provide a raw, unbiased basis for prioritizing which pavements are most "deserving" of maintenance which must then be "polished" with human experience and wisdom. This is accomplished by loading the prioritization data back into the GIS to allow visualization of spatial location and patterns allowing Engineering staff to develop a project scope accounting for various external factors including upcoming utility work or development and efficiency of construction. Maintenance methods are selected based upon the distresses noted in the condition survey as well as the functional use of the pavement and can be divided into two categories, repaving and preventive maintenance, each of which will be further discussed below.

Repaving

Repaving consists of laying a new conventional asphalt pavement over the existing pavement to provide skid resistance, aesthetics, to restore an impervious surface, and to add structural support. Repaving is usually utilized on older, cracked pavements in poor condition (PASER <4) which can no longer be maintained through another process. Generally repaving is referred to as an overlay. Typically because Municipal roadways have been paved over so many times the existing surface must be ground to a depth of 2-3" in order to remove deteriorated asphalt, re-establish crown, and minimize elevation issues with driveways and roof leaders prior to an overlay. This process is referred to as a "mill and overlay".

Preventive maintenance methods

Since our initial foray in 2008 the Municipality has become a regional leader in implementing preventive maintenance with the utilization of fog seals, sealcoats, scrub seals, flush coats, crack sealing, microsurfacing, and cape seals. The following is a discussion of preventive maintenance methods the Municipality currently utilizes and their applications and limitations.

Fog Seal

A fog seal is a proactive treatment meant to seal recently paved pavement (PASER 8-10) much as you would do with your driveway in order to extend the service life of the pavement at a lower annualized cost. The fog seal will not fill ruts, seal large cracks, or cure structural problems.

A fog seal consists of applying a light application of an asphalt emulsion ("tar" mixed with water) to a pavement via a distributor truck in order to seal the pores and micro-cracks in the pavement to prevent water intrusion, to bind the surface so that stones will not dislodge (called raveling), and to combat chemical drying and aging of the asphalt due to ultraviolet damage. The fog seal has the side benefit of restoring the pavement to a black surface that residents often confuse with new pavement. Sand is applied to the fog seal to enhance skid resistance.

Crack Sealing

Crack sealing is generally used on roads that are in very good to good condition (PASER 6-8) but where crack patterns have developed. We re-introduced crack sealing to our preventative maintenance "arsenal" in 2015 using outside contractors but over the last 3 years the Public Works Road Crew has taken over that work in-house at a tremendously reduced cost. The crack seal crew will use compressed air and other methods to clean the cracks and will then seal the cracks with a rubberized bituminous (tar) mixture.

Crack sealing is the most cost-effective method of preserving roads with the goal of keeping the cracks from multiplying or worsening which would occur if water was permitted to continue entering the cracks. Crack sealing becomes inappropriate when the road reaches a certain level of deterioration and therefore the Municipality will typically only crack seal a road once or twice before it is overlaid or sealcoated again.

Sealcoat

A sealcoat consists of a coat of polymer-modified asphalt emulsion applied by a distributor truck followed by an application of specially selected aggregate. The sealcoat is meant to seal a cracked pavement with a waterproof membrane and provide a uniform high traction surface. Ideally the sealcoat should be used on pavement with a PASER of 5 or 6 to seal the pavement and extend the service life at a lower annualized cost than conventional paving by delaying further deterioration. We have also used the sealcoat to seal pavements that were severely deteriorated (PASER 1-3) but were not budgeted to be paved in an attempt to stave off catastrophic failure. A sealcoat will not fill ruts or cure structural problems.

Sealcoat with Flush Coat

The sealcoat with flush coat is simply a sealcoat as discussed above with a fog seal applied over top (in this application the fog seal is referred to as a flush coat). The flush coat provides the following benefits over a sealcoat at a relatively low additional cost. Because of these benefits we generally employ this method over sealcoats.

- The flush coat is more aesthetically appealing as it resembles new asphalt pavement, making it more pleasing to residents and motorists which permits us to use this cost-effective method in more populated settings where sealcoats might be objectionable.
- The flush coat allows us to apply more sealant to the road, reducing loose stones, preventing plow damage, better sealing cracks, creating a smoother and quieter driving surface, and improving the longevity of the treatment.
- The flush coat allows for more contrast in pavement markings and better longevity of paint markings which improves safety.

The Municipality has also evaluated the following preventive maintenance methods either through actual demonstration projects or research:

- Cape Seal
- Chip Mats
- Cold In-Place Recycling
- MetroMat
- FiberMat
- Grip-Tight Fog Seal
- GSB-88 Rejuvenator/ Fog Seal
- Hot In-Place Recycling
- LD-7 Fog Seal
- Microsurfacing
- Novachip
- PASS Emulsion
- Ralumac
- Reclamite Rejuvenator
- Sand Seal
- Sandwich Seal
- Scrub Seal
- Slurry Seal

The Engineering Department is constantly looking for and researching innovative preventive maintenance methods to add to our "toolbox".

A table listing the different maintenance methods employed by the Municipality as well as their average lifespan, cost per mile, and annualized cost per mile is provided below as Exhibit 10.

Exhibit 10. Comparison of annualized unit costs for maintenance methods.

Maintenance Method	Years Added to Pavement Lifespan*	Unit Cost ($/Mile)	Annualized Cost ($/Mile/yr)
Fog Seal	2	$ 19,876	$ 9,938
Crack Seal (PASER = 7)	3	$ 1,795	$ 598
Sealcoat	5	$ 32,476	$ 6,495
Sealcoat w/ Flush Coat	7	$ 52,352	$ 7,478
3" Mill & Overlay	15	$ 212,725	$ 14,181

*Note- The lifespans of the methods shown are an average estimate, the actual longevity is predicated on numerous factors that make predicting longevity at a particular location impossible.

The right-most column of Exhibit 10 illustrates the cost savings associated with the preventive maintenance methods versus a conventional mill and overlay repaving. For example timely application of a sealcoat can maintain a pavement for less than one-half of the cost of conventional mill and overlay repaving. Of course the lifespan numbers depend on many variables and are simply estimates.

While the cost of fog sealing appears high, especially as the first step in the preservation program, it is essentially the only method available to begin preventative maintenance while the road is still in excellent condition, analogous to putting that first coat of deck sealer on your new deck even though it is brand new and not showing any aging yet.

Other communities including Murrysville, Plum Borough, North Huntington Township, and Peters Township have inquired about the Municipality's preventive maintenance pioneering and have commended our innovation.