City of Novi

Pavement Management Analysis

2012

City of Novi
45175 W. 10 Mile Road
Novi, MI, 48375

cityofnovi.org

OHM est.1962
Advancing Communities℠

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

OHM has been retained by the City of Novi to assist in the continued development of the City's road asset management strategy. Asset management as defined in Michigan is "an ongoing process of maintaining, upgrading and operating physical assets cost-effectively, based on a continuous physical inventory and condition assessment." [MCL247.659a(1)(a)] An organized and balanced approach to pavement maintenance is imperative to realizing the maximum service life of a road network. Often, a "worst-first" methodology is adopted, spending much of a road budget on full reconstruction of the pavements in the worst condition. The more balanced approach includes the maintenance of pavements in fair or good condition.

The first step in creating a pavement maintenance program is to determine the condition of the streets within the network. The City of Novi owns and maintains approximately 171 miles of roadway. Approximately 107 miles of roadway are asphalt, 62 miles are concrete, and 2 miles are gravel. Approximately 38 miles are classified as 'major roads' within the City as identified by the National Functional Classification, and 133 miles are classified as 'local roads'.

The Pavement Surface Evaluation and Rating (PASER) system is used to evaluate the condition of road segments. The PASER system rates each road segment on a scale of 1-10, with 1 being the worst condition, and 10 being the best condition (new pavement). The ratings directly correspond to the expected remaining service life as well as appropriate maintenance activities. The City has utilized the PASER system since 2001 to asses the network condition.

The City has allocated approximately $3,200,000 of funding per year over the last three years for a pavement maintenance program. This budget is available to be divided between local and major roads as necessary to maximize the service life of the overall network. This funding allocation does not include utility funds or other matching funds such as Federal Aid Surface Transportation Program – Urban (STP-U) or Congestion Mitigation and Air Quality (CMAQ) grants. The City has seen the average system condition decrease over the last couple years at the current funding level.

A model was prepared to evaluate the impact of different investment levels on the overall network condition. The model predicts that the downward trend of the average condition will continue at the current investment level of $3,200,000. An investment level of $4,000,000 results in a slight increase in the average system condition. Although the average system condition is improved, the model predicts miles of roads in 'poor' condition will increase. The analysis shows that a yearly investment between $4,500,000 and $5,000,000 is necessary to improve the average PASER condition rating, and prevent the percentage of the network in 'poor' condition from increasing.

Because the overall condition of the road network is dynamic, an effective maintenance program must be reviewed and revised regularly. The completed activities should be tracked in the RoadSoft database. This will help to identify any road segments that are not performing as expected, and provide the opportunity for preventative maintenance to

protect the capital investment. Additionally, this compilation of road data will help the City meet the requirements of Public Act 499 which requires all road agencies in the State to report annually to The Asset Management Council (TAMC).

II. NETWORK CHARACTERISTICS

The City of Novi currently has approximately 171 miles of roadway under its jurisdiction. The road network distributions for classification, condition, and surface type are summarized below.

Table 1: Road Network Classification

Classification	Typical Right of Way Width	Typical Pavement Width	Typical Cross Section	Total Miles
City Major	66'-120'	28'	Asphalt: 5" HMA on 12" Agg. Concrete: 9" PCC on 12" Agg.	38
City Local	66'	22'	Asphalt: 4" HMA on 8" Agg. Concrete: 7" PCC on 8" Agg.	133

Table 2: Road Network Condition

Classification	Good (PASER 10-6)	Fair (PASER 4-5)	Poor (PASER 3-1)	Total
City Major (Miles)	16	18	4	38
City Local (Miles)	38	80	15	133
Total (Percentage)	54 (32%)	98 (57%)	19 (11%)	171 (100%)

Table 3: Road Network Surface Type

Surface	Miles
Asphalt	107
Concrete	62
Gravel	2

III. DISTRESS TYPES

The PASER rating system is separated into categories, based on concrete and asphalt pavement types, which have different distresses that are specific to each pavement. Examples of common pavement distresses are illustrated in the summary tables taken from PASER Asphalt Roads and PASER Concrete Roads manuals located in Appendix A (Walker, 2002 & Walker, 1989). The key to a useful evaluation is identifying different types of pavement distress and linking them to a cause. Understanding the cause for current conditions is extremely important in selecting an appropriate maintenance or rehabilitation technique (e.g. load or age induced failures).

There are four major categories of common asphalt and common concrete distresses as shown below.

1. ASPHALT SURFACE DISTRESS

    a. *Surface Defects* - Raveling, Flushing, and Polishing
    b. *Surface Deformation* - Rutting, Distortion (including Rippling and Shoving, Settling, and Frost Heave)
    c. *Cracks* - Transverse, Reflection, Slippage, Longitudinal, Block, and Alligator cracks
    d. *Patches and Potholes*

2. CONCRETE SURFACE DISTRESS

    a. *Surface Defects* - Wearing and Polishing, Map Cracking, Pop-outs, Scaling, Shallow Reinforcing, and Spalling
    b. *Joint Failure* - Longitudinal and Transverse
    c. *Pavement Cracks* - Transverse Slab Cracks, D-cracking, Corner Cracking and Meander Cracking
    d. *Pavement Deformation* - Blow-ups, Faulting, Pavement Settlement or Heave, Utility Repairs, Patches and Potholes, Manhole and Inlet Cracking, and Curb or Shoulder Deformation.

The extent and severity of the different distresses dictate the appropriate PASER rating. Examples of roads at various PASER ratings are included in Appendix A.

IV. MAINTENANCE AND REPAIR ALTERNATIVES

There are three categories of maintenance/repairs available for maintaining roadway infrastructure: 1) Preventative Maintenance, 2) Road Rehabilitation and 3) Road Reconstruction. A brief overview of each category is followed by a more detailed description of the individual alternatives and their costs.

CATEGORIES

Preventative Maintenance

Preventative Maintenance (PM) is appropriate for newer roads in Very Good (8) to Good (6) condition. PM lengthens the service life of a structurally sound pavement. PM is limited to surface improvements such as crack seals, joint seals and surface seals.

Road Rehabilitation

Road Rehabilitation (RH) procedures are appropriate for roads in Fair (4-5) condition. More intense rehabilitation procedures can be appropriate for roads rated in Poor (3) condition. RH may include localized full depth removal and replacement, mill and overlay, or other methods to improve the base and/or cross section of the pavement such as pulverize, regrade, and overlay. RH procedures are more intensive than PM, but can restore a pavement to excellent condition at a significantly lower cost than full Road Reconstruction.

Road Reconstruction

Road Reconstruction (RC) procedures are appropriate for roads in Very Poor (2) to Failed (1) conditions. A rating of 1 or 2 means the road has no more useful service life. In this case, full reconstruction with extensive base repair is necessary. Often, other types of work need to be considered with a full reconstruction, such as drainage improvements or water main or sanitary sewer replacements.

ALTERNATIVES

The following are possible maintenance and repair alternatives along with costs associated with each improvement. Note that the costs are based on fair market prices bid for similar jobs, including miscellaneous items such as traffic control and restoration. The following costs are typical average total project costs. They include typical engineering costs, such as design, inspection, and materials testing. The costs will need to be evaluated each year and updated to reflect current market conditions. The category of the improvement is indicated next to each repair alternative in parentheses.

ASPHALT MAINTENACE PROGRAMS

Overband Crack Seal (PM)

Description: This process involves cleaning out cracks and applying an overbanding material. Overband crack seal material is comprised of rubber and tar with polyester fibers. Compressed air is used to clean each crack and its surrounding area prior to application of the material. The material is poured into the crack and onto the surrounding area creating a strip of overbanding material approximately 4-5 inches in width. Routing is not necessary to apply the material. This alternative can be used on asphalt roadways with cracks up to 3" deep.

Cost: The estimated cost for this alternative is $0.40 per square yard of pavement, but will vary with the severity of cracking.

Overband Crack Seal Application

Crack Rout and Fill (PM)

Description: This process involves using a mechanical device to rout each crack in order to widen, cut, and clean the cracks prior to filling with bituminous materials. The bituminous materials fill the entire volume of the crack providing structural integrity to the pavement while also preventing moisture from entering the pavement structure.

Cost: Crack Route & Fill is approximately $0.85 per square yard.

Slurry Seal (PM)

Description: Slurry seal is used in airport and city street maintenance where loose aggregate cannot be tolerated. It is made with fine crushed aggregate mixed with quickset-emulsified asphalt. The liquid slurry is machine applied with a sled-type box containing a rubber-edged strike-off blade. A slurry seal construction zone is typically open to traffic within hours of application. Slurry seals seal the surface, protect from oxidation, fill minor depressions, provide an easy to sweep surface, and improve skid resistance.

Cost: Slurry seals range from $1.00 to $2.00 per square yard.

Slurry Seal Application

Microsurfacing (PM)

Description: A mixture of fine aggregate, polymer-modified asphalt, mineral filler, and water that is applied in a similar process to a slurry seal. Unlike a slurry, microsurfacing uses a chemically controlled curing process instead of a thermal break process. Microsurfacing offers the same improvements as a slurry seal and provides an improved surface finish. It also has improved rut filling and is better able to retard pavement raveling.

Cost: Microsurfacing ranges from $3.00 to $5.00 per square yard.

Cape Seal (PM)

Description: Cape seal is a two step maintenance process used on local roads. First, a single chipseal is applied to the road surface. One week after chipseal application, an application of an asphalt slurry seal is applied. The cape seal construction zone is typically is open to traffic immediately following the chip course, and again within hours of the slurry course. Cape seals have the same improvements as a slurry seal with the added benefit of a single chip seal.

Cost: Cape seals range from $3.00 to $4.00 per square yard.

Cape Seal Application

Ultra Thin Overlay - 3/4" (RH)

Description: The ultra thin overlay places ¾" of a dense grade hot-mix asphalt pavement with an application rate varying between 65 to 90 lbs per square yard. The placement of this ultra thin overlay protects the pavement structure, slows the rate of deterioration, and improves skid resistance and ride quality. The ultra thin overlay is placed using standard asphalt paving equipment and construction time for placing the asphalt is minimal.

Cost: An ultra thin overlay is approximately $6.50 a square yard.

Mill and Overlay, 1.5" and 3" (RH)

Description: Milling is a process by which the top section of pavement is milled off and discarded. This results in a rough surface to which an additional layer of pavement or emulsified asphalt surface treatment can be applied. A mill and overlay operation typically has two different mill depths, 1.5" and 3" respectively, depending on the road condition and existing roadway depth. For roadway cross sections (<6") or with minor surface defects or deformation, a 1.5" milling is the preferred solution. For pavement cross sections with 6" or more of pavement, and where there is more substantial surface defects exists, a 3" milling is more appropriate. The 3" milling depth allows for the

removal of more substantial surface defects and rutting while also allowing for additional HMA material to be placed.

Cost: An estimate of cost for milling full width and placing a 1.5" overlay is approximately $18.00 per square yard depending on if curb repair is necessary. For 3" overlay the cost is approximately $28.00 per square yard depending on if curb repair is necessary.


Milled Surface


Overlay Paving Operation

Pulverization and Overlay (RH)

Description: This process involves breaking up the existing pavement in its current location and regrading the pulverized roadway. The pulverized material then acts as a new base material for the future pavement. Additional pavement (4" of HMA) is then added to the reshaped base. This process is essentially the same as removing the existing pavement and constructing a new roadway. Typically, curbed roadways are not pulverized, as the change in pavement elevation can cause drainage problems.

Cost: An estimate of cost to pulverize and reshape the existing pavement is approximately $32.00 per square yard including a 4-inch overlay of asphalt. Similar to milling, this method is not cost effective unless a significant quantity is pulverized.

Pulverizing Existing Pavement Prior To Overlay

CONCRETE MAINTENANCE PROGRAMS

Crack/Joint Sealing (PM)

Description: This process involves cleaning and routing cracks and/or joints, and then filling them with a sealing compound made of hot rubber. Sealing the cracks and/or joints inhibits water from penetrating the cracks, freezing, expanding and causing the pavement to fail.

Cost: An estimate of cost for this alternative is $2.00 per square yard of roadway to be maintained, but will vary with the severity of cracking and joint spacing.

Joint Sealant Being Applied

Joint Seal with Limited Slab Repair (PM)

Description: This process involves removing limited sections of the pavement to full depth, typically corners of slabs, and then resealing the joints surrounding the repair.

Cost: An estimate of cost for this alternative is $16.00 per square yard of roadway to be maintained, but will vary with the severity of cracking and joint spacing.

Spray Patch Joint Repair (PM)

Description: The Spay Patch Joint repair is a quick multistep process that involves cleaning and filling joints with asphalt and aggregate materials. First, the joint is cleaned with a high volume blower to remove any loose materials within the joint. Then, a tack coat of asphalt is applied to the area, followed by a mixture of aggregate and hot asphalt to fill the joint. The joint repair is completed with a finish coat of aggregate.

Cost: This method is estimated to cost $3.00 per square yard.

Joint Repair with HMA Overlay (RH)

Description: This process involves the placement of one lift of pavement typically 2-3 inches thick over the existing roadway. This also includes the repair of any existing failing joints in the concrete pavement. The thickness of the overlay depends on the existing conditions and the intended use of the road. An overlay provides an improved surface finish and adds structural stability to the pavement cross section.

Cost: A 2" overlay is approximately $25.00 per square yard while 3" overlay is approximately $35.00 per square yard. Additional costs may be required for pavement patching prior to placing the overlay and the amount of joint repairs required based on the existing pavement conditions.

Full Depth Slab Replacement (RH)

Description: This process involves the full reconstruction of the failed concrete slabs and resealing surrounding joints.

Cost: An estimate of cost for this alternative is $30.00 per square yard of roadway to be repaired (not area to be maintained; a typical road rated a PASER 5 is estimated to require 25% total replacement of area to be maintained.)

Failed Section Marked For Replacement

Saw Cutting Section For Removal

Replacement Section Prepped For Pour

Pouring New Concrete


Subdivision Street After Patching And Slab Repair.

FULL RECONSTRUCTION – ASPHALT PAVEMENT

Asphalt Road Reconstruction – City Local (RC)

Description: The reconstruction of local asphalt streets involves the removal of the existing asphalt pavement and base and includes the construction of a new asphalt paving section consisting of 4" of HMA placed on a 8" aggregate base.

Cost: An estimate of cost for this alternative is $54.00 per square yard of roadway to be replaced.

Asphalt Road Reconstruction – City Major (RC)

Description: The reconstruction of major asphalt streets involves the removal of the existing asphalt pavement and base and includes the construction of a new asphalt paving section consisting of 5" of HMA placed on a 12" aggregate base.

Cost: An estimate of cost for this alternative is $68.00 per square yard of roadway to be replaced.

FULL RECONSTRUCTION – CONCRETE PAVEMENT

Concrete Pavement Road Reconstruction – City Local (RC)

Description: The reconstruction of local asphalt streets involves the removal of the existing concrete pavement and base and ncludes the construction of a new concrete paving section consisting of 7" of concrete placed on a 8" aggregate base.

Cost: An estimate of cost for this alternative is $62.00 per square yard of roadway to be replaced.

Concrete Pavement Road Reconstruction – City Major (RC)

Description: The reconstruction of local asphalt streets involves the removal of the existing concrete pavement and base and includes the construction of a new concrete paving section consisting of 9" of concrete placed on a 12" aggregate base.

Cost: An estimate of cost for this alternative is $82.00 per square yard of roadway to be replaced.

Asphalt Treatments

Treatment	Description	Reason for Use	Considerations	Average Total Project Cost
Overband Crack Seal	Localized treatment of pavement cracks involving cleaning of the existing crack and placing sealant into & over the crack.	• Seal existing pavement cracks • Longitudinal, transverse, or minor block cracking • Prevent water intrusion into existing cracks	• Need thorough surface preparation (cleaning) • Needs to be redone every few years to maintain seal • Aesthetic appearance of roadway once completed, especially in residential areas	$0.40 / syd
Crack Rout and Fill	A mechanical device routs a crack in order to widen and clean a crack so additional bituminous material can be placed to seal the crack.	• Seal existing pavement cracks • Longitudinal or transverse • Prevent water intrusion into existing cracks	• Should not be used in areas with structural failure or extensive cracking • Appropriate for larger, more advanced cracks	$0.85 / syd
Slurry Seal	Mixture of fines, asphalt emulsion, water, & mineral filler that is spread over pavement surface. Treatment uses the thermal break process, which takes 2-8 hours depending on heat/humidity.	• Seal existing pavement surface • Seal small cracks in pavement • Oxidized pavement • Improved surface friction	• Should not be used in areas with structural failure or extensive cracking • To be applied as minor surface cracking first develops or pavement oxidizes • Type I for lower traffic, Type II for higher • Aesthetic appearance can be an issue after weathering	$1.30 / syd
Microsurfacing	Mixture of fines, polymer-modified emulsified asphalt, mineral filler, & water that is applied in similar process to slurry seal. Uses chemically-controlled curing process instead of thermal break process.	• Seal existing pavement surface • Seal small cracks in pavement • Oxidized pavement • Improved surface friction • Rut filling • Retard pavement raveling	• Should not be used in areas with structural failure or extensive cracking • To be applied as minor surface cracking first develops or pavement oxidizes • Fills minor rutting • No aesthetic issues like slurry seal • Specialized equipment, need to do a large quantity to be cost-effective	$3.50 / syd
Cape Seal	Combines the processes of chip seal and slurry seal or microsufacing to form a single, more durable surface. Chip seal is applied followed by a slurry seal.	• Provide new pavement surface • Seal minor cracking in pavement • Improved surface friction • Rut filling	• Should not be used in areas with structural failure or extensive cracking • Provides more "structure" than slurry or chip seal, but not as much as HMA overlay • Final surface is "rougher" than traditional HMA – not as desirable for some neighborhood streets where a lot of pedestrian use of the roadway	$3.25 / syd
HMA Ultra-Thin	High performance HMA mixture applied over existing pavement in thicknesses between ¾" & 1½".	• Provide new pavement surface • Repair minor surface cracking • Deteriorated pavement with solid underlying structure	• Should not be used in areas with underlying structural problems in the pavement • Reflective cracking from significant underlying cracks is an issue • Surface prep by milling and crack sealing/repairs • Provides smooth surface – ideal for neighborhoods	$6.50 / syd

Asphalt Treatments (Continued)

Treatment	Description	Reason for Use	Considerations	Average Total Project Cost
Mill & Overlay	Top section of existing pavement is removed by milling. New HMA pavement is placed to restore the roadway to its previous grade.	• Provide new pavement surface • Repair surface cracking • Deteriorated pavement with stable underlying structure • Provide longer useful life of roadway than maintenance treatment	• Areas with underlying structural problems can be patched after milling • Provides "new road" surface • Does not raise grade – good for roads with curb/gutter	$18.00 / syd (1.5" Overlay) $28.00 / syd (3" Overlay)
Pulverize & Overlay	The existing pavement is crushed and mixed with some of the underlying aggregate to form the new base material for future pavement. New HMA is placed over the crushed surface to form the new roadway. Areas of poor subgrade are addressed with undercuts.	• Significant pavement deterioration/failure • Drainage/profile corrections • Provide longer useful life of roadway	• Pulverized pavement becomes a thickened base section and increases the structure of the roadway • Areas of poor subgrade can be addressed • Provides "new road" surface • Allows for profile, cross-slope, drainage corrections • Raises grade, not for use with curb/gutter unless being replaced • Significant maintenance of traffic required due to removal of pavement surface and time of construction	$32.00 / syd (4" Overlay)

Concrete Treatments

Treatment	Description	Reason for Use	Considerations	Average Total Project Cost
Joint Sealing Remove and Relace	Localized treatment of pavement joints & cracks involving cleaning and routing the joint/crack and filling with hot rubber sealant.	• Seal existing pavement joints & cracks • Prevent water intrusion into existing joints &cracks	• Need good preparation work for sealing to be effective • Needs to be redone every few years to maintain seal • Aesthetic appearance of roadway once completed, especially in residential areas	$1.25 / syd
Joint Seal With Limited Slab Repair/Patch	Full-depth removal & replacement of limited concrete sections that are cracked (corner breaks, etc).	• Minor cracks, or broken corners • Deteriorated joints • Improve ride quality	• Need to seal joints around repair – typically combined with joint seal repairs • Smaller repair areas cost more per square yard than larger areas • Underlying base issues can be addressed prior to pavement replacement. • Significant maintenance of traffic required for pavement removal, placement, & cure.	$16.00 / syd
Spray Patch Joint Repair	Joints are cleaned and sealed with an asphalt emulsion and fine aggregate application.	• Seal existing pavement joints & cracks • Prevent water intrusion into existing joints &cracks • Aggregate material provides for additional structural integrity	• Need good preparation work for sealing to be effective • Aesthetic appearance of roadway once completed, especially in residential areas	$3.00 / syd
Concrete Patching	Existing concrete pavement is removed in limited portions and replaced with new concrete.	• Provides for removal of small failing areas when the majority of the slab remains in good condition • Prevents failure problems from spreading further within the slab	• Patching still requires the closure for lanes for adequate cure time to take place.	$8.00 / syd of area to be maintained
Joint Repair with HMA Overlay	The existing concrete pavement is used as base material for an asphalt overlay . Joints are also repaired and resealed.	• Provide new pavement surface • Deteriorated concrete • Provide longer useful life of roadway	• Provides “new road” surface • Existing concrete pavement should be stable – movement will cause cracks in the new overlay • Isolated areas of poor soil/movement can be addressed prior to placing the overlay • Roadway grade is increased, driveway and sidewalk ramps likely need to be reconstructed	$30.00 / syd
Full Depth Slab Replacement	Full removal of entire slabs. Cost assumes approximately 50% of the slabs replaced. Costs may be higher or lower depending on amount of replacement.	• Good structural base for roadway. • Concrete slab failures 50% of the total area or less.	• Not appropriate if there are underlying base issues. • Significant maintenance of traffic required for pavement removal, placement, & cure.	$30.00 / syd

VI. ROADSOFT MODELING

The RoadSoft software utilizes a model of the entire road network, populated with features of each road segment, such as length, width, and condition. The software applies user-entered parameters such as maintenance costs and total project budget to select a mix of maintenance procedures that will optimize the overall health of the network.

The model results need to be adjusted to account for constraints or conditions that are not reflected in the model. In other words, actual project selections are made based on a variety of factors, such as availability of matching or grant funding, which may not follow the idealized model.

RoadSoft requires the following inputs and parameters in order to perform an analysis:

- Road Length
- Road Width
- PASER Condition
- Deterioration Rates (Curves)
- Candidate Maintenance Procedures
- Candidate Maintenance Costs
- Maximum Program Budget
- Inflation Rates
- Program Duration (e.g. 5 year, 10 year, etc.)

The pavement optimization module in RoadSoft uses the input parameters to return the following results:

- Remaining Service Life (RSL) – Years until the segment is expected to drop from a PASER rating 4 to PASER rating 3, at which time maintenance procedure are no longer cost effective
- Miles of Road to Receive Specific Treatments Each Year
- Funding Allocation Per Treatment Per Year
- Total Budget Per Year

RoadSoft does not select specific segments to receive treatment. The next step in developing a program will include using the model output as guidance in selecting specific streets and subdivisions for treatment. As the road program progresses, treatments and new field ratings should be entered into RoadSoft to track the accuracy of the previous projections and improve future model accuracy.

VII. ANALYSIS AND RESULTS

The service life for a road can also vary greatly based on subsurface conditions, mix design, and other factors such as frequency of salt applications that were not evaluated as part of the PASER. For this analysis, a 21-year service life was used for concrete roads, and a 14-year service life was used for the asphalt roads. The service life is defined as the number of years after new construction before the road will be in poor condition. Once a road is in poor condition, maintenance procedures are no longer cost effective. The service life is extended beyond the initial values with preventative maintenance and rehabilitation processes as described above.

The entire road system was evaluated on a network level basis. This means the analysis was seeking to select a mix of fixes that would have greatest overall impact on the average network condition. Several iterations were performed for various funding levels and program durations. The analysis was narrowed to the four scenarios discussed below.

It is important to look at the projected condition distributions in two ways; the impact of a particular level of investment on the average condition of the system, or average PASER rating, and the distribution of the network at the conclusion of the program. Figure 1 illustrates the projected average system condition (PASER Rating) over a ten-year program at various funding levels. The average rating declines slightly at the current investment level of $3,200,000. The model projects an investment of $4,000,000 per year will result in a slight increase in average condition, while an investment of $5,000,000 has a dramatic impact over ten years, raising the average PASER rating from 6.5 to 7.5.

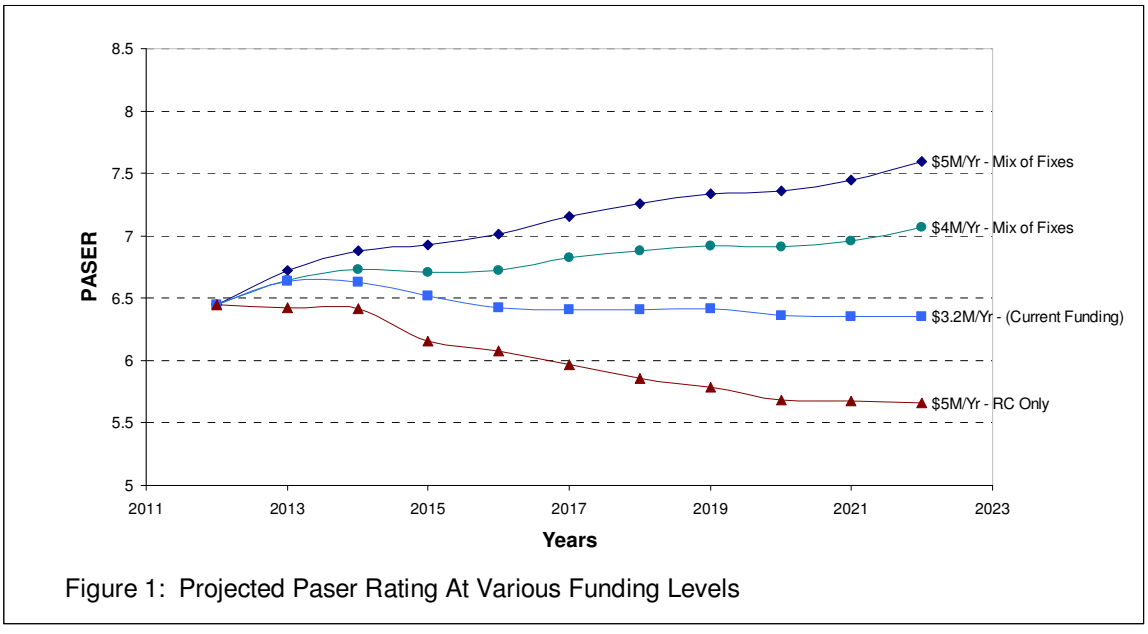


Figure 1: Projected Paser Rating At Various Funding Levels

Figure 2 illustrates how different investment levels impact the average Remaining Service Life (RSL) of the network. The RSL is the number of years before a road is expected to slip from a PASER 4 to PASER 3. This represents the transition from a rehabilitation candidate to a reconstruction candidate, or more specifically, the point in the life of the pavement when the more cost effective maintenance procedures are no longer alternatives. The RSL is a more accurate representation of the health of the network. While a road may have the same PASER rating for several years, each year of age is represented by one RSL. The average RSL is projected to continue to decline at the current funding level. The RSL increases slightly at a funding level of $4,000,000 per year, and more drastically at $5,000,000 per year.

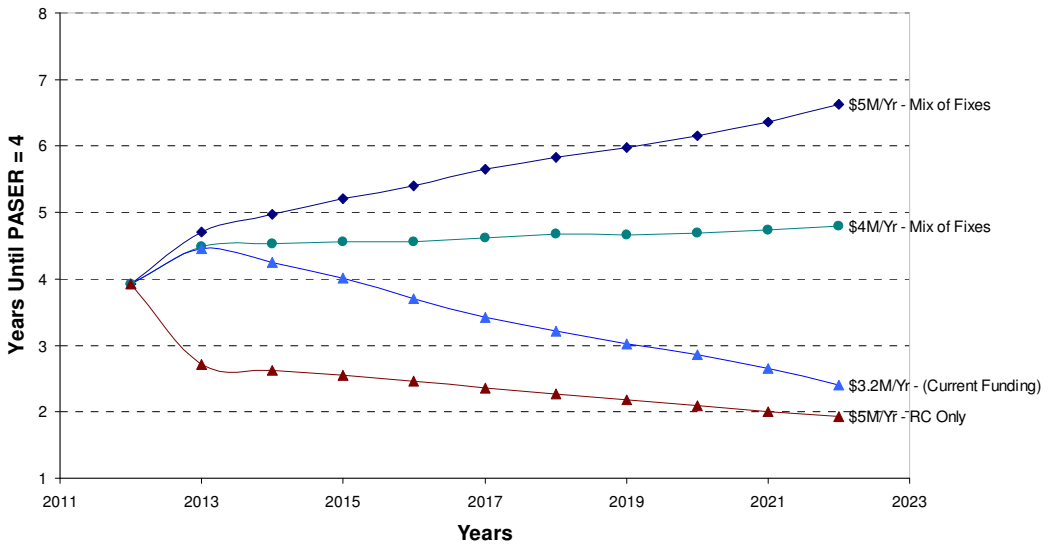


Figure 2: Projected Average years until PASER = 4

The average PASER and RSL are useful tools to gauge the impact on the overall system. It is also important to look at the actual breakdown on a percentage basis. Although the average system health may be improved, if more streets fall from fair to poor over time, the public perception of the average condition may worsen. Figure 3 illustrates the actual expected system distribution at the various funding levels. As shown, a funding level between $4,500,000 and $5,000,000 is necessary to prevent the percentage of the system currently in poor condition from increasing.

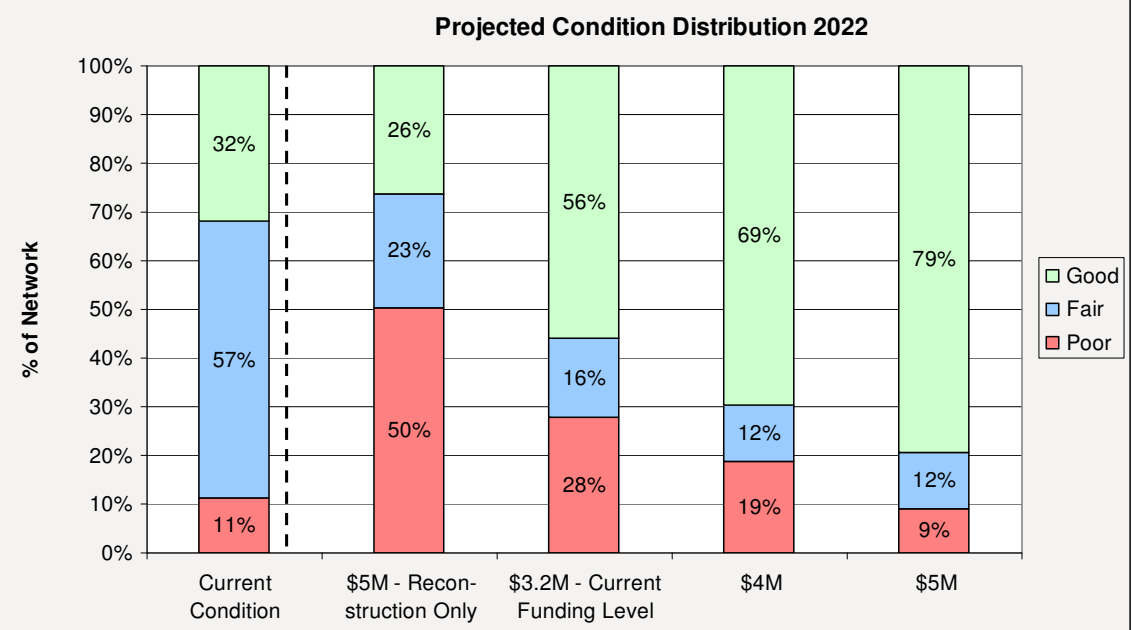


Figure 3: Projected Paser Rating

Figure 4 and 5 illustrate the model's projections of how the program dollars should be invested. It is interesting to note that over the ten-year program, the preventative maintenance component of the program only represents 10% of the expenditures, but accounts for over 80% of the centerline miles receiving treatment.

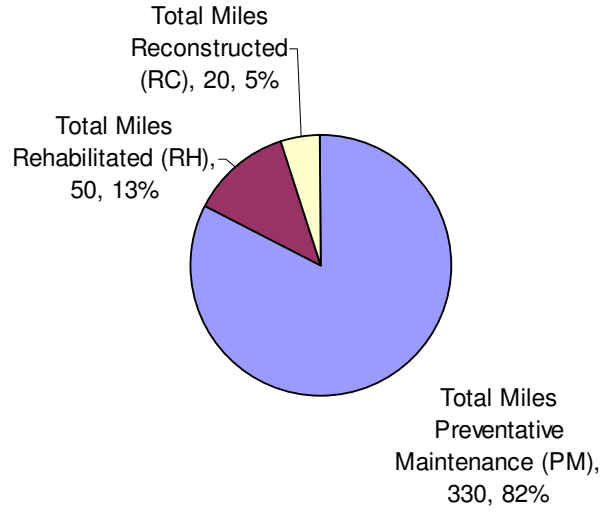


Figure 4: $5 Million / Year - 10 Year Program: Centerline Miles Receiving Treatment

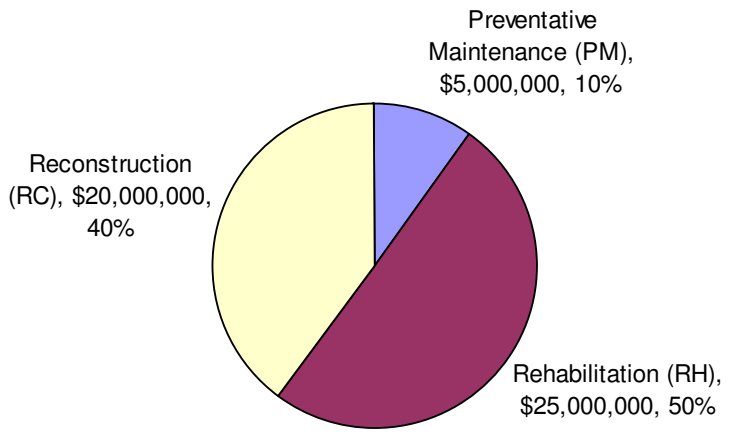


Figure 5: $5 Million / Year - 10 Year Program: Total $ Spent Over 10 Year Program

VIII. CONCLUSION & NEXT STEPS

The City has been proactive in managing its road network. Road condition data and maintenance history that the City collected allowed this analysis to be conducted. Further, the City has been meeting the State requirements for PASER certification and the Transportation Asset Management Council (TAMC) reporting for several years.

The next step in the process is identifying the investment level that will be dedicated to the road program and selecting specific neighborhoods and road segments for the various treatments. The analysis shows that the current funding level of $3,200,000 per year is not sufficient to maintain the health of the system. The analysis also shows that a funding level of approximately $4,000,000 per year is necessary to maintain and slightly improve the overall health of the network, though an increase in 'poor' roads is predicted at this funding level. The average system condition improves because most of the roads in Good and Fair condition are maintained and improved with PM and RH treatments. However, this is not a sufficient funding level to prevent some additional Fair roads from falling into the Poor category. In order to improve the overall health, and avoid increasing the percentage of the network in poor condition, an investment between $4,500,000 and $5,000,000 per year is required.

Once an investment level is determined, we recommend preparing a five year maintenance plan, with treatments and road segments identified for the first three years, and general strategies identified for years four and five. The plan will include the road network improvements that are scheduled as part of the capital improvement program, as well as the recommended maintenance procedures. RoadSoft should be used to track all capital and maintenance work. We recommend a condition rating for the entire system

be collected each year. Maintaining a complete database of yearly rating and maintenance procedures will allow the model to be further refined to provide more accurate projections into the future. The program should be reviewed on an annual basis, and be adjusted as necessary to meet the City's goals.

Appendix A

ASPHALT SURFACED PAVEMENTS

Surface Rating		Visible Distress
10	Excellent	New construction. No defects. Less than 1 year old
9	Excellent	Like new condition. Recent Overlay. No defects.
8	Very Good	Occasional transverse cracks > 40' apart. All cracks tight (hairline). Recent seal coat or slurry seal. Few if any longitudinal cracks on joints.
7	Good	Longitudinal crack on paving joint open < 1/4". Transverse cracks 10'-40' apart. Transverse cracks open < 1/4". First sign of wear. Little or no crack erosion. Little or no raveling. Few if any patches in good condition.
6	Good	Longitudinal cracks open 1/4"-1/2". Transverse cracks open 1/4"-1/2". Transverse cracks less than 10' apart. First sign of block cracking. Sound structural condition. Blocks are large and stable. Slight to moderate polishing or flushing. No patches or few in good condition. Slight raveling.
5	Fair	Longitudinal cracks > 1/2". Transverse cracks > 1/2". Secondary cracks (crack raveling). < 50% block cracking. First signs of longitudinal cracks at edges. Sound structural condition. Patching/wedging in good condition. Moderate raveling. Extensive to severe flushing and polishing.
4	Fair	Longitudinal cracking in the wheel paths. Rutting 1/2" - 1" deep. > 50% block cracking. First signs of structural weakening. Severe surface raveling. Multiple longitudinal & transverse cracks with slight crack erosion. Patching in fair condition.
3	Poor	< 25% alligator cracking (first signs). Moderate rutting 1" - 2" deep. Severe block cracking. Longitudinal & transverse cracks showing extensive crack erosion. Occasional potholes. Patches in fair/poor condition.
2	Very Poor	> 25% alligator cracking. Severe rutting or distortion > 2". Closely spaced cracks with erosion. Frequent potholes. Extensive patches in poor condition.
1	Failed	Loss of surface integrity. Extensive surface distress.
Note: Individual pavements will not have all of the types of distress listed for any particular rating. They may have only one or two types		

CONCRETE SURFACED PAVEMENTS

Surface Rating		Visible Distress
10	Excellent	New construction. Recent reconstruction. No defects. Less than 1 year old
9	Excellent	Like new. Slight traffic wear in wheel paths. Slight map cracking. Few pop outs.
8	Very Good	Joints in good condition. Partial loss of joint sealant. No transverse cracks. Minor surface defects - pop-outs, map cracking, or slight scaling. Isolated meander cracks (well sealed or tight). Light surface wear. Isolated cracks at manholes (well sealed or tight).
7	Good	Isolated transverse cracks. Full depth repairs all in excellent condition. Minor surface scaling. Some open joints. Some manhole cracks. Isolated settlement or heave areas. Pop outs can be extensive but sound.
6	Good	Meander and transverse cracks 1/4" open. Transverse joints open 1/4". Longitudinal joints open 1/4". Moderate surface scaling < 25% of surface. Several corner cracks tight or well sealed. First signs of shallow reinforcement cracks.
5	Fair	First sign of joint or crack faulting up to 1/4". First signs of joint or crack spalling. Moderate to severe scaling or polishing between 25% to 50% of surface. Spalling from shallow reinforcement. Multiple corner cracks.
4	Fair	Crack or joint faulting up to 1/2". Severe spalling on joints and cracks. Multiple transverse or meander cracks. Severe scaling, polishing, map cracking or spalling > 50% of surface. Corner cracks missing pieces or patches. Pavement blowups.
3	Poor	Severe crack or joint faulting up to 1". D-cracking evident. Many joints, transverse and meander cracks open and severely spalled. Extensive patching in fair to poor condition.
2	Very Poor	Extensive and severely spalled slab cracks. Extensive failed patches. Joints failed. Severe and extensive settlement and heaves.
1	Failed	Restricted speeds. Extensive potholes. Total loss of pavement integrity.
Note: Individual pavements will not have all of the types of distress listed for any particular rating. They may have only one or two types		

PASER Examples - Asphalt

PASER RATING 9

PASER RATING 8

PASER RATING 7

PASER RATING 6

PASER RATING 5

PASER RATING 4

PASER RATING 3

PASER RATING 2

PASER Examples - Concrete

PASER RATING 1

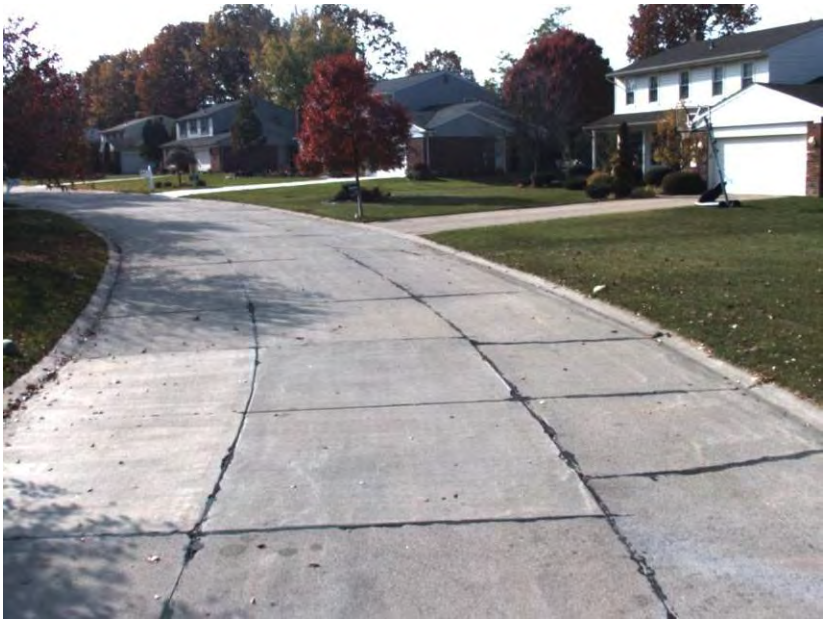
PASER RATING 10

PASER RATING 9

PASER RATING 8

PASER RATING 7

PASER RATING 6



PASER RATING 5

PASER RATING 4

PASER RATING 3

PASER RATING 2