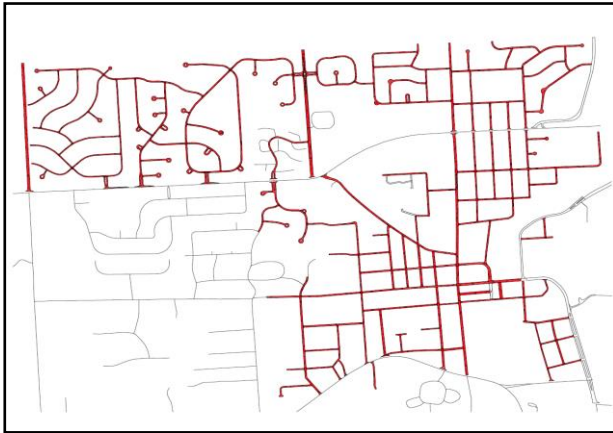


# CITY OF NORTHVILLE, MICHIGAN

## City of Northville Municipal Pavement Management System Report 2017 Update



DATE OF FIELD EVALUATION: May 26<sup>th</sup>, 2017

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# City of Northville

## Municipal Pavement Management System Report

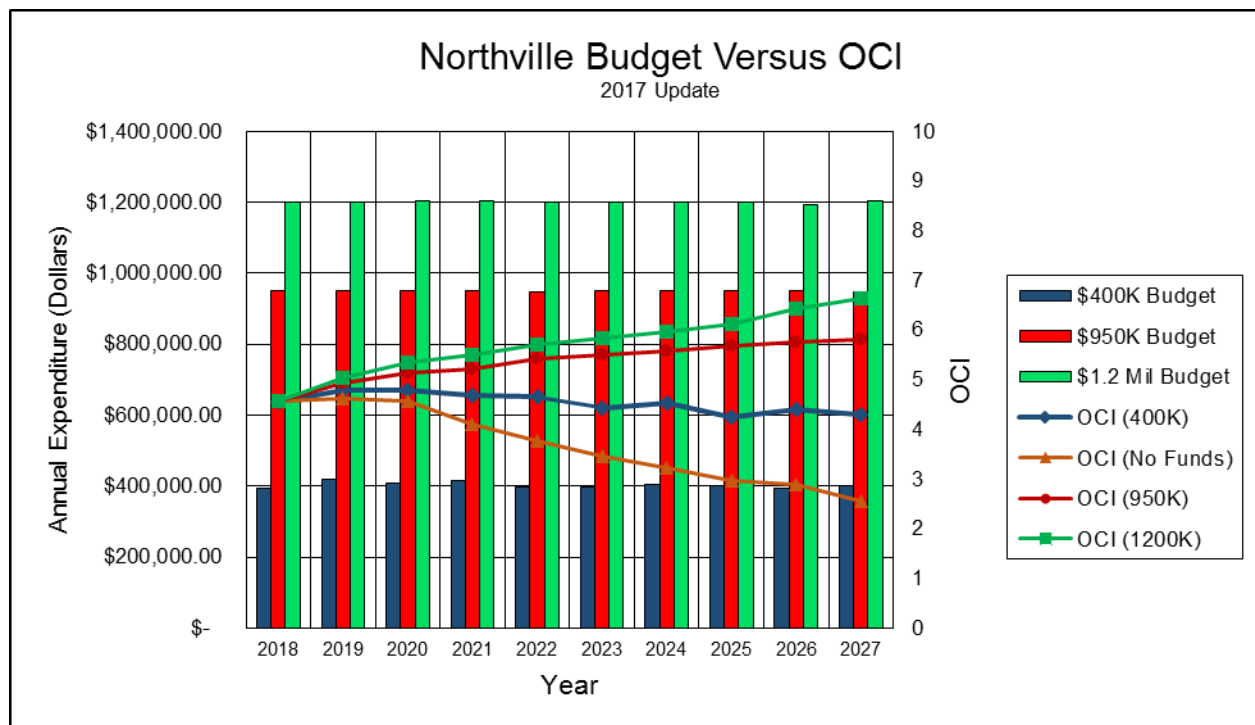
### 2017 Update

#### **EXECUTIVE SUMMARY:**

In May of 2017, Spalding DeDecker (SD) completed a field evaluation to update the condition inventory of all roadway pavements under the jurisdiction of the City of Northville (Northville). The revised information obtained from the field evaluation was used by SD to redevelop the municipal pavement management system, which includes recommendations for a conceptual ten-year work plan based on the budget scenario provided by Northville. The roadway network is approximately 25 miles long, and consists of asphalt, concrete, composite (asphalt over concrete), and brick pavements. The total pavement length was found to be approximately 52.7 lane miles, representing a total asset replacement value of approximately \$32 million. The overall condition of the pavement network was found to be fair, with a weighted average Overall Condition Index (OCI) rating of 4.57 on the 10 point scale.

As noted in the original municipal pavement management system report (2011), the 2013 updated report, and the 2016 updated report, a combination of preventative maintenance and extensive rehabilitation and reconstruction repairs is necessary to address the varying pavement conditions found in the network. Northville supplied SD with three possible budget scenarios. The existing budget scenario consists of a \$400,000 annual budget. The second and third scenarios are based on a proposed millage increase dedicated to street repairs. The second scenario consists of a \$950,000 annual budget, while the third scenario consists of a \$1,200,000 annual budget. Each annual budget includes a \$25,000 budget to provide preventative maintenance repairs and a \$35,000 allowance for isolated sidewalk repairs outside of the recommended annual scopes of work. The remainder is left for the program to choose the most cost-effective rehabilitative or reconstruction street repairs.

The analysis of the existing \$400,000 annual budget determined that the network-level OCI will fall throughout the ten-year time period, from a current level of 4.57, to a level of 4.30 at the end of the tenth year, implying significant project under-funding. The analysis of the \$950,000 annual budget determined that the network-level OCI will increase throughout the ten-year time period, from a current level of 4.57, to a level of 5.81 at the end of the tenth year. The analysis of the \$1,200,000 annual budget determined that the network-level OCI will increase throughout the ten-year time period, from a current level of 4.57, to a level of 6.63 at the end of the tenth year. If the budget for road improvements was to be eliminated entirely, the network-level OCI would decrease quickly, from a current level of 4.47, to a level of 2.55 at the end of the tenth year. An overview of these four budget scenarios can be seen in the chart and table below.



Funding Scenario	Approximate Ten-Year Cost	Existing OCI	Final Network OCI	Budget Trends
None	\$0	4.57	2.55	OCI steadily decreases annually
\$400K Annual	\$4,034,520	4.57	4.30	OCI decreases overall
\$950K Annual	\$9,502,188	4.57	5.81	OCI steadily increases annually
\$1.2 Million Annual	\$12,009,626	4.57	6.63	OCI steadily increases annually

One major component of updating the municipal pavement management system was to review the recent capital paving project's repair strategies and bid unit cost data, and update the information within the pavement management program software. SD was able to confirm the types of repairs to be implemented for certain scenarios with Northville, and the unit costs for these strategies were updated accordingly. Furthermore, the unit costs were also modified to include an allowance accounting for the sidewalk, ramp, and curb and gutter repairs needed for each individual road segment that is selected for repair. While a project-level analysis is still required to specify the exact repair and quantity information for each selected segment, this allowance will help forecast a more realistic and accurate budget for the purposes of this network-level analysis.

## **INTRODUCTION**

The following report is intended to overview the updated municipal pavement management system developed by SD for the City of Northville. The purpose of the management system is to provide an accessible pavement inventory as well as important management information pertaining to the approximately 25 mile long roadway network under the City's jurisdiction. In addition, the management system serves as a tool for developing short and long-term capital funding projections. Existing information from the network was obtained through a detailed site evaluation, and incorporated into the system to assist in development of a conceptual ten-year work plan. The work plan optimizes funding by strategically allocating budgets to suit the specific needs of the Northville network. The goal of the ten-year work plan is to help the City plan and project strategic annual repair projects, which will lead to tangible improvements in the overall pavement conditions.

The field evaluation update was conducted in May of 2017 to update the current pavement condition ratings. SD identified the visible distresses on each road for repair analysis. Pavement distresses such as deformations, depressions, cracks, patches, and potholes were identified and linked to a probable cause to help determine cost-effective repair strategies. A visual rating based on the established "PASER" rating system was given for all pavements to determine the Overall Condition Index (OCI).

Roadsoft software was used to develop the ten-year work plans. This software utilizes either Remaining Service Life (RSL) Driven Analysis or Budget-Driven Analysis to determine the predicted work for the ten-year plan. For this report, SD utilized the Budget-Driven Analysis, since Northville provided the annual budget that served as the funding parameters. The unit prices for each repair activity were updated to include allowances for sidewalk, ramp, and curb and gutter repairs within the recommended pavement segments for each year based on actual paving program pricing data. SD also provided a separate allowance in the budget to account for isolated sidewalk, sidewalk ramp, and curb and gutter repairs that are necessary outside of the recommended annual scope of work. General cost information and work plan maps from the Roadsoft output are provided for planning purposes in *Appendices F thru I*. We note that the results of the ten-year plan are not intended to directly fund actual repair projects. A more detailed, "project level" analysis is required prior to actual design and construction work. Therefore, the provided cost information may differ from the final chosen design depending on a number of factors.

The strength of the management system and ten-year work plan is built upon the Network Priority Ranking (NPR), observed pavement conditions, value-engineering repair strategies, and if/then budget scenarios, including other parameters discussed later in the report.

The following is a summary of our approach for the project update:

- Update the history of the pavements with collaboration from Northville personnel to include the most recent capital improvements.
- Inspect the roadways; document and inventory the updated existing pavement conditions for each pavement segment.
- Develop CAD drawings and colored-maps to overview the updated pavement characteristics throughout the network.



- Review input from City and project-level cost data from most recent capital projects to update network-level repair and unit cost information; include allowance for sidewalk, ramp, and curb and gutter repairs for each recommended segment in unit cost projection for each recommended repair activity.
- Provide pavement management strategies for the overall Northville pavement network. For example:
  - Maintain high priority pavements in “good” condition by recommending applicable preventative maintenance with budget information supplied by City.
  - Propose rehabilitation methods where possible for fair condition pavements before they deteriorate to poor condition and require more costly reconstruction.
  - Provide value-engineered alternatives where applicable.
  - Run the existing budget scenario provided by City to help confirm predicted funding or determine appropriate funding for the network.
- Prepare work plan maps with color-coding to show updated repair locations and types (preventative maintenance, rehabilitation, or reconstruction) for the ten-year plans.
- Give a general overview of predicted costs and resulting pavement conditions for the ten-year time period.

## **FIELD EVALUATION AND DATA COLLECTION**

The field evaluation was performed by visiting all roadways within the City limits, and obtaining detailed documentation of the updated existing characteristics and conditions. The roads were broken down into individual pavement segments, and each segment was assigned a rating according to the standard PASER method for asphalt and concrete roadways. The roads that consisted of brick were assigned a rating according to the modified PASER method for brick & block roadways. This method is identical to the established standard PASER method, except it uses 2, 4, 6, 8 scale instead of a standard 1-4 scale, where the standard rating is doubled to be consistent with the other pavement rating scales. A rating of 10 for brick & block roads is reserved for pavements that are in “like new” condition and are less than one year old. Standard PASER manuals for asphalt, concrete, and brick & block pavements are located in *Appendices J, K, and L*.

The City of Northville provided SD with information relating to existing pavement cross-sections. As seen in Table 1.0 below, pavement and aggregate base thicknesses vary with pavement use and pavement classification designations, which are discussed in detail later in the report. The typical subgrade material encountered was assumed to be Sandy Loam, based on past repairs in Northville. This information was assumed to be the basis for future roadway design and construction, and was accounted for in the Roadsoft conceptual repair costs. SD deemed this information sufficient for development of the pavement management system, and did not perform any pavement cores.

**Table 1.0 – Summary of Typical Pavement Cross-Sections**

<b>Pavement Classification</b>	<b>Pavement Use</b>	<b>Pavement Thickness</b>	<b>Aggregate Base Thickness</b>	<b>Subgrade Soil</b>
Asphalt Standard Duty (AC SD)	Residential – Local	3.0”	6.0”	Sandy Loam

Asphalt Standard Duty (AC SD)	Residential – Major	5.0"	6.0"	Sandy Loam
Asphalt Heavy Duty (AC HD)	Commercial – Local Commercial – Major	8.0"	6.0"	Sandy Loam
Concrete Standard Duty (PCC SD)	Residential – Local	7.0"	6.0"	Sandy Loam
Concrete Heavy Duty (PCC HD)	Commercial – Major	9.0"	6.0"	Sandy Loam
Asphalt Overlaid Concrete (APC)	Commercial – Major	3.0" – 4.0" Asphalt 7.0" – 9.0" Concrete	6.0"	Sandy Loam

## **DATA ORGANIZATION AND PAVEMENT CRITERIA**

Pavement segments were created to differentiate roadways based upon existing characteristics observed during the field evaluation. In addition to the PASER rating assigned to each segment, pavement was also categorized based on Use (typical traffic types and frequency), Classification (material and thickness of road), and Priority (precedence for receiving repair funds). Wherever any one of the categories changed, a new segment was created. The segment information and inventory for all roads within Northville can be found in *Appendix E*. This information was later utilized as input parameters for the Roadsoft program to develop the ten-year work plans.

Pavement areas for each pavement segment were determined by creating closed poly-lines in the AutoCAD drawings. The data was then compiled and used to create four color-coded maps showing the segment characteristics. Color-coded maps for the entire City of Northville are located in *Appendices A thru D*. The input parameters for pavement Overall Condition Index (OCI), Pavement Use, Pavement Priority and Pavement Classification are detailed below:

### **Overall Condition Index**

The Overall Pavement Condition Index (OCI) is used to determine whether or not pavement segments are in need of maintenance, repair, or replacement. The OCI of each segment was determined in the field by visually evaluating the pavement, and assigning a numerical PASER rating between 0 and 10. SD then set up Roadsoft to correspond with the PASER Ratings. The PASER rating scales for asphalt and concrete are displayed in Tables 2.0 through 4.0 below to show typical distresses in each rating category.

**Table 2.0 – Asphalt PASER Ratings**

<b>PASER Rating</b>	<b>Typical Distresses – Asphalt Pavement</b>
10 Excellent	None.
9 Excellent	Very few isolated cracks. All cracks sealed or tight (open less than 1/4").
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").
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.



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. Slight to moderate flushing or polishing. Occasional patching good condition.
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.
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).
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.
2 Very Poor	Alligator cracking (More than 25% of surface). Severe distortions (More than 2" deep). Extensive patching in poor condition. Potholes.
1 Failed	Severe distress with extensive loss of surface integrity.

**Table 3.0 – Concrete PASER Ratings**

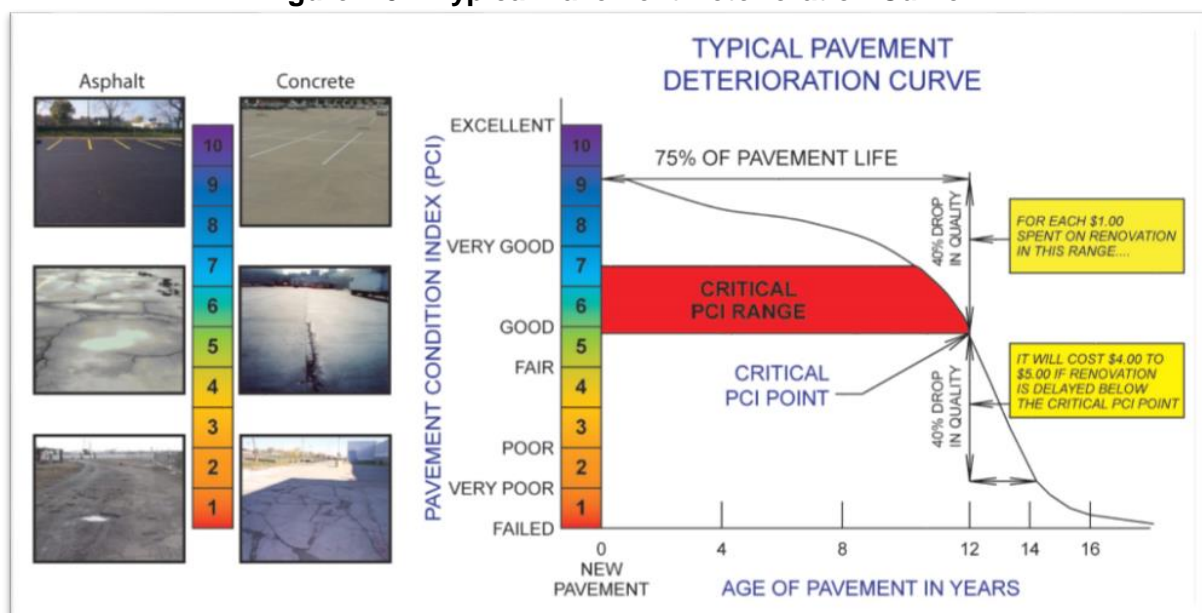
PASER Rating	Typical Distresses – Concrete Pavement
10 Excellent	None.
9 Excellent	Traffic wear in wheel path. Slight map cracking or pop-outs.
8 Very Good	Pop-outs, map cracking, or minor surface defects. Slight surface scaling. Partial loss of joint sealant. Isolated meander cracks, tight or well sealed. Isolated cracks at manholes, tight or well sealed.
7 Good	More extensive surface scaling. Some open joints. Isolated transverse or longitudinal cracks, tight or well sealed. Some manhole displacement and cracking. First utility patch, in good condition. First noticeable settlement or heave area.
6 Good	Moderate scaling in several locations. A few isolated surface spalls. Shallow reinforcement causing cracks. Several corner cracks, tight or well sealed. Open (1/4" wide) longitudinal or transverse joints and more frequent transverse cracks (some open 1/4").
5 Fair	Moderate to severe polishing or scaling over 25% of the surface. High reinforcing steel causing surface spalling. Some joints and cracks have begun spalling. First signs of joint or crack faulting (1/4" to 1/2"). Multiple corner cracks with broken pieces. Moderate settlement or frost heave areas. Patching showing distress.
4 Fair	Severe polishing, scaling, map cracking, or spalling over 50% of the area. Joints and cracks show moderate to severe spalling. Pumping and faulting of joints (1/2") with fair ride. Several slabs have multiple transverse or meander cracks with moderate spalling. Spalled areas broken into several pieces. Corner cracks with missing pieces or patches.
3 Poor	Most joints and cracks are open, with multiple parallel cracks, severe spalling, or faulting. D-cracking is evident. Severe faulting (1" or greater) giving poor ride. Extensive patching in fair to poor condition. Many transverse and meander cracks, open and severely spalled.
2 Very Poor	Extensive slab cracking is severely spalled and patched. Joints failed. Patching in very poor condition. Severe and extensive settlements or frost heaves.
1 Failed	Restricted speed. Extensive potholes. Almost total loss of pavement integrity.

**Table 4.0 – Brick & Block Modified PASER Ratings**

Modified PASER Rating	Typical Distresses – Brick & Block Pavement
10 Excellent	None. Less than one year old.
8 Very Good	None. More than one year old.
6 Good	Very few defects. Good ride.
4 Fair	Joint erosion, broken brick, discolored brick, gaps, and/or efflorescence, extending over 5% to 25% of the surface area. Ride may be uneven and rough. Areas of poor drainage. Open joints.
2 Poor	Joint erosion, broken brick, discolored brick, gaps, and/or efflorescence, covering more than 25% of the surface area. Numerous patches in fair to poor condition. Poor drainage.

The typical pavement deterioration curve as shown below, in Figure 1.0, shows how the deterioration rate varies depending on the OCI/PCI conditions throughout the life-cycle of the pavement. The Pavement Condition Index (PCI) of a pavement segment is equivalent to the OCI of that same segment. Deterioration rates are also dependent upon several other factors, including: original design, quality of original construction, subgrade condition, traffic loadings, and climate. Pavement deterioration can fluctuate significantly depending on these factors. As pavement condition reaches the critical range, loadings, moisture intrusion and other environmental conditions can allow the pavement to deteriorate from good condition (6-8) to poor condition (1-3) in a short time frame. SD developed unique deterioration curves in the Roadsoft program for each type of pavement found in Northville.

**Figure 1.0 – Typical Pavement Deterioration Curve**



The updated weighted average OCI of the Northville pavement network is at 4.57, which is below the approximate critical point of 5.7 on the deterioration curve. This indicates that the best management strategy will be a combination of preventative maintenance and major pavement repairs, which includes rehabilitation and reconstruction. SD recommends allocating an annual

allowance to provide preventative maintenance repairs such as crack and joint sealing, which will help prolong life expectancy in good condition areas, and “stretch” the deterioration curve. The remaining repair funds should be allocated to provide rehabilitation and reconstruction repairs, with a focus on providing cost-effective rehabilitation strategies before pavements deteriorate to the point where they require more costly reconstruction.

*End of Useful Life* - Pavement deteriorates based upon numerous factors as discussed above. Pavement deterioration follows a curve with a critical pavement condition index range that is generally considered to be between a PASER rating of 5.7 and 7.5 on the curve. The “critical point” of 5.7 on the curve is considered the threshold that when the pavement condition falls below, preventative maintenance measures become less cost-effective. Some form of rehabilitation is required for the pavement to restore serviceability when pavement falls below the critical point, which requires a significant increase in costs. Upon further deterioration, an end of useful life is reached when the pavement is considered to be a safety hazard; at this point, even more costly and extensive reconstruction repairs are required to restore the service condition. A PASER condition rating of 1.5 is typically viewed as the end of useful life. Evaluation of the pavement on a consistent basis will maximize capital expenditures by providing the most cost-effective repairs in each area.

#### Pavement Use

Each segment was also categorized by Pavement Use. Pavement Use is generally related to the location, degree of utilization, and expected traffic type/frequency of a particular road segment. How the pavement is used is a key determining factor for planning future repairs. The four Pavement Use categories are broken down as either Residential or Commercial, and either Local or Major roadways. Table 5.0 below gives an overview of the Pavement Use categories.

**Table 5.0 – Pavement Use Categories**

Use Category	Description
Commercial - Major	Road segments that service commercial areas that are frequently utilized by a high percentage of residents. These segments receive higher traffic loadings and volumes, and likely provide access to county or state roads.
Commercial - Local	Road segments that service low traffic commercial areas. These segments typically receive higher traffic loadings but lower traffic volumes. May service as commercial parking areas adjacent to streets in downtown.
Residential - Major	Road segments that service higher traffic residential areas. These segments typically receive higher traffic volumes, but lower traffic loadings, and typically provide primary access from residential areas to commercial areas.
Residential - Local	Road segments that service lower traffic residential areas. These segments typically receive lower traffic volumes and loadings, and typically provide access between residential areas, or secondary access to commercial areas.

### Pavement Priority

The segments were also categorized by Pavement Priority. Priority ratings are generally associated with the Pavement Use, and were developed to enable repair funding preferences to occur within the Northville pavement network. More frequently used segments, and those that are commonly seen by a higher volume of the general public, typically have a higher Pavement Priority. The Pavement Priority categories are: High, Medium, and Low, as shown in Table 6.0.

**Table 6.0 – Pavement Priority Categories**

Priority Category	Description
High	High priority pavements receive frequent amounts of commercial traffic and are regularly utilized by a high percentage of residents. <i>Typical corresponding Pavement Use category: Commercial - Major</i>
Medium	Medium priority pavements receive a combination of periodic commercial traffic and frequent residential traffic. <i>Typical corresponding Pavement Use categories: Commercial – Local, Residential - Major</i>
Low	Low priority pavements receive only residential traffic, and are mostly utilized by local residents. <i>Typical corresponding Pavement Use category: Residential - Local</i>

### Pavement Classification

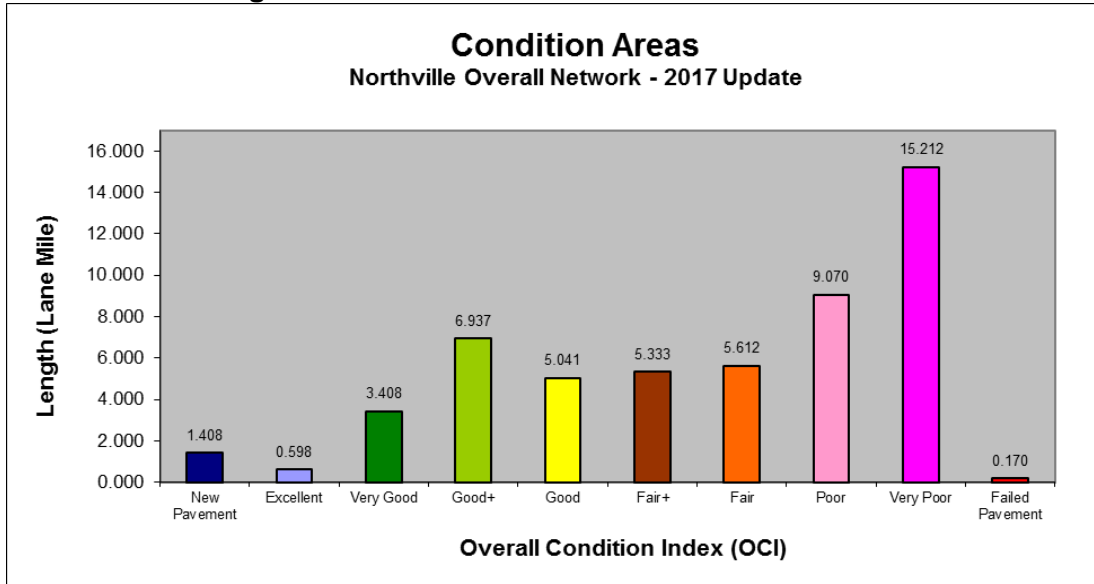
The Pavement Classification differentiates pavements based on material such as asphalt or concrete, as well as the pavement thickness, aggregate base thickness, and subgrade soil material. Pavement Classification is used to define the types of pavement that make up each road segment, and will affect future repair strategies and costs. For this project, the Pavement Classification categories are categorized based on surface material (asphalt or concrete), and cross-section thickness (standard or heavy duty cross-sections). Cross-section thicknesses generally correlate with the Pavement Use category when it came to classifying Major and Local roads. In addition to asphalt and concrete pavement, there were several areas that were classified as asphalt overlaid concrete. The five classification categories are: Asphalt Standard Duty (AC SD), Asphalt Heavy Duty (AC HD), Concrete Standard Duty (PCC SD), Concrete Heavy Duty (PCC HD), and Asphalt overlaid Concrete (APC). See Table 1.0 earlier in the report for specific information on each pavement type.

## **SUMMARY OF NORTHVILLE PAVEMENT NETWORK**

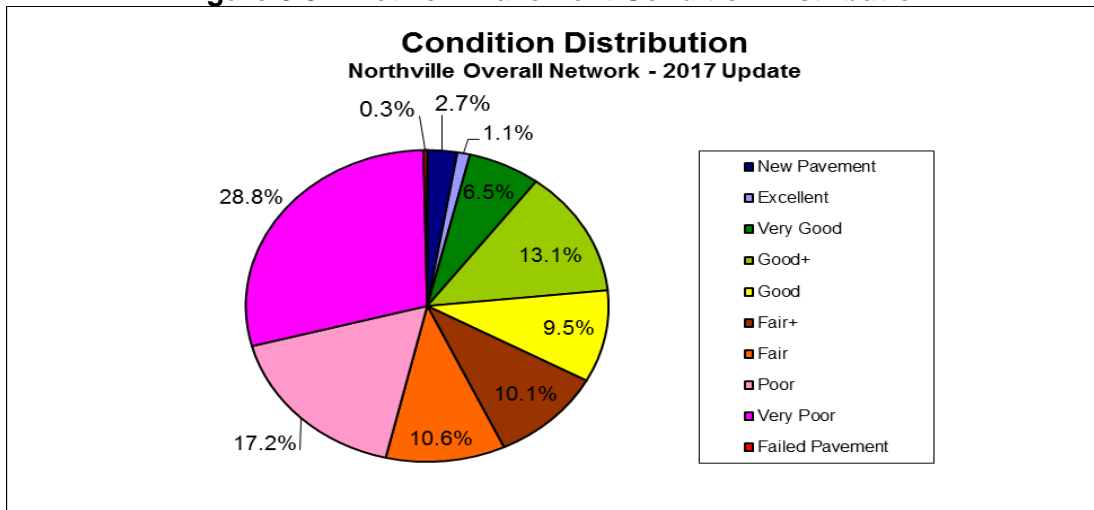
SD determined that there is a total of approximately 5 pavement classifications in the Northville network. The updated weighted average OCI for the overall pavement network is 4.57. This number encompasses all pavement segments that comprise roadways under Northville's jurisdiction. The two charts below, Figures 2.0 and 3.0, display the pavement conditions by total area and percentage distribution. As an overall network, a little less than one-half (46.3%) of Northville's pavement assets are currently in poor or worse overall condition. The widely-spread distribution of pavement conditions further emphasizes the need to establish a "mix of fixes"

repair strategy. Due to the size of the network, SD strongly recommends that Northville maintains an annual budget that specifies allocations for preventative maintenance, rehabilitation, and reconstruction. Doing so with an appropriate overall budget will help keep the backlog, or accumulation of needed repairs, from growing exponentially and will gradually improve the overall network OCI throughout the ten-year plan.

**Figure 2.0 – Network Pavement Condition Areas**

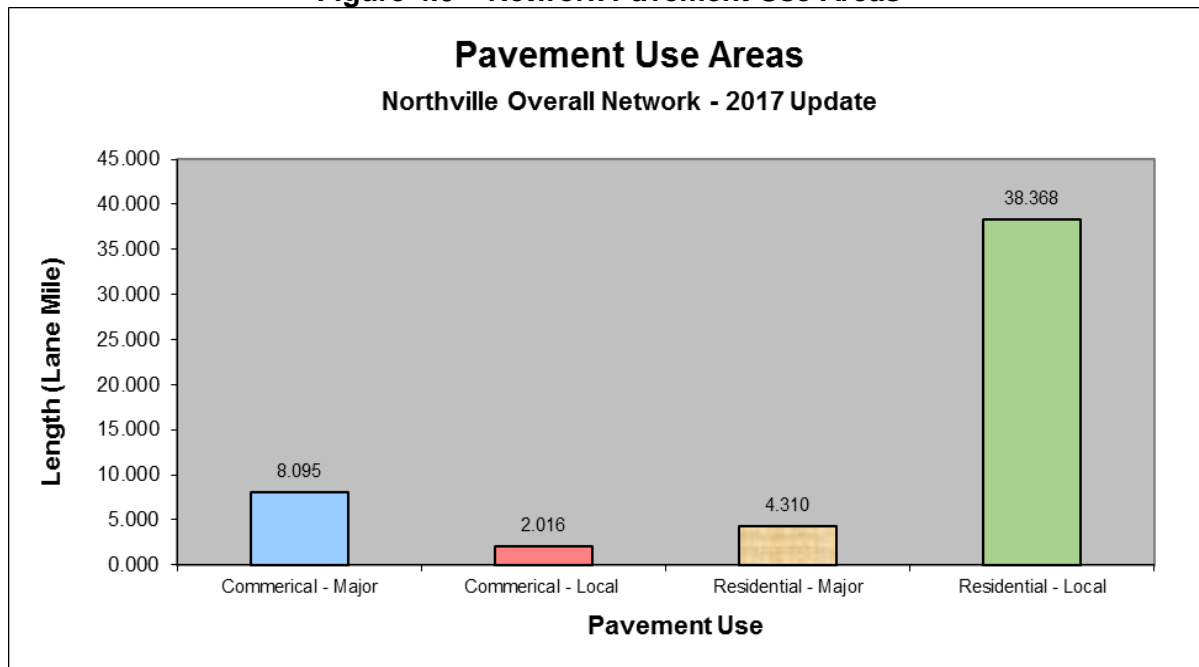


**Figure 3.0 – Network Pavement Condition Distribution**

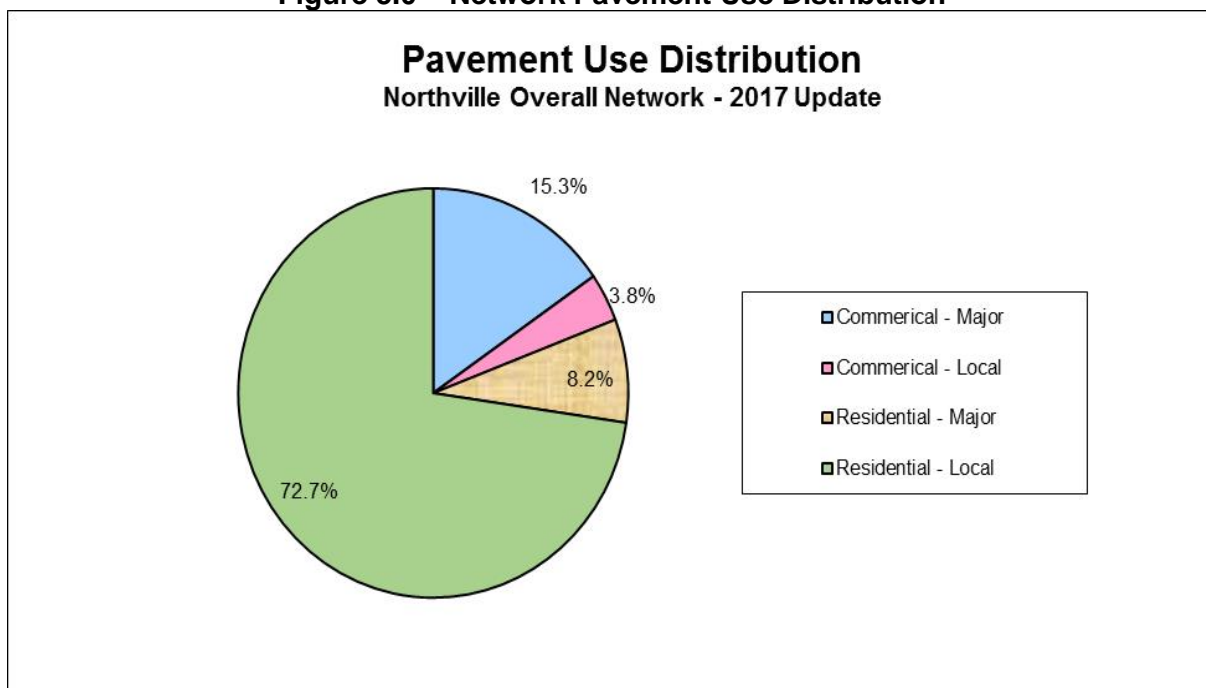


The charts below, Figures 4.0 and 5.0, show the Pavement Use areas and percentage distribution throughout the network. Note that pavements identified as “Residential – Local” roadways constitute over 65% of the entire network.

**Figure 4.0 – Network Pavement Use Areas**



**Figure 5.0 – Network Pavement Use Distribution**





The Pavement Priority distribution, Figure 6.0, is shown below. Low priority areas account for 70% of the network pavements, which corresponds with Residential-Local being the majority of the Pavement Use distribution.

**Figure 6.0 – Network Pavement Priority Distribution**

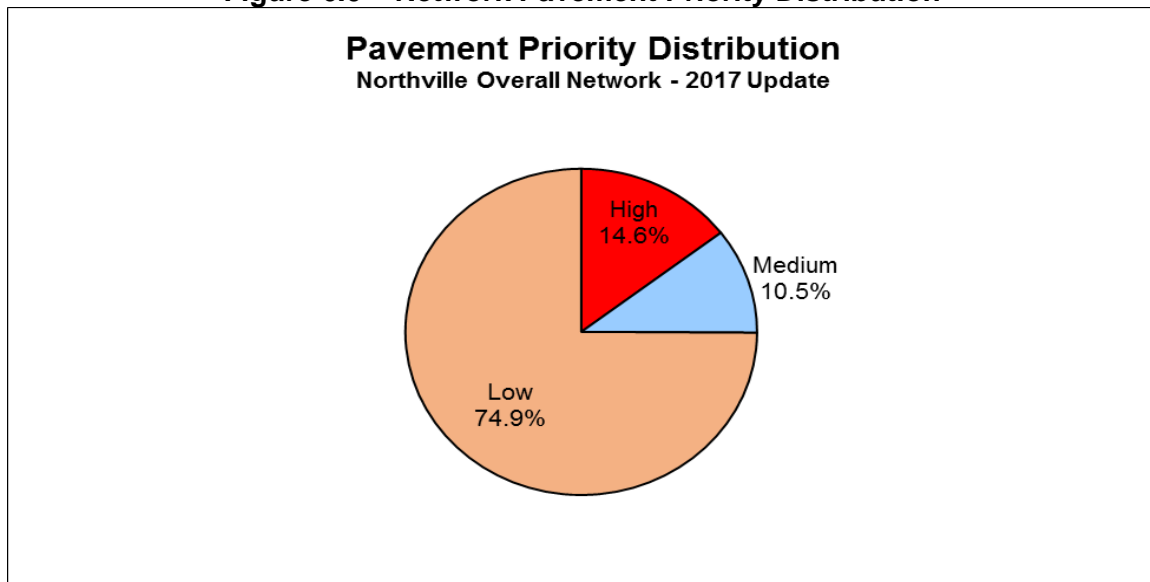


Figure 7.0 below, gives a distribution of the OCI ranges within each Pavement Priority category for the entire network pavement area. For example, 12.5% of the pavements in the network that were considered to be high priority had an OCI of 8 or better.

**Figure 7.0 – Network OCI Distribution within Priority Categories**

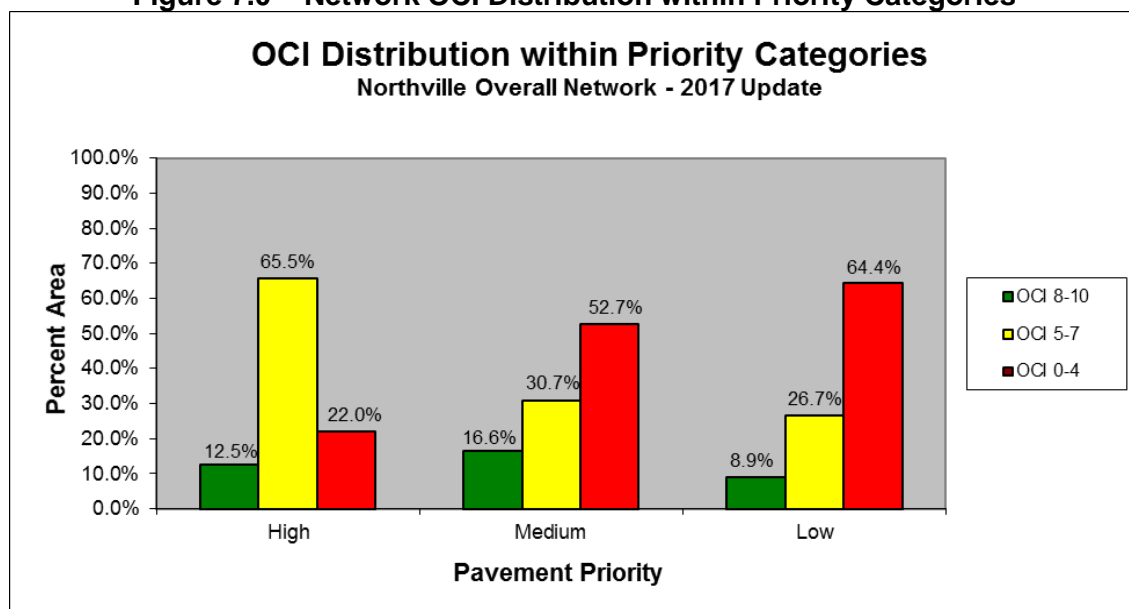
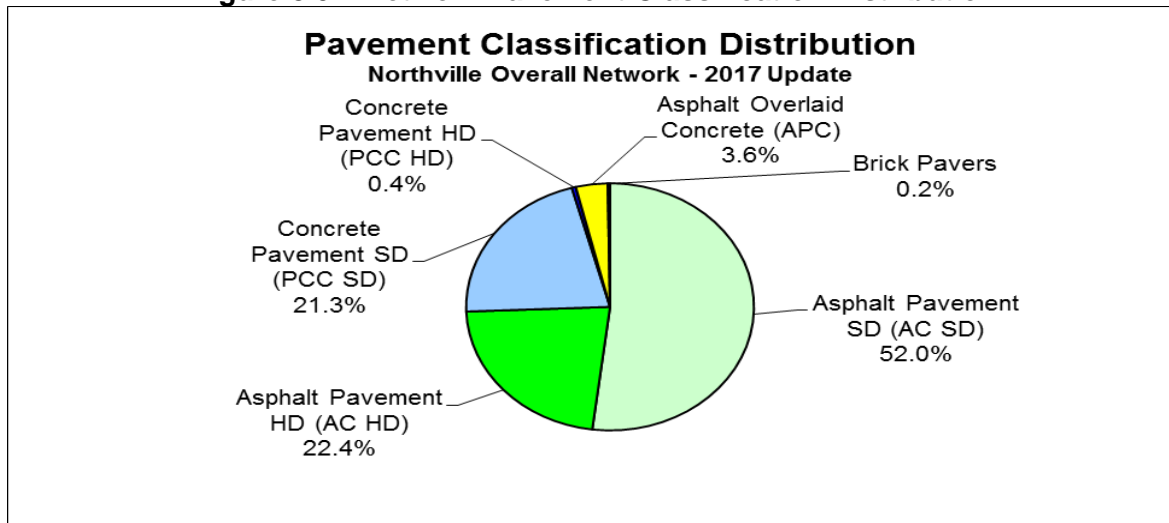


Figure 8.0 shows the pavement classification distribution of the entire network. Approximately 74% of the network is asphalt construction, while about 22% is concrete pavement. Asphalt overlaid concrete constitutes only 4% of the network.

**Figure 8.0 – Network Pavement Classification Distribution**



### **TEN-YEAR WORK PLAN PARAMETERS**

One of the primary goals of the pavement management system is to develop a conceptual, network wide, ten-year work plan to help predict future repairs. The work plan utilizes a budget based on Northville's projected funding allocations, and then distributes the funds for preventative maintenance, rehabilitation and reconstruction repairs based on the input parameters for each pavement segment. Each segment is re-evaluated in every year of the plan. A current OCI is determined based on appropriate deterioration curves that have been incorporated into the program, and any conceptual repairs that may have been assigned to a segment in a previous plan year. The system is then able to prioritize the overall network to determine which segments receive funding, how much funding is received, and how the conceptual repairs will improve the overall network OCI. After performing the inventory, inspection, and analysis of the pavement conditions throughout the Northville network, the ten-year work plan compares how effectively the proposed funds are at providing an acceptable overall condition index (OCI) for the network. SD utilizes Roadsoft software to assist in generating a ten-year work plan. This program can be easily customized to fit the requirements and philosophies of Northville, as they may change throughout the years. As with any computer prediction, the quality of the output is directly related to the quality of the input. Therefore, we present our goal for the analysis, the management strategy, and the input factors involved in this computer model.

**Goal** – In the case of a pavement management analysis, our goal is to predict the financial needs of the pavement system over a period of time to reach a defined benchmark. For this analysis, SD utilized the three budget scenarios that were provided by Northville for comparison. The goal is to determine how effective these budgets are at maintaining the pavement network throughout the ten-year time period. The network level OCI at the end of the tenth plan year

serves as the indicator for the effectiveness of each annual budget.

**Strategy** – The basic philosophy of pavement management is to apply preventive maintenance treatments at appropriate times to retard the rate of pavement deterioration. Both preventative maintenance and rehabilitation techniques should be applied at a time when they are cost-effective, instead of letting the pavement deteriorate to failure and require expensive reconstruction. Accordingly, our pavement management strategy follows this same philosophy. We target a repair strategy that combines preventative maintenance, rehabilitation, and reconstruction where necessary. Numerous studies have shown that a strategy of only reconstruction of the failed pavements will cost significantly more than this combined approach throughout a defined analysis period. The reason for this is properly applied preventive maintenance treatments effectively “stretch” the pavement deterioration curve.

**Input** - Most computer models require a significant amount of input information. A pavement condition prediction is no different. Some of the input factors are easily defined, whereas others require some assumptions and interpretation of related technical data. The findings from the field investigation such as OCI, Pavement Use, Pavement Priority, and Pavement Classification are the main inputs into the system. Additional information such as pavement age and previous repairs is also used in the analyses.

#### ***NPR – Network Priority Ranking (NPR)***

The concept of Network Priority Ranking (NPR) was used to prioritize the pavement segment repair selection. This calculation essentially computes a weighted average based on the selected input fields and weighting factors. The higher a particular segment’s NPR, the more likely it will be chosen for repair. The variables involved in the NPR calculation are almost limitless, but must contain at least the OCI (Overall Condition Index), Use, Pavement Priority, and Pavement Classification. Each of the factors has a rank associated with each value, which is defined by the user. If factors other than those recommended below are required for the computation, that data must be incorporated into the NPR computation. A ranking system of the variables must also be determined. The NPR used for the Northville 2017 update model analyses is shown in Table 7.0 below:

**Table 7.0 – Network Priority Ranking (NPR) Weighting Factors**

Input Factor	Weighting	Description
OCI	15	15/30 of the NPR
Priority	6	6/30 of the NPR
Use	5	5/30 of the NPR
Segment Length	3	3/30 of the NPR
Classification	1	1/30 of the NPR
<b>Total</b>	<b>30</b>	

#### ***OCI – Overall Condition Index (OCI)***

The numerical OCI value stands alone in this computation, and does not have a rank associated with it. Northville’s program was set up to assign the numerical value of [10 minus the segment OCI] to each particular segment, therefore assigning a higher weight to pavements in inferior condition.

### **Segment Length**

The numerical value for segment length stands alone in this computation, and does not have a rank associated with it.

The following charts outline the numerical values associated with rankings within each remaining input category, shown in Tables 8.0 through 10.0 below:

**Table 8.0 – Pavement Priority Values within NPR**

Pavement Priority Category	Rank
High	90
Medium	80
Low	70

**Table 9.0 – Pavement Use Values within NPR**

Use Category	Rank
Commercial - Major	90
Commercial - Local	85
Residential - Major	85
Residential - Local	80

**Table 10.0 – Surface Classification Values within NPR**

Classification Category	Rank*
Asphalt – Heavy Duty (AC HD)	90
Asphalt – Standard Duty (AC SD)	90
Concrete – Heavy Duty (PCC HD)	90
Concrete – Heavy Duty (PCC SD)	90
Asphalt Overlaid Concrete (APC)	90

\*It was decided not to differentiate segments based on Surface Classification since surface classifications generally correspond with Pavement Use and Priority.

The Roadsoft program uses general pavement repair activities for planning and budgeting purposes. The type of repair activity is chosen based on the OCI and Pavement Classification. For example, an “AC-50” repair activity is applied if the segment is asphalt concrete (AC), and the OCI falls within the range of 4.6 and 5.5. Since the activities are intended to address multiple segments that may fall into a particular OCI range due to varying distresses, they are setup to allow multiple repair actions instead of a single action for one particular distress. For example, a PCC-40 activity likely consists of approximately 25% slab replacement within the segment as well as isolated partial or full-depth joint repairs. Certain segments that meet the criteria for a PCC-40 might require more slab replacement, but less joint repairs.

Further detail for specific repairs on each segment will be determined on a yearly basis in the project-level analysis and subsequent design process. Some repair types are intended to repeat on a normal schedule, particularly those associated with preventative maintenance. For example, we recommend crack filling asphalt segments on a periodic basis. General repair activities have been created for each pavement classification type. The only exceptions are for

asphalt and concrete pavements with an OCI above 8. These pavements generally require no action be taken because they are new or in excellent condition.

The budget inputs are the last key series of data that affect the results of the ten-year work plan. There are two budget types that are included in the overall budget plan for Northville: 1) Preventative Maintenance and 2) General. The model was set up in this manner due to Northville's desire to allocate a specific annual allowance for preventative maintenance. Required rehabilitation and reconstruction repairs in each plan year will come out of the General budget. The budget types and dollar amounts can also be modified from year to year to account for fluctuations in the availability of real-world funds. Budgets affect the plan by limiting funds available for segments that meet the criteria for repair activities associated with each budget type. When the funding for one budget type is gone, no other repair activities within that budget will be done in that plan year. Table 11.0 below overviews the repair activities, budget types, and repair costs used in the Roadsoft model.

**Table 11.0 – Roadsoft Repair Activities**

Repair Activity	Budget Type	Pavement Type	Typical Repairs	Avg. Cost per S.Y.**
AC-80	Preventative Maintenance	Asphalt	Crack Sealing	\$ 0.54
AC-70	Preventative Maintenance	Asphalt	Crack Sealing	\$ 1.80
AC-60	General (Rehab)	Asphalt	Crack Sealing, Isolated Cut and Patch, Possible thin Overlay	\$ 29.26
AC-50	General (Rehab)	Asphalt	Isolated Cut and Patch, 1.5" Mill and Replace	\$ 33.44
AC-40	General (Rehab)	Asphalt	Isolated Cut and Patch, 2" Mill and Replace	\$ 42.50
AC-30	General (Rehab/Recon)	Asphalt	3" Mill and Replace, Possible Isolated full-depth patching	\$ 43.20
AC-20	General (Rehab/Recon)	Asphalt	3" Mill and Replace, Extensive full-depth patching with possible aggregate base undercutting	\$ 44.60
AC-10	General (Recon)	Asphalt	Full-Depth Asphalt and Base Reconstruction	\$ 73.75
PCC-70	Preventative Maintenance	Concrete	Crack Sealing	\$ 4.60
PCC-60	Preventative Maintenance	Concrete	Crack Sealing	\$ 28.80
PCC-50	General (Rehab)	Concrete	Approximately 10% Full-Depth Patching. Crack Sealing and Joint Cleaning/Sealing, Isolated Full- Depth Joint Repair.	\$ 38.90

PCC-40	General (Rehab)	Concrete	Approximately 25% Full-Depth Patching. Isolated Full-Depth Joint Repair or Chipping and Patching Spalled Joints.	\$ 48.80
PCC-30	General (Rehab/Recon)	Concrete	3" Mill and Asphalt Overlay Isolated Full-Depth concrete slab and joint repairs	\$ 51.60
PCC-20	General (Rehab/Recon)	Concrete	3" Mill and Asphalt Overlay Extensive Full-Depth concrete slab and joint repairs	\$ 50.50
PCC-10	General (Recon)	Concrete	Remove and Replace all Concrete Pavement. Extensive Undercutting and Base Replacement.	\$ 121.90
APC-80	Preventative Maintenance	Asphalt Overlaid Concrete	Crack Sealing	\$ 0.54
APC-70	Preventative Maintenance	Asphalt Overlaid Concrete	Crack Sealing	\$ 1.80
APC-60	General (Rehab)	Asphalt Overlaid Concrete	Approximately 10% Asphalt Surface Patching. Possible Thin Overlay	\$ 29.70
APC-50	General (Rehab)	Asphalt Overlaid Concrete	1.5" Mill and Replace Asphalt Isolated Full-Depth Concrete Patching	\$ 43.20
APC-40	General (Rehab)	Asphalt Overlaid Concrete	2" Mill and Replace Asphalt Isolated Full-Depth Concrete Patching	\$ 51.10
APC-30	General (Rehab/Recon)	Asphalt Overlaid Concrete	3" Mill and Replace Asphalt Isolated Full-Depth Concrete Patching	\$ 59.90
APC-20	General (Recon)	Asphalt Overlaid Concrete	Mill entire asphalt layer. Isolated full-depth concrete patching and undercutting. Replace entire asphalt layer.	\$ 67.30
APC-10	General (Recon)	Asphalt Overlaid Concrete	Remove all asphalt and concrete. Install heavy-duty concrete section. Extensive undercutting and base replacement.	\$ 137.00

\*\* Average cost associated with a series of repairs anticipated for the designated condition.

As part of the 2017 update of the program, SD reviewed the bid cost information from the most recent capital paving project in Northville. Along with input from the City, this cost information was used to update the repair strategy for the varying conditions as well as the overall unit cost for each repair activity. The unit cost for each repair activity includes an allowance per square



foot for the necessary sidewalk, ramp, and curb and gutter repairs for each segment so these can be implemented during the time of pavement construction. With that being said, a separate \$35,000 annual allowance for isolated sidewalk, ramp, and curb and gutter repairs is still included in the project budget for spot repairs outside of the annual recommended segment repairs.

Roadsoft has the ability to predict the repairs and costs that will be required to keep the overall pavement network at a pre-determined, acceptable condition level for the next ten years. This is referred to as Remaining Service Life Driven Analysis. Since Northville already has a predicted annual funding budget, SD instead utilized the Budget-driven Analysis. Budget-driven Analyses takes the provided budget and shows the resulting network OCI. The two types of analyses are fully described as follows:

(1) **Remaining Service Life (RSL) Driven Analysis:** predicts the repairs and costs that will be required to keep the overall pavement network at a user-specified condition level for the next ten years.

(2) **Budget-Driven Analysis:** predicts the repairs and resulting network pavement conditions throughout the next ten years using pre-determined budget allocations.

Roadsoft will add any activities that weren't completed because of lack of funds to the next plan year, and adjust the rest of the ten-year plan accordingly. For the updated program, the City of Northville informed SD that the \$400,000 budget used in the last two reports should still be used in the 2017 update analysis, as well as a potential annual budget of \$950,000 and \$1,200,000. An overview of the budget used in the Northville's analysis can be seen in Tables 12.0-14.0.

**Table 12.0 – Budget Plans \$400K**

<b>\$400K BUDGET SCENARIO</b>		<b>Dollar Allocation</b>
<b>FY2017 thru FY2026</b>	General (Rehabilitation or Reconstruction)	\$340,000
	Preventative Maintenance	\$25,000
	Sidewalk Allowance	\$35,000
	<b>ANNUAL TOTAL</b>	<b>\$400,000</b>

**Table 13.0 – Budget Plans \$950K**

<b>\$950K BUDGET SCENARIO</b>		<b>Dollar Allocation</b>
<b>FY2017 thru FY2026</b>	General (Rehabilitation or Reconstruction)	\$890,000
	Preventative Maintenance	\$25,000
	Sidewalk Allowance	\$35,000
	<b>ANNUAL TOTAL</b>	<b>\$950,000</b>

**Table 14.0 – Budget Plans \$1.2 Million**

<b>\$1.2 Million BUDGET SCENARIO</b>		<b>Dollar Allocation</b>
<b>FY2017 thru FY2026</b>	General (Rehabilitation or Reconstruction)	\$1,140,000
	Preventative Maintenance	\$25,000
	Sidewalk Allowance	\$35,000
	<b>ANNUAL TOTAL</b>	<b>\$1,200,000</b>

Roadsoft also has the ability to adjust the inflation for the plan period. The inflation rate was set to 1.0% to account for the increase in repair activity costs in the subsequent nine years of the ten-year plan. Inflation can be adjusted to be consistent with other projections.

It should be clearly understood that changes to any of the above technical inputs, or plan parameters will affect the results of the analysis. SD has selected the parameters based on some initial assumptions, information obtained from the City of Northville, and engineering judgment. The program can be modified in the future to account for changing goals, varying budgets, or altering management philosophies as required by the City of Northville.

Approaching a large pavement network with a ten-year plan strategy provides a comprehensive and detailed process that will lead to cost-effective annual repair projects. The process we have shown here in has been tested and proven over years of development and use.

## **TEN-YEAR WORK PLAN RESULTS AND RECOMMENDATIONS**

Roadsoft determines the NPR of each segment. It then determines which repair activities can be performed within the allocated total budget for the existing budget scenario, and the potential segments for repair that have the highest NPR are selected first in the repair recommendations. The program will select segments to repair until the annual budget allocations are gone. It will progress down the NPR ranking until it finds a suitable project that will both raise the network OCI to an acceptable level while also minimizing costs. As a result, we end up with some small projects, which we may not necessarily do, or projects too large to fit into a given years budget. We consider this the “raw” output or results. The “raw” results can be manipulated, and scenarios re-calculated. Some manual manipulation of the results was performed for this analysis to develop the work plan presented. The work plan is the result of a specific set of input criteria. Changes to any of the input criteria will impact the results of the plan.

The full Roadsoft output including budget summaries with resulting network OCI levels at the end of each year, along with specific segment repair recommendations and planned costs can be found in *Appendices F and G*. Work plan maps for the ten years of each budget scenario are located in *Appendix H*. A naming convention was developed for each segment to signify the road name, and segment number within each particular road, as most roads contain multiple pavement segments. For example, the second segment within Rayson Street is named: RYS 02. A spreadsheet with a complete list of segments in the Northville network is provided in *Appendix E*. All input parameters associated with each segment are also provided in this spreadsheet.

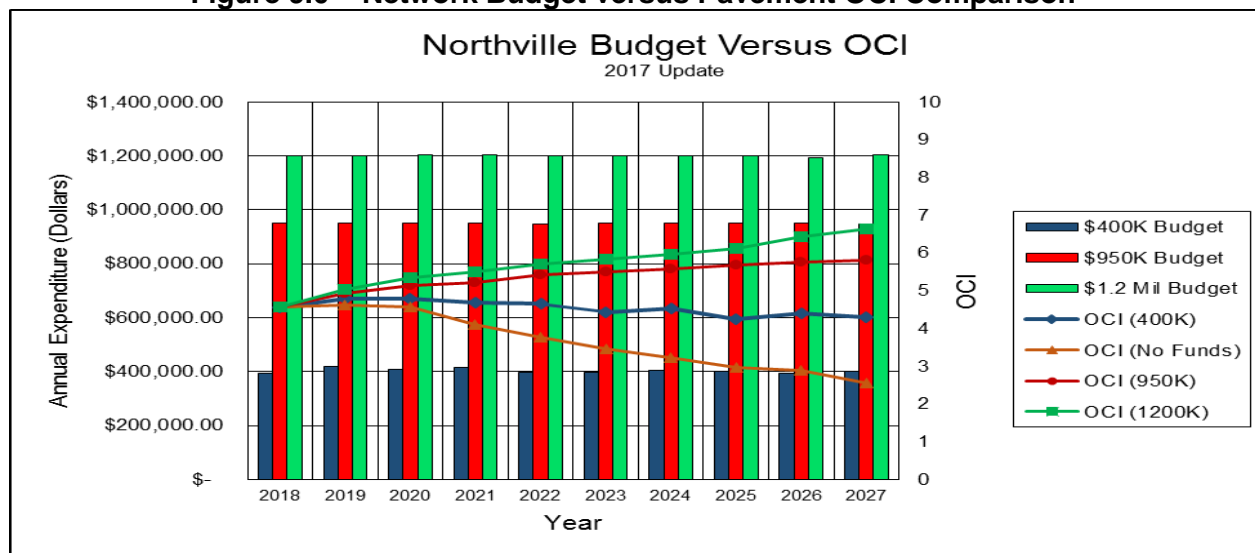
SD implemented the Budget-Driven scenario. The results of the Budget-Driven Analysis with the existing \$400,000 annual budget determined that the network-level OCI will consistently fall throughout the ten-year time period, from a current level of 4.57, to a level of 4.30 at the end of the tenth year, implying significant project under-funding. The results of the \$950,000 annual budget determined that the network-level OCI will increase throughout the ten-year time period, from a current level of 4.57, to a level of 5.81 at the end of the tenth year. The analysis of the \$1,200,000 annual budget determined that the network-level OCI will increase throughout the ten-year time period, from a current level of 4.57, to a level of 6.63 at the end of the tenth year. We also note that based on the total pavement area and projected funding amounts, these results are consistent with other large pavement networks with which SD has been involved in maintaining. The following information in Table 15.0 summarizes the results of the budget scenario.

**Table 15.0 – Summary of Budget Scenarios**

Funding Scenario		Approximate Ten-Year Cost	Existing OCI	Final Network OCI	Budget Trends
None		\$0	4.57	2.55	OCI steadily decreases annually
\$400K Annual		\$4,034,520	4.57	4.30	OCI decreases overall
\$950K Annual		\$9,502,188	4.57	5.81	OCI steadily increases annually
\$1.2 Million Annual		\$12,009,626	4.57	6.63	OCI steadily increases annually

Figure 9.0, below, shows the results of the budget scenarios on the network level OCI, compared to the network level OCI of a scenario where no funding is applied to the network. The \$400K annual budget scenario shows a steady decline in OCI, indicating network-level project under-funding. The \$950K and \$1.2 Million annual budget scenarios show a steady increase in OCI. In the scenario where no funding is applied to the network, the OCI drops to a level of 2.55 at the end of the ten year period.

**Figure 9.0 – Network Budget versus Pavement OCI Comparison**



The ten-year work plans for the budget scenario are presented in tabular form in *Appendix I*. Information displayed includes the Road Name, Segment ID number, the Segment Area, the Plan Activity, the Projected Cost of the proposed repair project, and the Anticipated Repairs to be performed for each project. The total cost for each plan year is also provided. Information within these tables corresponds directly with the pavement inventory spreadsheet, segment analysis recommendations, and work plan maps provided in *Appendices E, G, and H*, respectively.

We stress, and highly recommend that isolated distresses must continuously be repaired as part of an ongoing maintenance program beyond the initial repairs chosen by Roadsoft. This type of maintenance program is handled with yearly allocated funding. For example, a pothole on a “7” rated asphalt pavement needs immediate attention or repair even though the repair recommendations addressing the rating category do not speak to these specific repairs. In this case, an AC-70 repair does not include isolated pothole repair. We recommend that Northville establish a general maintenance fund to allow for the immediate action or repair when dealing with these isolated situations to avoid problems or situations that may result from these isolated distresses.

We caution using this plan for direct funding of repair projects. The purpose of an analysis of this level is to assist in selecting projects. Once projects are selected, a detailed “Project Level” analysis should be performed. It is during this inspection that specific repair techniques, overall scope of the project, and a project budget are determined. Once the project budget is determined, the funding should be requested. Skipping the project level inspection can result in under-funding or over-funding of the project, and potentially compromise the overall quality of the project. Over-funding can occur when the pavement deteriorates at a slower rate than predicted. When work is completed, the maintenance and repair database should be updated annually as work is completed. We also recommend re-assessing the ten-year plan annually at the end of construction.

## **PAVEMENT LIFE**

The repair activities used in the plan (Table 11.0) are intended to increase the pavement life expectancy. Repairs in the preventative maintenance category, such as crack sealing and surface sealing, are intended to retard the deterioration of the pavement, as opposed to dramatically increasing the pavement condition. Although rehabilitation or reconstruction will be needed eventually, the preventative maintenance activities provide the most cost-effective way to increase life-expectancy. Once a pavement reaches the point where rehabilitation repairs are required, the associated costs rise at an increasing rate as the condition deteriorates. Repairs such as cut and patching, overlays, and partial-depth milling and replacement increase the pavement condition rating and extend the life significantly, but at a greater cost than applying preventative maintenance. The repairs associated with reconstruction are the most extreme scenario. They essentially start the life-cycle over by increasing the condition rating to 10, but at the highest expense.

The intention of the ten-year plan is to minimize the amount of reconstruction needed, and implement rehabilitation when possible. Preventative maintenance repairs are included within the pre-determined annual budget allocation. The effects of different repairs on the pavement life-expectancy are shown in Table 16.0 below. This information was obtained from the Federal Highway Administration; it gives time ranges for the benefits to the pavement, not for the treatments themselves. It is important to understand that these are estimated values, as the actual gains depend on numerous factors such as original construction quality, varying traffic loadings, sub-grade type, and climate conditions. SD added the information regarding reconstruction activities.

**Table 16.0 – Extended Service Life Gains for Pavement Treatments**

<b>Repair Activity</b>	<b>Pavement Type</b>	<b>Extended Service Life (Years)</b>
Overband Crack Sealing	Flexible	Up to 2
	Composite	Up to 2
Crack Sealing	Flexible	Up to 3
	Composite	Up to 3
	Rigid	Up to 3
Single Chip Seal	Flexible	3 to 6
	Composite	NA*
Double Chip Seal	Flexible	4 to 7
	Composite	3 to 6
Slurry Seal	Flexible	NA*
	Composite	NA*
Micro-surfacing (Single Course)	Flexible	3 to 5**
	Composite	NA*
Micro-surfacing (Multiple Course)	Flexible	4 to 6**
	Composite	NA*
Ultrathin Asphalt Overlay (0.75")	Flexible	3 to 5**
	Composite	3 to 5**

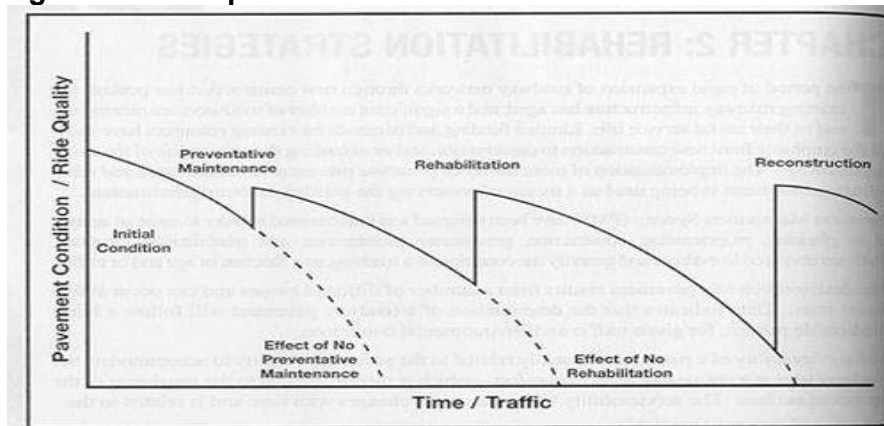
Asphalt Overlay (1.5")	Flexible	5 to 10
	Composite	4 to 9
Mill and Overlay (1.5")	Flexible	5 to 10
	Composite	4 to 9
Mill and Overlay (2.0")	Flexible	7 to 12
	Composite	7 to 12
Pulverization and Overlay	Flexible	8 to 14
	Composite	8 to 14
Full Reconstruction	Flexible	15 to 40
	Composite	15 to 40
Joint Resealing	Rigid	3 to 5
Spall Repair	Rigid	Up to 5
Full-depth Concrete Repairs	Rigid	3 to 10
Diamond Grinding	Rigid	3 to 5**
Dowel-bar Retrofit	Rigid	2 to 3**
Concrete Pavement Restoration	Rigid	7 to 15**
Full Reconstruction	Rigid	15 to 50

\*Sufficient data are not available to determine life-extending value

\*\*Additional information is necessary to quantify the extended life more accurately

Figure 10.0, below, further demonstrates the effects on pavement condition that preventative maintenance, rehabilitation, and reconstruction have throughout the life-cycle.

**Figure 10.0 – Repair Effects of Pavement Deterioration with Time**





## **SUMMARY AND CONCLUSIONS**

SD performed the field evaluation of the City of Northville's approximately 25 mile long pavement network in May of 2017. Roads consisting of asphalt, concrete, brick pavers, and composite (asphalt over concrete) construction were evaluated and categorized by Pavement Condition, Use, Priority and Classification. The total pavement area within the Northville network was found to be approximately 52.7 lane miles. This represents a total asset replacement value of approximately \$32 million.

The overall condition of the pavement network was found to be in fair condition, with a weighted average Overall Condition Index (OCI) rating of 4.57 on the 10 point scale. Individual pavement conditions ranged widely across the rating scale, but numerous concrete and asphalt pavement were found to be in poor condition, and are anticipated to deteriorate into failed condition within the next several years if heavy rehabilitation or reconstruction repairs are not implemented. A combination of isolated preventative maintenance, and extensive rehabilitation and reconstruction repairs is necessary to address the varying pavement conditions found in the network.

SD organized the pavement data into the Roadsoft software program to assist in development of individual ten-year work plans based on preliminary budget projections provided by the City of Northville. The updated ten-year work plans were developed to start in 2018. The budget scenarios included an annual budget of \$400,000, \$950,000, and \$1.2 Million. Each annual budget includes a \$25,000 budget to provide preventative maintenance repairs and a \$35,000 allowance for isolated sidewalk repairs outside of the recommended annual scopes of work. The remainder is left for the program to choose the most cost-effective rehabilitative or reconstruction street repairs. As part of this 2017 program update, the unit costs for each plan activity were updated to include allowances for the necessary sidewalk, ramp, and curb and gutter repairs for each particular segment selected for repair.

**Based on the comparison of the results of the budget-driven analysis, SD determined that the existing annual budget of \$400,000 is insufficient to adequately maintain the Northville Pavement Network.**

Significant investment has been made to inventory the roadway pavement network and develop an accurate management system. We strongly recommend continued investment into the program by the City of Northville, and to continually refine and update the inventory through future inspections. The maintenance and repair database should be updated annually as work is completed. We also recommend re-assessing the ten-year plan at least every three (3) years to account for any changes that may have occurred.

This comprehensive centralized program will provide easy access to pavement information, allow for proper budget allocation to optimize pavement repair resources, and reduce overall pavement maintenance repair spending. This program is an investment that will save Northville money by applying value engineered decisions now, therefore reducing the need for more costly repairs in the long run. Pavement management programs are not new to our industry, but how we use the technology that has been developed and proven in the field, and now incorporated into this municipal management system, represents an important step in asset management for the City of Northville.