CITY OF WATERLOO
Pavement Management Program
FY 2020-2026

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Waterloo Iowa

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Executive Summary

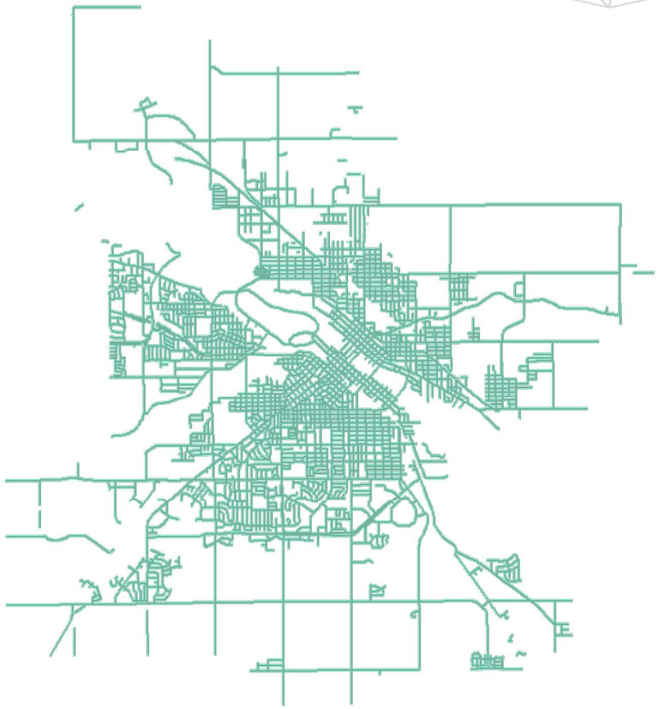
The City of Waterloo is a unique municipality in Iowa. The City has had a Local Option Sales Tax (LOST) dedicated for roadway improvements since 1991 and uses it to maintain its network of over ***420 miles of streets***. The majority of these streets also have some form of asphalt surface, which is unusual in Iowa. Both of these factors set the City apart from its peers within the State of Iowa, and for the better. The City of Waterloo has the ***highest average condition score***, based on the Iowa Pavement Management Program's (IPMP) condition assessment, of all major metropolitan areas in the state.

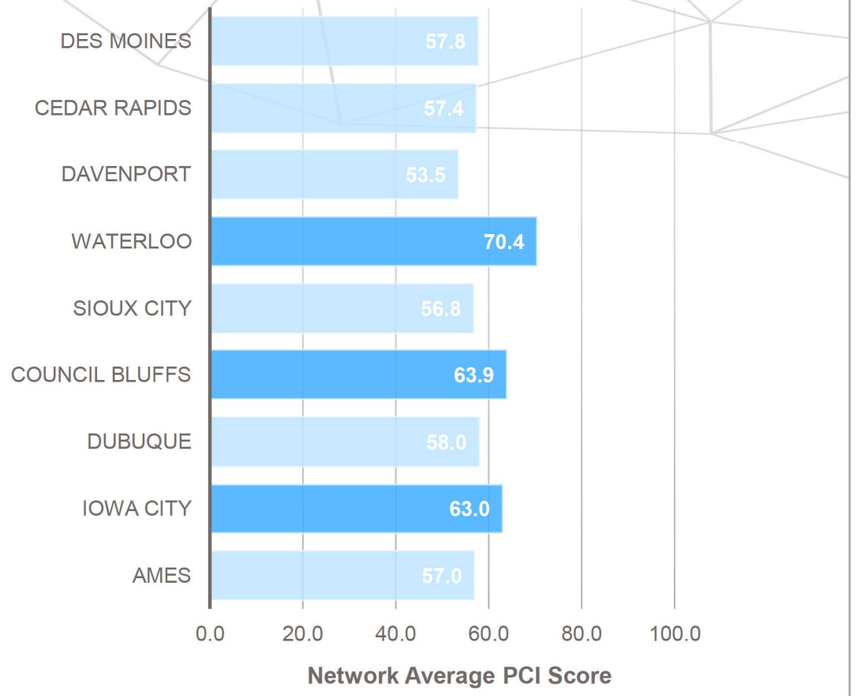
Having a LOST set up and the pavement rehabilitation practices used in Waterloo are indicative of a certain type of forward thinking by the City. It is that same forethought that led Waterloo to contract with ***HR Green, Inc***. to provide their pavement management planning services.

Pavement management is a *program* that carries out an important City *policy*. The policy objective is to improve overall street conditions in an efficient manner that maximizes public benefits. This proactive approach is important for a municipality tasked with maintaining the fourth largest roadway network in the state.

The goals of this pavement management program are to:

- Review the City's standards for street construction and maintenance practices
- Develop an inventory of the City's street system
- Evaluate the system's current roadway conditions using data provided by the Iowa Pavement Management Program (IPMP)
- Determine major rehabilitation and reconstruction alternatives and trigger thresholds for use in the data analysis and projections.
- Create a comprehensive pavement management model using the IPMP data and the Pavement Management Software dTIMS BA™
- Develop maintenance/replacement schedules with annualized costs for various funding levels and scenarios.





The City's pavement rehabilitation treatment alternatives and project determination process were reviewed and a memo was delivered to city staff in early 2019. A set of preferred treatment alternatives and appropriate selection criteria were developed from this review as well City feedback.

Pavement Condition Data has been collected statewide for all public roads in Iowa, at least every 2 years, since 2013. This is done through the ***Iowa Pavement Management Program***, which is funded by the Iowa Department of Transportation and is run out the Institute for Transportation at Iowa State University. The data collection consultant for the IPMP uses a specialized van outfitted with an array of sensors and drives every road in the state to collect information about the pavement distresses visible on the surface.

The most recent data collection for Waterloo was in 2018 and was very useful for assessing conditions in Waterloo and developing a comprehensive inventory in GIS. Each roadway segment collected had the distress data distilled into the City Pavement Condition Index (CityPCI) used throughout the state.

Based on the CityPCI results, Waterloo has ***an average score of 70/100***, which is considered "Good Condition" as well as the highest average score of all major metropolitan areas in Iowa. The street conditions throughout the City were found to be fairly homogenous. Different surface types and the various Wards were all well distributed and did not have significant differences between them. Local/Residential class roads were found to have slightly lower scores on average, however. This is somewhat expected because they make up the majority of streets and are less cost efficient to fix due to their dispersed nature. The Local streets are still considered to be in "Good Condition," on average, and since they are travelled at lower speeds and have smaller volumes of traffic, it should not be a major concern.

Using the IPMP data, existing City resources, and input from City staff, a complex pavement management model was created using the ***dTIMS Business Analytics™ software***. This model was then used to analyze various funding and performance based scenarios for the Waterloo streets program. The findings of the investigation determined that the current construction budget of approximately $7.5 Million may not be sufficient based on long-term sustainability.

Spending has been relatively flat over the past 5-years and ***revenue growth has been below the inflation rate***. This means that, while the budget is likely more than sufficient right now, it will slowly lose its purchasing power and less work will be completed for the same amount, in future years. The first funding hurdle is expected in 2026. Many resurfaced pavements older than 15 years are likely to need work before that time as well as the expected inflation will have increased construction costs by nearly 25%. This means annual funding may need to be increased or a sizable infusion of funds will be required.

The model determined that it would take an increase of at least $3 Million for each year's budget to keep the current condition steady over the next 15 years. That or a bonding effort of approximately $80 Million by 2026. Without these increases to funding, the overall average condition is expected to decline. However, the funding scenarios found that even the worst case still kept the City's overall average condition in the "Good" category. In fact, if no changes to funding occur in the next 15 years, Waterloo would still have a higher average condition score than nearly every other major metropolitan area in the state has currently! In this case, a slight decline in condition may not be considered necessarily a bad thing and instead the City should look at adopting a performance goal where they set target minimum condition for various classes of roads. One possible goal could be keeping Arterial Roads at 70/100, Collector Roads at 65/100, and Local Roads at 60/100.

Finally, the results of the scenario modelling exploration were then incorporated into the pavement management model which was used to generate an objective and computer optimized 7-Year Capital Improvement Plan (CIP). The CIP is a list of recommended projects for Waterloo to complete over the next 7 years. This list of projects was produced using the results of the dTIMS BA model, as well as several other factors, including the sewer separation mandate. The project list is optimized for the most effective use of available funds, based on the pavement condition data and planning-level information provided by the City. The complete list of recommended projects and maps identifying the location for the proposed treatments can be found in ***Appendix A: Capital Improvement Plan starting on page 72***

These lists and maps will serve as a tool to assist City staff during the project planning process, but they do not replace engineering judgement. Project types may change from what is in the CIP and projects will likely move between phases for various reasons. Some projects may even leave the plan entirely as new ones are added. Some reasons the program may change include field conditions not captured by the IPMP data, required utility improvements, or environmental hazards causing changes to local conditions. Consisting of ***151 Projects***, the recommended projects contained within the CIP will address nearly ***32 Miles*** of roads.

This document is not the end of the Pavement Management Program, however. Not only do the projects need to be constructed, still, but this should be considered a ***"Living Document"*** because it needs to shift and change with the conditions of the streets as well as the needs of its citizens. The City receives new IPMP data every 2 years, so this gives a good impetus for renewing the pavement management model and adjusting the plan based on new information. Expect to hear more things about this program, in the future, including updated city-wide condition performance metrics and revised CIP's!

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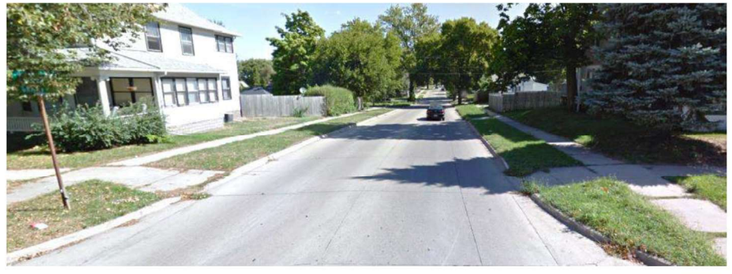

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1. Background

The City of Waterloo (City), located in Black Hawk County, Iowa, maintains an expansive roadway network consisting of over 420 centerline miles of streets and is the 4th largest road network in the state.

A limited streets program budget, primarily funded through Local Option Sales Tax (LOST) revenue, often requires elected officials to make difficult decisions when determining annual maintenance and reconstruction expenditures. The City's current method for prioritizing street improvements is not a clearly defined process. A combination of overall condition index (OCI) ratings, visual inspections, and public input all influence the decision-making process. Elected officials also make a concerted effort to ensure equitable distribution of projects amongst the City's five wards. This practice likely prevents the municipality from making objective and optimal decisions when managing its roadway assets and budgeting for future needs.

Budgeted LOST funds averaged $9.8 million between 2014-2018. The City dedicates approximately $7.5 Million to overlay and reconstruction activities but also reserves $400,000 per year for funding match money required by state or federal grants. The Public Works Department also receives $900,000 of the total annual allocation to complete seal coating activities. These funds cover costs associated with personnel, materials, equipment, and the actual construction.

2. Introduction

The City contracted HR Green, Inc. (HRG) to complete a Pavement Management Plan in December 2018. This project will help the City develop an objective, data driven, and sustainable approach to managing its roadway assets as well as to budget for future needs. HRG's effort involved the following actions:

- Reviewing the City's standards for street construction and maintenance practices
- Developing an inventory of the City's street system
- Evaluating the system's current roadway conditions using data provided by the Iowa Pavement Management Program (IPMP)
- Determining major rehabilitation and reconstruction alternatives and trigger thresholds for use in the data analysis and projections.
- Create a comprehensive pavement management model using the IPMP data and the Pavement Management Software dTIMS BA™
- Developing sustainable maintenance/replacement schedules with annualized costs for various funding levels and scenarios.

Data evaluation was restricted to the previous five years based on the typical duration of the City's Capital Improvement Program (CIP) as well as data availability from IPMP which began providing statewide coverage in 2013.

2.1. What is Pavement Management?

Pavement Management is a *program* that carries out an important City *policy*. The policy objective is to improve overall street conditions in an efficient manner that maximizes public benefits. This proactive approach is important for a municipality tasked with maintaining roadway infrastructure spanning over 62 square miles of land.

Using Pavement Management methodology, HR Green developed recommendations using the right pavement treatment, at the right time, on the right road. Large amounts of pavement condition data were collected and analyzed with complex computer models (further described in ***Section 3 Methodology***) to determine the best use of the LOST revenues to improve the overall condition of the City's road network. This report is the culmination of those efforts and includes a 7-year plan of recommended projects that capitalizes on $7.5 million in annual revenue set aside solely for the maintenance, rehabilitation, and reconstruction of public streets.

2.1.1. Pavement Life Cycles

Pavement management techniques are important as pavements do not decay at a constant rate over time. Time is a crucial factor in how much investment it takes to repair a road back to a serviceable condition. New pavement will not change drastically over the early years of its life; however, sharp declines can occur quickly with older pavements. The pavement may even reach failing status without intervention.

Small investments at appropriately-designated times can drastically improve and extend pavement life. Rehabilitating a pavement in "Fair" condition, for example, will usually cost less than 25% of reconstructing a failing pavement while extending pavement life significantly. It is important to invest wisely and early as a consequence. This plan sets the City of Waterloo on a course towards this practice.

Before an ideally-maintained roadway network can be reached, however, many of the worst roadways will require reconstruction or rehabilitation. Pavements within the "Poor" condition category will, in most cases, be deferred or given light maintenance with the intent of reconstructing before reaching "Very Poor" condition. This effectively saves money and squeezes the most life out of the network while still giving the opportunity to practice ideal Pavement Management elsewhere in the community.

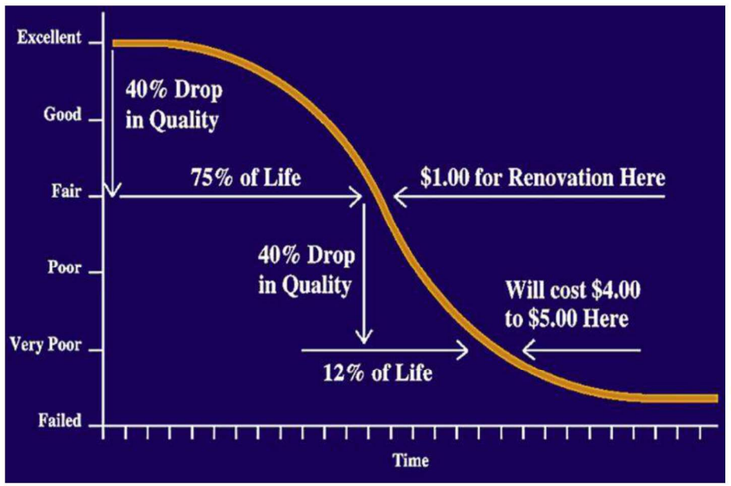


Figure 1:Performance Curve
Renovating a pavement in "Fair" condition will usually cost less than 25% of reconstructing a failing pavement. (FHWA)

2.2. Program Goals

The purpose of this Pavement Management Plan is to create a sustainable program for maintaining and improving street conditions within Waterloo. This document provides a framework to assist the City in maximizing the impact of its expenditures in the wisest and most cost-effective manner.

The Local Option Sales Tax has been a tremendous funding source for the city of Waterloo. It has allowed a large number of streets to be reconstructed, overlaid and seal-coated over the years. Even though LOST has provided a very stable funding platform over the years, there are still ways that the City can maximize its investment into our roads. The items listed below are intended to guide the City to do just that.

- Develop an objective and data-driven 7-year Pavement Management Plan
- Perform a full condition assessment of the existing street network
- Review City standards and maintenance practices for potential process improvements
- Select appropriate treatment alternatives and trigger conditions for the pavement management model
- Create a comprehensive inventory and pavement management model in dTIMS BA
- Identify any future funding deficiencies
- Determine if splitting maintenance funding by ward is a cost effective approach
- Examine the long-term cost-effectiveness of the existing seal coat program
- Assess potential target condition goals for different functional classifications and their feasibility given budget constraints.

3. Methodology

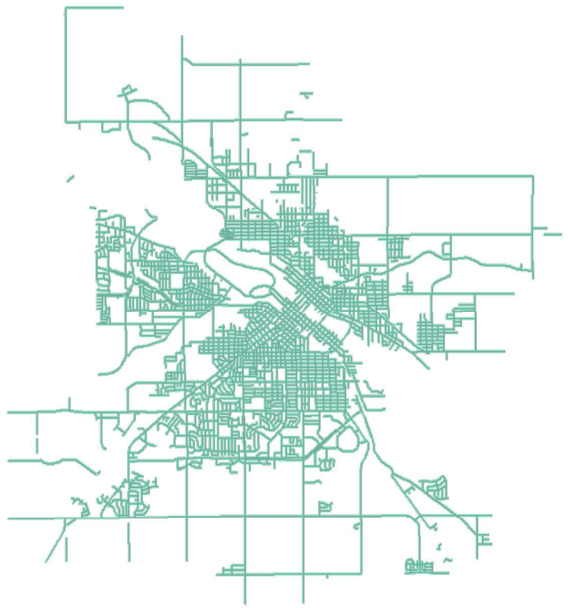
3.1. Data Collection

3.1.1. Base Inventory

The first step in any Pavement Management Program is to develop an accurate inventory of streets. City staff provided HR Green with detailed GIS information and historical reference material outlining its current network.

The majority of this baseline inventory data came from the City of Waterloo's former Cartegraph™ database. This database resource was substantially complete and offered a high level of detail compared to many agencies of Waterloo's size. However, that database is being decommissioned as part of the City moving over to ESRI™ enterprise software. Moving forward, all historic data and new work products from this plan, such as proposed projects or condition information, will be compatible with that format, exclusively.

Some spatial manipulation and data filtering was required to make better use of the Waterloo base files for modelling purposes. This included eliminating or combining short segments, ensuring accurate intersection contiguity, and developing a linear reference model.



3.1.2. Pavement Distress Data

After the inventory was established, the condition was then determined for each asset. This assists with prioritizing roadways by their current level of serviceability as well as helping estimate their respective remaining life spans.

Roadway pavement condition data were collected by an automated data collection vehicle, like the "Pathrunner" used by Pathways Services Inc., the Iowa DOT 's data vendor. This is a van outfitted with an array of sensors and cameras that automatically collect data on and around the road. These data include, but are not limited to cracking, potholes, faulting, spalling, rutting, etc. Examples of specific pavement distresses can be found in ***Section 3.1.3 .***

The pavement condition data was then processed and aggregated using the existing City of Waterloo's roadway segmentation for use in ESRI ArcGIS™ (a mapping and data analytics software) by the Iowa Pavement Management Program (IPMP). IPMP's services are provided through Iowa State University's Institute for Transportation, which is the agency currently supporting Iowa DOT's pavement management data collection.

Figure 2: A "Pathrunner" Automated Data Collection Vehicle (Pathways)
This is one of the van's that a previous data collection vendor used to collect pavement condition in Iowa from 2013-2017.

The collected pavement distress data were then combined into a Pavement Condition Index (PCI) for each street. A PCI is used to help more concisely communicate a road's pavement condition by rating it on a scale from 0 to 100, with 0 representing a failed pavement that has essentially turned completely to rubble and 100 representing an excellent pavement from a freshly paved street that is only a few days old. This plan uses the CityPCI method for calculating condition indices for urban areas in Iowa, as developed by the IPMP technical subcommittee.

Using this index as a guide, each of the roads was then placed into a condition category ranging from "Very Poor" to "Very Good." All of the data was then appended with additional information regarding traffic, functional class, number of lanes and the like, then stored within both GIS and dTIMS BA databases so that it could be analyzed in the pavement management models.

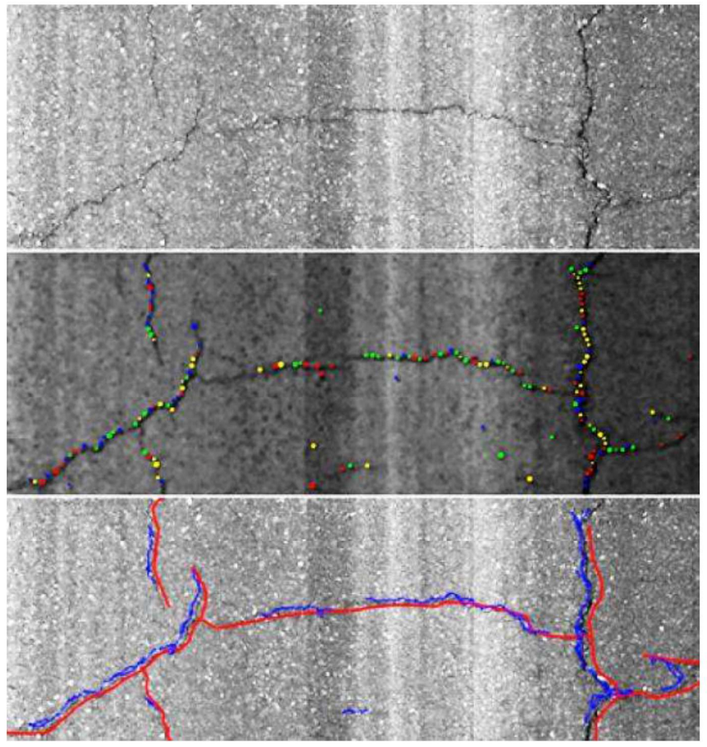


Figure 3: Automated Crack Analysis Software
This picture is a screenshot of an automated crack detection software that uses elevation information and photogrammetry to identify distresses and categorize their severity

3.1.3. Example Pavement Distresses

Figure 4: Example of Alligator Cracking (ASTM)
This image is from the ASTM D6433 "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys." Alligator Cracks are when pavement breaks into a "scaly" pattern typically caused by fatigue, either from repeated heavy loads, lack of sufficient subgrade support, or weakened material due to drainage issues.

Figure 5: Example of Block Cracking (ASTM)
This image is from the ASTM D6433 "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys." Block cracks are when pavement breaks into "chunks" or "blocks" that are roughly rectangular, caused by internal stress from temperature or lack of lateral support.

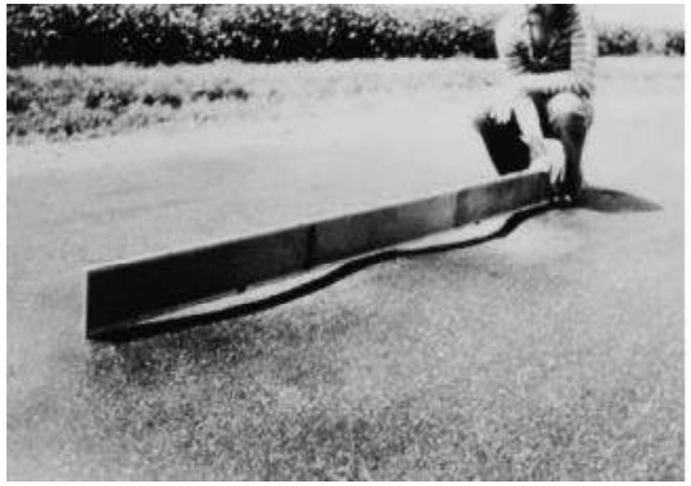


Figure 6: Example of Distortion (ASTM)
This image is from the ASTM D6433 "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys." Distortions are when the pavement warps its shape without much cracking. Typically caused by shifting or displaced underlying material.

Figure 7: Example of Transverse Crack (ASTM)
This image is from the ASTM D6433 "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys." A common distress caused by a wide variety of issues.

Figure 8: Example of Patching (ASTM)
This image is from the ASTM D6433 "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys." Patching is the result of corrective actions already taken and are indicative of underlying issues as well as a common point of failure.

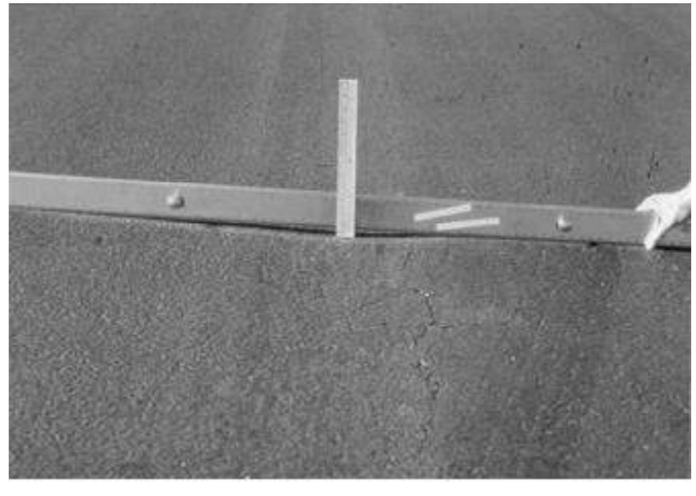


Figure 9: Example of Rutting (ASTM)
This image is from the ASTM D6433 "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys." Rutting is a depression along the wheel-path caused by traffic loads.

3.2. Condition Thresholds

The Pavement Condition Index (CityPCI) used in this plan helps differentiate and prioritize between individual streets, but due to the sampling methodology used by the data collection vendor ***it should not be interpreted as a 100% accurate,*** infallible rating. The difference between a 52/100 rating and a 55/100 could be only a few cracks. Since the data collection vehicle typically only drives one side of the street it may occasionally miss a few distresses near the middle or the other side could be in slightly better/worse condition. A difference of a few points one way or the other should not be interpreted as a definitive ruling on one street being better than the other. ***Changes in PCI less than 10 points are, in most cases, imperceptible to the naked eye.***

Instead of using CityPCI literally, condition categories were assigned to each street based on where the value fell on the 0 to 100 scale. For example, pavements with CityPCI ratings below 20 are considered to be "Very Poor" while those above 80 would be "Very Good." This was done to help with understanding and assessment of the ratings, as well as to allow them to be used in a practical sense

Figure 10: Condition Thresholds
This chart shows the proposed relationship between CityPCI and the condition categories used in this plan.

Figure 11: Example of "Very Good" Condition (HMA) – Mourning Dove Dr
This picture was taken from the 2018 data collection records. Mourning Dove Drive, north of Hummingbird Circle has a nearly perfect PCI of 97/100 because it demonstrates no visible pavement distresses.

Figure 12: Example of "Very Good" Condition (PCC) – Seneca Ave
This image shows Seneca Avenue from the 2018 data collection, in which it was rated as 86/100 and would be considered "Very Good" for a PCC pavement.

A score of 80/100 or greater is considered "Very Good." Roads with pavement in "Very Good" condition exhibit very few surface distresses, if any, and those that are apparent will be very low in severity. Most often, these pavements will be very new. The average age of "Very Good" pavements in Waterloo is less than 10 years, meaning they were either recently constructed or rehabilitated with an overlay in the past few years. As such, it may not be feasible to expect every street in a city to be "Very Good" because it would be prohibitively expensive resurface every street in 10 years' time.

Pavements with CityPCI scores between 61 and 80 are considered to be in "Good" condition. The distresses on these streets are more noticeable but do not cause much concern because they are minor and infrequent. Most drivers will not even notice the few cracks and distortions. Regular maintenance activities like crack sealing can help prevent the spread of these deficiencies and preserve these pavements for quite some time for low costs. The majority of Waterloo's streets would be considered to be in this category.

Figure 13: Example of "Good" Condition (HMA) – Liberty Ave
This picture of Liberty Ave between Oregon and Minnesota. It was rated as 75/100, which would be considered good for an HMA pavement. Low severity cracks and small distortions can be found, but nothing that impacts drivers.

Figure 14: Example of "Good" Condition (PCC) – Kingsley Ave
This image shows an example of a PCC pavement in "Good" condition. Kingsley Avenue between Fletcher and Lawnhill is rated as 69/100, because of a few cracked panels and small patches in decent repair.

"Fair" streets (CityPCI 41-60), have quite noticeable distresses. Either many low severity distresses, or a few high severity distresses. These will still not impact drivers very much, however.

Figure 15: Example of "Fair" Condition (HMA) – Oleson Road
This image of Oleson Road between Hammond and Bethel is an example of HMA pavement in "Fair" condition, with a PCI of 48/100. There are very noticeable distresses but they only impact drivers slightly.

Figure 16: Example of "Fair" Condition (PCC) – Ansborough Ave
This picture of Ansborough Ave between Stratford and Upton is an example of a PCC pavement that was rated as 51/100 which would be considered "Fair."

At this point in a pavement's life, it is about 75% of the way through its expected serviceability. It will begin deteriorating much more quickly and fall into "Poor" (21-40) or "Very Poor" (1-20) in only a few years, if neglected. However, because the distresses on "Fair" streets are still minor, this is often the ideal time to Rehabilitate them affordably. On the other hand, pavements that deteriorate further, into the "Poor" and "Very Poor" categories, will likely require Reconstruction, which is very costly.

Figure 17: Example of "Poor" Condition (HMA) – Sumner St
This image shows an HMA street whose pavement is rated as 33/100 and considered to be in "Poor" condition. Sumner Street, east of 4th suffers from widespread cracking and a few points of more severe failure that may likely cause impacts to drivers.

Figure 18: Example of "Poor" Condition (PCC) – Webster St
This image is an example of a PCC pavement in "Poor" condition. Webster street between Linn and North Barclay was rated as 26/100 due to uneven joints and numerous point failures that would certainly impact driver experience.

Figure 19: Example of "Very Poor" Condition (HMA) – 10th St East
This picture of 10th Street East, to the southwest of Sycamore street is one of the few HMA pavements in Waterloo considered to be in "Very Poor" condition. Rated as 17/100, this road's pavement exhibits distresses across the entirety of the street and even has grass growing through the cracks.

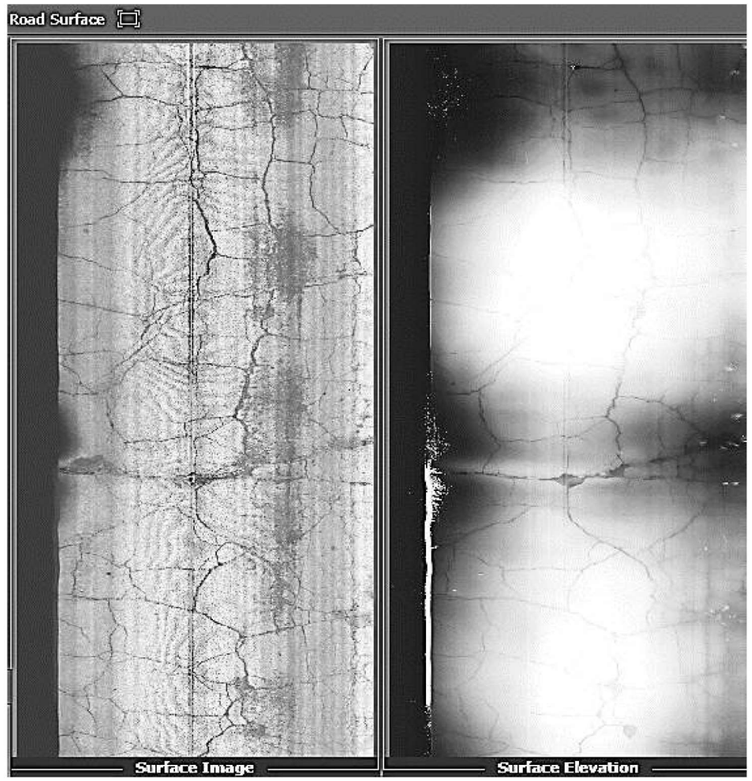


Figure 20: Roadway Imagery of a "Very Poor" HMA Pavement
This imagery is from the section of 10th Street East shown in Figure 19. *These were captured by the data collection vehicle's downward facing camera (left) and LIDAR array (right). These are one of the key resources used in evaluating pavement condition.*

Figure 21: Example of "Very Poor" Condition (PCC) – Fletcher Ave
This picture of Fletcher Street south of Black Hawk Road is the only PCC pavement of "Very Poor" condition in Waterloo. Rated as an 8/100 in 2018, it exhibits multiple points of severe distress that could not be addressed through any means other than rebuilding the road from the base up.

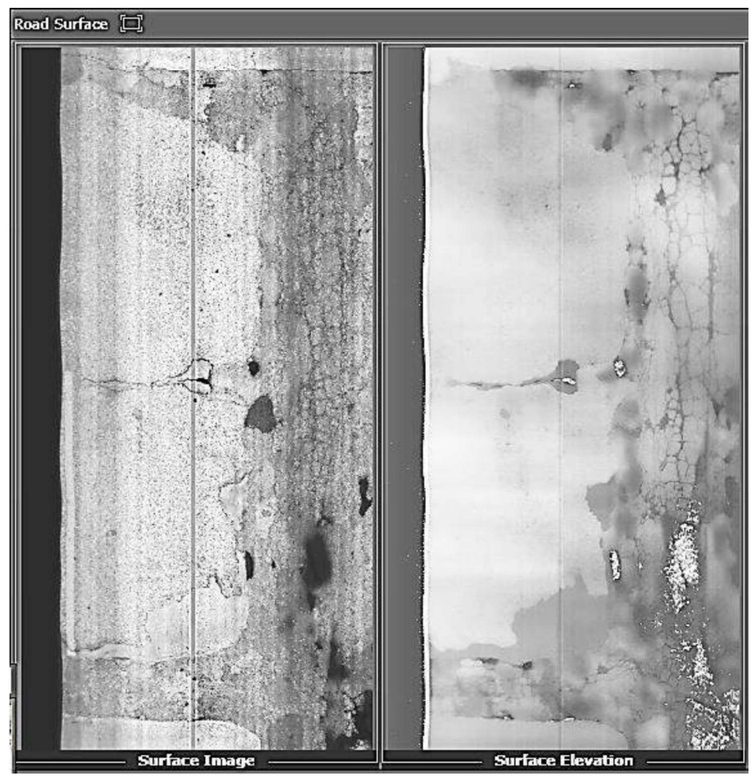


Figure 22: Roadway Imagery of a "Very Poor" PCC Pavement
This image is from the section of Fletcher shown in Figure 21. *These were captured by the data collection vehicle's downward facing camera (left) and LIDAR array (right). These are one of the key resources used in evaluating pavement condition.*