City of Huntington Pavement Management Program

JUNE 1, 2019

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1. Introduction

In November 2018, Kimley-Horn received authorization from the KYOVA Interstate Planning commission to proceed with the development of a pavement management program for the City of Huntington's roadway network. The project consisted of a roadway pavement and sidewalk inventory, an assessment of existing pavement and sidewalk conditions, and the preparation of a pavement and sidewalk management program for the city-maintained roadways and sidewalks. The pavement management program ("the program") focused on approximately 200 miles of roadways and 57 miles of sidewalk that are currently maintained by the City of Huntington ("the City"). Only roadways maintained by the City were included in the pavement management program analysis, and all roadways maintained by the State and Marshall University were excluded from the analysis.

The purpose of the program was to develop a plan to schedule pavement repair projects on roadways and sidewalks and make recommendations to cost effectively improve the condition of the transportation network. The program is a long-term strategic effort to make effective use of resources to preserve and upgrade the overall condition by tracking pavement condition over time. KYOVA and the City of Huntington are able to establish optimum pavement and maintenance/repair strategies using the program, which can then be used to determine annual funding levels needed to maintain the roadway infrastructure. The program will be managed through Microsoft Excel and GIS software which will allow both agencies to generate reports for budgeting and presentations, with flexibility to generate additional reports as needed.

The Scope of Work was broken out into seven tasks, a portion of which are discussed in this report:

1. Project Kick-off Meeting
2. Review Existing Documentation
3. On-Site Pavement and Sidewalk Assessment
4. Pavement and Sidewalk Data Analysis and Report
5. TAC and Policy Board Meetings
6. Stakeholder Meeting and Public Forum
7. Final Report

The following report is intended to provide an overview of the pavement management program and data analysis.

2. Review Existing Documentation

Kimley-Horn met with KYOVA and the City of Huntington to discuss the project and expectations in a kick-off meeting held on November 29, 2018. During that meeting, project expectations and deliverables were discussed and agreed upon. A discussion was held on how the roadways would be assessed by engineers driving and documenting each roadway, as well as how the data would ultimately be compiled and provided to KYOVA. KYOVA and the City of Huntington also provided other reference documents such as sidewalk and pavement schedules, roadway classifications, and LIDAR data for background information to be used in the data analysis.

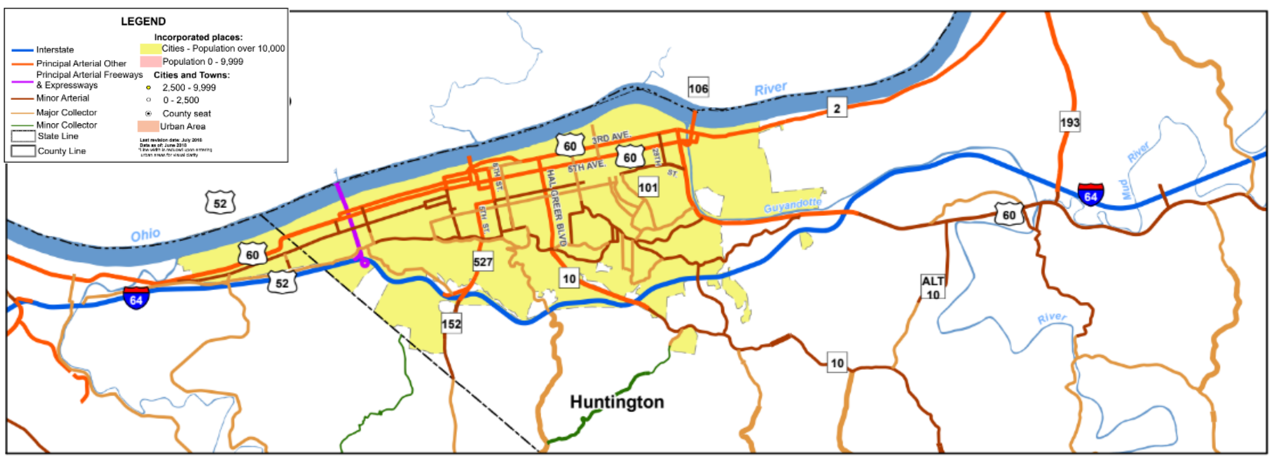
2.1 City of Huntington Sidewalk and Pavement Schedule

The City of Huntington provided Kimley-Horn with all of the streets and sidewalks slated for reconstruction in 2019, and beyond. Kimley-Horn was also provided with all of the streets that are maintained within the City's limits for use in the pavement assessment. LIDAR data was provided for the streets as developed by the West Virginia Department of Highways (WVDOH).

2.3 WVDOH Roadway Classifications

The WVDOH provided their State Functional Class Maps for use in identifying the classifications of each roadway. These maps are available through the WVDOH website within their GIS division, as illustrated in Figure 1.

Figure 1: WVDOH Functional Class Map of Huntington



2.2 WVDOH Pavement Management Program

As part of this project, Kimley-Horn was asked to evaluate how the West Virginia Department of Highways (WVDOH) assesses and manages their pavements, and determine if the City of Huntington Pavement Management Program could be integrated seamlessly into the WVDOH program. During Kimley-Horn's research, it was determined that the WVDOH utilizes programs that are installed in vehicles to drive and rate the thousands of lane miles that are part of WVDOH maintenance scheduled. These programs use various indices to rate and scale the conditions of their pavements from one to five.

In Section 3 of this report, the evaluation rating utilized by Kimley-Horn is explained through the use of the Pavement Surface Evaluation and Rating System (PASER) manual. The PASER manual uses a rating scale of 1-10, which can be correlated back to the WVDOH system for reference of conditions. While the two evaluation rating systems are different, the numerical values can be interpolated between the two systems for reference of condition based on the types and severity of distresses as well as common repair types.

3. On-Site Pavement and Sidewalk Assessment

Kimley-Horn performed the pavement and sidewalk assessments through multiple visits to the City of Huntington. The process included sending a team of two engineers to the City, where they would drive each individual roadway and document the distresses identified through visual observation. The engineers used the PASER manual for reference to determine the conditions of each pavement surface. The roadway conditions and distresses were collected and documented through GIS software on Apple iPads.

3.1 PASER Manual

The pavement condition is used to determine whether pavement segments need maintenance, repair, or reconstruction. The condition of the pavement is defined in terms of a Pavement Condition Index (PCI), which is based on the PASER manual. PASER was developed by the University of Wisconsin-Madison, Department of Engineering Professional Development, in conjunction with the Federal Highway Administration (FHWA). The PASER system utilizes a simple 0 to 10 scale to rate pavements based on observed distresses without requiring quantification of each distress. The Asphalt and Concrete PASER Manuals are contained in **Appendix C**. A modified PASER rating system was used for this project, which uses a 0 to 100 scale, with 100 representing new pavement. The modified scale allows for more detailed ratings while using the same observed distress criteria. By utilizing the PASER method, pavement segments can be rated in direct correlation to the type of repairs that should be performed. In addition to simplifying the evaluation process, the PASER method streamlines the conceptual analysis. The PCI rating scale corresponding with the modified PASER ratings for asphalt and concrete are displayed in **Table 1** and **Table 2**, on the following pages.

Table 1: Modified Asphalt PASER Ratings

PCI Rating	Visible Distress
100 – New Pavement	None.
90 – Excellent	Minor oxidation of asphalt material
80 – 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”).
70 – 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.
60 – Good	Slight raveling (loss of fine aggregates) 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.
50 – 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.
40 – 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).
30 – 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.
20 – Very Poor	Alligator cracking (More than 25% of surface). Severe distortions (More than 2” deep). Extensive patching in poor condition. Potholes.
10 – Failed	Severe distress with extensive loss of surface integrity.

Table 2: Modified Concrete PASER Ratings

PCI Rating	Visible Distress
100 – New Pavement	None.
90 – Excellent	Traffic wear in wheelpath. Slight map cracking or pop-outs.
80 – 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.
70 – 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.
60 – 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”).
50 – 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”). Multiple corner cracks with broken pieces. Moderate settlement or frost heave areas. Patching showing distress.
40 – 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 area broken into several pieces. Corner cracks with missing pieces or patches. Pavement blowups.
30 – Poor	Most joints and cracks are open, with multiple parallel cracks, severe spalling, or faulting. D-cracking is evident. Severe faulting (1”) giving poor ride. Extensive patching in fair to poor condition. Many transverse and meander cracks, open and severely spalled.
20 – Very Poor	Extensive slab cracking, severely spalled and patched. Joints failed. Patching in very poor condition. Severe and extensive settlements or frost heaves.
10 – Failed	Restricted speed. Extensive potholes. Almost total loss of pavement integrity.

3.2 GIS Software and Program Inputs

A Geographic Information System (GIS) was utilized to gather and collect the data for the assessment. The GIS application that was used is called Collector by ESRI and is available to download on any "smart" device. The program uses aerial photography to locate features that can be referenced to coordinate systems.

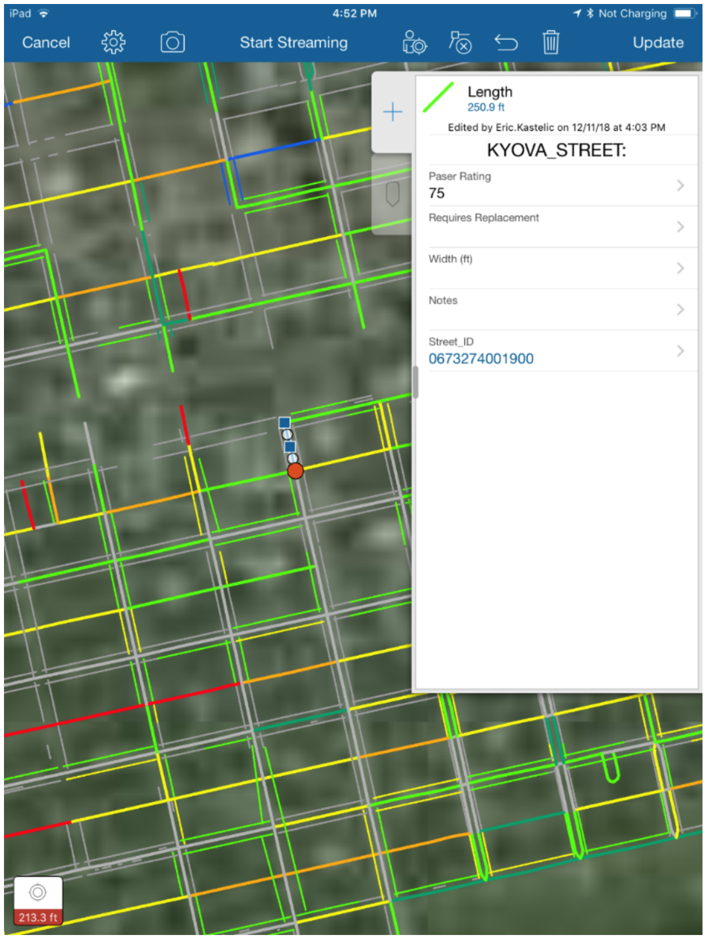
Prior to the assessment, KYOVA provided LiDAR data that was created and processed through the State's Department of Highways. The LiDAR data contained roadway segments that were imported for reference and use in the City of Huntington's Pavement Management Program. Each roadway was divided into segments for rating on-site through the assessment. Each segment of pavement for each roadway was assigned a unique Segment ID for later input into a spreadsheet as described in Section 4. A consistent methodology was used when assigning Segment IDs to individual pavement segments. Each Segment ID describes the road that it represents, with the first part of the Segment ID (before the hyphen) designating the street name. The last part of the Segment ID (after the hyphen) designates relative location along a street. The letters are assigned A-Z from north to south and west to east. For example, the Segment ID "ELLIS DR_A" would represent the northernmost segment on Ellis drive. Similarly, the Segment ID "10th AVE_G" would represent the easternmost segment along 10th Avenue.

The following features were collected in the field for each roadway segment:

- Pavement Condition (0 – 100)
- Roadway Name/Segment ID
- Segment Width
- Segment Length
- Roadway Classification
- Associated Future Construction Project (yes/no)
- State Roadway/Railroad Crossing

The information was exported to a Microsoft Excel Spreadsheet for analysis and evaluation. It should be noted that while these features were inputted into the system prior to the on-site assessment, they can be modified, added, or subtracted at any time through the GIS software. Each roadway segment can be updated in the future as needed by the end user. **Figure 2**, on the following page, is and example of the image an active user sees in the Collector Application.

Figure 2: Example of GIS Collector Application as used in the on-site assessment



4. Pavement and Sidewalk Data Analysis and Report

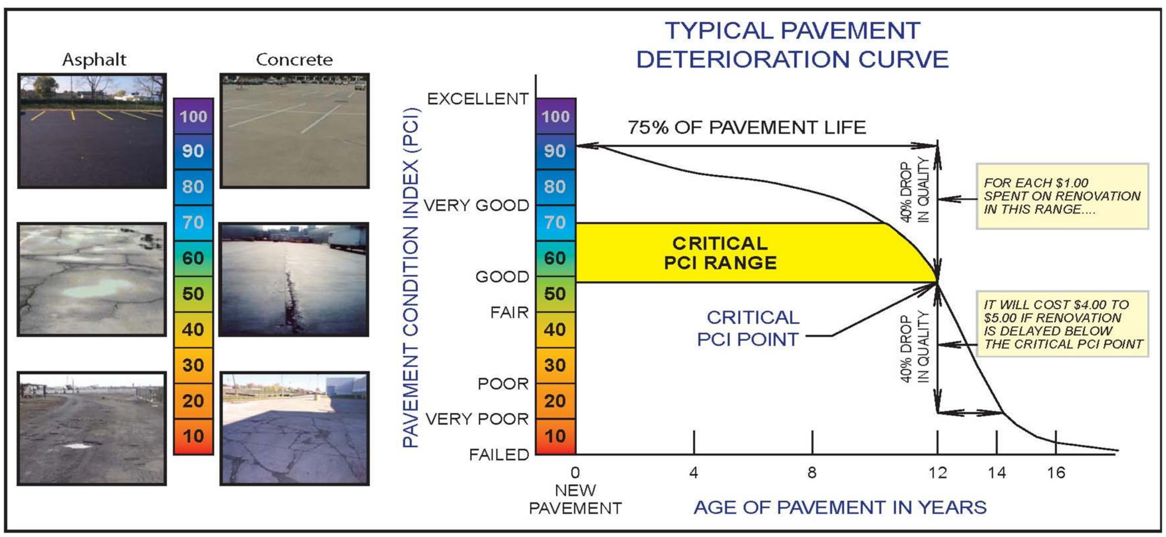
Once the on-site pavement and sidewalk assessment was completed, Kimley-Horn exported all of the collected data from the GIS software into an Excel Spreadsheet for analysis. Each of the features collected in the field can be translated into columns and rows of a spreadsheet, creating a seamless process for manually editing the data. Once the data is exported, the user may filter, sort, add, or subtract data as needed to create reports, prioritize roadway segments, estimate construction costs, etc. Tutorials are provided at the end of this report (Appendix D) to provide the user with guidance on the best practices for utilizing the pavement management program.

In order to understand the focus of developing a pavement management program, it’s important to first understand the philosophy behind prioritization and how pavements should be managed.

4.1 Pavement Management Program Philosophy

The basic philosophy of pavement management is to apply preventive maintenance treatments at appropriate times to slow the rate of pavement deterioration. Both preventative maintenance and rehabilitation techniques should be applied at times when they are cost-effective instead of letting the pavement deteriorate to failure, which requires more expensive reconstruction. A typical pavement deterioration curve, shown in **Figure 3,** demonstrates how the deterioration rate can vary depending on the Pavement Condition Index throughout the life-cycle of a pavement segment. Deterioration rates are dependent upon several factors including, but not limited to: original section design, quality of original construction, subgrade condition, traffic loadings, climate, and the quality and extent of the maintenance program in place. Pavement deterioration can fluctuate significantly depending on these factors. As pavement condition reaches the critical range, loadings, moisture intrusion, and other environmental conditions can cause the pavement to deteriorate from good condition (PCI 60-80) to poor condition (PCI 10-30) in a relatively short time frame.

Figure 3: Typical Pavement Deterioration Curve



Pavement deterioration follows a curve with a critical PCI range that is generally considered to be between a modified PASER PCI rating of 75 and 57 on the curve. The “critical point” of 57 on the curve is considered the threshold where preventative maintenance measures become less cost-effective. Some form of rehabilitation is required for the pavement to restore serviceability when the pavement falls below the critical point and typically requires costlier repairs. Upon further deterioration, the end of the useful life is reached when the pavement is considered a safety hazard. At this point, more costly and extensive reconstruction repairs are required to restore the service condition. A modified PASER PCI rating of less than 25 is typically viewed as the end of the pavement’s useful life. A small percentage of roadways were evaluated in the City of Huntington that are near the end of a useful life PCI rating. These roads may be recommended for reconstruction during the pavement management program work plan. Evaluation of the pavement on a consistent basis will maximize capital expenditures by providing the most cost-effective repairs relative to the type and extent of distresses in inspected or projected pavement.

When the network-wide average PCI is significantly more than the approximate critical point of 57 on the deterioration curve, the best management strategy will focus primarily on preventative maintenance while providing required rehabilitation and reconstruction repairs where needed. Alternatively, a network with an average PCI much lower than the approximate critical point will require a management strategy focusing on heavy rehabilitation and reconstruction while providing preventative maintenance where needed. The pavement management strategy used for the City of Huntington program follows this same philosophy. A targeted repair strategy combines preventative maintenance, rehabilitation, and reconstruction, where necessary. Numerous studies have shown that a strategy of only reconstruction of failed pavements, or reconstruction of pavements that do not require it, will cost significantly more than this combined approach throughout a defined analysis period. Properly applied preventive maintenance and rehabilitation treatments effectively extend the life of the pavement. When this approach is applied on a network-wide level, it frees up a considerable portion of the budget to spend on these cost-effective strategies that may have previously been dedicated to reconstruction of a much smaller percentage of the pavement network.

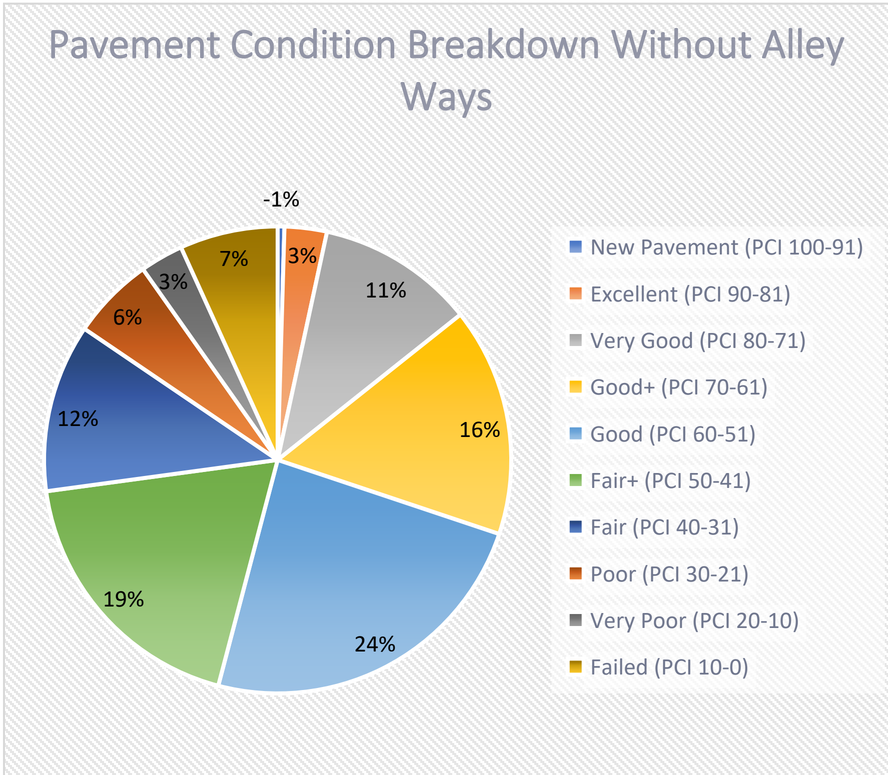
4.2 Program Inputs in Excel

4.2.1 PCI and PASER Rating System

Approximately 11,155,149 square feet of city-maintained pavement was assessed in the City of Huntington network using the PASER method. The weighted average PCI for the city-maintained roads within the pavement network is 41.40.

Figure 4 displays the pavement conditions by total area and percentage distribution. For the city-maintained roads, approximately 51% of the City of Huntington pavement assets currently have a PCI between 51 and 80 and are considered in “good” condition. This indicates that a vast majority if the city’s pavements fall within the “critical PCI” range. Approximately 36% of the city’s pavements fall below that range, and 13% are in “excellent” condition or are new pavements.

Figure 4: Pavement Condition Breakdown Without Alley Ways

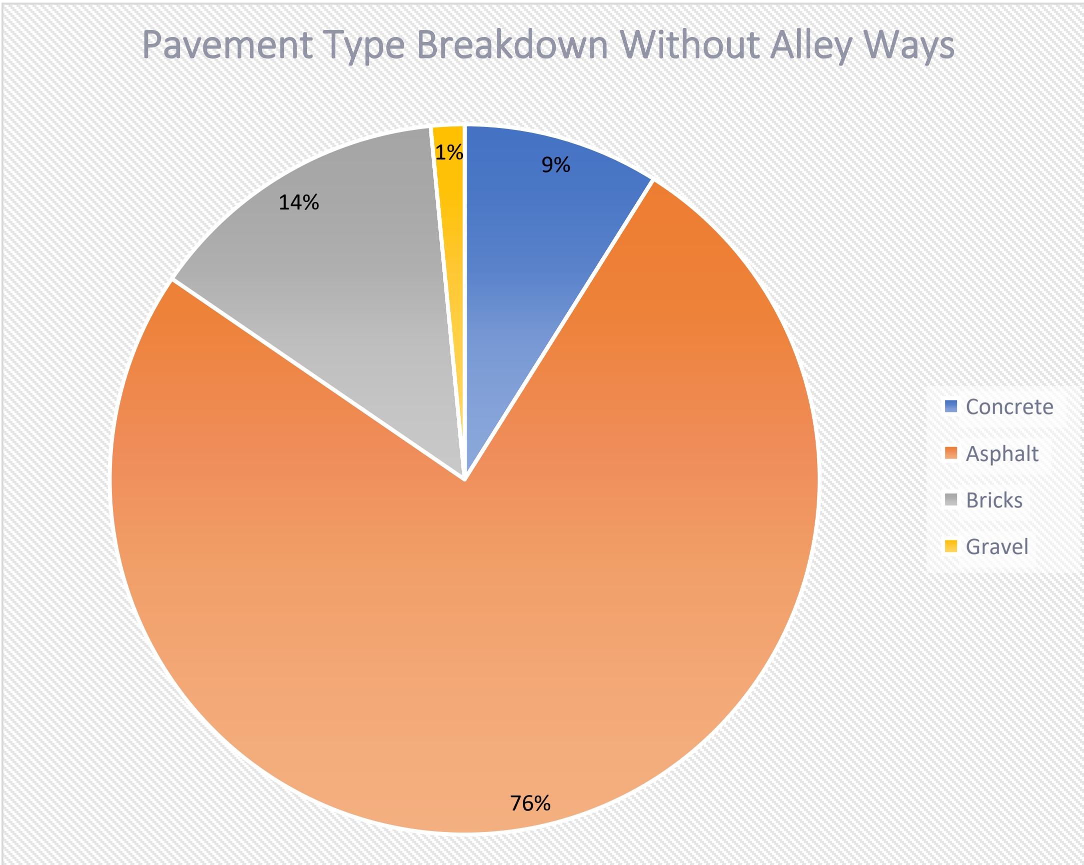


4.2.2 Pavement Surface Type and Width of Segments

The pavement surface type defines the types of pavement that make up a roadway. Each type of pavement performs differently under variable loading conditions. Several surface types were identified in the field (asphalt, gravel, brick, and concrete), with the majority being conventional asphalt pavement. The width of segments were recorded to help evaluate the estimated costs of repairs based on total square footage of roadway segments.

Figure 5, on the following page, shows the pavement surface type distribution of the network. Approximately 76% of the network is asphalt pavement, 9% is concrete pavement, 14% are brick pavers, and the remaining 1% is gravel.

Figure 5: Pavement Type Breakdown Without Alley Ways



4.2.3 Roadway Classification

The roadway classification defines the functional classification of a roadway segment. Each classification then differentiates the types of loading a street segment can go through in its life cycle. For this project, several classifications were identified (Local Road, Minor Collector, Major Collector, Minor Arterial, and Principal Arterial), with the majority being local roads.

4.2.4 Network Priority Ranking

The spreadsheet uses the concept of Network Priority Ranking (NPR) to prioritize the pavement segment repair selection. This calculation for prioritization 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. Each of the factors has a rank (weight) associated with it, which is defined by the spreadsheet user. The priority fields for the program development were identified through discussions with KYOVA and the City of Huntington staff. PCI was significantly the heaviest weighted factor, followed by other priority fields. A summary of each parameter and its associated NPR weight is shown in **Equation 1 and 2**, on the following page.

Equation 1: NPR Parameters with weighted factors for street segments

$$\frac{Network\ Priority\ Ranking}{(Streets)} = 8\left(\begin{array}{c}\underline{\text{PCI}}\\ \\ \frac{(0-10)=10}{\frac{(11-20)=9}{\frac{(21-30)=8}{\frac{(31-40)=7}{\frac{(41-50)=6}{\frac{(51-60)=5}{\frac{(61-70)=4}{\frac{(71-80)=3}{\frac{(81-90)=2}{(91-100)=1}}}}}}}}}\end{array}\right) + 7.5\overset{\underline{\text{Width}}}{\left(\frac{(19>X)=0}{\frac{(19<X>25)=5}{(25<X)=10}}\right)} + 4\overset{\underline{\text{Road Classification}}}{\left(\frac{(Principal\ Arterial)=10}{\frac{(Minor\ Arterial)=8}{\frac{(Major\ Collector)=6}{\frac{(Minor\ Collector)=4}{(Local\ Road)=2}}}}\right)}$$

Equation 2: NPR Parameters with weighted factors for sidewalk segments

$$\frac{Network\ Priority\ Ranking}{(Sidewalk)} = 2.5\left(\begin{array}{c}\underline{\text{PCI}}\\ \\ \frac{(0-10)=10}{\frac{(11-20)=9}{\frac{(21-30)=8}{\frac{(31-40)=7}{\frac{(41-50)=6}{\frac{(51-60)=5}{\frac{(61-70)=4}{\frac{(71-80)=3}{\frac{(81-90)=2}{(91-100)=1}}}}}}}}}\end{array}\right) + 1.5\overset{\underline{\text{Width}}}{\left(\frac{(5>X)=1}{(X<5)=5}\right)} + \overset{\underline{\text{Sidewalk Replacement Program}}}{\left(\frac{(Yes)=5}{(No)=0}\right)}$$

4.2.5 Pavement Repair Activities Defined

Repair activities are intended to increase the pavement life expectancy. Repairs in the preventative maintenance category, such as crack sealing and surface sealing, are intended to slow 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 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 costly. They essentially start the life-cycle over by increasing the condition rating to 100, but at the highest expense. The effects of different repairs on the pavement life-expectancy are shown in **Table 3**, on the following page. This information was obtained from The Federal Highway Administration (FHWA); 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.

Table 3: Extended Service Life Gains for Pavement Treatments

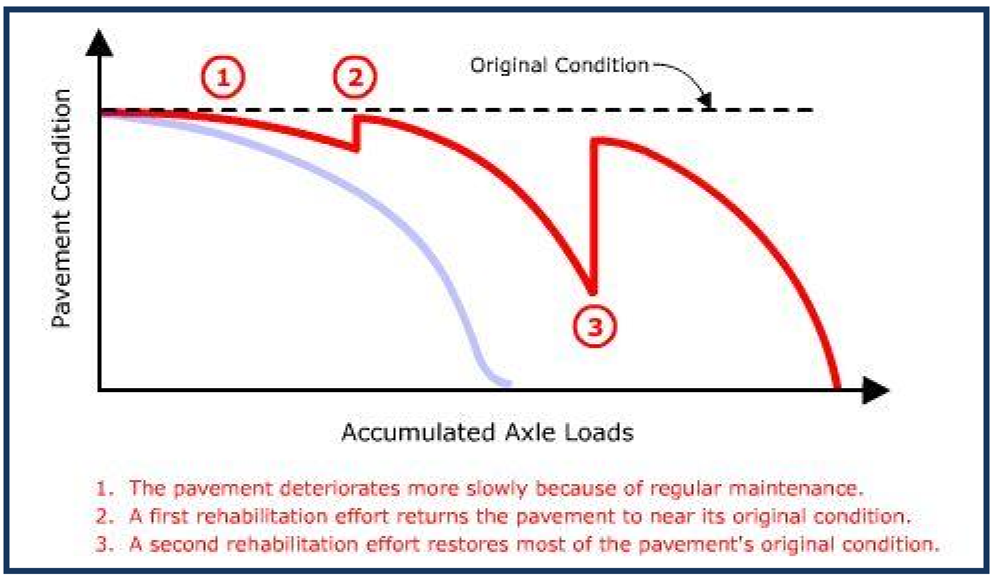
Repair Activity	Pavement Type	Extended Service Life (Years)
Overband Crack Sealing	Flexible	Up to 2
	Composite	Up to 2
Crack Sealing	Flexible	Up to 3
	Composite	Up to 3
	Rigid	Up to 3
Single Chip Seal	Flexible	3 to 6
	Composite	NA*
Double Chip Seal	Flexible	4 to 7
	Composite	3 to 6
Slurry Seal	Flexible	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 is not available to determine life-extending value
**Additional information is necessary to quantify the extended life more accurately

Figure 6, below, demonstrates the effects on pavement condition that preventative maintenance, rehabilitation, and reconstruction have throughout the life-cycle.

Figure 6: Repair Effects of Pavement Deterioration with Time



Source: http://classes.engr.oregonstate.edu/cce/winter2012/ce492/Modules/11_pavement_management/11-2_body.htm#effect

Deterioration rates of pavements are dependent on several different factors. Despite the rate of deterioration, it has become a well adopted concept proven continuously in the field that the deterioration of a pavement can be offset, and the life of a pavement greatly extended by properly performing maintenance and repair strategies at the appropriate times during the lifecycle of a pavement. As the life of a pavement is extended by performing less costly preventative maintenance and rehabilitation repairs, rather than constantly allowing a pavement to deteriorate to the point where more costly reconstruction is required, the more cost efficient the pavement life cycle will be. Over an entire pavement network, performing these typical repairs can yield significant long-term cost savings. While every pavement will require its own assessment to determine the best repair at the best time, there have been several studies performed to try to determine the typical preventative maintenance and rehabilitation schedule during the life of a pavement. **Table 4**, on the following page, shows the results of one study completed by the Minnesota Department of Transportation (MnDOT). While the typical pavement segment for a MnDOT pavement segment might slightly vary from that of a West Virginia pavement segment due to differing environmental conditions, the repair schedule still generally provides great scheduling insight for the City of Huntington.

MnDOT has studied the typical pavement repair cycle for multiple different scenarios, such as for asphalt pavement and concrete pavement, and also for high traffic loading and low traffic loading. **Table 4** is for an asphalt surface type with lower traffic counts. It is important to realize that the time shown for each repair assumes that all previous preventative maintenance and rehabilitation repairs have been performed. For example, the first mill and overlay can be expected somewhere around year 20 of the pavement life. This assumes that proper crack sealing was performed when needed and a surface treatment, such as a seal coat, was also performed when needed. If no work was done prior, it should be anticipated that the mill and overlay would be required significantly sooner than year 20 of the pavement life.

Table 4 provides great insight and can help in planning future repairs for the City of Huntington program, however, it should be noted that the years shown are just approximates, and that each pavement segment could require preventative maintenance or rehabilitation repairs much sooner or later than the years provided below.

Table 4: Typical Preventative Maintenance and Rehabilitation Schedule

Bituminous Pavement with 20-year BESALs less than 7 million
Year 0 – Initial construction
Year 6 - Rout and seal cracks
Year 10 – Surface treatment
Year 20 – Mill and overlay
Year 23 – Rout and seal cracks
Year 27 – Surface treatment
Year 35 – Mill and overlay
Year 38 – Rout and seal cracks
Year 43 – Surface treatment
Year 50 – End of analysis (no residual value)

4.2.6 Repair Activities and Estimated Costs

Pavement repair activities were developed for planning and budgeting purposes for KYOVA and the City of Huntington. The type of repair activity is chosen based on the PCI and pavement surface type. For example, a light rehabilitation repair activity is applied if the segment is asphalt and the PCI falls within the range of 41 to 59. Since the activities are intended to address multiple segments that may fall into a PCI range due to varying distresses, they are setup to account for multiple repair actions instead of a single action for one particular distress. However, before maintenance is performed on a specific segment, a detailed evaluation of this segment needs to be performed. Based on this project-level analysis, it may be determined that an alternative approach, such as isolated patching with a thick asphalt overlay, is more desirable based on field conditions. 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 but are not necessary year after year. These repairs are those associated with preventative maintenance, like crack filling segments on a periodic basis, such as every few years, which is typically recommended. These general repair activities were created for each pavement surface type throughout the condition spectrum. The only exceptions are for pavements with a PCI more than 90. Pavements with these ratings generally require no action be taken because they are in new or excellent condition.

The unit costs for repair activities used in the program also greatly affect the results, and in this case, were modeled to parallel bid results from recent, actual projects in the City of Huntington. Where data could not be gathered from information provided by the City of Huntington, unit costs from other recent projects in nearby areas were used. Each activity has a specific unit cost and budget type associated with it. **Table 5** below and **Table 6**, on the following page, outline the spreadsheet asphalt repair activities and concrete repair activities used in the City of Huntington work plan, respectively.

Table 5: Concrete Repair Activities

Remediation Type	PCI Range	Pavement Surface Type	Typical Repairs	**Average Cost (per SF)
Preventative Maintenance	89 to 80	Concrete	▪Crack sealing (up to 50% of area)	$0.10
	79 to 70	Concrete	▪Crack sealing	$0.20
	69 to 60	Concrete	▪Crack sealing and joint cleaning/sealing	$0.50
Light Rehabilitation	59 to 51	Concrete	▪Crack sealing and joint cleaning/sealing ▪Full depth joint repair	$1.00
	50 to 41	Concrete	▪Full depth joint repair ▪Chipping and patching spalled joints ▪Removal of isolated slabs	$1.78

Rehabilitation	40 to 31	Concrete	▪Full depth joint repair ▪Chipping and patching spalled joints ▪Removal of isolated slabs ▪Asphalt overlay ▪Re-stripe	$5.00
	30 to 21	Concrete	▪Subgrade undercutting and backfill ▪Joint and slab preparation ▪Full surface overlay	$8.40
Reconstruction	20 to 11	Concrete	▪Subgrade undercutting and backfill ▪Joint and slab preparation ▪Full surface overlay	$12.00
	10 to 1	Concrete	▪Full-depth concrete and base reconstruction required ▪Re-stripe	$15.75
	0	Concrete	▪Full-depth concrete and base reconstruction required with undercutting to strengthen sub-grade ▪Re-stripe	$20.10

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

Table 6: Asphalt Repair Activities

Remediation Type	PCI Range	Pavement Surface Type	Typical Repairs	**Average Cost (per SF)
Preventative Maintenance	89 to 80	Asphalt	▪Crack sealing (up to 50% of area)	$0.05
	79 to 70	Asphalt	▪Crack sealing	$0.11
	69 to 60	Asphalt	▪Crack sealing (some cracks may require routing)	$0.25
Light Rehabilitation	59 to 51	Asphalt	▪Crack sealing (requires routing) ▪Crack repairs (partial-depth milling and patching) ▪Cut and patch (up to 3% of area) ▪Surface seal (seal coat or slurry seal) ▪Re-stripe	$1.00
	50 to 41	Asphalt	▪Crack sealing (requires routing) ▪Cut and patch or isolated mill and replace (up to 10% of area) ▪Surface seal (slurry seal or micro-surface) ▪Thin asphalt overlay ▪Re-stripe	$1.50
Rehabilitation	40 to 31	Asphalt	▪Cut and patch or isolated mill and replace (up to 20% of area) ▪Thick overlay or partial-depth mill and replace (shallow-depth or profile) entire area ▪Re-stripe	$1.85
	30 to 21	Asphalt	▪Partial-depth mill and replace entire area ▪Proof-roll and perform incremental milling and replacement or full depth repairs where required ▪Repair isolated distress areas and overlay entire segment depending on existing site conditions ▪Re-stripe	$2.78
Reconstruction	20 to 11	Asphalt	▪Remove existing asphalt with full-depth milling or pulverization ▪20% base repair with undercutting to strengthen sub-grade ▪Addition of sub-base as needed ▪Install replacement asphalt section ▪Re-stripe	$3.78
	10 to 1	Asphalt	▪Full-depth asphalt and base reconstruction required ▪Re-stripe	$5.50
	0	Asphalt	▪Full-depth asphalt and base reconstruction required with undercutting to strengthen sub-grade ▪Re-stripe	$9.00

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

4.3 Prioritization

To determine the order in which repairs will be completed, a prioritization system must be established. Based on discussions with City of Huntington staff, several factors, in addition to the PCI of the roadway segments, were considered for determining the prioritization of repair projects. Priority was given to road classification, width, future construction projects, and where roadway segments cross state roadways or railroads. While each of these prioritization factors played an important role in determining the repair recommendations, the PCI, as determined during the Kimley-Horn field assessments, remained the heaviest weighted factor. The equations for calculating each prioritization value are shown in **Equation 1** and **2** in the previous section (page 15). The street prioritization functions as such: if you have a minor arterial that has a width of 24’ and a PCI rating of 40, its NPR will equate to 126 (Very High). Whereas, if you have a local road with a width of 24’ and a PCI of 30, the NPR would be 110 (High). This shows that even though the local road has a lower PCI value, the roadway with a higher traffic volume is given priority. Along the parameters noted, Kimley-Horn has also collected additional data on whether a road segment is adjacent to a state route or train tracks. This will aid in securing state funds for pavement repairs, or to coordinate road repairs with adjacent state projects. The sidewalk prioritization is calculated in a similar way. The sidewalk prioritization functions as such: if you have a segment that is part of the replacement program, that has a width of 5’ and PCI rating of 40, this will result in an NPR of 27 (High). If you have a segment that is not part of the replacement program, that has a width of 10’ and PCI rating of 20, this will result in an NPR of 30 (Very High). This indicated that even though some segments currently are part of the replacement plan, there are additional segments that should be given higher priority. In addition to the sidewalk’s NPR value, the excel sheets indicate the adjoining street’s priority level to help indicate during the budget phase if additional funds should be allocated for both roadway with sidewalk repairs. The prioritization breakdown is provided in **Table 7** and **8** on the following pages.

Table 7: Priority Level Summary for Streets

Priority Level	Priority Value
Very High	**115<**
High	**96-115**
Medium - High	**86-95**
Medium	**71-85**
Low - Medium	**51-70**
Low	**0-50**

Table 8: Priority Level Summary for Sidewalks

Priority Level	Priority Value
Very High	**28<**
High	**25-28**
Medium - High	**21-25**
Medium	**16-20**
Low - Medium	**8-15**
Low	**0-7**

The prioritization and weighted factors are based on Kimley-Horn's philosophy of pavement management. This program is designed to provide KYOVA and the City of Huntington with a measure for determining where funding should focus. This includes roadways that need preventative maintenance, roadways that need full reconstruction, and all other repair strategies in between. The program will also allow the end user to manipulate prioritization to fit their own pavement management philosophy. These tools are meant to be dynamic and have the ability to evolve as new information and changes in city priorities affect the city's roadway network.

4.4 Estimated Costs

Kimley-Horn Calculated the backlog of work that exists within the City of Huntington network. It was estimated that more than $22,000,000 in roads and $6,000,000 in sidewalk repairs is needed to complete all current backlogged work. In this scenario, each segment of roadway received any repair that helped increase the overall PCI. Although this is an extreme comparison, it demonstrates where the City of Huntington's current repair budget is compared to the "best-case" scenario. The information in **Tables 9** and **10,** summarizes the results of the backlog calculation for streets and sidewalk.

It's unrealistic for the City of Huntington to spend this type of money, therefore the key is for the City to find a median spending level that both meets a realistic budget plan while maintaining the network PCI at an acceptable level.

Table 9: Optimal Budget Breakdown

Pavement Repair Type	Percentage
Preventative Maintenance	**5%**
Light Rehabilitation	**20%**
Rehabilitation	**50%**
Reconstruction	**25%**

Table 10: Summary of Cost per Pavement Repair Type for street segments

Pavement Repair Type	Total Estimated Cost
Preventative Maintenance	**$ 1,796,900.00**
Light Rehabilitation	**$ 9,367,500.00**
Rehabilitation	**$ 6,529,000.00**
Reconstruction	**$ 4,622,000.00**
Total Estimated Cost	**$ 22,315,400.00**

Table 11: Summary of Cost per Pavement Repair Type for sidewalk segments

Sidewalk Repair Type	Total Estimated Cost
Preventative Maintenance (10% Slab Removal)	**$ 514,000.00**
Light Rehabilitation (40% Slab Removal)	**$ 3,776,500.00**
Rehabilitation (80% Slab Removal)	**$ 1,375,300.00**
Reconstruction (100% Slab Removal)	**$ 240,900.00**
Total Estimated Cost	**$ 5,906,700.00**

To promote more balanced prioritization management practices in the program, the annual budget should be intentionally split up to assure pavements entire life cycle curve are given funding where needed. The repair strategy budget breakdown is shown in **Tables 11** and **12**. This approach helps assure that appropriate funding levels are being applied to areas of need in a cost-effective way. A percentage of the budget should be used for reconstruction repairs, rehabilitation repairs, and preventative maintenance repairs, while sidewalks should be prioritized based on when a road repair is being performed. This will help minimize the disturbance to residents of that street. There should also be an additional budget generated to help budget for independent sidewalk repairs to be used for maintaining the city's sidewalks in a similar way. It is important to keep in mind that while the cost to benefit ratio is much higher for preventative maintenance repairs, these repair types are also much less expensive per square-foot of pavement. Therefore, it takes a much smaller percentage of the budget to complete these types of repairs across a larger percentage of the overall pavement network when compared to rehabilitation and reconstruction type repairs. In the case of the City of Huntington's pavement management program, the vast majority of the budget is reserved for the rehabilitation repair strategy bucket.

Table 12: Budget Plan for Road Segments

Pavement Maintenance Type	Allocation
Reconstruction (PCI 0-20)	**25%**
Rehabilitation (PCI 20-40)	**50%**
Light Rehabilitation (PCI 40-60)	**20%**
Preventative Maintenance (PCI 60-90)	**5%**
Total	**100%**

Table 13: Budget Plan for Sidewalk Segments

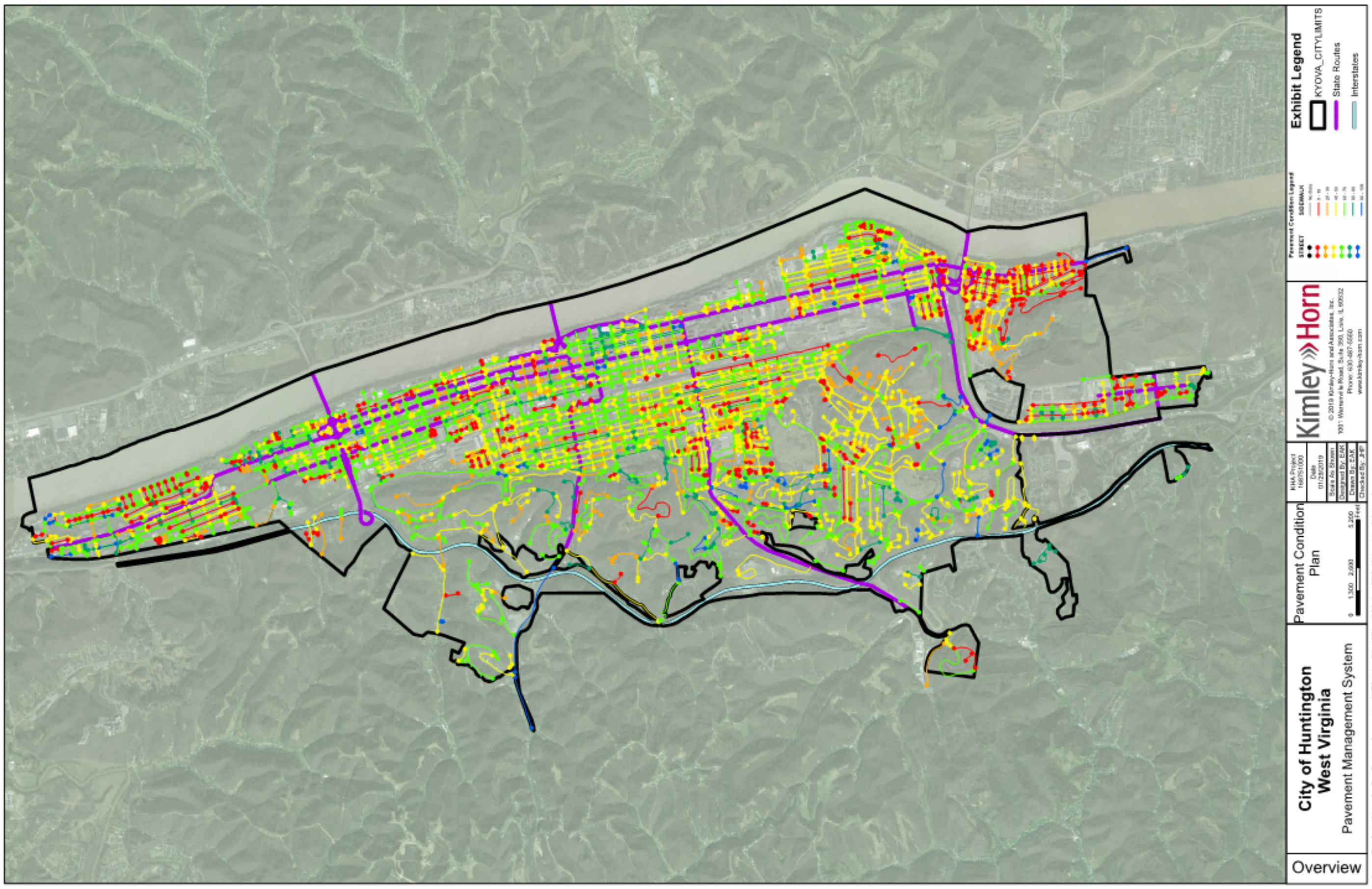
Sidewalk Maintenance Type	Allocation
Preventative Maintenance (10% Slab Removal)	**5%**
Light Rehabilitation (40% Slab Removal)	**25%**
Rehabilitation (80% Slab Removal)	**30%**
Reconstruction (100% Slab Removal)	**40%**
Total	**100%**

4.5 GIS Mapping Tools

To help the City of Huntington easily identify areas of concern, a visualization tool was set up in ArcGIS that uses a defined color-coding scheme based on the modified PASER PCI ratings, as shown in **Figure 7**, on the following page. First, the centerlines associated with each individual pavement segment were exported to a GIS shapefile and assigned a unique ID. The unique ID was then linked to the data exported to the spreadsheet to associate each centerline with output from the model. The color scale was then applied to the pavement segment shapefile, automatically shading sections based on the PCI value.

By utilizing ArcGIS, the method seamlessly links the spreadsheet with the individual pavement segment. The process eliminates the need to manually color individual pavement segments, saving time and cost as PCI values change year to year. After running the model and exporting the PCI values, the colors associated with each roadway can be updated automatically on the City of Huntington's PCI map by simply replacing the PCI values in the linked spreadsheet.

Figure 7: GIS Mapping Tool



5. Recommendations

By utilizing the spreadsheet and GIS mapping tools, KYOVA, and the City of Huntington are able to review and generate reports to identify and prioritize roadways based on estimated costs and priority levels as discussed previously in the report. The next steps after learning how to operate and utilize the Pavement Management Program is for KYOVA and the City of Huntington to work together to develop a plan for repairing and maintaining the streets that are identified in the Pavement Management Program Tools.

5.1 Developing Annual Pavement Repair Budget

Repair strategy budgets should be developed to promote more balanced prioritization management practices in the program. Defining separate repair strategy budget categories also helps assure that the appropriate funding levels are being applied to areas of need in a cost-effective way. Based on the analyses performed during this project, current optimal budget breakdown is as follows: 5% preventative maintenance, 20% light rehabilitation, 50% rehabilitation, and 25% reconstruction. The budget breakdown should be evaluated annually to obtain the most efficient program results. For example, some years it may be necessary for the reconstruction budget to exceed 25% to address larger road segments that cost more than the typical reconstruction budget is able to provide.

5.2 Project Prioritization

The City of Huntington will need to spend time with the GIS shapefiles and Microsoft Excel spreadsheets to calculate and plan their next steps forward. These tools were instrumental in successfully prioritizing roadways based on condition and other tangible factors. This model does not provide the knowledge of conditions that might be subjective to an individual living and working within the city limits. The prioritization of this tool should be filtered and expanded upon by KYOVA and the City of Huntington to identify projects based on their own knowledge and needs which change on a daily and annual basis.

5.3 Project-Level Analysis

We recommend that the City of Huntington take caution in using this plan for direct funding of repair projects. The purpose of an analysis of this level is to confirm network funding levels and assist in selecting projects. Once projects are selected, a detailed project-level analysis should be performed. A project-level analysis should identify the most cost-effective repair techniques, establish the scope of the project, develop a detailed project budget, and prepare a project schedule. We recommend the City of Huntington enlist the services of a licensed engineer to assist in the development of design plans. Additionally, we recommend that the City perform inspections during construction for quality control and quality assurance measures. The most current City of Huntington and State of West Virginia standards and specifications should be followed for all design and construction services.

5.4 Program Updates and Maintenance

Significant investment has been made to inventory the City of Huntington pavement network and in the development of this management program. Continued investment in the program is strongly recommended. The maintenance and repair database within GIS should be updated annually, or as repair measures are completed. The City of Huntington should also assess the work plan annually to account for any changes that may have occurred throughout the network. Lastly, Kimley-Horn recommends reassessing the current pavement conditions on a 3-5 year cycle. Results should be compared and the database inputs updated to account for actual deterioration life cycles of the existing network.

6. Conclusion

This Pavement Management Plan is the first step for KYOVA and the City of Huntington to reference and utilize an engineered document through a third-party consultant. Through many of the discussions with the City and KYOVA, a recurring theme was that many of the existing pavement management techniques were governed either by political pursuits, or the frustration of residents, which often go hand-in-hand. Kimley-Horn was able to bring years of expertise to KYOVA and the City to produce effective tools that will be utilized years into the future for managing the City's pavements and determining projects based on the optimal factors.

Many of the roadways identified in the City fall within the range of the "critical PCI", meaning that the time to proactively maintain and extend the lives of the pavements is now. The tools developed in this report identify which streets are at that critical point, through easily filterable and sortable tools, and visual maps that outline a clear path for the City to develop projects and budgets in the future. While this specific project has concluded, these tools can be easily modified as the City desires. During the Stakeholders Meeting that was held in May of 2019, a resident posed the question of using the tool to identify roadways that could be restriped to include bike lanes or new pedestrian crosswalks and wayfinding. While these features were not included in this project, these features could easily be added into the provided tools, through GIS attributes and additions into the spreadsheets. The features that could be added into these tools is nearly limitless. Kimley-Horn looks forward to continuing to develop and maintain these tools for KYOVA and the City of Huntington well into the future.