2017 Pavement Management Services
Pavement Condition Report
City of Amarillo, TX

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1.0 Executive Summary

This report is a summary of the City of Amarillo, TX pavement condition assessment performed throughout May and June of 2017; and provides pavement condition data and maintenance recommendations for the City's maintained roadway network. The report provides the information pertaining to the methodology used to perform the pavement condition survey and analysis, outlines the pavement maintenance and preservation methods that can be used by the City for the roadway network, and details funding guidelines and recommendations for pavement maintenance and preservation activities.

VUEWorks® Asset Management Software was used to calculate a Pavement Condition Index (PCI) value, analyze funding, and compare maintenance and preservation activities. VUEWorks® was also used in the development of various five-year pavement maintenance and preservation programs for the City's consideration.

The City's roadway network system surveyed as part of this pavement condition project included:

Item	Description	Centerline Miles	% of Centerline Miles
1	Asphalt Segments with PCI	986.04	95.50%
2	Concrete Segments with PCI	5.95	0.57%
3	Brick Roads	20.01	1.94%
4	Construction	0.85	8.00%
5	Not Collected – Does Not Exist	10.31	1.00%
6	Not Collected – Inaccessible	2.98	29.00%
7	Not Collected – Unsurfaced	6.40	0.62%
	TOTAL WITH PCI	991.99	96.07%
	TOTAL WITHOUT PCI	40.54	3.93%
	Total	1032.54	100%

Figure 1: City of Amarillo, TX Inspection Breakdown

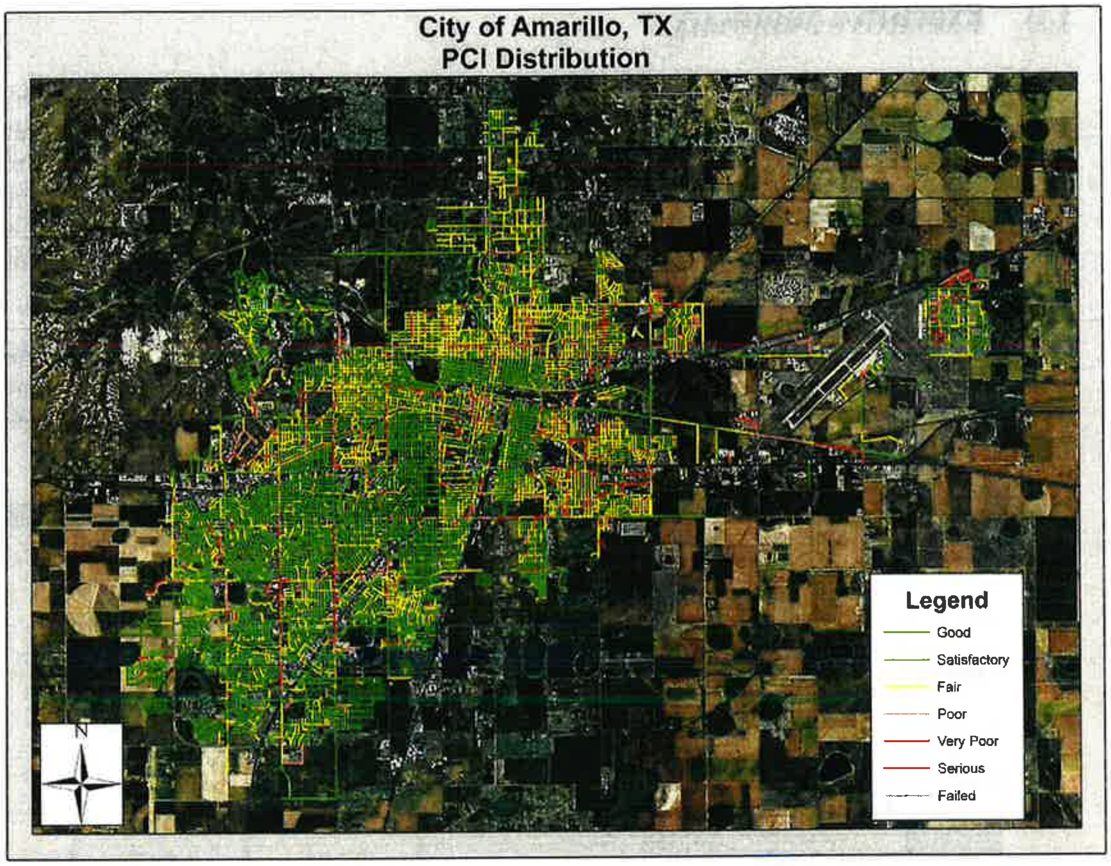


Figure 2: City of Amarillo, TX PCI Distribution Map

Review of the City's PCI value shows a general breakdown of the roadway by condition to be:

Pavement Condition Index (PCI) Range	Condition Description	Percent of Network	Legend
86-100	Good	9.51%	
71-85	Satisfactory	49.93%	
56-70	Fair	27.35%	
41-55	Poor	8.20%	
26-40	Very Poor	3.97%	
11-25	Serious	0.97%	
0-10	Failed	0.07%	
	Total	100%	

Figure 3: City of Amarillo, TX PCI Ranges by Percent

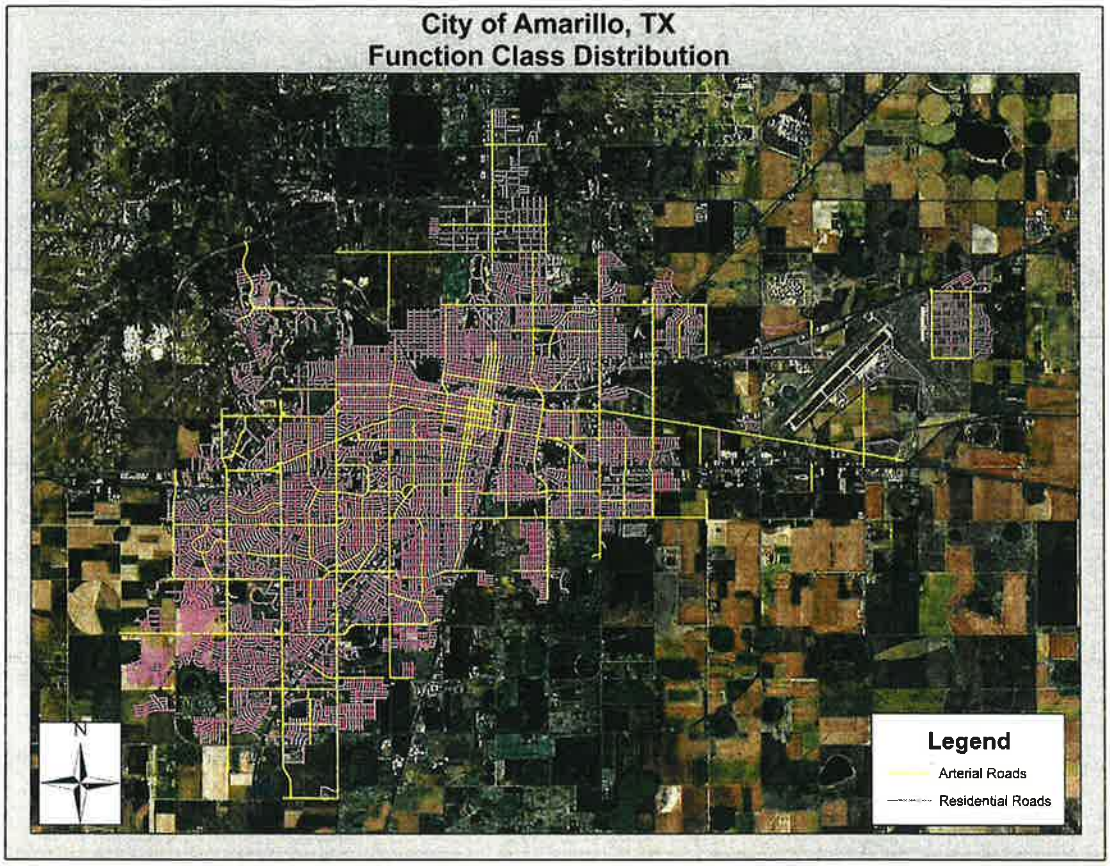


Figure 4: City of Amarillo, TX Function Class Distribution Map

The following tables provide a summary of the network overall pavement condition based on surface type and function class:

	City of Amarillo, TX Roadway Network by Surface Type						
	Good (86-100)	**Satisfactory** (71-85)	**Fair** (56-70)	**Poor** (41-55)	**Very Poor** (26-40)	**Serious** (11-25)	**Failed** (0-10)
Asphalt	9.24%	49.75%	27.34%	8.12%	3.93%	0.95%	0.07%
Concrete	0.27%	0.18%	0.01%	0.08%	0.04%	0.02%	0%
All	9.51%	49.93%	27.35%	8.20%	3.97%	0.97%	0.07%

Figure 5: City of Amarillo, TX Roadway Network by Surface Type with PCI Percentile

City of Amarillo, TX Roadway Network by Function Class					
	Arterial		Residential		All
	Asphalt	Concrete	Asphalt	Concrete	
Good (86-100)	2.09%	0.12%	7.15%	0.15%	9.51%
Satisfactory (71-85)	7.59%	0.12%	42.16%	0.06%	49.93%
Fair (56-70)	5.49%	0.01%	21.85%	0%	27.35%
Poor (41-55)	2.64%	0.05%	5.48%	0.03%	8.20%
Very Poor (26-40)	1.51%	0%	2.42	0.04%	3.97%
Serious (11-25)	0.37%	0%	0.58%	0.02%	0.97%
Failed (0-10)	0%	0%	0.07%	0%	0.07%

Figure 6: City of Amarillo, TX Roadway Network by Function Class with PCI Percentile

The average network PCI for the City's roadway at the time of collection was calculated to be **71**. This value indicates the roadway network is generally in 'Satisfactory' condition.

In order to develop a five-year long-term pavement maintenance and preservation program with corresponding budgets, the City of Amarillo has set a current yearly pavement budget of $7,597,000.00 for its road network. Based on the pavement maintenance and preservation methods outlined in Section 7 of this report, the City of Amarillo will experience a significant drop in their network PCI if they maintain their current budget for road maintenance. If the road maintenance budget is allocated relative to Section 7.3: 5-Year Current Budget Scenario (Worst Best) the City will slightly see an improvement in their network PCI. This and other budget scenarios can be found in Section 7.

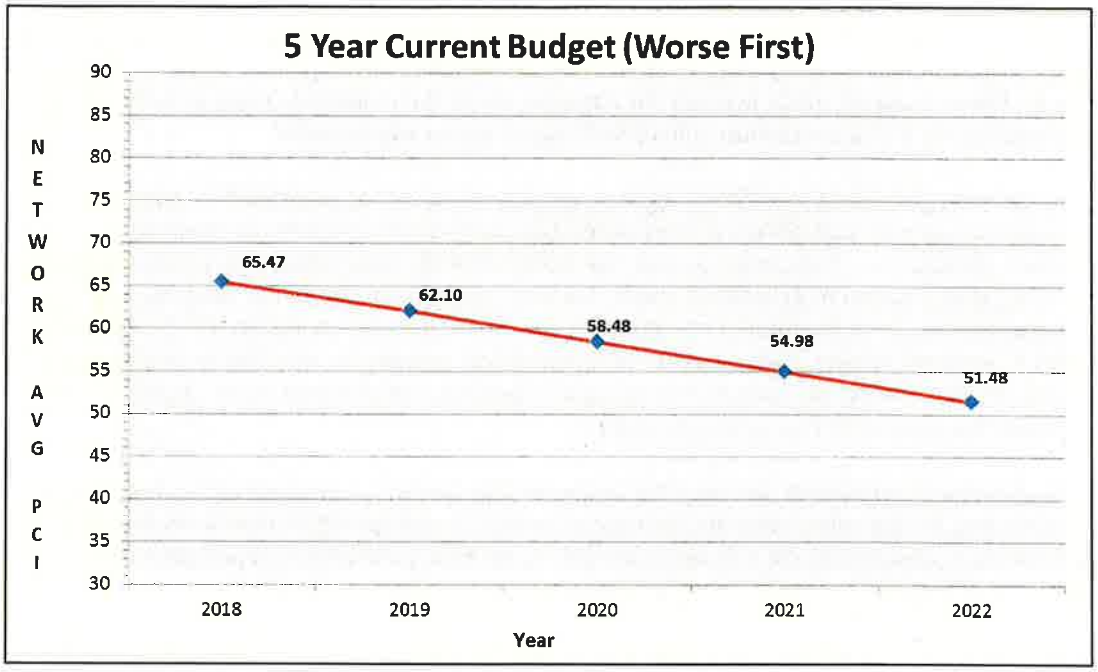


Figure 7: 5-Year Current Budget Scenario (Worst First) – PCI Plot

5-Year Current Budget (Worst First)		
Year	**Avg. PCI**	**Budget Required**
2018	65.47	$7,596,912.60
2019	62.10	$7,824,885.12
2020	58.48	$8,059,647.72
2021	54.98	$8,301,433.99
2022	51.48	$8,550,480.18

Figure 8: 5-Year Current Budget Scenario (Worst First) – Budget Information

2.0 Introduction

Data Transfer Solutions, LLC (DTS) performed a pavement condition survey throughout May and June of 2017 on 2,065 lane miles of the City's street network. DTS used a Mobile Asset Collection (MAC) vehicle to collect street level right-of-way images and pavement images. The collected pavement images were used to determine street segment pavement conditions while the street level right-of-way images were used to identify and extract various roadway assets.

Roadway networks are usually divided into four pavement surface types: asphalt (AC), concrete (PCC), brick (BR), and unsurfaced (UNS). Due to the nature and scope of the project, pavement imagery and data were only collected on asphalt, concrete, and brick roads. These types of roads account for the entirety of the collected roadway network, with approximately 1,012 centerline miles (98.01%) of surveyed roadway.

The project pavement condition survey employed a set of pre-defined parameters to develop a segment and network level index (number) that correlates to existing pavement surface conditions. This project used the ASTM D6433 'Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys' pavement condition analysis method to determine the road segment and network pavement condition index (PCI). The ASTM D6433 method covers the process of quantifying pavement conditions and identifies pavement distress types, distress extent measurements, and distress severity. ASTM D6433 outlines the method of PCI value calculation.

This pavement condition survey PCI becomes the basis for management, maintenance, project, and budget decisions for the City of Amarillo. Using the PCI value as the basis for pavement related decisions will allow the City to build a quantifiable, repeatable process for planning annual pavement maintenance or preservation project funding.

This project used VUEWorks® Asset Management Software for calculating the PCI value, analyzing the network PCI ranges, setting maintenance procedures and associated costs, developing budgets, and planning projects to meet the City's pavement maintenance requirements.

3.0 Purpose

The purpose of this document is to describe the tools, processes, and procedures used to collect and analyze the pavement condition data as well as provide a summary of the results obtained from calculating each segment's PCI using VUEWorks®

4.0 Project Scope & Methodology

The overall project scope of work contains five tasks outlined below:

- Verify City Street Network
- Mobile Image Data Collection
- Pavement Condition Assessment
- Pavement Final Report
- Budgeting Scenarios

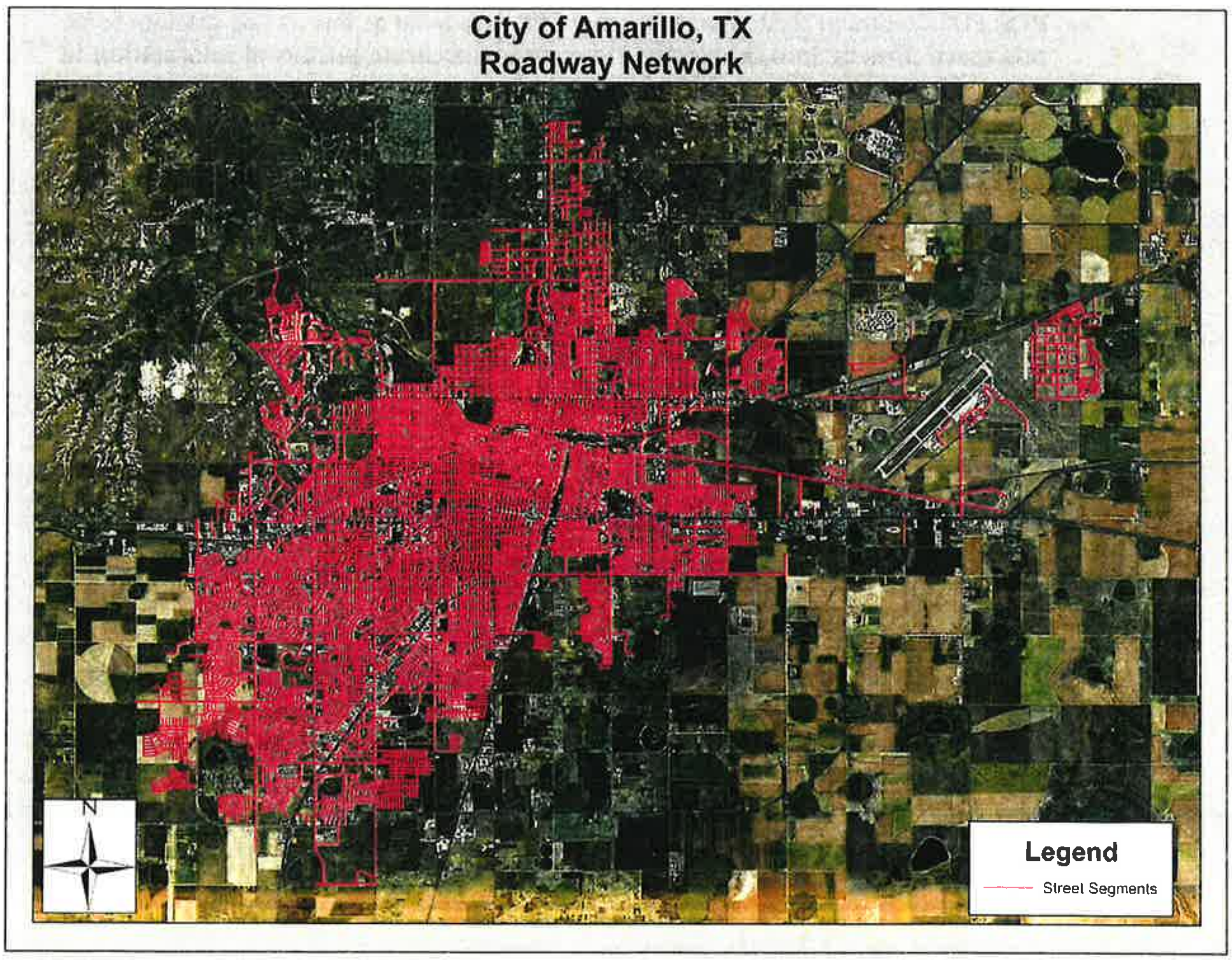


Figure 9: City of Amarillo, TX Roadway Network

5.0 Automated Data Collection and Equipment

In order to determine the general distress characteristics of each roadway segment, DTS utilized one of our Mobile Asset Collection (MAC) vehicles to collect street-level right-of-way imagery and downward pavement imagery. The automated distress data collection was performed in general accordance with ASTM D6433 (Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys) and ASTM Standard E1656 (Standard Guide for Classification of Automated Pavement Condition Survey Equipment), utilizing a Class 1 device as defined by the specifications.

DTS MAC vehicles combine multiple engineered technologies to collect real-time pavement data, right-of-way data and images at posted speed limits. This effectively eliminates the need to place pavement inspection technicians in the field in close proximity to vehicle traffic. Some MAC vehicle components include:

Navigation System

- **IMU**: Inertial Measurement Unit generates a true representation of vehicle motion in all three axes; producing continuous, accurate position and orientation information
- **PCS**: POS Computer System enables raw GPS data from as few as one satellite to be processed directly into the system, to compute accurate positional information in areas of intermittent, or no GPS reception
- **GPS Receivers**: Embedded GPS receivers provide heading aiding to supplement the inertial data
- **GPS Antennas**: Two GPS antennas generate raw observables data
- **Sub-meter accuracy:** The system is rated to get 0.3 m accuracy in the X,Y position and 0.5 m in the Z position

Distance Measuring Indicator (DMI)

- Allows for collection of high resolution imagery at posted speeds. Distance Measurement Indicator computes wheel rotation information to aid vehicle positioning.

Cameras

- High-definition cameras with precision lenses allow for accurate asset extraction and videolog recording
- Frame rate: 15 images per second, with 1936x1456 color resolution

Pavement Imaging System

- Two line-scan cameras and lasers configured to image 4m transverse road sections with 1 mm resolution (4000 pixel) at speeds that can reach 100 km/h
- Allows fully illuminated pavement image collection even in heavy shadow/canopy areas

Figure 10: DTS MAC Vehicle

Downward-facing pavement imagery was collected to be used in quantifying distress type, severity and extents present on segments of road. The resolution of the imagery allowed for distresses to be easily identified and measured during the analysis portion of the contract.

Mobile image collection of the City's roadway network was accomplished through coordination with City's staff. Efforts associated with the mobile image collection included review of client GIS street centerline file, route planning based on GIS street centerline, and coordination of existing construction projects along the City's streets. All MAC image collection routes were reviewed by both DTS and the City's staff to assure all of the City's streets attained complete image coverage. This effort was accomplished by reviewing a GIS shapefile of the MAC daily GPS point associated to each image collected overlaid on the City's GIS street centerline file.

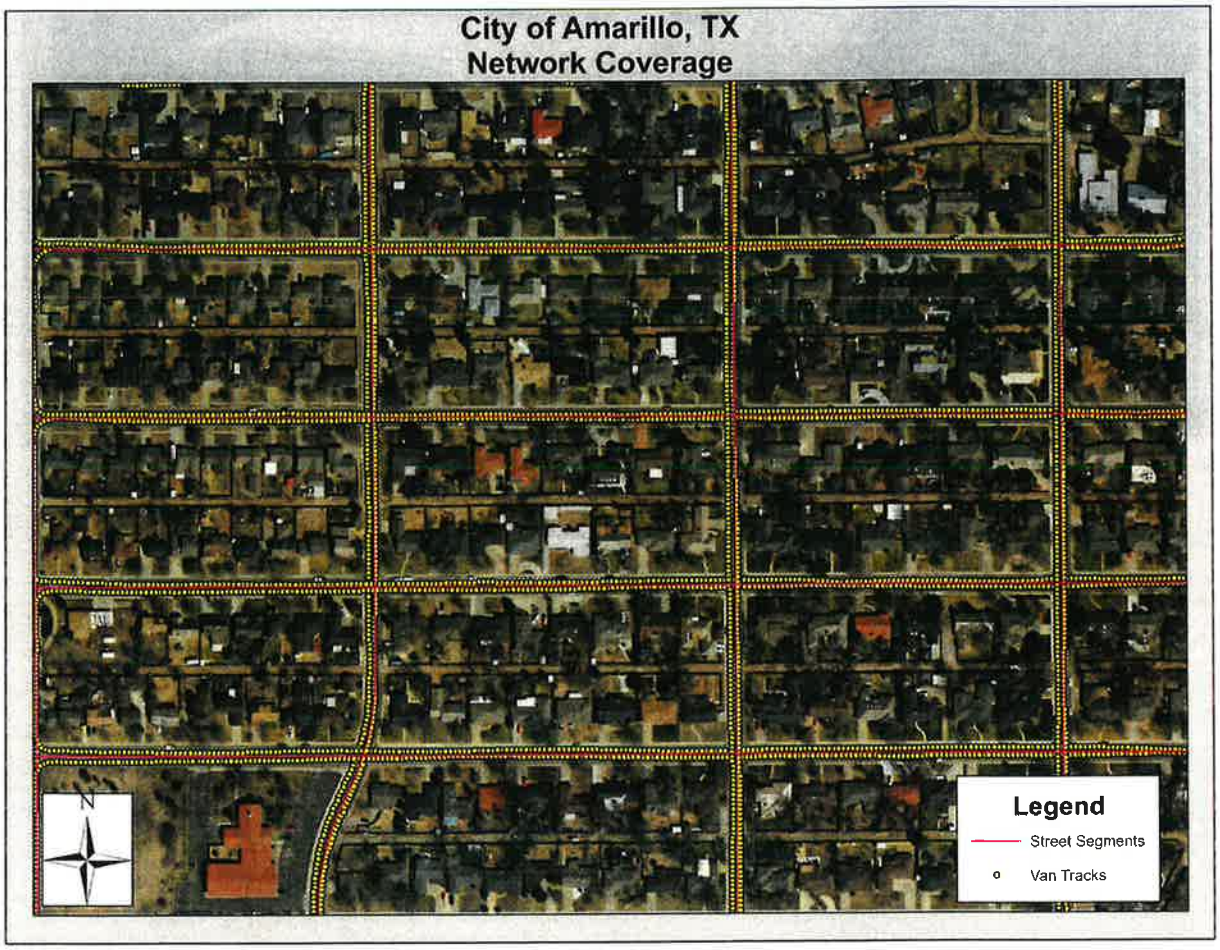


Figure 11: City of Amarillo, TX Network Coverage Map

DTS MAC image collection included a daily check of the on-board systems. This vehicle component check consisted of a calibration site survey of a nine-point grid in state plane coordinates. Each morning and afternoon, before and after a day's image collection, the MAC vehicle drove over the surveyed location. The MAC technician then extracted each point's location to verify the location of the point extracted was within approximately 3 feet of the surveyed points. DTS' QA/QC manual includes further details regarding MAC quality control procedures.

Figure 12: 9-Point Calibration Site Example

The DTS MAC vehicle collected pavement and right-of-way images every 25 feet along each street segment.

Each day's image and road data collection was recorded on a MAC server. Each night, the day's collection data was backed up to an external hard drive. The external hard drives were then mailed back to DTS' project office where the data was placed on a production server for post-processing of images and data, quality control review, and pavement distress inventory.

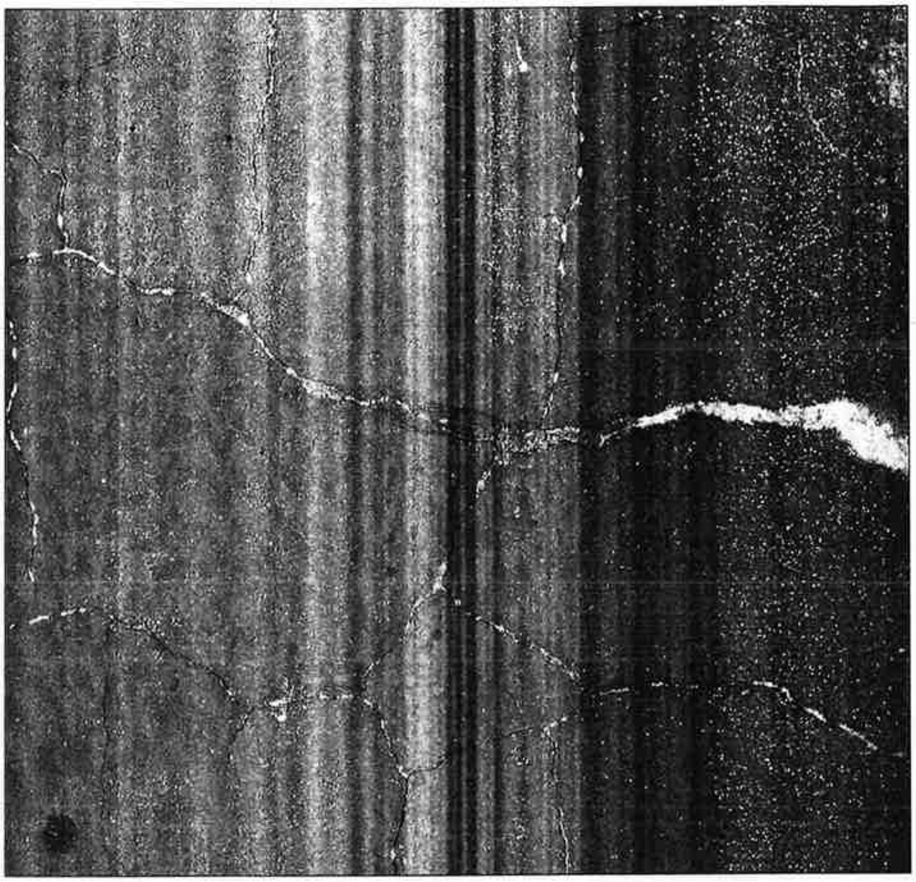


Figure 13: Pavement Image Example

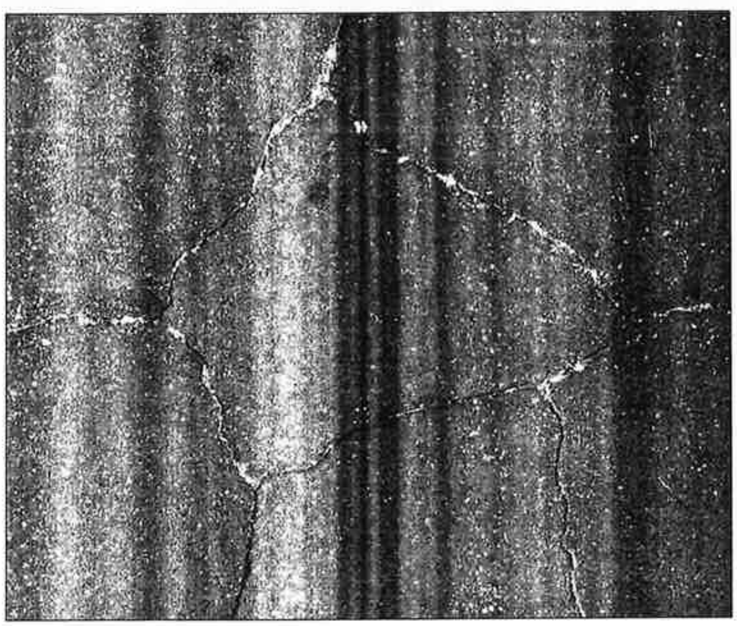


Figure 14: Example Zoomed Pavement Image

Right-of-way (ROW) images were also collected as part of this contract. The MAC vehicle was configured with a four-camera setup for this; three forward-facing cameras and one rear-facing camera. The images were captured at roughly 25-foot intervals and were post-processed using collected inertial and GPS data. This allowed for more accurate asset extraction to be completed.

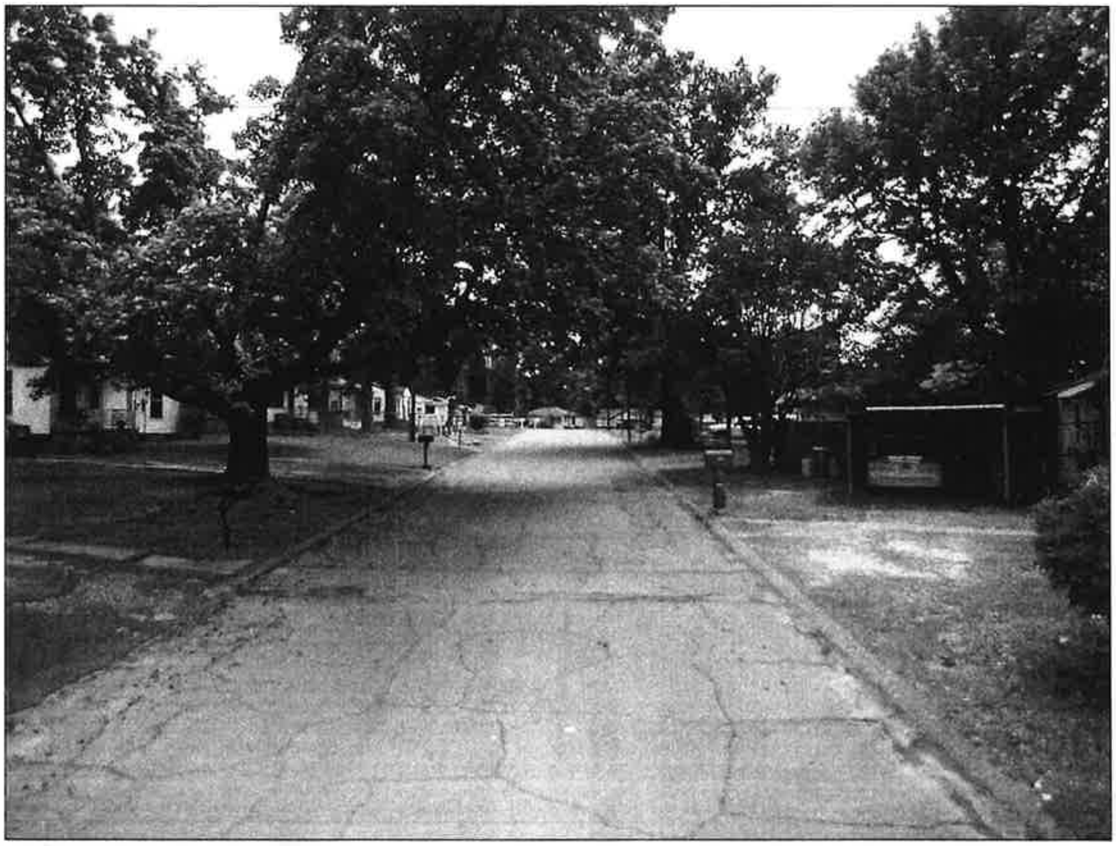


Figure 15: Right-of-Way Image Example

The automated data collection effort for the City of Amarillo roadway network began in May and was completed in June of 2017.

6.0 Pavement Condition Assessment

DTS post-processes the MAC GPS, IMU, DMI, and Right-of-Way (ROW) imagery for each day of image collection. With a completed day of images and data, DTS pavement engineers and GIS analysts prepared a project data dictionary that includes all distress types and allowable severities. This data library is provided to trained pavement condition technicians along with the images and associated data for a day's image collection.

DTS utilized our spatial image analysis software EarthShaper™ to analyze and digitize pavement distress types, extents and severities as a point, line or polygon. Depending on the distress type measurement required by the project data dictionary, each pavement image's distress data was digitized and recorded to a database and associated to the street section being surveyed. Each distress type, severity and extent is recorded to the project pavement condition database; and each street section's total type, severity and extent is calculated.

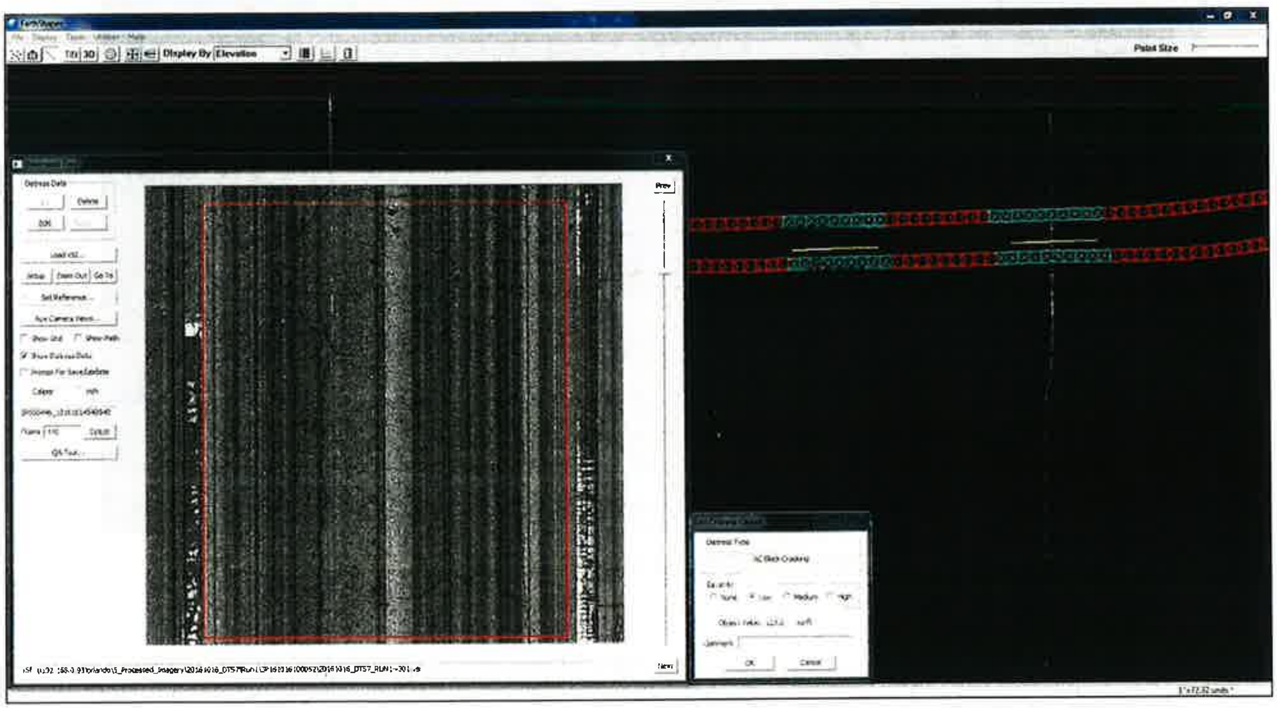


Figure 16: EarthShaper™ Pavement Tool Example

This method of pavement distress inventory provides a quantifiable and repeatable process to the City of Amarillo. Each street segment, in conjunction with the pavement and right-of-way imagery, allows pavement engineers to review each pavement technician's data, allowing for an open quality control process that is defendable and repeatable. This distress data was then imported into VUEWorks® Asset Management Software, where the PCI and was calculated. The distribution of the roadway network by surface type and function class can be observed below.

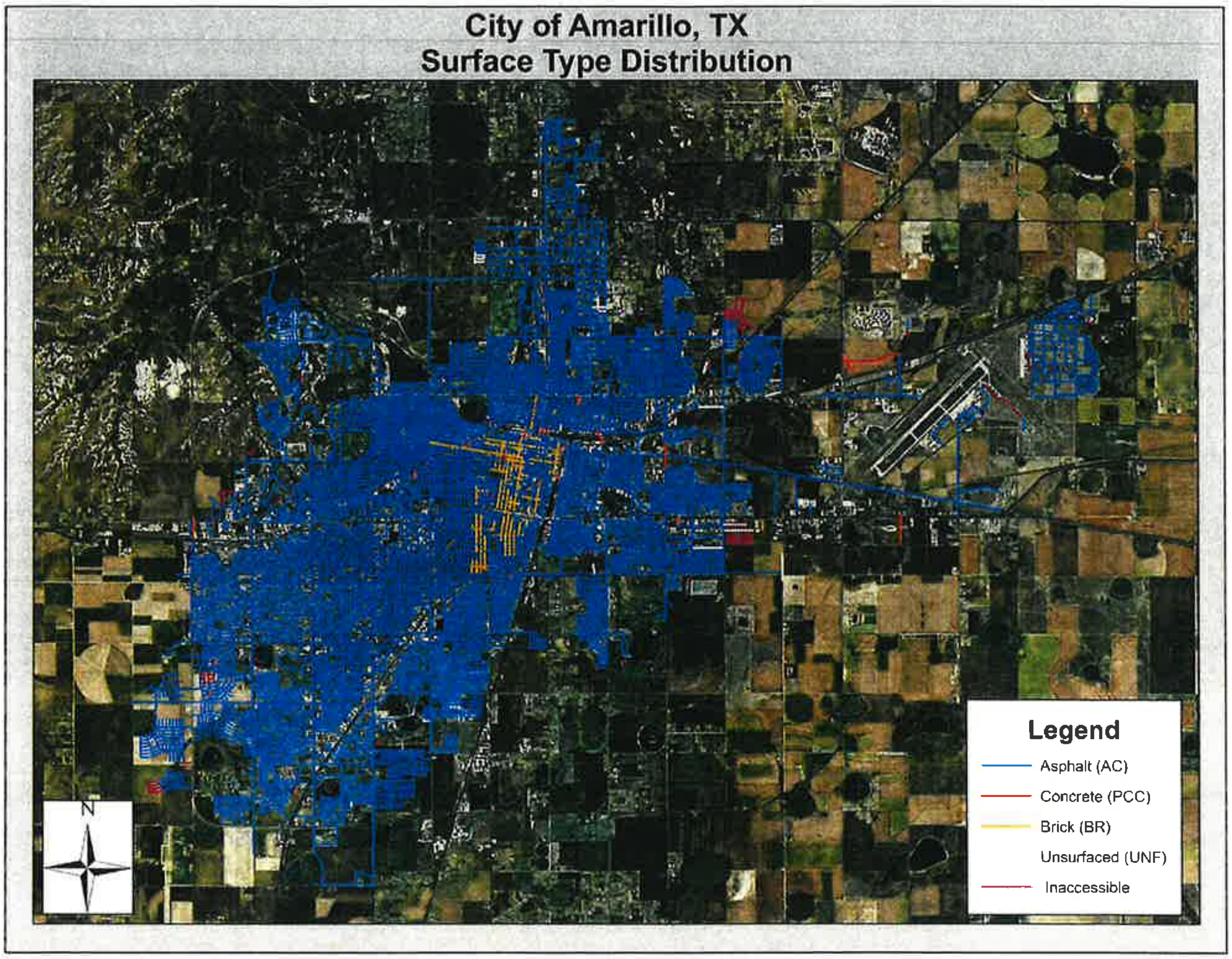


Figure 17: City of Amarillo, TX Surface Type Distribution

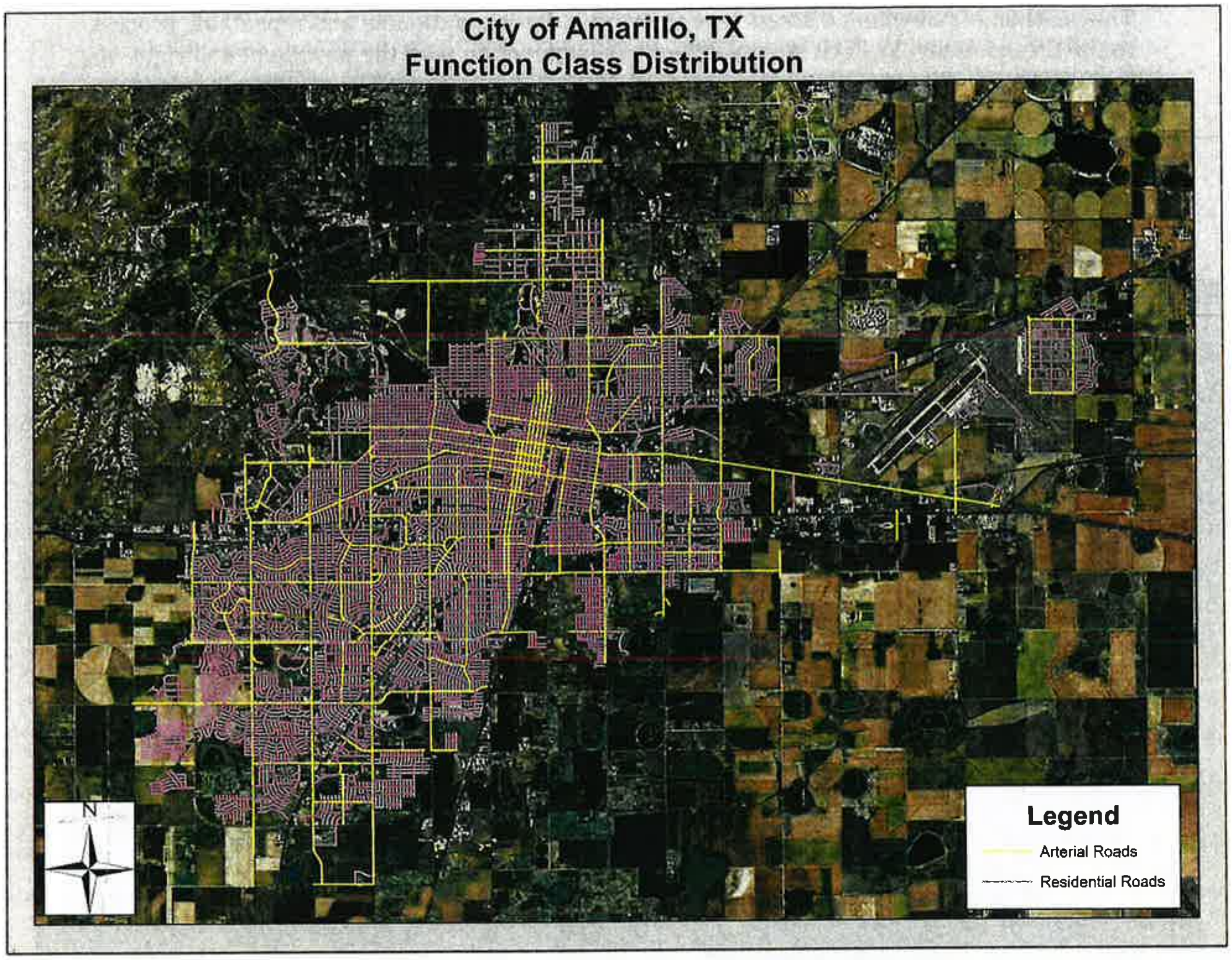


Figure 18: City of Amarillo, TX Function Class Distribution

6.1 Pavement Distress Inventory

A pavement distress inventory consists of identifying specific pavement surface distress types that are associated with the degradation of a pavement surface due to traffic loads, environmental factors, lack of maintenance and other man-made or natural occurrences. The distress type is then assigned a severity rating (low/moderate/high), and the extents of the distress type and severity are recorded. For this project, the pavement distress types, severity definitions and measurements were inventoried utilizing the ASTM D6433 method of pavement condition assessment for both Asphalt Concrete surface (AC) and Portland Cement Concrete (PCC) pavements. The inspections covered 100% of the length of a Sample for the outside lane of travel and for roads with three or more lanes the inspection covered the outside and the inside lane. Those roads were inspected utilizing the ASTM D6433 sampling approach (completed for both directions of travel).

Definitions (units of measure)

- AC Bleeding & Pumping (ft.^{2}) represents excessive use of bituminous binder in the asphalt mix.
- AC Fatigue (Alligator) Cracking (ft.^{2}) is associated with fatigue due to traffic loading and visually looks as interconnected cracks forming small pieces ranging in size from about 1" to 6" typically in the wheel path.
- AC Block Cracking (ft.^{2}) usually intersect at nearly right angles and range from one foot to 10' or more across. The closer spacing indicates more advanced aging caused by shrinking and hardening of the asphalt over time.
- AC Edge Cracking (ft.) is parallel to and usually within 1.5 feet of the outer edge of the pavement. This distress is accelerated by traffic loading and can be caused by frost-weakened base or subgrade near the edge of the pavement.
- AC/PCC Lane/Shoulder Drop-off (ft.) is a difference in elevation between the pavement edge and the shoulder. This distress is caused by shoulder erosion, shoulder settlement, or by building up the roadway without adjusting the shoulder level.
- AC Linear Cracking (trans/long) (ft.) typically occurs in overlays where the crack is reflected through the overlaying asphalt surface.
- AC Patching (ft.^{2}) is an area of pavement that has been replaced with new material to repair existing pavement.
- AC Potholes (count) are small, usually less than 30 inches in diameter, bowl-shaped depressions in the pavement surface. Generally have sharp edges and vertical sides near the top of the hole.
- AC Raveling & Weathering (ft.^{2}) is loss of pavement material from the asphalt surface. Typically raveling is caused by stripping of the bituminous film from the aggregate or hardening of asphalt due to aging. Poor compaction, especially in cold weather construction, or insufficient asphalt content are also causes of raveling.
- AC Slippage Cracking (ft.^{2}) is crescent of half-moon shaped cracks, usually transverse to the direction of travel. They are produced when braking or turning wheels cause the pavement to slide or deform.
- AC Rutting (ft.^{2}) is a surface depression in the wheel paths.
- PCC Corner Break (slab count) is a crack that intersects the joints. Load repetition combined with loss of support and curling stresses usually cause corner breaks.
- PCC Divided Slab (slab count) is when a slab is divided into four or more pieces due to overloading, or inadequate support.

- PCC Durability "D" Cracking (slab count) is caused by freeze-thaw expansion of the large aggregate, which gradually breaks down the concrete. Usually appears as a pattern of cracks running parallel and close to a joint or linear crack.
- PCC Joint Sealant Damage (slab count) is any condition that enables soil or rocks to accumulate in the joints or allows significant water infiltration.
- PCC Linear Cracking (trans/long) (slab count) divide the slab in two or three pieces and are usually caused by a combination of repeated traffic loading, thermal gradient curling and repeated moisture loading.
- PCC Patching, Large/Utility Cut (slab count) is an area where the original pavement has been removed and replaced by new pavement.
- PCC Patching, Small (slab count) is an area where the original pavement has been removed and replaced by filler material.
- PCC Polished Aggregate (slab count) is caused by repeated traffic applications. There are no rough or angular aggregate particles to provide good skid resistance.
- PCC Popouts (slab count) is a small piece of pavement that breaks loose from the surface due to freeze-thaw action, combined with expansive aggregates. Usually range in diameter from 1 to 4 inches and in depth from ½ to 2 inches.
- PCC Punchout (slab count) is a localized area of the slab that is broken into pieces. This distress is caused by heavy repeated loads, inadequate slab thickness, and loss of foundation support or localized concrete construction deficiency.
- PCC Scaling/Map Cracking/Crazing (slab count) is a network of shallow, fine or hairline cracks that extend only through the upper surface of the concrete. Usually caused by concrete over-finishing and may lead to scaling, which is the breakdown of the slab surface to a depth of ¼ to ½ in.
- PCC Shrinkage Cracks (slab count) are hairline cracks usually less than 6 feet long and do not extend across entire slab. They are formed during the setting and curing of the concrete and do not extend through the depth of the slab.
- PCC Spalling, Corner (slab count) is the breakdown of the slab within 1.5 feet of the corner. Usually caused by traffic loading or infiltration of incompressible materials, weak concrete and/or water accumulation and freeze-thaw action.
- PCC Spalling, Joint (slab count) is the breakdown of the slab edges within 1.5 feet of the joint. Usually caused by traffic loading or infiltration of incompressible materials, weak concrete and/or water accumulation and freeze-thaw action.

6.2 Pavement Condition Index (PCI) Calculation

Each street segment's Pavement Condition Index (PCI) was calculated utilizing VUEWorks® Asset Management Software (AMS). This AMS is based on the ASTM D6433 method of calculating a street segment's pavement condition index value using the pavement inventory database and ASTM D6433 deduct curve.

With a completed pavement condition inventory database, DTS imported the street segment, inspection, sample and distress information into VUEWorks®, where the PCI was calculated. ASTM D6433 is based on a 0 to 100 rating scale where 0 represents a failed roadway condition and 100 represent an excellent roadway condition.

Pavement Condition Index (PCI)		CONDITION DESCRIPTION
100 86		GOOD
85 71		SATISFACTORY
70 56		FAIR
55 41		POOR
40 26		VERY POOR
25 11		SERIOUS
10 0		FAILED

Figure 19: ASTM D6433 PCI Description Groups

Review of the City's PCI values shows a general breakdown of the roadway by condition to be:

Pavement Condition Index (PCI) Range	Condition Description	Percent of Network	Legend
86-100	Good	9.51%	
71-85	Satisfactory	49.93%	
56-70	Fair	27.35%	
41-55	Poor	8.20%	
26-40	Very Poor	3.97%	
11-25	Serious	0.97%	
0-10	Failed	0.07%	
	Total	100%	

Figure 20: City of Amarillo, TX PCI Ranges by Percent

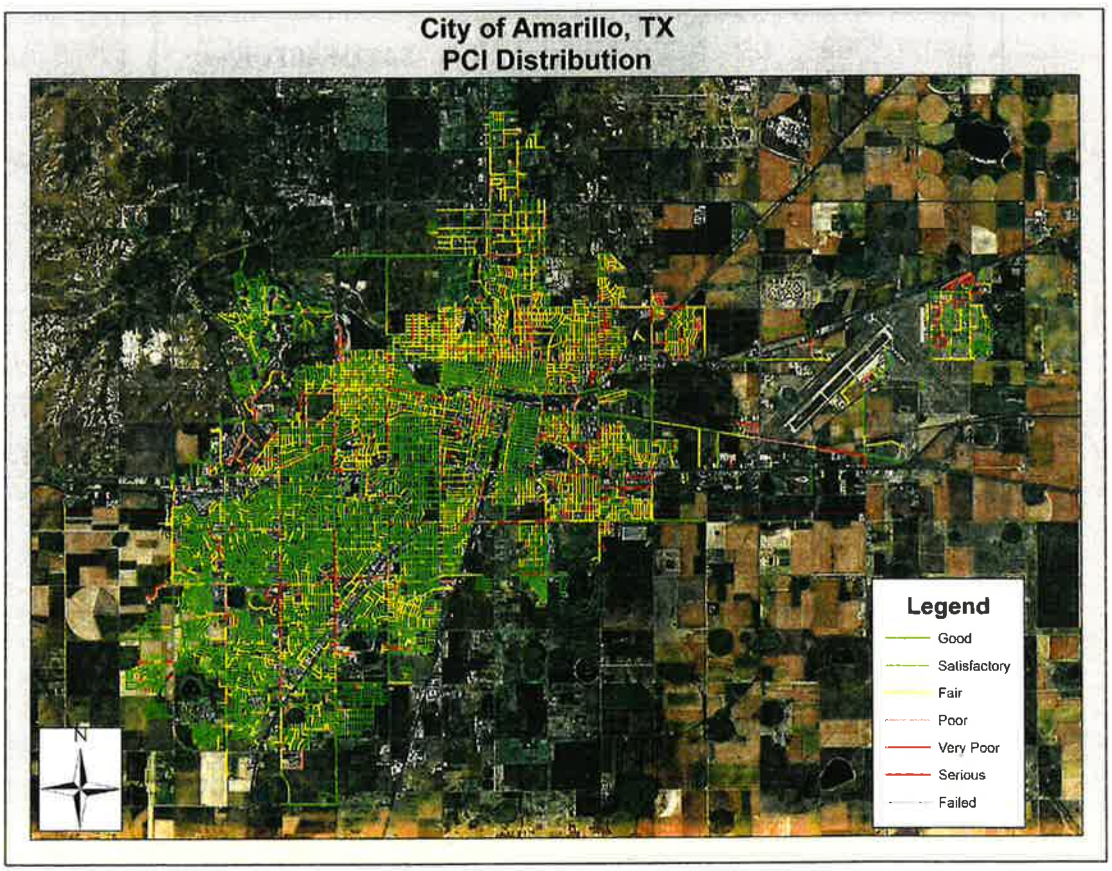


Figure 21: City of Amarillo, TX PCI Distribution Map

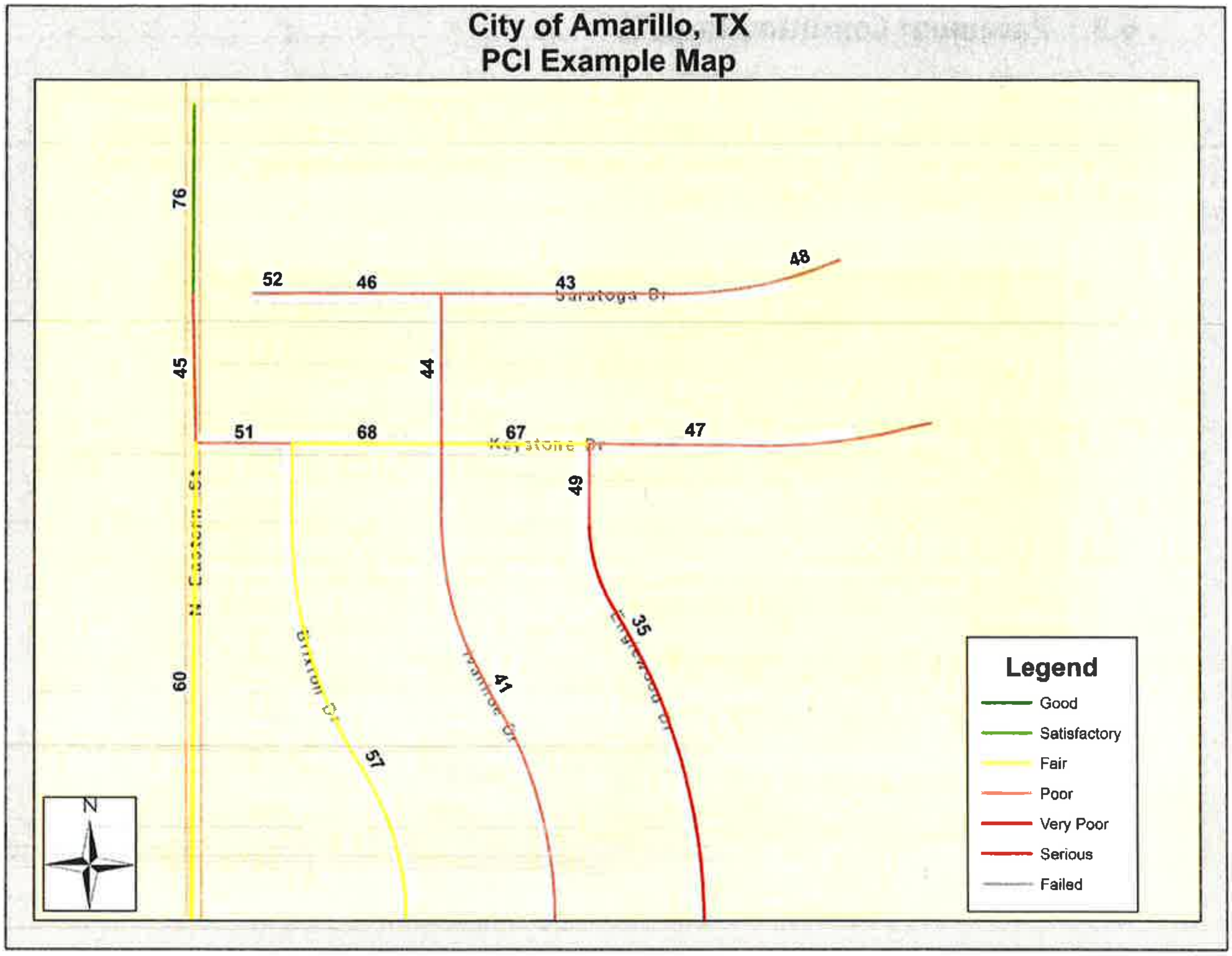


Figure 22: City of Amarillo, TX PCI Example Map

The PCI value for each road segment can be viewed in the final Geodatabase delivered to the City of Amarillo. The average of the road segment PCI values for the collected roads was calculated to be **71** at the time of collection. This value indicates the roadway network is generally in 'Satisfactory' condition.

6.3 Pavement Condition Results

The roadway network consists of 1,032.54 centerline miles of roadway. The distribution of the current roadway network by surface type is presented below and outlines the number of miles that were able to be collected and analyzed, as well as the number of miles that were not able to be collected (with reason why).

Item	Description	Centerline Miles	% of Centerline Miles
1	Asphalt Segments with PCI	986.04	95.50%
2	Concrete Segments with PCI	5.95	0.57%
3	Brick Roads	20.01	1.94%
4	Construction	0.85	8.00%
5	Not Collected – Does Not Exist	10.31	1.00%
6	Not Collected – Inaccessible	2.98	29.00%
7	Not Collected – Unsurfaced	6.40	0.62%
	TOTAL WITH PCI	991.99	96.07%
	TOTAL WITHOUT PCI	40.54	3.93%
	Total	1032.54	100%

Figure 23: City of Amarillo, TX Inspection Breakdown

The breakdown of the types of distresses for asphalt and concrete can be seen below.

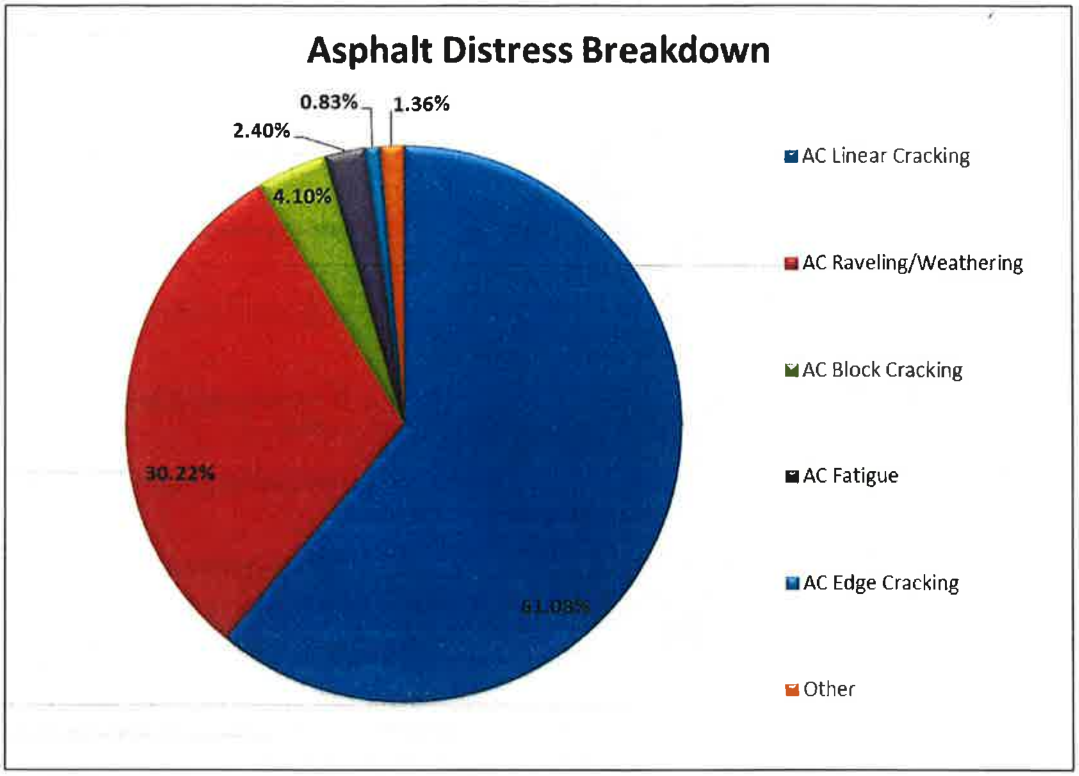


Figure 24: City of Amarillo, TX Asphalt Distress Breakdown

Asphalt Distress Breakdown by Severity			
Type / Severity	LOW	MEDIUM	HIGH
AC Linear Cracking	53.693%	7.281%	0.106%
AC Raveling/Weathering	30.033%	0.159%	0.033%
AC Block Cracking	3.438%	0.652%	0.008%
AC Fatigue	0.858%	1.477%	0.067%
AC Edge Cracking	0.556%	0.253%	0.026%
AC Jt. Reflection Cracking	0.034%	0.004%	0 %
AC Lane/Shoulder Drop-off	0.020%	0.004%	0.001%
AC Pothole	0.005%	0.004%	0.002%
AC Bleeding & Pumping	0.572%	0.036%	0.003%
AC Patching	0.529%	0.138%	0.003%
AC Slippage Cracking	0%	0.007%	0%

Figure 25: City of Amarillo, TX Asphalt Distress Breakdown by Severity

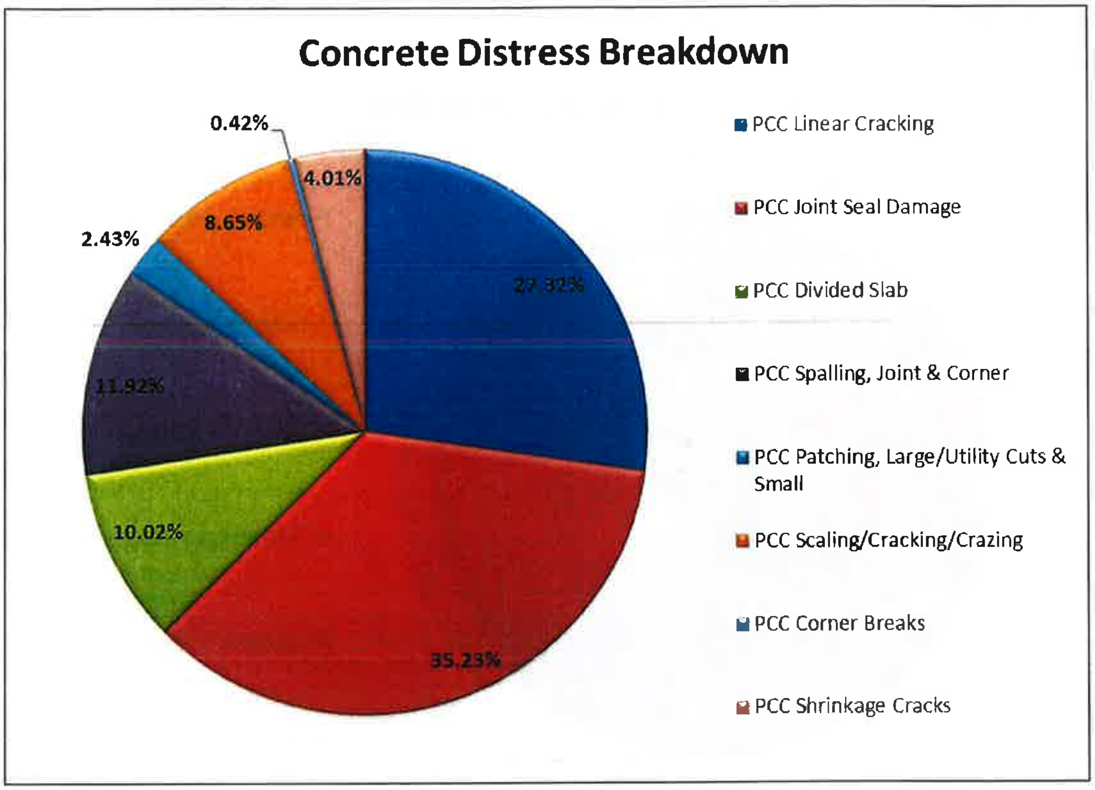


Figure 26: City of Amarillo, TX Concrete Distress Breakdown

Concrete Distress Breakdown by Severity			
Type / Severity	LOW	MEDIUM	HIGH
PCC Corner Breaks	0.316%	0.105%	0%
PCC Divided Slab	1.899%	6.013%	2.110%
PCC Joint Seal Damage	16.139%	12.236%	6.857%
PCC Linear Cracking	19.831%	5.802%	1.688%
PCC Patching, Large/Utility Cuts	0.844%	0.738%	0%
PCC Patching, Small	0.738%	0.105%	0%
PCC Shrinkage Cracks	4.008%	0%	0%
PCC Scaling/Cracking/Crazing	5.169%	3.165%	0.316%
PCC Spalling, Corner	2.004%	1.160%	0.316%
PCC Spalling, Joint	6.224%	1.477%	0.738%

Figure 27: City of Amarillo, TX Concrete Distress Breakdown by Severity

Below is a summary of the network PCI based on surface type and function class:

	City of Amarillo, TX Roadway Network by Surface Type						
	Good (86-100)	**Satisfactory** (71-85)	**Fair** (56-70)	**Poor** (41-55)	**Very Poor** (26-40)	**Serious** (11-25)	**Failed** (0-10)
Asphalt	9.24%	49.75%	27.34%	8.12%	3.93%	0.95%	0.07%
Concrete	0.27%	0.18%	0.01%	0.08%	0.04%	0.02%	0%
All	9.51%	49.93%	27.35%	8.20%	3.97%	0.97%	0.07%

Figure 28: City of Amarillo, TX Roadway Network by Surface Type with PCI Percentile

City of Amarillo, TX Roadway Network by Function Class					
	Arterial		**Residential**		**All**
	Asphalt	**Concrete**	**Asphalt**	**Concrete**	
Good (86-100)	2.09%	0.12%	7.15%	0.15%	9.51%
Satisfactory (71-85)	7.59%	0.12%	42.16%	0.06%	49.93%
Fair (56-70)	5.49%	0.01%	21.85%	0%	27.35%
Poor (41-55)	2.64%	0.05%	5.48%	0.03%	8.20%
Very Poor (26-40)	1.51%	0%	2.42	0.04%	3.97%
Serious (11-25)	0.37%	0%	0.58%	0.02%	0.97%
Failed (0-10)	0%	0%	0.07%	0%	0.07%

Figure 29: City of Amarillo, TX Roadway Network by Function Class with PCI Percentile

The graph below represents the overall pavement condition distribution based on the segment count (i.e. how many segments fall within each PCI range).

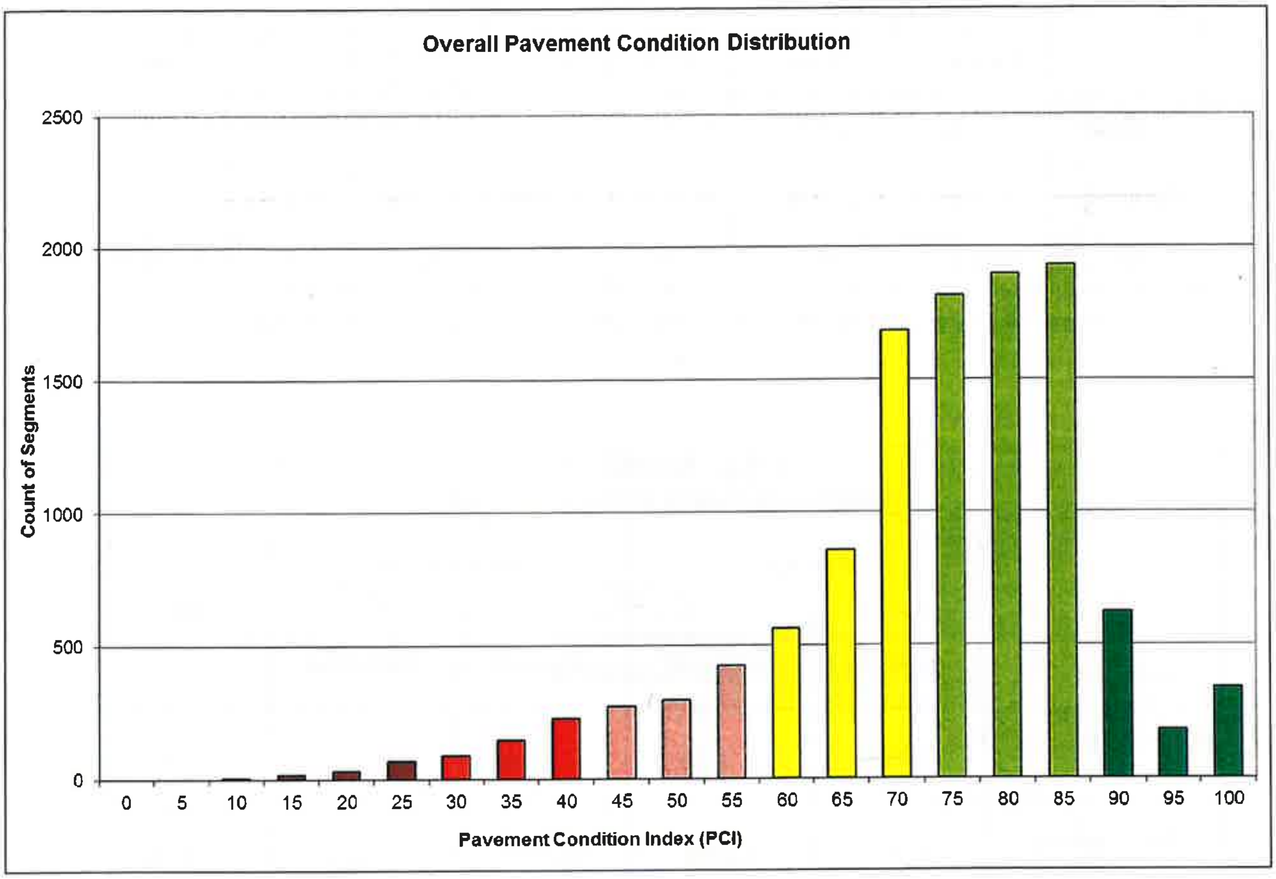


Figure 30: City of Amarillo, TX Overall Pavement Condition Distribution

7.0 Pavement Maintenance/Preservation Methods

The specific activity to perform on each road depends upon the pavement distresses observed. The following pavement maintenance and preservation methods are currently performed on the City of Amarillo's roadways.

Crack Sealing
Sealing and filling asphalt concrete (AC) pavement cracks is a common road maintenance activity. Specialized materials are placed into or above cracks to prevent the intrusion of water and incompressible material into the cracks, and to reinforce the adjacent pavement. This type of distress treatment will address alligator cracking, longitudinal/transverse cracking, and block cracking.

HA5 Treatment
HA5 is a High Density Mineral Bond uniquely emulsified with a near neutral charge that is able to hold a proprietary blend of fine aggregates. Limiting oxidative damage from moisture is fundamental to HA5's preservation qualities. But just as critical to the prevention of oxidative damage from moisture is preventing oxidative damage from UV rays. UV rays are strong throughout the western U.S., especially in higher elevations as well as desert regions. For HA5 to be properly installed, specialized equipment is required that can uniformly disperse a thixotropic material housing the required density of fine aggregate.

Chipseal
A single chip seal is an application of binder followed by an aggregate. This is used as a pavement preservation treatment and provides a new skid resistant wearing surface, arrests raveling, and seals minor cracks. A double chip seal is a built-up seal coat consisting of double applications of binder and aggregate. As an example, a double chip seal consists of a spray application of binder, spreading a layer of aggregate, rolling the aggregate for embedment, applying an additional application of binder, spreading another layer of aggregate (approximately half the average least dimension of the base coat aggregate), and rolling once more. Sweeping should be done between applications. Double chip seals are used where a harder wearing and longer lasting surface treatment is needed.

Microsurface
Micro surfacing is the installation of a protective seal coat which extends the life of pavement. It is a thin, tough layer of asphalt emulsion blended with finely crushed stone for traction. This is a cost-effective method to renew the road surface and seal minor cracks and other irregularities. This preventive maintenance process protects the pavement from moisture penetration and oxidation. Similar to painting a house, micro surfacing creates a protective layer which preserves the underlying structure and prevents the need for more expensive repairs in the future.

Overlay
An overlay consists of one or more courses of asphaltic concrete placed over existing pavement. The process of overlaying usually includes cleaning and application of a tack coat, followed by a leveling course. The pavement thicknesses usually range between 1.5 inches and 2 inches for thick overlay and 0.625 inch and 1.125 inches for thin overlays.

Full Depth Reconstruction

Reconstruction is the replacement of the entire existing pavement structure by the placement of the equivalent or increased pavement structure. Reconstruction usually requires the complete removal and replacement of the existing pavement structure. Reconstruction may utilize either new or recycled materials incorporated into the materials used for the reconstruction of the complete pavement section. Reconstruction is appropriate when a pavement has structurally failed and can no longer support the traffic demand. Reconstruction increases the structural capacity of the pavement to a level that is required for long term performance.

7.1 Pavement Maintenance/Preservation Funding

DTS performed various five-year pavement maintenance and preservation program scenarios for the City's consideration using VUEWorks® Asset Management Software. The City's current total budget includes:

- An annual pavement budget of $7,597,000 for Street Division Operation & CIP

The scenarios performed for the City include:

1. 10-Year Baseline Scenario: no budget was allocated to see how the network will deteriorate over 10 years with no work.
2. 5-Year Current Budget Scenario (Worse First): using the City's current pavement budget of $7.597M/year for five years to perform maintenance to those roads at the lowest PCI level first.
3. 5-Year Current Budget Scenario (Best First): using the City's current pavement budget of $7.597M/year for five years to perform maintenance to those roads at the highest PCI level first.
4. 5-Year Increase & Maintain PCI of 71 Scenario: using an unlimited pavement budget for five years to increase and maintain a roadway network PCI of 71.
5. 5-Year Increase PCI to 75 Scenario: using an unlimited pavement budget for five years to increase the roadway network PCI to 75
6. 5-Year Increase PCI to 80 Scenario: using an unlimited pavement budget for five years to increase the roadway network PCI to 80

As part of this project, an inventory of the City's current activities, budgets, conditions, and decision matrices was compiled and reviewed. The City of Amarillo provided a list of current treatments types used within their Preservation, Rehabilitation, and Reconstruction work. Included in this list was the cost of each of these treatment types per square yard. These treatment activities and costs were entered into VUEWorks® within the Manage Jobs section.

Treatment Type	Activity	Cost per SY
Preservation	Crack Seal	$0.46
Preservation	HA5 Treatment	$1.58
Preservation	Chipseal	$3.00
Rehabilitation	Chipseal w/ Mill & Fill	$9.00
Rehabilitation	Chipseal w/ Partial Reconstruction	$17.00
Reconstruction	Full Depth Reconstruction	$54.00

Figure 31: City of Amarillo, TX Maintenance Activities and Costs for Residential Roads

Treatment Type	Activity	Cost per SY
Preservation	Crack Seal	$0.46
Preservation	Microsurface	$3.65
Rehabilitation	Overlay w/ Minor Repair	$16.50
Rehabilitation	Overlay w/ Major Repair	$29.00
Reconstruction	Full Depth Reconstruction	$54.00

Figure 32: City of Amarillo, TX Maintenance Activities and Costs for Arterial Roads

Each road segment's construction date, and in turn its percent (%) life used, was back-calculated based upon its current PCI rating and the VUEWorks® asphalt deterioration curve. Every road segment's PCI value is anticipated to deteriorate according to this curve until pavement maintenance work is performed. The VUEWorks® deterioration curves are based on the assumption of a 20 year life for asphalt roads and 60 year life for concrete roads.

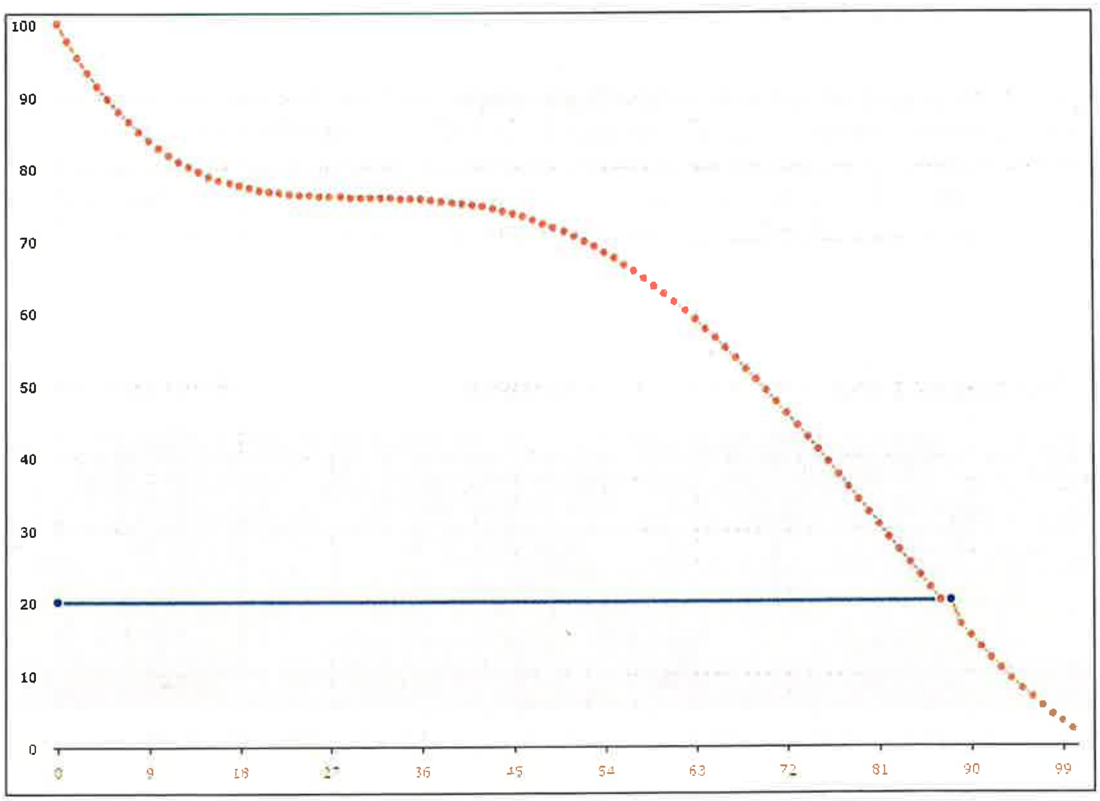


Figure 33: VUEWorks® Deterioration Curve

Using information collected from the City of Amarillo, our experience with other pavement management systems, and industry standards; DTS assigned the impacts below to each treatment type within the Budget Forecasting – Job Assignments section of VUEWorks®.

Treatment Type	Activity	Impact	PCI Range
Preservation	Crack Seal	5 Points	90 – 95
Preservation	HA5 Treatment	5 Points	75 – 84
Preservation	Chipseal	15 Points	75 –84
Rehabilitation	Chipseal w/ Mill & Fill	15 Points	45 – 74
Rehabilitation	Chipseal w/ Partial Reconstruction	90 Fixed	26 – 44
Reconstruction	Full Depth Reconstruction	100 Fixed	0 – 25

Figure 34: City of Amarillo, TX Maintenance Activities Impact for Residential Roads

Treatment Type	Activity	Impact	PCI Range
Preservation	Crack Seal	5 Points	90 – 95
Preservation	Microsurface	15 Points	75 – 84
Rehabilitation	Overlay w/ Minor Repair	20 Points	45 – 74
Rehabilitation	Overlay w/ Major Repair	95 Fixed	26 – 44
Reconstruction	Full Depth Reconstruction	100 Fixed	0 – 25

Figure 35: City of Amarillo, TX Maintenance Activities Impact for Arterial Roads

These scenarios are for network budgeting purposes only. Actual projects can be individually set up in VUEWorks® based on the City's priorities.

7.2 10-Year Baseline Scenario

At the time of inspection, June of 2017, the average network pavement condition index (PCI) for the City's network was 72.09 and 66.21 for residential and arterial roads respectively, with an overall of 69.15 for all roadway. For this budget analysis VUEWorks® uses this simple average of all roadways to calculate the change in network condition. If no work is performed over the next ten years, this PCI rating would be expected to decrease to 32.29 and 25.87 by 2026 for residential and arterial roads respectively.

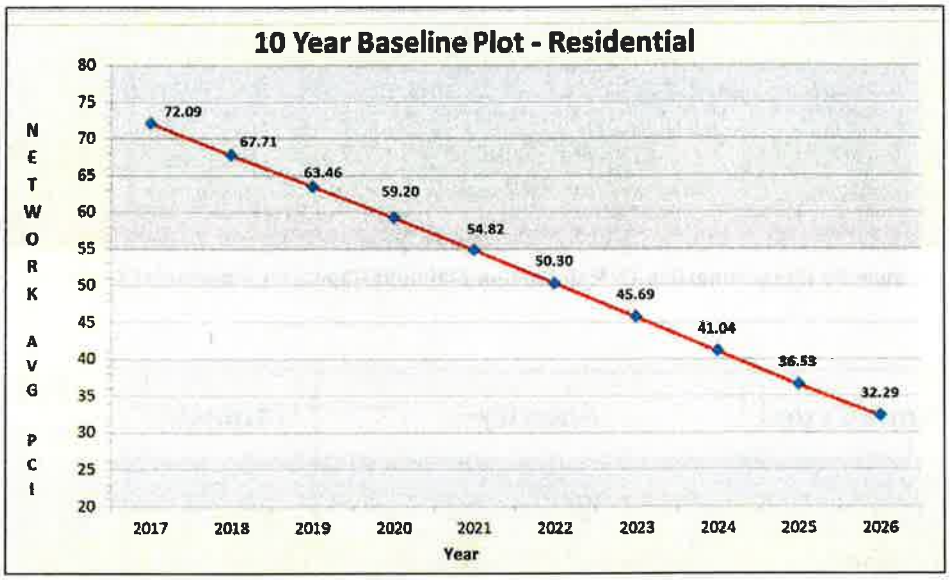


Figure 36: 10-Year "Do-Nothing" Baseline Plot for Residential Roads

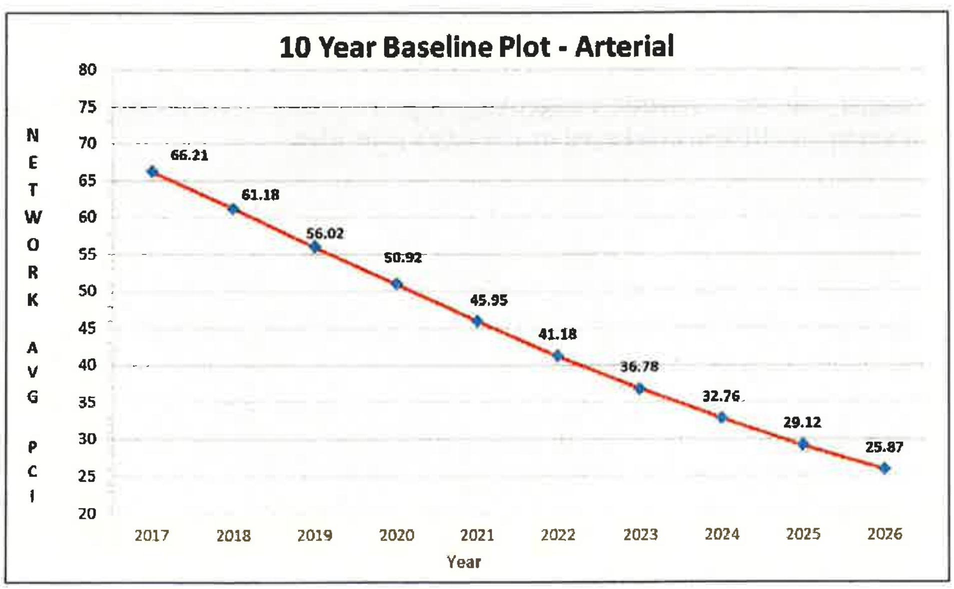


Figure 37: 10-Year "Do-Nothing" Baseline Plot for Arterial Roads

7.3 5-Year Current Budget Scenario (Worse First)

The City's current yearly pavement budget of $7,597,000.00 for road maintenance was applied to the network in VUEWorks® Budget Forecasting module. The detailed steps on how this budget was created are shown in the following figures.

Step 1:

The analysis type selected for this scenario was the 'Automated Budget Forecast...'. This is the best option to prioritize roads requiring funding based upon a multi-year budget.

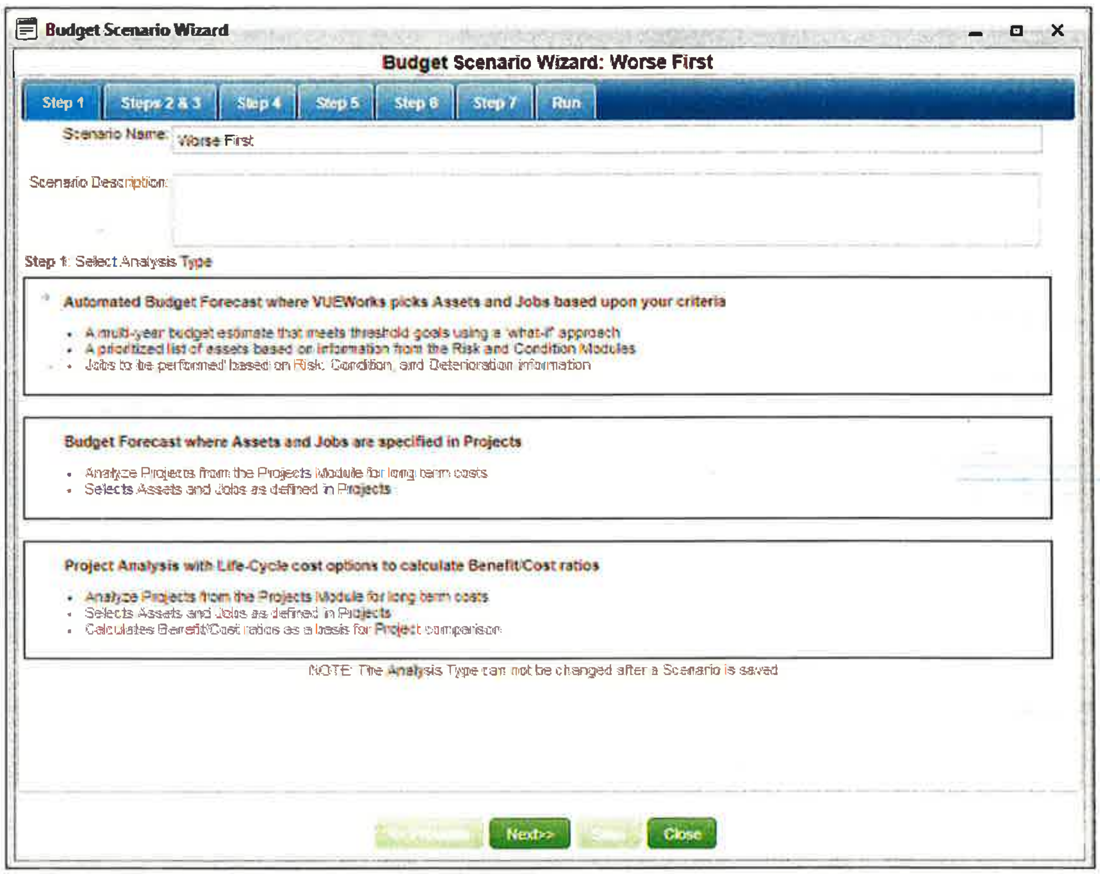


Figure 38: 5-Year Current Budget Scenario (Worst First) – Scenario Wizard – Step 1

Step 2 & 3:

For this project, residential and arterial road asset types were added to the scenario. In order for the scenarios to run correctly, both road types must be accounted for. A '1' indicates the corresponding road type is present while a '0' indicates it is not. In this instance, both road asset types are set to '1'

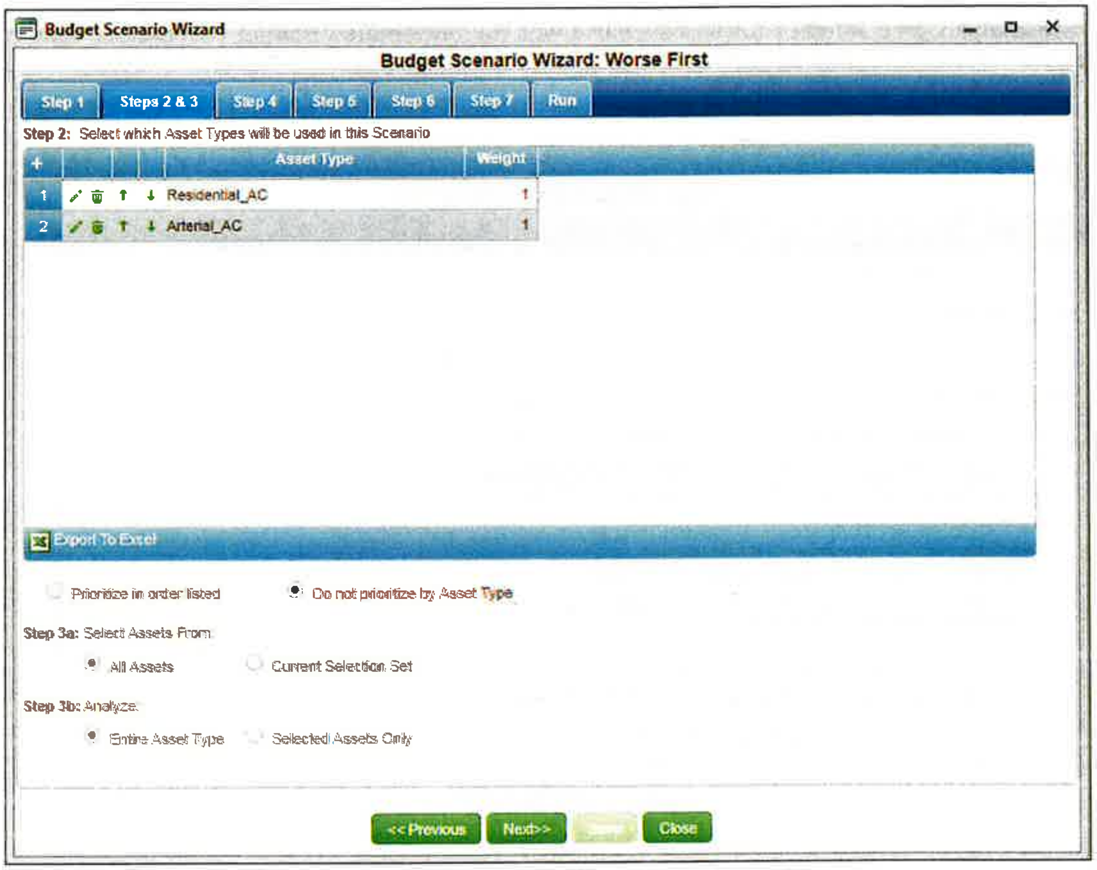


Figure 39: 5-Year Current Budget Scenario (Worst First) – Scenario Wizard – Steps 2 & 3

Step 4:

For this scenario, only the "Use Long Term Criteria" was used. The "Use Near Term Criteria" can be used to prioritize a certain set of assets to be evaluated prior to the rest of the assets.

If checked, the 'Prioritize assets with less deterioration' gives the option to have the scenario prioritize the road work recommendations from highest to lowest PCI.

The first criterion that this budget prioritizes by is the "Deterioration Curve Value" or the PCI value. The second criteria used for prioritization is the "% Life Used". This can only be used if the installation date has been provided by the client. If a known installation date is not provided, the amount of life used is based upon the deterioration curve and the second criterion is left blank.

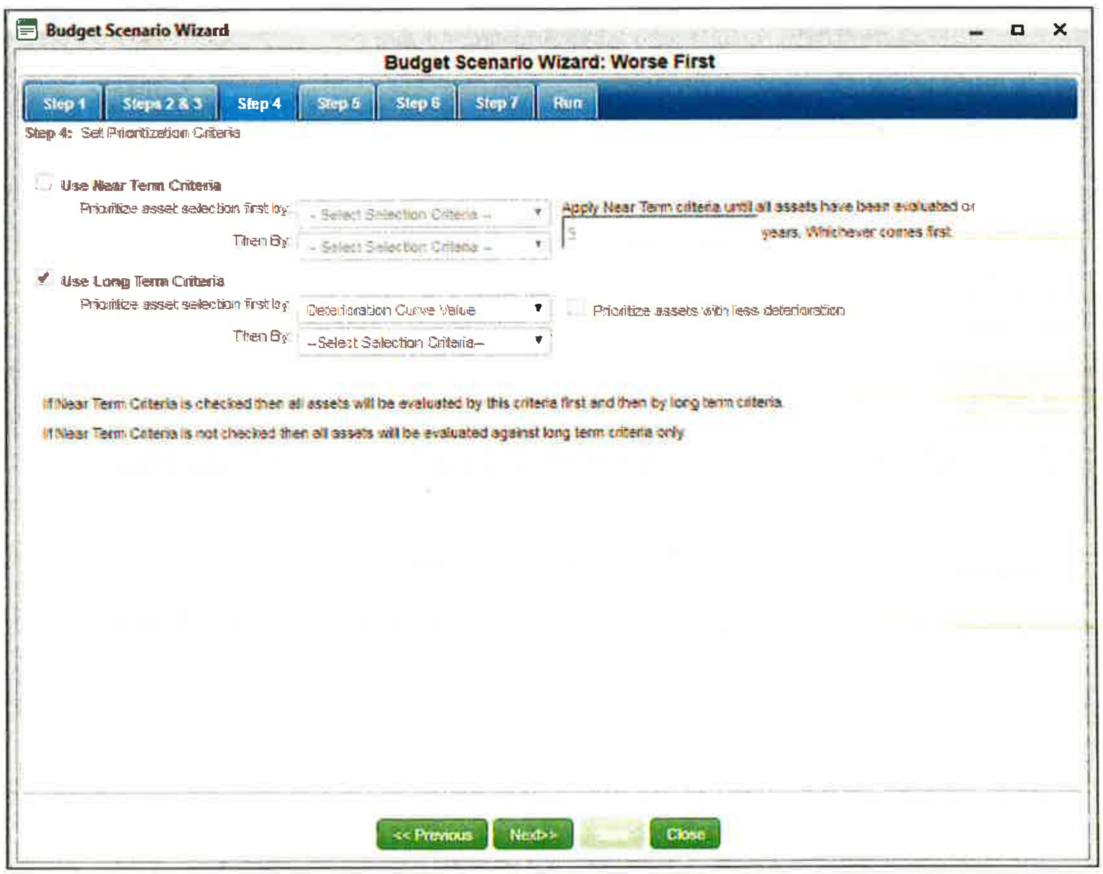


Figure 40: 5-Year Current Budget Scenario (Worst First) – Scenario Wizard – Step 4

Step 5:

This is where the job criterion is set by asset type based on the Deterioration Curve Value/PCI of the road.

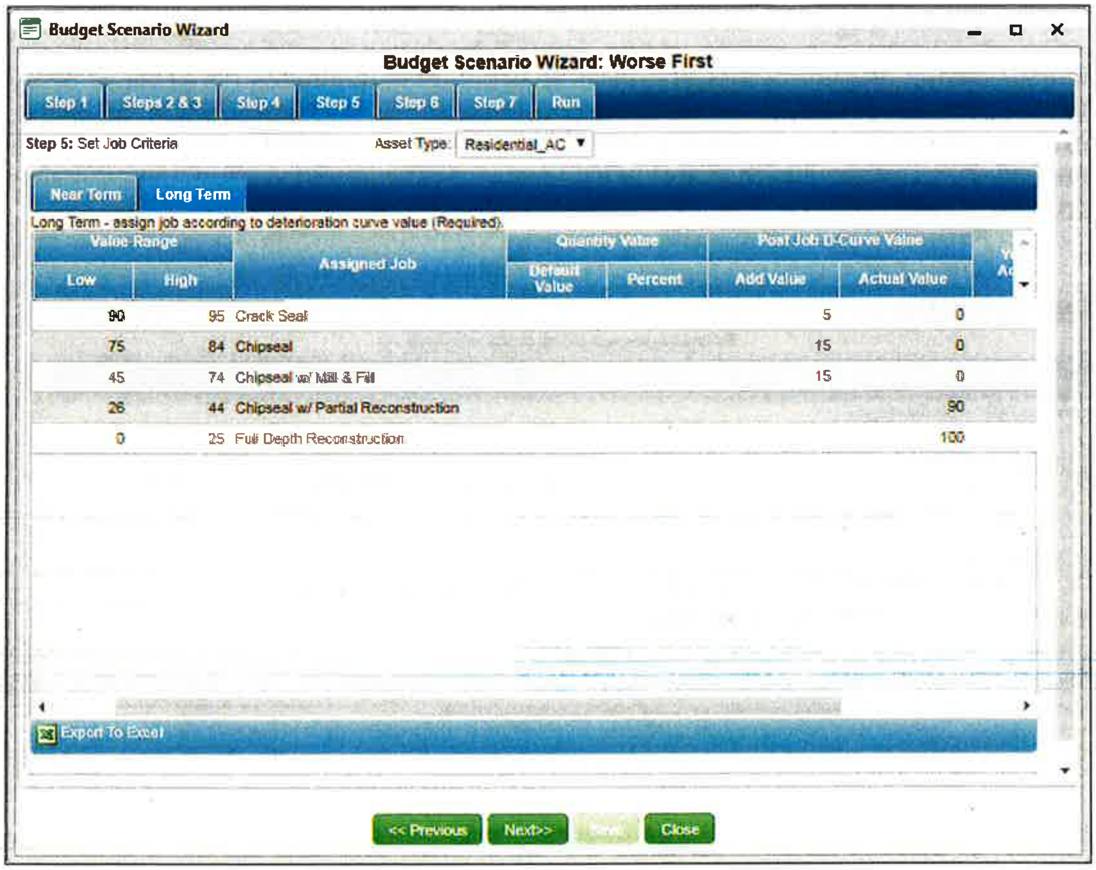


Figure 41: 5-Year Current Budget Scenario (Worst First) – Scenario Wizard – Step 5.1 – Residential

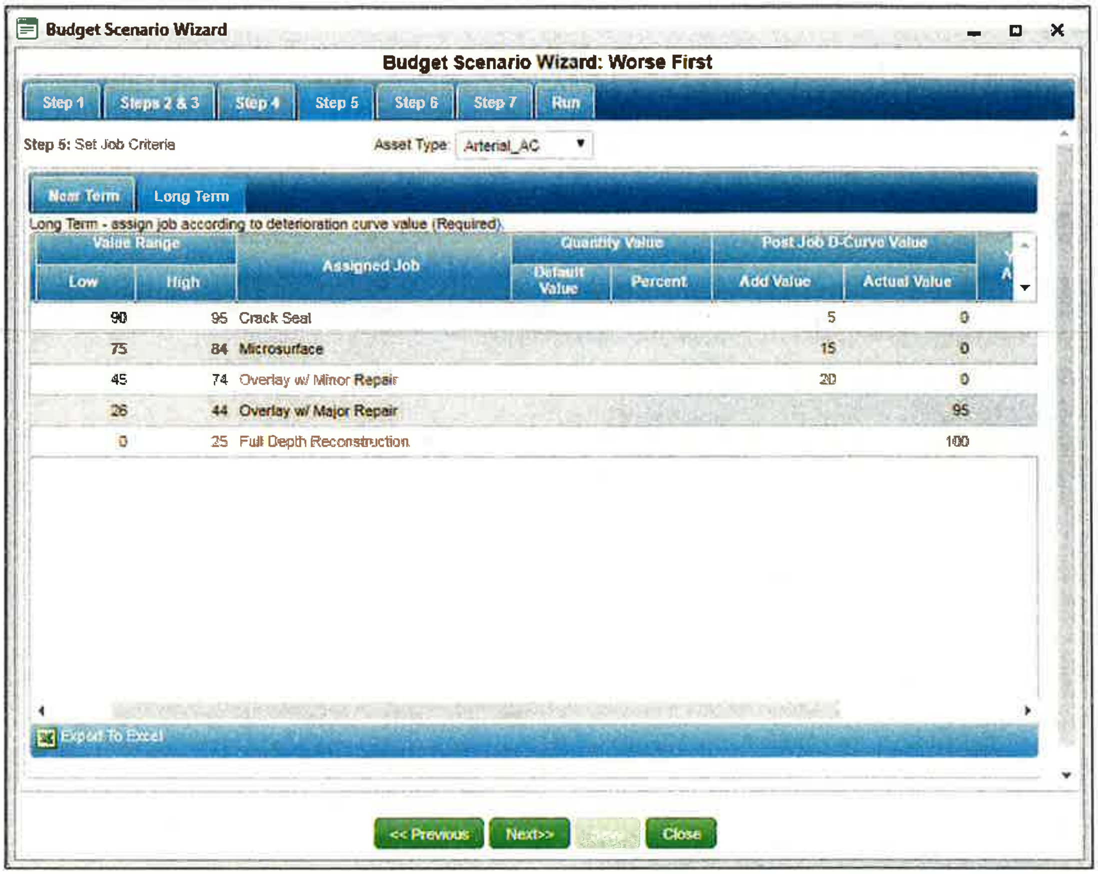


Figure 42: 5-Year Current Budget Scenario (Worst First) – Scenario Wizard – Step 5.2 – Arterial

Step 6:

Target Deterioration Values were not set for this scenario. We want to try to reach the maximum average PCI with the current budget.

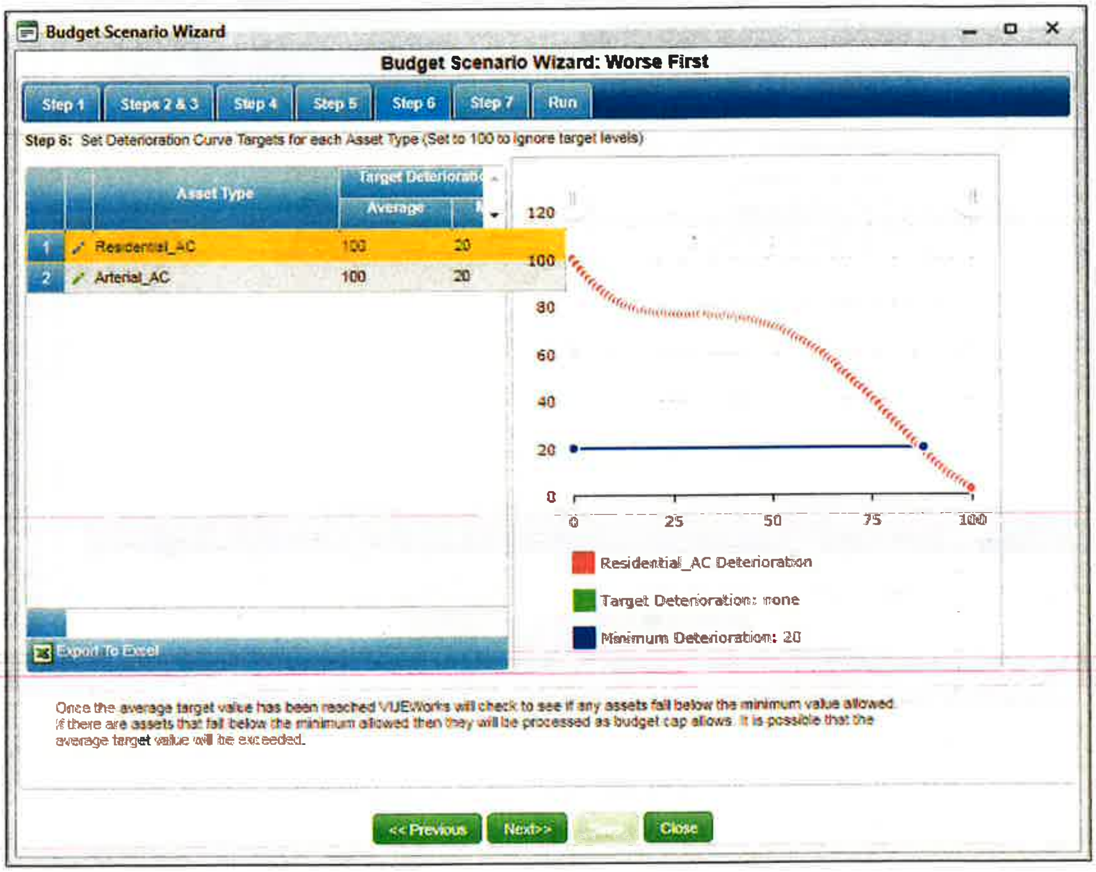


Figure 43: 5-Year Current Budget Scenario (Worst First) – Scenario Wizard – Step 6

Step 7:

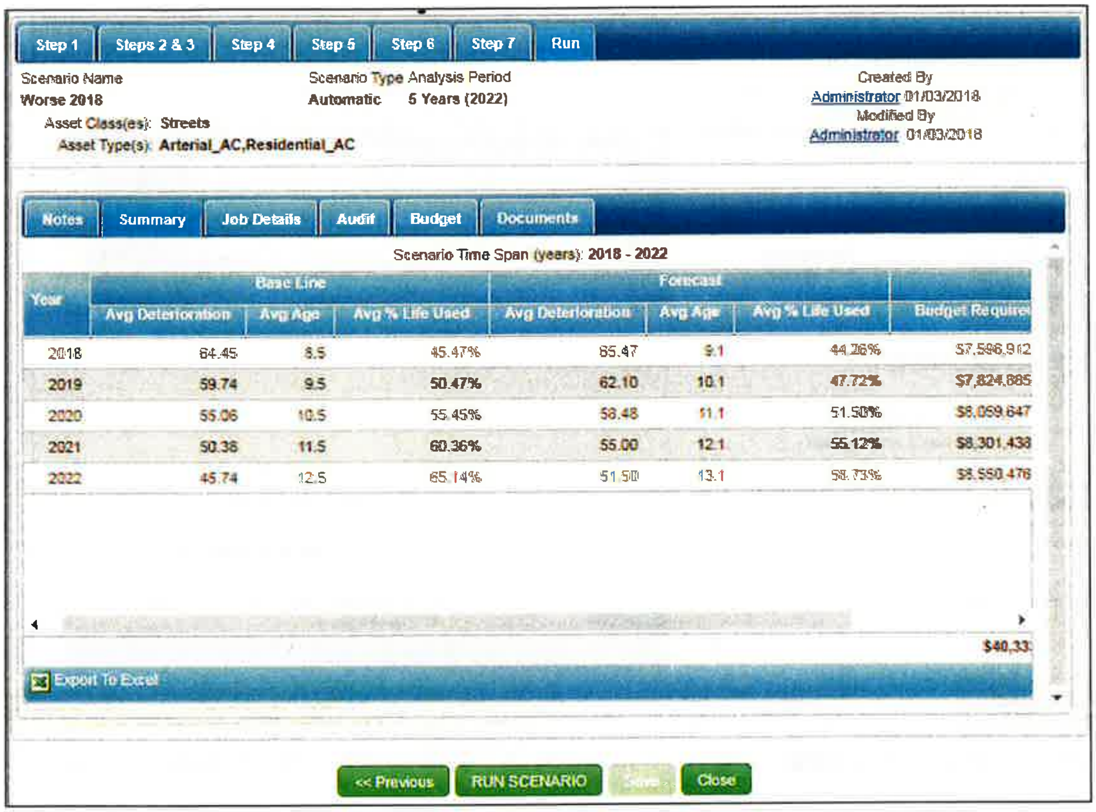
This is where the budget cap and number of years for the scenario to run are set.

Figure 44: 5-Year Current Budget Scenario (Worst First) – Scenario Wizard – Step 7.1 – Budget Constraints

Figure 45: 5-Year Current Budget Scenario (Worst First) – Scenario Wizard – Step 7.1 – Budget Cap

Run Scenario:

The final step was to run the scenario and review the summary and job details by year.



Year	Base Line			Forecast			
	Avg Deterioration	Avg Age	Avg % Life Used	Avg Deterioration	Avg Age	Avg % Life Used	Budget Require
2018	64.45	8.5	45.47%	65.47	9.1	44.26%	$7,596,912
2019	59.74	9.5	50.47%	62.10	10.1	47.72%	$7,824,885
2020	55.06	10.5	55.45%	58.48	11.1	51.50%	$8,059,647
2021	50.38	11.5	60.36%	55.00	12.1	55.12%	$8,301,438
2022	45.74	12.5	65.14%	51.50	13.1	58.73%	$8,550,476

Figure 46: 5-Year Current Budget Scenario (Worst First) – Scenario Wizard – Run Scenario

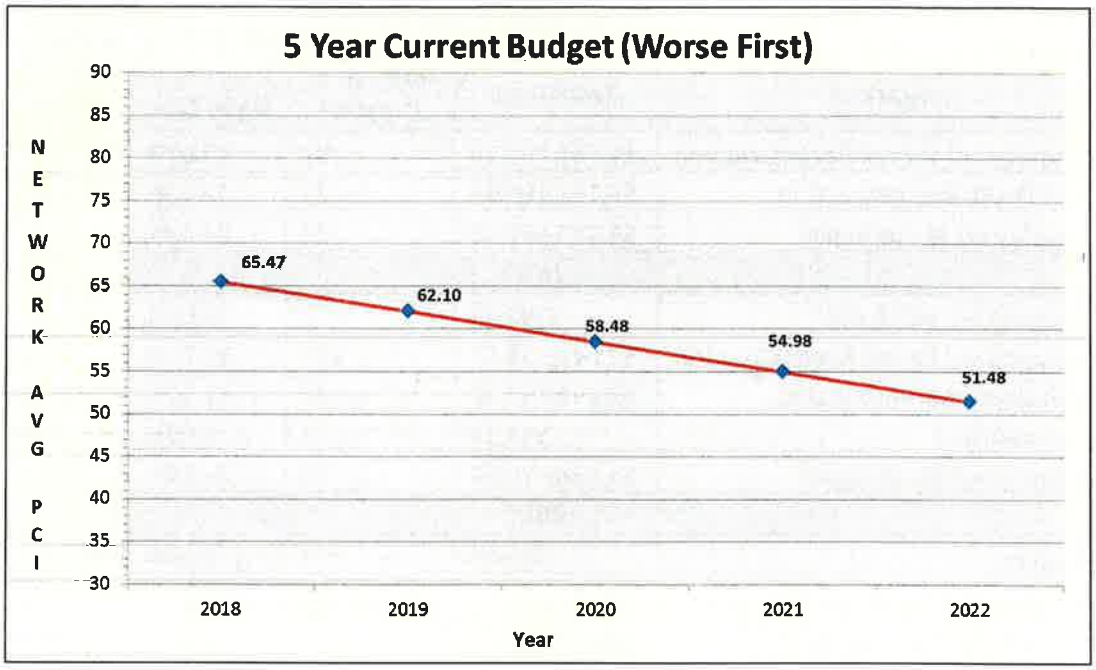


Figure 47: 5-Year Current Budget Scenario (Worst First) – PCI Plot

5-Year Current Budget (Worst First)		
Year	**Avg. PCI**	**Budget Required**
2018	65.47	$7,596,912.60
2019	62.10	$7,824,885.12
2020	58.48	$8,059,647.72
2021	54.98	$8,301,433.99
2022	51.48	$8,550,480.18

Figure 48: 5-Year Current Budget Scenario (Worst First) – Budget Information

Activity	Total Cost	Number of Projects	Percent of Total Cost	Percent of Projects
2018				
Chipseal w/ Partial Reconstruction	$2,568,785.14	93	33.81%	62.00%
Full Depth Reconstruction	$3,198,480.00	25	42.10%	16.67%
Overlay w/ Major Repair	$1,829,647.46	32	24.08%	21.33%
2019				
Chipseal w/ Mill & Fill	$390.44	2	0.00%	1.19%
Chipseal w/ Partial Reconstruction	$2,641,683.65	104	33.76%	61.90%
Full Depth Reconstruction	$3,294,197.31	28	42.10%	16.67%
Microsurface	$43.18	1	0.00%	0.60%
Overlay w/ Major Repair	$1,888,570.54	33	24.14%	19.64%
2020				
Chipseal	$39.66	1	0.00%	0.70%
Chipseal w/ Partial Reconstruction	$2,721,518.18	89	33.77%	62.24%
Full Depth Reconstruction	$3,392,937.03	25	42.10%	17.48%
Overlay w/ Major Repair	$1,945,152.85	28	24.13%	19.58%
2021				
Chipseal	$119.63	1	0.00%	0.59%
Chipseal w/ Partial Reconstruction	$2,802,277.03	111	33.76%	65.68%
Full Depth Reconstruction	$3,496,384.80	33	42.12%	19.53%
Overlay w/ Major Repair	$2,002,652.53	24	24.12%	14.20%
2022				
Chipseal w/ Partial Reconstruction	$2,953,049.44	92	34.54%	60.93%
Crack Seal	$19.81	1	0.00%	0.66%
Full Depth Reconstruction	$3,601,533.33	34	42.12%	22.52%
Overlay w/ Major Repair	$1,995,877.61	24	23.34%	15.89%

Figure 49: 5-Year Current Budget Scenario (Worst First) – Work Breakdown

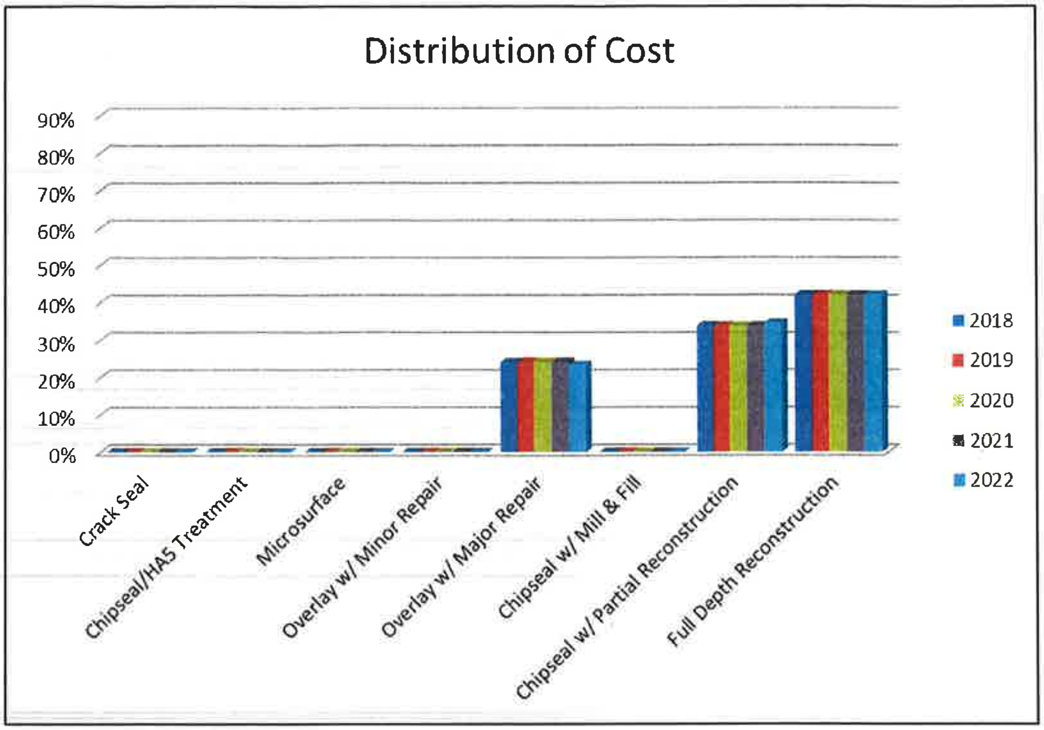


Figure 50: 5-Year Current Budget Scenario (Worst First) – Distribution of Cost

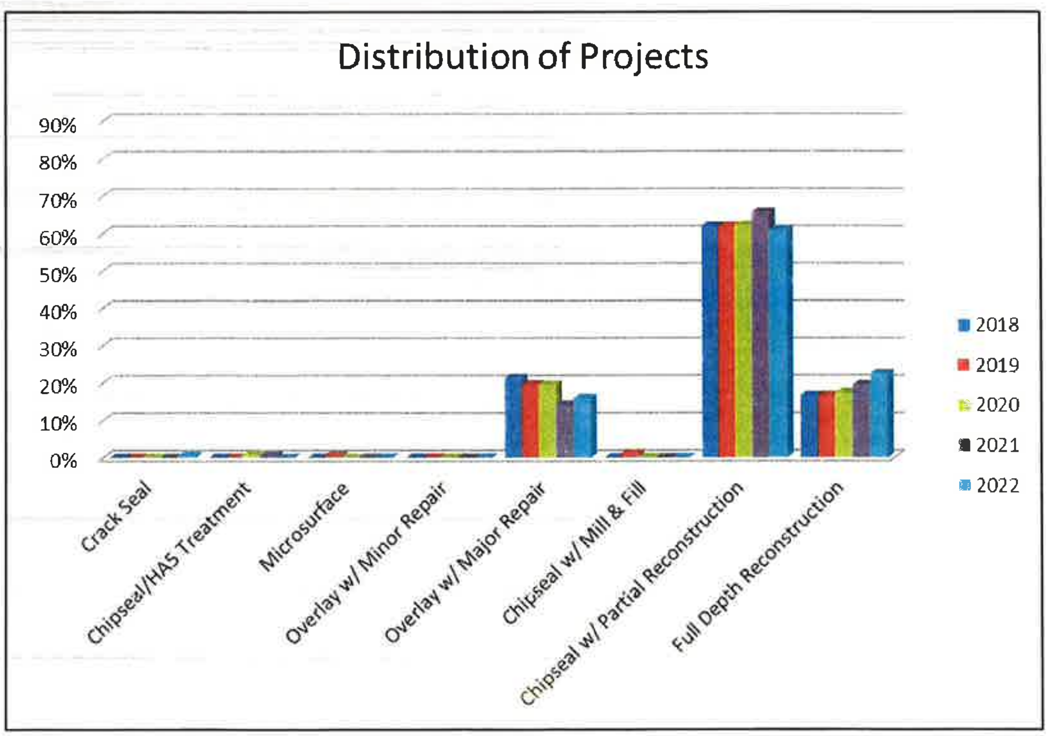


Figure 51: 5-Year Current Budget Scenario (Worst First) – Distribution of Projects

Synopsis:

The average network PCI would be decline from an approximate 65.47 in 2018 to an approximate 51.48 in 2022 if the City utilized their current budget of $7,597,000.00 per year using the Worst First methodology. In this scenario, the city street segments with the lowest PCI values would be targeted first; hence Full Depth Reconstruction. This scenario maximizes the City's pavement budget and is the best option for improving the overall network condition.

7.4 5-Year Current Budget Scenario (Best First)

This budget scenario was setup to use the current budget for five years by targeting the roads in better condition first (highest PCI).

Steps 1 through 7 in VUEWorks® are identical to section 7.3 "5-Year Current Budget Scenario (Worst First)," with an exception of step 4.

Step 4:

For this scenario, the "Prioritize assets with less deterioration" box was checked.

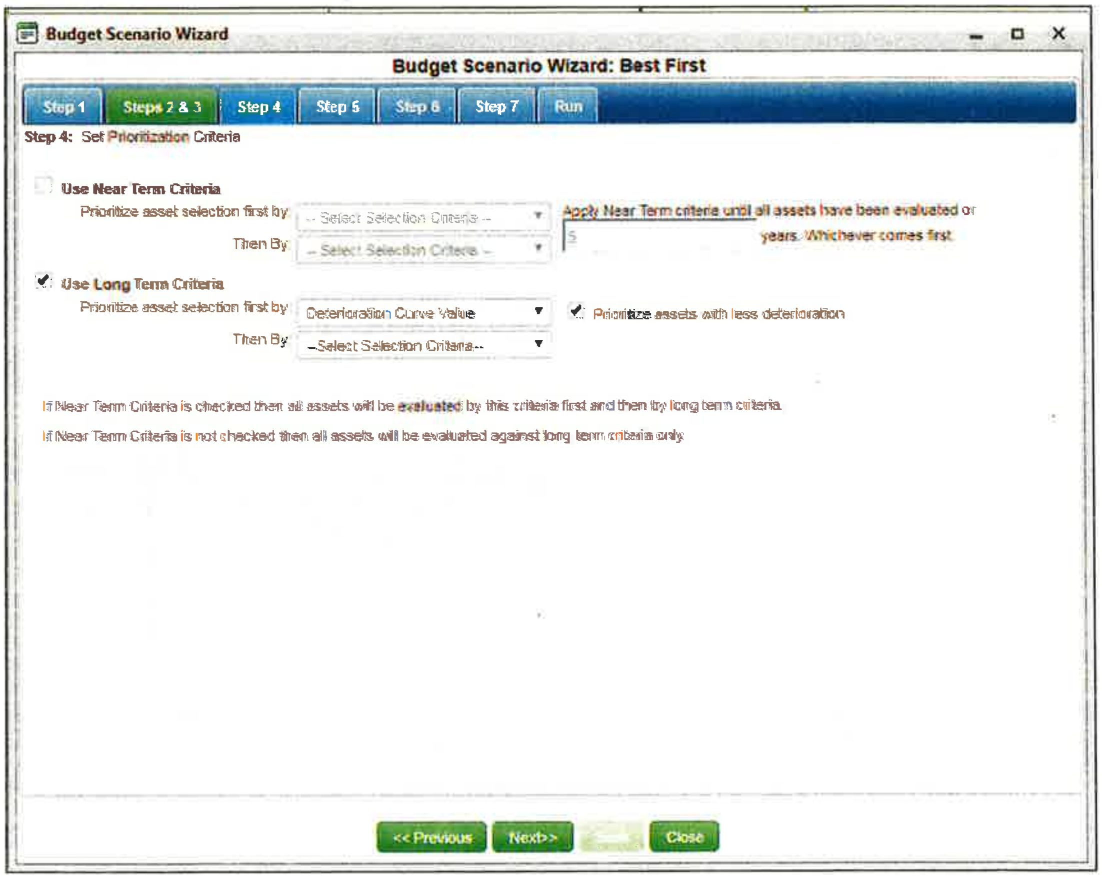


Figure 52: 5-Year Current Budget Scenario (Best First) – Scenario Wizard – Step 4

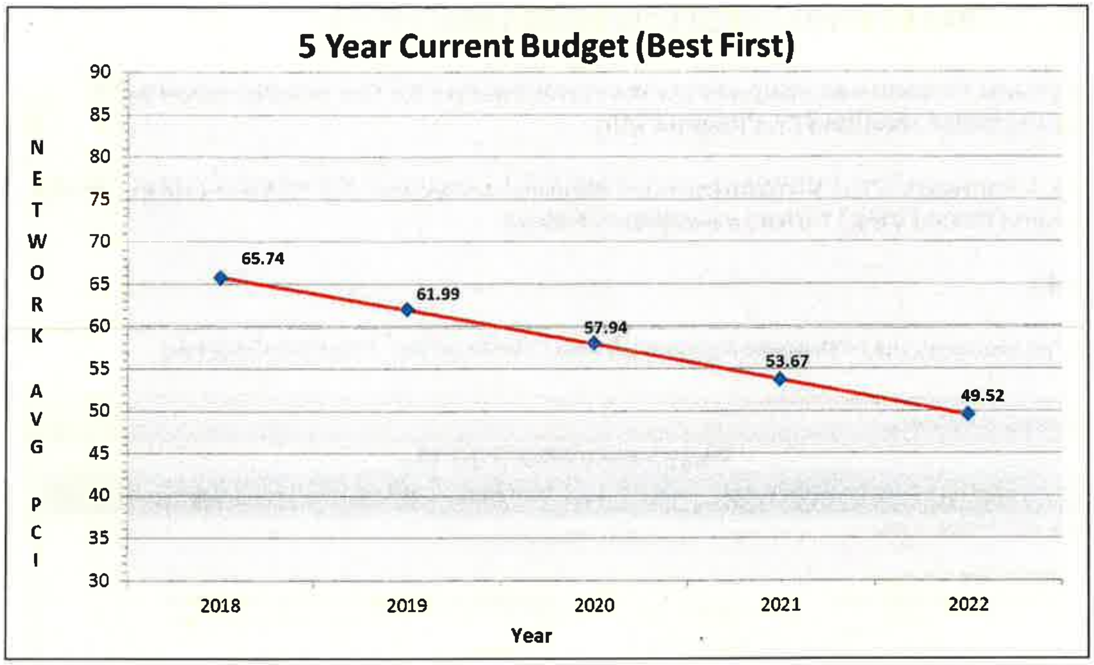


Figure 53: 5-Year Current Budget Scenario (Best First) – PCI Plot

5-Year Current Budget (Best First)		
Year	**Avg. PCI**	**Budget Required**
2018	65.74	$7,596,959.73
2019	61.99	$7,824,809.40
2020	57.94	$8,059,634.36
2021	53.67	$8,301,405.22
2022	49.52	$8,550,450.78

Figure 54: 5-Year Current Budget Scenario (Best First) – Budget Information

2018				
Activity	**Total Cost**	**Number of Projects**	**Percent of Total Cost**	**Percent of Projects**
Chipseal	$2,099,973.02	468	27.64%	54.29%
Chipseal w/ Mill & Fill	$2,490,211.79	172	32.78%	19.95%
Crack Seal	$4,946.23	10	0.07%	1.16%
Microsurface	$2,099,930.67	181	27.64%	21.00%
Overlay w/ Minor Repair	$901,898.01	31	11.87%	3.60%
2019				
Chipseal	$2,162,990.19	500	27.64%	54.53%
Chipseal w/ Mill & Fill	$2,534,243.85	169	32.39%	18.43%
Microsurface	$2,162,762.98	220	27.64%	23.99%
Overlay w/ Minor Repair	$964,812.39	28	12.33%	3.05%
2020				
Chipseal	$2,227,774.99	463	27.64%	51.67%
Chipseal w/ Mill & Fill	$2,627,674.09	166	32.60%	18.53%
Microsurface	$2,227,719.12	237	27.64%	26.45%
Overlay w/ Minor Repair	$976,466.16	30	12.12%	3.35%
2021				
Chipseal	$2,294,627.97	497	27.64%	57.86%
Chipseal w/ Mill & Fill	$2,366,055.06	137	28.50%	15.95%
Microsurface	$2,294,285.05	192	27.64%	22.35%
Overlay w/ Minor Repair	$1,346,437.14	33	16.22%	3.84%
2022				
Chipseal	$2,363,349.33	428	27.64%	51.32%
Chipseal w/ Mill & Fill	$2,381,555.24	137	27.85%	16.43%
Microsurface	$2,363,387.22	237	27.64%	28.42%
Overlay w/ Minor Repair	$1,442,159.00	32	16.87%	3.84%

Figure 55: 5-Year Current Budget Scenario (Best First) – Work Breakdown

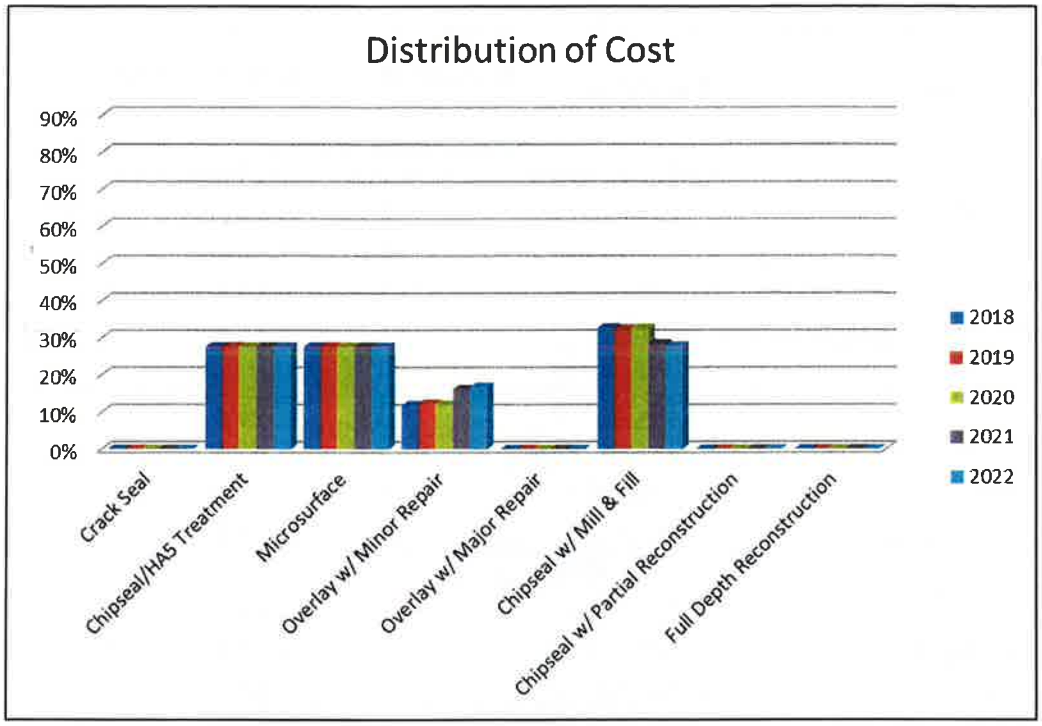


Figure 56: 5-Year Current Budget Scenario (Best First) – Distribution of Cost

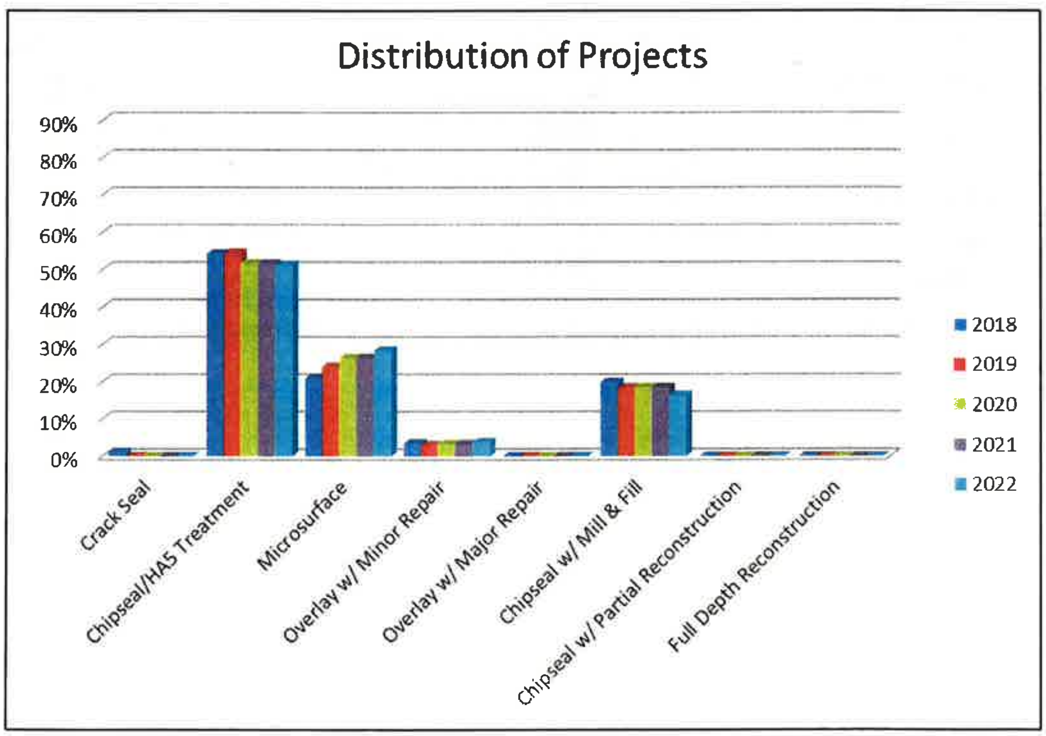


Figure 57:: 5-Year Current Budget Scenario (Best First) – Distribution of Projects

Synopsis:

The average network PCI would be decline from an approximate 65.74 in 2018 to an approximate 49.52 in 2022 if the City utilized their current budget of $7,597,000.00 per year using the Best First methodology. In this scenario, the majority of maintenance activities required is Chipseal. The negative effect of this scenario is that few roads receive reconstruction treatments because the majority of the budget is expended on preservation and rehabilitation treatments.

7.5 5-Year Increase & Maintain PCI of 71 Scenario

This budget scenario was setup to increase and maintain a network PCI of 71 for five years by targeting the roads in worse condition first (lowest PCI) and by using an unlimited pavement budget for maintenance.

Steps 1 through 5 in VUEWorks® are identical to section 7.3 “5-Year Current Budget Scenario (Worse First).”

Step 6

The Target Deterioration Value was changed to 71. We want to try to maintain this average PCI level and see what resulting budget would be required to maintain it.

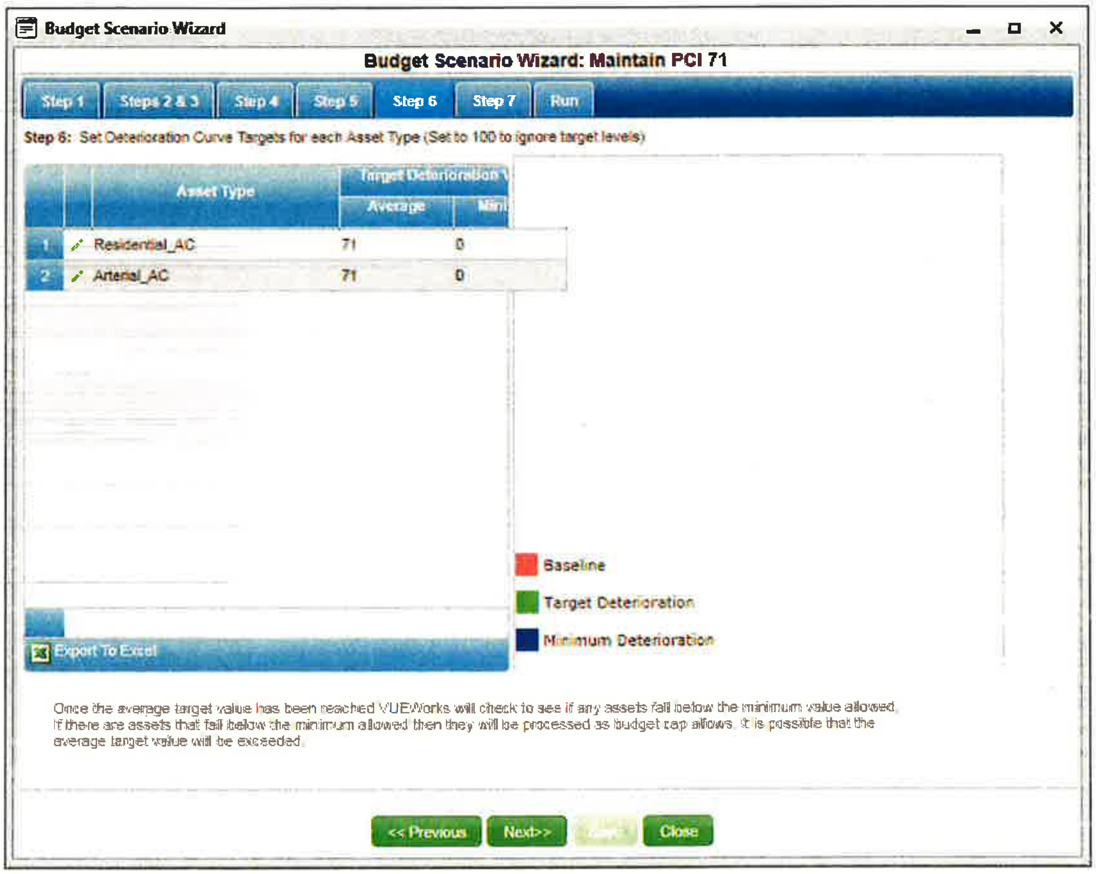


Figure 58: 5-Year Increase & Maintain PCI of 71 Scenario – Scenario Wizard – Steps 6

Step 7:

We utilized an unlimited amount for the pavement maintenance budget.

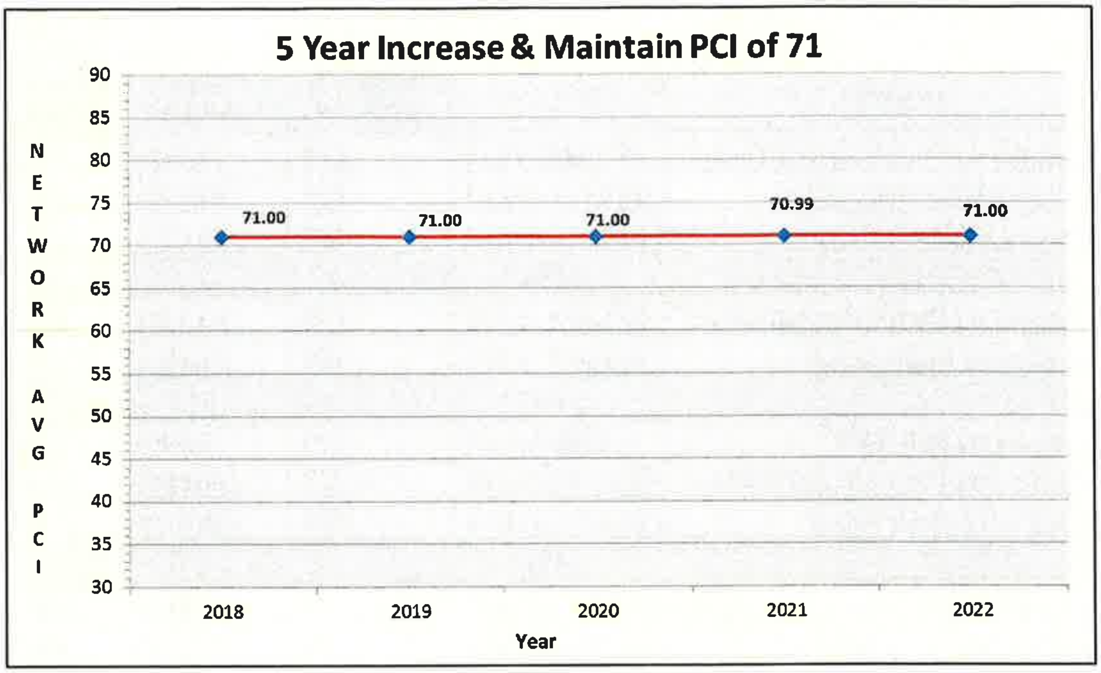


Figure 59: 5-Year Increase & Maintain PCI of 71 Scenario – PCI Plot

5-Year Increase & Maintain PCI of 71		
Year	**Avg. PCI**	**Budget Required**
2018	71.00	$54,999,287.72
2019	71.00	$34,997,471.56
2020	71.00	$36,356,701.77
2021	70.99	$34,444,695.37
2022	71.00	$33,128,271.53

Figure 60: 5-Year Increase & Maintain PCI of 71 Scenario – Budget Information

Activity	Total Cost	Number of Projects	Percent of Total Cost	Percent of Projects
2018				
Chipseal w/ Partial Reconstruction	$7,989,999.10	285	14.53%	37.80%
Full Depth Reconstruction	$32,792,642.61	275	59.62%	36.47%
Overlay w/ Major Repair	$14,216,646.01	194	25.85%	25.73%
2019				
Chipseal w/ Partial Reconstruction	$21,389,753.59	740	61.12%	80.09%
Overlay w/ Major Repair	$13,607,717.97	184	38.88%	19.91%
2020				
Chipseal w/ Mill & Fill	$903,526.14	49	2.49%	5.18%
Chipseal w/ Partial Reconstruction	$22,157,977.61	727	60.95%	76.85%
Overlay w/ Major Repair	$13,295,198.02	170	36.57%	17.97%
2021				
Chipseal w/ Partial Reconstruction	$20,899,365.43	679	60.68%	81.91%
Overlay w/ Major Repair	$13,545,329.94	150	39.32%	18.09%
2022				
Chipseal w/ Partial Reconstruction	$19,066,169.32	584	57.55%	81.91%
Overlay w/ Major Repair	$14,062,102.21	129	42.45%	18.09%

Figure 61: 5-Year Increase & Maintain PCI of 71 Scenario – Work Breakdown

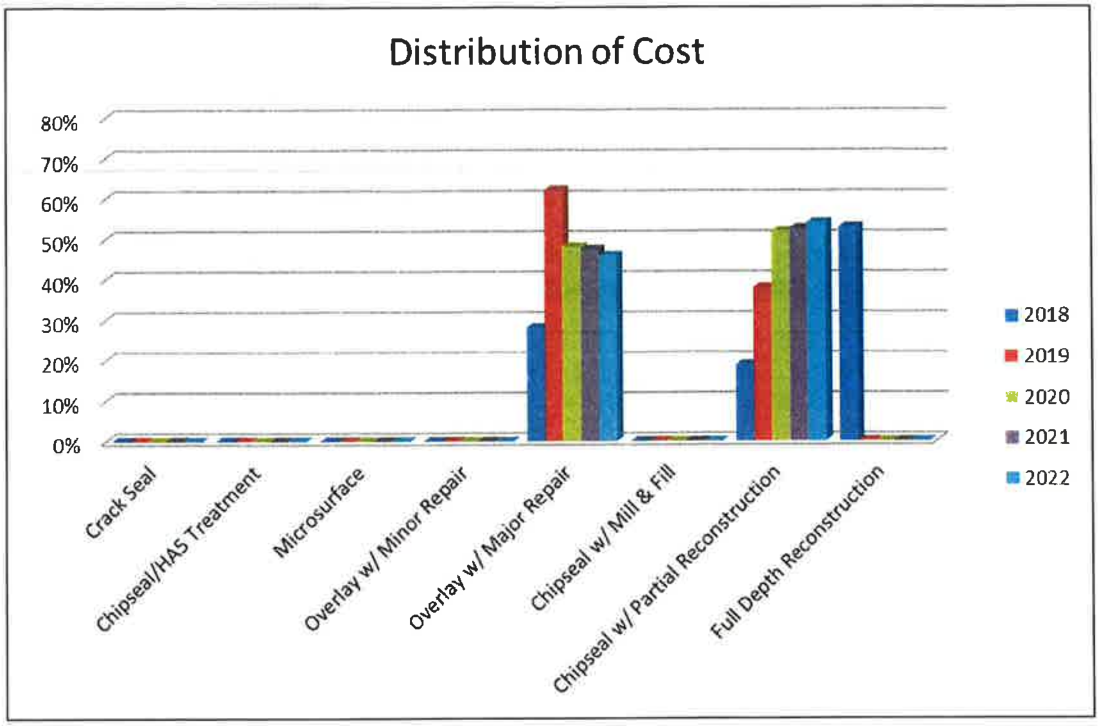


Figure 62: 5-Year Increase & Maintain PCI of 71 Scenario – Distribution of Cost

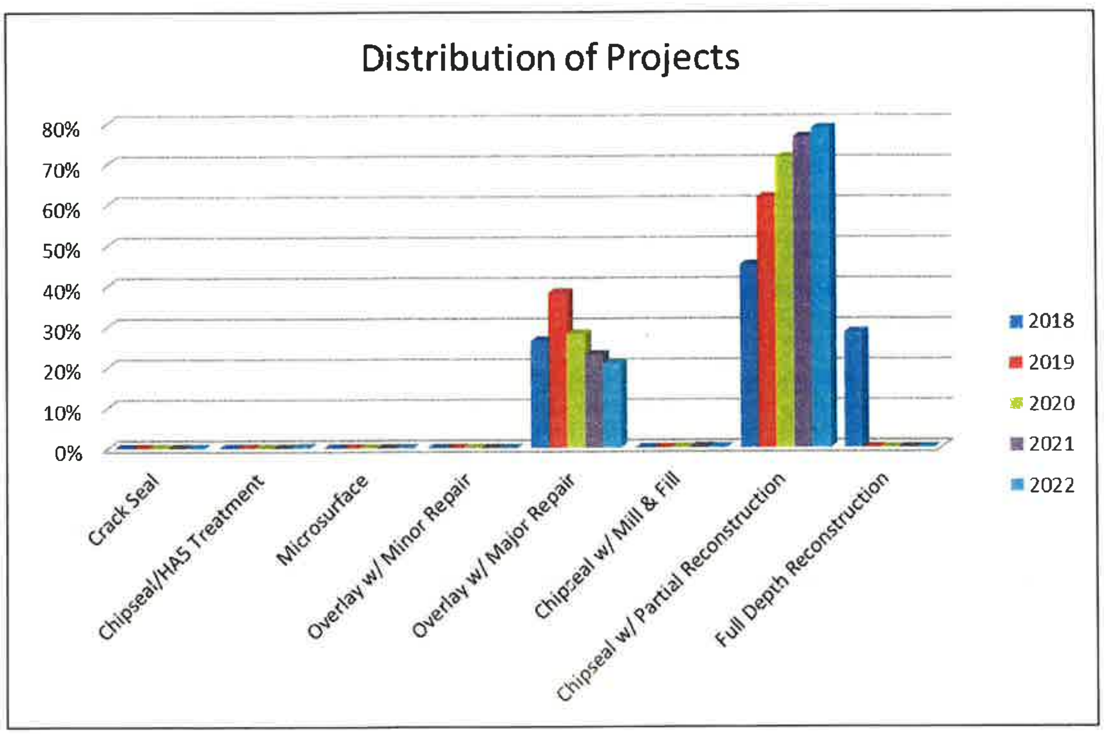


Figure 63: 5-Year Increase & Maintain PCI of 71 Scenario – Distribution of Projects

Synopsis:

In 2018 the average network PCI would be increase to 71 and be maintain near its current level for the following four years, if the City uses the budget amount shown in Figure 60. In this scenario the majority of the work and cost is focused on the rehabilitation treatment. The majority of the efforts will be to maintain the PCI by reconstructing and applying rehabilitation to the lower performing roads. At some point a preventive philosophy would need to be implemented to help maintain the conditions. We believe a more realistic approach may include a balance of reconstruction and preventive maintenance.

7.6 5-Year Increase PCI to 75 Scenario

This budget scenario was setup to increase the network PCI to 75 over a period of five years by targeting the roads in worse condition first (lowest PCI) and by using an unlimited pavement budget for maintenance.

Steps 1 through 5 in VUEWorks® are identical to section 7.5 "5-Year Increase & Maintain PCI of 71 Scenario," except for step 6. In step 6 the target deterioration value was changed to 75.

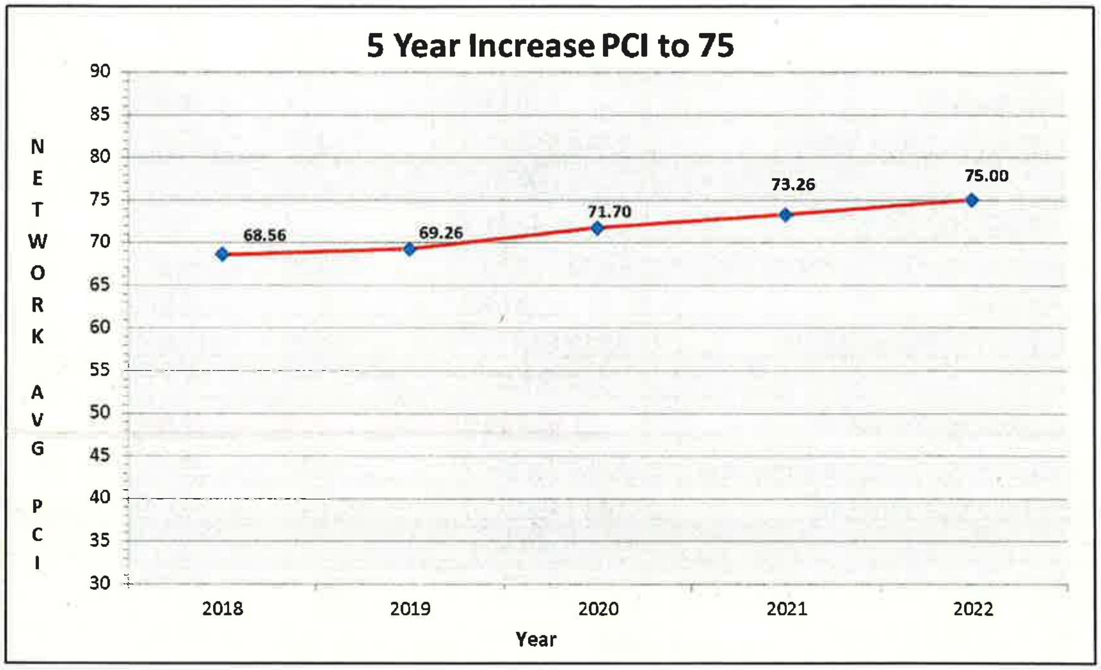


Figure 64: 5-Year Increase PCI to 75 Scenario – PCI Plot

5-Year Increase PCI to 75		
Year	**Avg. PCI**	**Budget Required**
2018	68.56	$39,999,906.66
2019	69.26	$44,999,991.56
2020	71.70	$49,999,993.70
2021	73.26	$54,999,923.77
2022	75.00	$52,255,812.51

Figure 65: 5-Year Increase PCI to 75 Scenario – Budget Information

2018				
Activity	**Total Cost**	**Number of Projects**	**Percent of Total Cost**	**Percent of Projects**
Chipseal w/ Partial Reconstruction	$3,044,136.55	110	7.61%	24.66%
Full Depth Reconstruction	$32,792,642.61	275	81.98%	61.66%
Overlay w/ Major Repair	$4,163,127.51	61	10.41%	13.68%
2019				
Chipseal w/ Partial Reconstruction	$8,468,135.30	294	18.82%	44.34%
Crack Seal	$52.53	2	0.00%	0.30%
Full Depth Reconstruction	$24,303,204.12	202	54.01%	30.47%
Microsurface	$43.18	1	0.00%	0.15%
Overlay w/ Major Repair	$12,228,556.42	164	27.17%	24.74%
2020				
Chipseal w/ Mill & Fill	$382.91	2	0.00%	0.16%
Chipseal w/ Partial Reconstruction	$26,170,612.38	906	52.34%	74.57%
Crack Seal	$18.67	1	0.00%	0.08%
Overlay w/ Major Repair	$23,828,979.74	306	47.66%	25.19%
2021				
Chipseal w/ Mill & Fill	$1,730.74	3	0.00%	0.24%
Chipseal w/ Partial Reconstruction	$32,569,785.91	1012	59.22%	81.68%
Overlay w/ Major Repair	$22,428,407.12	224	40.78%	18.08%
2022				
Chipseal w/ Partial Reconstruction	$41,645,802.49	1266	79.70%	89.72%
Overlay w/ Major Repair	$10,610,010.02	145	20.30%	10.28%

Figure 66: 5-Year Increase PCI to 75 Scenario – Work Breakdown

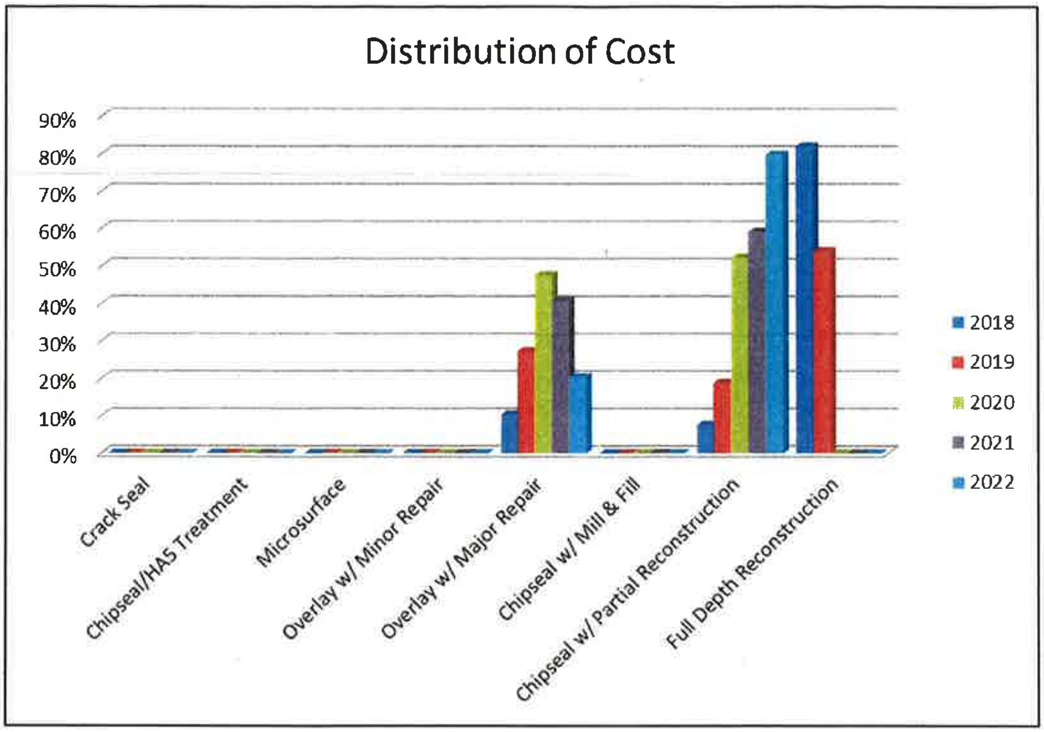


Figure 67: 5-Year Increase PCI to 75 Scenario – Distribution of Cost

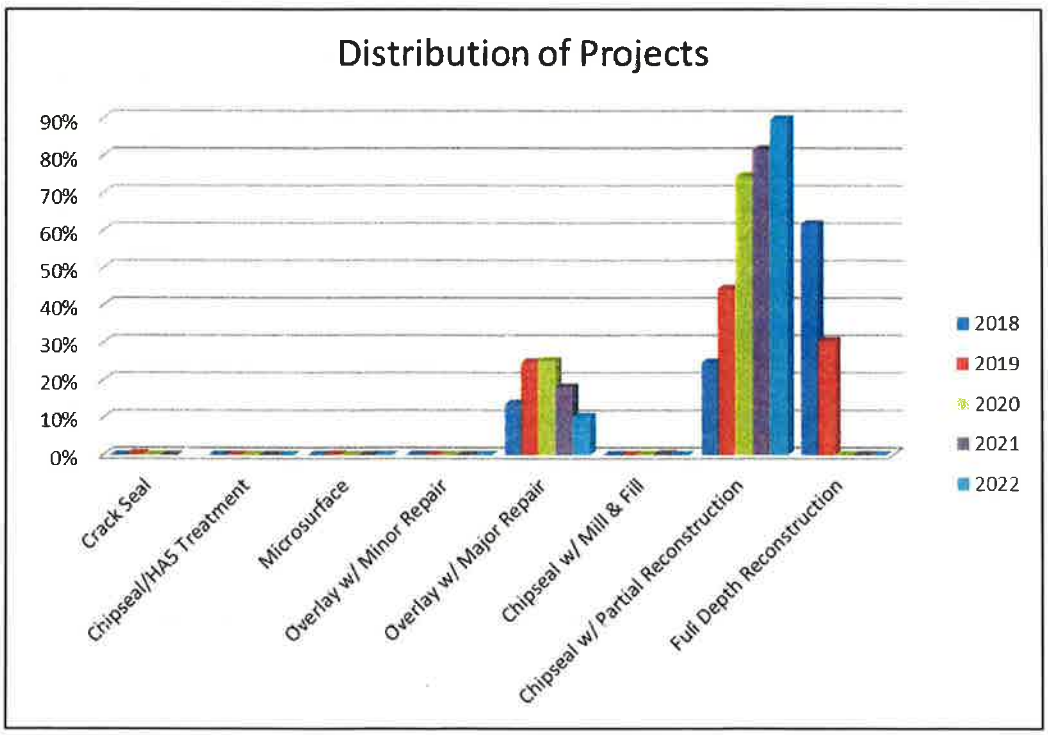


Figure 68: 5-Year Increase PCI to 75 Scenario – Distribution of Projects

Synopsis:

In order to increase the average network PCI to 75 over a period of five years, from 2018 to 2022, the City would need to allocate the recommended budget amount shown in Figure 65 to their pavement maintenance work plan. The majority of the budget is expended on rehabilitation and reconstruction treatment.

7.7 5-Year Increase PCI to 80 Scenario

This budget scenario was setup to increase the network PCI to 80 over a period of five years by targeting the roads in worse condition first (lowest PCI) and by using an unlimited pavement budget for maintenance.

Steps 1 through 7 in VUEWorks® are identical to section 7.5 "5-Year Increase & Maintain PCI of 71 Scenario," except for step 6. In step 6 the target deterioration value was changed to 80.

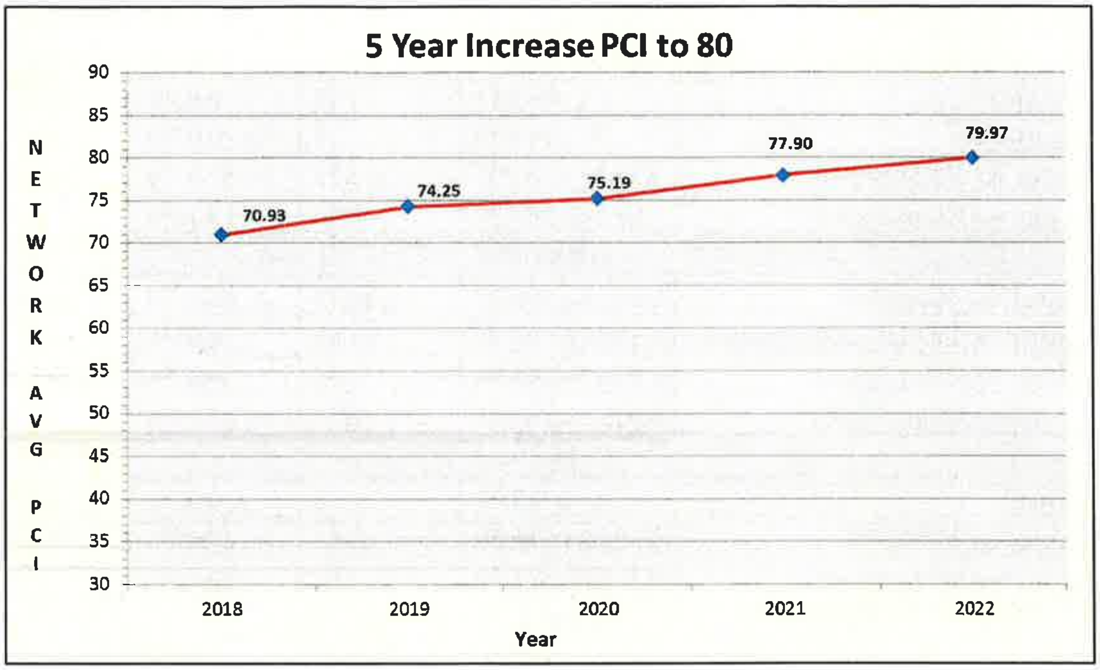


Figure 69: 5-Year Increase PCI to 80 Scenario – PCI Plot

5-Year Increase PCI to 80		
Year	**Avg. PCI**	**Budget Required**
2018	70.93	$54,999,986.75
2019	74.25	$64,999,987.95
2020	75.19	$74,999,964.72
2021	77.90	$84,999,985.44
2022	79.97	$53,439,721.84

Figure 70: 5-Year Increase PCI to 80 Scenario – Budget Information

Activity	Total Cost	Number of Projects	Percent of Total Cost	Percent of Projects
2018				
Chipseal w/ Mill & Fill	$516.28	2	0.00%	0.26%
Chipseal w/ Partial Reconstruction	$8,318,558.87	298	15.12%	39.16%
Full Depth Reconstruction	$32,792,642.61	275	59.62%	36.14%
Overlay w/ Major Repair	$13,888,268.99	186	25.25%	24.44%
2019				
Chipseal w/ Mill & Fill	$9,574,195.66	612	14.73%	32.11%
Chipseal w/ Partial Reconstruction	$22,437,264.57	781	34.52%	40.98%
Crack Seal	$49.41	1	0.00%	0.05%
Microsurface	$43.18	1	0.00%	0.05%
Overlay w/ Major Repair	$24,419,132.91	331	37.57%	17.37%
Overlay w/ Minor Repair	$8,569,302.23	180	13.18%	9.44%
2020				
Chipseal w/ Mill & Fill	$49,582,998.23	3041	66.11%	84.38%
Chipseal w/ Partial Reconstruction	$2,103,507.50	61	2.80%	1.69%
Overlay w/ Major Repair	$2,535,206.94	23	3.38%	0.64%
Overlay w/ Minor Repair	$20,778,252.05	479	27.70%	13.29%
2021				
Chipseal	$935.61	3	0.00%	0.07%
Chipseal w/ Mill & Fill	$59,005,018.80	3563	69.42%	86.21%
Overlay w/ Minor Repair	$25,994,031.02	567	30.58%	13.72%
2022				
Chipseal	$4,478,085.79	768	8.38%	22.82%
Chipseal w/ Mill & Fill	$38,536,163.10	2210	72.11%	65.66%
Microsurface	$2,154,302.15	208	4.03%	6.18%
Overlay w/ Minor Repair	$8,271,170.80	180	15.48%	5.35%

Figure 71: 5-Year Increase PCI to 80 Scenario – Work Breakdown

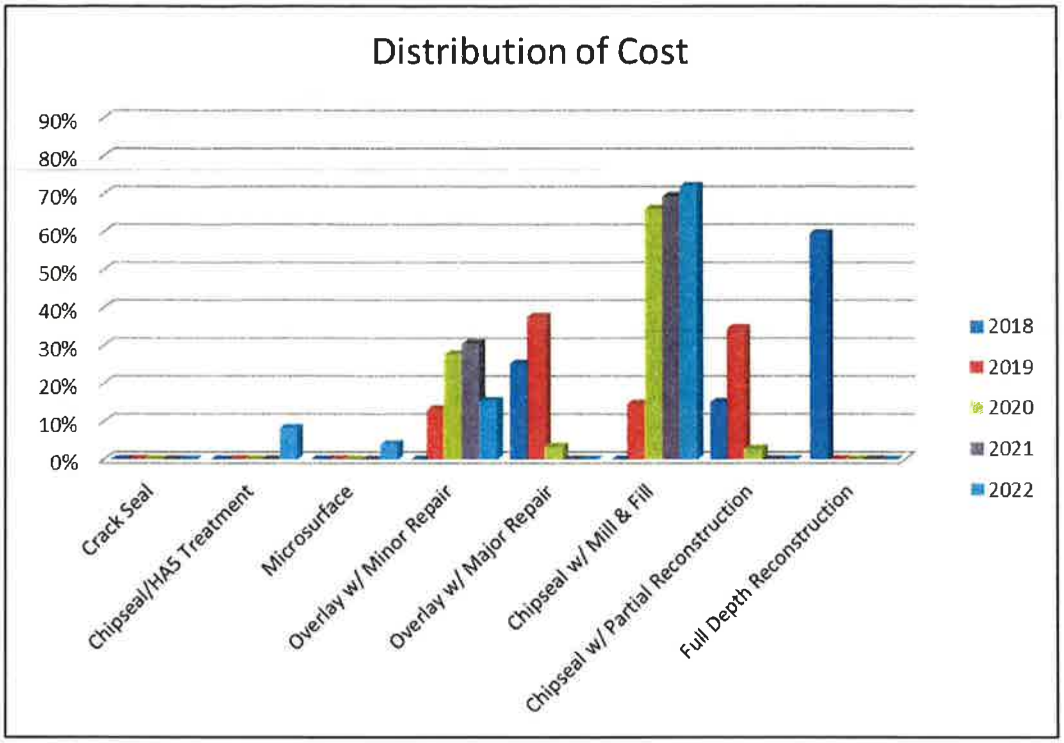


Figure 72: 5-Year Increase PCI to 80 Scenario – Distribution of Cost

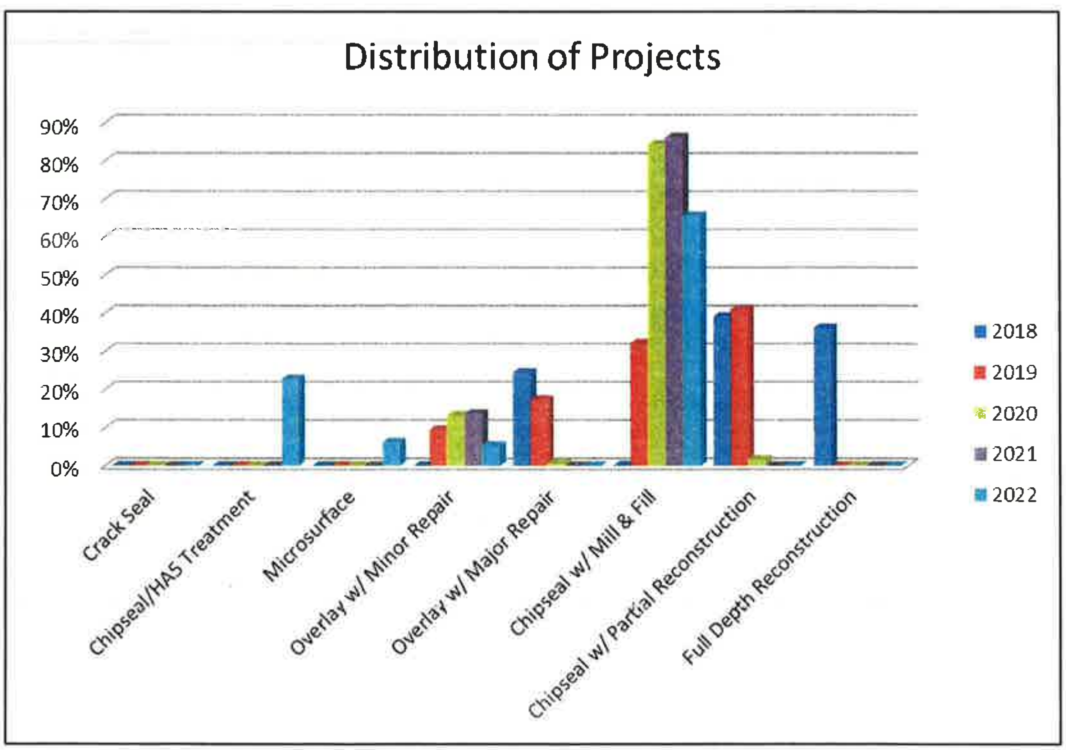


Figure 73: 5-Year Increase PCI to 80 Scenario – Distribution of Projects

Synopsis:

In order to increase the average network PCI to 80 over a period of five years, from 2018 to 2022, the City would need to allocate the recommended budget amount shown in Figure 70 to their pavement maintenance work plan. The majority of the budget is expended on rehabilitation and reconstruction treatment.