Pavement Condition Assessment update

for

City of Arvada

December 2015

Section 1. Executive Summary

Atkins North America was contracted by the City of Arvada, Colorado to update the pavement management system (PMS) for the City's (467.16 centerline mile/1524.5 lane mile) roadway network. The intent of the PMS is to provide the City with easily accessible inventory and management information for managing their pavement. The PMS also provides a framework for long term financial planning while easily assessing the implications of alternative funding levels. Finally, the PMS facilitates planning and implementation of a specific maintenance and rehabilitation program while monitoring its effectiveness.

Atkins utilizes the PAVER™ software program, which was originally developed in the late 1970s to assist the Department of Defense in managing the maintenance and repair (M&R) of its inventory of pavements. It utilizes visual inspection data and a pavement condition index (PCI) scoring from zero (failed) to 100 (excellent) for rating a pavement's condition and for forecasting its future M&R needs. In order to update the PMS the Atkins team performed the following tasks as outlined in the statement of work:

- City wide pavement condition assessment with the Cartegraph Automated Pavement Data Collection vehicle
- Data Entry and Update existing pavement
- Run pavement management scenarios
- Summary report/project documentation
- Verification of section widths (for new roadway sections)

This project was a comprehensive pavement management system update including validated GIS inventory information, inspection data that complies with the ASTM D-6433-11 standards of practice, objectively computed PCI values for each section, pavement life cycle models developed from updated data, costing models created in collaboration with City staff, and work plan scenarios designed to provide realistic views of future budget and condition models. The overall goals of the implementation were intended to accomplish the following:

- Provide the City with an up to date inventory of their pavement network that includes age, quantity, area, and use category data.
- Establish a baseline of objectively computed condition index data that can be used by the City to prioritize work planning and accurately represent current pavement status.
- Leverage pavement data to create life-cycle models that will assist the City in extending pavement life throughout the community.
- Produce engineering-based work plans designed to model various budget scenarios and provide decision support to maximize return on investment of limited financial resources.
- Increase awareness of pavement condition and provide defensible and justifiable budgets to decision makers.

Atkins applied quality control measures throughout the project to ensure data integrity, cost control, and schedule adherence. Quality control measures included:

- PAVER database data verification – Inventory and inspection tasks
- Pavement distress identification clarification and data collection process check – Inspection task
- Comparable organization cost and life cycle model cross checks – Work Planning (with prediction modeling) task

Section 2 of this report will detail the work that was carried out during each task. Section 3 will provide current inventory and condition data. Finally, Section 4 will outline nine budget scenarios that will provide decision support information for the City's future planning activities.

Section 2. Task Detail

For clarification, this project consists of five tasks numbered tasks 2-5 and optional task 1 – which will be presented below in the sequence that they were performed.

Task 2 – Condition Assessment

This task involved updating inventory and inspection data on the entire pavement network. PAVER inventory management is based on a hierarchical structure composed of networks, branches, and sections, with the section being the smallest managed unit. This structure allows users to easily organize their inventory while providing numerous fields and levels for storing pavement data. Using City provided information, the following inventory information required by PAVER was updated in the 2015:

- Network, Branch, and Section IDs
- Section Rank
- Surface Type
- Last Construction Date
- Lengths and Widths of typical sections

A brief description of the required inventory elements is provided below.

2.1. Network, Branch, and Section IDs

The network is the term used for the largest area that needs to be classified. In this case Arvada served as one overall network.

The branch is each major segment within the network. Street names served as the perfect Branch ID within the Arvada network.

The Section ID is the management unit that must have the same pavement type, age, condition and overall characteristics.

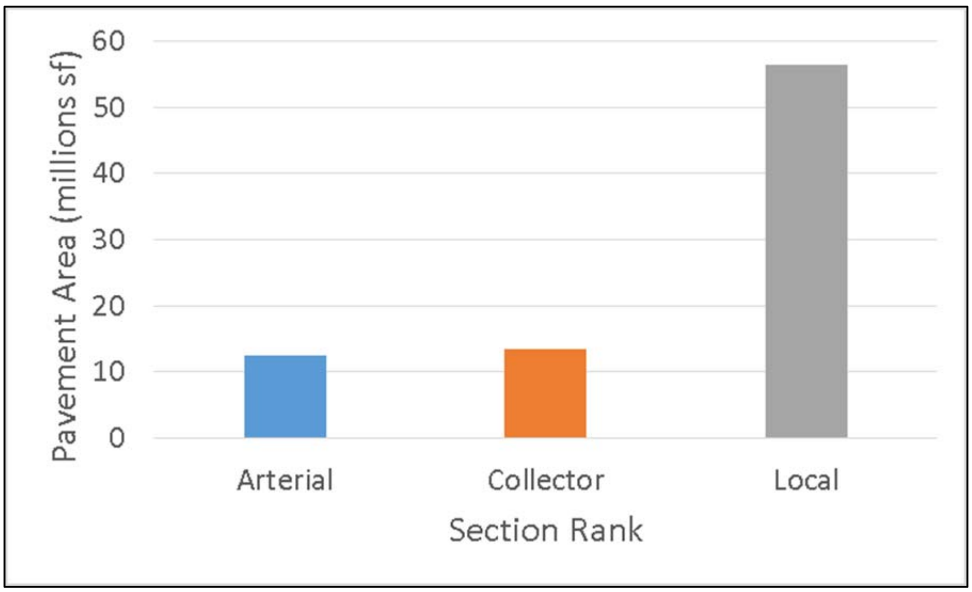
2.2. Section Rank

Section ranks represents the class of the roadway element based on traffic volume. Rank letters are designated to represent the following classes:

- A = Arterial Roads (Example: Ralston Road)
- C = Collector Roads (Example: Carr Street)
- E = Local Roads (Example: Dudley Street)

Figure 2-1 shows the breakdown of the City's pavement network by section rank classification.

Figure 2-1: Arvada Pavement Rank Distribution



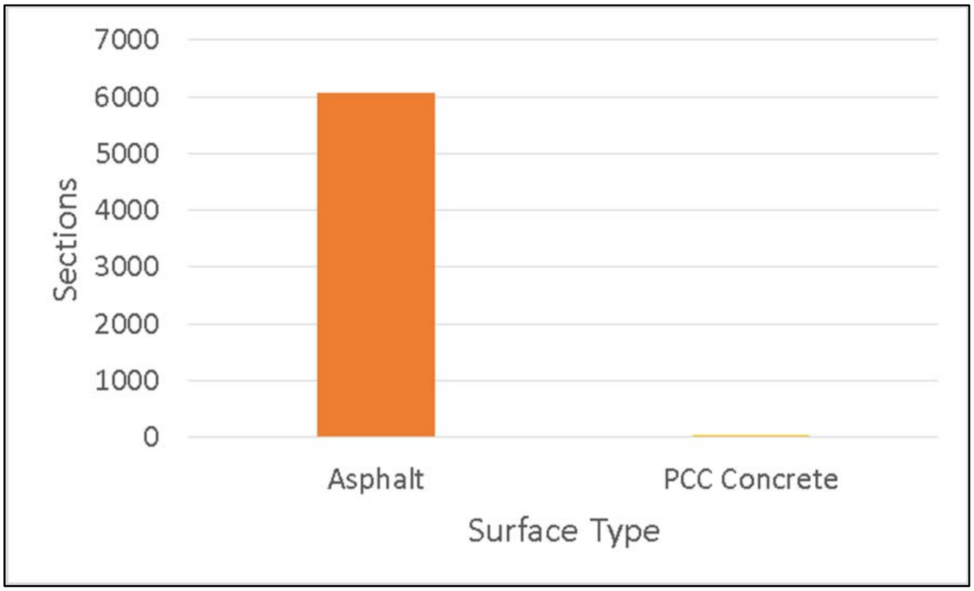
2.3. Surface Type

The surface type input data represents the classification of the pavement surface. The following surface types were identified for the City:

- AAC = Full-depth Asphalt Concrete which is the technical term for "Asphalt" (Example: 72nd Avenue from Quaker St. to Virgil Way)
- PCC = Portland Cement "Concrete" (Example: Holman Street)

Figure 2-2 shows the distribution of all sections in the City network and their surface type classification with over 99% being asphalt.

Figure 2-2: Arvada Pavement Surface Distribution

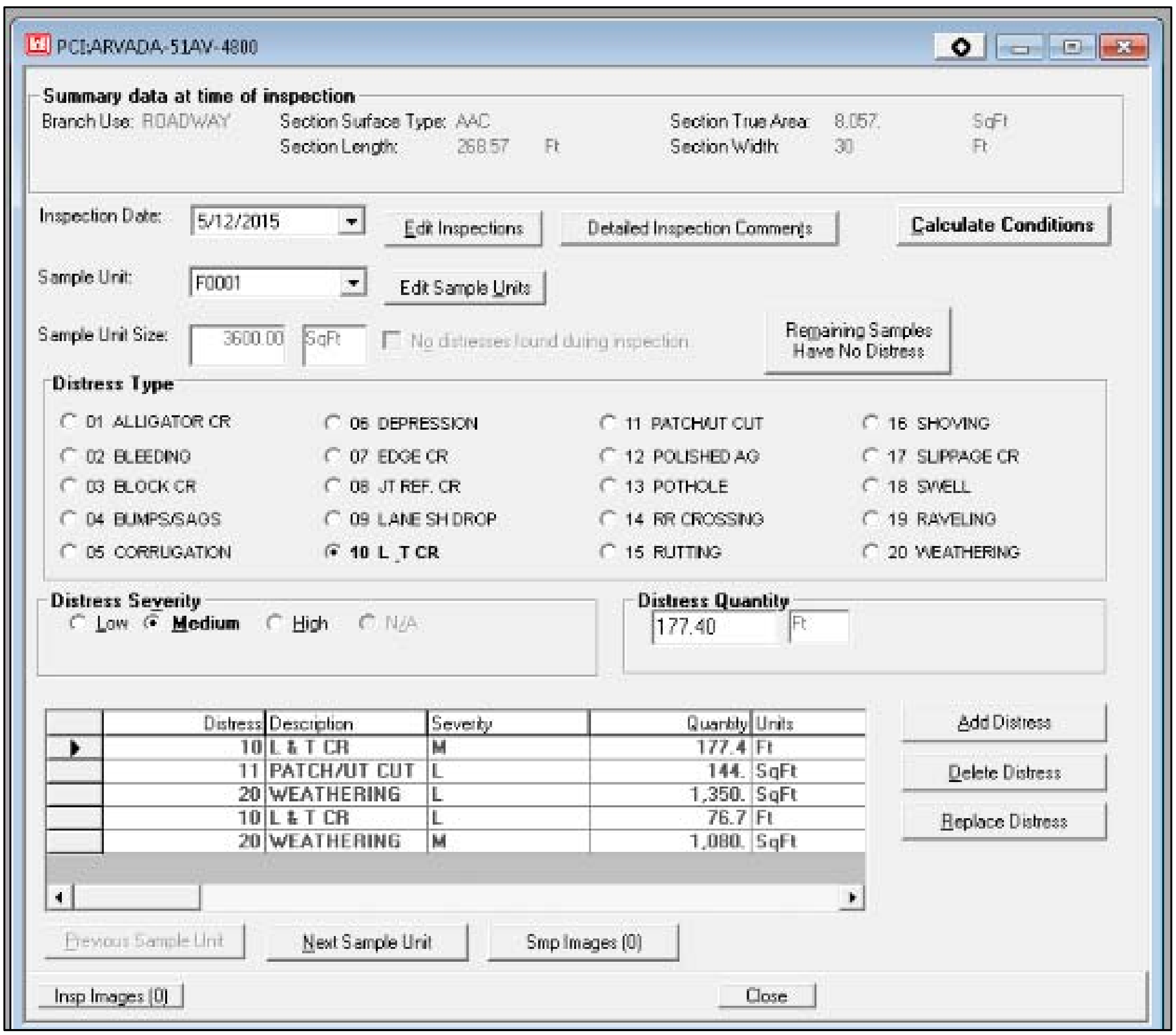


2.4 Last Construction Date

The last construction date represents the most recent date in which improvements were made to a pavement section. Atkins obtained baseline information from the City staff that will be updated in PAVER as major rehabilitation efforts take place. Atkins collaborated with City GIS personnel to validate the PAVER database with updated (City verified) inventory data. The database utilizes existing City GIS segmentation (intersection to intersection) to establish a pavement network sectioned in compliance with both PAVER guidelines and the City's GIS maps. Atkins received an updated shape file from the City complete with required inventory elements – and updated the previously created PAVER database from that information. The new database was quality checked using PAVER to identify missing or incomplete data.

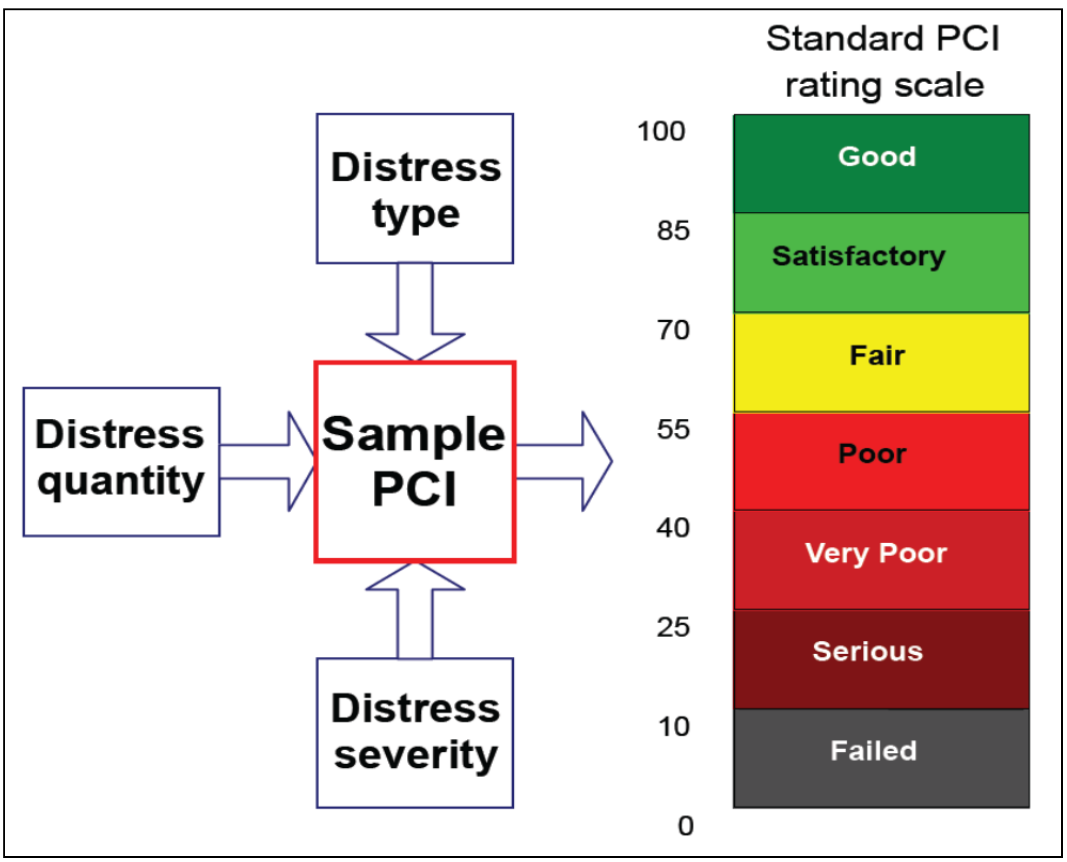
Once this segmentation was established, the inspection team was deployed with the updated database mapping to collect inspection data for each section. The inspection team spent three weeks in the field collecting inspection data in accordance with inspection procedures outlined in ASTM D-6433-11, Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys. This included proper identification of distress types, as well as proper establishment of representative samples. Figure 2-3 below shows a snapshot of the inspection data entry dialogue box from the PAVER program.

Figure 2-3: Inspection Data Entry



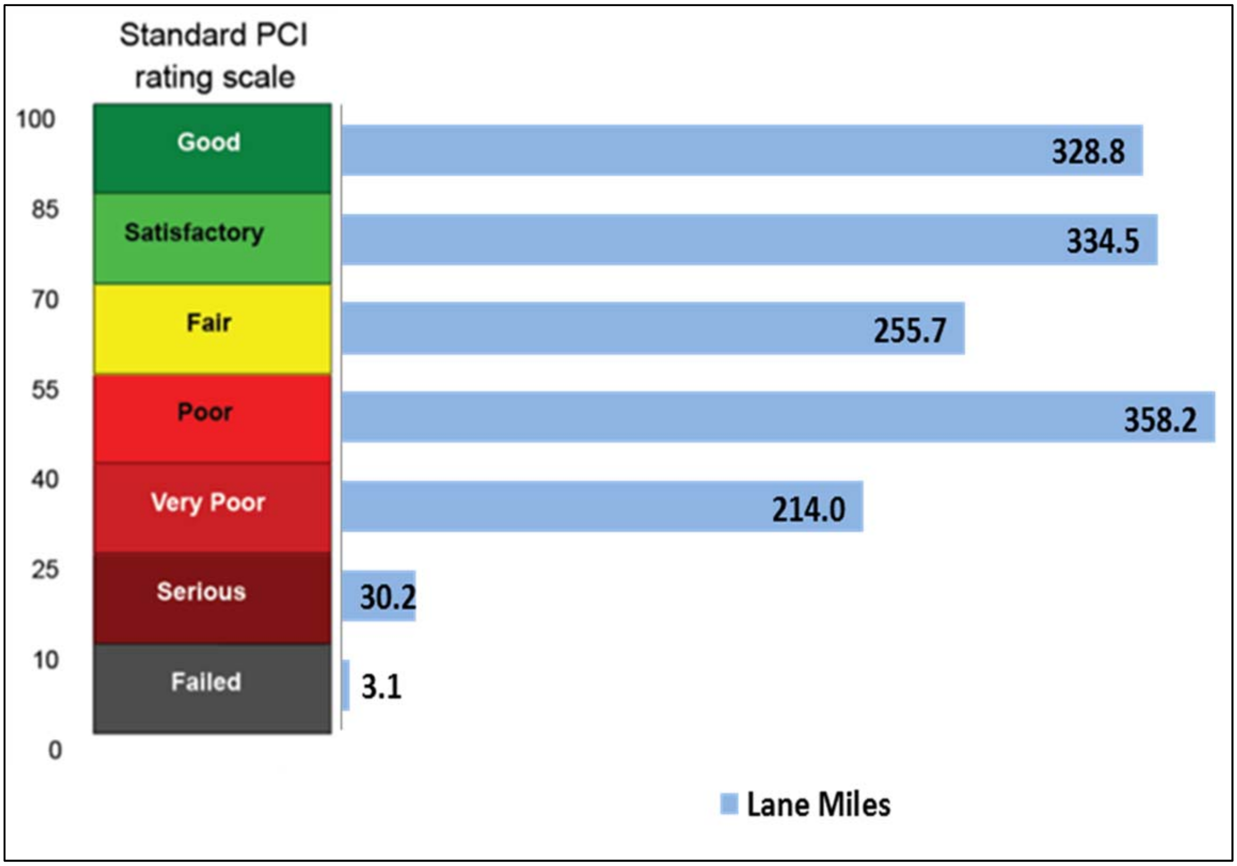
To assess pavement conditions, PAVER uses the Pavement Condition Index (PCI) as its primary standard. Per ASTM D-6433-11, the PCI is a numerical indicator that provides a measure of the present condition of the pavement based on the distress observed on the surface of the pavement. The PCI also indicates the structural integrity and surface operational conditions. The PCI measures pavement condition on a scale from 0 to 100, with 0 representing "Failed" condition, and 100 representing "Excellent" condition. As future visual inspections are conducted and the results recorded in PAVER, the PCI will be updated, if conditions change. Continuous monitoring of the PCI is used to establish the rate of pavement deterioration, which permits early identification of major rehabilitation needs. Figure 2-4 below represents the PCI rating scale per ASTM D-6433-11 that is utilized by the PAVER software.

Figure 2-4: PCI Rating Scale



Once the inspection process was complete, the data set was checked for missing data and errors, corrections were made, and PCI values were calculated for each section. Appendix A shows the full list of the PCI values calculated for each section within City pavement inventory while Figure 2-5 below shows the amount of lane miles that fall within each condition bucket.

Figure 2-5: PCI summary by lane miles



Optional Task A – Verification of Street Widths

Atkins managed the verification of the section widths by the Cartegraph field inspection team. This process took place simultaneously with the automated pavement data collection effort and provided a database with essential inventory updates. Width information was gathered by comparing field measurements that were collected – with (in the case of unusual section shapes) geo referenced aerial photography. These updates were then written to the production copy of the PAVER database. This provided the sequence of database updates needed to comply with the PAVER process. Shape files containing the updated information were created to assist the City in updating their width information in existing City GIS maps.

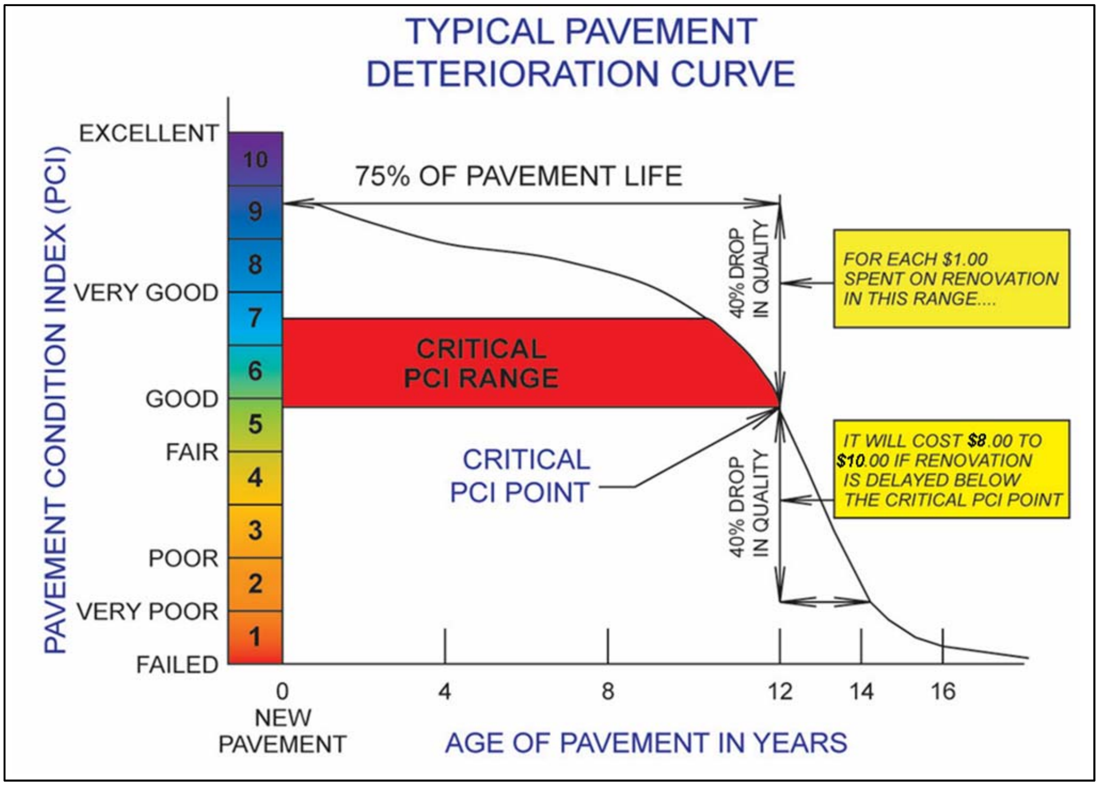
Task 3 – Data Entry/Database Update

After all inspection data was collected, it was then uploaded into the current (production) copy of the PAVER database. Once the data upload was complete, Atkins validated the information using tools internal to the PAVER application and discussions with City staff.

Task 4 – Pavement Management Scenarios

Pavement condition does not deteriorate in a straight line over time; rather it is an “S-Curve”. Figure 2-6 on the following page shows this curve style with a color coded PCI scale. There is a point in time when the PCI reaches the so called “Critical PCI Range”. During the time when the PCI is in this Critical PCI Range is the optimal time for investment. If you repair a roadway too early you might be wasting 1-2 more years before the slope of the curve turns downward. However, if you miss the investment point, the roadway deteriorates very rapidly and repairs become much more costly. For example, City roadway professionals recently completed a patch and chip seal effort on Quaker Street in 2014. If the City decided to wait another year to fix that street the alligator cracking would have become more severe and likely pop out chunks of asphalt. This would allow more water to penetrate into the base course and propagate the damage throughout the entire section. If the City waited even longer the deterioration rate accelerates leading to much more costly efforts to reconstruct the entire section.

Figure 2-6: Typical Pavement Deterioration Curve



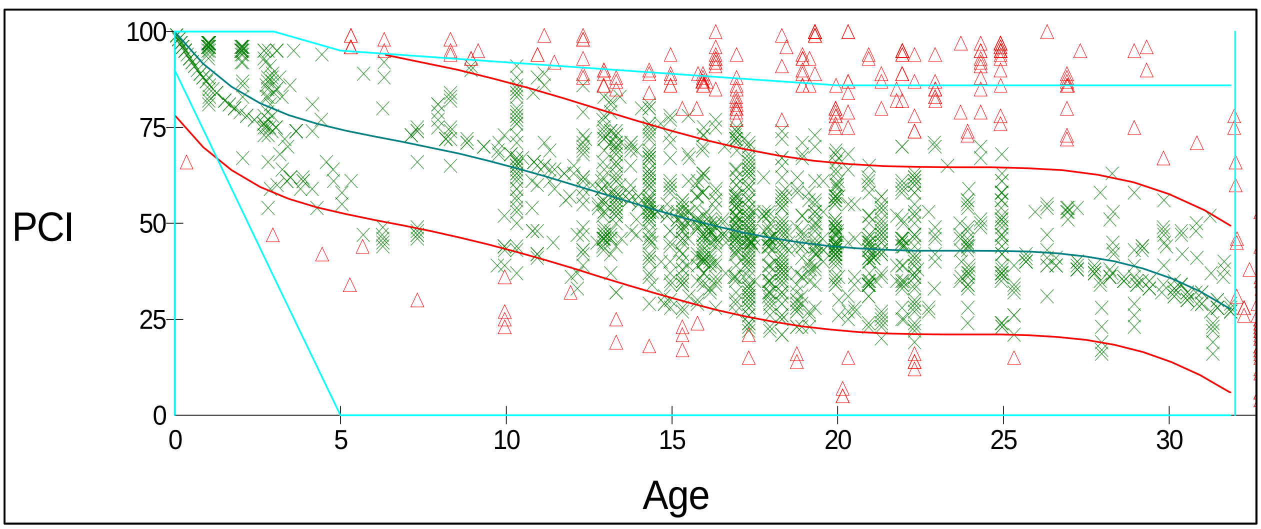
The typical range for the critical PCI for roadways is 55 to 65. This is why the City set the goal for 70% of it roadways to be fair or better.

Once Atkins verified data from the previous tasks, the first step in producing work plans was to update pavement family life cycle models and organization specific cost tables. Pavement sections were grouped together into "families" that were formed around two primary inventory characteristics: surface type and section rank. Within the PAVER software, the work planning function uses the M&R Families along with inspection data, maintenance policies, maintenance costs, and predictions of future pavement conditions to recommend M&R activities at the section level.

Arvada pavements are grouped into two surface types: asphalt (AAC) and concrete (PCC) and into three section rank categories: arterials (A), collectors (C), and locals (E). Considering that decomposition, Atkins created prediction (life cycle) models that represent the following groups: AAC-A, AAC-C, AAC-E, and PCC-All. Cost tables were updated from information provided by the City and their current list of work practices.

Using three years of actual pavement cost data, City staff determined that costs increased by about 8% since the last analysis in 2012. Cost model (M&R) families were then updated to more efficiently connect sections with their appropriate cost tables for increased accuracy in work planning. Figure 2-7 on the following page shows the pavement family models for the AAC pavement. It is built with actual condition assessment data points shown by the X's. There are three lines that represent the statistical confidence bands and best fit line in the middle. The triangle represents a data point outside the statistical confidence range.

Figure 2-7: Arvada Asphalt Roadways Pavement Deterioration Curve



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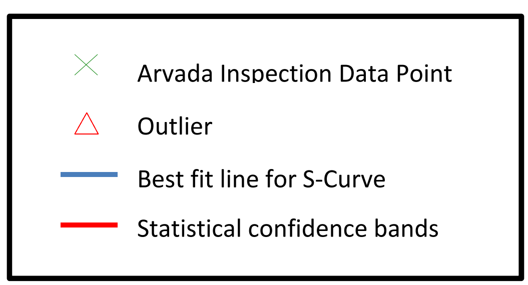


After consulting with the City, Atkins updated the previous two work plan scenarios around the following parameters:

- 10 year plan using a $5.5M/year budget
- 10 year plan with the goal of eliminating the backlog of work by year 10 at a cost of $19.0M per year

Based on that information one more work plan scenarios was considered:

- 10 year plan using a $16.2M/year budget to stabilize the current condition level.

Results for each of these scenarios include a condition distribution table, funded and unfunded totals, and section level work item recommendations for the first ten fiscal years of each plan. The work planning tools in PAVER are designed such that the City can run multiple scenarios to compare results – and re-run scenarios as often as necessary to capture the effects of data changes/updates.

<u>Task 5 – Summary Report/Project Documentation</u>

This final report accomplishes task 5 and provides the details of each requested task in the statement of work as well as PAVER outputs for each work plan scenario.

Section 3. Work Planning Data

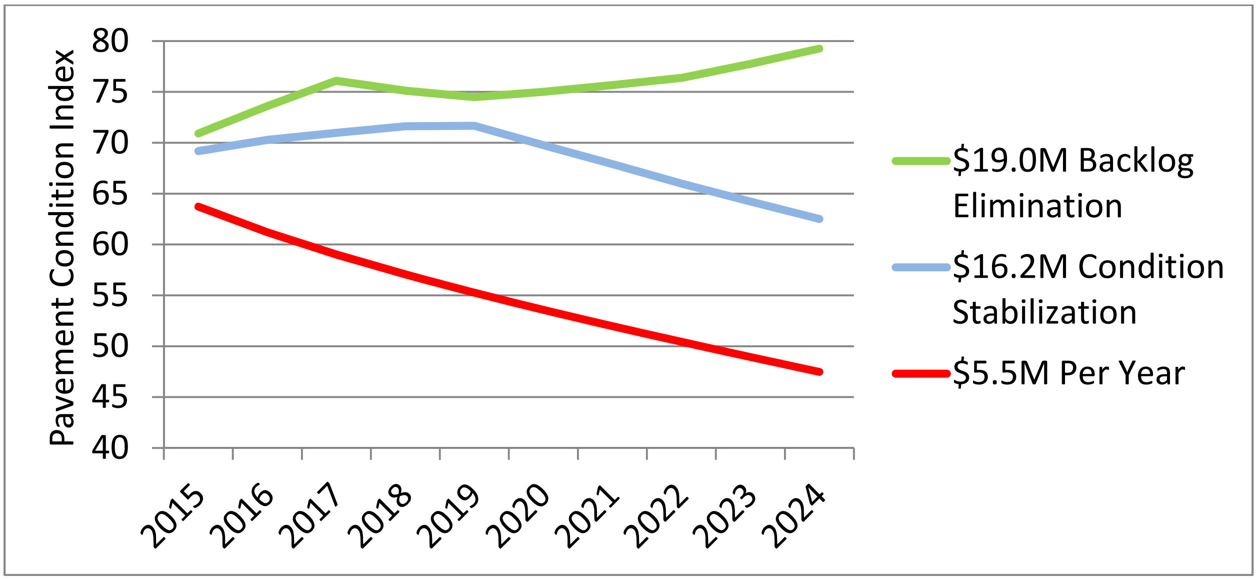
As outlined earlier, three total scenarios were considered in the production of the work planning data:

- 10 year plan using a $5.5M/year budget
- 10 year plan with the goal of eliminating the backlog of work by year 10 at a cost of $19.0M per year
- 10 year plan using a $16.2M/year budget to stabilize the current condition level.

The following information is provided for these scenario plans:

1. A network level condition plot of all three scenarios contracted on one report
2. Individual "Cost of the Plan" – tables that will illustrate condition and financial trends for each scenario. Comparison of these plans will provide the City with penalty cost of deferred maintenance data.

Scenario PCI Projections



Scenario	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
$19.0M Backlog Elimination	70.91	73.6	76.1	75.12	74.49	75.01	75.66	76.37	77.74	79.25
$16.2M Condition Stabilization	69.18	70.29	70.97	71.62	71.67	69.76	67.9	65.98	64.22	62.51
$5.5M Per Year	63.72	61.2	59.01	57.06	55.26	53.57	51.97	50.44	48.94	47.47

Cost of Scenario Tables

The following tables represent a total scenario cost view for each of the work plan scenarios. The “Total Cost” value is calculated by adding all of the years of the “Funded” column to the last year of the “Backlog” column. The last year of the backlog column represents the final adjusted backlog amount for the entirety of the plan. Comparing the total costs of each scenario will serve as the basis for computing the penalty costs of deferring maintenance incurred for various plans.

Work Plan Scenario: Condition Stabilization

Year	Condition/PCI	Funded	Unfunded
2015	69.18	$16,215,529.11	$72,360,499.51
2016	70.29	$16,215,561.37	$73,161,981.53
2017	70.97	$16,215,062.68	$74,023,353.32
2018	71.62	$16,212,491.27	$75,582,962.04
2019	71.67	$16,213,298.51	$77,754,081.02
2020	69.76	$16,214,848.65	$80,155,971.08
2021	67.9	$16,216,670.26	$84,032,795.63
2022	65.98	$16,210,874.29	$89,989,962.54
2023	64.22	$16,216,913.55	$98,051,289.11
2024	62.51	$16,216,664.13	$106,449,016.56
	Total:	**$162,147,913.82**	

Total Cost: $268,596,930.38

Work Plan Scenario: Backlog Elimination

Year	Condition/PCI	Funded	Unfunded
2015	70.91	$19,077,475.01	$69,284,149.11
2016	73.6	$19,077,163.93	$66,506,917.82
2017	76.1	$19,076,749.59	$63,155,714.30
2018	75.12	$19,073,484.83	$59,267,662.95
2019	74.49	$19,074,152.15	$54,370,234.17
2020	75.01	$19,078,237.23	$47,186,261.64
2021	75.66	$19,075,444.60	$38,038,304.17
2022	76.37	$19,073,581.54	$26,260,115.69
2023	77.74	$19,074,604.40	$13,120,635.08
2024	79.25	$15,652,185.30	$0.00
	Total:	**$187,333,078.58**	

Total Cost: $187,333,078.58

Work Plan Scenario: $5.5M Per Year

Year	Condition/PCI	Funded	Unfunded
2015	63.72	$5,499,987.56	$83,318,574.13
2016	61.2	$5,499,996.93	$94,245,379.78
2017	59.01	$5,499,968.80	$104,889,748.83
2018	57.06	$5,499,997.77	$115,644,812.04
2019	55.26	$5,499,997.75	$126,756,615.80
2020	53.57	$5,499,998.73	$136,989,430.93
2021	51.97	$5,499,990.35	$147,149,772.24
2022	50.44	$5,499,960.86	$157,664,787.61
2023	48.94	$5,499,975.99	$169,297,673.56
2024	47.47	$5,499,974.50	$181,439,039.59
	Total:	**$54,999,849.24**	

Total Cost:	**$236,438,888.83**

Section 4. Summary and Recommendations

Atkins and Cartegraph were pleased to help the City of Arvada accomplish their pavement management goals through this 2015 inspection. Since 2012, over 350 new sections and 84.5 lane miles were added to the system which raised the overall average network PCI to 64.3. However, pulling out those new sections results in the equivalent year over year overall PCI of 62.4. This is about a 0.2 point increase from the 62.2 rating in 2012. What this shows is that maintenance forces are addressing the critical sections while the rest of the network continues to deteriorate. Increased investment is warranted to strategically recapitalize the pavement network while actually spending the least amount of money over time in deferred maintenance costs. Methodically ramping up from the current $5.5M budget to a $17M budget over the next 10 years is the best way to infuse capital into the pavement network.

Atkins recommends the next network-wide to take place in another 3 years. This will add more data points to the life-cycle curves and provide an overall view of how the network is performing as a result of the recommended budget increases.

Appendix A: Pavement Network Condition Data

The following section condition report includes the following data for the entire pavement network:

- Section by section inventory data
- Current inspection PCI values
- Adjusted Last Construction Data information