City of Glendale, Arizona

Pavement Management Analysis Report

Current Year Plan (FY 2014)
and
Five-Year Plan (FY 2015 – 2019)

December 2013

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List of Acronyms and Abbreviations

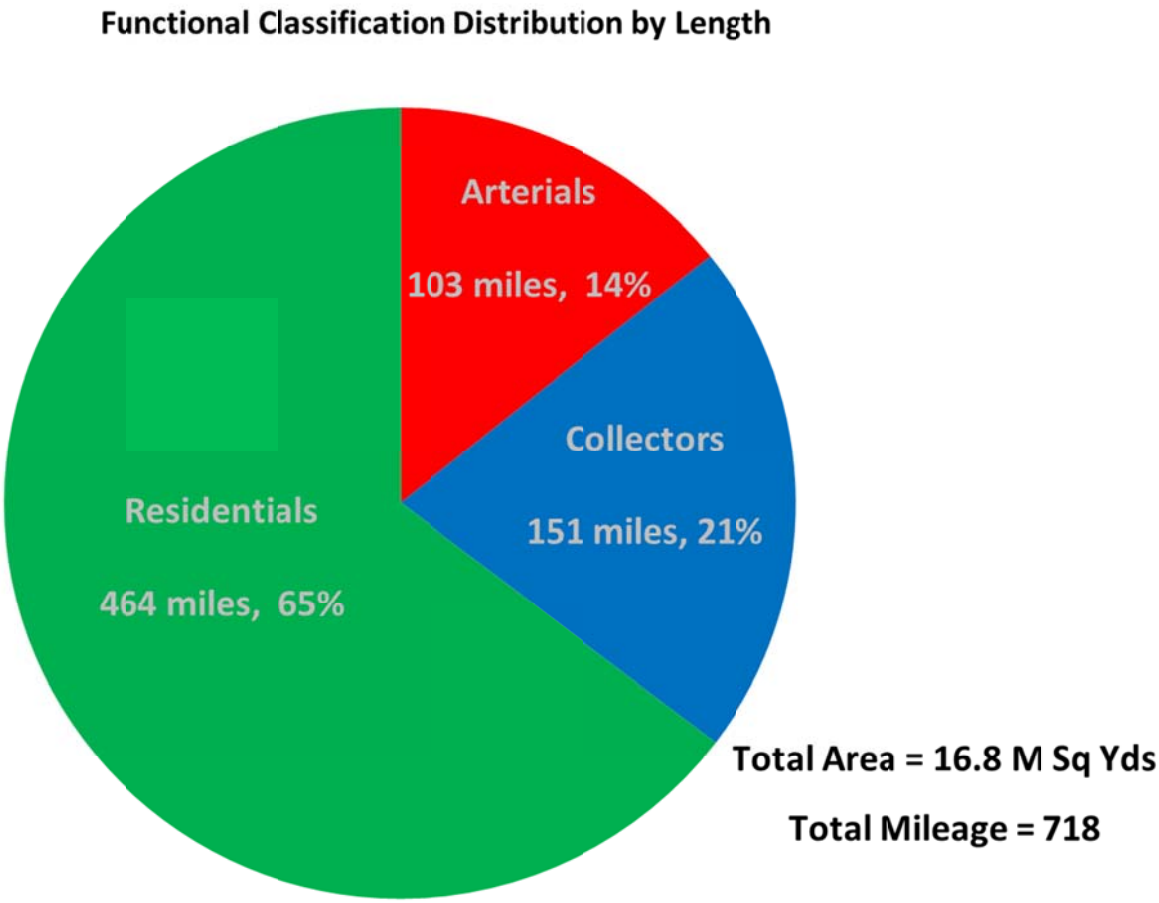
Abbreviation or Acronym	Definition
$M	Dollars in millions
ACP	Asphalt Concrete Pavement - asphalt streets
ART	Arterial roadway functional classification
ASTM	American Society of Testing Methods
Brk	Break
CAL	Coarse Aggregate Loss
CDV	Corrected Deduct Value
COL	Collector roadway functional classification
Crk	Crack
DeflCON	Deflection Condition - structural load analysis
Dvdd Slab	Divided Slab
DynaCON	Dynamic Condition - structural layer analysis
ft or FT	Foot
ft2 or FT2	Square foot
FunCL	Functional Classification
FWD	Falling weight deflectometer
GCI	Gravel Condition Index
GFP	Good - Fair - Poor
GIS	Geographic Information System
GISID	GIS segment identification number
H&V	Horizontal and Vertical
IRI	International Roughness Index
Jt	Joint
L&T	Longitudinal and Transverse
LAD	Load associated distress
LOC	Local roadway functional classification - same as RES
LOG	Lip of Gutter
m	metre
m2	sqaure metre
M	Moderate
MaxDV	Maximum Deduct Value
mi or Mi	Mile
MnART	Minor arterial roadway functional classification
MOD	Moderate
NLAD	Non-load associated distress
OCI	Overall condition index, also known as PCI
Olay	Overlay
PCC	Portland Cement Concrete - concrete streets
PCI	Pavement Condition Index - generic term for OCI
R&R	Remove and replace
Recon	Reconstruction
Rehab	Rehabilitation
RES	Local roadway functional classification - same as LOC
RI or RCI	Roughness Index
S	Strong
SDI	Surface Distress Index
SI	Structural Index
STA	Station or chainage
Surf Trtmt	Surface Treatment
TDV	Total Deduct Value
W	Weak

1.0 PROJECT DESCRIPTION

1.1 PRINCIPLES OF PAVEMENT MANAGEMENT

Nationwide, billions of dollars have been invested in roadway networks by municipal, state and federal governments. Locally, the City of Glendale has 103 miles of arterial roadways (urban and rural arterials) plus an additional 615 miles of residential roadways (residential, collectors and major collectors) encompassing over 16.8 million square yards of asphalt surfacing (Figure 1). At a replacement cost approaching $1 million per mile plus the cost of the right of way and improvements, the city has over $1 billion dollars invested in their paved roadway network.

Figure 1 – Functional Classification Distribution of the Glendale Roadway Network



Total Replacement Value = $1 Billion

Preservation of existing road and street systems has become a major activity for all levels of government. There is a shortage of funds to maintain street systems at all government levels. Funds that have been designated for pavement preservation must therefore be used as effectively as possible. One proven method to obtain maximum value of available funds is through the use of a pavement management system.

Pavement management is the process of planning, budgeting, funding, designing, constructing, monitoring, evaluating, maintaining, and rehabilitating the pavement network to provide maximum benefits from the available funds. A pavement management system is a set of tools or methods that assists decision makers in finding optimum strategies for providing and maintaining pavement in a serviceable condition over a given time period. The condition of a street is affected by a number of factors, including:

- Surface condition (roughness, cracking, etc.)
- Moisture intrusion and drainage (street profile, cross section, storm sewer)
- Sub-grade strength and conditions
- Traffic characteristics and loading
- Pavement age
- Prior maintenance (overlays, micro resurfacing, crack filling, seal coating, patching)

Each of the above listed factors contributes to the overall condition and lifecycle of the street system.

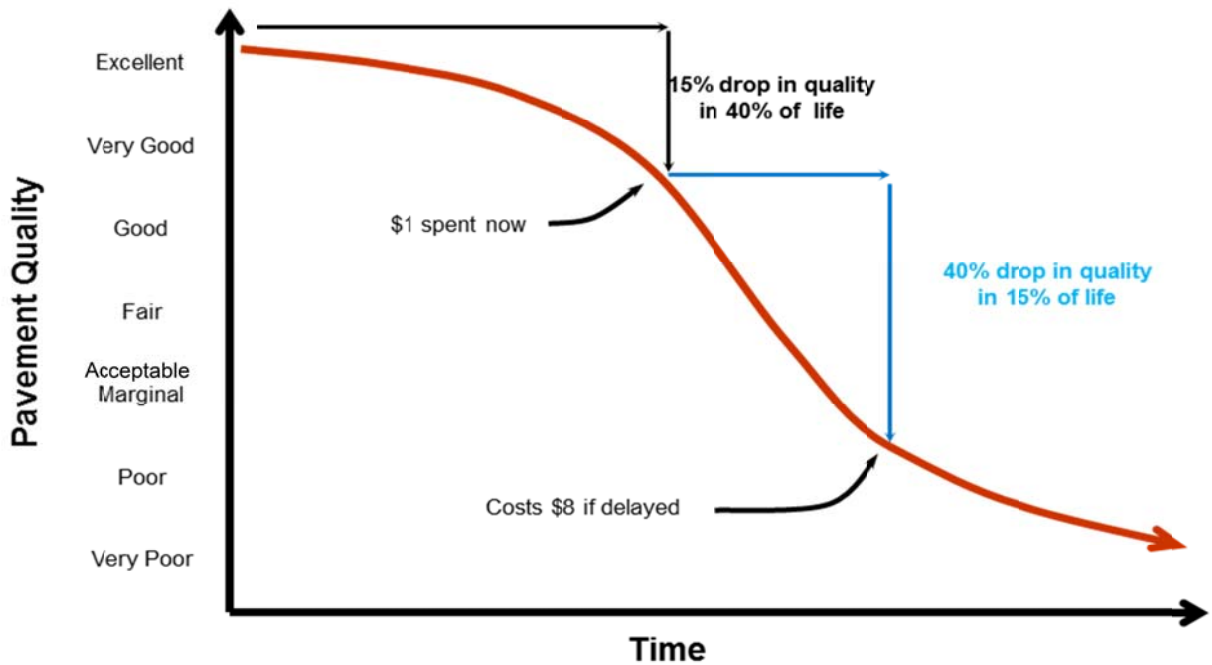


Figure 2 – Pavement Deterioration and Life Cycle Costs

As shown in Figure 2, streets that are repaired when they are in a good condition will cost less over their lifetime than streets that are allowed to deteriorate to a poor condition. Without an adequate routine pavement maintenance program, streets require more frequent reconstruction, thereby costing millions of extra dollars. Over time, pavement quality drops until the pavement condition becomes unacceptable. For each street, the rate of deterioration, and hence shape of the curve, is dependent on many factors – foremost of which are the strength of the roadway structure and traffic loading. Prevention of moisture intrusion into the base and subgrade layers through crack sealing, surface treatments and effective drainage is critical to maintaining pavement strength. The key to a successful pavement management program is to develop a reasonably accurate performance model of the roadway, and then identify the

optimal timing and rehabilitation strategy. The resultant benefit of this exercise is realized by the long term cost savings and the ability to maintain pavement quality over time. As illustrated in Figure 2, pavement typically deteriorates rapidly once it hits a specific threshold. A $1 investment after 40% lifespan is much more effective than deferring maintenance until heavier overlays or reconstruction is required just a few years later.

Once implemented, an effective pavement information management system can assist agencies in developing long-term rehabilitation programs and budgets. The key is to develop policies and practices that delay the inevitable total reconstruction for as long as practical yet still remain within the target zone for cost effective rehabilitation.

That is, as each roadway approaches the steep part of its deterioration curve, apply a remedy that extends the pavement life - at a minimum cost, thereby avoiding far more costly heavy overlays and reconstruction. Thus, the goal of a pavement management system is to identify the optimal level of funding, timing, and renewal strategy agencies should adopt to keep their roadway network at a satisfactory level of service.

Figure 3 illustrates the concept of extending pavement life through the application of timely rehabilitation activities.

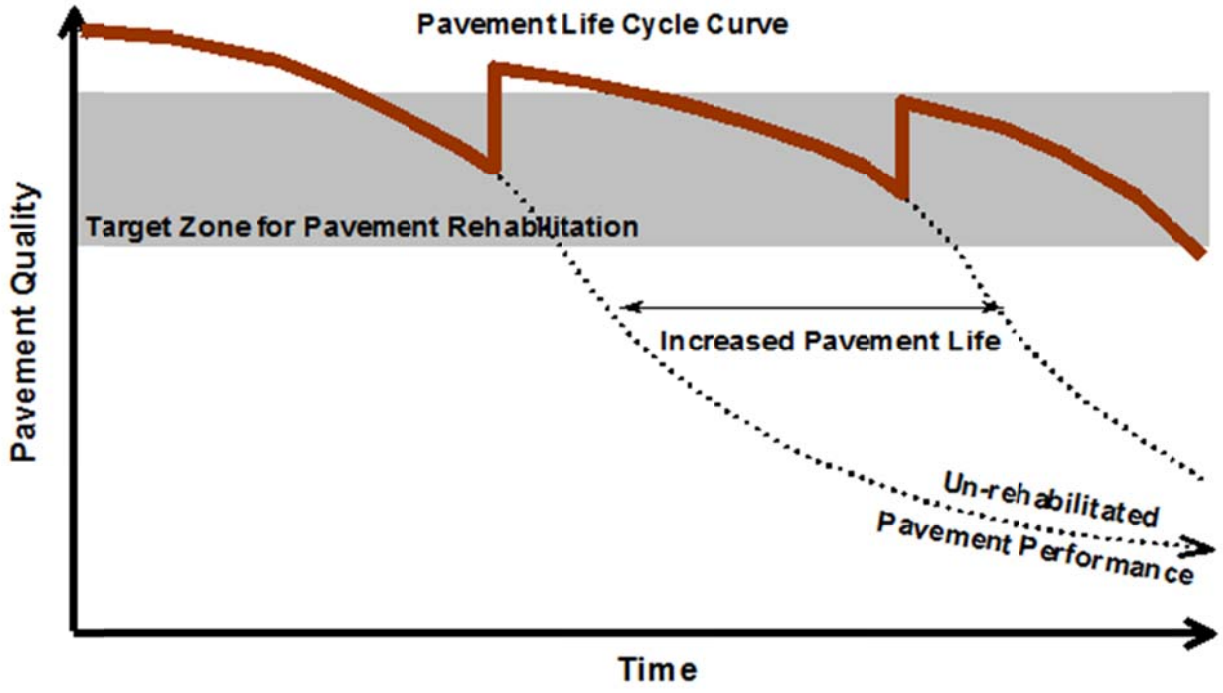


Figure 3 – Pavement Life Cycle Curve

Ideally, the lower limit of the target zone shown in Figure 3 would be a condition rating of 60 – that is to keep maintenance requirements on as many streets as possible to a thin overlay or less. The upper limit should be close to the upper range of the good category – that is a pavement condition score of 85.

Other functions of a pavement management system include assessing effectiveness of maintenance activities and new technologies, and storing historical data and images.

1.2 THE PAVEMENT MANAGEMENT PROCESS

The actual pavement management process involves three unique, but important steps, and is presented graphically in Figure 4. Each activity builds on the previous, until the end result is a prioritized paving and rehabilitation program.

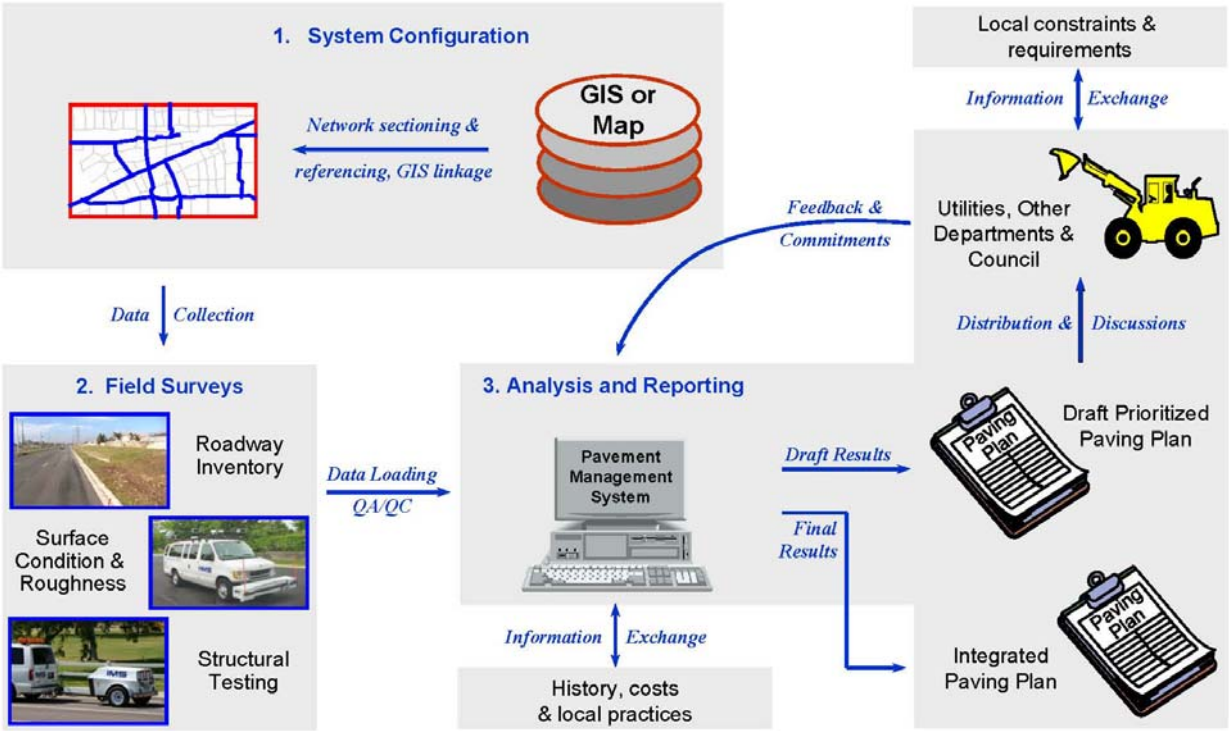


Figure 4 - The Pavement Management Process

Highlights of the City of Glendale pavement management process include:

1. **System Configuration** – this step involves identifying all roadways in the city's network, assigning them a unique identifier, listing their physical characteristics (length, width, etc.,) and demographic attributes (pavement type, traffic, functional classification), and linking the network to the city's GIS map.

2. **Field Surveys** – following a set of pre-defined assessment protocols matching the city's Lucity Pavement Management software (ASTM D6433), a specialized piece of survey equipment - referred to as a Laser Road Surface Tester (Laser RST, pictured on page 6), was used to collect observations on the condition of the pavement surface, as well as collect digital imagery and spatial coordinate information. The Laser RST surveyed each street from end to end in a single pass, with arterial roadways completed in two passes.

   Data collected by the Laser RST includes:

   - Rutting – measurement of wheel path rut depths by severity and length on asphalt roads. Rut depths are a concern for two reasons – if there is insufficient cross slope, they can hold water and thus cause loss of vehicle control. They also identify areas of loss of

structural base or asphalt strength. On asphalt streets, rutting is incorporated into the surface distress observations.

- Roughness Index – Roughness is measured following the industry standard "International Roughness Index" (IRI). It is an open-ended score that measures the amount of deviation up or down the longitudinal profile of a roadway has from a fixed plane and includes removal of the effects of elevation changes and the impact of the measurement vehicle. In common terms, it provides a measure of the number of bumps per unit length and is reported in millimeters/meter. The IRI value is converted to a 0 to 100 score and reported as the Roughness Index (RI). Roughness Index scores for like new pavements are above 85; Smooth roads fall in the 75 to 85 range; Streets displaying a progressively rough surface fall in the 50 to 75 range (but can be made serviceable again); and a roughness Index score below 40 indicate a new pavement surface is required.

- Surface Distress Index – The Laser RST collects surface distress observations based on the extent and severity of distress encountered along the length of the roadway following a modified version of the ASTM D6433 protocols for asphalt and concrete pavements. The surface distress condition (cracking, potholes, raveling and the like) is considered by the traveling public to be the most important aspect in assessing the overall pavement condition.

  Not all distresses are weighted equally within the Surface Distresses Index. Certain distresses caused by traffic loading, such as rutting or alligator cracking on asphalt streets, or divided slab on concrete streets, have a much higher impact on the surface distress index than non-load associated ones such as raveling or patching. Even at low extents and moderate severity – less than 10% of the total area, load associated distresses can drop the Surface Distress Index considerably.

  Load associated distress (LAD) are those that are caused by traffic and include rutting, alligator (fatigue) cracking, longitudinal cracking, edge cracking, distortions and patching and potholes. The remaining non-load associated distresses (NLAD) are material or environmental in nature and include transverse cracking, block (map cracking), bleeding and raveling. Examination of the amount of load associated distresses compared to the Pavement Condition Index provides an insight into subgrade quality.

- Structural Index – The major roadway network was also tested for structural adequacy using a Dynaflect device. Dynaflects impart a non-destructive cyclical load on the pavements that is received by a series of geophones. The field data is then compared to what loads the road is expected to carry as well as used to develop a layer analysis to evaluate if the base materials and pavement structure are working as a single unit. The final result is a single 0 to 100 index value. Scores above a 75 indicate the pavement is structurally adequate, between a 50 and 75 indicate additional structure is required, while those below a 50 generally require replacement.

  On streets where no deflection testing was completed, the relationship between the final pavement condition score and amount of load associated distresses is used.

3. **Analysis and Reporting** - The final Pavement Condition Index (PCI) is made up from the three inputs, namely Surface Distress Index, Roughness Index and Structural Index as follows:

Minor Roadways PCI = 33% Roughness Index + 67% Surface Distress Index

Major Roadways PCI = 25% Roughness + 50% Surface Distress + 25% Structural

The block by block segmentation was then aggregated into homogeneous projects (referred to as SuperSegments) for budget and level of services analysis using Glendale specific rehabilitation strategies, unit rates, priorities and pavement performance curves.

Laser Road Surface Tester (Laser RST)

1.3 PAVEMENT TREATMENT DESCRIPTIONS

A variety of pavement maintenance techniques are used to preserve city streets and the cost for each treatment can vary significantly. The following is a description of each maintenance treatment by the least expensive to most expensive, and the potential benefits of the treatment.

Surface Treatments - Various surface treatments provide for the installation of a thin surface coating, typically an oil emulsion and small aggregate to seal and rejuvenate the pavement surface. This allows for an extension of the pavement surface life by minimizing the effects of the sun and weather on the existing asphalt material and re-establishing a wearing surface. Surface treatments do not increase pavement strength and are typically either a fog seal (sprayed on liquid asphalt) or a slurry seal (liquid asphalt and sand) on residential or collector streets, and a microsurface on arterial roadways. Microsurface treatments are similar to slurry seals with the exception the size of the aggregate is slightly larger resulting in a thicker treatment on the order of ¼" to 3/8".

Overlay - An overlay provides for the addition of another layer of asphalt or rubberized asphalt pavement on the existing roadway. This can be performed either through the removal and replacement of a 1 to 2-inch thick layer to maintain the current surface elevations or by placing an additional layer of pavement on top of the existing surface. An overlay of this thickness extends the life of the roadway by adding additional material to the surface, reestablishing the cross slope of the road to promote drainage and creating a smooth driving surface.

Surface Reconstruction - Surface reconstruction provides for full depth overlay, typically 3-5 inches, by removing the existing pavement in place and replacing it with new asphalt. The existing pavement is ground up and blended into the aggregate base, and the new pavement is installed to restore the proper cross slope and provide a stronger roadway section. This process is typically less expensive than full reconstruction and is usually only done on arterial roadways where the depth of the asphalt is much thicker than residential roadways.

Full Reconstruction - Full reconstruction provides for the removal of the existing roadway and the rebuilding of the road from the sub-grade (native earth) through to the pavement surface. Sub-grade correction consists of the removal of unsuitable materials, backfill with granular materials, aggregate base, and new asphalt pavement. This method is typically applied in areas where the pavement is showing significant areas of major distress and where it is unlikely that a surface reconstruction will properly repair the street.

1.4 UNDERSTANDING THE PAVEMENT CONDITION SCORE

The following illustration compares Pavement Condition Index (PCI) to commonly used descriptive terms. The divisions between the terms are not fixed, but are meant to reflect common perceptions of condition.

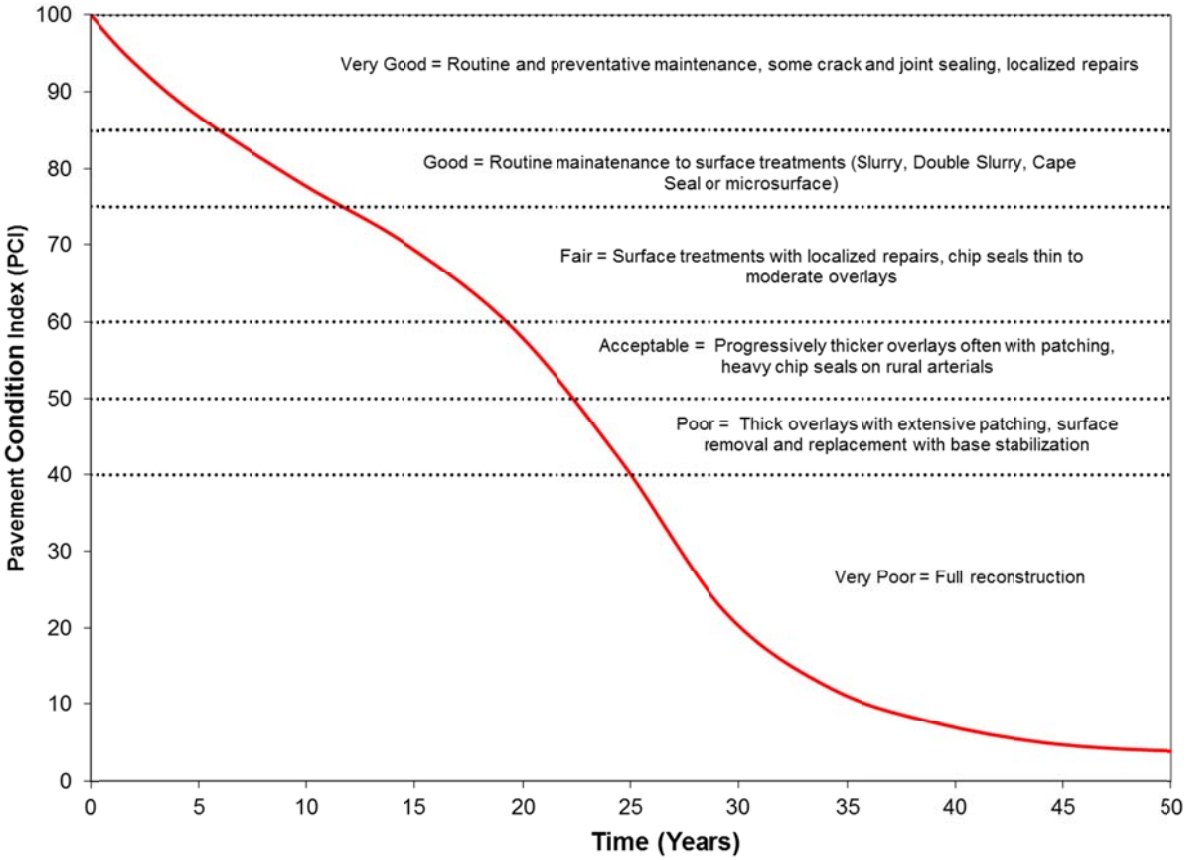


Figure 5 – Understanding the Pavement Condition Index Score

The general idea of what these condition levels mean with respect to remaining life and typical rehabilitation actions is included in the following table:

PCI Range	Description	Relative Remaining Life	Maintenance Treatment
85 – 100	Very Good	20 to 40 Years	Like new condition – little to no maintenance required when new; or routine maintenance such as crack and joint sealing.
75 – 85	Good	15 to 20 Years	Routine maintenance such as patching, crack sealing with possible surface treatments - chip seals, seal coats, slurries or microsurfacing.
60 – 75	Fair	10 to 15 Years	Heavier surface treatments accompanied with patching, thin to moderate overlays.
50 - 60	Acceptable	8 to 12	Moderate to thick overlays with localized patching
40 – 50	Poor	7 to 10 Years	Progressively thicker overlays with localized repairs; surface reconstruction such as surface removal, base stabilization and overlay.
0 – 40	Very Poor	0 to 10 Years	High percentage of full reconstruction – but only at lower end of the range.

The images presented in the following pages provide a sampling of the Glendale streets that fall into the various condition categories with a discussion of potential rehabilitation strategies.

Very Poor (PCI = 0 to 40) Full Reconstruction

Streets rated in this category display extensive base failures, as evidenced by the considerable amount of fatigue (alligator) cracking, wheel path rutting, edge failure, and patching. A mill and overlay on them would not be suitable as the base has failed and would not meet an extended service life of at least 15 years.

In the case of Camelback Road, pictured below, the outside westbound lane as had some localized grind and inlay completed in an attempt to keep the pavement serviceable and safe until reconstruction can be completed.

Camelback Rd West of 55th Ave, PCI = Mid Teens

Deferral of reconstruction of streets rated as very poor will not cause a substantial decrease in pavement quality as the streets have passed the opportunity for overlay based strategies. Due to the high cost of reconstruction, very poor streets are often deferred until full funding is available in favor of completing more streets that can be rehabilitated at lower costs resulting in a greater net benefit to the city. This strategy however must be sensitive to citizen complaints forcing the street to be selected earlier or if safety issues override all other concerns.

Poor (PCI = 40 to 50) – Last Opportunity for Surface Based Rehabilitation

Rated at the low end of the poor range with a PCI in the low 40's, West Missouri Ave near 83rd Ave., pictured below, is suitable for either a partial reconstruction or full width mill and overlay based rehabilitation depending on when the city can fund the rehabilitation and final project level testing and design. This street displays distresses that are moderate to severe in nature, but can be dug out and repaired preventing a full reconstruction. The curb lines are straight and drainage is functioning adequately.

In general, the service life of poor streets is approaching the end of the opportunity for an overlay based rehabilitation, and if deferred for too long would require more costly full reconstruction. Streets rated as poor are typically selected first for rehabilitation as they provide the greatest cost benefit to the city – that is the greatest increase in life per rehabilitation dollar spent. The thickness of the milling and overlay is dependent on the functional classification of the road, traffic, and existing pavement thickness. Coring and possibly structural testing would confirm the design of overlay and result in the optimum pavement thickness being applied and determine the extent of any base repairs.

West Missouri near 83rd Ave, PCI = Low 40's

Major roadways rated at the upper end of the poor category tend to deteriorate fairly rapidly – at about 2 PCI points per year, and should be inspected every two to three years in order to maximize their service life and identify the optimal timing for rehabilitation. Minor roads with the same rating deteriorate at a slower rate and thus a three to five year inspection cycle is appropriate. Other factors to consider in the selection process are safety (addressed by routine inspections), disturbance to traveling public and adjacent landowners, and criticality of the road – are there alternate routes in case of closure.

Acceptable (PCI = 50 to 60) – Progressively Thicker Overlays

When streets are rated as acceptable, they can either be repaired by placing a progressively thicker overlay on them or applying a slightly thinner overlay with considerable amounts of localized dig outs. Since they fall above the partial reconstruction/thick overlay range, but below thin overlays they are often not selected for upgrading as they may be left unfunded until they fall into their need year as a poor segment. Acceptable streets have distresses that tend to be localized and moderate in nature – that is they do not extend the full length of the segment and can be readily dug out and repaired. The street segment pictured below (North 49th Avenue near Belmont) highlights this characteristic as the failed area does not extend the full length or width of the roadway and is still servicable. However, it also highlights the relationship between base and pavement quality. Placing an overlay on this street without repairing the base would not achieve a full 15 year life as the failure would continue to occur over time.

Since the failure is localized and not extensive in nature, it presents the opportunity for the city to complete a localized repair on failed area and then possibly apply a thinner overlay on the remainder of the segment. These type of decisions need to be made on a street by street basis when designing the overlay project.

North 49th Ave near Belmont, PCI = Low 50's

Fair (PCI = 60 to 75) – Surface Treatment and Thin to Moderate Overlays

Streets rated in the Fair category typically display localized amounts of load and non-load associated cracking and other slight distresses. The surfaces are smooth and relatively non-weathered with good curb lines and drainage. Some patching may be required prior to applying a surface treatment or thin to moderate overlay, depending on the functional classification and nature of the distresses. Crack sealing at the higher end on the fair category provides considerable benefit through preservation of the base and subgrade layers through reduction of water infiltration.

North 59th Ave near Michigan, PCI = Low 60's

North 59th Avenue near Michigan, pictured above, has distresses that are prevalent but slight in severity and tend to be localized. The pavement surface is smooth with minimal rutting and raveling and has been patched in the past. The curb line and drainage are good making these types of streets candidates for surface treatment based rehabilitation such as microsurfacing or slurry seals, or mill and overlays with localized dig ups in a few years.

Good (PCI = 75 to 85) – Surface Treatments

Tonto Drive near 66th Avenue, pictured below, has a PCI that falls at the lower end of the good category and is performing adequately for its age, traffic and environmental conditions. It displays small amounts of distresses that can easily be crack sealed or removed and replaced and then covered to restore the visual appearance of the roadway. Also, the curb lines appear to be straight and the drainage looks adequate.

Tonto Drive near 66th Avenue, PCI = Mid 70's

Streets rated at the higher end of the fair category with adequate structural integrity and streets rated as good are ideal candidates for thinner surface based rehabilitations and local repairs such as microsurfacing and slurry seals.

Additional cost benefits of early intervention include:

- Less use of non-renewable resources through thinner rehabilitation strategies.
- Less build-up of crown for the first and possibly second rehabilitation cycle.
- Less intrusive rehabilitation and easier to maintain access during construction.
- Easier to maintain existing drainage patterns.

Very Good (PCI= 85 to 100)

This segment of West Peoria Ave Near 55th, pictured below, is rated as very good, displaying no rutting and only minor amounts of cracking that are localized. The ride is smooth and the surface is non-weathered and the base is still strong. In a couple of years, this street segment would be an ideal candidate for routine maintenance activities such as crack sealing.

West Peoria Ave near 55th, PCI = Low 90's

The pavement discoloration in the lower left part of the picture is caused by sprinkler water run off. In certain parts of the Valley, municipal water from sprinklers can actually damage the pavement surface by advancing oxidation of the asphalt cement and water infiltration into the base layers.

2.0 ROADWAY NETWORK CONDITION AND FINDINGS

2.1 ROADWAY NETWORK SIZE

The Glendale paved roadway network is broken into two groups consisting of a total of 6 functional classifications. The two groups are the Major Roadway Network consisting of the arterial, secondary arterial and rural arterial roadways. The other group is the Minor Roadway Network consisting of the major and minor collectors and residential roadways.

The major roadway network consists of 103 centerline miles of roadway and has an average PCI score of 71. The minor roadway network contains 615 miles of roadway and has an average PCI of 73. The following table summarizes the functional class splits within the system.

	Pavetype	Network	Majors Network	Minors Network
Segment Count	All Streets	8,412	755	7657
	Asphalt	7,683	26	7657
	Rubberized AC	729	729	0
Length (mi)	All Streets	717.7	103	615
	Asphalt	621.8	7	615
	Rubberized AC	95.9	96	0
PCI Average	All Streets	72	71	73

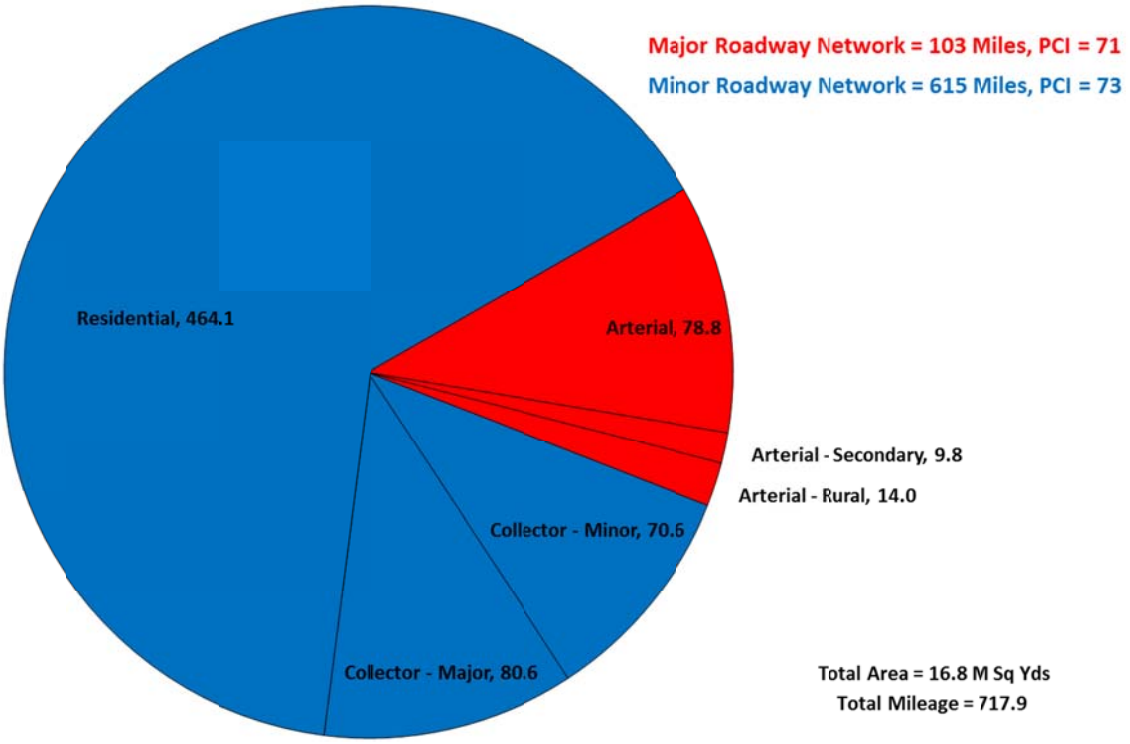


Figure 6 – Functional Class Distribution by Network Type

2.2 NETWORK PRESENT CONDITION

Figure 7 presents the distribution of pavement condition for the complete roadway network (all majors and minors) in the City of Glendale on a 0 to 100 scale, 0 being worst and 100 being best condition. At the time of the last field survey in 2009, the network overall average PCI was 73, and since that time through aging of the streets and applied rehabilitations and maintenance, the current 2013 network overall average PCI is 72. Nationwide, the average PCI score for similar cities to Glendale is 65 to 70.

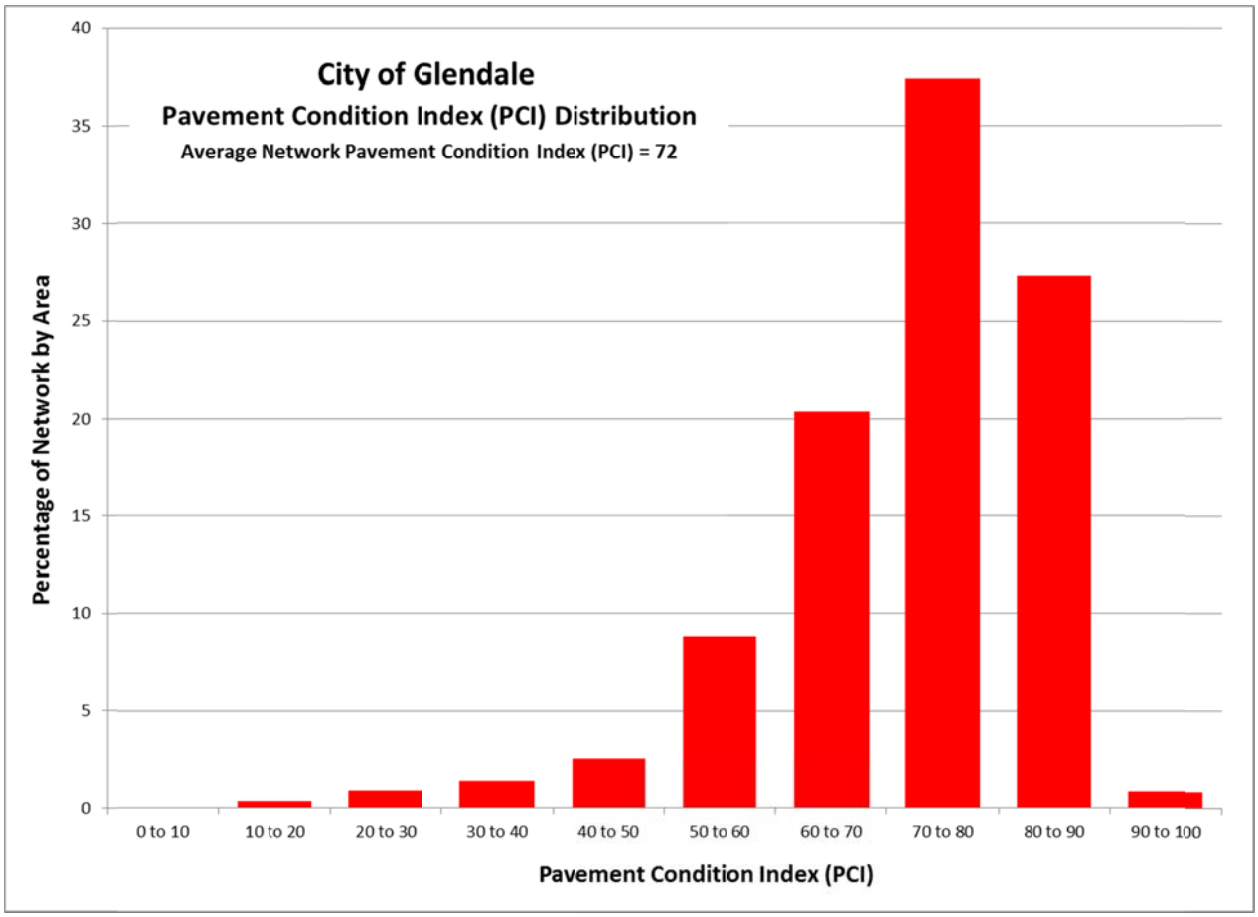


Figure 7 – Network Pavement Condition Index Distribution

This is reflective of a roadway network that has an older center core surrounded by concentric rings of steady growth followed by a ring of newer streets all constructed within a relative short time frame. The streets within the central core have undergone routine, but sometimes deferred maintenance, such that only a few have totally failed. However, a high percentage of streets are at or approaching the end of their service life where overlay based rehabilitation will be effective and will require considerable rehabilitation efforts to return them to like new condition unless rehabilitated in the short term future.

The following graph (Figure 8) plots the same pavement condition information for 2013 as well as a comparison to the 2009 network distribution, but instead of using the actual Pavement Condition Index value, descriptive terms are used to classify the roadways. The groupings relate to their present condition, as well as appropriate rehabilitations that may be applied. Although the 2013 network average is higher than the national average for similar cities, this PCI rating places the overall street network into the “fair” category for describing the overall pavement condition.

As the chart shows, 13 percent (or 93 miles), of the total street network can be considered in very good condition with a PCI score greater than 85. These streets are in like new condition and only require routine maintenance. Nationwide, the amount of roadways falling into this category is about 15 percent, so this value is below the national average. Roughly 32 percent (or 230 miles) of the street network falls into the good category; these are roads that benefit the most from preventative maintenance techniques such as a microsurface treatment, slurry seals, and localized repairs. If left untreated these roadways will drop in quality to become heavy surface treatment or overlay candidates.

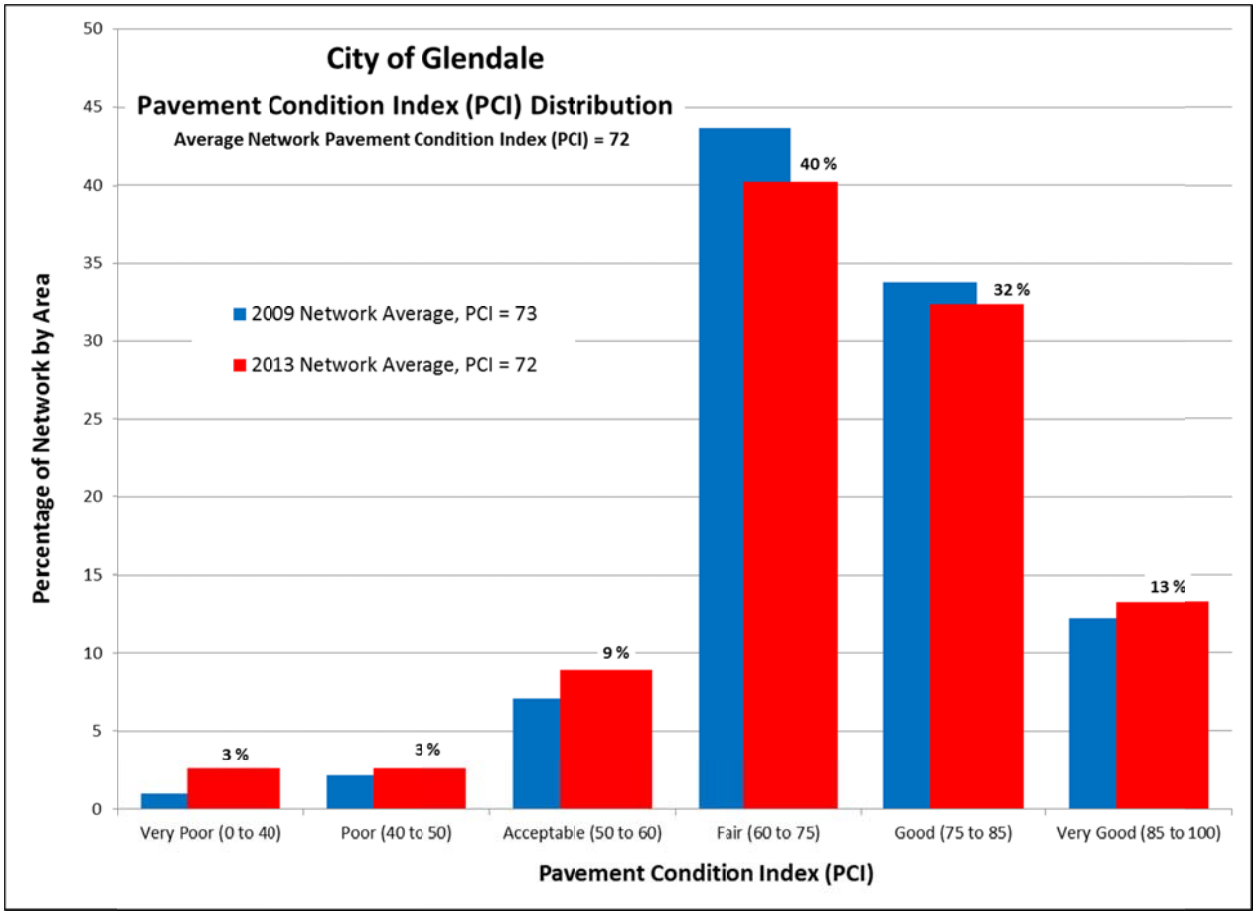


Figure 8 – Roadway Network Condition Using Descriptive Terms

Figure 8 also shows that 40 percent (or 287 miles) of the streets are rated as fair and are candidates for heavy surface treatment rehabilitation and thin overlays. Nine percent (or 65 miles) of the street network can be considered as acceptable, representing candidates for progressively thicker overlay rehabilitation or panel replacements if concrete. If left untreated, they will decline rapidly into reconstruction candidates. The remaining 6 percent (or 43 miles) of the network is rated as poor or very poor condition, meaning these roadways have failed or are past the point for an overlay or surface based rehabilitation to be an effective treatment. Streets in poor or very poor condition will require progressively heavier or thicker forms of rehabilitation (i.e., surface reconstruction, deep patch and paving) or total reconstruction.

Because of the declining and/or limited allocation of funds to Glendale's pavement management program over the past several years (since 2009), the applied maintenance treatments have not kept pace with the aging of the street network. As streets in Glendale continue to receive only routine preventative maintenance treatments as well as experience deferred maintenance or rehabilitation due to lack of funding, the percentage of poor and very poor conditions streets will increase as these streets fast approach or reach the end of their service life.

2.3 STRUCTURAL AND LOAD ASSOCIATED DISTRESS ANALYSIS

Structural testing and analysis was completed on the major roadway network using a Dynaflect device. Dynaflects apply a known load to the pavement and measures the pavement response to the load through a series of geophones. From these results, the structural integrity of the roadway segment may be assessed. The purpose of the structural analysis is threefold, namely:

1. The results are used to identify and report sections with inadequate structural capacity by completing a layer analysis of the subgrade, base and pavement layers.
2. The structural index provides input into which performance curve each segment is to use - performance curves are used to predict pavement deterioration over time.
3. Assists in rehabilitation selection by constraining inadequate pavement sections from receiving too light weight of a rehabilitation.

As a pavement ages, its condition deteriorates from a potential high of 100 to a lower value until it is rehabilitated – the deterioration is fairly predictable using pavement performance curves based on current conditions and testing. Along with the drop in PCI, a corresponding decrease in structural capacity (as represented by its Structural Index - SI) also occurs. Figure 9 presents the structural adequacy of the arterial roadway network as tested in 2010 against its average pavement condition; each marker represents one segment of roadway.

The diagonal black line in the plot provides an indication of roadway segments that are performing above structural expectations and those that do not provide full structural benefits over the life of the pavement. The large number of roadways falling below the diagonal line indicates the city has a high percentage of roadways that are structurally inadequate. This is typically the result of insufficient base and structural materials during the original construction, or the application of overlays that were too thin during the lifetime of the roadway.

It should be noted that two segments can have similar PCI values yet have differing subgrade ratings based on their testing results. Once they enter the rehabilitation planning, the Structural Index value would also ensure a thicker overlay or additional localized repairs are applied to the street segment with the lower SI score.

Street segments that have a PCI greater than 75, yet a structural index score less than 75 represent a small number of like new streets that have a low structural index (highlighted in the shaded blue area of Figure 9) yet are relatively new in age. The exact cause of low SI score is underdetermined and beyond the scope of this assignment, however, resources permitting, the city may wish to investigate these segments to identify the cause of the low SI through core holes and project level testing.

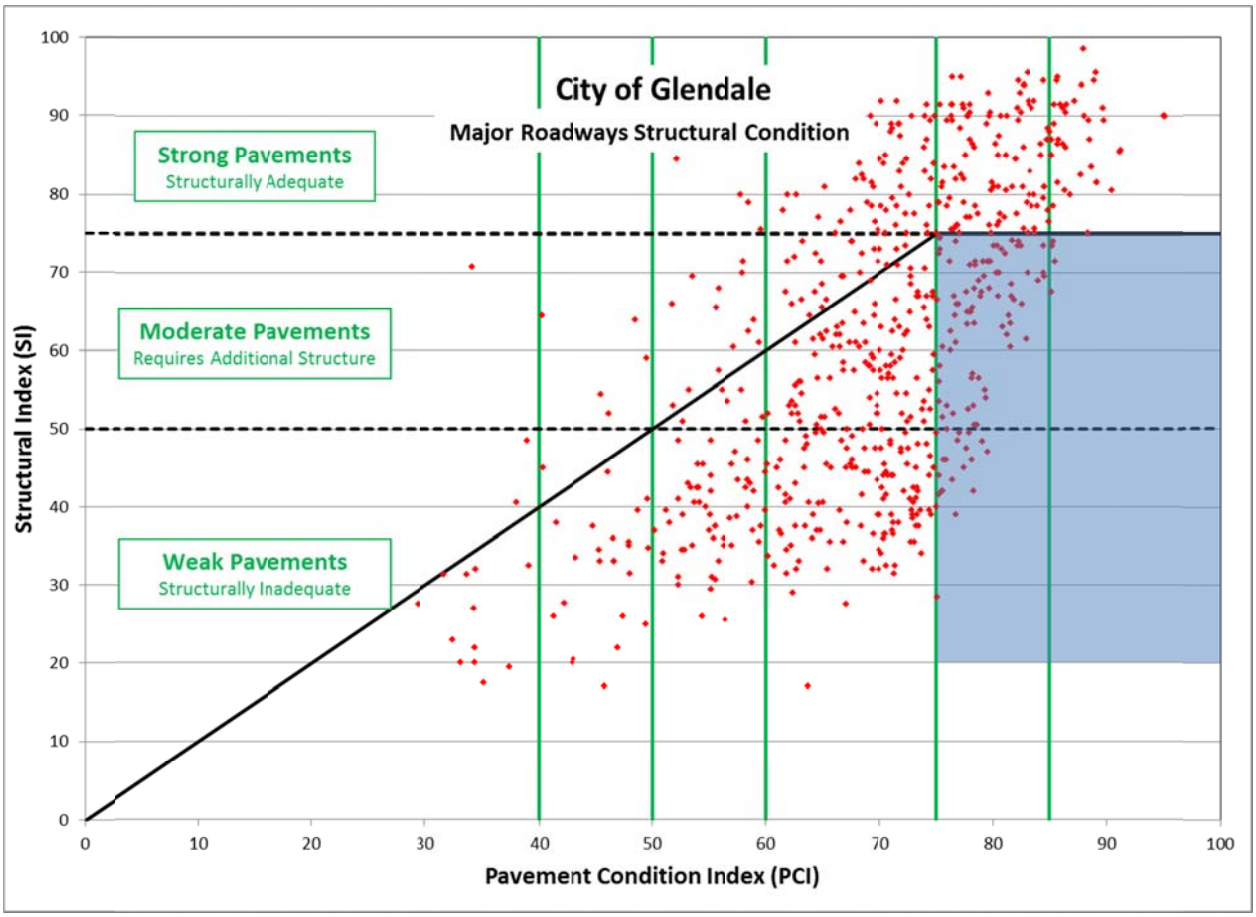


Figure 9 – Structural Adequacy of the Major Roadway Network

The horizontal black dashed lines (Figure 9) highlight the Structural Index ranges used as selection criteria during the budget analysis. The structural adequacy of a road is expressed as a 0 to 100 score with several key ranges: roadways with a Structural Index greater than 75 are deemed to be structurally adequate for the loading and may be treated with lightweight surface treatments or thin overlays; those between 50 and 75 typically reflect roads that require additional pavement thickness; and scores below 50 typically require reconstruction and increased base and pavement thickness.

For the minor roadway network, closer examination of the surface defects as they relate to the overall pavement condition support the findings of the pavement condition survey. Generally, load associated distresses affect the overall condition score more than non-load associated distresses – and this is the case in Glendale. Load associated distresses are those that are directly related to traffic loading and structural capacity. Non-load associated distresses are those that result from materials or environmental issues including shrinkage (transverse) cracking, bleeding and raveling. Figure 10 plots the relationship of the load associated distresses against pavement condition. As can be seen from the plot, at higher PCI scores, it is the non-load associated distresses that have a higher concentration of deducts over the load associated distresses. As the PCI score drops, the load associated distresses typically affect the PCI score to a higher degree. This is indicative of a network that has good pavement performance for the first half of a street's life; it then suffers from progressive structural or base failures over time. High PCI

score (above 60) rehab selection should focus on pavement preservation activities such as surface treatments or thin overlays, possibly with some localized pavement repairs and crack sealing.

The upper black diagonal line identifies segments that have a high ratio of load associated distresses compared to their PCI score and are defined as weak. The lower black diagonal line identifies segments that have a low ratio of load associated distresses compared to their PCI score and are defined as strong. In between the two lines, and all segments with a PCI > 80 are assigned a moderate pavement strength.

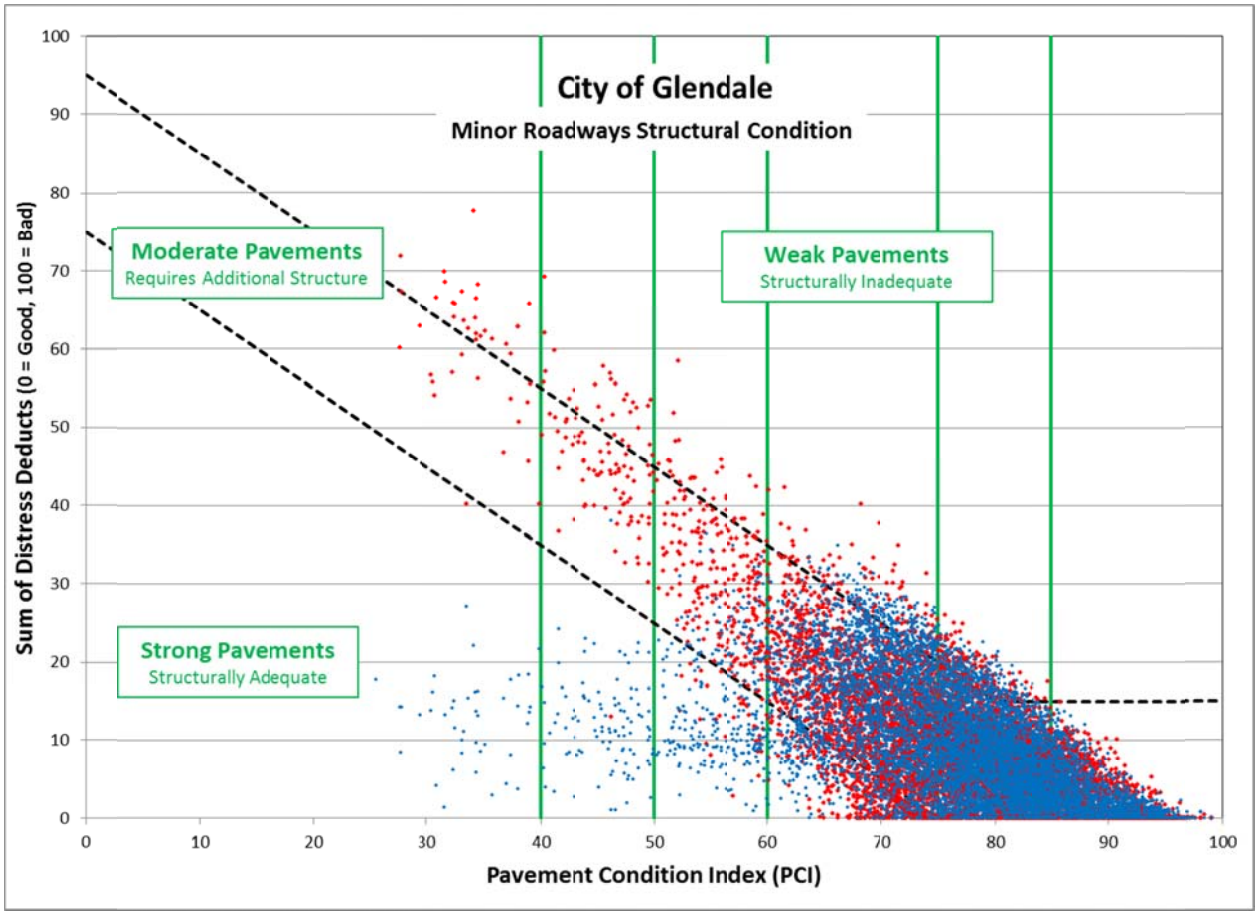


Figure 10 – Structural Adequacy of the Minor Roadway Network

2.4 PAVEMENT CONDITION DISTRIBUTION BY NETWORK TYPE

The **major roadway network** consists of three functional classes, covering approximately 103 centerline miles of pavement. The average pavement condition of the arterial roadway network in 2013 is 71. The following table presents key statistics of the arterial roadway network.

	Pavetype	Arterial	Arterial Secondary	Arterial Rural	Majors Network
Segment Count	All Streets	646	72	37	755
	Asphalt	20	3	3	26
	Rubberized AC	626	69	34	729
Length (mi)	All Streets	78.8	9.8	14.0	103
	Asphalt	3.8	0.7	2.2	7
	Rubberized AC	75.0	9.1	11.8	96
PCI Average	All Streets	72	76	62	71

The following bar chart (Figure 11) presents the 2013 distribution of pavement condition for the arterial roadway network in the City of Glendale using descriptive terms complete with a comparison to the 2009 distribution. In 2009, the average PCI was 72, so this value has decreased slightly while the number of streets rated as very good has increased considerably through limited light weight rehabilitation activities. Unfortunately, this increase is offset by slight increases at the lower PCI values where significant rehabilitation costs exist due to deferred maintenance. The drops in the streets rated as fair and good are a result of applying surface treatments to these roadways.

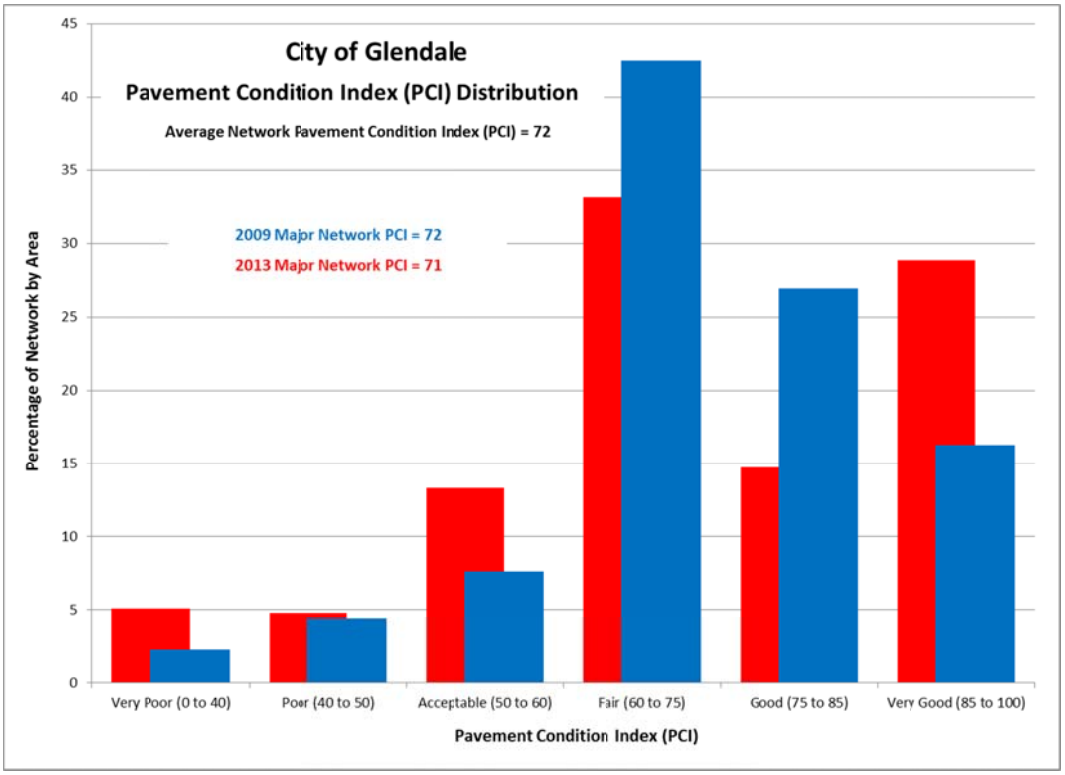


Figure 11 – Current Major Roadway Network Condition

This type of street renewal (selecting higher quality streets for a lightweight treatment) is certainly an effective strategy, but has a finite life as eventually the street rated below a 60 need to be addressed, and streets may only be surface treated a limited number of times before they need to be milled and overlaid.

The **minor roadway network** consists of three functional classes, covering approximately 615 centerline miles of pavement. The average pavement condition of the arterial roadway network in 2013 is 73. The following table presents key statistics of the minor roadway network.

	Pavetype	Collector Minor	Collector Major	Residential	Minors Network
Segment Count	All Streets	889	839	5,929	7657
	Asphalt	889	839	5,929	7657
	Rubberized AC	0	0	0	0
Length (mi)	All Streets	70.6	80.6	463.9	615
	Asphalt	70.6	80.6	463.9	615
	Rubberized AC	0.0	0.0	0.0	0
PCI Average	All Streets	69	70	74	73

The following bar chart (Figure 12) presents the 2013 distribution of pavement condition for the minor roadway network in the City of Glendale using descriptive terms complete with a comparison to the 2009 distribution. In 2009, the average PCI was 73, so this value has stayed steady while the number of streets rated as good has also increased through limited light weight rehabilitation activities. Unfortunately, this increase is offset by a noticeable increase at the lower PCI values where significant rehabilitation costs exist due to deferred maintenance. The drops in the minor streets rated as fair are a result of applying surface treatments to these roadways. Similar to the major roadway network, the opportunity to apply repeated light weight surface treatment is limited as eventually the streets will require a mill and overlay.

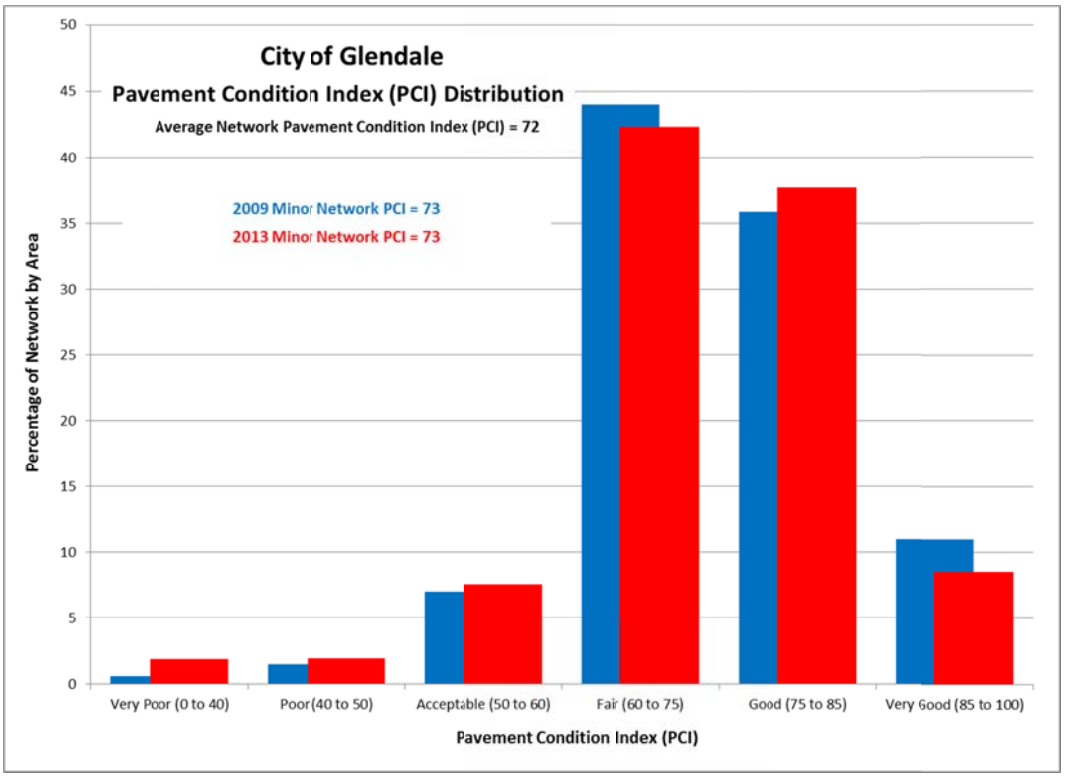


Figure 12 – Current Minor Roadway Network Condition

3.0 ANNUAL FUNDING AND BUDGET ANALYSIS

3.1 KEY ANALYSIS SET POINTS

Pavement management systems require user inputs in order to perform condition forecasting and prioritization. Key operating parameters, based on national empirical data and Glendale specific conditions, used in the analysis are as follows:

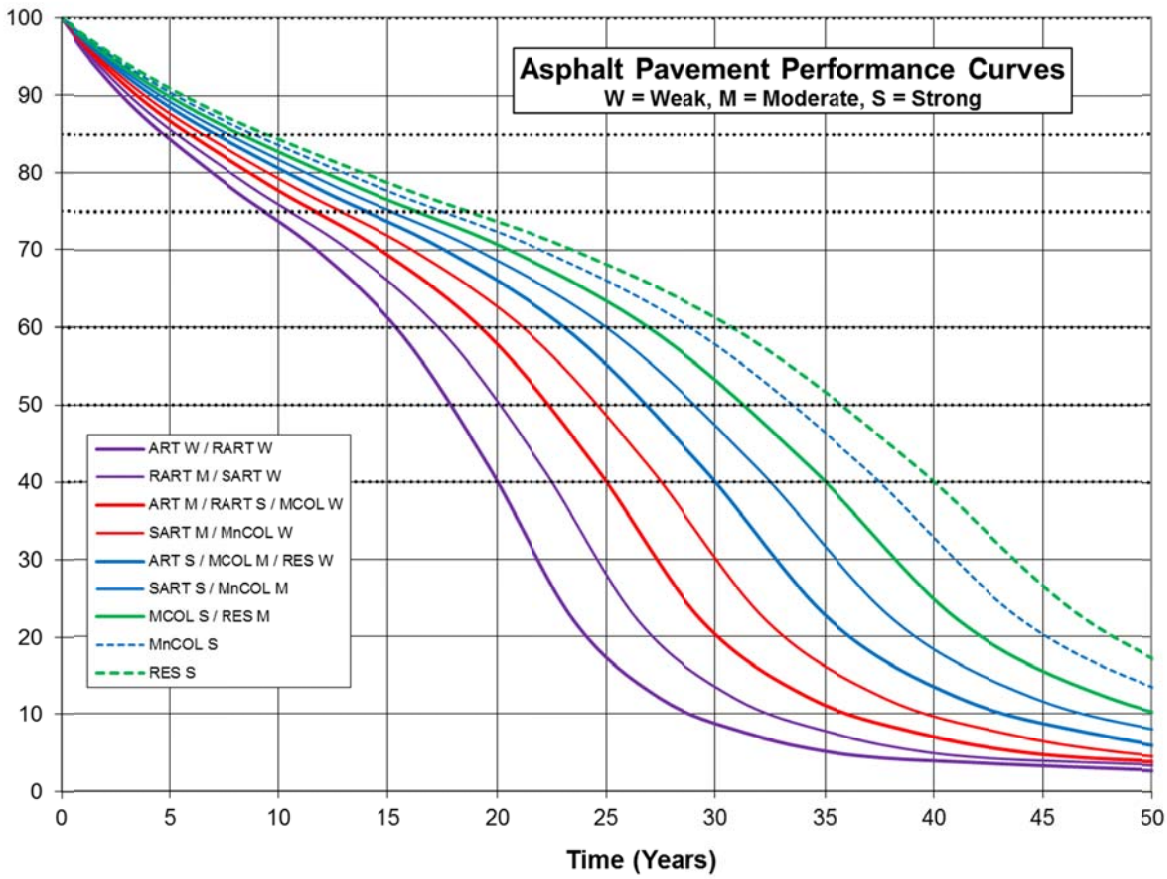


Figure 13 – Asphalt Performance Curves by Functional Class and Strength

The basic shape of the asphalt performance curves follows traditional sigmoidal deterioration models such as those contained in MicroPaver and other commonly used pavement management applications. The curves are constructed such that a typical overlay following new pavement construction does not occur until 15 to 25 years have passed, and full reconstruction does not occur until 30 to 55 years have passed or the street has a PCI below 10. Each street is assigned a curve based on its pavement type, functional classification, and pavement strength as determined in Section 2. The curves assume an ultimate life of between 75 and 100 years and are designed to be asymptotic to the X-axis (Time) to reflect the salvage value of the pavement once it has reached the end of its service life with a PCI less than 10.

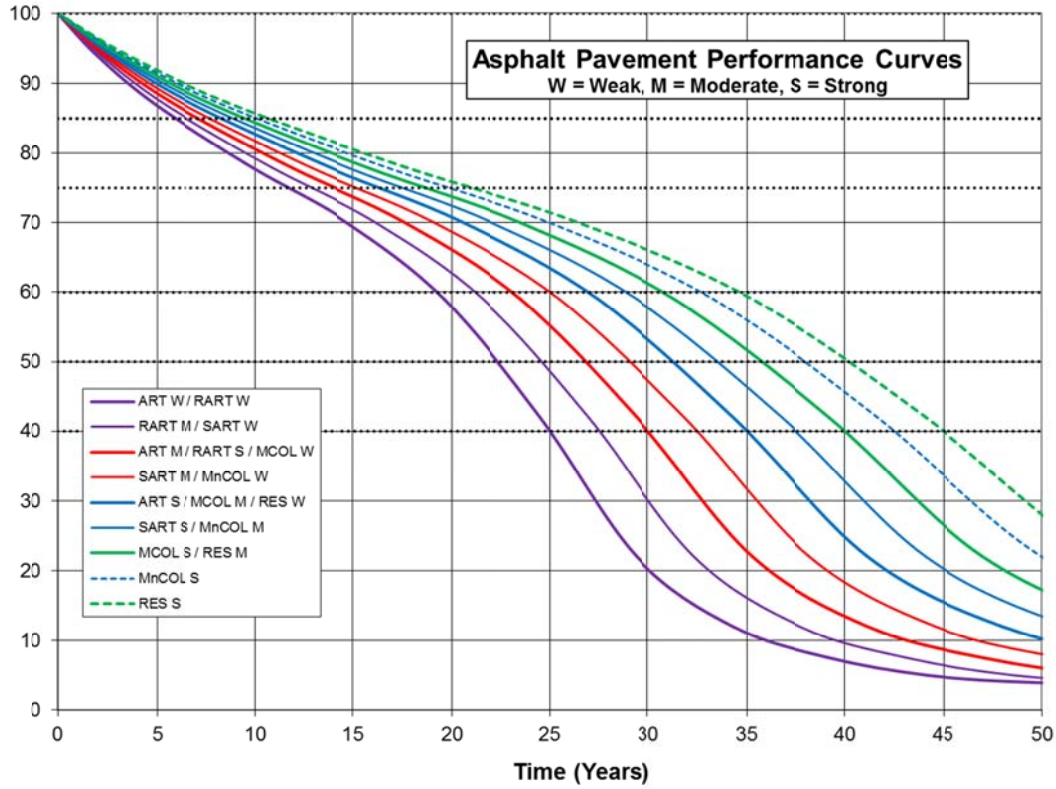


Figure 14 – Rubberized Asphalt Performance Curves by Functional Class and Strength

Priority and Priority Weighting Factor (PWF)

The city's pavement management program incorporates a user defined value, referred to as the Priority Weighting Factor (PWF), to prioritize the street segments for rehabilitation selection. The rehab selection order is not worst first, but rather designed to capture as many segments in the need year based on the incremental cost of deferral. Coupled with the rehabilitation sequence, the priority weighting factor defines the order in which streets are selected for rehabilitation. The streets are lined up in order of priority then the software applies the various rehabilitation strategies in order of sequence starting with the critical roadways, followed by non-critical roadways pending available funding. The effect of these two settings is to develop the most cost effective rehabilitation plan that maximizes pavement life before applying a rehabilitation. Applied at the project or SuperSegment level, Priority = (100 – PCI) x PWF and has a scale ranging from 0 to 10,500 and is initially calculated for all projects (listed as Superseg Priority) in the inventory.

The priority weighting factor for Glendale is threefold in nature. The assigned PWF follows functional classification (the more important the street, the higher PWF) followed by strength. Weak streets are assigned a slightly higher PWF over moderate and strong as they deteriorate at a higher rate.

Strength	Arterial	ART - Secondary	ART - Rural	COL - Major	COL - Minor	Residential
Weak	105	85	75	80	70	60
Moderate	100	80	70	75	65	55
Strong	95	75	65	70	60	50

Rehabilitation Strategies and Unit Rates

The rehab strategies, unit rates, PCI ranges and selection criteria used in the pavement analysis are presented in the following paragraphs and table.

Pavement Rehab and Thickness – is the user defined name assigned to each rehabilitation strategy incorporated into the pavement management system. Not all strategies have to be used, but rather are meant to reflect the full spectrum of options available for incorporation into budget development. The pavement rehab provides the end user with a guideline of what work needs to be done, how much money was set aside to accomplish the work, and the final impact to the street. The actual strategy may vary depending on project level testing and final design of the work. The relative terms of thin, moderate and thick are used to describe the overlay thickness presented in the adjacent columns. This is to facilitate consistency in the naming convention, but does not imply the same material thickness has to be used for each functional classification. For example, a moderate overlay on an arterial is assumed to be 2.0 to 3.0 inches thick, while the same overlay on a residential would be 1.5 to 2.5 inches. The RR1 or RR2 suffix after the name is a placeholder to indicate additional funding has been set aside for localized patching and repair.

Rehab Priority – defines the order in which rehabilitations are applied to the prioritized list of streets. The sequence has been developed based on the additional cost to defer an activity. For example, the cost of an arterial thick overlay is $18.50/yd2 increasing to $40.00/yd2 if deferred resulting in an incremental cost of $21.50/yd2, while the cost to defer a thin overlay to a moderate overlay is only $3.00/yd2. Thus a critical thick overlay is assigned a higher priority (lower sequence) than a thin overlay.

Min PCI, Breakpoint (BP PCI) and Max PCI - defines the Pavement Condition Index (PCI) range applicable to the rehab selection. The Breakpoint PCI defines when a segment is in its need year and is deemed to be critical, otherwise if deferred, the street declines in PCI past the point which the rehabilitation is no longer appropriate.

Min and Max Structural Index (Min SI, Max SI) – the Structural Index constraint acts as a qualifier to the PCI based rehab selection and is based on the results of the structural testing for the arterial roads or amount of load associated distresses a pavement has as described in Section 2. For asphalt roads the Structural Index constraint facilitates a lighter rehab to be selected if the road has sufficient structural capacity or does not display high load associated distresses associated with structural failures. It also provides additional money to complete localized repairs if the amount of load associated distresses is high relative to the PCI score.

Unit Rates – the rehabilitation costs are presented on a per square yard basis for each pavement type–functional class–rehabilitation activity combination. The rates were developed using typical national averages for similar activities and then were adjusted for Glendale's location and unique conditions. The defined rates are based on an average supply and install cost of asphalt at $85.00 per ton.

City of Glendale Rehabilitation Unit Rates and Strategies – Asphalt

Classification	Description	Rehab Priority	Min PCI	BP PCI	Max PCI	Min Structural	Max Structural	Reset PCI	Reset LAD	Reset NLAD	Reset Structural	Reset Roughness	Base Unit Rate ($/yd2)	Contingency (%)	Traffic Control (%)	Agency Overheads (%)	Misc. Peripheral Work (%)	Asphalt Rehab Unit Rate ($/yd2)	Rubberized Asphalt Rehab Unit Rate ($/yd2)	Average Rehab Cost per Mile ($/mi)	ADA Allowance
Arterial / Arterial - Secondary	Single Slurry Seal	12	85	87	100			85	10	5	85	85	2.51	5	5	0	5	2.89	2.89	110,000	No ADA allowance included
Arterial / Arterial - Secondary	Surface Treatment	6	75	77	85	75	100	88	8	4	88	88	3.01	5	5	0	5	3.46	3.46	130,000	No ADA allowance included
Arterial / Arterial - Secondary	Surface Trtmnt + RR1	5	75	77	85	0	75	88	8	4	88	88	3.51	5	5	0	5	4.04	4.04	160,000	No ADA allowance included
Arterial / Arterial - Secondary	Surf Trtmnt + 2X RR2	4	65	67	75	75	100	88	8	4	88	88	4.51	5	5	0	5	5.19	5.19	200,000	No ADA allowance included
Arterial / Arterial - Secondary	Moderate Olay (2.0 - 3.0")	11	65	67	75	50	75	95	3	2	95	95	17.19	5	5	0	5	19.77	21.74	800,000	ADA Allowance Included
Arterial / Arterial - Secondary	Mod Olay (2.0 - 3.0") + RR1	10	65	67	75	0	50	95	3	2	95	95	18.19	5	5	0	5	20.92	23.01	840,000	ADA Allowance Included
Arterial / Arterial - Secondary	Mod Olay (2.0 - 3.0") + RR2	9	50	52	65	75	100	95	3	2	95	95	19.19	5	5	0	5	22.07	24.27	890,000	ADA Allowance Included
Arterial / Arterial - Secondary	Thick Overlay (> 3.0")	8	50	52	65	50	75	96	3	1	96	96	20.86	5	5	0	5	23.99	26.39	970,000	ADA Allowance Included
Arterial / Arterial - Secondary	Thick Overlay (>3.0") + RR1	2	50	52	65	0	50	96	3	1	96	96	21.86	5	5	0	5	25.14	27.66	1,020,000	ADA Allowance Included
Arterial / Arterial - Secondary	Thick Overlay (>3.0") + RR2	1	40	43	50	50	100	96	3	1	96	96	23.36	5	5	0	5	26.87	29.56	1,090,000	ADA Allowance Included
Arterial / Arterial - Secondary	Surf Rmvl, Base Rehab & Olay	3	40	43	50	0	50	98	1	1	98	98	44.76	5	5	0	5	51.48	56.62	2,080,000	ADA Allowance Included
Arterial / Arterial - Secondary	Full Reconstruction	7	0	30	40			100			100	100	66.16	5	5	0	5	76.08	79.89	3,000,000	ADA Allowance Included
Arterial - Rural	Rubber Chip	11	65	67	75	50	100	85	10	5	85	85	3.88	5	5	0	5	4.47	4.47	160,000	No ADA allowance included
Arterial - Rural	Rubber Chip + RR1	10	65	67	75	0	50	85	10	5	85	85	7.38	5	5	0	5	8.49	8.49	310,000	No ADA allowance included
Arterial - Rural	Double Rubber Chip	8	50	52	65	50	100	85	10	5	85	85	6.38	5	5	0	5	7.34	7.34	270,000	No ADA allowance included
Arterial - Rural	Double Rubber Chip + RR1	7	50	52	65	0	50	85	10	5	85	85	12.09	5	5	0	5	13.91	13.91	510,000	No ADA allowance included
Arterial - Rural	Deep Patch & Overlay	6	40	43	50			90	7	3	90	90	11.09	5	5	0	5	12.76	14.03	490,000	No ADA allowance included
Arterial - Rural	Full Reconstruction	9	0	10	40			100			100	100	55.59	5	5	0	5	63.93	67.13	2,410,000	Partial ADA Allowance Included
Collector - Minor / Major	Single Slurry Seal	12	85	87	100			85	10	5	85	85	2.07	5	5	0	5	2.38	2.38	60,000	No ADA allowance included
Collector - Minor / Major	Surface Treatment	6	75	77	85	75	100	88	8	4	88	88	2.48	5	5	0	5	2.85	2.85	70,000	No ADA allowance included
Collector - Minor / Major	Surface Trtmnt + RR1	5	75	77	85	0	75	88	8	4	88	88	3.03	5	5	0	5	3.49	3.49	80,000	No ADA allowance included
Collector - Minor / Major	Surface Trtmnt + RR2	4	65	67	75	59	100	88	8	4	88	88	3.58	5	5	0	5	4.12	4.12	100,000	No ADA allowance included
Collector - Minor / Major	Thin Overlay (<= 1.5")	11	65	67	75	50	59	94	4	2	94	94	15.45	5	5	0	5	17.76	19.54	440,000	ADA Allowance Included
Collector - Minor / Major	Thin Overlay (<= 1.5") + RR1	10	65	67	75	0	50	94	4	2	94	94	16.55	5	5	0	5	19.03	20.93	470,000	ADA Allowance Included
Collector - Minor / Major	Thin Overlay (<= 1.5") + RR2	9	50	52	65	75	100	94	4	2	94	94	17.65	5	5	0	5	20.29	22.32	500,000	ADA Allowance Included
Collector - Minor / Major	Moderate Olay (1.5 - 2.5")	8	50	52	65	50	75	95	3	2	95	95	17.20	5	5	0	5	19.78	21.76	490,000	ADA Allowance Included
Collector - Minor / Major	Mod Olay (1.5 - 2.5") + RR1	2	50	52	65	0	50	95	3	2	95	95	18.30	5	5	0	5	21.05	23.15	520,000	ADA Allowance Included
Collector - Minor / Major	Mod Olay (1.5 - 2.5") + RR2	1	40	43	50	50	100	95	3	2	95	95	19.40	5	5	0	5	22.31	24.54	550,000	ADA Allowance Included
Collector - Minor / Major	Surf Rmvl, Base Rehab & Olay	3	40	43	50	0	50	98	1	1	98	98	39.22	5	5	0	5	45.10	49.61	1,120,000	ADA Allowance Included
Collector - Minor / Major	Full Reconstruction	7	0	20	40			100			100	100	59.48	5	5	0	5	68.40	71.82	1,660,000	ADA Allowance Included
Residential	Single Slurry Seal	12	85	87	100			85	10	5	85	85	1.88	5	5	0	5	2.16	2.16	40,000	No ADA allowance included
Residential	Surface Treatment	6	75	77	85	75	100	88	8	4	88	88	2.26	5	5	0	5	2.60	2.60	50,000	No ADA allowance included
Residential	Surface Trtmnt + RR1	5	75	77	85	0	75	88	8	4	88	88	2.76	5	5	0	5	3.17	3.17	60,000	No ADA allowance included
Residential	Surface Trtmnt + RR2	4	65	67	75	59	100	88	8	4	88	88	3.26	5	5	0	5	3.75	3.75	70,000	No ADA allowance included
Residential	Thin Overlay (<= 1.5")	11	65	67	75	50	59	94	4	2	94	94	14.04	5	5	0	5	16.15	17.76	340,000	ADA Allowance Included
Residential	Thin Overlay (<= 1.5") + RR1	10	65	67	75	0	50	94	4	2	94	94	15.04	5	5	0	5	17.30	19.03	360,000	ADA Allowance Included
Residential	Thin Overlay (<= 1.5") + RR2	9	50	52	65	75	100	94	4	2	94	94	16.04	5	5	0	5	18.45	20.29	390,000	ADA Allowance Included
Residential	Moderate Olay (1.5 - 2.5")	8	50	52	65	50	75	95	3	2	95	95	15.64	5	5	0	5	17.98	19.78	380,000	ADA Allowance Included
Residential	Mod Olay (1.5 - 2.5") + RR1	2	50	52	65	0	50	95	3	2	95	95	16.64	5	5	0	5	19.13	21.05	400,000	ADA Allowance Included
Residential	Mod Olay (1.5 - 2.5") + RR2	1	40	43	50	50	100	95	3	2	95	95	17.64	5	5	0	5	20.28	22.31	430,000	ADA Allowance Included
Residential	Surf Rmvl, Base Rehab & Olay	3	40	43	50	0	50	98	1	1	98	98	35.65	5	5	0	5	41.00	45.10	860,000	ADA Allowance Included
Residential	Full Reconstruction	7	0	20	40			100			100	100	54.07	5	5	0	5	62.18	65.29	1,270,000	ADA Allowance Included

Included in the unit rates are the following assumptions and allowances:

- Supply, installation and compaction of all tack coats, slurries, surface treatments, base materials and asphalt overlays and all associated materials on large scale – multi-block projects.
- Unit rates include allowances for surface preparation (sweeping, etc.), crack sealing where appropriate, edge or full width milling as required, and temporary pavement markings and striping as appropriate for each functional classification.
- Manhole and valve raising based on 3 valves or manholes per block and 8 blocks per mile.
- Allowance for ADA compliance cost are noted for each rehabilitation activity and was based on a ramp rehabilitation cost of $3,000 each or about $4.00/yd2 of pavement surface, based on 3

deficient ramps per block and 8 blocks/mile. ADA compliance does not include allowances for wholesale replacement of existing ramps that may be deficient in the geometry or commercial/residential driveway crossings. Only overlay and reconstruction activities received the ADA allowance in their unit rate. Slurry seals and surface treatment projects have no ADA allowance included. Rural arterial roadways only have a partial ADA allowance at approximately 50% of the full $4.00/yd2 rate.

- The rates also include a 15% allowance to cover costs for various work related activities, such as: Contingency for unforeseen work and /or conditions (5%); Traffic control and barricading (5%); Miscellaneous peripheral work, to include concrete repairs (aprons/valley gutters), removal of old striping, and installation of permanent thermal striping, markings and signal loops (5%).
- No allowances were made for right of way improvements, peripheral concrete repairs or replacement (with the exception of $15/yd2 for curb and gutter rehabilitation on reconstruction projects), drainage improvements, signage and signalization, or widening of city roadways.

Reset Values – post rehabilitation reset values for pavement condition (PCI, load and non-load associated distresses); structural index and roughness are used by the software to define the network condition following a rehabilitation.

The following plots, Figures 15, 16 and 17, graphically presents the application of pavement rehabilitations for asphalt streets by PCI and Structural Index the major minor and rural arterial roadway networks. Note: The numerical values shown in parenthesis in each of these figures are a record number or placeholder used by the Pavement Management Program software.

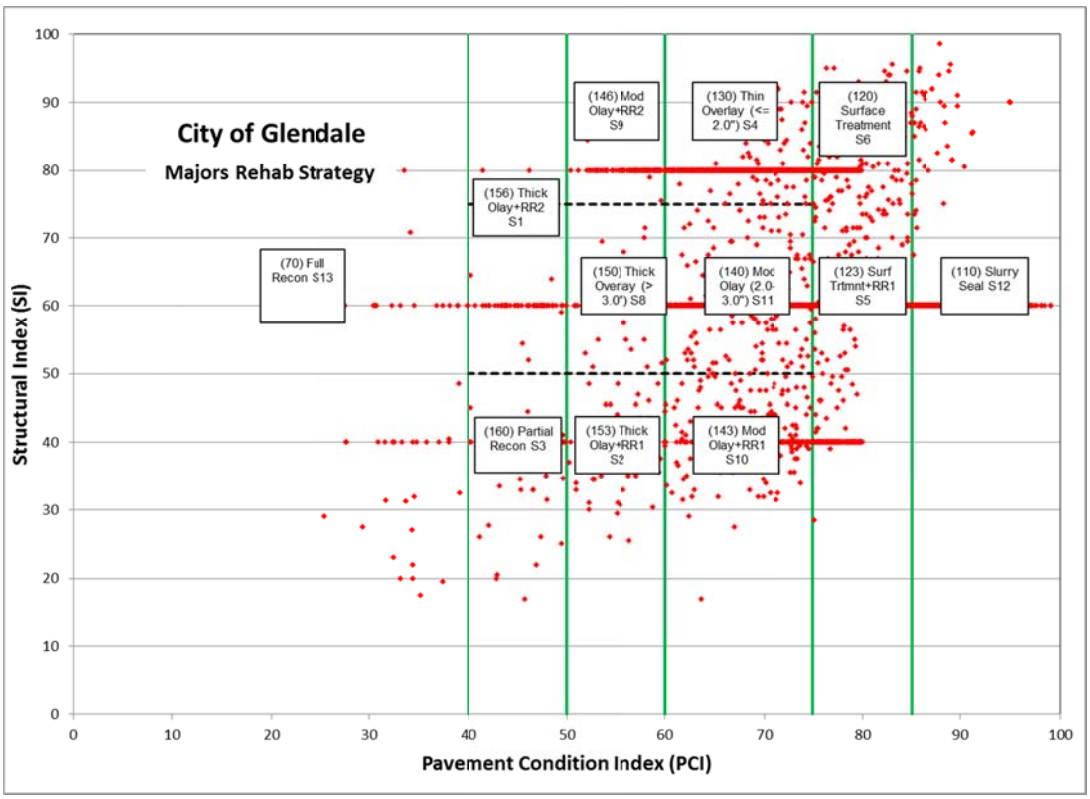


Figure 15 – Rehabilitation Strategies the Major Roadway Network

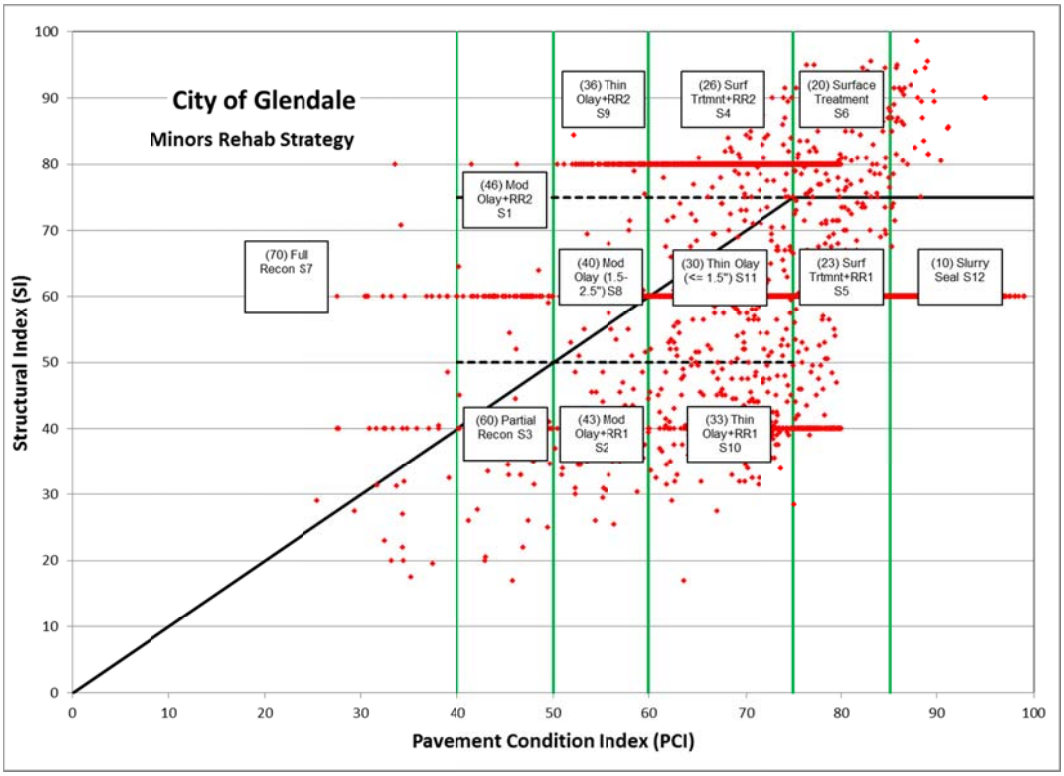


Figure 16 – Rehabilitation Strategies the Minor Roadway Network

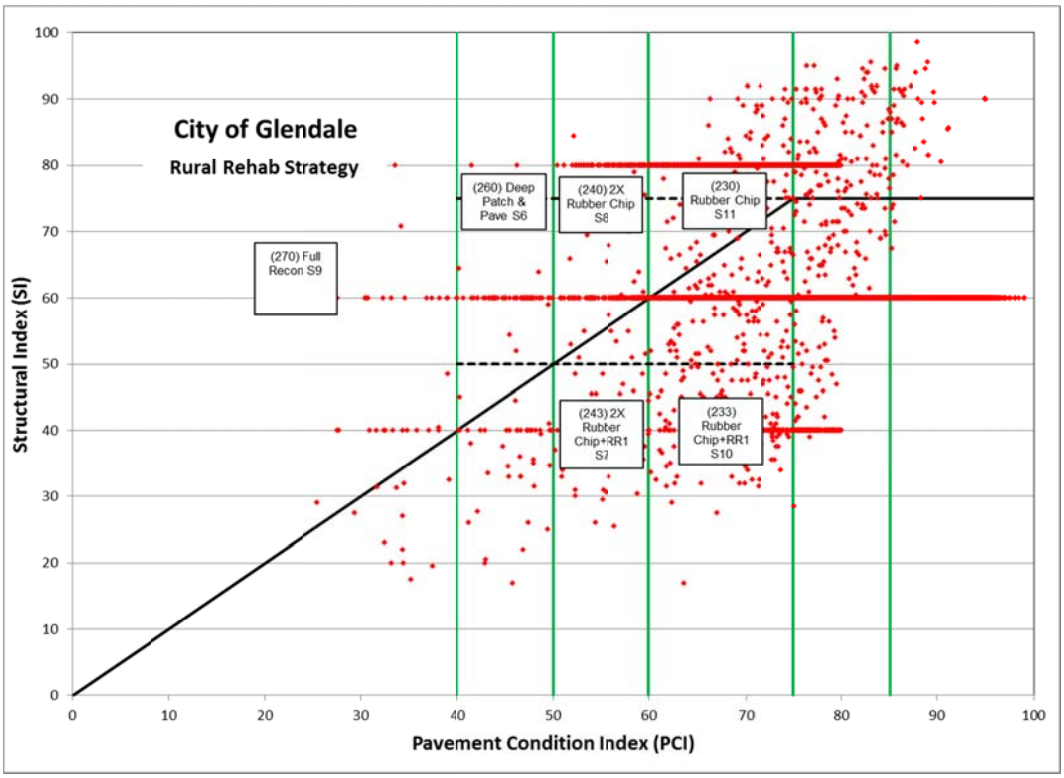


Figure 17 – Rehabilitation Strategies the Rural Arterial Network

3.2 ANNUAL FUNDING LEVELS FOR FISCAL YEARS 2014 THROUGH 2019

The pavement management analysis provided in this report for fiscal years (FY) 2014 through 2019 is based on the current funding levels as well as proposed additional bond funding. Available funding of $2 million dollars per year for pavement management improvements comes from the half-cent transportation sales tax of the Glendale Onboard (GO) Program, and this funding is scheduled to run through FY 2031. The $2 million in GO funding is programmed annually into Glendale's Pavement Management capital improvement plan (CIP).

For FY 2014, $5.25 million is budgeted for roadway maintenance in Glendale, which includes $2 million in Pavement Management CIP funding (GO Program), a Glendale City Council approved one-time supplemental of $3 million in Highway User Revenue Fund (HURF), and $250,000 in Community Development Block Grant (CDBG) funds. The funding in FY 2014 currently is programmed to pay for street network improvements on residential roadways (residential, minor collectors, and major collectors) only. Furthermore, the sale of HURF bonds is proposed, which would be made possible due to the retirement of current debt service in FY 2015 and would allow for approximately $28 million in HURF funding to be available for pavement management. For FY 2015 and FY 2016, the proposed plan is to use the $2 million in annual Pavement Management CIP funding (GO Program, plus the $28 million in HURF bond funding for arterial and residential/collector streets in Glendale. For FY 2017 through FY 2019, the $2 million annually of GO Program funding is programmed in the Pavement Management CIP for surface treatments to residential streets in the city. The current annual funding levels are outlined in the following table:

Year	Base ($M)	Additional ($M)	CDBG ($M)	Bond ($)	Less Additional Work ($M)	Annual Budget ($M/yr)
2014	2.00	3.00	0.25	0.00	1.35	3.90
2015	2.00	0.00	0.00	14.00	3.60	12.40
2016	2.00	0.00	0.00	14.00	3.60	12.40
2017	2.00	0.00	0.00	0.00	0.50	1.50
2018	2.00	0.00	0.00	0.00	0.50	1.50
2019	2.00	0.00	0.00	0.00	0.50	1.50
Totals	12.00	3.00	0.25	28.00	10.05	33.20

The Annual Budget column (in the table above) provides the construction costs related directly to the placement of pavement on the streets. Whereas, the Less Additional Work column represents the indirect administrative costs such as engineering design and construction administration services, construction inspection and testing services, and internal costs for finance and engineering contract administration services, as well as the Arts Fund contribution (1% of construction cost). These two columns combined (Less Additional Work plus Annual Budget) provide the total amount of funding available for each fiscal year from FY 2014 through FY 2019.

3.3 BUDGET ANALYSIS MODELS

The following section of this report presents the analysis results on four budget models for the pavement management program. These models are illustrated in Figure 18 below. The X axis highlights the annual budget, while the Y axis plots the five-year network post-rehabilitation PCI value (i.e., the network average PCI assuming all rehabilitations have been completed according to plan). The diagonal blue line is the analysis results. The models can be described as the following:

1. **Do Nothing Model** – this model identifies the effect of spending no capital for 5 years. It is depicted on Figure 18 where the diagonal blue line intersects the Y axis. After 5 years, the Do Nothing option results in a PCI drop from 72 to a 63.

2. **Current Budget Model** – this model identifies the resultant network PCI at a $2.0M annual budget or funding level. After 5 years, the $2.0 million option results in a PCI drop from 72 to 64.5.

3. **Five-Year Plan Model** – this model identifies the resultant network PCI with the $28M in bond funding distributed over 2 years starting in 2015. This model also assumes a base of $2 million per year from 2015 through 2019 that is currently received in CIP funding (GO Program) for annual street maintenance. After 5 years, the Proposed Bond option results in a PCI rating of 68.

4. **Steady State Model** – this model identifies the required annual budget to maintain Glendale's current network average PCI at 72. The steady state option requires that:

The annual budget needed to maintain the current 2013 PCI at 72 = $13 Million

As part of the budget analysis, an upper limit of spending (or a "Fix All" budget) was calculated in order to calibrate the four budget models. The Fix All budget expends $208 million. Assuming this funding is initially spent in the first year the PCI would increase to 89 and would taper off to a PCI rating of 84 in five years.

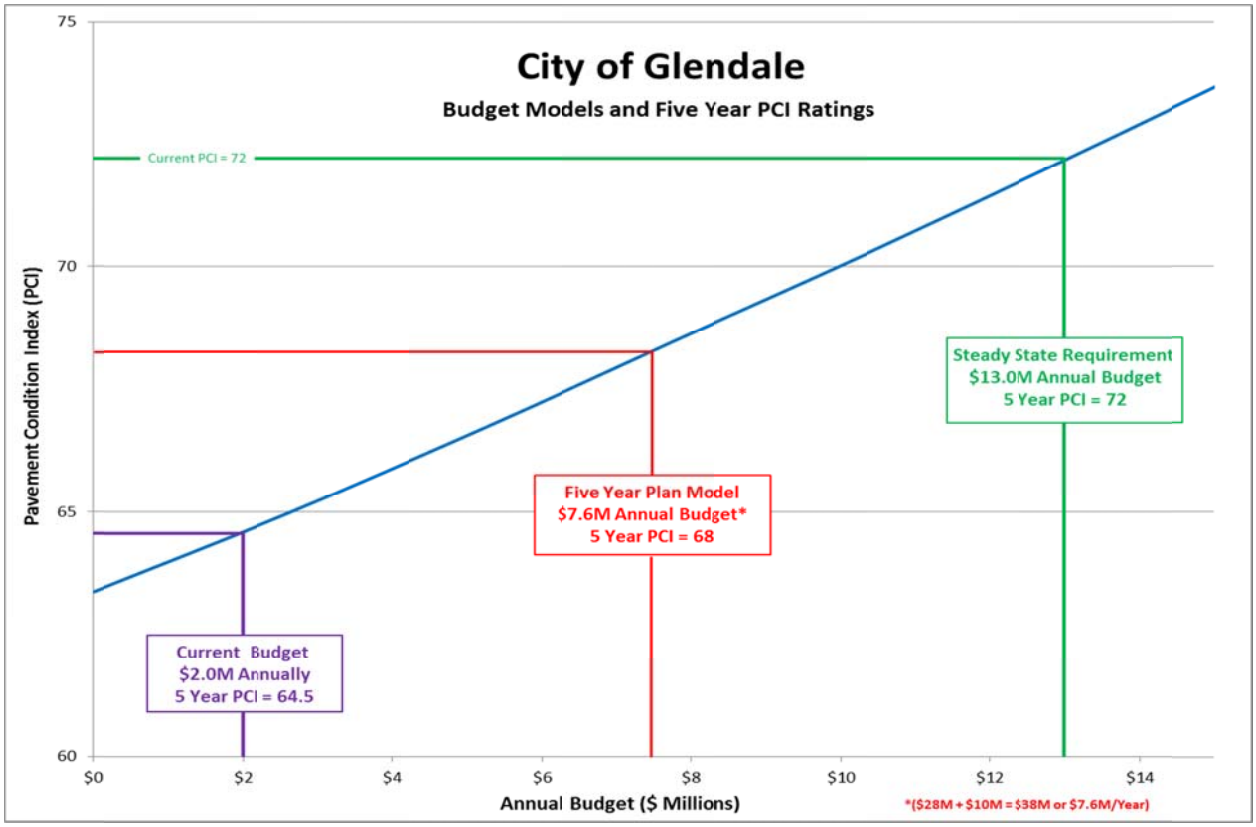


Figure 18 – Five Year Network PCI Analysis Results

Figure 18 may also be used to identify the impact to the street network of other budget levels; based on the chart you can also select any particular dollar amount ($6.0 M, $10.0M, or $12.0M, for example) to identify the resulting network PCI at each funding level. Alternatively, Figure 18 may also be used to identify the required budget to achieve a specific target PCI within five years. For example, selecting a network average target PCI of 70 would require an annual budget of $10 million.

By 2019, even with the investment of the $28 million bond funds applied to roadway rehabilitation, the amount of streets rated below a PCI rating of 50 (or classified in "poor or "very poor" condition) is expected to double to 13 percent (or 93 miles). The biggest increase will be seen in the major roadway network (103 total miles) where close to one quarter (or 26 miles) of the arterial roadways will be classified as poor or very poor. This causes a greater funding concern due to the much higher rehabilitation cost for arterials streets as compared to residential streets. For instance, the cost to rehabilitate a collector/residential street is approximately half the cost to rehabilitate an arterial street in all categories as a residential street is typically one half to one third the width of an arterial roadway.

Figure 19 presents a similar analysis as shown in Figure 18, except the analysis results plotted on an annual year basis instead of on an annual budget basis. In this plot, each colored line represents a different budget amount and highlights the effect the budget has on the average network condition score.

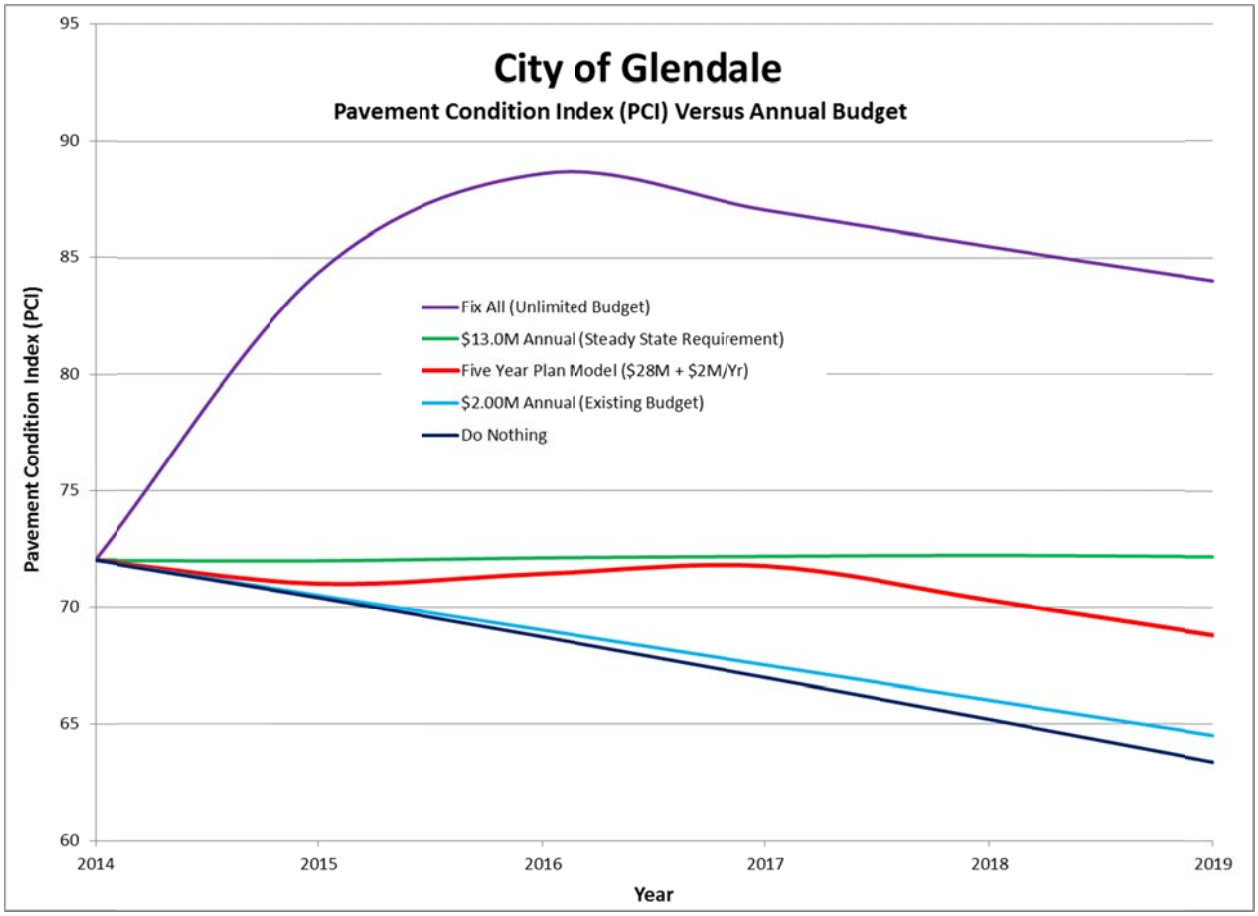


Figure 19 – Five Year Annual PCI

Figure 19 shows that annual budgets below the steady state $13 million per year cause the network to deteriorate on an annual basis, while amounts above $13 million will cause a rise in quality. The red line is the $28 million Bond option and illustrates how the large infusion of monies in a short time frame is unable to effect large scale changes to the network average PCI as most of the monies are expended on high cost rehabilitations that would otherwise be unaffordable to the city. With the bond option, the final network PCI would drop to a 68 and have noticeable increases in streets rated at a PCI below 50 despite the infusion of large amounts of capital.

4.0 PROPOSED REHABILITATION PLANS

4.1 REHAB PLAN DEVELOPMENT

The general methodology for developing the proposed rehabilitation plans for Glendale's street network is based on current PCI ratings, functional classification and strength, and the funding available for roadway maintenance. A slightly different approach was used for the Current Year Plan (FY 2014) in comparison to the Five-year Plan (FY 2015 through 2019). The methodologies are described below in more detail. The selection of roadways and the proposed pavement maintenance work to be performed in each year is located in Appendix A of this executive summary report.

4.2 CURRENT YEAR PLAN (FY 2014)

The approach for developing the current year rehabilitation plan was to select residential roadways (residential, minor collectors, and major collectors) only for pavement improvements during FY 2014. This plan was developed with previous City Council feedback and input related to community priorities and needs. The methodology to identify streets involved selecting the lowest rated streets that could be rehabilitated, ranking in order based on the PCI from lowest to highest, selecting the type of pavement treatment required, and determining how much could be completed based on available funding within the current fiscal year. Figure 20 displays the costs, percentages, and miles associated with each type of rehabilitation activity proposed for the current year plan. Figure 20 further identifies a significant trend in costs versus miles for the rehabilitation activities. For instance, reconstruction work consumes a similar percentage of the available funding for only 0.5 miles rehabilitated as compared to 8.4 miles of streets that will receive surface treatments.

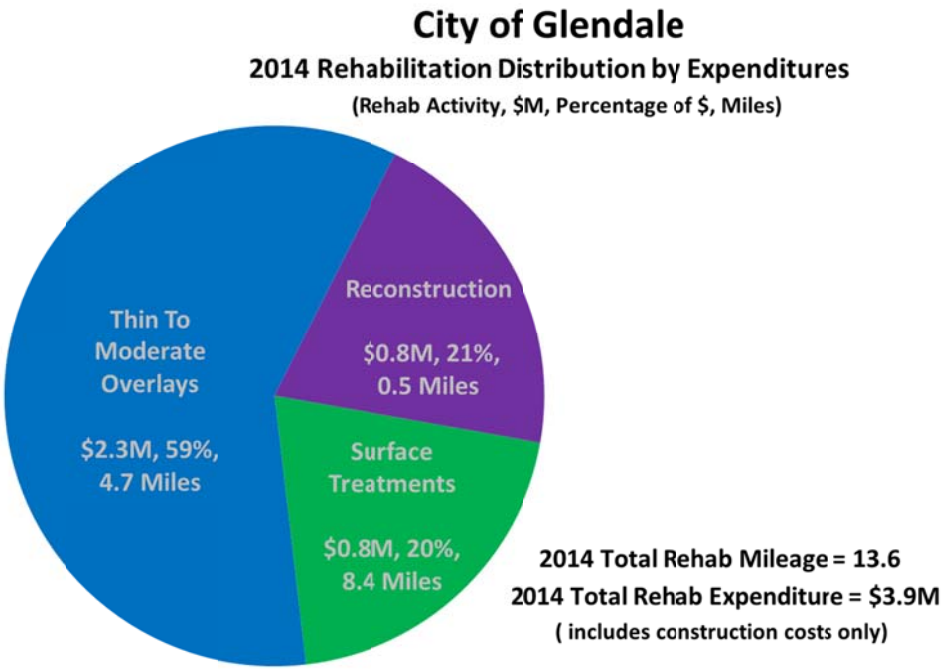


Figure 20 - Current Year (FY 2014) Plan Rehabilitation Summary

Based on this approach, a total investment of $5.25 million, which includes both construction ($3.9 million) and administrative overhead costs ($1.35 million), will allow for roughly 13 miles of surface and overlay treatments and one-half mile of residential/collector reconstruction work. Additionally, in FY 2014 the city will reconstruct a little over a half-mile of roadway at the Bethany Home Frontage Road, from 61st Avenue to 66th Avenue, and the 67th Avenue Frontage Road, from Keim Drive to Rose Lane using the $250,000 in CDBG funds and $200,000 from the GO Program. The GO Program funded portion of this project is included in the total annual budget funding for FY 2014.

4.3 FIVE-YEAR PLAN (FY 2015 THROUGH FY 2019)

The approach for developing the five-year rehabilitation plan involved prioritizing and selecting both arterial and residential streets for pavement improvements. The methodology used included assigning the appropriate rehabilitation activity (or pavement treatment) to all street segments in the roadway network first, and then the critical streets having the highest cost of deferral were selected followed by less critical streets having a lower incremental cost of deferral. For example, the cost of an arterial thick overlay is $18.50/yd2 increasing to $40.00/yd2 if deferred resulting in an incremental cost of $21.50/yd2, while the cost to defer a thin overlay to a moderate overlay is only $3.00/yd2. Thus a critical thick overlay is assigned a higher priority (lower sequence) than a thin overlay. Under this approach, the streets were ranked from lowest to highest PCI after selecting the type of required pavement treatment or rehabilitation activity.

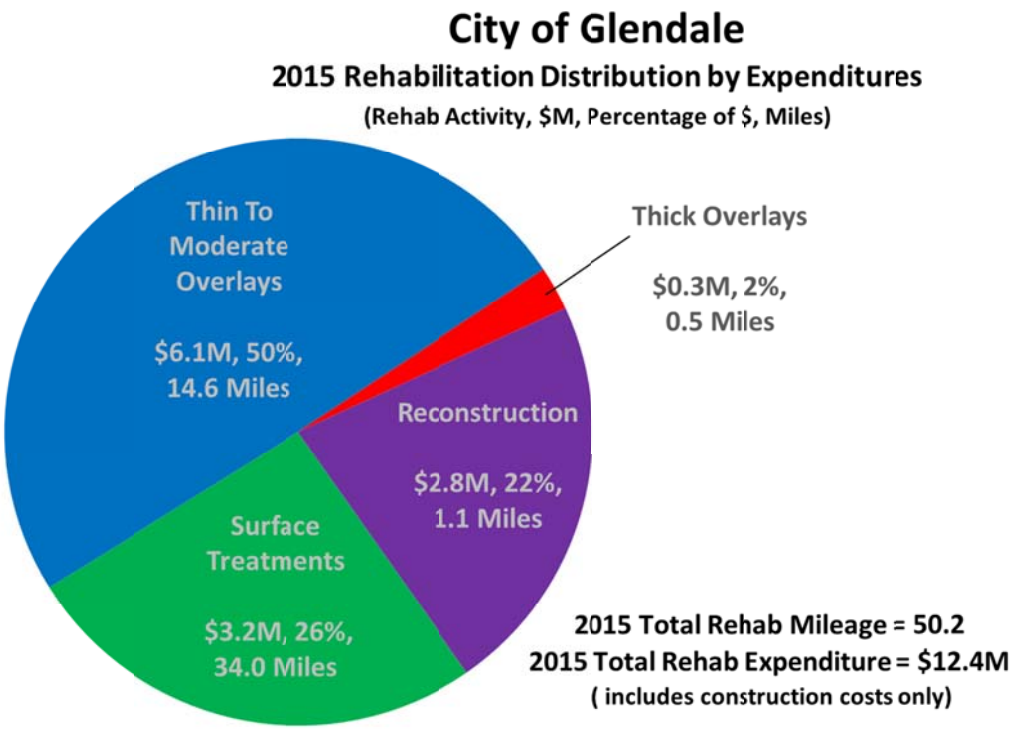


Figure 21 - FY 2015 Plan Rehabilitation Summary

The effect of utilizing this methodology for the five-year plan is to develop the most cost effective rehabilitation strategy that maximizes pavement life. Figure 21 and 22 displays the costs, percentages, and miles associated with each type of pavement treatment proposed for the five-year (FY 2015 through FY 2019) plan.

Based on this approach, part of the recommended plan is to spread the HURF bond funding equally over years 2015 and 2016 ($14 million each). The other funding available for street rehabilitation during each of the five years, 2015 through 2019, includes the $2 million in annual Pavement Management CIP funding. The $32 million investment in 2015 and 2016 (funded mostly through the $28 million HURF bond), will allow for roughly 94 miles of surface and overlay treatments and 2.4 miles of reconstruction work. For the remaining $6 million to be spent from 2017 through 2019, slightly less than 14 miles of residential streets could be maintained for this investment. Therefore, the grand total investment for the five-year plan includes approximately $29 million in construction costs and $9 million in administrative overhead costs for a total amount of $38 million to be expended on roughly 110 miles (50.2 miles in 2015 and 59.7 miles in 2016 through 2019) of Glendale's street network.

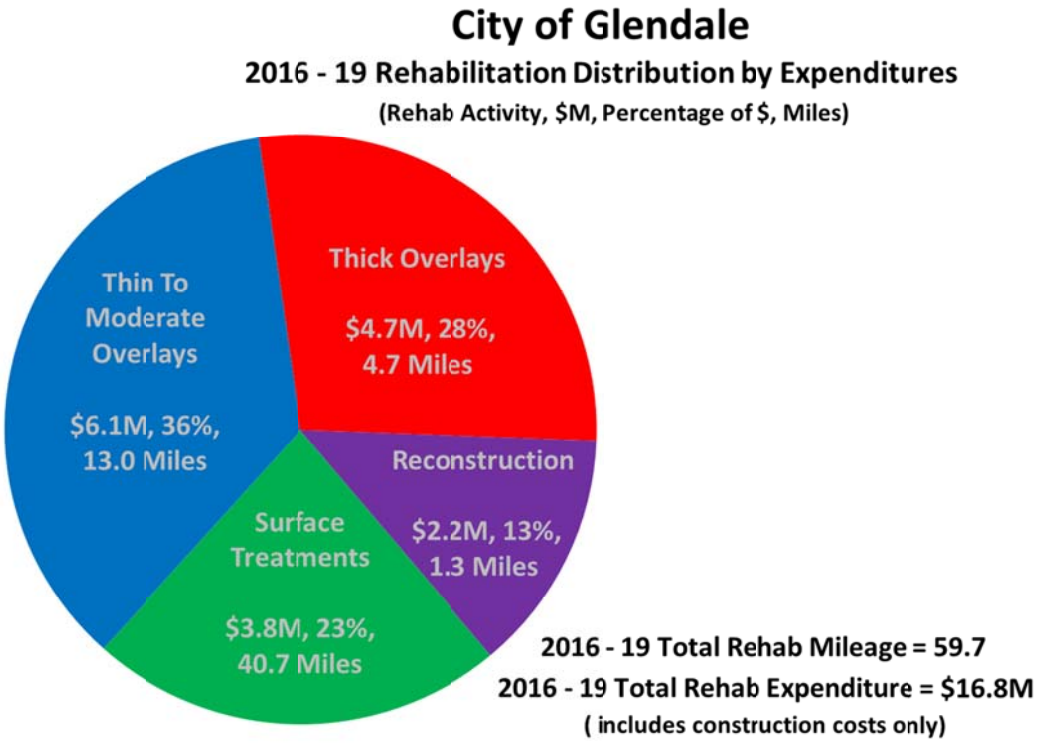


Figure 22 - FY 2016 - 2019 Plan Rehabilitation Summary

Figures 21 and 22 further identify the trend already shown in Figure 20 (above) and related to the greater costs versus smaller number of miles for the more intensive rehabilitation activities (thick overlays and reconstruction) as compared to the less intensive pavement treatments (surface or thin to moderate overlays). Overall, this shows the importance of developing detailed rehabilitation plans in order to effectively prioritize pavement treatment activities and to avoid millions of extra or unnecessary street rehabilitation costs.

5.0 SUMMARY AND RECOMMENDATIONS FOR COUNCIL GUIDANCE

As outlined in this pavement management analysis, it is planned to spend $5.25 million to complete the Current Year Plan (FY 2014), which focuses on residential street rehabilitation and improvement activities. This current year plan was developed with previous City Council feedback and input related to community priorities and needs.

The Five-Year Plan (FY 2015 through 2019) provides a proposed program to complete street network improvements across all roadway types (residential, arterials, collectors, etc.); funding sources for these improvements includes HURF bond funding in the amount of $28 million spread equally ($14 million each) during years 2015 and 2016 as well as an additional $2 million in HURF funding during each of the five years. Although a larger amount of spending is proposed during FY 2015 and 2016 than what traditionally has been spent during previous fiscal years, additional funding will eventually be needed to have an effective program for on-going maintenance to properly repair the city's roadways and to extend the useful life of this city asset.

Lastly, the Pavement Management Report provided by IMS Infrastructure Management Services, L.L.C. in cooperation with Field Operations, to the City of Glendale identifies a number of recommendations to be considered by the City Council. The recommendations for which policy guidance is sought are the following:

1. Move forward with the $28.0 million bond option; it is also recommended to spend this funding over a two-year period in FY 2015 and FY 2016.

2. Adopt a policy statement identifying the desired overall pavement condition rating and establishing a maximum percentage for streets allowed to have a PCI rating lower than 50 (or classified in "poor" or "very poor" condition); recommended targets include maintaining the current network profile at or above a PCI rating of 72 for 5 years and establishing a maximum percentage of 12 percent (12%) for streets with PCI rating lower than 50.

   An annual budget of at least $13 Million is required to achieve this goal.

3. Review annually the comprehensive plan of proposed rehabilitation strategies and unit rates, which can have considerable effects on the finalized construction program placed out for bid; all costs are in constant 2013 dollars, so no allowances have been made for annual inflation or fluctuations in rehabilitation costs.

4. Complete an updated field survey assessment and analysis of pavement conditions for Glendale's entire street network in FY 2014, which will provide current field data to assist with future short and/or long-range planning efforts related to the pavement management program.

5. Incorporate budget allowances for network growth into annual pavement management program. As the city expands or increases the amount of paved roads, increased budgets will be required. No allowance has been made for routine maintenance activities such as crack sealing, sweeping, striping or patching. These costs are assumed to be outside the pavement management costs and will affect the network performance if not completed.

6. Increase annual funding for compliance with the Americans with Disabilities Act (ADA), which is required on all roadway rehabilitation projects. An increased level of funding will be necessary should the city elect to become fully ADA compliant.

Appendix A

Summary Map of Rehabilitation Plans for 2014, 2015, and 2016-2019

Appendix B

Detailed Map Index of Rehabilitation Plans for 2014, 2015, and 2016-2019

Appendix C

Map of Current Pavement Condition Index (PCI) Rating