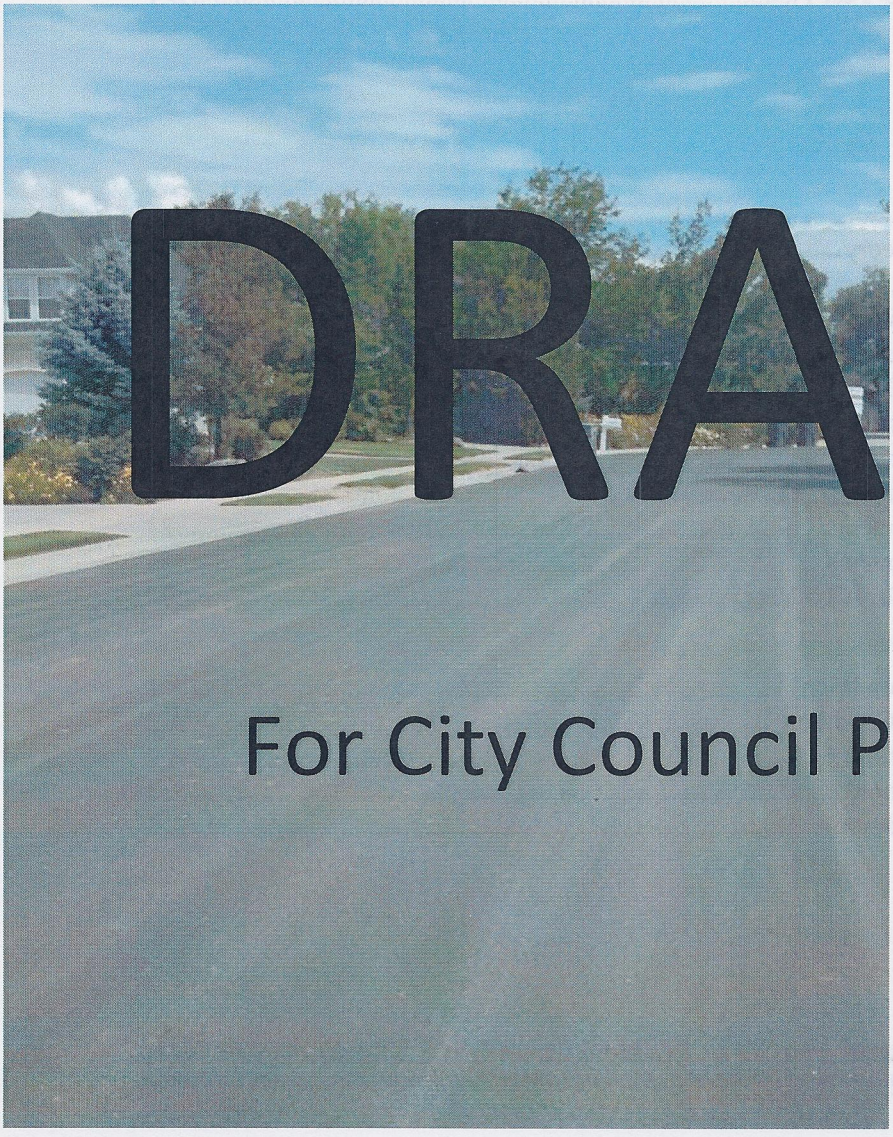
HIGHLAND CITY

2014

Five Year Road Maintenance Management Plan



DRAFT

For City Council Presentation

Highland City Public Works Department

Highland City

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Introduction and History

The road network is the single most valuable asset of most municipalities. Pavements are often designed to last 20 years. However, by maintaining the asphalt on a properly constructed road, the life of the asphalt can be extended by many years.

Pavement is made up of aggregate and asphalt binder (a by-product of refining crude oil), and may include additives to improve its performance. The asphalt binder naturally deteriorates over time due to environmental factors such as ultraviolet rays, oxidation, and freeze/thaw cycles. Deterioration is accelerated by factors such as penetration of water into the asphalt layer, penetration of water into the soil under the pavement and under the roadway, traffic loading, and physical damage such as utility cuts and trenching.

There are different activities that can be used to preserve the condition of pavement and extend its life; the appropriate activity depends upon the condition of the asphalt and the adequacy of the materials under the asphalt. The activities that are suitable when a road is in good condition are much less expensive than the activities that are required when a road has deteriorated significantly. Therefore, the most cost effective way to maintain roads is to keep them good, thereby avoiding, or at the very least delaying, the need for the more expensive activities. The longer adequate maintenance activities are delayed, the more expensive it will be to preserve and restore the asphalt.

Highland City currently owns and maintains over 81 miles of paved road. In 2011, J-U-B Engineers conducted a pavement condition inventory, including approximately 553 inspections throughout the city, in an attempt to better understand the current status of the city's road network. During the inspections, we measured specific distresses in the roads and documented distress type, quantity, and severity. This information allows calculation of a PCI value using ASTM Standard D-6433-03.

The results of this study were that approximately 9% of the city's roads are in very poor condition, another 19% are in a poor condition, and the remaining 72% are in a good or better condition.

A letter grade breakdown was determined by Highland City that follows the standard classification of PCI values. Figure 1 shows the pavement condition index (PCI) and relates the PCI value to the Highland letter grade for ease of understanding a road's current condition.

Appendix A contains photographs of roads in Highland having various PCI values.

The city categorized roads in two groups. The first group was roads that have a PCI value of 55 or better. These are roads that are classified as good, very good, or excellent (ie. the "good" roads). These are the less expensive roads to maintain. The second group was roads with a PCI value of less than 55. These are roads that are classified as poor to very poor (ie. the "poor" roads) and are a much more expensive to maintain. The city's philosophy is to apply

available funding to maintain the good roads as much as possible, since it is less expensive to keep good roads good than to improve roads that are already in poor condition.

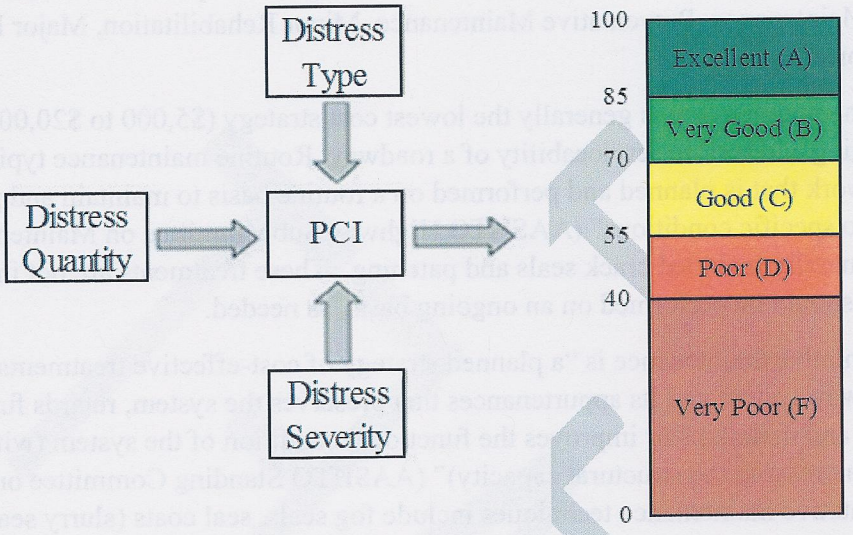


Figure 1. Pavement Condition Index

Highland City asked J-U-B Engineers to recommend how to put available maintenance funding to best use on the good roads, and to estimate how much funding would be required to preserve the condition of the good roads. Therefore, this report addresses maintenance of the good roads – those that have a PCI value greater than 55. Maintenance of the poor roads (those with a PCI value lower than 55) is well beyond current funding availability and will be addressed separately at a later date.

Pavement Treatment Types

There are many different surface treatments that help preserve the pavement surface from distresses and extends the life of the pavement. The categories of pavement surface treatment are Routine Maintenance, Preventative Maintenance, Minor Rehabilitation, Major Rehabilitation, and Full Reconstruction.

Routine maintenance is generally the lowest cost strategy ($5,000 to $20,000 per mile). It can reduce aging and restore serviceability of a roadway. Routine maintenance typically "consists of work that is planned and performed on a routine basis to maintain and preserve the condition… to specific conditions" (AASHTO Highway Subcommittee on Maintenance). These treatments generally included crack seals and patching. These treatments are not included in the model – they should be performed on an ongoing basis, as needed.

Preventative maintenance is "a planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without significantly increasing the structural capacity)" (AASHTO Standing Committee on Highways, 1997). Preventative maintenance techniques include fog seals, seal coats (slurry seal and micro-surfacing), and high density mineral (HDMB). These treatments are typically performed between two and thirteen years after initial construction of the roadway and on a repeating cycle, depending on the condition of the road. Preventative maintenance typically costs about $25,000 to $50,000 per roadway mile of repair and can restore the service life of the road by five to eight years. For Highland, the preventative maintenance treatments used in modeling the system was either micro-surfacing or HDMB.

Minor rehabilitation consisting of a structural overlay (up to 2-inches) is a pavement strategy typically used on road sections with a high level of deterioration that require increased structural capacity but do not need full reconstruction. This is a lower cost alternative for roads that have not completely failed but are on the verge of failing. Structural overlays typically cost about $375,000 per mile, and are typically performed on roads that have a remaining service life between 11 and 16 years. Benefits of a structural overlay include increasing the road capacity, reducing the aging of the road, and restoring serviceability of the road. This overlay typically restores the service life of the road by 9 to 11 years.

Major rehabilitation is required when a road has deteriorated past the point of preservation. These roads may experience frequent and heavy loads, exposure to the elements, ir may not have had preventative maintenance performed routinely. Major rehabilitation "consists of structural enhancements that both extend the service life of an existing pavement and/or improve its load-carry capacity" (AASHTO Highway Subcommittee on Maintenance Definition). Major rehabilitation techniques consist of a thick overlay (2-inches or greater) or milling deteriorated asphalt at the top of the asphalt layer followed by an overlay. This type of repair typically costs about $550,000 per mile, or more depending on the thickness, and adds

approximately 15 to 17 years to the remaining service life of a road. This type of repair is generally performed on pavement with a remaining service life ranging from one to ten years.

Minor reconstruction consists of full replacement of the asphalt. It is necessary when the asphalt as deteriorated beyond the point of providing a suitable surface for an overlay, but when the base course and subgrade materials are adequate and stable. It may be accomplished by removing and replacing the asphalt, or by pulverizing the asphalt with the base course, removing excess materials, reshaping and compacting the pulverized materials to comprise the new base course layer, and placing a new asphalt layer. Minor reconstruction of a road typically costs about $675,000 per mile, or more, depending on the thickness.

Major reconstruction is an extreme measure that is often used on roads that have deteriorated to a point where the road is unsafe, unusable, or irreparable. This is the most costly strategy, but is sometimes necessary to resolve underlying causes of asphalt failure, such as inadequate base thickness or unstable subgrade soils. It is usually not a pavement management technique that is planned for or ever needed on every road. Major reconstruction of a road might range between $750,000 to $1,200,000, or more, per mile, depending on the cause of the pavement failure and activities that must be conducted to correct it.

Both minor and major reconstruction are typically performed on failing roads with a remaining service life of zero years and restores the service life of the road to 30 years. As this study is only focusing on those roads whose condition is either good or better (PCI greater than 55), reconstruction is not included in the analysis.

The treatment types are summarized in Table 1 below.

Table 1. Treatment Types

Treatment		Applied		Effect on Pavement		
Type	Description	RSL	PCI	RSL	PCI	Cost per Mile
Major Reconstruction	Reconstruct entire structure	0	0 to 38.5	Set to 30	Set to 100	$1,200,000
Minor Reconstruction	Replace asphalt	0	0 to 38.5	Set to 30	Set to 100	$665,000
Major Rehabilitation	Mill and overlay	0 to 10	38.6 to 56	Set to 30	Set to 100	$550,000
Minor Rehabilitation	Thin overlay	11 to 16	56.1 to 65.75	Increase by 17	Increase by 35	$370,000
Preventative Maintenance	Crack seal & seal coat	17 to 24	65.76 to 81.5	Increase by 7	Increase by 13	$68,500
Preventative Maintenance	Crack sealing & fog seal or HDMB	25 to 27	81.6 to 89.5	Increase by 7	Increase by 13	$50,000
Routine Maintenance	Crack sealing, fill potholes	28 to 30	89.6 to 100	None	None	varies

Table B-1 in Appendix B contains costs from actual bids and projects. These, in addition to our professional opinion and judgment, form the basis of our opinion of likely pavement management treatment costs.

It is noteworthy that under current federal ADA requirements, construction of many pavement treatments triggers the need to bring adjacent pedestrian ways up to current standards. This is not within the scope of the pavement management program, but does result in the city incurring additional costs in conjunction with pavement management projects. Accessibility Transition Plans are documents that identify where improvements are needed to bring pedestrian ways into compliance with ADA requirements. They identify specific locations of deficiencies and estimate the costs of improvements.

Pavement Management Philosophy

The philosophy of pavement management begins with the idea of keeping good roads good. Roads require maintenance, and a jurisdiction can provide periodic preventative maintenance for a road throughout the life of the pavement or it can wait until the service life of a road has been depleted to a point where reconstruction is necessary. It is less expensive to apply the less expensive preventative maintenance treatments every few years while pavement is still in good condition rather than waiting until it is damaged, and have to apply the more expensive rehabilitation or reconstruction treatments.

Paved roads are typically designed for a 20 or 30 year life cycle. In theory, one could estimate the remaining service life of a road by subtracting its age from the design life. For example, a road designed for a 30 year life that is 10 years old would have a remaining service life of 20 years (30 - 10 = 20) if no maintenance was performed.

Managing pavement means performing certain treatment activities as pavement ages in order to extend its service life.

For example, here are several different ways of managing pavement on a road:

1. Perform any necessary crack sealing and apply a fog seal or high density mineral bond to a road that was built six years ago. A high density mineral bond can add about five years to the remaining service life of a road. After the treatment the remaining service life of this five year old road would be about 29 years (30 – 6 + 5 = 29). It may cost about $0.27 per square foot to do the crack sealing and fog seal or high density mineral bond.
2. Apply no treatments for 20 years, at which time the road would likely require an overlay with new asphalt. It would add about 12 years to the life of a 22 year old road, resulting in a remaining service life of 20 years (30 – 22 + 12 = 20). The overlay would cost about $2.00 per square foot.
3. Apply no treatments for 30 or more years, at which time the road would likely require full reconstruction. This would restore the road to new condition, with a remaining service life of 30 years. Depending on various factors such as soil characteristics, water present, etc., reconstruction could cost anywhere from a few dollars per square foot to $8 or $10 or more per square foot. For our purposes we are estimating an average of $3.60 per square foot.

These examples illustrate the value of applying the correct treatments at the right time. The effect of each of these maintenance activities over time is shown in Figure 2 and Table 2.

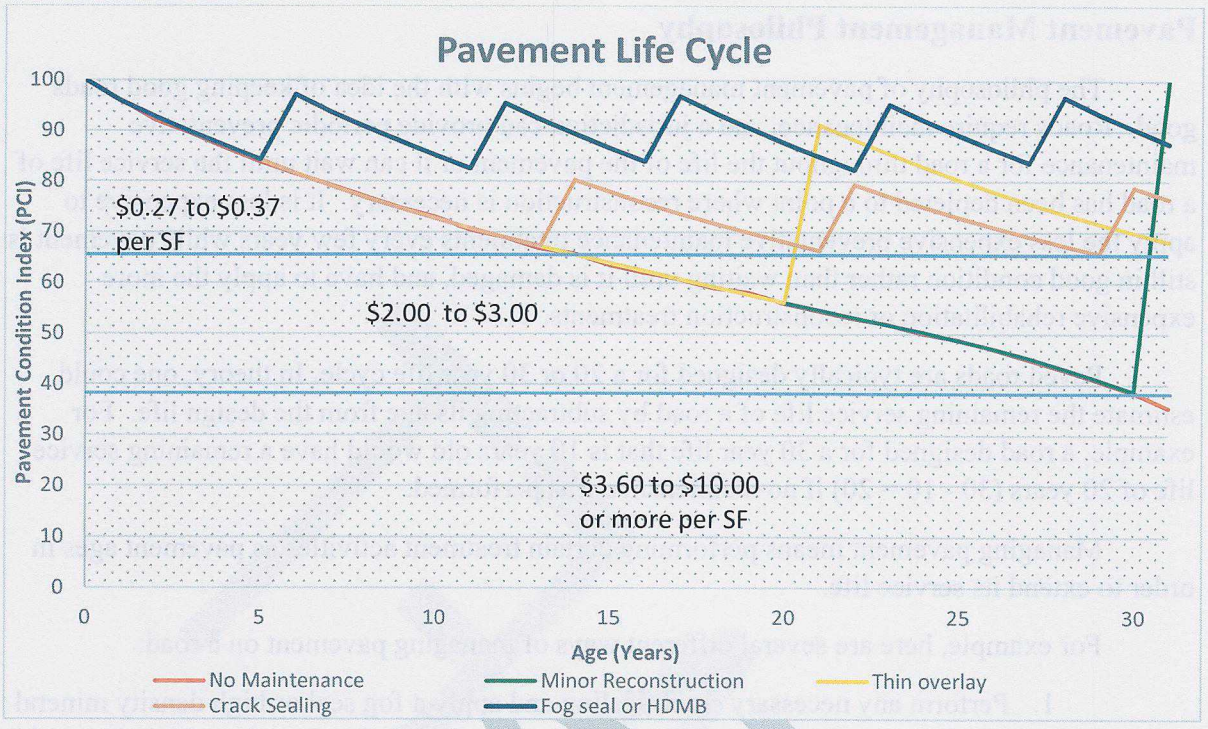


Figure 2. Preventative Maintenance Theory

Figure 2 illustrates the benefits of wise pavement management. Performing Preventative maintenance can restore serviceability and reduce the aging of a roadway. Performing preventative preservation on regular schedule will typically lower the long-term cost of repairing a road to an acceptable level of service rather than allowing the road to completely fail, requiring reconstruction. It is most cost effective to apply treatments as soon as they are needed. When the well-designed and well-built pavement is properly maintained the pavement surface remains in excellent condition for a long period of time.

Table 2. Benefits of Preventive Maintenance

Treatment Type	Number of Treatments	Cost of Each Treatment/SF	Total Cost/Mile Over 31 Years	Years Above a PCI of 70
Fog seal or HDMB*	5	$0.16	$147,840	31
Seal coat*	3	$0.26	$144,144	23
Thin overlay	1	$2.00	$369,600	20
Full reconstruction	1	$3.60	$665,280	12

*Note that these costs do not include the cost of crack sealing, since this is something that should be ongoing anyway

As is evident in Table 2, preventative maintenance is the least expensive category of treatments, and they result in the best road condition year after year. For instance, in this example repeated preventative maintenance would result in a total maintenance cost of about $350,000 over 44 years, and in all 44 of those years the road would have a PCI of 70 or greater (which corresponds to excellent or very good condition). Compare this to minor reconstruction, which would cost nearly 4 times as much, and the road would have been in such a good condition only about half of those years.

In these examples we are assuming that the road has a 35 foot wide surface, and is built on stable soil (roads that are not built on stable soil cannot be maintained over long periods of time with inexpensive treatments).

Roadway Valuation

Quantifying the value of the roadway network requires considering the condition of each road. As the pavement surface ages and the remaining service life decreases, the value of the roads will decrease. One can quantify the value of a road by beginning with the value of the road in its new condition and subtracting the loss of value that results when a road ages and deteriorates. This loss of value when a road ages is equivalent to the theoretical cost of restoring it to new condition. A road that requires full major reconstruction to restore its condition is considered to have lost all financial value, since the entire pavement section requires replacement, even though it is still usable. The cost of replacing the failed road with a newly constructed road represents the value of a new road.

Figure 3 illustrates this loss in roadway value over time. The roadway value plummets between 17 and 16 years of remaining service life. This is due to the increased cost of rehabilitation at 16 years of remaining service life, vs. the cost of preventative maintenance at 17 years of remaining service life. Other less significant jumps occur at critical junctures when one treatment is no longer effective and a more expensive one is necessary.

Figure 3. Roadway Value

The estimated value of Highland roads having a PCI greater than 55 is $33.6 million.

Appendix C shows samples costs from pavement management projects and bids. These samples, in addition to our experience and judgment form the basis for the opinions of costs in this report.

Analysis and Findings

We linked the location of the roads mapped in 2011 with the PCI and the letter grades using specialized Geographical Information Systems (GIS) software (ArcGIS and Spatial IM). We then estimated the 2014 PCIs and letter grades by adjusting them to account for the deterioration estimated to occur over three years. 2014 PCI groupings are shown in Figure 3.

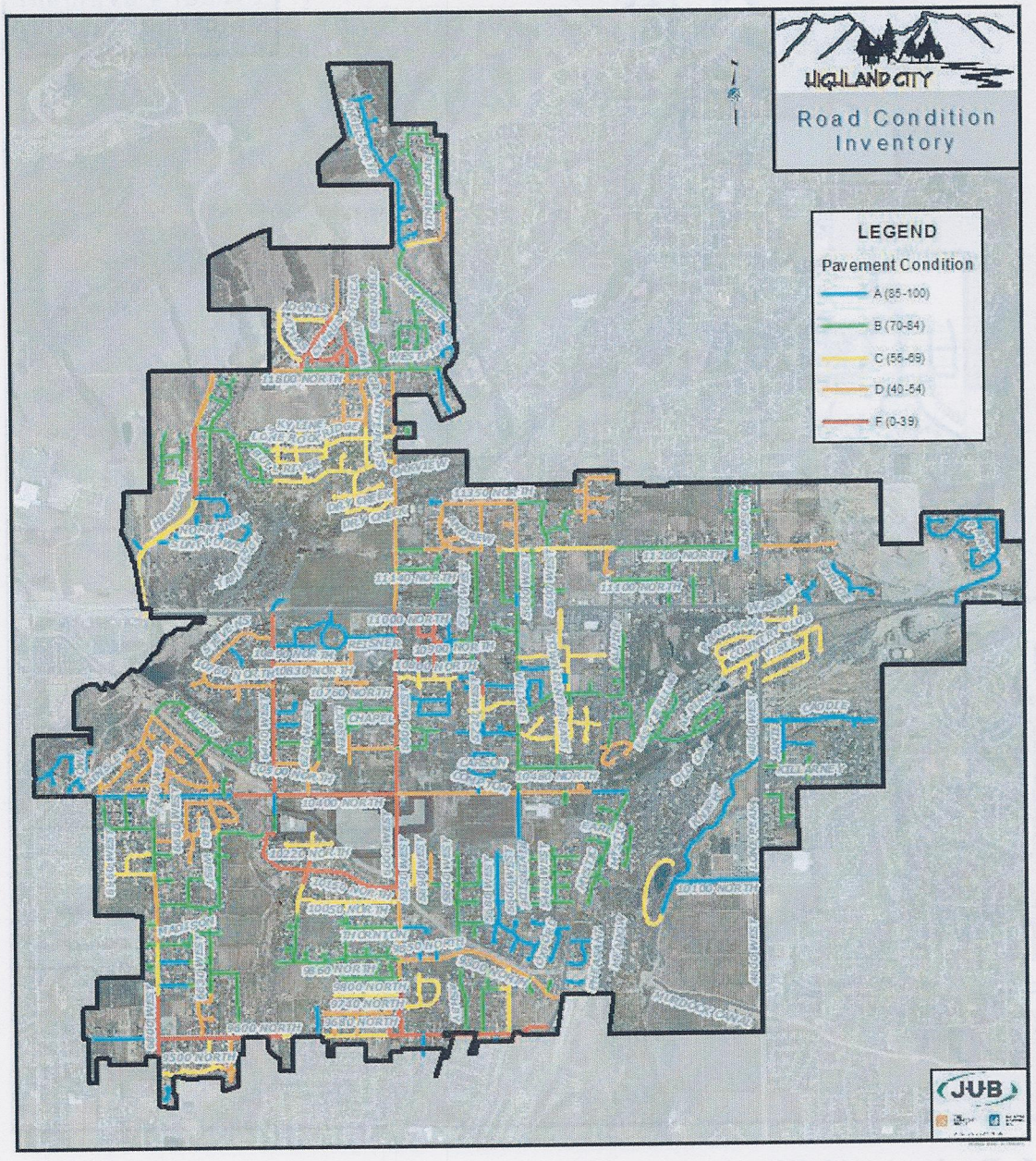


Figure 4. 2014 Inventory of Road Conditions Based on Letter A, B, C, D, F

This same information is presented differently in Figure 4, below. Note that our analysis only considers the roads shown in blue (those with a PCI over 55).

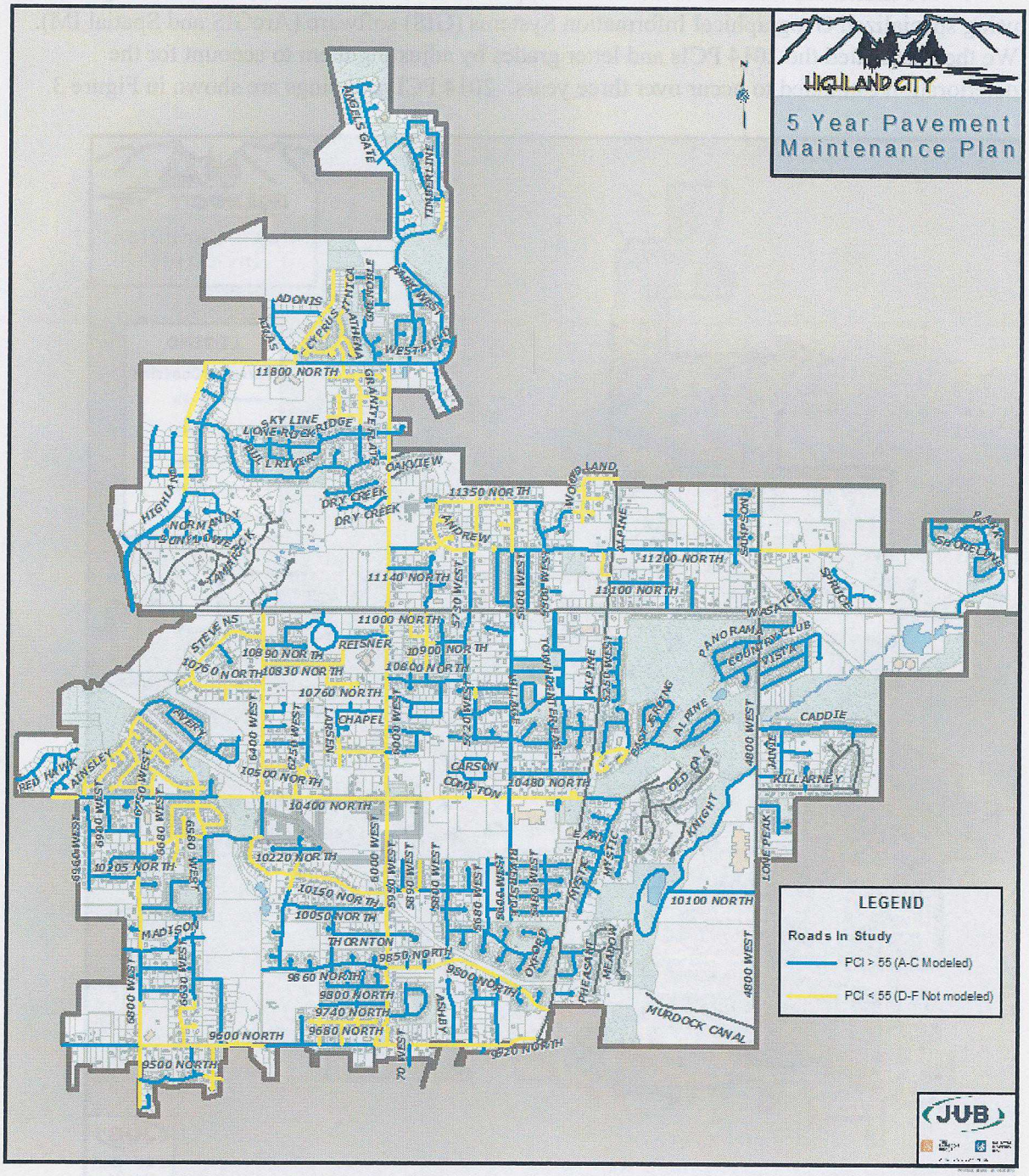


Figure 5. Roadways with PCI greater than 55

Figures 4 and 5 are a snapshot of the City's road network and the corresponding PCI rating of the roads. Mapping this information allows the information to be more visual and helps in understanding the status of specific roads throughout the City.

Figure 6 shows the distribution of Highland roads in each category.

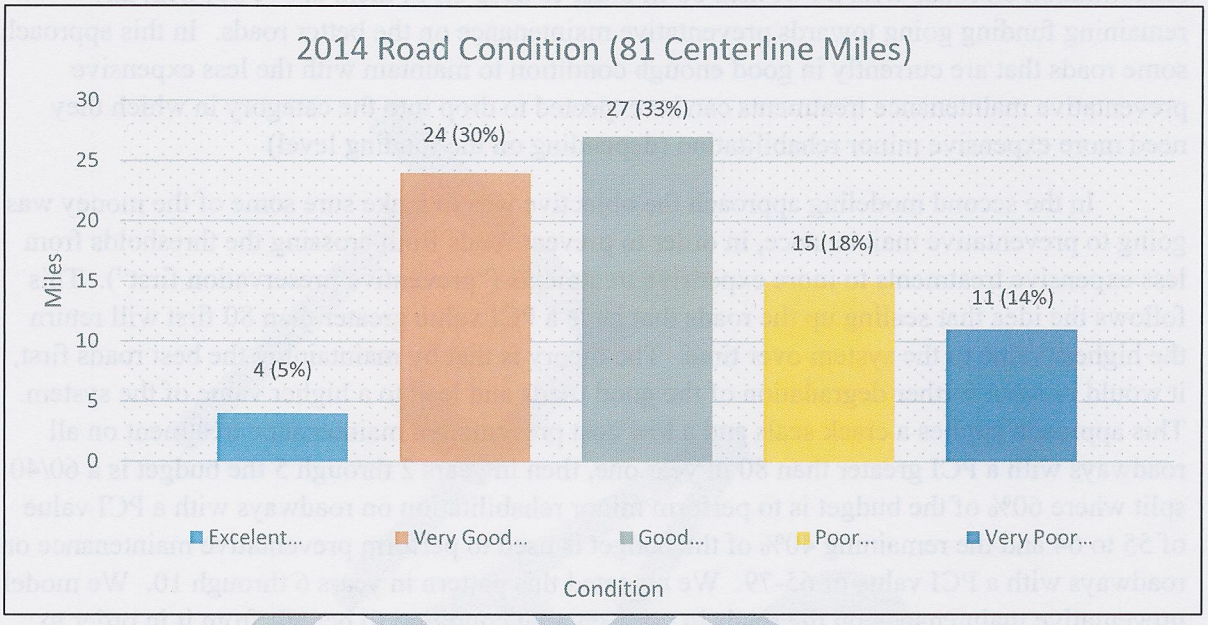


Figure 6. 2014 Current PCI Centerline Miles

Using background information (existing condition of the 81 miles of roadways and the budget provided by Highland City) and pavement maintenance strategy criteria we analyzed different improvement scenarios using Cartégraph. It is pavement management modeling software that can maximize the benefit of maintenance activities that can be performed over a sequence of years for a given budget based on criteria we provide. The results can then be displayed in GIS to map the recommended maintenance activities.

The goal was to identify which pavement preservation treatments should be done on which roads at what time in order to maximize the benefit of the money spent.

Once the PCI values of the City's road network were known, the next step in the process was determining the amount of funding that would need to be allocated to the roads to adequately maintain the system. To evaluate the minimum required budget to maintain this group of roads, maintenance budgets of $300,000, $500,000, $700,000, and $900,000 were modeled for a 10 year cycle. Based on a library of treatments and protocol specified in the model (which consists of the type of information contained in Table 1 and other criteria that provide constraints for the software), Cartégraph selects projects for funding in an effort to maximize the benefit of the funding.

We developed two approaches to evaluate the funding level that would return the best value for the City.

In the first approach the objective was to prevent roads from dropping from above the 55 PCI level to below the 55 PCI level ("keep roads above 55"). This requires performing minor rehabilitation on roads with a PCI near 55 in order to keep all of them above 55, with any remaining funding going towards preventative maintenance on the better roads. In this approach some roads that are currently in good enough condition to maintain with the less expensive preventative maintenance treatments can be expected to drop into the category in which they need more expensive minor rehabilitation (depending on the funding level)

In the second modeling approach the objective was to make sure some of the money was going to preventative maintenance, in order to prevent roads from crossing the thresholds from less expensive treatments to more expensive treatments ("preventive preservation first"). This follows the idea that sealing up the roads that have a PCI value greater than 80 first will return the highest value to the system over time. The theory is that by maintaining the best roads first, it would prevent further degradation of the good roads and lead to a higher value of the system. This approach applies a crack seals and a low cost preventative maintenance treatment on all roadways with a PCI greater than 80 in year one, then in years 2 through 5 the budget is a 60/40 split where 60% of the budget is to perform minor rehabilitation on roadways with a PCI value of 55 to 64 and the remaining 40% of the budget is used to perform preventative maintenance on roadways with a PCI value of 65-79. We repeated this pattern in years 6 through 10. We model preventative maintenance on the roads in good enough condition to benefit from it in order to keep them in excellent or very good condition, and we model minor rehabilitation on roads as funding allows, which improves them to the point that they can be maintained using the less expensive preventative maintenance measures. In this approach some of the roads with a PCI of near 55 can be expected to drop lower and require more expensive major rehabilitation or reconstruction (depending on the funding level).

These evaluations provide guidance on how much funding is needed and what effect the two approaches have on roadway conditions over 10 years.

Tables 3 and 4 show the results of the first approach ("keep roads above 55") and second approach ("preventative preservation first"), respectively, to the analysis we performed. They represent resulting data after 10 years of maintenance at the indicated budget amounts. The budgets and costs shown in Tables 3 and 4 are construction totals in present day dollars, and do not included funding for emergency maintenance or mobilization.

The initial PCI of the network of roads referenced in Tables 3 and 4 is 71.6, and it has a value of $33.6 million.

Table 3. Approach 1 ("keep roads above 55") After 10 Years

Annual Budget	Roadway Network after 10 Years		Total Cost Over 10 Years (millions)	Roadway Value Preserved Over 10 Years (millions)
	PCI	Value (millions)		
$0	55.3	$6.3	$0.0	$0.0
$300,000	62.1	$16.8	$3.0	$10.4
$500,000	65.3	$20.8	$5.0	$14.4
$700,000	67.1	$29.9	$7.0	$23.5
$900,000	68.7	$30.7	$9.0	$24.4

PCI 71.6
current

Table 4. Approach 2 ("pavement preservation first") After 10 Years

Annual Budget	Roadway Network after 10 Years		Total Cost Over 10 Years (millions)	Roadway Value Preserved Over 10 Years (millions)
	PCI	Value (millions)		
$0	55.3	$6.3	$0.0	$0.0
$300,000	61.3	$16.7	$0.0	$0.0
$500,000	65.4	$22.5	$0.0	$5.7
$700,000	69.1	$31.0	$0.0	$14.3
$900,000	72.3	$31.2	$0.0	$14.5

$500k
keep

Note the following points from Tables 3 and 4:

- Highland roadways with a PCI value over 55 would lose over 80% of their value after just 10 years if there were no maintenance (other than routine maintenance) performed on them. We estimate that the average PCI would be 55.3 and that the value would be $6.3 million.
- The two approaches seem to provide similar results, particularly at the lower funding levels. However, at the higher funding levels Approach 2 yields significantly better average PCI values. In the interest of simplicity we have calculated roadway values based on average PCI values. We suspect that if we were to calculate individual roadway values and add them up the difference in roadway values between Approach 2 and Approach 1 would be more pronounced.
- The PCI in Approach 2 is higher than the existing PCI at the $900,000 funding level, while the PCI in Approach 1 at the $900,000 funding level is less than the existing PCI. This means that at that level of funding employing Approach 2 would result in

an improving road network, while employing Approach 1 would result in roads that are deteriorating faster than they are being maintained.

- Funding in the neighborhood of $900,000 per year and wise use of the money is needed to reverse the trend of roadway deterioration in Highland.

In order to better project the actual cost and budget, we used an inflation rate of 5% (based on an average of UDOT"s recommended inflation projections over the next 5 years) in both the construction costs as well as the amount of budget allocated each year. Since the cost of construction continues to increase, indexing the funding amount to construction costs will preserve the buying power of the pavement management funds.

While based on observed data, this analysis is still somewhat idealistic. In reality, true roadway performance will differ from that in the analysis for the following reasons:

1. The deterioration rate of roadways is based on industry data, not a historical record of pavement condition for Highland.
2. It uses the same deterioration curve for all roads. In practice some roads deteriorate faster than others.
3. We didn't evaluate the adequacy of soil conditions under existing roads, since that was beyond the scope of this analysis. This analysis depends upon road design having accounted for existing underlying soil conditions. However, some older roads were probably never designed, but just evolved over the years as roads were graveled, then chip sealed, then paved. Also, soil conditions are variable and some roads, or sections of roads, may be built on soil that does not adequately support the roads.
4. It depends upon roads having been built as they were designed. Sometimes roads do not get built as they were designed, either because of inadequate compaction of roadbase or asphalt, placement of thinner layers of roadbase or asphalt, failure to compact well around manholes, placement of asphalt in poor weather, inadequate seam adhesion and compaction, etc.
5. Water contributes to roadway deterioration, and does so significantly when a road deteriorates and water gets under the road due to cracks in the asphalt. However, the analysis assumes that there are no other sources of water that will compromise the roadway. In reality water damage tends to affect some road in other ways, such as from leaking water lines, low points in roadways, inadequate drainage along roadway shoulders, etc. These accelerate roadway deterioration.
6. Nearly all roadways have buried utilities under the asphalt. When the backfill material in utility trenches is inadequately compacted, the utility trench settles, causing the asphalt surface to settle and crack. While existing settling would have been observed and accounted for in the PCI calculation in 2011, settling is something that can occur over time, so new areas of settling can show up at any time. Such settling results in premature failure of roadways.

7. Utility trenches in existing roadways lead to premature failure of roadways. This occurs for several reasons: cuts in the asphalt result, which provide a path for water to get under the asphalt; soil on each side of the trench is susceptible to settling due to the loss of lateral support when the soil in the trench is excavated; the potential exists for pavement failures related to inadequate compaction of trench backfill, roadbase and asphalt.
8. On the positive side, advances in pavement formulations and pavement management technology is accelerating, resulting in better asphalt and ways of maintaining it.

As a result of the many things that can go wrong with pavement, there will inevitably be some accelerated deterioration and premature failures of roadways that will require work not anticipated in the Cartégraph model.

While some of the sources of failure are beyond our control, there are several things Highland City can do to minimize many of the risks. This includes assuring that the pavement section on new roads is properly designed and based on reliable information about underlying soil conditions. It includes conducting thorough inspection and material and compaction testing of construction in roadways – during utility construction and during roadway construction.

Conclusion and Recommendations

We make the following recommendations:

1. Implement a 5 year maintenance program using the treatments shown on the roads in Figures 7 – 11 on the following pages as a guide. These reflect the results of the modeling under Approach 2 ("preventative maintenance first") at a funding level of $400,000 to be spend on preservation and rehabilitation treatments (in addition to money being spent on routine maintenance). In order to preserve the objectively and in the interest of efficiency, we have preserved the model's recommendations of roadway improvements by year, rather than grouping them in logical projects. Highland City Public Works Staff will need to exercise judgment as to the grouping and timing of the maintenance activities, and should coordinate utility replacement work with pavement maintenance activities. A listing of the roadways, required treatments and our opinion of the likely treatment cost is found in Appendix D. Note that these are in 2014 dollars.
2. Establish a policy similar to Approach 2, which would make sure that preventative maintenance is completed so that no roads move from being candidates for preventative maintenance (less expensive) to rehabilitation (more expensive).
3. Fund routine maintenance activities such crack sealing and filling potholes.
4. As soon as possible increase funding for preservation and rehabilitation treatments from $400,000 to at least around $900,000. The system will continue to deteriorate faster than it can be maintained until funding levels are in the $850,000 to $900,000 range.
5. Index funding levels to be automatically adjusted for inflation.
6. Take care in requiring and reviewing pavement designs for new roads, and take great care in performing thorough inspections of utility and roadway construction, particularly related to compact testing.
7. Perform an evaluation of what it will cost to rehabilitate and reconstruct the "poor" and "very poor" roads (those with a PCI of less than 55), then fund major rehabilitation and reconstruction projects to restore them.
8. Perform yearly updates to the model to assure that the newly constructed and reconstructed roadways are added to the model and receive the proper maintenance activities.
9. Re-inventory roadways at least every 5 years, incorporate better ways of managing pavement as they are developed, and update construction costs and funding levels. Use the condition history that accumulates to refine the model to more accurately predict deterioration.
10. Consider creation of an Accessibility Transition Plan to estimate the cost of bring pedestrian ways into compliance with ADA requirements, and provide funding to begin eliminating barriers to access, including those required in conjunction with pavement management projects.

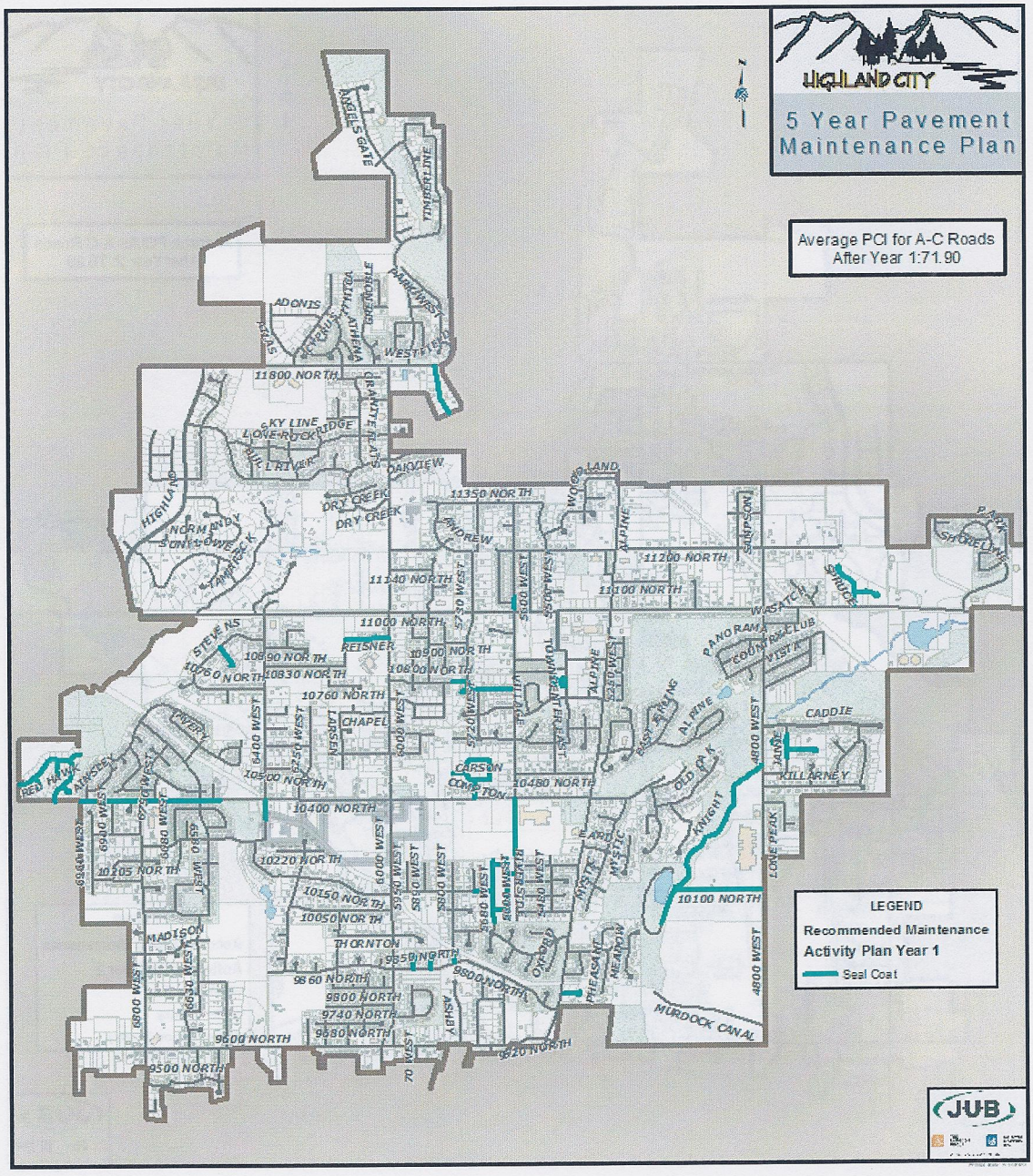


Figure 7. Year 1 Recommended Treatments

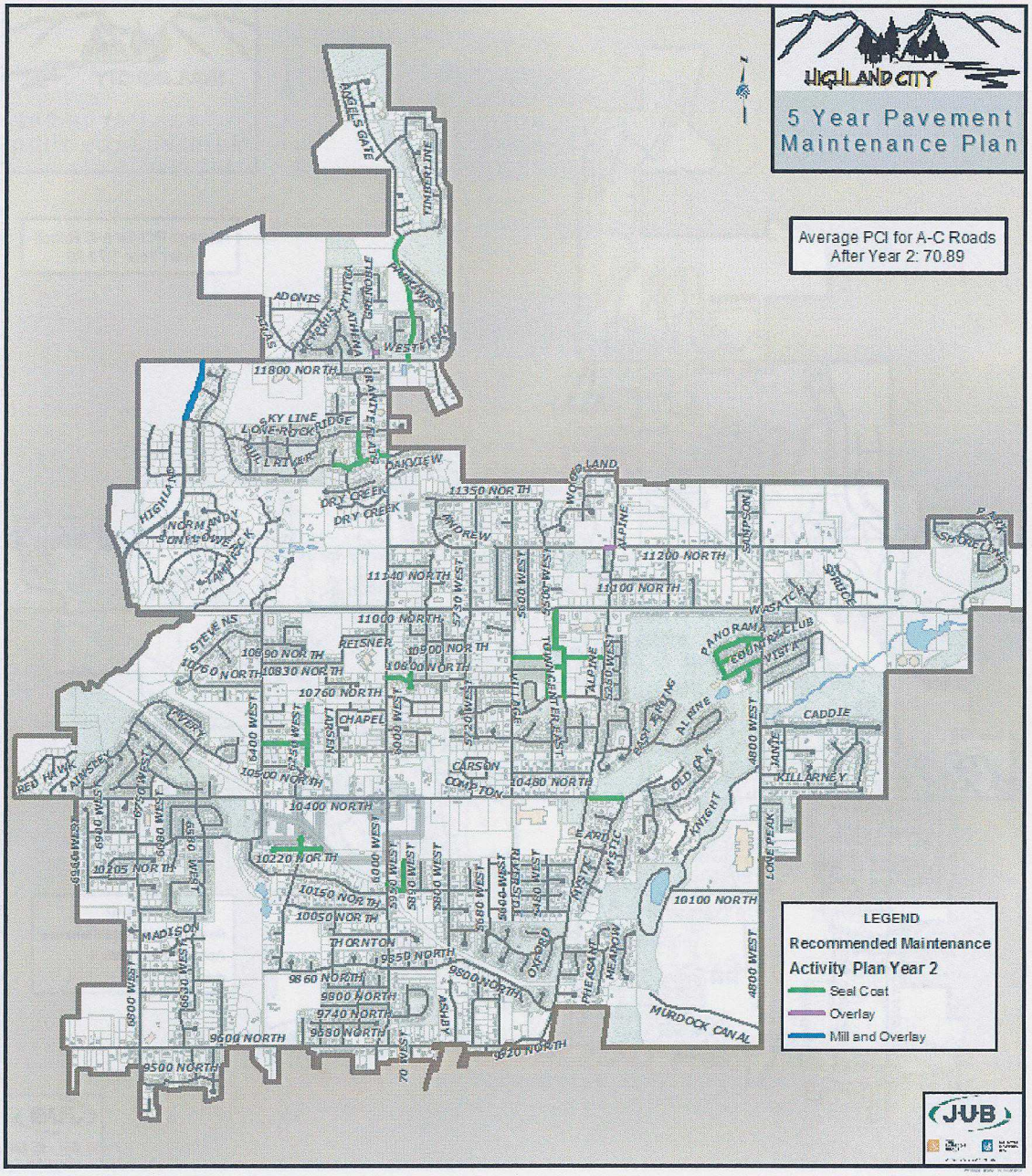


Figure 8. Year 2 Recommended Treatments

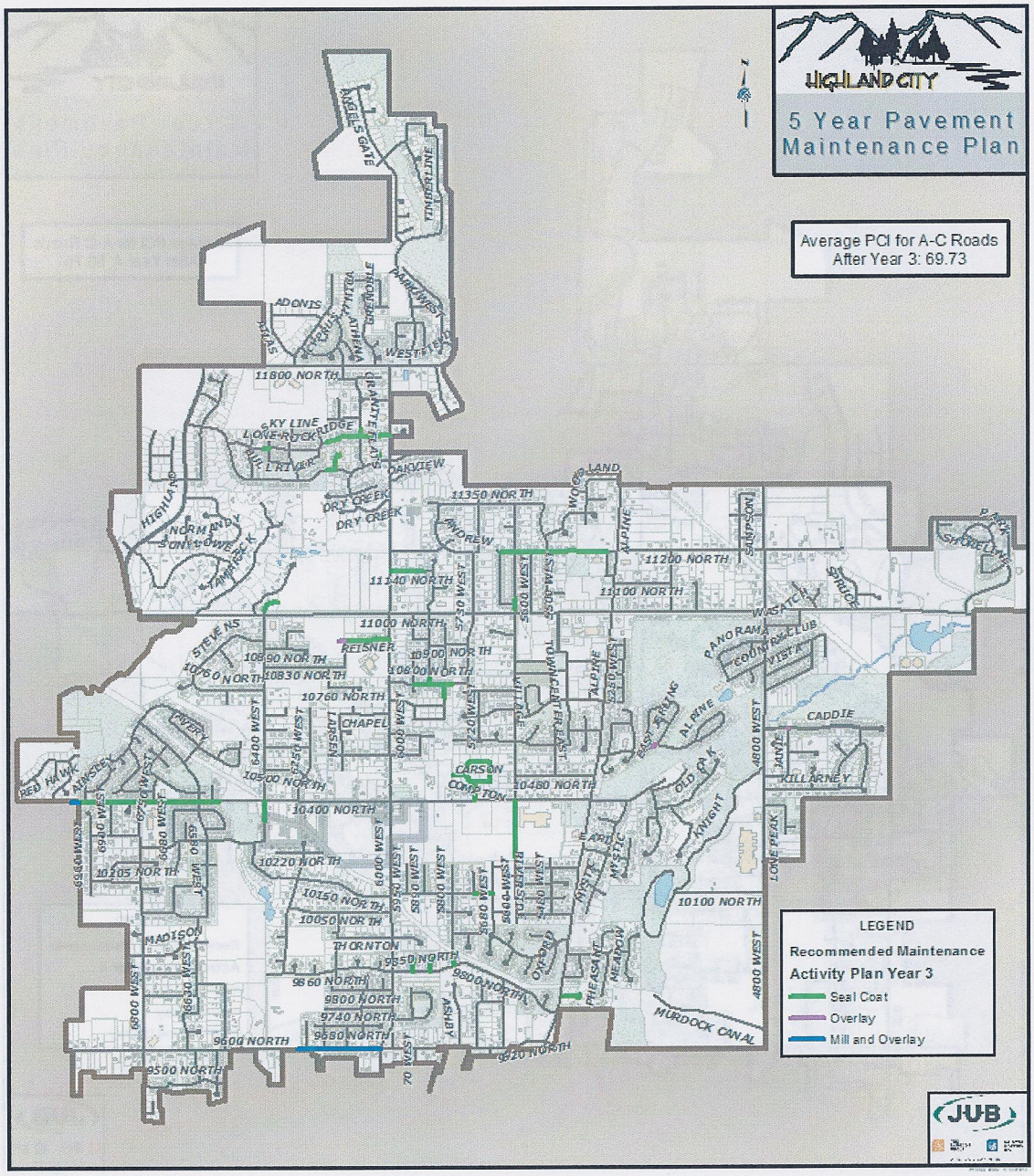


Figure 9. Year 3 Recommended Treatments

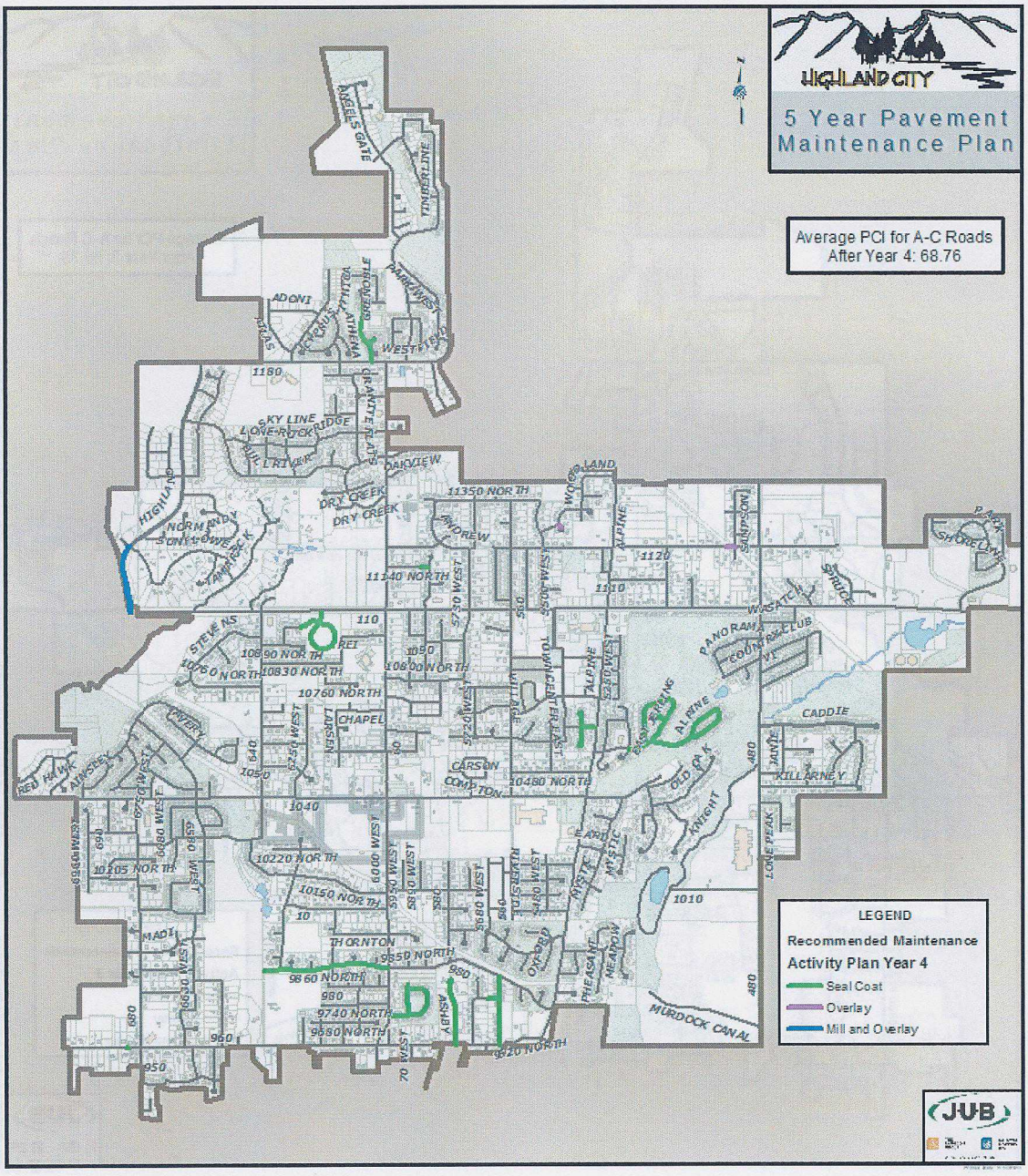


Figure 10. Year 4 Recommended Treatments

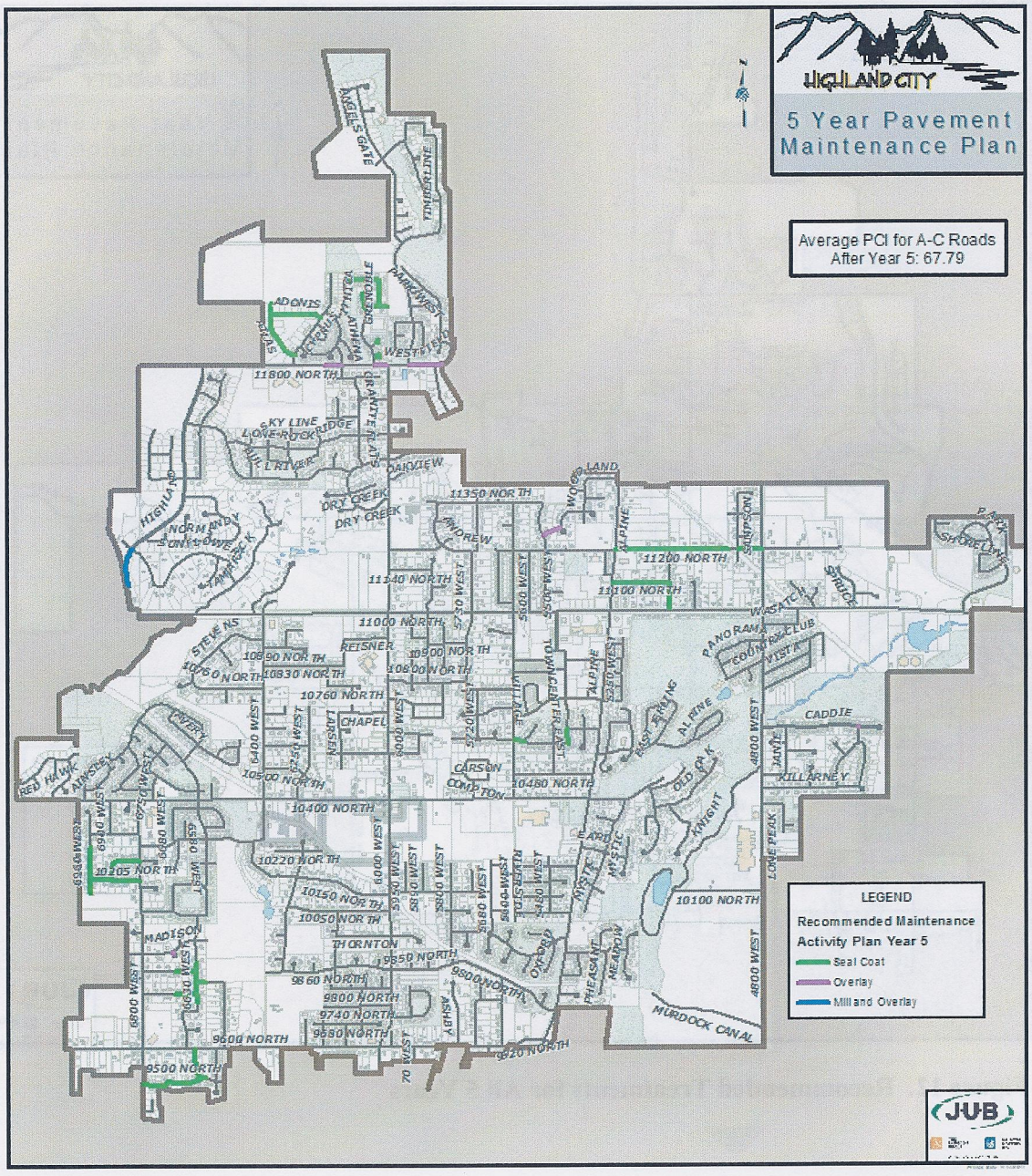


Figure 11. Year 5 Recommended Treatments

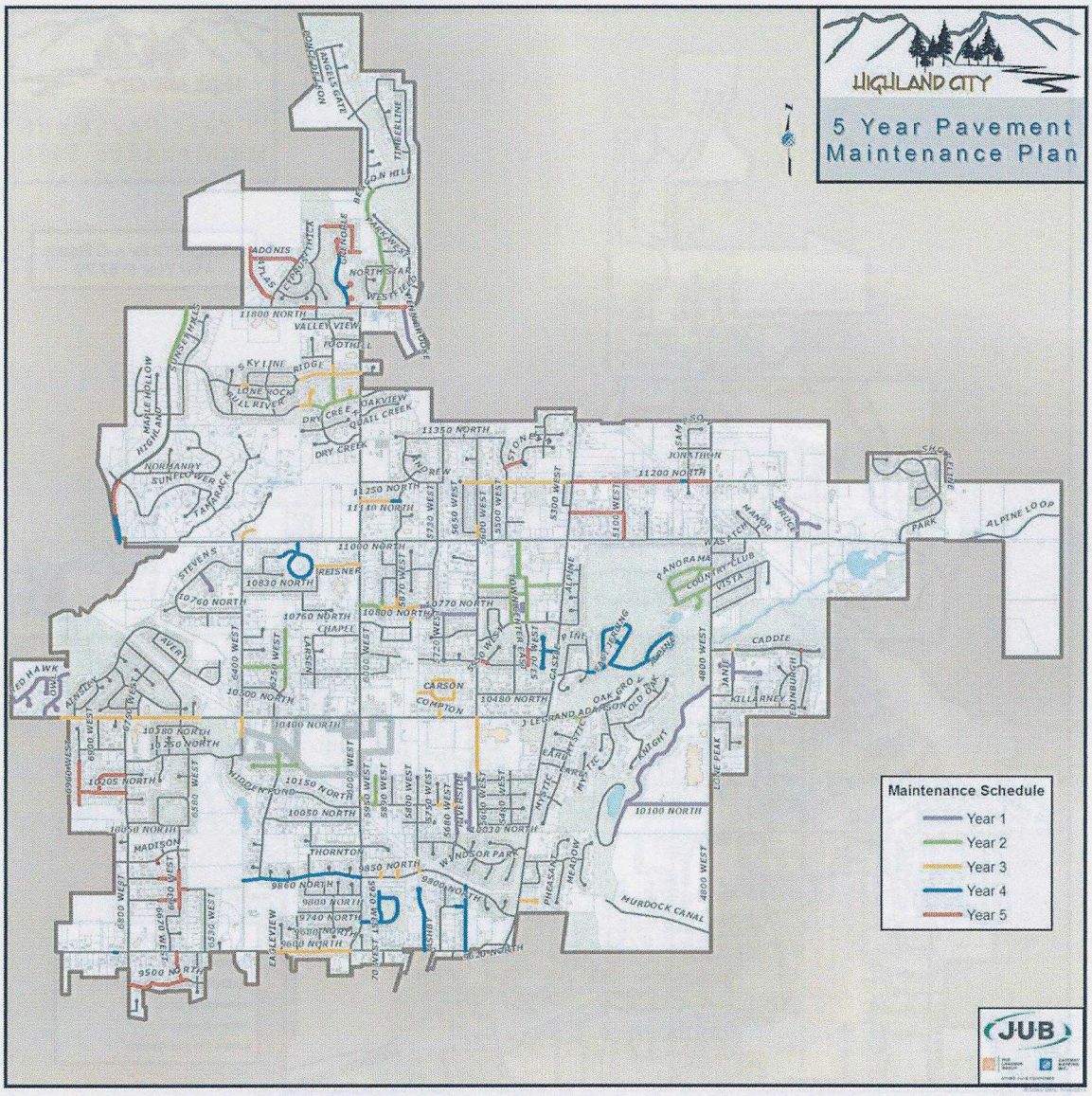


Figure 12. Recommended Treatments for All 5 Years

Tables D-1 through D-5 in Appendix D show the 5 year plan for roadway treatments. Note that the Highland City Public Works Department will need to exercise judgment in the actual grouping and timing of roadway treatments to package projects, coordinate with utility work, match cost of treatments performed to available funding, etc.

Appendix A. Roadways with known PCI Values

The photographs in Figures A-1 through A-5 show examples of roads in Highland at each of the 5 categories of pavement condition.

Figure A - 1. PCI = 96 (A - Excellent Condition)

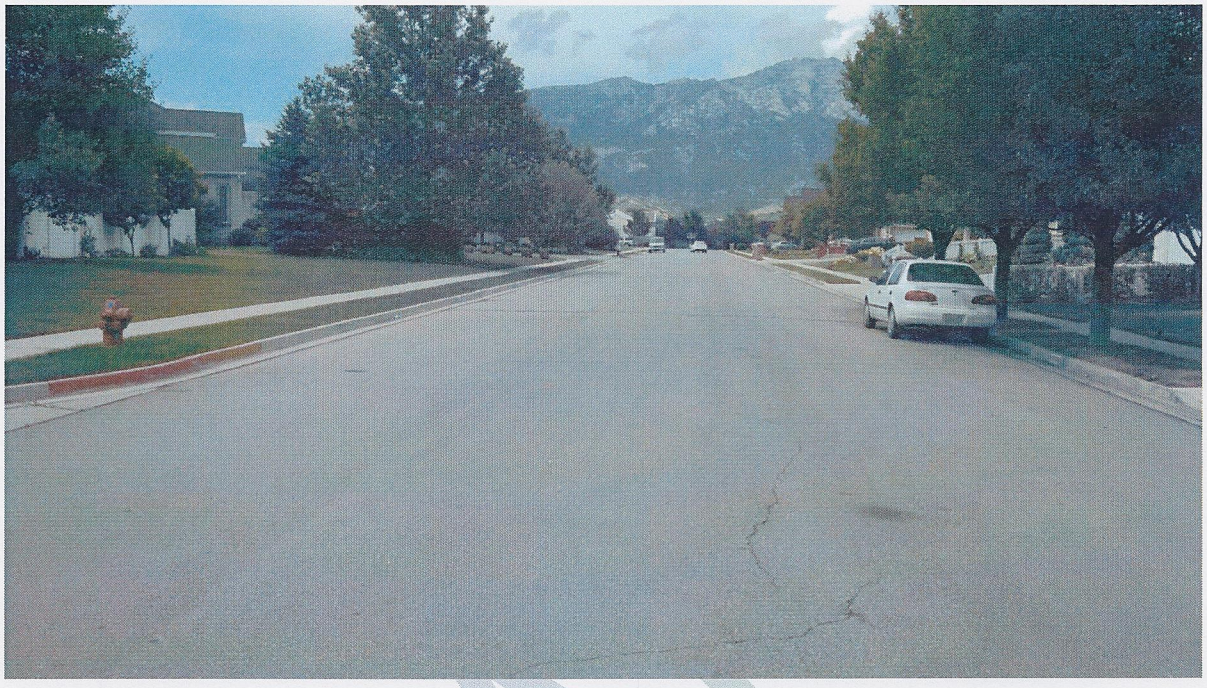


Figure A - 2. PCI = 74 (B - Very Good Condition)

Figure A - 3. PCI= 59 (C - Good Condition)

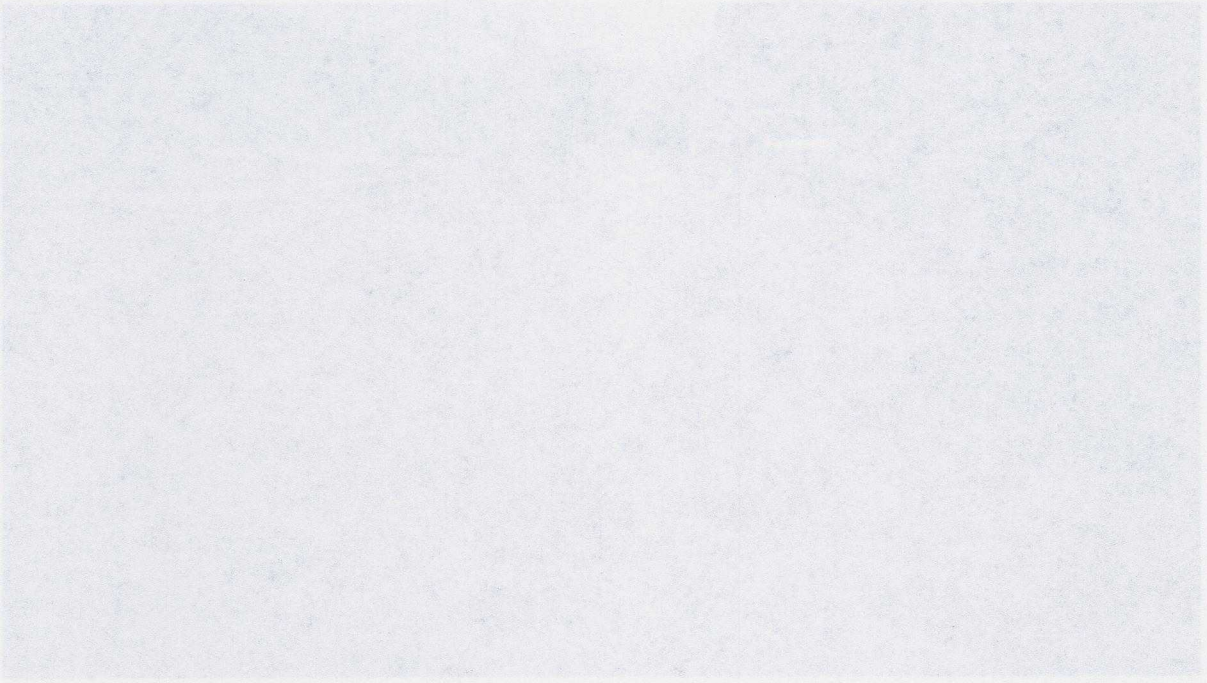
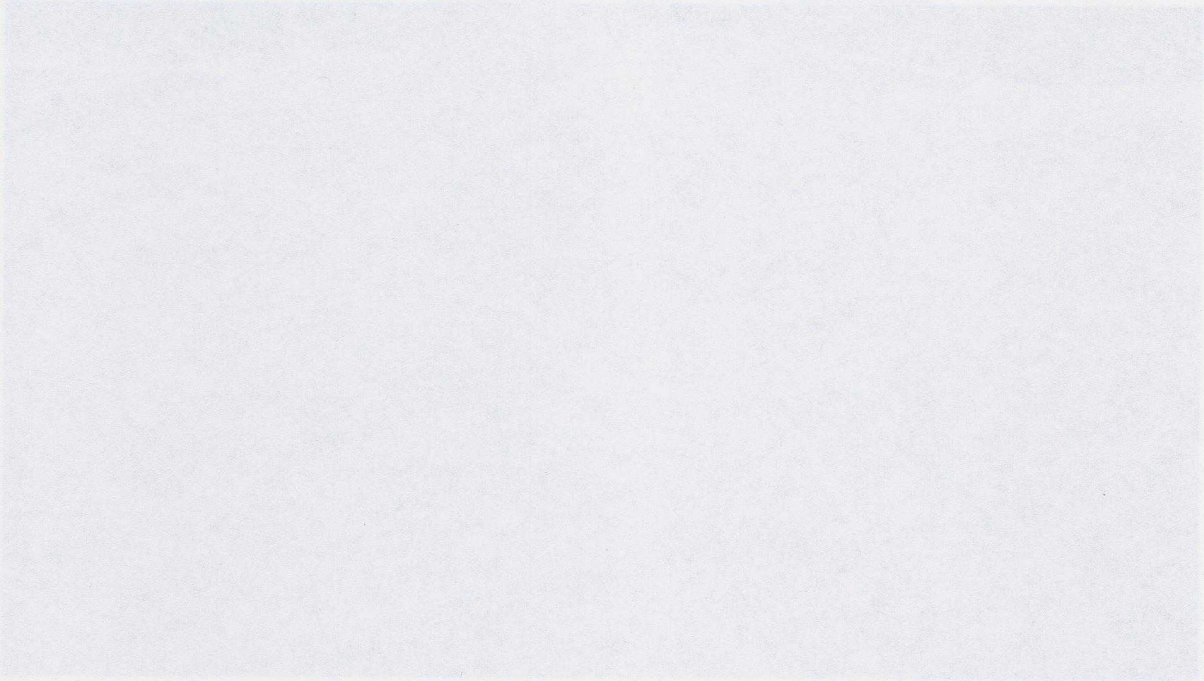


Figure A - 4. PCI = 44 (D - Poor Condition)

Figure A - 5. PCI = 27 (F - Very Poor Condition)



Appendix B. Treatment Cost Samples

Table B - 1. Treatment Cost Samples

City	Treatment	Year of Construction	Project Cost Range		2014 Cost Projection	
			Low	High	Low	High
Lindon	Crack Seal	2014	$ 0.37	$ 0.37	$ 0.37	$ 0.37
Pleasant Grove	HA5	2013	$ 0.17	$ 0.17	$ 0.18	$ 0.18
Lindon	HA5	2014	$ 0.17	$ 0.17	$ 0.17	$ 0.17
Pleasant Grove	Overlay	2009	$ 1.26	$ 1.43	$ 1.46	$ 1.66
Lindon	Overlay	2014	$ 1.56	$ 2.02	$ 1.56	$ 2.02
Lindon	Overlay	2010	$ 1.61	$ 2.04	$ 1.81	$ 2.30
Lindon	Patching	2014	$ 3.00	$ 3.00	$ 3.00	$ 3.00
Lindon	Reconstruct	2014	$ 1.56	$ 1.79	$ 1.56	$ 1.79
Lindon	Reconstruct	2014	$ 2.54	$ 2.74	$ 2.54	$ 2.74
Lindon	Reconstruct	2011	$ 2.95	$ 4.34	$ 3.22	$ 4.74
Lindon	Reconstruct	2007	$ 3.24	$ 3.87	$ 3.98	$ 4.76
Pleasant Grove	Seal Coat	2013	$ 0.16	$ 1.43	$ 0.16	$ 1.47
American Fork	Seal Coat	2014	$ 0.25	$ 0.25	$ 0.25	$ 0.25
Lindon	Seal Coat	2014	$ 0.25	$ 0.25	$ 0.25	$ 0.25

Appendix C. Roadway Valuation Example

If the cost of major reconstruction of a mile of roadway is $646,800, then the value of the segment in new condition is $646,800. If the segment has deteriorated to the point of having a PCI of 58, the theoretical cost of bringing it back to new condition (or having a PCI of 100), would be the cost of minor rehabilitation such as a thin overlay ($369,600), which would bring the PCI up to 75.4, plus the cost of a seal coat ($48,048), which would bring the PCI up to 89, plus the cost of a HDMB ($29,568), which would bring the PCI up to 98, plus a few thousand dollars ($2,000) to account for the routine maintenance that might be needed on a nearly new road. One would never actually perform all of these pavement management treatments one after another in succession; considering the cost of each is simply a technique used to evaluate the value of the pavement deterioration. The resulting value of the mile of road having a PCI of 58 is therefore $197,584 (= $646,800 - $369,600 - $48,048 - $29,568 - $2000). Using this method, we have determined the value of pavement with any given PCI value.

Appendix D. Listing of Projects in the 5 Year Plan

The listing of projects on the following pages should be considered to be a guide. In order to preserve the objectively and in the interest of efficiency, we have preserved the model's recommendations of roadway improvements by year, rather than grouping them in logical projects. Highland City Public Works Staff will need to exercise judgment as to the grouping and timing of the maintenance activities, and should coordinate utility replacement work with pavement maintenance activities. Note that these are in 2014 dollars.

The recommended treatments are in categories of treatments, not specific treatments. Public Work Staff should choose the specific treatment within the category that they feel would be most suitable for each given road.

Table D-1. Year 1 Projects (2015)

Street Name	Street Section		Recommended Treatment	Estimated Treatment Cost
10770 North	5760	5779	Crack Seal and Seal Coat	$2,000
Iverson	7030	7049	Crack Seal and Seal Coat	$1,800
East Crimson	9900	9904	Crack Seal and Seal Coat	$2,000
Sego Lily	4750	4774	Crack Seal and Seal Coat	$2,000
Pebble	5410	5449	Crack Seal and Seal Coat	$4,500
Riverside	10010	10029	Crack Seal and Seal Coat	$1,400
Peyton	10500	10524	Crack Seal and Seal Coat	$3,500
Spruce	11000	11049	Crack Seal and Seal Coat	$4,200
10400 North	6830	6899	Crack Seal and Seal Coat	$6,600
10770 North	5600	5719	Crack Seal and Seal Coat	$9,500
5800 West	9850	9899	Crack Seal and Seal Coat	$3,000
Owl	10500	10529	Crack Seal and Seal Coat	$3,700
Riverside	10190	10199	Crack Seal and Seal Coat	$1,500
Spruce	4420	4499	Crack Seal and Seal Coat	$5,800
Spruce	11100	11149	Crack Seal and Seal Coat	$2,000
10400 North	6750	6799	Crack Seal and Seal Coat	$5,100
West Crimson	9875	9904	Crack Seal and Seal Coat	$2,000
Natalie	10850	10899	Crack Seal and Seal Coat	$7,500
Pebble	5390	5409	Crack Seal and Seal Coat	$2,000
Riverside	10030	10149	Crack Seal and Seal Coat	$8,500
5750 West	10760	10799	Crack Seal and Seal Coat	$2,100
Owl	10475	10499	Crack Seal and Seal Coat	$2,000

Iverson	10400	10449	Crack Seal and Seal Coat	$5,200
Red Hawk	7150	7199	Crack Seal and Seal Coat	$4,900
Natalie	5600	5619	Crack Seal and Seal Coat	$2,100
Kaden	5620	5679	Crack Seal and Seal Coat	$3,300
5680 West	9970	10029	Crack Seal and Seal Coat	$3,000
10400 North	6570	6579	Crack Seal and Seal Coat	$7,300
10400 North	6900	6959	Crack Seal and Seal Coat	$8,500
Iverson	7025	7029	Crack Seal and Seal Coat	$2,000
10800 North	5750	5799	Crack Seal and Seal Coat	$4,200
Compton	5730	5749	Crack Seal and Seal Coat	$3,100
Haymaker	10460	10499	Crack Seal and Seal Coat	$5,200
Wood Duck	7000	7029	Crack Seal and Seal Coat	$3,200
Spruce	11050	11099	Crack Seal and Seal Coat	$8,300
Penn Brooke	11600	11799	Crack Seal and Seal Coat	$14,300
10100 North	5680	5749	Crack Seal and Seal Coat	$4,500
Maddie	5750	5799	Crack Seal and Seal Coat	$3,900
Spruce	4400	4419	Crack Seal and Seal Coat	$2,000
Quail	10435	10449	Crack Seal and Seal Coat	$2,000
Yorkshire	10190	10209	Crack Seal and Seal Coat	$1,200
5680 West	10030	10099	Crack Seal and Seal Coat	$4,400
Knight	10100	10499	Crack Seal and Seal Coat	$46,000
Red Hawk	7070	7149	Crack Seal and Seal Coat	$8,300
Red Hawk	7030	7069	Crack Seal and Seal Coat	$3,200
Iverson	10450	10549	Crack Seal and Seal Coat	$7,900
Compton	5675	5729	Crack Seal and Seal Coat	$4,100
10400 North	6800	6829	Crack Seal and Seal Coat	$3,300
5680 West	10100	10189	Crack Seal and Seal Coat	$6,300
10770 North	5720	5749	Crack Seal and Seal Coat	$2,900
West Crimson	9870	9874	Crack Seal and Seal Coat	$2,700
10770 North	5750	5759	Crack Seal and Seal Coat	$1,300
Brookridge	4615	4649	Crack Seal and Seal Coat	$2,000
Brookridge	4650	4689	Crack Seal and Seal Coat	$7,300
Sego Lily	4735	4749	Crack Seal and Seal Coat	$3,000
Quail	10450	10499	Crack Seal and Seal Coat	$2,800
10100 North	4800	4999	Crack Seal and Seal Coat	$24,300
Walker	10400	10499	Crack Seal and Seal Coat	$5,100
Braden	5620	5679	Crack Seal and Seal Coat	$3,300
Janie	10550	10569	Crack Seal and Seal Coat	$2,000
5600 West	10180	10185	Crack Seal and Seal Coat	$9,900

East Crimson	9870	9899	Crack Seal and Seal Coat	$2,800
Riverside	10150	10189	Crack Seal and Seal Coat	$2,200
Riverside	10000	10009	Crack Seal and Seal Coat	$1,700
Reisner	6000	6149	Crack Seal and Seal Coat	$12,000
Carson	5670	5769	Crack Seal and Seal Coat	$5,600
10400 North	6960	6999	Crack Seal and Seal Coat	$2,400
10400 North	6580	6749	Crack Seal and Seal Coat	$11,200
10400 North	6580	6749	Crack Seal and Seal Coat	$4,300
Janie	10470	10549	Crack Seal and Seal Coat	$2,400
Janie	10570	10599	Crack Seal and Seal Coat	$2,100
Parking Lot			Crack Seal and Seal Coat	$6,100
Parking Lot			Crack Seal and Seal Coat	$6,300
6400 West	10350	10399	Crack Seal and Seal Coat	$5,600
5600 West	11030	11199	Crack Seal and Seal Coat	$4,300
5600 West	10180	10185	Crack Seal and Seal Coat	$6,500
Knight			Crack Seal and Seal Coat	$6,900
			Total	**$403,400.00**

Table D-2. Year 2 Projects (2016)

Street Name			Recommended Treatment	Estimated Treatment Cost
11830 North	6035	6039	Overlay	$4,200
11200 North	5275	5299	Overlay	$11,400
Highland Blvd		11798	Mill and OverLay	$56,600
Highland Blvd		11799	Mill and OverLay	$56,600
Highland Blvd		11798	Mill and OverLay	$19,100
Highland Blvd		11798	Mill and OverLay	$40,500
Highland Blvd		11799	Mill and OverLay	$41,900
West Panorama	10800	10874	Crack Seal and Seal Coat	$2,800
6250 West	10500	10569	Crack Seal and Seal Coat	$3,900
Town Center East	10700	10819	Crack Seal and Seal Coat	$5,300
Mountain View	10240	10274	Crack Seal and Seal Coat	$1,400
10220 North	6300	6359	Crack Seal and Seal Coat	$4,800
Bull River	6130	6179	Crack Seal and Seal Coat	$3,000
Beacon Hill	11990	12059	Crack Seal and Seal Coat	$2,400
5920 West	10760	10769	Crack Seal and Seal Coat	$1,400
5920 West	10770	10799	Crack Seal and Seal Coat	$900
Panorama	4830	4949	Crack Seal and Seal Coat	$7,100
6250 West	10570	10679	Crack Seal and Seal Coat	$7,600
10570 North	6250	6399	Crack Seal and Seal Coat	$8,600
10100 North	5950	5999	Crack Seal and Seal Coat	$3,000
Highland	10850	10919	Crack Seal and Seal Coat	$2,700
Town Center West	10810	10819	Crack Seal and Seal Coat	$700
Granite Flats	11500	11599	Crack Seal and Seal Coat	$5,700
Country Club			Crack Seal and Seal Coat	$500
Town Center		10998	Crack Seal and Seal Coat	$3,800
Bull River	6000	6029	Crack Seal and Seal Coat	$2,000
Bull River	6090	6129	Crack Seal and Seal Coat	$2,700
West Panorama	10875	10909	Crack Seal and Seal Coat	$1,900
Parkway West	5490	5599	Crack Seal and Seal Coat	$6,600
Town Center East	10820	10849	Crack Seal and Seal Coat	$1,700
Country Club	4850	4914	Crack Seal and Seal Coat	$4,300
10800 North	5920	5999	Crack Seal and Seal Coat	$4,600
Beacon Hill	11950	11989	Crack Seal and Seal Coat	$3,000
10220 North	6240	6299	Crack Seal and Seal Coat	$3,300

Parkway East	5250	5399	Crack Seal and Seal Coat	$7,400
Panorama	4800	4829	Crack Seal and Seal Coat	$2,400
5950 West	10100	10199	Crack Seal and Seal Coat	$5,800
Town Center		10999	Crack Seal and Seal Coat	$3,800
Bull River	11500	11519	Crack Seal and Seal Coat	$1,100
Mountain View	10230	10239	Crack Seal and Seal Coat	$1,900
10220 North	6215	6239	Crack Seal and Seal Coat	$1,400
Highland Circle	10805	10849	Crack Seal and Seal Coat	$1,400
Town Center West	10700	10809	Crack Seal and Seal Coat	$5,100
Town Center Park West	10850	10899	Crack Seal and Seal Coat	$3,200
J Legrand Adamson	5250	5299	Crack Seal and Seal Coat	$6,300
Beacon Hill	12060	12219	Crack Seal and Seal Coat	$10,600
Bull River	6030	6089	Crack Seal and Seal Coat	$3,100
10220 North	6360	6369	Crack Seal and Seal Coat	$1,400
Civic Center	5400	5499	Crack Seal and Seal Coat	$3,100
Country Club	4800	4849	Crack Seal and Seal Coat	$3,300
Mountain View	4830	4924	Crack Seal and Seal Coat	$7,700
Town Center West	10820	10849	Crack Seal and Seal Coat	$1,600
Town Center East	10850	10899	Crack Seal and Seal Coat	$3,300
Beacon Hill	11850	11949	Crack Seal and Seal Coat	$5,700
Beacon Hill	11800	11849	Crack Seal and Seal Coat	$2,700
5920 West	10800	10899	Crack Seal and Seal Coat	$1,600
Mountain View	10150	10219	Crack Seal and Seal Coat	$1,900
			Total	**$411,800.00**

Table D-3. Year 3 Projects (2017)

Street Name			Recommended Treatment	Estimated Treatment Cost
4730 West			Overlay	$1,000
Country Club	5110	5129	Overlay	$8,500
Cemetery			Overlay	$4,800
9600 North	6040	6149	Mill and Overlay	$70,800
9600 North	6150	6219	Mill and Overlay	$50,500
9600 North	6220	6249	Mill and Overlay	$41,000
9600 North	6250	6299	Mill and Overlay	$22,000
10400 North	7000	7049	Mill and Overlay	$20,300
10400 North	6830	6899	Crack Seal and Seal Coat	$4,700
10400 North	6750	6799	Crack Seal and Seal Coat	$3,600
10400 North	6570	6579	Crack Seal and Seal Coat	$5,100
10400 North	6900	6959	Crack Seal and Seal Coat	$6,000
10400 North	6800	6829	Crack Seal and Seal Coat	$2,400
10400 North	6960	6999	Crack Seal and Seal Coat	$1,700
10400 North	6580	6749	Crack Seal and Seal Coat	$7,900
10400 North	6580	6749	Crack Seal and Seal Coat	$3,000
East Crimson	9900	9904	Crack Seal and Seal Coat	$1,400
Pebble	5410	5449	Crack Seal and Seal Coat	$3,200
Peyton	10500	10524	Crack Seal and Seal Coat	$2,500
10800 North	5800	5869	Crack Seal and Seal Coat	$2,900
5800 West	9850	9899	Crack Seal and Seal Coat	$2,100
11200 North	5500	5549	Crack Seal and Seal Coat	$3,800
10800 North	5870	5919	Crack Seal and Seal Coat	$2,900
West Crimson	9875	9904	Crack Seal and Seal Coat	$1,400
Stoneshire	10690	10799	Crack Seal and Seal Coat	$2,400
Pebble	5390	5409	Crack Seal and Seal Coat	$1,400
11200 North	5550	5599	Crack Seal and Seal Coat	$3,900
11040 North	6380	6399	Crack Seal and Seal Coat	$2,400
Compton	5730	5749	Crack Seal and Seal Coat	$2,200
Haymaker	10460	10499	Crack Seal and Seal Coat	$3,600
11200 North	5300	5499	Crack Seal and Seal Coat	$5,400
6400 West	11000	11044	Crack Seal and Seal Coat	$1,000
10100 North	5680	5749	Crack Seal and Seal Coat	$3,100
Maddie	5750	5799	Crack Seal and Seal Coat	$2,700

11200 North	5600	5649	Crack Seal and Seal Coat	$2,800
Compton	5675	5729	Crack Seal and Seal Coat	$2,900
West Crimson	9870	9874	Crack Seal and Seal Coat	$1,900
Ridge	6090	6199	Crack Seal and Seal Coat	$6,600
Ridge	6000	6089	Crack Seal and Seal Coat	$5,500
Walker	10400	10499	Crack Seal and Seal Coat	$3,600
Bull River	11520	11529	Crack Seal and Seal Coat	$1,400
Granite	11505	11509	Crack Seal and Seal Coat	$3,000
Granite	11510	11539	Crack Seal and Seal Coat	$1,400
11140 North	5860	5999	Crack Seal and Seal Coat	$5,900
5600 West	10180	10185	Crack Seal and Seal Coat	$7,000
East Crimson	9870	9899	Crack Seal and Seal Coat	$1,900
Reisner	6000	6149	Crack Seal and Seal Coat	$8,400
Carson	5670	5769	Crack Seal and Seal Coat	$3,900
Lone Rock	6390	6439	Crack Seal and Seal Coat	$1,200
Bull River	6180	6309	Crack Seal and Seal Coat	$1,800
Granite Flats	11600	11629	Crack Seal and Seal Coat	$1,600
5870 West	10800	10879	Crack Seal and Seal Coat	$1,600
10800 North	5750	5799	Crack Seal and Seal Coat	$1,600
11200 North	5300	5499	Crack Seal and Seal Coat	$7,400
6400 West	10350	10399	Crack Seal and Seal Coat	$4,000
5600 West	11030	11199	Crack Seal and Seal Coat	$3,000
5600 West	10180	10185	Crack Seal and Seal Coat	$4,500
			Total	**$384,500**

Table D-4. Year 4 Projects (2018)

Street Name			Recommended Treatment	Estimated Treatment Cost
Canterbury Park	5870	5919	Crack Seal and Seal Coat	$2,600
Canterbury Park	5845	5919	Crack Seal and Seal Coat	$3,700
Jerling		5089	Crack Seal and Seal Coat	$1,300
Athena		11829	Crack Seal and Seal Coat	$1,600
Highland Blvd		11249	Mill and Overlay	$61,000
5920 West	9800	9819	Crack Seal and Seal Coat	$1,200
Country Club	5130	5189	Crack Seal and Seal Coat	$3,800
5300 West	10550	10609	Crack Seal and Seal Coat	$1,400
Athena	11860	11999	Crack Seal and Seal Coat	$7,800
Hy Land Acres	5265	5369	Crack Seal and Seal Coat	$2,800
9860 North	6250	6319	Crack Seal and Seal Coat	$4,300
East Jerling	10620	10659	Crack Seal and Seal Coat	$4,600
9750 North	5650	5739	Crack Seal and Seal Coat	$2,100
Stone Creek	11250	11279	Overlay	$6,900
9860 North	6180	6249	Crack Seal and Seal Coat	$3,400
9860 North	6370	6399	Crack Seal and Seal Coat	$3,800
5920 West	9700	9799	Crack Seal and Seal Coat	$4,900
Jerling	5090	5099	Crack Seal and Seal Coat	$1,400
North Jerling	5090	5159	Crack Seal and Seal Coat	$4,700
Canterbury Park	5920	5999	Crack Seal and Seal Coat	$3,900
5370 West	10610	10659	Crack Seal and Seal Coat	$2,300
9860 North	6040	6109	Crack Seal and Seal Coat	$5,800
11860 North	6040	6044	Crack Seal and Seal Coat	$1,500
Athena	11830	11859	Crack Seal and Seal Coat	$2,100
Ashby	9780	9809	Crack Seal and Seal Coat	$1,000
Canterbury Park	9700	9799	Crack Seal and Seal Coat	$4,200
Country Club	4915	5009	Crack Seal and Seal Coat	$8,100
Ashby	9600	9779	Crack Seal and Seal Coat	$8,600
5650 West	9600	9749	Crack Seal and Seal Coat	$7,600
9860 North	6320	6369	Crack Seal and Seal Coat	$2,200
5370 West	10550	10609	Crack Seal and Seal Coat	$3,100
5300 West	10660	10684	Crack Seal and Seal Coat	$1,400
East Jerling	10660	10699	Crack Seal and Seal Coat	$4,300
9860 North	6000	6039	Crack Seal and Seal Coat	$3,900

West Jerling	10620	10699	Crack Seal and Seal Coat	$7,500
5650 West	9750	9799	Crack Seal and Seal Coat	$3,000
9860 North	6110	6179	Crack Seal and Seal Coat	$6,300
Alpine	4940	5009	Crack Seal and Seal Coat	$7,800
Country Club	5010	5109	Crack Seal and Seal Coat	$8,500
Country Club	10660	10699	Crack Seal and Seal Coat	$1,400
Cemetery	0	0	Crack Seal and Seal Coat	$1,300
Cemetery	0	0	Crack Seal and Seal Coat	$6,100
Cemetery	0	0	Crack Seal and Seal Coat	$2,600
Cemetery	0	0	Crack Seal and Seal Coat	$2,300
11200 North			Overlay	$18,200
9860 North			Crack Seal and Seal Coat	$2,000
9600 North			Crack Seal and Seal Coat	$500
Highland Blvd			Mill and Overlay	$61,900
Highland Blvd	0	11198	Mill and Overlay	$61,900
11140 North	5860	5999	Crack Seal and Seal Coat	$800
11140 North	5860	5999	Crack Seal and Seal Coat	$900
			Total	**$376,300**

Table D-5. Year 5 Projects (2019)

Street Name			Recommended Treatment	Estimated Treatment Cost
Stone Creek	5450	5499	Overlay	$27,900
11800 North	6000	6039	Overlay	$30,400
6690 West	9900	9914	Overlay	$3,600
Westfield	5900	5929	Overlay	$40,400
Westfield	5850	5899	Overlay	$14,400
4500 West			Overlay	$1,100
11800 North	6150	6299	Overlay	$36,400
Highland Blvd			Mill and Overlay	$62,400
11100 North	5100	5269	Crack Seal and Seal Coat	$10,800
Lausanne	6050	6149	Crack Seal and Seal Coat	$5,400
6630 West	9770	9809	Crack Seal and Seal Coat	$2,100
Town Center East	10600	10609	Crack Seal and Seal Coat	$3,100
10205 North	6800	6889	Crack Seal and Seal Coat	$4,600
Adonis	6220	6379	Crack Seal and Seal Coat	$9,500
6960 West	10150	10299	Crack Seal and Seal Coat	$6,200
Chamberry	6000	6049	Crack Seal and Seal Coat	$1,600
6960 West	10120	10149	Crack Seal and Seal Coat	$2,500
Atlas	11960	11999	Crack Seal and Seal Coat	$2,100
6620 West	9500	9599	Crack Seal and Seal Coat	$5,900
5100 West	11000	11099	Crack Seal and Seal Coat	$5,400
10150 North	6800	6889	Crack Seal and Seal Coat	$5,400
Atlas	11835	11959	Crack Seal and Seal Coat	$9,600
10600 North	5550	5599	Crack Seal and Seal Coat	$2,100
10150 North	6890	6959	Crack Seal and Seal Coat	$3,900
11200 North	5100	5274	Crack Seal and Seal Coat	$5,300
6630 West	9810	9849	Crack Seal and Seal Coat	$2,300
Chamberry	12000	12029	Crack Seal and Seal Coat	$2,500
11200 North	4800	4879	Crack Seal and Seal Coat	$5,600
Chamberry	6050	6099	Crack Seal and Seal Coat	$2,600
11830 North	6020	6034	Crack Seal and Seal Coat	$1,400
Grenoble	12000	12099	Crack Seal and Seal Coat	$5,100
11860 North	6020	6039	Crack Seal and Seal Coat	$1,400
9500 North	6620	6799	Crack Seal and Seal Coat	$11,200
Chamberry	12030	12049	Crack Seal and Seal Coat	$1,400

6890 West	10150	10205	Crack Seal and Seal Coat	$3,700
11200 North	4880	5099	Crack Seal and Seal Coat	$11,100
6630 West	9850	9949	Crack Seal and Seal Coat	$1,600
Vintage	6630	6799	Crack Seal and Seal Coat	$4,100
9770 North	6630	6799	Crack Seal and Seal Coat	$4,200
6630 West	9720	9769	Crack Seal and Seal Coat	$1,600
9810 North	6530	6629	Crack Seal and Seal Coat	$1,600
9500 North	6560	6619	Crack Seal and Seal Coat	$1,300
11200 North	5100	5274	Crack Seal and Seal Coat	$5,400
			Total	**$370,200**

11200 North	4880	5009	Crack Seal and Seal Coat	$11,100
Vinings	6630	6729	Crack Seal and Seal Coat	$4,100
6930 West	9720	9749	Crack Seal and Seal Coat	$1,600
9500 North	6800	6819	Crack Seal and Seal Coat	$1,300
			Total	$270,200