2012 Pavement Management Update

Salem, New Hampshire

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MAY 2013

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Introduction

In the spring of 2012, the Town of Salem hired Vanasse Hangen Brustlin, Inc (VHB) to update the town's pavement management system by performing a town-wide pavement condition inventory and evaluation, updating the town's pavement management software to a GIS (Geographic Information System) based system, and performing road network analysis. The primary goals of the project were to assess the current status of the town's road network, assist in development of roadway maintenance and rehabilitation plans, and to analyze the results of potential funding scenarios.

The following report describes the relevant concepts of pavement management practice, the steps undergone by VHB through the course of the project, a summary of the pavement conditions found in the Town, and the budget analysis performed by VHB.

In addition to the results presented in this report; at the conclusion of this project, the Town will also have a GIS integrated pavement management system which will allow it to track future condition of its pavements, maintain a live database of the pavement management information, and allow the town to continue to analyze funding levels and produce road program candidate project lists..

Theory of Pavement Management

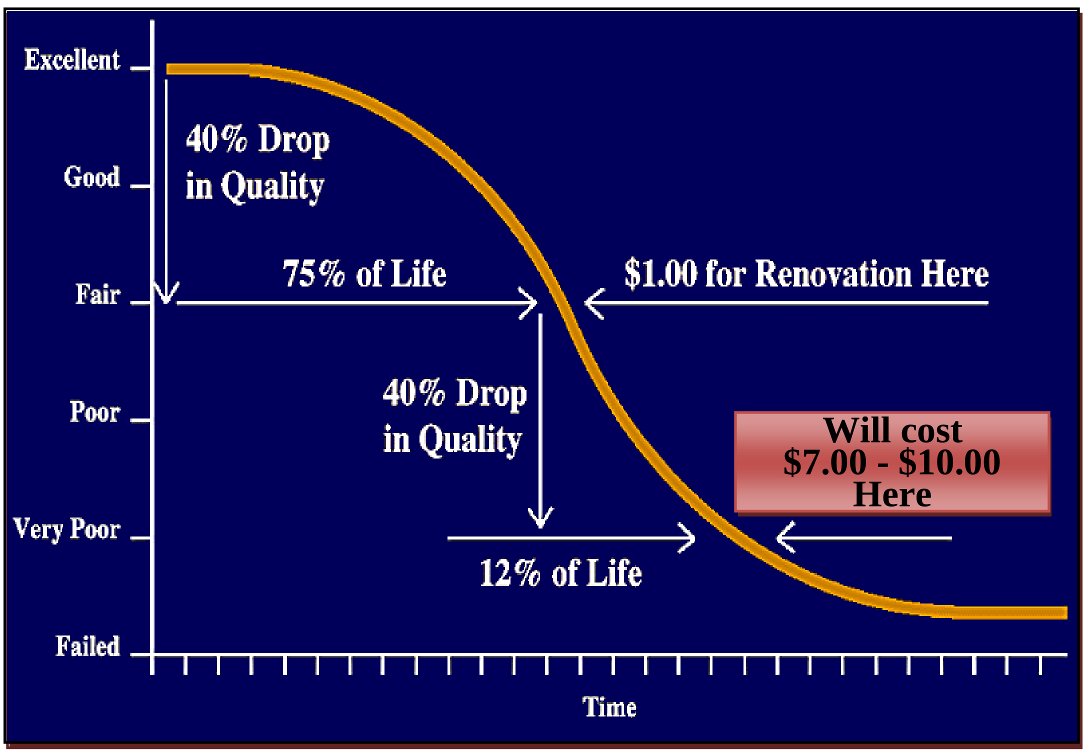
Pavement management is the practice of planning for pavement repairs and maintenance with the goal of maximizing the value and life of a pavement network.

To accomplish this, a community needs to have several repair techniques in its arsenal and the knowledge of when to apply them. This is where pavement management comes into play. With a comprehensive database of road conditions, the pavement management software can model when to perform which repairs on a road network. Of course, engineering judgment is required to finalize any list of street repairs, as no computer model can take every variable analyzed in making a repair decision into account. The computer system is a great springboard to help a community start its repair program for each year and is an excellent method of storing the repair data.

The Pavement Deterioration Curve

Below is a model of how a street's pavement deteriorates over time. Interpreting the curve, a street starts out in excellent condition when it is newly constructed. Midway through its life, a low cost repair such as crack seal and full depth patch will cost approximately a dollar a square yard. It takes only a few years for the window of opportunity to perform this low cost maintenance to pass after which the road would need an overlay costing $7- $10 per square yard. By performing timely maintenance, road conditions can be improved today thereby extending the life of the road.

Figure 1 – Pavement Deterioration Curve



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Methodology

VHB performed a detailed condition evaluation on Salem's 178.1 miles of paved public roadways to build the pavement management system. The first step was to identify the roadway network. The second step was to further break each street in the roadway network into pavement management sections. The third step was to carefully categorize, measure, and record the individual pavement distresses within each pavement management section. Finally, the fourth step was to customize the road repair treatment selection and unit costs within the pavement management software through discussions with Town officials. All these steps were performed prior to the study of funding scenarios.

Network Identification

Network Identification builds an inventory of streets that describe the municipality's complete roadway network. The direction of travel, street length, width, ownership, classification, zone and pavement type are among the items identified at this initial phase in the pavement management process. This integral step ensures the streets surveyed are the definitive set to be analyzed.

Part of the network identification process included correlating the previously used functional classification of roadways with the classification system currently used by the Town. Arterial and Collector road designations were updated to match the Town's "Operational" road network.

Pavement Management Section Identification

Once the Network Identification is complete, the field work begins. Each street contains one or more pavement management sections. A pavement management section defines the limits of previous construction or maintenance activities within each street. Sections are defined by having the same width, typical distresses, functional class, etc. The goal is to set up homogenous areas of pavement to aid in assigning the appropriate repair. A street may be one section, or it may be comprised of several pavement management sections, depending on its construction history.

Surface Distress Assessment

For each pavement management section, the severity and extent of nine major pavement distresses are recorded, and then entered into a weighted formula to arrive at a Pavement Condition Index (PCI). The distresses are categorized as base related or surface related distresses. Base related distresses indicate that the pavement structure is inadequate for the existing traffic load and soil conditions. Streets that show significant base related distresses may need to have the pavement structure strengthened with either thicker or stronger base or pavement materials. Surface related distresses are caused by age and weathering of the pavement. Streets that have predominantly surface related distresses are excellent candidates for maintenance sealing to inhibit further pavement oxidization (the main effect of aging). Streets with more of the base related distresses will most likely need some full depth patching, structural overlays or reclamation/reconstruction.

The four base related distresses are:

- potholing or non-utility patching
- alligator cracking
- distortion
- rutting

The five surface related distresses are:

- block cracking
- transverse or longitudinal cracking
- bleeding or polished aggregate
- surface wear or raveling
- shoving, slippage or corrugation

The RoadManager pavement distress rating system, described above, and PCI formula shown below, was developed by Vanasse Hangen Brustlin, Inc. specifically to allow the efficient rating of the distresses and conditions found on New England roadways, and is used by over 100 municipalities throughout the region.

PCI Defined

A PCI was generated for each inventoried pavement management section in Salem using the surface distress data collected by VHB. PCI is measured on a scale of zero to one hundred, with one hundred representing a pavement in perfect condition and zero describing a road in impassable condition. Each type of observed pavement distress is assigned a deduct value based on the type, severity and extent of the distress. A weighted sum of the deduct points is subtracted from the perfect "one hundred" road in order to generate a PCI for each pavement management section. In general, base related (pavement foundation) distresses are weighted more heavily than surface related distresses. For example, if 15% of a road section had medium severity "Alligator Cracking" it would received a deduct of 40 points. Whereas the same area of "Block Cracking" would only receive a deduct of 15 points. The actual PCI calculation follows:

PCI = 100 – (Highest Deduct Value) – (25% of remaining base related deduct values) – (10% of remaining surface related deduct values)

The Five Treatment Bands

The pavement management system uses broad ranges to group the individual repair types into five major treatment bands. Treatment bands are a useful tool to summarize data on a Town-wide basis. An individual road segment will fall into a particular category based on the strategy table's output of repair types and will vary due to functional classification. The goal is to gain a broad understanding of the existing conditions in simple yet meaningful terms.

Table 1 - Treatment Band Descriptions

TREATMENT BAND	PCI*	Description
DO NOTHING	93-100	Excellent condition - in need of no maintenance.
ROUTINE MAINTENANCE	86-92	Good condition – may be in need of crack sealing or minor localized repair.
PREVENTIVE MAINTENANCE	73-85	Fair condition – pavement surface may be in need of surface sealing, full depth patch and/or crack sealing.
STRUCTURAL IMPROVEMENT	61-72	Deficient condition – pavement surface structure in need of added strength for existing traffic. Typical repairs are overlay with or without milling.
BASE REHABILITATION	0-60	Poor condition – in need of base improvement. Typical repairs are reclamation or full depth reconstruction.

Note: The Treatment bands are defined below.

*These are only general PCI ranges for reference purposes, and represent only one pavement type. There are several fields considered by the strategy table when assigning repair types to each individual street.

Do Nothing

The Do Nothing category exhibits roads which are in need of no maintenance. These roads are in excellent condition and existing distresses generally do not need to be addressed.

Routine Maintenance

Routine maintenance activities are those which are taken to correct a specific pavement distress. Routine maintenance usually addresses localized pavement defects and includes activities such as:

- Full depth patching;
- Skin patching;
- Crack sealing.

Preventive Maintenance

Preventive maintenance activities are those which are performed at planned intervals to protect and seal the pavement. Seals are designed to provide one or more of the following benefits:

- Prevent the intrusion of air and moisture;
- Fill small cracks and voids;
- Rejuvenate an oxidized binder;
- Provide a new wearing surface.

Structural Improvement

Structural improvement includes the work necessary to restore the pavement to a condition that will allow it to perform satisfactorily for several years. Generally a structural improvement will consist of milling the existing pavement down and applying a new Hot Mix Asphalt Overlay allowing existing grades to be maintained. When the existing grade can be increased a new Hot Mix Asphalt course can simply be placed upon the existing surface.

Structural improvements also include the work necessary to prepare the pavement for an overlay, either with or without milling. The major activities involved in the preparation process are:

- Partial depth patching;
- Full depth patching;
- Joint and crack sealing.
- Grinding and milling
- Hot Mix Asphalt Leveling Courses.

Base Rehabilitation

Base rehabilitation utilizes one of two methods:

- Reclamation;
- Reconstruction.

Reclamation is the process of rehabilitating existing deteriorated pavements. The existing pavement and base, subbase, and possibly subgrade are pulverized and blended to create a homogenous pavement base. This reclaimed pavement base is then paved with a new Hot Mix Asphalt surface.

Reconstruction is the complete removal and replacement of a failed pavement, and might also involve widening, realignment, traffic control devices, safety hardware, and major base and drainage work.

Customizing Repair Strategies

VHB met with the Town Engineering staff to review VHB's typical repair strategies, and to learn how to customize these strategies to meet the Town's specific needs. VHB also refined repair unit costs. VHB's goal was to understand Salem's decision-making process and simulate that process in the budget analysis software based on the pavement condition and other criteria of each pavement section.

Salem's pavement management system was configured to implement the town's primary repair strategy of Reconstruction, Reclamation, and Hot Mix Asphalt Overlays.

Preparing Budget Scenarios

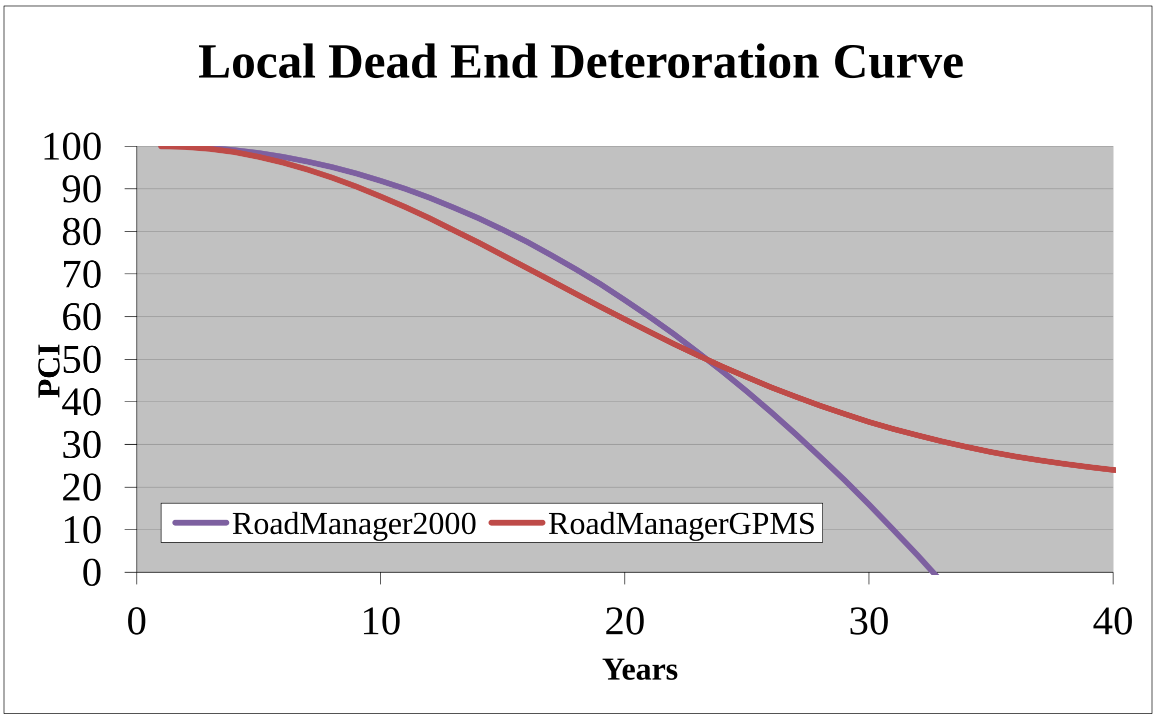
Once the roadway conditions are inventoried and analyzed, and the repair strategies are defined, the impact of various spending programs on the roadway network is assessed. These studies can range from 1 to 20 years; however, for the purpose of this report 10-year studies are used. The purpose of the budget planning process is to determine the impact of various spending levels to find a funding level that will best meet Salem's needs. The budget analysis software uses pavement deterioration curves, unit costs, and the strategy tables developed in the repair strategy definition phase to assign each street a repair type and associated cost for each year of the study. The software also assigns each street a benefit value that is used to prioritize which streets the software will select for repair each year. **It is important to understand that a pavement management system is a network-wide planning tool, and is not intended to give definitive street-by-street repair data. Field verification and testing are recommended to confirm any street repair list generated.**

Deterioration Curves

In order to properly plan for future repairs, the budget analysis feature of the pavement management system uses deterioration curves. The deterioration curves estimate the rate at which the pavement condition decreases over time. These pavement deterioration curves depict two major categories of functional classification - arterials and collectors (Operational Roads) in one curve and local roads in the other as well as a differentiation for pavement type.

During the course of this project, the town moved their pavement management system from the RoadManager2000 platform, to RoadManagerGPMS™. One change in the system was the ability to have a more complex pavement deterioration curve. The previous system used a Polynomial formula to calculate the deterioration, whereas the new system uses an Exponential formula. The Exponential formula allows the curve to better model the RoadManager PCI scale, which does not accelerate to 0 over time such as the older curve would indicate. A sample of the old and new curves is shown below, and all curves used in the system are included in the Appendices.

Figure 2 – Sample Curve from Salem Pavement Management System



Project Prioritization

The budget analysis software prioritizes needed system repairs based on the estimated "Benefit Value". The Benefit Value formula is calculated using variables representing traffic volume, repair service life, PCI, and unit repair costs for each pavement management section. The calculation for the Benefit Value is shown below. For each plan year, the software prepares a future roadway condition projection, exhausts the assigned budget, and then produces an annual list of roads included in the repair program. The system also allows the user to enter an inflation rate to account for estimated increases in future year construction costs. A 4% inflation rate was used for Salem's construction costs.

The Benefit Value prioritization process generally favors cost effective maintenance alternatives. Repair actions are typically delayed on those sections that require reconstruction or major rehabilitation because the benefits for dollars spent are generally lower than maintenance candidates. After the relatively good roads are "saved", improvements are directed towards the poorer arterial and collector roads, and then to the local roads in need of major rehabilitation.

The calculation of Benefit Value is as follows:

$$Benefit\ Value = \frac{ADT * Life\ of\ Repair}{PCI * Unit\ Cost\ of\ Repair}$$

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Existing Conditions

Town Roads Pavement Conditions

VHB conducted the field evaluation of pavement conditions in the summer and fall of 2012. The average PCI for Salem's paved road network was found to be an **80**. A PCI of 80 represents a road in fairly good condition.

In discussion with Town officials, it was determined that there are two main subsets of roadways for which the town may have different expectation on condition and analysis. These are the Operational roads which include the main network of collector roads used by a larger percentage of the population and local roads used by mostly local traffic. This section will summarize the condition of the town's road network as a whole, and also within these subsets. In addition, conditions on Route 28 (North and South Broadway) will be summarized individually.

The average PCI for the town's entire Town Accepted network, as well as the subsets described above, are shown below. All mileages are for paved roads only. The Town also has 4.1 miles of gravel road.

- All Town Accepted Paved Roads (178.1 miles) = 80 PCI
- Operation Roads
  - All (59.3 miles)= 83 PCI
  - W/out Route 28 (52.8 miles) = 82 PCI
  - Route 28 only (6.5 miles[1]) = 87 PCI
- Local Roads (118.8 miles) = 78 PCI

This clearly shows that Salem has focused its attention on maintaining the condition of the roads used by most drivers, as is recommended by good pavement management practice.

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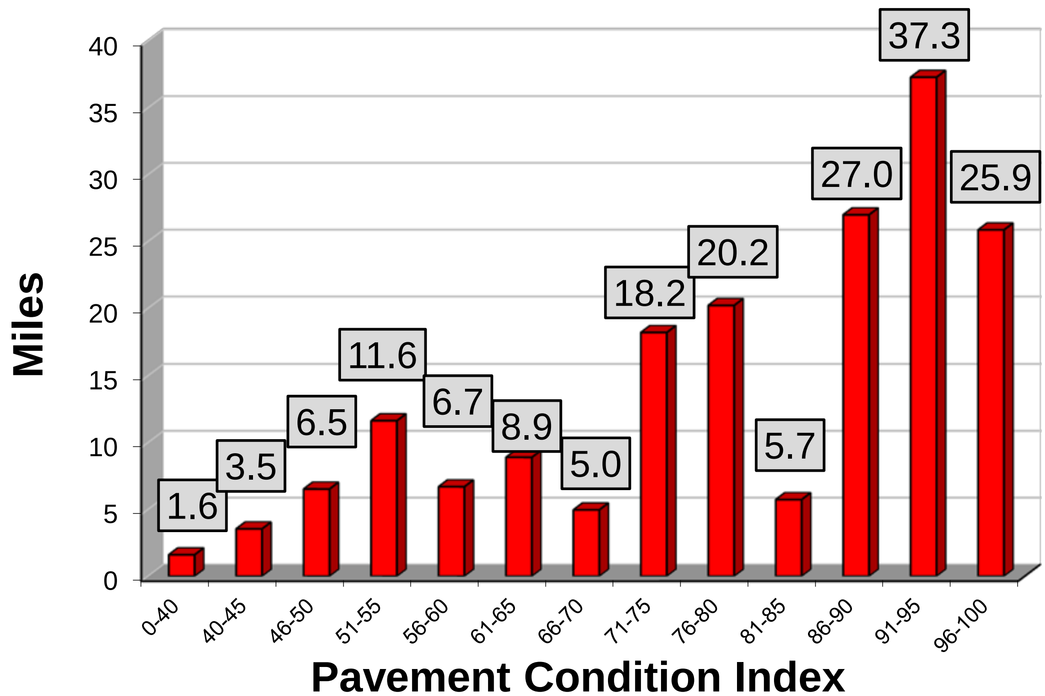
[1] Route 28 northbound and southbound lanes were inventoried separately from 1000' N of Geremonty Dr southerly to Methuen town line, thus doubling the mileage for this section.

The following chart shows the distribution of conditions in small PCI increments which give a more detailed picture of the state of Salem's roads.

Figure 3 - PCI Distribution- All Roads

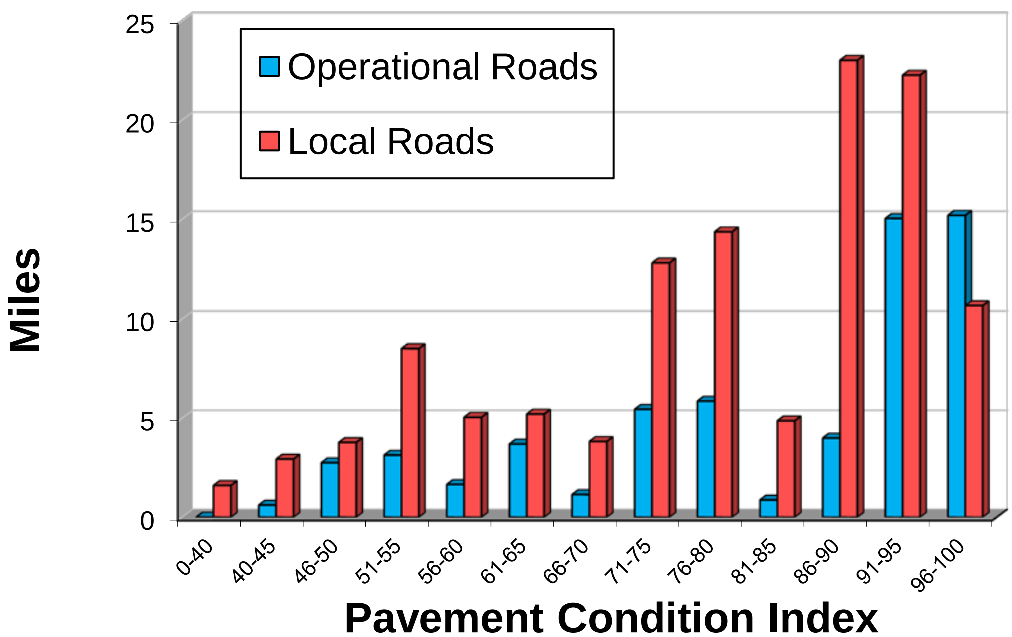


With a large number of road miles in good and excllent condition, this indicates that maintenance of of the good roads should be a priority in coming years, to protect the investment in new pavement that the town has made. The 44 miles of roadway between 71 and 85 PCI may be good candidates for town to look at a surface treatment option to seal surface defects and slow the aging of the pavement by keeping rain, sun radiation, and oxygen away from the existing pavement structure.

Operational vs. Local Roads

The following chart breaks the pavement distribution down by Operational and Local Roads.

Figure 4 - PCI Distribution- by Functional Class



This chart shows a fairly similar distribution of conditions between the local and operational roads, except the operational roads have a distinct increase in percentage or roads in the highest PCI bands, showing the signficant recent investments in improving the condition of the operational road network.

Table 2 – PCI Distribution by Functional Class

PCI Band	Operational Roads (miles)	Local Roads (miles)
0-40	0	1.6
40-45	0.61	2.93
46-50	2.75	3.77
51-55	3.13	8.50
56-60	1.65	5.04
61-65	3.69	5.20
66-70	1.14	3.82
71-75	5.44	12.79
76-80	5.85	14.36
81-85	0.87	4.86
86-90	3.98	23.01
91-95	15.02	22.26
96-100	15.19	10.67

Operational Roads (With and Without Route 28)

The operational road network conditions are summarized below, both with and without Route 28.

Figure 5 - PCI Distribution- By Pavement Type

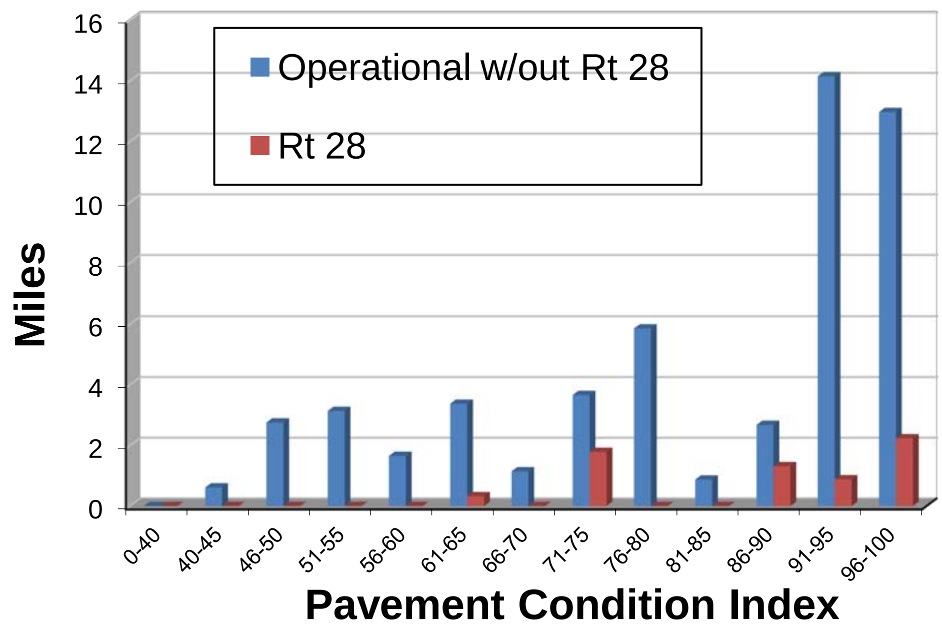


Table 3 – PCI Distribution- Operational Roads

PCI Band	Operational W/Out Route 28 (miles)	Route 28 Only (miles)
0-40	0	
40-45	0.61	
46-50	2.75	
51-55	3.13	
56-60	1.65	
61-65	3.37	0.32
66-70	1.14	
71-75	3.66	1.78
76-80	5.85	
81-85	0.87	
86-90	2.67	1.31
91-95	14.14	0.88
96-100	12.96	2.23

Backlog of Work (All Paved Roads)

Applying the five treatment bands shown in Table 1 and unit costs referenced in Appendix A to Salem's road network, a summary of outstanding work was developed. The following table gives the miles and dollars associated with each treatment band for the conditions at the time of the evaluation.

Table 4 - Summary of Miles and Dollars of Outstanding Work

Treatment Bands	Miles	Cost
Base Rehabilitation	29.97	$38,043,000.00
Structural Improvement	19.39	$3,279,000.00
Preventive Maintenance	38.65	$1,410,000.00
Routine Maintenance	37.22	$411,000.00
Do Nothing	52.9	$0.00
Totals:	**178.1**	**$ 43,143,000**

Figure 6 – Current Backlog Mileage by Treatment Band

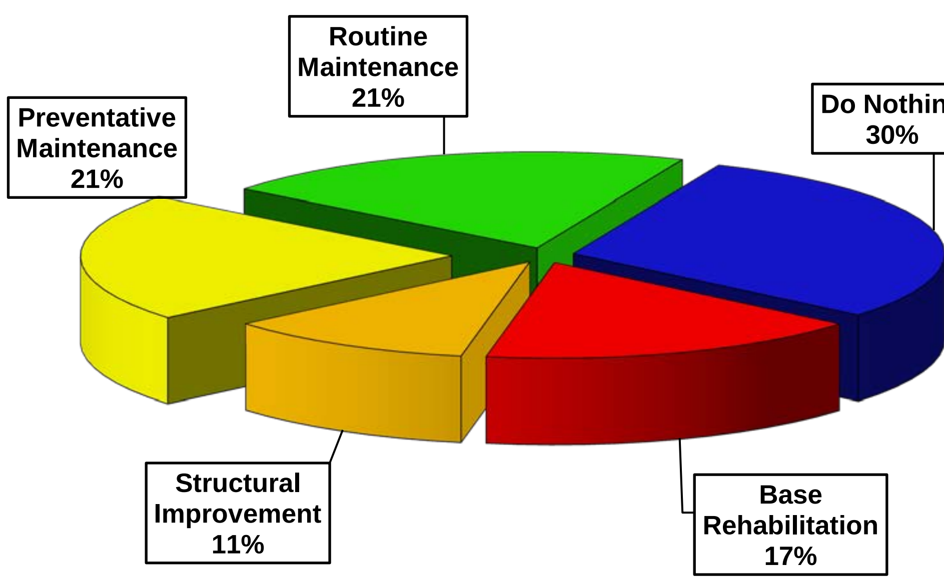
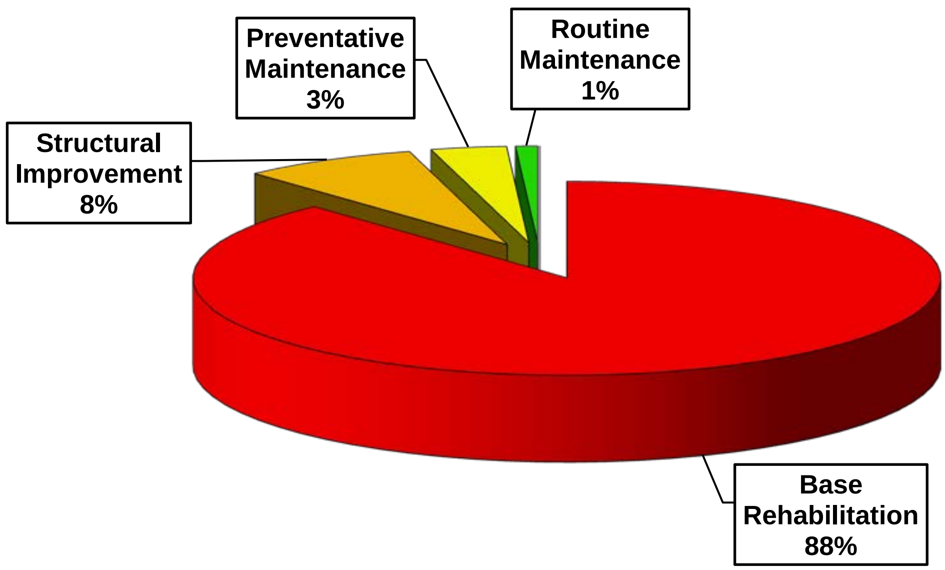


Figure 7 – Current Backlog Cost by Treatment Band



Figures 6 and 7 show that while only about 20% of the towns roads are in need of base rehabilitation, those miles make up almost 90% of the dollar backlog while the 40% of miles in the two maintenance bands make up only about 4% of the dollar backlog.

This emphasizes the importance of maintaining the roads in good condition for short dollars, but also indicates considerable funds are needed to rehabilitate the roads in poor condition.

Backlog of Work (Operational Roads)

Table 5 - Summary of Miles and Dollars of Outstanding Work

Treatment Bands	Miles	Cost
Base Rehabilitation	8.12	$15,331,000.00
Structural Improvement	7.63	$1,860,000.00
Preventive Maintenance	9.37	$389,000.00
Routine Maintenance	9.05	$113,000.00
Do Nothing	25.14	$0.00
Totals:	**59.3**	**$ 17,693,000**

Figure 8 – Current Backlog Mileage by Treatment Band

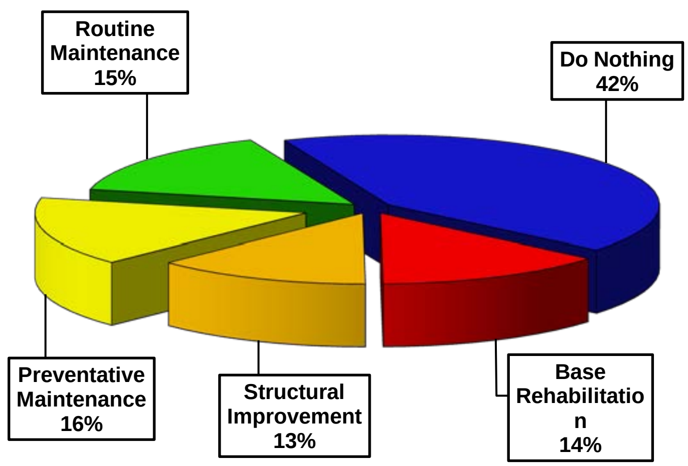
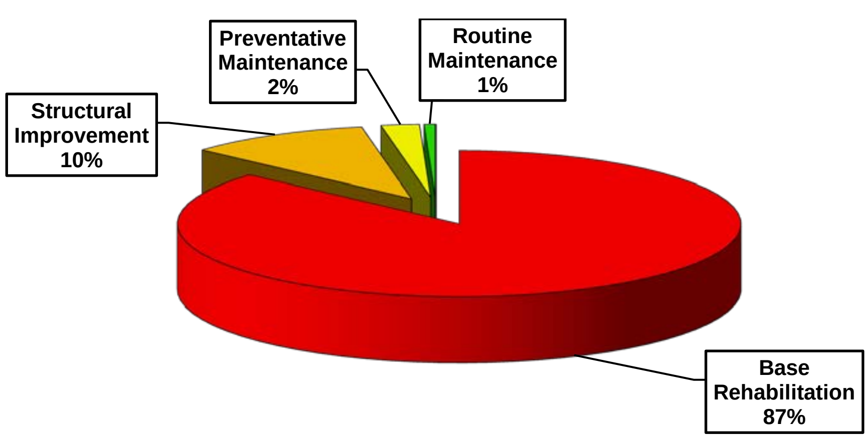


Figure 9 – Current Backlog Cost by Treatment Band



Backlog of Work (Local Paved Roads)

Table 6 - Summary of Miles and Dollars of Outstanding Work

Treatment Bands	Miles	Cost
Base Rehabilitation	21.85	$22,712,000.00
Structural Improvement	11.76	$1,419,000.00
Preventive Maintenance	29.28	$1,021,000.00
Routine Maintenance	28.17	$298,000.00
Do Nothing	27.76	$0.00
Totals:	**118.8**	**$ 25,450,000**

Figure 10– Current Backlog Mileage by Treatment Band

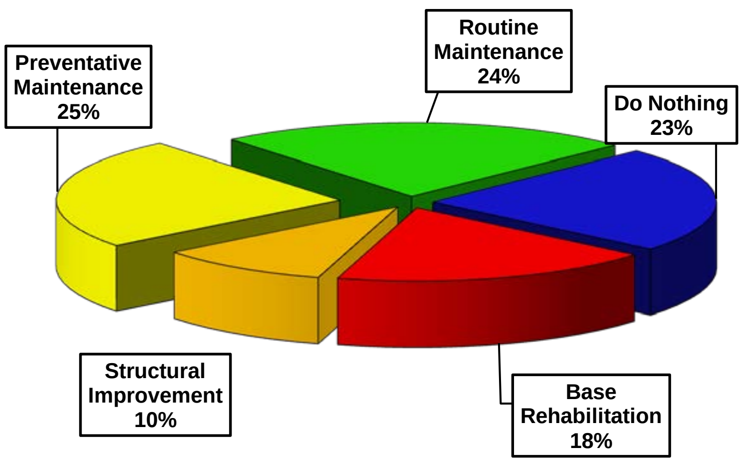
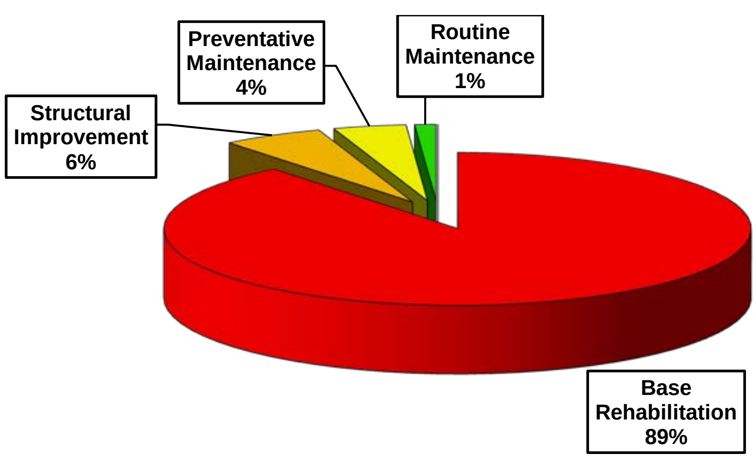


Figure 11 – Current Backlog Cost by Treatment Band



GIS Map of Current Pavement Conditions

By linking the Town's pavement database to a GIS roadway centerline, the town is able to create thematic maps to help in the analysis and presentation of the information within the database. Having the system reside in the same GIS as the Town's other infrastructure data, such as water and sewer systems, will facilitate the coordination of projects between multiple public facilities. The following maps, which display current pavement condition, are examples of the possible types of maps that can be generated.

Figure 12– PCI Map of All Town Roads

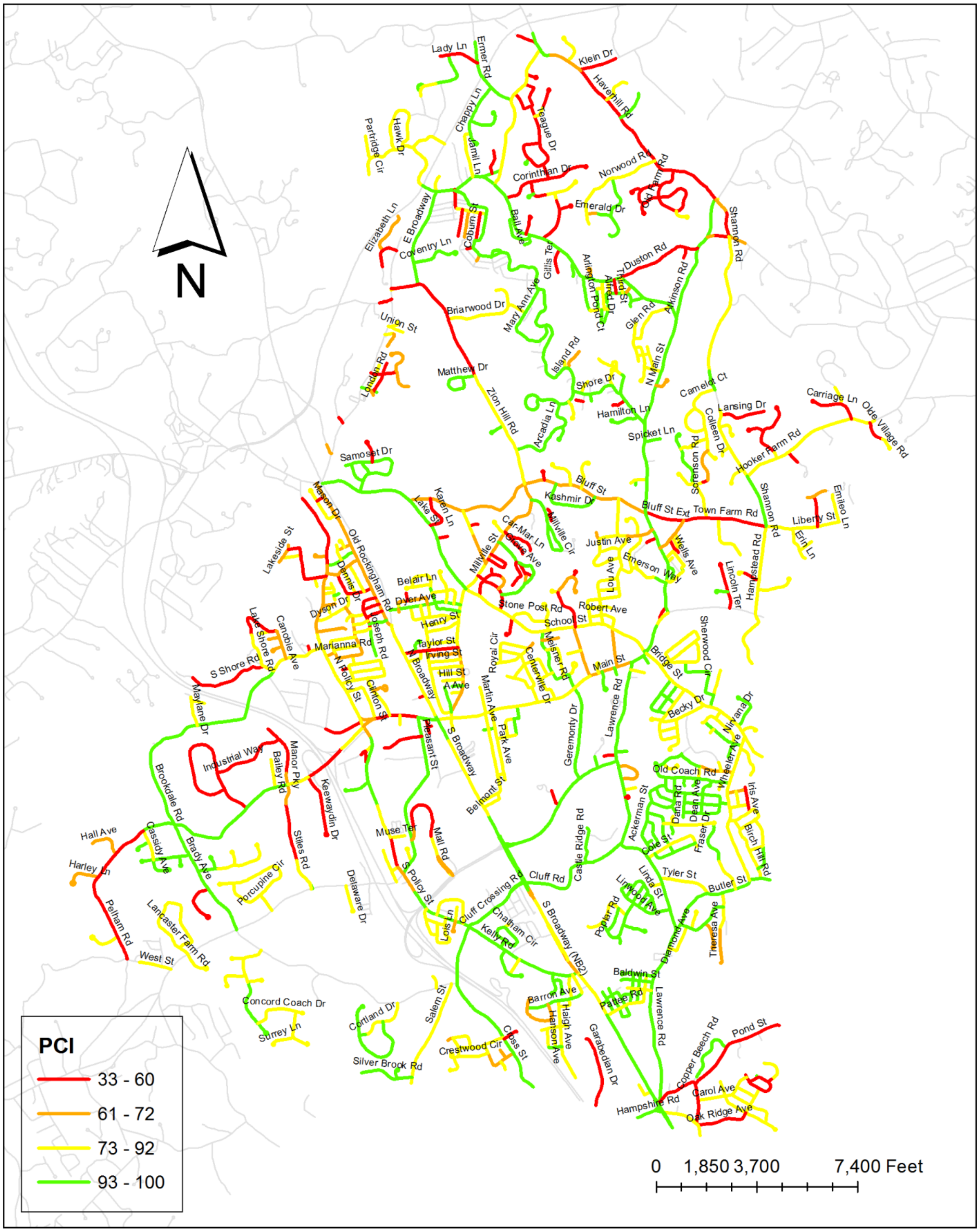


Figure 13 – PCI Map of Operational Roads

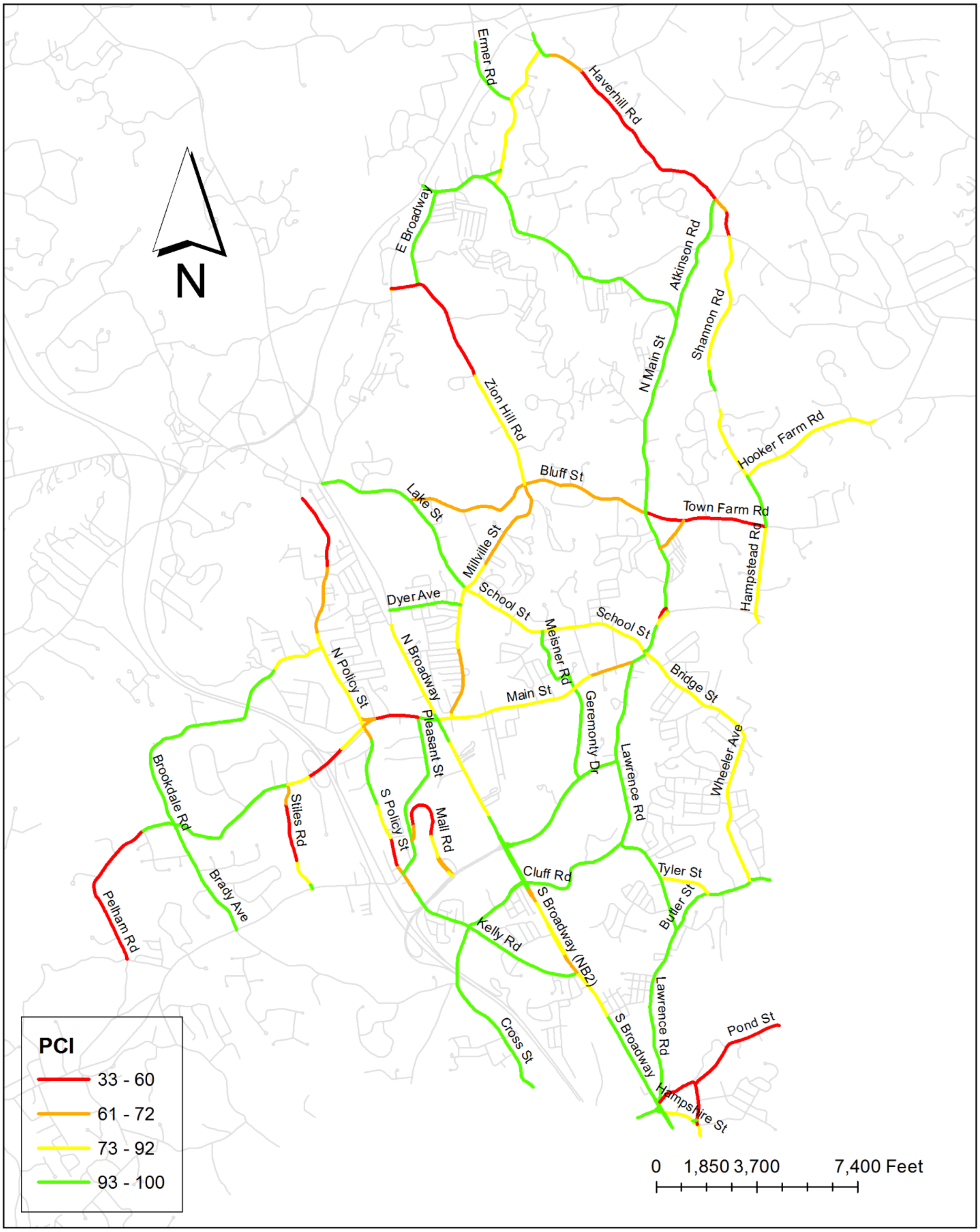
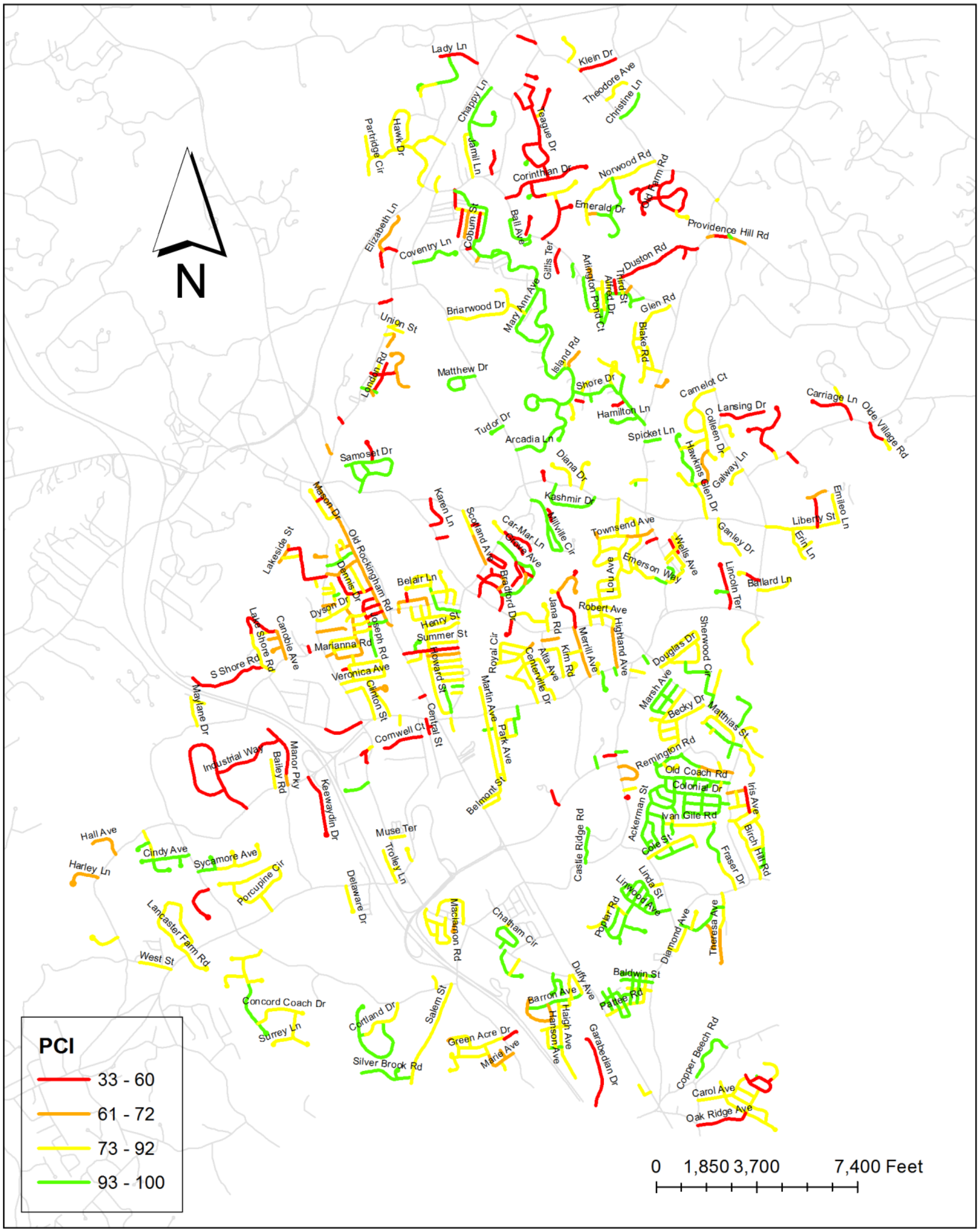


Figure 14 – PCI Map of Local Roads



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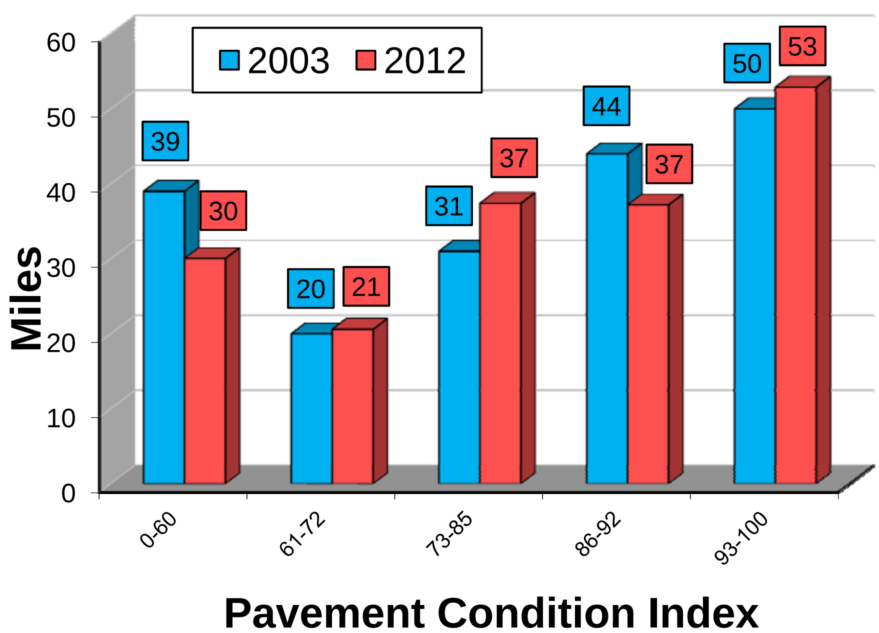
2003-2012 Comparison

VHB originally surveyed the condition of all town roads in 2003. At that time, it was reported that the town-wide PCI was a 79; one point less than the 80 it is today. Thus, despite inflated fuel, pavement, and construction costs, the town has adequately appropriated funds to maintain the condition of the road network.

In 2003, the distribution of conditions was reported using the PCI bands shown below, which very nearly correlate to the Treatment Bands used in the backlog analysis in the latter portion of Chapter 3. Thus, for purposes of comparison between the 2003 findings and today, the current data has also been grouped into these PCI bands and displayed below.

Figure 15 – 2003-2012 PCI Distribution Comparison[2]



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[2] 2012 chart values represent town paved roads only. 2003 chart values include ~4 miles of gravel road and ~2 miles of paved road not currently maintained by the town.

Prior to the pavement evaluations performed in 2012, analysis and projection of the previous survey data had predicted that the town's average PCI would be a 69 at this time; much lower than the 80 indicated in this report. This was due to the pavement deterioration model being used. As shown previously in Figure 2, the town previous version of the pavement management system included a deterioration curve that showed very steep deterioration in the later years of the pavement life. Further analysis has shown that the PCI rating scale typically flattens out after a road reaches the failure point and rarely degrades below a 25. The town system now uses a model that better reflects this.

5

Budget Analysis

Salem has a major investment in its 178.1 miles of paved public roads. It is easy to forget that roadways are a community's single largest investment. Based on the unit cost established for reconstruction of Salem's roads it would cost Salem nearly $250 million in today's dollars to replace the existing Town accepted roadway infrastructure. The final phase of the pavement management process that VHB undertook for this report was to project the results of anticipated funding levels.

Funding Scenarios Examined

Since the initial pavement evaluation done by VHB in 2003, the town has gradually increased its roadway maintenance and rehabilitation funding level from $1.4 million to $4.65 million. The effects of this have been obvious, as the town has maintained its road network at a fairly good level despite a sharp rise in pavement construction costs.

VHB analyzed the effects of various budget scenarios, with a focus on two parameters:

- Funding Level
- Project Prioritization

The following sections will describe the parameters of the analysis that was performed and summarize the results of each.

Funding Levels

The first set of scenarios were analyzed to determine what funding levels would be required to maintain and to improve the overall town PCI by prioritizing projects using VHB's standard Benefit Value calculation as described previously in this report. The two funding levels summarized below are:

- Current Funding Level: $4.65 million per year
- Improve PCI Funding level: $6.65 million per year

For both scenarios, the budget is exactly as shown for the first year, then inflated by 3% annually. $60,000 (inflated by 3% annually) per year from this budget is allocated specifically for routine maintenance (crack sealing). The remainder of the funding is prioritized by the system for Overlays (with or without milling), and reclaim/reconstruction projects.

After the scenarios were calculated, VHB looked at how much of the funding was allocated by the software into those two categories. The following chart shows the average annual amount allocated to the two major repair categories:

Table 7 – Project Category Distribution

Scenario	Overlay/ Mill & Overlay	Reclamation/ Reconstruction
$4,650,000/Year +3%	$9,595,000 (18%)	$43,712,000 (82%)
$6,650,000/Year +3%	$13,722,000 (18%)	$62,513,000 (82%)

The following tables show the budget, projected town-wide average PCI, and projected backlog of outstanding repairs for each year of a ten year analysis period for both of the funding levels.

Table 8 - $4,650,000 /Year

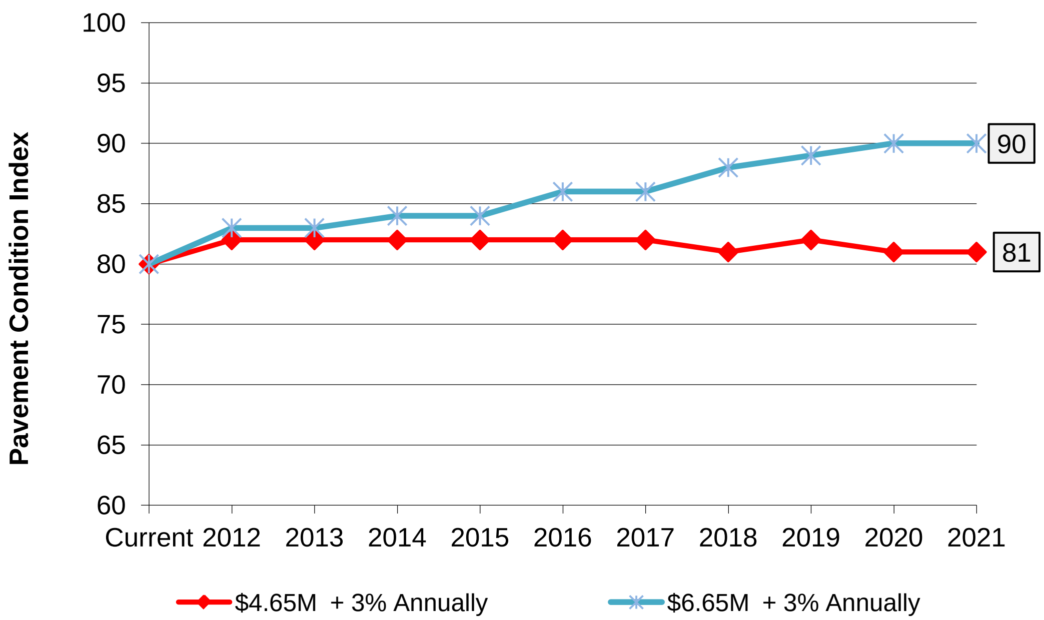
Plan Date	Budget	PCI	Backlog
Current		80	$43,138,000
2013	$4,650,000	82	$44,519,000
2014	$4,789,500	82	$45,608,000
2015	$4,933,185	82	$46,880,000
2016	$5,081,181	82	$46,374,000
2017	$5,233,616	82	$47,731,000
2018	$5,390,624	82	$50,174,000
2019	$5,552,343	81	$51,006,000
2020	$5,718,913	82	$51,608,000
2021	$5,890,481	81	$49,527,000
2022	$6,067,195	81	$49,628,000

Table 9 - $6,650,000 /Year

Plan Date	Budget	PCI	Backlog
Current		80	$43,138,000
2013	$6,650,000	83	$44,519,000
2014	$6,849,500	83	$43,434,000
2015	$7,054,985	84	$42,098,000
2016	$7,266,635	84	$38,789,000
2017	$7,484,634	86	$36,388,000
2018	$7,709,173	86	$35,236,000
2019	$7,940,448	88	$32,805,000
2020	$8,178,661	89	$26,758,000
2021	$8,424,021	90	$20,723,000
2022	$8,676,742	90	$13,034,000

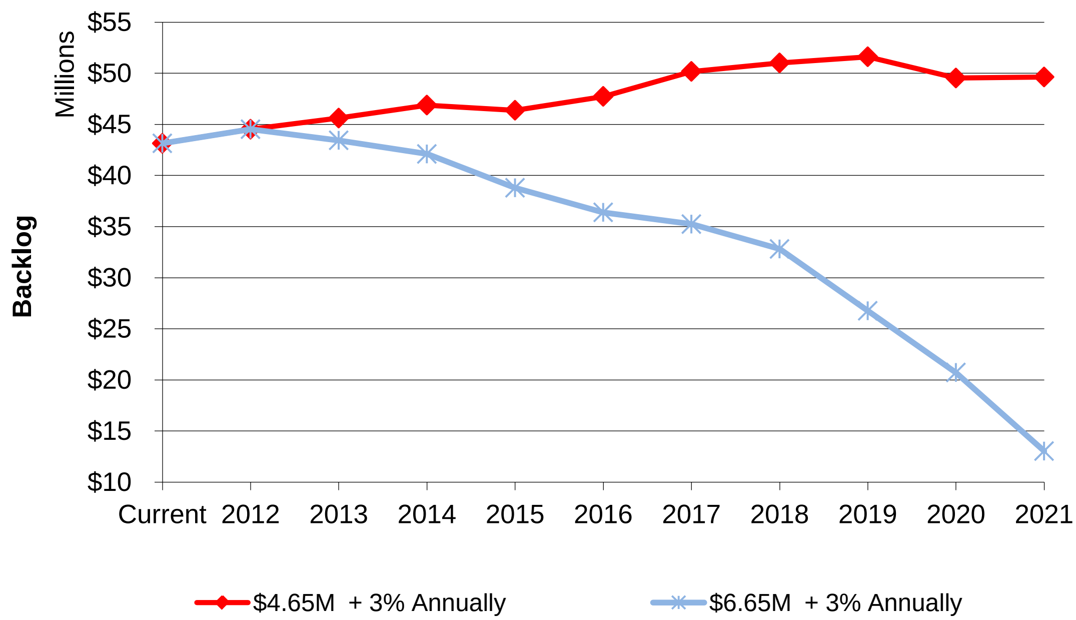
The following charts display the trend in the projected PCI and Backlog for the analyzed funding levels.

Figure 16 – Projected Pavement Condition



The above chart demonstrates that the current funding level would maintain roadway conditions at their current level, while increasing the budget by $2 million per year would improve the conditions by 9 PCI points over the ten year analysis period.

Figure 17 – Projected Backlog Summary



This chart demonstrates that the current budget would allow a slow increase in the backlog, while the $6.5 million per year budget would drastically reduce the backlog to less than $15 million.

Project Selection

The second sets of scenarios were analyzed to determine what the effect would be if the prioritization of projects were changed to remove traffic volume on a roadway from consideration. The two project prioritization calculations used were:

- Standard RoadManager Benefit Value = (Average Daily Traffic x Estimate Life of Repair) / (PCI x Unit Cost of Repair)
- Modified Benefit Value = (1000 x Estimate Life of Repair) / (PCI x Unit Cost of Repair)

For both scenarios, the same budget, $4.65M/year +3% annually, was used.

After the scenarios were calculated, VHB looked at how much of the funding was allocated by the software into the Overlay and Reconstruction categories. The following chart shows the average annual amount allocated to the two major repair categories:

Table 10 - $4,650,000 /Year

Scenario	Overlay/ Mill & Overlay	Reclamation/ Reconstruction
Standard VHB Benefit Value	$9,595,000 (18%)	$43,712,000 (82%)
Modified (No Traffic) Benefit Value	$12,794,000 (24%)	$40,513,000 (76%)

The following tables show the budget, projected town-wide average PCI, and projected backlog of outstanding repairs for each year of a ten year analysis period for both of the funding levels.

Table 11 – RoadManager Standard Benefit Value

Plan Date	Budget	PCI	Backlog
Current		80	$43,138,000
2013	$4,650,000	82	$44,519,000
2014	$4,789,500	82	$45,608,000
2015	$4,933,185	82	$46,880,000
2016	$5,081,181	82	$46,374,000
2017	$5,233,616	82	$47,731,000
2018	$5,390,624	82	$50,174,000
2019	$5,552,343	81	$51,006,000
2020	$5,718,913	82	$51,608,000
2021	$5,890,481	81	$49,527,000
2022	$6,067,195	81	$49,628,000

Table 12 – Modified (No Traffic) Benefit Value

Plan Date	Budget	PCI	Backlog
Current		80	$43,138,000
2013	$4,650,000	83	$44,519,000
2014	$4,789,500	84	$48,481,000
2015	$4,933,185	85	$49,823,000
2016	$5,081,181	86	$57,205,000
2017	$5,233,616	87	$58,436,000
2018	$5,390,624	88	$60,956,000
2019	$5,552,343	88	$58,646,000
2020	$5,718,913	88	$57,989,000
2021	$5,890,481	88	$55,484,000
2022	$6,067,195	87	$52,680,000

The following charts display the trend in the projected PCI and Backlog for the analyzed funding levels.

Figure 18 – Projected Pavement Condition

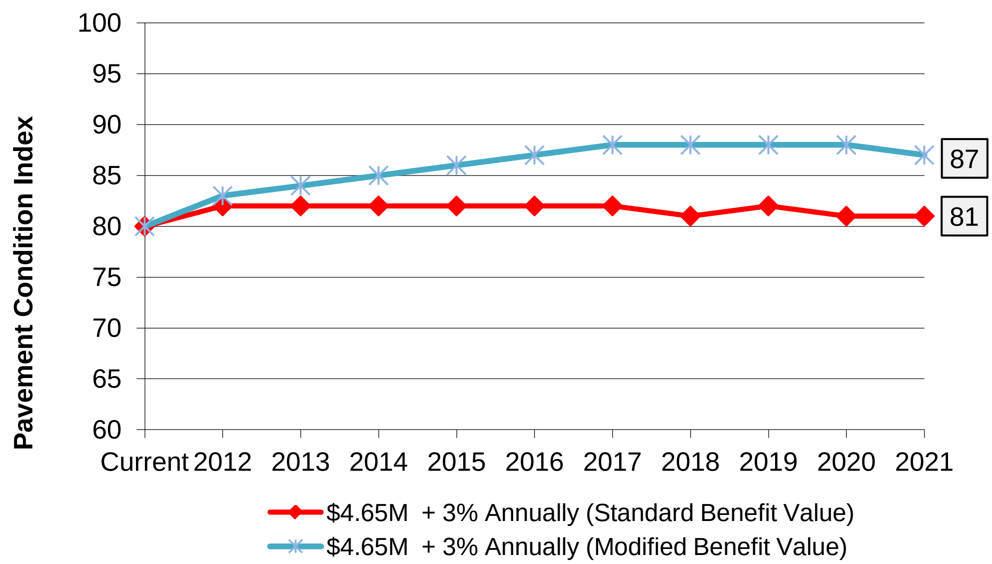
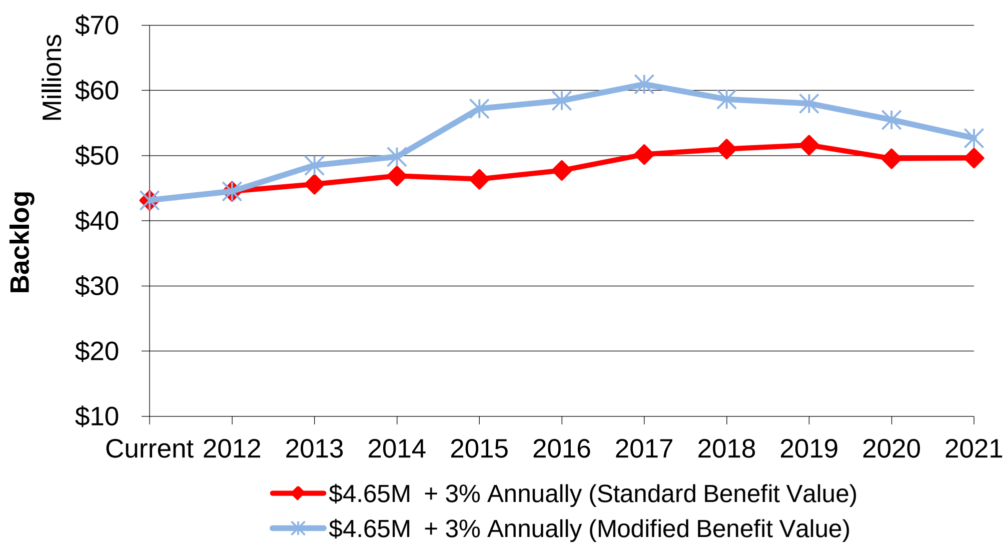


Figure 19 – Projected Backlog Summary



As shown in Figure 18, removing traffic volume from the prioritization of projects yields a significantly higher average PCI at the end of the 10 year anlysis period. In this model, pavement maintenance and rehabilitation priorities are weighted evently among all roads, such that, for example, an overlay on a local dead end road might receive the same or even higher priority as an overlay on the town's busiest collectors, based on condition and repair cost.

However, the modified approach allows a larger increase in dollar backlog of work. This would happen because less work performed on major roads would allow more of those roads to fall into deficient condition, and the rehabilitation of the major roads carries a significantly higher price tag than that of the local roads.

The philosophy behind the RoadManager Benefit Value approach is that keeping the roads used by the most people in the best condition will provide the most benefit to the Town. The analysis in this section shows that this comes at a cost of the overall townwide average PCI. It is up to Town decision makers to determine which approach will better serve the town's goals for its road network.

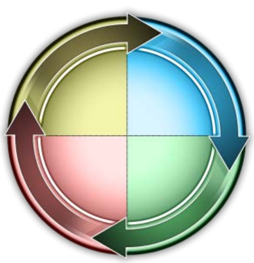
6

Concluding Remarks

The Town of Salem has a pavement management system based on road condition data and descriptive information collected in 2012. The Salem pavement management system gives Town decision-makers a picture of existing roadway infrastructure conditions and a dollar estimate to improve streets in poor condition while protecting those pavements already in good condition.

The Pavement Management System being implemented by the Town is a planning tool, with primary functions of determining the funding levels required to achieve Town wide condition goals, and to identify candidate road projects to achieve those goals. Any project list generated by the system needs to be reviewed by the Engineering Department staff and adjusted based on numerous factors, including coordination with utility work, and geographic issues.

Recommendations – *Pavement Management*



- Budget adequate funds to achieve pavement condition goals
- Make timely maintenance repairs
- Repair localized base problems before applying an overlay
- Address major rehabilitation needs as funding allows
- **Develop multi-year road programs**
- Coordinate with local utilities to perform upgrades and repairs in advance of projected construction projects
- **Perform project level testing prior to major rehabilitation projects to ensure proper life of new pavement**
- **Provide for construction inspection at the plant and in the field to ensure quality material is provided and quality work is being performed**
- Update database to reflect work that is done (maintains accuracy of system)
- Update pavement conditions at a minimum of every 4 years or 25%per year
- Track specific and overall conditions periodically
- **Evaluate funding levels periodically**

7

Appendices

Appendix A – Repair Alternatives

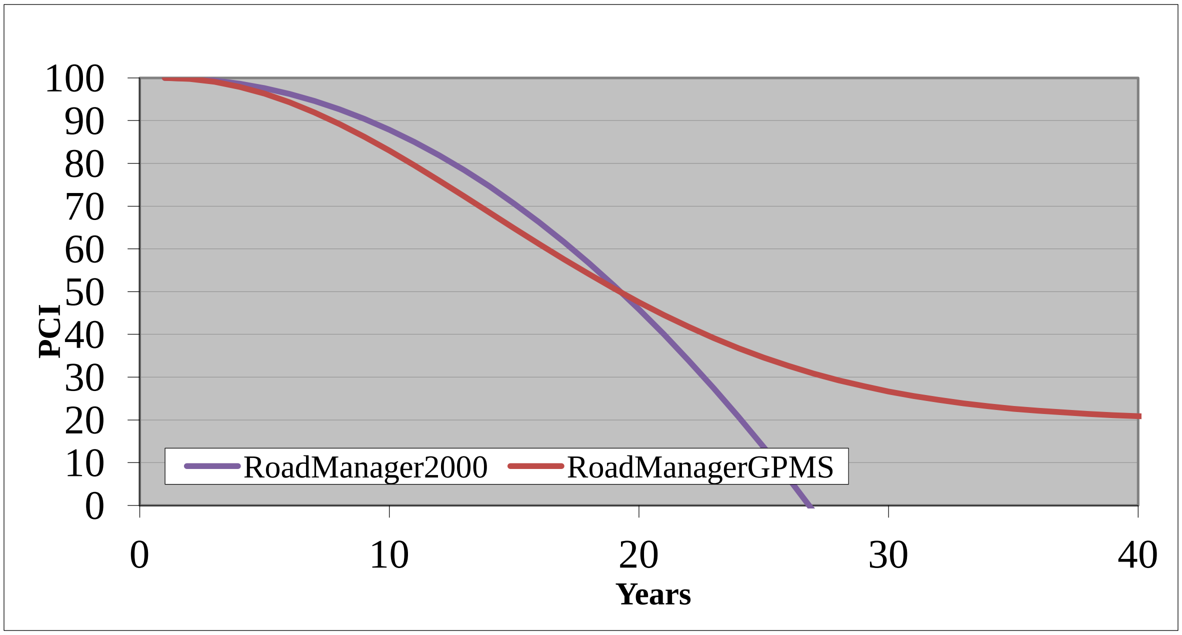
Unit Costs

Alternative Name	Treatment Band	Unit Cost (SY)
Reconstruct Operational Road with Curb and Sidewalks	Base Rehabilitation	$200.00
Reconstruct Operational Road	Base Rehabilitation	$137.50
Reclaim Operational Road with Curb and Sidewalk	Base Rehabilitation	$175.00
Reclaim Operational Road	Base Rehabilitation	$112.50
Pave Gravel Road	Base Rehabilitation	$125.00
Reconstruct Local Road	Base Rehabilitation	$80.50
Reclaim Local Road	Base Rehabilitation	$69.00
Mill/Overlay Operational Road	Structural Improvement	$13.00
Mill/Overlay Local Road	Structural Improvement	$11.00
Overlay Operational Road	Structural Improvement	$10.00
Overlay Local Road	Structural Improvement	$8.00
Preventative Maintenance (CrSeal, Patch or SurfaceTreat)	Preventive Maintenance	$2.50
Routine Maintenance (Crackseal)	Routine Maintenance	$0.75

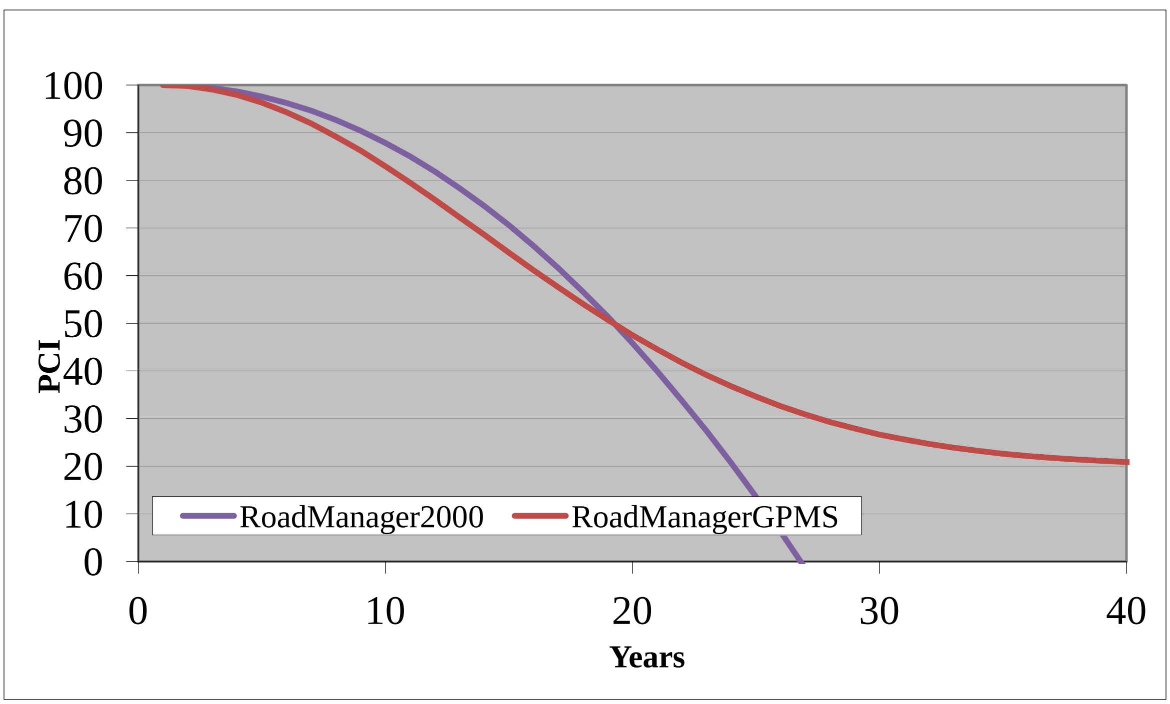
Appendix B– Deterioration Curves

The following graphics show the former and current pavement condition deterioration curves used by the town's pavement management system.

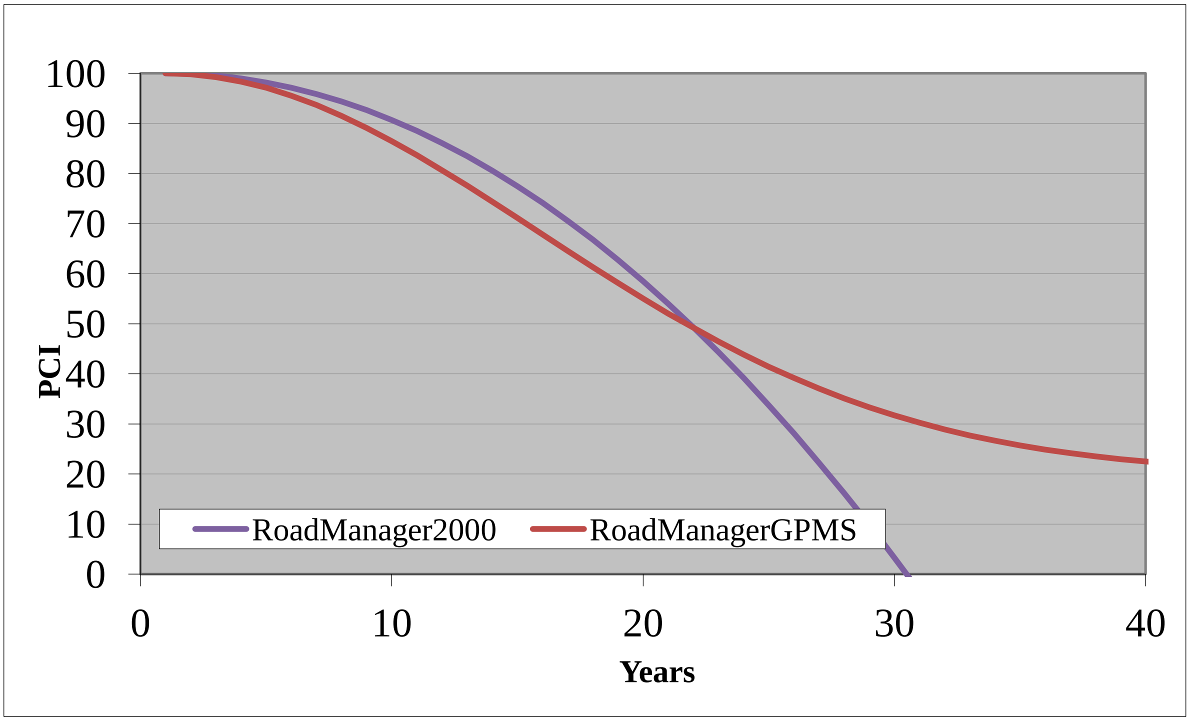
Arterials (Route 28)



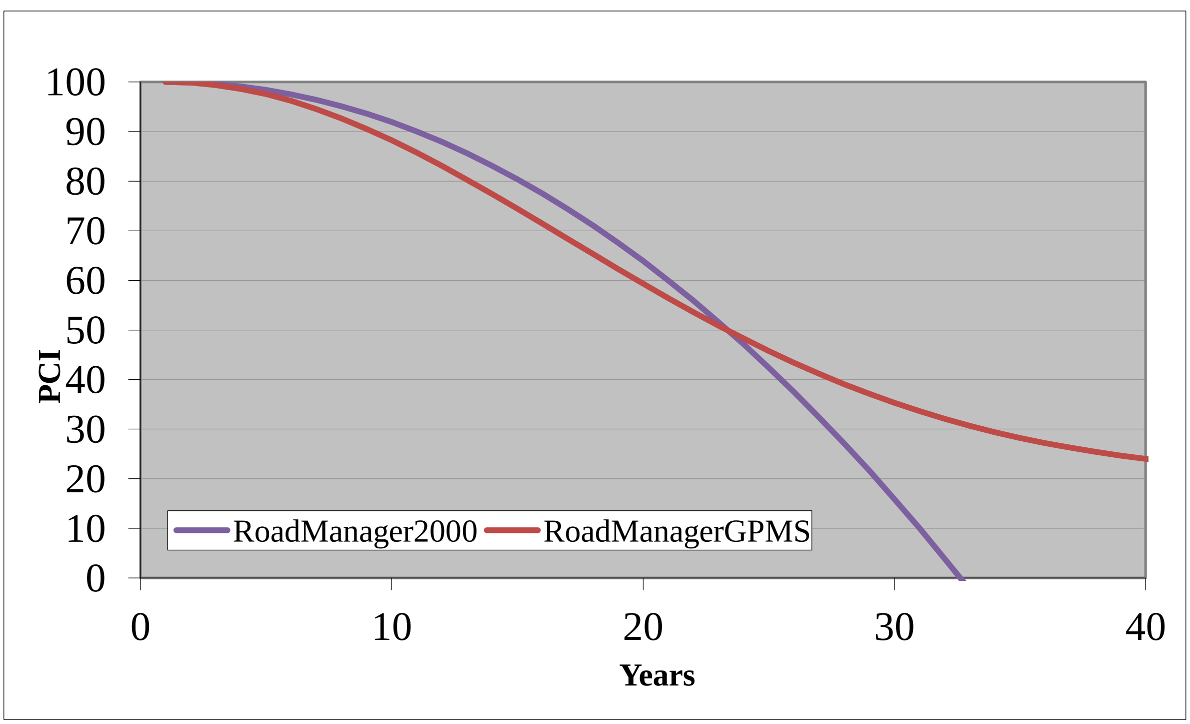
Collectors (Operational Roads except Rt 28)



Local- Through Roads



Local- Dead End Roads



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