City of Ridgecrest

Pavement Management System

FISCAL YEAR
2010 - 2011

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PART 1

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EXECUTIVE SUMMARY

In response to the need to protect the City's large capital investment in streets, the Ridgecrest Public Works Department retained Willdan to update the City's pavement management system (PMS). A PMS is basically a system designed to gather, store, and analyze data about the City's streets and provide a strategized program for implementing preventive maintenance and rehabilitation projects citywide. The PMS represents a proactive approach to maintaining the existing streets. It benefits the City by preserving investment on the roadways, enhancing pavement performance, ensuring cost-effectiveness, extending pavement life, and providing improved safety and mobility. Additionally, maintaining a fully implemented PMS protects the City's ability to acquire state and federal funding for street improvement projects. Virtually all funding sources require local agencies to plan and document ongoing maintenance of the funded street improvements. Including these streets in the City's PMS meets this requirement.

The City's street network represents one of the largest capital investments on the City's books. Currently in the pavement management system there is a total of 120.0 miles of streets with total replacement cost of $ 135,800,000 . The arterial and secondary street system in the PMS is set up to be consistent with the City's General Plan Circulation Element. In the City of Ridgecrest, there are 36.5 miles of arterial and secondary streets or approximately 9,230,000 square feet of such pavement. The total estimated replacement cost of just these streets would be in excess of $64,600,000 . There are few assets in the City's purview that rival these statistics. The sheer dollar value of the street system underscores the importance of maintaining a fully implemented PMS to protect this investment.

The City of Ridgecrest PMS has projected a total of 30.8 miles or 84.5% of the City arterial and secondary streets qualifying for major maintenance. This means that these streets are in need of rehabilitation such as an overlay or reconstruction. For collector and local streets, the PMS has projected 73.3 miles or 87.7% of all local streets in need of major maintenance. Coupled together there are 104.7 total miles of all streets or 86.7% of all streets qualifying for major maintenance at the present time. Some of these roadways are in the early stages of structural fatigue, while others are structurally sound but have severe raveling, patching or other distress that cause a very low PCI value that warrants major maintenance.

Present day estimated cost for performing the identified major maintenance for all arterial and secondary streets is $20,510,000 . The analogous figure for local streets is $30,670,000 . These figures include 15% contingency on the construction cost and 25% for engineering on that total. Cost figures used in this report are intended to cover budgetary considerations, and numerous undefined factors that lie between the PMS assessment and the time of construction.

The City has approximately $15 million in Redevelopment Agency Funds (available through the TAB program) that must be spent in the next three years. These funds have been included in the budget forecast modeling in the Findings and Recommendations section of this report. In addition, a prioritized street project by year listing has been included in the

Findings and Recommendations section of this report to assist the City in making the best use of these funds.

The following is a tabulated summary of the data figures explained above:

OVERALL INVENTORY

	Total Areas (SF)	Length (in miles)
Local/Collector Streets	15,824,000	83.58
Arterial/Secondary Streets	9,230,000	36.46
All Roadways	25,054,000	120.03

TOTAL REPLACEMENT COSTS

	Cost per SF	Total
Local/Collector Streets	$ 4.50	$ 71,208,000
Arterial/Secondary Streets	$ 7.00	$ 64,610,000
All Roadways		$ 135,818,000

MAJOR MAINTENANCE INVENTORY

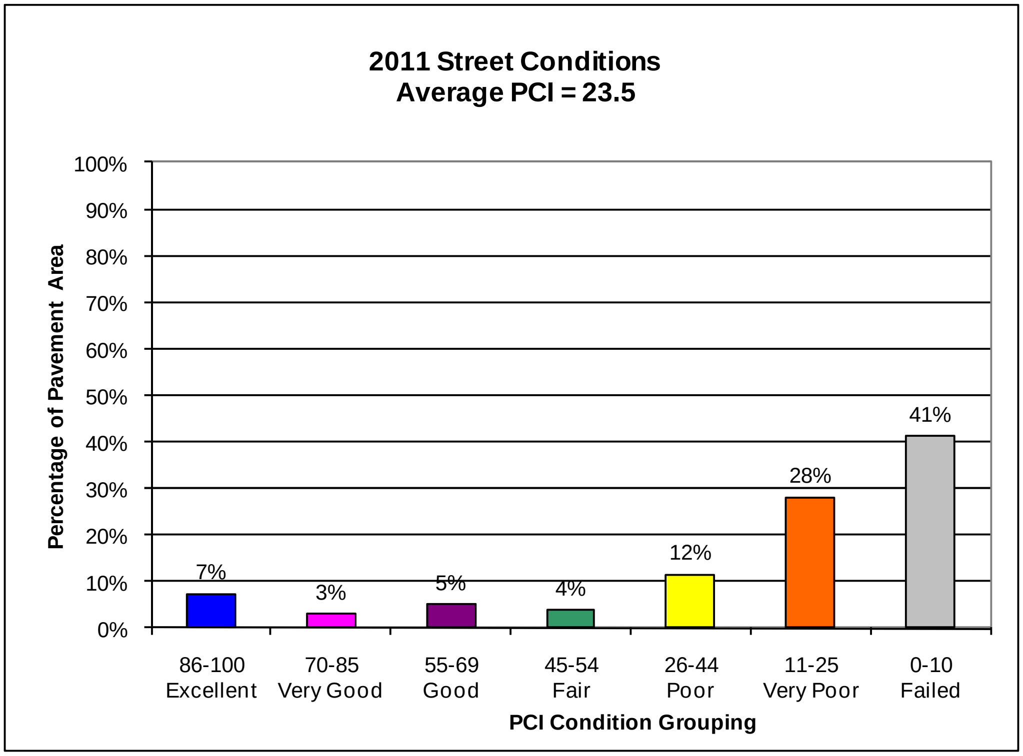
	Total Costs	Length (in miles)	Total (%)
Local/Collector Streets	$ 30,670,000	73.31	87.7%
Arterial/Secondary Streets	$ 20,510,000	30.79	84.5%
All Roadways	$ 51,180,000	104.10	86.7%

One index used to gauge the relative condition of the streets is PCI (pavement condition index), which is the conventional overall deterioration index provided in conformance with standard protocols of the U.S. Army Corps of Engineers (USACOE). There is also an SI, the structural index, which is similar to the PCI but focused solely on structural conditions. The SI provides a different perspective on street condition; it is a useful way to evaluate the cracking that usually drives the final decision to provide a structural upgrade (which normally takes the form of an overlay). The structural index often does not correspond very closely with the PCI because other distresses—such as surface texture, bumps, and utility cuts—can have a disproportionate impact on the PCI as compared to the SI. For example, a street with a midrange SI value of 75 may have a very low PCI value of 19. This means that this street segment does not have a lot of structural cracking; however it has significant levels of utility patching, surface raveling and/or poor ride quality which have lowered the PCI value. Using both PCI and SI indexes together in our decision process, it is apparent that a structural upgrade is a lower priority for this segment over another segment that has both a low SI and a low PCI.

The standard rankings for PCI values (per USACOE protocols) are stratified as follows:

PCI	From	To
Excellent	100	86
Very Good	85	70
Good	69	55
Fair	54	45
Poor	44	26
Very Poor	25	11
Failed	10	0

A graph of the PCI groupings for the City of Ridgecrest streets is shown on the next page. The overall average PCI is 23.5, which is considered “Poor” under the USACOE standard rankings. A PCI of 70 is considered a desirable level for an average PCI of street pavements, though most cities in Central and Southern California are near 60 and consider that to be a reasonable level. The Ridgecrest street network is in need of some significant funding commitments to bring the system up to an acceptable overall condition level.



SI values are computed by starting with a nominal value of 100 to represent a street with no cracking in the wheel path area, then subtracting the percentage of cracked wheel paths in a target segment. The results are arrayed as follows:
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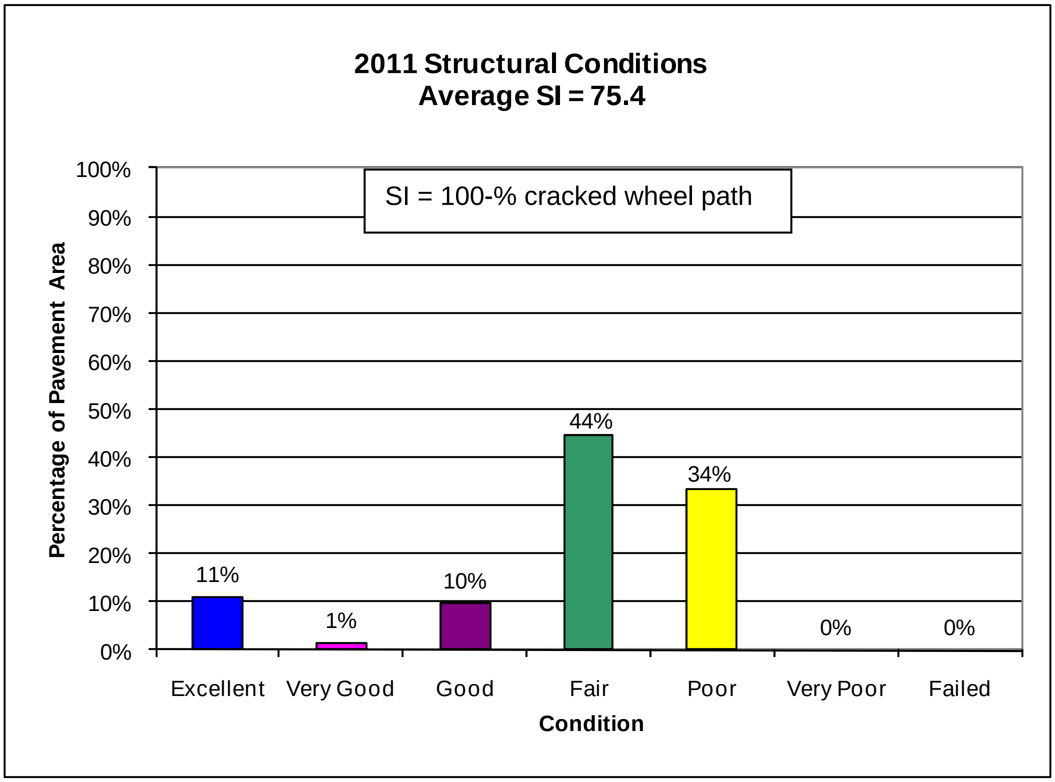
SI	From	To
Excellent	100	98
Very Good	97	95
Good	94	90
Fair	89	70
Poor	69	30
Very Poor	29	11
Failed	10	0

The current structural conditions of pavements in the street network can be represented by an average SI that ranges 0 to 100, and is normalized among all the streets in Ridgecrest by area of pavement. The more cracking that occurs, the lower the structural index becomes. The SI is equal to 100 minus the percentage of the wheel paths that are cracked, based on visual inspection. A graph of SI groupings for the City of Ridgecrest streets is shown below; the qualitative difference between the SI groupings and the PCI distribution is quite apparent when the SI results are compared to the PCI graph. The overall average SI for the streets in Ridgecrest is at 75.4 , which is considered “Fair” condition.

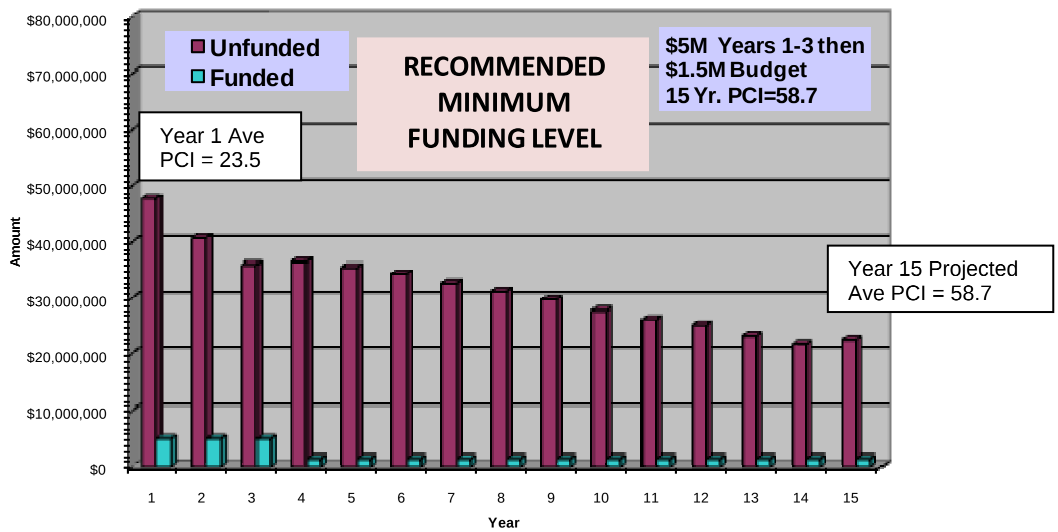


The structural distress on roadways within the City is a function of many factors, including age and traffic. Once a pavement becomes cracked in a traffic area, the structural deterioration accelerates. Stopping this process requires major maintenance, and identifying the needs and the optimal approach and timing to fill those needs is a primary function of the PMS. This is also the foundation for setting priorities in the system. The savings that can be attained by providing major maintenance before deterioration occurs is the basis on which priorities are founded. This benefit—divided by the cost of the major maintenance—normalizes the benefit and allows for comparison of one segment to another. This is commonly called the benefit/cost ratio.

The benefit/cost ratio is a rigorous engineering economics value derived by weighing benefit against cost; it indicates the annual return that would accrue by investing in the overlay at this time. For example, a benefit/cost ratio of 0.04 indicates that an overlay of that street would offer a return on the investment of 4% per year. Street deterioration accelerates over time, imposing greater costs for repairs made prior to any overlay, and also requiring thicker overlays. Avoidance of these extra costs by doing an overlay now (as opposed to later) is the "benefit" in the benefit/cost ratio.

An additional exhibit—one of the tools for optimizing budget planning—is provided below. This projection simply indicates the potential for long-term developments based on a particular budget strategy being applied to a set of major maintenance activities across corresponding PCI categories. The major maintenance needs are identified consistent with the Strategy Logic Tree criteria shown in Figure 2 of the Pavement Management Systems section of this report. A budget level of $5,000,000 in each of the first three years has been assigned in order to exhaust the $15,000,000 of available redevelopment agency funding before it expires. The 15-year projection graph shows by present value how a recommended annual budget of $5,000,000 in Years 1 through 3 and then $1,500,000 through Year 15 will reduce the work backlog, and result in a corresponding improvement in overall average PCI of the street network.

BUDGET FORECAST



This graph represents the results of an optimization of strategies and assignment of funds to various deterioration levels: (1) worst case; (2) rapidly deteriorating; and (3) just before start of rapid deterioration. The optimization process establishes two primary parameters to be used as a basis for the budget forecast. The first parameter is the PCI ranges that define the three deterioration categories. The second parameter is the proportions for assignment of budgeted funds. For this budget forecast model, the following PCI ranges and corresponding budget assignments were found to be the optimal parameters:

Assignment of Funds		Arterial and Secondary Streets PCI Ranges		Local and Collector Streets PCI Ranges	
Deterioration Category	**Portion of Budget**	**Upper PCI Limit**	**Lower PCI Limit**	**Upper PCI Limit**	**Lower PCI Limit**
Worst Case	15%	10	0	10	0
Rapidly Deteriorating	25%	45	11	40	11
Prior to Start of Rapid Deterioration	60%	60	46	50	41

The key goal of the budget forecast is to demonstrate a solid reduction of the unfunded major maintenance over time. Improvements in the PCI and SI will naturally follow along. Lowering the funding level significantly could lead to the accumulation of unsatisfactory levels of unfunded major maintenance in later years and corresponding low overall PCI and SI values.

Being a candidate for major maintenance does not necessarily mean a particular street is in bad condition; it only means the cracking on the street has reached a stage where a progression toward failure has begun. That progression runs for a long time on residential streets, normally a decade or two. In addition, the City of Ridgecrest has a number of streets that have a road mixed asphalt surfacing (RMAS), which generally return a low PCI value that indicates a need for overlay. After many years and a number of PMS updates, the approach to optimally deal with these streets will be worked out, as for the streets currently in need of maintenance that are identified in this report. Generally, RMAS can be prepared to serve as a good base layer to receive overlay and as such, these streets have been included in the major maintenance program for AC overlay based on their current PCI values.

By updating this report triennially, the effectiveness of the program can be maintained throughout succeeding years.

A more detailed discussion of the report findings can be found in the Findings and Recommendations section of this report.

GLOSSARY OF TERMS

AC: Asphalt concrete (normal material used to construct street pavement).


Alligator Cracking

ALLIGATOR CRACKING: Pattern of cracks usually 4 to 6 inches apart, resembling the texture of alligator skin.

ARAM: Asphalt-rubber and aggregate membrane is placed on a deteriorated street either by itself, with a slurry, or with an overlay on top. ARAM forms a layer that is highly resistant to cracks coming through it.

ARHM: Asphalt-rubber hot mix - similar to AC, but asphalt-rubber is used as cement instead of plain asphalt oil.

BACKLOG: Major maintenance work that is currently needed based on the criteria applied in the PMS decision tree.

BASE FAILURE: Area of alligator cracking deteriorated such that the support material underlying the pavement has been damaged and/or where the alligator pavement is loose without interlocking support.

CROWN: Where the central area of a street is high in elevation relative to edges of roadway.

INTERLIFT: A highly flexible rubberized asphalt concrete interlayer material between the overlay and the underlying existing pavement; it absorbs the stresses of reflection cracking such that the overlay experiences only low stresses. The material is ¾"-thick, and provides a structural element of that same thickness.

MAJOR MAINTENANCE: Includes any improvement to a pavement that adds significantly to structural strength. This usually involves adding a layer of asphalt. Reconstruction is included in the term major maintenance.

MINOR MAINTENANCE: Includes any improvements that generally do not add structural strength, such as crack sealing or slurry seals.

ORIGINAL CONSTRUCTION: Defined as that portion of the existing pave-ment that was constructed on the natural soil. (Each latest reconstruction project replaces the previous original construction.)

OVERLAY: A layer of AC or ARHM on existing pavement.

PCC: Portland cement concrete (normal concrete).

PCI: Pavement Condition Index. PCI values from 0 to100 indicate the overall condition of the pavement based on distresses, with 0 being extremely poor and 100 being excellent.

RAVELING: Pavement surface where fine rock particles in the AC have worn away, leaving larger rocks protruding with little surrounding support.

RECONSTRUCTION: Involves the removal of existing pavement and replacement with a new pavement.

RESTRUCTURING: Involves addition of layers of pavement that increase the structural strength without removal of the existing pavement.

RESURFACING: A supplemental layer of asphalt concrete placed over the existing pavement surface to restore the ride quality and/or add structural strength.

R-VALUE: The R-value (resistance value) is an index of the capability of a soil to resist deformations from wheel loads, beyond which the soil will not "spring back" to its original surface elevation. It ranges from 0 to 100.

SI: The Structural Index ranges from 0 to 100; an index of 100 means no cracking in the wheel path, and 0 means full wheel path alligator cracking.

STRUCTURAL SECTION: Includes all of the layers placed over the natural soil to form the actual structure of the pavement. This includes all aggregate base layers, asphalt concrete, Portland cement concrete, and structural interlayers.

TI: The Traffic Index is a numerical representation of traffic loading, but not simply traffic volume. It has a range from 4 for neighborhood streets to 12 or more for freeways. It is primarily dependent on the prevailing percentage of truck traffic.

USACOE: The U.S. Army Corps of Engineers.

WHEEL PATH: Area of the pavement where wheels of the predominant traffic pass directly over. See figure below.

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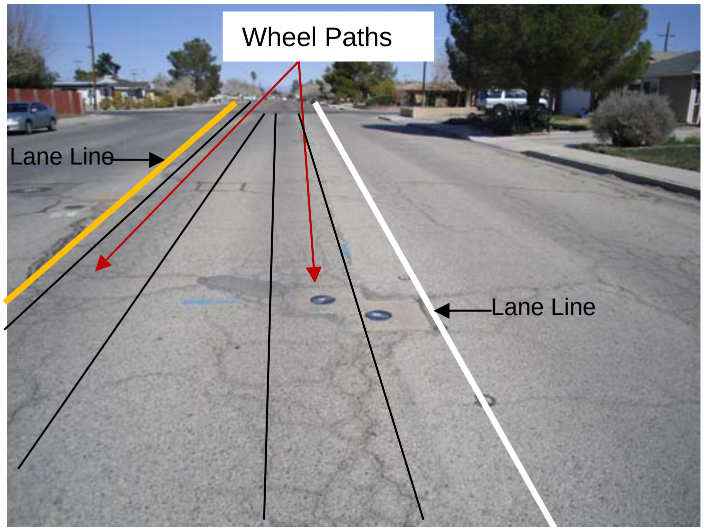


PAVEMENT MANAGEMENT SYSTEMS

INTRODUCTION

Nationwide, municipalities are faced with ever increasing street maintenance budget problems due to reduced availability of funds. The problem is compounded due to an apparent increase in the number of deteriorated streets each year and a disproportionate increase in the cost per mile for maintenance. The City of Ridgecrest has confronted this issue directly by developing a pavement management program to get ahead of these problems and avoid long-term budgetary difficulties.

Street pavement is one of the major capital investments of a municipality. It is also one of its most important assets. In the absence of a well-maintained street system, the transportation needs of the public, business, industry, and government cannot be met. Further, local real property values tend to be diminished by poorly maintained streets. Therefore, it is important that agencies at all levels of government develop improved means of allocating their limited financial resources to maintain street pavement.

A pavement management system (PMS) is being used increasingly by agencies as a way of meeting this need. PMS is not a new concept. It has been in use for many years, and has become fairly prevalent in public works administration.

The basic idea behind a PMS is to improve the efficiency and effectiveness of management decision-making in the allocation of limited funds for maintenance, resurfacing, and reconstruction of a community's roadway facilities.

A PMS is an orderly listing of all roads maintained by an agency and the condition they are in. This listing usually includes information such as the type of surface, condition of pavement, width of pavement surface, street length, and the most recent date of resurfacing or seal coating. A computer can sort this “databank” in a variety of useful ways. In addition, a PMS provides the means to assign meaningful priority rankings to projects and their associated costs to assist in multiyear programming and annual budgeting for maintenance and capital improvements. Once implemented, the PMS must be updated every three years in order to be an ongoing, effective management system.

HISTORY

Diminished funding, or a lack of funding increases, has caused cities to reevaluate their historical approach to pavement maintenance and seek other alternatives for pavement management. Earlier non-systematic approaches resulted in gradual overall deterioration and higher than necessary costs. Major backlogs of work were common.

Prior to the development of PMS, cities typically established yearly street maintenance budgets that emphasized maintenance improvements on a worst-case first basis, or in response to citizen complaints and political priorities. This approach worked satisfactorily for some communities, as long as sufficient funding was available. However, while funding sources dried up and maintenance budgets decreased or stayed constant, the need for improvements increased due to greater traffic volumes, aging of pavement and inflated material costs.

Instead of providing preventive structural maintenance at an early stage, streets were left untended until much more expensive reconstruction was needed. Unfortunately, the short span of extra service years (during the delay of maintenance) was purchased at a very high price in terms of increased structural upgrade costs. To orderly prioritize streets for maintenance at the earlier, cost-effective time, a PMS was needed.

Initial efforts to use PMS occurred in the late 1960s. The states of Texas and California were researching various uses of system procedures for application to pavement design and management. The first definitive publication on PMS was authored in 1973. By 1974, a number of states had initiated studies and developed programs designed to improve pavement management processes; they included simple database management programs. The Federal Highway Administration recognized the importance and benefits associated with the PMS concept and designated pavement management as an emphasis area in fiscal year 1979. That decision encouraged states and local agencies to review the PMS concept and appreciate its usefulness.

Every city and county in California has developed and is currently implementing some form of pavement management program.

A PMS DEFINED

In order to discuss the benefits and uses of a PMS, it is first necessary to understand the major components of PMS. The primary purposes of any PMS are to (1) improve the efficiency of making decisions; (2) provide feedback as to the consequences of these decisions; (3) ensure consistency of decisions made at different levels within the same organization; and (4) improve the effectiveness of all decisions in terms of efficiency of results. These all relate to maintaining good control over street maintenance. The general means for accomplishing these purposes include the following:

1. A systematic method for collecting and storing data.

2. A method to effectively analyze data.

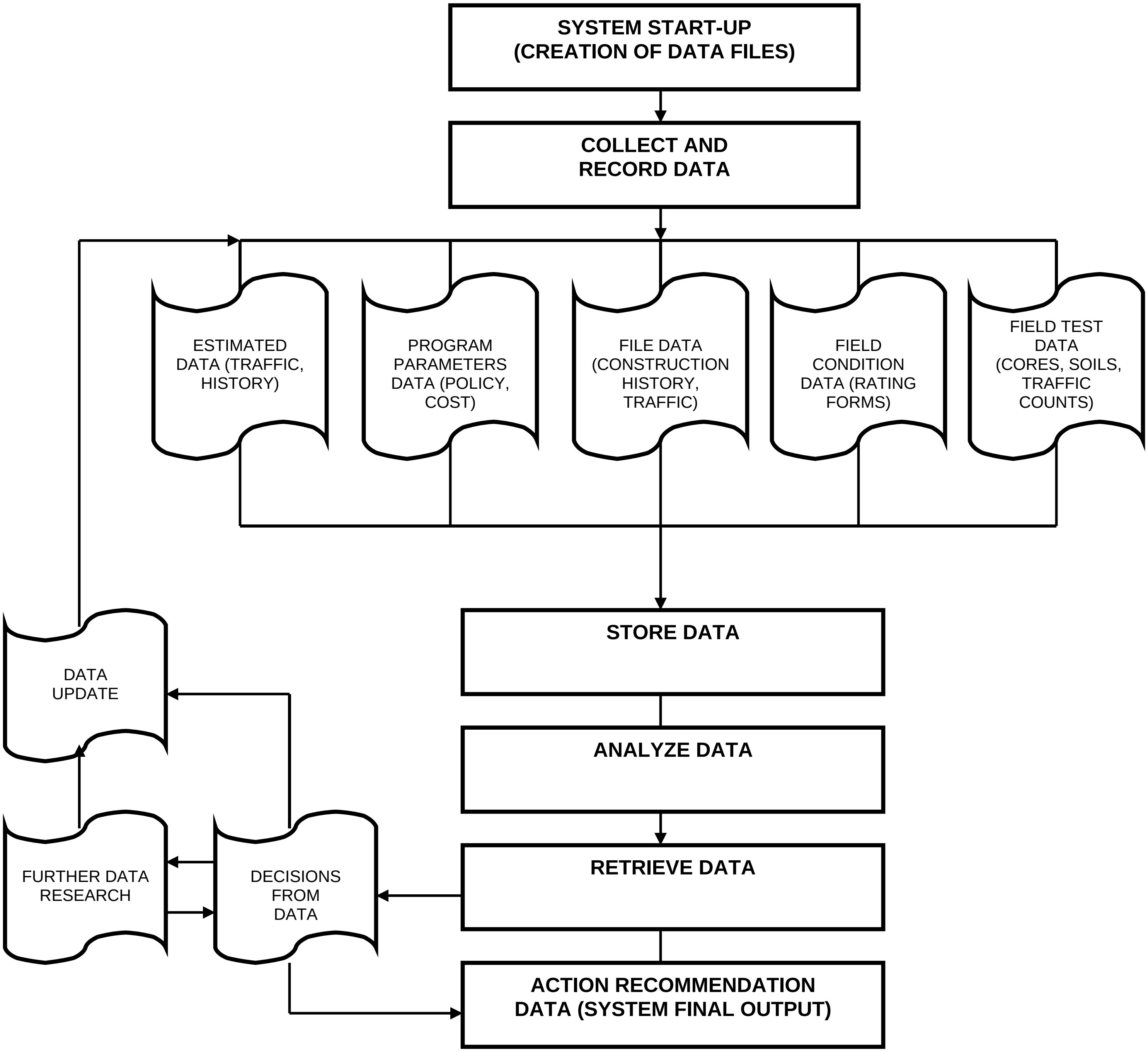
3. A process for retrieving data in a meaningful format.

4. Procedures for decision making based on objective data (often incorporating research outside of the system).

5. Procedures for updating the database (including data from outside research).

Figure 1 summarizes the general components of a PMS.

Figure 1. PMS Components



PROJECT SCOPE

A PMS developed for a city includes the arterial roadways that provide general traffic circulation within the city, as well as all paved local public streets. Basic PMS components are as follows:

- Data acquisition process
- Database
- Retrieval methods
- Analysis methods
- Updating procedures

The PMS database is established using a combination of field inventory and data research methods to develop the information needed for good pavement maintenance decision making. It includes a pavement condition survey and rating of every street to identify structural deterioration, surface deterioration/condition, ride quality, potholes, and related data.

Data is also compiled from record data on pavement width, length, structural sections, maintenance histories, and traffic conditions. One of the main benefits of the database is this inventory of streets.

The collected data, which forms the heart of the PMS, is stored on a computer for ease of database sorting, updating, and retrieval. The program readily operates on a personal computer.

Once the database is established, the data is used for analyzing each street (between major intersections, or in shorter segments when necessary); identifying pavement requiring major or minor maintenance; ranking the candidate projects; and formulating recommended annual programs based on different funding scenarios.

Updating the database and analysis of the resulting new information should be accomplished every three years in conjunction with the budget preparation process. A PMS developed for a city can easily be updated to reflect changed conditions, incorporate improvements undertaken during the intervening period, update cost factors, and develop new budget scenarios.

The following sections of the report provide a more complete description of (1) what a PMS is; (2) the methodology and information used to compile the City's database; (3) the data analysis program; and (4) the results of the analysis—including computer printouts of the various reports.

The Data

The effectiveness of any PMS is dependent on the data being used. Four primary types of data are needed: pavement condition ratings, costs, roadway construction and maintenance history, and traffic loading.

A major emphasis of any PMS is to identify and evaluate pavement conditions and determine the causes of deterioration. To accomplish this, a pavement evaluation system should be developed that is rapid, economical, and easily repeatable.

Pavement condition data must be collected periodically to document the changes of pavement conditions.

Typically, condition inventories are input, stored, and retrieved on a roadway segment basis. Segments are ideally defined as reasonably sized projects of 1,000 feet to a quarter mile in length, beginning and ending at intersections. Occasionally, varying traffic or construction history will make shorter segments necessary.

The maintenance costs used in a PMS usually include the best available information on the cost of activities normally conducted in the community. Costs are typically shown as total unit cost per square foot. Cost information must be easily updated to reflect current dollar values. The cost data is used to make estimates for maintaining a pavement at a given condition and for projecting long-range budgets, based on the condition of the pavement.

Additional data elements that can be used for pavement management systems include drainage conditions, roadway shoulder conditions, ride quality, utility cuts, and soil conditions. This listing is not meant to be exhaustive, since any other unique information or conditions can be included within the database. However, the extent of such additional data should be evaluated to assess its usefulness against the cost of collecting the information. It is important to keep in mind that a PMS is only as accurate and useful as the type and quality of data stored in the database.

Data Analysis

Having accumulated the information contained within the database, the next step was to proceed with analysis of the data. The data analysis phase involved the development of a computer program that utilized the database to determine project recommendations. The following discussion describes the components of the data analysis. The overall processing of information to attain the principal information that has the most useful value is shown in the flowchart (figure 2) at the end of this report section. The key elements of analysis are outlined directly below, with information that describes their meaning, usefulness, and how they are derived.

Data Retrieval

It is critical that the data be easily retrieved, and in such a format that it is meaningful. The computer has the advantage of permitting quick retrieval at a single source, plus the flexibility to display data in any format desired. A computer is essentially unlimited in its capacity to prepare tables, graphs, and charts. In comparison, doing the simplest tasks of this type from hard-copy files is very time-consuming.

The database can be used to answer specific questions at each level of decision making. Questions concerning the entire system, individual projects, or project implementation can be asked, and the PMS can provide answers. Such questions could include the following examples: What will be the effect and budget implications of increased improvement costs? If additional funding can be provided each year, what is the increase in number of streets improved?

A PMS can readily answer numerous questions of this type through straightforward manipulation of data. Usually a computer program is developed to array the retrieved information in the desired format.

Updating Data

An efficient procedure for updating the database must be included within the PMS. The procedures should easily update information on pavement conditions, pavement history, the cost of improvements, and traffic loading.

USE OF A PMS

With this understanding of the database in hand, an examination of the typical uses of a PMS can be undertaken. The material below briefly describes the main areas where a PMS is applied, and the benefits achieved from each.

Street Inventory

The most immediate use of the PMS is in having a complete and readily accessible inventory of the city's street system, including up-to-date conditions. This information is frequently very valuable for day-to-day use in tracking maintenance work, and as a reference source when preparing reports or studies.

Developing Maintenance Budgets

Rather than preparing the typical one-year maintenance budget, a PMS allows a city to prepare a series of budgets. These budgets can take the form of a multiyear program, identifying not only short-term (one-year) needs, but outlining needs over the course of many years. Further, alternatives or options can be prepared and presented to the budget decision makers.

Prioritization

A PMS allows for the prioritization of maintenance projects based primarily on condition ratings, but it also accommodates factors such as traffic and costs. The next step can be the selecting and ranking of projects for the upcoming budget year, as well as for long-term financial planning.

SUMMARY

The components and capabilities that are typically found in a PMS result in numerous benefits, including the following:

- An inventory of the street system
- Overall pavement condition ratings

- Annual budget estimates for various scenarios
- Project identification and ranking
- Improved decision making

Obviously, some of the benefits are more quantifiable than others. Nevertheless, implementation of a PMS results in improved pavement conditions and more effective use of limited funding resources.

THE RIDGECREST PAVEMENT MANAGEMENT SYSTEM

The Ridgecrest Pavement Management System (PMS) has four basic components:

1. Data collection and storage
2. Data analysis
3. Data retrieval
4. Data updates

These elements naturally give rise to further useful extensions, including (1) decision making based on data, and (2) outside research related to those decisions.

The system used to store and process data is MicroPaver. It is a useful system for storing PMS data and providing data output and certain types of reports. The Willdan system goes much further, extracting data from the MicroPaver database to allow for very specific and accurate assessment of street segments on a structural and financial basis—a capability that is not available in MicroPaver. Capital improvement reports generation is much more flexible and straightforward using the Willdan software.

The report sections that follow cover the four main forms of data handling in the Ridgecrest PMS.

DATA COLLECTION AND STORAGE

Parameters

The first step in developing the PMS for the City of Ridgecrest was to select specific fixed parameters under which the program would operate, such as construction inflation rates, the nominal design life spans of improvements, and strategies for overlays. This was done in consultation with the Director of Public Works, the City Engineer, the Engineering Technician, and the Street Superintendent at the outset of the project.

Pavement Condition Survey

Each paved City street within the City of Ridgecrest's existing PMS was visually surveyed to determine the condition of the pavement. The survey concentrated on identifying structural deterioration, which is the primary source of increased maintenance cost.

Over 590 rating forms were prepared for roadway segments within the City. These forms were later entered on a matching computer screen by a trained pavement technician. The information contained on the rating forms was used as part of the database system for the PMS.

<u>"As Built" and Maintenance History Records</u>

Historical files and records of streets within the City of Ridgecrest were acquired for the period since the last update, and also for many streets that existed but were not in the previous PMS.

Traffic Data

The Traffic Circulation Element of the City's General Plan and the City's Road Standards were used to assign a traffic index (TI) to each roadway segment of the City. Arterials have a TI = 10, Secondary streets have a TI = 8.5, Collector Streets have a TI = 7 and Local streets have a TI = 5. This information is important for determining the overlay thickness for major maintenance and the benefit cost ratio for priority.

Cost Data

Cost factors used in estimating the costs of improvements were determined from average recent construction bids on representative projects for each type of construction within this report.

All costs have been increased by 25% to account for engineering, construction inspection, and administration. An additional 15% was added for contingencies. See the "Maintenance and Rehabilitation Costs" and the "Unit Cost Calculation" spreadsheets on the following pages for details of the cost parameters.

The cost estimates used in the PMS are considered to be representative for the upcoming year. To give a general indication of future year's costs, an inflation factor of 3 percent has been included within the computer program to adjust for expected increases in cost.

To ensure accuracy for future program years, it is recommended that cost data be updated annually to give an accurate account of the fluctuations in construction costs.

A total cost for each segment is calculated by multiplying the area of pavement in the segment by the unit cost.

DATA ANALYSIS

Having accumulated the information contained within the database, the next step was to proceed with analysis of the data. The data analysis phase involved the development of a computer program that utilized the database to determine project recommendations. The following discussion describes the components of the data analysis.

CITY OF RIDGECREST
PAVEMENT MANAGEMENT SYSTEM
MAINTENANCE AND REHABILITATION COSTS

Legend:

LC	Leveling Course - AC 3/8" mix
Glassgrid	Rienforcing mesh w/glass fiber grid
AC	Convential Asphalt Concrete Overlay
Slurry	Type II emulsion aggregate slurry seal
HTF	High Tensile Fabric
CIR	Rienforcing mesh w/glass fiber grid
REJV	Rejuvinating seal coat
TC, SS, MH's	Traffic Control, Signing/Striping and Manhole raising
ARAM	Asphalt Rubber Asphalt Membrane (rubberized chip seal)
Interlift	Asphalt Rubber Asphalt Hot Mix 3/8" Mix
Lane Mile	Assumes 12' wide lane x 5280' in one mile

Base Rates:	$/sf	$/Ton or Notes
ARAM	$0.78	approx $7/SY
3/4" Interlift	$0.51	$110.00
Glassgrid	$0.50	$0.75/SF over 2/3 of road
1" AC	$0.49	$80.00
REJV	$0.24	City crew to do clean-up/TC, no striping
1/2" LC	$0.25	$80.00
R&R	$6.00	remove and replace
CIR	$1.00	cold in place recycling
HTF	$0.35	High Tensile Fabric
Edge Grind	$0.08	assume 1/4 sf grind/sf of street
Full Grind	$0.40	full width grind
Type II or RAP Slurry	$0.25	$375/ELT
Crack Seal	$0.08	Assumes $7K/day at 90K sf/day
TC, SS, MH's =	$0.58	Overlays only

Major Arterials and Secondary Streets (TI > 7)

MAINTENANCE

PCI Value	Street Condition	Treatment	Construction Unit Cost ($/sf)	Engineering & Inspection	Total Unit Cost ($/sf)	Lane Mile Cost ($/Lane Mile)	Assumptions
86-100	AC dry surface.	No Action	$0.00	0%	$0.00	$0	
85-92	AC dry surface with some raveling	REJV	$0.24	10%	$0.26	$16,727	City crew to do clean-up/TC, no striping
60-84	AC raveled or polished aggregate.	Slurry Seal	$0.25	20%	$0.30	$19,008	No R&R required

REHABILITATION (Bolded font strategies are implemented in the PMS Logic Tree)

PCI Value	Street Condition	Treatment	Construction Unit Cost ($/sf)	Engineering & Inspection	Total Unit Cost ($/sf)	Total Unit Cost ($/Lane Mile)	Assumptions
41-59	SI < 80; Substantial Wheel Path Alligator Cracking < 6% of Total Area	**2.5" AC Overlay**	**$2.41**	**25%**	**$3.01**	**$190,960**	**2% R&R Required**
26-40	SI <40; Extensive Wheel Path Alligator Cracking > 6% & Base Failure < 3.5% of Total Area	**2.5" AC Overlay**	**$2.50**	**25%**	**$3.13**	**$198,088**	**3.5% R&R Required**
11-25	SI <20; Extensive Wheel Path Base Failure > 3.5% But < 7% of Total Area.	Interlift+2" AC	$2.67	25%	$3.34	$211,717	2% R&R Required
		LC+ARAM+2" AC	$3.19	25%	$3.99	$252,736	2% R&R Required
		LC+Glassgrid+2" AC	**$2.91**	**25%**	**$3.64**	**$230,560**	**2% R&R Required**
0-10	Serious Overall Structural Failure; Wheel Path Base Failure > 7% of Total Area	**CIR+2" AC**	**$3.03**	**25%**	**$3.78**	**$239,712**	1% R&R required

Residential, Minor Collectors and Rural (TI ≤7)

MAINTENANCE

PCI Value	Street Condition	Treatment	Construction Unit Cost ($/sf)	Engineering & Inspection	Total Unit Cost ($/sf)	Total Unit Cost ($/Lane Mile)	Assumptions
86-100	AC dry surface.	No Action	$0.00	0%	$0.00	$0	
71-85	AC raveled or polished aggregate.	Slurry Seal	$0.25	20%	$0.30	$19,008	No R&R required
51-70	AC block cracking and raveled or polished aggregate.	Slurry Seal	$0.25	20%	$0.30	$19,008	No R&R required

REHABILITATION (Bolded font strategies are implemented in the PMS Logic Tree)

PCI Value	Street Condition	Treatment	Construction Unit Cost ($/sf)	Engineering & Inspection	Total Unit Cost ($/sf)	Total Unit Cost ($/Lane Mile)	Assumptions
41-50	SI>30; Substantial Wheel Path Alligator Cracking Less Than Approx. 6% of Total Area	ARAM+2" AC	$2.56	25%	$3.20	$202,708	1% R&R Required
		2.5" AC Overlay	**$2.09**	**25%**	**$2.61**	**$165,220**	2% R&R Required
21-40	SI>20; Extensive Wheel Path Alligator Cracking >6% of Total Area & Base Failure < 3.5% of Total Area: Block Cracks smaller than 6' diameter or severe edge cracking over 40%	LC+HTF+2" AC	$2.42	25%	$3.02	$191,532	3% R&R Required
		LC+ARAM+2" AC	$2.73	25%	$3.41	$216,084	1% R&R Required
		2.5" AC Overlay	**$2.15**	**25%**	**$2.68**	**$169,972**	**3% R&R Required**
10-20	Extensive Wheel Path Base Failure > 3.5% But < 7% of Total Area.	**2.5" AC Overlay**	**$2.27**	**25%**	**$2.83**	**$179,476**	**5% R&R Required**
0-9	Serious Overall Structural Failure; Wheel Path Base Failure Greater Than 7% of Total Area	**CIR+1.5" AC**	**$2.78**	**25%**	**$3.48**	**$220,176**	**1% R&R required**
		ARAM + Slurry	$1.03	18%	$1.22	$77,008	Cost Saving Alt. (stop gap)

CITY OF RIDGECREST
PAVEMENT MANAGEMENT PROGRAM
CONSTRUCTION UNIT COST BREAKDOWNS

The construction unit costs indicated on the "Maintenance and Rehabilitation Costs" spreadsheet combine several cost factors to come up with one price per square foot that includes everything that will be needed to accomplish the chosen treatment strategy. The following are example calculations to show how the Unit Cost figures are obtained:

EXAMPLE NO. 1

Treatment = 2.5" AC Overlay- **Arterials and Collectors (PCI 26-40)**

This strategy includes placement of an overlay of 2.5" thick asphalt concrete (AC). The unit cost breakdown includes full width grinding of the street, crack seal, removal and replacement of failed areas (R&R), traffic control during construction (TC), raising of manholes (MHs) and restriping (SS).

Item Description	Unit Cost $/sf	Notes
Crack Seal	$0.08	Based on cost of approx. $5K per day, completing 90K SF per day
Grinding	$0.40	Assumes full width grind
2.5" AC	$1.23	2.5 times the 1" AC $/sf (based on $80/ton)
3.5% R&R	$0.21	Assumes 3.5% of pavement area is failed
TC, SS, MHs	$0.58	Based on cost of approx. $16 per linear foot of street
TOTAL =	**$2.50**	Construction unit cost per square foot of street pavement

EXAMPLE NO. 2

Treatment = 2.5" AC Overlay - R**esidential and Collector (PCI 41-50)**

This strategy includes construction of a 2.5" thick asphalt-concrete overlay, including crack fill, edge grinding both sides of the street plus header grinds where the overlay joins existing pavement. The unit cost breakdown will include edge grinding, removal and replacement of failed areas (R&R) and Traffic Control, Signing/STriping and raising of Manholes and water valves.

Item Description	Unit Cost $/sf	Notes
Crack Seal	$0.08	Based on cost of approx. $5K per day, completing 90K SF per day
Grinding	$0.08	Assumes edge grinding area is equivalent to 1/4 of street pavement
2.5" AC Overlay	$1.23	2.5 times the 1" AC $/sf (based on $80/ton)
2% R&R	$0.12	Assumes 2% of pavement area is failed
TC, SS, MHs	$0.58	Based on cost of approx. $16 per linear foot of street
TOTAL =	**$2.09**	Construction unit cost per square foot of street pavement

Strategies

Roadway conditions vary in the City of Ridgecrest and, therefore, a system for grouping street segments with similar conditions was needed to provide for assignment of appropriate maintenance treatments. Street condition groupings are determined by the extent of structural failure and other deterioration factors. The condition groupings and their corresponding strategies for major maintenance are shown in figure 2, at the end of this section. Once strategies were assigned to each of the various condition states, base costs were determined for the construction activities to be used.

The assigned strategy is a general representation of the type of improvement that may be undertaken for each segment in order to arrive at estimated improvement costs. The final scope of improvements for any segment would have to be determined through more detailed field investigation and engineering analysis, including soils investigations. The actual costs of construction will vary from these estimates, though on average any variations would be insignificant for a group of streets.

The strategy assignment is based on a combination of PCI and SI considerations, along with reconstruction repairs. There are cases where a low PCI can be associated with a high SI and an overlay would be inappropriate. The inverse also occurs occasionally. Potentially excessive reconstruction repairs sometimes make it more economical to shift strategies—regardless of the PCI and SI values.

Priority

The calculation of project priorities requires a sophisticated algorithm that determines the benefit/cost ratio for each segment. The benefit/cost ratio is the engineering economics method used to prioritize streets relative to each other, comparing them in terms of their relative advantage. This comparison provides a sound economic basis for decision making, and that is precisely what the Ridgecrest PMS does. The estimated increase in cost per year due to delay of major maintenance is divided by the cost of the applicable major maintenance overlay. This yields a number that represents an annual return on an investment in the street overlay—that is the benefit/cost ratio for the segment.

The calculation of PCI also uses a highly sophisticated algorithm, one that assigns points that are to be *deducted* from a starting maximum score of 100 (for a street in excellent condition in every respect). These “deduct” points are assigned individually, one set for each of three severity levels (low, medium, and high) for each type of deterioration. For example, alligator cracking is one type of deterioration. The quantity of each level of deterioration (low, medium, and high) is stored separately. Quantities of 15 types of deterioration are stored in a similar manner. This is the same method used in the USACOE standard protocols, and by many other agencies nationwide. It provides a perspective on the general overall condition of the roadway, based on all pertinent factors. It is not used for establishing priority directly; however, it could be used to trigger an overlay when PCI becomes very low.

The PCI algorithm assigns deduct points for each severity level of each deterioration type. The sophistication of the USACOE system is in the way these points are combined; the total deduct points never reach 100, so the final PCI is never less than zero. Willdan has enhanced this system such that the principal driver of PCI is cracking in the traffic area.

Other factors still have a major effect on the final value. This ensures that the primary consideration is once again the potential financial loss that will occur if cracked pavement is allowed to completely fail under traffic loads. When that happens full pavement reconstruction is necessary, which generally costs three times the cost of pavement restructuring performed *prior* to failure.

A third way to view the priority of pavements is the SI value. This is the way people first see the need for an overlay—by looking at the cracks in the road. It is a very effective way to assess the need for an overlay, but the benefit/cost ratio is preferred for setting the ultimate priority, because of economic and traffic factors that are not obvious based on cracking alone.

Minor Maintenance Priority
The need for minor surface maintenance is established by two factors:

1. The raveling off of fine aggregate particles from the surface due to weathering.
2. Aging in general, including weathering.

The minor maintenance treatment is usually a Type I or Type II slurry, though other techniques such as a rejuvenator or fog seal can be elected. All streets designated for minor maintenance in Ridgecrest are rejuvenator or slurry projects. It should be noted that concrete (PCC) pavements are not compatible with seal coats.

Crack filling is not recommended with slurry seals unless the crack fill is applied at least eight months in advance—including a full summer season. The crack filler can disrupt the thin hard layer of the slurry, often yielding multiple hairline cracks and other distortions of the uniform slurry coating. In warm climates, uncured crack filler commonly flushes through the slurry after a few years, creating a dark black strip along the crack. It contrasts sharply against the lighter gray color of the slurry. If instead the cracks are blown clean of debris and dirt just prior to slurry, the slurry will fill the cracks and yield a uniform surface. The only imperfection will be a single hairline crack that returns within a few weeks.

However, if the crack filler is allowed to cure prior to slurry, there are application methods that can provide an essentially crack-free pavement without the black lines reflecting through. In this case, there are two particularly good products to use for slurry: a TRM slurry seal (TRMSS), or recycled asphalt pavement slurry (RAP slurry). The TRMSS is the same as conventional slurry, except the binder that is used is TMAC binder as specified in the *Standard Specifications for Public Works Construction* (*Greenbook*). It is an asphalt rubber binder that stays dark much longer, and it is more compatible with the crack fill material. The RAP slurry uses recycled asphalt pavement as its aggregate, instead of new rock. Therefore the asphalt oil is very uniformly applied through the depth of the slurry coat, causing the black appearance to last longer than conventional slurry. Since the price for Type II or RAP slurry is about the same, the PMS just uses one maintenance cost and projection for slurry seal. The City may choose which application it prefers on a project-by-project basis. However, the TMAC-based TRMSS will cost approximately 40% more than the Type II or RAP slurry.

The minor maintenance program prioritizes streets first based on slurry, then rejuvenator, but with both of these treatments applied to arterials ahead of local streets.

Cost

The Willdan system calculates the required overlay thicknesses based on pavement conditions and traffic. The overlay thickness plus the actual reconstruction repair quantities extrapolated from field survey data are then used to calculate the overlay cost of each roadway segment. Other costs such as cold milling and interlayers do vary between streets, so those are incorporated individually into the cost calculation also. This is the process used in producing the major maintenance inventory and budget reports. The great benefit here is that budgetary planning in the short term of three years is reliable and accurate, producing a cost-effective program of expenditures. The calculation of the benefit/cost ratio uses the same data.

Given the volatility of asphalt prices in recent years, the Public Works Department also requested a formula that could be used to adjust rehabilitation costs based on this variable. We recommend using the California Statewide Paving Asphalt Price Index (API) available at the Caltrans Division of Engineering Web site located at http://www.dot.ca.gov/hq/esc/oe/asphalt_index/astable.html The adjustment should only be considered when the API has increased by more than 10% from the current index. January 2011 API is reported to be 474.3. Using this figure, a price adjustment can be calculated using the following formula:

Cost Adjustment (\$/sf) = $5.15(I_u/477.1 - 1.10)$

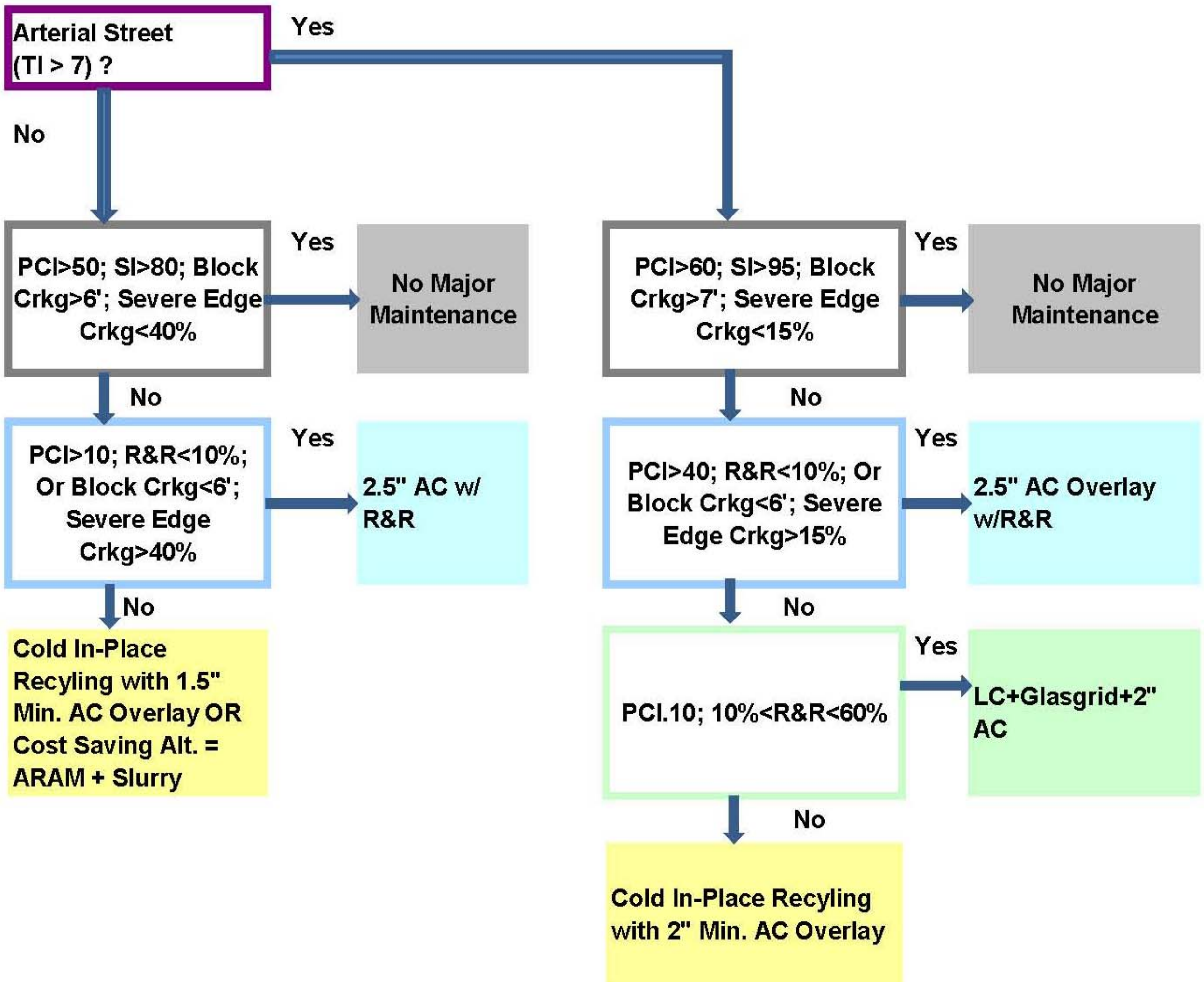
Where I_u = The current month Statewide Paving Asphalt Price Index per website noted above. Any price adjustment is based on an API increase of over 10%.

The resulting adjustment figure should be rounded to the nearest cent and multiplied by the total square footage of pavement that is to be rehabilitated to determine the additional cost associated with a particular fluctuation of paving asphalt prices.

Figure 2

CITY OF RIDGECREST PAVEMENT MANAGEMENT REPORT

STRATEGY LOGIC TREE FOR MAJOR MAINTENANCE



LEGEND

TI = Traffic Index. Indicates level of traffic loading. Typical range is 4.5 (low loading/cul-de-sac) to 11 (high loading/arterial).

PCI = Pavement Condition Index
Indicates overall pavement condition based on observed distresses.
0 = Failed to 100 = Excellent

SI = Structural Index
Indicates amount of wheelpath that is cracked. 100 = no wheelpath cracking.
Calculation: 100-% wheelpath cracked
Example: SI =60 indicates that 40% of the wheelpath is cracked (100-40 = 60)

LC = 1/2" Leveling Course

Glasgrid = Reinforcing mesh w/glass fiber grid for adding tensile strength to mitigate reflective crack patterns

Cold In-Place Recycling = Grinding, cold recycling and repaving existing AC section only in place. Does not enter base section. Remove and replace failed base sections in advance.

DATA UPDATE

The budget projections are considered to be relatively accurate for the first year, and to a lesser extent for the second and third years. Projects requiring minor or major maintenance will increase in cost-effectiveness as years go by. Updating the PMS every three years will automatically shift priorities and bring all factors within good relative accuracy. Updated cost values must be programmed into the system as part of each update.

The updating of the system should include a review of the pavement condition data and incorporation of any revised data on the soil type, traffic conditions, and changes in structural section and surface treatment of each street segment.

OTHER TOOLS

Pavement management systems are highly technical in their application strategy. The Public Works Department is often challenged to communicate its technical decisions to very nontechnical audiences. For this reason, we have included the following simplified priority matrix as an additional tool for the presentation of PMS priorities. This chart emphasizes the relationship of average daily traffic volumes (ADT) and PCI values as a basis for assignment of rehabilitation priority.

PAVEMENT MANAGEMENT PRIORITY MATRIX

PCI / ADT	≥70 & <92	≥40 & <70	<40
≥5000	**1**	**3**	**6**
<5000 & >=3500	**2**	**5**	**9**
<3500 & ≥1000	**4**	**8**	**10**
<1000 & ≥100	**7**	**11**	**12**
<100	**13**	**14**	**15**

ADT = Average Daily Traffic count
PCI = Pavement Condition Index

This chart denotes a simplified priority matrix that emphasizes the relationship of traffic loading (ADT) to pavement distress (PCI) as a basis to assign maintenance and rehabilitation strategies. Note:

1) Priority number 1 indicates the highest priority, whereas 15 is the lowest priority.

2) The highest priority is assigned to high volume streets in good condition, as applying maintenance to streets that are still in a state of good repair is the most cost effective pavement management funding allocation

3) Streets that have fallen into a state of significant disrepair require the most costly rehabilitation or reconstruction have lower priority relative to streets that are in good condition and require maintenance or streets in fair condition and are just about to start the process of rapid deterioration.

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PART 2

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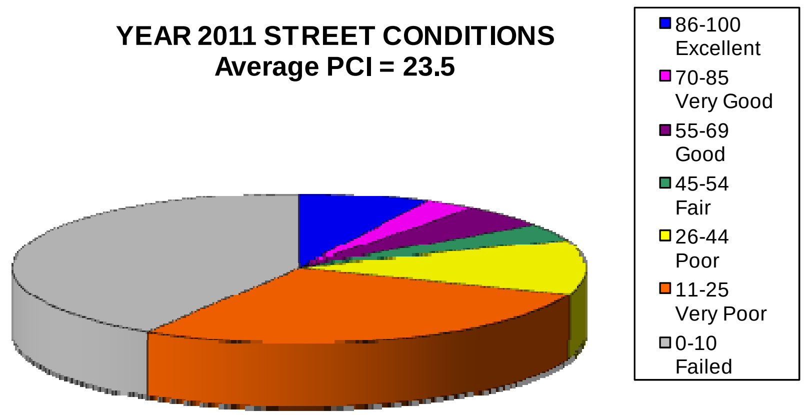
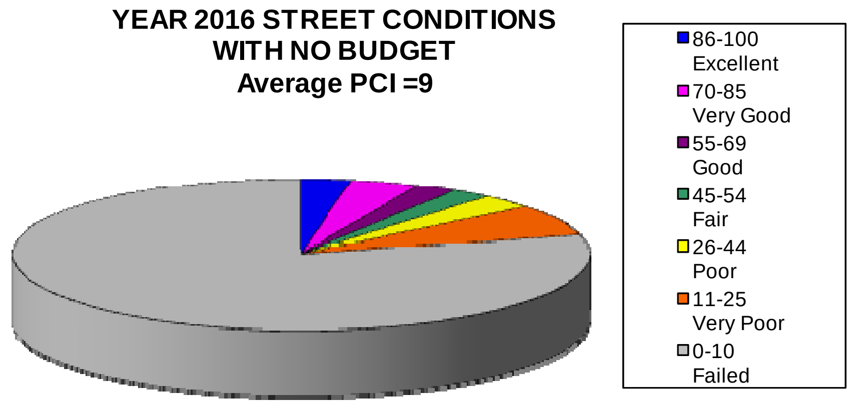
FINDINGS AND RECOMMENDATIONS

1. There are 120.0 miles of streets in the City of Ridgecrest, which includes all public streets. The total pavement area is 25,054,000 square feet. The length of arterials is 36.5 miles and the area is 9,230,000 square feet. Total arterial replacement value is estimated at $64,600,000 .Based on the field survey ratings and analysis of the available data, the pavement on the majority of streets is characterized as being in very poor to failed condition. Based on PCI value, the progressive deterioration will leave 79% of the streets in failed condition if nothing is done over the next five years, as indicated on the following table and pie charts:

PCI Ranges - Table A

	86-100 Excellent	70-85 Very Good	55-69 Good	45-54 Fair	26-44 Poor	11-25 Very Poor	0-10 Failed
2011	7.4%	2.9%	5.0%	3.8%	11.6%	28.1%	41.2%
2016	2.8%	3.9%	2.3%	2.2%	3.0%	6.7%	79.0%





This information is also shown in histogram format in graphs 1 and 2 in the Future Projections section of this report.

2. The major maintenance needs result from extensive cracking or failing RMAS which in nearly all cases can be satisfied by restructuring with a normal AC overlay after possible pretreatment. The Major Maintenance Inventory report includes 104.1 miles of streets needing an overlay (which is 87.2% of all streets), at a total estimated cost of $51,180,000 .

3. Arterial and secondary streets are especially important, because once they begin to crack, the progression to complete failure is very rapid compared to residential streets. There are 30.8 miles or 84.5% of all arterial/secondary streets in a condition making them potential candidates for overlay, with a total cost of $20,510,000 .

4. As discussed in more detail in the Future Projections section of this report, the recommended level of funding is $5,000,000 in each of Years 1 through 3, then $1,500,000 per year. This will provide for a solid decrease in unfunded major maintenance over 15 years and provide a marked improvement in overall pavement conditions. Lowering the funding levels significantly could lead to unsatisfactory levels of unfunded major maintenance in later years.

5. There are 8.5 miles of local streets that are candidates for minor maintenance, or 10.2% of all streets, at a total cost of $845,400 (based on using Type II or RAP slurry). The slurry candidates frequently have singular (block-type) cracks. It is recommended a banded crack fill about 1/8"-thick and 2-inches wide be applied over all such cracks at least eight months ahead of the slurry application, followed by use of a RAP slurry. If this is done, even hairline cracks will not reflect through the slurry and the extended cure time will prevent the crack filler from bleeding through the slurry.

6. The prioritized major maintenance listings in the appendices can be utilized to prepare a street rehabilitation program that takes advantage of all of the street condition information that this PMS has documented. The dedicated funding levels for each program year should be applied to the major maintenance priority lists based on benefit cost ratio, and then adjusted to reduce priority on streets that have a high benefit cost ratio and also have a relatively high SI value. The streets with higher SI values would be moved down in priority in favor of prioritizing streets with lower SI, even though they may be residential and therefore show a lower benefit to cost ratio. The readily available benefit to cost, SI and PCI values allow the Engineer to customize the program as appropriate.

IMPLEMENTATION

The main function of the pavement management system is to support the implementation of capital improvements such that every dollar spent is maximized toward extending the life span of the street network. Each year the maintenance inventory reports can be used directly as a guide to budgeting funds for the following year. Use of the major maintenance map, the SI map, the PCI map, and the construction history map can be very effective in identifying areas of local streets to target for an overlay project. The color-coding on these maps indicates the various parameters.

To facilitate assessment and selection of overlay projects, listings of major maintenance requirements are provided in prioritization order based on three different priorities. The economic basis is by benefit/cost ratio. Another important way to view priorities is on a structural basis, and that is provided by the prioritized listing by structural index, or SI. Finally, there is the PCI listing, which is a view of overall conditions. It includes utility cuts, bumps and sags, patches, and a host of other miscellaneous potential distresses, averaged in with structural factors. Sometimes an overlay may be driven by a very low PCI, but typically only on very old residential pavements.

Though the report is a powerful tool for planning and budgeting, there are always special considerations, such as aesthetics, which the PMS cannot always incorporate fully into its prioritization method. The City is not bound by the recommendations of the PMS. Projects can be manually added to or deleted from the list of recommended projects at any time.

Updates of the PMS should be performed every three years on arterial streets due to the rapid deterioration that can occur under heavy traffic. An arterial can slip from “marginal” to “seriously deteriorated” in just a few years, and resultant cost increases can be substantial. To maintain the key goal of maximum cost-effectiveness of funding, the data must be kept reasonably current. Changing pavement conditions have a major effect on costs and priorities, so local streets also need to be updated on a regular basis—at least every six years.

When design plans are prepared for each street, the details of the strategies for maintenance are refined based on testing and more involved calculations, using the more precise test data. Special factors also must be considered on some streets where these factors affect the roadway design. Drainage is the most common factor of this type. It can influence the design such that a street may need reconstruction instead of an overlay to change the drainage characteristics of the roadway.

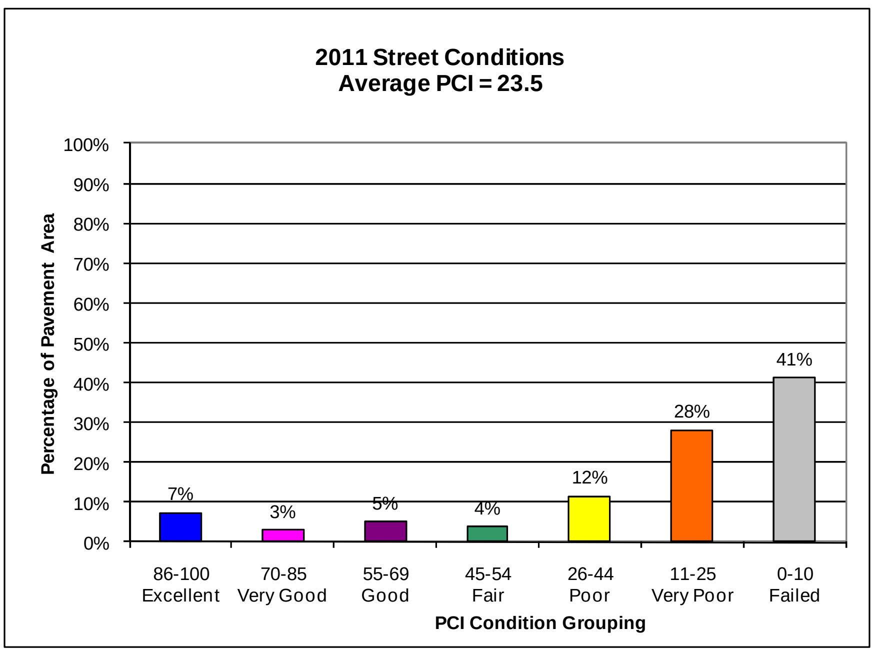
The costs presented in the PMS reports include enough contingency to cover the occasional problem of this type. The costs presented also are set to encompass design, contract administration, and inspection for each street.

FUTURE PROJECTIONS

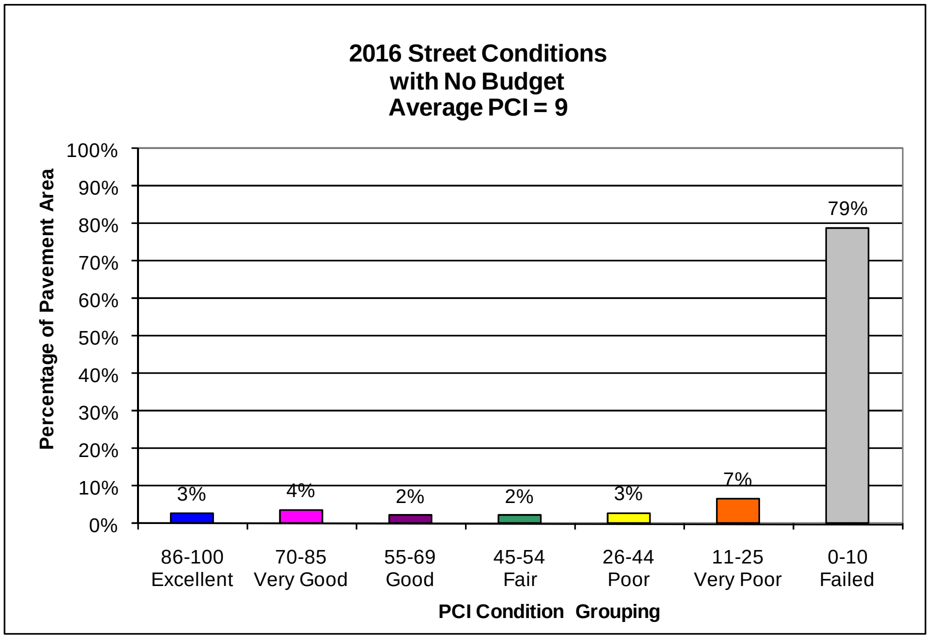
To provide a meaningful perspective on pavement conditions, the program projects future conditions and estimates the consequences that various budget levels will have on the goal of improving the pavement network. Curves of deterioration over time are assigned to different street classes (defined by level of traffic). The curves were developed based on construction history information and the present conditions of all City streets. These curves were used to project future conditions.

Graph 1 below shows the present distribution of PCI normalized by area of pavement in each segment. For example, a street that is 100 feet long should not have the same weight in determining the average PCI as a street that is 1,000 feet long. The normalized average is equal to the summation each segment's PCI times its area divided by the total area of all segments. All average PCI and SI values in this study are normalized in this way. Graph 2 shows the projected condition of the network after five years, assuming no funding is provided for restructuring. With no funding, the PCI for the network drops from 23.5 , which is considered "Poor," down to 9.0, considered "Failed"—a more difficult level to recover from. Willdan has carefully reviewed and refined the projection curves and finds these projections to be reasonable.

With no funding, there is an expected downward progression in all upper ranges, with corresponding upward shifts in the low ranges—typical of roadway pavement networks. As can be seen in the graphs for Ridgecrest, there is a gradual shift downward, with more and more streets in failed and very poor condition based on the PCI projection.



Graph 1 – Present Condition Distribution



Graph 2 – Condition Distribution in 5 Years –(No Budget)

The present 23.5 PCI for Ridgecrest's street system is relatively low among cities and counties in Central and Southern California. Most of these agencies have average PCIs somewhere around 60.

The older street surfaces in the system continually and gradually degrade overall. If this trend is allowed to continue unabated, it becomes increasingly more costly to turn the tide as deterioration rates accelerate over time. Early implementation of maintenance is generally more cost-effective, since the cost of maintenance is less when undertaken at an earlier time (when streets are in relatively better condition). Projections indicate that without continuing maintenance efforts aimed at restructuring existing pavements, fairly rapid deterioration can be anticipated on over 75% percent of the City's streets.

The best approach moving forward is to determine the funding level and appropriate allocation of funding to be applied to create a gradual reduction of unfunded maintenance for streets over the term of the projection. A budget of $2,000,000 can well achieve this, as graph 3 indicates, reducing the backlog of unfunded street work over the long term.

As discussed above, more streets tend to slip into poorer condition states as time passes. Therefore, a budget of $1,000,000 (as shown in graph 4) is not recommended because the backlog of maintenance grows continuously over time. There is a risk that costs could escalate more than anticipated, or an unforeseen temporary shortfall of funding for a few years could yield a difficult situation thereafter. It would be best to have as minimal a backlog as possible.

The midrange budget of $1,500,000 (graph 5) is more satisfactory in providing for long-term needs. As with the $2,000,000 budget, there is still a solid reduction in unfunded major maintenance over a 15-year period.

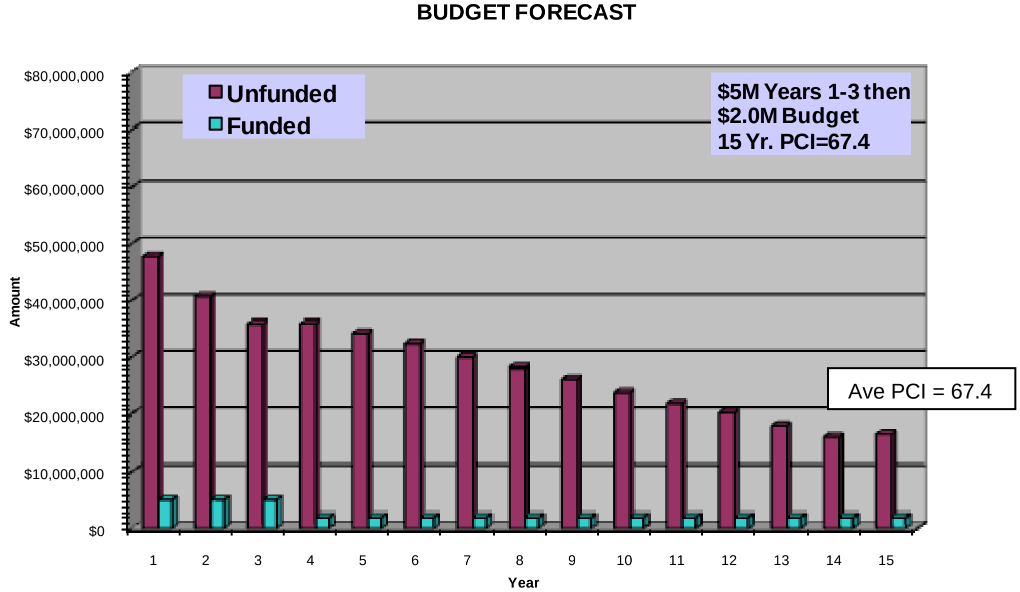
These graphs are extended using a 3% increase in costs and budget year over year to represent inflation. These numbers are then reduced to present value to allow for a more easily understood presentation in the graphs. The unfunded amounts shown in the graphs are the residual amounts still required after expending the budget amount for the year. The total backlog at the beginning of the year is the sum of the unfunded and funded amounts. For example, on Graph 5 in Year 5 the present value of the initial backlog of identified major maintenance work is $37,070,000. The present value of the Year 5 budget for major maintenance, represented by the blue bar in the chart, is $1,500,000. Therefore, the present value of the unfunded backlog in Year 5, represented by the purple bar in the chart, is $35,570,000.

On a financial basis, the reductions in backlog and return on investments of additional funding can be viewed in the following table. These figures demonstrate the effects of raising a baseline budget of $1,000,000 by applying first a $1,500,000, and then a $2,000,000 budget level over a 15-year period (as described above). The annual average rate of return that is generated by the additional investments can be determined by comparing the backlog reductions that result at each increment of additional funding. In both scenarios, the incremental increase is $500,000 per year over 15 years, or $7,500,000 of extra funding. The figures indicate that an increase from $1,000,000 to $1,500,000 has a very high return on investment, and a further increase from $1,500,000 to $2,000,000 yields a similarly high return.

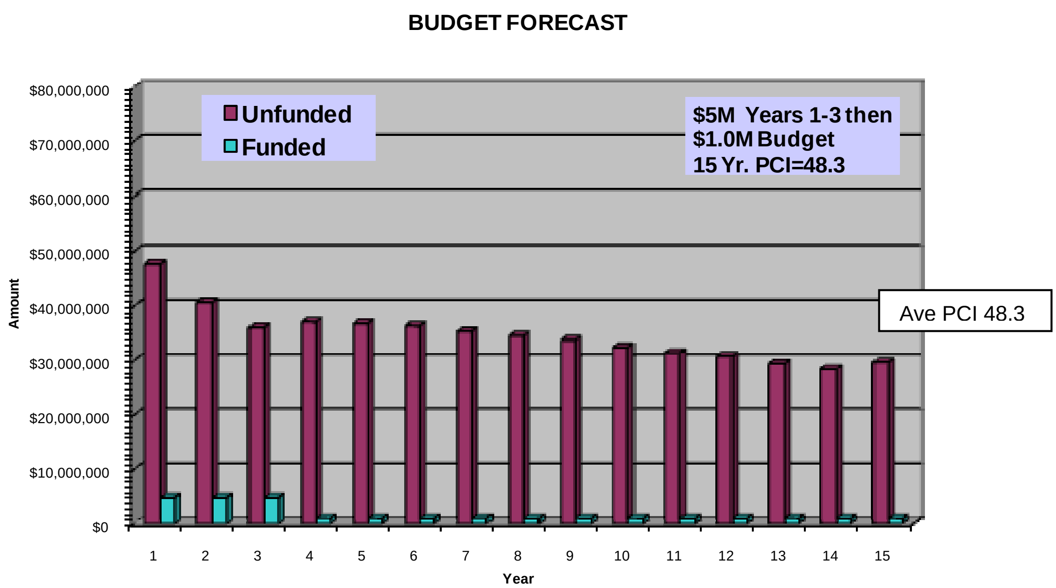
	Incr. from $1.0 to $1.5M	**Incr. from $1.5 to $2.0M**
Difference in Backlog Reduction	$7,148,532	$5,951,447
% Reduction	24.0%	26.3%
Extra Funding	$ 7,500,000	$ 7,500,000
Total Return	95.3%	79.4%
Annual Avg Return	**6.4%**	**5.3%**

If funds are available, the $2,000,000 is preferable because it will reduce the backlog—and consequently improve overall PCI—in a shorter time frame. However, even the $1,500,000 annual budget scenario will result in a significant backlog reduction over time; it is the minimum commitment level required in order to produce meaningful improvement in PCIs.

Graph 3

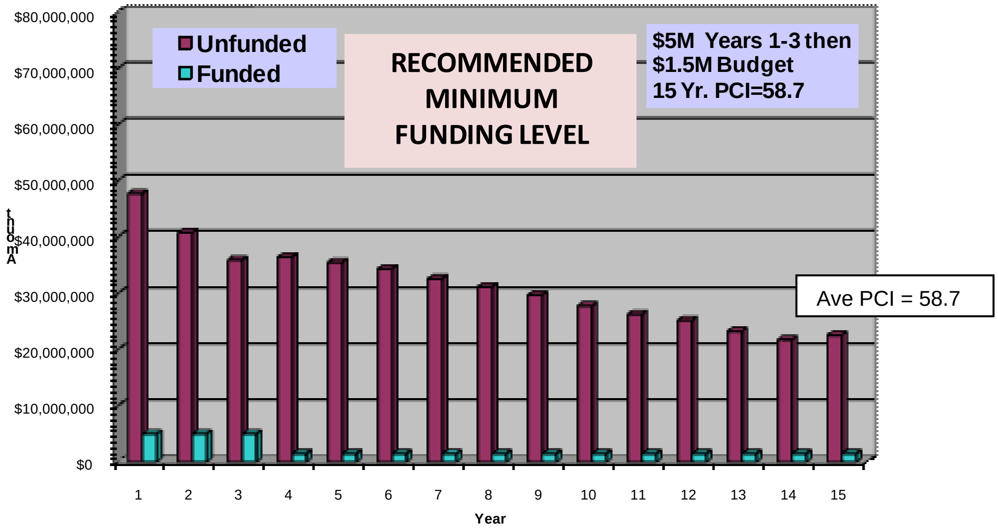


Graph 4



GRAPH 5

BUDGET FORECAST



DATA RETRIEVAL & APPENDIX DEFINITIONS

The Ridgecrest PMS contains several report appendices, which have been generated using the information in the database. The following listing of appendix definitions is provided to catalog the various reports and what information they are intended to communicate.

Appendix 1 - Construction History: This is a full listing of the available history of minor and major maintenance work performed on each roadway. If no historical information was available, an *assumed* original construction date (1965) was set. The listing is sorted by branch identification number, then section identification number. A branch may consist of a single section or several sections. Each section of a branch is a unique street segment. Not all information is readily available, resulting in various data fields that remain blank throughout the listing. For example, the "Traffic Type:" data is not a parameter that has been incorporated into this report and therefore this field is blank in all records.

Appendix 2 - Overall List of Segments: This table is an alphabetical index of all PMS road segments. This is a tool for quick look up of section data by street name. It also serves as a cross-reference to find projects by benefit/cost, PCI, or SI on the major maintenance reports.

Appendix 3 - Major Maintenance Inventory by Benefit Cost Ratio: This table is a priority listing of all streets identified as needing major maintenance sorted by descending benefit to cost ratios. This is a tool for ascertaining which street segments would have the highest priority to receive major maintenance based only on which streets have the highest benefit to cost, and therefore provide the best return on investment.

Appendix 3-1 - Major Maintenance Priority by Street Classification: This is a listing of the information provided in Appendix 3, however it is divided into separate tables by street classification. In addition, the available average daily traffic (ADT) data has been inserted in a column to the right of the PCI data.

Appendix 4 - Major Maintenance Inventory by Structural Index (SI): This table is a priority listing of all streets identified as needing major maintenance sorted by ascending SI values. This is a tool for ascertaining which street segments would have the highest priority to receive major maintenance based only on which streets have the lowest structural index, and therefore are in the worst structural condition.

Appendix 5 - Major Maintenance Inventory by Pavement Condition Index (PCI): This table is a priority listing of all streets identified as needing major maintenance sorted by ascending PCI values. This is a tool for ascertaining which street segments would have the highest priority to receive major maintenance based only on which streets have the lowest PCI, and therefore are exhibiting the highest amount of pavement distresses across all categories.

Appendix 6 - Major Maintenance Inventory Alphabetical: This table is an alphabetical listing of streets selected for overlay or reconstruction. This is a tool for quick look up of overlay or reconstruction data by street name.

Appendix 7 - Minor Maintenance Priority Inventory: This is a priority listing of streets identified as meeting conditions for a minor maintenance surface treatment based on severity of raveling. This is a tool for scheduling minor maintenance activities such as slurry seal and rejuvenator applications.

Appendix 8 - Minor Maintenance Alphabetical Inventory: This is an alphabetic listing of streets identified as meeting conditions for a minor maintenance. This is a tool for quick look up of minor maintenance data by street name.

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