PAVEMENT MANAGEMENT SYSTEM

CITY OF RANCHO PALOS VERDES FISCAL YEAR 2008-09

TABLE OF CONTENTS

PART 1

EXECUTIVE SUMMARY

In response to the need to protect the City's large capital investment in streets, the City of Rancho Palos Verdes retained Willdan to update the City's pavement management system (PMS). The PMS includes construction history for overlays, pavement reconstruction and slurries performed since the previous PMS report, Only the arterial streets were field rated for distresses, because that is required by a number of funding sources. Residential streets do not have that requirement and also do not deteriorate nearly as quickly. The residential streets are to be rated on a 6 year cycle and the arterials on a 3 year cycle.

A summary of information developed in the PMS is shown in the following table. The arterial system formed an approximate ¼ mile grid and included streets with traffic indices equal to or greater than 7.2.

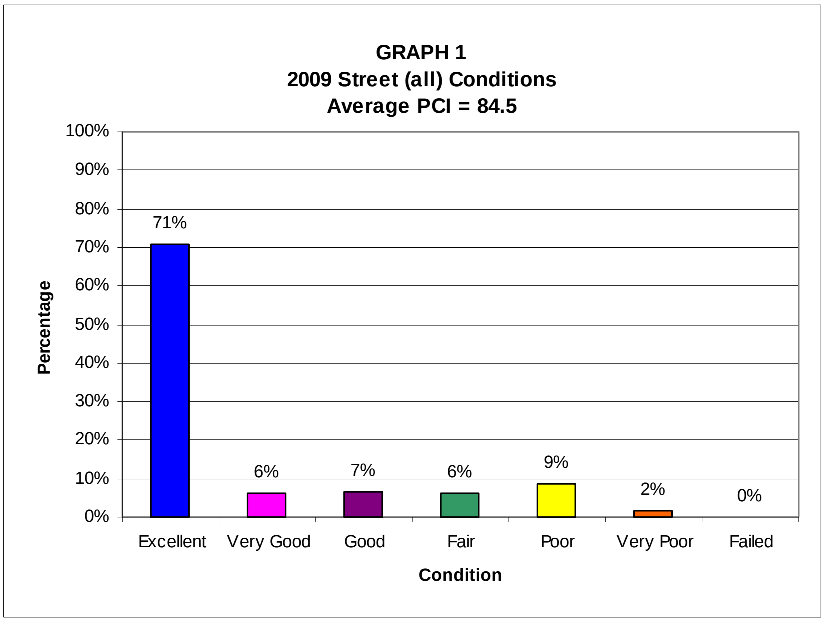
TABLE A

OVERALL INVENTORY					TOTAL REPLACEMENT COSTS		
	Total Areas SF	Lengths miles			per SF	Total	
Local Streets	17,118,000	105.79			$ 5.00	$ 85,590,000	
Arterials	6,240,000	36.12			$ 7.00	$ 43,680,000	
All Roadways	23,358,000	141.91				$ 129,270,000	
MAJOR MAINTENANCE INVENTORY							
	Total Costs	Lengths miles	% of Total				
Local Streets	$ 2,540,000	9.36	8.8%				
Arterials	$ 4,090,000	10.61	29.4%				
All Roadways	$ 6,630,000	19.97	14.1%				

As shown above, the City of Rancho Palos Verdes Pavement Management System (PMS) has projected a total of 10.6 miles or 29.4% of the City arterial streets qualifying for major maintenance, i.e structural overlay. The same figures for local streets are 9.4 miles or 8.8% of all local streets. Coupled together there are 20.1 total miles of all streets or 14.1% of all streets qualifying for major maintenance at the present time. Nearly of these roadways are in the early stages of structural fatigue, and very few are advanced in structural deterioration.

Present day estimated cost of all arterial streets identified for major maintenance is $4,090,000 . The same figure for local streets is $2,540,000 . These figures include 15% contingency on the construction cost and 20% for engineering on that total. Figures used in this report are intended to cover budgetary considerations, and numerous undefined factors lie between the PMS assessment and the time of construction.

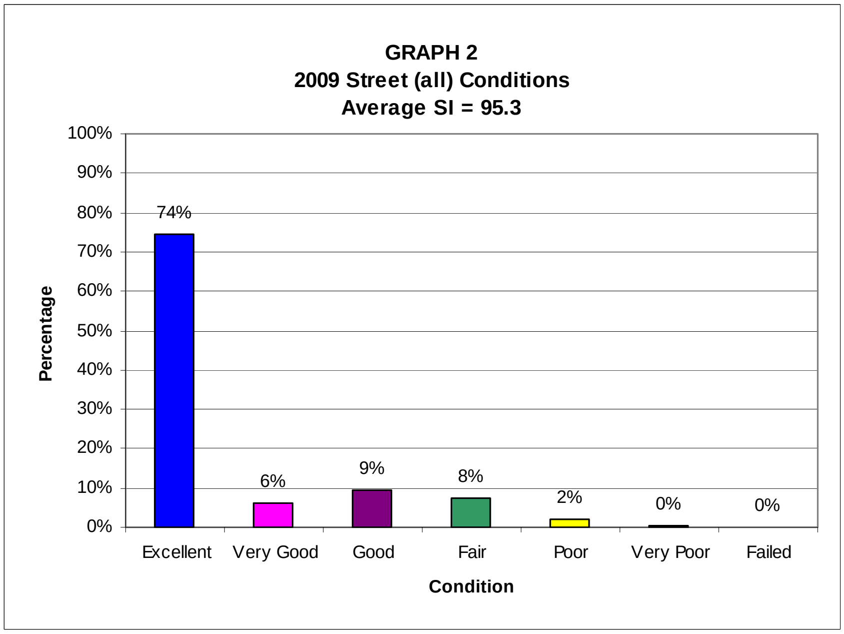
The index used in the previous report to gauge the relative condition is PCI (Pavement Condition Index), which is the conventional overall deterioration index provided in conformance with Corps of Engineers protocols. There is also an SI used in this updated report, the Structural Index, which is similar to the PCI, but is focused solely on structural conditions. The more cracking, the lower is the structural index similar to the PCI. Cracking is what drives the need for a structural overlay, the costs of which in turn drives the analysis of future budgets. The extent of cracking can be reasonably estimated, therefore the SI is used exclusively for projecting budgetary forecasts in this report. Oftentimes the structural index 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. Such factors cannot be estimated in any reliable sense, so again PCI is not used for financial considerations. The overall Pavement Condition Index (PCI) for the streets is 84.2, which is considered Very Good under the Corps of Engineers standard rankings. A PCI of 70 is considered a desirable level for an average PCI of street pavements, though most cities in Southern California are near 60 and consider that a reasonable level. The distribution of PCI for the street network is represented in this graph:



The ranges for PCI are 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

The current structural conditions of pavements in the street network can be represented by an average Structural Index (SI) that ranges 0 to 100, and is normalized among all the arterial streets or residential streets as applicable in Rancho Palos Verdes by area in the following graph:



The ranges for SI are 100 minus percentage of cracked wheel paths as follows:

SI	From	To
Excellent	100	98
Very Good	97	96
Good	95	90
Fair	89	70
Poor	69	30
Very Poor	29	11
Failed	10	0

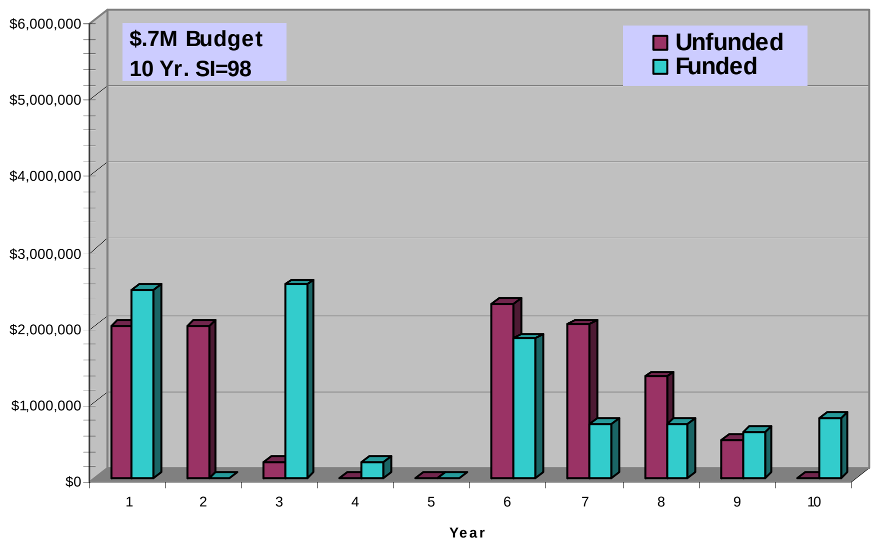
The structural distress on roadways within the City is a function of many factors including age and traffic. Once a pavement becomes cracked in a traffic area, the structural deterioration accelerates. Stopping this process requires major maintenance, and identifying the needs and most optimal approach and timing to fill those needs is a primary function of the PMS. This is also the foundation for priorities in the system. The savings from providing major maintenance before deterioration occurs is the basis in which priorities are founded. This benefit divided by the cost of the major maintenance normalizes the benefit 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 benefit versus cost, and indicates the annual return on investment in the overlay at this time. For example, .025 Benefit/Cost indicates a return on the investment from an overlay of that street to be 2.5% per year. Streets accelerate in their deterioration over time, yielding greater costs for repair prior to overlay and also thicker overlays. Avoidance of these extra costs by doing an overlay now as opposed to later is the benefit in the benefit cost ratio. The benefit cost ratio is used in developing lists of specific street segments to be included in budgets for individual years.

An additional exhibit has been provided below and is one of the tools for optimizing budget planning. The projection simply provides an indication of the potential for long-term developments based on a particular budget strategy applied to a set of major maintenance activities applied to corresponding SI categories. The 10-year projection graph shows by present value how a budget of $700,000 will work out over the long-term in reducing the backlog of major maintenance for arterial streets. The budget amounts for the first 3 years were established as different amounts of $2,500,000, $0, and $2,700,000 in that order.

This level of expenditures will bring about a zero backlog in year 4 and maintain the present structural condition at 10 years and provide an easily managed backlog in the long term. Higher and lower budget levels were reviewed, and the rate of return on investment in a higher budget was too low and the risk developing a large backlog over the long term was too great to reduce the budget.

GRAPH 3
BUDGET FORECAST



This graph represents 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 key goal of the budget forecast is to demonstrate a solid reduction of the unfunded major maintenance over time. Lowering the funding level significantly could lead to unsatisfactory levels of unfunded major maintenance in later years.

Being a candidate for major maintenance does not mean the street is necessarily in bad condition; it only means the cracking on the street has reached a stage that a progression towards failure has begun. That progression runs for a long time on residential streets, actually a decade or two. After many years and a number of PMS updates, the approach to most optimally deal with these streets will be worked out, as for the streets currently in need of maintenance in this report.

The approach recommended in this report is only optimal under the current circumstances, and the large group of streets in the long term will likely be handled in different manner to reduce their impact on funds available. Most important right now is maintaining consistent funding to keep the backlog under control, so the streets coming up in the long term will not have to wait for a backlog of streets in the past to be worked off. Their deterioration will accelerate once they become cracked, and costs will continue to increase while they wait. Coincidentally with maintaining a low backlog, the current average SI will be maintained and not decrease.

By updating this report tri-annually, 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

Certain terms used in this report may not be familiar to all readers. A review of the following list of terms and their definitions will make for easier reading:

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

ALLIGATOR CRACKING: Pattern of cracks usually 4 to 6 inches apart, resembling 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. 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.

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 central area of street is high in elevation relative to edges of roadway.

INTERLIFT: A layer of highly flexible interlayer material between the overlay and the underlying existing pavement that 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, for example 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 from 0 to100 indicating the overall condition of the pavement based on distresses, where 0 is extremely poor and 100 is 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 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: Structural Index from 0 to 100, 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 percentage of truck traffic.

WHEEL PATH: Area of pavement where wheels of predominant traffic pass directly over.

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 deteriorated streets each year and a disproportionate increase in the cost per mile for maintenance.

Street pavement is one of the major capital investments of a municipality. It is also one of its most important assets. Without a well-maintained street system, the transportation needs of the public, business, industry, and government cannot be met. In general, local real property values tend to suffer from 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, data of resurfacing or seal coating, etc. A computer can sort the “databank” in a variety of useful ways. In addition, a PMS provides the means to assign meaningful priority rankings of projects and their associated costs to assist in multi-year programming and annual budgeting for maintenance and capital improvements. Once implemented, the PMS must be updated tri-annually in order to be an ongoing, effective management system.

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HISTORY

Diminished funding, or 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 or 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 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 1960's. The States of Texas and California were researching various uses of system procedures for application to pavement design and management. In 1973, the first definitive publication on PMS was authored. By 1974, a number of states had initiated studies and developed programs designed to improve pavement management processes, which 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. The significance of such a decision was to encourage states and local agencies to review PMS and appreciate their usefulness.

Every city and county throughout California has developed and is currently implementing pavement management programs.

WHAT IS A PMS?

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: 1) to improve the efficiency of making decisions; 2) to provide feedback as to the consequences of these decisions; 3) to ensure consistency of decisions made at different levels within the same organization; and 4) to 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:

1. A systematic method for collecting and storing data.

2. A method to effectively analyze data.

3. A process to retrieve data in a meaningful format.

4. Procedures for decision-making based on 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.

PROJECT SCOPE

A PMS developed for a City includes public streets consisting of arterial roadways that provide traffic circulation within the City, as well as all paved local public streets and alleys. Basic PMS components are:

- 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 included a pavement condition survey and rating of every street to identify structural deterioration, surface deterioration/condition, ride quality, skid resistance, 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 microcomputer for ease of database sorting, updating, and retrieval. The computer program operates on a personal computer.

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

Updating the database and analysis of the resulting new information should be accomplished every 3 years in conjunction with the budget preparation process. A PMS developed for a City can easily be updated to reflect changed conditions, reflect 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 what a PMS is, of the methodology and information used to compile the City's database, of the data analysis program, and of the results of the analysis, including computer printouts of the various reports

The Data

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

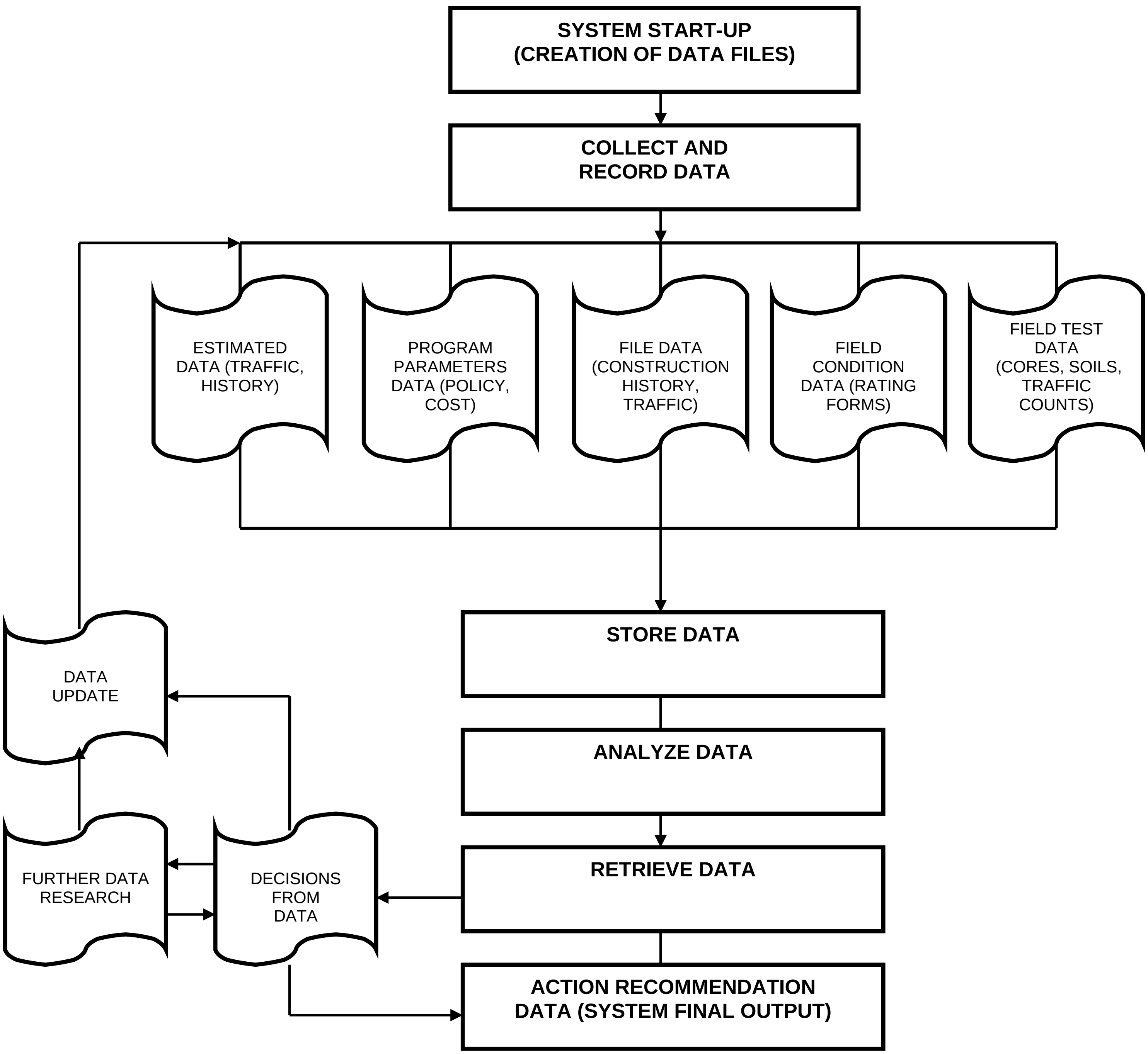
A major emphasis of any PMS is to identify and evaluate pavement conditions and determine the causes of deterioration. To accomplish this, a pavement evaluation system should be developed that is rapid, economical and easily repeatable.

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 ¼ mile in length, beginning and ending at intersections. Occasionally, varying traffic or construction history make shorter segments necessary.

FIGURE 1

PMS COMPONENTS



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 for activities. 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 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 determine its usefulness versus cost for 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.

<u>Data Analysis</u>

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 descriptive information that describes their meaning, usefulness and how they are derived.

<u>Data Retrieval</u>

It is critical that the data be easily retrieved, and in such a format that it is meaningful.

The computer has the advantage of quick retrieval at a single source, plus the flexibility to display data in any format desired. The computer is essentially unlimited in this capacity to prepare tables, graphs, and charts. In comparison, doing the simplest tasks of this type from files is very time consuming.

The database can be used to answer special questions at each level of decision-making. Questions concerning the entire system, individual projects or implementation can be asked, and the PMS can provide answers. Such questions could include: 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 has the potential to answer numerous questions of this type, through straightforward manipulation of data. Usually a computer program is developed to provide the information in the desired format, from the database within the computer memory.

Updating Data

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

USE OF A PMS

With an understanding of the database, an examination of the typical uses of a PMS can be undertaken. The following material 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 for reference in preparing reports or studies.

Developing Maintenance Budgets

Rather than preparing the typical 1-year maintenance budget, a PMS allows a city to prepare a series of budgets. These budgets can be in the form of a multi-year program, identifying not only short-term (1 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 on condition ratings primarily, and other factors of traffic, and cost. 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

These are the components and capabilities that are typically found in a PMS, resulting in numerous benefits including:

- Inventory of Street System
- Overall Pavement Condition Rating
- Annual Budget Estimates for Various Scenarios
- Project Identification and Ranking
- Improved Decision Making

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

THE RANCHO PALOS VERDES PAVEMENT MANAGEMENT SYSTEM

The Rancho Palos Verdes Pavement Management System (PMS) has four basic components:

1. Collection and Storage of Data

2. Analysis of Data

3. Retrieval of Data

4. Update of Data

Further extensions of these are: 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 to store PMS data and provide data output and certain types of reports. The Willdan system extracts data from the MicroPaver database to allow for very specific and accurate assessment of street segments on a structural and financial basis, which is not available in in MicroPaver. Capital improvement reports generation is much more flexible and straightforward using the Willdan software.

The following sections of the report cover the four main forms of data handling in the Rancho Palos Verdes PMS.

DATA COLLECTION AND STORAGE

Parameters

The first step in developing the PMS for the City of Rancho Palos Verdes was to select specific fixed parameters, under which the program would operate such as construction inflation rates and nominal design lifespans of improvements and strategies for overlay. This was done in conference with the Director of Public Works at the outset of the project.

Pavement Condition Survey

Each arterial street within the City of Rancho Palos Verdes was visually surveyed to determine the condition of the pavement. The survey concentrated on determining structural deterioration, which is the primary source of increased maintenance cost.

Over 90 rating forms were prepared for arterial roadway segments within the City. These forms were updated on an electronic handheld data entry unit by a trained pavement rater in the field. The information contained on the rating forms was used as part of the database system for the PMS.

"As Built" and Maintenance History Records

Historical files and records of streets within the City of Rancho Palos Verdes were acquired for the period since the last update.

There is a default date for streets without available construction history and 1950 was used for these older streets.

Traffic Data

Willdan's staff performed a review of traffic conditions, including estimates of truck volumes. By reviewing traffic volumes and expected usage situations an estimated traffic index (TI) was assigned to each roadway segment of the City. This is important for determining the overlay thickness for major maintenance and the benefit cost ratio for priority.

Cost Data

Cost factors used in estimating 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 20 percent to account for engineering, construction inspection, and administration. An additional 25% was added for contingencies.

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.

Strategies

Roadway conditions vary in the City of Rancho Palos Verdes and, therefore, a system for grouping street segments with similar conditions was needed to provide for assignments of appropriate maintenance treatments. The extent of structural failure and other deterioration factors determine street condition groupings. The condition groupings and their corresponding strategies for major maintenance are shown in Figure 2. 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, which may be undertaken for each segment in order to arrive at estimated improvement costs. It should be recognized that 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.

Priority

The calculation of the priority, or Benefit Cost Ratio, is a sophisticated algorithm, which determines the benefit cost ratio for each segment. The benefit cost ratio is the engineering economics method to prioritize streets relative to each other to compare them in terms of their relative advantage. This comparison provides a sound economic basis for decision-making, and that is what the Rancho Palos Verdes 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 investment in the overlay on the street, and that is the Benefit/Cost ratio for the segment.

The calculation of Pavement Condition Index (PCI) is also a highly sophisticated algorithm, which assigns points to be deducted from a maximum score of 100 for a street in excellent condition in every respect. These “deduct” points are assigned individually, one set for each of 3 severity levels: low, medium and high; for each type of deterioration. For example, alligator cracking is one type of deterioration. 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 by the Corps of Engineers standard protocols, and is used by many agencies nationwide. It provides a perspective on the general overall condition of the roadway based on all factors. It is not used for priority directly; however, it would be used to provide for 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 Corps of Engineers system is in the way these points are combined such that 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 this happens, full pavement reconstruction is necessary which generally costs 3 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; that is 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 is preferred for 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 a single factor:

The raveling off of fine aggregate particles from the surface due to weathering.

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

It should be noted that crack filling is not recommended with slurry seals, unless the crack fill is applied at least 8 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 contrasted 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 crackfiller is allowed to cure prior to slurry, there is an application method that can provide an essentially crack free pavement. A good product to use for slurry in this case is a TRM Slurry Seal (TRMSS). This is the same as a 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, which stays dark in color much longer and is more compatible with the crack fill material. It also will allow for a surface recycling treatment for ARHM pavements if they were to be slurried.

An interesting and possibly very important note on slurry seals is that asphalt rubber pavements do not need slurry treatments, because their surface does not ravel or deteriorate in any measurable way. A properly compacted asphalt rubber pavement is highly impregnable to water, with few fines existing in the surface to ravel. The tough resilient asphalt rubber binder tightly binds the few fines that do exist in the surface. The surface binder does have some potential for degradation from sun and rain, but the anti-ageing chemicals provided by the tires used in production of asphalt rubber strongly inhibit even this action. Considering that the cracking that ultimately limits the lifespan of ARHM pavements begins at the bottom of the layer, at the interface with the cracks in the old pavements underneath, the slight degradation of the surface binder properties is not very consequential.

It is not that slurries cannot be applied to asphalt rubber; they can in the same manner as for AC pavements. The serious drawback is that once the ARHM is slurry sealed with conventional slurry, the potential for in-place recycling of the ARHM as an interlayer for the next overlay is lost. Slurries always make recycling difficult, and with ARHM the problem is compounded, because the binder in the slurry will contaminate the asphalt rubber binder. If properly recycled, the old ARHM overlay can provide a flexible structural element for the subsequent overlay. The advantages include reduced thickness for the next overlay and less change in street profile, plus the increasing savings as the cost of asphalt and aggregate continue their steep increase. Fortunately the TRM Slurry Seal is available now so if an ARHM is determined to be appropriate for slurry seal, it can be done without losing the recycle potential.

Generally, the minor maintenance program prioritizes the raveled streets first based on severity. Then AC streets with the largest time since the last slurry or overlay, but that time must be greater than the minimum elected slurry seal cycle time. The streets included based on cyclical considerations are prioritized with the longest time since the last treatment yielding a higher priority. The cycle time has been selected to be eight years. Slurries generally do not wear off for at least twelve years, but tend to discolor and gather stains within a much shorter period.

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 reconstruction repairs 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 value here is that budgetary planning in the short term of 3 years is reliable and accurate and produces cost effective program of expenditures. The calculation of the benefit/cost ratio uses the same data.

Figure 2

STRATEGY LOGIC TREE FOR MAJOR MAINTENANCE

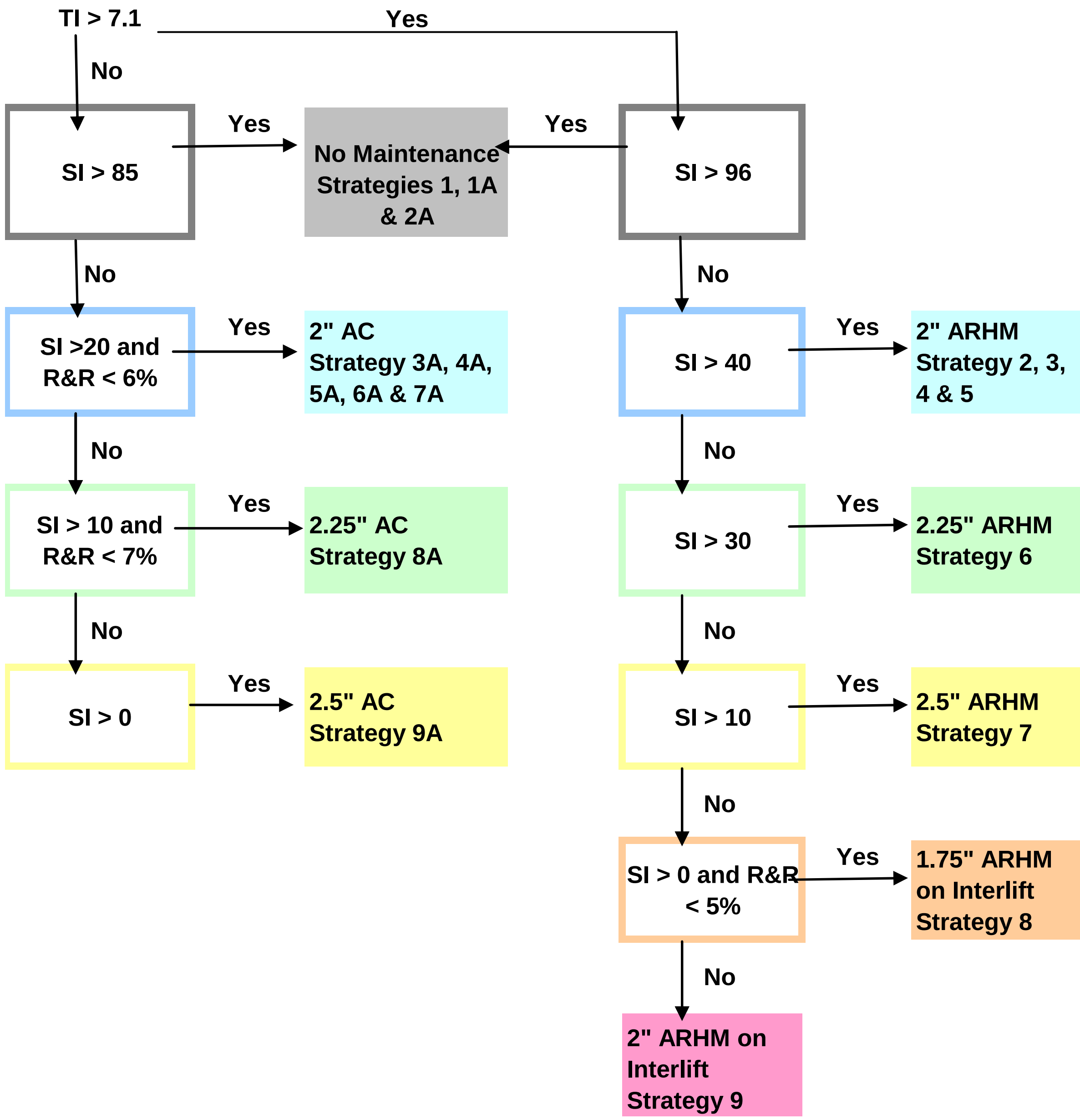
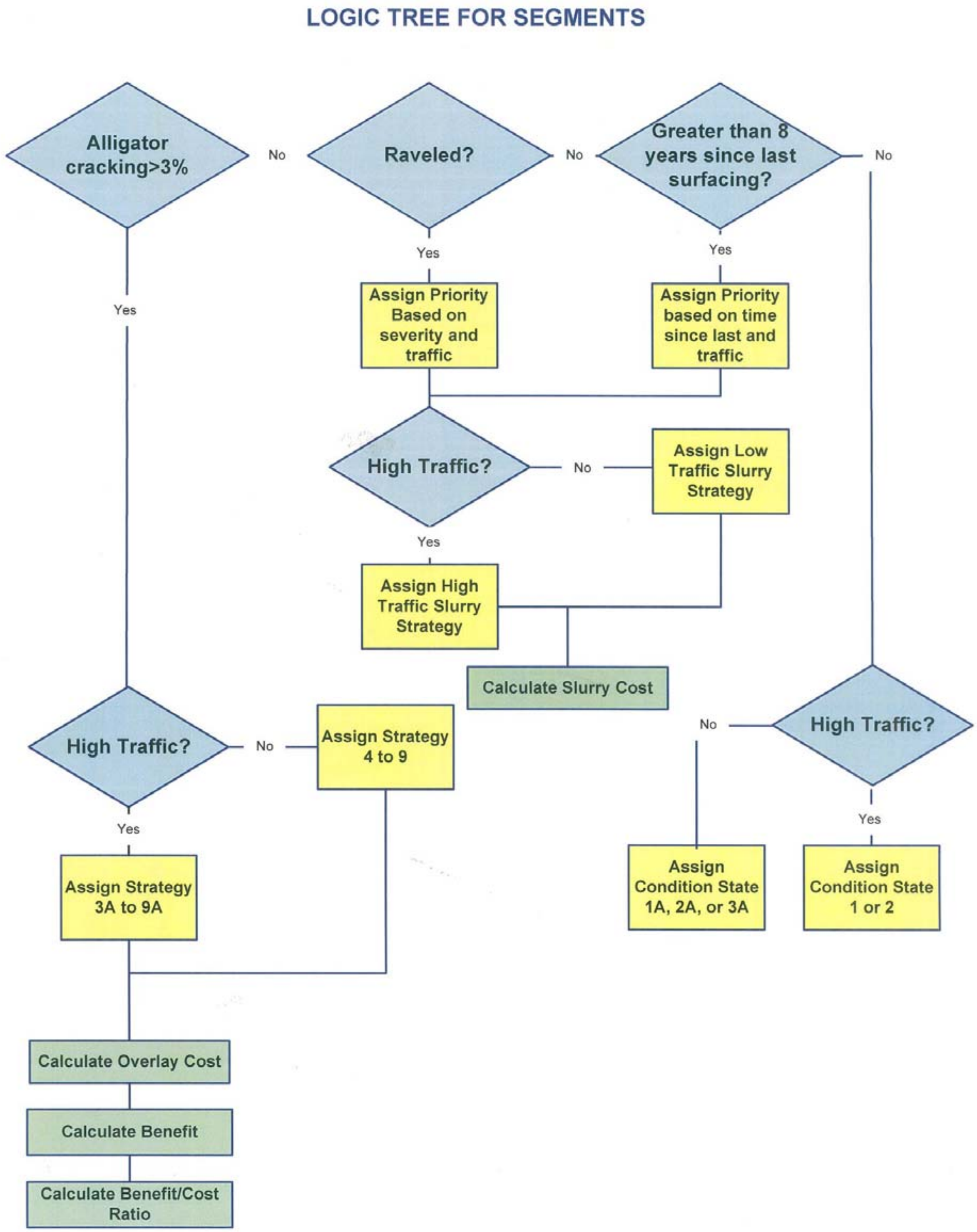


Figure 3


LOGIC TREE FOR SEGMENTS
Alligator cracking>3%
No
Raveled?
No
Greater than 8 years since last surfacing?
No
Yes
Yes
Yes
Assign Priority Based on severity and traffic
Assign Priority based on time since last and traffic
High Traffic?
No
Assign Low Traffic Slurry Strategy
Yes
Assign High Traffic Slurry Strategy
Calculate Slurry Cost
High Traffic?
No
Assign Strategy 4 to 9
No
High Traffic?
Yes
Yes
Assign Strategy 3A to 9A
Assign Condition State 1A, 2A, or 3A
Assign Condition State 1 or 2
Calculate Overlay Cost
Calculate Benefit
Calculate Benefit/Cost Ratio

DATA UPDATE

The budget projections are considered to be relatively accurate for the first year and to a lesser extent the second and third years. Projects requiring minor or major maintenance will increase in cost-effectiveness as years go by. Updates of the PMS every 3 years will automatically shift priorities and bring all factors within good relative accuracy. Also, updated cost values must be programmed into the system on the 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.

PART 2

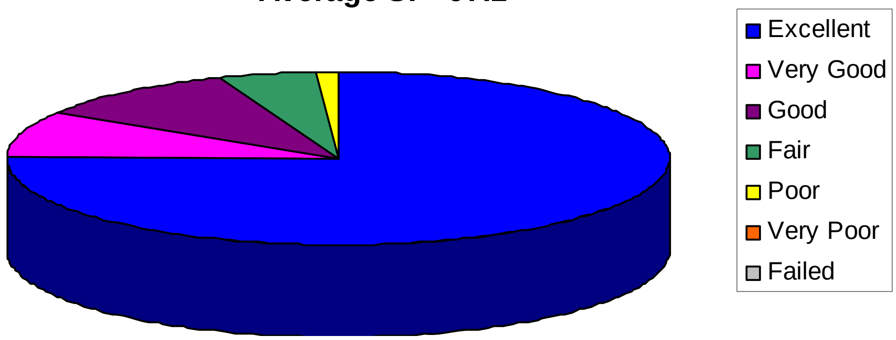
FINDINGS AND RECOMMENDATIONS

1. There are 141.9 miles of streets in the City of Rancho Palos Verdes, which includes all public streets. The total pavement area is 23,358,000 square feet, with a total replacement cost of 129,290,000 . The length of arterials is 36.1 miles, and the area is 6,240,000 square feet. Total arterial replacement value is estimated at $43,700,000 .Based on the field survey ratings and analysis of the available data, the existing street pavement conditions on the great majority of streets are characterized as being in good to excellent condition.

   The residential distribution of conditions is shown below based on structural index, essentially corresponding to the cracking in the travel areas. The residential streets were not rated in this update, so the base year is 2006. A projection of future conditions is not meaningful for these streets because the construction performed in the past 3 years has been updated and therefore starting points in the projection vary depending on the time of last maintenance work.

	SI Ranges Residential - Table B						
	Excellent	Very Good	Good	Fair	Poor	Very Poor	Failed
2006	75.2%	8.6%	10.3%	4.8%	1.0%	0.0%	0.0%

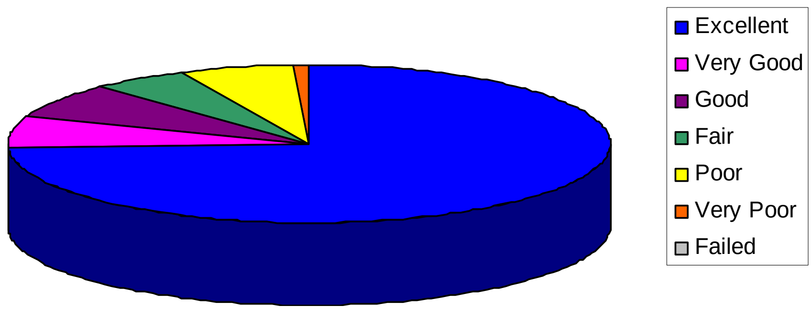
GRAPH 4
YEAR 2006 RESIDENTIAL STREET CONDITIONS
Average SI = 97.1



A chart of overall conditions (PCI) is the next chart below based on the same conditions.

	PCI Ranges Residential Table C						
	Excellent	Very Good	Good	Fair	Poor	Very Poor	Failed
2006	74%	7%	7%	5%	6%	1%	0%

GRAPH 5
YEAR 2006 RESIDENTIAL STREET CONDITIONS
Average PCI = 87.6

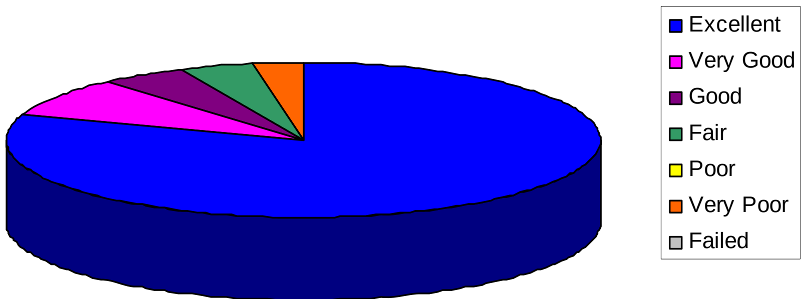


2. The major maintenance needs result from pavement cracking, which can be satisfied by restructuring with a normal AC overlay on residential streets or an ARHM overlay on arterial streets after possible reconstruction repairs. The Major Maintenance Inventory includes 20.0 miles of residential streets needing an overlay, which is 29.4% of all streets, estimated at a total cost of $6,630,000 . Residential overlays are applied on a 7 year cycle to zones, and a funding level of $600,000 per year is recommended for street overlays to maintain the current structural conditions.

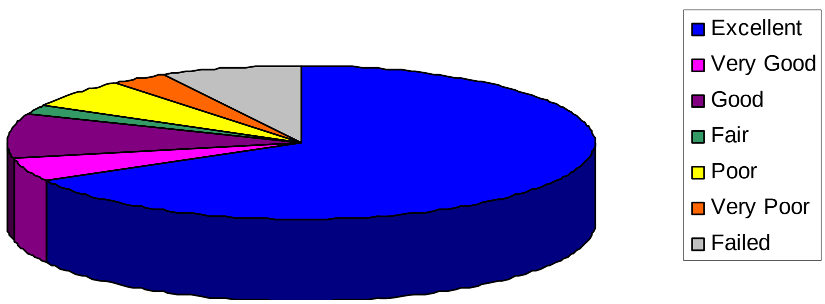
3. Arterials streets are especially important, because once they begin to crack, the progression to complete failure is very rapid compared to residential streets. There are 10.6 miles or 29.4% of all arterials in a condition making them potential candidates for overlay, with a total cost of $4,090,000 . The structural condition distribution for arterial streets is shown below for present conditions and also as projected with no funding for 5 years for perspective on the rate that the system could deteriorate without any action.

	Arterial SI Projection $0 Budget - Table D						
	Excellent	**Very Good**	**Good**	**Fair**	**Poor**	**Very Poor**	**Failed**
2009	80.4%	8.3%	4.6%	4.1%	0.0%	2.7%	0.0%
2014	66.8%	5.0%	9.2%	2.1%	6.1%	2.9%	7.9%

GRAPH 6
YEAR 2009 ARTERIAL STREET CONDITIONS
Average SI = 90.8



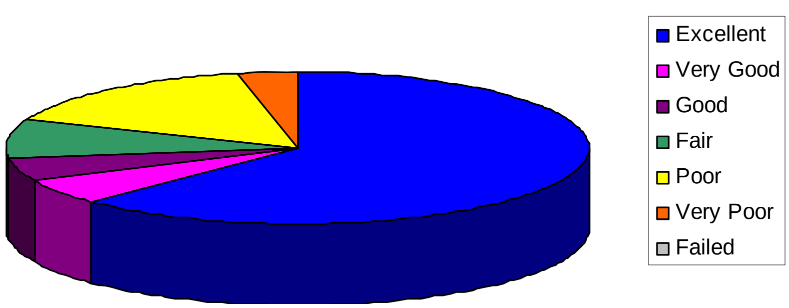
GRAPH 7
2014 ARTERIAL STREET CONDITIONS
with $0 Budget Average SI=76.1



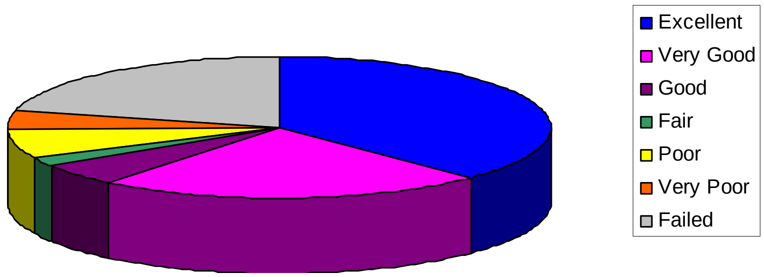
Another set of graphs is provided for overall conditions (PCI).

	Arterial PCI Projection $0 Budget - Table E						
	Excellent	**Very Good**	**Good**	**Fair**	**Poor**	**Very Poor**	**Failed**
2009	62.5%	5.2%	5.1%	8.3%	15.7%	3.2%	0.0%
2014	37.6%	23.2%	5.0%	2.0%	6.8%	4.3%	21.0%

GRAPH 8
YEAR 2009 ARTERIAL STREET CONDITIONS
Average PCI = 76.8



GRAPH 9
YEAR 2014 ARTERIAL STREET CONDITIONS
with $0 Budget Average PCI = 61.4



The following is a list of the arterial streets that appear to be in the progression that occurs at the end of pavement lifespan.

TABLE F

Sec ID	Name	From	To	Length	Width	Lanes	TI	PCI	SI	Overlay	Ben/$	Cost
1429	Miraleste Dr Eb	Via Bramante W/s	Via Colinita	2578	30	2	8	24	23.3	2.75	0.237	239,771
1449	PVDS WB	Conqueror Dr W/s	Schooner Dr E/s	1785	16	2	8	18	25.9	2.75	0.221	93,419
1427	PVDE	Colt Rd (Private)	Clevis Rd S/s	1100	60	3	9	33	54.1	2	0.179	147,363
1426	PVDE	Clevis Rd S/s	Coach Rd S/s	1255	32	2	9	31	53.7	2	0.179	90,214
1673	PVDE	Coach Rd S/s	Raon Dr S/s	1165	32	2	9	30	57.0	2	0.171	83,744
1464	PVDS EB	Crestmont Ln W/s	Seahill Dr W/s	1670	27	2	8	29	53.0	2	0.168	102,404
1470	PVDW SB	400' S/Golden Cove	Coast Guard Station	1300	28	2	8	29	54.1	2	0.166	82,462
1467	PVDS WB	Station 0.89	Coast Guard Station	1580	36	4	8	26	46.6	2.25	0.164	141,950
1452	PVDS EB	Schooner Dr E/s	Conqueror Dr W/s	1780	16	1	8	28	51.2	2	0.161	69,169
1431	Miraleste Dr Wb	Via Colinita	Palos Verdes Dr	3380	30	2	7.4	23	18.2	2	0.156	228,684
1423	PVDE	Sunnyside Ridge Rd N	City Limits	4120	32	2	9	30	61.7	1.75	0.124	261,342
1460	PVDS EB	Barkentine Rd E/s	Seacove Dr W/s	1085	56	2	8	40	60.3	1.75	0.120	119,926

As discussed in more detail in the Future Projections section below, the recommended level of funding is $600,000 per year for arterial streets. This will maintain the structural integrity and control the backlog of major maintenance and sustain a high PCI. Lowering the funding levels significantly could lead to unsatisfactory levels of unfunded major maintenance in later years.

4. The City's program of applying slurry to all streets within each zone at the time of overlay of the zone has proven successful. There is another strategy available now, and this product is about 50% more expensive than conventional slurry, but maintains a dark color for a number of years and provides recycling of scrap tires. It is best used when applied in a program to maintain crackfree pavement. The slurry candidates frequently have singular (block type) cracks. It is recommended to apply a banded crackfill about 1/8" thick, 2-inches wide over all such cracks at least 8 months ahead of the slurry application. If this is done, even hairline cracks will not reflect through the slurry and the extended cure time will eliminate the crackfiller from bleeding through the slurry. This same approach can be performed with conventional slurry, but the TRMSS is more flexible and likely to last longer without cracking. It is an asphalt rubber product so it is compatible with the crackfiller.

IMPLEMENTATION

The main function of the pavement management system lies in the implementation of capital improvements such that every dollar spent is maximized towards extending the lifespan 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 and the SI Map and also the PCI map along with the Construction History Map can be very effective in identifying areas of local streets to target 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 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, SI. Finally, there is the PCI listing, which is an overall conditions view. 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 to the recommendations of the PMS. Projects can be manually added to or deleted from the list of recommended projects during the preparation of the report or future updates, and in any year between. The system will incorporate the changes as part of the normal update process.

Updates should be performed tri-annually in Rancho Palos Verdes as part of overall implementation procedures. To maintain the key goal of maximum cost effectiveness of funding, the data must be kept current. Changing pavement conditions have a major effect on costs and priorities and so need to be updated on a regular basis.

At time of preparing design plans for each street, the details of the strategies for maintenance are refined based on testing and more involved calculations with the more precise test data. Special factors also must be considered on some streets where these factors impact 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. With these understandings, the budget report can be used directly as a guide for implementing the capital improvement program for the City's network of roadways. However, beyond 3 years the projection should be reviewed based on a PMS update.

FUTURE PROJECTIONS

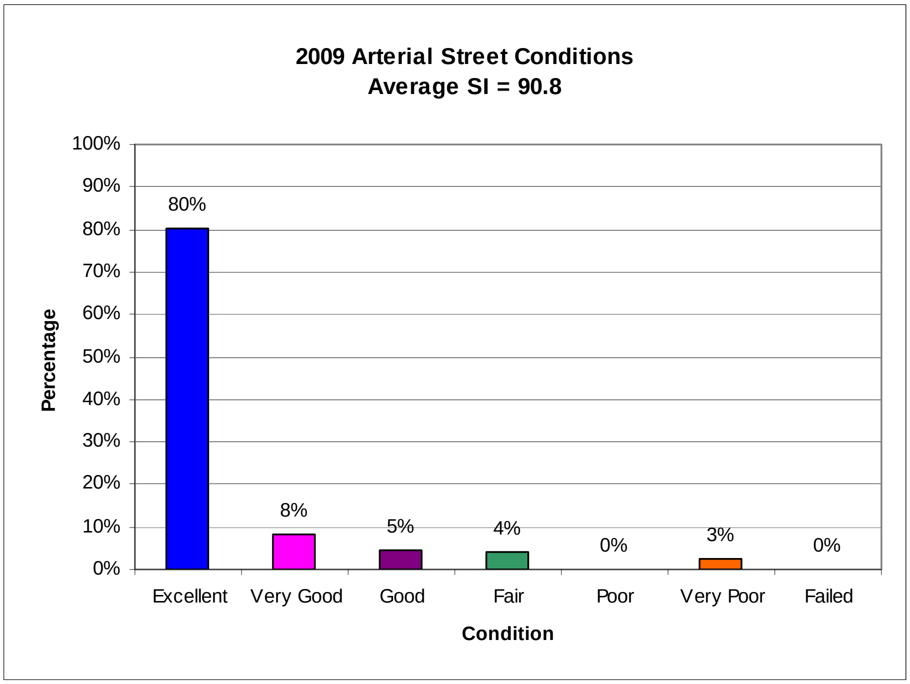
To provide a meaningful perspective on pavement conditions, the program provides projections of future conditions and consequences of various budget levels towards improving the pavement network. Curves of deterioration over time are assigned to classes of streets defined by level of traffic. The curves were developed based on construction history information and the present conditions of all City streets. These curves were used to project future conditions.

Graph 10 below shows the present distribution of structural conditions normalized by area of pavement in each segment. (All average SI values in this study are normalized in this way.) Graph 11 shows the projected structural conditions of the network after 5 years with no funding for restructuring for 5 years. With no funding on arterial streets, the overall Structural Index for the network drops from 90.8 , which is considered Good, down to 74.8, considered Fair but a more difficult level to recover from. On residential streets the network drops from 97, which is considered Very Good, down to 89, considered Good. Again the drop makes recovering to the previous level much more difficult.

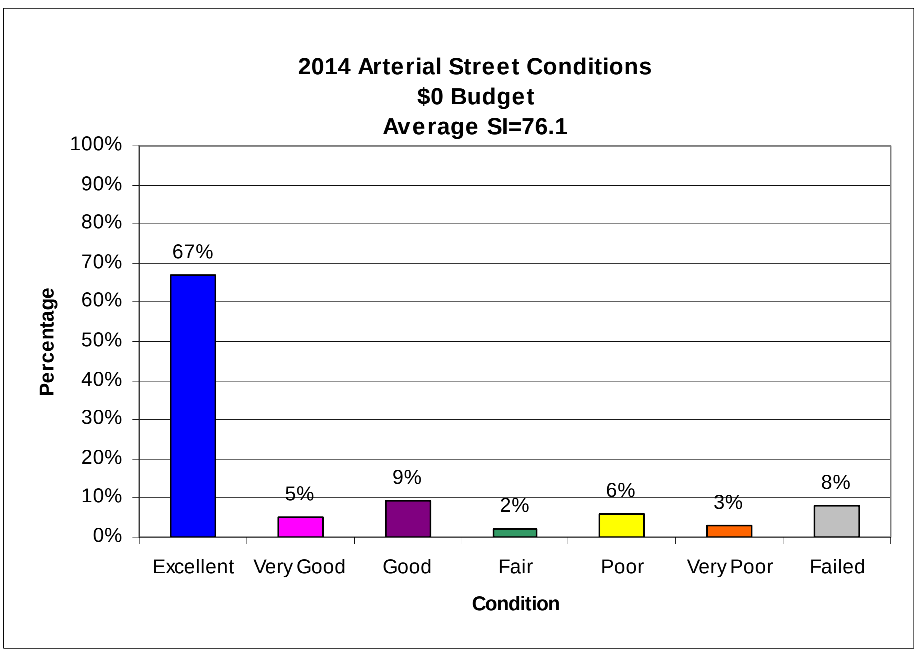
With no funding on arterials, there is the expected progression down in all ranges, typical of roadway pavement networks. There is a large shift down from Excellent to Fair, because of the continuous progression of pavements towards the end of their lifespan. Streets already in Good and Fair condition slide into Poor and Failed condition. Excellent is essentially no cracks at all and a pavement that is young in its projected lifespan. Very Good, also a narrow range, indicates a pavement reaching the point where it may be beginning to crack, but not anything to be concerned about. Good usually reveals a situation where the lifespan prior to cracking is essentially over and a progression of some cracking of the type that leads to structural failure is present. Good for residential streets of little concern, since the progression is very slow. For arterial streets, monitoring would be the only action necessary. Fair and below represent various stages in which an overlay is reasonable to consider.

For residential streets, the predominant shift similar, but the shift is much more gradual from Excellent to Good.

Graph 10 – Present Condition Distribution



Graph 11 – Condition Distribution in 5 Years –(No Budget)



The present average Structural Index value of 90.8 for the arterial streets in Rancho Palos Verdes's street system is very good among cities in Southern California, in fact quite enviable. The high levels of excellent and good condition streets show that good major maintenance strategies have been in use in the past.

There remains the usual difficulty that 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 at an earlier and better state of condition.

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 a term of the projection.

ARTERIAL PROJECTIONS

Using the projected curves of deterioration, a budget of $900,000 easily achieves the desired low levels of backlog as shown in Graph 12. All of the budget projections include $2.5 million in the first year, $2.7 million in the third year and zero budget in the second year, and all of them reduce the backlog to zero in year 4 and maintain that in year 5 because of this heavy upfront funding. The concern is the following wave of deterioration, and the projections for both $900,000 and $700,000 (Graph 13) deal with that quite well taking the backlog back to zero in year 10.

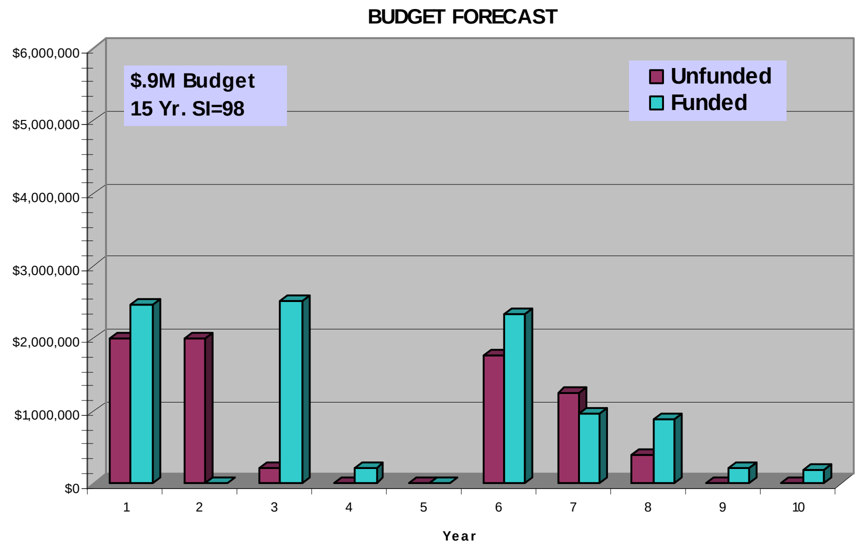
Graph 14 shows that the $500,000 budget level could make it difficult to keep the backlog under control. Increased deterioration over the longer term or unforeseen shortfalls in funding could lead to a difficult situation to recover from.

These graphs are extended using budgets and costs with a 3% increase in costs and budget year over year to represent inflation. Excess budget remaining if all streets in backlog are completed in a given year is rolled over to the following year. Due to the give and take involved in selecting streets each year, this is the best representation of expenditures over time. These numbers are then reduced to present value to allow for a more easily understood presentation in the graphs. It should be noted that the unfunded amounts shown in the graphs are the amount 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. To provide a more reasonable long term view, excess budget from previous years is rolled over into future years to produce a projection similar to the varying budgets that occur based on current projected needs in any given year.

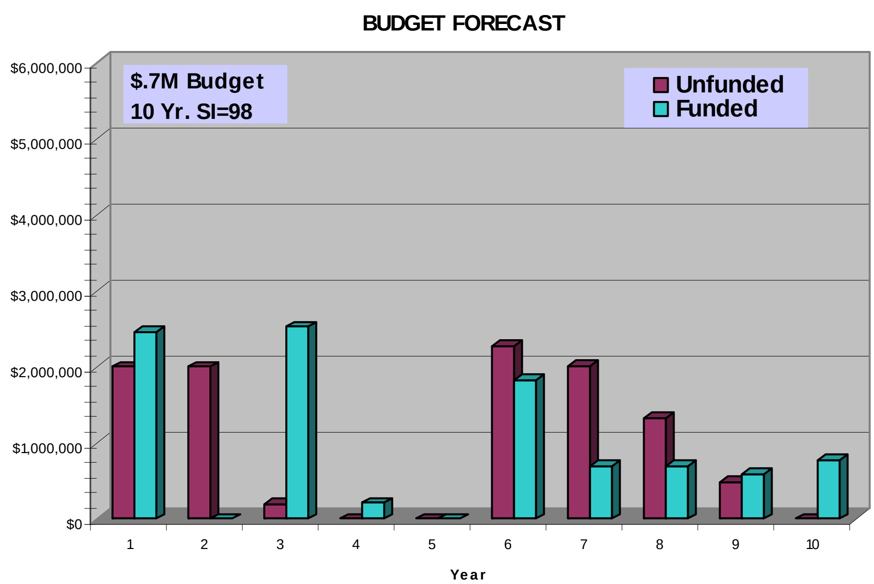
On a financial basis, the reductions in backlog and return on investments of additional funding can be viewed in the following table. The figures indicate that an increase from $500,000 to $700,000 yields a return of 4.5% on the investment of the additional funds, plus a major decrease in backlog, while an increase to from $700,000 to $900,000 yields a 0% return, not worth the additional investment.

TABLE G

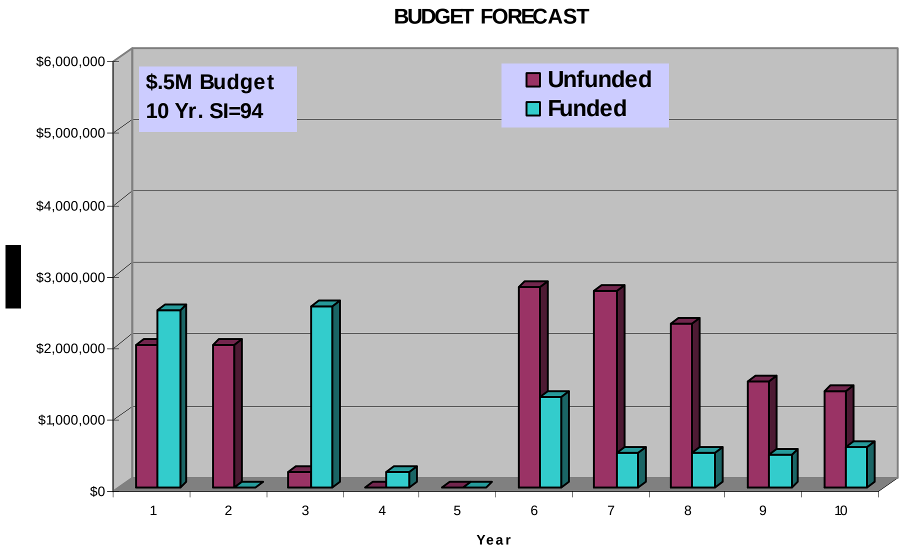
	Incr. to $.7M	Incr. to $.9M
Backlog Reduction	$1,349,341	$0
% Reduction	67.5%	0.0%
Extra Funding	$ 2,000,000	$ -
Total Return	67.5%	0.0%
Annual Avg Return	4.5%	0.0%



Graph 12



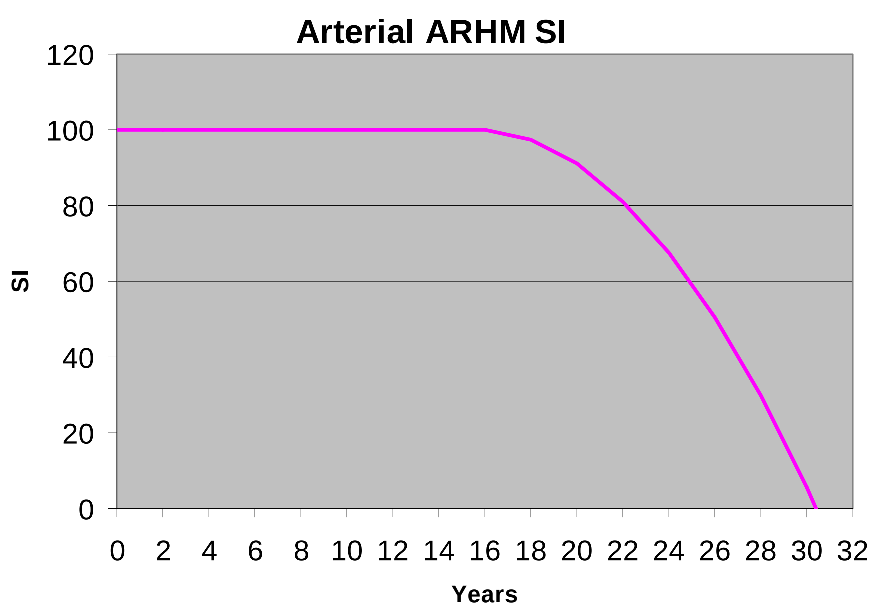
Graph 13



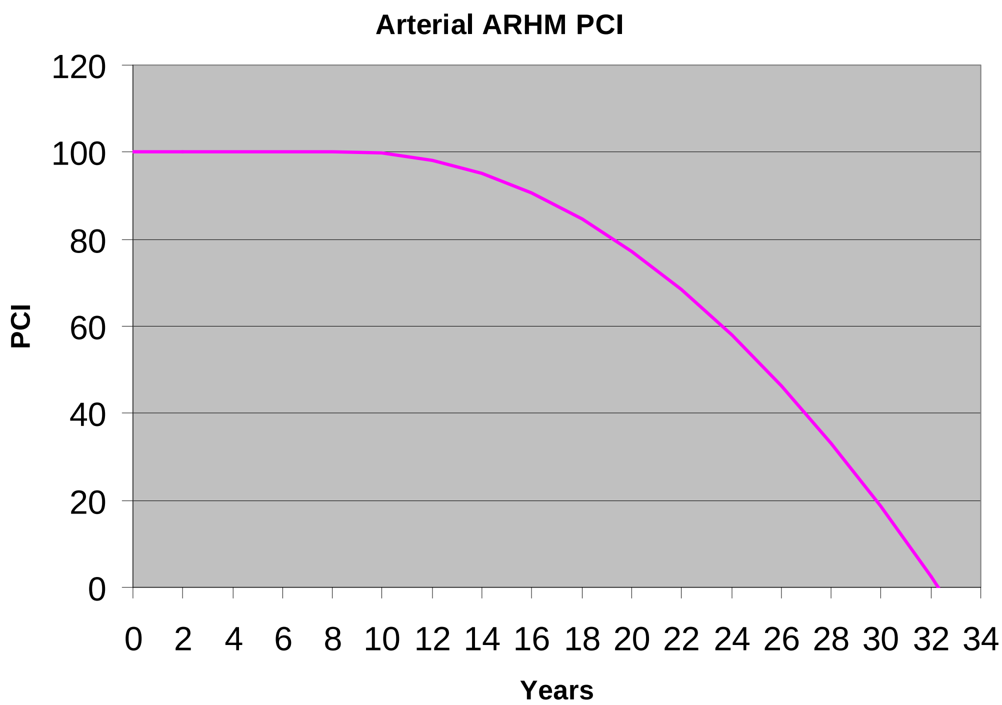
Graph 14

PROJECTION CURVES

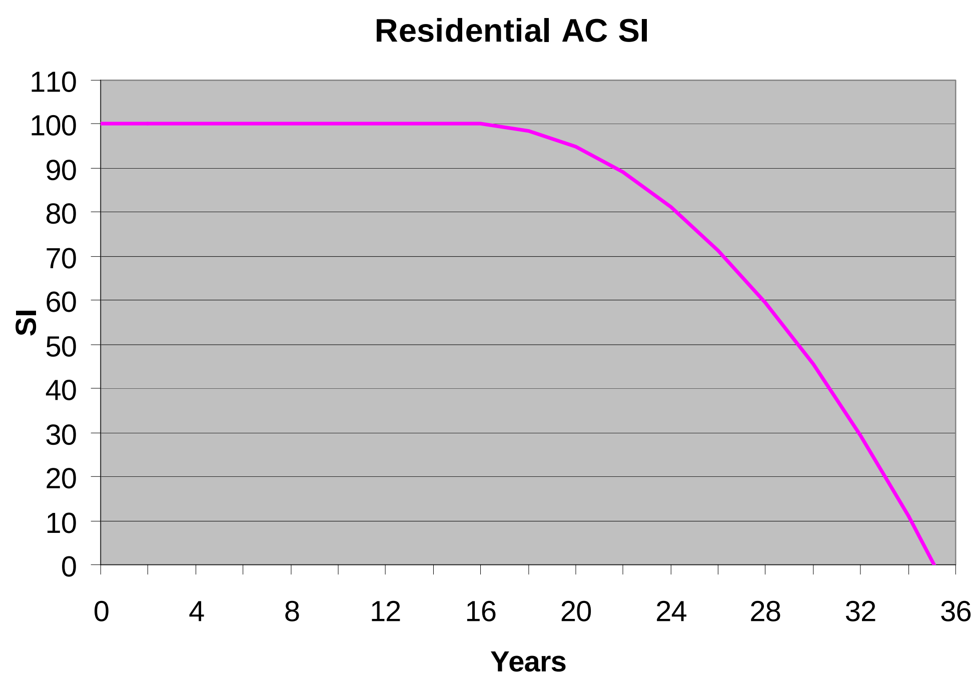
The projection over time of Structural Index and Pavement Condition Index for arterial and residential streets as used to project the graphs in this report are shown in the following curves.



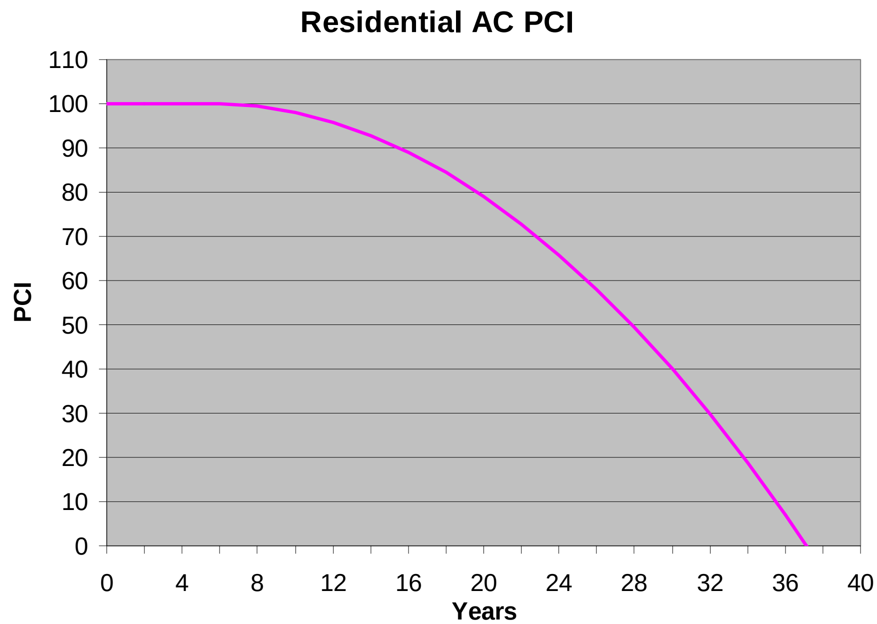
Graph 15



Graph 16



Graph 17


Residential AC PCI
PCI
Years
110
100
90
80
70
60
50
40
30
20
10
0
0
4
8
12
16
20
24
28
32
36
40

Graph 18

DATA RETRIEVAL

The Rancho Palos Verdes PMS contains the following reports, which have been generated using the information in the database.

1. Construction History. This is a complete inventory of history of construction of all the City's streets.

2. Overall List of Segments. This listing is in alphabetical order for all streets, and serves as a cross reference to find projects by Benefit/Cost, PCI or SI on the major maintenance reports.

3. Major Maintenance Inventories. These are listings of all projects identified as needing major maintenance. One set of these reports is listed in alphabetical order and others in order of priority for Major Maintenance. The priority listings are ordered by Benefic/Cost Ratio, Structural Index (SI) and Pavement Condition Index (PCI).

4. GIS generated maps of major maintenance for arterials and residential streets, a map of PCI values on each segment, and Si values on each segment, and also a history of overlays map, along with a zone map.