A Guide for Local Agency Pavement Managers

Washington State Department of Transportation

A Guide for Local Agency Pavement Managers

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The Pavement Management System
Guidebook Review Team

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Preface

ISTEA legislation has brought many changes and challenges to Washington State local agencies. Included in this legislation is the mandate that all roadways in the state using federal funds be covered by a pavement management system (PMS). Because of this mandate, local agencies have the responsibility for implementing and using a pavement management system to manage their roadways.

The purpose of this guide is to provide Washington's local agencies with a practical document that will assist local agency pavement managers in understanding the pavement management process and the steps necessary to implement their own pavement management systems. The guide has been developed with extensive input from local agency pavement managers across Washington State and draws heavily on their knowledge and experience.

This guide is only the beginning. There are other resources available to local agencies. Information sharing between pavement managers throughout the state either by phone or at pavement management meetings are good ways to increase your knowledge and understanding of pavement management.

TransAid will continue to support local agencies in the development and use of their pavement management systems and we encourage all of you to become active participants in this endeavor.

DENNIS B. INGHAM
Assistant Secretary
TransAid Service Center

Acknowledgments

A Guide for Pavement Managers

The guide was developed in cooperation with staff from the Washington State Department of Transportation (WSDOT) TransAid Service Center and various local agency members of the Nondestructive Testing Users Group and the Northwest Pavement Management System Users Group. These individuals made up the review team which provided the original information, reviewed numerous drafts, and provided comments at the progress meetings.

Particular thanks is extended to the team members' local agencies and their management staff for encouraging and supporting their participation in this project. The contribution of time and knowledge through the participation of Randy Firoved, Steve Pope, Dave Shepard, Dave Whitcher, and Bill Whitcomb was irreplaceable.

Special thanks go to George Crommes, Northwest Technology Transfer Center; Martha Roney, TransAid Technical Writer, for the writing and publication of the numerous drafts; and Paul Sachs, TransAid, for contributing information based upon his years of experience and knowledge of pavement management.

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Our sincere appreciation is also extended to all persons who contributed information for the use in this guide.

Introduction

Purpose of This Guidebook

This guide is meant to serve as a tool to assist agencies in understanding how a pavement management system (PMS) functions and how to implement one. The guide combines an explanation of the various PMS components and other supporting materials to help local agencies understand and implement a system that will work for them.

Many local agencies are implementing a PMS in an effort to maximize their effectiveness and efficiency in roadway management. PMS can be extremely helpful to engineers and technicians responsible for maintenance and rehabilitation of their roadways, and to public works directors, engineers, and managers who must know the costs and justify them.

How to Use the Guidebook

The guide does not duplicate the specific PMS aspects and details that can be found in other available materials. For example, information on rating pavements in the field can be found in the *Pavement Surface Condition Rating Manual*. Similarly, descriptions of various PMS software programs and their use are not included. For that information, PMS software users will want to refer to documentation provided with their software packages.

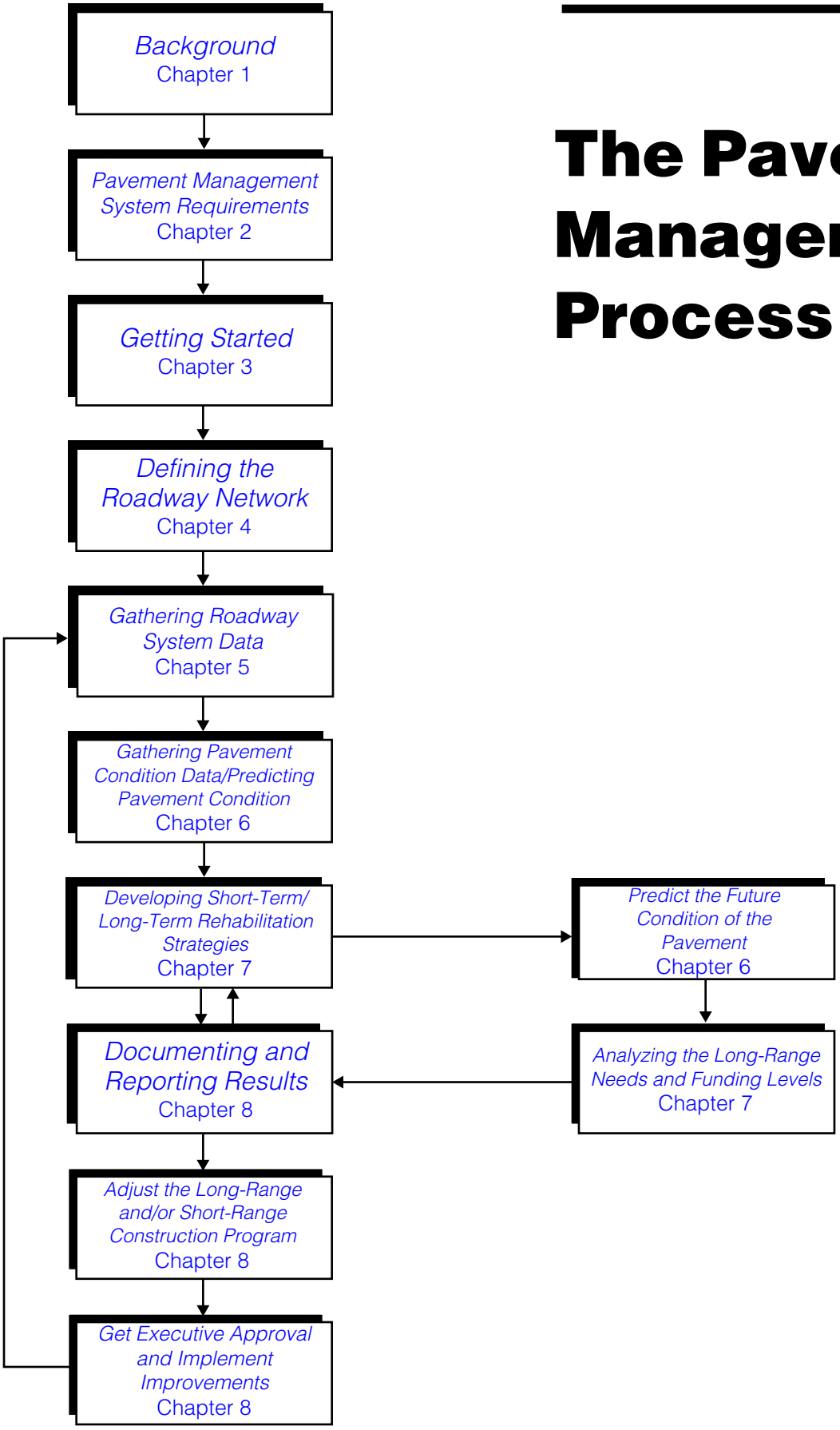
The chapters in this guide are arranged in the same order or sequence of steps that a local agency would take in order to implement a PMS. The flow chart on the following page, “The Pavement Management Process,” illustrates these steps, shows where each step in the process is taken, and indicates how the steps relate to one another.

A flow chart placed at the head of each chapter highlights the step in the PMS process that the chapter will discuss and includes a short summary of the chapter’s content.

Additional Sources of Information

For readers’ information and use, this guide also includes a bibliography of “Sources Consulted,” a listing of acronyms and definitions, and appendices containing statutes which mandate PMS. For more in-depth information, a bibliography has been provided in Appendix A.

The Pavement Management Process



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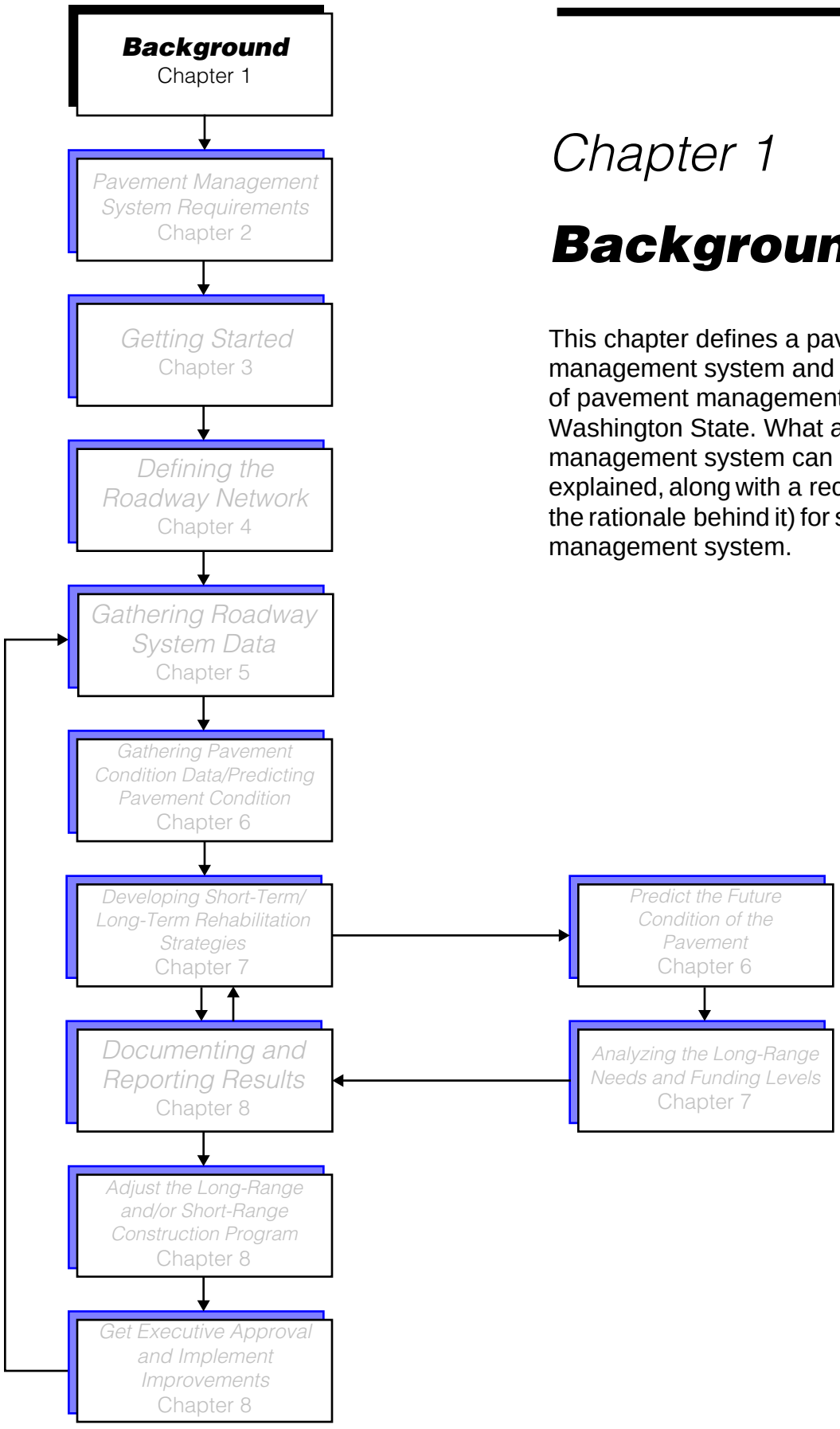

Chapter 1

Background

This chapter defines a pavement management system and provides a history of pavement management development in Washington State. What a pavement management system can and cannot do is explained, along with a recommendation (and the rationale behind it) for starting a pavement management system.

Chapter 1 Background

What Is a Pavement Management System?

The American Public Works Association (APWA) defines a pavement management system (PMS) as, "A systematic method for routinely collecting, storing, and retrieving the kind of decision-making information needed (about pavements) to make maximum use of limited maintenance (and construction) dollars." It is also a set of "steps" or computer routines for quickly using the information and making the calculations necessary to arrive at these decisions. Pavement management is not an end product in itself, but rather an additional tool to help the engineer, the budget director, the maintenance manager, and others to do their jobs better. In all cases, professional judgment is enhanced, not replaced by a PMS.

Through a systematic analysis of pavement life cycles, a PMS can determine the most appropriate time to rehabilitate pavement, what the most cost-effective method is, and how many dollars it will take to maintain a roadway system at a desirable condition level.

All agencies manage their pavements in some way; they are already using some level of pavement management. A formalized PMS is not something entirely new but an improvement on an agency's existing practices. It aids, not replaces, what a jurisdiction is already doing.

A Brief History of Pavement Management

Historically, there have been only two criteria that jurisdictions considered when deciding which roadways would be maintained or rehabilitated. These were "Worst First," that is, roadways that looked bad received the first attention, and "Political Priorities" which were motivated by citizen concerns or requests. Determining which roadways "looked bad" was accomplished by windshield survey of the city's roadways done by staff engineers or inspectors. Evaluations were subjective, were not based on standard criteria, and varied from inspector to inspector. Individual problem areas identified by citizens would be addressed by adjusting maintenance programs. These roadway sections (or "trouble spots" from the citizens' point of view) were selected for attention without objective comparison to the entire roadway network.

Many cities and counties also established a routine maintenance repair strategy which included crack sealing. This strategy was applied only occasionally and funding for it came out of the regular pavement maintenance budget. Funding for the pavement maintenance program was based on a fixed budget adjusted for inflation from year to year. There was no procedure for determining whether the funding level was improving the roadway system or allowing it to slowly or rapidly deteriorate.

A more objective, quantifiable approach was needed to provide methods for predicting pavement deterioration more accurately and thus, ensure that paving dollars were spent wisely.

Using a PMS will enable cities and counties to better manage their pavements.

Pavement Management in Washington

The first formalized, automated PMS in Washington was a visually-based system implemented by the Washington State Department of Transportation (WSDOT) in response to legislation passed in the 1960s. Known as Chapter 47.05 RCW, the Priority Programming Law, this legislation mandated that WSDOT prioritize proposed state highway construction projects according to defined needs.

The roadway's structural ability to carry loads was selected as the primary measure of pavement needs. In 1993, the legislature amended the Priority Programming Law to reference life cycle costing as well as need.

In the late 1960s, a procedure was developed for conducting a periodic visual survey of the entire state highway network and of recording pavement surface defects. Defects were selected to provide a clear indication of structural adequacy. Numeric values representing various severities were established for these defects and used to define an overall condition index. The sum of the defect numeric values was subtracted from a possible total score of 100. The resulting numeric value was equivalent to the approximate percentage of life remaining in the pavement and came to be known as the Pavement Condition Rating (PCR).

The system then produced a list of prioritized projects using the most recent PCR values associated with each predefined highway segment; projects in the worst condition ranked first. This was Washington's first PMS although it was not called pavement management at the time.

In the late 1970s, WSDOT began the development and implementation of the Washington State Pavement Management System (WSPMS). The WSPMS has been fully functional over the entire state highway network since 1983. WSPMS is based on developing project specific performance curves which are used to predict pavement condition into the future. The diverse rates of deterioration among various projects are addressed through the use of these project-specific performance curves. This has provided a reasonable, reliable method for establishing future, multiple-year programs.

After several years of experience in pavement management, WSDOT has been able to target the time of lowest life cycle cost for most rehabilitation projects. While this process is based on very simplistic models, it does offer a way to minimize rehabilitation costs while preserving the structure of the highway network.

Subsequent to the development of WSPMS, the state's cities and counties developed their own versions of PMS, based on the WSPMS. Although the majority of Washington's local agencies currently use visual assessment for determining distress, two counties are developing systems that use nondestructive testing techniques rather than visual assessment to determine pavement condition. Although there is no correlation between the two systems at this time, it is hoped that an equivalent pavement condition rating between the two can be achieved at some future time.

What a Pavement Management System Can Do

A PMS can:

- Provide an inventory of pavements that includes data on location, type of pavement, functional classification, mileage, pavement area, etc.
- Provide a comprehensive database containing information relating to pavement condition, traffic levels, construction, maintenance and rehabilitation histories, and any additional quantifiable information that may be needed or specified.
- Show the current “health” (or condition) of the pavement network based on systematic and sound engineering procedures for obtaining objective pavement condition information.
- Help to predict the “projected health” of the network over time, as a function of the funds available to make improvements.
- Define an estimated budget required to bring the total roadway network from its current condition to desired condition levels.
- Define estimated budgets to maintain a roadway network at specific levels of performance for multiple years, i.e., 5 to 20 or more, depending on the level of sophistication included in the system.
- Provide specific programs and proposed budgets for single- or multi-year programming cycles.
- List ways to prioritize expenditures when funding is less than required to meet specific performance objectives.
- Be a base for communication among groups — such as planning, design, construction, and maintenance — within an agency.
- Be a base for communication among groups outside an agency, such as state legislatures, city councils, the media, public interest groups, etc.
- Serve as a base for comparing alternate preservation strategies for maintenance, rehabilitation, and reconstruction of pavements within the network.
- Produce a list of maintenance and rehabilitation projects. This list will be reviewed by the agency for final project selection.

What a Pavement Management System Cannot Do

A PMS will not:

- Be an "all or nothing" proposition that requires replacement of an agency's current procedures with a fully computerized system.
- Act as a substitute for proper maintenance.
- Replace engineering evaluation of individual projects.
- Make all the decisions at the press of a button.
- Provide agencies with all the answers.

A PMS will identify the overall needs of the agency's roadway network.

Why Initiate a Pavement Management System?

Most local agencies are constrained by budget limitations; therefore, accurate assessment of pavement distress can provide a consistent and rational method for allocating limited resources. Managing pavements to achieve optimum roadway condition costs less.

Numerous studies indicate that if roadways are properly maintained in a perpetual "good" to "excellent" condition, the total annual maintenance investment is 1/4th to 1/5th the cost of allowing pavement to cycle through to "poor" and "failed" conditions and then applying rehabilitation. The major reason for this is that with preventive maintenance, only the pavement surface is being maintained. If the pavement is allowed to deteriorate to a "poor" or "failed" condition, it will probably be necessary to repair and rehabilitate the entire pavement structure including the base or subbase.

It is important to have an accurate assessment of the roadway system and be able to identify those roadway segments where a treatment can be applied. This treatment will extend the pavement life at the optimum time without costing the agency thousands of dollars.

Pavement condition deteriorates at an accelerated rate. A pavement will normally deteriorate by 40 percent during the first 75 percent of its life. During the next 12 percent of life, a pavement will deteriorate an additional 40 percent.

With proper timing of preventive maintenance, light rehabilitation, and reasonably consistent traffic patterns, roadways can be kept in good condition for many years at less cost. The key is to start a preventive maintenance program. Implementing a PMS achieves this objective.

With a thorough briefing on PMS history and an understanding of what a PMS can and cannot do for an agency, the next major issue of inquiry is statutory requirements: What do statutes require a PMS to do? And, what is required of local agencies? Those questions are answered in the following chapter, ***Pavement Management System Requirements****.*

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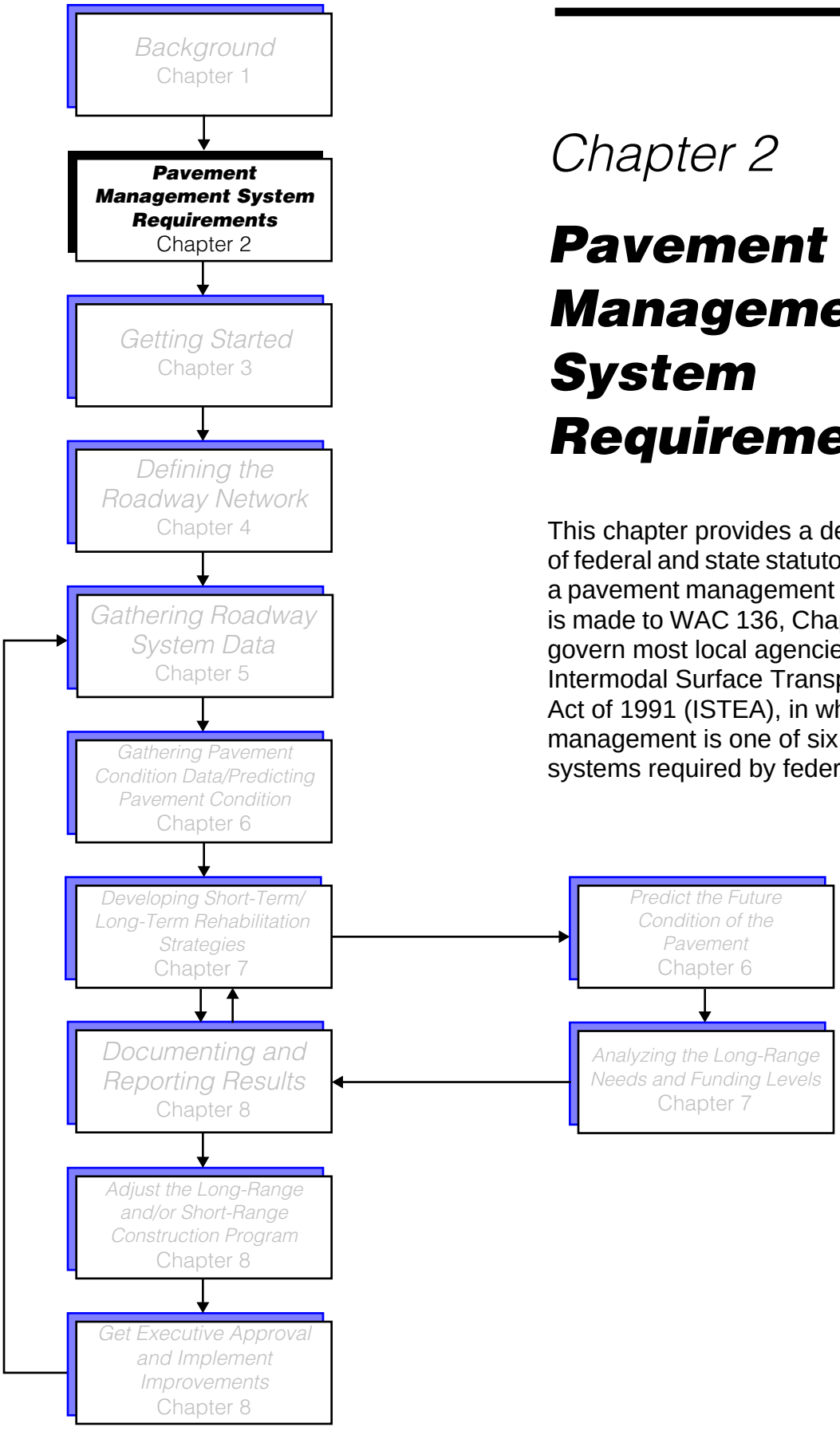


Chapter 2

Pavement Management System Requirements

This chapter provides a detailed explanation of federal and state statutory requirements for a pavement management system. Reference is made to WAC 136, Chapter 320, which will govern most local agencies, and to the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), in which pavement management is one of six management systems required by federal law.

Chapter 2 Pavement Management System Requirements

Statutory Requirements for a Pavement Management System

Pavement management system (PMS) requirements mandated by statute apply to local agencies through federal and state statutes. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) assigns the states responsibility for assuring that all roadways in the state using federal funds, except those that are federally owned, are to be covered by a PMS. Determining which federally owned public roadways shall be covered by a PMS is to be done cooperatively by the state, the Federal Highway Administration (FHWA), and the agencies which own the roadways.

State Requirements (WAC 136, Chapter 320)

On the state side, RCW 46.68.095 requires that all counties have a PMS that meets specific requirements in order to be eligible for County Arterial Preservation Program (CAPP) funds. These requirements are specified in WAC 136-320. (See Appendix B.)

- All arterials shall be surveyed for visual pavement distress at least biennially.
- All visual distresses (or defects) for both flexible and rigid pavements shall be as defined both in severity and extent within the *Pavement Surface Condition Rating Manual*.

Measurement may be by a manual or automated visual condition rating process. Distress information will be converted to a pavement condition rating in accordance with a standard deduct matrix or continuous deduct value curves as provided by the County Road Administration Board (CRAB). Alternate deduct matrices may be used by a county for internal management analyses. Alternate distress determination and evaluation methodologies may be used if approved by CRAB in accordance with WAC 136-320-040. Refer to Chapter 6 for more about deduct matrices.

- Measurement may be at the project, segment, or sample unit level. Measurement for each distress will be by:
  * Selection of the most predominant severity and its extent.
  * Determination of the extent (percentage) of each level of severity.

- The PMS shall provide for the recording and storage of pavement resurfacing, rehabilitation, and reconstruction history data, including surfacing and base layer types and thicknesses, and year of application. Counties will not be required to determine such information for any work done prior to the county's implementation date.
- The PMS shall include a future pavement condition prediction model that uses periodic pavement condition distress data to forecast future pavement condition and to determine an estimate of service life.
- The PMS shall provide for annual downloading to CRAB of one of the following for all paved arterials surveyed for pavement condition in the previous 12 months:
  * The individual pavement distresses,
  * The resultant pavement condition rating based on the CRAB provided standard deduct matrix, or
  * The resultant pavement condition rating for an approved alternative PMS as described in WAC 136-320-040.

When downloading to CRAB, the file shall be called the pavement condition data file. It shall be keyed to the county roadlog and transmitted in the electronic medium and format specified by CRAB, along with the annual roadlog update required by WAC 136-60.

I-5, an NHS roadway which meets ISTEA requirements, is on WSDOT's PMS.

Federal Requirements (ISTEA)

National Highway System Roadways

ISTEA requires that all roads on the federal aid system be managed by a PMS. ISTEA also defines the National Highway System (NHS) which is primarily composed of interstate and state routes; however, the NHS does include a few roadways that are owned by local agencies. These NHS roadways will have different PMS requirements than non-NHS roadways that are federally funded.

The minimum requirements for NHS roadways are:

1. Data Collection and Management
    - An inventory of physical pavement features including the number of lanes, length, width, surface type, functional classification, and shoulder information.
    - A history of project dates and type of construction, reconstruction, rehabilitation, and preventive maintenance.
    - Condition surveys that include ride, distress, rutting, and surface friction.
    - Traffic information including volumes, classification, and load data.
    - A database that links all data files related to the PMS. The database is to be the source of pavement related information reported to FHWA.
2. Analyses, at a frequency established by the state which is consistent with PMS objectives.
    - A pavement condition analysis that includes distress, ride, rutting, and surface friction. (ISTEA does not require collection of surface friction data. However, if an agency is collecting such data, ISTEA requires that it be included in the agency PMS. Ride data is only required for Highway Performance Monitoring System [HPMS] samples.)
    - A pavement performance analysis that includes an estimate of present and predicted performance for specific pavement types and an estimate of the remaining service life of all pavements on the network.
    - An investment analysis that includes:
        * A network level analysis that estimates total costs to correct present and projected conditions across the network. (Refer to page 4-1 for discussion of network and project level pavement management.)

* A project level analysis that determines options for the use of funds. This is to include a prioritized list of recommended candidate projects with assigned preservation treatments that span single- and multi-year periods, using life-cycle cost analysis.
* Appropriate time periods, as determined by the state, for these investment analyses.

- An engineering analysis for appropriate sections that includes the evaluation of design, construction, rehabilitation, materials, mix designs, and preventive maintenance as they relate to pavement performance.

3. Based on the agency's current policies, engineering criteria, practices, and experience, the PMS must be evaluated annually and updated as necessary.

At a minimum, cities and counties having NHS roadways in the state of Washington, will have to meet the preceding requirements for the NHS portion of their roadway network.

Non-NHS roadways which receive federal aid are subject to different PMS requirements — depending upon their ownership.

Non-NHS Roadways

For non-NHS roadways which receive federal aid dollars, the following requirements apply:

- **All Counties and Larger Cities.** For all counties and for cities with populations of 22,500 or greater, the PMS for non-NHS roadways must be modeled on the components described in WAC 136, as described earlier in this chapter.
- **Small Cities.** For cities with populations of 22,500 or less, a simplified pavement management system is being developed for non-NHS roadways. That system is discussed below and on the following pages.

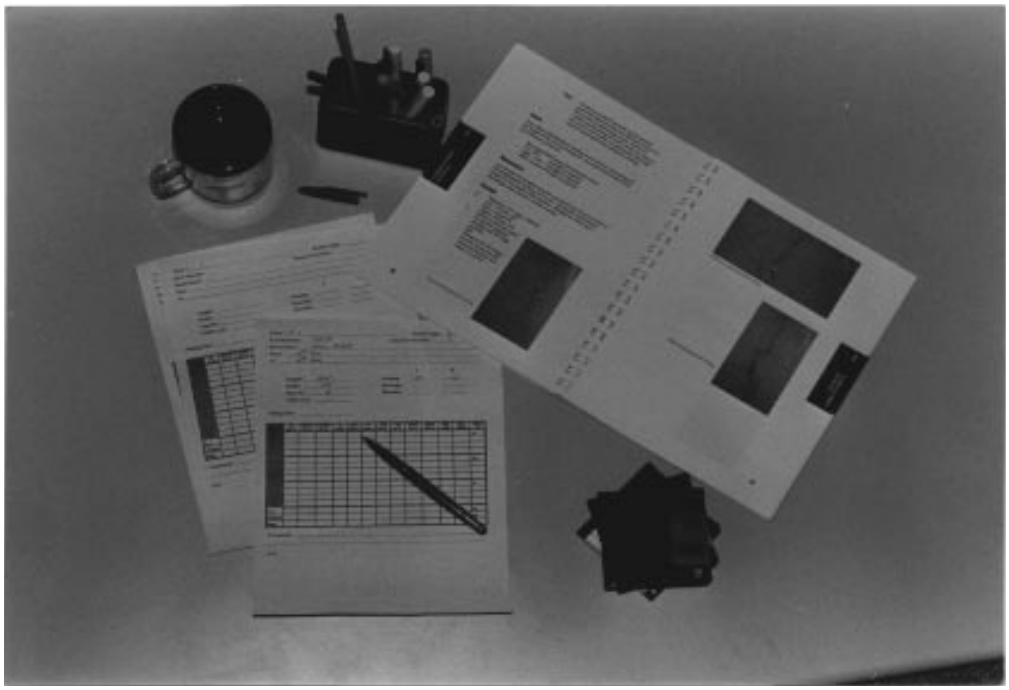
Simplified Pavement Management System for Smaller Agencies

For cities with populations of less than 22,500, the WSDOT simplified PMS is currently in development. The basic pavement management system requirements for smaller agencies are:

- A reliable referencing system (street identifier/segment locator) must be adopted.
- A visual condition survey which produces a ranked list of proposed projects must be performed at least biennially.

While a simplified PMS will be allowed, smaller agencies are strongly encouraged to adopt and implement a PMS program like those in use by larger jurisdictions.

A PMS to be used by smaller agencies in Washington State will be developed with those agencies' cooperation. At this writing, it is anticipated that the following components will be contained in a smaller agency PMS.



Many items are needed when beginning to use a PMS.

Data Collection and Management Requirements

1. **Inventory.** The inventory of pavement segments shall include connection to the reference system (street identifier/segment locator), street name, pavement type, number of lanes, length, width, area, and functional classification.
2. **History.** Previous construction information pertinent to each segment is to be recorded if known. All new construction, reconstruction, rehabilitation, or major maintenance shall be recorded as part of the history data.
3. **Condition Survey.** A distress survey shall be done on a regular basis using a survey rating scheme based on the requirements set forth in the *Pavement Surface Condition Rating Manual*. The visual rating process offers simplicity and is convertible to a more sophisticated type of survey; if an agency then chooses to upgrade to a full PMS, the data will be usable.
4. **Traffic.** Some estimate of ADT and heavy trucks should be available for pavement design purposes.

5. **Database.** Smaller agencies may not require a large database to accomplish the intent of a PMS. For them, pavement management data may be as simple as a card file or a normal paper file. As the complexity and size of the PMS increase, the small agency will be encouraged to upgrade to a computerized PMS.

   Note: For the minimum standards required in a more sophisticated PMS, refer to "State Requirements (WAC 136, Chapter 320)," earlier in this chapter. For the complete text of WAC 136, see Appendix B.

Analysis

1. **Pavement Condition Analysis.** Pavement condition scores for each roadway shall be collected, stored, and analyzed to determine which pavements are in the worst condition and whether or not those pavements have degenerated from the previous year. An average condition rating for the overall network shall be calculated to monitor the network condition.
2. **Pavement Performance Analysis.** This level of analysis is not required. If an agency wants individual performance curves to indicate remaining life and other performance characteristics for each paved segment, that agency will be encouraged to upgrade to a computerized PMS.
3. **Investment Analysis.** This level of analysis is not required. To develop scenarios using combinations of thresholds and budgets, an agency would be encouraged to upgrade to a computerized PMS.
4. **Engineering Analysis.** Using the results of the PMS data and related models, improvements to design and construction practices may be suggested.

As an agency becomes more sophisticated and its need for additional information and more complex analysis increases, it will be encouraged to upgrade to a computerized PMS and PMS software. The complete federal regulations regarding PMS are found in Appendix C.

With an understanding of PMS statutory requirements, the process of developing and implementing a PMS can begin. In the following chapter, ***Getting Started****, this process is thoroughly discussed — from establishing an agency PMS Steering Committee to selecting software and hardware.*

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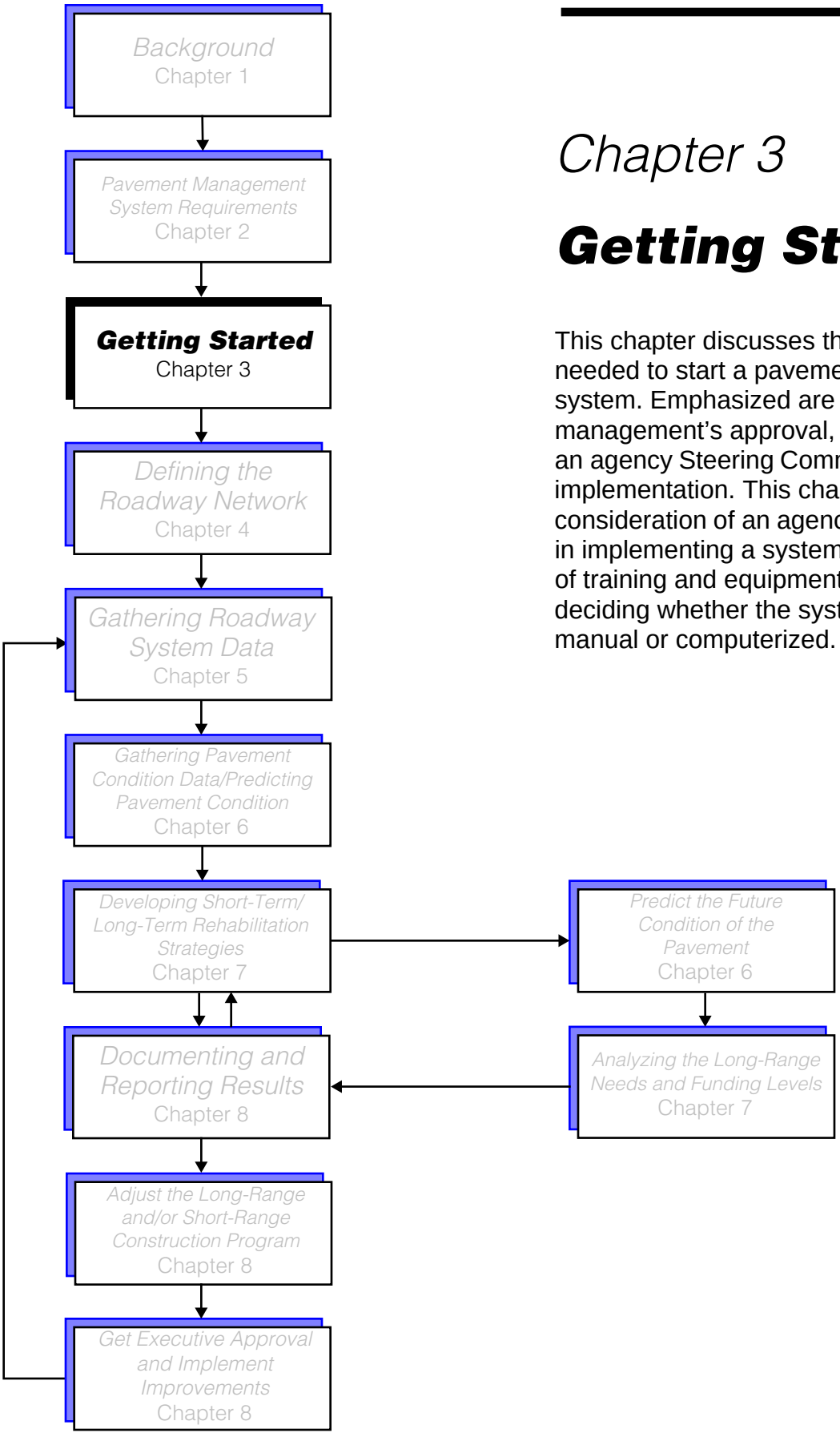

Chapter 3

Getting Started

This chapter discusses the basic steps needed to start a pavement management system. Emphasized are the need to get management's approval, and creation of an agency Steering Committee to guide PMS implementation. This chapter also includes consideration of an agency's needs, its goals in implementing a system, the importance of training and equipment flexibility, and deciding whether the system will be manual or computerized.

Developing Your Pavement Management System

With a basic understanding of what a pavement management system (PMS) can and cannot do, and having made the decision to implement a system, the PMS development process can begin. Among the first steps in this process is exploring options for: funding system development and implementation; selecting the level of sophistication for the system; and identifying the resources that are necessary to put the system into action.

Funding a Pavement Management System for the First Time

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) contains funding provisions for local agencies seeking PMS implementation funds. Local agencies must apply for State Transportation Plan (STP) funds through their STP regional process. Applications for STP funds are usually submitted once a year, although this can vary depending upon the region. Funding decisions are made by lead agencies, which select projects such as PMS implementation through the regional competitive process. Each agency needs to coordinate with their program development office to determine the right process for their agency.

Implementation Steps

It is important to have a full understanding of the PMS process before embarking on PMS implementation. The following steps have worked successfully in other local agencies, and should be used as a guide.

A Decision to Start a PMS

This is the key step. With many PMS regulatory requirements now in place, it is important for all local agencies to consider implementing a PMS. But the regulatory requirements should not be the driving force for implementation. An agency should understand the benefits of a PMS and begin. There is usually one person who will be responsible for promoting use of the PMS in an agency. It is important that this person not only understand the benefits of PMS, but convey these ideas to others in the agency. To successfully implement a PMS, the PMS manager will need to develop alliances with other sections in the agency as well as secure top management support. This will help get pavement management on the agency's agenda and assist in starting a PMS successfully.

An agency steering committee is needed to insure that all affected divisions are included in the process.

Formation of an Agency PMS Steering Committee

After the decision has been made to start a PMS, it is important to form an agency PMS steering committee. This committee should be comprised of individuals from every section in the agency where the PMS will have an impact. This includes individuals from maintenance, engineering, finance, and a representative from executive management.

The steering committee's first task is to develop the PMS program objectives and a work plan. The steering committee should be given the authority to decide the PMS program objectives:

- What data to include in the PMS.
- Which department will be accountable for the PMS.
- How each department will provide information to the PMS.
- How each department will use the PMS results.
- A time line indicating when certain activities will occur.

The steering committee should also give a presentation to the elected board/ council. This presentation should be short and understandable since the audience will not be technical experts or engineering professionals. The presentation should cover what a PMS is, the benefits of PMS, and the estimated time it will take to achieve the stated objectives outlined in the work

plan. This presentation is important. It will educate the board/council on PMS so that when the PMS budget presentation is made later on, the board/council will have an idea of its basic concepts.

Gaining Commitments for Funding the PMS

Real commitment is achieved in most agencies when funding is committed. This is the next step of PMS implementation. The steering committee should ensure that adequate funding to support pavement management implementation has been allocated. The available funds may control the rate at which implementation can proceed.

Select a PMS

Elements to be included in an agency's PMS should be identified and clearly defined by the agency's PMS steering committee with the approval of top management. The system must include what an agency needs now, with the flexibility to add components to meet later needs. Some basic considerations include the following:

- A PMS can be simple or complex, depending upon the size, needs, and style of the organization.
- A system can be manual or automated.
- Any system selected should be dynamic and be built incrementally or in phases. By doing so, applications not yet needed can be added at some future time, when they are needed.
- If a custom system is being developed, it should be kept as practical as possible to avoid unnecessary technical complexity.
- The system should not be built so quickly that the agency and its staff have a difficult time adjusting.
- The system should include ongoing training and technical support.
- Most important — the system should be easy to use.

Trial Implementation

After a PMS has been selected, it is important to evaluate its capabilities on a small area of the roadway network. This is done for a couple of reasons. First of all, an agency will want to "test drive" the software before implementing the system on the entire network. This way, as issues arise, an agency can adapt and modify the system if necessary before the full roadway network has been included. If, after the trial implementation, an agency does not feel that the software meets their needs, it can be dropped and a new software system started without the loss of too much time and too many resources. For the trial

implementation, take a small area of the city or implement the PMS on all of the arterials and collectors in the agency. After the trial implementation has been completed, the agency can evaluate any modifications it may want when the full implementation is undertaken.

Implementing a PMS takes time and you can expect delays along the way.

Modify PMS

In this step, the PMS steering committee changes the PMS process and the software as a result of the findings from the trial implementation. A change could be as simple as adding an additional data element to the inventory form or modifying the way the condition survey is done.

PMS Implementation on the Entire Roadway Network

After modifying the PMS software, full implementation can take place. The steering committee may want to review its work plan at this point to see if they are still on schedule. They may want to consider placing themselves on the council/board agenda again to present a progress report on implementation.

Modify Pavement Management Systems for Future Years

After the PMS has been fully implemented, the steering committee should review the need to modify the system. Remember, the PMS is not a one-time activity, and if there is a way to do the PMS work better in the future, changes should be made.

The benefits of PMS training cannot be over emphasized. The more familiar and comfortable employees are with the system, the more effective the system will be.

Training

At several points during development, implementation, and continued use, an agency can benefit from training in preparation for specific tasks. These include:

- Basic concepts, establishing goals and a work plan prior to starting implementation.
- Network division and data entry.
- Distress identification, inspection procedures, and data entry.
- Life cycle cost analysis, life extension, treatment cost calculation and their impact on budget needs.
- Cost-effectiveness analysis, stop-gap maintenance concepts, costs, level of service, and deferred maintenance and rehabilitation fund concepts.
- Inspection scheduling and updating maintenance and rehabilitation information in the PMS database.

For cities and counties, this training can be acquired through WSDOT TransAid Service Center; for counties, training is available from the County Road Administration Board (CRAB). Other sources of training include WSDOT's Northwest Technology Transfer Center (T^2), TRANSPEED, Northwest Pavement Management Association, industry associations, and city and county associations. Some agencies may also wish to contract for training with pavement management consultants.

Computerized Pavement Management Systems

Software

As an agency's PMS becomes more complex, a decision may be made to implement a computerized pavement management system. Some specific issues to consider when choosing a PMS software package include:

User Involvement

Solicit suggestions and input from those who will be or are already using the software. Discuss agency and user needs and proficiency to decide which software might best accommodate agency objectives and user efficiency.

Easy to Learn and Use

The selected software should not be so complex that employees must spend months learning it. Complex software that is difficult to use requires more extensive training time and can erode user support and commitment to the system.

Appropriate Level of Sophistication

Choose software powerful enough to meet the agency's present and **future** needs but not so powerful and complex as to produce data and sophisticated analyses that the agency does not require for decision making.

Costs

Cost should not be the overriding factor in software selection. Ease of operation, upgrade availability and expense, and vendor support are just as important as the initial software cost.

Software Flexibility

As jurisdictions change, it may be necessary to upgrade the software. Determine whether upgrades are/will be available at reasonable cost if they are needed. Find out whether the software company will assist or advise in upgrade installation if necessary.

Support for your agency's PMS is an important factor to consider when choosing a PMS.

Support

Some software companies provide free, on-call user support. This may be an important factor in the purchasing decision if an agency is somewhat new to computer technology. Ensure that any software package will include thorough, clear documentation and that off-site training will be readily available and conveniently located.

Software and support are offered to public agencies through the WSDOT TransAid Service Center and through CRAB. The private sector software market has programs available at reasonable prices that conform to management system practices used by most agencies in Washington State. Whatever software programs are selected, they should conform to state and federal requirements, be capable of performing the functions desired, and include usable instruction manuals and after-sale support provided by the suppliers.

Most PMS software used in Washington is based on the concepts and practices of WSDOT's Washington State Pavement Management System (WSPMS). These concepts include the basic theory of fatigue-based performance curves, definitions of specific defect types and their severities, and units of measure. This system has evolved over time and requires a minimum of information and data collection. It also provides uniformity and consistency for comparison purposes.

While there is no mandate to use any particular PMS software program, systems that meet general WSPMS concepts are strongly encouraged since they meet WAC and ISTEA requirements and the majority of agencies are adopting them, thus providing a large support network. Some important elements include:

- Condition ratings in compliance with the *Pavement Surface Condition Rating Manual*. (***Note:*** This is **critical**. All Washington agencies currently involved with PMS use these pavement condition survey specifications. It is the primary building block for the visually based PMS and complies with all federal and state management system requirements.)
- Training on pavement rating in accordance with the *Pavement Surface Condition Rating Manual*.
- Performance prediction modeling.

Hardware

If an agency does not have a computer to run the PMS software, the following guidelines may be helpful to determine the appropriate hardware:

Involve Users

The employees who will actually use the machine should be involved in establishing requirements and in the selection process. This not only ensures that their needs are met but also enlists their support and commitment to use the system properly.

Specify Requirements

Basic hardware requirements which will evolve from software selection are an operating system, the amount of required memory, and disk storage requirements. Other important features such as keyboard feel and screen readability are largely matters of personal preference and can be evaluated during hands-on visits to dealers.

Keep Price in Perspective

Price should not be the overriding factor in equipment selection. System requirements, unique hardware characteristics important to a given application, user performance, maintenance, and dealer qualifications are at least as important as the purchase price.

Once these elements are in place or underway, a more detailed approach to PMS implementation can be taken. That approach includes defining the roadway inventory — the foundation of any pavement management system — and learning how to start and build it; gathering the basic, required information about each roadway in the inventory; defining and gathering other information required for good decision-making; and, dividing the inventory into manageable sections or segments that can receive consistent maintenance treatments. These steps and associated information are explained in *Chapter 4,* ***Defining the Roadway Network****.*

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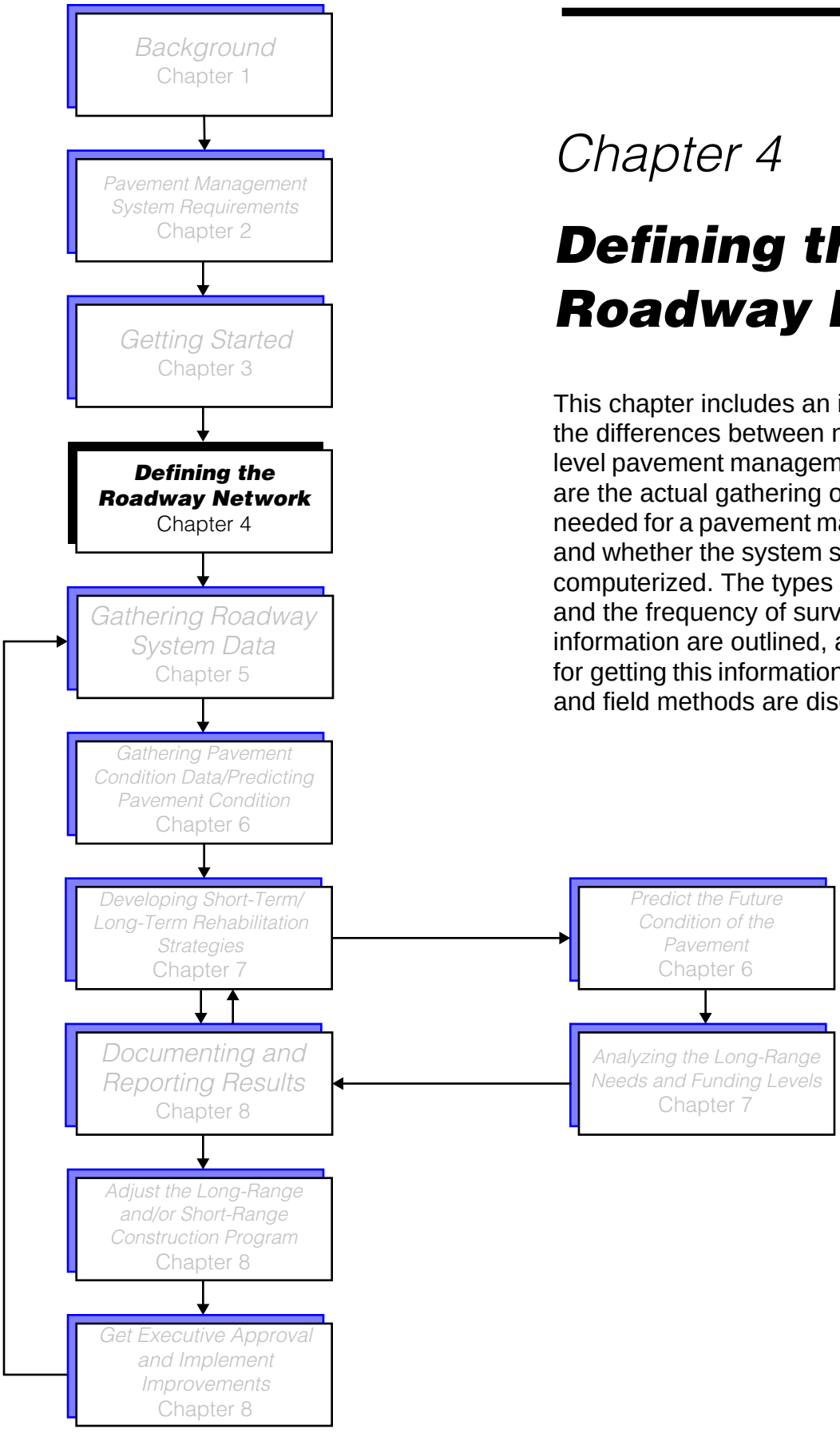

Chapter 4

Defining the Roadway Network

This chapter includes an introduction to the differences between network and project level pavement management. Also explained are the actual gathering of inventory data needed for a pavement management system, and whether the system should be manual or computerized. The types of inventory items and the frequency of surveys for updated information are outlined, and techniques for getting this information through both office and field methods are discussed.

Chapter 4 Defining the Roadway Network

Basic System Components

Network and Project Levels of Pavement Management

Before any data is collected, it is important to understand the differences between network and project level pavement management. A network level pavement management system (PMS) is related to program and policy issues for the entire network; therefore, a network level analysis will be of the most use and interest to the mayor, manager, budget director, etc. Network level analysis is best used for overall budget estimates, examining hypothetical or projected circumstances, or for policy "what if" kinds of questions. The network level requires more summarized information because of its use by administrators and council or commission members.

Project level PMS analysis is a series of steps to determine the cause and extent of pavement deterioration; in local agencies, it would normally follow network level analysis. Project level analysis includes coring samples and other engineering techniques that go beyond the normal data collection that occurs for the network level.

The differences between the network and project levels also relate to the amount and type of data required. Data collection is expensive, and it is often not known exactly what type and how much data will be required until some of it has been collected. Excessive data collection has created problems in implementation and in the continued use of a PMS.

To avoid this dilemma, the absolute minimum data is normally collected at the network level. This allows the PMS to be implemented with less initial investment in data collection; however, the data collected at the network level is then inadequate for making most project level decisions. For project level, more complete data must be collected on individual pavement sections identified by the network level analysis as primary candidates for maintenance or rehabilitation. The need to minimize data collection costs is a fundamental reason for separating pavement management elements into network and project level elements.

The differences between network and project decisions are normally found both in the quantity of pavement being considered as well as the purpose of the decision. In network level elements, agencies generally include all of the pavements under their jurisdiction; however, they may also break out subsets, such as arterial roadways, bus routes, or industrial streets. The quantity of pavement considered at the project level is normally a single management section, which often corresponds to an original construction section. These sections may be combined or subdivided in the analysis.

The purpose of the network level management process is normally related to the budget process. The primary results of network level analysis include maintenance and rehabilitation needs, funding needs, prioritized listings of sections needing repair, and forecasted future conditions for various funding options.

At the project level, the purpose is to provide the best original design, maintenance, or rehabilitation strategy possible for a selected section of pavement for the funds available. The primary results of the project level analysis include an assessment of the cause of deterioration, identification of possible design, maintenance and rehabilitation strategies, and selection of the "best" strategy within imposed constraints. This requires a considerable quantity of detailed data.

However, not all of the data required for project level decisions is required for network level decisions. Generally, network level decisions can be made using a data set that is much less complete than that required for the section specific project level decisions. To reduce the cost of implementing a PMS, only the minimum data required is collected.

By adopting project level PMS elements that complement the network level system, the minimum required data can be collected initially and more complete data can be captured through project level analysis when that data is necessary to support the decisions being made. This approach allows an agency selecting a PMS to focus only on collecting the required minimum amount of data and not data that becomes obsolete.

Roadway Inventory

The roadway inventory is the foundation of any pavement management system, since it supports the other system components and provides the information those components will need to function.

The inventory contains all the roadways that the agency is responsible for managing. Most agencies choose to include all their pavements into a single network. A network is defined as the entire paved roadway system. However, many agencies are including sidewalks, parking lots, bike pathways, gravel roads, and asphalt pathways adjacent to the roadway in their inventory. The basic purpose of the inventory is to provide information describing the pavement's physical features.

Certain basic information must be known about each roadway in the inventory. The minimum required data includes:

- Data entry date.
- Road number/name or designation.
- Beginning location — from milepost (the beginning milepost number).
- Ending location — to milepost (the ending milepost number).

- Functional classification.
- Number of lanes.
- Pavement type.
- Pavement thickness.
- Pavement width.
- Pavement length.
- Jurisdiction (or ownership).
- Construction year (last surface).
- Average Daily Traffic (ADT).

Building Your Pavement Management Inventory

Most local agencies already have a pavement inventory whether they are using a computerized PMS or a manual one. This inventory might simply be a map showing all roadways maintained by a city or county, or construction project files containing data such as construction dates, project length, width, and pavement type. An inventory in a format that can be recalled and used easily should contain all the information needed to make sound management decisions.

Some inventory data — roadway geometrics, pavement type, location, and design traffic loads — does not require updating unless it has changed. Conversely, pavement condition, actual traffic, and surface friction data need to be updated on an established schedule or frequency.

Other information that may be helpful and important relates to traffic, drainage, parking/shoulder, and the geographic/environmental area. However, one fundamental rule applies here: use your agency's resources efficiently by gathering and maintaining only PMS-related data that can be used in later decision making.

Each data item requires time, effort, and money to collect, store, retrieve and later, use. Therefore, each agency needs to determine whether or not to limit their data collection efforts to what their current forces can collect. Implementation of systems that require data collection support beyond existing staff capabilities will require additional expense.

A good inventory does not require a sophisticated computer system. While a computer can quickly and easily manipulate large amounts of data and may be desirable in many cases, the immediate purchase of a computer is not essential. Data storage can be as simple as a card file. Data forms and system files can be designed to permit manual operation initially, then provide a smooth

transition to computer applications at some future time. Whether the inventory is compiled and maintained manually or by computer is strictly a local choice, as is the level of sophistication built into the inventory itself.

Dividing the Network Into Manageable Units

One of the key factors in building a PMS inventory is deciding how the network should be divided and determining the size of each segment in the network. For a roadway system to be manageable, it needs to be broken down into small units for data collection and analysis. That is the primary reason that most jurisdictions choose to divide the roadways in their inventories into units or subunits that can be managed efficiently. These units and subunits, defined below, may be called projects, segments, or sample units:

Project: A section of roadway that has similar age, geometry, and construction type.

Segment: A subdivision of a project. There may be one or more segments within a project, such as city blocks.

Sample Unit: A subdivision of a segment that allows detailed analysis and recording of pavement defects. A sample unit is commonly — though not always — a 100-foot portion of a segment.

A pavement manager uses overheads to explain the division of the roadway network.

Another primary reason for dividing the inventory into small units is to identify areas that engineers can treat as a complete section — one to which the same maintenance treatment would normally be applied. To identify these sections, they must be measured from one reference point to another.

For example, segments are defined so that the pavement within their boundaries is consistent in terms of physical and functional characteristics. Any one of the following factors could define the boundary between two segments:

- A change in the number of traffic lanes.
- A change in pavement type.
- An abrupt change in traffic patterns or volume.
- A change in drainage characteristics (such as curb and gutter to ditch segment).
- A change in pavement structure (thickness, material, etc.).
- A change in natural subgrade characteristics.
- Previous construction projects (different projects reflect different designs, materials, ages, and other factors).

In addition, geographic or manmade boundaries may offer or force segment boundaries, such as:

- Roadway intersections.
- Rivers or streams.
- Bridges.
- City or township limits.
- County lines.
- Railroad crossings.

Once segment boundaries are established, they tend to become permanent; therefore, every effort should be made to reference segments to permanent, recognizable factors. Using signs as segment boundaries, for example, is not recommended. Signs can be knocked down and replaced in different locations, removed, or simply relocated.

Local agencies will find it necessary to manage two basic types of segments: static and dynamic. Static segments are uniform throughout in structure and/or makeup and have the same environmental exposure and the same traffic loads; their end points remain fixed. If, however, a segment does not perform similarly throughout its length, it becomes dynamic, requiring different treatments for different portions and a redefinition of the new segment or segments. Past construction is what usually defines a segment and there is no

requirement that local agencies use historic end points for their projects. Therefore, new rehabilitation projects usually define new segments.

For an example of how one city in Washington divided its roadway network, see Appendix D.

Most county roadway networks are divided by milepost.

Mileposts

At present, counties inventory their roadways using mileposts as reference points for tracking various features, including pavement. Each county employs its own method for mileposting; as long as that method remains consistent, there are few, if any, problems. In general, counties establish mileposts from south to north and from west to east. There are two ways to milepost dead end roadways: from south to north or west to east is one method; from the nearest intersection to the dead end is another. Either method is acceptable as long as it is done consistently.

This city block represents a segment in a PMS.

City Blocks

Using city blocks to identify the start and end of a pavement project or segment has the advantage of providing relatively uniform units to manage since agencies normally do not construct, rehabilitate, or apply preventive maintenance to less than a block at one time.

Some agencies divide their roadway networks by intersections.

Intersections

Designating smaller units of the network by intersection defines projects or segments that have uniform characteristics and are located between given intersections. These units may be several blocks long in a city or a few miles long in a county. They are selected because they are known to have basically the same structure, the same construction date, the same traffic loads and are generally performing in the same manner.

Using this method decreases the number of projects or segments to be managed and reduces the data collection effort, data processing time, and data analysis. It does require more complete information on construction, traffic and performance and some sections may have to be subdivided at a later date.

Designating projects or segments by intersection is probably most applicable to agencies which have relatively complete data, to counties with long, uniform construction sections, and to subdivisions which were constructed at the same time. Cities usually divide their pavement networks into units by measuring from one intersection to another, although some have used both intersections and city blocks.

Pavement Types

As stated previously, a change in pavement type represents the beginning of a new segment. Most agencies manage two types of pavement: flexible and rigid. Flexible pavements, such as asphalt concrete (ACP) are layered systems; each successive layer increases the pavement's strength, provided the subbase is adequate and undamaged. Rigid pavements, such as Portland Cement Concrete (PCC), consist of a concrete slab over a base. Rigid pavement will bridge imperfections in the subbase, since its strength is internal and exceeds the strength of the subbase. Most of the load is carried by the slab itself.

As a general rule, flexible pavement distresses are an indication of the pavement's subbase condition, while rigid pavement distresses reflect surface, not subbase conditions.

Pavement types typically included in a pavement management system are:

Portland Cement Concrete (PCC)

A composite material consisting essentially of a binding medium embedded with particulates or fragments of aggregate. In Portland cement concrete, the binder is a mixture of Portland cement and water that, when set, attains hardness and strength not unlike stone.

Asphalt Concrete Pavement (ACP)

A thoroughly controlled hot mixture of asphalt cement and well-graded, high quality aggregate, held together by a binder and thoroughly compacted into a uniform dense mass.

APC (ACP Over PCC)

One or more courses of asphalt construction on an existing concrete pavement. The overlay may include a leveling course to correct the contour of the old pavement, followed by a uniform course or courses to provide needed thickness.

Bituminous Surface Treatment (BST)

The placement of one or more applications of asphalt and one or more sizes of aggregate as a seal. BST is used primarily as a pavement maintenance remedy for asphalt surfaces but is also used to upgrade gravel roads and is the primary surfacing used on low volume roads.

Slurry Seal

A pavement maintenance remedy in which liquid or emulsified asphalt is mixed with suitable aggregate and applied to the pavement surface.

Gravel and Dirt Roadways

Some local agencies choose to include gravel and dirt roadways in their PMS even though they are not paved and therefore, are not subject to the same measures of adequacy or systematic deterioration as paved roadways. These roadways are included for maintenance purposes only to aid the agency in revising and prioritizing their maintenance needs.

Geometrics

Geometric data in the inventory should include:

- Pavement width.
- Number of lanes.
- Median width.
- Shoulder width and type.
- Parking width.
- Curb height.

Construction History

It is important to obtain the last date that the pavement was either reconstructed or overlaid. This date is used to determine future life expectancy if a PMS computer software package is being used.

Functional Classes

Which functional classes to include in the roadway inventory will be decided by the agency's Pavement Management Steering Committee and approved by management. Funding requirements will need to be considered in this decision. ISTEA requires that an agency's PMS include all functional classes except local collectors and city streets. For counties to be eligible for CAPP funds, their systems must include all county arterials. For further details on these requirements, see Chapter 2, Pavement Management System Requirements.

A functional classification defines the major role that a roadway serves within the total existing and future roadway network. Whether they are in an urban or a rural setting, highways and roadways function as arterials, collectors, or local access. Arterials and collectors provide the highest degree of mobility and limited access to local property, and local roadways emphasize land access over mobility.

In addition to funding requirements, an important factor to consider when deciding which functional classes to include is system flexibility: even very small jurisdictions need to anticipate future population growth and maintain the ability to include more classifications if necessary. Functional classes are coded by the Federal Highway Administration (FHWA) as either rural or urban.

Rural: An area with a population of less than 5,000.

Rural roads are categorized into the functional classifications listed below.

Federal Code	*Functional Class*
01	Principal Arterial — Interstate
02	Principal Arterial — Other
06	Minor Arterial
07	Major Collector
08	Minor Collector
09	Local Access

Urban: An area with a population of 5,000 or greater.

Urban roadways are categorized into the functional classifications listed below.

Federal Code	*Functional Class*
11	Principal Arterial — Interstate
12	Principal Arterial — Expressway
14	Principal Arterial — Other
16	Minor Arterial
17	Collector
19	Local Access

The National Highway System

Whether a jurisdiction has roadways on the National Highway System (NHS) is an additional, major consideration when deciding which functional classes to include. As stated previously, ISTEA mandates certain minimum PMS requirements for roadways on the NHS.

The NHS will include:

- The interstate system.
- Other routes identified for their strategic defense characteristics.
- Routes providing access to major ports, airports, public transportation, and intermodal transportation facilities.
- Principal arterials that provide regional service.

The NHS is currently being developed by the states in cooperation with local and regional officials based on guidelines established by the United States Secretary of Transportation and on functional classification. The states, metropolitan planning organizations, and other local officials have the flexibility of proposing routes for the NHS if they are consistent with NHS objectives. This cooperative designation process is well underway.

Congress is expected to take action on approving the system by 1995. Until then, the NHS in Washington will include all state highways classified as principal arterials, and the interstate system. The NHS in Washington is expected to total approximately 3,300 miles.

This chapter discussed the factors that need to be considered when defining the roadway network and explained the criteria used to break the roadway network into manageable segments. Once the network is in manageable segments, all the data associated with each segment needs to be collected. This process is discussed in *Chapter 5,* ***Gathering Roadway System Data.***

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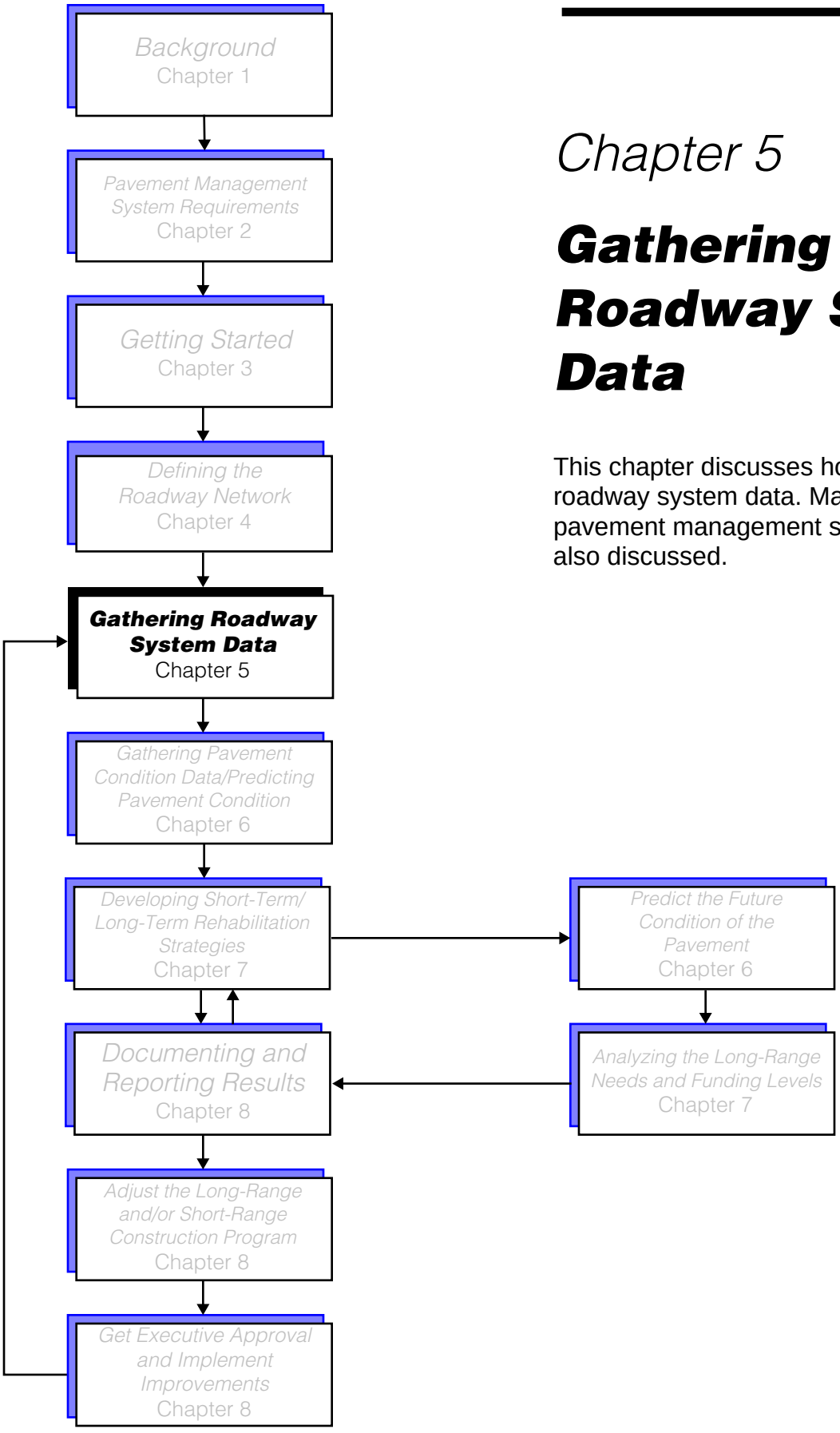

Chapter 5

Gathering Roadway System Data

This chapter discusses how to collect roadway system data. Maintaining the pavement management system over time is also discussed.

Collection of General Inventory Data

The intent of gathering data is to collect enough detailed information about the network to relate it to pavement condition, traffic, cost, and funding. The process of collecting general inventory data can be accomplished over time and should be done in three phases:

1. Determine the types of data needed.
2. Determine which data already exists in office records.
3. Determine the remaining data which must be gathered by a survey team.

Once these three steps have been completed, inventory data collection forms must be designed to collect this information. The forms will be used by the survey team and by office personnel to record the information that the agency has decided to collect. No data relating to pavement condition is placed on these forms. This data will essentially constitute a permanent record in that it will not be updated unless physical characteristics change or major projects occur.

If necessary, the agency should establish priorities for the roadway network inventory. All roadways will eventually become part of the inventory; however, if the inventory cannot be completed immediately, the following sequence is suggested:

1. Arterials.
2. Collectors.
3. Local access streets.

Once inventory data collection forms have been designed, a survey team should be selected to conduct the physical inventory. The team members should have a basic knowledge of:

- Roadways in the network.
- The inventory data collection form.
- The concept of segment and reference points.
- The agency’s existing records system.

The survey team should be provided a map showing:

- Roadway classification.
- Any established segment boundaries.
- All route numbers or names.
- Geographic details and political boundaries.

Any or all of the segment boundaries may be established in the field by the survey team.

The team must also be assigned a vehicle and some type of distance measuring equipment. Both vehicle mounted devices and walk-behind wheels are available. For larger networks, the purchase of an electronic distance meter should be considered. Using the vehicle odometer is not recommended because the accuracy is usually questionable and measurements in tenths of a mile will often not be sufficient to define many features.

Once the team is properly prepared and equipped, the following sequence of activities is suggested:

1. Determine the area to be inventoried.
2. Drive along the selected route to establish segment boundaries.
3. Measure and record physical dimensions.
4. Drive back through the segment, complete the inventory collection form, and record the segment length.

As much data as possible should be gathered in the office before beginning the field inventory. Data on construction history can be added to the inventory later as time permits.

Collection Frequency of General Inventory Data

As stated previously, permanent pavement data such as ownership, number of lanes, pavement type, and width, etc., will be recorded once and will not be updated unless physical characteristics change.

A roadway's lifespan is directly related to the ADT (above) and the percentage of trucks (on the following page) using it.

Traffic

A pavement's life expectancy is directly related to present and projected traffic demand. The two primary factors considered in calculating that demand are volume and load. This is why traffic data should include both Average Daily Traffic (ADT) and truck data based on truck classifications. Traffic information can also be used in choosing rehabilitation solutions and in analyzing why and how certain pavement types react and last under varying traffic conditions.

When projecting traffic volume and load, consideration should also be given to existing or expected land use laws: a calculated ADT should reflect the heavy truck and equipment use associated with constructing or serving new industrial development or large residential developments. Heavy equipment use of a roadway during land clearing or a harvest period should also be considered in calculating how long a pavement can be expected to last.

Drainage

There is a direct relationship between pavement aging and moisture. All pavements are susceptible to damage from moisture that cannot be drained away sufficiently. Therefore, the adequacy of roadway drainage systems should be evaluated in determining the cause of pavement aging or deterioration.

Drainage information is also very important in maintenance and rehabilitation decision-making. For example, deciding to do an overlay can correct drainage problems that currently exist or anticipate drainage problems that may occur as a result of the overlay.

Data on drainage characteristics should describe the drainage system for a given segment: a storm sewer, paved or unpaved side ditches, a curb and gutter system, or subsurface drainage.

The survey team should be instructed to note locations where surface drainage problems are obvious. Other signs of deficient surface drainage that may be detected during a visual survey are:

- Standing water in the ditch lines.
- Concentrated weed growth indicating saturated soil in the ditch line or at the edge of the pavement.
- Evidence of water ponding at the shoulder.

Practical Steps in Gathering Roadway System Data

There are some key steps for local agencies to follow when they are defining their roadways:

1. Obtain a Recent Map of the Roadway Network

   To begin, a local agency should obtain a recent map of the roadway network they are responsible for maintaining. The roadways on the map should be verified and all roadways accounted for.

2. Break the Roadway Network Into Manageable Segments

   The process of dividing the roadway network into manageable segments is the next step. Agencies should have a beginning address and use landmarks, if necessary.

   The information in "Dividing the Network Into Manageable Units" (Chapter 4) can be used to divide the roadway network on a map.

3. For Each Manageable Segment, Assign a Unique Road Number

   While dividing the network into segments, it is important to identify each one with a unique number. There is no right or wrong method for numbering the segments; however, it is important to ensure that those using the PMS can easily identify the segments and locate them for inspections and repair work. Pavement management systems used in Washington normally have a road number and a segment number which is used to identify one segment from another.

   Cities throughout the state have numbered their roadways in different ways. One city assigned road numbers from north to south and east to west, starting at 1,000. Another took a city map and assigned four-digit road numbers to all east-west streets from the west and all north-south streets from the south. They then assigned segment numbers in increments of 10. Still other cities had name-driven systems with road numbers assigned alphabetically and segment numbers in increments of 10.

   For example, Main Street in a small local agency is 1 mile long. It intersects 14 streets in its 1 mile of length. The agency broke the network so that Main Street had a new segment at each intersection. Main Street maintained the same road number for each of the segments, because the road name is the same. However, there was a different number for each segment in order to identify the segments separately.

   In Washington, every county has a computerized inventory of their road system known as the County Road Log. Implemented by the Washington State Department of Transportation (WSDOT) in the late 1960s, the roadlog assigned each county road a four-digit number that is based on mileposts. Some counties renumbered their entire road systems with four-digit numbers; others used their existing numbers and added leading

zeroes to get four digits. Later, the numbers were changed to five digits with most counties adding leading or trailing zeroes to get enough digits. These are the road numbers still in use today. Most counties use the roadlog numbering system; however, they have the choice of developing their own numbering system.

Legislation passed in 1985 transferred responsibility for the County Roadlog to CRAB and the road number and milepost inventory methods were retained. Following this transfer of responsibility, CRAB used the County Roadlog as a foundation for developing today's County Road Information System (CRIS system). The basic network on which the CRIS System is built is defined by the County Roadlog.

4. Ensure That All Manageable Segment Data is Correct

   This is an important control step. After a unique road number has been assigned and the network has been divided into manageable segments, the next step is gathering the roadway system data. The gathering of this data should be done slowly to ensure that the information is correct. The quality control aspect of this data collection cannot be emphasized enough. The time taken at this point to ensure the quality of the roadway data will lead to fewer headaches as the PMS is used in later tasks.

Regular updating of the PMS will ensure current information that jurisdictions need to make effective decisions.

Maintaining Your Pavement Management System

It is important to realize that the PMS is only as good as the data stored in the database. For the system to provide the information an agency needs for accurate decision-making, the data must be periodically reviewed and/or updated. This includes condition of the pavements, maintenance and rehabilitation treatments applied to the pavements, maintenance and rehabilitation unit costs, and other associated costs.

Some steps involved in maintaining your PMS include:

- Enter roadway information into the PMS database for section(s) that were rehabilitated or had maintenance work.
- Enter roadway construction information into the PMS database for section(s) newly constructed and/or reconstructed.

A PMS will be a part of an agency's comprehensive maintenance management. Ultimately, the system will help schedule replacement or repairs of all elements, safety devices, drainage facilities, utilities, and structures. For example, a deficient deep culvert needs replacing in two years, but overlay is scheduled for this year. A combined analysis can determine an optimum schedule for this scenario.

After all the roadway system data for inventory development has been collected, the next step is gathering the pavement condition data. This information, which can be used to predict future pavement condition, is the topic of the next chapter.

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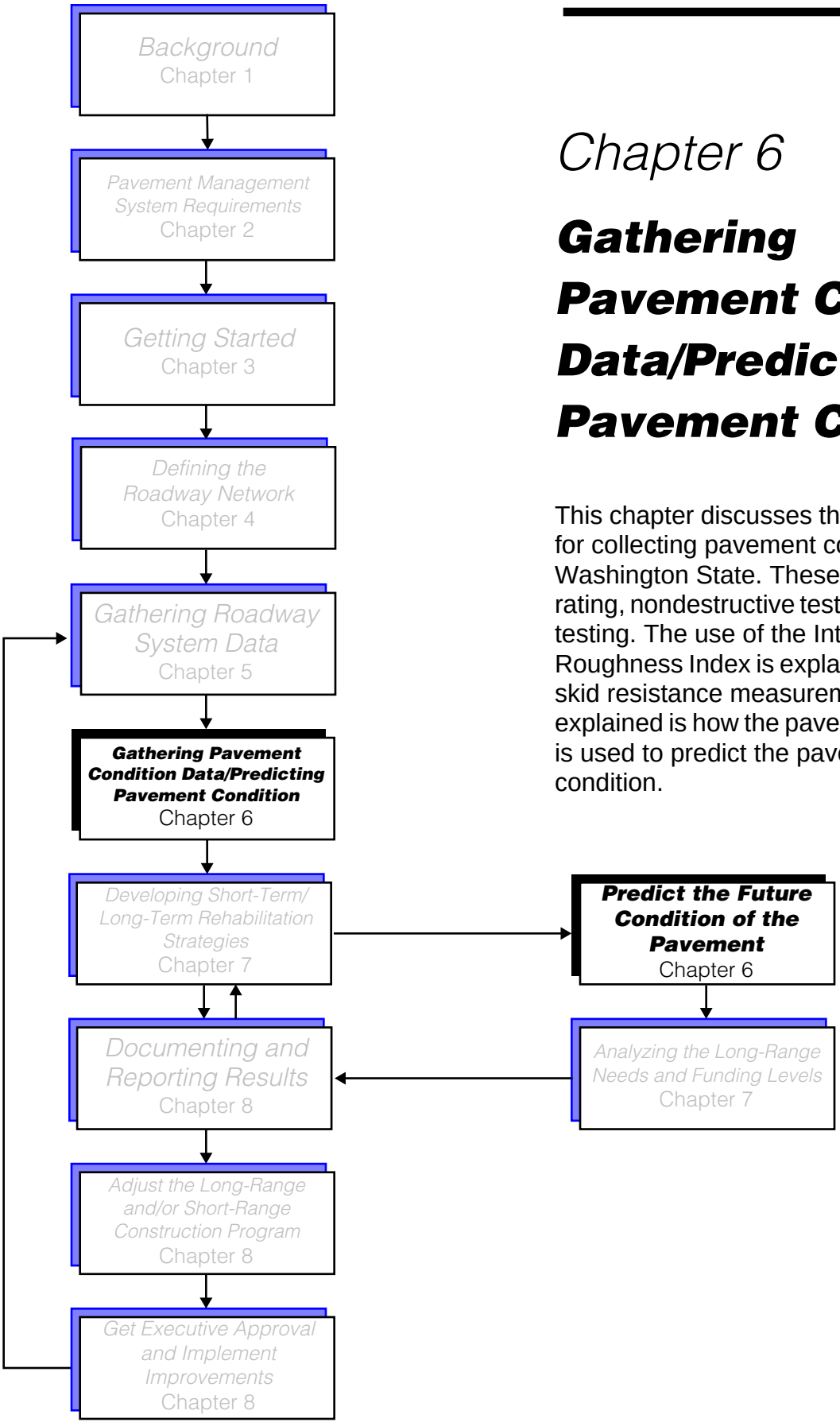


Chapter 6

Gathering Pavement Condition Data/Predicting Pavement Condition

This chapter discusses the different methods for collecting pavement condition data in Washington State. These include visual rating, nondestructive testing, and destructive testing. The use of the International Roughness Index is explained as is the use of skid resistance measurements. Also explained is how the pavement condition data is used to predict the pavement's future condition.

Chapter 6 Gathering Pavement Condition Data/ Predicting Pavement Condition

Pavement Condition Evaluation

Pavement rehabilitation costs continue to increase, making it essential to have fast, reliable methods to accurately determine a pavement's condition. When a pavement's condition begins to show deficiencies, the development of certain types of surface distress appear. For example, extensive cracking in the wheel path is an indication of load-related failure that is caused by heavy loads. This indication provides a starting point for further investigation in deciding how to improve and maintain the pavement.

After the pavement management inventory has been created and all the data has been collected for each segment, pavement condition evaluation can begin. In Washington, there are three methods for determining pavement condition: visual rating, nondestructive testing (NDT), and destructive testing.

The visual rating method is most commonly used. All agencies are gathering information on their pavements based on a visual survey. However, the extent to which they gather the data varies.

The NDT method is generally used in the roadway design phase and for project level information to enhance visual ratings. NDT enables an agency to identify problems, examine their extent, and solve them effectively. A few agencies also use NDT data for network as well as project level evaluation.

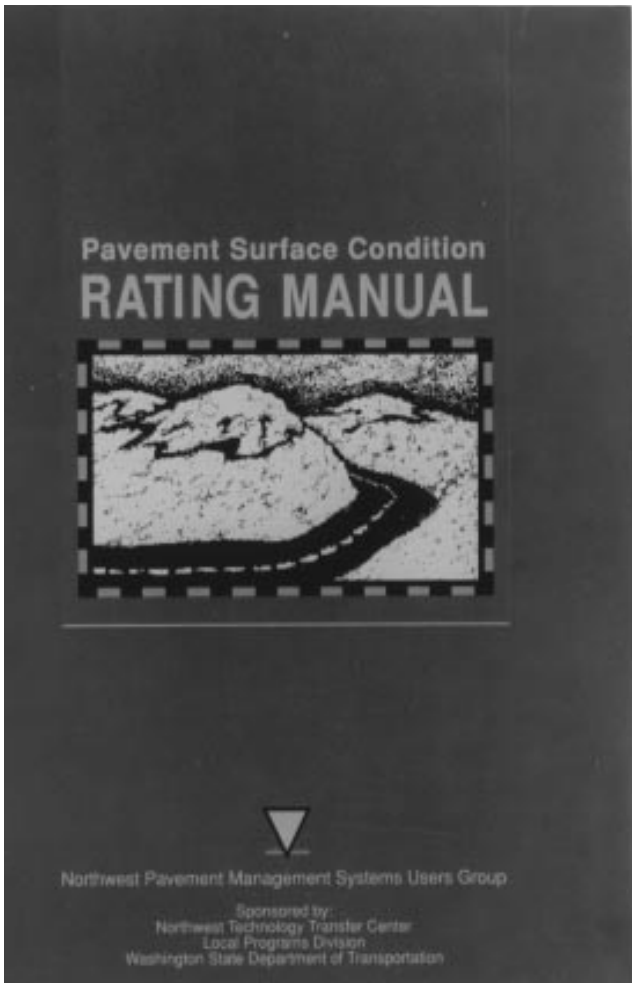
Destructive testing is primarily used to support design analysis in identifying roadway makeup, reasons the roadway failed, and solutions for improving the roadway. This includes pavement coring, boring, and test pits, along with evaluation.

Alligator cracking is a common pavement distress noted during a pavement condition evaluation.

Visual Method

Assessing pavement distress involves identifying the distress type, measuring or estimating portions of the affected segment, and assessing severity. The distress type may be identified visually and the affected area estimated in accordance with the *Pavement Surface Condition Rating Manual*. Examples of visual distresses include transverse and longitudinal cracks, alligator cracking, rutting, raveling, and flushing.

The visual rating process uses a pavement condition rating as a measure of the observed pavement surface distress and ranges from 100 (for no distress) to 0 or below (for extensive distress). A pavement condition rating gives an approximate percentage of remaining pavement life and is primarily determined by measures of the extent and severity of pavement surface distress collected by field surveys.



Visual rating methods may be automated or manual. The automated visual method uses a vehicle equipped with cameras that videotape the pavement surface as the vehicle moves down the roadway. This data is transferred to a tape for further processing, either by a software program or by individuals, based upon what they see on the tape. The automated visual ratings will need to be evaluated by the agency to ensure that the results of the videos meet the agency's standards.

Manual visual inspections are usually performed by one or two people and involve driving roadway segments at slow speeds and stopping occasionally, or walking the entire segment or at least three to five randomly selected portions. Walking provides more accurate data than driving but is more expensive and time consuming. When selecting a surveying method, it is important for the agency to be aware that as speed increases from a walking pace to a 5 to 10 mph rolling speed in a vehicle, much of the detail identifying minor and some moderate deficiency severities can be lost, reducing the accuracy and consistency in data collection. Also, the time of day, direction of travel, and light conditions can significantly impact the ability to see the distress. Agencies need to evaluate these trade-offs in selecting their method.

Another critical element of visual inspections is consistency and experience. Providing training on a continuous basis that will enable personnel to perform objective, repeatable data collection is vital because of the inherent difficulties involved in transferring experience from one person to another.

Every year, the Washington State Department of Transportation (WSDOT) offers training on visual rating to both beginning and experienced raters. Some agencies are putting together their own in-house training sessions for their visual raters.

Methods for Collecting Pavement Condition Data

Local agencies throughout the state have implemented some practical, innovative methods for collecting pavement condition data. These agencies are using various methods of distress collection. They range from visual ratings by driving, bicycling, and walking to a nondestructive testing method and/or automated data collection. Some of the agencies use a combination of two of these methods.

Whatever method is selected, all agencies use some type of pavement evaluation rating form. Four examples of rating forms being used in the state of Washington can be found in Appendix E.

Collection Frequency of Pavement Condition Data

Not all pavements need a pavement condition inspection every year, but an inspection scheduling procedure should be developed to assist in determining which segments should be reinspected during the next year. A recommended pavement condition inspection policy helps to identify those pavement management segments which need reinspection, and it minimizes the overall inspection effort required of the agency.

Pavements which have been recently constructed or overlaid will be in excellent condition and need not be inspected immediately. A two-year inspection interval after construction is normal. Pavements which have had a surface treatment applied will initially look very good; however, after a short period of time, the cracks may reappear. A two-year inspection interval is also suggested for these pavements. Other pavement segments should be scheduled for inspection based on their rate of deterioration. Those which are deteriorating more quickly should be inspected more often.

Residential and local roadways comprise the bulk of the pavements maintained by local agencies and they require the majority of the inspection effort. It may not be economically prudent to inspect these roadways using the above procedures. For residential/local roadways, some agencies have found it more economical in inspection and administrative effort to inspect all of the pavements in a geographical area at one time. The residential/local pavements for which the agency is responsible are divided into groups which are then

inspected at one time on a cyclical basis. Typical inspection periods for these residential/local roadways is three to five years. For example, local agencies may inspect all of the residential/local pavements in the southwest quadrant in one year, all of the residential/local pavements in the southeast quadrant the following year, etc., until all four quadrants are inspected. This results in the inspection of all residential/local roadways once every four years.

A walking visual inspection of the roadway segment will provide highly accurate pavement condition data.

Nondestructive Testing Method

Nondestructive testing, or NDT, can provide sufficient information to determine a pavement's structural load-carrying capacity, and it can be used to determine the overlay thickness required to support future expected traffic. NDT can also provide measurements of the overall pavement structural response to an external force or load without disturbing or destroying the pavement components. There are advantages that NDT has over destructive testing methods:

- NDT provides on-site information about physical properties of the pavement.
- NDT does not damage the pavement.
- NDT minimizes laboratory tests.
- NDT can be accomplished in a timely and efficient manner.

The nondestructive testing devices which are commonly used to evaluate on-site properties of pavement are:

- Road Rater.
- Falling weight deflectometer.

These devices operate by measuring the pavement response to an imposed force. The response is generally in terms of surface deflections at one or more points on the pavement. Major differences among these devices include the load levels, the way the load is applied to the pavement, and the number of points at which deflections are measured.

Nondestructive testing equipment collects an average of 15 to 20 miles of data per day.

There are several types of nondestructive testing equipment available varying in price from $60,000 to $150,000. When deciding on which equipment to purchase, lease, or rent, choose an NDT device that will test the majority of the roadways your agency maintains. Analyze the roadway sections (depth of materials) and select a machine that will best suit your agency's needs.

The number of personnel required to operate NDT equipment varies from one to three, depending on the amount of data collected at the time. Some counties do visual ratings and structural data collection simultaneously. Most agencies use one to two employees to collect the data with an average of 15 to 20 miles of data collected per day. The time spent collecting data varies from three to nine months and from season to season.

When selecting an NDT device, it is best to choose a machine that can test the majority of roadways within the jurisdiction. Knowledge of roadway structures is also important as it will influence the size of the machine chosen.

A training program should be established to educate and familiarize operators with the machine. One county requires a minimum of 40 hours of “hands on” training before unsupervised use of the equipment is allowed.

Because NDT equipment measures very small deflections to assure consistent and accurate readings, routine calibration is necessary. Calibrating NDT equipment requires creating and maintaining a calibrated test site. One county uses a covered area with a concrete floor marked with painted dots to indicate where the sensors are to be placed during the calibration test. This area is tested each week before the week’s work, to check the sensor readings and to visually check the machine during operation. The sensors should provide consistent readings and the machine should operate smoothly. If this is not the case, the manufacturer should be contacted for assistance.

All NDT equipment should have routine annual maintenance, including replacement of the hydraulic fluid, tire balancing, a grease job, checking of pressure gauges, etc. Although it is not required, counties using the equipment recommend that it be parked in a protected area out of the weather.

If the NDT equipment is used to collect condition data at the network level, it is recommended that all roadways be tested at a minimum of ten tests per mile with the exception of arterials, which should be tested at 20 tests per mile to provide an adequate amount of survey information. After the data is processed and a priority array is developed, a more in-depth testing schedule can be developed for design.

At the project level, a minimum of 20 tests per mile is recommended. Highly distressed areas of roadway should be tested at enough points to allow isolation of these areas for appropriate repair prior to an overlay.

Although an exception in Washington, a structurally-based pavement management system (PMS) can be set up when structural data is collected. After analysis is completed, an overlay program can be scheduled by depth required to raise the structural adequacy to the desired level. All segments requiring a certain depth can be overlaid and the remaining segments can be scheduled for future overlay or retesting. Segments should be retested and analyzed if traffic (ADT), percent of growth, or truck percentage changes.

For network analysis, most agencies do not routinely collect structural data for monitoring pavements. Such data is normally confined to locations where distress and roughness surveys indicate structural problems and to areas where asphaltic concrete overlays are anticipated.

The need for structural evaluation can also be influenced by other elements of pavement evaluation. For example, if pavement skid resistance drops below a level which indicates the need for maintenance or rehabilitation, it may be wise to perform a structural evaluation — before addressing skid resistance — to ensure that the pavement is structurally adequate to safely support future predicted traffic loads. In such a case, a thick overlay may be needed to upgrade the load carrying capacity rather than a slurry seal to correct friction deficiencies.

Data is entered into the computer at the testing site.

In general, structural deficiencies cannot be corrected by inexpensive maintenance treatment; more costly rehabilitation treatments are usually needed. The purpose of structural evaluation is to assess the structural condition of an in-service pavement to determine its structural adequacy and to provide information to be used in the pavement rehabilitation design procedures.

Destructive Testing

Corings

Coring is conducted by using a smooth bore bit, generally 4 to 6 inches in diameter, to drill into the pavement. This test is usually conducted to gather information about the pavement from the pavement surface down to the subgrade. Corings provide a very detailed picture of how the roadway structure exists at the point cored.

A backhoe is used for a test pit to get information about the material underlying the roadway.

Borings

Boring is used for deeper exploration of soil condition to provide information on the identity and condition of subsurface soils. There are several methods for this investigation; some of the most popular are rotary core drilling, auger drilling, and split tube sampler.

Determining the bearing capacity of the roadway foundation is important in choosing methods for extending pavement life. In some instances, the most cost-effective method could be to scarify and re-ballast, improve drainage, or both. Consideration of these alternatives should be based upon soil analysis and moisture content. During extreme conditions, the vulnerability of surface damage during freeze-thaw cycles is relative to the ability of the subgrade to drain.

Test Pits

Test pit testing is usually performed with a backhoe to provide information about the type of material underlying the pavement structure. This testing method disturbs a lot of soil when conducted so it is not as precise as boring. It is also limited in depth. A “normal” backhoe can go to a depth of 11 feet or to 16 feet with an extend-a-hoe. As a rule, the larger the backhoe, the deeper the penetration — and the higher the cost.

Ride Quality

Roughness of ride is a supplemental method for measuring distress. Roadways are designed to provide a smooth ride with the capacity to transfer wheel loads from an even surface. Therefore, if the roadway is uneven, a problem exists which needs to be corrected.

Roughness (International Roughness Index)

Roughness is the irregularity of the road surface familiar to all road users, and perceptions of the riding quality have long been considered important criteria for the acceptability of the service provided by the road. Roughness affects the dynamics of moving vehicles, increases the wear on vehicle parts, and affects vehicle handling ability. It has an appreciable impact on vehicle operating costs, safety, comfort, and speed of travel. It also increases the dynamic loadings imposed by vehicles on the surface, accelerating the deterioration of the pavement structure. Roughness can have adverse effects on surface drainage and can cause water to pond on the surface, thereby causing adverse impacts on both pavement performance and vehicle safety.

There are many procedures for collecting roughness data from roadways. In the early 1980s, it became imperative that a roughness standard be designed to establish a correlation among the different methods of roughness measurements. The International Roughness Index (IRI) was selected as the standard and is a component required by ISTEA for roadways on the National Highway System (NHS). The IRI is a mathematically-defined statistic of the profile in the wheel path of a traveled road surface. The IRI is representative of the vertical motions caused by moving vehicles which affects both vehicle response and the comfort perceived by the occupants.

Roadway roughness is a primary cause of citizen complaints.

Skid Resistance

A pavement's skid resistance is understood to be the force developed between a tire and the pavement, that prevents the tire from sliding on pavement surfaces under fast braking or cornering conditions. Nearly all pavement surfaces lose skid resistance over time as a result of the daily exposure to traffic and the environment.

Skid resistance testing measures the coefficient of friction as a skid number. This can be accomplished using portable field devices or "locked wheel" trailer devices.

Skid resistance measurements are often performed in high-frequency accident locations where accidents are often attributed to hydroplaning and skid resistance problems. These measurements are usually conducted by police or other safety officials. Suspected segments can also be identified from accident records; any location that shows an abnormal number of wet weather accidents is a candidate to be checked for skid problems.

Skid resistance measurements of local roadways are generally performed only on locations where accidents are suspected of being caused by deficiencies in surface skid resistance. If an agency collects skid resistance data, ISTEA requires that the data be included as part of the PMS.

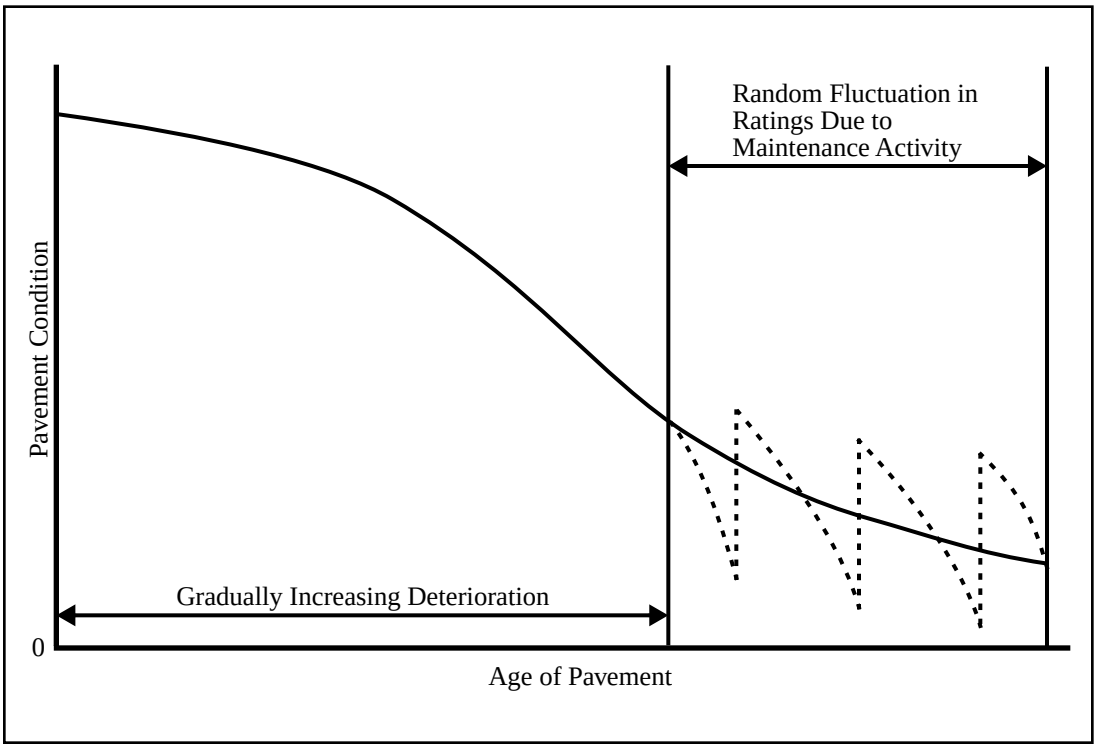
Pavement Serviceability Index

During the AASHTO Road Test conducted several years ago, an index was developed to measure serviceability. The Pavement Serviceability Index (PSI) correlated roughness measurements to the user's response to pavement condition. PSI divides the condition into a scale of zero to five. A user considers a pavement with a rating of five perfect and a pavement with a rating of zero impassable. WSDOT has developed a method for converting the PCR to an approximate PSI equivalent.

Predict the Future Condition of the Pavement

Once the condition of each pavement segment is determined in terms of PCR, a procedure for predicting future condition is required in network level analysis to identify when maintenance and rehabilitation are needed and to determine budget needs for each segment.

In Washington, most local agencies using a computerized PMS achieve pavement condition predictions by producing a performance curve for each segment. The curve represents the pavement's anticipated performance over time. It is calculated by evaluating past historical data on the segment, such as treatments or condition assessments, as well as current condition information. These points are then plotted and the resulting deterioration curve or performance curve is achieved. The curve can then be used to predict future performance.



Typical Performance Curve

A typical curve, like the one shown on the previous page, illustrates that as a pavement ages, the rate of deterioration usually increases each year. Deceleration can be attributed to application of temporary fixes to hold the pavement together until a major remedy can be applied. These fixes tend to cause short, random fluctuations in the pavement rating.

In most PMS software, the performance curve also includes a tabulation of the annual condition ratings with the mathematically fitted performance curve. By studying this, it is possible to see how well the curve fits the pavement rating and how long the pavement might last until rehabilitation is required.

Once the pavement condition information is collected, a short-term budget can be developed after determining rehabilitation strategies. A long-term budget can also be developed after predicting the pavement's future condition and determining rehabilitation strategies. Developing rehabilitation strategies and short-term and long-term maintenance and rehabilitation budget lists are discussed in the next chapter, as are network and project level pavement management.

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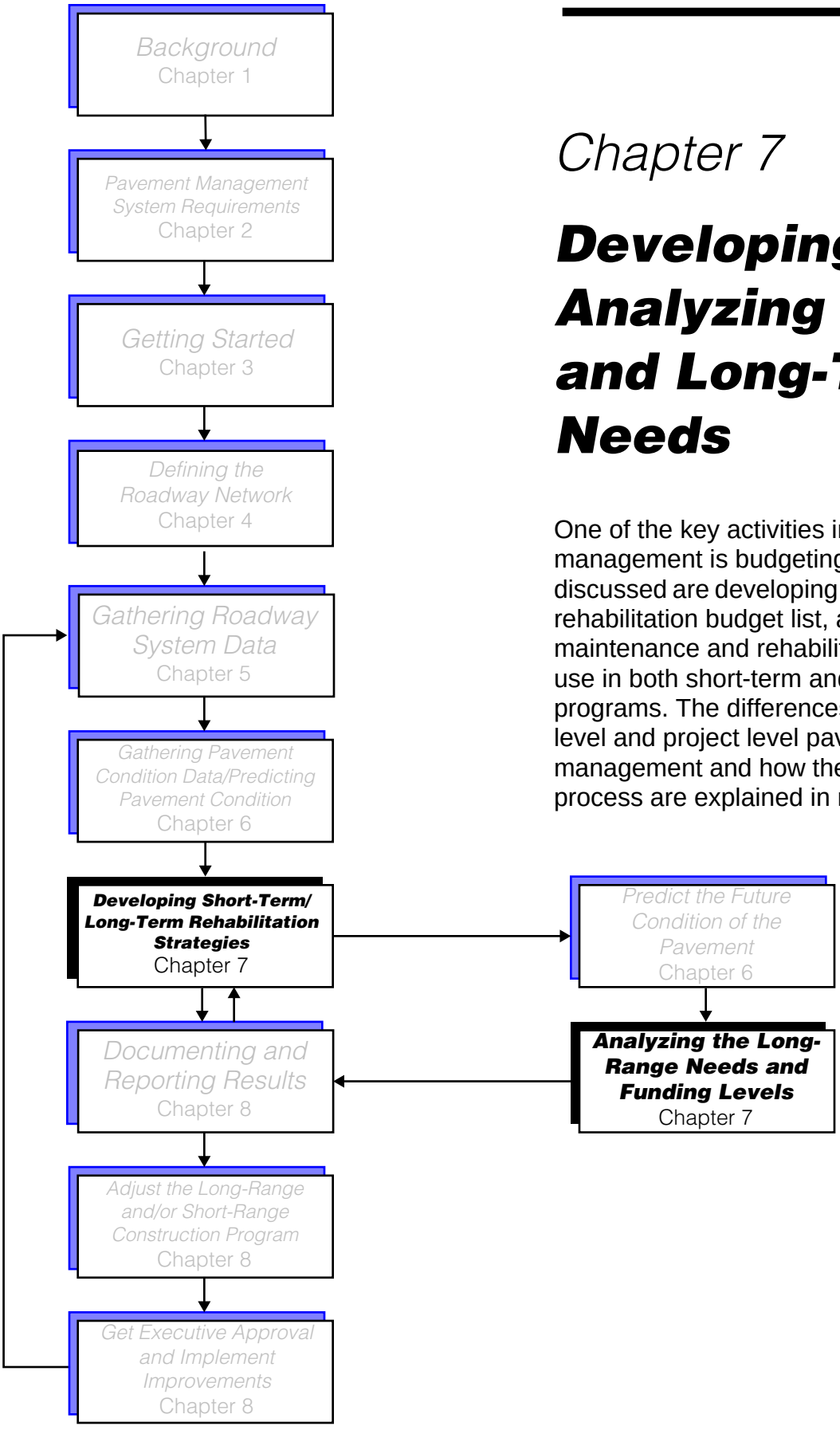


Chapter 7

Developing and Analyzing Short- and Long-Term Needs

One of the key activities in pavement management is budgeting. The next steps discussed are developing a maintenance and rehabilitation budget list, and selecting maintenance and rehabilitation strategies for use in both short-term and long-term budget programs. The differences between network level and project level pavement management and how they affect the budget process are explained in more detail.

Budget Analysis Techniques

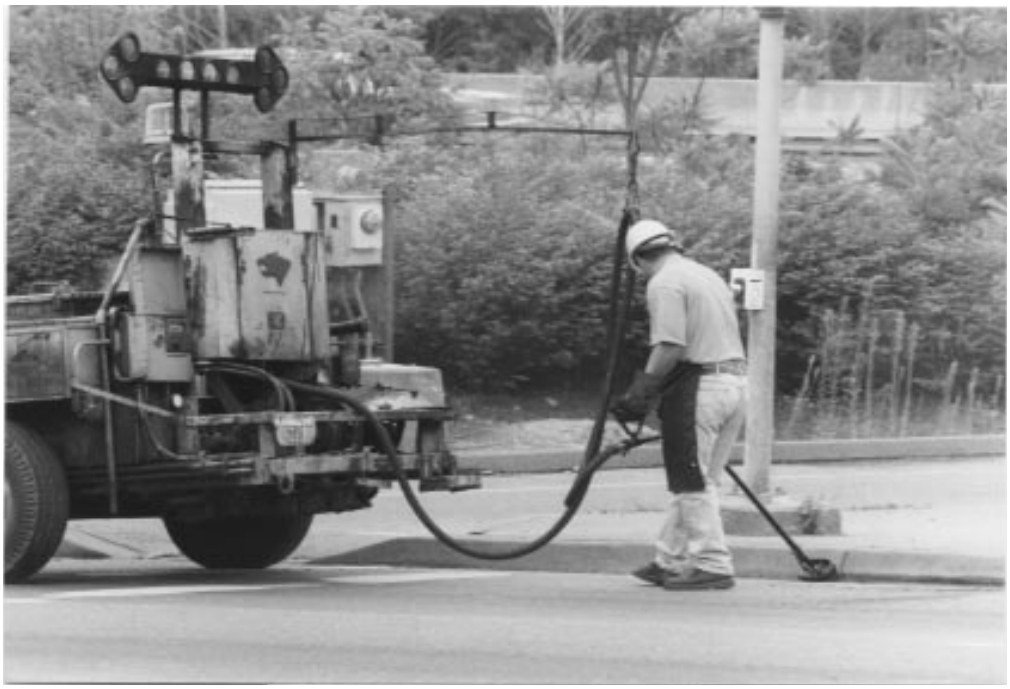
Once all needed pavement information has been collected and entered into the database, methods to analyze that information are needed to make budget decisions at two levels: network and project.

Network Level. As stated previously, decisions at this level are related to program and policy issues for the entire network; therefore, a network level analysis will be of the most use and interest to the mayor, manager, budget director, etc. Network level decisions include:

- Establishing pavement preservation policies.
- Identifying priorities.
- Estimating funding needs.
- Allocating budgets for maintenance, rehabilitation, and reconstruction.

Network level analysis is best used for overall budget estimates, examining hypothetical or projected circumstances, or for policy "what if" kinds of questions. The network level requires more summarized information because of its use by administrators and council or commission members.

Project Level. This level of analysis is a series of steps to determine the cause and extent of pavement deterioration. Project level analysis will be done primarily by the engineering and technical staff to identify cost-effective maintenance and rehabilitation remedies required for specific pavements at specific locations. Reports should be prepared and designed for potential users *in their language*. It is important to remember the audience and to ensure that the right message is sent and will be used to better manage pavements. As stated before, the project level PMS will require more technical information due to actions being planned and taken on individual projects. Project level is discussed in greater detail later in this chapter.



The crack sealing being done on this roadway could be for rehabilitation or maintenance purposes.

What Does Rehabilitation Involve?

Pavement rehabilitation refers to extensive corrective actions to repair pavement which has deteriorated past a condition that can be corrected through preventive or routine maintenance. Treatments are applied to return the pavement to a condition similar to its original condition. This may increase its structural capacity.

Rehabilitating a moderately deteriorated residential roadway could mean patching and a seal coat to return the pavement to a more serviceable condition; yet, a seal coat could also be applied as a preventive maintenance treatment. At the other extreme, rehabilitating a badly deteriorated arterial roadway could mean complete reconstruction.

Some rehabilitation treatments can be used as both preventive maintenance and rehabilitation, depending on when and why they are applied. Some feasible treatments in use, or recommended for use, by cities and counties, include:

The crack sealing on this local access roadway has been completed.

- Chip seal (single, double, and rubberized)
- Slurry seal
- Chip seal and slurry seal
- Mill and chip seal (single and double)
- Spot seal
- Seal cracks
- Reconstruct entire structure
- Mill and overlay (thin and thick)
- Maintenance ACP overlay (thin)
- Heater scarify and overlay
- Shallow patch
- Deep patch
- Reconstruct surface

Doing nothing is also an alternative rehabilitation treatment. It can be deliberately chosen because the pavement is found to be in such condition that not even routine or preventive maintenance is required, or when plans are in the works for major reconstruction, turnbacks, or elimination of the facility. Most often, however, doing nothing is chosen by default because the appropriated funds are not adequate to complete all of the work needed. Funding for completion of major rehabilitation projects may depend upon federal or other outside sources.

Understanding how treatments perform in a particular region is also critical to having a successful program. All viable options available to the agency need to be identified, taking into consideration the availability of materials, necessary equipment, and expertise.

Patching is another commonly used pavement maintenance or rehabilitation activity.

Rehabilitation Strategies

To develop a rehabilitation program, an agency needs to define its rehabilitation strategy. That is, select the treatments that will be applied and at what condition level. In a pavement management system, this is handled in a number of ways. Three of the most common methods are a distress strategy matrix, rehabilitation matrix, and a decision tree process.

The distress strategy matrix works in the following manner: a table is developed which refers to common treatments in an agency. For example, the agency uses chip sealing, patching, crack sealing, 1-inch overlay, 2-inch overlay, mill and 2-inch overlay, and total reconstruction. Next, the agency

decides at what level of distress the treatment will be applied. For instance, if a section of pavement is to be repaired and it has high severity alligator cracking, the agency might decide that it will do a mill and 2-inch overlay. For a segment that has low severity transverse cracks, the agency might decide that it will do crack sealing. Remember these are only suggestions. Before the actual roadway is fixed, a more detailed analysis (or project level work) on the segment should occur. This is done to make sure that the strategy selected with the matrix is the correct treatment.

The decision tree and rehabilitation matrix processes of selecting treatments is different from the distress strategy matrix. Distress is taken into account, but each segment has a numerical rating on the scale of 0 to 100. This rating, or pavement condition rating, is calculated by finding distresses in segments. Each distress has a deduct value associated with it. For instance, if a segment was to have 100 percent raveling on it, the deduct value associated for it is 17. This deduct is then subtracted from 100, thus the segment has a PCR of 83. Each segment has different distresses and thus has a different PCR.

Both of these methods rely on a list of rehabilitation treatments an agency currently uses.

It should be noted that this list is used for network analysis and budgetary purposes. Each individual project should have an engineering analysis or project analysis to determine what specific action will occur.

The rehabilitation matrix selects a proposed treatment based on the method shown in the appropriate cell.

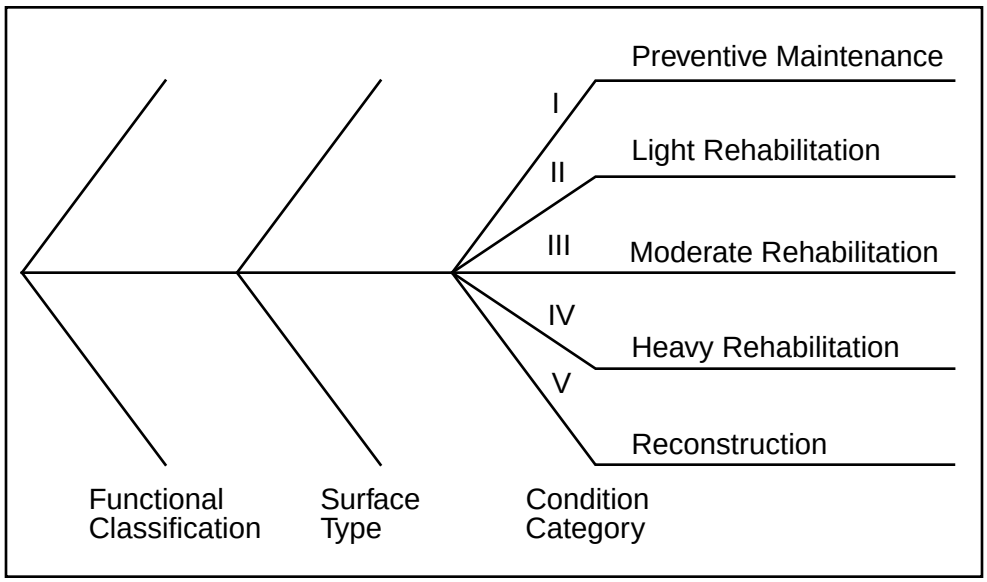
Func. Class	**Pavement Condition**			
	100 - 60	**60 - 50**	**50 - 40**	**40 - 0**
Urban Arterial	1	4	5	6
Rural Arterial	1	3	5	6
Urban Access	1	2	4	6
Rural Access	1	3	4	6

Rehabilitation List

1 — Do Nothing
2 — Slurry Seal
3 — Chip Seal
4 — Thin Overlay
5 — Thick Overly
6 — Reconstruct

The decision tree process can have a variety of criteria. A typical decision tree could be composed of three elements: functional class, surface type, and PCR. An example of this type of tree appears below.

For example, a segment of an arterial with an asphalt concrete surface and a PCR of 65 would be treated differently from a segment of a local access road with the same surface type and a PCR of 65. A strategy has to be developed for each branch of the decision tree and should reflect the practices currently employed by the local agency.



Many different fixes are possible when considering rehabilitation strategies and a tremendous number of rehabilitation combinations are possible. A rehabilitation strategy could be defined as a combination of rehabilitation alternatives designated by type, sequence, and application. To get the most cost-effective methods for providing satisfactory pavement condition, all strategies possible within a set timeframe can be economically analyzed. Basic to the analysis is the stipulation that a minimum level of pavement condition be maintained throughout the consideration period. All costs associated with each strategy can then be totaled for comparison with other strategies — and the desired strategy will be the one with the least total cost.

Short-Term Rehabilitation Strategies

Once an agency's rehabilitation strategies have been defined and accurate costs have been identified, a maintenance program can be developed. An agency can develop the next year program with current condition information and rehabilitation strategies. This is normally called a short-term program. An agency first relies on a list of roadway segments generated from the pavement management system. This list will suggest the rehabilitation strategy and estimated cost to do the work. The pavement manager should then use the list to verify whether the suggested action is correct. This process includes discussion with other individuals in the agency. It is important to remember that the PMS is only a tool to help the manager select short-term projects. It takes good sound judgment by agency staff to review the list and modify it accordingly.

Once the list has been agreed upon, this information, along with the total estimated cost, should be formulated into a budget proposal. The proposal should first be presented to the public works director and then, after changes to the document, presented to the publicly elected board/council. See Appendix H for an example.

Long-Term Budget Program Development

One of the key outputs from a PMS is a long-term budget needs estimate for an agency. Long-term can be 5, 10, 15, or 20 years, depending on the agency's desires. Long-term budget needs can be used to plan for future rehabilitation work as well as for short-term work. A long-term budget program is normally developed by using a computerized PMS. It will provide an estimate of funding needed to preserve the pavement network at prescribed levels of performance. For instance, after long-term strategies have been entered into the program, including estimated costs, an agency might want to know how much it will cost to fix all of its roadways with an unconstrained budget over a six-year budget horizon. In this scenario, the agency would get a budget list which includes all the roadways in their network. The list would most likely cost much more than the agency can afford. How then can an agency develop a long-term budget which factors in fiscal realities?

In most cases, funding needs will exceed available funding. When this happens, one of the methods for prioritizing and optimizing will be needed in order to prepare a maintenance and rehabilitation program. The following is a list of methods for establishing priorities; however, alternate methods can be developed based on an agency's policies and administrative decisions.

- The **matrix** method can be based on such factors as condition and traffic; i.e., the highest priority is given to pavements in the worst condition and with the heaviest traffic.
- The **condition index** method can be based on relative scores usually ranked from 0 (for worst) to 100 (for best). Priorities can combine condition score with such factors as functional class or traffic in order to develop a final list of projects.
- In the **benefit-cost** ratio process, the segments with the highest benefit-to-cost ratio would have the highest priority. Whereas the previous methods are likely to favor a "worst-first" policy, the benefit-cost rationale can provide high priorities for pavements in fair-to-poor condition rather than always starting with the pavements in the worst condition.
- The **cost-effectiveness** procedure is similar to benefit-cost except that the function is to maximize the performance of the segment while considering cost. Performance, in this case, is a measure of the effectiveness of a particular strategy on a segment over time. Each segment in the agency's network can then be ranked against each other to arrive at a list of maintenance and rehabilitation options. This method does not require a "worst first" approach.
- The **maximum benefits procedure** is inherent in most optimization methods. However, methods for maximizing benefits can also be developed with prioritization and life cycle costs. For example, that group of projects from all candidate projects, which maximizes the combined benefit-cost ratio or cost effectiveness for a specific budget, would be selected for maintenance and rehabilitation treatments.

These methods are only a guide for project selection. An agency should select its own prioritization routine over time.

Whatever prioritization routine is selected, an agency should understand the power of this component in a PMS. For example, if an agency's unconstrained needs are equal to $9 million over a six-year horizon, but the agency only has $5 million, the prioritization routine will assist in how to best spend the agency's resources. Remember, this list is only a guide, but the prioritization process will enable an agency to consider candidate segments that may not have been selected otherwise. The prioritization routine is also a powerful tool in developing a pavement maintenance budget report for the elected board or council. This will be discussed in the next chapter on documenting results.

With performance curves, alternatives, and costs known for each project, both short-term and long-range network level analyses can be performed.

Project Level Evaluation

Once the results of the network maintenance and rehabilitation program have been established, it will be necessary to prepare plans and specifications for individual construction projects. Since the network level analysis only provides target maintenance, rehabilitation treatments, and expected costs for individual segments, additional information will be required before designs are finalized.

Project level analysis can be approached as a series of steps to determine the cause of deterioration and identify relevant constraints. The answers to a set of questions are then used to identify feasible treatments. It is essential, however, that the process determine the cause and extent of deterioration to insure that the solution or strategy developed addresses the cause of the problem rather than just a symptom.

The size of the project and the importance of the roadway to the agency influence the amount of time and funds which will be expended in project-level evaluation. Major roadways with high volumes should be subjected to more testing and evaluation than low-volume roadways. The concepts and evaluation procedures described are valid for any roadway with any volume of traffic; only the amount of testing and the time expended in reaching the conclusions should vary.

A project level evaluation should always include the following questions:

Causes of Deterioration

1. Is the pavement structurally adequate for future traffic?
2. Is the pavement functionally adequate?
3. Is the rate of deterioration normal?
4. Are the pavement materials durable?
5. Is the drainage adequate?
6. Has previous maintenance been normal and regular?

Determine Whether the Basic Management Segment Should be Changed

7. Is the condition consistent over the length of the entire project?

Special Constraints to Consider

8. Are there special environmental considerations?
9. What traffic control options are available?
10. What geometric factors will impact on the design?
11. What is the condition of the shoulders?

The objective function of a project level PMS will usually be the same as that for a network: minimize life cycle costs, maximize benefit-cost ratios, etc. The project level PMS can consider additional maintenance and rehabilitation treatments which may be applicable or necessary at a particular site. It can also use more accurate unit cost estimates based on project location. Thus, there will be some chance that the project level PMS will recommend an action different from that of the network system.

Once a prioritized list of roadways is developed, they should be formulated into a budget document and presented to the policy board/council. This procedure is discussed in the next chapter.

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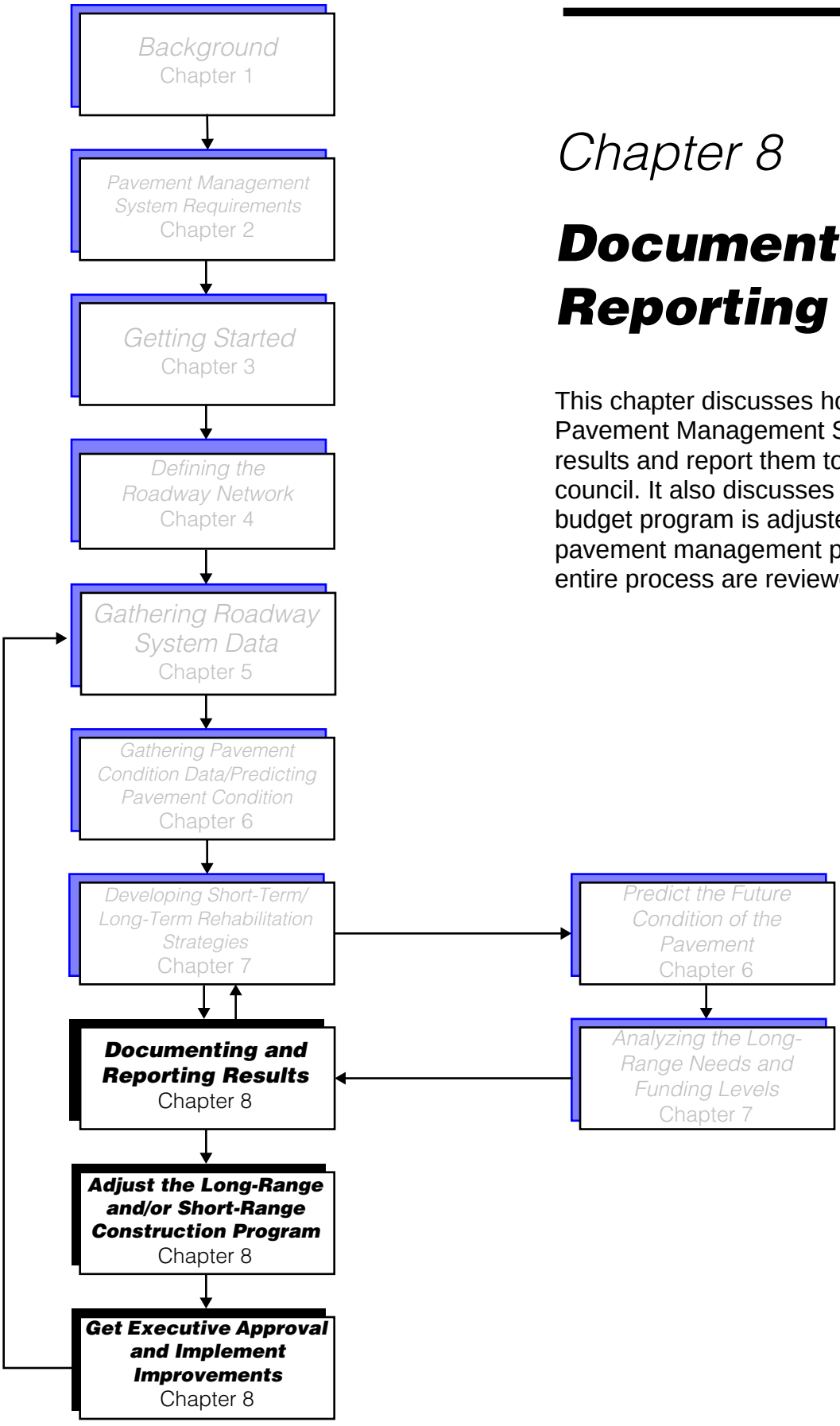

Chapter 8

Documenting and Reporting Results

This chapter discusses how to document Pavement Management System budget results and report them to the policy board/ council. It also discusses what to do if the budget program is adjusted. Finally, pavement management products from the entire process are reviewed.

Presentations to Public Officials

After obtaining the budget results from the pavement management system (PMS), the job of the Pavement Manager changes. The focus becomes how to "sell" the program to the elected board/council. Due to the technical nature of the data and the analysis, it is desirable to translate the findings from the PMS into clear terms that are understandable to decision makers and the public who are not technical experts or engineering professionals.

Once the PMS produces budget figures for various maintenance and rehabilitation alternatives, this information is presented to the agency's decision makers.

In presenting PMS findings to the decision makers, it is important to be brief and to point out key facts which will enable them to make better decisions. Key areas of the budget presentation might address:

- The current condition of the roadway network.
- The future condition of the roadway network, at different funding levels.

- How much deferred maintenance will occur and what its cost will be if the current funding level does not allow for all of the roads to be fixed.

With a computerized PMS, the key factors outlined above can be accessed easily. For instance, if an agency knows the level of funding it will receive over a six-year period, it can place this budget estimate into the software and obtain a recommended maintenance program list.

If, for example, the level of funding equals $3 million over six years, this budget option needs to be presented to the policy board. In addition, an unconstrained budget option of the entire network might be presented. This will enable the board to see how much it will cost to fix the entire network.

Other budget options also need to be presented. For the example above, a likely option to be presented is $3.6 million over six years. This increases the budget by $100,000 a year.

Pavement management presentations to city councils and county commissions should be clear, accurate, and provide various funding alternatives.

It is this “what if” game playing that is the key to the budget presentation. If the presentation shows four or five different options with the impact of each one, the decision makers can evaluate the proposals and make a better decision based on the accurate assessment of the roadway network’s future condition.

Appendix F contains a writer's guide for composing a budget options report for pavement management. It could be used by a local agency as a guide in creating a budget report. Appendix G contains an example budget report that was written for a local agency. Its intended audience is the public works department. It could be used by a local agency as an example of how to write a similar document. Appendix H is an executive summary of the full budget report found in Appendix G. This could be used by a local agency in developing a budget report for a board/council.

When demonstrating how various funding levels could affect an agency's pavement maintenance program, it is crucial to present the results with eye-catching charts and tables which clearly illustrate the successes and failures of projected dollar allocations. Each agency will need to decide the best way to approach their council/board with a budget presentation.

An article on creating charts and graphs for pavement management budget presentations is provided in Appendix I. Some additional sample graphs of a roadway network history which can be presented to a board/council are included in Appendix J.

Adjust the Program

The council may suggest an additional option for the pavement manager to try which is not part of the original presentation. This is a very common occurrence. In this case, it is imperative to run this option, evaluate it, and present its impacts to the council. By suggesting a different budget level, the council has changed assumptions based on budget options that were part of the budget report. For everyone concerned to understand the true impacts of the council's suggested adjustment, the results need to be presented. This presentation need not be as formal as the original one or the option can be added to the original report at the council's discretion. If the last case is selected, the council will have this option to compare to the other alternatives.

With executive approval, an agency's construction and maintenance programs can begin improving the roadway network.

Get Executive Approval

After all the adjustments to the report have been made by the council, they should be able to adopt a budget for the pavement maintenance program. The important thing to remember is not to despair if there is a huge backlog of projects and the council provides an additional dollar amount that will take care of only 10 percent of the backlog. First of all, presenting the results, got an additional 10 percent as well as executive approval. Secondly, the pavement management budget process should be looked at as an incremental process. If a city or county had a $7 million backlog over a six-year period and only received an additional $700,000 in the first year, that is more than the city received in the past. Also, once the money is spent on roadway improvements, the council will see the results of the additional work and should be open to providing additional dollars in future years. The important component is getting executive approval in the first year. That approval lays the foundation for additional budget requests in future years.

Pavement Management is Not a One-Time Activity

After the council has adopted the budget program, the list of approved roadway projects is ready for project level analysis, if required. Project level routines were discussed in an earlier chapter. After the project level work has been completed and the maintenance work has been done on each of the roadway segments, this information needs to be used in your PMS for future years. Any roadway maintenance work needs to be either entered into a computer database if such a system is being used or stored with all of the segment information, if a manual system is being used. This is a key element of a PMS: if the maintenance information is not stored in a computer and a network analysis is run the following year, there will be a very good chance that the segment that was fixed the previous year will be selected for repair in the new year. If this happens, the PMS is a useless tool.

Pavement Management System Products

PMS products, usually in the form of reports or computer outputs, can be divided into different categories — for management, engineers, boards and commissions, legislators, media, and other interest groups. Examples of the types of reports available from a PMS include:

- The current condition of pavements, by project or segment.
- Budget requirements to meet performance objectives — current and future.
- Summary of distress levels over time.
- Condition of pavements as a function of various budget(s), current and future.
- Site specific plans for maintenance and/or rehabilitation.
- Answers to “what if” questions, such as “what if” the budget is reduced? “What if” PMS guidelines change? “What if” performance standards are modified? “What if” new maintenance and rehabilitation actions are used?
- Priorities for allocating maintenance and rehabilitation funds by pavement projects or segments.
- A history of maintenance and rehabilitation by project, segment, or year.
- A summary of traffic by route and location.
- Estimated maintenance and rehabilitation costs by project or segment.

The number and types of reports should be carefully controlled and distributed; otherwise, potential users could be overwhelmed with information. Reports for management and legislators should be in the form of a summary with a minimum of technical detail.

The reports listed previously indicate the types of information available from a PMS. Not so obvious at first is the number of PMS benefits for the agency and for the public in general. An agency will benefit by being able to maximize the effectiveness of each dollar available for maintenance and rehabilitation. And the public benefits through a pavement management program that provides a maximum level of service for their tax dollars. Specific examples of benefits include:

- Minimizing the cost required for maintenance and rehabilitation of individual pavement segments.
- Allocating funds fairly on the basis of established procedures and priorities.
- Consistent agency-wide procedures for evaluating and measuring pavement condition.
- Availability of timely information relative to pavement condition, maintenance, rehabilitation, and their costs.
- Central database of information relative to pavements.
- Ability to evaluate the consequences of deferred maintenance.
- Scheduling of timely maintenance and rehabilitation.
- Ability to answer “what if” kinds of questions.
- Basis for internal and external communications among agency personnel, the council or commission, and the public.

Pavement management professionals like these can be a source of invaluable information and support for your efforts.

Resources to Contact

Suggestions and ideas from local agency pavement managers throughout the state have been incorporated into this manual. Of particular value is information about their experiences in PMS implementation as well as information that would be of most value to them if they were starting the process over again.

Thus, when developing a PMS for your agency, you do not have to "start from scratch." Contact any or all of the agencies which participated in putting this guide together. The Northwest Pavement Management Association is also an excellent resource for finding out how other agencies are managing their pavements. They may provide suggestions that will help in the development of your PMS. And, the ***Sources Consulted*** section of this guide provides a variety of other possible contacts and information sources.

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Acronyms and Definitions

ACP — Asphalt concrete pavement.

ADT — Average daily traffic.

APC — Asphalt over concrete (or over Portland Cement Concrete).

APWA — American Public Works Association.

Benefit-Cost Analysis — Relates the economic benefits of a solution to the costs incurred in providing that solution.

BSS — Bituminous slurry seal.

BST — Bituminous surface treatment.

CAPP — County Arterial Pavement Preservation Program.

Cost-Effectiveness — Benefits exceeding the costs for a given treatment, strategy, or improvement.

CRAB — County Road Administration Board.

DRT — An abbreviation which designates dirt roadways in some pavement management systems.

FHWA — Federal Highway Administration.

GRV — An abbreviation which designates gravel roadways in some pavement management systems.

IRI - International Roughness Index — An index resulting from a mathematical simulation of vehicular response to the longitudinal profile of a traveled surface.

ISTEA — The Intermodal Surface Transportation Efficiency Act of 1991.

NDT — Nondestructive testing. Entails structural testing of pavements by placing a known load on the pavement and measuring deflections; nondestructive testing devices usually employ either a falling weight or a vibrating load.

Network Level — The level at which key administrative decisions affecting programs for road networks (or systems) are made.

Network Level Analysis — Evaluation of pavement to enable the selection of candidate projects, project scheduling, and budget estimates.

Overlay — A layer of paving material applied over the original road surface.

Pavement Structural Capacity — The maximum accumulated traffic loads that a pavement can withstand without incurring unacceptable distress.

PCC — Portland cement concrete.

PCI — Pavement Condition Index.

PCR — Pavement Condition Rating.

PMS — Pavement Management System.

Pavement Condition — A quantitative representation of distress in pavement at a given point in time.

Pavement Distress — The physical manifestations of defects in a pavement.

Pavement Maintenance — All routine actions, both responsive and preventative, which are taken by the state or other parties to preserve the pavement structure, including joints, drainage, surface, and shoulders as necessary for its safe and efficient utilization.

Pavement Management System — A tool (usually computerized) that records and analyzes pavement condition and helps plan maintenance and rehabilitation requirements.

Project Level — The level at which technical management decisions are made for specific projects or pavement segments.

Project Level Analysis — Evaluation of pavement to select the type and timing of rehabilitation or maintenance.

RCW — Revised Code of Washington.

Reconstruction — Construction of the equivalent of a new pavement structure which usually involves complete removal and replacement of the existing pavement structure including new and/or recycled materials.

Rehabilitation — Work undertaken to restore serviceability and extend the service life of an existing facility. This may include partial recycling of the existing pavement, placement of additional surface materials or other work necessary to return an existing pavement, including shoulders, to a condition of structural or functional adequacy.

Seal Coat — A thin, liquefied asphalt surface treatment used to waterproof the pavement and give it the texture of an asphalt surface. Seal coats may or may not be covered with aggregate, depending on the intended purpose. Main types of seals are fog seals, sand seals, slurry seals, and aggregate seals (often referred to as “chip seals”).

Serviceability — The ability of a section of pavement to serve traffic in its existing condition.

Strategy — A plan or method for dealing with all aspects of a particular problem. For example, a rehabilitation strategy is a plan for maintaining a pavement in a serviceability condition for a specified time period.

Treatments — Materials and methods used to correct a deficiency in a pavement surface.

USDOT — United States Department of Transportation.

WAC — Washington Administrative Code.

WSDOT — Washington State Department of Transportation.

WSPMS — Washington State Pavement Management System.

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Sources Consulted

The following publications and articles were consulted in researching and gathering information for this guide. We wish to express our thanks to the authors of these materials, whose knowledge, hard work, and expertise contributed so much to the completion of this guide.

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Interviews

The following interviews were conducted by telephone by Martha Roney, WSDOT TransAid Technical Writer. Local agency personnel implementing and using pavement management systems every day, were consulted. Their answers, comments, and suggestions were invaluable in enhancing the substance of this guide.

Bob Aiello, P.E.; Senior Civil Engineer; City of Seattle

Patricia Carroll; Assistant Design Engineer/Pavement Manager; Thurston County

Chad Coles, P.E.; Pavement Management Engineer; Spokane County

R. Lyle Davis; Senior Engineering Tech. Supervisor; City of Anacortes

Randy Firoved; Data Management Supervisor; Snohomish County

Bob Goenen; Pavement Management Engineer; City of Bellevue

Vicki Griffiths; Engineering Technician; Skagit County

Dave Harmon, P.E., Traffic Engineer and Maintenance Management Engineer; and Don Hora, Traffic Supervisor; Grays Harbor County

Dorothy Ketchum; Maintenance Planner; City of Bellingham

Vince Kiley; Pavement Engineer; Pierce County

Janice Marlega; Transportation Planner; Kitsap County

Bill McEntire; Technical Services Analyst; Clark County

Kathleen Neuman; Engineer Technician; Franklin County

David Phelps, P.E.; Civil Engineer; City of Bothell

Steve Pope; Pavement Management System Administrator; City of Tacoma

Sue Schuetze; Engineering Technician; Benton County

Dave Whitcher, P.E.; Inventory/Pavement Management Systems Engineer; County Road Administration Board

John Wisdom; Engineering Technician; City of Everett

Bill Wressell; Street Maintenance Lead; City of Renton

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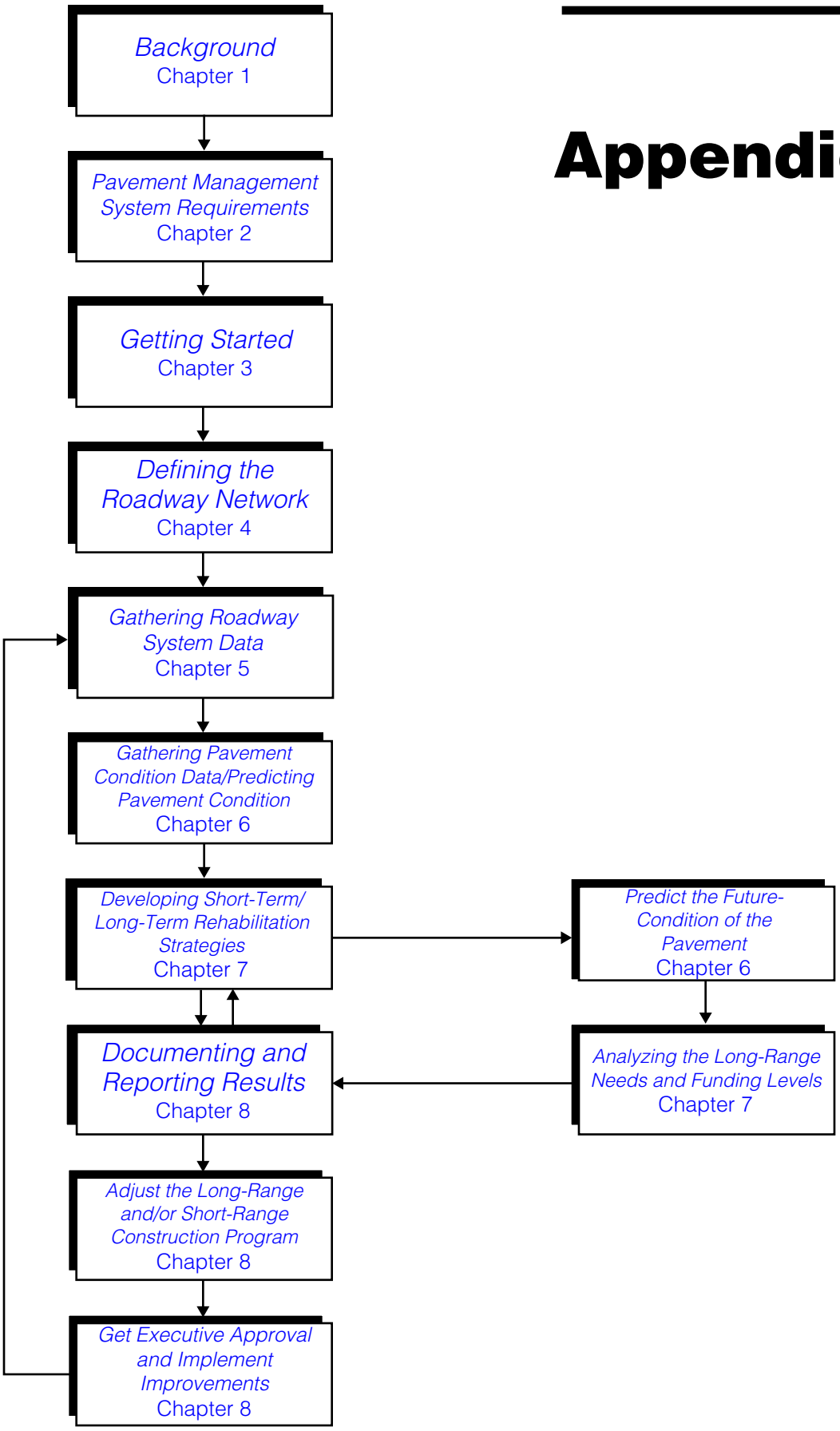
Appendices


Background
Chapter 1
Pavement Management System Requirements
Chapter 2
Getting Started
Chapter 3
Defining the Roadway Network
Chapter 4
Gathering Roadway System Data
Chapter 5
Gathering Pavement Condition Data/Predicting Pavement Condition
Chapter 6
Developing Short-Term/ Long-Term Rehabilitation Strategies
Chapter 7
Predict the Future-Condition of the Pavement
Chapter 6
Analyzing the Long-Range Needs and Funding Levels
Chapter 7
Documenting and Reporting Results
Chapter 8
Adjust the Long-Range and/or Short-Range Construction Program
Chapter 8
Get Executive Approval and Implement Improvements
Chapter 8

Appendix A
Additional Pavement Management Technical Information

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Appendix B
CAPP — Pavement Management Systems
WAC 136 Chapter 320

WAC 136-320-010

Definition. A pavement management system is a systematic analytical tool used to preserve and maintain paved road systems by periodic surveys of pavement condition and analysis of pavement life cycles to assess overall system performance and costs, and to determine the alternative strategies and costs necessary to prevent significant road deterioration. A key element of a PMS is its ability to provide pavement preservation alternatives based upon a predictive pavement deterioration model.

WAC 136-320-020

Application. A pavement management system shall be used by all counties to guide the pavement preservation and rehabilitation activities on all county paved arterial roads. Beginning January 1, 1996, each county shall utilize a computer-based pavement management system (PMS) meeting the requirements of WAC 136-320-030 on all county paved arterial roads in order to retain eligibility for CAPP funds. Application of the PMS to the local access system will not be required to retain eligibility for CAPP funds.

WAC 136-320-030

Pavement Management System Requirements. Each county's PMS shall meet the following standards:

(1) All county jurisdiction paved arterials, ad defined by the most recently approved county road log as described in WAC 136-60, shall be surveyed for visual pavement distress at least biennially. Distress rating information must be keyed to the county road log by both road number and mileposts.

(2) All visual distresses (or defects) for both flexible and rigid pavements, both in severity and extent, shall be as defined within the "Pavement Surface Condition Rating Manual" (March 1992, produced by the Washington State Transportation Center in cooperation with the Northwest Pavement Management Systems Users Group and the Washington State Department of Transportation). Only those distresses

noted as "Core Program Defect" are required to be surveyed. Measurement may be at the project, segment or sample unit level. Measurement for each distress will be by:

(a) Selection of the most predominant severity and extent combination, or

(b) Determination of the extent percent of each level of severity.

Measurement may be by a manual or automated visual condition rating process. The distress information will be converted to a pavement condition rating in accordance with a standard deduct matrix or continuous deduct value curves as provided by the CRAB Board. Alternated deduct matrices may be used by a county for internal management analyses. Alternate distress determination and evaluation methodologies may be used if approved by the CRAB Board in accordance with 136-320-040.

(3) The PMS shall provide for the recording and storage of pavement resurfacing, rehabilitation and reconstruction history data, including surfacing and base layer types and thicknesses, and year of application. Counties will not be required to determine such information for any work done prior to the county's implementation date.

(4) The PMS shall include a future pavement condition prediction model that uses the periodic pavement condition distress data to forecast future pavement condition and to determine an estimate of service life.

(5) The PMS shall provide for annual downloading to the CRAB of one of the following for all paved arterials surveyed for pavement condition in the previous twelve months:

(a) the individual pavement distresses,

(b) the resultant pavement condition rating based on the CRAB-provided standard deduct matrix, or

(c) the resultant pavement condition rating for an approved alternative PMS as described in WAC 136-320-040.

Such downloading shall be called the pavement condition data file. It shall be keyed to the county road log, and shall be transmitted in the electronic medium and format specified by the CRAB Board, along with the annual road log update required by WAC 136-60.

WAC 136-320-040

Alternative Pavement Management System Requirements. Alternative PMS distress determination and evaluation methodologies, processes or systems may be used if they yield pavement condition ratings comparable to the process described in WAC 136-320-030 (2). Counties intending to use an alternative process must satisfactorily demonstrate to the CRAB Board that the alternative process is based on sound pavement engineering principles and is comparable in quality and scale through research results, documented conversion equations, statistical sampling, or other methods.

WAC 136-320-050

Statewide Pavement Condition Data File. The County Road Administration Board shall maintain a pavement condition data file, organized by county, containing the pavement condition ratings as provided annually by each county.

WAC 136-320-060

Annual Review. On an annual basis, beginning in calendar year 1993, the Executive Director of the County Road Administration Board shall review the implementation of and, beginning in calendar year 1995, the compliance with, the requirements of WAC 136-320-030 or 136-320-040 and report the results to the CRAB Board.

WAC 136-320-070

CRAB Assistance. To enable each county to meet its eligibility requirements, CRAB shall provide a PMS software application and training as part of its agency-supported County Road Information System. CRAB shall also provide to counties, upon request, administrative and technical assistance related to defining, developing, operating, managing and utilizing pavement management technology.

WAC 136-320-080

Use of Pavement Management System Data for Distribution of County Arterial Preservation Account Funds. The results and/or data from the individual or collective county PMS's will not be used to distribute County Arterial Preservation Funds nor to establish priorities for specific projects or otherwise alter the statutory fund distribution. Said results and/or data will be used to evaluate regional or statewide arterial pavement preservation and rehabilitation needs and to demonstrate compliance with the enabling legislation.

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Appendix C
Chapter 23 — Code of Federal Regulations

Part 500 — Management and Monitoring Systems
Subpart B — Pavement Management System

Section 500.201

Purpose. The purpose of this subpart is to set forth requirements for development, establishment, implementation, and continued operation of a pavement management system (PMS) for Federal-aid highways in each State in accordance with the provisions of 23 U.S.C. 303 and subpart A of this part.

Section 500.203

PMS Definitions. Unless otherwise specified in this part, the definitions in 23 U.S.C. 101(a) and Sec. 500.103 are applicable to this subpart. As used in this part:

Pavement design means a project level activity where detailed engineering and economic considerations are given to alternative combinations of subbase, base, and surface materials which will provide adequate load carrying capacity. Factors which are considered include: materials, traffic, climate, maintenance, drainage, and life cycle costs.

Pavement management system (PMS) means a systematic process that provides, analyzes, and summarizes pavement information for use in selecting and implementing cost-effective pavement construction, rehabilitation, and maintenance programs.

Section 500.205

PMS General Requirements.

(a) Each state shall have a PMS for Federal-aid highways that meets the requirements of Sec. 500.207 of this subpart.

(b) The State is responsible for assuring that all Federal-aid highways in the State, except those that are federally owned, are covered by a PMS. Coverage of federally owned public roads shall be determined cooperatively by the State, the FHWA, and the agencies that own the roads.

(c) PMSs should be based on the concepts described in the "AASHTO Guidelines for Pavement Management Systems." /1/

Note /1/ AASHTO Guidelines for Pavement Management Systems, July 1990, can be purchased from the American Association of State Highway and Transportation officials, 444 North Capitol Street NW, Suite 225, Washington, D.C. 20001. Available for inspection as prescribed in 49 CFR Part 7, Appendix D.

(d) Pavements shall be designed to accommodate current and predicted traffic needs in a safe, durable, and cost-effective manner.

Section 500.207

PMS Components.

(a) The PMS for the National Highway System (NHS) shall, as a minimum, consist of the following components:

(1) Data collection and management.

(i) An inventory of physical pavement features including the number of lanes, length, width, surface type, functional classification, and shoulder information.

(ii) A history of project dates and types of construction, reconstruction, rehabilitation, and preventive maintenance.

(iii) Condition surveys that include ride, distress, rutting, and surface friction.

(iv) Traffic information including volumes, classification, and load data.

(v) A data base that links all data files related to the PMS. The data base shall be the source of pavement related information reported to the FHWA for the HPMS in accordance with the HPMS Field Manual. /2/

Note /2/ Highway Performance Monitoring System (HPMS) Field Manual for the Continuing Analytical and Statistical Data Base, DOT/FHWA, August 30, 1993, (FHWA Order M5600.1B). Available for inspection and copying as prescribed in 49 CFR Part 7, Appendix D.

(2) Analyses, at a frequency established by the State consistent with its PMS objectives.

(i) A pavement condition analysis that includes ride, distress, rutting, and surface friction.

(ii) A pavement performance analysis that includes an estimate of present and predicted performance of specific pavement types and an estimate of the remaining service life of all pavements on the network.

(iii) An investment analysis that includes:

(A) A network-level analysis that estimates total costs for present and projected conditions across the network.

(B) A project level analysis that determines investment strategies including a prioritized list of recommended candidate projects with recommended preservation treatments that span single-year and multi-year periods using life-cycle cost analysis.

(C) Appropriate horizons, as determined by the State, for these investment analyses.

(iv) For appropriate sections, an engineering analysis that includes the evaluation of design, construction, rehabilitation, materials, mix designs, and preventive maintenance as they relate to the performance of pavements.

(3) Update. The PMS shall be evaluated annually, based on the agency's current policies, engineering criteria, practices, and experience, and updated as necessary.

(b) The PMS for Federal-aid highways that are not on the NHS shall be modeled on the components described in paragraph (a) of this section, but may be tailored to meet State and local needs. These components shall incorporate the use of the international roughness index or the pavement serviceability rating data as specified in Chapter IV of the HPMS Field Manual.

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Appendix D
Dividing the Roadway Network

The following two pages illustrates how the city of Bellingham took a map of their entire roadway network and first divided it into zones, then took each of the 22 zones and created projects and segments.

Prior to implementing a pavement management system, the city had already designated 22 neighborhood districts, each having a representative who worked with the city on issues of importance to the district. A map of these districts is found on the next page. Rather than creating an entirely new zoning scheme, the Public Works Department of Bellingham used these 22 districts when it started its pavement management system.

After the zoning system had been determined, each zone had to be broken into individual projects and segments. On the page following the 22 zones, one zone has been highlighted. Each street in Bellingham has the same project number. At each intersection, the city creates a new segment. For example, in zone 17, Harris Avenue has the same project number, but from 12th to 13th is one segment and from 13th to 14th is another, etc.

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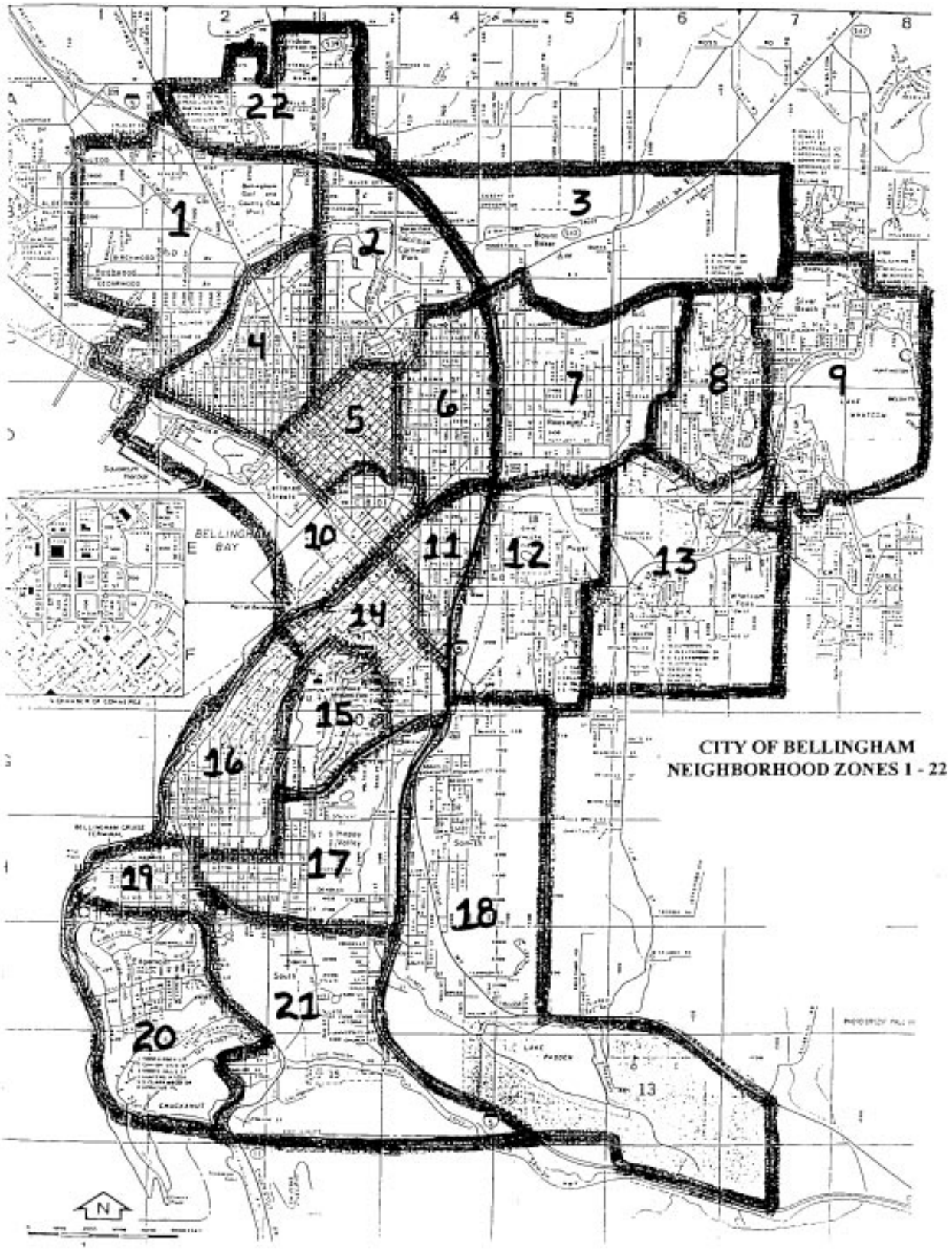
CITY OF BELLINGHAM
NEIGHBORHOOD ZONES 1 - 22
BELLINGHAM BAY
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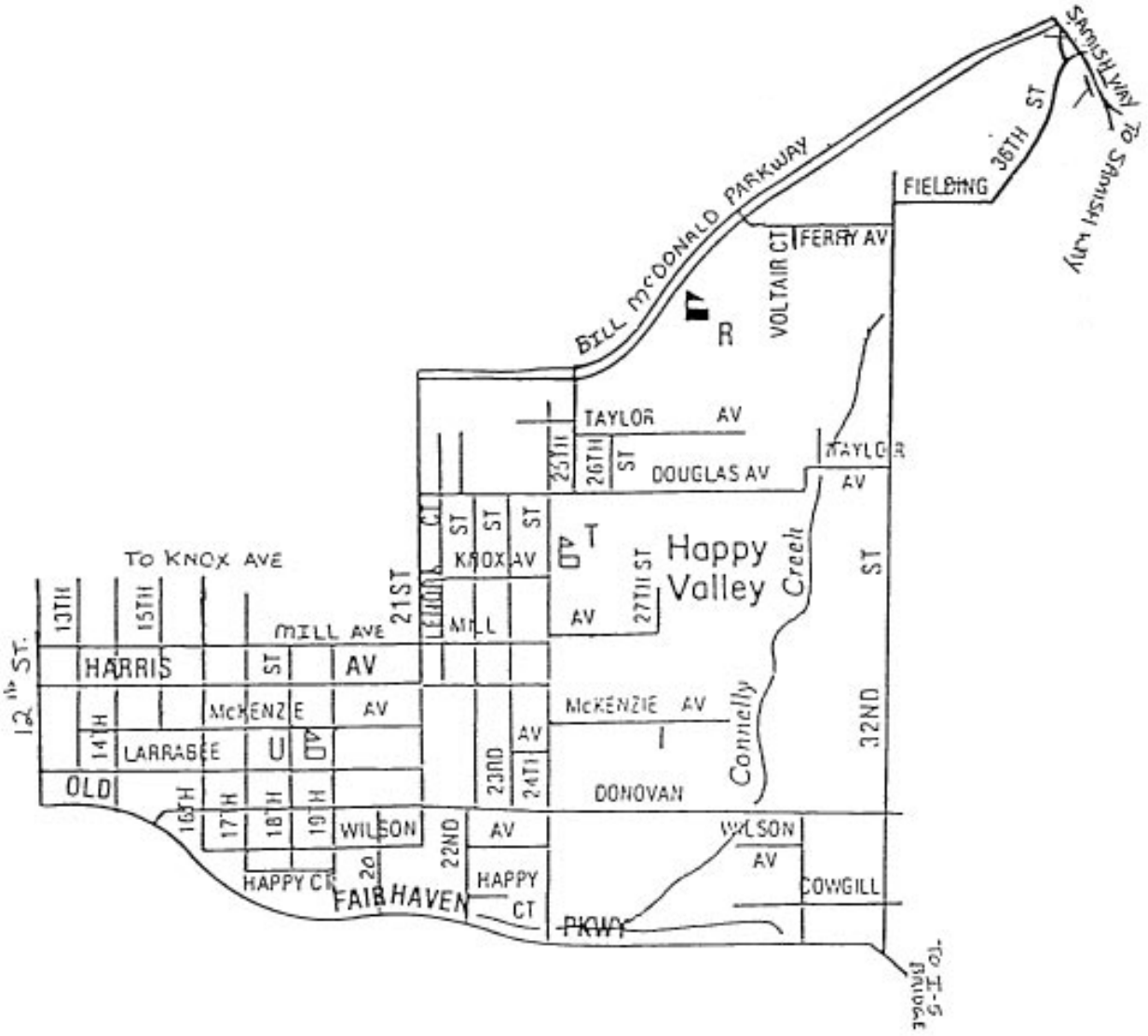

ZONE 17
HAPPY VALLEY

Appendix E
Rating Forms

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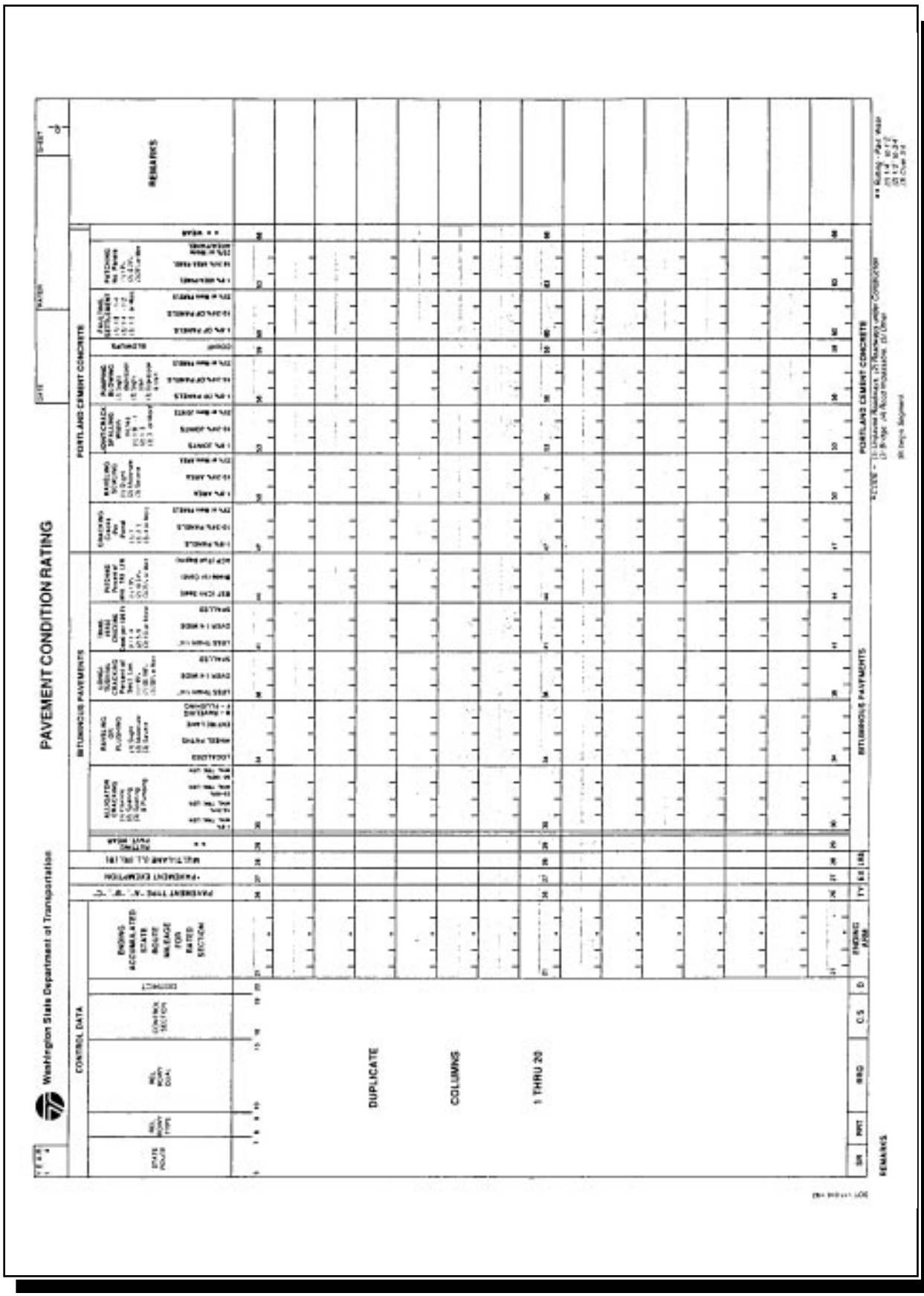

PAVEMENT CONDITION RATING
Washington State Department of Transportation
CONTROL DATA
BITUMINOUS PAVEMENTS
PORTLAND CEMENT CONCRETE
REMARKS
DUPLICATE
COLUMNS
1 THRU 20

PAVEMENT CONDITION RATING

CRAB

CONTROL DATA						BITUMINOUS PAVEMENTS																																									
Road Number	Beginning Milepost of Rated Section	Ending Milepost of Rated Section	Function Class	Pavement Type	Lanes Rated	Rutting & Wear (Select one Severity)			Alligator Cracking (% of both Wheel Paths)			Longitudinal Cracking (% of Seg Length)			Transverse Cracking (No. per 100')			Raveling (Localized Wheel Path, or Entire Lane)			Flushing (Localized Wheel Path, or Entire Lane)			Patching (% of both Wheel Paths)			Corrugation & Waves (% of Road)			Sags & Humps (% of Road)			Block Cracking (Select one Severity)			Pavement Edge Cond. (% of Road)			Crack Seal Condition (% of length of cracks)		
						¼" to ½"	½" to 3/4"	over 3/4"	Hair Line < ¼"	Spalling	Spalling & Pumping	< ¼" wide	> ¼" wide	Spalled	< ¼" wide	> ¼" wide	Spalled	Slight	Moderate	Severe	Slight	Moderate	Severe	Chip seal patch	Blade patch	Dig-out	1/8" to 2" chg per 10'	2" to 4" chg per 10'	Over 4" chg per 10'	1/8" to 2" chg per 10'	2" to 4" chg per 10'	Over 4" chg per 10'	9' x 9' and larger blocks	5' x 5' to 8' x 8' blocks	2' x 2' to 4' x 4' blocks	Edge Raveling	Edge Patching	Lane < 10'	minimal leak	substantial leak	non-existent sealant

ACP/BST STREET RATING FORM

ZONE: STREET NO: SEGMENT NO: TYPE:

STREET NAME:

FROM:

TO:

LENGTH: WIDTH: SH L: DR L: PK L:

LANES: SH R: DR R: PK R:

RATING DATE:_____

RUTTING (ave. depth in 0.25 increments)	ASSUME FULL SEGMENT LENGTH					
FATIGUE (ALLIGATOR) CRACKING (area in sq. feet)	LOW(<1/4")	MED(SPALLING)	HIGH(PUMPING)	L	M	H
LC FATIGUE (length in ln. feet)	LOW(<1/4")	MED(>1/4")	HIGH(SPALLING)	L	M	H
LC REFLECTIVE (length in ln. feet)	LOW(<1/4")	MED(>1/4")	HIGH(SPALLING)	L	M	H
TC (count)	LOW(<1/4")	MED(>1/4")	HIGH(SPALLING)	L	M	H
RAVELING (predominate (1)local,(2)wheel,(3)lane)	LOW(STARTED TO WEAR)	MED(ROUGH SURFACE)	HIGH(VERY PITTED SURFACE)	L	M	H
FLUSHING (predominate (1)local,(2)wheel,(3)lane)	LOW(SLIGHTLY COVERED)	MED(MODERATELY COVERED)	HIGH(SEVERLEY COVERED)	L	M	H
PATCHING (area in sq. feet)	ONLY CONCIDER BLADE PATCHING AND ENTER AS MEDIUM SEVERITY			M		
CORRIGATION/WAVES (area in sq. feet)	LOW(1/8 TO 2" PER 10 FT)	MED(2 TO 4" PER 10 FT)	HIGH(>4" PER 10 FT)	L	M	H
SAGS/HUMPS (area in sq. feet)	LOW(1/8 TO 2" PER 10 FT)	MED(2 TO 4" PER 10 FT)	HIGH(>4" PER 10 FT)	L	M	H
BLOCK CRACKS (area in sq. feet)	LOW(<1/4")	MED(>1/4")	HIGH(SPALLING)	L	M	H
EDGE RAVELING (% of 2 x length)	< 6" FROM EDGE OF ROADWAY					
EDGE PATCHING (% of 2 x length)	< 6" FROM EDGE OF ROADWAY					
UTILITY CUTS (count)	FULL DEPTH PATCHES AND UTILITY CUTS					
CRACK SEAL CONDITION (% of predominate seal condition)	LOW(GOOD SEAL)	MED(OPEN SEAL)	HIGH(NO SEAL)	L	M	H

COMMENTS:_____

PCC STREET RATING FORM

ZONE: STREET NO: SEGMENT NO: TYPE:

STREET NAME:

FROM:

TO:

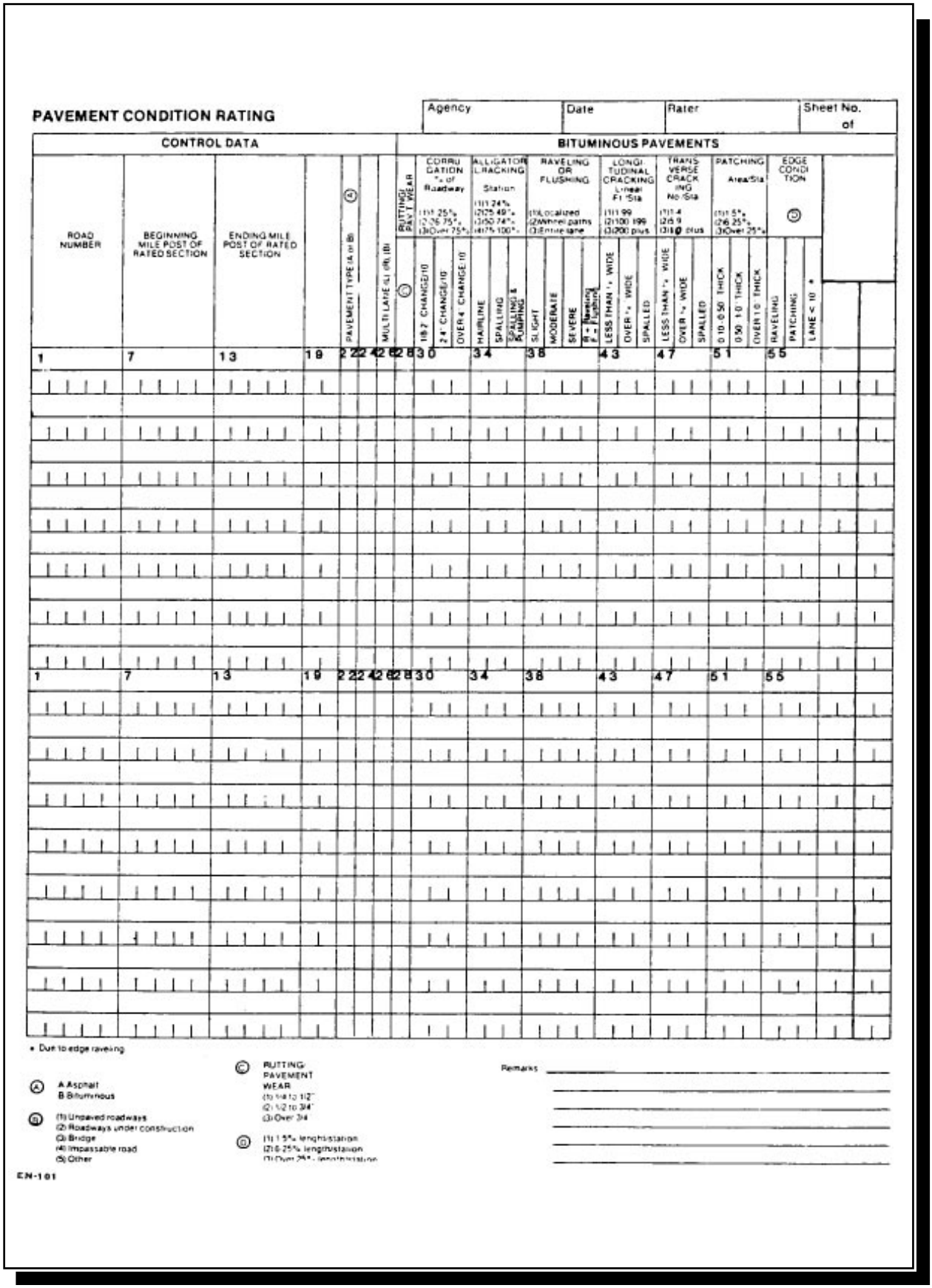
LENGTH: WIDTH: SH L: DR L: PK L:

LANES: SH R: DR R: PK R:

RATING DATE:_____

CRACKING (% of panels effected)	LOW(1 per panel)	MED(2 to 3 per panel)	HIGH(>4 per panel)	L	M	H
JOINT & CRACK SPALLING (% of joints & cracks effected)	LOW(<1")	MED(1 to 3")	HIGH(>3")	L	M	H
PUMPING & BLOWING (% of panels showing evidence)	LOW(slight depression)	MED(significant depression)	HIGH(severe depression)	L	M	H
FAULTING & SETTLEMENT (% of occurances)	LOW(<1/4")	MED(1/4 to 1/2")	HIGH(>1/2")	L	M	H
PATCHING (% of panels effected)	LOW(1 to 9% of panel)	MED(10 to 24% of panel)	HIGH(> 25% of panel)	L	M	H
RAVELING OR SCALING (% of segment length)	LOW(SLIGHTLY ROUGH)	MED(MODERATELY ROUGH & PITTED)	HIGH(DEEPLY PITTED & ROUGH)	L	M	H
BLOWUPS (count)	SHATTERING OR BUCKELING AT TRANSFERSE CRACKS OR JOINTS					
MEAN WEAR (ave. depth in 0.25 increments)	ASSUME FULL SEGMENT LENGTH					
CRACK SEAL CONDITION (% of predominate seal condition)	LOW(GOOD SEAL)	MED(OPEN SEAL)	HIGH(NO SEAL)	L	M	H

COMMENTS:_____



PAVEMENT CONDITION RATING

Agency | Date | Rater | Sheet No. of

CONTROL DATA									BITUMINOUS PAVEMENTS																								
ROAD NUMBER	BEGINNING MILE POST OF RATED SECTION	ENDING MILE POST OF RATED SECTION			PAVEMENT TYPE (A or B)		MULTI LANE (L) (R) (B)	RUTTING PAVT WEAR	CORRUGATION % of Roadway (1) 5% (2) 26-75% (3) Over 75%			ALLIGATOR CRACKING Station (1) 24% (2) 25-49% (3) 50-74% (4) 75-100%			RAVELING OR FLUSHING (1) Localized (2) Wheel paths (3) Entire lane			LONGITUDINAL CRACKING Linear Ft/Sta (1) 99 (2) 100-199 (3) 200 plus			TRANSVERSE CRACKING No./Sta (1) 4 (2) 5-9 (3) 10 plus			PATCHING Area/Sta (1) 5% (2) 25% (3) Over 25%			EDGE CONDITION					
										10-2' CHANGE/10	2-4' CHANGE/10	OVER 4' CHANGE/10	HAIRLINE	SPALLING	SPALLING & PUMPING	SLIGHT	MODERATE	SEVERE B = Bleeding F = Fighting	LESS THAN ½" WIDE	OVER ½" WIDE	SPALLED	LESS THAN ½" WIDE	OVER ½" WIDE	SPALLED	0.10-0.50' THICK	0.50-1.0' THICK	OVER 1.0' THICK	RAVELING	PATCHING	LANE < 10' *		
1	7	13		19	22	42	62	28	30			34			38			43			47			51			55					
1	7	13		19	22	42	62	28	30			34			38			43			47			51			55					

* Due to edge raveling

Ⓐ A Asphalt
B Bituminous

Ⓑ (1) Unpaved roadways
(2) Roadways under construction
(3) Bridge
(4) Impassable road
(5) Other

Ⓒ RUTTING PAVEMENT WEAR
(1) ¼ to ½"
(2) ½ to ¾"
(3) Over ¾"

Ⓓ (1) 5% length/station
(2) 6-25% length/station
(3) Over 25% length/station

Remarks _____

EN-101

Appendix F
Writer's Guide for Composing a Budget Options Report

A Writer's Guide for Composing a Budget Options Report

I. Introduction

This guide describes the basic structure and components that should be considered within a city's or a county's own budget options report. Modifications or alterations are fully encouraged to provide flexibility for cities and counties to write reports suited to their justification's needs. The basic purpose of writing budget options reports is to better assess the adequacy of cities' and counties' revenues to meet the maintenance needs recommended by their pavement management systems. Written properly, these reports should increase the chances of getting a maximum return for expenditures by documenting the need for (1) the implementation of a multi-year street rehabilitation program; (2) the development of a preventive maintenance program; and (3) the generation of additional revenue to make street networks cost effective to maintain.

II. Basic Structure and Components in a Budget Options Report

A budget options report is most effective if it contains pertinent information presented in a manner that is easy to follow and understand by decision makers, agency staff, and the general public. In the basic structure of a budget options report, a table of contents is followed by an introduction and statement of purpose. Generally, the table of contents serves to guide the reader in following the topics covered within the budget options report. Basic topics normally covered include the following:

A. Project Description of Pavement Management System
    1. Introduction
    2. Statement of Purpose
    3. Background
    4. Steps Taken for Implementing Pavement Management
    5. Current Use of Pavement Management System

B. Summary of Findings

C. Pavement Management Budget Analysis
    1. Historical Pavement Management Revenue
    2. Historical Pavement Management Expenditures

3. Pavement Management Budget Needs Analysis
4. Pavement Management Projected Expenditures Compared to Actual Budget Needs

D. Discussion of Alternative Budget Scenarios

E. Conclusions

F. Recommendations

G. Glossary

H. Appendix (also include charts, graphs, tables, and other technical information)

1. Potential Funding Sources Discussion of alternative funding sources supplementing potential shortfalls from inadequate funding by current funding sources.

III. Discussion of Contents Within a Budget Options Report

A. Description of Pavement Management

The description of pavement management used in the agency should contain within it (1) an introduction, (2) a statement of purpose, (3) background information, (4) an explanation of the steps taken for implementing a pavement management program, and (5) a description of the current use of pavement management.

1. Introduction

   - Introduce the reader to your budget options report.

2. Statement of Purpose

   - Supply a statement of purpose for preparing a budget options report.
   - Make sure your statement is clearly visible and easy to locate within your budget options report. It will enable readers to view the statement with ease. This can be accomplished through bolding or underlining this portion of the report.

     An excerpt taken from one county's budget options report gives an excellent account of how cities and counties can declare their statement of purpose:

     "the purpose of the Pavement Management Study overview that we will present is not only to identify and quantify our road maintenance and construction needs, but to help recognize road maintenance priorities such as repairs and resurfacings, and the scheduling of treatments needed to extend pavement life of those roads in good enough condition to do so …"

3. Background

   - Declare the purpose of implementing a pavement management system in your jurisdiction.
   - Provide information covering the current status of the roads and street conditions within your jurisdiction.
   - State the major goals you are trying to achieve with a road maintenance program for your jurisdiction.

4. Steps Taken Prior to Implementing a Program for Pavement Management

   Six major steps are recommended for formulating a pavement management program. These steps may differ from steps taken within your own jurisdiction. In any event, providing a brief description of each of your steps will help the reader understand how the pavement management system became implemented. The six recommended steps are:

   (a) Commitment to PMS/Develop Work Plan

   (b) Define Network Sections

   (c) Survey of Pavement Condition

   (d) Determination of Cost-Effective Maintenance Treatments

   (e) Projection of a Five-Year Program and Budget

   (f) Test of Alternative Five-Year Programs and Budgets

5. Current Use of Pavement Management System

   It is important to document the uses of the pavement management process in your jurisdiction. In doing so, decision makers, agency staff, and the public will develop a better understanding of the basis of recommendations provided based on the pavement maintenance program. Some uses of the pavement management process include:

   (a) devising a long-range financial planning program or master plan,

   (b) formulating an up-to-date inventory and record keeping system,

   (c) estimating the network level planning costs of future projects,

   (d) examining the performance and costs of various treatments to verify their direct correlation to the expected fixes and unit costs within the system,

   (e) evaluating priorities for road repair at the local level, and

   (f) monitoring pavement conditions over time.

B. Summary of Findings

Generally, the summary of findings section of a budget options report is quick to read and easy to understand: the results of the study are succinctly presented as a list. This list of findings should contain technical data supporting the recommendations along with a brief explanation of each finding. The summary of findings from a typical budget options report includes the following information:

- Historic pavement maintenance revenue and estimated revenue over the next five years. Revenue information can be found in the State Controller's Reports for prior years. From this total amount, indicate how much revenue is available for pavement repair.
- Estimate of the historic pavement maintenance expenditures needed for pavement repair using the most cost-effective strategies. Expenditure information can be found in the State Controller's Reports for prior years.
- Compare the needs with the projected revenues to repair your jurisdiction's street network (budget needs). Based on your projections, indicate the amount of surplus or deficit you expect to have over a five-year period.
- Illustrate the results of the budget options tested for your jurisdiction. This involves testing various budget levels, maintenance options, and evaluation of different pavement repair expenditure levels over a five-year period using the scenario report.

C. Pavement Management Budget Analysis

The main purpose of a budget needs description in a budget options report is to provide a base line analysis of the impact if your jurisdiction funds all needed pavement maintenance treatments over a multiple year period. The following needs analysis will present information showing recommended repair strategies and costs needed to raise the condition of all pavement sections to a PCI level at which preventive maintenance can be applied. After describing the budget needs within the jurisdiction, include an analysis of pavement management revenues and expenditures of the past, the present, and the future. The topics normally covered within this section include:

General

(1) Current overall health of the street network.

(2) Revenue needed for repair strategies to make the street network the most cost effective to maintain.

(3) Major issues/options if the budget needs in your jurisdiction predict a deficit or surplus in revenue.

Specific

(1) Historical Pavement Maintenance Revenue — a historical view and discussion of available funding sources from the past to the present for projecting revenue levels available for future pavement maintenance.

(2) Historical Pavement Maintenance Expenditures — a historical view and discussion of expenditures allocated from the past to the present for projecting future available expenditure levels.

(3) Pavement Management Budget Needs Analysis — a discussion of budget needs within your jurisdiction.

(4) Pavement Management Projected Expenditures Compared to Actual Budget Needs — an analysis and discussion comparing projected pavement maintenance expenditures to actual budget needs.

- Supply graphs, charts, and tables illustrating pavement management budget needs and analysis. They can be inserted within this section or placed under the appendix section of your budget options report.

D. Discussion of Alternative Budget Scenarios

Testing alternative budget scenarios helps cities and counties compare and evaluate different budget levels and repair strategies. Showing the impact of each budget level considered will show available options and how your jurisdiction went about choosing the alternative with the most cost-effective expenditure of funds. Some key features to consider when writing this section of the report include:

- Provide a brief description of how the budget scenario module of the PMS was utilized for testing alternative maintenance/budget scenarios.
- Present Budget Levels/Maintenance Options with Projected PCI Conditions for a five-year program. Information can be provided in the form of graphs, charts, and tables. They may appear in this section or in the appendix section of your budget options report.

- Provide a subsection clearly marked for discussing specific observations and concerns worthy for the reader to acknowledge.

E. Conclusions

The conclusion section of a budget options report serves to summarize (1) the average PCI level of pavement conditions within the jurisdiction; (2) the impact of different funding alternatives on pavement conditions over a five-year period; (3) the course of action to meet the goals established by the agency; and (4) the impact of the selected alternative on the PCI, deferred funding need, stop-gap needs, and percentage of pavements in unacceptable condition.

F. Recommendations

This section of a budget options report includes recommendations based on evaluating alternative budget scenarios. Some important criteria to include in evaluating scenarios are (1) change in PCI over time, (2) change in deferred maintenance over time, (3) change in stop-gap maintenance needs, and (4) change of pavement in unacceptable condition. The two key items to emphasize in evaluating budget scenarios are (1) to show a PCI increasing over time and (2) to show deferred maintenance decreasing over time. This will facilitate selecting the best option. When making recommendations provide the following information:

- Give a brief description of each option along with an opinion of how one option compares fiscally to all other options within your budget options report.
- Generate a list and brief description of additional revenues your jurisdiction can rely upon should it face a shortfall from current funding sources supporting your pavement management system. Furthermore, an in depth discussion of potential funding sources should be located in the appendix of your budget options report.
- Evaluate alternative maintenance program options. Examples of alternative maintenance programs include: (1) grouping pavement management projects of similar type, location, and year; (2) setting priorities on repairs so more densely traveled streets (arterials) are repaired first; (3) coinciding pavement repair work schedules with utility work schedules; (4) evaluating recommended pavement repair treatments in more detail to build projects/contracts; and (5) developing and fully funding preventive maintenance programs, including the required stop-gap maintenance on deferred projects.

G. Glossary

A glossary is fundamental to a budget options report because it defines terms for readers who may be unfamiliar with a pavement management system. As a reminder, a budget options report is written effectively only if it conveys meaning to its audience. Therefore, it is essential that cities and counties provide a glossary of pavement management terms mentioned within their budget options report. For example, this can include a definition of each road class or a brief description of the pavement management condition index. A general list of pavement management terms is provided in the back of this guide.

H. Appendix

The appendix section of a budget options report primarily contains technical information in the form of charts, graphs, and tables supporting the recommendation made within a budget options report. Generally, technical information is placed within this section to prevent readers from being overwhelmed by an enormous amount of data. "Padding" a budget options report with too much technical information only makes it difficult to read and hard to follow. An appendix helps this problem by providing a place for readers to refer to for additional information. Other than technical information, an appendix in a budget options report should include a list and brief discussion of potential funding sources. Each potential funding source in this subsection is an alternative funding source supplementing potential shortfalls from inadequate funding by current funding sources.

IV. Conclusion

The goal of this guide is to help cities and counties prepare their own budget options report. By documenting pavement management uses, cities and counties can use budget options reports as tools to justify their requests for additional road system funding.

22:F:GPM2

Appendix G
Sample Budget Report for Public Works

Sample Budget Options Report

I. Purpose

The purpose of the Network-Level Budget Options Report is to assist the agency in utilizing the results of the agency's Network-Level Pavement Management System (PMS). Specifically, we are trying to link the PMS recommended repair program costs to your budget and improve your overall maintenance and rehabilitation strategy. This report should help you to assess the adequacy of your revenues to meet the maintenance needs recommended by the PMS program. It should also help you in getting a maximum return for your expenditure by: (1) implementing a multi-year roadway rehabilitation and maintenance program, (2) developing a preventive maintenance program, and (3) selecting the most cost effective repairs.

II. Summary and Findings

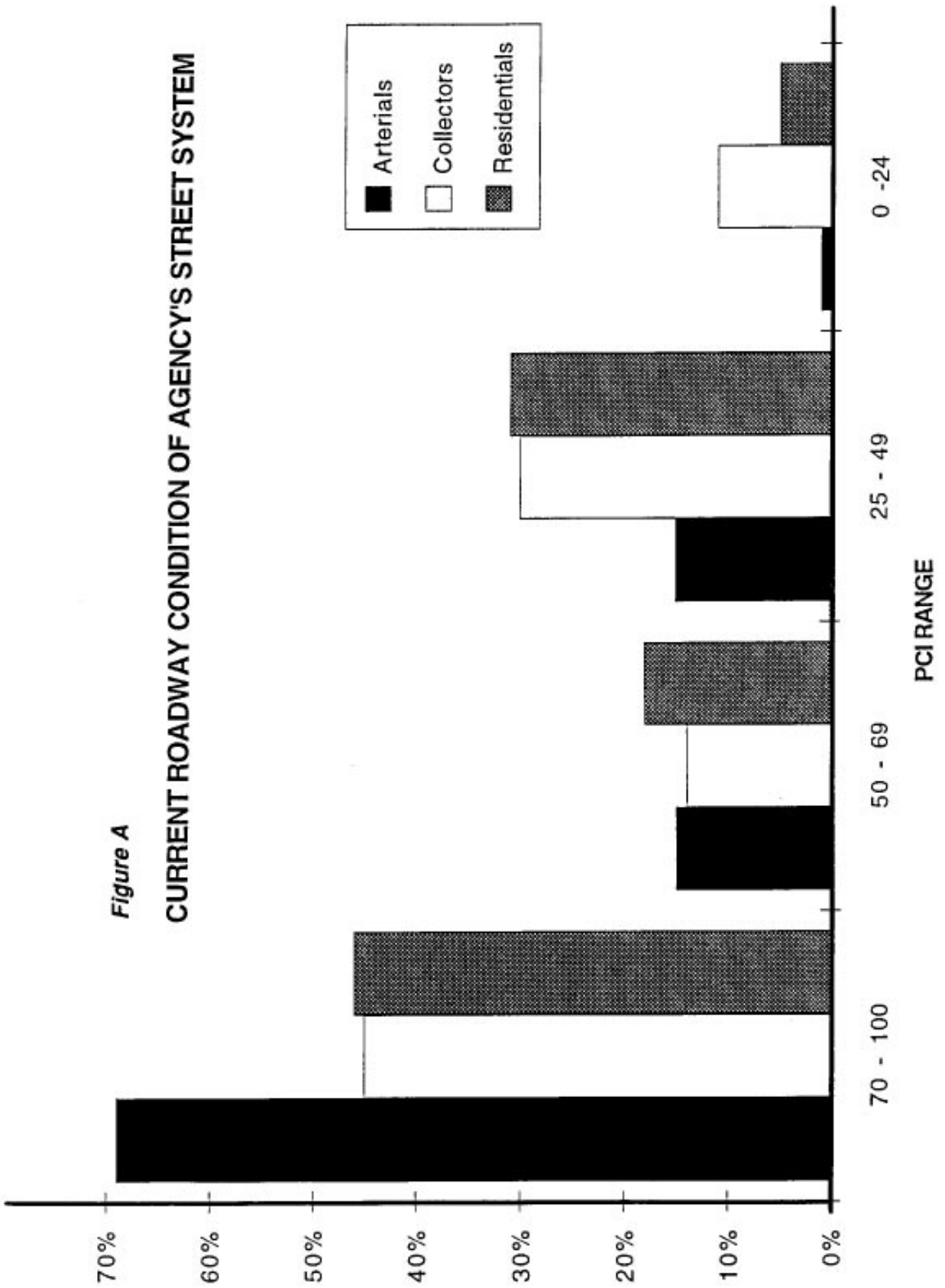
- The estimate of the agency's total Department of Public Works (DPW) roadway related revenues projected over the next five years is $6.36 million. Of that amount, $1.97 million is estimated to be available for pavement repair.
- Based on the survey of the agency's roadway network and past spending practices, the overall Pavement Condition Index (PCI) of the system is 75[1] or a "Very Good" condition. Section III-C illustrates the current condition of the agency's roadways. **Figure A** shows the current condition of the agency's roadways — functional class by condition.
- **Using the most cost-effective strategies, the PMS Recommended Program will require an expenditure of $7.0 million over the next five years or roughly $1.4 million per year, if this expense is spread evenly.**
- **Comparison of the cost to fix the network with the projected estimated revenues indicates a deficit of $5.0 million over the five-year period, based on staff estimates.**

[1]On a scale of 0-100:

70-100	=	Excellent/Very Good
50-69	=	Good/Fair
25-49	=	Fair/Poor
0-24	=	Very Poor/Failed

Figure A

CURRENT ROADWAY CONDITION OF AGENCY'S STREET SYSTEM



- Various budget levels and maintenance options have been tested to illustrate and evaluate various levels of pavement repair expenditures over a five-year analysis period. The four budget options programs tested are as follows:

  Option 1 — The PMS Recommendation (heavy needs in first year)

  Cost — $7.0 million over five years with $4.4 million in the first year.

  Rehabilitation/Preventive Maintenance Split — Varies by year from 0 percent to 26 percent for preventive maintenance.

  Result — PCI is raised from 75 to 84 in the first year and then maintained at 84. There is no deferred maintenance in any year.

  Option 2 — Modified PMS Recommendation (needs spread evenly over five years)

  Cost — $7.0 million over five years at $1.4 million per year.

  Rehabilitation/Preventive Maintenance Split — A constant 9 percent per year for preventive maintenance.

  Result — PCI gradually rises to 84 by fifth year, and a deferred maintenance cost of $3.0 million in the first year has dropped to $.5 million by the fifth year.

  Option 3 — Test Funding Level Between PMS Recommendation and Estimate of the Agency's Revenues

  Cost — $4.5 million over five years at $0.9 million per year.

  Rehabilitation/Preventive Maintenance Split — A constant 9 percent per year for preventive maintenance.

  Result — PCI rises to 82 by fifth year, and deferred maintenance is $3.5 million in year one increasing slightly to $3.7 million by year five.

  Option 4 — Constrained to Estimate of the Agency's Revenues

  Cost — $1.9 million over five years; $0.32 million in first year projected at a 10 percent growth rate per year.

  Rehabilitation/Preventive Maintenance Split — A constant 9 percent per year for preventive maintenance.

  Result — PCI slightly decreasing to low 70s, and deferred maintenance of $4.1 million rises to $7.0 million by year five.

- **Figure B** is a chart showing the impact of the maintenance and rehabilitation options on the roadway network PCI over a five-year period. **Figure C** is a chart showing the impact of deferred maintenance on the roadway network by option over a five-year period.
- The future condition of the roadway network under selected options over a five-year production period will be:

		Years				
		1	**2**	**3**	**4**	**5**
No Maintenance Option:	PCI =	69	67	65	63	61
Option 1:	PCI =	84	84	84	84	84
Option 2:	PCI =	76	78	82	83	84
Option 3:	PCI =	74	77	78	79	82
Option 4:	PCI =	71	71	71	72	72

- **Figure D** shows the above table graphally.

III. Overview

A. Organization of Report

The report is composed of six sections. Each section identifies and evaluates a technical or financial component linking the output of the program to the jurisdiction's budget process.

Section A estimates total Department of Public Works' (DPW) roadway revenues available over the next five years. Based on a 10 percent annual growth rate, the agency will generate roughly $6.36 million in total roadway revenues over the five-year projection period shown in Table 4. Based on seven-year historical trends (see Table 2), 31 percent of total roadway revenues is available for pavement repair work yielding a pavement repair budget of $1.97 million over the next five years.

Section B identifies the existing condition of the roadway network and recommended treatments utilizing outputs from the Budget Needs module. The objective of the model is to bring the roadway network up to a very good condition and maintain it there. Based on a PCI developed to measure the health of the existing pavement, the current overall condition of the agency's network is considered to be in very good condition (PCI 75). Based on the analysis and past spending practices, a portion of the current network is suffering from load-related distress and some deferred maintenance. If not corrected, the

Figure B

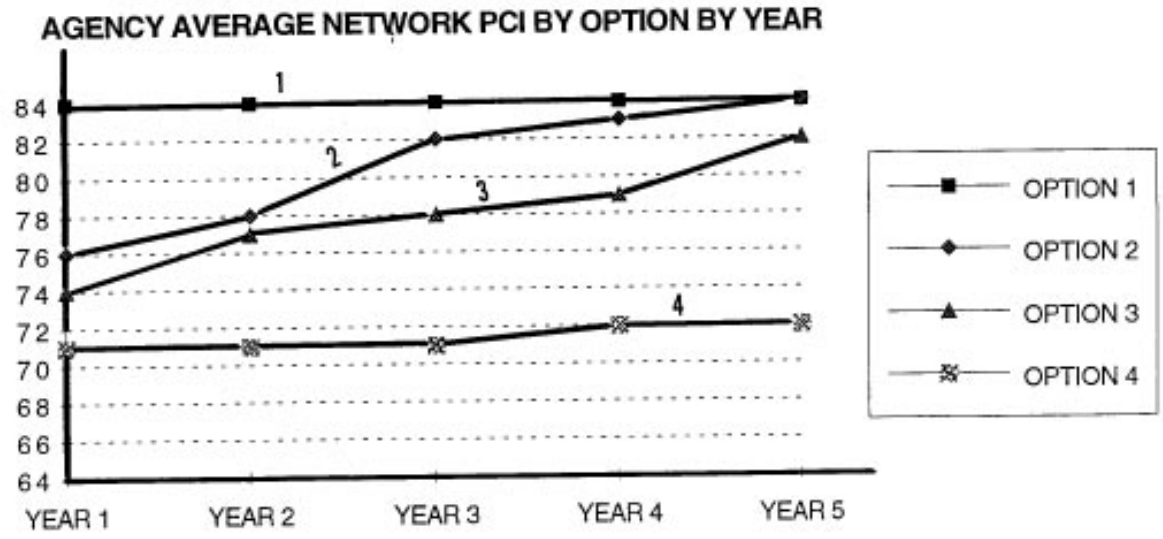


Figure C

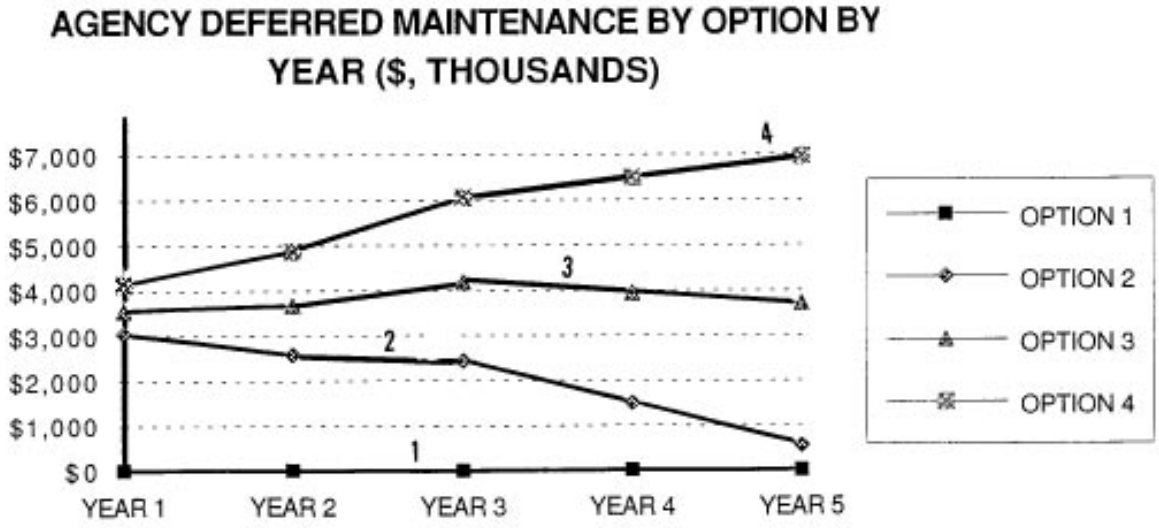
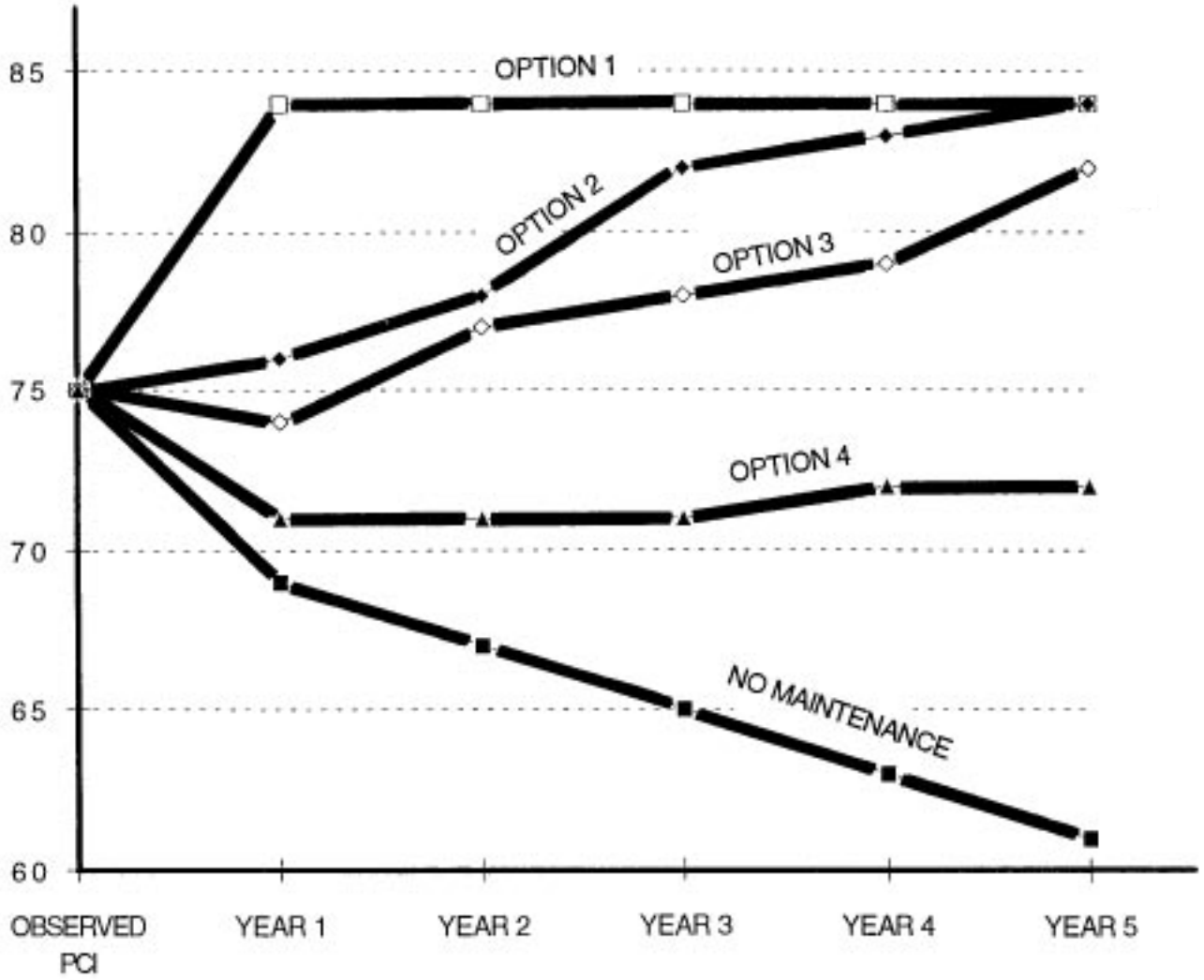


Figure D

IMPACT ON THE PAVEMENT CONDITION INDEX OF THE NO MAINTENANCE OPTION AND 4 OTHER OPTIONS



quality of the roadway network will decline. Correcting this deficiency requires the implementation of a cost-effective spending level to improve the roadway network, and a cost-effective maintenance and rehabilitation strategy. As a result of the data entered by the agency into the model, the condition of the current network now requires the city to spend roughly $7.0 million over the next five years to repair the network, based on the costs to fix roadways.

If no maintenance is applied to the network over the next five years, its condition will continue to deteriorate (down to an average PCI of 61 due to the acceleration of existing distresses identified in the analysis).

Section C compares projected revenues against the cost to fix the network. Generally, the cost to fix will initially be very high if past spending practices have resulted in deferred maintenance. Table 4 shows that the deficits resulting from a front-loaded repair program are from a program that spreads expenditures evenly over the five-year period. As shown in Table 4, based on the revenue assumptions applied, the agency's five-year needs call for spending roughly $7.0 million. Roughly 65 percent of this PMS needs repair program or $4.44 million is programmed in year one to catch up on deferred maintenance and reduce roadway repair costs in the other years. We estimate that the city is short roughly $5 million over the five-year period for roadway repair needs.

Section D reviews options and issues that the agency may wish to consider in revising their maintenance strategy. We have listed five items for consideration.

Section E compares budget levels and maintenance options. Utilizing the budget module permits the testing of alternative budget levels and splits between rehabilitation and preventive maintenance. Four options are tested an the impacts are evaluated.

Section F provides recommendations that the agency's staff may wish to consider as they continue to build and refine their pavement maintenance program and budget.

B. Next Steps

The results of this analysis are but a beginning in building an effective roadway maintenance program. You should, for example, check to validate your distress survey since it is possible that errors in survey data may have been overlooked. In addition, sections identified for treatment should require more detailed subsurface information before major rehabilitation projects are undertaken. You should evaluate the specific treatments and costs used to verify that they match the fixes and unit costs you would expect to use. You should also test other budget options, varying revenues, preventive/rehabilitation splits, and

even repairs on specific roadways. Finally, we recommend that you prepare a brief memo to the council outlining the recommended five-year repair program. The memo should include the amount of revenue available for pavement repair, a list of roadways, the types of repairs to be completed by year, and a request for action.

C. Profile of Jurisdiction

Profile of Roadways

Total Centerline Miles: 79

Length by Functional Class — Centerline Miles

	Centerline Miles	Lane Miles
Arterials	15	31
Collectors	10	19
Residentials	54	108
Total	79	158

Replacement Cost: $71,700,000

Replacement Cost Per Lane Mile: $454,000

Sections: (The 158-lane miles were divided into roughly 431 sections.)

Arterials	34
Collectors	26
Residentials	371
	431

Conditions

Grade	No. of Sections	PCI	%
A,B	280	70-100	65%
C	70	50-69	16%
D	66	25-49	15%
E	15	24	4%
	431	75 =	Average PCI for all roadways

IV. Budget Analysis Report: Evaluation and Discussion of Component Sections

A. Estimate of Roadway Revenues and Expenditures

Roadway Revenues

The agency's total roadway revenues by source from FY 81/82 to FY 87/88 are as follows:

Table 1

Total Roadway Revenues
($, Thousands)

	Year							7-Year	% of
	1981/2	1982/3	1983/4	1984/5	1985/6	1986/7	1987/8	Total	Total
Federal	0	0	0	0	0	0	0	0	0%
State	133	192	260	254	409	340	298	1,886	30%
Local	342	395	402	366	754	658	1,387	4,304	70%
Total	475	587	662	620	1,163	998	1,685	6,190	100%
Total (less SB 300)	475	587	662	620	1,025	970	1,685	6,024	100%
Growth Rate (%)	24	13	(6)	65	(5)	73	Ave. = 27.3		

Discussion

As shown in Table 1 above, total roadway revenues increased considerably during the seven-year period. During this time, the agency experienced an average growth rate of 27 percent in roadway revenue. In 1981/82, total roadway revenues were $475,000. By 1987/88, they had increased to $1,685,000. This large increase can be attributed to the agency claiming TDA Article 8 funds in 1985/86, 1986/87, and 1987/88. During this three-year period, close to $1.3 million was derived from Article 8 of the Transportation Development Act (TDA). These funds were instrumental in resurfacing many of the agency's roadways over the three year-period beginning in 1985/86. Local revenues consisting of both general purpose funds and TDA Article 8 funds amounted to 70 percent of the agency's total roadway budget. State revenue provided 30 percent of the budget. These funds were almost entirely derived from gas tax

revenue, although there were increases in the state share in 1985/86 and in 1986/87. This was attributed to a one-time SB 300 allocation which was used for roadway overlay programs. The agency received no federal funds during the seven years. Future total revenues for this report were based on the average seven-year total of $860,571 and were projected based on a more modest 10 percent annual growth rate. See Table 4 for projection details.

Pavement Expenditures

The agency's pavement repair expenditures by type of repair from FY 8l/82 to FY 87/88 are as follows:

Table 2

Total Pavement Repair Expenditures ($, Thousands)

	Year							7-Year	% of
	1981/2	1982/3	1983/4	1984/5	1985/6	1986/7	1987/8	Total	Total
Reconstruction	0	1	0	0	52	107		1,125	58%
Patching	0	0	0	0	0	0	0	0	0%
Overlay/ Seals	30	35	179	0	236	332	6	818	42%
Total	30	36	179	0	288	439	971	943	100%
% of Total Revenues	(6%)	(6%)	(27%)	(0%)	(25%)	(44%)	(58%)	(31%)	

Discussion

In reviewing Table 2 (above), there are two different agencies to discuss. Of the 1,943,000 that went into pavement repair during the seven-year period, only $245,000 or less than 13 percent was expended in the first four years of the analysis. In FY 1985/86 through FY 1987/88, $1,698,000 or 87 percent was spent. During these last three years, $1,124,000 was spent on reconstruction. In comparison, nothing was spent in the first four years. This trend was similar for overlays/seals. In the last three years, $574,000 was spent, whereas in the first three years, only $244,000 was expended. The higher level of spending in the last three years can be attributed to the influx of TDA Article 8 funds which were used for resurfacing projects. While this complete

reversal of spending practices can be attributed to better recognition of roadway network deterioration and then applying proper funding, it is unlikely that this trend can continue. It is also unlikely that the low level of expenditure that occurred in the first four years of this analysis will again become the norm. Therefore, for the purposes of projecting revenues available, the staff proposes to use 31 percent of total public works roadway revenues available for pavement repair purposes. Thirty-one percent is the seven-year average of total roadway revenues that were made available for pavement repair in FY 1981/82 through FY 1987/88. As a result, an estimated $1,971,000 is to be made available for pavement repair over the five-year period. This represents an average of 42 percent higher per year expenditure for pavement repair than the agency previously spent in the seven years starting in FY 1981/82 and ending in FY 1987/88. **Figure E** details projected and future road revenues and pavement repair expenditures.

B. Recommended Repair Strategy and Cost

The needs program generates the optimum treatments for a five year period. It also shows the resulting pavement condition (PCI) if the recommended treatments are followed. The summary for the agency is shown in Table 3. **Figure F** shows a breakdown of the five-year needs program of maintenance treatments for the city, compared to the historical program.

Discussion

As shown in Table 3, the current overall health of the network is considered to be in very good condition (75) based on the pavement condition index (PCI). Implementation of the optimum needs program increases the network PCI condition to a very good condition (84) by the fifth year. If no maintenance rehabilitation treatments are applied to the network in the next five years, the overall network condition will deteriorate to a fair condition (PCI of 61) by year five.

The needs program calls for spending roughly $7.0 million over the next five years based on the condition of the agency's network and the treatments and repair costs that reflect those utilized in the agency. Of that amount, roughly $6.4 million (92 percent) is programmed for rehabilitation treatments and $0.6 million (8 percent) is programmed for preventive maintenance treatments.

The optimum or recommended objective is to bring the roadway network up to a PCI level of around 85 (excellent) because that is the level at which it is the most cost effective to maintain the network over time. Anything significantly less than a PCI of 85 means more dollars are expended on more expensive repairs.

Figure E

AGENCY HISTORY AND PROJECTIONS OF REVENUES AND EXPENDITURES ($ THOUSANDS)

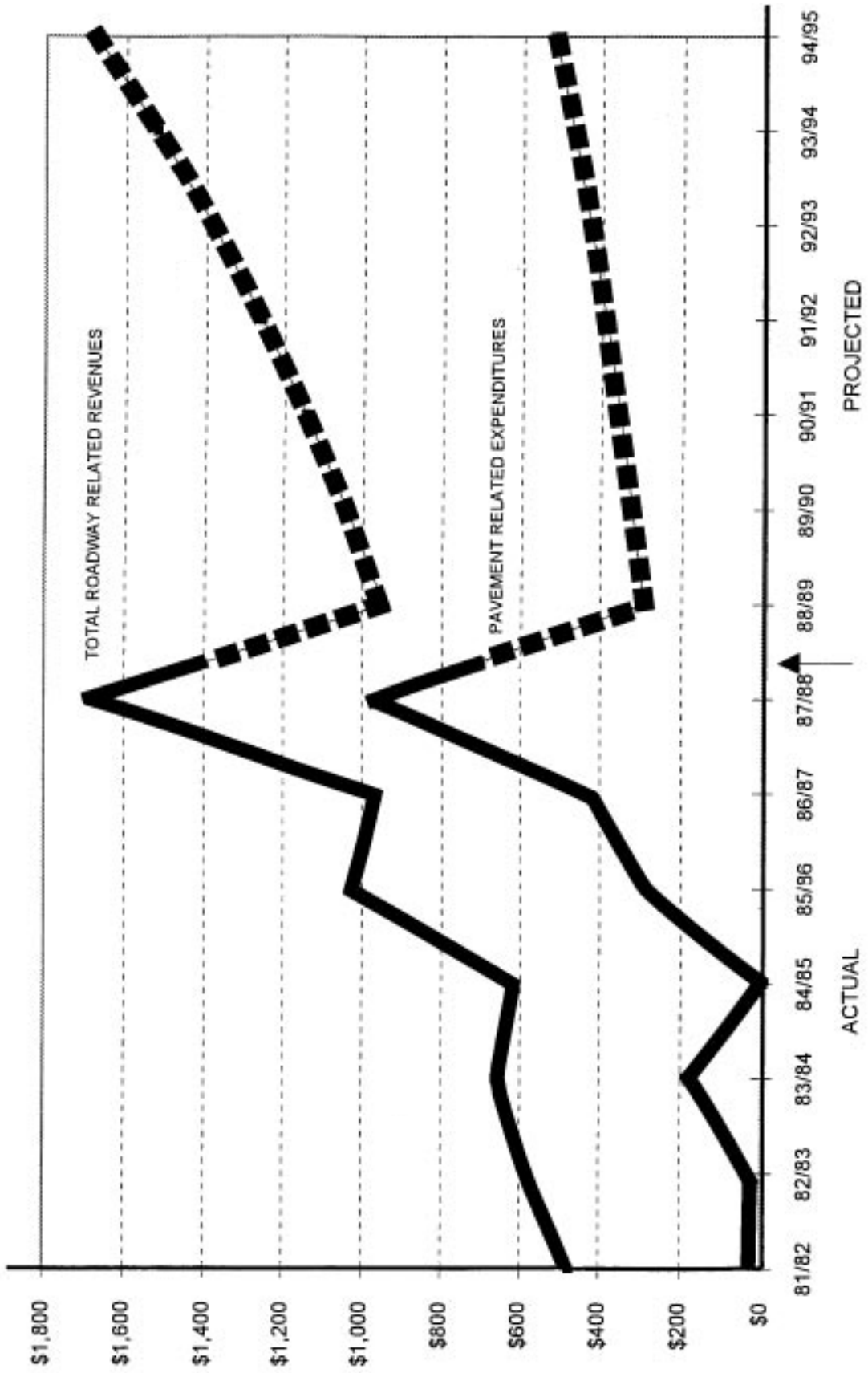


FIGURE F1

AGENCY ACTUAL EXPENDITURES 1981/82 - 1987/88

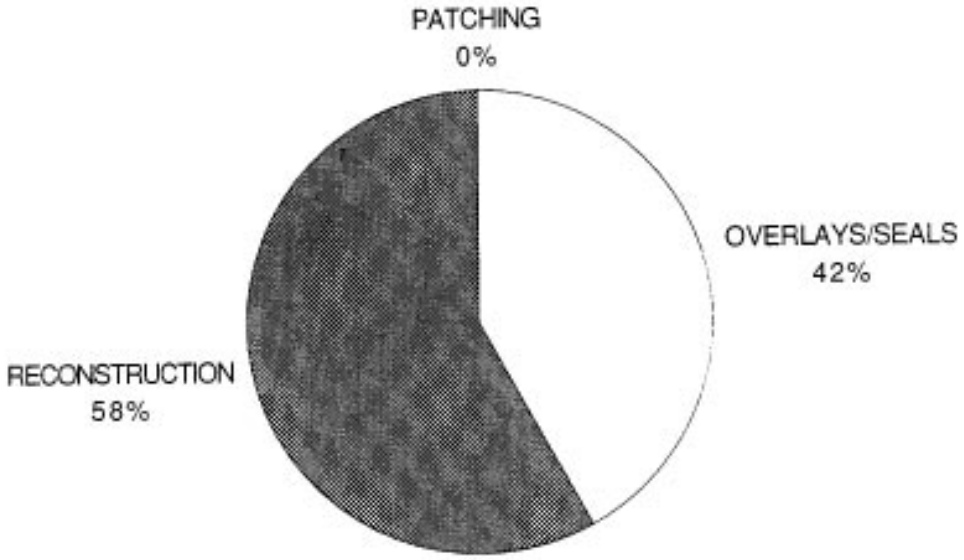
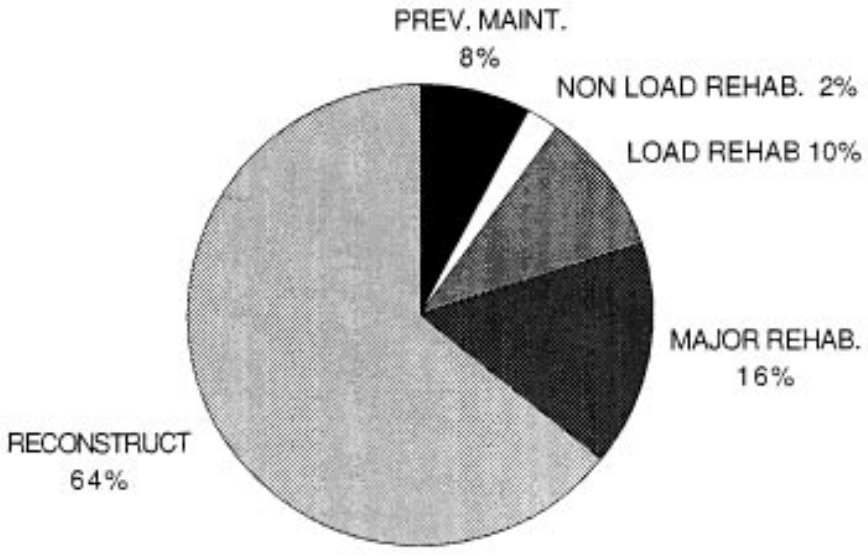


FIGURE F2

AGENCY RECOMMENDED TREATMENTS 1990/91 - 1994/95



This shift toward higher levels of spending on the pavement is the result of:

1. Catching up on prior deferred maintenance. Though the agency has applied the funding into roadway repair in FY 1985/86 to 1987/88, the neglect that occurred prior to this infusion of capital still persists.
2. An unbalanced repair program. Though considerable effort has been put into overlays and reconstruction, this implies that the agency has embarked on a "worst-first" strategy. Even though this is necessary to improve the level of the roadway network, special considerations should be given to a preventive maintenance program once the roadways have improved. Over time, this will bring down the costs of repair. If no preventive maintenance program is adopted, then the agency can expect to continue to pay for major rehabilitation projects at a much higher cost.

C. Revenues Compared to Needs to Determine Surplus/Deficit

Table 4 compares the revenues projected in Section A with the costs projected in Section B. The distribution of these costs over the five years is "front loaded." That is, basic pavement management concepts state that the best maintenance strategy is to bring the pavement sections up to a "very good" condition and keep them that way. Consequently, if some roadways have been allowed to deteriorate (deferred maintenance), there will be higher front end costs. In most cases, given limited levels of funding, the local government budget process is difficult to front load. Table 4 shows both the front loaded PMS needs scenario and one in which repair costs are spread evenly. Over the five year period, there is roughly a total deficit of $5.0 million. As a result, the estimate of the agency's revenues will cover roughly 28 percent of its total pavement repair needs over the next five years.

D. Major Issues/Options

- The deficit can be either:
  - Deferred (thereby reducing the overall network condition and increasing maintenance costs in future years); or
  - Addressed by reducing other nonpavement related expenses, additional local revenues, or some combination of the two.
- Additional public works revenues in year one to address backlog.

Table 3

PMS Recommended Treatments and Costs — Resulting PCI ($, Thousands)

Treatments (PM)	Year (1)	(2)	(3)	(4)	(5)	5-Year Total	% of Total
Seal Cracks	1	0	0	1	5	7	0%
Slurry Seal	370	99	2	98	17	586	8%
Total Cost (PM)	371	99	2	99	22	593	8%
Treatments (Rehab.)							
Slurry Seal	99	31	31	0	0	161	2%
Mill and Thin Overlay	261	250	90	61	0	662	9%
Thin AC Overlay (1.5 inches)	68	0	0	0	0	68	1%
Thick AC Overlay (2.5 inches)	16	0	0	0	0	16	0%
Heater Scarify and Overlay	590	180	209	0	55	1,034	15%
Reconstruct Surface	3,037	186	750	217	295	4,486	64%
Total Cost (Rehab)	4,071	647	1,081	278	350	6,427	92%
Total Cost (Rehab & PM)	4,442	746	1,083	377	372	7,020	
Percent. of Recommended Program	63%	11%	16%	5%	5%	100%	
Projected PCI Mean at Year One = 75 (A)	84	84	84	84	84	84	
No Maintenance PCI Mean at Year One = 75 (A)*	69	67	65	63	61	65	

*On a scale of 0-100:

70-100	=	Excellent/Very Good
50-69	=	Good/Fair
25-49	=	Fair/Poor
0-24	=	Very Poor/Failed

- Errors committed during roadway surveys and subsequent computer data entry can have appreciable affects on the assessed roadway condition and the subsequent costs of maintenance repair programs. At all stages of data acquisition and processing, it is prudent to check the data for errors, including quality control checks on pavement condition surveyors, and to carefully edit all data entered into the computer.
- Prior experience shows that treatment unit costs can significantly impact total pavement repair. These costs should be carefully reviewed to see that they represent typical costs incurred by the agency.
- Breaking the network down by functional classification (i.e., arterials, collectors, residentials) creates three networks within one to test various budget levels, maintenance strategies, and possible priorities. For example, the city might want to consider directing higher repair priorities to arterials.

E. Testing Alternative Budget Levels and Repair Strategies

The PMS budget options module allows the agency to test alternative maintenance/budget scenarios. A base year revenue estimate, a growth rate and a split between preventive (lighter maintenance applied to sections with PCI between 100 and 70) and rehabilitation (heavier maintenance applied to sections with PCI between (69 and 0) are user-specified. The PMS matches this budget with the PMS recommended fixes which are prioritized by section based on an effectiveness measure.

The process for each year starts with the rehabilitation budget in which projects are selected in priority order down to the dollar amount specified. If more sections require rehabilitation, stop-gap costs are assigned. These costs are taken from the preventive maintenance budget. The preventive budget then selects projects in priority order, as with rehabilitation, until the budget is exhausted. Projects not selected are deferred to the next year and the process repeats through each of the five years. Outputs by year include average network PCI as well as dollars going to rehabilitation, preventive maintenance, stop-gap, and deferred maintenance.

Four options have been tested. See the following pages for a brief summary and description of each option.

Table 4

Five-Year Roadway Related Revenue/Pavement Repair Summary Table ($, Thousands)

	Year					5-Year
	1	2	3	4	5	Total
Total Projected Revenues (10%)[1]	1,041	1,145	1,260	1,386	1,525	6,357
Revenues to Pavement Repair (31%)[1]	323	355	390	430	473	1,971
Front Loaded						
Recommended PMS Program Five Years	4,442	746	1,083	377	372	7,020
Repair Program Surplus (Deficit)	(4,119)	(391)	(693)	53	101	(5,049)
Spread Evenly						
Recommended PMS PMS Program Spread Evenly	1,404	1,404	1,404	1,404	1,404	7,020
Repair Program Surplus (Deficit)	(1,081)	(1,049)	(1,014)	(974)	(931)	(5,049)

[1]Note the two key assumptions: a 10 percent revenue growth rate (which is less than the average annual growth rate from 1987/88) and 31 percent of revenues going to pavements for patching, sealing, overlays, and rehabilitation. The average seven-year revenue total of $860,571 was used in 1988/89 and was increased to reflect 1990/91 in year 1 above.

Table 5-1

Option 1
Budget Levels/Maintenance Options

0% Budget Increase Factor | 0% Interest | 5% Inflation

Year PM % Year Totals	8% Year 1	13% Year 2	0% Year 3	26% Year 4	5% Year 5
Budgets	$4,442,082	$746,588	$1,082,767	$377,386	$ 371,628
Rehabilitation	4,071,109	647,047	1,080,407	277,808	349,933
Prev. Maint.	370,973	99,541	2,360	99,578	21,695
Stop Gap	0	0	0	0	0
Deferred	0	0	0	0	0
Surplus PM	0	0	0	0	0

Category of Repairs	Totals
Rehabilitation	$ 6,426,304
Preventive Maintenance	$ 594,147
Stop Gap Maintenance	$ 0
Average Annual Deferred Preventive Maintenance Change	$ 0
Average Annual Surplus Preventive Maintenance Change	$ 0

Projected PCI Condition

	Latest PCI	Year 1	Year 2	Year 3	Year 4	Year 5
Network Mean	74.7	83.6	83.9	84.3	83.7	83.8

Discussion

This is the optimum budget level ($7.02 million) “front loaded,” as recommended by PMS. Points to highlight are: (1) the PCI level immediately rises to an average of 84 and remains at that level, and (2) there is no deferred maintenance in any of the five years. Note also that the rehabilitation/preventive maintenance split follows the exact splits recommended by the PMS.

Table 5-2
Option 2
Budget Levels/Maintenance Options

0% Budget Increase Factor 0% Interest 5% Inflation

Year PM % Year Totals	9% Year 1	9% Year 2	9% Year 3	9% Year 4	9% Year 5
Budgets	$1,404,090	$1,404,090	$1,404,090	$1,404,090	$ 1,404,090
Rehabilitation	1,274,830	1,276,554	1,276,664	1,277,356	1,264,493
Prev. Maint.	128,095	122,340	127,143	91,324	31,804
Stop Gap	1,165	5,172	0	0	0
Deferred	3,039,157	2,582,474	2,444,133	1,503,749	548,195
Surplus PM	0	24	283	35,410	107,793

Category of Repairs	Totals
Rehabilitation	$ 6,369,897
Preventive Maintenance	$ 500,706
Stop Gap Maintenance	$ 6,337
Average Annual Deferred Preventive Maintenance Change	$ -662,741
Average Annual Surplus Preventive Maintenance Change	$ 26,948

Projected PCI Condition

	Latest PCI	Year 1	Year 2	Year 3	Year 4	Year 5
Network Mean	74.7	76.3	77.5	82.4	83.1	83.8

Discussion

This is the optimum budget level ($7.02 million) as recommended by PMS, but spread evenly over the five-year period at $l.4 million per year. Of special note is that the PCI gradually climbs from 76 in the first year to 84 in the fifth year, but there is a significant amount of deferred maintenance ($3 million in year one, decreasing to $.55 million in the fifth year). About $6,000 is pulled from the preventive maintenance program to provide stop-gap maintenance on those sections where repairs are deferred.

Table 5-3
Option 3
Budget Levels/Maintenance Options

0% Budget Increase Factor | 0% Interest | 5% Inflation

Year PM % Year Totals	9% Year 1	9% Year 2	9% Year 3	9% Year 4	9% Year 5
Budgets	$ 899,000	$ 899,000	$ 899,000	$ 899,000	$ 899,000
Rehabilitation	817,316	814,283	811,892	817,983	805,596
Prev. Maint.	71,432	77,940	85,220	80,798	92,975
Stop Gap	10,252	6,777	1,818	0	0
Deferred	3,553,334	3,678,659	4,184,706	3,946,267	3,708,236
Surplus PM	0	0	70	219	429

Category of Repairs	Totals
Rehabilitation	$ 4,067,070
Preventive Maintenance	$ 408,365
Stop Gap Maintenance	$ 18,847
Average Annual Deferred Preventive Maintenance Change	$ 38,726
Average Annual Surplus Preventive Maintenance Change	$ 107

Projected PCI Condition

	Latest PCI	Year 1	Year 2	Year 3	Year 4	Year 5
Network Mean	74.7	74.3	76.9	78.3	79.3	82.1

Discussion

This option represents a budget level of $4.5 million, roughly halfway between the required $7.02 million and the agency's estimate of available revenues: $1.97 million. It improves the average PCI from a 74 in the first year to an 82 in year five. It also begins to curtail the increase of deferred maintenance by year five. Nonetheless, deferred maintenance is $3.7 million by the fifth year. About $9,000 is pulled from the preventive maintenance program to provide stop-gap maintenance on those sections where repairs are deferred.

Table 5-4
Option 4
Budget Levels/Maintenance Options

0% Budget Increase Factor | 0% Interest | 5% Inflation

Year PM % Year Totals	**9% Year 1**	**9% Year 2**	**9% Year 3**	**9% Year 4**	**9% Year 5**
Budgets	$ 323,000	$ 355,000	$ 390,000	$ 430,000	$ 473,000
Rehabilitation	293,031	322,576	352,596	391,216	428,892
Prev. Maint.	5,041	19,405	28,627	37,125	44,058
Stop Gap	24,928	13,019	8,777	1,642	0
Deferred	4,144,010	4,869,216	6,067,808	6,505,569	6,966,580
Surplus PM	0	0	0	17	50

Category of Repairs	**Totals**
Rehabilitation	$ 1,788,311
Preventive Maintenance	$ 134,256
Stop Gap Maintenance	$ 48,366
Average Annual Deferred Preventive Maintenance Change	$ 705,641
Average Annual Surplus Preventive Maintenance Change	$ 12

Projected PCI Condition

	Latest PCI	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Network Mean	74.7	70.8	71.0	70.6	72.2	71.7

Discussion

This option utilizes the agency's estimated available revenues — $323,000 in year one, escalated by 10 percent per year up to $473,000 in year five. This option maintains the PCI in the low seventies, though the first year deferred maintenance is $4.1 million. This amount increases to $7 million by year five. Stop-gap maintenance increases to $50,000.

F. Recommendations

In evaluating PMS options, the following criteria should be considered.

1. A pavement condition index (PCI) that is increasing over the five-year period.
2. Deferred maintenance that is decreasing over time.

Clearly, the PMS recommended Option l provides the most cost-effective expenditure of funds. However, this would require the agency to generate an additional $5.0 million in revenues (in the next five years) beyond the $2.0 million estimate. Further, almost 63 percent of the total revenues of $7.0 million would be required in the first year. If the agency wants to consider this option, there are a number of funding strategies available, including assessment districts, bonding, and initiatives.

Option 2 spreads the five-year $7.0 million costs evenly by year. This is the second best option.

Option 3 tests the impact of a $4.5 million budget level which is between Option 2 and 4. This would be a minimally acceptable level since it begins to reduce the deferred maintenance, albeit slowly.

Option 4 tests the impact of a trend projection of the agency's revenues. It shows a significant deferred maintenance cost in the first year which grows throughout the five years. This is unacceptable.

We would recommend that the agency continue to evaluate other scenarios which test differing budget levels and differing maintenance program priorities. Given that the agency's pavement maintenance needs require more than triple the projected revenues, all of the following actions are necessary:

- Seek Additional Revenues
    * Spend existing pavement maintenance revenues more cost effectively.
    * Examine the feasibility of reallocating other public works revenues to pavement maintenance.
    * Seek additional funds.

With the passage of SB 975 in 1989, pavement maintenance can now be used under the benefit assessment act of 1982. This act allows the council to levy a benefit assessment pursuant to specified procedures to finance the maintenance of roadways or highways.

Also, if Prop. 111 passes (SCA 1) in June 1990, it is estimated that the agency will receive $153,000 in additional gas tax subvention revenues a year. Though this puts only a dent in the large shortfall, the amount will assist the agency in the long run.

- Evaluate maintenance Program Options
    * Develop and fully fund the preventive maintenance program including the required stop-gap maintenance on deferred projects.
    * Recommended treatments (particularly the heavier repairs like reconstruction) should be evaluated in more detail to build projects/ contracts.
    * Link major repairs with utility schedules, if possible.
    * Group projects of similar type, location, and year.
    * Consider setting priorities on repairs so that the more heavily traveled roadways (arterials) are repaired first.

23:F:GPM3

Appendix H
Sample Budget Report for Board/Council

I. Purpose

The purpose of the Executive Summary Network-Level Budget Options Report is to assist the agency in utilizing the results of the agency's Network-Level Pavement Management System (PMS). Specifically, we are trying to link the PMS recommended repair program costs to your budget and improve your overall maintenance and rehabilitation strategy. This report should help you to assess the adequacy of your revenues to meet the maintenance needs recommended by the PMS program. It should also help you in getting a maximum return for your expenditure by: (1) implementing a multi-year street rehabilitation and maintenance program, (2) developing a preventive maintenance program, and (3) selecting the most cost-effective repairs.

II. Summary of Findings

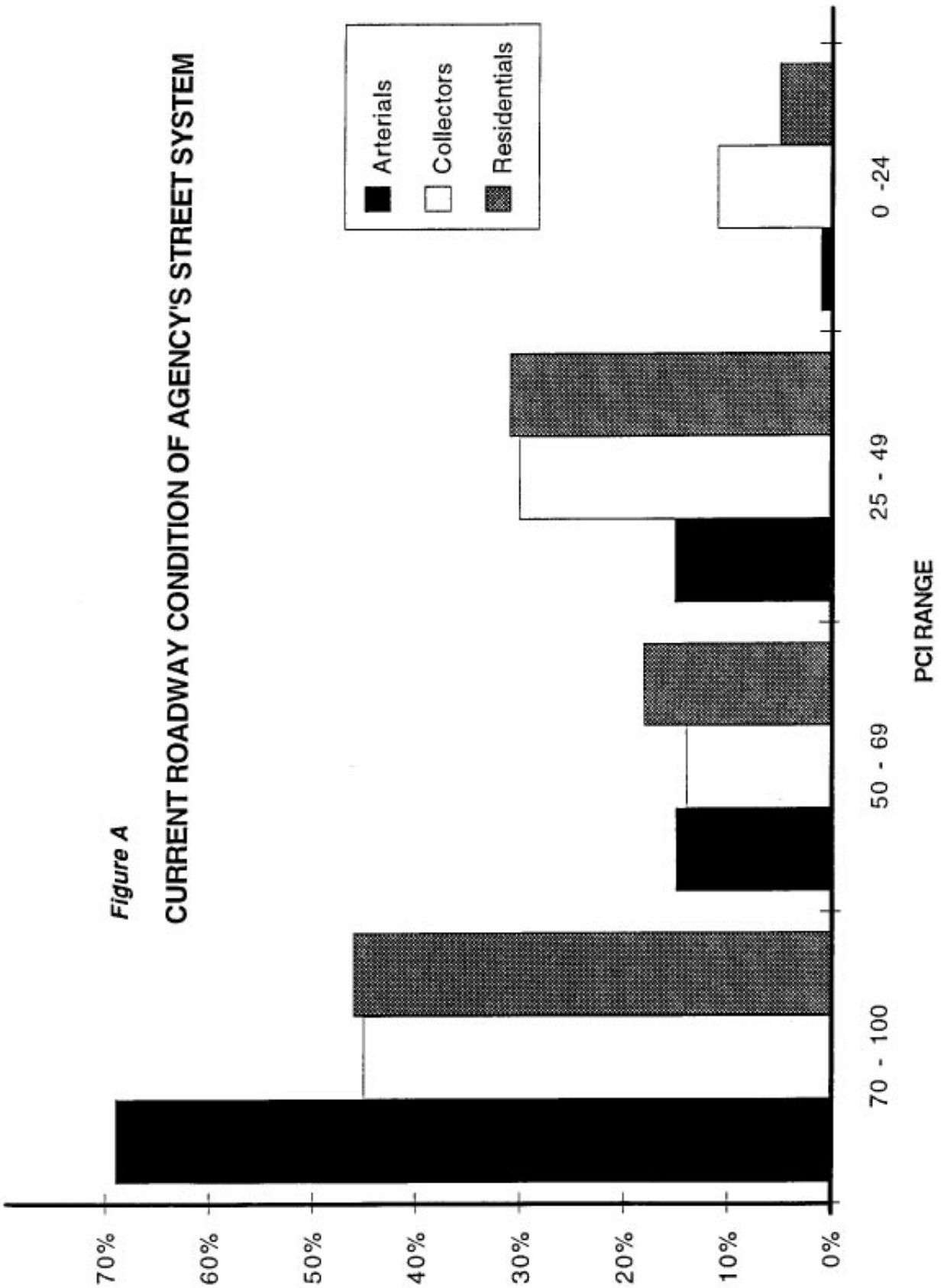
- The estimate of the agency's total Department of Public Works (DPW) street related revenues projected over the next five years is $6.36 million. Of that amount, $1.97 million is estimated to be available for pavement repair.
- Based on the survey of the agency's street network and past spending practices, the overall Pavement Condition Index (PCI) of the system is 75[1] or a "Very Good" condition. **Figure A** shows the current condition of the agency's streets — functional class by condition.
- **Using the most cost-effective strategies, the PMS Recommended Program will require an expenditure of $7.0 million over the next five years or roughly $1.4 million per year, if this expense is spread evenly.**
- **Comparison of the cost to fix the network with the projected estimated revenues indicates a deficit of $5.0 million over the five-year period, based on staff projections.**

[1]On a scale of 0-100:

70-100	=	Excellent/Very Good
50-69	=	Good/Fair
25-49	=	Fair/Poor
0-24	=	Very Poor/Failed

Figure A

CURRENT ROADWAY CONDITION OF AGENCY'S STREET SYSTEM



- Various budget levels and maintenance options have been tested to illustrate and evaluate various levels of pavement repair expenditures over a five-year analysis period. The four budget options programs tested are as follows:

  Option 1 — The PMS Recommendation (heavy needs in first year)

  Cost — $7.0 million over five years with $4.4 million in the first year.

  Rehabilitation/Preventive Maintenance Split — Varies by year from 0 percent to 26 percent for preventive maintenance.

  Result — PCI is raised, from 75 to 84 in the first year and then maintained at 84. There is no deferred maintenance in any year.

  Option 2 — Modified PMS Recommendation (needs spread evenly over five years)

  Cost — $7.0 million over five years at $1.4 million per year.

  Rehabilitation/Preventive Maintenance Split — A constant 9 percent per year for preventive maintenance.

  Result — PCI gradually rises to 84 by fifth year, and a deferred maintenance cost of cost $3.0 million in the first year has dropped to $.5 million by the fifth year.

  Option 3 — Test Funding Level Between PMS Recommendation and Estimate of the Agency's Revenues

  Cost — $4.5 million over five years at $0.9 million per year.

  Rehabilitation/Preventive Maintenance Split — A constant 9 percent per year for preventive maintenance.

  Result — PCI rises to 82 by fifth year, and deferred maintenance is $3.5 million in year one increasing slightly to $3.7 million by year five.

  Option 4 — Constrained to Estimate of the Agency's Revenues

  Cost — $l.9 million over five years; $0.32 million in first year projected at a 10 percent growth rate per year.

  Rehabilitation/Preventive Maintenance Split — A constant 9 percent per year for preventive maintenance.

  Result — PCI slightly decreasing to low 70s, and deferred maintenance of $4.1 million rises to $7.0 million by year five.

- **Figure B** is a chart showing the impact of the maintenance and rehabilitation options on the PCI of the street network over a five-year period. **Figure C** is a chart showing the impact on deferred maintenance of the street network by option over a five-year period.
- The future condition of the street network under selected options over a five-year production period will be:

		Years				
		1	2	3	4	5
No Maintenance Option:	PCI =	69	67	65	63	61
Option 1:	PCI =	84	84	84	84	84
Option 2:	PCI =	76	78	82	83	84
Option 3:	PCI =	74	77	78	79	82
Option 4:	PCI =	71	71	71	72	72

- **Figure D** shows the above table graphically.

Figure B

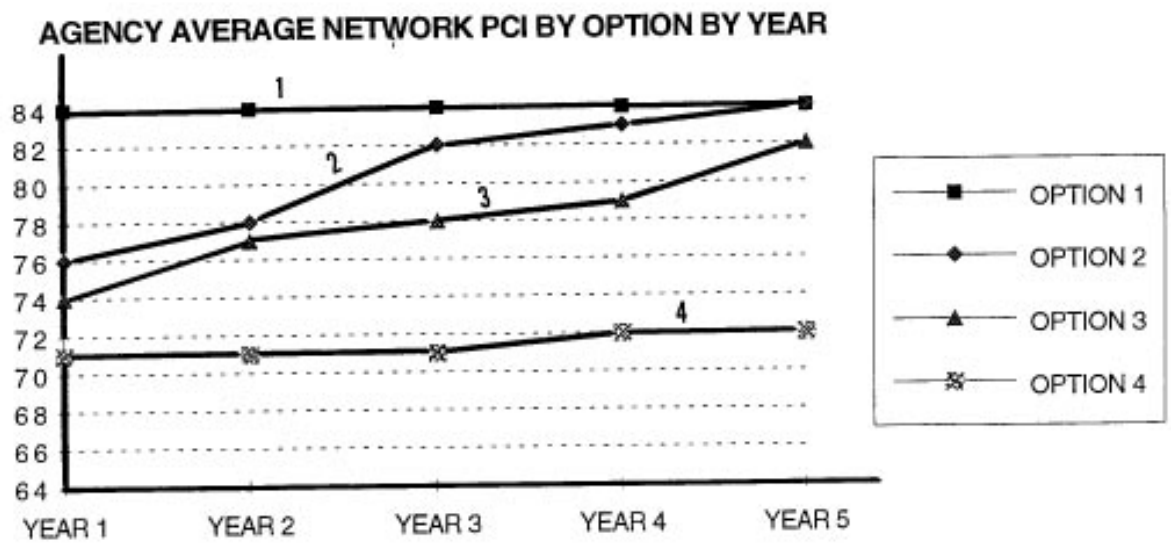


Figure C

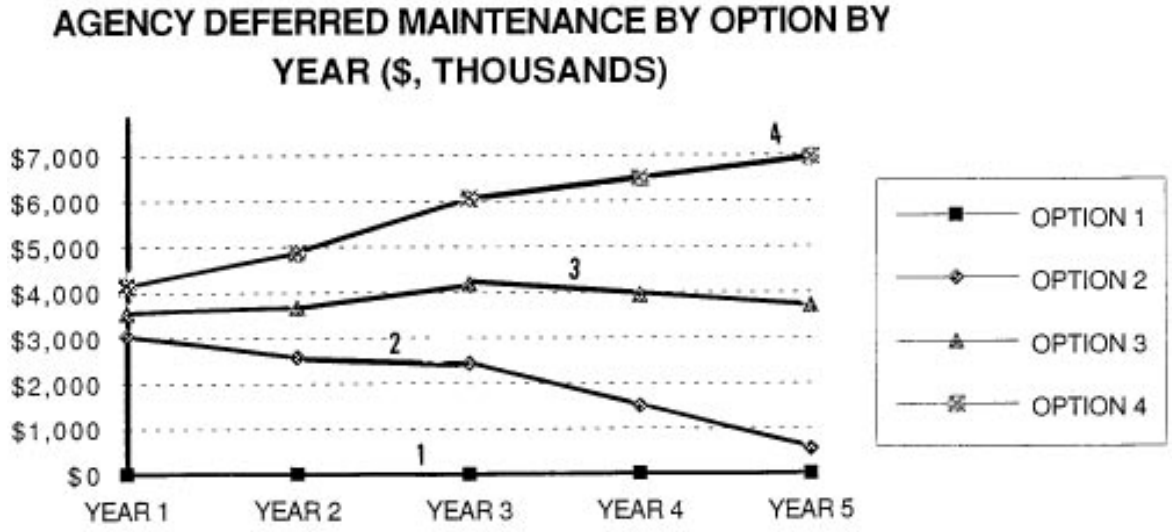
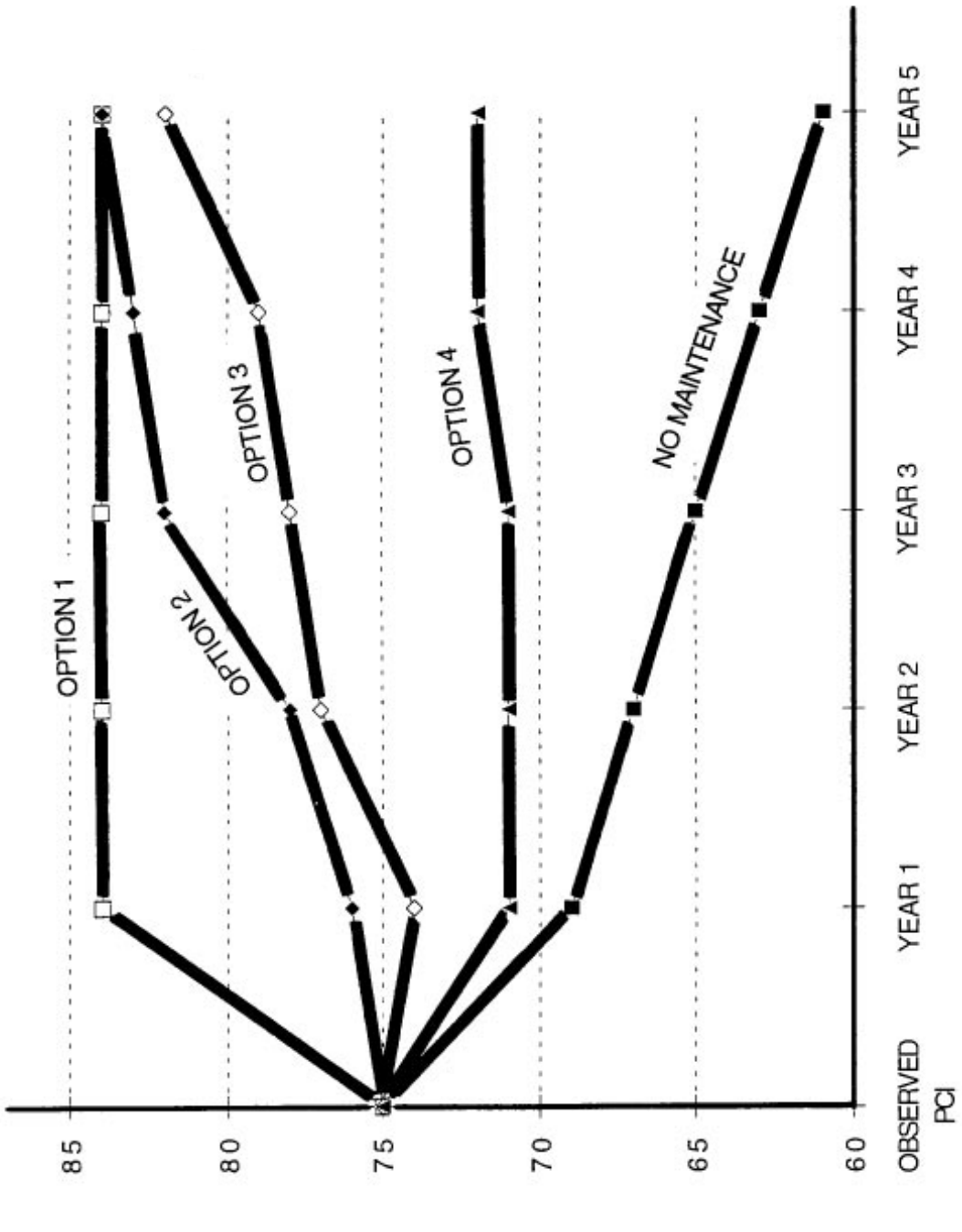


Figure D

IMPACT ON THE PAVEMENT CONDITION INDEX OF THE NO MAINTENANCE OPTION AND 4 OTHER OPTIONS



The following table shows the current profile of the agency's streets and roads.

Profile of Roadways

Total Centerline Miles: 79

Length by Functional Class — Centerline Miles

	Centerline Miles	Lane Miles
Arterials	15	31
Collectors	10	19
Residentials	54	108
Total	79	158

Replacement Cost: $71,700,000

Replacement Cost Per Lane Mile: $454,000

Sections: (The 158-lane miles were divided into roughly 431 sections.)

Arterials	34
Collectors	26
Residentials	371
	431

Conditions

Grade	No. of Sections	PCI	%
A,B	280	70-100	65%
C	70	50-69	16%
D	66	25-49	15%
E	15	24	4%
	431	75 =	Average PCI for all roadways

III. Recommendations

In evaluating PMS options, the following criteria should be considered:

1. A PCI that is increasing over the five-year period.
2. Deferred maintenance that is decreasing over time.

Clearly, the PMS recommended Option l provides the most cost-effective expenditure of funds. However, this would require the agency to generate an additional $5.0 million in revenues (in the next five years) beyond the $2.0 million estimated. Further, almost 63 percent of the total revenues of $7.0 million would be required in the first year. If the agency wants to consider this option, there are a number of funding strategies available, including assessment districts, bonding, and pavement maintenance special districts.

Option 2 spreads the five-year $7.0 million costs evenly by year. This is the second best option.

Option 3 tests the impact of a $4.5 million budget level which is between Option 2 and 4. This would be a minimally acceptable level since it begins to reduce the deferred maintenance, albeit slowly.

Option 4 tests the impact of a trend projection of the agency's revenues. It shows a significant deferred maintenance cost in the first year which grows throughout the five years. This is unacceptable.

We would recommend that the agency continue to evaluate other scenarios which test differing budget levels and differing maintenance program priorities. Given that the agency's pavement maintenance needs require more than tripling projected revenues, all of the following actions are necessary:

- Seek Additional Revenues
  - * Spend existing pavement maintenance revenues more cost effectively.
  - * Examine the feasibility of reallocating other public works revenues to pavement maintenance.
  - * Seek additional funds.

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Also, if Prop. 111 passes (SCA 1) in June 1990, it is estimated that the agency will receive $153,000 in additional gas tax subvention revenues a year. Though this puts only a dent in the large shortfall, the amount will assist the agency in the long run.

- Evaluate Maintenance Program Options
    * Develop and fully fund the preventive maintenance program including the required stop-gap maintenance on deferred projects.
    * Recommended treatments (particularly the heavier repairs like reconstruction) should be evaluated in more detail to build projects/contracts.
    * Link major repairs with utility schedules, if possible.
    * Group projects of similar type, location, and year.
    * Consider setting priorities on repairs so higher traveled streets (arterials) are repaired first.

24:F:GPM4

Appendix I
Budget Presentation Materials for Budgets

Translating Pavement Management System Budget Results Into Action

by Paul Sachs

Over the past 10 years, cities and counties throughout the United States have widely adopted Pavement Management Systems (PMS).

Each jurisdiction or agency has its own reason for implementation. Many want a list of ranked street projects for next year's maintenance work. Others use the information to verify centerline and lane mileage figures. Still others use the data to evaluate the present condition of their roads.

While all this is readily available with PMS, many agencies fail to utilize the full capabilities of their PMS software. PMS software should be used as a tool in the agency's overall budgeting process. Until this is accomplished, a network level PMS has not been fully implemented.

No single method can be applied to all agencies. Each agency has a unique set of circumstances which must be individually addressed. However, it is increasingly clear that the development of an effective marketing strategy to sell PMS to local government is at least as important as the integrity of the PMS software itself.

What Do I Do Now?

Once the inventory and condition survey for the entire street and road network has been completed, the PMS user can assess projected costs to fix the entire street and road network over a prescribed period of time. The results can then be used in the agency's overall budgeting process and translated into the following actions:

- Attaching PMS results to the agency's budgeting process.
- Acquiring additional revenues for pavement maintenance activities in case of a shortfall.

Laying the Groundwork

Three steps are critical in laying the groundwork for presenting PMS results:

- Form a steering committee of individuals from different agency departments.
- Keep the elected board or council informed of PMS implementation and development.
- Have the steering committee set up goals and objectives for PMS implementation and a time line scheduling PMS activities.

The steering committee should include at least one person from each department where the PMS will be implemented, including engineering, maintenance, management information, and finance. While the presence of a financial expert on the committee does not assure additional revenues for pavement maintenance, it does provide that committee member with valuable exposure to the PMS process. When the time comes to present PMS results, the finance section will be sufficiently knowledgeable in PMS to understand and encourage its application. In addition, as PMS results are produced, the finance department's representative may serve as an important bridge between the public works department and the board.

It is crucial to prepare the board with a carefully planned introduction to PMS long before presenting them with PMS results. Often this critical step is overlooked. Without a solid foundation in PMS, the board could become bogged down in the basics of how PMS works, and lose sight of the results presentation.

Clarifying the Goals

The Pavement Manager in charge of PMS implementation should work with the steering committee to develop a set of goals and objectives for the project. These could include a projected schedule for completing the inventory or a start-up schedule for the condition survey.

As red letter dates come up, information items should be placed on the board's agenda, apprising the board of progress made to date. Once again, this is an opportunity to explain what PMS can do for an agency.

All this lays the groundwork for presenting PMS results. It familiarizes and prepares the board with the PMS program before budget discussions begin.

Once PMS results are in, the job of a Pavement Manager begins. The results may indicate that over a given time period, say five years, the pavement maintenance program's needs have exceeded available revenues. Do not despair! Changes occur slowly in agencies. The pavement maintenance budget will not increase substantially in a period of just one year.

Often, staff who have presented PMS results to the board feel their work has gone unnoticed when the board does not respond by increasing the budget to the proposed amount.

In some instances, this slight has prevented staff from planning future presentations. This is why it is crucial to set realistic goals when preparing a formal presentation. If the expectation is for a tenfold increase from $200,000 to $2,000,000, disappointment will surely ensue.

Budget Negotiations and PMS

While preparing the presentation, keep in mind the advantage PMS can play in budget negotiations. Prior to PMS, the board allocated a set amount of money for the pavement maintenance program. As a result, the money spent for each project equaled the allocated amount.

PMS enables the user to modify that process to a more systematic and planned approach. With PMS results in hand, the user can argue for increased funding, while demonstrating the impacts of the deteriorating pavement condition, as well as rising deferred maintenance costs over time, if the money is not acquired.

When demonstrating how funding levels could affect an agency's pavement maintenance program, it is crucial to present the results with eye-catching charts and tables that clearly illustrate the successes and failures of projected dollar allocations.

For example, if an agency has a five-year need of $10 million, but has projected only $3 million in revenues, one table could show the impact of that level of expenditure on roadway conditions. Another could show the impact of deferred maintenance. As a comparison, this table could include a $4 million level of expenditure for pavement maintenance, and a $5 million expenditure extrapolated over the five-year period. This will allow the board to visualize the impact of expanded funding levels on the pavement condition of the agency's street and road network.

Capitalize on the Audience

More often than not, it is not the data that tells the whole story, it is the way the data is presented. Following this narrative is the kind of data summary table most commonly used in PMS presentations. The table shows five budget options that demonstrate the dollar impact on a variety of funding levels over a five-year period.

Impact of Five Options on Deferred Maintenance

Five-Year Need = $10 Million

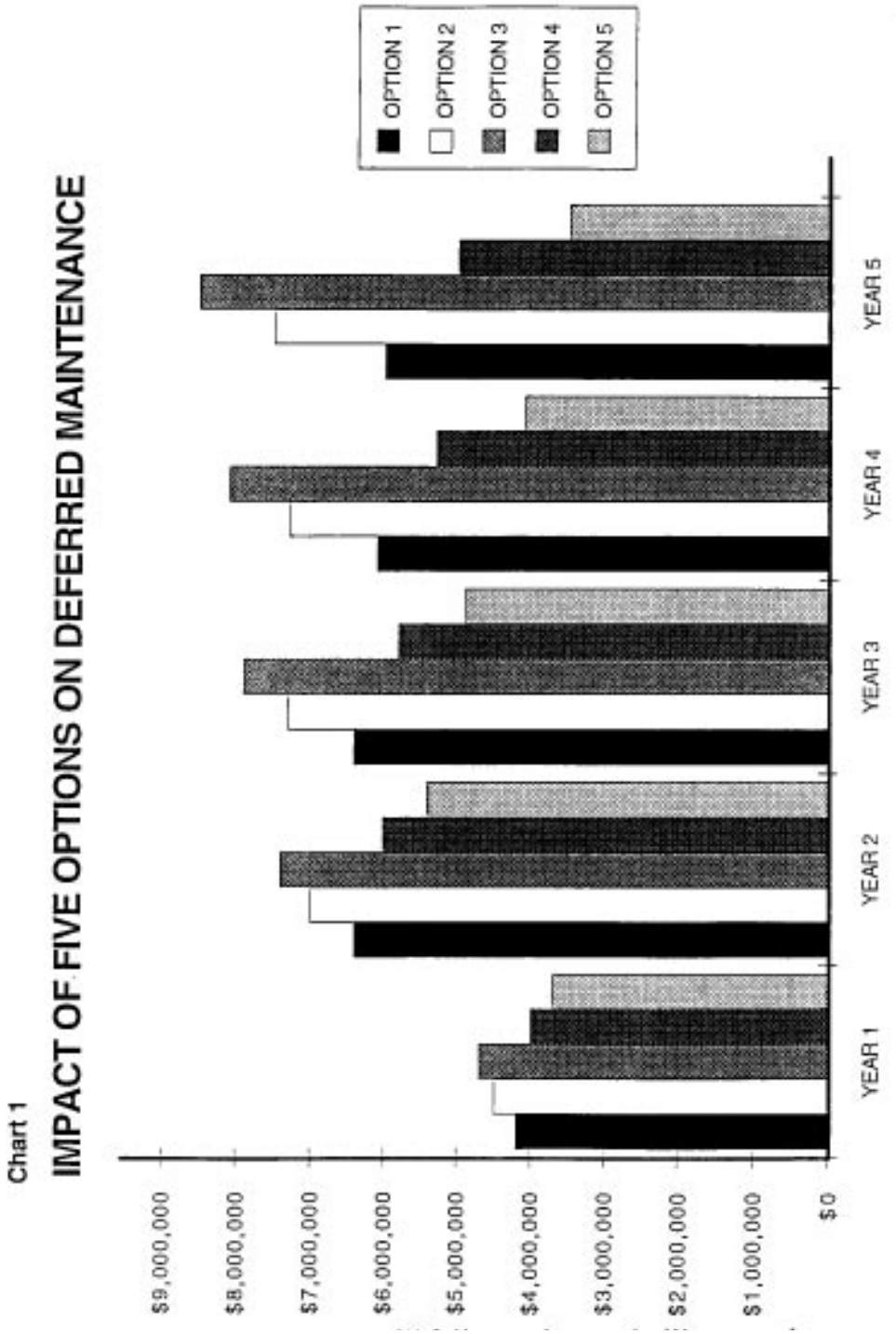
Option 1	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Need	$ 5,000,000	$ 3,000,000	$ 800,000	$ 500,000	$ 700,000
Funding Level	800,000	800,000	800,000	800,000	800,000
Deferred Maint.	4,200,000	6,400,000	6,400,000	6,100,000	6,000,000
Resultant PCI*	62	63	65	65	65
Option 2					
Need	$ 5,000,000	$ 3,000,000	$ 800,000	$ 500,000	$ 700,000
Funding Level	500,000	500,000	500,000	500,000	500,000
Deferred Maint.	4,500,000	7,000,000	7,300,000	7,300,000	7,500,000
Resultant PCI	59	57	56	56	55
Option 3					
Need	$ 5,000,000	$ 3,000,000	$ 800,000	$ 500,000	$ 700,000
Funding Level	300,000	300,000	300,000	300,000	300,000
Deferred Maint.	4,700,000	7,400,000	7,900,000	8,100,000	8,500,000
Resultant PCI	57	52	50	50	49
Option 4					
Need	$ 5,000,000	$ 3,000,000	$ 800,000	$ 500,000	$ 700,000
Funding Level	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Deferred Maint.	4,000,000	6,000,000	5,800,000	5,300,000	5,000,000
Resultant PCI	63	64	66	67	69
Option 5					
Need	$ 5,000,000	$ 3,000,000	$ 800,000	$ 500,000	$ 700,000
Funding Level	1,300,000	1,300,000	1,300,000	1,300,000	1,300,000
Deferred Maint.	3,700,000	5,400,000	4,900,000	4,100,000	3,500,000
Resultant PC	64	66	68	71	72

**Resultant Pavement Condition Index Scale (0-100) 100 = Excellent 0 = Very Poor*

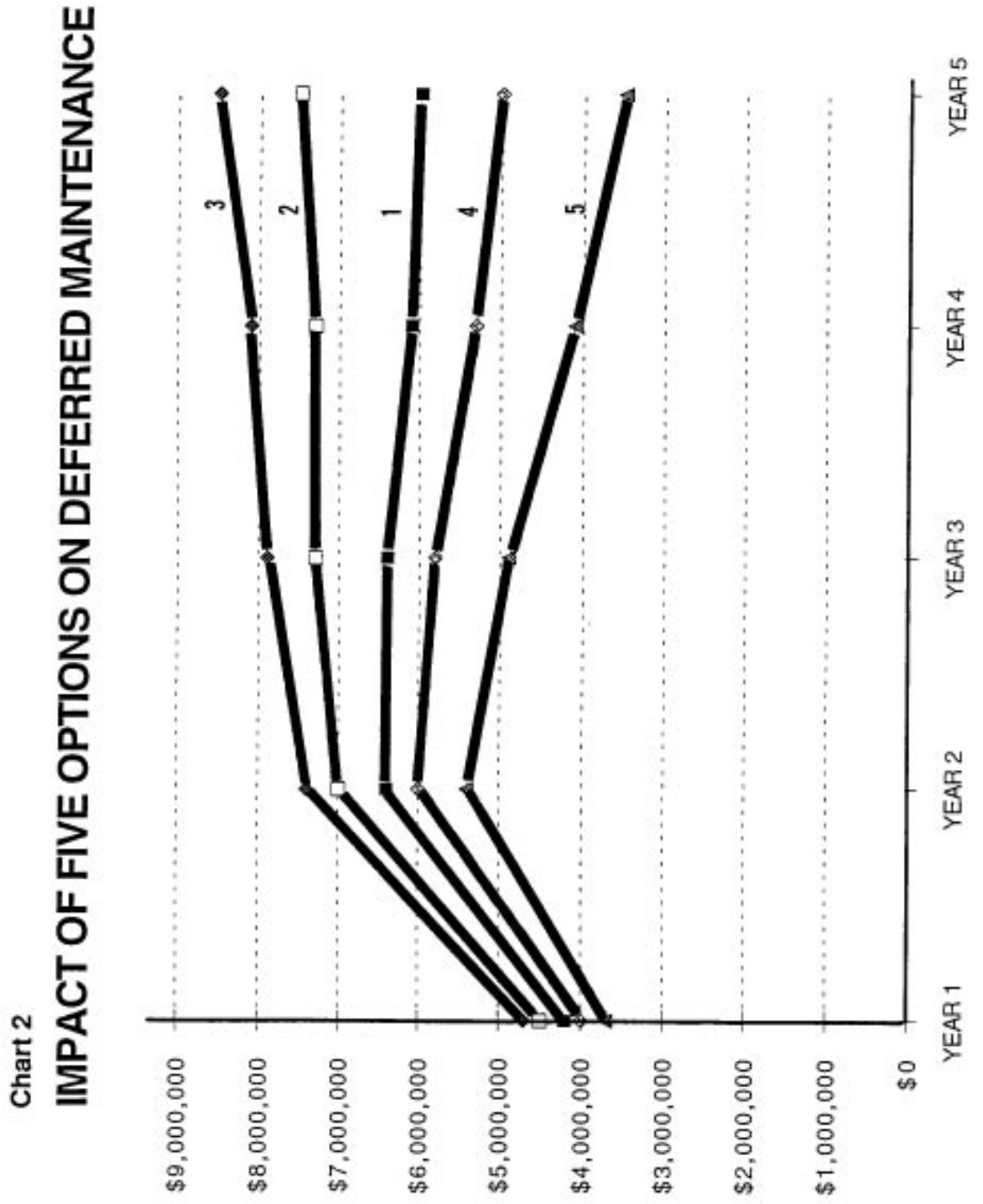
While the information shown here is accurate, it will probably fail to attract the attention of a board simply because it is not eye-catching enough. A more dramatic presentation package would include charts such as those shown on the next pages.

An Alternative Set of Presentation Graphics

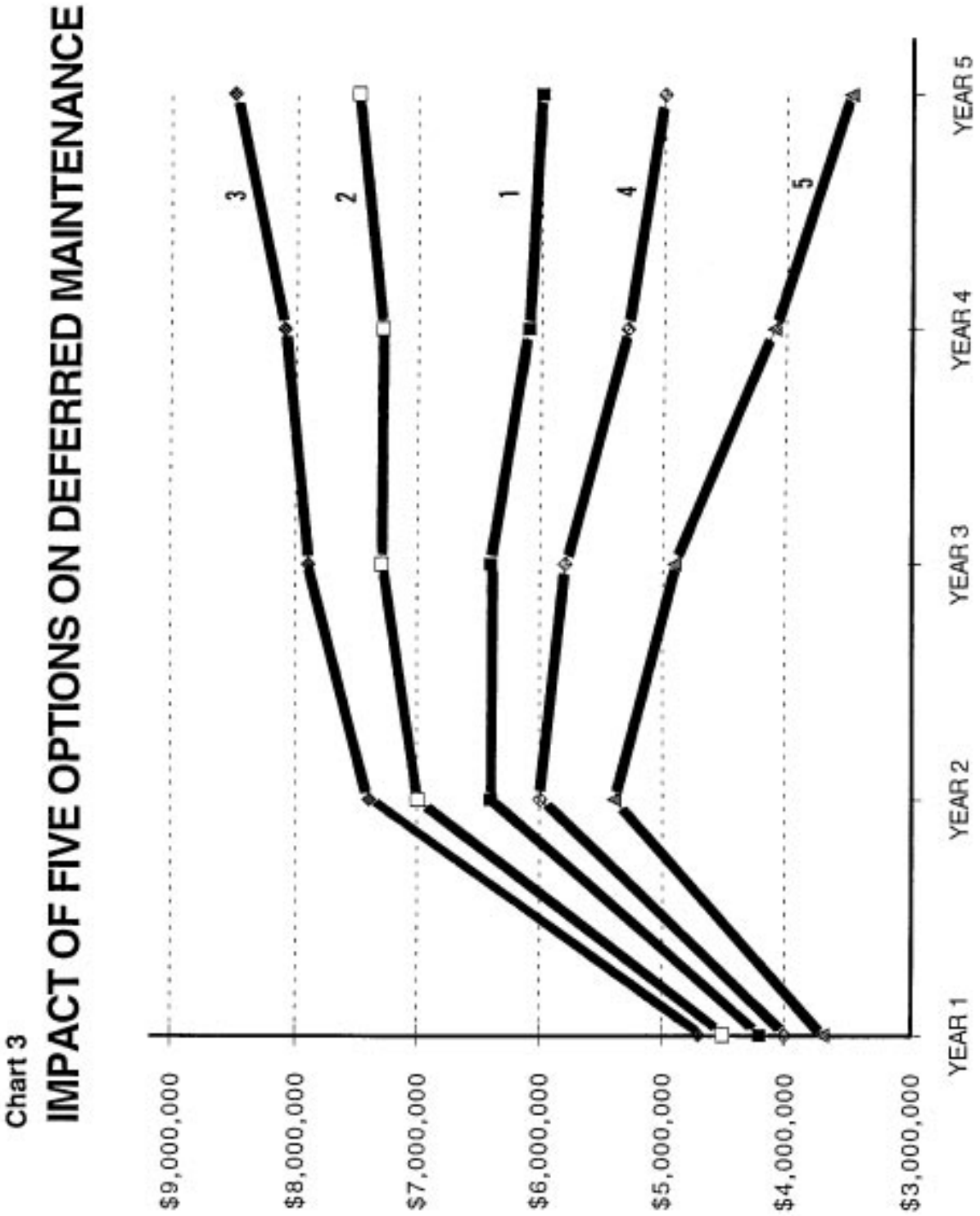
The following charts effectively illustrate the data presented in the previous table. Note that the visual impact of the data increases from Chart 1 to Chart 4.



While more effective than the previous table, this bar chart still fails to adequately illustrate the full impact of the five options on deferred maintenance.



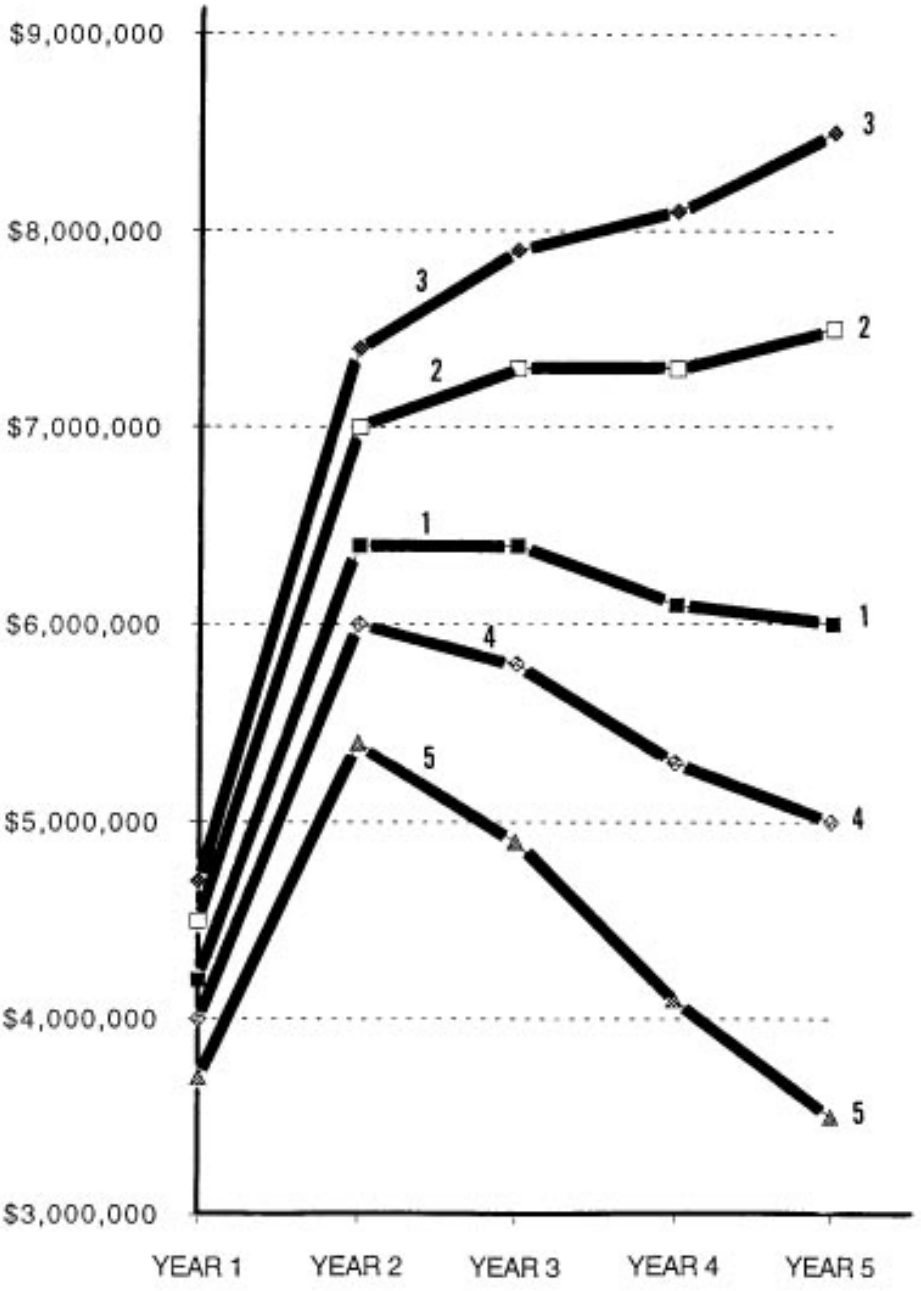
This line chart more effectively illustrates the five options' impact allowing the audience to easily follow the financial trends.



While the data in this line chart is identical to that of Chart 2, the value axes have been lifted from $0 to the $3 million level. The steep line gradient produced creates a dramatic visual impact.

Chart 4

IMPACT OF FIVE OPTIONS ON DEFERRED MAINTENANCE



The most effective communicator of PMS results, this chart replicates the data of Chart 3, but it has been printed horizontally, thereby maximizing the impact of the steep line gradient.

A Case in Point

User cities throughout the country have successfully translated PMS results into action. This has been accomplished in large part through effective presentations. Even so, a successful marketing strategy and sterling presentations do not always ensure additional dollars for pavement maintenance on the first try. It is a gradual process, and the first year's full request may not be met.

Changes in agencies take place slowly. Having realistic goals and expectations is important. However, a number of local agencies have made great strides in improving their pavements through the use of PMS.

One of the first local agencies to complete a condition survey and accurately define its needs was the city of San Leandro in Alameda County, California. In April of 1986, the City Council was presented with the city's street and road network financial report with a need totaling $11.5 million for a five-year period.

Available revenues for pavement maintenance over that period were estimated to be only $5.5 million. Seven months later, the Council asked the Department of Public Works and the Bay Area MPO staff to make a formal presentation.

In the meantime, a referendum was in place to increase the county sales tax by .5 cent. Almost 20 percent of the revenue generated from the proposed increase would go to the public works department for use on streets and roads.

In this case, the estimated percentage of revenue to be returned to public works was equal to the $6 million shortfall estimated for pavement maintenance. The evening before the referendum came to a vote, the city public works and MPO staff went before the Council. After hearing the presentation, the Council determined that if the referendum passed, the portion of funds to be returned to the city would be used for pavement maintenance.

The referendum did pass, giving the city a reliable source of revenue for pavement maintenance. About three years later, the City Council asked the MPO to make another presentation on the status of PMS. This time, the city's needs were $8 million over five years. The MPO estimated that $10 million was available for pavement maintenance. The Pavement Condition Index (PCI) rose from a yearly average of 66 in 1986 to 79 in 1990.

Summing Up

This process can be effectively utilized by any agency with a PMS. With PMS results, the board has the data to make informed decisions on the future condition of their agency's road network. In today's environment, having PMS is only the first step toward improved pavement maintenance.

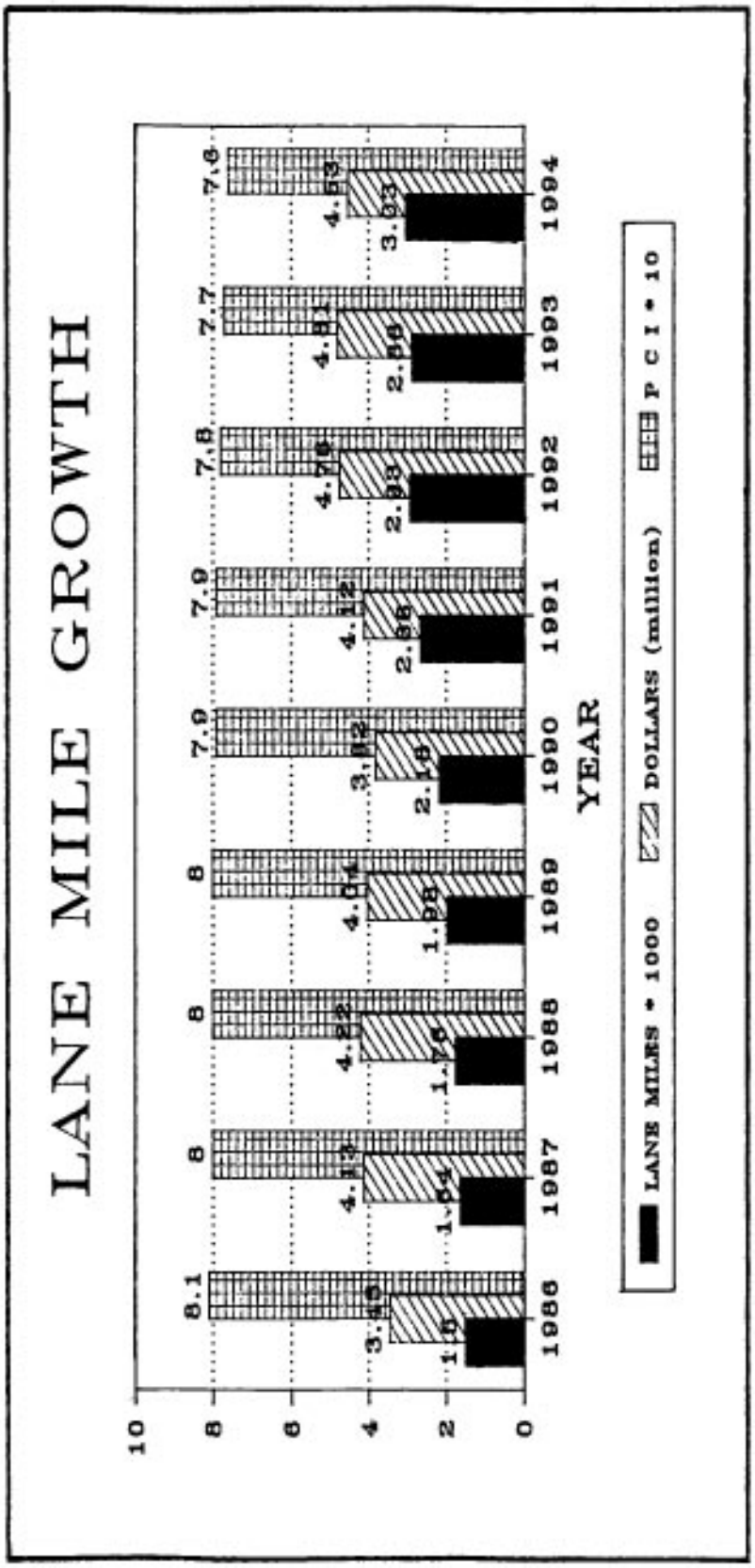
25:F:GPM5

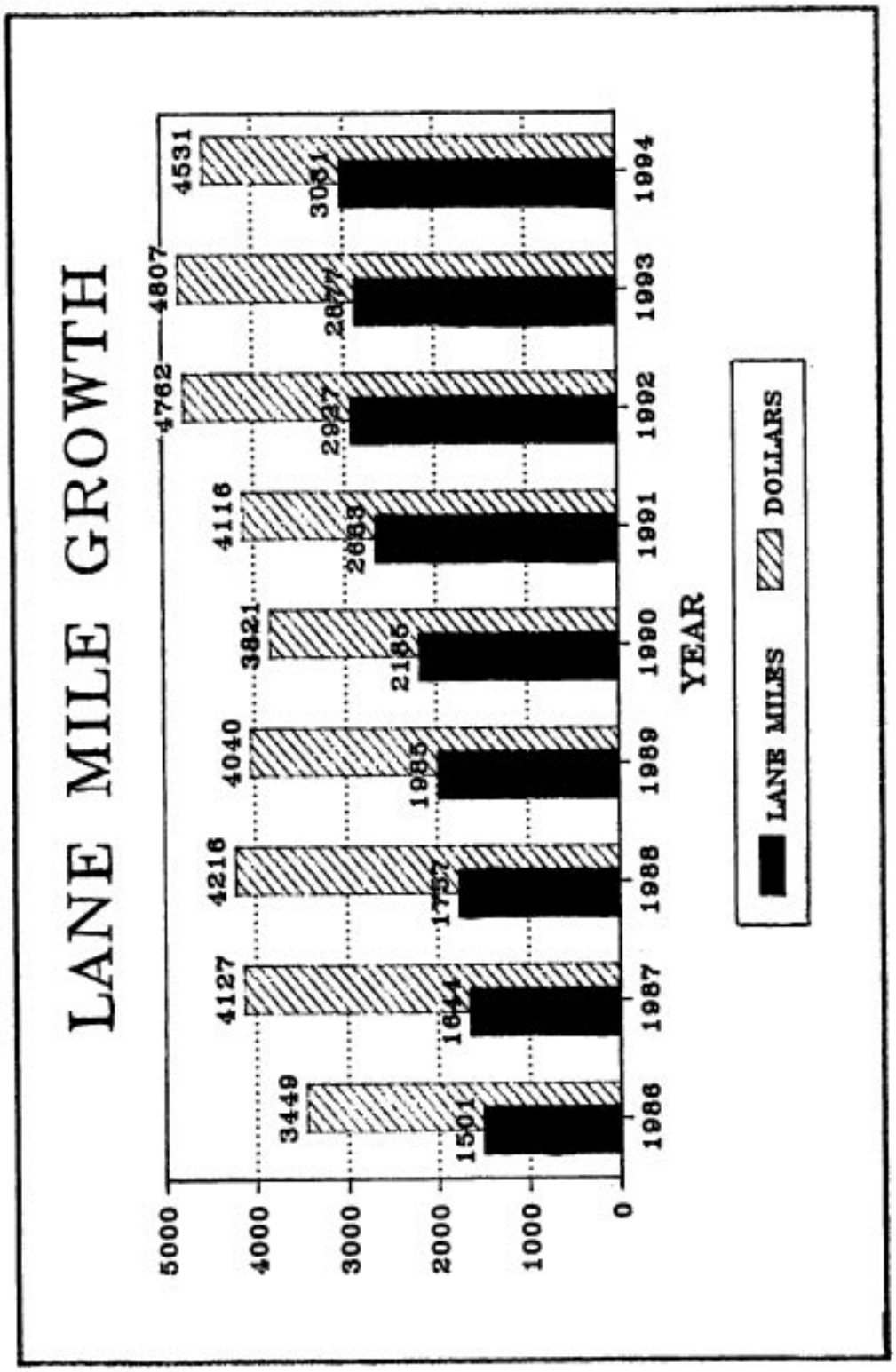
Appendix J
Sample Graphs, Roadway Network History

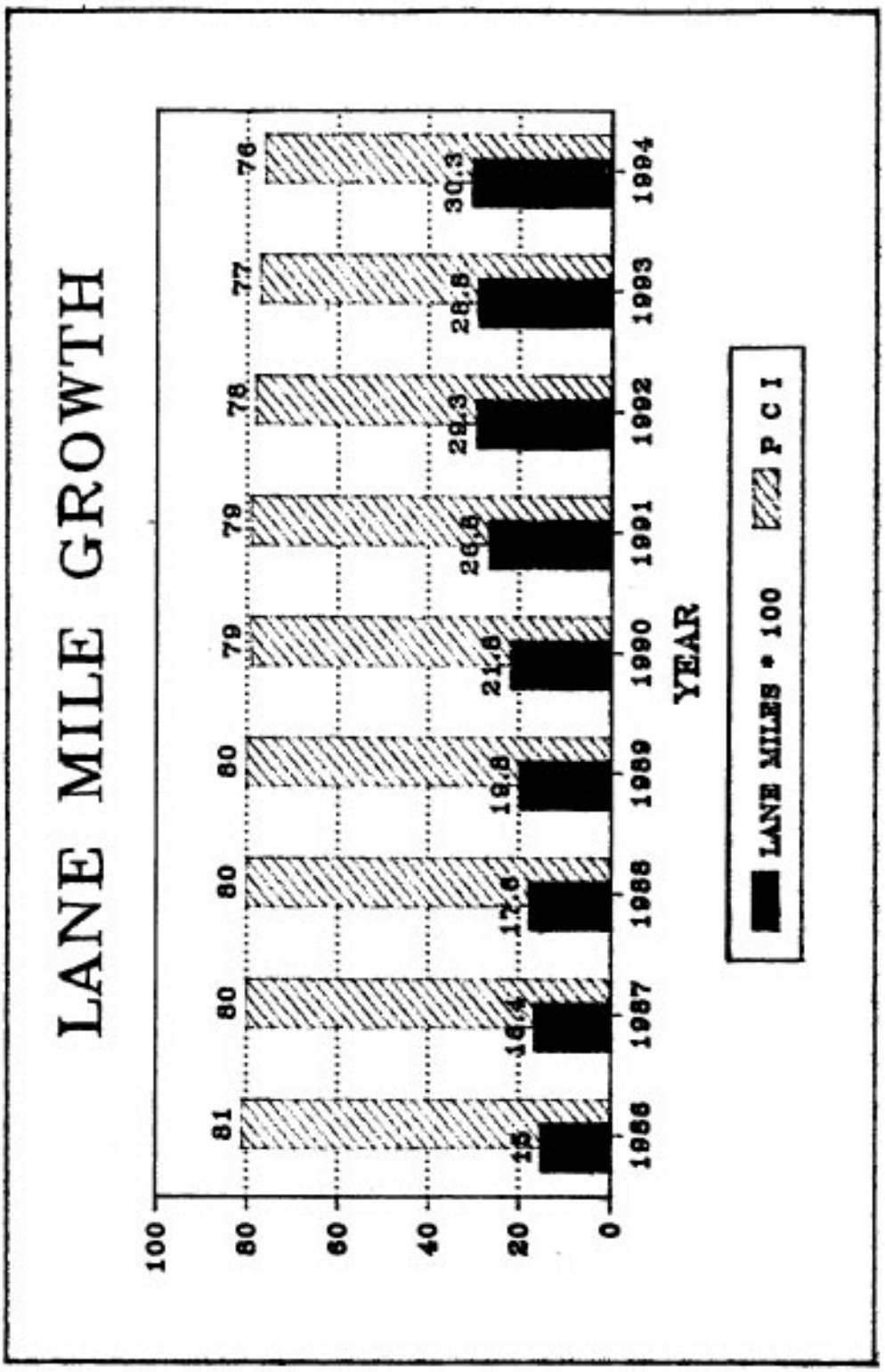
Included in the next few pages are example graphs that illustrate an agency's roadway history including the number of lane miles, the dollars used for maintenance, and the Pavement Condition Index for the entire network.

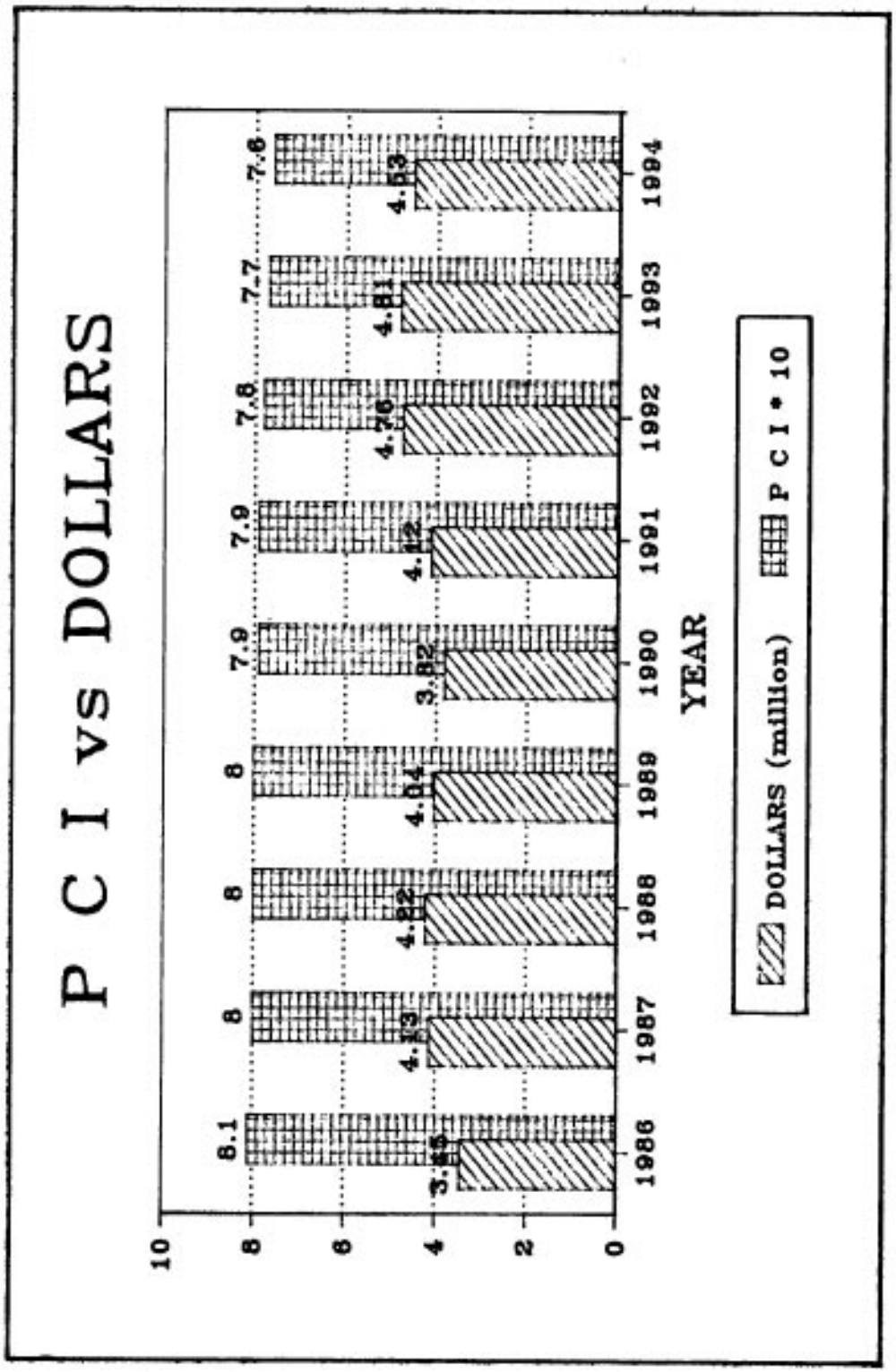
These graphs show the same information in different ways depending on the message you are trying to express to an audience.

26:F:GPM2


LANE MILE GROWTH
YEAR
LANE MILES * 1000
DOLLARS (million)
P C I * 10
1986
1987
1988
1989
1990
1991
1992
1993
1994
8.1
8
8
8
7.9
7.9
7.8
7.7
7.8
3.45
4.13
4.22
4.04
3.82
4.12
4.76
4.81
4.53
1.6
1.64
1.76
1.98
2.18
2.36
2.33
2.56
3.03
0
2
4
6
8
10


LANE MILE GROWTH
5000
4000
3000
2000
1000
0
4531
4807
4762
4116
3821
4040
4216
4127
3449
1986
1987
1988
1989
1990
1991
1992
1993
1994
YEAR
LANE MILES
DOLLARS


LANE MILE GROWTH
100
80
60
40
20
0
81
80
80
80
79
79
78
77
76
15
16.4
17.6
19.8
21.6
26.6
28.3
28.8
30.3
1986
1987
1988
1989
1990
1991
1992
1993
1994
YEAR
LANE MILES * 100
P C I


P C I vs DOLLARS
DOLLARS (million)
P C I * 10
YEAR
1986
1987
1988
1989
1990
1991
1992
1993
1994
8.1
8
8
8
7.9
7.9
7.8
7.7
7.6
3.16
4.13
4.22
4.01
3.82
4.12
4.76
4.81
4.53
10
8
6
4
2
0

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27:GPM2

StreetWise

A Simplified Local Agency Pavement Management System

Washington State Department of Transportation
TransAid Service Center

StreetWise

A Simplified Pavement Management System for Local Agencies

Washington State Department of Transportation

StreetWise

A Simplified Pavement Management System for Local Agencies

Developed for Washington State Local Agencies by WSDOT TransAid Service Center

Information concerning streetwise can be obtained by contacting:

WSDOT TransAid Service Center
Management System Office
(360) 705-7383

Washington State Department of Transportation
TransAid Service Center
Management System Office

Acknowledgments

StreetWise, A Simplified Pavement Management System for Local Agencies

For agencies wishing to use a simplified, noncomputerized pavement management system, the Washington State Department of Transportation (WSDOT) TransAid Service Center has developed StreetWise. This system and the accompanying manual were developed and produced by Paul Sachs and Dan Sunde, P.E.

Appreciation is extended to Paul Sachs for his development of the PCR tables and to Martha Roney for her editorial review and comments.

Special thanks are extended to Butch McGuire of the city of Snohomish for his information on his own noncomputerized method which assisted in developing the basic concept of StreetWise.

Special thanks are also extended to Ken Gardner of the city of Steilacoom, Rick Hill of the city of Langley, Sue Schuetz of Benton County, Andy Dempsey of the city of Buckley, and Melvin Wiemerslage of the city of Burlington for their valuable input in making the system functional and tailoring it to the users' needs.

Additional copies of StreetWise can be received upon request through the TransAid Service Center at:

Washington State Department of Transportation
TransAid Service Center
P.O. 47390
Olympia, WA 98504-7390

(360) 705-7383
(360) 705-6822 (Fax)

Preface

In these days of dwindling resources, it is becoming more incumbent on agencies to use the most effective means available to manage those resources. For those managing roadways, pavement management systems offer an objective and effective method for doing so.

We are committed to support you in your efforts to implement pavement management. As a part of our ongoing support, we are providing StreetWise, a simplified system, for those agencies which do not need a sophisticated computerized system.

The purpose of StreetWise is to provide a practical system that is functional, easy to use, consistent, and easily converted to a computerized system in the future if the agency opts to do so.

StreetWise is just one more in a series of tools that TransAid is making available to assist you in managing your transportation resources.

DENNIS B. INGHAM
Assistant Secretary TransAid

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Introduction

Background

To assist smaller cities in the state of Washington in implementing a Pavement Management System (PMS), the Washington State Department of Transportation (WSDOT) has developed a manually operated simplified system, StreetWise, based on the principles of the computerized systems that larger agencies use. Implementation of this system will meet the Intermodal Surface Transportation Efficiency Act (ISTEA) requirements for cities with populations of less than 22,500.

A user can implement the system by simply filling out the Pavement Condition Rating forms provided with this user manual and filing them along with the project construction and maintenance records. We strongly encourage agencies to feel free to modify the forms provided with the system, according to their needs. The forms have been developed by WSDOT with the assistance of a number of local agencies. They are not meant to be set in stone. We do ask that if you alter the forms, please let us know so that we can provide the forms to other local agencies as alternatives to the ones provided. Keep in mind that the data on the form needs to remain in its entirety but the formatting can be altered since it is the minimum necessary to make the system functional.

This simplified system is developed with the intention that an agency can eventually move to a computerized PMS. All the information that an agency collects using StreetWise can be entered into any of the computerized systems that other local agencies are currently using throughout the state. The pavement condition evaluation performed has been also simplified, yet it is similar to the method being used by the other agencies.

If you are interested in how this PMS has been simplified, please read the next section that deals with this system's approach. If you want to get right into applying the system, please turn to the section dealing with How to Use StreetWise.

How StreetWise Works

StreetWise is based on all of the principles that more sophisticated computerized PMS's have, but it has been tailored to smaller agencies. The implementation steps an agency would go through for StreetWise are the same as for the computerized systems. These steps are:

1. Break the Pavement Street Network into Segments and Create an Inventory
2. Survey the Pavement Condition of each Segment in the Inventory
3. Calculate a Pavement Condition Score for each Segment
4. Determine a Treatment and Cost for each Segment based on Pavement Condition
5. Develop a Method of Prioritizing Segments when Funding Constraints Exist in a Pavement Maintenance Program

6. Determine a Network Level Average Condition Score

Descriptions of each of these steps can be found in *A Guide for Local Agency Pavement Managers*.

Instead of entering the pavement inventory information into a computer, all of the above implementation steps are done on a couple of sheets of paper. Each segment in your system will have an Pavement Condition Rating form and may have some additional data on other sheets. Follow the above implementation steps to start the system. How to actually implement the system is outlined in the next section, "How to Use StreetWise."

The inventory data needed for this system is less than that needed for a computerized system. Also, the pavement condition evaluation has been modified so that the rating is based on two predominant distress types, (Alligator Cracking and the most predominant of four other distresses). All of this will become much clearer as you go through the section on how to use the system.

How to Use StreetWise

To begin using StreetWise, follow these steps

Step 1. Fill Out the Inventory Information Section of the Data Sheets

You will need to define a referencing system for your pavement network. A referencing system defines one segment of a pavement network from another. For a city, this will usually be a city block or groups of city blocks. For a detailed description of referencing systems and how to define or break your pavement network into segments, review Chapters 4 and 5 of *A Guide for Local Agency Pavement Managers*.

Information that you will need to enter on the inventory form is:

- The Road Number and the Sequence Number
- The Street Name and the Beginning and Ending location of the Segment
- The Number of Traffic Lanes on the Segment
- The Functional Classification of the Segment
- The Surface Type of the Segment
- The Length, Width and the Area of the Segment

There are two boxes in the Inventory Information section that need to be calculated from the segment length, the "Wheelpath Length" and the segment "Area." These are located in the bottom right-hand corner of this section in the boxes labeled "B" and "C." The segment "Length," "Number of Lanes" and the "Width" are arranged in a simple mathematical layout to assist in calculation. Enter the length, width, and number of lanes. From left to right, multiply the "Length" times "Number of Lane" times two and enter the answer in box B, "Wheelpath Length." Now multiply the "Length" times "Width" and enter the answer in box C, "Area." These boxes only need to be calculated once and the information transferred to later forms as long as the roadway geometrics and segment length have not changed.

All of the boxes on the form need to be filled out to complete this step.

The system comes with a pad of 50 data sheets. If you feel you will need more, please make additional copies before filling them out. Copies may also be printed off the Internet under the TransAid Homepage.

An example of this step is found on page 8.

Step 2. Conduct a Pavement Condition Survey on Each Segment

Take the filled-out inventory form into the field and perform the condition survey. The survey is conducted using the techniques that are outlined in the *Pavement Surface Condition Rating Manual*. You should have a copy of the manual with you as you collect the distress information. The purpose of the survey is not to collect precise measurements of distress information, but to estimate the approximate area of the distress types you visually observe in the segment you are inspecting. You will need to collect observed estimates of the following distress types:

- Alligator Cracking
- Longitudinal Cracking
- Patching
- Raveling
- Transverse Cracking

Each occurrence of these distresses are estimated for each severity level over the entire segment. These distresses are written down on the distress information section of the Pavement Condition Rating form below the inventory information. An example of where to record in the distress information collected in the field is found on page 8. Definitions of the distresses, as well as the differences in the three severity types, are discussed in the *Pavement Surface Condition Rating Manual*.

After all distresses for the five types listed are found, return to the office and total each of the different distress types for each of the three severity levels.

For example, if you found three different areas that contain alligator cracking in the segment, and the first area was 130 feet of medium severity; the second was 200 feet of low severity, and the third was 170 feet of medium severity, you would add the two medium severities together to come up with a total of 300 feet of medium severity alligator cracking and 200 feet of low severity. These totals are written into the bottom of the shaded boxes where the distress information was collected. This example can be found on page 8. The breakdown of distresses by severity levels is applied to all distresses observed and the resultant totals are placed in the appropriate boxes.

Step 3. Find the Percent Range of Alligator Cracking

Next, when all of the distresses are totaled, you will need to determine a percent range for the most predominant severity of alligator cracking. That is, the severity level (low, medium, high) that has the highest amount.

Using the example found in step 2, where there was 300 feet of medium severity alligator cracking and 200 feet of low severity, medium severity is the predominant severity. Mark this severity in the summary section beside "Alligator Cr."

The next step is to determine the percent range that the distress covers on the segment. There are five different percent ranges that are used in the StreetWise system. They are:

- 0 percent to 1 percent of the total segment
- 1 percent to 5 percent of the total segment
- 5 percent to 10 percent of the total segment
- 10 percent to 25 percent of the total segment
- Above 25 percent of the total segment

Next, take the quantity of the predominant severity level of alligator cracking outlined previously and divide by box "B," "Wheelpath Length." For example, if you have 300 feet of medium severity alligator cracking and 1,400 total lane feet, the result would be:

$$\left(\frac{\text{Length of Cracking in Wheelpath}}{\text{Total Length of Wheelpaths}}\right) 100 = \text{percent}$$

(300/1400) 100 = 21 percent

In this example, there is 21 percent medium severity alligator cracking. This falls into the 10 percent to 25 percent range. Mark this range down in the area provided on the form marked "Alligator Cr." under "PCR calculations." An example is shown on page 8.

Step 4. Find the Percent Range of the Other Distress

Even though you have collected distress information for five different distress types, StreetWise was designed to evaluate only two of these, the predominant severity level of Alligator Cracking and the predominant distress type of any of the other four types. For instance, using the example section found on page 8, the extent of the assumed distresses other than alligator cracking are:

• Patching	Low severity	400 square feet
• Raveling	Medium Severity	1200 square feet
• Longitudinal Cr.	Low Severity	15 linear feet
• Patching	Medium Severity	200 square feet
• Transverse Cr.	Low Severity	8 each
• Longitudinal Cr.	High Severity	5 linear feet

In order to determine the most predominate distress, you need to calculate the percentage for each severity. To do this, add up the total estimated quantity of each distress severity and write the sum on the "Total" line of the data collection area of the "Distress Information" section. Next, divide

the “Total” by the maximum possible quantity for that distress. These are identified at the top of the columns in the “Percentages from ‘Distress Information.’” For Longitudinal and Transverse Cracks it is the segment length, box A. For Raveling and Patching, you divide by the area of the segment, box C. Write the calculated percentage in the appropriate area in the subsection “Percentages from ‘Distress Information.’” The most predominate distress severity is the one with the highest percentage.

In this example, medium severity Raveling would be the other predominant distress to be evaluated with Alligator Cracking. The percentage range for the distress is:

$$\left(\frac{\text{Area of Raveling}}{\text{Total Area of Segment}}\right) 100 = \text{percent}$$

(1200/7800 square feet) 100 = 15 percent

This falls within the 10 percent to 25 percent range for medium severity raveling.

Mark this percent range and severity level on the form in the area provided for “Other Distress” under the section “PCR Calculations.”

Step 5. Find the Pavement Condition Score for the Segment

To find the PCR for the segment that has been rated you will need to use the PCR tables. There are three tables based on the three levels of severity (low, medium, and high) of alligator cracking. These are each divided into five groups of subtables by extent of alligator cracking.

There is also an additional PCR table for those few cases where there is a single distress.

The general procedure is to first find the appropriate PCR table, select the correct group of subtables on the page, select the appropriate subtable within the group, and finally, from the subtable, then select the PCR based on the distress type and its extent.

In our example, the severity of alligator cracking is medium, select the table labeled “PCR Tables for **MEDIUM** Severity Alligator Cracking.” See the example on page 9.

You will see five groups of subtables on the page, each representing the five different percent ranges listed in step 3. For our example, the range for medium alligator cracking is 10 percent to 25 percent. The table that would be used to look up the condition score would be the fourth one on the page. It is labled “10% to 25% Medium Alligator Cracking.”

Next, locate the severity level of the second distress. In our example, the severity of the second distress is also medium. Follow the shaded area across the page to the subtable labled “Medium.” You have now selected the appropriate substable.

Using this subtable, the PCR is identified by, locating the distress and percentage range of that distress. In the example above, Raveling 10 percent to 25 percent was used. First find the column for Raveling labeled "Ravel." Then move down the column until you arrive at the box aligned with the row labeled "10 percent to 25 percent."

For our example, the condition score would equal 46.

Place this number in the box provided on the sheet labeled "PCR" (Pavement Condition Rating).

In order to monitor the condition of your network it is helpful to be able to compare the overall condition of your roadway network from one year to another. A simple way to do this is to calculate the average PCR for the entire network by adding all of the PCRs and dividing by the total number of segments. By keeping track of these scores, you can compare the average network level PCR to see if the condition of your network is changing and by how much. You may find it helpful to do this by functional class as well.

Step 6. Select a Possible Treatment for the Segment

After having determined a PCR score for the segment, you will need to calculate a range that the score falls within to assist in selecting a possible treatment. For example, if your segment is in good shape with a PCR of 75, it would receive a different treatment than a segment in worse shape rated as 40. In the "Maintenance Strategy" section below the "PCR" box, you will find a block of numbers from 0 to 100 in four ranges labeled by groups. These ranges represent the 0 to 100 scale of the PCR. The four groups represent a type of treatment you would prefer to do based on the pavement condition within that range. The groups are:

Group 1	PCR score of 75 to 100
Group 2	PCR score of 50 to 75
Group 3	PCR score of 25 to 50
Group 4	PCR score of 0 to 24

In the previous example, the PCR of the segment was 46. You would move up the page and check the box corresponding to Group 3. Group 3 is selected because the segment PCR is between 25 and 50.

As you gain experience with the system, you may choose to modify the values for the groupings, depending on your own use of treatments and at what level you apply certain treatments.

After you have decided which group your segment is in, you will need to determine which treatment you will use for each group. For an explanation on how to do this, please see Chapter 7 of *A Guide for Local Agency Pavement Managers*. Each group represents the opportunity to insert a different treatment for a particular pavement condition (PCR). The treatments your agency uses should reflect your local conditions.

After a treatment has been selected, it is important to develop an estimated cost of repairing the segment. If you are using treatments that you have used in the past, you probably have a contract which breaks down the cost of the treatment by square yards. For example, if you had a firm do a number of 2-inch overlay projects at $4.15 a square yard, this would be the unit cost for the segment. To find the total cost, take the cost per square yard and multiply it by the total area of the segment in square yards. In the example above, if we use the $4.15 a square yard and apply it to the total area, the cost of the project would be:

$4.15 × (7800 square feet/9*) or
* (the number 9 is used here as a conversion from feet to yards

$4.15 × 867 square yards = $3,597

Place this number in the area provided on the form below the PCR

Step 7. Prioritization of Segments

After you have calculated the PCRs for all of the segments in your network, and determined the treatment and the cost, you will need to apply a method for choosing a logical order to address the segments. This process is called prioritization. For a detailed discussion of prioritization, please review Chapter 7 of *A Guide for Local Agency Pavement Managers*. Prioritization can be as simple as a "Best Segment First" or a "Worst Segment First" strategy.

Worksheets (Budget Worksheet) to assist you in determining the strategy that works best for you has been provided with this manual.

We have provided a seven step simplified system to implement a Pavement Management System in your agency. We encourage suggestions on how to improve this system to better serve your needs. Please review each of the steps and try an example out for yourself. It is through this interactive process that you will be better able to understand the Simplified PMS and make it work for you.

1:P:SW

Washington State Department of Transportation

StreetWise Pavement Condition Rating

Inventory Information

Road Number 10125	Sequence No. 10	Functional Class Pr. Arterial
Street Name Main St.		
From 1ST Ave	To 2ND Ave	

Length (A)		No. of Lanes	X 2	= Wheelpath Length	(B)
350'	X	2		1,400'	
		Width 22'-3"		= Area 7800 Sq. Ft.	(C)

Distress Information

Rating Date 6/1/95 Direction North Rater P.S. & D.S.

	Alligator Cracking Lin. Ft.	Longitudinal Cracking Lin. Ft.	Transverse Cracks Each	Raveling Sq. Ft.	Patching Sq. Ft.
Low	200	10	8		150
		5			250
	Total 200	15	8		400
Medium	150			200	75
	170			700	125
				300	
	Total 300			1200	200
High		5			
	Total	5			

PCR Calculations

Percentages from "Distress Information"

	(Total / Box (B)) 100	(Total / Box (A)) 100	(Total / Box (A)) 100	(Total / Box (C)) 100	(Total / Box (C)) 100
Low	~~14.3%~~	4.3%	2.3%		5.1%
Medium	21.4%			15.4%	2.6%
High		1.4%			

	Severity Summary (X One)			Extent Summary (X One)				
	Low	Med.	High	0 - 1%	1% - 5%	5% - 10%	10% - 25%	Above 25%
Alligator Cr.	☐	X	☐	☐	☐	☐	X	☐
Other (Raveling)	☐	X	☐	☐	☐	☐	X	☐

Maintenance Strategy

Treatment Groups (X One)

Group 1 PCR Between 75 - 100	☐
Group 2 PCR Between 50 - 74	☐
Group 3 PCR Between 25 - 49	X
Group 4 PCR Between 0 - 25	☐

Comments

PCR ➡ 46

Treatment for Segment ➡ 2" Overlay

Estimated Cost to Repair ➡ $ 3,597

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Example

0% to 1% Medium Severity Alligator Cracking

Other Distress	Low LC	Low TC	Low Ravel	Low Patch	Medium LC	Medium TC	Medium Ravel	Medium Patch	High LC	High TC	High Ravel	High Patch
0 to 1 %	90	90	90	90	90	90	85	86	81	90	81	80
1% to 5%	85	86	90	85	78	82	80	77	67	75	72	69
5% to 10%	79	83	86	79	70	76	77	71	50	62	62	57
10% to 25%	73	78	84	74	62	71	73	61	37	53	52	45
Above 25%	65	78	79	65	55	71	62	48	30	53	40	33

1% to 5% Medium Severity Alligator Cracking

Other Distress	Low LC	Low TC	Low Ravel	Low Patch	Medium LC	Medium TC	Medium Ravel	Medium Patch	High LC	High TC	High Ravel	High Patch
0 to 1 %	78	78	78	78	78	78	73	75	70	78	70	69
1% to 5%	74	75	78	74	67	71	69	64	56	63	61	59
5% to 10%	69	71	75	68	59	65	64	60	41	52	52	47
10% to 25%	62	67	72	62	52	60	62	51	29	43	42	35
Above 25%	55	67	68	54	45	60	52	38	25	43	30	25

5% to 10% Medium Severity Alligator Cracking

Other Distress	Low LC	Low TC	Low Ravel	Low Patch	Medium LC	Medium TC	Medium Ravel	Medium Patch	High LC	High TC	High Ravel	High Patch
0 to 1 %	69	69	69	69	69	69	63	65	60	69	60	60
1% to 5%	64	65	69	64	58	61	60	57	48	54	52	50
5% to 10%	59	62	65	59	50	56	57	51	32	43	43	38
10% to 25%	53	58	62	53	43	51	53	42	22	35	33	28
Above 25%	45	58	59	45	35	51	43	30	15	35	24	19

10% to 25% Medium Severity Alligator Cracking

Other Distress	Low LC	Low TC	Low Ravel	Low Patch	Medium LC	Medium TC	Medium Ravel	Medium Patch	High LC	High TC	High Ravel	High Patch
0 to 1 %	61	61	61	61	61	61	56	58	53	61	53	53
1% to 5%	57	59	61	57	51	54	53	50	41	48	45	43
5% to 10%	52	55	58	52	43	50	50	44	27	37	37	32
10% to 25%	46	51	55	47	36	44	46	35	16	30	29	23
Above 25%	40	51	52	39	30	44	36	25	10	30	19	14

PCR

Above 25% Medium Severity Alligator Cracking

Other Distress	Low LC	Low TC	Low Ravel	Low Patch	Medium LC	Medium TC	Medium Ravel	Medium Patch	High LC	High TC	High Ravel	High Patch
0 to 1 %	50	50	50	50	50	50	45	47	43	50	43	42
1% to 5%	46	48	50	46	41	43	42	40	31	37	35	32
5% to 10%	42	44	47	41	33	39	40	33	19	28	28	24
10% to 25%	35	41	45	36	27	33	35	27	9	21	20	15
Above 25%	30	41	41	30	20	33	27	16	5	21	12	7

NOTE: To use these tables for **Transverse Cracks (TC)** read the % as "number of cracks per 100 ft. of segment lenghth". All other distresses are in percentage as shown.

Example

Example

Washington State Department of Transportation

StreetWise Budget Worksheet

Road No.	Sequence No.	Street Name	From	To	PCR	Cost	Accumulative Total Cost
10125	10	Main St.	1ST Ave	2ND Ave	46	$ 3,597	$3,597
10150	20	Elm St.	Fir St.	Cedar St.	47	4,717	8,314
10125	20	Main St.	2ND Ave	3RD Ave	49	3,597	11,911
10140	10	Fifth Ave.	Maple St.	Pine St.	49	4,612	16,523
				Current Budget = $ 12,000			
							D.L.S.
							8/1/95

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Sheet No. 1 of 1

StreetWise Budget Worksheet

PCR Tables

0% to 1% Low Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	93	93	93	93	93	93	90	91	86	93	86	86
1% to 5%	90	91	93	90	84	87	86	83	72	79	77	75
5% to 10%	85	88	91	85	75	82	83	76	55	68	68	62
10% to 25%	78	84	89	79	67	76	78	66	42	59	57	50
Above 25%	70	84	85	70	60	76	67	52	35	59	44	38

1% to 5% Low Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	86	86	86	86	86	86	81	83	78	86	78	77
1% to 5%	82	84	86	82	75	79	77	75	64	71	69	66
5% to 10%	76	79	83	76	67	74	75	68	48	60	60	54
10% to 25%	70	75	80	71	59	68	70	59	34	51	50	42
Above 25%	65	75	76	62	50	68	59	45	25	51	37	31

5% to 10% Low Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	79	79	79	79	79	79	74	75	71	79	71	70
1% to 5%	75	76	79	75	68	71	70	67	57	64	62	59
5% to 10%	69	72	75	69	60	66	67	60	41	53	53	48
10% to 25%	62	68	73	63	52	60	62	52	29	44	43	35
Above 25%	55	68	69	55	45	60	52	38	23	44	31	26

10% to 25% Low Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	71	71	71	71	71	71	66	68	63	71	63	62
1% to 5%	67	69	71	67	60	64	62	60	50	57	55	52
5% to 10%	62	65	68	61	53	59	60	53	34	46	46	41
10% to 25%	55	60	65	56	45	53	55	45	24	38	36	30
Above 25%	50	60	61	48	35	53	45	32	15	38	26	20

Above 25% Low Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	60	60	60	60	60	60	55	56	52	60	52	52
1% to 5%	55	57	60	55	50	53	52	49	40	46	44	42
5% to 10%	51	53	56	50	42	48	49	43	26	35	35	30
10% to 25%	45	50	54	45	35	43	45	34	16	29	27	22
Above 25%	35	50	50	38	25	43	36	24	10	29	17	13

NOTE: To use these tables for **Transverse Cracks (TC)** read the % as "number of cracks per 100 ft. of segment length". All other distresses are in percentages as shown.

0% to 1% Medium Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	90	90	90	90	90	90	85	86	81	90	81	80
1% to 5%	85	86	90	85	78	82	80	77	67	75	72	69
5% to 10%	79	83	86	79	70	76	77	71	50	62	62	57
10% to 25%	73	78	84	74	62	71	73	61	37	53	52	45
Above 25%	65	78	79	65	55	71	62	48	30	53	40	33

1% to 5% Medium Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	78	78	78	78	78	78	73	75	70	78	70	69
1% to 5%	74	75	78	74	67	71	69	64	56	63	61	59
5% to 10%	69	71	75	68	59	65	64	60	41	52	52	47
10% to 25%	62	67	72	62	52	60	62	51	29	43	42	35
Above 25%	55	67	68	54	45	60	52	38	25	43	30	25

5% to 10% Medium Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	69	69	69	69	69	69	63	65	60	69	60	60
1% to 5%	64	65	69	64	58	61	60	57	48	54	52	50
5% to 10%	59	62	65	59	50	56	57	51	32	43	43	38
10% to 25%	53	58	62	53	43	51	53	42	22	35	33	28
Above 25%	45	58	59	45	35	51	43	30	15	35	24	19

10% to 25% Medium Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	61	61	61	61	61	61	56	58	53	61	53	53
1% to 5%	57	59	61	57	51	54	53	50	41	48	45	43
5% to 10%	52	55	58	52	43	50	50	44	27	37	37	32
10% to 25%	46	51	55	47	36	44	46	35	16	30	29	23
Above 25%	40	51	52	39	30	44	36	25	10	30	19	14

Above 25% Medium Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	50	50	50	50	50	50	45	47	43	50	43	42
1% to 5%	46	48	50	46	41	43	42	40	31	37	35	32
5% to 10%	42	44	47	41	33	39	40	33	19	28	28	24
10% to 25%	35	41	45	36	27	33	35	27	9	21	20	15
Above 25%	30	41	41	30	20	33	27	16	5	21	12	7

NOTE: To use these tables for **Transverse Cracks (TC)** read the % as "number of cracks per 100 ft. of segment length". All other distresses are in percentage as shown.

0% to 1% High Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	85	85	85	85	85	85	79	80	76	85	76	75
1% to 5%	79	81	85	79	73	76	75	72	62	69	67	64
5% to 10%	75	76	80	74	65	73	72	65	45	58	58	52
10% to 25%	68	73	78	69	57	65	68	56	32	49	48	41
Above 25%	65	73	74	60	48	65	57	43	20	49	35	30

1% to 5% High Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	69	69	69	69	69	69	64	65	61	69	61	60
1% to 5%	65	66	69	65	59	62	60	58	48	55	53	50
5% to 10%	60	62	65	59	51	57	58	52	32	46	44	39
10% to 25%	53	59	63	54	43	52	53	43	22	35	34	29
Above 25%	50	59	59	46	40	52	43	30	19	35	24	19

5% to 10% High Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	58	58	58	58	58	58	53	54	50	58	50	50
1% to 5%	53	55	58	53	48	51	50	47	38	44	42	40
5% to 10%	49	52	54	48	41	46	47	41	24	33	33	30
10% to 25%	43	48	52	43	33	41	43	32	15	27	26	20
Above 25%	40	48	48	35	30	41	33	22	10	27	16	12

10% to 25% High Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	50	50	50	50	50	50	45	47	43	50	43	42
1% to 5%	46	48	50	46	41	43	42	40	31	37	35	32
5% to 10%	42	44	47	41	33	39	40	33	19	28	28	24
10% to 25%	35	41	45	36	27	33	35	27	9	21	20	15
Above 25%	30	41	41	30	20	33	27	16	5	21	12	7

Above 25% High Severity Alligator Cracking

	Low				Medium				High			
Other Distress	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch	LC	TC	Ravel	Patch
0 to 1 %	41	41	41	41	41	41	35	37	33	41	33	32
1% to 5%	36	38	41	36	31	33	32	30	23	29	27	25
5% to 10%	32	34	37	31	25	30	30	26	12	20	20	16
10% to 25%	27	31	35	28	20	26	27	19	4	14	13	8
Above 25%	20	31	31	22	15	26	20	10	2	14	5	2

NOTE: To use these tables for **Transverse Cracks (TC)** read the % as "number of cracks per 100 ft. of segment length". All other distresses are in percentages as shown.

Alligator Cracking

	Low	Medium	High
0 to 1 %	93	86	79
1% to 5%	82	71	59
5% to 10%	72	58	43
10% to 25%	62	48	32
Above 25%	46	32	17

Longitudinal Cracking

	Low	Medium	High
0 to 1 %	100	100	89
1% to 5%	94	85	70
5% to 10%	87	74	46
10% to 25%	78	63	26
Above 25%	n/a	n/a	n/a

Patching

	Low	Medium	High
0 to 1 %	100	95	88
1% to 5%	94	84	73
5% to 10%	86	75	56
10% to 25%	79	62	38
Above 25%	67	42	20

Raveling

	Low	Medium	High
0 to 1 %	100	93	89
1% to 5%	100	88	77
5% to 10%	95	84	64
10% to 25%	92	78	49
Above 25%	86	63	30

Transverse Cracking

	Low	Medium	High
0 to 1 crack per 100 ft.	100	100	100
1 to 5 cracks per 100 ft.	96	90	80
5 to 10 cracks per 100 ft.	91	83	64
10 to 25 cracks per 100 ft.	85	75	51
Above 25 cracks per 100 ft.	85	75	51

Forms

Washington State Department of Transportation

StreetWise Pavement Condition Rating

Inventory Information

Road Number	Sequence No.	Functional Class
Street Name		
From	To	

Length (A)	x	No. of Lanes	X 2	=	Wheelpath Length (B)
		Width		=	Area (C)

Distress Information

Rating Date _____ Direction _____ Rater _____

	Alligator Cracking Lin. Ft.	Longitudinal Cracking Lin. Ft.	Transverse Cracks Each	Raveling Sq. Ft.	Patching Sq. Ft.
Low					
	Total				
Medium					
	Total				
High					
	Total				

PCR Calculations

Percentages from "Distress Information"

	(Total / Box (B)) 100	(Total / Box (A)) 100	(Total / Box (A)) 100	(Total / Box (C)) 100	(Total / Box (C)) 100
Low					
Medium					
High					

	Severity Summary (✗ One)			**Extent Summary (✗ One)**				
	Low	Med.	High	0 - 1%	1% - 5%	5% - 10%	10% - 25%	Above 25%
Alligator Cr.	☐	☐	☐	☐	☐	☐	☐	☐
Other (_____)	☐	☐	☐	☐	☐	☐	☐	☐

Maintenance Strategy

Treatment Groups (✗ One)

Group 1 PCR Between 75 - 100	☐
Group 2 PCR Between 50 - 74	☐
Group 3 PCR Between 25 - 49	☐
Group 4 PCR Between 0 - 25	☐

Comments _____

PCR ➥ _____

Treatment for Segment ➥ _____

Estimated Cost to Repair ➥ _____

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Washington State
Department of Transportation

StreetWise Budget Worksheet

Road No.	Sequence No.	Street Name	From	To	PCR	Cost	Accumulative Total Cost

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Sheet No. _____ of _____