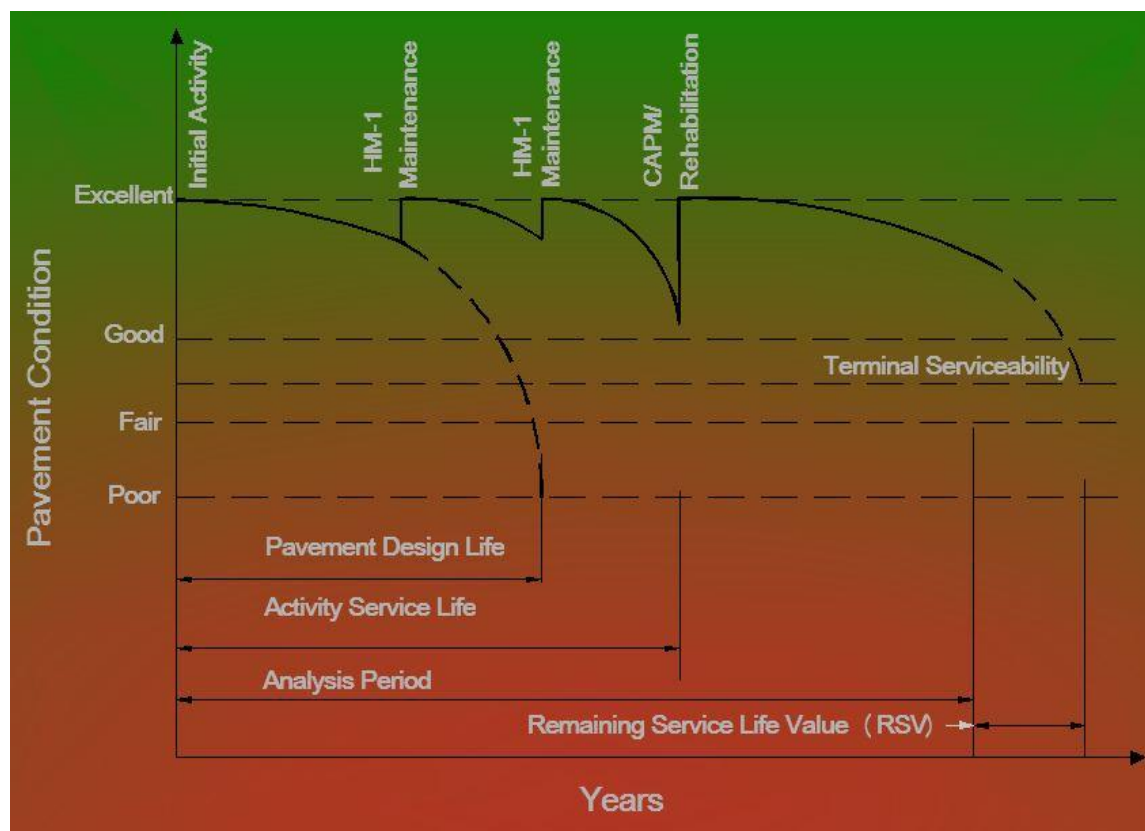


LIFE-CYCLE COST ANALYSIS PROCEDURES MANUAL



2013

For RealCost Version 2.5CA



**State of California
Department of Transportation
Division of Maintenance
Pavement Program**

DISCLAIMER

This manual is intended for the use of Caltrans and non-Caltrans personnel on projects on the State Highway System regardless of funding source. Engineers and agencies developing projects off the State Highway System may use this manual at their own discretion. Caltrans is not responsible for any work outside of Caltrans performed by non-Caltrans personnel using this manual.

ACKNOWLEDGMENT

The information contained in this manual is a result of efforts of many individuals in the Department of Transportation, Pavement Program, Division of Maintenance, LCCA Users Group, California Pavement Preservation Center, and University of California Pavement Research Center.

PREFACE

Caltrans utilizes Life-Cycle Cost Analysis (LCCA) to study the pavement investment alternative on the state highway projects in California. LCCA is an analytical technique that uses engineering economic principles to evaluate long-term investment options. The analysis enables total cost comparison of competing pavement alternatives with equivalent benefits. LCCA accounts for relevant costs to the sponsoring agency, owner, operator of the facility, and the roadway user that will occur throughout the analysis period of alternatives.

It is Caltrans' policy that life-cycle cost impacts are fully taken into account when making project-level decisions for pavements. Beginning in 2007, a LCCA is required for all pavement projects that are done on the State Highway System, regardless of funding source, with the exceptions of HM-1, Minor A and Minor B, encroachment permit, maintenance pullout, and landscaping projects. In 2013, CAPM projects no longer require LCCA.

Caltrans uses life-cycle cost analysis software, which is called *RealCost*. *RealCost* is a program developed by the Federal Highway Administration (FHWA) and was chosen by Caltrans as the official software for evaluating the long term cost effectiveness of alternative designs for new and existing pavements. The first version that was used by Caltrans was *RealCost 2.2CA* starting in 2007. In 2013, Caltrans developed a newer version of *RealCost Version 2.5CA*, which is a modified version of FHWA *RealCost Version 2.5* to include many improved features.

Caltrans has developed Life-Cycle Cost Analysis Procedure Manual to provide LCCA procedures and step-by-step instructions on how to use *RealCost*. Caltrans revises the manual periodically due to changes in policy, procedures, data and software. The purpose of the revisions is to save engineers' time and improve the accuracy and consistency of the analysis.

The most recent version of LCCA Procedures Manual and *RealCost* software program shall be used to ensure proper reference to current LCCA policies, data, procedures, and guidance.

The contents of this manual are organized as follows:

Chapter 1 is an introductory chapter, which goes over the basic concepts of LCCA, including policies and applications of LCCA within Caltrans and the benefits of using LCCA. The policy changes include elimination of the required LCCA on CAPM projects.

Chapter 2 outlines the principles and procedures of LCCA including new processes to select pavement alternatives.

Chapter 3 discusses LCCA methodology in detail, along with *RealCost Version 2.5CA* installation and detailed step by step instructions.

Chapter 4 gives insight on analyzing the LCCA results, and some of the limitation involved with using LCCA. There are discussions on comparing results for choosing the most cost effective pavement alternative.

There are also eight appendices, which include various tables and references.

Additional information including LCCA examples and HQ LCCA Coordinator contact information can be found at the LCCA website:
<https://dot.ca.gov/programs/maintenance/pavement/concrete-pavement-and-pavement-foundations/life-cycle-cost-analysis>.

Questions regarding LCCA may be directed to the HQ LCCA Coordinator.

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CHAPTER 1 INTRODUCTION

1.1 Purpose of This Manual

This manual describes uniform policies and procedures of Life-Cycle Cost Analysis (LCCA), for projects with pavement on the State Highway System, regardless of funding source. This manual provides step-by-step instructions for using *RealCost Version 2.5CA*, a program developed by the Federal Highway Administration (FHWA) and modified by Caltrans to better meet the needs of California.

This manual provides guidance and data for performing LCCA for pavement. It will help assure that pavement alternatives are analyzed objectively and consistently statewide, regardless of who engineers, builds, or funds the project. The *RealCost Version 2.5CA* program, this procedure manual, and additional information including LCCA examples can be accessed from the Caltrans LCCA Website at:

<https://dot.ca.gov/programs/maintenance/pavement/concrete-pavement-and-pavement-foundations/life-cycle-cost-analysis>.

1.2 MAP-21 & Asset Management

On July 6, 2012, President Barack Obama signed into law P.L. 112-141, the Moving Ahead for Progress in the 21st Century Act (MAP-21). MAP-21 provides transportation funds and transforms the framework for investments to guide the growth and development of the country's vital transportation infrastructure. It ensures that investments of federal-aid funds are directed to support progress toward achieving performance targets established in an asset management plan.

“Asset Management is a strategic approach to managing transportation infrastructure. The goal of Asset Management is to get the best results and performance from the preservation, improvement, and operation of infrastructure assets with the resources available. LCCA provides decision makers with the ability to determine the least-cost solution for a transportation investment requirement and is therefore a natural fit within the Asset Management framework.”¹

1.3 Purpose of LCCA

With increasing public scrutiny, government agencies are under great obligation to demonstrate their stewardship of public funds. MAP-21 encourages the use of LCCA for the evaluation of all major investment decisions in order to increase the effectiveness of those

¹“Life-Cycle Cost Analysis Primer”, U.S. Department of Transportation, Federal Highway Administration, Office of Asset Management, August 2002.

decisions. The goal is to achieve and sustain a desired state of good repair over the life-cycle of the assets at minimum practicable cost. (23 U.S.C. 101(a)(2), MAP-21 § 1103). Managing and preserving pavements is an increasingly important goal of highway agencies around the country.

LCCA identifies the most cost-effective pavement alternatives for the long-term (initial costs plus long term maintenance and repair costs.). As transportation funds are tighter, Caltrans holds the responsibility towards taxpayers that California's transportation systems are cost effective and efficient. This responsibility begins at the initial capital expenditure and extends to the later maintenance and operations expenditures, throughout the entire life-cycle of the pavement.

1.4 Caltrans' Policy

The pavement alternative with the lowest life-cycle is viewed as having the lowest impact to Caltrans even if it has a higher initial cost.¹

HDM Topics 612 and 619 identify situations where a LCCA must be performed to assist in determining the most appropriate alternative for a project by comparing the life-cycle costs of different pavement types and design strategies including:

- 1) Pavement types (flexible, rigid, or composite);
- 2) Rehabilitation strategies;
- 3) Pavement design lives comparisons (e.g., 20 vs. 40 years); and
- 4) Implementation strategies (combining, widening and rehabilitation projects vs. constructing them separately).

LCCA must be performed and documented, using the procedures and data in this manual, for all projects which include pavement work on the State Highway System except for the following types of projects:

- Major maintenance (HM-1)
- Minor A and Minor B
- Permit Engineering Evaluation Reports (PEER)
- Maintenance pullouts
- Landscape paving
- CAPM

For the exempted projects, the Project Engineers and the project development team may determine on a case-by-case basis to perform a life-cycle cost analysis and how it should be documented for each project development phase.

¹ See Deputy Directive #107 "Use of Life Cycle Cost Analysis in Project Decision Making", by Malcolm Dougherty, Chief Deputy Director dated June 30, 2010.

Pavement work consists of all the work associated with constructing a pavement structure, including subgrade, subbase, base, surfacing, earthwork, pavement drainage, traffic handling to construct the pavement, removal of existing pavement or earthwork, and other costs necessary to build the pavement. It should also include associated support costs for planning, engineering, and construction oversight. It can consist of constructing, widening, rehabilitating, or overlaying lanes, shoulders, gore areas, intersections, parking lots, or other similar activities.

1.4.1 LCCA Exception Request

Exemptions from LCCA require the written approval of the Chief Office of Concrete Pavement and Pavement Foundations in the HQ Pavement Program, and must be documented in the project initiation and approval documents. It is policy not to grant exemptions due to shortages in resources, funding sources, or not having sufficient time. Exemptions should involve a unique or unusual situation not addressed in this manual. Exemption requests must be submitted to the HQ LCCA Coordinator and must include project description, layout, typical cross sections, and reason for exemption.

1.4.2 When to Perform LCCA

LCCA should be completed as early as possible in the project development process. Perform a LCCA during the Project Initiation Document (PID) phase and again during the Project Approval & Environmental Document (PA&ED) phase.

With the exception of rehabilitation (program code 120, 122, and 125), performing a LCCA can be deferred from the PID phase to the PA&ED phase at the discretion of the district if any of the following apply:

- 1) Construction costs will not be programmed from the PID, such as the Project Study Report-Project Development Support (PSR-PDS).
- 2) Project is programmed for construction using the pavement and traffic control costs for the pavement alternative with the higher initial costs.

Any deferral of LCCA should be documented in the PID and include the necessary resources to complete the analysis during the PA&ED phase.¹ **LCCA must be completed prior to the PA&ED date.**

If a change in pavement design alters the pavement design life or other performance objectives during the design of the project, update the LCCA to include the new pavement alternative.

¹ Pavement Policy Bulletin PPB 10-04, approved on April 12, 2010.

1.4.3 Where to Document LCCA

To document life-cycle costs in project documents follow the procedures in Appendix O-0 of the Project Development Procedures Manual (PDPM). **When the pavement alternative with the lowest life-cycle cost is not selected, the reasons must also be documented.**

1.4.4 LCCA in Value Analysis

This manual is intended to provide the procedures required to implement the current LCCA policies. LCCA must conform to the procedures and data in this manual. **Life-cycle cost analysis performed as part of a Value Analysis study can only be used to meet the requirements for LCCA in HDM 619 and Project Development Procedures Manual, Chapter 8 if the analysis is done in accordance with the requirements found in this Life-Cycle Cost Analysis Procedures Manual for pavements.**

1.4.5 LCCA in Other References

Additional information can be found in Chapter 8 of the PDPM. This manual shall supersede any conflicting LCCA procedures found in the PDPM. This manual does not supersede HDM design procedures.

1.5 Roles and Responsibilities

The roles and responsibilities for LCCA within Caltrans are defined below.

- *HQ Pavement Program* is responsible for the development of Caltrans' policies, programs, guidelines, manuals, procedures, and standards that are used statewide for project pavement design.
- *HQ LCCA Coordinator* provides technical LCCA expertise and assistance to district staff.
- *District Directors*:
 - Ensures that their district follows Caltrans policies, procedures, and guidelines;
 - Implement quality control and quality assurance practices for each project development component; and
 - Implement independent quality assurance (commonly referred to as oversight) for each project development component.

It is up to the individual districts to determine how to execute LCCA. Most Districts bear the responsibility to Design, while others to Materials or Cost Estimating Unit.

- *District Project Engineer* in Planning and Design are "responsible in charge" of the project development documents:
 - Establishes design parameters;
 - Verifies alternatives meet needs;
 - Development of LCCA;
 - Determines best pavement structure for the project; and
 - Documents decisions made.

- *District Materials* recommends pavement alternatives for new construction, widening, and rehabilitation. Provides expert advice. A preliminary Materials Report should be issued for LCCA (PID and PA&ED).
- *District Traffic* provides traffic data to the Project Engineer such as traffic forecasting, traffic volumes, traffic index, and transportation management plan.
- *District Maintenance* provides existing pavement conditions and may provide pavement alternatives for Maintenance and CAPM projects.
- *Project Managers, Functional Managers, and Supervisors* empower employees with appropriate tools, resources, time, and training to deliver project components. Ensure project compliance with policies, standards, procedures, and best practices.
- *Outside Entities (i.e. Local Agencies and Consultants)* are to use LCCA when performing on projects on the State Highway System. Districts are Caltrans' contacts with outside entities and are responsible for coordinating processes with the outside entity to ensure compliance with Caltrans' project development procedures.

CHAPTER 2 LCCA APPROACHES

2.1 LCCA Basis

When making decisions about pavement design, LCCA:

- Compares pavement alternatives; and
- Identifies the best strategy based on current information as well as meeting the project performance objectives.

The study of costs, over a long analysis period, gives useful insight into which pavement alternative is the most cost effective. LCCA accounts for relevant costs, which include initial construction, maintenance and rehabilitation, project support, work zone effects, and user costs. The result of LCCA is a comparison of pavement alternatives.

The total life-cycle cost associated with a project is divided into two types of costs:

- *Agency Costs* are costs that Caltrans pays for initial construction and future maintenance and rehabilitation with support cost.
- *User Costs* are the costs associated with the public motorists for the additional travel time and vehicle operation costs caused by construction related traffic delays converted to a dollar amount.

2.2 LCCA Elements

The elements required to perform a LCCA are:

- 1) Pavement alternatives
- 2) Analysis period
- 3) Traffic data
- 4) Discount rate
- 5) Future maintenance and rehabilitation sequences
- 6) Costs (both Agency and User)
- 7) *RealCost Version 2.5CA* software

2.2.1 Source

The LCCA procedures described herein were derived from the FHWA's *RealCost User Manual* (2004) and *LCCA Technical Bulletin* (1998), "Life-Cycle Cost Analysis in Pavement Design," and the *Life-Cycle Cost Analysis Primer* (2002). The additional tables, figures, and other resources included in this manual are specifically developed for projects in the State Highway System to guide the data inputs needed for running *RealCost Version 2.5CA*.

2.3 Selecting Pavement Alternatives

A LCCA begins with the selection of pavement alternatives that will accomplish the same performance objectives for a project. For example, comparisons can be made between

flexible vs. rigid pavements; rubberized hot mix asphalt (RHMA) vs. conventional hot mix asphalt (HMA) pavements; HMA mill-and-overlay vs. HMA overlay; and 20-year vs. 40-year pavement design lives. Each selected pavement alternative must be a viable pavement structure that is both constructible and cost effective.

This manual includes decision tree flowcharts to guide selection of pavement alternatives based on pavement project type. Pavement project types are divided into the following categories:

- New construction/reconstruction (see Figure 2-1 flowchart)
- Widening (see Figure 2-2 flowchart for Lane Widening, Figure 2-3 flowchart for Shoulder and Intersection Widening, Figure 2-4 flowchart for Ramp Widening)
- CAPM and rehabilitation (see Figure 2-5 flowchart for existing rigid pavement CAPM and rehabilitation projects and Figure 2-6 flowchart for existing flexible pavement CAPM and rehabilitation projects)

The HDM Topic 603 provides definition for each of the project type.

Please note that the flowcharts do not show all possible alternatives, which may be considered for a particular project. Additional pavement alternatives can be analyzed as determined by the project development team. However, the lowest life-cycle pavement design must be identified and where required in HDM Topic 612. For example, if the new construction flowchart indicates that a 40-yr Flexible and 40-yr CRCP (Continuously Reinforced Concrete Pavement) must be analyzed, a 40-yr JPCP (Jointed Plain Concrete Pavement) may also be analyzed. In order for 40-yr JPCP to be selected, it must be the lowest life-cycle cost of the 3 pavement alternatives.

2.3.1 Use of Flowcharts for Selecting Design Alternatives

LCCA NEW CONSTRUCTION AND RECONSTRUCTION PAVEMENT TYPE SELECTION FLOWCHART

See Notes

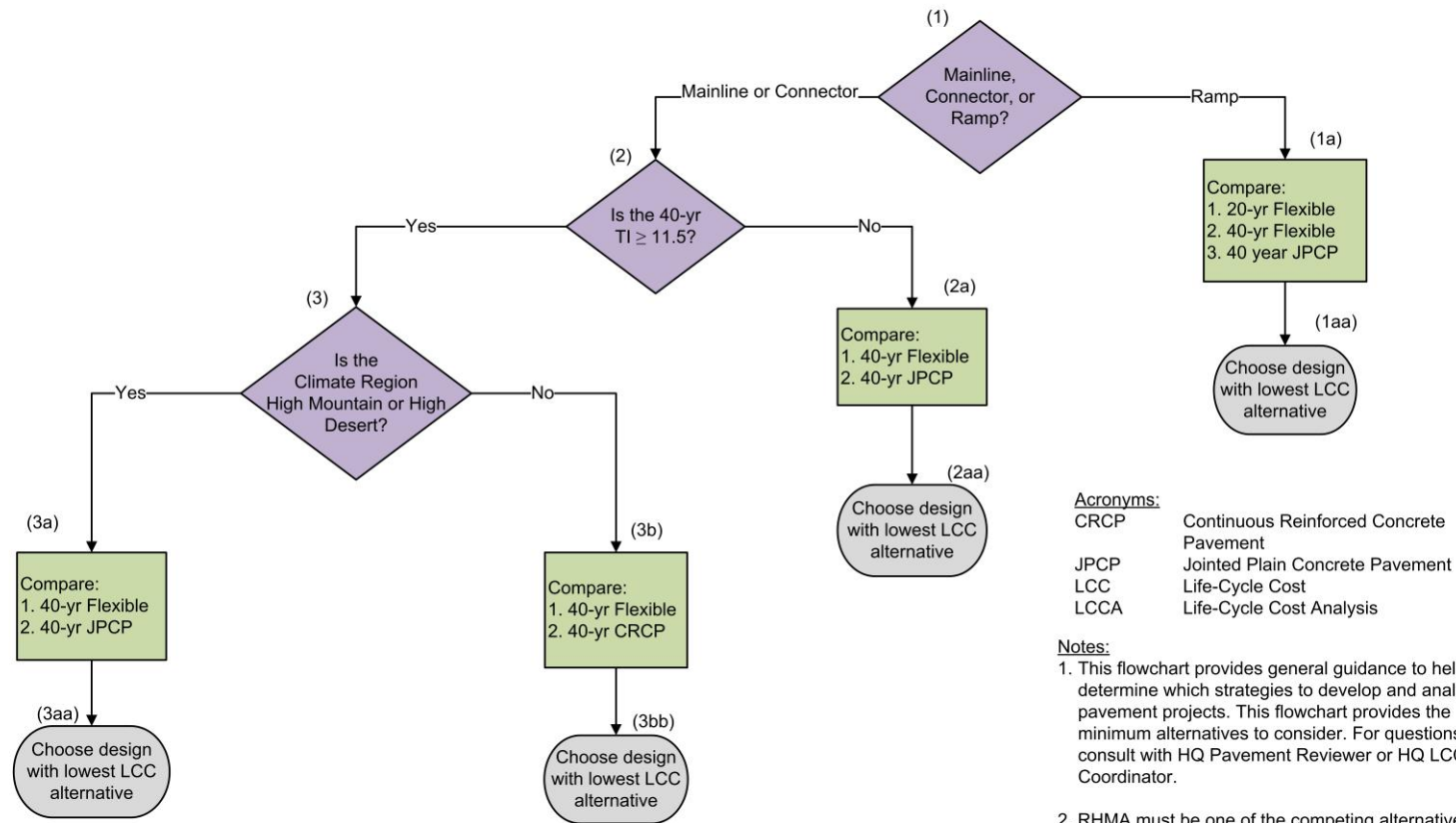


Figure 2-1 New Construction and Reconstruction Pavement Alternatives Selection Flowchart

Instructions for Using New Construction or Reconstruction Flowchart:

- (1) Using Figure 2-1, select whether the pavement is for a mainline, connector, or ramp. Go to (1a) or (2).
- (2) If the pavement is for a mainline or connector, determine whether the 40-year TI is greater than or less than 11.5. Go to (2a) or (3).
 - (2a) If the 40-year TI is less than 11.5, compare a 40-year flexible pavement with a 40-year JPCP pavement. Choose the pavement alternative with the lowest life-cycle cost (LCC) (2aa).
 - (3) If the 40-year TI is greater than or equal to 11.5, determine whether the project is in a high mountain or high desert climate region. Go to (3a) or (3b)
 - (3a) If the project is in a high mountain or high desert climate region, compare a 40-year flexible pavement with a 40-year JPCP pavement. Choose the alternative with the lowest LCC (3aa).
 - (3b) If the project is not in a high mountain or high desert region, then compare a 40-year flexible pavement with a 40-year CRCP pavement. Choose the pavement alternative with the lowest LCC (3bb).
- (1a) If the pavement is for ramps, compare a 20-year flexible, a 40-year flexible, and 40-year JPCP pavement. Choose the pavement alternative with the lowest LCC (1aa).

Widening Flowchart:

The following flowcharts provide instructions on how to choose alternatives for various widening projects, including widening lane, ramp, shoulder, and intersection.

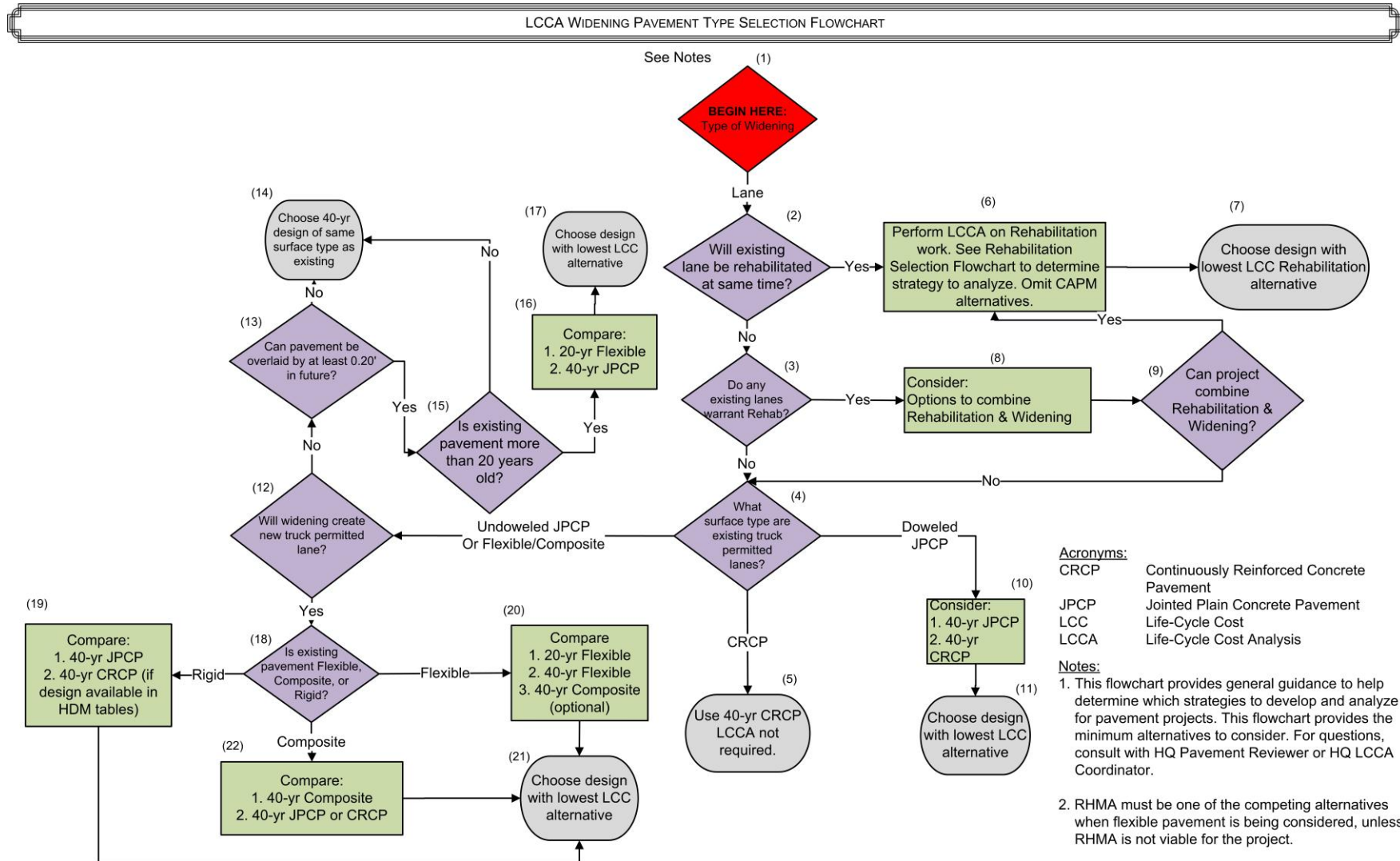


Figure 2-2 LCCA Lane Widening Flowchart

Instructions for Using Lane Widening Flowchart

Using Figure 2-2:

- (1) Begin here, and then proceed to step (2).
- (2) Decide if existing lane will be rehabilitated at the same time. If yes, proceed to step (6). If no, proceed to step (3).
- (6) If existing lane needs rehabilitation, perform LCCA on Rehabilitation work. Determine the strategy to analyze by using the Rehabilitation Selection Flowchart. Proceed to step (7).
- (7) Choose the alternative with lowest Rehabilitation cost.
- (3) Decide if the existing lanes warrant Rehab. If yes proceed to step (8). If no, proceed to step (4).
- (8) If existing lanes warrant rehab, consider between the options to combine Rehabilitation & Widening. Proceed to step (9).
- (9) Decide whether the Rehabilitation & Widening can be combined. If yes, proceed to step (6). If no, proceed to step (4).
- (6) If existing lane needs rehabilitation, perform LCCA on Rehabilitation work. Determine the strategy to analyze by using the Rehabilitation Selection Flowchart. Proceed to step (7).
- (7) Choose the alternative with lowest Rehabilitation cost.
- (4) Choose the type of surface for truck permitted lanes. Choose between Doweled JPCP step (10) or CRCP step (5) or (Un-doweled JPCP or Flexible/Composite) step (12).
- (5) If the CRCP surface is chosen, use 40-yr CRCP. LCCA is not required.
- (10) If the Doweled JPCP is chosen, consider between a 40-yr JPCP and a 40- yr CRCP. Proceed to step (11).
- (11) Choose the design with the lowest LCC alternative.
- (12) If un-doweled JPCP is chosen, decide if the widening will create a new truck permitted lane. If yes, proceed to step (18). If no, proceed to step (13).

- (18) Decide if the existing pavement is Composite, Flexible or Rigid. Proceed to step (22), (20) or (19), respectively.
- (22) If the existing pavement is Composite, compare between a 40-yr Composite and a 40-yr JPCP or CRCP. Proceed to step (21).
- (20) If the existing pavement is Flexible, compare between a 20-yr Flexible, 40-yr Flexible or 40-yr Composite (optional). Proceed to step (21).
- (19) If the existing pavement is concrete, compare between a 40-yr JPCP and a 40-yr CRCP. Proceed to step (21).
- (21) Choose design with lowest LCC alternative.
- (13) Decide if the pavement can be overlaid by at least 0.20' in the future. If yes, proceed to step (15). If no, proceed to step (14).
- (15) Determine if the existing pavement is more than 20-yrs old. If no, proceed to step (14). If yes, proceed to step (16).
- (16) If the existing pavement is more than 20 yrs. old, compare the options of a 20-yr Flexible and a 40- yr JPCP. Proceed to step (17).
- (17) Choose design with lowest LCC alternative.
- (14) Choose 40-yr design of same surface type as the existing surface type.

LCCA WIDENING PAVEMENT TYPE SELECTION FLOWCHART

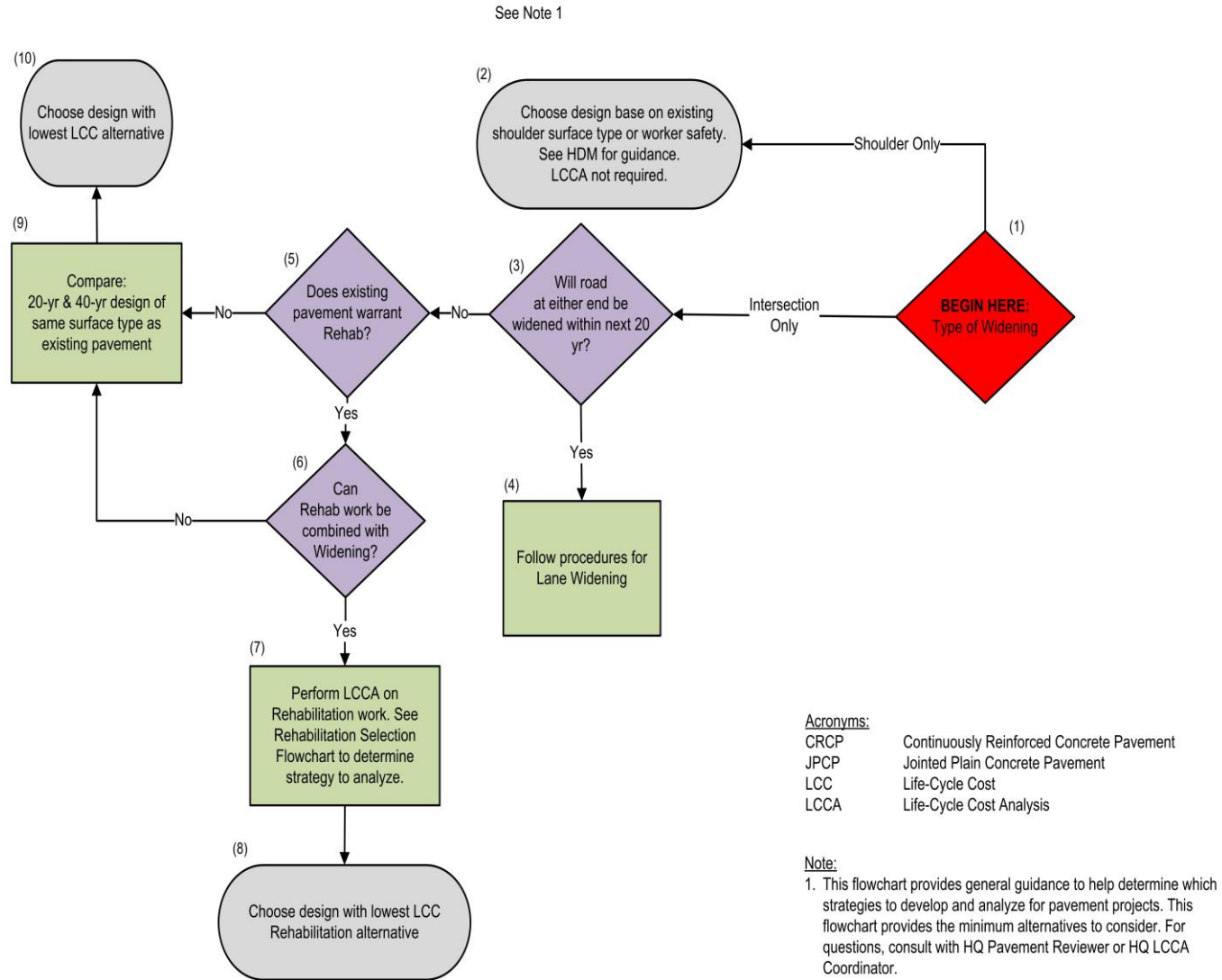


Figure 2-3 Shoulder and Intersection Widening Flowchart

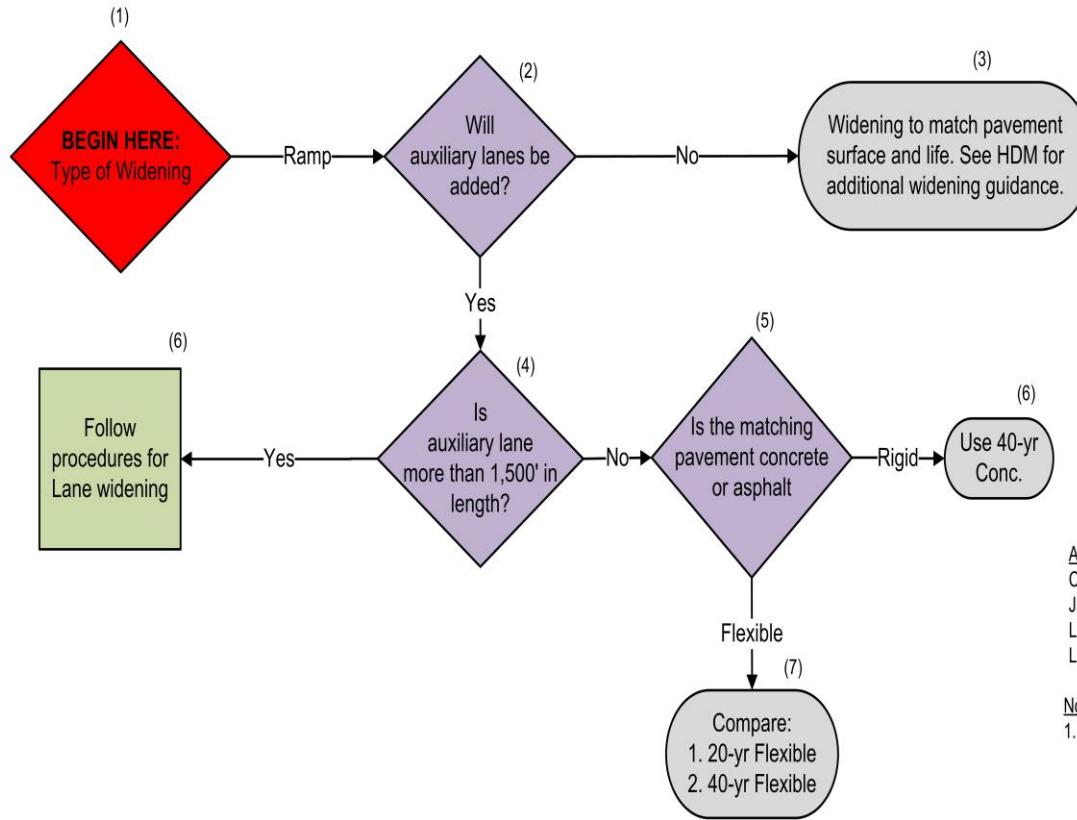
Instructions for Using Shoulder and Intersection Widening Flowchart

Using Figure 2-3:

- (1) Begin here, and then proceed to step (2) for Shoulder Widening or proceed to step (3) for Intersection Widening.
- (2) Choose design based on existing shoulder surface type or worker safety. See HDM for guidance. LCCA not required.
- (3) Decide if the existing road will be widened within the next 20-yrs. If yes proceed to step (4). If no, proceed to step (5).
- (4) Follow procedures for Lane Widening.
- (5) If the existing road does not need to be widened within the next 20 yrs, decide if the existing pavement warrants Rehab. If yes, proceed to step (6). If no, proceed to step (9).
- (6) If the existing pavement warrants rehabilitation, decide if rehabilitation can be combined with widening. If yes, proceed to step (7). If no, proceed to (9).
- (7) If rehabilitation and widening can be combined, perform LCCA on rehabilitation work. See rehabilitation selection flowchart to determine strategy to analyze. Proceed to step (8).
- (8) After LCCA on rehabilitation work, choose design with lowest LCCA rehabilitation alternative.
- (9) If the existing pavement does not warrant rehabilitation and cannot be combined with widening, compare 20-yrs & 40-yrs design of same surface type as existing. Proceed to step (10).
- (10) After comparing alternatives from step (9), choose design with lowest LCC alternative.

LCCA WIDENING PAVEMENT TYPE SELECTION FLOWCHART

See Notes



Acronyms:
 CRCP Continuously Reinforced Concrete Pavement
 JPCP Jointed Plain Concrete Pavement
 LCC Life-Cycle Cost
 LCCA Life-Cycle Cost Analysis

Notes:
 1. This flowchart provides general guidance to help determine which strategies to develop and analyze for pavement projects. This flowchart provides the minimum alternatives to consider. For questions, consult with HQ Pavement Reviewer or HQ LCCA Coordinator.

2. RHMA must be one of the competing alternatives when flexible pavement is being considered, unless RHMA is not viable for the project.

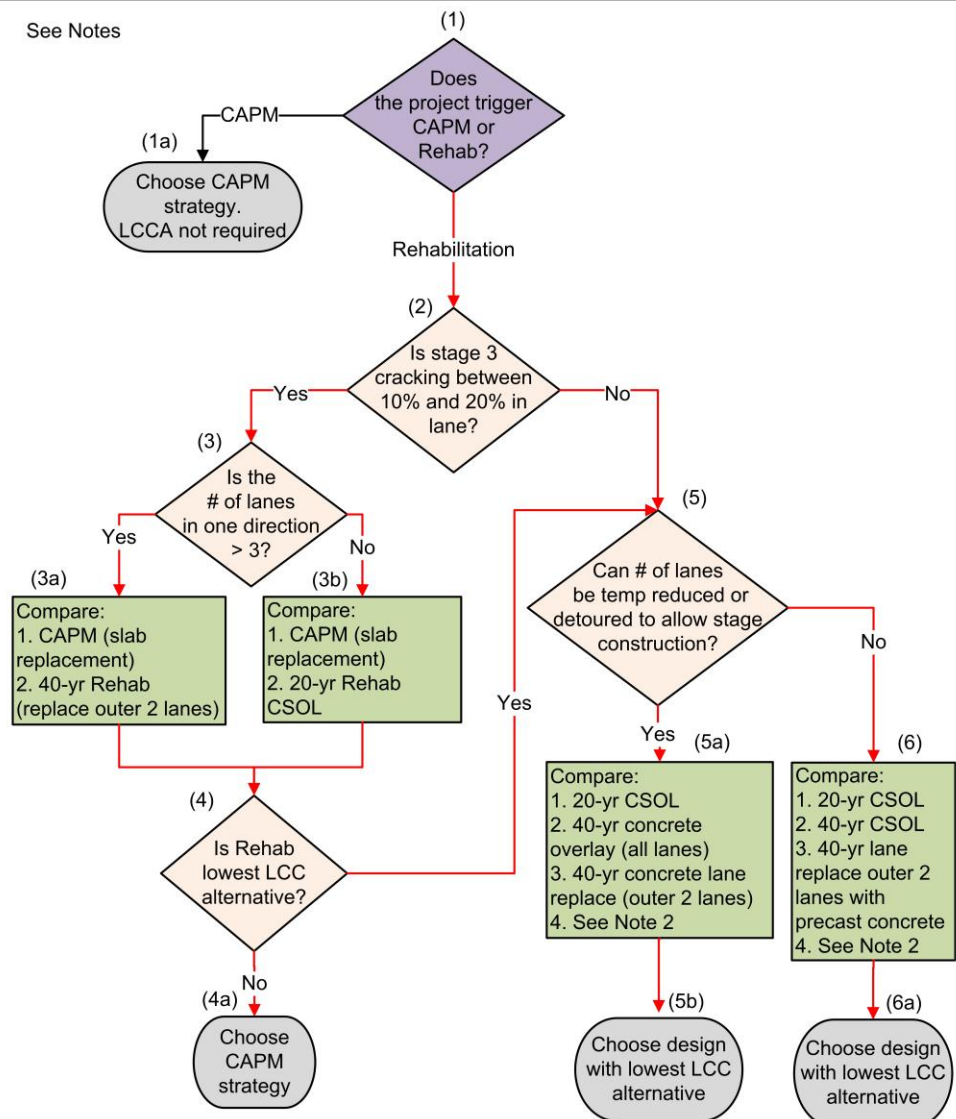
Figure 2-4 Ramp Widening Flowchart

Instructions for Using Ramp Widening Flowchart

Using Figure 2-4:

- (1) Begin here, and then proceed to step (2).
- (2) Decide if auxiliary lanes will be added. If yes, proceed to step (4). If no, proceed to step (3).
- (4) If auxiliary lanes are to be added, decide if lanes will have more than 1,500 feet in length. If yes, proceed to step (8). If no, proceed to step (5).
- (8) If auxiliary lane is more than 1,500 feet, follow procedures for lane widening.
- (5) If auxiliary lane is less than 1,500 feet, decide if the matching pavement is concrete or asphalt. If concrete proceed to step (6). If asphalt proceed to step (7).
- (6) If matching pavement is concrete, use 40 yr.
- (7) If matching pavement is asphalt, compare between 20-yr vs. 40 yr.
- (3) If no auxiliary lanes are to be added, widen ramp to match pavement surface and life. See HDM for additional widening guidance.

LCCA CAPM AND REHABILITATION PAVEMENT TYPE SELECTION FLOWCHART FOR EXISTING RIGID PAVEMENT



<p>Acronyms:</p> <p>CAPM Capital Preventive Maintenance CSOL Crack, Seat, and Overlay FDR Full Depth Reclamation LCC Life-Cycle Cost LCCA Life-Cycle Cost Analysis</p>	<p>Notes:</p> <p>1. This flowchart provides general guidance to help determine which strategies to develop and analyze for pavement projects. This flowchart provides the minimum alternatives to consider. For questions, consult with HQ Pavement Reviewer or HQ LCCA Coordinator.</p> <p>2. Where constraints exist, such as sound walls or floodplains, consult with HQ Pavement Reviewer or HQ LCCA Coordinator.</p> <p>3. RHMA must be one of the competing alternatives when flexible pavement is being considered, unless RHMA is not viable for the project.</p>
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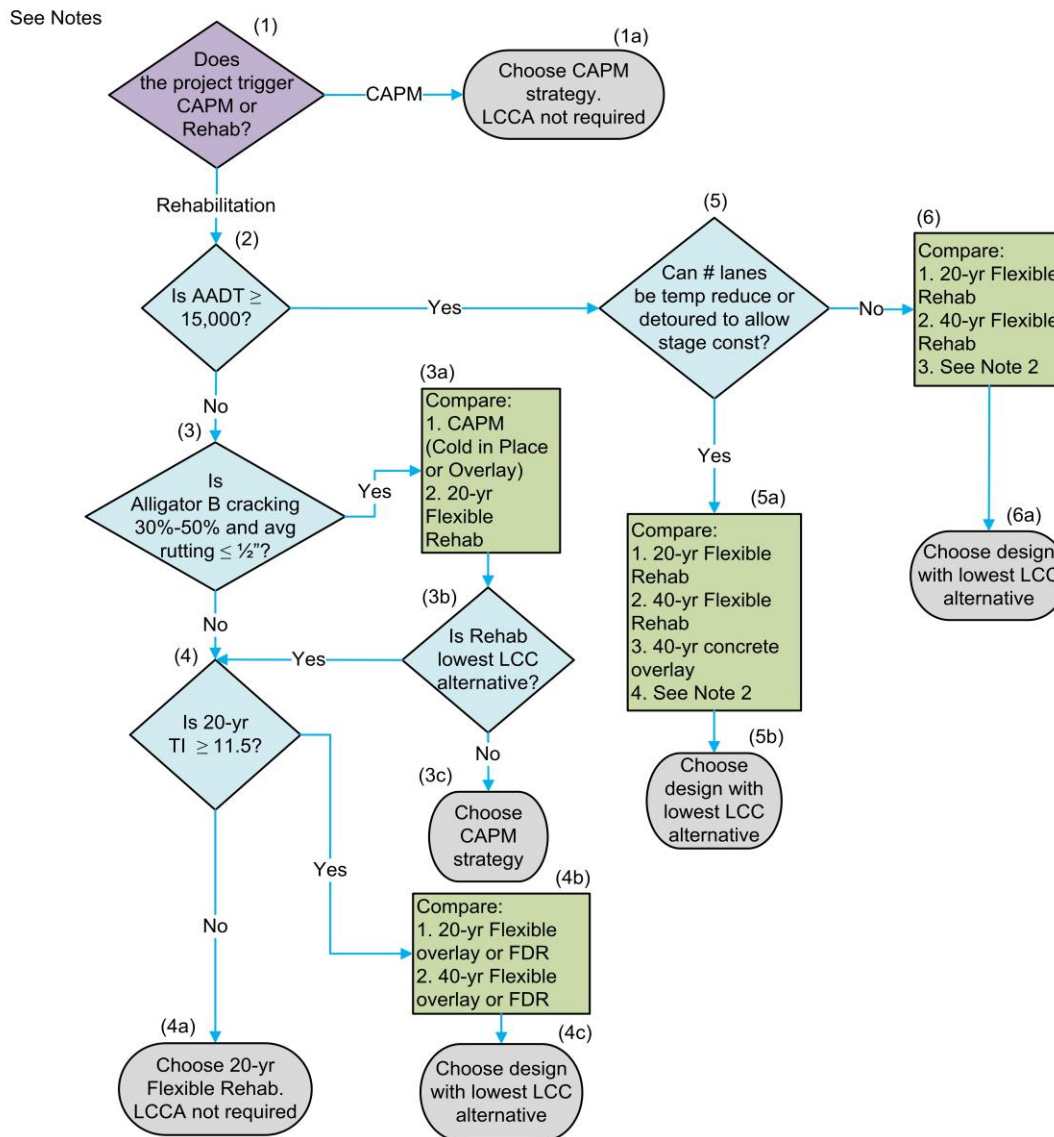
Figure 2-5 CAPM and Rehabilitation Pavement Alternatives Selection for Existing Rigid Pavement Flowchart

Instructions for Using CAPM and Rehabilitation Flowchart for Existing Rigid Pavement:

Using Figure 2-5:

- (1) Begin here and determine if the project is a CAPM or rehabilitation. Go to (1a) or (2).
 - (1a) If it is a CAPM, LCCA is not required.
- (2) If the project qualifies for rehabilitation determine if there is 10% to 20% stage 3 cracking. Refer to the Pavement Condition Report. Go to (3) or (5). Note: if the project has less than 10% stage 3 cracking, it is considered a CAPM project (refer to Design Information Bulletin 81).
- (3) If the pavement condition falls between 10% to 20% stage 3 cracking, determine if the number of lanes in one direction is greater than 3. Go to (3a) or (3b).
 - (3a) If the number of lanes in one direction is greater than 3, compare a CAPM slab replacement and a 40-year rehabilitation in which the outer two lanes being replaced with concrete. Go to (4).
 - (3b) If the number of lanes in one direction is 3 or less, compare a CAPM slab replacement with a 20-year crack, seat, and overlay (CSOL) rehabilitation. Go to (4).
- (4) If the CAPM strategy prevails as the lowest LCC, choose a CAPM strategy for your project (4a). If the CAPM does not give the lowest LCC, and the rehabilitation strategy is lower, go to (5) and run additional LCCA for further analysis.
 - (4a) Choose CAPM strategy.
- (5) Determine if stage construction can allow for lane reduction or detouring traffic. Go to (5a) or (6).
 - (5a) If the decision is “yes”, compare 20-year crack, seat, and overlay (CSOL), 40-year concrete overlay (white topping), and 40-year concrete lane replacement of the outer 2-lanes. Go to (5b).
 - (5b) If there constrains such as sound walls or floodplains which make these alternatives unviable, contact the HQ LCCA Coordinator, otherwise choose the rehabilitation strategy with the lowest LCC.
- (6) If you are unable to temporarily reduce the number of traffic lanes or detour the traffic, then compare 20-year CSOL, 40-year CSOL, and 40-year precast concrete lane replacement of the outer two lanes. Go to (6a).
 - (6a) If there constrains such as sound walls or floodplains which make these alternatives unviable, contact the HQ LCCA Coordinator, otherwise choose the rehabilitation strategy with the lowest LCC.

LCCA CAPM AND REHABILITATION PAVEMENT TYPE SELECTION FLOWCHART FOR EXISTING FLEXIBLE PAVEMENT



<p>Acronyms:</p> <p>CAPM Capital Preventive Maintenance CSOL Crack, Seal, and Overlay FDR Full Depth Reclamation LCC Life-Cycle Cost LCCA Life-Cycle Cost Analysis</p>	<p>Notes:</p> <p>1. This flowchart provides general guidance to help determine which strategies to develop and analyze for pavement projects. This flowchart provides the minimum alternatives to consider. For questions, consult with HQ Pavement Reviewer or HQ LCCA Coordinator.</p> <p>2. Where constraints exist, such as sound walls or floodplains, consult with HQ Pavement Reviewer or HQ LCCA Coordinator.</p> <p>3. RHMA must be one of the competing alternatives when flexible pavement is being considered, unless RHMA is not viable for the project.</p>
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Figure 2-6 CAPM and Rehabilitation Pavement Alternatives Selection for Existing Flexible Pavement Flowchart

Instructions for CAPM and Rehabilitation Flowchart for Existing Flexible Pavement:

Using Figure 2-6:

(1) Begin here and determine if the project is a CAPM or rehabilitation. Go to (1a) or (2).

(1a) If it is a CAPM, LCCA is not required.

(2) If the existing pavement is qualifies for rehabilitation, determine if the current year AADT is greater than or equal to 15,000. Go to (3) or (5).

(3) If the AADT is less than 15,000, determine if alligator B cracking is between 30% to 50% and average rutting is less than or equal to $\frac{1}{2}$ ". Go to (3a) or (4).

(3a) If the alligator B cracking is between 30% and 50% and average rutting is less than or equal to $\frac{1}{2}$ ", compare CAPM (cold in place) or overlay strategy and a 20-year flexible rehabilitation strategy. Go to (3b). (Note: if the project has less than 30% alligator B cracking, it is considered a CAPM project (refer to Design Information Bulletin 81).

(3b) Decide if the rehabilitation is the lowest LCC. If no, go to (3c). If yes, go to (4).

(3c) If the rehabilitation is not the lowest LCC, then choose the CAPM strategy.

(4) If alligator B cracking is greater than 50% or average rutting is greater than $\frac{1}{2}$ " check to see if the 20-year TI is greater than or equal to 11.5. Go to (4a) or (4b).

(4a) If the TI is less than 11.5, then choose a 20-year flexible rehabilitation. LCCA is not required.

(4b) If the TI is greater than or equal to 11.5, compare 20-year flexible overlay or full depth reclamation (FDR) with 40-year flexible overlay or FDR. Go to step (4c).

(4c) Choose the alternative with the lowest LCC alternative.

(5) If the AADT is greater than 15,000, determine if the number of lanes can be temporarily reduced or if there is a viable detour to allow construction staging. If yes, go to step (5a). If no, go to step (6).

(5a) If stage construction allows for lane reduction or detour, compare 20-year flexible rehabilitation, 40-year flexible rehabilitation, and 40-year concrete overlay (white topping). Go to step (5b).

(5b) If there constrains such as sound walls or floodplains which make these alternatives unviable, contact the LCCA coordinator, otherwise choose the rehabilitation strategy with the lowest LCC.

(6) If lanes cannot be reduced or detoured, compare 20-year flexible rehabilitation with a 40-year rehabilitation. If these pavement alternatives are not feasible, refer the issues to the Pavement Reviewer or the LCCA Coordinator. Go to step (6a)

(6a) Choose the alternative with the lowest LLC.

Additional Provisions for Selecting Alternatives

The pavement selection flowcharts provide guidance on what pavement alternatives to compare. As a reminder, the following provisions were incorporated into the flow charts development:

1. Rubberized Hot Mix Asphalt (RHMA) must be one of the competing alternatives when flexible pavement is being considered unless RHMA is not viable for the project. If RHMA is not a viable alternative, justification must be included in the Project Initiation Document (PID) or the Project Report (PR). For further information on when and how to use RHMA, see HDM Index 631.3 and the Asphalt Rubber Usage Guide.
2. The alternatives being evaluated should provide equivalent improvements or benefits. For example, comparison of 20-year and 40-year rehabilitation alternatives or comparison of new construction of flexible or rigid pavement alternatives is valid because the alternatives offer equivalent improvements. Conversely, comparing alternatives such as pavement rehabilitation to adding lanes, or overlay to drainage repair, do not result in equivalent benefits. Projects that provide different benefits should be analyzed using a Benefit-Cost Analysis (BCA), which considers the overall benefits (safety, environmental, social, etc.) of an alternative as well as the costs. For further information on BCA, refer to the Life-Cycle/Benefit-Cost Model (Cal-B/C) user manuals and technical supplements, which are available from the Division of Transportation Planning website at <http://www.dot.ca.gov/hq/tpp/tools.html>.

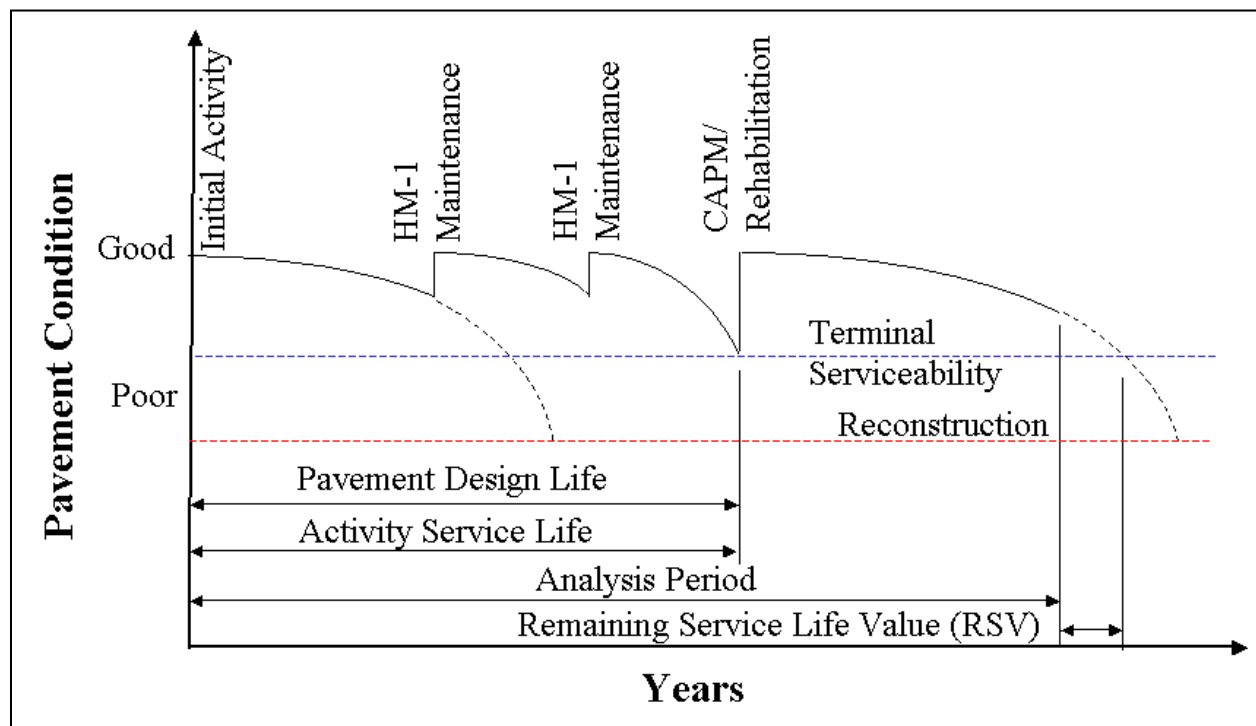
2.4 Analysis Period

The *analysis period* is the period of time during which the initial and any future costs for the project pavement alternatives will be evaluated. Table 2-1 provides the common analysis periods to be used when comparing alternatives of a given design life or lives. When comparing two or more alternatives, determine the analysis period based on the longest design life. For example, an analysis period of 35 years should be used if CAPM and 20-year design life alternatives are compared; and an analysis period of 55 years if 20-year and 40-year design lives are compared.

Table 2-1 LCCA Analysis Periods

Alternative Life	CAPM	20-Yr	More than 20 years
CAPM	20 years	35 years	55 years
20-Yr	35 years	35 years	55 years
More than 20 years	55 years	55 years	55 years

LCCA assumes that the pavement will be properly maintained and rehabilitated to carry the projected traffic over the specified analysis period. As the pavement ages, its condition will gradually deteriorate to a point where some type of maintenance or rehabilitation treatment is warranted. Thus, after the initial construction, reasonable maintenance and rehabilitation (M&R) strategies must be established for the analysis period. Figure 2-7 shows the typical relationship between pavement condition and pavement life when appropriate maintenance and rehabilitation strategies are applied in a timely manner.



Note: see Appendix 1, "Glossary and List of Acronyms," for definitions of terms used in the figure.

Figure 2-7 Pavement Condition vs. Years

Additional information about M&R strategies for various types of pavements can be found in Section 2.7, "Maintenance and Rehabilitation Sequences."

2.5 Traffic Data

The Traffic data needed to conduct LCCA are:

1. Construction year AADT (both directions)
2. Total truck percentage
3. 2-axle percentage truck AADT
4. Annual growth rate of traffic percentage
5. Traffic index
6. Lane closure chart

2.6 Discount Rate

Discount rate is the interest rate by which future costs (in dollars) will be converted to present value. In other words, it is the percentage by which the cost of future benefits will be reduced to present value (as if the future benefit takes place in the present day). Real discount rates (as opposed to nominal discount rates) reflect only the true time value of money without including the general rate of inflation. Real discount rates typically range from 3% to 5% and represent the prevailing interest of U.S. Government 10-year Treasury Notes. **Caltrans currently uses a discount rate of 4% in the LCCA of pavement structures.**

2.7 Maintenance and Rehabilitation Sequences

After viable alternatives are identified and the information is gathered, determine the pavement M&R schedule for each pavement alternative. Pavement M&R schedules identifies the sequence and timing of future activities that are required to maintain and rehabilitate the pavement over the analysis period.

Pavement M&R schedules found in Appendix 4 of this manual must be used in the LCCA for pavement projects on the State Highway System. To determine the applicable pavement M&R schedule for a pavement alternative in Appendix 4, the following information is needed:

- 1) *Existing/New Pavement Type*. The types are: flexible, rigid, and composite.
- 2) *Pavement Climate Region*. There are five groups of climate regions; see map in Figure A4-1, Appendix 4, which is also available on the Pavement Engineering website. Table 2-2 shows the difference between the “Caltrans Climate Regions” and the “Climate Regions for Pavement M&R Schedules”.

Table 2-2 Caltrans Climate Region Classification

Caltrans Climate Regions	Climate Regions for Pavement M&R Schedules
North Coast	All Coastal
Central Coast	
South Coast	
Inland Valley	Inland Valley
High Mountain	High Mountain and High Desert
High Desert	
Desert	Desert
Low Mountain	Low Mountain and South Mountain
South Mountain	

- 3) *Project Type*. The types are: New Construction/Reconstruction, CAPM, and Rehabilitation.
- 4) *Final Pavement Surface Type*. The final pavement surface type is the pavement alternative being investigated for LCCA. Options include:
- Hot Mix Asphalt (HMA)
 - Hot Mix Asphalt with Open Graded Friction Course (HMA w/ OGFC)
 - Hot Mix Asphalt with Rubberized Hot Mix Asphalt (HMA w/ RHMA)
 - Rubberized Hot Mix Asphalt-Gap Graded (RHMA-G)
 - Rubberized Hot Mix Asphalt-Gap Graded with Rubberized Hot Mix Asphalt-Open Graded (RHMA-G w/ RHMA-O)
 - Jointed Plain Concrete Pavement (JPCP)
 - Continuously Reinforced Concrete Pavement (CRCP)
- 5) *Pavement Design Life*. See the HDM Topic 612 for guidance.
- 6) *Maintenance Service Level (MSL)*. MSL is the state highway classification used by the Division of Maintenance for maintenance program purposes. From the Pavement Condition Survey, a 'Priority Number' for the project can be found. Then using Table 2-3, MSL can be found. Refer to Appendix 1, "Glossary and List of Acronyms," for further definition of MSL.

Table 2-3 Priority Matrix

Ride Quality	Structural Distress	MSL 1	MSL 2	MSL 3
		Priority Number	Priority Number	Priority Number
Poor Ride	Major	1	2	11
	Minor	3	4	12
	None	5	6	12
Acceptable Ride	Major	7	8	13
	Minor	9	10	14
	None	31, 32, 33	31, 32, 33	31, 32, 33
	No Distress	98, 99	98, 99	98, 99

These M&R schedule tables are integrated into the *RealCost Version 2.5CA* program. The program automatically selects the appropriate M&R schedule, based on the input of the project type, pavement design life, pavement climate region, and MSL. Select the schedule that closely matches the project scope and follow the rehabilitation sequence.

The use of precast panel concrete pavement is currently under development by Caltrans. It offers the potential of rapid construction using materials that are cast and cured away from the construction site which and produce a more durable longer lasting pavement than other options. Please contact the HQ LCCA Coordinator for current information on precast concrete panel concrete pavement M&R schedule, production rate, and cost.

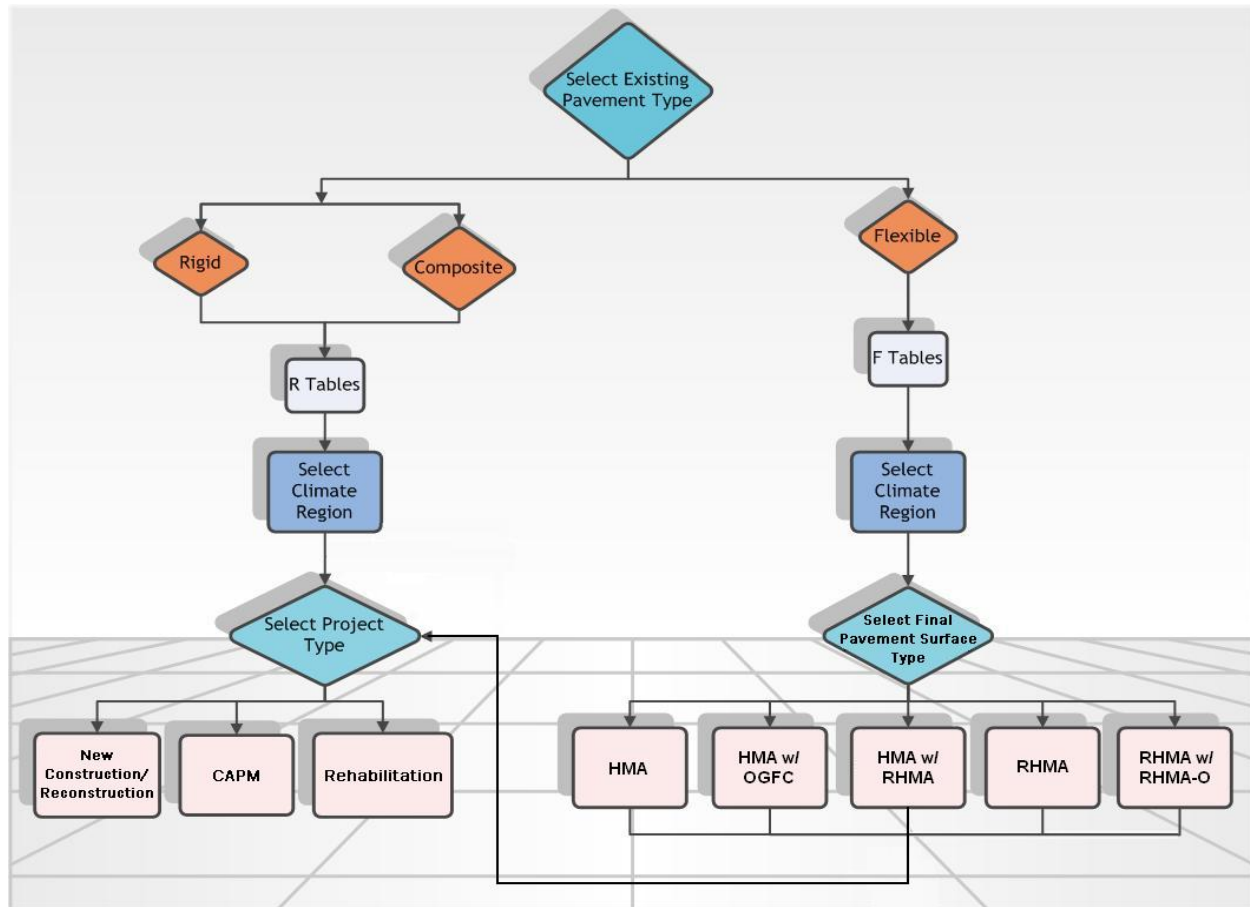


Figure 2-8 Pavement M&R Schedule Determination Flow Chart

Figure 2-9 shows an example of the Pavement M&R Schedules found in Appendix 4 for pavements with RHMA surface type in the State’s “coastal” climate region. The M&R schedule tables have been derived from the “Pavement M&R Decision Trees” prepared by each Caltrans district and experience with pavement performance in California (*Note: these schedules assume there will be no early failures*). As shown in Figure 2-9, the M&R schedules include the initial alternative as well as the future CAPM, rehabilitation, or reconstruction activities and their estimated service lives (see “Activity Service Life (years)” box in Figure 2-9. Interim maintenance treatments such as Major Maintenance (HM-1) projects and work by maintenance field crews performed between each scheduled activity have been converted into an annualized maintenance cost in dollars per lane mile (\$/lane-mile).

TABLE F-1 (d) All Coastal Climate Regions RUBBERIZED HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE																		
Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55			
New Construction/Reconstruction																		
RHMA	20	1,2	Year of Action		0				22		28				50			
			Activity Description		New / Reconstruct				CAPM RHMA		Rehab RHMA (20 yr)				CAPM RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,200	6	900	22	2,500	6	900						
		3	Year of Action		0				22				32				42	
			Activity Description		New / Reconstruct				CAPM RHMA				CAPM RHMA				Rehab RHMA (20 yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,200	10	4,100	10	4,000	9	4,400	22	2,500				
CAPM																		
RHMA	5+	1,2	Year of Action		0		6		28		34							
			Activity Description		CAPM RHMA		Rehab RHMA (20 yr)		CAPM RHMA		Rehab RHMA (20 yr)							
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	6	900	22	2,500	6	900	22	2,500						
		3	Year of Action		0		10		20		29				51			
			Activity Description		CAPM RHMA		CAPM RHMA		CAPM RHMA		Rehab RHMA (20 yr)				CAPM RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	4,000	10	4,100	9	4,400	22	2,500	10	4,000				
Rehabilitation																		
RHMA	20	1,2,3	Year of Action		0				22		28				50			
			Activity Description		Rehab RHMA (20 yr)				CAPM RHMA		Rehab RHMA (20 yr)				CAPM RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,500	6	900	22	2,900	6	900						

Note: These tables are now an integrated part of *RealCost Version 2.5CA* and are automatically entered with the alternative selections.

Figure 2-9 Example of Pavement M&R Schedule

EXAMPLE 2.1**Using: RealCost Version 2.5CA**

Suppose that one of the alternatives being considered for flexible pavement is a “Rehabilitation HMA w/ RHMA” located in the north coast climate region with a maintenance service level of 2. Since the project is Rehabilitation, the design year is 20 years. To determine the appropriate pavement M&R schedule, select these options in the M&R panel section of RealCost Version 2.5CA, and the maintenance schedules for the alternative will be automatically entered into the program.

Using: Appendix 4 Table Lookup (1)

The M&R schedule can be chosen from Appendix 4. Since the project is in the north coast region, select the M&R schedules with the heading “All Coastal Regions”. Next, find among the selected schedules the one that addresses the final pavement surface type for the alternative being considered, for this example “Hot Mix Asphalt w/ RHMA”. Thus, the appropriate schedule will have the heading “Table F-1 (c), All Coastal Climate Regions, Hot Mix Asphalt w/ RHMA Pavement Maintenance and Rehabilitation Schedule”. Finally, knowing that the project type is Rehabilitation and the MSL is 2, we can find the appropriate row and sequence. In this example, the sequence is the seventh row from the top. From this schedule, it can be determined that the Rehab HMA w/ RHMA alternative is expected to last 23 years and the annualized cost for maintenance (HM-1) is estimated at \$3,500 per lane-mile over the activity service life. The M&R schedule also calls for a “CAPM HMA W/ RHMA” at year 23 after the implementation of the Rehab HMA w/ RHMA alternative. This rehab has an annualized maintenance cost of \$3,500 per lane-mile over a 10 year activity service life.

Note (1): Tables in Appendix 4 included in RealCost Version 2.5CA Program.

2.8 Estimating Costs

Life-cycle costs include two types of cost: agency costs and user costs.

2.8.1 Agency Costs

Agency costs are direct costs. These costs are an estimate of what it would cost Caltrans to build, maintain, and extend the life of the pavement. Agency costs include initial, maintenance, rehabilitation (including CAPM), support, and remaining service life value costs.

2.8.2 User Costs

User costs are indirect costs (not directly borne by Caltrans). These costs are measured in dollars, which are associated with the additional travel time and related vehicle operating

costs incurred by the traveling public due to construction traffic delays from initial construction and future rehabilitation activities.

Best-practice LCCA calls for consideration of not only agency costs, but also costs to roadway users. *User costs* include travel time costs and vehicle operating costs (excluding routine maintenance) incurred by the traveling public. User costs arise when work zones restrict the normal flow of the facility and increase the travel time of the user by generating queues or speed change through the work zones. Although user costs are also incurred during normal operations, they are not considered in LCCA because normal travel costs are not dependent on individual project alternatives. User costs are given serious consideration and can become a significant factor when a large queue occurs for a given alternative, since Caltrans' duty is to serve the public. These user costs are computed within *RealCost Version 2.5CA*.

2.8.3 Initial Costs

Initial costs must include estimated construction costs to be borne by an agency for implementing a project alternative. The initial construction costs (first activity in the M&R sequence) are determined from the engineer's estimate. Costs for mainline and shoulder pavement, base, subbase, pavement drainage, joint seals, earthwork, traffic control, and time-related overhead should be included. The following items should not be included:

- Add-on costs such as minor items, supplemental work, mobilization, and contingencies.
- Right of way costs.
- Project support costs for design, environmental, project management, construction administration and inspection, etc.

These above items are not included because their actual costs (at PS&E) between alternatives are typically and should be assumed to be equivalent.

Construction costs that will not change between alternatives — such as bridges, traffic signage, and striping — may be excluded if those costs can be separated from the rest of the estimate. In other words, if there are common pay items that are the same between alternatives, they do not need to be included in the initial construction cost estimate.

The initial costs for each alternative must be estimated to the same level of detail and accuracy for all alternatives. This includes needed items of work which may differ with each alternative. Examples of items that are often overlooked in estimating alternatives include:

- Costs to replace pavement at transition tapers and to maintain bridge clearance.
- Costs of pre-overlay repairs for overlay strategies such as digouts and slab replacements.
- Cost to shoulder pavement placement/replacement (including shoulder backing costs).

See the PDPM for information and work sheets for estimating costs in the PID and the PR. A sample initial construction cost estimate spreadsheet can be found on the LCCA website.

2.8.4 Maintenance Costs

Maintenance costs include costs for routine, preventive, and corrective maintenance, such as joint and crack sealing, void undersealing, chip seal, patching, spall repair, individual slab replacements, thin HMA overlay, etc., whose purpose is to preserve the service life of a pavement. Caltrans uses the annualized maintenance costs included in the pavement M&R schedules in Appendix 4. These annualized costs are based on the “Pavement M&R Decision Trees” prepared by each Caltrans district and historical cost data collected by the Division of Maintenance.

2.8.5 Rehabilitation Costs

Rehabilitation (including CAPM) costs for a particular activity should include costs for project support and costs for all the necessary appurtenance work for drainage, safety, and other features.

After an applicable pavement M&R sequence for the pavement alternatives is selected within the *RealCost Version 2.5CA* program (as discussed in Section 2.6, “Maintenance and Rehabilitation Sequences”), use the program to estimate the cost of future rehabilitation activities to be performed after initial construction. For those future rehabilitation activities whose project type is the same as the proposed project alternative, the engineer can assume its rehabilitation costs to be the same as the initial costs estimated for the project alternative.

2.8.6 Future Project Support Costs

Costs for future project support should be estimated based on the costs identified in the proposed future activity for a project alternative, such as for design, environmental, project management, construction administration and inspection, etc. *RealCost Version 2.5CA* has default values built into the program which includes the Agency Support Cost Multiplier. The Agency Support Costs are added to the Agency Construction Costs to determine the total Agency Costs.

For future rehabilitation projects, the *RealCost Version 2.5* uses the following assumptions to estimate total Agency Costs:

- Miscellaneous cost is 10% of the calculated pavement costs. These are miscellaneous items such as joint seal, tack coat, drainage, etc.
- Traffic handling is assumed to be \$2,000 per day.
- COZEEP is assumed to be \$2,000 per day. This assumes work zone closures requiring CHP enforcement. This option can be omitted if COZEEP is not anticipated.
- Other traffic costs are assumed to be \$2,000 per day. This includes additional traffic handling cost such as k-rail.

- Indirect costs, or contingency costs, are computed at 20% of the project construction costs.
- Support costs are computed at 25% of the project construction costs.

For future CAPM projects, the *RealCost Version 2.5* uses the following assumptions to estimate total Agency Costs:

- Traffic handling is assumed to be \$2,000 per day.
- COZEEP is assumed to be \$2,000 per day. This option can be omitted if COZEEP is not anticipated.
- Indirect costs are computed at 20% of the project construction costs.
- Support costs are computed at 20% of the project construction costs.

The indirect and support cost percentages come from the SHOPP programming estimation.

2.8.7 Remaining Service Life Value

If an activity, typically the last rehabilitation activity, has a service life that exceeds the end of the Analysis Period (AP), the difference is known as the *Remaining Service Life Value* (RSV). Any rehabilitation activities (including the initial construction), except for the last rehabilitation activity within the AP, will not have a RSV. The RSV of a project alternative at the end of the analysis period is calculated by prorating the total construction cost (agency and user costs) of the last scheduled rehabilitation activity.

2.8.8 Calculating Life-Cycle Costs

Calculating life-cycle costs involves direct comparison of the total life-cycle costs of each pavement alternative. However, dollars spent at different times have different present values, the anticipated costs of future rehabilitation activities for each alternative need to be converted to their value at a common point in time. This is an economic concept known as “discounting.”

A number of techniques based upon the concept of discounting are available. FHWA recommends the present value (PV) approach, which brings initial and future costs to a single point in time, usually the present or the time of the first cost outlay. The equation to discount future costs to PV is:

$$PV = F \frac{1}{(1+i)^n} \quad (\text{Equation 2-1})$$

Where:

F = future cost at the end of nth years

i = discount rate

n = number of years

The equivalent uniform annual cost (EUAC) approach is also used nationally. It produces the yearly costs of an alternative as if they occurred uniformly throughout the analysis period. The PV of this stream of EUAC is the same as the PV of the actual cost stream. Whether PV or EUAC is used, the decision supported by the analysis will be same. **Caltrans requires the LCCA results to be documented using the present value approach.**

CHAPTER 3 REALCOST VERSION 2.5CA

3.1 Methodology

This chapter discusses LCCA methodology in detail, along with *RealCost Version 2.5CA* installation and operation instructions, which will allow the engineer to effectively utilize the program to perform LCCA. This chapter shows the engineer the *RealCost Version 2.5CA* input panels with detailed step-by-step instructions on how to successfully execute the program.

1. Gather project information:

- Existing pavement type
- Project scope
- Project location
 - Post mile limit
 - Climate region
- Expected construction year
- Traffic information
 - AADT for Construction Year (total for both directions)
 - Single Unit Truck Percentage
 - Combination Truck Percentage
 - Annual Growth Rate of Traffic
 - Operating Speed
 - Number of lanes (each direction)
 - Traffic Hour Distribution (if available)
 - Lane closure window
- Remaining service life of existing pavement (for widening)
- Maintenance Service Level (MSL)

2. Select pavement alternatives.

Use the Pavement Type Selection Flowcharts as specified in Section 2.3.1 or the preferred methodology recommended by your district for selecting pavement alternatives. Selection of pavement alternatives must follow the requirements specified in Section 2.3 of this manual.

After selecting the pavement alternatives, determine the pavement structure associated with their design lives and estimate initial construction costs.

3. Determine the "Analysis Period."

Once the alternatives are selected, use Table 2-1 to determine the appropriate analysis period.

4. Determine the traffic flow information.

Use Table 3-1 to determine the traffic flow inputs for *RealCost Version 2.5CA*. Traffic flow inputs include:

- Maximum AADT total for both traffic directions
- Free Flow Capacity of the facility

- Queue Dissipation Capacity of Work Zone
 - Expected maximum queue length
5. Determine the future rehabilitation sequence.
For each pavement alternative selected, *RealCost Version 2.5CA* retrieves the recommended M&R schedule for future maintenance and rehabilitation activities. Appendix 4 lists the database for the various maintenance sequences, which are incorporated in *RealCost Version 2.5CA*.
 6. Determine initial construction cost.
See Section 2.8.3 for information on how to develop initial construction costs.
 7. Determine the future rehabilitation cost.
There is a cost associated with each of the future rehabilitation activities in the sequence. See Section 3.5.3 for information on how to determine these costs.
 8. Determine the “Work Zone Duration.”
Work Zone Duration (WZD) is the estimated number of days lane closures are in effect for the entire project construction work. For each alternatives and activities, determine the WZD. For initial construction WZD, it is advised to consult with area Construction Engineer to verify the estimate. For each future rehabilitation activity WZD, use Tables 3-4 to 3-7 as shown in this chapter.
 9. Evaluate the results.

Developing quality input data and knowing how to use it to best estimate the life-cycle cost is the true challenge of the analysis. Use your engineering judgment.

3.2 Installing & Starting *RealCost Version 2.5CA*

3.2.1 Installation

In order to prepare a life-cycle cost estimate using *RealCost Version 2.5CA*, the software must first be installed. The software can be downloaded from:
<https://dot.ca.gov/programs/maintenance/pavement/concrete-pavement-and-pavement-foundations/life-cycle-cost-analysis>.

Follow the installation instructions provided on the website. Because *RealCost Version 2.5CA* is an add-on program designed to run in Microsoft Excel 2007 (or later), it should not require installation by Caltrans’ IT staff.

3.2.2 Start Up

Select “*RealCost Version 2.5CA*” from the Windows “Start Menu”, Programs > RealCost > RealCost 2.5CA, or from a shortcut on your desktop to launch the program.

When prompted by Excel, choose “Enable Macros” to run *RealCost Version 2.5CA*. Excel will also prompt a message regarding Active X controls. Click “OK” to dismiss the message as shown in Figure 3-1.

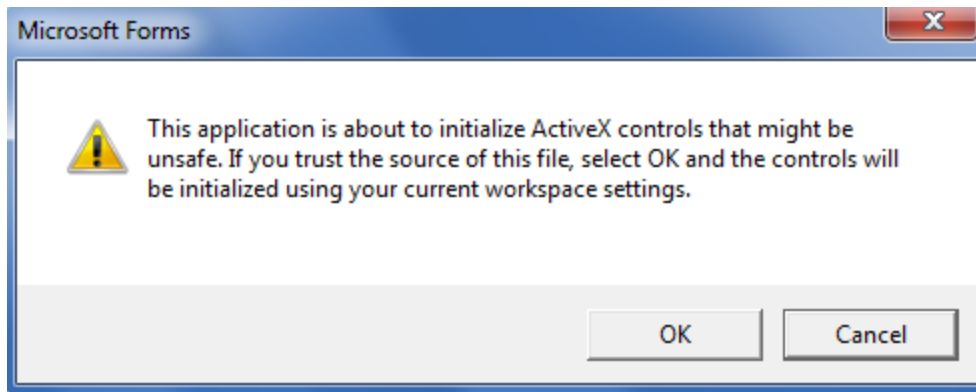


Figure 3-1 Active X Control Excel Message

Immediately after the worksheet appears, the “Switchboard” panel will open over it. If the “Switchboard” does not appear, go to the “Tools” drop down menu, select “Macro,” and change the security to medium. If the “Switchboard” is closed, it can be reopened by clicking the “Click to START” button, as shown in Figure 3-2, located in the “start” tab of the spreadsheet (first tab).

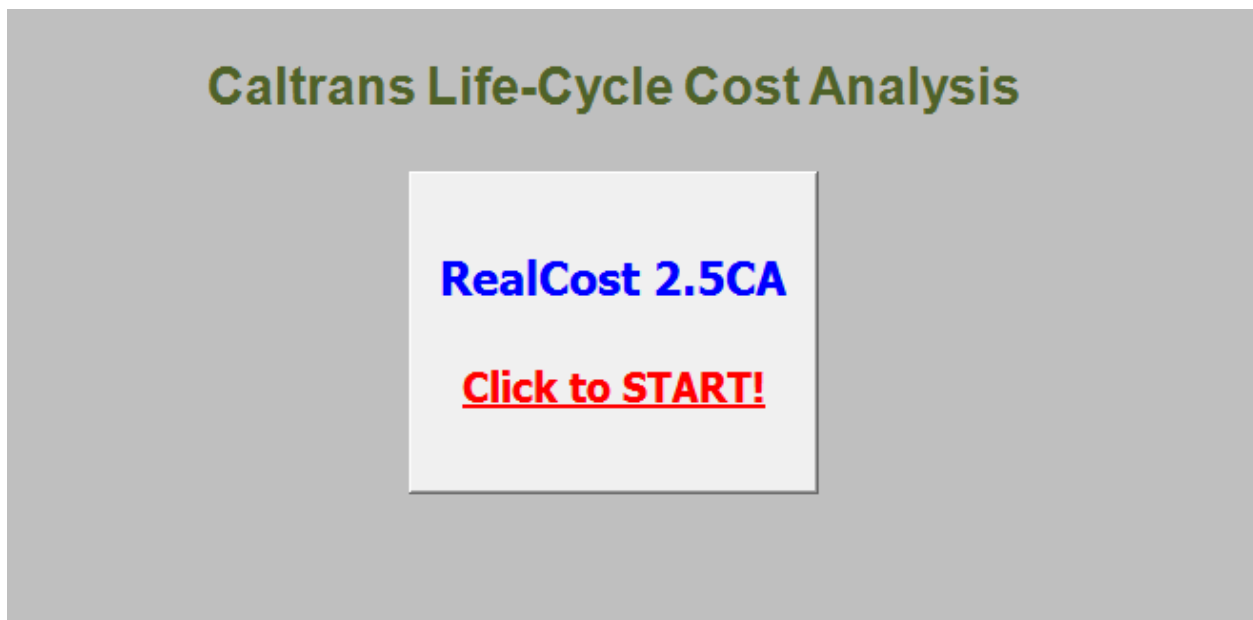


Figure 3-2 Initial Panel “Click to START”

3.3 *RealCost Version 2.5CA* Program Operations

Figure 3-3 shows the “Switchboard” for the *RealCost Version 2.5CA* program. This is the backbone or main menu for using the program, and it allows navigation between the sections.

The “Switchboard” consists of five sections as shown in Figure 3-3. The sections are listed as:

- Project-Level Inputs
- Alternative-Level Inputs
- Input Warnings
- Simulation and Outputs
- Administrative Functions

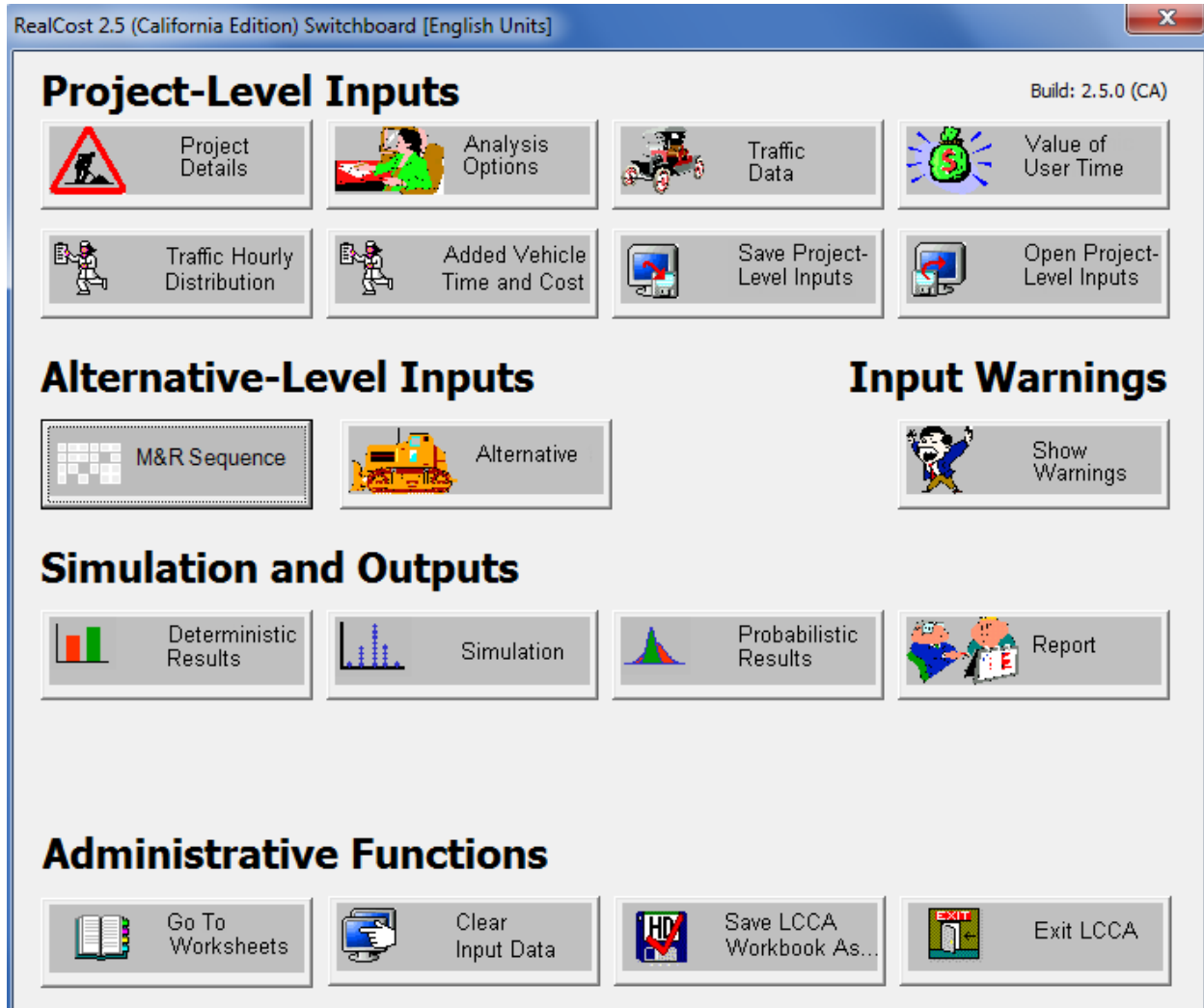


Figure 3-3 *RealCost Version 2.5CA* “Switchboard”

Note:

The program allows you to input data through the “Switchboard”. This chapter contains instructions for entering information by using the “Switchboard” which must be use. “Worksheets” are available for the engineer to view, which show the data for the project. The “Worksheets” should not be used to change data directly on them.

The “Switchboard” can be closed by clicking the “X” in the upper right-hand corner. To restore it later, click the “Click to START” in the start menu box.

3.4 Project-Levels Inputs

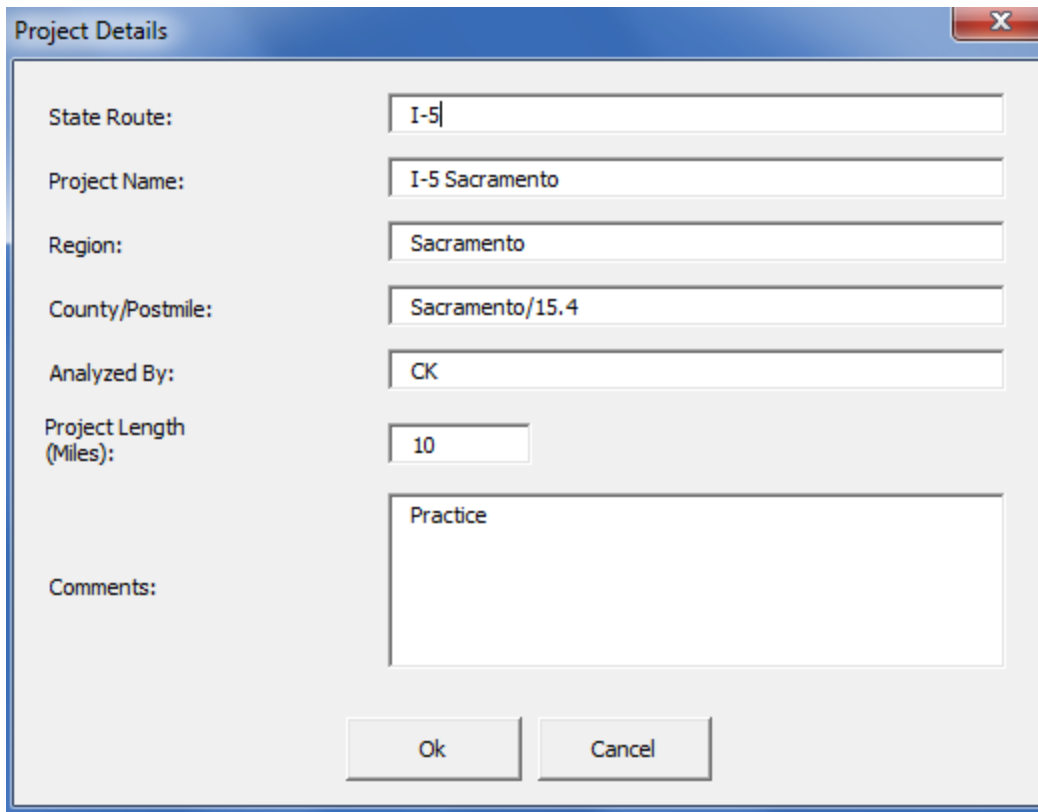
Gathering the necessary project information may be challenging and may require that the engineer be resourceful in finding all the data resources. Information can be obtained on the Caltrans website, while other data needs can be filled by contacting functional units within the District for information.

The information should include the following:

- Existing pavement type (Project inspection)
- Remaining service life of existing pavement (for widening) (District Maintenance or Materials Unit)
- Project location (PID and project programming)
- Project climate region (Caltrans climate map – see LCCA website)
- Project scope (PID and project programming)
- Potential final pavement surface type & project type
- Maintenance Service Level
- Expected construction year (Funding information and PID)
- Construction scheme such as staging, direction, construction windows, etc.
- Traffic information (i.e. Caltrans Traffic Operations website)

3.4.1 “Project Details” Input

The “Project Details” panel is shown in Figure 3-4 and is used to enter the project information details. Except for “Project Length” input data, information entered here will not be used in the analysis. This information is used to identify the project. “Project Length” input is used to automatically estimate the annualized maintenance cost in the “Alternative” input panel, as discussed in section 3.5.2. Once all the project documentation details are entered, click the “Ok” button to return to the “Switchboard” or the “Cancel” button to start over.



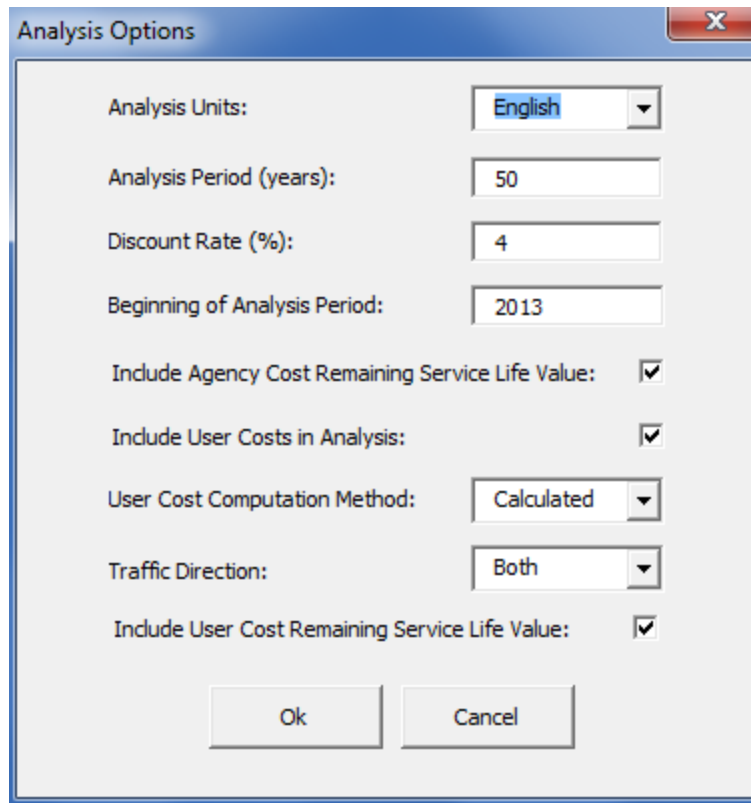
The image shows a software dialog box titled "Project Details". It contains several input fields and a text area. The fields are: "State Route:" with the value "I-5"; "Project Name:" with the value "I-5 Sacramento"; "Region:" with the value "Sacramento"; "County/Postmile:" with the value "Sacramento/15.4"; "Analyzed By:" with the value "CK"; "Project Length (Miles):" with the value "10"; and a "Comments:" text area containing the word "Practice". At the bottom of the dialog are "Ok" and "Cancel" buttons.

State Route:	I-5
Project Name:	I-5 Sacramento
Region:	Sacramento
County/Postmile:	Sacramento/15.4
Analyzed By:	CK
Project Length (Miles):	10
Comments:	Practice

Figure 3-4 Project Details Panel

3.4.2 "Analysis Options" Input

The "Analysis Options" panel, as shown in Figure 3-5, is used to define values that will be applied to all pavement alternatives in the analysis. This panel is where the actual analysis input for the project begins. The data inputs and analysis options available on this panel are detailed below.



The screenshot shows a dialog box titled "Analysis Options". It contains the following settings:

- Analysis Units: English
- Analysis Period (years): 50
- Discount Rate (%): 4
- Beginning of Analysis Period: 2013
- Include Agency Cost Remaining Service Life Value:
- Include User Costs in Analysis:
- User Cost Computation Method: Calculated
- Traffic Direction: Both
- Include User Cost Remaining Service Life Value:

Buttons: Ok, Cancel

Figure 3-5 Analysis Options Panel

- ***Analysis Units:*** Select either “English” or “Metric” to set the units to be used in the analysis. Caltrans uses “English” units for cost estimate purposes.
- ***Analysis Periods (years):*** Enter an analysis period (in years) during which project alternatives will be compared. Table 2-1 lists appropriate analysis periods. **When comparing three or more alternatives, determine the analysis period using the longest design life.**
- ***Discount Rate (%):*** Enter the Caltrans default value of 4 percent for deterministic analysis.
- ***Beginning of Analysis Period:*** Enter the year in which construction of the project alternative is expected to begin. This is the same as the construction year ADT found in the design designation or traffic projections for the project, which are provided by the Traffic Forecasting Unit (see Figure 3-6 from HDM Index 103.1). This should be the same year as the construction year AADT from the design designation, typically, the end of construction year. If the project did not require a design designation (i.e. traffic projections) or traffic projections were not done, use the year you expect the project will end construction.

ADT (2015) = 9800	D = 60%
ADT (2035) = 20 000	T = 12%
DHV = 3000	V = 70 mph
ESAL = 4 500 000	TI ₂₀ = 11.0

Figure 3-6 Design Designation

- **Include Agency Cost Remaining Service Life Value:** Select the checkbox for *RealCost Version 2.5CA* to automatically calculate and include the prorated share of the agency cost of the last future rehabilitation activity if it extends beyond the analysis period.
- **Include User Costs in Analysis:** Select the checkbox to have *RealCost Version 2.5CA* include user costs (see Section 2.8.2) in the analysis and display the calculated user costs results.

Note:

As an option, CA4PRS can be used to calculate the user costs for the life-cycle cost analysis. CA4PRS (Rapid Rehab Software) is software developed by Caltrans and others to compare the impacts on construction schedules and the traveling public of various traffic management alternatives. One of the outputs from the program is user costs. The program is currently limited on what options it can investigate but is being expanded as resources allow. The latest version of CA4PRS and the user manual can be obtained from the Division of Research and Innovation website at:

<http://www.dot.ca.gov/research/roadway/ca4prs/ca4prs.htm>

If CA4PRS data is used, analyses will be needed for all of the initial construction options and future rehabilitation options. If CA4PRS generated data is used, select “Specified” under “User Cost Computation Method”.

- **User Cost Computation Method:** Select “Calculated” to have *RealCost Version 2.5CA* calculate user costs based on project-specific input data.
- **Traffic Direction:** Directs *RealCost Version 2.5 CA* to calculate user costs for the “Inbound” lanes, the “Outbound” lanes, or “Both” lanes. Select the traffic direction that will be affected by work zone operations. “Inbound” is used for the direction where traffic peaks in the AM hours. “Outbound” is used for the direction where traffic peaks in the PM hours. “Both” is used when construction is occurring in both directions.
- **User Cost Remaining Service Life Value (RSLV):** Select the checkbox to have *RealCost Version 2.5CA* include the RSLV of a project alternative. Once all the analysis options are defined, click the “Ok” button to return to the “Switchboard”.

3.4.3 “Traffic Data” Input

Much of this data can be accessed from within *RealCost Version 2.5CA* or the Traffic Operation’s website; however, the engineer should check with the districts traffic unit for the latest and most current data. Traffic data inputs include the follow data:

1. AADT for construction year
2. Single Unit Truck percentage
3. Combination Trucks percentage
4. Normal operating speed
5. Numbers of lanes open under normal conditions

The “Traffic Data” panel is shown in Figure 3-7 and is used to enter project-specific traffic data that will be used to calculate work zone user costs in accordance with the method outlined in the FHWA’s *LCCA Technical Bulletin* (1998) and “Life-Cycle Cost Analysis in Pavement Design.”

Traffic data is developed by the district’s Traffic Operations unit for PIDs and PRs when pavement work is involved. Some of the data for the “Traffic Data” panel can be found in the design designation as shown in Figure 3-6, traffic projections generated for a specific project, or from the Division of Traffic Operations website (<https://dot.ca.gov/programs/traffic-operations/census>).

Traffic Data

AADT Construction Year (total for both directions):

Single Unit Trucks as Percentage of AADT (%):

Combination Trucks as Percentage of AADT (%):

Annual Growth Rate of Traffic (%):

Speed Limit Under Normal Operating Conditions (mph):

Lanes Open in Each Direction Under Normal Conditions:

Free Flow Capacity (vphpl): Info.

Free Flow Capacity Calculator

Queue Dissipation Capacity (vphpl):

Maximum AADT (total for both directions):

Maximum Queue Length (miles):

Ok Cancel

Figure 3-7 Traffic Data Panel

- **AADT Construction Year (total for both directions):** Enter the annual average daily traffic (AADT) total for both directions in the beginning year of the analysis. This is the same as the construction year ADT found in the design designation or traffic projections for the project (see HDM Index 103.1 and Figure 3-6). For an example of what to do if a design designation or traffic forecast was not developed for the project, see Appendix 6.
- **Single Unit Trucks as Percentage of AADT (%):** Enter the percentage of the AADT that is single unit trucks (i.e., commercial trucks with two-axes and four tires or more) by doing the following:

RTE	DIST	CNTY	MILE	L POST E G DESCRIPTION	VEHICLE AADT TOTAL	TRUCK AADT TOTAL	TRUCK % TOT VEH	TRUCK AADT TOTAL				% TRUCK AADT				EAL 2-WAY (1000)	YEAR VER/ EST
								2	3	4	5+	2	3	4	5+		
001	12	ORA	R.129	A DANA POINT, JCT. RTE. 5	36500	2270	6.22	770	1074	304	122	33.93	47.32	13.39	5.36	213	03E
001	12	ORA	R.78	A DANA POINT, DOHENY PARK ROAD	38300	1865	4.87	633	883	250	100	33.93	47.32	13.39	5.36	175	03E
001	12	ORA	9.418	B LAGUNA BEACH, JCT. RTE. 133 NORTH	37900	659	1.74	258	303	61	38	39.08	45.98	9.2	5.75	59	03E
001	12	ORA	9.418	A LAGUNA BEACH, JCT. RTE. 133 NORTH	37900	659	1.74	258	303	61	38	39.08	45.98	9.2	5.75	59	03E

Figure 3-8 Average Annual Daily Truck Traffic Information

Go to the Division of Traffic Operations Traffic Data Branch website (<https://dot.ca.gov/programs/traffic-operations/census>) and find the most current file of “Average Annual Daily Truck Traffic” data available is shown in Figure 3-8.

Find the “% Truck AADT” for 2-axle trucks (TA) at the project location. There may be several values given within the limits of the project. Choose the one that best represents the overall project, the average, or the weighted average.

Then, obtain the truck traffic volume (T) from the design designation (HDM Topic 103.1, Figure 3-8). This value is measured as a percentage. If there is no design designation, use the Total Trucks % value from the Division of Traffic Operations web site referred to above (use selection process similar to the one used for 2-axle truck).

Note:
The total truck volume in the design designation does not need to match the total truck percentage on the Division of Traffic Operations website. If there is a wide disparity in values between the two numbers, the engineer should refer this to the district’s Traffic Operations Unit to review the accuracy of the traffic projections in the design designation and have the design designation updated if necessary.

Use Equation 3-1 to calculate the “Single Unit Trucks as Percentage of AADT (%)” (Assumption: “Total Trucks %” and “Single Unit Trucks %” will remain the same in future years):

$$SUT = T \times \left(\frac{TA}{100} \right) \quad (\text{Equation 3-1})$$

Where:

SUT = Single Unit Trucks as Percentage of AADT (%)

T = Truck Traffic Volume (% of AADT Total)

TA = 2-Axle Percent (percentage of Truck AADT Total)

Example 3.1:

Given:

Total Trucks % = 6.22

2-Axle % = 33.93

Find:

The Single Unit Trucks as Percentage of AADT

Using Equation 3-1, the Single Unit Trucks as Percentage of AADT (%) is

$$6.22 \times \left(\frac{33.93}{100} \right) = 2.11 \%$$

- **Combination Trucks as Percentage of AADT (%)**: Enter the percentage of the AADT that is combination trucks (i.e., trucks with three axles or more). This value is obtained by subtracting the “Single Unit Trucks as Percentage of AADT (%)” (SUT) from the “Total Trucks % (percentage of AADT Total)” (T).

$$\text{ComboTrucks} = T - SUT \quad (\text{Equation 3-2})$$

- **Annual Growth Rate of Traffic (%)**: Enter the percentage by which the AADT in both directions will increase each year. Contact the Division of Transportation System Information for the “Annual Growth Rate of Traffic” or calculate the approximate value with the available AADT values (in the most current and future years) using the following equation:

$$A = \left[\left(\frac{FT}{MT} \right)^{\left(\frac{1}{FY-MY} \right)} - 1 \right] \times 100 \quad (\text{Equation 3-3})$$

Where:

A = Annual Growth Rate of Traffic (%)

FT = Future Year AADT (total for both directions) obtained from the project design designation (HDM 103.1)

MT = Most Current Year AADT (total for both directions) obtained from the project design designation (HDM 103.1)

FY = Future Year in which AADT is available

MY = Most Current Year in which AADT is available

Example 3.2:

Given:

Future Year AADT (total for both directions) = 18,000 (year 2025)

Most Current Year AADT (total for both directions) = 9,800 (year 2005)

Find:

Using Equation 3-3, the Annual Growth Rate of Traffic is:

$$\left[\left(\frac{18,000}{9,800} \right)^{\frac{1}{2025-2005}} - 1 \right] \times 100 = 3.09\%$$

- **Speed Limit under Normal Operating Conditions (mph):** Enter the posted speed limit at the project location. If the project is a new construction, enter an anticipated speed limit based on traffic laws. District Traffic Operations can provide a recommendation if needed.
- **Lanes Open in Each Direction under Normal Conditions:** Enter the number of lanes open to traffic in each direction under normal operating conditions of the facility. For new construction and/or widening of an existing roadway, enter the number of lanes¹ that will open after completing the initial construction.

Use Table 3-1 to determine the traffic flow inputs for *RealCost Version 2.5CA*. Traffic flow inputs include:

- Maximum AADT total for both traffic directions
- Free Flow Capacity of the facility
- Queue Dissipation Capacity of Work Zone
- Expected maximum queue length, per Table 3-1

¹ Using the ultimate lane configuration and entering a “Work Zone Duration” (“Alternative 1,” Figure 3-17) of zero for the initial construction of each new construction or widening alternative will generate acceptable results of the analysis of future rehabilitation activities.

Table 3-1 Traffic Input Values

Type of Terrain	Two-Lane Highways			Multi-Lane Highways		
	Level	Rolling	Mountainous	Level	Rolling	Mountainous
Free Flow Capacity (vphpl)	1,620	1,480	1,260	2,170	1,950	1,620
Queue Dissipation Capacity (vphpl)	1,710	1,570	1,330	1,700	1,530	1,270
Maximum AADT Per Lane	40,955	37,390	31,850	53,773	48,305	40,140
Work Zone Capacity (vphpl) ⁽³⁾	1,050	960	820	1,510	1,360	1,130
Maximum Queue Length	One or two exits prior to the work zone or 7.0 miles if the estimated maximum queue length is longer than 7.0 miles			One or two exits prior to the work zone or 5.0 miles if the estimated maximum queue length is longer than 5.0 miles		

Notes:

(1) Derived from Highway Capacity Manual 2000.

(2) Refer to the calculation procedures included in Appendix 5, "Traffic Inputs Estimation".

(3) Assumed one lane to be open for traffic in single-lane highways and two or more lanes to be open for traffic in multi-lane highways.

- Free Flow Capacity (vphpl)***: Enter the number of vehicles per hour per lane (vphpl) under normal operating conditions. Table 3-1 provides typical values for standard lane and shoulder widths for various types of terrain. If there are nonstandard lane and shoulder widths or if it is desired to get a more specific free flow capacity, click the "Free Flow Capacity Calculator" in *RealCost Version 2.5* shown in Figure 3-7 to open a panel that calculates free flow capacities based upon the Highway Capacity Manual (1994, 3rd Ed.) shown in Figure 3-9, "Free Flow Capacity Calculation". To use the calculator, the following project-specific information is shown: number of lanes in each direction, lane width, proportion of trucks and buses (for state highways use % of trucks only), upgrade, upgrade length (for multiple slopes use the average grade throughout the project), obstruction on two sides, and distance to obstruction/shoulder width (Where the existing shoulder width is unknown, use the standard shoulder width as the input). When the "Calculate" button is clicked, the Free Flow Capacity (vphpl) is entered onto Figure 3-9, "Free Flow Capacity Calculation" panel. Click "Copy to Free Flow Capacity Field" button to import the calculated free flow capacity into Figure 3-7, "Traffic Data Panel."

An alternate procedure for estimating "Free Flow Capacity" can be found in Appendix 5.

- Queue Dissipation Capacity (vphpl)***: Enter the vehicles per hour per lane capacity of each lane during queue-dissipation operating conditions. Table 3-1 provides values for typical two-lane and multi-lane (in each direction) highways. As an alternative, estimate the queue dissipation capacity using the procedures for "Queue Dissipation Capacity" in Appendix 5.

- **Maximum AADT (total for both directions):** Enter the maximum AADT (total for both directions) at which the traffic growth will be capped. This value recognizes that there is only so much traffic that can be placed on a roadway in a 24-hour period. Table 3-1 provides recommended per lane values for typical two-lane and multi-lane highways, multiply the value by the total number of lanes for both directions to obtain the Maximum AADT. As an alternative, the volume may be estimated using the procedures for “Maximum AADT” in Appendix 5.
- **Maximum Queue Length (miles):** Enter a practical maximum length of queue in miles. Reasonable maximum queue length could be one or two exits prior to the work zone or an exit that leads to a reasonable alternate route. Queue-related user costs, which are based upon queue length, will be calculated with this value in cases when the *RealCost*-calculated queue lengths exceed this value. If a project-specific value is not available, enter seven (7) miles for two-lane highways and five (5) miles for multi-lane highways respectively as shown in Table 3-1.

Note:

Appendix 5 provides an explanation on the demand-capacity model – queuing theory – that *RealCost* uses in calculating maximum queue length.

Free Flow Capacity Calculation

Number of Lanes in Each Direction: 3

Lane Width (ft): 12

Proportion of Trucks and Buses (%): 5

Upgrade (%): 0.0

Upgrade Length (miles):

Obstruction on Two Sides:

Distance to Obstruction / Shoulder Width (ft): 6

Calculate

Free Flow Capacity (vphpl): 2146

Copy to Free Flow Capacity Field Cancel

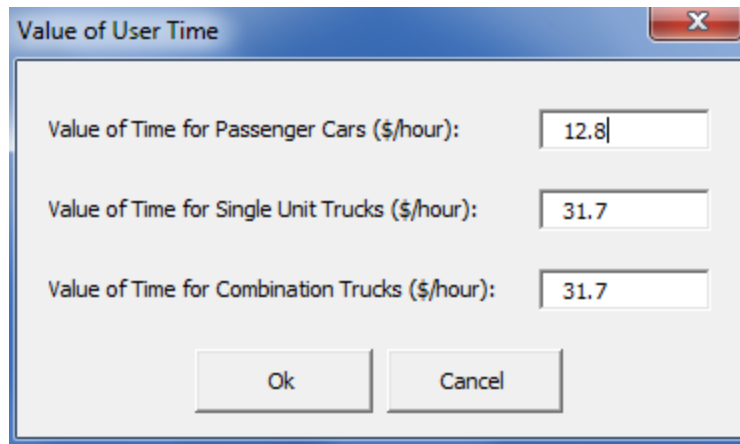
Figure 3-9 “Free Flow Capacity Calculation” Panel

Note:

An alternate procedure for estimating “Free Flow Capacity” can be found in Appendix 5.

3.4.4 Value of User Time

Figure 3-10 shows the 2013 default values for “Value of User Time” and is used to estimate cost applied to an hour of user time. The dollar value of user time can be different for each type of vehicle and is used to calculate user costs associated with delay during work zone operations. These values are updated annually by Caltrans’ Economic Analysis Branch. **Use the most up to date Value of User Time values, which can be found at the LCCA website.** Once the dollar values have been entered, click the “Ok” button to return to the “Switchboard” or click the “Cancel” button to start over.



Vehicle Type	Value of Time (\$/hour)
Passenger Cars	12.8
Single Unit Trucks	31.7
Combination Trucks	31.7

Figure 3-10 Value of User Time

3.4.5 Traffic Hourly Distribution

The “Traffic Hourly Distribution” panel is shown in Figure 3-11 and is used to convert AADT to an hourly traffic distribution. If project-specific data is not available, there are four default traffic patterns to select from, which were generated by Caltrans 2009 traffic count data at selected highway locations and can be used for any location in the State. However, the district’s Traffic Operations should be contacted before making the decision to use the default values for your project.

Figure 3-12 through Figure 3-15 show the four different traffic patterns that are available to choose from.

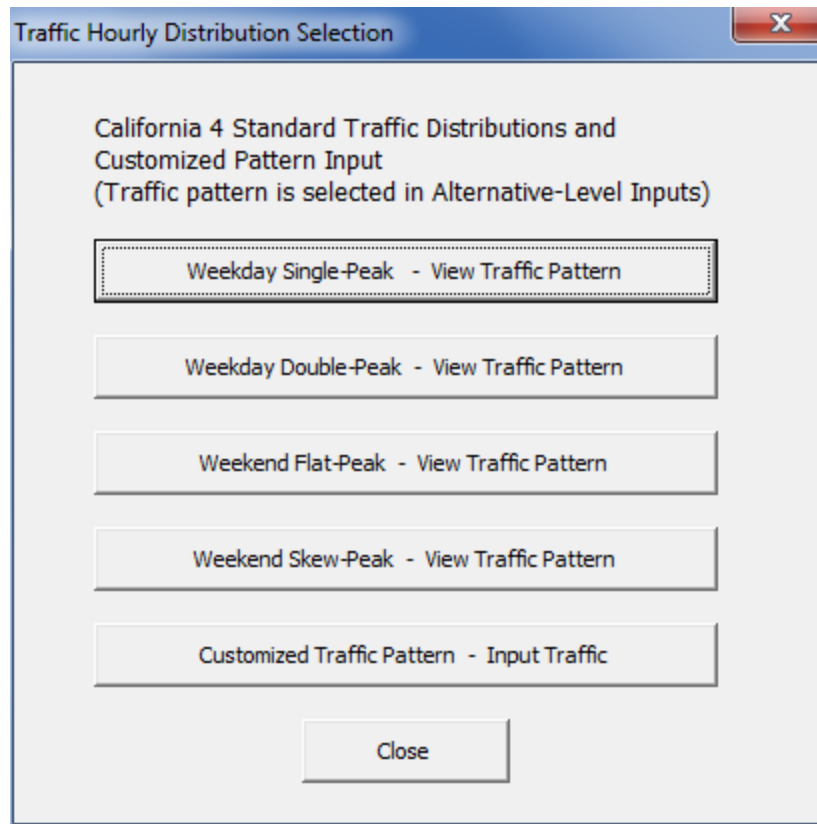


Figure 3-11 Traffic Hourly Distribution Selection

The Weekday Single Peak traffic pattern contains one peak period for each direction. A morning-peak appears in one direction, and an afternoon-peak appears in the other. Figure 3-12 shows a Weekday Single Peak pattern. This traffic pattern is often observed in the boundary areas of central business districts (CBDs) or perimeters of downtown areas.

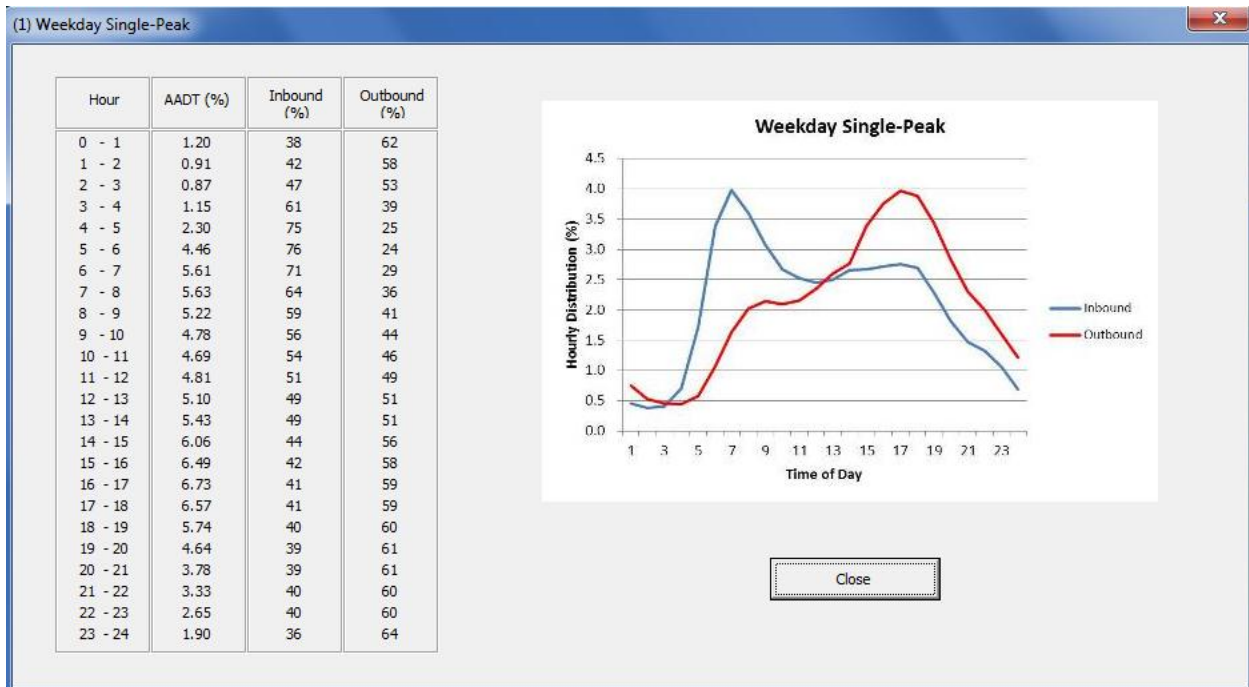


Figure 3-12 Weekday Single Peak Traffic Hourly Distribution Pattern

The Weekday Double Peak traffic pattern contains two peak periods for both directions. The first peak appears and diminishes in the morning for both directions, and the second peak appears and diminishes in the afternoon for both directions. Figure 3-13 shows a Weekday Double Peak traffic pattern. This traffic pattern is often observed on urban freeways inside central business districts (CBDs) or downtown areas during weekdays.

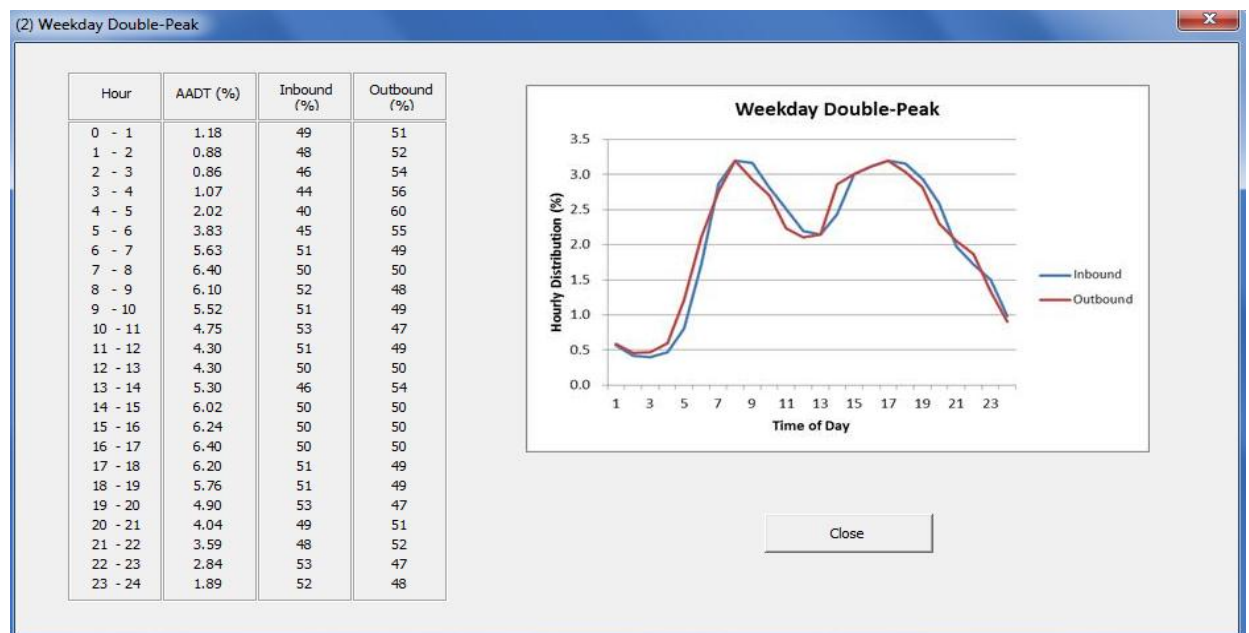


Figure 3-13 Weekday Double Peak Traffic Hourly Distribution Pattern

The Weekend Flat Peak traffic pattern contains one flat peak period for each direction throughout most of the day. The curve shape is gentle and flat during the peak period. Figure 3-14 shows a Weekend Flat Peak pattern. This traffic pattern is mostly observed on urban freeways inside CBDs or downtown areas during Saturdays and Sundays.

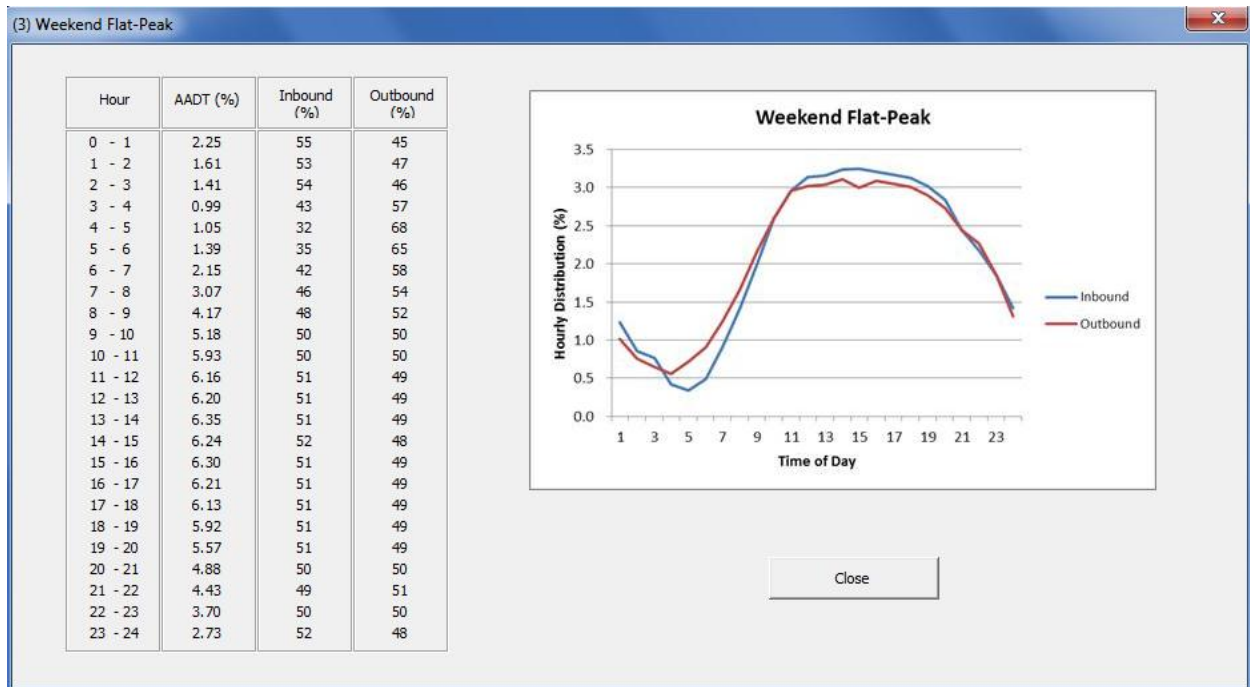


Figure 3-14 Weekend Flat Peak Traffic Distribution Pattern

The Weekend Skew Peak traffic pattern contains one sharp evening peak period for each direction. The curve shape is skewed and narrow during peak period. Figure 3-15 shows an example of Weekend Skew Peak pattern. This pattern is particularly observed on freeways connecting leisure sites, including amusement parks and tourist destinations.

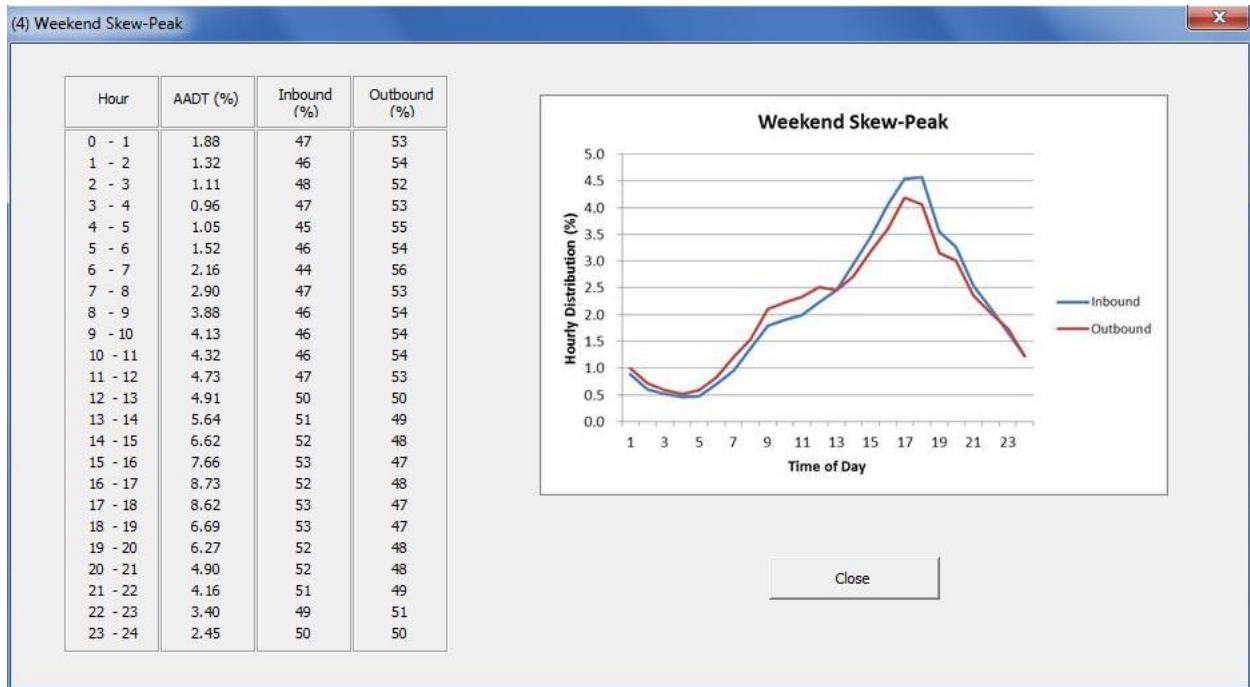
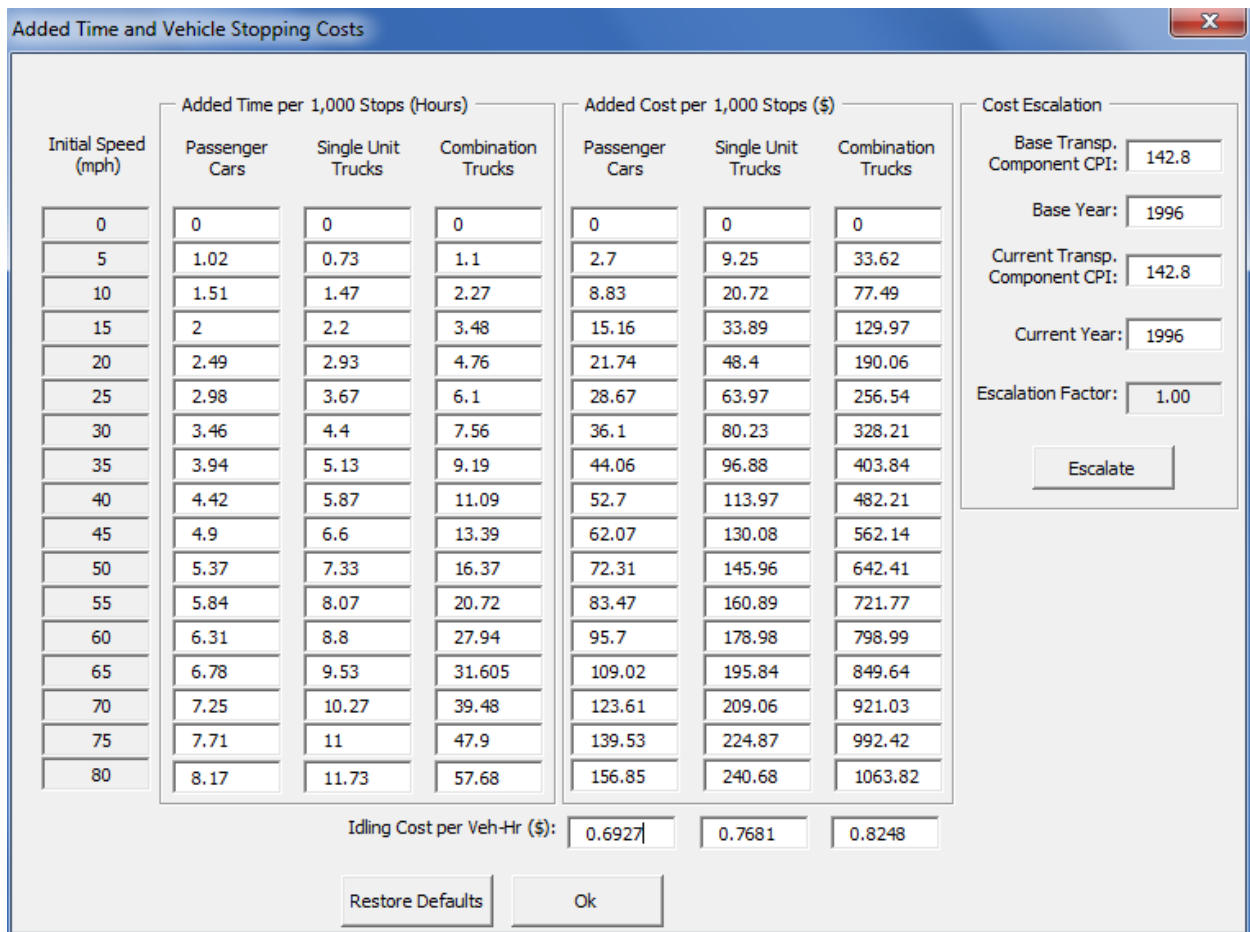


Figure 3-15 Weekend Skew Peak Traffic Distribution Pattern

In addition to the four California standard traffic hourly distribution patterns, the customization function allows users to input a site-specific traffic hourly distribution pattern by selecting the customized Input Traffic button in the Traffic Hourly Distribution window. In the Traffic Hourly Distribution—Customized Pattern window that appears in Figure 3-16, engineers can directly input either hourly proportions and directional split proportions or hourly volumes for inbound and outbound. By clicking the relevant View Graph button after inputting either traffic pattern by AADT or hourly traffic volumes, engineers can obtain a corresponding graph of the customized traffic patterns, which can then be selected for each activity of the respective alternative.

Research Program (NCHRP) Study 133 (1996), *Procedures for Estimating Highway User Costs, Air Pollution, and Noise Effects*. These values are used to calculate user delay and vehicle operating costs due to speed changes that occur during work zone operations. The “Idling Cost per Veh-Hr (\$)” is used to calculate the additional vehicle operating costs that result from moving through a traffic queue under stop-and-go conditions.

An escalation factor is built into the program to escalate the vehicle operating cost associated with speed change and idling by entering the current year and the associated transportation-component Consumer Price Index (CPI). The current year will be the year when construction is expected to begin. Table 3-2 shows the transportation-component CPI’s collected and projected by the Bureau of Labor Statistics. Since the statewide transportation-component CPI’s are not available yet, the U.S. transportation-component CPI’s (in bold text) can be used. The values for specific areas like Los Angeles (LA), San Francisco (SF), and San Diego (SD) can be used for those specific areas. Figure 3-17 is the added cost for 2012. CPI values are updated annually. For current Transportation CPI values, see the LCCA website.



Note: “Escalation Factor” value returns to 1.00 after the escalation has been performed.

Figure 3-17 “Added Vehicle Time and Cost” Panel

Example 3.3:

For a 2013 year analysis:

Enter “2013” for “Current Year” and “217.3” for “Current Transp. Component CPI”

Click the “Escalate” button (see Figure 3-17).

The program will update the cost data. To get back to the default values, click the “Restore Defaults” button.

Note: 1996 is the default base.

Table 3-2 Transportation Component Consumer Price Indexes

Year	US	LA CMSA ⁽¹⁾	SF CMSA ⁽²⁾	SD CMSA ⁽³⁾
1996	143.0	144.3	133.5	150.8
1997	144.3	145.2	133.6	152.2
1998	141.6	142.6	132.0	149.4
1999	144.4	146.8	135.8	152.1
2000	153.3	154.2	143.1	162.4
2001	154.3	155.3	143.7	164.9
2002	152.9	154.5	141.0	163.0
2003	157.6	160.3	144.9	168.0
2004	163.1	166.5	149.6	175.6
2005	173.9	174.8	156.1	185.5
2006	180.9	181.6	161.5	190.4
2007	184.7	183.2	166.6	193.2
2008	195.5	192.6	176.3	200.7
2009	179.3	178.6	166.7	184.7
2010	193.4	190.9	178.1	200.4
2011	212.4	207.8	190.8	222.7
2012	217.3	214.0	197.3	227.7

Notes:

* Source: US Department of Labor, Bureau of Labor Statistics

<http://www.bls.gov/cpi/>

(1) LA CMSA (Consolidated Metropolitan Statistical Area): includes counties of Los Angeles, Orange, Riverside, San Bernadino, & Ventura.

(2) SF CMSA (Consolidated Metropolitan Statistical Area): includes counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, & Sonoma.

(3) SD CMSA (Consolidated Metropolitan Statistical Area): includes county of San Diego.

Once all the “Project Level Inputs” has been completed, click the “Ok” button to return to the “Switchboard” or the “Cancel” button to start over.

3.4.7 Save Project-Level Inputs

To save the project level inputs file, go back to the “Switchboard” as shown in Figure 3-3, and select the “Save Project-Level Inputs” button, or select “Save LCCA Workbook As...” button to save all modified level inputs including traffic data inputs. *RealCost Version 2.5CA*

will save the project-level inputs at the specified location. The project input file will be automatically saved with a *.LCC extension. To retrieve the file later, select the “Open Project Level Inputs” button located on the “Switchboard”.

Note:

Saving the project-level inputs does not make any changes made to default data in “Traffic Hourly Distribution” or “Added Time and Vehicle Stopping Costs.” Any of this project-specific data must be reentered when reopening *RealCost Version 2.5CA*. If required, use “Save LCCA workbook as” button to save all modified level inputs.

3.5 Alternative-Level Inputs

3.5.1 “M&R Sequence” Input

After the “Project-Level Inputs” entries are completed, select the “M&R Sequence” button from the “Switchboard” menu to begin the “Alternative-Level Inputs”. In this section of the program, M&R sequence schedule is selected for each pavement alternatives as shown in Figure 3-18, which is an example of “M & R Sequence Selection”.

Up to four pavement alternatives can be compared simultaneously in one analysis run. If more than four pavement alternatives are to be analyzed, additional runs will be required.

Make selections for the “General Criteria,” which is a common input for all pavement alternatives.

- Project Type. From the drop down menu, choose the project type:
 - 1.) New Construction/Reconstruction/Widening,
 - 2.) Rehabilitation, or
 - 3.) CAPM (Although LCCA is not required on CAPM projects, the option is available with *RealCost Version 2.5CA*)
- Climate Region. Choose the value from the Caltrans Pavement Climate Regions Map based on the geographical location of the project as shown in Figure A4-1 in Appendix 4 and available on the following website: Pavement Climate Regions Map (PDF)

The choices are:

- 1) North Coast
- 2) Central Coast
- 3) South Coast
- 4) Inland Valley
- 5) High Mountain
- 6) High Desert
- 7) Desert
- 8) Low Mountain

9) South Mountain

- Maintenance Service Level. This value is selected from the drop down menu. The choices are 1, 2, or 3.

Next make selections for each of the pavement alternatives.

- Final Pavement Surface. There are 15 selection to choose from as shown in Table 3-3:

Table 3-3 Final Pavement Surface Choices

Final Pavement Surface		
Flexible	Rigid	
HMA	JPCP	CRCP
HMA W/OGFC	JPCP CPR A	CRCP PR A
HMA W/RHMA	JPCP CPR B	CRCP PR B
RHMA	JPCP CPR C	CRCP PR C
RHMA W/ RHMA O	Composite—HMA or RHMA over Rigid (crack, seat, and overlay)	

- Design Life. Choose from
 - 1) 5 or 10 years (for CAPM projects)
 - 2) 20 years
 - 3) 40 years

Once all selections are made, click on “Find M&R Sequence”

For each pavement alternative, the program automatically selects the appropriate M&R schedule from Appendix 4 tables and transfers the data as shown in Figure 3-18.

Note:
 Not all combination of inputs will yield a M&R schedule. For example, if a 20 year design life and final pavement surface of JPCP CPR A is selected, the M&R sequence schedule will be “N/A” because JPCP CPR A only applies to 5 or 10 year design life.

The automatic inputs include the “Activity Number”, “Activity Name”, “Year of Action”, “Annual Maintenance Cost (\$)”, and “Activity Service Life (Years)”, for each pavement alternative as shown in Figure 3-18, “M&R Sequence Selection” panel.

- **Activity Number:** The sequential order of each activity. Activity 1 is the initial construction activity. Activity 2 and above are future rehabilitation activities.
- **Activity Name:** The name of the pavement strategy.
- **Agency Maintenance Cost (\$1000):** *RealCost Version 2.5 CA* automatically enters “Maintenance Costs,” this includes the costs of preventive, corrective, and routine maintenance treatments to preserve or to extend the service life of initial construction and any future rehabilitation activities. Cost is per lane mile.
- **Activity Service Life (years):** The activity service life of initial construction and future rehabilitation activities are automatically entered by the program. Refer to Appendix 4 for the appropriate pavement M&R schedule that shows the activity service lives estimated for the initial construction and the future rehabilitation activities each pavement alternative.

Click the check box for the pavement alternatives to analyze. Click “OK” to transfer information to the “Alternative” panel or click the “CANCEL” button to start the procedure over.

The screenshot shows the 'M&R Sequence Selection' window with the following details:

General Criteria:
 Project Type: New/Reconstruction/Widen
 Climate Region: Desert
 Maintenance Service Level: 1

Alternative 1: Final Pavement Surface: HMA, Design Life: 20

Activity Number	Activity Name	Year of Action	Annual Maint. Cost(\$)	Activity Service Life (Year)
1	NEW/RECONST HMA (20YR)	0	3600	18
2	CAPM HMA	18	1100	5
3	REHAB HMA (20 YR)	23	3000	18
4	CAPM HMA	41	1100	5
5	REHAB HMA (20YR)	46	3000	18
6	N/A	64	0	0

Alternative 2: Final Pavement Surface: CRCP, Design Life: 20

Activity Number	Activity Name	Year of Action	Annual Maint. Cost(\$)	Activity Service Life (Year)
1	NEW/RECONST CRCP (20YR)	0	200	30
2	CAPM (PR C)	30	1400	5
3	CAPM (PR B)	35	600	10
4	CAPM (PR A)	45	600	10
5	N/A	55	0	0
6	N/A	55	0	0

Alternative 3: Final Pavement Surface: HMA W/ OGFC, Design Life: 40

Activity Number	Activity Name	Year of Action	Annual Maint. Cost(\$)	Activity Service Life (Year)
1	NEW/RECONST HMA W/OGFC (40Y)	0	6700	38
2	CAPM HMA W/ OGFC	38	4100	9
3	REHAB HMA W/ OGFC (20YR)	47	4000	20
4	N/A	67	0	0
5	N/A	67	0	0
6	N/A	67	0	0

Alternative 4: Final Pavement Surface: HMA W/ RHMA, Design Life: 20

Activity Number	Activity Name	Year of Action	Annual Maint. Cost(\$)	Activity Service Life (Year)
1	NEW/RECONST HMA W/RHMA (20Y)	0	5400	21
2	CAPM HMA W/ RHMA	21	4000	9
3	REHAB HMA W/ RHMA (20YR)	30	3700	21
4	CAPM HMA W/ RHMA	51	5400	9
5	N/A	60	0	0
6	N/A	60	0	0

Buttons: Find M&R Sequence, CANCEL, OK

Figure 3-18 Example of M&R Sequence Selection Panel

3.5.2 “Alternative” Input

The Alternative panels between each of the pavement alternatives are identical and are used to input information for the alternative being analyzed. The rehabilitation activities for each alternative are transferred from the “M&R Sequence” panel. Each activity is in sequential order. For example, Activity 1 is the initial construction and Activity 2 is the next rehabilitation activity after initial construction.

The data inputs required under each activity tab on the panel are described below.

DESCRIPTION

- **Alternative Description:** Enter a new description for the pavement alternative such as “20-yr Rehab (HMA Overlay).”
- **Activity Description:** The activity description is automatically transferred from the “M&R Sequence” panel. Additional description should be added.

ACTIVITY COST AND SERVICE LIFE INPUTS

- **Agency Construction Cost (\$1000):** Under the “Activity 1” tab, enter the total initial construction cost in thousands of dollars for each of the pavement alternatives (see section 2.8.3, ‘Initial Costs’). For each future rehabilitation activity after the initial construction (Activity 1), use the “COST” button calculator to estimate the total rehabilitation cost, which is entered in as thousands of dollars. There are four future rehabilitation and CAPM cost estimate calculators shown in Figure 3-19, “Cost Estimate”. Instructions for the future rehabilitation cost calculators are detailed in section 3.5.3.
 1. Flexible or Composite Rehabilitation
 2. Rigid Rehabilitation
 3. Flexible or Composite CAPM
 4. Rigid CAPM

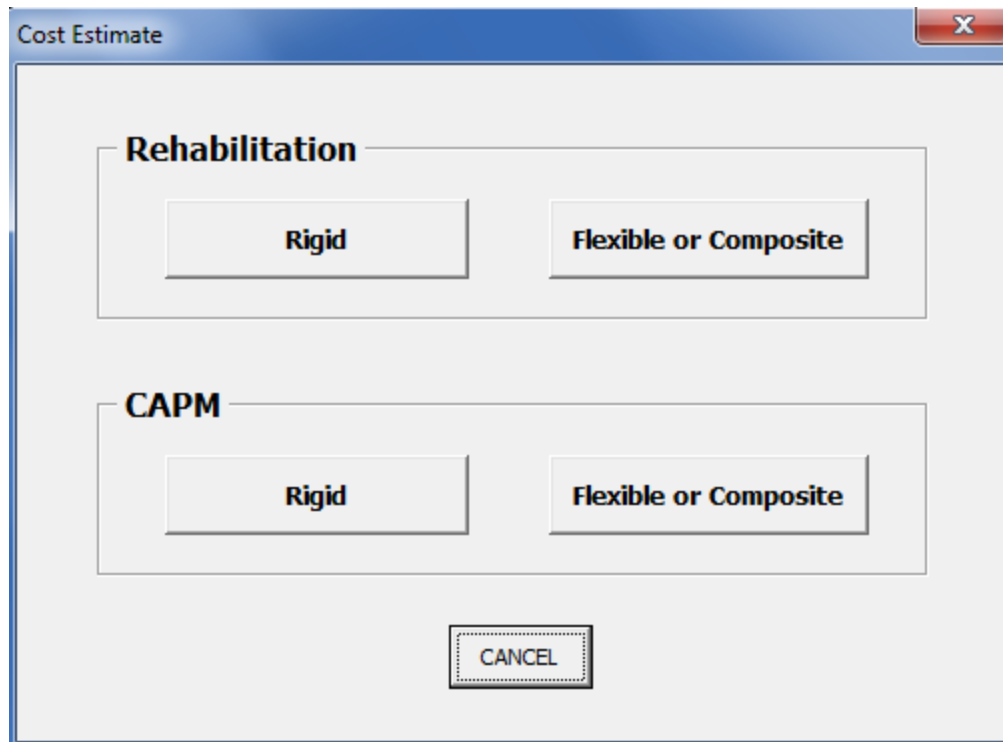


Figure 3-19 “Cost Estimate” Pavement Type, Project Type Panel

- **Activity Service Life (years):** As discussed section 3.5.1, the activity service life is automatically transferred from the M&R Sequence panel.
- **User Work Zone Costs (\$1000):** This field is inaccessible because the “User Cost Computation Method” panel in Figure 3-5, “Analysis Options” panel is set to “Calculated”. If this is not the case, go to “Analysis Options” panel to modify the “User Cost Computation Method.”
- **Maintenance Frequency (years):** The default value is one (1) year as the “Maintenance Frequency,” because the cost of maintenance treatments shown in the M&R schedules have been annualized (see section 2.8.4)
- **Annual Maintenance Cost (\$1000):** The Agency Maintenance Cost is automatically calculated. The project length from “Project Details” panel is multiplied by the number of lanes open in each direction from the “Traffic Data” panel times the number of directions also from the “Traffic Data” panel times the annualized maintenance cost from the “M&R Sequence” panel. The engineers may enter their own calculation. If the project length is modified after M&R Sequence is selected, M&R Sequence must be selected again to recalculate the Annual Maintenance Cost.

Note: The “Second Period of Lane Closure” requires an “End” number greater than “0”.

Figure 3-20 Alternative 1 Panel

ACTIVITY WORK ZONE INPUTS

- Work Zone Length (miles):** This input refers to the length (in miles) of the work zone being considered for initial construction and for each future rehabilitation activity. The work zone length should be based on what is allowed from the Traffic Management Plan (TMP) for the initial construction or historical experience. Note that the Work Zone Length (WZL) is not necessarily the full length of the project limits. It should be measured from beginning to end of the reduced speed area where the work zone speed limit will be in effect daily or nightly based on the activity. Additional information and recommendations can be obtained from the District Construction and Traffic Operations if needed.

- **Work Zone Duration (days):** Refers to the number of days during which the work zone will be affecting traffic. For example, if the work zone is in effect five days a week for four weeks, the duration is twenty. Determine the Work Zone Duration (WZD) using the following formula:

$$WZD = \frac{\text{Lane - miles}}{PR} \quad (\text{Equation 4})$$

Where:

WZD = Work Zone Duration in days

PR = Productivity Rate in lane-miles per day

Note:

Several special cases to be aware of:

Continuous lane closures – If a lane is closed for the duration of the pavement work, it is treated as a 24-hour closure (from hour 0 to hour 24) for each working day it is closed. Therefore, if the lane is closed for 3 months the total number of closures is 3 months times 21 work days per month, for a total of 63 days.

Weekend (55-hour) closures – multiply 2.3 (=55/24) by the number of closures needed in order to get the number of days needed. This is necessary because the RealCost Version 2.5CA program can only analyze closures within a 24-hour period and weekend closures last for over 2 days.

Where lanes can be detoured and work can be done behind K-rail or other separation from traffic, no lane closure is required, and hence, the work zone duration (for this work) is zero.

For initial construction, the work zone duration should be estimated as part of establishing the critical path method (CPM) schedule for the project. **Work Zone Duration is not the same as the number of working days used to build the project. WZD is the estimated number of days lane closures are in effect for project construction work.** Use a WZD of zero¹, for each of the competing alternatives, when the initial construction is a new construction or a widening. For future rehabilitations, the estimated work zone duration must be determined using the total length of pavement structure work in lane-miles, and the corresponding productivity rate from Table 3-4 to Table 3-7. See Equation 4 for the computation method for WZD.

Tables 3-4 to 3-7 provide the estimates of work that can be completed during different construction windows, such as nighttime closure, weekend closure, etc. When using

¹ Using a WZD = 0 for the initial construction of each new construction or widening alternative and entering the ultimate lane configuration in “Lanes Open in Each Direction Under Normal Conditions” (“Traffic Data,” Figure 3-6) will generate acceptable results of the analysis of future rehabilitation activities.

typical M&R strategies for flexible pavements, use Table 3-4, and for rigid and composite pavements use Table 3-6. These production rates are estimates developed using CA4PRS, “Construction Analysis for Pavement Rehabilitation Strategies”, software and assuming typical working conditions and resource configurations observed in past projects.

Relative to agency costs, user costs can have a major impact on the total life-cycle cost, so it is important to use the most cost effective traffic management practice possible. In some cases, such as when comparing flexible and rigid pavement strategies, the most cost effective traffic management plan may not be the same for all the alternatives (initial and future rehabilitation) being considered. If the traffic management plan does not provide a strategy for the initial or future rehabilitation strategy or if the strategy needs to be checked to be sure it is the most cost effective, the engineer can use the construction traffic analysis software CA4PRS (freeways only) to analyze options.

- **Work Zone Capacity (vphpl):** Enter the vehicular capacity of one lane of the work zone for one hour. Table 3-1 provides values for typical two-lane and multi-lane highways. As an alternative, the capacity may be estimated using the procedures for “Work Zone Capacity” in Appendix 5.
- **Work Zone Speed Limit (mph):** This is the expected operating speed within the work zone. Enter a speed that is 5 mph less than the posted speed limit unless there is an approved reduced speed limit for the project. Approved reductions in posted speed limits can be found in the traffic management plan.
- **No. of Lanes Open in Each Direction During Work Zone:** Enter the number of lanes to be open when the work zone is in effect. The number of lanes to be open applies to each direction. This information can be obtained from the traffic management plan or District Traffic Operations.

Note:

If the project is a two-lane highway, and the work zone is anticipated to be under one-directional traffic control, enter one (1) lane to be open in each direction during work zone and reduce the work zone capacity by half.

- **Work Zone Hours:** Enter the zone hours using a 24-hour clock (starting from 0 to 24) during which the work zone is in effect. Work zone timing can be modeled separately for inbound and outbound traffic for up to three separate periods during each day. During these hours, road capacity is limited to the work zone capacity. Work zone hours can be obtained from the TMP or District Traffic Operations. If the traffic management plan includes variable work zone hours (lane closures) for the project, use the hours that apply most often to the project as a whole.

Note:

For weekend closures, enter 0 to 24 on first period line. The end of closure time must be greater than 0.

Example:

If the nightly lane closure hour is from 8pm to 6am, then the first period line is from 0 to 6, and the second period line is from 20 to 24 for both inbound and outbound traffic.

Table 3-4 Productivity Estimates of Typical Future Rehabilitation Strategies for Flexible Pavements

Final Surface Type	Future M&R Alternative	Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure				
				Daily Closure (Weekday)		Continuous Closure		
				5 to 7-Hour Closure	8 to 12-Hour Closure	16 hour/Day Operation	24 hour/day Operation	55-hour Weekend Closure
CAPM								
HMA	Overlay	5+	1,2,3	0.84	1.73	2.9	4.81	12.25
	Mill & Overlay	5+	1,2,3	0.36	0.75	1.18	2.21	5.20
HMA w/OGFC	Overlay	5+	1,2,3	0.55	1.14	1.9	3.17	8.09
	Mill & Overlay	5+	1,2,3	0.30	0.61	0.97	1.86	4.35
HMA w/RHMA	Overlay	5+	1,2,3	0.55	1.14	1.9	3.17	8.09
	Mill & Overlay	5+	1,2,3	0.30	0.61	0.97	1.86	4.35
RHMA-G	Overlay	5+	1,2,3	1.12	2.32	3.86	6.41	16.33
	Mill & Overlay	5+	1,2,3	0.48	1.00	1.56	2.93	6.88
RHMA-G w/RHMA-O	Overlay	5+	1,2,3	0.84	1.73	2.9	4.81	12.25
	Mill & Overlay	5+	1,2,3	0.34	0.72	1.14	2.17	5.13
Rehabilitation								
HMA	Overlay	10	1,2,3	0.47	0.98	1.63	2.72	6.94
		20	1,2,3	0.33	0.69	1.15	1.91	4.87
	Mill & Overlay	10	1,2,3	0.21	0.45	0.73	1.37	3.23
		20	1,2,3	0.15	0.31	0.49	0.93	2.18
HMA w/OGFC	Overlay	10	1,2,3	0.35	0.75	1.26	2.10	5.37
		20	1,2,3	0.27	0.57	0.95	1.58	4.04
	Mill & Overlay	10	1,2,3	0.19	0.39	0.64	1.23	2.9
		20	1,2,3	0.14	0.28	0.45	0.86	2.01
HMA w/RHMA	Overlay	10	1,2,3	0.35	0.75	1.26	2.1	5.37
		20	1,2,3	0.27	0.57	0.95	1.58	4.04
	Mill & Overlay	10	1,2,3	0.19	0.39	0.64	1.23	2.90
		20	1,2,3	0.14	0.28	0.45	0.86	2.01
RHMA-G	Overlay	10	1,2,3	0.84	1.73	2.90	4.81	12.25
		20	1,2,3	0.55	1.14	1.90	3.17	8.09
	Mill & Overlay	10	1,2,3	0.37	0.75	1.18	2.21	5.20
		20	1,2,3	0.25	0.52	0.84	1.58	3.73
RHMA-G w/RHMA-O	Overlay	10	1,2,3	0.55	1.14	1.9	3.17	8.09
		20	1,2,3	0.40	0.83	1.41	2.36	6.03
	Mill & Overlay	10	1,2,3	0.30	0.61	0.97	1.86	4.35
		20	1,2,3	0.21	0.44	0.72	1.39	3.28

Notes:

- (1) Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.
- (2) Production rates in the table are based on representative assumptions that are applied consistently throughout the table. These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose. More project specific user costs for some freeway situations can be obtained from the CA4PRS software.
- (3) 24-hour continuous closure with 16 hours of operation per day
- (4) 24-hour continuous closure with 24 hours of operation per day
- (5) 55-hour extended closure over the weekend

Table 3-5 Productivity Estimates of Typical Future Rehabilitation Ramp Strategies for Flexible Pavements

Final Surface Type	Future M&R Alternative	Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure				
				Daily Closure (Weekday)		Continuous Closure		
				5 to 7-Hour Closure	8 to 12-Hour Closure	16 hour/Day Operation	24 hour/day Operation	55-hour Weekend Closure
CAPM								
HMA	Overlay	5+	1,2,3	0.51	1.02	1.71	2.85	7.29
	Mill & Overlay	5+	1,2,3	0.22	0.44	0.70	1.32	3.10
HMA w/OGFC	Overlay	5+	1,2,3	0.32	0.66	1.11	1.87	4.81
	Mill & Overlay	5+	1,2,3	0.17	0.36	0.57	1.10	2.60
HMA w/RHMA	Overlay	5+	1,2,3	0.32	0.66	1.11	1.87	4.81
	Mill & Overlay	5+	1,2,3	0.17	0.36	0.57	1.10	2.60
RHMA-G	Overlay	5+	1,2,3	0.68	1.36	2.28	3.79	9.69
	Mill & Overlay	5+	1,2,3	0.29	0.59	0.93	1.75	4.10
RHMA-G w/RHMA-O	Overlay	5+	1,2,3	0.51	1.02	1.71	2.85	7.29
	Mill & Overlay	5+	1,2,3	0.20	0.42	0.67	1.29	3.05
Rehabilitation								
HMA	Overlay	10	1,2,3	0.28	0.57	0.96	1.61	4.13
		20	1,2,3	0.19	0.40	0.68	1.13	2.90
	Mill & Overlay	10	1,2,3	0.13	0.26	0.43	0.81	1.92
		20	1,2,3	0.09	0.18	0.29	0.55	1.30
HMA w/OGFC	Overlay	10	1,2,3	0.21	0.43	0.73	1.24	3.19
		20	1,2,3	0.15	0.33	0.55	0.93	2.40
	Mill & Overlay	10	1,2,3	0.11	0.23	0.37	0.72	1.72
		20	1,2,3	0.08	0.16	0.26	0.51	1.19
HMA w/RHMA	Overlay	10	1,2,3	0.21	0.43	0.73	1.24	3.19
		20	1,2,3	0.15	0.33	0.55	0.93	2.40
	Mill & Overlay	10	1,2,3	0.11	0.23	0.37	0.72	1.72
		20	1,2,3	0.08	0.16	0.26	0.51	1.19
RHMA-G	Overlay	10	1,2,3	0.51	1.02	1.71	2.85	7.29
		20	1,2,3	0.32	0.66	1.11	1.87	4.81
	Mill & Overlay	10	1,2,3	0.22	0.44	0.70	1.32	3.10
		20	1,2,3	0.15	0.31	0.50	0.94	2.22
RHMA-G w/RHMA-O	Overlay	10	1,2,3	0.32	0.66	1.11	1.87	4.81
		20	1,2,3	0.23	0.49	0.82	1.39	3.58
	Mill & Overlay	10	1,2,3	0.17	0.36	0.57	1.10	2.60
		20	1,2,3	0.12	0.26	0.42	0.82	1.95

Notes:

- (1) Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.
- (2) Production rates in the table are based on representative assumptions that are applied consistently throughout the table. These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose. More project specific user costs for some freeway situations can be obtained from the CA4PRS software.
- (3) 24-hour continuous closure with 16 hours of operation per day
- (4) 24-hour continuous closure with 24 hours of operation per day
- (5) 55-hour extended closure over the weekend

Table 3-6 Productivity Estimates of Typical Future Rehabilitation for Rigid and Composite Pavements

Final Surface Type	Future M&R Alternative	Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure						
				Daily Closure		Continuous Closure		Weekend Closure (55-Hour)		
				5 to 7-Hour Closure	8 to 12-Hour Closure	16 hour/day Operation	24 hour/day Operation			
CAPM										
Flexible/ Composite	Flexible Overlay		5+	1,2,3	1.16	2.32	3.86	6.41	16.33	
	Flexible Overlay w/Salb Replacements (FO+JPCP SR)	4-hr RSC 12-hr RSC	5+	1,2,3	0.63 1.90	1.69 5.84	3.05 1.90	4.37	12.66	
Rigid-Jointed Plain Concrete Pavement (JPCP)	Concrete Pavement Rehab A	4-hr RSC 12-hr RSC	5+	1,2,3	0.48 1.07	1.79 4.17	4.17 3.93	16.11		
		4-hr RSC 12-hr RSC	5+	1,2,3	0.67 1.50	2.51 5.51	5.84 22.56			
	Concrete Pavement Rehab B	4-hr RSC 12-hr RSC	5+	1,2,3	1.67 3.75	6.27 13.77	14.61 56.40			
		4-hr RSC 12-hr RSC	5+	1,2,3	0.08 0.11	0.17 0.24	0.66 0.92	0.67 0.94	4.51 6.31	
Rigid-Continuously Reinforced Concrete Pavement (CRCP)	Punchout Repair A	4-hr RSC 12-hr RSC	5+	1,2,3	0.11 0.27	0.24 0.60	0.92 2.31	0.94 2.34	6.31 15.78	
		4-hr RSC 12-hr RSC	5+	1,2,3	0.27 0.96	0.60 2.31	2.31 9.96	2.34 9.96	15.78 63.12	
	Punchout Repair B	4-hr RSC 12-hr RSC	5+	1,2,3	0.27 0.96	0.60 2.31	2.31 9.96	2.34 9.96	15.78 63.12	
Rehabilitation										
Flexible / Composite	Flexible Overlay w/ Slab Replacement (FO + JPCP SR)	4-hr RSC	10	1,2,3	0.31	0.89	1.66			
	Flexible Overlay w/ Slab Replacement (FO + JPCP SR)	12-hr RSC	10	1,2,3			0.91	2.27	6.83	
	Mill, Slab Replacement & Overlay (MSRO)	4-hr RSC	10	1,2,3	0.19	0.50	0.85			
	Mill, Slab Replacement & Overlay (MSRO)	12-hr RSC	10	1,2,3			0.91	2.27	6.83	
	Mill, Slab Replacement & Overlay (MSRO)	4-hr RSC	20	1,2,3	0.15	0.38	0.64			
	Mill, Slab Replacement & Overlay (MSRO)	12-hr RSC	20	1,2,3			0.49	1.10	2.82	
	Crack, Seal, & Flexible Overlay (CSFOL)		10		0.47	0.98	1.63	2.72	6.94	
			20	1,2,3	0.44	0.75	1.26	2.10	5.37	
	Replace with Flexible		20		0.21	0.44	0.75	1.26	3.22	
			40	1,2,3	0.15	0.31	0.53	0.89	2.30	
	Replace with Composite	4-hr RSC 12-hr RSC	20	1,2,3	0.02 0.02	0.08 0.07	0.18 0.17	0.16 0.17	0.65 0.65	
		4-hr RSC 12-hr RSC	40	1,2,3	0.02 0.02	0.07 0.07	0.17 0.17	0.17 0.17	0.65 0.65	
	Jointed Plain Concrete Pavement (JPCP)	Lane Replacement	4-hr RSC 12-hr RSC	20	1,2,3	0.03 0.03	0.07 0.07	0.17 0.17	0.17 0.17	0.65 0.65
			4-hr RSC 12-hr RSC	40	1,2,3	0.02 0.02	0.06 0.06	0.14 0.14	0.14 0.14	0.53 0.53
4-hr RSC 12-hr RSC			20	1,2,3	0.01 0.01	0.03 0.03	0.11 0.11	0.11 0.11	0.66 0.66	
4-hr RSC 12-hr RSC			40	1,2,3	0.01 0.01	0.03 0.03	0.10 0.10	0.10 0.10	0.63 0.63	

FO = Flexible Overlay JPCP = Jointed Plain Concrete Pavement SR = Slab Replacement RSC = Rapid Set Concrete CRCP = Continuously Reinforced Concrete Pavement

Notes:

- Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.
- Production rates are based on the lower end of the representative assumptions for the range and are applied consistently throughout the table.
These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose. More project specifics user cost for some freeway situations can be obtained from the CA4PRS software.
- 24-hour continuous closure with 16 hours of operation per day
- 24-hour continuous closure with 24 hours of operation per day
- 55-hour extended closure over the weekend
- Punchout Repair A involves **significant** punchout repairs and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement that had previous punchout repairs and a flexible overlay.
- Punchout Repair B involves **moderate** punchout repair and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement where the total number of current and previous punchout repairs exceed 4 per mile.
- Punchout Repair C involves **minor** punchout repairs and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement where the total number of current and previous punchout repairs do not exceed 4 per mile.
- Precast panel concrete pavement is under development. See HQ LCCA Coordinator for assistance.

Table 3-7 Productivity Estimates of Typical Future Ramp Rehabilitation for Rigid and Composite Pavements

Final Surface Type	Future M&R Alternative	Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure					
				Daily Closure		Continuous Closure		Weekend Closure (55-Hour)	
				5 to 7-Hour Closure	8 to 12-Hour Closure	16 hour/day Operation	24 hour/day Operation		
CAPM									
Flexible/ Composite	Flexible Overlay		5+	1,2,3	0.27	0.54	0.85	1.61	3.78
	Flexible Overlay w/Salb Replacements (FO+JPCP SR)	4-hr RSC 12-hr RSC	5+	1,2,3	0.20 0.52	0.43 1.16	0.71 1.16		3.06
Rigid-Jointed Plain Concrete Pavement (JPCP)	Concrete Pavement Rehab A	4-hr RSC 12-hr RSC	5+	1,2,3	0.28 0.40	0.60 0.84	1.26 1.76		
	Concrete Pavement Rehab B	4-hr RSC 12-hr RSC	5+	1,2,3	0.99 1.35	2.10 4.20	4.41 4.20		
	Concrete Pavement Rehab C	4-hr RSC 12-hr RSC	5+	1,2,3	0.21 0.93	0.45 1.89	1.89 1.89		11.91
Rigid-Continuously Reinforced Concrete Pavement (CRCP)	Punchout Repair A	4-hr RSC 12-hr RSC	5+	1,2,3	0.06 0.08	0.13 0.18	0.54 0.76		
	Punchout Repair B	4-hr RSC 12-hr RSC	5+	1,2,3	0.21 0.93	0.45 1.89	1.89 1.89		
	Punchout Repair C	4-hr RSC 12-hr RSC	5+	1,2,3	0.06 0.08	0.13 0.18	0.54 0.76		3.40
Rehabilitation									
Flexible / Composite	Flexible Overlay w/ Slab Replacement (FO + JPCP SR)	4-hr RSC	10	1,2,3	0.03	0.07	0.13		
	Flexible Overlay w/ Slab Replacement (FO + JPCP SR)	12-hr RSC					0.04	0.13	0.49
	Mill, Slab Replacement & Overlay (MSRO)	4-hr RSC	10	1,2,3	0.03	0.06	0.12		
	Mill, Slab Replacement & Overlay (MSRO)	12-hr RSC					0.04	0.12	0.45
	Mill, Slab Replacement & Overlay (MSRO)	4-hr RSC	20	1,2,3	0.03	0.06	0.11		
	Mill, Slab Replacement & Overlay (MSRO)	12-hr RSC					0.04	0.12	0.42
	Crack, Seal, & Flexible Overlay (CSFOL)		10		0.28	0.57	0.96	1.61	4.13
			20	1,2,3	0.21	0.43	0.73	1.24	3.19
	Replace with Flexible		20		0.12	0.26	0.43	0.74	1.91
			40	1,2,3	0.08	0.18	0.31	0.52	1.37
	Replace with Composite	4-hr RSC 12-hr RSC	20	1,2,3	0.01 0.01	0.05 0.04	0.11 0.10		
		4-hr RSC 12-hr RSC	40	1,2,3	0.01 0.01	0.04 0.04	0.10 0.09		0.39 0.36
Jointed Plain Concrete Pavement (JPCP)	Lane Replacement	4-hr RSC 12-hr RSC	20	1,2,3	0.01 0.01	0.04 0.04	0.10 0.09		0.37
		4-hr RSC 12-hr RSC	40	1,2,3	0.01 0.01	0.04 0.03	0.09 0.08		0.33
Continuously Reinforced Concrete Pavement	Lane Replacement	4-hr RSC 12-hr RSC	20	1,2,3	0.01 0.01	0.02 0.02	0.06 0.06		0.40
		4-hr RSC 12-hr RSC	40	1,2,3	0.01 0.01	0.02 0.02	0.06 0.06		0.38

FO = Flexible Overlay JPCP = Jointed Plain Concrete Pavement SR = Slab Replacement RSC = Rapid Set Concrete CRCP = Continuously Reinforced Concrete Pavement

Notes:

- Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.
- Production rates are based on the lower end of the representative assumptions for the range and are applied consistently throughout the table.
These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose. More project specific user cost for some freeway situations can be obtained from the CA4PRS software.
- 24-hour continuous closure with 16 hours of operation per day
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- Precast panel concrete pavement is under development. See HQ LCCA Coordinator for assistance.

3.5.3 Cost Estimate Calculators for Future Rehabilitation and CAPM

There are four future rehabilitation and CAPM cost estimate calculators to choose from and are to be used when developing construction cost estimate for future M&R activities. The Cost Estimate window shown in Figure 3-21 appears when the “COST” button is selected in activities beyond the “Activity 1” panel. Choose the appropriate calculator that matches the rehabilitation or CAPM activity. For example, if the activity requires CAPM HMA, then the CAPM flexible calculator should be selected.

Unit prices are based on a weighted average between 2002 to 2012 from Caltrans construction contract cost database at the following website

(<http://sv08data.dot.ca.gov/contractcost/>).

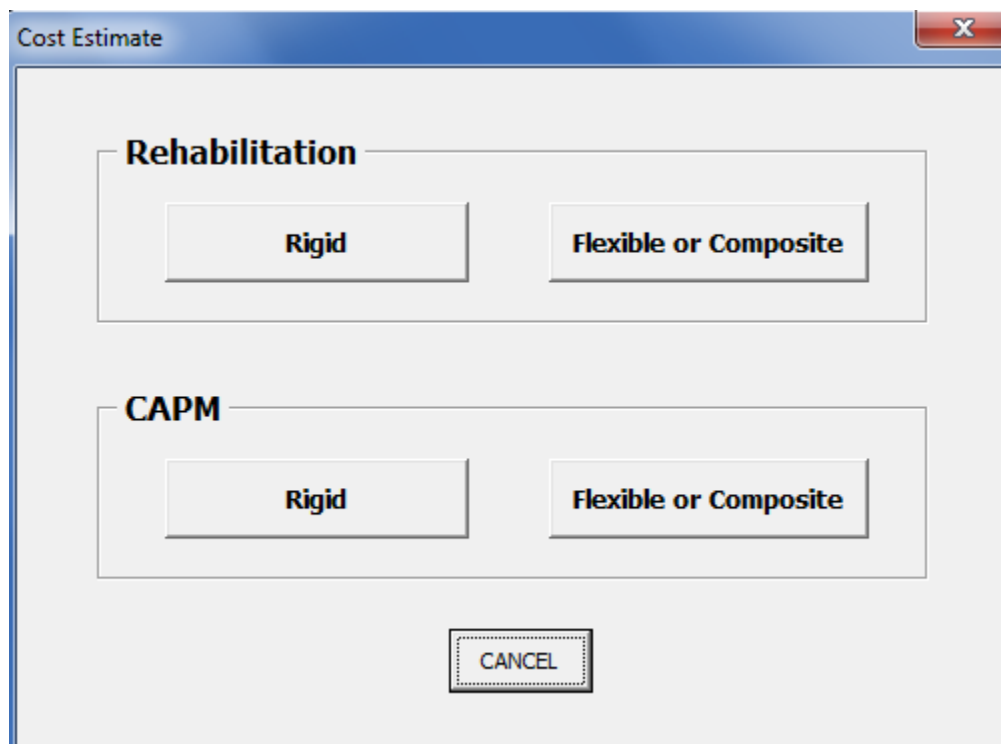


Figure 3-21 Cost Estimate Calculator Options

3.5.3.1 Rehabilitation Flexible Pavement Cost Estimator

Figure 3-22 is the cost estimator panel for the “Rehabilitation Flexible or Composite Pavement”.

Figure 3-22 “Rehabilitation Flexible Pavement” Panel

The following are the steps to calculate the flexible pavement rehabilitation costs:

- 1) Enter the number of pavement lane miles in the project. Click the “Pavement Cost” button as shown in Figure 3-22, then the Figure 3-23 “Pavement Selection” Panel will be displayed.

Pavement Selection

Traffic Index: 15

Design Year: 20

Existing Structure Depth

- HMA (ft): 1
- RHMA (ft): 0.2
- AB (ft): 1
- Rigid Base Depth (ft) (for Composite Pavement): 0

Pavement Option: Overlay

New Structure Depth

- HMA (ft): 0.25
- RHMA (ft): 0.2
- Mill Pavement (ft): 0

CANCEL Use Selected Structure

Figure 3-23 “Pavement Selection” Panel

- 2) Click the “Traffic Index” button, as shown in Figure 3-23, Figure 3-24 “Traffic Index (TI) Computation for Flexible Pavement” panel will be displayed.

Traffic Index (TI) Computation for Flexible Pavement

Location Selection: Route, District, County, Prefix, Postmile, Ahead/Back
 1 12 ORA R.129 A Import

Location Information		Truck Traffic	
Route	1	2 Axle %	33.93
District	ORA	3 Axle %	47.32
Post Mile	R.129	4 Axle %	13.39
Design Life (yr)	20	5+ Axle %	5.36
Lane Distribution Factor (LDF)	1	Total Truck %	6.22

Use Current (Data) Year AADT (2-Ways)
 Input Target Year AADT (2-Ways)

Use Current (Data) Year AADT (2-Ways)		Input Target Year AADT (2-Ways)	
Year	2011	Target Year	2035
AADT (Current Year)	36500	AADT for GP for Target Year	80000
Growth Rate (%)	1	AADT for HOV for Target Year	20000
Baseline Year (Construction complete)	2013		

OR

Calculate TI

Traffic Index Output			
County	ORA	Baseline Year	2013
Route	1	AADT for Target Year	41129
Postmile	R.129	Total ESAL	4778200
		Target Year	2023
		Calculated TI	10.8
		Design TI	11

CANCEL USE THIS TI

Figure 3-24 Traffic Index (TI) Computation for Flexible Pavement” Panel

- 3) Determine the TI by selecting the “Location Selection” and “Import” traffic data for the project, and the program calculates the TI. The calculated TI, is used if the “Use this TI” button is clicked. This TI is automatically entered on the “Traffic Index” panel as shown in Figure 3-23, “Pavement Selection” which is displayed again.
- 4) Enter the initial construction pavement structure.
- 5) The pavement thickness is calculated when the “Calculate Thickness” button is clicked. By clicking the “Use Selected Thickness” button, the new structure depth thickness is accepted and Figure 3-22 “Flexible Rehabilitation Pavement” panel with updated “Pavement Cost (\$) (1)” is displayed.

The pavement structure of the flexible rehabilitation activity is dependent of the TI and existing pavement structure, which may be the initial construction structure section. The initial structure section is to be determined by the Materials Branch. However, the TI can be calculated by using the “Traffic Index” panel shown in Figure 3-24, which contains traffic data from the Traffic Operation’s 2011 truck data. The TI may also, be furnished by the district’s Traffic Operations branch, which may have more recent data.

The lane distribution factor is dependent on the number of lanes in each direction per HDM Table 613.3B. Normally, the pavement structure is designed for a uniform lane distribution factor due to excessive construction costs incurred by using multiple pavement structural thicknesses for the same section of highway.

3.5.3.2 Rehabilitation Rigid Cost Estimator

Figure 3-25 is the cost estimation panel for the “Rehabilitation Rigid Pavement”.

Rehabilitation Rigid Pavement

Alternative/Activity

Alternative Number: 1

Activity Number: 2

Pavement Mainline (lane-m): 12

Misc. Item Cost

Misc. Item Cost % of Sum of (1)~(3): 10

Misc Item Cost (\$) (3): 585,028

Indirect (Contingency) Cost

Indirect Cost % of Sum of (1)~(4): 20

Indirect Cost (\$) (5): 1,299,061

Pavement Cost

Pavement Cost (\$) (1): 5,709,285

Traffic Cost

Work Zone Duration (day): 10

Daily Traffic Handling Cost (\$): 2,000

Daily COZEEP Cost (\$): 2,000

Other Traffic Cost (\$): 2,000

Traffic Cost (\$) (4): 60,000

Supporting Cost

Supporting Cost % of Sum of (1)~(5): 25

Supporting Cost (\$) (6): 1,948,592

Total Project Cost

Total Project Cost (\$1,000) (7): 9,743

Sum of (1)~(6)

CANCEL OK

Shoulder Cost

Flexible Shoulder

	Area(sy)	Unit Cost (\$/sy)
Milling	2,000	2
HMA	5,000	85
	Depth(ft)	Unit Cost (\$/ton)
	0.2	85

Rigid Shoulder

	Area(sy)	Unit Cost (\$/sy)
Grinding	20,000	4

Shoulder Cost (\$) (2): 140,993

Figure 3-25 “Rehabilitation Rigid Pavement” Cost Estimation Panel

After click on “Pavement Cost (\$)” button, you can calculate pavement cross-section (structure) by selecting the following in Figure 3-26, “Rehab Rigid Pavement Selection” panel:

- Climate region—Options include Coastal, Inland Valley, High Mountain and High Desert, Desert, and Low Mountain and South Mountain. The climate region information is found in the Caltrans Climate Regions Map.
- Subgrade Soil Type—Options are Type I or Type II. Refer to HDM for description of soil type.
- Traffic Index—*RealCost Version 2.5CA* branches to Figure 3-27 for calculations.
- Lateral Support Existence—Options are “Yes” or “No”. Refer to HDM for description of lateral support.
- Click the check box if the project includes Remove Concrete Pavement and Base.

Climate Region: Inland Valley

Subgrade Soil Type: Type II

Traffic Index (TI): 16.5

Lateral Support Existence: No

Show Rigid Pavement Structural Depth

	Material	Depth (ft)
<input type="radio"/> Option 1	JPCP	1.25
	LCB	0.35
	AS	0.7
<input type="radio"/> Option 2	JPCP	1.25
	HMA-A	0.25
	AS	0.7
<input checked="" type="radio"/> Option 3	CRCP	1.1
	HMA-A	0.25
	AS	0.7
<input type="radio"/> Option 4	-	0
	-	0
	-	0

Include 'Remove Concrete Pavement and Base'

CANCEL NEXT

Figure 3-26 “Rehab Rigid Pavement Selection” Panel

Figure 3-27, “Traffic Index (TI) Computation for Rigid Pavement” panel allows for the selection of the project location and imports the traffic data. The TI is then calculated. Click on the “USE THIS TI” to accept the data in the pavement structure options in Figure 3-27. If the rigid pavement option is selected, then the program goes back to the panel shown in

Figure 3-26. Then click the “Show Rigid Pavement Structure Depth” button after the data entries are completed.

Figure 3-27 “Traffic Index (TI) Computation for Rigid Pavement” Panel

Click the “Next” button in Figure 3-26, you will see the “Rehab Rigid Pavement Cost” panel shown in Figure 3-28. Click on “OK” button, the calculated “Pavement Total Cost \$” will be transferred to the “Rehabilitation Rigid Pavement” Cost Estimation Panel shown in Figure 3-25.

Pavement Item	Depth(ft)	Quantity	Unit	Unit Cost(\$)	Pavement Item Cost(\$)
Remove Conc Pvmt	0	0	CY	40	0
		0	CY	200	0
		0	CY	85	0
		0	CY	50	0
Pavement Total Cost(\$)					0

Figure 3-28 Rehab Rigid Pavement Cost Panel

3.5.3.3 CAPM Rigid Cost Estimator

Figure 3-29 shows the cost estimator for the CAPM Rigid Pavement.

Field	Value
Alternative Number	1
Activity Number	2
Mainline CPR or PR Cost	
CPR Type	CPR A: 7%
CRCP Punchout Repair	PR A
Concrete Pavement Area (sy)	28,160
Concrete Depth (ft)	1.00
Base Depth (ft)	1.00
Base Repair Percent (%)	50
Concrete Unit Cost (\$/cy)	400
Shoulder Pavement	
Concrete Shoulder Area (sy)	1,000
Grinding Unit Cost (\$/sy)	4
Asphalt Shoulder Area (sy)	2,000
Milling Unit Cost (\$/sy)	2
Pavement Cost (Mainline + Shoulder) (\$) (1)	51,333
Traffic Cost	
Work Zone Duration (day)	20
Daily Traffic Handling Cost (\$)	2,000
Daily COZEEP Cost (\$)	<input checked="" type="checkbox"/> 2,000
Traffic Cost (\$) (2)	80,000
Indirect Cost	
Indirect Cost Percentage of (1)~(2)	20
Indirect Cost (\$) (3)	26,267
Supporting Cost	
Supporting Cost Percentage of (1)~(3)	20
Supporting Cost (\$) (4)	31,520
Total Project Cost	
Total Project Cost (\$1,000)(5)	189
Sum of (1)~(4)	

Figure 3-29 “CAPM Rigid Pavement” Estimate Data Panel

Generating an estimate for future rigid CAPM activity requires the following steps:

- 1) Select the appropriate concrete pavement restoration type based on Figure 3-30 and Figure 3-31.
- 2) Enter the pavement area in square yard.
- 3) Enter the concrete thickness in feet.
- 4) Enter base thickness in feet.
- 5) Enter shoulder area (square yard) in the appropriate pavement type.

- 6) Enter the total number of work zone duration days.
- 7) Press “Calculate”

CRR	Number of Lanes per Direction				Average CPR
	1	2	3	4	
CPR C (≤2%)	2%				2.0%
	1%	2%			1.5%
	0%	1%	2%		1.0%
	0%	0%	1%	2%	0.8%
CPR B (2-5%)	5%				5.0%
	2%	5%			3.5%
	0%	2%	5%		2.3%
	0%	1%	3%	5%	2.3%
CPR A (5-7%)	7%				7.0%
	3%	7%			5.0%
	1%	3%	7%		3.7%
	1%	3%	5%	7%	4.0%

For 5 Lanes,
 $[(5-4) \times 0.70 + 4 \times (0.75)] / 5$

OK

Figure 3-30 CAPM CPR Selection Table

For the base repair of rigid pavement for CAPM, 50 percent of damaged slabs are required to be repaired for CPR A and 25 percent of the damaged slabs are required to be repaired for CPR B. No base repair is required for CPR C.



Figure 3-31 M&R Rigid Pavment – Base Repair Information Window

3.5.3.4 CAPM Flexible or Composite Pavement Cost Estimator

Figure 3-32 shows the cost estimate panel for the CAPM flexible pavement.

The screenshot shows the 'CAPM Flexible or Composite Pavement' cost estimate panel. It is organized into several sections with input fields and calculated values:

- Pavement Area:** Alternative Number (1), Activity Number (3), Pavement Area (sy) (Mainline+Shoulder) (200,000).
- Flexible Pavement:**
 - RHMA Depth (ft) (0.15), Unit Cost (\$/ton) (95)
 - HMA Depth (ft) (0.20), Unit Cost (\$/ton) (85)
 - Overlay Quantity (ton) (26,820), **Overlay Cost (\$) (1)** (2,279,700)
- Slab Replacement Cost (for Composite Pavement):**
 - Depth of Slab Replacement (ft) (0.00)
 - Quantity and Unit Cost (\$):

Material	Quantity	Unit Cost (\$)
HMA (ton)	0.00	85
PCC (cy)	0.00	400
 - Slab Replacement Cost (\$) (2)** (0)
- Milling Existing Pavement Option:** Milling Area (sy) (20,000), Unit Cost (\$/sy) (2), **Milling Cost (\$) (3)** (40,000)
- Sacrificial Course Option:** Sacrificial Course Type (HMA-O), Depth (ft) (0.1), Unit Cost (\$/ton) (90), **Sacrificial Cost (\$) (4)** (972,000)
- Digout Option:** Digout Percentage of Lane-Mile (%) (5), Unit Cost (\$/cy) (185), **Digout Cost (\$) (5)** (308,333)
- Traffic Cost:** Work Zone Duration (day) (100), Daily Traffic Handling Cost (\$) (2,000), Daily COZEEP Cost (\$) (checked) (2,000), **Traffic Cost (\$) (6)** (400,000)
- Indirect Cost:** Indirect Cost Percentage of (1)~(6) (20), **Indirect Cost (\$) (7)** (800,007)
- Supporting Cost:** Supporting Cost Percentage of (1)~(7) (20), **Supporting Cost (\$) (8)** (960,008)
- Total Cost:** **Total Project Cost (\$1,000) (9)** (5,760), Sum of (1)~(8)

Buttons for CANCEL and OK are located at the bottom right.

Figure 3-32 “CAPM Flexible Pavement” Cost Estimate Panel

Generating an estimate for future flexible CAPM activity requires the following steps.

- 1) Enter the pavement area (mainline and shoulder) in square yard.
- 2) Select the pavement surface type.
- 3) If applicable, enter the milling area in square yard.
- 4) If applicable, select if the sacrificial course type.
- 5) Enter the total number of work zone duration days.
- 6) Press “Calculate”

3.6 Input Warnings and Errors

To see a list of missing or potentially erroneous data, click the “Show Warnings” button on the “Switchboard”, Figure 3-3, before running the analysis. Figure 3-33 shows an example of “Warnings”. “Warnings” call attention to certain inputs that fall out of expected ranges and do not necessarily indicate input errors. “Errors” are fatal inputs that will prevent the program from running and providing LCCA results. If “Warnings” or “Errors” occur, it is

advisable to recheck inputs and project assumptions to ensure the analysis is realistic and accurate.

A common error is “mismatch: 13,” which can mean that there is an empty input or a bad input. If this error occurs, review all inputs.

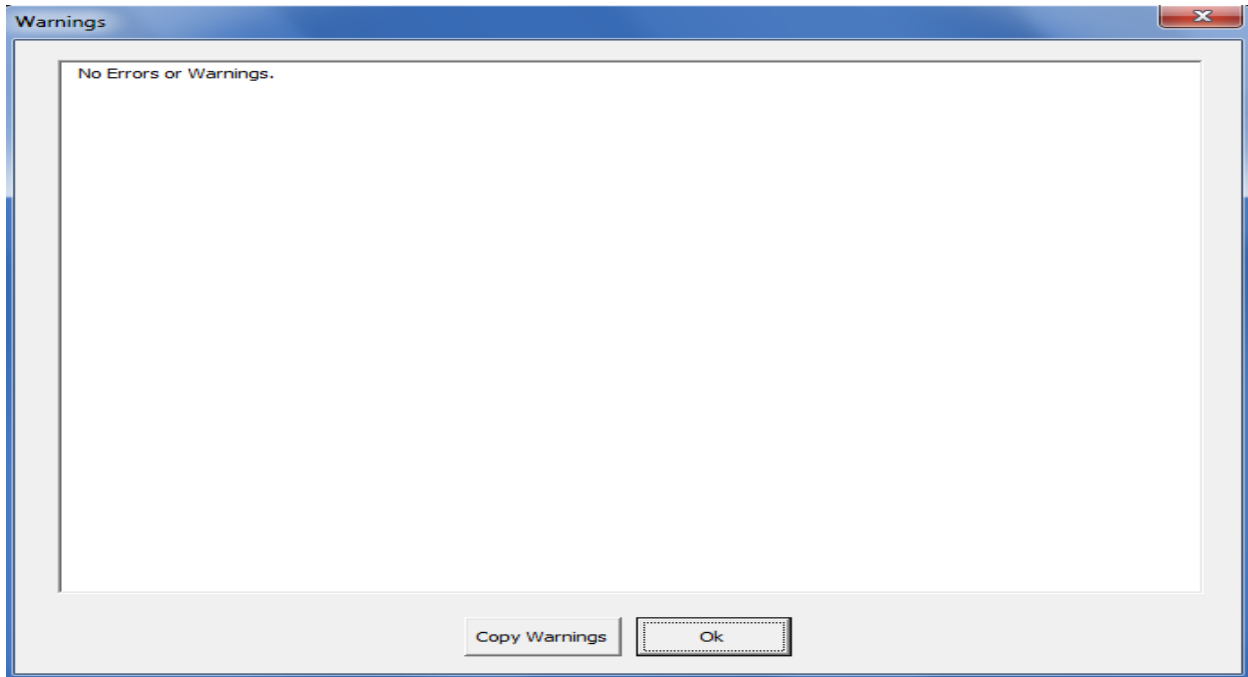


Figure 3-33 Input Warnings

3.7 Simulation and Outputs

The “Simulation and Outputs” section of the *RealCost Version 2.5CA*, “Switchboard”, Figure 3-3, includes buttons to view deterministic life-cycle cost results. (The buttons to run simulations of probabilistic inputs are not active).

Deterministic Results: Click this button to have *RealCost Version 2.5CA* calculate and display deterministic values for both agency and user costs based upon the deterministic inputs. The “Deterministic Results” panel as shown in Figure 3-34, which provides a direct link “Go to Worksheet” button to the “Deterministic Results Excel Worksheet” that contains all the information needed to investigate the deterministic results.

Deterministic Results

Deterministic Results

Total Cost	Alternative 1:		Alternative 2:		Alternative 3:		Alternative 4:	
	Agency Cost (\$1000)	User Cost (\$1000)	Agency Cost (\$1000)	User Cost (\$1000)	Agency Cost (\$1000)	User Cost (\$1000)	Agency Cost (\$1000)	User Cost (\$1000)
Undiscounted Sum	\$25,347.00	\$15,744.41	\$37,191.75	\$16.40				
Present Value	\$16,550.62	\$5,666.52	\$21,212.69	\$10.08				
EUAC	\$770.43	\$263.78	\$987.45	\$0.47				
Lowest Present Value Agency Cost	Alternative 1:							
Lowest Present Value User Cost	Alternative 2:							

Go to Worksheet Close

Figure 3-34 Deterministic Results Panel

- **Reports:** Click this button to have *RealCost Version 2.5* produce a multi-page report that shows the “Project Level” inputs and M&R sequences. Details of the “Alternative-Level” inputs can be access through the “Agency Cost Detail” button.

3.8 Administrative Functions

The “Administrative Functions” section of the *RealCost Version 2.5CA*, “Switchboard”, as shown in Figure 3-3 allows the engineer to save, clear, retrieve data, and close the “Switchboard” of *RealCost Version 2.5CA*.

- **Go to Worksheets:** Clicking this button will allow direct access to any input or result worksheet.
- **Clear Input Data:** Clicking this button clears the project-level inputs, alternative-level inputs, and results from the program and the worksheets.
- **Save LCCA Workbook As...:** Clicking this button allows you to save the entire Excel workbook, including all inputs and results worksheets, under a user-specified name.
- **Exit LCCA:** Clicking this button will close *RealCost Version 2.5CA*.

CHAPTER 4 SUMMARY AND CONCLUSIONS

4.1 Summary

Life-cycle cost analysis is a project cost evaluation tool that compares the economic impacts of different pavement alternatives. The data and procedures in this manual are not designed to provide cost-benefit (non-economic) or network level analysis. The goal of this LCCA Procedures Manual is to provide consistent analysis by making the same assumptions between pavement alternatives in order to determine the most cost effective strategy in the long term by comparison.

LCCA is focused around quantifying two distinct types of costs throughout the project limits over a given analysis period: agency costs and user costs.

- Agency costs are direct costs that Caltrans pay for – initial construction, future maintenance and rehabilitation including support costs.
- User costs are an estimate of the costs associated with delaying the traveling public during the various construction activities within the analysis period converted to a dollar amount. User costs are not borne by Caltrans.

The results are in Present Value dollar amounts generated by *RealCost Version 2.5CA*. These results should not be used for project budgeting or estimating. The costs are not an estimate of the actual cost to Caltrans or the public. Although life-cycle costs are reported in dollars, the results should be viewed as a relative comparison of cost effectiveness between the pavement alternatives analyzed. By using the same LCCA methodology to analyze alternative pavement strategies over the same analysis period, most differences between assumptions inherent in the analysis and future development are negated by the comparison between alternatives.

LCCA is not a means to predict the future. Calculations are based on today's prices and historical average costs for similar projects. Market factors and other events could have dramatic impact on the actual long-term costs but not in the comparison. The results of the analysis don't reveal any information about the merits or benefits of a single project, just how the long-term costs of one pavement alternative compare to another. **Sound engineering judgment is required when comparing results.**

To generate reasonable and consistent results, the pavement alternatives being evaluated must provide equivalent benefits, although the costs and scheduled maintenance activities between alternatives will typically vary in dollar amount and timing over the analysis period. For example, alternatives that only differ in design life or pavement surface type are considered to have equivalent benefits. Conversely, an alternative that includes widening or increases vehicle capacity is not equivalent to a strategy that only rehabilitates an existing pavement structure. Similarly, a preventative maintenance strategy such as a slurry or chip seal is not equivalent to a pavement rehabilitation overlay that adds strength to the pavement structure.

4.2 Limitations of *RealCost Version 2.5CA*

RealCost is a tool to calculate the life-cycle costs. As with any tool, *RealCost* has limits. It is a software program designed to model project conditions in order to compare the costs of selected pavement alternatives over a given analysis period, also known as the life-cycle.

Engineers should be mindful of the “garbage in, garbage out” mentality. How well *RealCost* models a project is determined by how well the engineer is able to match the project conditions with the program’s data input. To assure the consistency of the analysis and to minimize the amount of time needed to perform an analysis, data tables for costs, schedules, and user cost inputs have been generated using existing Caltrans data and other sources.

Although data tables and instructions are intended to cover nearly all the situations that may be encountered with a project, situations will arise that are not covered in the manual. Because LCCA involves nearly every aspect of a project, it is advisable to seek out experience within an office, district, or region to take advantage of their familiarity with the area where the project is located. This will help the engineer verify any assumptions beyond what is found in this manual made as part of the analysis. LCCA calculations should be checked and verified to ensure that the results are realistic. At a minimum, the results should be analyzed for input errors, excessive cost differences between alternatives, and given a reality check (e.g. do the inputs and outputs make sense?). The more time and care that are invested in developing accurate input data, the better the quality of the results. However, investing excessive time refining inputs is not always justified, since the models in *RealCost Version 2.5CA* may not be sensitive enough to change the ultimate results of the project alternatives comparison.

4.3 Project with Variable Conditions

Despite the numerous inputs in the *RealCost Version 2.5CA* program, the geometric and traffic models are relatively simple compared to typical project conditions. Projects may have multiple segments, routes, or project types (widening and rehabilitation together). The engineer should break these projects into segments before running *RealCost Version 2.5CA*. Each project segment should be run separately to get the most accurate results.

Variable closure windows (number of lanes, day of the week, month, traffic direction), and variable geometrics such as the number of lanes, may warrant multiple segments and may warrant running *RealCost Version 2.5CA* separately for each segment. Given the variable sensitivity of the software model to different inputs, an alternative solution is to vary the inputs and analyze the results to determine if more in-depth analysis is necessary. How a project is broken down is subject to the engineer’s judgment. Potential methods include adjusting the post mile inputs in *RealCost Version 2.5CA* or using a percentage of the total cost based on relative project lengths or surface area. If the project requires a variable Traffic Management Plan (TMP), a reasonable assumption may be to use the requirements that cover the majority of the project. The engineer should consider how well an overall assumption applies to different selected project alternatives.

4.4 Comparing Pavement Alternatives Costs

RealCost Version 2.5CA is a valuable tool for the engineer to compare different rehabilitation strategies as well as new construction strategies over a long period time. Not only are the initial construction costs, but the annual maintenance costs, subsequent rehabilitation costs, and user costs are also considered.

The *RealCost Version 2.5CA* prepares a detailed report for the engineer with the cost comparisons and a recommendation based on the costs. However, costs alone may not be the deciding factor for project strategy selection. There may be environmental issues or right-of-way issues to be considered before a final strategy selection can be made. Also, initial project costs may exceed the funding for a rehabilitation project, and the district may decide to delay the rehabilitation and simply do a CAPM strategy until the funding can be secured for a later date. Project strategy selection is not always a clear choice based on costs alone.

The “Deterministic Results” shown in Figure 4-1 is an example of the results shown in the *RealCost Version 2.5CA* generated “Report”. Alternative 1 is a Rehabilitation using an HMA, and Alternative 2 is CAPM using HMA.

Deterministic Results

Total Cost	Alternative 1:		Alternative 2:		Alternative 3:		Alternative 4:	
	Agency Cost (\$1000)	User Cost (\$1000)	Agency Cost (\$1000)	User Cost (\$1000)	Agency Cost (\$1000)	User Cost (\$1000)	Agency Cost (\$1000)	User Cost (\$1000)
Undiscounted Sum	\$23,336.67	\$18,312.16	\$20,440.50	\$12,358.68				
Present Value	\$15,529.71	\$11,350.38	\$10,342.97	\$6,742.07				
EUAC	\$494.21	\$361.21	\$420.74	\$214.55				

Figure 4-1 Deterministic Results from *RealCost Version 2.5CA* Report

With the deterministic approach, life-cycle costs are computed based on the present values of the comparison of the differential pavement alternative costs. The results are a single present value for each pavement alternative.

Best-practice LCCA considers both, agency and user costs. User costs should also be compared to see if an alternative has a disproportionately high or low impact on users compared to other alternatives. If the lowest-agency-cost alternative has a disproportionately high user-cost impact, the engineer may use this information to revisit that alternative to mitigate user costs, or may recommend that an alternative with somewhat higher agency costs but much lower user costs be pursued in preference to the lowest-agency-cost (FHWA 2002).

In the example shown in Figure 4-1, the engineer should determine if there is a way to lower the User Costs for Alternative 1. Perhaps, by improving the traffic management plan the User Costs could be lowered.

4.5 *RealCost* Output Values

The deterministic outputs produced from *RealCost* are categorized by Undiscounted Sum, Present Value, and EUAC and by Agency and User costs.

- *Undiscounted Sums* are the costs as if all the costs occurred today. This is not relevant to the analysis result since all of the costs will not incur upfront.
- *Present Value* is all of the future expenditures over the analysis period converted to present value dollars. Caltrans use this approach to compare alternatives.
- *EUAC* or equivalent uniform annual costs are the total costs discounted to present value divided by the analysis period. In other words, it is the yearly costs of an alternative as if they occurred uniformly throughout the analysis period. This is not relevant to the analysis since costs will not expend uniformly.

4.6 Document the Preferred Pavement Alternative

Other than the mandatory design standards detailed in Topic 612, “Pavement Design Life,” of the HDM, there is no absolute requirement to choose the pavement alternative with the lowest total life-cycle cost, although it is strongly encouraged. **If the lowest total life-cycle cost is not selected, reason must be documented.** Some possible reasons that another alternative other than the one with the lowest life-cycle cost might be chosen include safety, scope, schedule, constructability, environmental, accommodation of future growth or capacity improvements, or political reasons. LCCA project decisions should be documented in the PID, PR, or other appropriate project document (see PDPM Appendix O-O).

4.7 Status of LCCA Procedures Manual

This manual includes a variety of tables and data developed for Caltrans engineers to run the *RealCost Version 2.5CA* program. The data found in this manual are based on the most accurate information available at this time from Caltrans data, computer traffic modeling, FHWA, and other sources. Data and modeling updates will be made from time to time to improve the user-friendliness of LCCA process and the accuracy of the results. In particular, cost data will change periodically to reflect market fluctuation, inflation, and policy changes. Future updates of this manual will strive to capture the most accurate information available and meet changing needs and conditions.

4.8 Additional Information

Visit the LCCA website for LCCA examples, current economic values, and other examples.

4.9 Transmittal of Life-Cycle Cost Information

Submit your LCCA to HQ for data collection. Per PDPM Appendix O-O, a copy of the completed project initiation document, project report, or project scope summary report with life-cycle costs included shall be sent to:

Attn: HQ Program Advisor
HQ Division of Maintenance, Pavement
Program 2389 Gateway Oaks, Suite 200, MS 91
Sacramento, CA 95833

or

e-mail PDF files to
LCCA@dot.ca.gov

REFERENCES

1. Federal Highway Administration, "Life-Cycle Cost Analysis in Pavement Design," FHWA-SA-98-079, Pavement Division Interim Technical Bulletin, September 1998.
2. Federal Highway Administration, Life-Cycle Cost Analysis, *RealCost* User Manual, August 2004.
3. Federal Highway Administration, "Life-Cycle Cost Analysis Primer," August 2002.
4. California Department of Transportation, "2004 State of the Pavement," Division of Maintenance, Office of Roadway Rehabilitation and Roadway Maintenance, July 2005.
5. California Department of Transportation, "Highway Design Manual," Sixth Edition, September 2006.
6. California Department of Transportation, "Historical Cost Analysis of Capital Outlay Support for FYs 1998 to 2002," Division of Project Management, Office of Project Workload and Data Management, May 2005.
7. Washington State Department of Transportation, "Pavement Type Selection Protocol," Environmental and Engineering Program Division, January 2005.

APPENDIX 1: GLOSSARY AND LIST OF ACRONYMS

A. Glossary

Analysis Period: the period of time during which the initial and any future costs for the project alternatives will be evaluated.

Activity Service Life: the estimated time period that the asset will remain viable for public use (at or above a minimum level of service).

Capital Preventive Maintenance (CAPM): CAPM consists of work performed to preserve the existing pavement structure utilizing strategies that preserve or extend pavement service life. See HDM Index 603.2 and the CAPM Guidelines (DIB 81) for further information.

Composite Pavement: pavements comprised of both rigid and flexible layers. Currently, for purposes of the procedures in the HDM, only flexible over rigid composite pavements are considered composite pavements.

Continuously Reinforced Concrete Pavement (CRCP): one type of rigid pavement with reinforcing steel and no transverse joints except at construction joints or paving stops for more than 30 minutes. CRCP pavements are reinforced in the longitudinal direction, and additional steel is also used in the transverse direction to hold the longitudinal steel. Due to the continuous reinforcement in the longitudinal direction, the pavement develops transverse cracks spaced at close intervals. These cracks develop due to changes in the concrete volume, restrained by the longitudinal reinforcement steel, resulting from moisture and temperature variation. Crack width can affect the rate of corrosion of the reinforcing steel at the crack locations when water or de-icing salts (if used) penetrate the cracks. In a well-designed CRCP, the longitudinal steel should be able to keep the transverse cracks tightly closed.

Crack, Seat, and Flexible Overlay (CSFOL): A rehabilitation strategy for rigid pavements. CSFOL practice requires the contractor to crack and seat the rigid pavement slabs, and place a flexible overlay with a pavement reinforcing fabric (PRF) interlayer.

Flexible Pavement: Pavements engineered to transmit and distribute traffic loads to the underlying layers. The highest quality layer is the surface course (generally asphalt binder mixes), which may or may not incorporate underlying layers of a base and a subbase. These types of pavements are called “flexible” because the total pavement structure bends or flexes to accommodate deflection bending under traffic loads.

Hot Mix Asphalt (HMA): formerly known as asphalt concrete (AC), is a graded asphalt concrete mixture (aggregate and asphalt binder) containing a small percentage of voids which is used primarily as a surface course to provide the structural strength needed to distribute loads to underlying layers of the pavement structure.

Hot Mix Asphalt with Open Graded Friction Course (HMA w/ OGFC): Open graded friction course (OGFC), formerly known as open graded asphalt concrete (OGAC), is a wearing course placed on top of HMA. OGFC is a wearing course mix consisting of asphalt binder and aggregate with relatively uniform grading and little or no fine aggregate and mineral filler. OGFC is designed to have a large number of void spaces in the compacted mix as compared to hot mix asphalt.

Hot Mix Asphalt with Rubberized Hot Mix Asphalt (HMA w/ RHMA): Rubberized hot mix asphalt (RHMA), formerly known as rubberized asphalt concrete (RAC) is a wearing course placed on top of HMA. RHMA is a material produced for hot mix applications by mixing either asphalt rubber or asphalt rubber binder with graded aggregate. RHMA may be gap- (RHMA-G) or open- (RHMA-O) graded.

Jointed Plain Concrete Pavement (JPCP): one type of rigid pavement, also referred to as Portland Cement Concrete Pavement (PCCP), constructed with longitudinal and transverse joints. JPCPs do not contain steel reinforcement, other than tie bars and dowel bars. JPCPs are doweled in the transverse joints to improve load transfer and prevent faulting of the slabs from occurring. Tie bars are used in the longitudinal joints to hold adjoining slabs together.

Lane Replacement: the removal of individual slabs (or panels) of concrete pavement where the total length of consecutive slabs is greater than 100 feet.

Maintenance Service Level (MSL): For maintenance programming purposes, the State highway system has been classified as Class 1, 2, and 3 highways based on the MSL descriptive definitions:

- MSL 1 – Contains route segments in urban areas functionally classified as Interstate, Other Freeway/Expressway, or Other Principal Arterial. In rural areas, the MSL 1 designation contains route segments functionally classified as Interstate or Other Principal Arterial.
- MSL 2 – Contains route segments classified as an Other Freeway/Expressway or Other Principal Arterial not in MSL 1, and route segments functionally classified as minor arterials not in MSL 3.
- MSL 3 – Indicates a route or route segment with the lowest maintenance priority. Typically, MSL 3 contains route segments functionally classified as major or minor collectors and local roads with relatively low traffic volumes. Route segments where route continuity is necessary are also assigned MSL 3 designation.

The MSL can be found in the Pavement Condition Report developed by the Division of Maintenance.

Pavement Structure: The planned, engineered system of layers of specified materials (typically consisting of surface course, base, and subbase) placed over the subgrade soil to support the cumulative traffic loading anticipated during the design life of the pavement.

The pavement is also referred to as the pavement structure and has been referred to as pavement structural section.

Open Graded Friction Course (OGFC): Formerly known as open graded asphalt concrete (OGAC), OGFC is a wearing course mix consisting of asphalt binder and aggregate with relatively uniform grading and little or no fine aggregate and mineral filler. OGFC is designed to have a large number of void spaces in the compacted mix as compared to hot mix asphalt.

Pavement Design Life: Also referred to as performance period, is the period of time that a newly constructed or rehabilitated pavement is engineered to perform before reaching a condition that requires at least Capital Preventive Maintenance (CAPM) or before reaching its terminal serviceability. The selected pavement design life varies depending on the characteristics of the highway facility, the objective of the project, and projected traffic volume and loading. See HDM Topic 612 for more information.

Precast Panel Concrete Pavement (PPCP): PPCPs use panels that are precast off-site instead of cast-in-place. The precast panels can be linked together with dowel bars and tie bars or can be post-tension after placement.

Rapid Strength Concrete (RSC): Also known as Rapid Set Concrete, which is a type of concrete that cures in 3 to 24 hours. RSC is used to replace concrete slabs and lanes during short construction windows where conventional Portland cement concrete will not have time to cure and gain strength.

Rehabilitation: Rehabilitation is work undertaken to extend the service life of an existing facility. This includes placement of an overlay and/or other work necessary to return an existing roadway, including shoulders, to a condition of structural or functional adequacy, for the specified service life. This might include the partial or complete removal and replacement of portions of the pavement structure. Rehabilitation work is classified as pavement rehabilitation activities and roadway rehabilitation activities.

Remaining Service Life Value (RSV): The value of the remaining activity service life beyond the end of the analysis period of a project alternative.

Rigid Pavement: pavements with a rigid surface course (typically Portland cement concrete or a variety of specialty cement mixes for rapid strength concretes), which may incorporate underlying layers of stabilized or non-stabilized base or subbase materials. These types of pavements rely on the substantially higher stiffness rigid slab to distribute the traffic loads over a relatively wide area of underlying layers and the subgrade. Some rigid slabs have reinforcing steel to help resist cracking due to temperature changes and repeated loading.

Rubberized Hot Mix Asphalt (RHMA): a material produced for hot mix applications by mixing either asphalt rubber or rubberized asphalt binder with graded aggregate. RHMA may be gap- (RHMA-G), or open- (RHMA-O) graded.

Rubberized Hot Mix Asphalt-Gap Graded (RHMA-G): a gap graded mixture of crushed coarse and fine aggregate, and of paving asphalt that is combined with specified percentages of granulated (crumb) reclaimed rubber. RHMA-G can be used as either a surface course or a non-structural wearing course.

Rubberized Hot Mix Asphalt-Open Graded (RHMA-O): same as RHMA-G, except RHMA-O is used only as a non-structural wearing course.

Slab Replacement: the removal of individual slabs (or panels) of concrete pavement with the total length of consecutive slabs being 100 feet or less.

Terminal Serviceability: the condition of the pavement at the end of its pavement design life. In California, this is defined as a condition that requires a CAPM, a major rehabilitation or reconstruction.

B. List of Acronyms

AADT	=	Annual Average Daily Traffic
BCA	=	Benefit-Cost Analysis
Caltrans	=	California Department of Transportation
Cal-B/C	=	California Life-Cycle Benefit/Cost Model
CAPM	=	Capital Preventive Maintenance
CRCP	=	Continuously Reinforced Concrete Pavement
CSFOL	=	Crack, Seal, and Flexible Overlay
FHWA	=	Federal Highway Administration
FO	=	Flexible Overlay
HDM	=	Highway Design Manual
HMA	=	Hot Mix Asphalt
JPCP	=	Jointed Plain Concrete Pavement
LCCA	=	Life-Cycle Cost Analysis
M&R	=	Maintenance & Rehabilitation/Reconstruction
MSL	=	Maintenance Service Level
MSRO	=	Mill, Slab Replacement & Overlay
OGFC	=	Open Graded Friction Course
PA&ED	=	Project Approval & Environmental Document
pcphpl	=	passenger cars per hour per lane
PDPM	=	Project Development Procedures Manual
PID	=	Project Initiation Document
PR	=	Project Report
PSSR	=	Project Scope Summary Report
RHMA	=	Rubberized Hot Mix Asphalt
RHMA-G	=	Rubberized Hot Mix Asphalt-Gap Graded
RHMA-O	=	Rubberized Hot Mix Asphalt-Open Graded
RSC	=	Rapid Strength Concrete
RSL	=	Remaining Service Life
SR	=	Slab Replacement
TI	=	Traffic Index
vph	=	vehicles per hour
vphpl	=	vehicles per hour per lane

APPENDIX 2: LIST OF *REALCOST* LIMITATIONS AND BUGS

A. Notes:

RealCost appears to calculate salvage value based on a round-down if activity service life is a decimal of less than 0.5 year. Don't use decimals in the activity service life.

When saving the project-level inputs file, *RealCost* will not save the escalation in the "Added Time and Vehicle Stopping Costs" panel. Escalate these values every time *RealCost* is re-started.

B. Limitations to the Program:

RealCost Version 2.5CA can only analyze four alternatives at once. To analyze more alternatives, run the program enough times to analyze each alternative and manually compare the results.

APPENDIX 3: PROCEDURES FOR ESTIMATING RAMP ALTERNATIVES

Procedures for Analyzing Ramps

The following procedures are provided to clarify ramp analysis and aid engineers in analyzing ramps as well as providing allowances to simplify the process. These procedures should be considered as the minimum allowable analysis for LCCA for state highways. Districts always have the discretion to analyze or require more locations and options than what is presented in this manual.

Omit Ramp Analysis

- Ramps as Part of a Larger Project
When ramps are included as part of a larger project to widen, rehabilitate, or build a state highway, the district may omit the analysis of the ramps in the LCCA. When omitting, it is assumed that the results for the ramps will be the same as the result for the mainline. It is also assumed that the pavement design criteria and design life used for the mainline will be used for the ramps.
- When it is for minor ramp maintenance, such as remove and replace open grade friction course. This is often done when a major project is being done on mainline.
- When the ramp project is a CAPM.

Example:

Suppose a project proposes to add one mainline lane and completely reconstruct an existing interchange. If the ramp pavement structure proposes to be the same as the mainline, a ramp LCCA is not required. However, if the ramp pavement structure is not anticipated to match the mainline pavement structure, then a ramp LCCA is required.

- Include Ramp analysis:

See the process below for Ramps as Part of a Separate Project. The user cost associated with ramp construction assumes additional traffic delay on the mainline. **Therefore, only off-ramps are analyzed for LCCA since off-ramps affect mainline traffic.** For example, if motorists do not take an off-ramp exit from the mainline, then it is assumed that there will be an additional traffic delay on the mainline which will increase user costs. On-ramps are mainly associated with local road traffic and are not used for LCCA.

Ramps as Part of a Separate Project

For projects that propose pavement work only on ramps (such as interchange modification projects), it is not necessary to perform an LCCA for each individual ramp. Instead, the engineer should select one off-ramp which has the highest traffic volume that best represents all the off ramps for the project.

If the project proposes auxiliary lanes, a separate analysis is not required provided the following conditions are met.

- Auxiliary-lanes are short (typically around 1000-feet in length or less) and serve only to aid with traffic handling for the ramp and do not extend to the next interchange.
- There are no plans to extend the auxiliary lanes to the next interchange or convert the lane into a through traffic lane within the life span of the pavement.

The District is responsible for making the determination as to whether the above conditions have been met.

Agency Construction Cost Considerations for Ramp Analysis

Ramps have three basic segments, the gore, middle, and the terminus at the intersection with the local road. (Note: not all ramps have an end treatment.)

When analyzing the middle segment, the designer should take into account the constructability of the entire ramp when estimating costs and making final decisions. For example, when the gore area is concrete and the ramp terminus is also concrete, it may be more cost effective in initial costs to pave the entire ramp with concrete because of the lower labor and mobilization costs.

Estimating User Cost

When estimating the user cost for ramps, the following assumptions can be made unless District Traffic Operations provides specific data for the ramp.

For the Project-Level and Traffic Data Inputs, enter the following:

- It is assumed that motorists will detour and exit at the downstream interchange.
- Traffic Direction
If the ramp peaks in the AM hours, then select “Inbound” as the Traffic Direction. If the ramp peaks in the PM hours, then select “Outbound” as the Traffic Direction. When either “Inbound” or “Outbound” is selected, *RealCost Version 2.5CA* analyzes user costs in one direction, the peak direction.
- AADT Construction Year (total for both directions)

Add mainline traffic volume in both directions to twice the off-ramp ramp traffic volume. Ramp LCCA analyze users cost in one traffic direction. However, the traffic volume input in *RealCost Version 2.5CA* must be for both directions. The off-ramp AADT is doubled to simulate traffic conditions in both directions, but *RealCost Version 2.5CA* will analyze just the selected peak traffic hourly distribution in one traffic direction.

Example:

The construction year AADT of the mainline road in both directions before the off-ramp is 17,000, as shown in Figure A3-1. The construction year AADT of the auxiliary lane or off-ramp is 3,000. The AADT Construction Year (total for both directions) **RealCost Version 2.5CA** input is $17,000 + 2 \times 3,000$ or 23,000 at the overcrossing during construction. This is because the traffic that would have normally travelled on the off-ramp is forced into the mainline. See AADT details in Figure A3-2 and Figure A3-3.

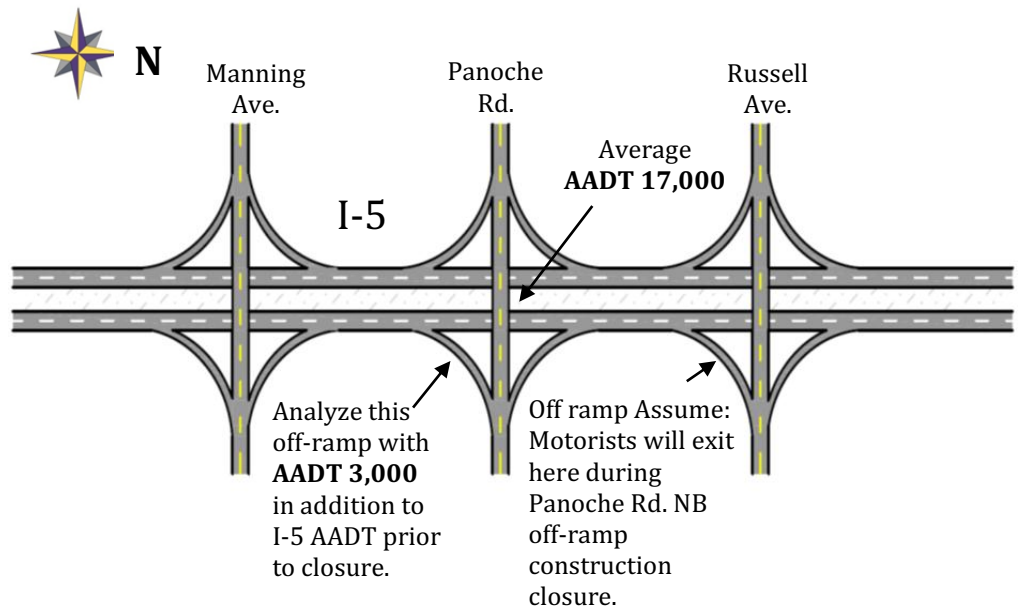


Figure A3-1 Layout showing AADT for I-5 and for off-ramp (pre-construction)

Figures A3-2 and Figure A3-3 show the AADT's at the ramp location prior to construction and during construction. It is assumed that the traffic that normally exits at Panoche Road (NB) is going to exit on the next exit, which is Russell Avenue. This causes a potential queue and traffic delay south of Panoche Road, and a user cost delay for up to 20,000 vehicles in a day.

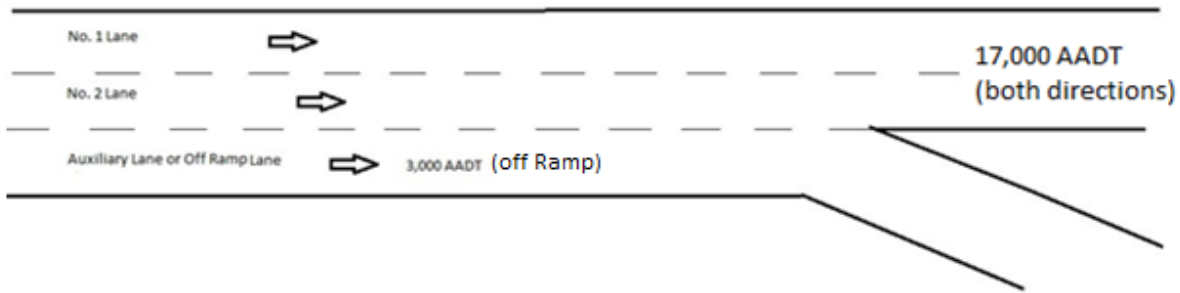


Figure A3-2 Pre-Construction AADT for Off-Ramp Scenario

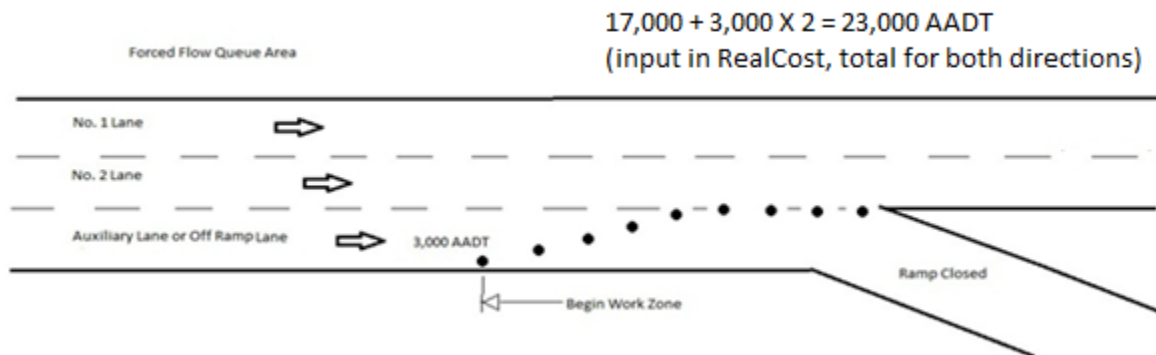


Figure A3-3 Construction AADT during Off-Ramp Closure

In Figure A8-3, a forced flow queue area is shown. This may cause a reduced speed delay, or a stopping delay for motorists, depending on the peak traffic, and if there is a lane reduction.

- Speed Limit Under Normal Operating Conditions
Use posted speed limit of the mainline in that direction (mph)
- Lanes Open in Each Direction Under Normal Conditions
Use number of through lanes on the mainline in that direction
+ 1 lane (to represent the off-ramp)

Example:

If the number of through lanes in the direction of the mainline highway that is feeding the off-ramp is 3, then the **RealCost Version 2.5CA** input for number of lanes open in each direction is 4 lanes (3 through mainline highway lane + 1 ramp lane).

- Maximum AADT (total for both directions)

Calculate the value by using the total number of through lanes on the mainline.

Example:

If the number of thru lanes in the direction of the mainline highway that is feeding the off-ramp is 3, then the **RealCost Version 2.5CA** input for Maximum AADT (total for both directions) is

$$3 \text{ lanes} \times 2 \text{ direction} \times \text{value from Table 3 - 1}$$

- All other values are entered as per the manual based on data and information of the mainline.

Once the Project Level Inputs, and the M & R Sequence is complete, the Alternative section of *RealCost Version 2.5CA* needs to be completed by entering the following:

- Agency Construction Cost, and Activity Service Life.
- Based on the information of the ramp you are analyzing.
- Work Zone Length:
Enter a length of no less than 1 mile.
- Number of Lanes Open in Each Direction During Work Zone:
Enter the number of thru lanes of the mainline.
- Work Zone Duration:
Based on the information of the ramp you are analyzing and the construction window prescribed under Work Zone Hours in Section 3.5.2.
- Work Zone Speed Limit:
Enter a speed that is 5 mph less than the posted speed limit unless there is an approved reduced speed limit for the project as determined by District Traffic Operations.
- Work Zone Hours:
Enter the time frame the ramp is closed from the Traffic Management Plan. If no traffic closure data is available, enter 0 to 6 as the First period of closure and enter 21 to 24 as the Second period of closure.

APPENDIX 4: TYPICAL PAVEMENT M&R SCHEDULES FOR CALIFORNIA

The following pavement M&R schedules are the consolidation of the “Pavement M&R Decision Trees” (used for activity scheduling) included in Caltrans districts’ ten-year pavement plans. Currently, each Caltrans district has its own set of pavement decision trees, most of which have different sequences of pavement M&R activities, depending on route class (alternatively known as maintenance service level) and pavement type. The following compilation of California-specific pavement M&R schedules has been developed to simplify the selection of a pavement M&R schedule for the LCCA.

The categorization of these California-specific pavement M&R schedules was based on four factors: the climate region, maintenance service level, existing pavement type/final surface type, and project type/initial M&R strategy (i.e., project alternative). The nine climate regions shown in Figure A4-1 are grouped into the five climate regions (i.e., All Coastal, Inland Valley, High Mountain & High Desert, Desert, and Low Mountain & South Mountain), and the pavement M&R decisions applicable to these five climate regions are collected from the district offices.

If a pavement decision tree for a particular pavement type was not available for a particular climate region, a similar decision tree from another region was utilized. For pavement decision trees for products with limited to no examples available in California (such as continuously reinforced concrete pavement), information from national sources and other states with similar climates/products was used.

Remaining Service Life (RSL)

When doing a widening project with a RSL alternative that is different from the values in the M&R Schedules, the life of the initial activity must be adjusted to reflect the difference in pavement design life. So for example, if a widening project has a RSL alternative of 25 years, and the service life of the initial activity in the M&R schedule for a 20-year pavement design life is 23 years, then the initial activity period that should be entered into *RealCost* should be 28 years (23 + 5 from difference in remaining life of existing pavement to theoretical 20-year pavement.)

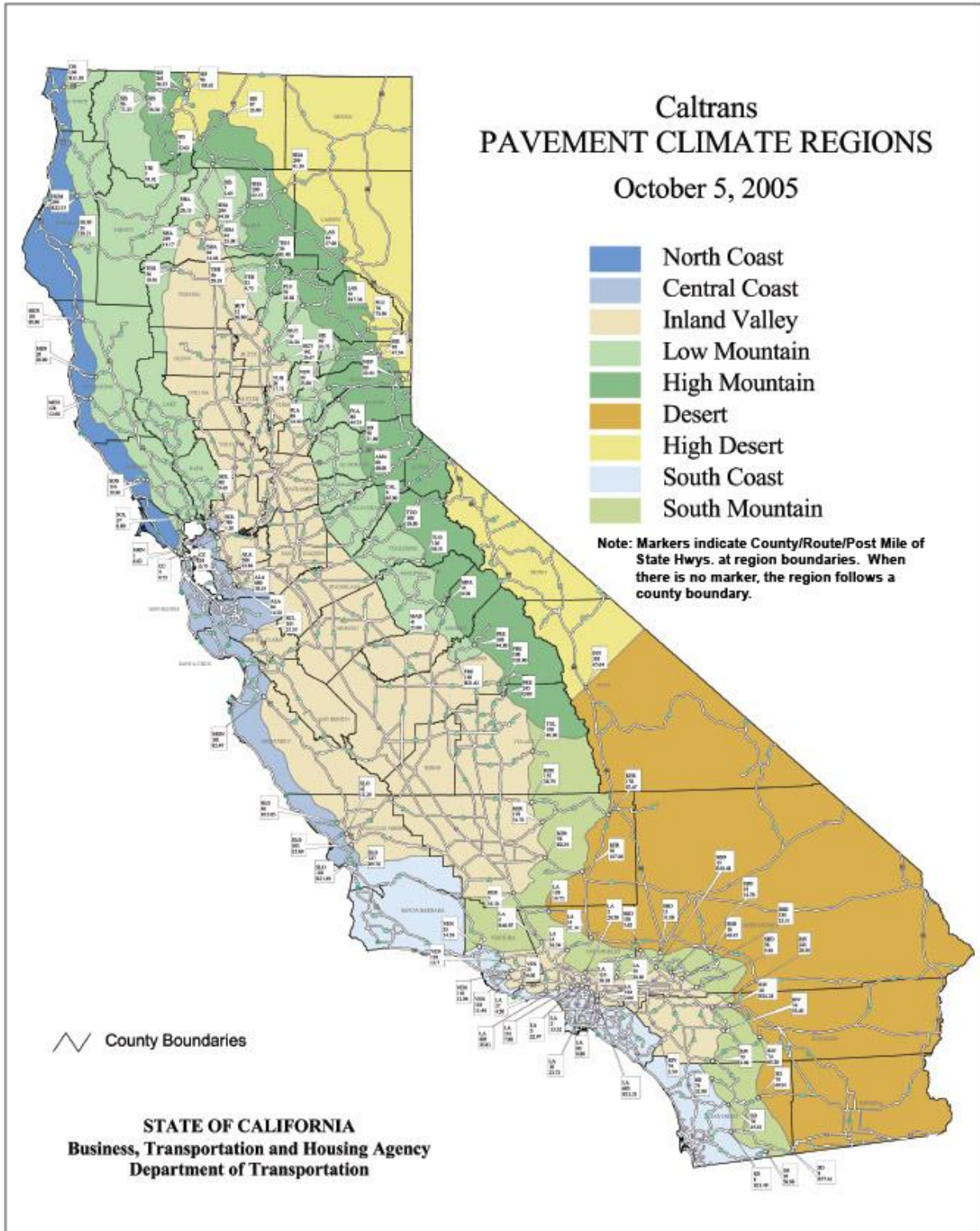


Figure A4-1: Map of Caltrans Climate Regions
 (This map can be found at Pavement Climate Regions Map (PDF))

TABLE F-1 (a)
All Coastal Climate Regions
HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pmnt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55				
New Construction/Reconstruction																			
HMA	20	1,2	Year of Action	0				20		25				45		50			
			Activity Description	New / Reconstruct				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	3,300	5	1,100	20	2,900	5	1,100	20	2,900					
		3	Year of Action	0				20				30				40		45	
			Activity Description	New / Reconstruct				CAPM HMA				CAPM HMA				CAPM HMA		Rehab HMA (20 yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	3,300	10	6,100			10	6,100			5	1,100	20	2,900	
CAPM																			
HMA	5+	1,2	Year of Action	0		5				25		30				50			
			Activity Description	CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	1,100	20	2,900	5	1,100	20	2,900			5	1,100			
		3	Year of Action	0				10				30		35					
			Activity Description	CAPM HMA				CAPM HMA				CAPM HMA		Rehab HMA (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	6,200	10	6,100			5	1,100	20	2,900					
Rehabilitation																			
HMA	20	1,2,3	Year of Action	0				20		25				45		50			
			Activity Description	Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	2,900	5	1,100	20	2,900	5	1,100	20	2,900					

TABLE F-1 (b)
All Coastal Climate Regions
HOT MIX ASPHALT W/ OGFC PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55					
New Construction/Reconstruction																				
HMA w/ OGFC	20	1,2	Year of Action	0					22				32		54					
			Activity Description	New / Reconstruct					CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)		CAPM HMA w/ OGFC					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,300					10	3,700			22	3,600	10	3,700		
		3	Year of Action	0					22				32		42		52			
			Activity Description	New / Reconstruct					CAPM HMA w/ OGFC				CAPM HMA w/ OGFC		CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,300					10	3,700			10	6,800	10	6,800	22	3,600
	40	1,2	Year of Action	0									40		50					
			Activity Description	New / Reconstruct									CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20-yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,200									10	3,700			22	2,300
		3	Year of Action	0									40		50					
			Activity Description	New / Reconstruct									CAPM HMA w/ OGFC		CAPM HMA w/ OGFC					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,200									10	3,700			10	3,700
CAPM																				
HMA w/ OGFC	5+	1,2	Year of Action	0					10				32		42					
			Activity Description	CAPM HMA w/ OGFC					Rehab HMA w/ OGFC (20 yr)				CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	3,700					22	2,300			10	4,000			22	3,200
		3	Year of Action	0					10		20				30		52			
			Activity Description	CAPM HMA w/ OGFC					CAPM HMA w/ OGFC		CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)		CAPM HMA w/ OGFC			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	3,700					10	6,800	10		6,800			22	3,600	
Rehabilitation																				
HMA w/ OGFC	20	1,2,3	Year of Action	0					22				32		54					
			Activity Description	Rehab HMA w/ OGFC (20 yr)					CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)		CAPM HMA w/ OGFC					
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,300					10	4,000			22	3,200			10	4,000		
	40	1,2,3	Year of Action	0									40		50					
Activity Description			Rehab HMA w/ OGFC (40 yr)									CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (40 yr)						
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,700									10	3,700			40	5,700			

TABLE F-1 (c)
All Coastal Climate Regions
HOT MIX ASPHALT W/ RHMA PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55						
New Construction/Reconstruction																					
HMA w/ RHMA	20	1,2	Year of Action	0								23		33							
			Activity Description	New / Reconstruct								CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)							
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	23	2,700							10	3,500	23	3,500					
		3	Year of Action	0								23		33		43		53			
			Activity Description	New / Reconstruct								CAPM HMA w/ RHMA		CAPM HMA w/ RHMA		CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	23	2,700							10	3,500	10	6,500	10	6,500	23	3,500	
	40	1,2	Year of Action	0												40		50			
			Activity Description	New / Reconstruct												CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	4,000											10	3,500	23	2,700	
		3	Year of Action	0												40		50			
			Activity Description	New / Reconstruct												CAPM HMA w/ RHMA		CAPM HMA w/ RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	4,000											10	3,500	10	3,500	
CAPM																					
HMA w/ RHMA	5+	1,2	Year of Action	0						10						33		43			
			Activity Description	CAPM HMA w/ RHMA						Rehab HMA w/ RHMA (20 yr)						CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	3,500					23	3,500					10	3,500	23	3,500	
		3	Year of Action	0						10		20						30		53	
			Activity Description	CAPM HMA w/ RHMA						CAPM HMA w/ RHMA		CAPM HMA w/ RHMA						Rehab HMA w/ RHMA (20 yr)		CAPM HMA w/ RHMA	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	3,500					10	7,600	10	7,600					23	3,500	23
Rehabilitation																					
HMA w/ RHMA	20	1,2,3	Year of Action	0								23		33							
			Activity Description	Rehab HMA w/ RHMA (20 yr)								CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)							
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	23	3,500							10	3,500	23	3,500					
		40	1,2,3	Year of Action	0												40		50		
				Activity Description	Rehab HMA w/ RHMA (40 yr)												CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (40 yr)		
				Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	4,800											10	3,500	40	4,800

TABLE F-1 (d)
All Coastal Climate Regions
RUBBERIZED HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55		
New Construction/Reconstruction																	
RHMA	20	1,2	Year of Action	0				22		28				50			
			Activity Description	New / Reconstruct				CAPM RHMA		Rehab RHMA (20 yr)				CAPM RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,200	6	900	22	2,500	6	900					
		3	Year of Action	0				22				32				51	
			Activity Description	New / Reconstruct				CAPM RHMA				CAPM RHMA		CAPM RHMA		Rehab RHMA (20 yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,200	10	4,100			10	4,000			9	4,400	22
CAPM																	
RHMA	5+	1,2	Year of Action	0		6		28		34							
			Activity Description	CAPM RHMA		Rehab RHMA (20 yr)		CAPM RHMA		Rehab RHMA (20 yr)							
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	6	900	22	2,500	6	900	22	2,500					
		3	Year of Action	0		10		20		29				51			
			Activity Description	CAPM RHMA		CAPM RHMA		CAPM RHMA		Rehab RHMA (20 yr)				CAPM RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	4,000	10	4,100	9	4,400	22	2,500	10	4,000			
Rehabilitation																	
RHMA	20	1,2,3	Year of Action	0				22		28				50			
			Activity Description	Rehab RHMA (20 yr)				CAPM RHMA		Rehab RHMA (20 yr)				CAPM RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,500	6	900	22	2,900	6	900					

TABLE F-1 (e)
All Coastal Climate Regions
RUBBERIZED HOT MIX ASPHALT W/ RHMA-O PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55	
New Construction/Reconstruction																
RHMA w/ RHMA-O	20	1,2	Year of Action		0				24		35					
			Activity Description		New / Reconstruct				CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	24	2,700	11	3,100	24	1,900						
		3	Year of Action		0				24		35		46			
			Activity Description		New / Reconstruct				CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	24	2,700	11	3,100	11	7,000	11	7,000				
	40	1,2	Year of Action		0								40		51	
			Activity Description		New / Reconstruct								CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	3,800							11	3,100	24	1,900
		3	Year of Action		0								40		51	
			Activity Description		New / Reconstruct								CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	3,800							11	3,100	11	7,000
CAPM																
RHMA w/ RHMA-O	5+	1,2	Year of Action		0		11				35		46			
			Activity Description		CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)			
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	11	3,800	24	1,900	11	3,800	24	1,900					
		3	Year of Action		0		11		22		33					
Activity Description			CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)							
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	11	3,800	11	7,000	11	7,000	24	1,900							
Rehabilitation																
RHMA w/ RHMA-O	20	1,2,3	Year of Action		0				24		35					
			Activity Description		Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)					
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	24	1,900	11	3,300	24	1,900								
	40	1,2,3	Year of Action		0								40		51	
Activity Description			Rehab RHMA w/ RHMA-O (40 yr)								CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (40 yr)			
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,000									11	3,300	40	5,000	

TABLE F-2 (a)
Inland Valley Climate Region
HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55								
New Construction/Reconstruction																							
HMA	20	1,2	Year of Action	0						18		23				41		46					
			Activity Description	New / Reconstruct						CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	3,600	5	1,100	18	2,700	5	1,100	18	2,700	5	1,100	18	2,700					
		3	Year of Action	0						18				27				36		43			
			Activity Description	New / Reconstruct						CAPM HMA				CAPM HMA				CAPM HMA		Rehab HMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	3,600	9	5,600	9	4,900	7	5,700	18	2,700									
CAPM																							
HMA	5+	1,2	Year of Action	0		5						23		28				46		51			
			Activity Description	CAPM HMA		Rehab HMA (20 yr)						CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	1,100	18	2,700	5	1,100	18	2,700	5	1,100	18	2,700	5	1,100	18	2,700			
		3	Year of Action	0				9				18		25				43				52	
			Activity Description	CAPM HMA				CAPM HMA				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA				CAPM HMA	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	9	5,600	9	5,100	7	5,700	18	2,700	9	5,600									
Rehabilitation																							
HMA	20	1,2,3	Year of Action	0						18		23				41		46					
			Activity Description	Rehab HMA (20 yr)						CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	2,700	5	1,100	18	2,700	5	1,100	18	2,700	5	1,100	18	2,700					

TABLE F-2 (b)
Inland Valley Climate Region
HOT MIX ASPHALT W/ OGFC PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55	
New Construction/Reconstruction																
HMA w/ OGFC	20	1,2	Year of Action	0			20		28		48					
			Activity Description	New / Reconstruct			CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)		CAPM HMA w/ OGFC					
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	2,700	8	4,400	20	3,600	8	4,400					
		Year of Action	0			20		30		40		50				
	Activity Description	New / Reconstruct			CAPM HMA w/ OGFC		CAPM HMA w/ OGFC		CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)					
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	2,700	10	3,700	10	6,800	10	6,800	20	3,600				
	40	1,2	Year of Action	0							38		48			
			Activity Description	New / Reconstruct							CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20-yr)			
Activity Service Life (years)		Annual Maint. Cost (\$/lane-mile) over Activity Service Life	38	6,400					10	3,400	20	3,600				
3		Year of Action	0							38		48				
	Activity Description	New / Reconstruct							CAPM HMA w/ OGFC		CAPM HMA w/ OGFC					
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	38	6,400					10	3,400	10	3,400					
CAPM																
HMA w/ OGFC	5+	1,2	Year of Action	0			8		28		36					
			Activity Description	CAPM HMA w/ OGFC			Rehab HMA w/ OGFC (20 yr)		CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)					
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	8	4,400	20	5,600	8	4,400	20	5,600						
	3	Year of Action	0			10		20		30		50				
Activity Description		CAPM HMA w/ OGFC			CAPM HMA w/ OGFC		CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)		CAPM HMA w/ OGFC					
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	3,700	10	6,800	10	6,800	20	3,600	10	3,700					
Rehabilitation																
HMA w/ OGFC	20	1,2,3	Year of Action	0			20		28		48					
			Activity Description	Rehab HMA w/ OGFC (20 yr)			CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)		CAPM HMA w/ OGFC					
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	5,600	8	4,400	20	3,600	8	4,400						
	40	1,2,3	Year of Action	0							38		46			
Activity Description			Rehab HMA w/ OGFC (40 yr)							CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (40 yr)				
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	38	5,200					8	4,400	38	5,200					

TABLE F-2 (c)
Inland Valley Climate Region
HOT MIX ASPHALT W/ RHMA PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55						
New Construction/Reconstruction																					
HMA w/ RHMA	20	1,2	Year of Action	0					21			31									
			Activity Description	New / Reconstruct					CAPM HMA w/ RHMA			Rehab HMA w/ RHMA (20 yr)									
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	3,000					10	3,700			21	2,000					
		3	Year of Action	0					21			31			41			51			
			Activity Description	New / Reconstruct					CAPM HMA w/ RHMA			CAPM HMA w/ RHMA			CAPM HMA w/ RHMA			Rehab HMA w/ RHMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	3,000					10	3,700	10		6,800	10		6,800	21		2,000
	40	1,2	Year of Action	0									40			50					
			Activity Description	New / Reconstruct									CAPM HMA w/ RHMA			Rehab HMA w/ RHMA (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	7,200									10	3,700			21	3,400	
		3	Year of Action	0									40			50					
			Activity Description	New / Reconstruct									CAPM HMA w/ RHMA			CAPM HMA w/ RHMA					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	7,200									10	3,700			10	3,700	
CAPM																					
HMA w/ RHMA	5+	1,2	Year of Action	0					10			31			41						
			Activity Description	CAPM HMA w/ RHMA					Rehab HMA w/ RHMA (20 yr)			CAPM HMA w/ RHMA			Rehab HMA w/ RHMA (20 yr)						
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	3,700					21	3,400	10		3,700	21		3,400			
		3	Year of Action	0					10			20			30			51			
			Activity Description	CAPM HMA w/ RHMA					CAPM HMA w/ RHMA			CAPM HMA w/ RHMA			Rehab HMA w/ RHMA (20 yr)			CAPM HMA w/ RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	3,700					10	6,800	10		6,800	21		2,000	10		3,700
Rehabilitation																					
HMA w/ RHMA	20	1,2,3	Year of Action	0					21			31									
			Activity Description	Rehab HMA w/ RHMA (20 yr)					CAPM HMA w/ RHMA			Rehab HMA w/ RHMA (20 yr)									
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	3,400					10	3,700			21	3,400			10	3,700	
	40	1,2,3	Year of Action	0									40			50					
			Activity Description	Rehab HMA w/ RHMA (40 yr)									CAPM HMA w/ RHMA			Rehab HMA w/ RHMA (40 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	7,000									10	3,700			40	7,000	

TABLE F-2 (d)
Inland Valley Climate Region
RUBBERIZED HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55						
New Construction/Reconstruction																					
RHMA	20	1,2	Year of Action	0								21		26		47		52			
			Activity Description	New / Reconstruct								CAPM RHMA		Rehab RHMA (20 yr)		CAPM RHMA		Rehab RHMA (20 yr)			
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	2,200							5	1,100	21	2,600	5	1,100	21	2,600		
		Year of Action	0								21		30		39		47				
3	Activity Description	New / Reconstruct								CAPM RHMA		CAPM RHMA		CAPM RHMA		Rehab RHMA (20 yr)					
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	2,200							9	4,400	9	4,400	8	5,100	21	2,600			
CAPM																					
RHMA	5+	1,2	Year of Action	0		5								26		31		52			
			Activity Description	CAPM RHMA		Rehab RHMA (20 yr)								CAPM RHMA		Rehab RHMA (20 yr)		CAPM RHMA			
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	1,100	21	2,600							5	1,100	21	2,600	5	1,100		
		Year of Action	0						9		18		23		44		53				
3	Activity Description	CAPM RHMA				CAPM RHMA		CAPM RHMA		Rehab RHMA (20 yr)		CAPM RHMA		CAPM RHMA		CAPM RHMA					
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	9	4,400			9	4,400	5	5,100	21	2,600	9	4,400	9	4,400					
Rehabilitation																					
RHMA	20	1,2,3	Year of Action	0								21		26		47		52			
			Activity Description	Rehab RHMA (20 yr)								CAPM RHMA		Rehab RHMA (20 yr)		CAPM RHMA		Rehab RHMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	2,600							5	1,100	21	2,600	5	1,100	21	2,600	

TABLE F-2 (e)
Inland Valley Climate Region
RUBBERIZED HOT MIX ASPHALT W/ RHMA-O PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55			
New Construction/Reconstruction																		
RHMA w/ RHMA-O	20	1,2	Year of Action	0				22				32				54		
			Activity Description	New / Reconstruct				CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O		
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,900	10	3,700	22	3,800					10	3,700			
		Year of Action	0				22				32				42		53	
	Activity Description	New / Reconstruct				CAPM RHMA w/ RHMA-O				CAPM RHMA w/ RHMA-O				CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)		
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,900	10	3,400	10	6,300	11	6,300			22	3,800				
	Year of Action	2900		New / Reconstruct								40				50		
	Activity Description	New / Reconstruct										CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)		
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	4,900									10	3,700	22	3,800			
40	3	Year of Action	0								40				50			
		Activity Description	New / Reconstruct								CAPM RHMA w/ RHMA-O				CAPM RHMA w/ RHMA-O			
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	4,900									10	3,400	10	3,400		
	Year of Action	0		New / Reconstruct								40				50		
Activity Description	New / Reconstruct										CAPM RHMA w/ RHMA-O				CAPM RHMA w/ RHMA-O			
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	4,900									10	3,400	10	3,400			
CAPM																		
RHMA w/ RHMA-O	5+	1,2	Year of Action	0		10				32				42				
			Activity Description	CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)				
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	3,400	22	3,800	10	3,400					22	3,800				
	Year of Action	0		10		20				30				52				
Activity Description	CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O					
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	3,400	10	3,400	10	3,400	22	3,800					10	3,400			
Rehabilitation																		
RHMA w/ RHMA-O	20	1,2,3	Year of Action	0				22				32				54		
			Activity Description	Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O		
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	3,800	10	3,700	22	3,800					10	3,700				
	Year of Action	0		Rehab RHMA w/ RHMA-O (40 yr)								40				50		
Activity Description	Rehab RHMA w/ RHMA-O (40 yr)										CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (40 yr)			
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,100									10	3,700	40	5,100			

TABLE F-3 (a)
Desert Climate Region
HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55									
New Construction/Reconstruction																								
HMA	20	1,2	Year of Action		0				18		23													
			Activity Description		New / Reconstruct				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)							
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	3,600	5	1,100	18	3,000			5	1,100	18	3,000								
		3	Year of Action		0				18		25				31		37							
			Activity Description		New / Reconstruct				CAPM HMA		CAPM HMA				CAPM HMA		Rehab HMA (20 yr)							
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	3,600	7	5,700	6	5,700			6	6,800	18	3,000								
CAPM																								
HMA	5+	1,2	Year of Action		0		5				23		28				46		51					
			Activity Description		CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	1,100	18	3,000			5	1,100	18	3,000			5	1,100	18	3,000				
		3	Year of Action		0				7		14		20				38				45		52	
			Activity Description		CAPM HMA				CAPM HMA		CAPM HMA		Rehab HMA (20 yr)				CAPM HMA				CAPM HMA		CAPM HMA	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	7	5,700	7	5,500	6	6,800	18	3,000			7	5,700			7	5,500	6	6,800		
Rehabilitation																								
HMA	20	1,2,3	Year of Action		0				18		23				41		46							
			Activity Description		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)							
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	3,000	5	1,100	18	3,000			5	1,100	18	3,000								

TABLE F-3 (b)
Desert Climate Region
HOT MIX ASPHALT W/ OGFC PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55				
New Construction/Reconstruction																			
HMA w/ OGFC	20	1,2	Year of Action	0				20				28				48			
			Activity Description	New / Reconstruct				CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)				CAPM HMA w/ OGFC			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	4,900	8	4,600	20	4,000	8	4,500							
		3	Year of Action	0				20				29		38				47	
			Activity Description	New / Reconstruct				CAPM HMA w/ OGFC				CAPM HMA w/ OGFC		CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	4,900	9	4,000	9	7,400	9	7,400	20	4,000					
	1,2	Year of Action	0										38				47		
		Activity Description	New / Reconstruct										CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20-yr)		
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	38	6,700					9	4,100	20	4,000						
	40	3	Year of Action	0										38				47	
			Activity Description	New / Reconstruct										CAPM HMA w/ OGFC				CAPM HMA w/ OGFC	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	38	6,700					8	4,100	9	7,400					
CAPM																			
HMA w/ OGFC	5+	1,2	Year of Action	0		8				28				36					
			Activity Description	CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)				CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	8	4,600	20	4,000	8	4,600	20	4,000							
	3	Year of Action	0		9		18				27				47				
		Activity Description	CAPM HMA w/ OGFC		CAPM HMA w/ OGFC		CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)				CAPM HMA w/ OGFC				
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	9	4,000	9	7,400	9	7,400	20	4,000	9	4,000						
Rehabilitation																			
HMA w/ OGFC	20	1,2,3	Year of Action	0				20				28				48			
			Activity Description	Rehab HMA w/ OGFC (20 yr)				CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)				CAPM HMA w/ OGFC			
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	4,000	8	4,600	20	4,000	8	7,300									
	40	1,2,3	Year of Action	0								38				46			
Activity Description			Rehab HMA w/ OGFC (40 yr)								CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (40 yr)				
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	38	7,300	8	4,600	38	7,300												

TABLE F-3 (c)
Desert Climate Region
HOT MIX ASPHALT W/ RHMA PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55						
New Construction/Reconstruction																					
HMA w/ RHMA	20	1,2	Year of Action	0								21		30		51					
			Activity Description	New / Reconstruct								CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)		CAPM HMA w/ RHMA					
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	5,400							9	4,000	21	3,700			9	5,400		
		Year of Action	0								21		31		41		51				
		Activity Description	New / Reconstruct								CAPM HMA w/ RHMA		CAPM HMA w/ RHMA		CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)				
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	3,300							10	3,700	10		7,900	10		7,900	21	
	40	1,2	Year of Action	0										40				49			
			Activity Description	New / Reconstruct										CAPM HMA w/ RHMA				Rehab HMA w/ RHMA (20-yr)			
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,400									9	4,000			21	4,300		
		Year of Action	0										40				49				
		Activity Description	New / Reconstruct										CAPM HMA w/ RHMA				CAPM HMA w/ RHMA				
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,400									9	4,000			9	4,000		
CAPM																					
HMA w/ RHMA	5+	1,2	Year of Action	0		9			30			39									
			Activity Description	CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)			CAPM HMA w/ RHMA			Rehab HMA w/ RHMA (20 yr)									
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	9	4,100	21	3,700	9			4,100	21			3,700						
	3	Year of Action	0		10			20			30			51							
		Activity Description	CAPM HMA w/ RHMA		CAPM HMA w/ RHMA			CAPM HMA w/ RHMA			Rehab HMA w/ RHMA (20 yr)			CAPM HMA w/ RHMA							
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	3,700	10			7,900	10			7,900	21			3,700	10			3,700
Rehabilitation																					
HMA w/ RHMA	20	1,2,3	Year of Action	0								21		30		51					
			Activity Description	Rehab HMA w/ RHMA (20 yr)								CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)		CAPM HMA w/ RHMA					
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	3,700							9	4,100	21	3,700			9	4,100			
	40	1,2,3	Year of Action	0										40		49					
Activity Description			Rehab HMA w/ RHMA (40 yr)										CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (40 yr)						
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,900									9	4,000			40	5,900				

TABLE F-3 (d)
Desert Climate Region
RUBBERIZED HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55										
New Construction/Reconstruction																									
RHMA	20	1,2	Year of Action	0								20		25											
			Activity Description	New / Reconstruct								CAPM RHMA		Rehab RHMA (20 yr)											
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	2,500							5	1,100	20	3,500										
		Year of Action	0								20						45		50						
RHMA	20	3	Activity Description	New / Reconstruct								CAPM RHMA						45		50					
			Activity Description	New / Reconstruct								CAPM RHMA		Rehab RHMA (20 yr)											
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	2,500							7	2,900					7	5,500	7	5,700	20		3,500	
		Year of Action	0								20						27		34						
CAPM																									
RHMA	5+	1,2	Year of Action	0		5								25		30									
			Activity Description	CAPM RHMA		Rehab RHMA (20 yr)								CAPM RHMA		Rehab RHMA (20 yr)									
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	1,100	20	3,500							5	1,100	20	3,500								
		Year of Action	0				7		14								21		41						
RHMA	5+	3	Activity Description	CAPM RHMA				CAPM RHMA		CAPM RHMA								Rehab RHMA (20 yr)		CAPM RHMA					
			Activity Description	CAPM RHMA				CAPM RHMA		CAPM RHMA								Rehab RHMA (20 yr)		CAPM RHMA					
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	7	5,500			7	5,500	7	5,700							20	3,500	7	5,500				
		Year of Action	0				7		14								21		41						
Rehabilitation																									
RHMA	20	1,2,3	Year of Action	0								20		25											
			Activity Description	Rehab RHMA (20 yr)								CAPM RHMA		Rehab RHMA (20 yr)											
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	3,500							5	1,100	20	3,500									

TABLE F-3 (e)
Desert Climate Region
RUBBERIZED HOT MIX ASPHALT W/ RHMA-O PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55			
New Construction/Reconstruction																		
RHMA w/ RHMA-O	20	1,2	Year of Action	0					22		32				54			
			Activity Description	New / Reconstruct			CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O			
		Activity Service Life (years)	22	3,100			10	3,700			22	3,900			10	3,700		
		Year of Action	0					22		33		44				55		
	Activity Description	New / Reconstruct			CAPM RHMA w/ RHMA-O				CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)			
	Activity Service Life (years)	22	3,100			11	3,400			11	3,400	11		6,800	22		3,900	
	40	1,2	Year of Action	0									40				50	
			Activity Description	New / Reconstruct									CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20-yr)	
Activity Service Life (years)		40	4,500									10	3,700			22	4,500	
Year of Action		0											40				51	
Activity Description	New / Reconstruct											CAPM RHMA w/ RHMA-O				CAPM RHMA w/ RHMA-O		
Activity Service Life (years)	40	4,500									11		3,400			11	4,500	
CAPM																		
RHMA w/ RHMA-O	5+	1,2	Year of Action	0			10				32				42			
			Activity Description	CAPM RHMA w/ RHMA-O			Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)			
	Activity Service Life (years)	10	3,700			22	3,900			10	3,700			22	3,900			
	3	Year of Action	0					11		22		33						
Activity Description		CAPM RHMA w/ RHMA-O			CAPM RHMA w/ RHMA-O				CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)							
Activity Service Life (years)	11	3,400			11	4,500			11	6,800	22		3,900					
Rehabilitation																		
RHMA w/ RHMA-O	20	1,2,3	Year of Action	0					22		32				54			
			Activity Description	Rehab RHMA w/ RHMA-O (20 yr)					CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O			
	Activity Service Life (years)	22	3,900					10	3,700			22	3,900	10		3,700		
	40	1,2,3	Year of Action	0									40				50	
Activity Description			Rehab RHMA w/ RHMA-O (40 yr)									CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (40 yr)		
Activity Service Life (years)	40	6,100									10	3,700			40	6,100		

TABLE F-4 (a)
Low Mountain & South Mountain Climate Regions
HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year		Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55						
New Construction/Reconstruction																						
HMA	20	1,2	Year of Action		0				19		24				43		48					
			Activity Description		New/Reconstruct				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	19	3,500	5	1,100	19	2,800	5	1,100	19	2,800								
		3	Year of Action		0				19				28				37		45			
			Activity Description		New/Reconstruct				CAPM HMA				CAPM HMA				CAPM HMA		Rehab HMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	19	3,500	9	5,700	9	5,700	8	5,600	19	2,800								
CAPM																						
HMA	5+	1,2	Year of Action		0		5				24		29				48		53			
			Activity Description		CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	1,100	19	2,600	5	1,100	19	2,600	5	1,100	19	2,600						
		3	Year of Action		0				9				18				26				45	
			Activity Description		CAPM HMA				CAPM HMA				CAPM HMA				Rehab HMA (20 yr)				CAPM HMA	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	9	5,700	9	5,700	8	5,600	19	2,800	9	5,700	9	5,700						
Rehabilitation																						
HMA	20	1,2,3	Year of Action		0				19		24				43		48					
			Activity Description		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	19	2,600	5	1,100	19	2,600	5	1,100	19	2,600								

TABLE F-4 (b)
Low Mountain & South Mountain Climate Regions
HOT MIX ASPHALT W/ OGFC PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55		
New Construction/Reconstruction																	
HMA w/ OGFC	20	1,2	Year of Action	0				22		28				50			
			Activity Description	New / Reconstruct				CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)				CAPM HMA w/ OGFC			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,700	6	500	22	3,700	6	500					
		3	Year of Action	0				22				32				52	
			Activity Description	New / Reconstruct				CAPM HMA w/ OGFC				CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	2,700	10	4,800			10	6,800			10	6,800	22
	40	1,2	Year of Action	0								40				46	
			Activity Description	New / Reconstruct								CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20-yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	7,500					6	500			22	2,700	
		3	Year of Action	0								40				50	
			Activity Description	New / Reconstruct								CAPM HMA w/ OGFC				CAPM HMA w/ OGFC	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	7,500					10	6,800			10	6,800	
CAPM																	
HMA w/ OGFC	5+	1,2	Year of Action	0		6				28				34			
			Activity Description	CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)				CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	6	500	22	3,700			6	500			22	3,700	
		3	Year of Action	0		10				20				30		52	
			Activity Description	CAPM HMA w/ OGFC		CAPM HMA w/ OGFC				CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (20 yr)		CAPM HMA w/ OGFC	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	4,800	10	6,800			10	6,800			22	3,700	10
Rehabilitation																	
HMA w/ OGFC	20	1,2,3	Year of Action	0				22		28				50			
			Activity Description	Rehab HMA w/ OGFC (20 yr)				CAPM HMA w/ OGFC		Rehab HMA w/ OGFC (20 yr)				CAPM HMA w/ OGFC			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	22	3,700	6	500	22	3,600			6	500			
	40	1,2,3	Year of Action	0								40				46	
			Activity Description	Rehab HMA w/ OGFC (40 yr)								CAPM HMA w/ OGFC				Rehab HMA w/ OGFC (40 yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	7,800					6	500			40	7,800	

TABLE F-4 (c)
Low Mountain & South Mountain Climate Regions
HOT MIX ASPHALT W/ RHMA PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55		
New Construction/Reconstruction																	
HMA w/ RHMA	20	1,2	Year of Action	0				23		30				53			
			Activity Description	New / Reconstruct				CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)				CAPM HMA w/ RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	23	3,000	7	800	23	3,900	7	800					
		3	Year of Action	0				23				33		43		53	
			Activity Description	New / Reconstruct				CAPM HMA w/ RHMA				CAPM HMA w/ RHMA		CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	23	3,000	10	600	10	5,300	10	5,300	23	3,900			
	40	1,2	Year of Action	0								40		47			
			Activity Description	New / Reconstruct								CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20-yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,000	7	800	23	3,000							
	3	3	Year of Action	0								40		50			
			Activity Description	New / Reconstruct								CAPM HMA w/ RHMA		CAPM HMA w/ RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,000	10	600	10	5,300	10	5,300					
CAPM																	
HMA w/ RHMA	5+	1,2	Year of Action	0		7				30		37					
			Activity Description	CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)				CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	7	800	23	4,000	7	800	23	4,000					
		3	Year of Action	0		10		20		30				53			
			Activity Description	CAPM HMA w/ RHMA		CAPM HMA w/ RHMA		CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)				CAPM HMA w/ RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	600	10	5,100	10	5,100	23	3,900	10	600			
Rehabilitation																	
HMA w/ RHMA	20	1,2,3	Year of Action	0				23		30				53			
			Activity Description	Rehab HMA w/ RHMA (20 yr)				CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)				CAPM HMA w/ RHMA			
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	23	4,000	7	800	23	4,300	7	800							
	40	1,2,3	Year of Action	0								40		47			
Activity Description			Rehab HMA w/ RHMA (40 yr)								CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (40 yr)				
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	5,400	7	800	40	5,400										

TABLE F-4 (d)
Low Mountain & South Mountain Climate Regions
RUBBERIZED HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55					
New Construction/Reconstruction																				
RHMA	20	1,2	Year of Action		0						21		26		47		52			
			Activity Description		New / Reconstruct						CAPM RHMA		Rehab RHMA (20 yr)		CAPM RHMA		Rehab RHMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	2,300					5	1,100	21	2,600			5	1,100	21	2,600
		3	Year of Action		0						21		30		39		47			
			Activity Description		New / Reconstruct						CAPM RHMA		CAPM RHMA		CAPM RHMA		Rehab RHMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	2,300					9	4,400	9	4,400	8		4,900	21		2,600
CAPM																				
RHMA	5+	1,2	Year of Action		0		5						26		31		52			
			Activity Description		CAPM RHMA		Rehab RHMA (20 yr)						CAPM RHMA		Rehab RHMA (20 yr)		CAPM RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	1,100	21	2,600					5	1,100	21	2,600			5	1,100
		3	Year of Action		0				9		18		26		47					
			Activity Description		CAPM RHMA				CAPM RHMA (10 yr)		CAPM RHMA		Rehab RHMA (20 yr)		CAPM RHMA					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	9	4,400			9	4,400	8		4,900	21		2,600	8		4,400	
Rehabilitation																				
RHMA	20	1,2,3	Year of Action		0						21		26		47		52			
			Activity Description		Rehab RHMA (20 yr)						CAPM RHMA		Rehab RHMA (20 yr)		CAPM RHMA		Rehab RHMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	21	2,600					5	1,100	21	2,600			5	1,100	21	2,600

TABLE F-4 (e)
Low Mountain & South Mountain Climate Regions
RUBBERIZED HOT MIX ASPHALT W/ RHMA-O PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55		
New Construction/Reconstruction																	
RHMA w/ RHMA-O	20	1,2	Year of Action	0				24				32					
			Activity Description	New / Reconstruct				CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)					
			Activity Service Life (years)	24	2,600			8	700			24	3,500				
		Year of Action	0				24				34		44		54		
		Activity Description	New / Reconstruct				CAPM RHMA w/ RHMA-O				CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)		
		Activity Service Life (years)	24	2,600			10	600			10	600	10		5,000	24	3,500
	40	1,2	Year of Action	0								40					
			Activity Description	New / Reconstruct								CAPM RHMA w/ RHMA-O				48	
			Activity Service Life (years)	40	3,900							8	700			24	4,100
		Year of Action	0								40				50		
		Activity Description	New / Reconstruct								CAPM RHMA w/ RHMA-O				CAPM RHMA w/ RHMA-O		
		Activity Service Life (years)	40	3,900							10	600			10	700	
CAPM																	
RHMA w/ RHMA-O	5+	1,2	Year of Action	0		8				32				40			
			Activity Description	CAPM RHMA w/ RHMA-O		Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)			
			Activity Service Life (years)	8	700	24	5,200			8	700			24	5,200		
		Year of Action	0		10				20				44		54		
		Activity Description	CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O		CAPM RHMA w/ RHMA-O		
		Activity Service Life (years)	10	600	10	5,000			24	3,500			10	600	10		600
Rehabilitation																	
RHMA w/ RHMA-O	20	1,2,3	Year of Action	0				24				32					
			Activity Description	Rehab RHMA w/ RHMA-O (20 yr)				CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (20 yr)					
	Activity Service Life (years)	24	5,200			8	700			24	3,500						
	40	1,2,3	Year of Action	0								40				48	
Activity Description			Rehab RHMA w/ RHMA-O (40 yr)								CAPM RHMA w/ RHMA-O				Rehab RHMA w/ RHMA-O (40 yr)		
Activity Service Life (years)	40	3,100									8	700	40		3,100		

TABLE F-5 (a)
High Mountain & High Desert Climate Regions
HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year		Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55				
New Construction/Reconstruction																				
HMA	20	1,2	Year of Action		0				18		23				41		46			
			Activity Description		New / Reconstruct				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	2,300	5	1,100	18	2,300	5	1,300	18	900						
		3	Year of Action		0				18				26		34		42			
			Activity Description		New / Reconstruct				CAPM HMA				CAPM HMA		CAPM HMA		Rehab HMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	2,300	8	3,500	8	7,700	8	7,700	18	2,300						
CAPM																				
HMA	5+	1,2	Year of Action		0		5				23		28				46		51	
			Activity Description		CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	1,100	18	2,300	5	1,100	18	2,300	5	1,100	18	2,300				
		3	Year of Action		0				8		16		24				42		50	
			Activity Description		CAPM HMA				CAPM HMA		CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		CAPM HMA	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	8	3,500	8	7,700	8	7,700	18	2,300	8	3,500	8	7,700				
Rehabilitation																				
HMA	20	1,2,3	Year of Action		0				18		23				41		46			
			Activity Description		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)				CAPM HMA		Rehab HMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	2,300	5	1,100	18	3,300	5	1,100	18	900						

TABLE F-5 (b)
High Mountain & High Desert Climate Regions
HOT MIX ASPHALT W/ RHMA PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55			
New Construction/Reconstruction																		
HMA w/ RHMA	20	1,2	Year of Action	0				20		25				45		50		
			Activity Description	New / Reconstruct				CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)				CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)		
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	8,800	5	0	20	9,800			5	0	20	9,800			
		Year of Action	0				20				30		40		50			
	Activity Description	New / Reconstruct				CAPM HMA w/ RHMA				CAPM HMA w/ RHMA		CAPM HMA w/ RHMA		Rehab HMA w/ RHMA				
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	8,800	10	5,900			10	7,900			10	7,900			20	9,800
	40	1,2	Year of Action	0								40		45				
			Activity Description	New / Reconstruct								CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)				
Activity Service Life (years)		Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	12,300							5	0	20	9,800				
Year of Action		0										40		50				
Activity Description	New / Reconstruct										CAPM HMA w/ RHMA		CAPM HMA w/ RHMA		Rehab HMA w/ RHMA			
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	12,300							10	5,900			10	5,900			
CAPM																		
HMA w/ RHMA	5+	1,2	Year of Action	0		5				25		30				50		
			Activity Description	CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)				CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)				CAPM HMA w/ RHMA		
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	0	20	9,800			5	0	20	9,800			5	0		
	Year of Action	0						10				20		30		50		
Activity Description	CAPM HMA w/ RHMA						CAPM HMA w/ RHMA				CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)		CAPM HMA w/ RHMA			
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	5,900			10	7,900			10	7,900			20	9,800			
Rehabilitation																		
HMA w/ RHMA	20	1,2,3	Year of Action	0				20		25				45		50		
			Activity Description	Rehab HMA w/ RHMA (20 yr)				CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)				CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (20 yr)		
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	9,800	5	0	20	9,800			5	0	20	9,800				
	Year of Action	0										40		45				
Activity Description	Rehab HMA w/ RHMA (40 yr)										CAPM HMA w/ RHMA		Rehab HMA w/ RHMA (40 yr)					
Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	40	14,300									5	0	40	14,300			

TABLE F-5 (c)
High Mountain & High Desert Climate Regions
RUBBERIZED HOT MIX ASPHALT PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Surface Type	Pvmt Design Life	Maint. Service Level	Year		Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55				
New Construction/Reconstruction																				
RHMA	20	1,2	Year of Action		0				20		25				45		50			
			Activity Description		New / Reconstruct				CAPM RHMA		Rehab RHMA (20 yr)				CAPM RHMA		Rehab RHMA (20 yr)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	2,100	5	1,100	20	3,100	5	1,100	20	3,100	5	1,100	20	3,100		
		3	Year of Action		0				20				29				38		47	
			Activity Description		New / Reconstruct				CAPM RHMA				CAPM RHMA				CAPM RHMA		Rehab RHMA (20 yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	2,100	9	3,100	9	6,700	9	6,700	9	6,700	20	3,100				
CAPM																				
RHMA	5	1,2	Year of Action		0		5				25		30				50			
			Activity Description		CAPM RHMA		Rehab RHMA (20 yr)				CAPM RHMA		Rehab RHMA (20 yr)				CAPM RHMA			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	1,100	20	3,100	5	1,100	20	3,100	5	1,100	20	3,100				
		3	Year of Action		0				9		18				27				47	
			Activity Description		CAPM RHMA				CAPM RHMA		CAPM RHMA				Rehab RHMA (20 yr)				CAPM RHMA	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	9	3,100	9	6,700	9	6,700	20	3,100	9	3,100						
Rehabilitation																				
RHMA	20	1,2,3	Year of Action		0				20				25				45		50	
			Activity Description		Rehab RHMA (20 yr)				CAPM RHMA				Rehab RHMA (20 yr)				CAPM RHMA		Rehab RHMA (20 yr)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	20	3,100	5	1,100	20	3,100	5	1,100	20	3,100						

TABLE R-1 (a)
Inland Valley, Desert, Low Mountain, South Mountain, and all Coastal Climate Regions
RIGID AND COMPOSITE PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Pavement Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55		
New Construction/Reconstruction																	
Composite	20	1,2,3	Year of Action		0				30		38		45		Select a lane replace option listed under the rigid and composite pavement M&R table and follow the strategy sequence		
			Activity Description		New / Reconstruct				CAPM (FO+ JPCP SR)		CAPM (FO+ JPCP SR)		Lane Replace				
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	30	4,100			8	700			7	800					
	Year of Action		0														
40	1,2,3	Activity Description		New / Reconstruct										50			
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	50	4,800									CAPM (FO+ JPCP SR)			
Rigid - Jointed Plain Concrete Pavement (JPCP)	20	1,2,3	Year of Action		0				25		30		40		45		
			Activity Description		New / Reconstruct				CAPM (CPR C ³)		CAPM (CPR B ²)		CAPM (CPR A ¹)		Roadway Rehab		
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	25	700			5	3,000	10	1,500			5	3,100	Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence		
	Year of Action		0												50		
40	1,2,3	Activity Description		New / Reconstruct										CAPM (CPR C ³)		CAPM (CPR B ²)	
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	45	800									5	3,000	10	1,500
Rigid - Continuously Reinforced Concrete Pavement (CRCP)	20	1,2,3	Year of Action		0				30		35		45				
			Activity Description		New / Reconstruct				CAPM (PR C ⁷)		CAPM (PR B ⁶)		CAPM (PR A ⁵)				
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	30	200			5	1,400	10	600			10	600			
	Year of Action		0														
40	1,2,3	Activity Description		New / Reconstruct													
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	55	200												

CPR = Concrete Pavement Rehabilitation, CSFOL = Crack, Seal, and Flexible Overlay, FO = Flexible Overlay, MSRO = Mill, Slab Replacement & Overlay, PR = Punchout Repair, SR = Slab Replacement

Notes:

- Concrete Pavement Rehabilitation A involves pavement grinding, **significant** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs that were replaced or exhibit third stage Rigid Cracking greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
- Concrete Pavement Rehabilitation B involves pavement grinding, **moderate** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking between 2 and 5%.
- Concrete Pavement Rehabilitation C involves pavement grinding, **minor** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking 2% or less.
- The schedule for this strategy is based on pavement that has previously been cracked, sealed and overlaid. It should not be used as an alternative on rigid JPCP pavements with cracking or faulting near or above the threshold for roadway rehabilitation.
- Punchout Repair A involves **significant** punchout repairs & 0.15' of flexible overlay. It applies to **continuously reinforced concrete pavements** that had previous punchout repairs and a flexible overlay.
- Punchout Repair B involves **moderate** punchout repairs & 0.15' of flexible overlay. It applies to **continuously reinforced concrete pavements** where the total number of current & previous punchout repairs exceed 4 per mile.
- Punchout Repair C involves **minor** punchout repairs & limited diamond grinding around the punchout repair area. It applies to **continuously reinforced concrete pavements** where the total number of punchout repairs do not exceed 4 per mile.

TABLE R-1 (b)
Inland Valley, Desert, Low Mountain, South Mountain, and all Coastal Climate Regions
RIGID AND COMPOSITE PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Pavement Type	Pvmt Design Life	Maint. Service Level	Year	0	5	10	15	20	25	30	35	40	45	50	55
CAPM															
Slab Replacement (CPR ²)	10	1,2,3	Year of Action	0		10		15		20					
			Activity Description	CAPM (CPR C ³)		CAPM (CPR B ²)		CAPM (CPR A ¹)		Roadway Rehab ⁴		Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	2,098	5	4,135	5	4,135					
Composite	5	1,2,3	Year of Action	0		5		10		15					
			Activity Description	CAPM (Flex Overlay)		CAPM (PR A ⁵)		CAPM (PR B ⁶)		CAPM (PR A ⁵)		The maintenance and rehabilitation schedules depend on the previous history and condition of the existing pavement. To determine the appropriate M&R schedule to use, first determine the initial pavement type and the original rehabilitation completed. Next, determine any other rehabilitations and/or CAPM projects completed after the initial rehabilitation. Ignore projects that only removed and replaced RHMA-G or RHMA-O. Finally, find a schedule on the rehabilitation M&R table that best describes the original rehabilitation completed and that sequence. However, from the pavement history, take into consideration the activities already completed in that sequence.			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life											
Composite	5	1,2,3	Year of Action	0		5		10		15					
			Activity Description	CAPM (FO + JPCP SR)		CAPM (PR B ⁶)		CAPM (PR A ⁵)		CAPM (PR A ⁵)		EXAMPLE: You are doing a Flexible Overlay and JPCP Slab Replacement on a previously cracked, sealed, and overlaid project (doesn't matter whether it was 10 or 20 year). Previous work included a remove and replace FHMA-O 7 years after the crack, seat, and flexible overlay (CSFOL) rehabilitation, and a 0.10' HMA overlay at 18 years after the CSFOL project. From this information it can be determined that the initial pavement type was rigid and the original rehabilitation completed was a CSFOL. If the RHMA-O project at year 7 is ignored, it can be determined that the best fit for this sequence is the 20-year CSFOL. The 0.10' HMA overlay at 18 years after the completion of the CSFOL is the first CAPM under this sequence and the future activities will include a CAPM (FO + JPCP SR) at Year 23 and a 20-year rehab at Year 28. Remember to follow the sequence until you fulfill the analysis period.			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life											
Rigid - Jointed Plain Concrete Pavement (JPCP)	5	1,2,3	Year of Action	0		5		10		15					
			Activity Description	CAPM (CPR A ¹)		Roadway Rehab		CAPM (CPR A ¹)		Roadway Rehab		Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	3,100			5	3,100					
	10	1,2,3	Year of Action	0		5		10		15					
			Activity Description	CAPM (CPR B ²)		CAPM (CPR B ²)		CAPM (CPR A ¹)		Roadway Rehab		Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	1,500			5	3,100					
5	1,2,3	Year of Action	0		5		10		15						
		Activity Description	CAPM (CPR C ³)		CAPM (CPR B ²)		CAPM (CPR B ²)		CAPM (CPR A ¹)						
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	3,000	10	1,500			5					3,100
Rigid - Continuously Reinforced Concrete Pavement (CRCP)	5	1,2,3	Year of Action	0		5		10		15					
			Activity Description	CAPM (PR A ⁵)		Lane Replace with CRCP		CAPM (PR A ⁵)		CAPM (PR A ⁵)		Select a lane replace option listed under the rigid and composite pavement M&R table and follow the strategy sequence			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	600									
	10	1,2,3	Year of Action	0		5		10		15					
			Activity Description	CAPM (PR B ⁶)		CAPM (PR B ⁶)		CAPM (PR A ⁵)		CAPM (PR A ⁵)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	600	10	600							
10	1,2,3	Year of Action	0		5		10		15						
		Activity Description	CAPM (PR C ⁷)		CAPM (PR B ⁶)		CAPM (PR B ⁶)		CAPM (PR A ⁵)						
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	1,400	10	600	10	600						

Notes:

- Concrete Pavement Rehabilitation A involves pavement grinding, **significant** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs that were replaced or exhibit third stage Rigid Cracking greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
- Concrete Pavement Rehabilitation B involves pavement grinding, **moderate** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking between 2 and 5%.
- Concrete Pavement Rehabilitation C involves pavement grinding, **minor** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking 2% or less.
- The schedule for this strategy is based on pavement that has previously been cracked, sealed and overlaid. It should not be used as an alternative on rigid JPCP pavements with cracking or faulting near or above the threshold for roadway rehabilitation.
- Punchout Repair A involves **significant** punchout repairs & 0.15' of flexible overlay. It applies to **continuously reinforced concrete pavements** that had previous punchout repairs and a flexible overlay.
- Punchout Repair B involves **moderate** punchout repairs & 0.15' of flexible overlay. It applies to **continuously reinforced concrete pavements** where the total number of current & previous punchout repairs exceed 4 per mile.
- Punchout Repair C involves **minor** punchout repairs & limited diamond grinding around the punchout repair area. It applies to **continuously reinforced concrete pavements** where the total number of punchout repairs do not exceed 4 per mile.

TABLE R-1 (c)
Inland Valley, Dessert, Low Mountain, South Mountain, and all Coastal Climate Regions
RIGID AND COMPOSITE PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Pavement Type	Pvmt Design Life	Maint. Service Level	Year	0	5	10	15	20	25	30	35	40	45	50	55						
Rehabilitation (a)																					
Flexible/ composite	20	1,2,3	Year of Action	0								18		23		28		46		51	
			Activity Description	20-yr Rehab (CSFOL)								CAPM (Flex Overlay)		CAPM (FO + JPCP SR)		20-yr Rehab (MSRO)		CAPM (FO + JPCP SR)		CAPM (FO + JPCP SR)	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	1,400							5	1,100	5	1,100	18	1,400	5	1,100	7
	20	1,2,3	Year of Action	0								18		23		30		Select a lane replace option listed under the rigid and composite pavement M&R table and follow the strategy sequence			
			Activity Description	20-yr Rehab (MSRO)								CAPM (FO + JPCP SR)		CAPM (FO + JPCP SR)		Lane Replace					
	20 & 40	1,2,3	Year of Action	0								Follow the strategies for new construction/reconstruction in the applicable flexible pavement tables for the appropriate climate region									
			Activity Description	Lane Replace																	
	20	1,2,3	Year of Action	0								30		38		45		Select a lane replace option listed under the rigid and composite pavement M&R table and follow the strategy sequence			
			Activity Description	20-yr Rehab (Lane Replace)								CAPM (FO+ JPCP SR)		CAPM (FO+ JPCP SR)		Lane Replace					
	40	1,2,3	Year of Action	0								8		7		800		50 CAPM (FO+ JPCP SR) 8 700			
Activity Description			40-yr Rehab (Lane Replace)								30		38		45						
40	1,2,3	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	30	4,100							8	700	7	800						
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	50	4,800																

CPR = Concrete Pavement Rehabilitation, CSFOL = Crack, Seal, and Flexible Overlay, FO = Flexible Overlay, MSRO = Mill Slab Replacement & Overlay, PR = Punchout Repair, SR = Slab Replacement

Notes:

- Concrete Pavement Rehabilitation A involves pavement grinding, **significant** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs that were replaced or exhibit third stage Rigid Cracking greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
- Concrete Pavement Rehabilitation B involves pavement grinding, **moderate** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking between 2 and 5%.
- Concrete Pavement Rehabilitation C involves pavement grinding, **minor** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking 2% or less.
- The schedule for this strategy is based on pavement that has previously been cracked, sealed and overlaid. It should not be used as an alternative on rigid JPCP pavements with cracking or faulting near or above the threshold for roadway rehabilitation.
- Punchout Repair A involves **significant** punchout repairs & 0.15' of flexible overlay. It applies to **continuously reinforced concrete pavements** that had previous punchout repairs and a flexible overlay.
- Punchout Repair B involves **moderate** punchout repairs & 0.15' of flexible overlay. It applies to **continuously reinforced concrete pavements** where the total number of current & previous punchout repairs exceed 4 per mile.
- Punchout Repair C involves **minor** punchout repairs & limited diamond grinding around the punchout repair area. It applies to **continuously reinforced concrete pavements** where the total number of punchout repairs do not exceed 4 per mile.

TABLE R-1 (d)
Inland Valley, Dessert, Low Mountain, South Mountain, and all Coastal Climate Regions
RIGID AND COMPOSITE PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Pavement Type	Pvmt Design Life	Maint. Service Level	Year	0	5	10	15	20	25	30	35	40	45	50	55				
Rehabilitation (b)																			
Rigid - Jointed Plain Concrete Pavement (JPCP)	20	1,2,3	Year of Action	0						25		30		40		45			
			Activity Description	20-yr Rehab (Lane Replace)						CAPM (CPR C ³)		CAPM (CPR B ²)		CAPM (CPR A ¹)		Roadway Rehab		Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence	
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	25	700	5	3,000	10	1,500	5	3,100							
	Year of Action	0										45		50					
	40	1,2,3	Activity Description	40-yr Rehab (Lane Replace)										CAPM (CPR C ³)		CAPM (CPR B ²)			
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	45	800							5		3,000		10		1,500
Year of Action			0																
Rigid - Continuously Reinforced Concrete Pavement (CRCP)	20	1,2,3	Year of Action	0						30		35		45					
			Activity Description	20-yr Rehab (Lane Replace)						CAPM (PR C ⁷)		CAPM (PR B ⁶)		CAPM (PR A ⁵)					
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	30	200	5	1,400	10	600	10	600							
	40	1,2,3	Year of Action	0															
			Activity Description	40-yr Rehab (Lane Replace)															
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	55	200													

CPR = Concrete Pavement Rehabilitation, CSFOL = Crack, Seal, and Flexible Overlay, FO = Flexible Overlay, MSRO = Mill, Slab Replacement & Overlay, PR = Punchout Repair, SR = Slab Replacement

Notes:

- Concrete Pavement Rehabilitation A involves pavement grinding, **significant** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs that were replaced or exhibit third stage Rigid Cracking greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
- Concrete Pavement Rehabilitation B involves pavement grinding, **moderate** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking between 2 and 5%.
- Concrete Pavement Rehabilitation C involves pavement grinding, **minor** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking 2% or less.
- The schedule for this strategy is based on pavement that has previously been cracked, sealed and overlaid. It should not be used as an alternative on rigid JPCP pavements with cracking or faulting near or above the threshold for roadway rehabilitation.
- Punchout Repair A involves **significant** punchout repairs & 0.15' of flexible overlay. It applies to **continuously reinforced concrete pavements** that had previous punchout repairs and a flexible overlay.
- Punchout Repair B involves **moderate** punchout repairs & 0.15' of flexible overlay. It applies to **continuously reinforced concrete pavements** where the total number of current & previous punchout repairs exceed 4 per mile.
- Punchout Repair C involves **minor** punchout repairs & limited diamond grinding around the punchout repair area. It applies to **continuously reinforced concrete pavements** where the total number of punchout repairs do not exceed 4 per mile.

TABLE R-2 (a)
High Mountain and High Desert Climate Regions
RIGID AND COMPOSITE PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Pavement Type	Pvmt Design Life	Maint. Service Level	Year	Begin Alternative Construction	5	10	15	20	25	30	35	40	45	50	55		
New Construction/Reconstruction																	
Composite	20	1,2,3	Year of Action		0						30		40		45		
			Activity Description		New / Reconstruct						CAPM (FO+ JPCP SR)		CAPM (FO+ JPCP SR)		Lane Replace		Select a lane replace option listed under the rigid and composite pavement M&R table and follow the strategy sequence
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	30	7,300	10	5,900	5	1,100							
	Year of Action		0						50		CAPM (FO+ JPCP SR)		50 CAPM (FO+ JPCP SR) 5 1,100				
	Activity Description		New / Reconstruct						50		CAPM (FO+ JPCP SR)						
	Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	50	8,400													
Rigid - Jointed Plain Concrete Pavement (JPCP)	20	1,2,3	Year of Action		0		25		30		40		45		50		
			Activity Description		New / Reconstruct		CAPM (CPR C ³)		CAPM (CPR B ²)		CAPM (CPR A ¹)		Roadway Rehab		Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence		
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	25	3,100	5	3,000	10	1,500	5	3,100					
	40	1,2,3	Year of Action		0						45		50		50		
			Activity Description		New / Reconstruct						CAPM (CPR C ³)		CAPM (CPR B ²)		50		
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	45	3,800					5	3,000	5	1,500			

CPR = Concrete Pavement Rehabilitation, CSFOL = Crack, Seal, and Flexible Overlay, FO = Flexible Overlay, MSRO = Mill Slab Replacement & Overlay, SR = Slab Replacement

Notes:

1. Concrete Pavement Rehabilitation A involves pavement grinding, **significant** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs that were replaced or exhibit third stage Rigid Cracking greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
2. Concrete Pavement Rehabilitation B involves pavement grinding, **moderate** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking between 2 and 5%.
3. Concrete Pavement Rehabilitation C involves pavement grinding, **minor** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking 2% or less.
4. The schedule for this strategy is based on pavement that has previously been cracked, seated and overlaid. It should not be used as an alternative on rigid JPCP pavements with cracking or faulting near or above the threshold for roadway rehabilitation.

TABLE R-2 (b)
High Mountain and High Desert Climate Regions
RIGID AND COMPOSITE PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Pavement Type	Pvmt Design Life	Maint. Service Level	Year	0	5	10	15	20	25	30	35	40	45	50	55	
CAPM																
Slab Replacement (CPR ²)	10	1,2,3	Year of Action	0		10		15		20						
			Activity Description	CAPM (CPR C ³)		Roadway Rehab ⁴						Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence				
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	2,098	5	4,135	5	4,135						
Composite	5	1,2,3	Year of Action	0		5		10		15						
			Activity Description	CAPM (Flex Overlay)						The maintenance and rehabilitation schedules depend on the previous history and condition of the existing pavement. To determine the appropriate M&R schedule to use, first determine the initial pavement type and the original rehabilitation completed. Next, determined any other rehabilitations and/or CAPM projects completed after the initial rehabilitation. Ignore projects that only removed and replaced RHMA-G or RHMA-O. Finally, find a schedule on the rehabilitation M&R table that best describes the original rehabilitation completed and that sequence. However, from the pavement history, take into consideration the activities already completed in that sequence.						
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5											
	5	1,2,3	Year of Action	0		5		10		15						
			Activity Description	CAPM (FO + JPCP SR)						EXAMPLE: You are doing a Flexible Overlay and JPCP Slab Replacement on a previously cracked, seated, and overlaid project (doesn't matter whether it was 10 or 20 year). Previous work included a remove and replace RHMA-O 7 years after the crack, seat, and flexible overlay (CSFOL) rehabilitation, and a 0.10' HMA overlay at 18 years after the CSFOL project. From this information it can be determined that the initial pavement type was rigid and the original rehabilitation completed was a CSFOL. If the RHMA-O project at year 7 is ignored, it can be determined that the best fit for this sequence is the 20-year CSFOL. The 0.10' HMA overlay at 18 years after the completion of the CSFOL is the first CAPM under this sequence and the future activities will include a CAPM (FO + JPCP SR) at Year 23 and a 20-year rehab at Year 28. Remember to follow the sequence until you fulfill the analysis period.						
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life												
Rigid - Jointed Plain Concrete Pavement (JPCP)	5	1,2,3	Year of Action	0		5		10		15						
			Activity Description	CAPM (CPR A ¹)		Roadway Rehab						Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence				
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	5,100										
	10	1,2,3	Year of Action	0		5		10		15						
			Activity Description	CAPM (CPR B ²)		Roadway Rehab						Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence				
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	10	1,500	5	3,100								
5	1,2,3	Year of Action	0		5		10		15		20					
		Activity Description	CAPM (CPR C ³)		CAPM (CPR B ²)		Roadway Rehab						Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence			
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	5	3,000	5	1,500	5	4,393							

CPR = Concrete Pavement Rehabilitation, CSFOL = Crack, Seat, and Flexible Overlay, FO = Flexible Overlay, MSRO = Mill, Slab Replacement & Overlay, SR = Slab Replacement

Notes:

- Concrete Pavement Rehabilitation A involves pavement grinding, **significant** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs that were replaced or exhibit third stage Rigid Cracking greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
- Concrete Pavement Rehabilitation B involves pavement grinding, **moderate** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking between 2 and 5%.
- Concrete Pavement Rehabilitation C involves pavement grinding, **minor** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking 2% or less.
- The schedule for this strategy is based on pavement that has previously been cracked, seated and overlaid. It should not be used as an alternative on rigid JPCP pavements with cracking or faulting near or above the threshold for roadway rehabilitation.

TABLE R-2 (c)
High Mountain and High Desert Climate Regions
RIGID AND COMPOSITE PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Pavement Type	Pvmt Design Life	Maint. Service Level	Year	0	5	10	15	20	25	30	35	40	45	50	55			
Rehabilitation (a)																		
Flexible/ Composite	20	1,2,3	Year of Action	0				18		23		28		46		51		
			Activity Description	20-yr Rehab (CSFOL)				CAPM (Flex Overlay)		CAPM (FO+ JPCP SR)		20-yr Rehab (MSRO)		CAPM (FO+ JPCP SR)		CAPM (FO+ JPCP SR)		
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	6,300	5	1,100	5	1,100	18	6,300	5	1,100	7	900		
	20	1,2,3	Year of Action	0				18		23		30		Select a lane replace option listed under the rigid and composite pavement M&R table and follow the strategy sequence				
			Activity Description	20-yr Rehab (MSRO)				CAPM (FO + JPCP SR)		CAPM (FO + JPCP SR)		Lane Replace						
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	18	6,300	5	1,100	7	900								
	20 & 40	1,2,3	Year of Action	0		Follow the strategies for new construction/reconstruction in the applicable flexible pavement tables for the appropriate climate region												
			Activity Description	Lane Replace														
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life														
	20	1,2,3	Year of Action	0						30				40		45		Select a lane replace option listed under the rigid and composite pavement M&R table and follow the strategy sequence
			Activity Description	20-yr Rehab (Lane Replace)						CAPM (FO+ JPCP SR)				CAPM (FO+ JPCP SR)		Lane Replace		
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	30	7,300			10	5,900			5	1,100				
40	1,2,3	Year of Action	0															
		Activity Description	40-yr Rehab (Lane Replace)															
		Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	50												8,400		
														5	1,100			

CPR = Concrete Pavement Rehabilitation, CSFOL = Crack, Seat, and Flexible Overlay, FO = Flexible Overlay, MSRO = Mill, Slab Replacement & Overlay, SR = Slab Replacement

Notes:

- Concrete Pavement Rehabilitation A involves pavement grinding, **significant** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs that were replaced or exhibit third stage Rigid Cracking greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
- Concrete Pavement Rehabilitation B involves pavement grinding, **moderate** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking between 2 and 5%.
- Concrete Pavement Rehabilitation C involves pavement grinding, **minor** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking 2% or less.
- The schedule for this strategy is based on pavement that has previously been cracked, seated and overlaid. It should not be used as an alternative on rigid JPCP pavements with cracking or faulting near or above the threshold for roadway rehabilitation.

TABLE R-2 (d)
High Mountain and High Desert Climate Regions
RIGID AND COMPOSITE PAVEMENT MAINTENANCE AND REHABILITATION SCHEDULE

Final Pavement Type	Pvmt Design Life	Maint. Service Level	Year	0	5	10	15	20	25	30	35	40	45	50	55				
Rehabilitation (b)																			
Rigid - Jointed Plain Concrete Pavement (JPCP)	20	1,2,3	Year of Action		0						25		30		40		45		Select a rehabilitation option listed under the rigid and composite pavement M&R table and follow the strategy sequence
			Activity Description		20-yr Rehab (Lane Replace)						CAPM (CPR C ³)		CAPM (CPR B ²)		CAPM (CPR A ¹)		Roadway Rehab		
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	25	3,100					5	3,000	10	1,500	5	5,100			
			Year of Action		0						45		50						
Concrete Pavement (JPCP)	40	1,2,3	Year of Action		0						45		50						
			Activity Description		40-yr Rehab (Lane Replace)						CAPM (CPR C ³)		CAPM (CPR B ²)						
			Activity Service Life (years)	Annual Maint. Cost (\$/lane-mile) over Activity Service Life	45	3,200					5	3,000	10	1,500					
			Year of Action		0						45		50						

CPR = Concrete Pavement Rehabilitation, CSFOL = Crack, Seat, and Flexible Overlay, FO = Flexible Overlay, MSRO = Mill, Slab Replacement & Overlay, SR = Slab Replacement

Notes:

1. Concrete Pavement Rehabilitation A involves pavement grinding, **significant** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs that were replaced or exhibit third stage Rigid Cracking greater than or equal to 5% and less than or equal to 7%. For greater than 7%, the project should be scoped and analyzed as a roadway rehabilitation project.
2. Concrete Pavement Rehabilitation B involves pavement grinding, **moderate** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking between 2 and 5%.
3. Concrete Pavement Rehabilitation C involves pavement grinding, **minor** slab replacement, spall repair, & joint seal repair. It is for **JPCP** projects with a total number of slabs in the lane that were replaced or exhibit third stage Rigid Cracking 2% or less.
4. The schedule for this strategy is based on pavement that has previously been cracked, seated and overlaid. It should not be used as an alternative on rigid JPCP pavements with cracking or faulting near or above the threshold for roadway rehabilitation.

APPENDIX 5: TRAFFIC INPUTS ESTIMATION

A. Free Flow Capacity

The alternate procedure for estimating the “Free Flow Capacity (vphpl)” is as follows:

(Assume standard lane and shoulder widths)

Select a passenger car equivalent factor, E (passenger cars/heavy vehicle), corresponding to the project terrain from Table A5-1

Table A5-1. Passenger Car Equivalent Factors

	Type of Terrain		
	Level	Rolling	Mountainous
E	1.5	2.5	4.5

Use Equation A5-1 to convert “Free Flow Capacity” in terms of pcphpl to vphpl (vehicles per hour per lane):

$$FC = \frac{F \times 100}{[(100 + P \times (E - 1))]} \quad \text{(Equation A5-1)}$$

Where:

FC = Free Flow Capacity (vphpl)

F = roadway capacity (passenger car per hour per lane)

= 1,700 pcphpl for two-lane highways

= 2,300 pcphpl for multi-lane highways

P = percentage of heavy vehicles (i.e., “Total Trucks %” at the project location. Input as percentage.)

E = passenger car equivalent (passenger cars/heavy vehicle)

B. Queue Dissipation Capacity

The procedure for estimating the “Queue Dissipation Capacity (vphpl)” is as follows: (Assume standard lane and shoulder widths)

Select a passenger car equivalent factor, E (passenger cars/heavy vehicle), corresponding to the project terrain from Table 15;

Use Equation A5-2 to convert “Queue Dissipation Capacity” in terms of pchpl to vphpl (vehicles per hour per lane):

$$QC = \frac{Q \times 100}{[(100 + P \times (E - 1))]} \quad \text{(Equation A5-2)}$$

Where:

QC = Queue Dissipation Capacity (vphpl)

Q = base capacity (passenger cars per hour per lane)

= 1,800 pchpl for both single-lane and multi-lane highways

P = percentage of heavy vehicles (i.e., “Total Trucks %” at the project location. Input as percentage.)

E = passenger car equivalent (passenger cars/heavy vehicle)

C. Maximum AADT (total for both directions)

The procedure for estimating the “Maximum AADT (total for both directions)” is as follows:

Select a passenger car equivalent factor, E (passenger cars/heavy vehicle), corresponding to the project terrain from Table A5-1;

Use Equation A5-3 to calculate “Maximum AADT (total for both directions)”:

$$AADT_{\max} = \frac{M \times N \times 100}{[(100 + P \times (E - 1))]} \quad \text{(Equation A5-3)}$$

Where:

AADT_{max} = Maximum AADT (total for both directions)

M = 43,000 for two-lane highways or 57,000 for multi-lane highways

N = number of lanes (total for both directions)

P = percentage of heavy vehicles (i.e., “Total Trucks %” at the project location. Input as percentage.)

E = passenger car equivalent (passenger cars/heavy vehicle)

D. Work Zone Capacity

The procedure for estimating the “Work Zone Capacity (vphpl)” is as follows:
(Assume standard lane and shoulder widths)

Select a passenger car equivalent factor, *E* (passenger cars/heavy vehicle), corresponding to the project terrain from Table A5-1.

Use Equation A5-4 to convert “Work Zone Capacity” in terms of pcphpl to vphpl (vehicles per hour per lane):

$$WC = \frac{W \times 100}{[100 + P \times (E - 1)]} \quad \text{(Equation A5-4)}$$

Where:

WC = Work Zone Capacity (vphpl)

W = base work zone capacity (passenger cars per hour per lane)

W = 1,100 pcphpl for two-lane highways

= 1,600 pcphpl for multi-lane highways

P = percentage of heavy vehicles (i.e., “Total Trucks %” at the project location. Input as percentage.)

E = passenger car equivalent (passenger cars/heavy vehicle)

E. Maximum Queue Length Estimation

The maximum number of queued vehicles during the time the work zone is in effect is estimated by using the traffic demand-capacity model, as shown in Figure A5-1. When demand exceeds capacity, the queue starts to build up. The maximum number of queued vehicles is measured where the difference between the demand curve and the capacity curve is the greatest. Then the maximum queue length can be obtained by multiplying the maximum number of queued vehicles by the average vehicle length (i.e., 40 feet).

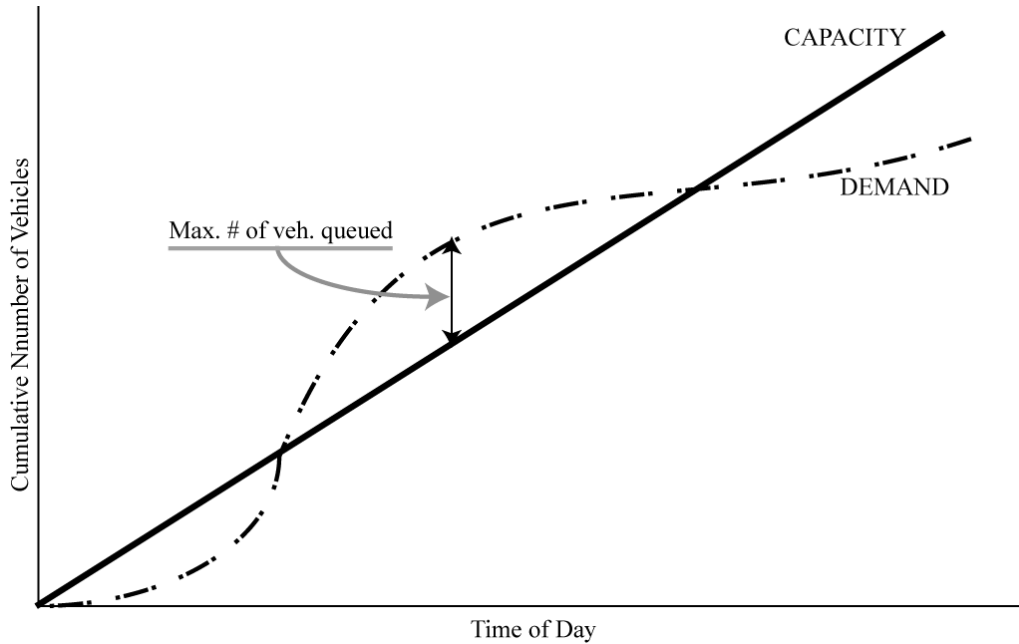


Figure A5-1: Traffic Demand-Capacity Model

Example:

Maximum Queue Length Estimation

During construction on a three-lane urban freeway section, one lane will be closed and two lanes will be open. The work zone capacity is assumed to be 1,600 passenger cars per hour per lane (pcphpl). The hourly traffic demands, expressed in vehicles per hour (vph), are assumed to be those shown in the second column in Table A5-2. Ten percent of the traffic volume is assumed to be occupied by single-unit and combination trucks. The procedure for estimating the maximum queue length is:

The hourly passenger car capacity of one lane (1,600 pcphpl) of the work zone is converted to the hourly vehicular capacity of one lane [1,524 vphpl (vehicles per hour per lane)] of the work zone using Equation A5-4.

Table A5-2 Maximum Queue Length Estimation

Hour	Volume (vph)	Capacity (pcphpl)	Capacity (vphpl)	No. of lanes open	Capacity (vph)	Cumulative Queued veh.
1	340	1,600	1,524	2	3,048	0
2	350	1,600	1,524	2	3,048	0
3	350	1,600	1,524	2	3,048	0
4	400	1,600	1,524	2	3,048	0
5	800	1,600	1,524	2	3,048	0
6	1,200	1,600	1,524	2	3,048	0
7	3,000	1,600	1,524	2	3,048	0
8	3,400	1,600	1,524	2	3,048	352
9	3,600	1,600	1,524	2	3,048	904
10	3,000	1,600	1,524	2	3,048	856
11	1,800	1,600	1,524	2	3,048	0
12	1,300	1,600	1,524	2	3,048	0
13	1,200	1,600	1,524	2	3,048	0
14	1,000	1,600	1,524	2	3,048	0
15	1,200	1,600	1,524	2	3,048	0
16	1,900	1,600	1,524	2	3,048	0
17	3,400	1,600	1,524	2	3,048	352
18	3,650	1,600	1,524	2	3,048	954
19	2,400	1,600	1,524	2	3,048	306
20	1,000	1,600	1,524	2	3,048	0
21	800	1,600	1,524	2	3,048	0
22	760	1,600	1,524	2	3,048	0
23	300	1,600	1,524	2	3,048	0
24	300	1,600	1,524	2	3,048	0
Max. queued veh.						954
Max. queued veh. on 3 lanes, at upstream of work zone						318
Average vehicle length						40 ft
Max. queue length						12,720 ft
						<u>2.41 mi</u>

As shown in Table A5-2, the queue starts at slightly after 7 AM when the traffic demand exceeds the work zone capacity (3,048 vph) and starts dissipating after 10 AM when the sum of the hourly demand becomes less than the work zone capacity. The queue is completely dissipated by 11 AM, and starts again at about 5 PM when the traffic demand exceeds the work zone capacity (3,048 vph).

The maximum number of queued vehicles is 954 at 6 PM when the cumulative number of the queued vehicles is the greatest. The maximum number of queued vehicles per lane upstream of the work zone is 318 (954 vehicles divided by 3 lanes). Thus, the maximum queue length from the work zone operation is estimated at 2.41 miles (318 vehicles multiplied by 40 ft. average vehicle length).

APPENDIX 6: ALTERNATE PROCEDURE FOR CALCULATING CONSTRUCTION YEAR AADT

The following steps describe how to get a construction year AADT:

- 1) Go to the Division of Traffic Operations website (<http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/index.htm>). Download the most current year AADT data available (such as “2011 AADT” in Excel file format). Find “Back AADT” and “Ahead AADT” numbers at the project location and average those two numbers to get the total AADT for both directions in the most current year.
- 2) Contact the Division of Transportation System Information for the “Annual Growth Rate of Traffic” or AADT values (in the most current and future years) expected at the project location. An approximate “Annual Growth Rate of Traffic” can be estimated with the available AADT values using Equation A6-1 below:

$$A = \left[\left(\frac{FT}{MT} \right)^{\left(\frac{1}{FY - MY} \right)} - 1 \right] \times 100 \quad \text{(Equation A6-1)}$$

Where

A = Annual Growth Rate of Traffic (%)

FT = Future Year AADT (total for both directions)

MT = Most Current Year AADT (total for both directions)

FY = Future Year in which AADT is available

MY = Most Current Year in which AADT is available.

Example:

Given:

Future Year AADT (total for both directions) = 18,000 (year 2025)

Most Current Year AADT (total for both directions) = 9,800 (year

The Annual Growth Rate of Traffic is

$$\left[\left(\frac{18,000}{9,800} \right)^{\left(\frac{1}{2025 - 2005} \right)} - 1 \right] \times 100 = 3.09\%$$

Use the following equation to calculate the AADT total for both directions in the initial construction year or the beginning year of the analysis period:

$$I_AADT = MT \times \left(1 + \frac{A}{100}\right)^{(IY - MY)} \quad \text{(Equation A6-2)}$$

Where:

I_AADT = Initial Construction Year AADT (total for both directions)

MT = Most Current Year AADT (total for both directions)

A = Annual Growth Rate of Traffic (%)

IY = Initial Construction Year (same as the first year of the analysis period)

MY = Most Current Year in which AADT is available.

Example:

Using the most current year AADT (2005) = 9,800

Determine AADT for 2007 as the Initial Construction year

The Initial Construction year AADT is:

$$(9,800) \times \left(1 + \frac{3.09}{100}\right)^{(2007-2005)} = 10,415$$

APPENDIX 7: LIST OF TABLES

Table 2-1 LCCA Analysis Periods

Alternative Life	CAPM	20-Yr	More than 20 years
CAPM	20 years	35 years	55 years
20-Yr	35 years	35 years	55 years
More than 20 years	55 years	55 years	55 years

Table 2-2 Caltrans Climate Region Classification

Caltrans Climate Regions	Climate Regions for Pavement M&R Schedules
North Coast	All Coastal
Central Coast	
South Coast	
Inland Valley	Inland Valley
High Mountain	High Mountain and High Desert
High Desert	
Desert	Desert
Low Mountain	Low Mountain and South Mountain
South Mountain	

Table 2-3 Priority Matrix

Ride Quality	Structural Distress	MSL 1	MSL 2	MSL 3
		Priority Number	Priority Number	Priority Number
Poor Ride	Major	1	2	11
	Minor	3	4	12
	None	5	6	12
Acceptable Ride	Major	7	8	13
	Minor	9	10	14
	None	31, 32, 33	31, 32, 33	31, 32, 33
	No Distress	98, 99	98, 99	98, 99

Table 3-1 Traffic Input Values

Type of Terrain	Two-Lane Highways			Multi-Lane Highways		
	Level	Rolling	Mountainous	Level	Rolling	Mountainous
Free Flow Capacity (vphpl)	1,620	1,480	1,260	2,170	1,950	1,620
Queue Dissipation Capacity (vphpl)	1,710	1,570	1,330	1,700	1,530	1,270
Maximum AADT Per Lane	40,955	37,390	31,850	53,773	48,305	40,140
Work Zone Capacity (vphpl) ⁽³⁾	1,050	960	820	1,510	1,360	1,130
Maximum Queue Length	One or two exits prior to the work zone or 7.0 miles if the estimated maximum queue length is longer than 7.0 miles			One or two exits prior to the work zone or 5.0 miles if the estimated maximum queue length is longer than 5.0 miles		

Notes:

(1) Derived from Highway Capacity Manual 2000.

(2) Refer to the calculation procedures included in Appendix 5, "Traffic Inputs Estimation".

(3) Assumed one lane to be open for traffic in single-lane highways and two or more lanes to be open for traffic in multi-lane highways.

Table 3-2 Transportation Component Consumer Price Indexes*

Year	US	LA CMSA ⁽¹⁾	SF CMSA ⁽²⁾	SD CMSA ⁽³⁾
1996	143.0	144.3	133.5	150.8
1997	144.3	145.2	133.6	152.2
1998	141.6	142.6	132.0	149.4
1999	144.4	146.8	135.8	152.1
2000	153.3	154.2	143.1	162.4
2001	154.3	155.3	143.7	164.9
2002	152.9	154.5	141.0	163.0
2003	157.6	160.3	144.9	168.0
2004	163.1	166.5	149.6	175.6
2005	173.9	174.8	156.1	185.5
2006	180.9	181.6	161.5	190.4
2007	184.7	183.2	166.6	193.2
2008	195.5	192.6	176.3	200.7
2009	179.3	178.6	166.7	184.7
2010	193.4	190.9	178.1	200.4
2011	212.4	207.8	190.8	222.7
2012	217.3	214.0	197.3	227.7

Notes:

* Source: US Department of Labor, Bureau of Labor Statistics

<http://www.bls.gov/cpi/>

(1) LA CMSA (Consolidated Metropolitan Statistical Area): includes counties of Los Angeles, Orange, Riverside, San Bernadino, & Ventura.

(2) SF CMSA (Consolidated Metropolitan Statistical Area): includes counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, & Sonoma.

(3) SD CMSA (Consolidated Metropolitan Statistical Area): includes county of San Diego.

Table 3-3 Final Pavement Surface Choices

Final Pavement Surface		
Flexible	Rigid	
HMA	JPCP	CRCP
HMA W/OGFC	JPCP CPR A	CRCP PR A
HMA W/RHMA	JPCP CPR B	CRCP PR B
RHMA	JPCP CPR C	CRCP PR C
RHMA W/ RHMA O	Composite—HMA or RHMA over Rigid (crack, seat, overlay)	

Table 3-4 Productivity Estimates of Typical Future Rehabilitation Strategies for Flexible Pavements

Final Surface Type	Future M&R Alternative	Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure				
				Daily Closure (Weekday)		Continuous Closure		
				5 to 7-Hour Closure	8 to 12-Hour Closure	16 hour/Day Operation	24 hour/day Operation	55-hour Weekend Closure
CAPM								
HMA	Overlay	5+	1,2,3	0.84	1.73	2.9	4.81	12.25
	Mill & Overlay	5+	1,2,3	0.36	0.75	1.18	2.21	5.20
HMA w/OGFC	Overlay	5+	1,2,3	0.55	1.14	1.9	3.17	8.09
	Mill & Overlay	5+	1,2,3	0.30	0.61	0.97	1.86	4.35
HMA w/RHMA	Overlay	5+	1,2,3	0.55	1.14	1.9	3.17	8.09
	Mill & Overlay	5+	1,2,3	0.30	0.61	0.97	1.86	4.35
RHMA-G	Overlay	5+	1,2,3	1.12	2.32	3.86	6.41	16.33
	Mill & Overlay	5+	1,2,3	0.48	1.00	1.56	2.93	6.88
RHMA-G w/RHMA-O	Overlay	5+	1,2,3	0.84	1.73	2.9	4.81	12.25
	Mill & Overlay	5+	1,2,3	0.34	0.72	1.14	2.17	5.13
Rehabilitation								
HMA	Overlay	10	1,2,3	0.47	0.98	1.63	2.72	6.94
		20	1,2,3	0.33	0.69	1.15	1.91	4.87
	Mill & Overlay	10	1,2,3	0.21	0.45	0.73	1.37	3.23
		20	1,2,3	0.15	0.31	0.49	0.93	2.18
HMA w/OGFC	Overlay	10	1,2,3	0.35	0.75	1.26	2.10	5.37
		20	1,2,3	0.27	0.57	0.95	1.58	4.04
	Mill & Overlay	10	1,2,3	0.19	0.39	0.64	1.23	2.9
		20	1,2,3	0.14	0.28	0.45	0.86	2.01
HMA w/RHMA	Overlay	10	1,2,3	0.35	0.75	1.26	2.1	5.37
		20	1,2,3	0.27	0.57	0.95	1.58	4.04
	Mill & Overlay	10	1,2,3	0.19	0.39	0.64	1.23	2.90
		20	1,2,3	0.14	0.28	0.45	0.86	2.01
RHMA-G	Overlay	10	1,2,3	0.84	1.73	2.90	4.81	12.25
		20	1,2,3	0.55	1.14	1.90	3.17	8.09
	Mill & Overlay	10	1,2,3	0.37	0.75	1.18	2.21	5.20
		20	1,2,3	0.25	0.52	0.84	1.58	3.73
RHMA-G w/RHMA-O	Overlay	10	1,2,3	0.55	1.14	1.9	3.17	8.09
		20	1,2,3	0.40	0.83	1.41	2.36	6.03
	Mill & Overlay	10	1,2,3	0.30	0.61	0.97	1.86	4.35
		20	1,2,3	0.21	0.44	0.72	1.39	3.28

Notes:

- (1) Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.
- (2) Production rates in the table are based on representative assumptions that are applied consistently throughout the table. These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose. More project specific user costs for some freeway situations can be obtained from the CA4PRS software.
- (3) 24-hour continuous closure with 16 hours of operation per day
- (4) 24-hour continuous closure with 24 hours of operation per day
- (5) 55-hour extended closure over the weekend

Table 3-5 Productivity Estimates of Typical Future Rehabilitation Ramp Strategies for Flexible Pavements

Final Surface Type	Future M&R Alternative	Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure				
				Daily Closure (Weekday)		Continuous Closure		
				5 to 7-Hour Closure	8 to 12-Hour Closure	16 hour/Day Operation	24 hour/day Operation	55-hour Weekend Closure
CAPM								
HMA	Overlay	5+	1,2,3	0.51	1.02	1.71	2.85	7.29
	Mill & Overlay	5+	1,2,3	0.22	0.44	0.70	1.32	3.10
HMA w/OGFC	Overlay	5+	1,2,3	0.32	0.66	1.11	1.87	4.81
	Mill & Overlay	5+	1,2,3	0.17	0.36	0.57	1.10	2.60
HMA w/RHMA	Overlay	5+	1,2,3	0.32	0.66	1.11	1.87	4.81
	Mill & Overlay	5+	1,2,3	0.17	0.36	0.57	1.10	2.60
RHMA-G	Overlay	5+	1,2,3	0.68	1.36	2.28	3.79	9.69
	Mill & Overlay	5+	1,2,3	0.29	0.59	0.93	1.75	4.10
RHMA-G w/RHMA-O	Overlay	5+	1,2,3	0.51	1.02	1.71	2.85	7.29
	Mill & Overlay	5+	1,2,3	0.20	0.42	0.67	1.29	3.05
Rehabilitation								
HMA	Overlay	10	1,2,3	0.28	0.57	0.96	1.61	4.13
		20	1,2,3	0.19	0.40	0.68	1.13	2.90
	Mill & Overlay	10	1,2,3	0.13	0.26	0.43	0.81	1.92
		20	1,2,3	0.09	0.18	0.29	0.55	1.30
HMA w/OGFC	Overlay	10	1,2,3	0.21	0.43	0.73	1.24	3.19
		20	1,2,3	0.15	0.33	0.55	0.93	2.40
	Mill & Overlay	10	1,2,3	0.11	0.23	0.37	0.72	1.72
		20	1,2,3	0.08	0.16	0.26	0.51	1.19
HMA w/RHMA	Overlay	10	1,2,3	0.21	0.43	0.73	1.24	3.19
		20	1,2,3	0.15	0.33	0.55	0.93	2.40
	Mill & Overlay	10	1,2,3	0.11	0.23	0.37	0.72	1.72
		20	1,2,3	0.08	0.16	0.26	0.51	1.19
RHMA-G	Overlay	10	1,2,3	0.51	1.02	1.71	2.85	7.29
		20	1,2,3	0.32	0.66	1.11	1.87	4.81
	Mill & Overlay	10	1,2,3	0.22	0.44	0.70	1.32	3.10
		20	1,2,3	0.15	0.31	0.50	0.94	2.22
RHMA-G w/RHMA-O	Overlay	10	1,2,3	0.32	0.66	1.11	1.87	4.81
		20	1,2,3	0.23	0.49	0.82	1.39	3.58
	Mill & Overlay	10	1,2,3	0.17	0.36	0.57	1.10	2.60
		20	1,2,3	0.12	0.26	0.42	0.82	1.95

Notes:

- (1) Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.
- (2) Production rates in the table are based on representative assumptions that are applied consistently throughout the table. These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose. More project specific user costs for some freeway situations can be obtained from the CA4PRS software.
- (3) 24-hour continuous closure with 16 hours of operation per day
- (4) 24-hour continuous closure with 24 hours of operation per day
- (5) 55-hour extended closure over the weekend

Table 3-6 Productivity Estimates of Typical Future Rehabilitation for Rigid and Composite Pavements

Final Surface Type	Future M&R Alternative	Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure					
				Daily Closure		Continuous Closure		Weekend Closure (55-Hour)	
				5 to 7-Hour Closure	8 to 12-Hour Closure	16 hour/day Operation	24 hour/day Operation		
CAPM									
Flexible/ Composite	Flexible Overlay		5+	1,2,3	1.16	2.32	3.86	6.41	16.33
	Flexible Overlay w/Slab Replacements (FO+JPCP SR)	4-hr RSC 12-hr RSC	5+	1,2,3	0.63 1.90	1.69 4.37	3.05 12.66		
Rigid-Jointed Plain Concrete Pavement (JPCP)	Concrete Pavement Rehab A	4-hr RSC 12-hr RSC	5+	1,2,3	0.48 1.07	1.79 3.93	4.17 16.11		
	Concrete Pavement Rehab B	4-hr RSC 12-hr RSC	5+	1,2,3	0.67 1.50	2.51 5.51	5.84 22.56		
	Concrete Pavement Rehab C	4-hr RSC 12-hr RSC	5+	1,2,3	1.67 3.75	6.27 13.77	14.61 56.40		
Rigid-Continuously Reinforced Concrete Pavement (CRCP)	Punchout Repair A	4-hr RSC 12-hr RSC	5+	1,2,3	0.08 0.27	0.17 0.67	0.66 4.51		
	Punchout Repair B	4-hr RSC 12-hr RSC	5+	1,2,3	0.11 0.38	0.24 0.94	0.92 6.31		
	Punchout Repair C	4-hr RSC 12-hr RSC	5+	1,2,3	0.27 0.96	0.60 2.34	2.31 15.78		
Rehabilitation									
Flexible / Composite	Flexible Overlay w/ Slab Replacement (FO + JPCP SR)	4-hr RSC	10	1,2,3	0.31	0.89	1.66		
	Flexible Overlay w/ Slab Replacement (FO + JPCP SR)	12-hr RSC					0.91	2.27	6.83
	Mill, Slab Replacement & Overlay (MSRO)	4-hr RSC	10	1,2,3	0.19	0.50	0.85		
	Mill, Slab Replacement & Overlay (MSRO)	12-hr RSC					0.91	2.27	6.83
	Mill, Slab Replacement & Overlay (MSRO)	4-hr RSC	20	1,2,3	0.15	0.38	0.64		
	Mill, Slab Replacement & Overlay (MSRO)	12-hr RSC					0.49	1.10	2.82
	Crack, Seat, & Flexible Overlay (CSFOL)		10 20	1,2,3	0.47 0.44	0.98 0.75	1.63 1.26	2.72 2.10	6.94 5.37
	Replace with Flexible		20 40		1,2,3	0.21 0.15	0.44 0.31	0.75 0.53	1.26 0.89
	Replace with Composite	4-hr RSC	20	1,2,3		0.02	0.08	0.18	
		12-hr RSC					0.09	0.16	0.65
Jointed Plain Concrete Pavement (JPCP)	Lane Replacement	4-hr RSC	20	1,2,3	0.03	0.07	0.17		
		12-hr RSC					0.04	0.16	0.62
		4-hr RSC	40	1,2,3	0.02	0.06	0.14		
		12-hr RSC					0.05	0.14	0.53
Continuously Reinforced Concrete Pavement	Lane Replacement	4-hr RSC	20	1,2,3	0.01	0.03	0.11		
		12-hr RSC					0.05	0.11	0.66
		4-hr RSC	40	1,2,3	0.01	0.03	0.10		
		12-hr RSC					0.04	0.10	0.63

**FO = Flexible Overlay JPCP = Jointed Plain Concrete Pavement SR = Slab Replacement RSC = Rapid Set Concrete
CRCP = Continuously Reinforced Concrete Pavement**

Notes:

- (1) Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.
- (2) Production rates are based on the lower end of the representative assumptions for the range and are applied consistently throughout the table.
These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose.
More project specifics user cost for some freeway situations can be obtained from the CA4PRS software.
- (3) 24-hour continuous closure with 16 hours of operation per day
- (4) 24-hour continuous closure with 24 hours of operation per day
- (5) 55-hour extended closure over the weekend
- (6) Punchout Repair A involves **significant** punchout repairs and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement that had previous punchout repairs and a flexible overlay.
- (7) Punchout Repair B involves **moderate** punchout repair and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement where the total number of current and previous punchout repairs exceed 4 per mile.
- (8) Punchout Repair C involves **minor** punchout repairs and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement where the total number of current and previous punchout repairs do not exceed 4 per mile.
- (9) Precast panel concrete pavement is under development. See HQ LCCA Coordinator for assistance.

Table 3-7 Productivity Estimates of Typical Future Ramp Rehabilitation for Rigid and Composite Pavements

Final Surface Type	Future M&R Alternative	Pavement Design Life (years)	Maintenance Service Level	Average Lane-mile Completed Per Closure						
				Daily Closure		Continuous Closure		Weekend Closure (55-Hour)		
				5 to 7-Hour Closure	8 to 12-Hour Closure	16 hour/day Operation	24 hour/day Operation			
CAPM										
Flexible/ Composite	Flexible Overlay		5+	1,2,3	0.27	0.54	0.85	1.61	3.78	
	Flexible Overlay w/Slab Replacements (FO+JPCP SR)	4-hr RSC 12-hr RSC	5+	1,2,3	0.20 0.43	0.71	0.52	1.16	3.06	
Rigid-Jointed Plain Concrete Pavement (JPCP)	Concrete Pavement Rehab A	4-hr RSC 12-hr RSC	5+	1,2,3	0.28 0.60	1.26	0.39	1.21	4.63	
	Concrete Pavement Rehab B	4-hr RSC 12-hr RSC	5+	1,2,3	0.40 0.84	1.76	0.54	1.68	6.43	
	Concrete Pavement Rehab C	4-hr RSC 12-hr RSC	5+	1,2,3	0.99 2.10	4.41	1.35	4.20	16.08	
Rigid-Continuously Reinforced Concrete Pavement (CRCP)	Punchout Repair A	4-hr RSC 12-hr RSC	5+	1,2,3	0.06 0.13	0.54	0.27	0.54	3.40	
	Punchout Repair B	4-hr RSC 12-hr RSC	5+	1,2,3	0.08 0.18	0.76	0.26	0.76	4.76	
	Punchout Repair C	4-hr RSC 12-hr RSC	5+	1,2,3	0.21 0.45	1.89	0.93	1.89	11.91	
Rehabilitation										
Flexible / Composite	Flexible Overlay w/ Slab Replacement (FO + JPCP SR)	4-hr RSC	10	1,2,3	0.03	0.07	0.13			
	Flexible Overlay w/ Slab Replacement (FO + JPCP SR)	12-hr RSC					0.04	0.13	0.49	
	Mill, Slab Replacement & Overlay (MSRO)	4-hr RSC	10	1,2,3	0.03	0.06	0.12			
	Mill, Slab Replacement & Overlay (MSRO)	12-hr RSC					0.04	0.12	0.45	
	Mill, Slab Replacement & Overlay (MSRO)	4-hr RSC	20	1,2,3	0.03	0.06	0.11			
	Mill, Slab Replacement & Overlay (MSRO)	12-hr RSC					0.04	0.12	0.42	
	Crack, Seal, & Flexible Overlay (CSFOL)			10	1,2,3	0.28	0.57	0.96	1.61	4.13
				20		0.21	0.43	0.73	1.24	3.19
				40		0.12	0.26	0.43	0.74	1.91
	Replace with Flexible			40	1,2,3	0.08	0.18	0.31	0.52	1.37
			40	1,2,3	0.01	0.05	0.11			
Replace with Composite	4-hr RSC	20	1,2,3			0.04	0.10	0.39		
	12-hr RSC	40	1,2,3			0.04	0.09	0.36		
Jointed Plain Concrete Pavement (JPCP)	Lane Replacement	4-hr RSC	20	1,2,3	0.01	0.04	0.10			
		12-hr RSC	40	1,2,3			0.04	0.09	0.37	
Continuously Reinforced Concrete Pavement	Lane Replacement	4-hr RSC	20	1,2,3	0.01	0.02	0.06			
		12-hr RSC	40	1,2,3			0.03	0.06	0.40	
		4-hr RSC	20	1,2,3	0.01	0.02	0.06			
		12-hr RSC	40	1,2,3			0.03	0.06	0.38	

FO = Flexible Overlay JPCP = Jointed Plain Concrete Pavement SR = Slab Replacement RSC = Rapid Set Concrete CRCP = Continuously Reinforced Concrete Pavement

Notes:

- (1) Refer to Appendix 1, "Glossary and list of Acronyms" for definitions of terms used in the table.
- (2) Production rates are based on the lower end of the representative assumptions for the range and are applied consistently throughout the table.
These rates are only for calculating future user costs for the procedures in this manual and not for any other purpose.
More project specifics user cost for some freeway situations can be obtained from the CA4PRS software.
- (3) 24-hour continuous closure with 16 hours of operation per day
- (4) 24-hour continuous closure with 24 hours of operation per day
- (5) 55-hour extended closure over the weekend
- (6) Punchout Repair A involves **significant** punchout repairs and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement that had previous punchout repairs and a flexible overlay.
- (7) Punchout Repair B involves **moderate** punchout repair and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement where the total number of current and previous punchout repairs exceed 4 per mile.
- (8) Punchout Repair C involves **minor** punchout repairs and 0.15' of flexible overlay. It applies to continuously reinforced concrete pavement where the total number of current and previous punchout repairs do not exceed 4 per mile.
- (9) Precast panel concrete pavement is under development. See HQ LCCA Coordinator for assistance.

APPENDIX 8: LCCA PAVEMENT TYPE SELECTION FLOW CHARTS

LCCA NEW CONSTRUCTION AND RECONSTRUCTION PAVEMENT TYPE SELECTION FLOWCHART

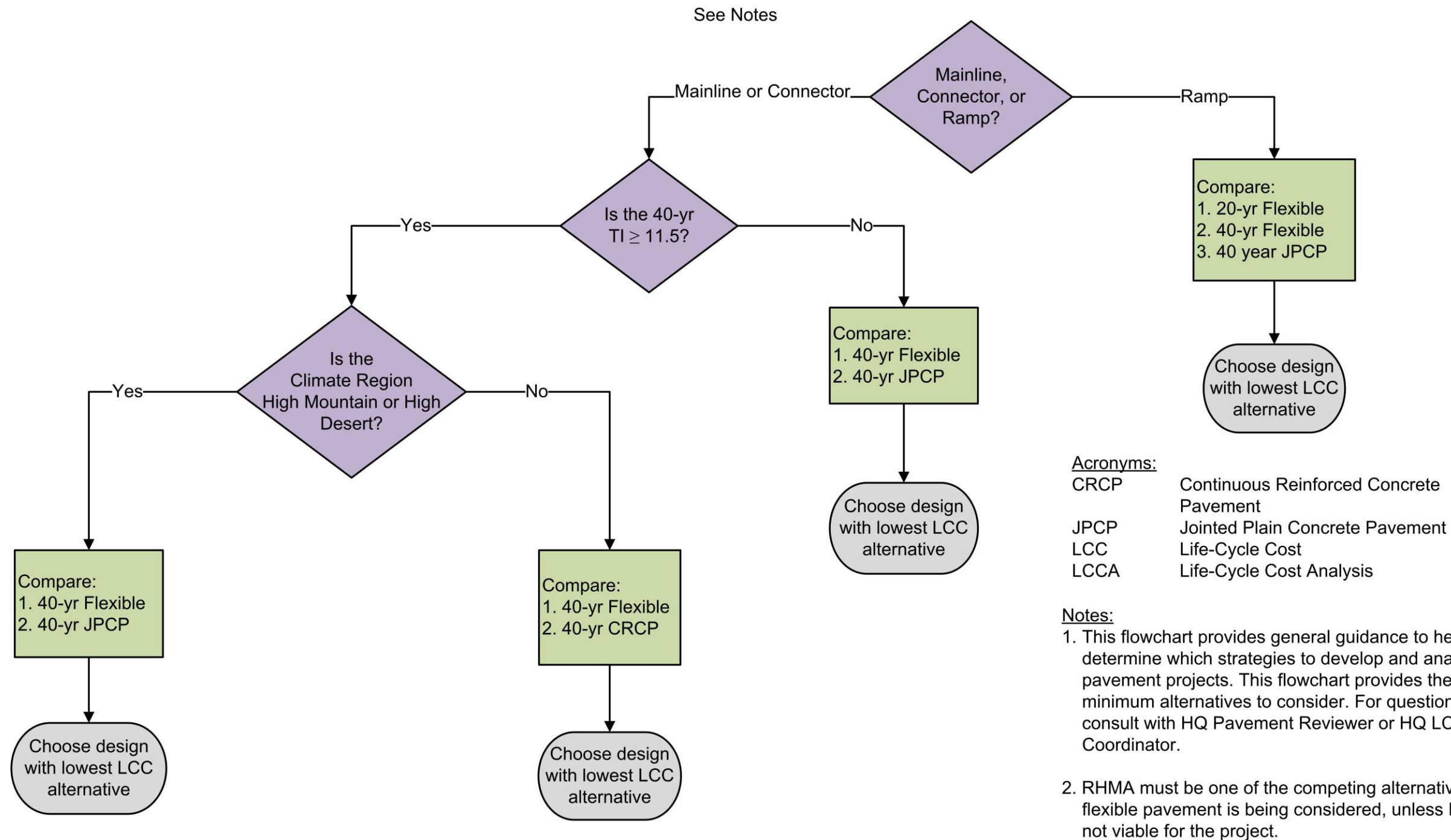
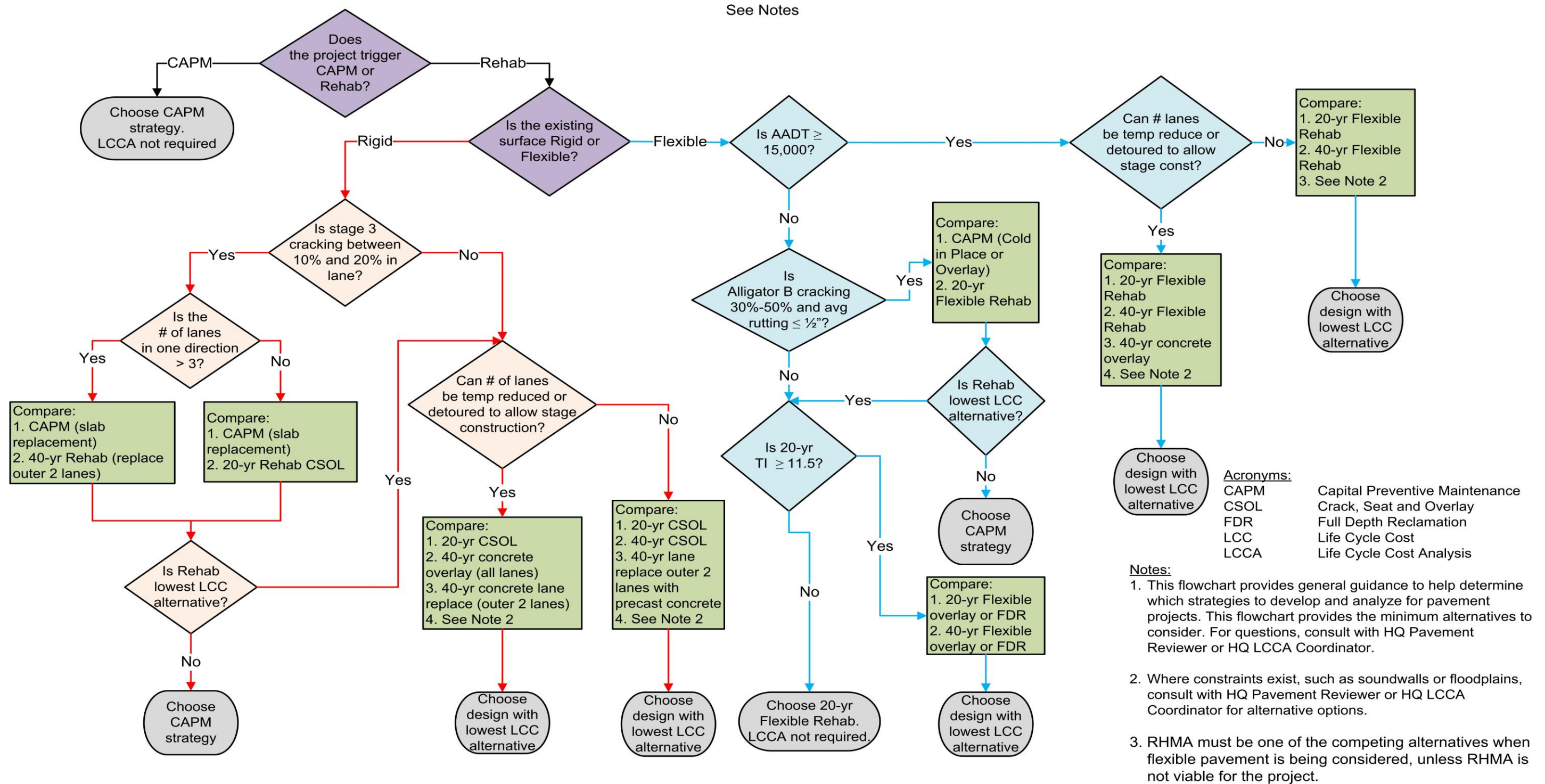


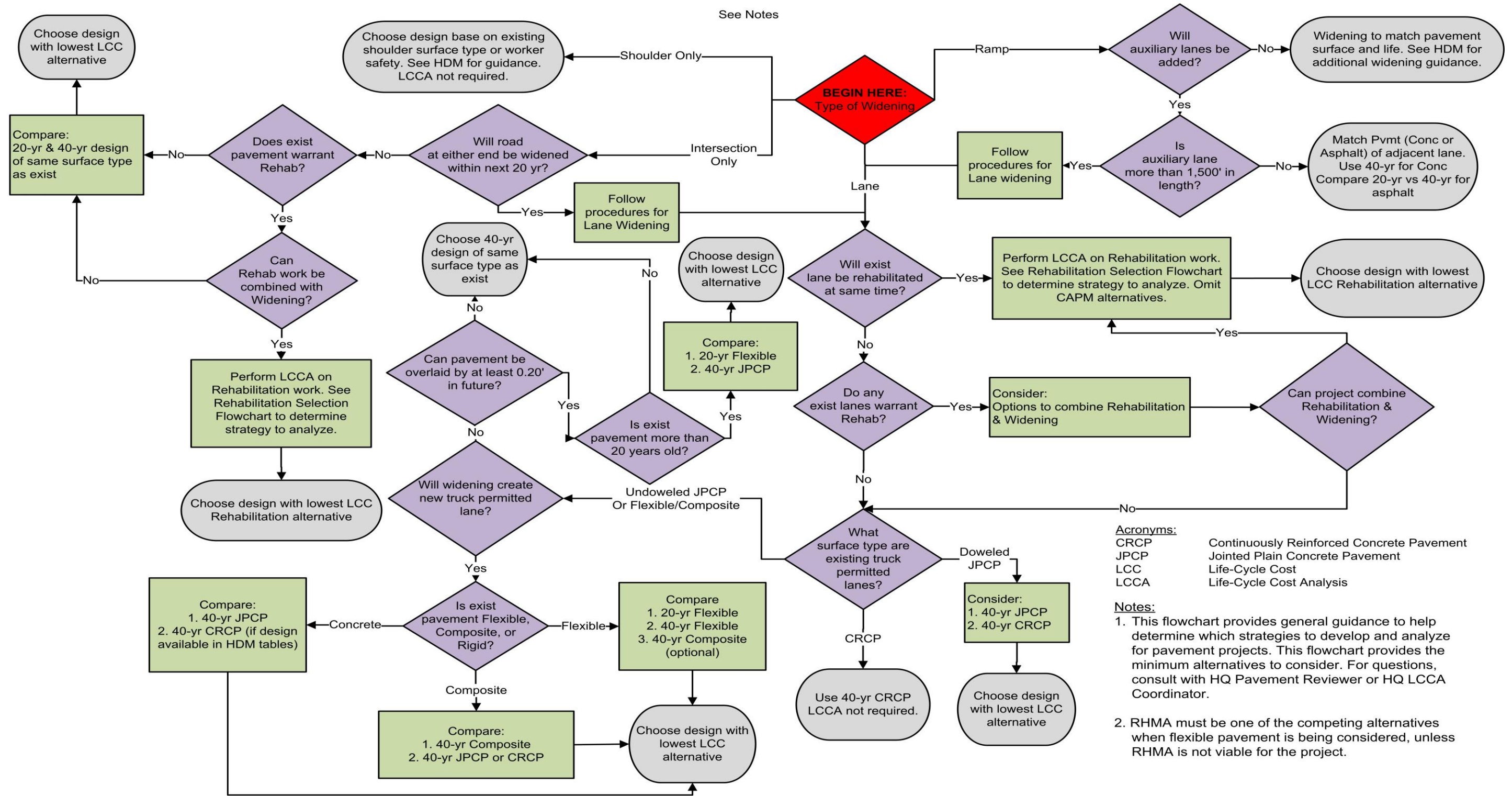
Figure 2-1 New Construction and Reconstruction Pavement Alternatives Selection Flowchart

LCCA CAPM AND REHABILITATION PAVEMENT TYPE SELECTION FLOWCHART



Combined Figure 2-5 and Figure 2-6 Pavement Type Selection Flowchart for LCCA CAPM and Rehabilitation Project

LCCA WIDENING PAVEMENT TYPE SELECTION FLOWCHART



Combined Figure 2-2, Figure 2-3, and Figure 2-4 LCCA Widening Pavement Type Selection Flowchart