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16. Abstract

The primary objectives of this study were to develop models to forecast future pavement conditions and to determine remaining service life of pavements based on the forecasted conditions. Based on available data in the ODOT pavement database, which contains the condition history of each pavement section, along with its location, year of construction, thickness, materials used, climate, and rehabilitation records, individual regression, family regression, and Markov probabilistic models were developed . For the latter two models, pavements were first grouped into “families” with similar characteristics, based on pavement type, priority, District location, and past performance. Forecasting models were then developed for each such “family”. The developed models were evaluated by comparing the predicted conditions with the actual observed conditions for the five year period between 2001 and 2005. The Markov model was found to have the highest overall prediction accuracy among all the models evaluated, and it can also predict future distresses in addition to the PCR values. As a result of this study, ODOT can forecast future pavement conditions and estimate the remaining service life of pavements. Future rehabilitation needs can also be determined. Such capabilities will significantly benefit planning and management decision-makings at both project and network levels.

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Pavement Forecasting Models

Final Report

State Job No. 134148

Principal Investigator: Eddie Y. Chou

Co-Authors: Haricharan Pulugurta, Debargha Datta

The University of Toledo

Prepared in Cooperation with

The Ohio Department of Transportation

and

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March 2008

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Principle Investigator:
Eddie Y. Chou, Ph.D., P.E.
University of Toledo
419-530-8123
ychou@utnet.utoledo.edu

ODOT Contacts:
Technical:
Roger Green
Andrew Williams
Office of Pavement Engineering
614-995-5993
614-752-4059
Administrative:
Monique R. Evans, P.E.
Administrator, R&D
614-728-6048

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Ohio Department of Transportation
Office of Research & Development
1980 West Broad Street
Columbus, OH 43223

Problem

The ability to forecast future pavement condition is highly valuable in supporting various pavement management decisions. ODOT has compiled roadway inventory, pavement condition history, and construction activities data into a comprehensive pavement management database. To fully benefit from this database to support decisions regarding future repair strategies, it is necessary to forecast future conditions and to determine the remaining service life of pavement sections. Such forecasting capability will significantly benefit ODOT in choosing the most cost-effective rehabilitation strategies to maintain and preserve the State's highway systems.

Objectives

1. To develop models to forecast future pavement conditions using data available to ODOT.
2. To determine remaining service life of pavement sections based on the forecasted condition.
3. To develop decision trees for selecting rehabilitation strategies.
4. To determine an appropriate initial PCR rating for a rehabilitated pavement section.
5. To include local federal aid routes in the pavement management database.

Description

After reviewing the literature, several different pavement condition forecasting models were developed based on available data in the ODOT

pavement database, which contains the condition history of each pavement section, along with its location, year of construction, thickness, materials used, climate, and rehabilitation records.

Individual regression, family regression, and Markov probabilistic models were developed. For the latter two types of models, pavement sections were first grouped into "families" of similar characteristics, based on pavement type, priority, District location, and past performance. Forecasting models were then developed for each such "family". The developed models were evaluated by comparing the predicted conditions with the actual measured conditions for the five year period of 2001-2005.

Findings

The Markov model has the highest overall prediction accuracy among all the models evaluated, and it has the important advantage of being able to predict future distresses in addition to the PCR values.

The remaining service life of each pavement section is determined based on the conditions predicted by the Markov model and a terminal condition specified by the user. The default terminal condition for Priority system pavements is a PCR value below 65, and for General system pavements, a PCR below 60.

Appropriate initial PCR values after various maintenance and rehabilitation treatments were determined after analyzing distress progressions after the treatment. These initial PCR values provide a more realistic reflection of the actual pavement condition, and encourage selection of treatments that are longer-lasting.

A set of rehabilitation treatment decision trees were developed in cooperation with the Office of Pavement Engineering staff. These decision trees consider pavement type, priority, traffic volume, past treatment and performance, and current distress condition to recommend an appropriate maintenance or rehabilitation treatment for a given pavement. A tool has also been developed to apply the decision trees to the forecasted pavement conditions, thereby allowing the consequences of different multiyear work plans to be evaluated.

In addition to the database for the entire State highway network, a database for local federal-aid routes was developed as an addendum to this study. Although the data currently available for local routes are much less complete than that for State routes, tools have been developed to help local agencies manage their pavement assets.

Conclusions & Recommendations

As a result of this study, ODOT can forecast future pavement conditions and estimate the remaining service life of pavements. Current and future rehabilitation needs can also be determined. Such capabilities will benefit planning and management decision-makings at both project and network levels.

The Markov model is recommended due to its overall accuracy and its ability to predict individual distress in addition to PCR. Further efforts to integrate the outcomes of this study into a decision support tool that will be used routinely by the Central and Districts Offices is recommended.

Implementation Potential

The pavement forecasting model and various tools developed in this study have been included in the current ODOT pavement management database. They may be implemented readily as part of a comprehensive Pavement Management System.

INTRODUCTION

The Ohio Department of Transportation (ODOT) spends several hundred million dollars each year on pavement reconstruction and rehabilitation. Allocating the available budget to various competing projects requires a proper decision making process supported by knowledge regarding the current and future system conditions.

The ability to forecast future pavement condition is very useful in supporting various pavement management decisions. Decision makers can use the predicted future pavement conditions to determine the budget level required for maintenance and rehabilitation, to prioritize pavement repairs, and to develop multiyear rehabilitation work plans.

ODOT has compiled roadway inventory, pavement condition history, and construction activities data into a pavement management database. To fully benefit from this database to support decisions regarding future repair strategies, it is necessary to forecast future conditions and determine the remaining service life of pavement sections.

The main purpose of this study was to use the data available in the ODOT pavement database to develop a pavement forecasting model to predict future pavement conditions and to estimate the remaining service life of pavements. The ability to forecast the future condition and to estimate the remaining service life of pavements will significantly benefit ODOT in choosing the most cost-effective maintenance and rehabilitation strategies to preserve the State's highway systems.

Figure 1 shows the central role of pavement condition forecasting models within a pavement management system.

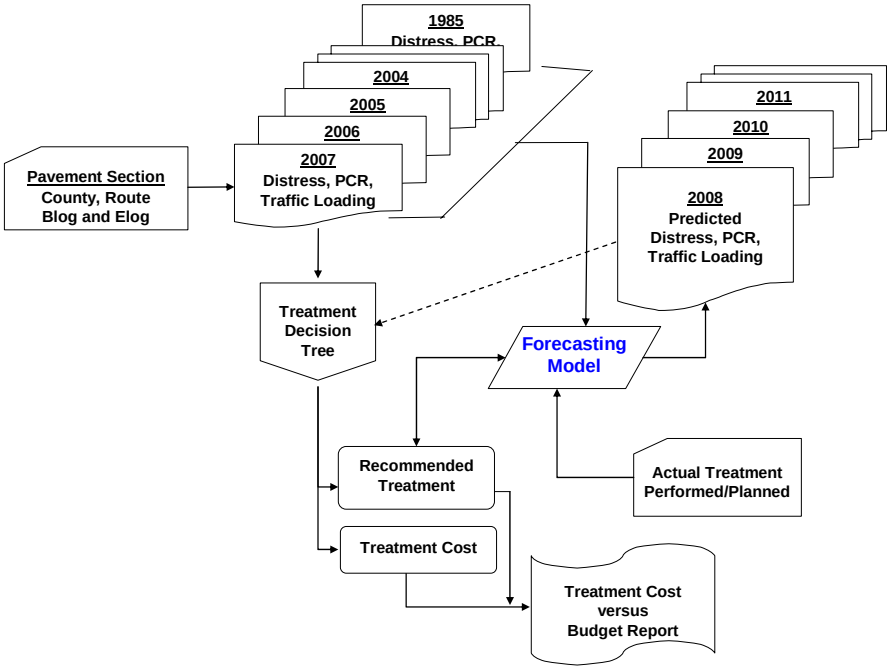


Figure 1. Role of Condition Forecasting Model in a Pavement Management System

The current pavement condition rating (PCR) system assigns a rating of 100 to new/under construction sections, if the pavement is being rehabilitated when the rater visits. However, depending on the actual rehabilitation treatment performed, some of the existing distresses may not be completely eliminated and could resurface rather quickly after treatment. As a result, some rehabilitated pavement sections deteriorate much faster than others, depending on the repair treatment applied and the distress condition prior to the repair. If many such 'band-aid' repairs were performed, the average PCR values in a single year can be misleading. Therefore, the second purpose of this study was to determine the most reasonable initial rating for the repaired section taking into account the distress condition of the pavement being repaired and the specific repair treatment applied.

Given the specific condition and traffic loading of a pavement, the most suitable maintenance or rehabilitation treatment action can often be determined with the help of a decision tree. Another purpose of this study was to develop and implement pavement maintenance and rehabilitation decision trees for different pavement types and priorities, in cooperation with

the Office of Pavement Engineering. By applying the decision trees to the forecasted pavement conditions, treatment needs in future years can be determined. ODOT decision makers can then formulate multi-year work plans based on budgetary and other constraints.

Background

Various models have been proposed to predict future pavement conditions. Given the numerous known and unknown parameters that can influence the performance of a pavement, a statistical approach based on past performance history is most widely accepted by highway agencies. Some statistical models are developed based on data collected from a single test road. For example, the AASHTO Design Equations originated from the results of the AASHO road test. Other statistical models are based on data collected from test roads located at diverse geographical locations. The LTPP test project is a rather extreme example, with pavement sections monitored throughout the entire United States. However, due to the enormous cost to construct and monitor pavements, the number of LTPP sites in Ohio is rather limited. Therefore, a more practical and sensible approach is to develop prediction models based on data collected from in-service pavements in a state or region. The ODOT pavement management database, which contains detailed in-service pavement conditions, traffic, and construction records since 1985 for all highways in the State of Ohio, provides an excellent basis to develop pavement condition forecasting models for Ohio. This database includes the most essential information needed to forecast pavement performance. These include functional class, pavement type and location, construction date (pavement age) and the specific maintenance and rehabilitation treatment performed, pavement structural buildup and materials used, pavement condition rating (PCR) and individual distress rating history, and traffic loading.

The first step in developing a pavement condition forecasting model is to determine the parameter or parameters to be predicted and the factors that affect the predicted parameter. ODOT has been using PCR as the primary indicator of pavement condition and for decision-making. Therefore, predicting a pavement section's PCR is obviously important. Previous studies have found that a pavement's PCR value is mostly dependent on age, with different pavement types having different rates of deterioration. Despite their simplicity, however,

such models are rather inaccurate in their prediction. That is, they often have relatively large prediction errors and low coefficients of determination (R-square). In fact, pavements of the same type can have significantly different deterioration trends due to differences in structures (layer thicknesses and materials), subgrade soil support, climate, pre-existing defects, traffic loadings, maintenance practices, etc. Figure 2 show the deterioration trends of overlays constructed between 1995 and 2006 on Districts 2 and 11 General system flexible pavements. It is apparent that pavements with the same age can have significantly different PCR values.

A pavement's PCR value is determined from the observed surface distresses: cracking, rutting, raveling, etc. The ODOT pavement database contains both the PCR history and the corresponding individual distresses. Different distresses may progress quite differently with time, and different repair treatments may be required depending on the type of distresses present. Therefore, it is desirable to utilize the individual distress data available in the ODOT pavement database to provide prediction of the future distress conditions. The PCR value of a pavement section can then be obtained by combining the predicted individual distresses.

The ODOT PCR procedure rates each individual distress based on its severity and extent. Severity levels are categorized as low, medium or high (represented using L, M and H). Extent levels are categorized as occasional, frequent and extensive (represented using O, F and E). Hence, the resulting distress rating categories are LO, LF, LE, MO, MF, ME, HO, HF, and HE. For example, a distress rating of HF indicates that the severity of the distress is high and frequently occurring. Further, a category of NULL is used to indicate the absence of a particular distress. Therefore, for each distress, a total of ten levels ranging from NULL, LO, LF, LE, …, to HE, corresponding to ten discrete deduct values are possible. However, these discrete deducts values are 'stepped.' For example, a pavement section may receive a transverse cracking rating of MF (medium severity and frequent extent) five years in a row, followed by a rating of HE (high severity and extensive extent). The numerical deduct values would indicate the distress condition remained the same during those five years, but became significantly worse at the following year. The actual deterioration of the pavement is more likely to progress gradually, rather than following a 'stepped' function with time. A method to 'extract' and 'smooth' the individual distress data to reflect the actual deterioration is necessary to predict future distresses. The "smoothing" of distress data also lays the

foundation to calibrate available mechanistic models, such as for rutting and cracking distresses.

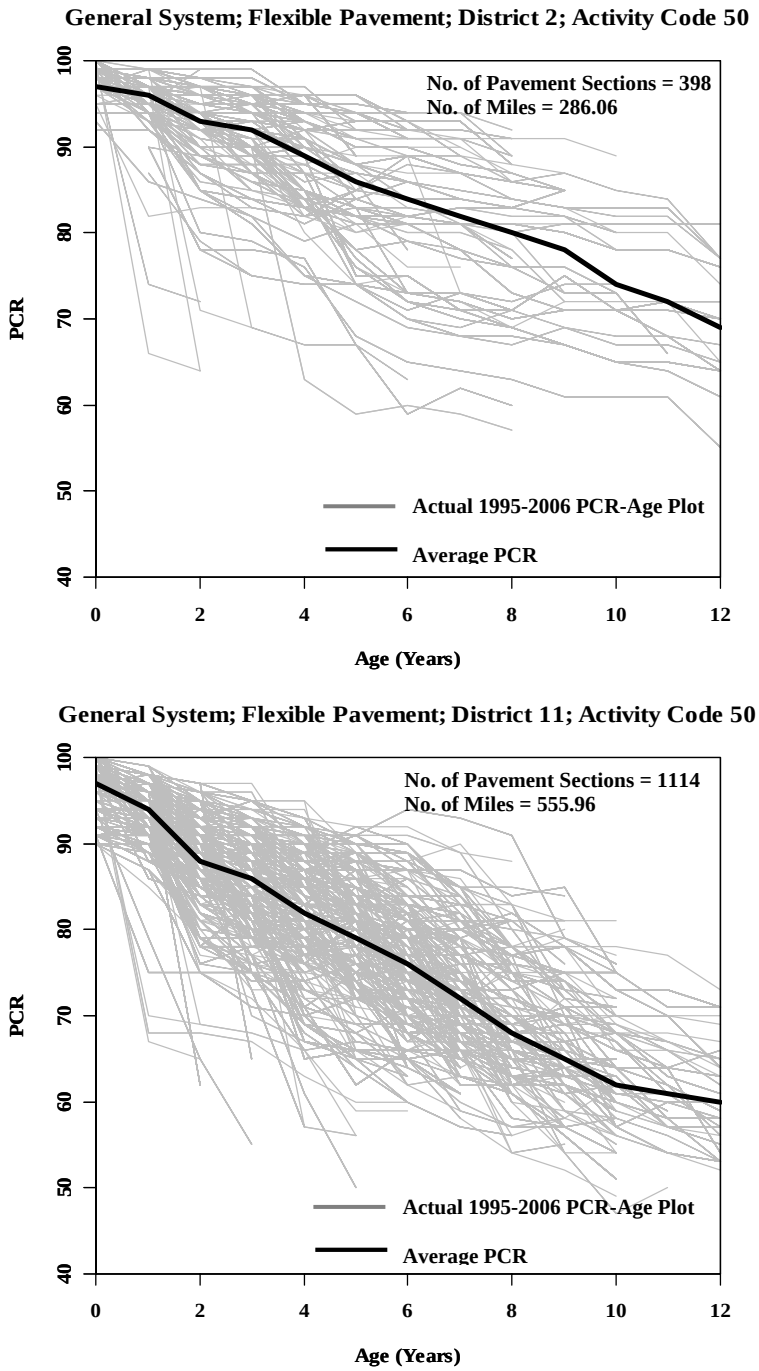


Figure 2. Pavement Condition Deterioration Trend for General System Flexible Pavement Treated with Activity Code 50 in Districts 2 and 11

Objective of the Research

The objectives of the study were:

1. To develop models to forecast future pavement conditions using data available to ODOT;
2. To determine remaining service life of pavement sections based on forecasted condition;
3. To develop decision trees for selecting rehabilitation strategies based on estimated remaining life of pavement sections; and
4. To determine an appropriate initial PCR rating for a rehabilitated pavement section.

The first addendum to the original contract added the following objectives:

5. To incorporate the new distress types, for example, thermal cracking, into the pavement forecasting models based on 2004, 2005, and 2006 PCR data.
6. To implement the Pavement Quality Index into the pavement management information system.
7. To revise the recommended rehabilitation treatment report function in the Pavement Management Information System to include estimated project cost based on user supplied unit cost.

The objectives of the second addendum were:

8. To incorporate the existing pavement condition data for local federal aid routes into the ODOT pavement management database.
9. To modify the existing analysis and reporting tools to support pavement management decisions for local federal routes.

GENERAL DESCRIPTION OF RESEARCH

This research project consists of the following tasks.

- Task 1 was to review literature and survey existing models
- Task 2 was to develop and select a forecasting model for predicting future pavement conditions
- Task 3 was to determine remaining pavement service life based on specified terminal conditions
- Task 4 was to determine appropriate initial PCR for rehabilitated pavements
- Task 5 was to develop decision trees for selecting rehabilitation strategies
- Task 6 was to update the existing PMIS to accommodate the updated PCR procedure implemented in 2004
- Task 7 was to incorporate local federal aid routes into the pavement database and develop corresponding management tools
- Task 8 was to prepare a draft final report for this study.

The above tasks are further described in the following paragraphs.

Task 1 Literature Review and Survey of Existing Models

The pavement deterioration process is influenced by many interacting parameters including, but not limited to, pavement design, layer thicknesses, materials used, construction quality, underlying soil characteristics, climate, traffic loading, and maintenance activities. Some of the parameters are not quantifiable or yet fully understood, while most of the parameters are subject to different levels of variations. Therefore, in order to predict future pavement condition, statistical models based on observed past performance of pavements are the most accepted approach.

Most of the existing statistical forecasting models can be categorized into two types: regression models and Markov transitional probability models. Both models rely on available

past performance data to predict likely future conditions. To reduce the variability typically associate with pavement performance data, both models first group pavements into similar "families," based on pavement type (concrete, asphalt or composite), functional class, and/or District jurisdiction. The regression models then use a selected set of independent variables, such as the age of the pavement, cumulative traffic loading, climatic conditions, etc., to predict the dependent variable – future pavement condition. Linear or nonlinear regression models (i.e., sigmoid or reversed S-shaped curves) have been developed by various researchers/highway agencies.

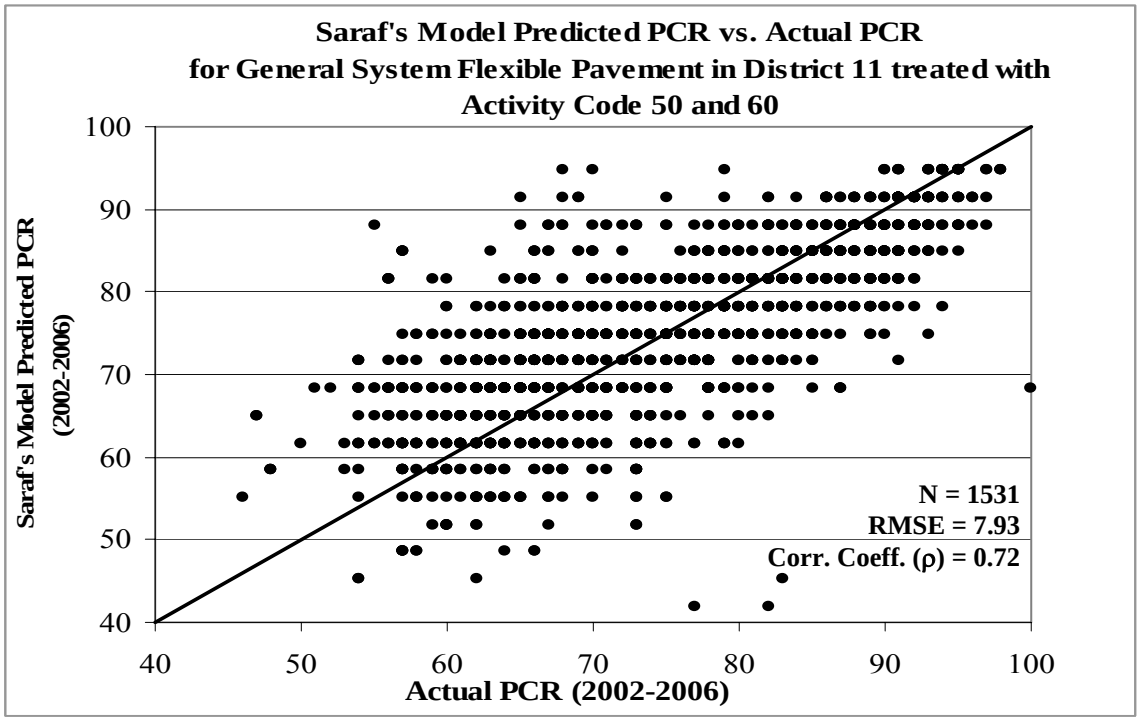
The current ODOT Pavement Design & Rehabilitation Manual contains a set of linear regression equations (Section 101-1) as the pavement deterioration models for new or rehabilitated rigid, flexible, and composite pavements. These equations are shown in Table 1. Factors not considered in these equations include: (1) functional class (i.e., priority versus general/urban systems) as the traffic levels, design thicknesses, and construction specifications are quite different among different functional classes, resulting in different rates of deterioration, (2) district jurisdiction, which contributes to variations in climate, materials used, traffic composition, and maintenance and rehabilitation practices. As a result, these simple linear regression models may not provide very accurate predictions.

Figure 3 shows a comparison of the actual versus the predicted PCR during the time period of 2000-2006 for overlays without repair (treatment activity 50) on District 11 General system flexible pavements. The regression equation used for prediction is the non-structural overlays with minimum repair on flexible pavements. As can be seen in Figure 3, the predicted and actual PCR values do not match very well, as pavement age is the only independent parameter for prediction. As shown earlier, pavements with the same age can have very different conditions, and hence, PCR values.

Saraf and Majidzadeh (1992) developed 40 different equations to forecast pavement distress and PCR for Ohio. An exponential deterioration trend was assumed, and pavement condition data from 1986 to 1990 were used to determine the model parameters. Pavement conditions were assumed to be a function of traffic ESAL, pavement thickness, and estimated modulus of elasticity of subgrade and each pavement layer. The 40 regression equations developed

Table 1. Existing Performance Prediction Equations
(from ODOT Pavement Design and Rehabilitation Manual Section 101-1)

Type of M&R Action	Equation as in Section 101
(1)	*(2)*
RIGID PAVEMENT	
All Overlays with and without Repairs	PCR = 96.0 - 3.7*AGE
CPR	96.2 - 7.0 *AGE
New Rigid Pavement & Unbonded Concrete Overlay	99.1 - 0.9 *AGE
FLEXIBLE PAVEMENT	
Non-Structural Overlay with Minimal Repairs	98.1 - 3.3 *AGE
Non-Structural Overlay with Repairs	98.6 - 3.8 *AGE
Structural Overlay with Minimal Repairs	98.3 - 3.3 *AGE
Generic Minor Rehabilitation (all of the above)	98.0 - 3.3 *AGE
Fractured Slab Technique	98.0 - 3.4 *AGE
New Flexible Pavement	99.5 - 2.0 *AGE
COMPOSITE PAVEMENT	
Non-Structural Overlay with Minimal Repairs	96.1 - 4.0 *AGE
Non-Structural Overlay with Repairs	96.1 - 3.8 *AGE
Structural Overlay with Minimal Repairs	96.1 - 4.3 *AGE
Structural Overlay with Repairs	96.1 - 3.3 *AGE
Generic Minor Rehabilitation (all of the above)	96.0 - 3.7 *AGE
New Composite Pavement	99.6 - 3.3 *AGE



Predicted PCR = 98 – 3.3 * AGE

Figure 3. Actual versus Predicted PCR Using Straight Line Equation

were for 5 different M&R actions (8 for each action). The M&R actions included were: non-structural AC overlay (less than or equal to 3 inches thick) with and without repairs, structural AC overlay with and without repairs (greater than 3 inches), and crack and seat with AC overlay. The model requires the modulus of elasticity for subgrade and each pavement layer. These modulus values were estimated from the soil classifications and material types used. Actual modulus values vary significantly with temperature and moisture content, and between individual pavements. Therefore, accuracies of these regression models are questionable. Since accurate soil and pavement modulus values are not available for most pavements, this approach is not used in the current study.

The Markov models require defining pavement conditions into a finite number of 'states.' For example, a pavement may be in the condition state of excellent, good, fair, poor, or very poor, defined by its PCR values or individual distresses. The probabilities that a pavement may deteriorate from a given condition state to other condition states are assumed to be

constant. These probabilities are called transitional probabilities, and are stored in a Markov Transition Matrix, P, expressed by:

$$P = \begin{bmatrix} P_{11} & P_{12} & . & . & . & P_{1n} \\ P_{21} & P_{22} & . & . & . & P_{2n} \\ . & . & & & & . \\ . & . & & & & . \\ . & . & & & & . \\ P_{n1} & P_{n2} & . & . & . & P_{nn} \end{bmatrix}, \qquad (1)$$

where $P_{ij} = P[X_{t_n} = j \mid X_{t_{n-1}} = i]$ is the transitional probability that the pavement deteriorates from condition state i to state j, and n is the total number of condition states. The transitional probabilities are subject to the following constraints:

$$P_{ij} \geq 0, \text{ for all } i \text{ and } j. \qquad (2)$$

$$\sum_{j=1}^{n} P_{ij} = 1, \text{ for all } i. \qquad (3)$$

If a particular P_{ij} has value of 1.0, then all the other probabilities in the same row (P_{ik}, k = 1, .., n, but k $\neq$ j) must all be equal to zero, indicating once a pavement reaches the condition state corresponding to P_{ij}, it will not go to other condition states. This condition state is called a "absorbing state." In most cases, the poorest distress condition, HE (high severity and extensive extent), should be the absorbing state, unless no pavement ever reach that level of distress condition.

Previous researchers often used assumed transitional probabilities. When historical pavement condition data are available, the transitional probabilities can be estimated based on the mileage of the pavements that deteriorate from one condition state to other condition states in the subsequent year. This approach was employed in the current study.

Pavement condition is typically measured on a yearly basis; resulting in a transition period of one year. The above Markov transition matrix, ***P***, is therefore a one-year transition matrix.

By multiplying the one-year transition matrix, predicted condition in future years can be obtained, i.e. $P^2 = P \times P, P^3 = P \times P \times P, \ldots\ldots, P^n = P \times P \times P \ldots\ldots \times P$.

Task 2 Develop Pavement Condition Forecast Models for Ohio

The two most common types of pavement forecasting model ─ the regression models and the Markov transition models ─ were investigated in this study. Two of the regression models, namely the family regression and the individual regression models, were investigated.

Family Regression Models

A "family" regression model is developed for a group of pavements with similar characteristics. In this study, system priority, pavement type, activity performed, and district jurisdictions are used as parameters to form pavement groups, or pavement 'families'. Pavements in some Districts tend to perform more poorly than those in other Districts, due to differences in subgrade soils, quality of locally available materials, climatic conditions (e.g., average temperature and amount of snow fall), traffic loading, maintenance practices, and rehabilitation decisions.

It has been shown that pavements constructed during different time periods, e.g., those constructed prior to 1995 versus those constructed since 1995, have different performance trends, likely due to improved specifications and quality control practices. Therefore, time period of construction is also a "family" characteristic. However, a "family" must have a significant number of pavements at various condition states in order to have a reliable forecast of future pavement conditions. Therefore, the time period selected should be sufficiently long, say, ten years.

To predict an individual pavement section's future condition, the corresponding family regression model is modified based on the known current condition of this particular pavement using a method called 'Age Shift,' originally proposed by Shahin (1994). Figure 4 illustrates the 'Age Shift' method, where a six-year old pavement has a PCR score of 85, which is the typical PCR score for a three-year old pavement in the same pavement "family."

Therefore, the 'age shift' is three years to the right, which means the entire family PCR curve is shifted three years to the right to represent the predicted PCR curve for this particular pavement.

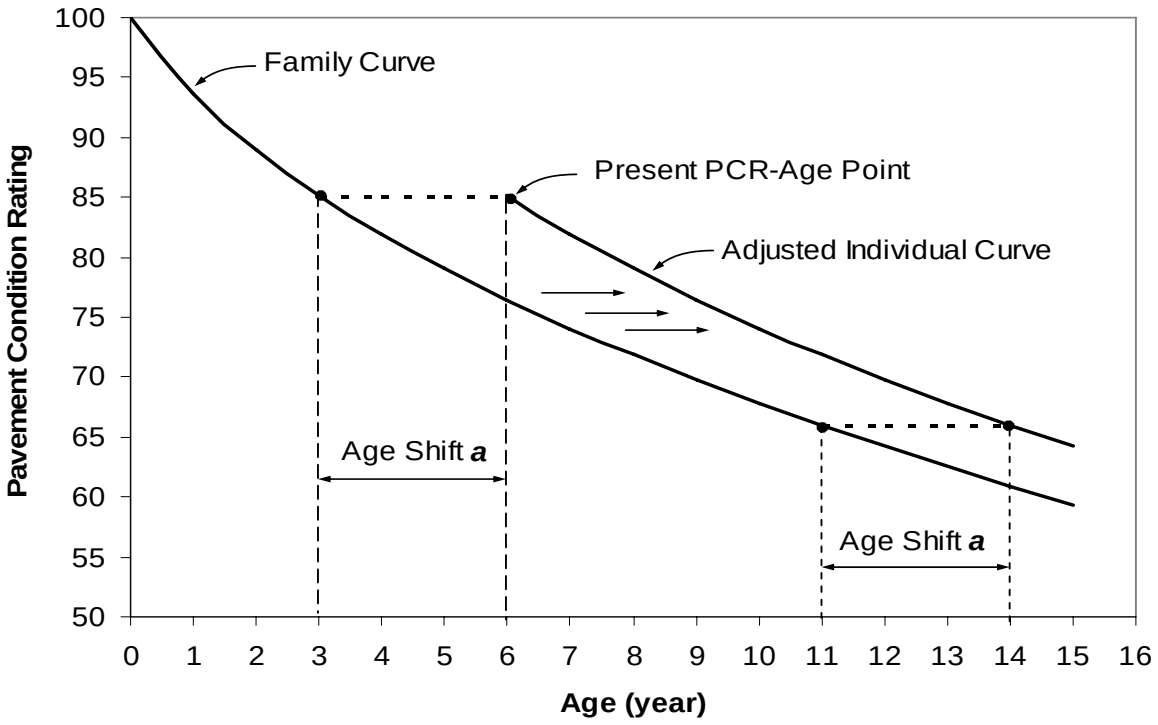


Figure 4. Adjusting Individual Deterioration in Relation to Family Deterioration (Adapted from Shahin 1994)

Individual Regression Models

In this approach, a best fit regression curve is fitted for each pavement section that has three or more PCR data points. Future PCR values for the pavement are obtained by extrapolating the fitted curve. When a pavement section has less than three available PCR data points (either because it's a recently rehabilitated pavement, or because the pavement was rehabilitated before three PCR values were measured), the "family" regression curve that the pavement corresponds to is used to represent the pavement's "expected" performance. The "Age Shift" method is employed to predict future condition starting from the latest available PCR data.

Markov Models

In this study, the Markov transitional probabilities are derived from the past condition data available in the ODOT pavement database. For a specific group of pavements with similar characteristics (i.e., in the same 'family'), the transition probabilities are calculated using the following equation:

$$P_{ij} = \frac{\text{Total Miles from State } i \text{ to State } j}{\text{Total Miles in State } i}. \tag{4}$$

A pavement currently in condition state i may be in one of several condition states the following year, as long as the corresponding transition probability, P_{ij}, is not zero. The condition state that the pavement will most likely to be in can be determined by finding the expected value of the distribution:

$$w_{t_{n+1}}^{k} = \sum_{j=1}^{n} P_{ij} \times W_j , \tag{5}$$

where $w_{t_{n+1}}^{k}$ is the expected deduct value of distress k at time t_{n+1}, $k = (1, 2, \ldots, 15)$, P_{ij} is the probability that the pavement is moving from state i to j for distress k, and W_j is the corresponding deduct value of distress k at state j, obtained from the PCR Rating System (ODOT 2004). The final predicted PCR value is obtained by using Equation (6).

$$PCR_{t_{n+1}} = 100 - \sum_{k=1}^{15} w_{t_{n+1}}^{k} , \tag{6}$$

where $PCR_{t_{n+1}}$ is the predicted PCR value at time t_{n+1}.

Dropouts

Pavement performance data are often subject to attrition over time; that is, fewer pavements survive to later ages. This attrition of data is referred to as "dropouts" (Laird 2004). For example, when pavement condition data are arranged according to age (i.e., condition scores for newly rehabilitated pavements are denoted as PCR0, and scores for one year old

pavements are denoted as PCR1, etc.,) the available PCR data for older pavements are less than for newer pavements, as poorer-performing pavements receive rehabilitation and "drop out" from the analysis. Overtime, only better performing pavements remain, and the PCR values in the later years are biased towards the better performing pavements. Forecasting models that do not consider dropouts tend to overestimate PCR value in the later stages of a pavement's life. This overestimation of pavement condition increases as the forecasting model predicts pavement conditions further into the future.

Figure 5 shows the actual average and Markov predicted PCR curves for the Priority system flexible pavements after receiving an overlay without repair (treatment activity code 50).

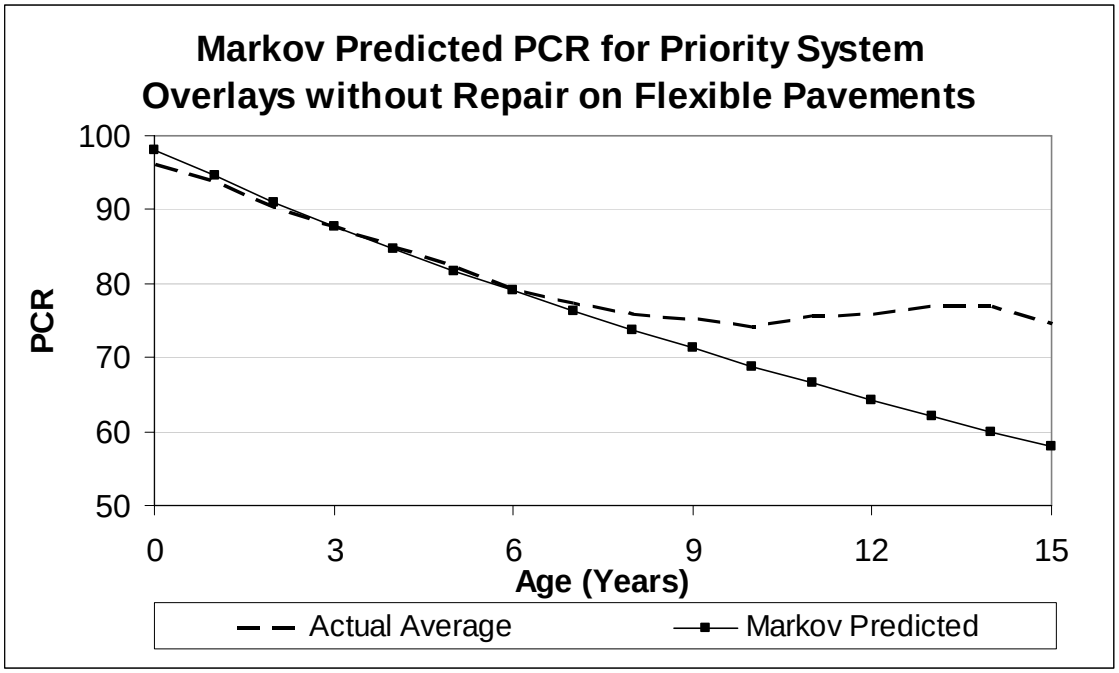


Figure 5. Markov PCR Prediction versus Actual Average Trends

It can be seen from Figure 5 that the differences between the Markov predicted PCR values and the actual average PCR values are very small during the first several years after overlay. In later years, however, the average PCR values are higher than the Markov predicted PCR values. This is due to the tendency of poorly performing pavements receiving repair treatment sooner than better performing pavements. As a result, the average PCR scores in later years are biased towards the better performing and longer lasting pavements. The

dropout phenomenon also causes the Markov prediction to demonstrate decreasing deterioration rates in later years. Dropouts cause overestimation of PCR values (and remaining service life), particularly at the later stage of pavement life span, when a significant portion of poorly performing pavements have been repaired and "dropped out" from the data.

This overestimation can be countered by imputation (Laird 2004), a widely accepted approach for handling dropouts. In its simplest form, imputation is conducted by extrapolating the deterioration trends for those pavement sections that have "dropped out" of the analysis. Figure 6 compares the average actual PCR deterioration trend and the average imputed trend, where all individual pavement deterioration trends are extrapolated by extending their final year PCR deterioration rates. The average actual PCR curve shows a decrease in the deterioration rate starting around six years of age, when poor performing pavements began to be replaced, and even shows an unrealistic upward trend after about 13 years, when very few pavements actually survived. In contrast, the imputed curve shows a more consistent deterioration trend.

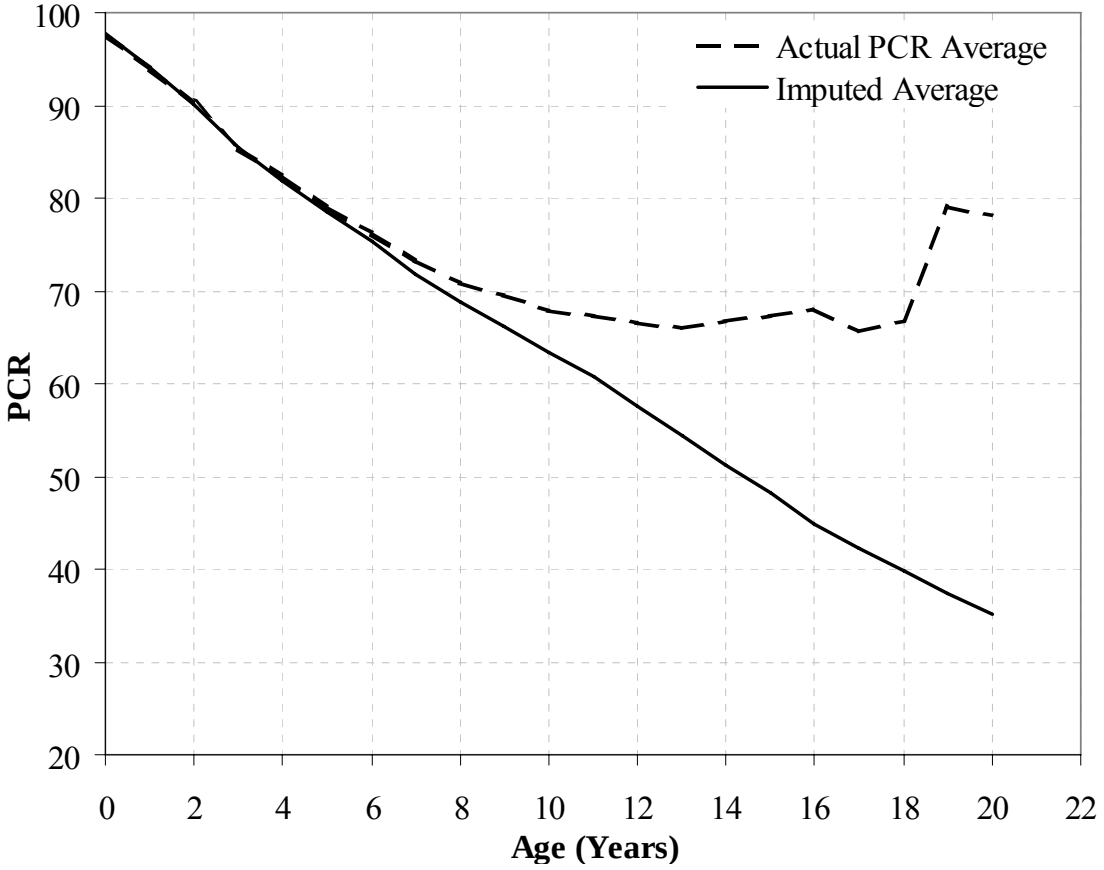


Figure 6. Imputed Average and Actual Average

Prediction of Individual Distresses

In this study, the severity and extent of each individual distress is predicted first, and then the deduct values from all the distresses are combined to determine the predicted PCR value.

The ODOT PCR procedure describes pavement distress condition according to its severity and extent. Severity of each distress is classified as either low (L), medium (M), or high (H), whereas the extent is described by three levels: occasional (O), frequent (F), or extensive (E). Furthermore, a NULL rating is given when a distress is not present. Therefore, each distress can be in one the following ten condition states: NULL, LO, LF, LE, MO, MF, ME, HO, HF, HE. A more detailed description of the PCR distress rating procedure can be found in the PCR manual available at the Office of Pavement Engineering web site.

For a group of pavements in the same "family", the Markov transitional probabilities for each individual distress are generated based on actual distress data collected during a given time period. A separate Markov transition matrix is developed for each distress, and future levels of each distress can then be predicted. By adding the predicted individual distress deducts and subtracting the total deduct from 100, the predicted PCR for future years can be obtained.

A "family" must have a sufficiently large number of pavements in various condition states in order to develop a reliable Markov transition matrix. This requirement is even more important for the Markov model than for the family regression model, and it is the main reason that the Markov model has not been widely used. However, the ODOT pavement management database contains a very large number of pavement sections, allowing many "families" to be formed, except for treatment activities that have not been used extensively. For this study, it was determined that a "family" must have at least 300 pavement sections, otherwise it is 'merged' with other similar families.

Table 2 shows the various states and transitional probabilities between these states for rutting distress on District 11 General system flexible pavements after an overlay without repairs (Activity Code 50). This transition matrix is denoted as $\boldsymbol{P}$.

Table 2. Transition Matrix for Rutting Distress, District 11, General Flexible Pavements Overlays (Activity 50) Constructed During 1995-2006

		Next Year Condition									
		NULL	LO	LF	LE	MO	MF	ME	HO	HF	HE
Current Year Condition	NULL	0.82	0.14	0.03	0.01	0	0	0	0	0	0
	LO	0.01	0.76	0.19	0	0.03	0	0	0	0	0
	LF	0.01	0.05	0.69	0.18	0.05	0.02	0	0	0	0
	LE	0	0.06	0.06	0.78	0.08	0.01	0.01	0	0	0
	MO	0	0.03	0	0	0.50	0.36	0.05	0.06	0	0
	MF	0	0	0	0	0	0.41	0.33	0.22	0.04	0
	ME	0	0	0	0	0	0.07	0.64	0	0.19	0.05
	HO	0	0	0	0	0	0	0.74	0.24	0.02	0
	HF	0	0	0	0	0	0	0	0	0.59	0.41
	HE	0	0	0	0	0	0	0	0	0	1

For example, within this group of pavements, a section with a rutting rating of NULL (non-existent) has a 82% chance to remain at NULL the following year, 14% chance that it will deteriorate to LO (Low Severity, Occasional Extent), 3% chance that it will deteriorate to LF (Low Severity, Frequent Extent), and 1% chance that it will deteriorate to LE (Low Severity, Extensive Extent). Mathematically, the second year probability vector is obtained by multiplying the first year probability vector to the one-year transition matrix, ***P***:

$$< 1 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 > \boldsymbol{P} = < 0.82 \;\; 0.14 \;\; 0.03 \;\; 0.01 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 > \qquad (7)$$

Since each distress condition level corresponds to a known deduct value, the expected deduct value can be obtained by summing up the product of each probability to the corresponding deduct. The pavement will most likely be in the condition state closest to the expected deduction value the following year.

To predict the condition two years later, the second year probability vector is multiplied to the one-year transition matrix ***P***:

$$< 0.82 \;\; 0.14 \;\; 0.03 \;\; 0.01 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 > \boldsymbol{P} = < 0.67 \;\; 0.22 \;\; 0.07 \; 0.04 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 > \qquad (8)$$

In other words, the same section has a 67% chance to remain at NULL in the third year, 22% chance that it will deteriorate to LO, 7% chance that it will deteriorate to LF, and 4% chance that it will deteriorate to LE (Low Severity, Extensive Extent). The above process is repeated for prediction of any future year conditions and for other distresses.

Figure 7 shows a comparison of the Markov Model predicted deterioration trends versus the actual average trend for rutting distress on General system flexible pavement overlays in District 11. Note the Markov predicted trend is 'smoother' than the actual average trend.

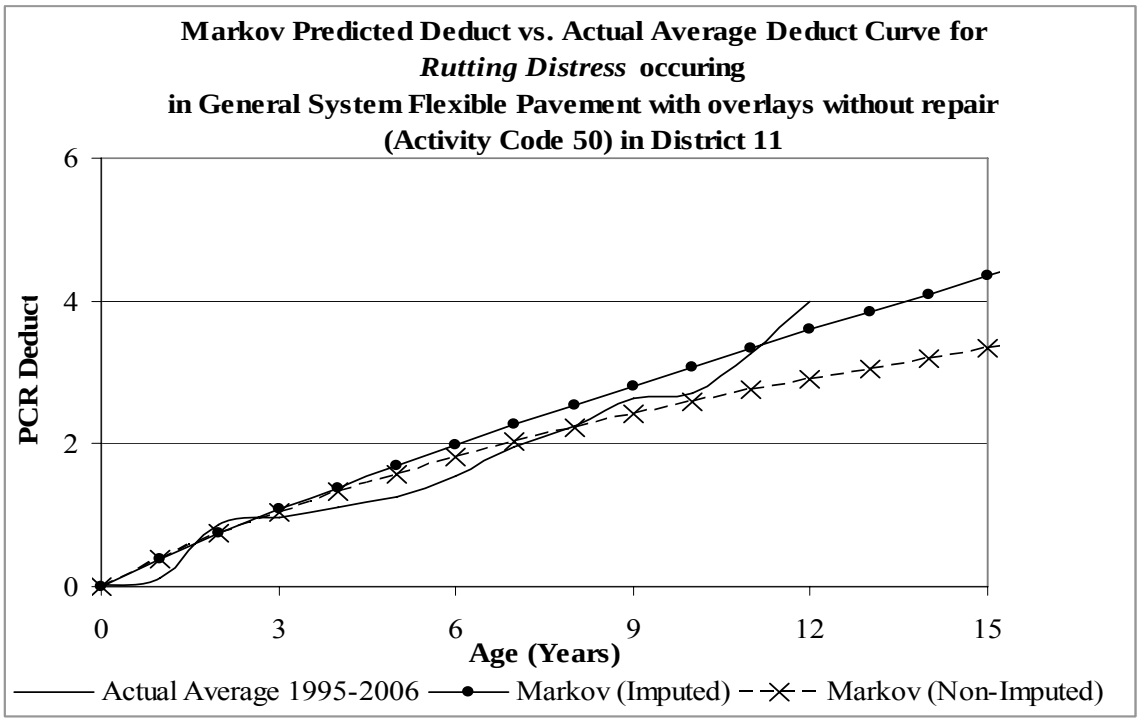


Figure 7. Predicted and Actual Average Rutting Deducts in District 11

Table 3 shows the transition matrix for block and transverse cracking (District 11 General system overlays on flexible pavements). Figure 8 shows the average distress trend and the predicted based on Markov model block and transverse cracking for this group of pavements.

Table 3. Transition Matrix for Block and Transverse Cracking, District 11, General Flexible Pavements Overlays (Activity 50) 1995-2006

		Next Year Condition									
		NULL	LO	LF	LE	MO	MF	ME	HO	HF	HE
Current Year Condition	NULL	.35	0.37	0.19	0.05	0.02	0.01	0.01	0	0	0
	LO	0	0.49	0.44	0.01	0.03	0.02	0	0	0	0
	LF	0	0.03	0.55	0.22	0.03	0.13	0.02	0.01	0	0
	LE	0	0	0.07	0.55	0.02	0.24	0.10	0.02	0	0
	MO	0.01	0	0	0.16	0.45	0.37	0.01	0.01	0	0
	MF	0	0	0.05	0	0	0.60	0.21	0.11	0.02	0
	ME	0	0	0.02	0.04	0	0.07	0.73	0	0.05	0.09
	HO	0	0	0	0	0	0.01	0.40	0.52	0.07	0
	HF	0	0	0	0	0	0	0.55	0	0.18	0.26
	HE	0	0	0	0	0	0	0.16	0	0	.84

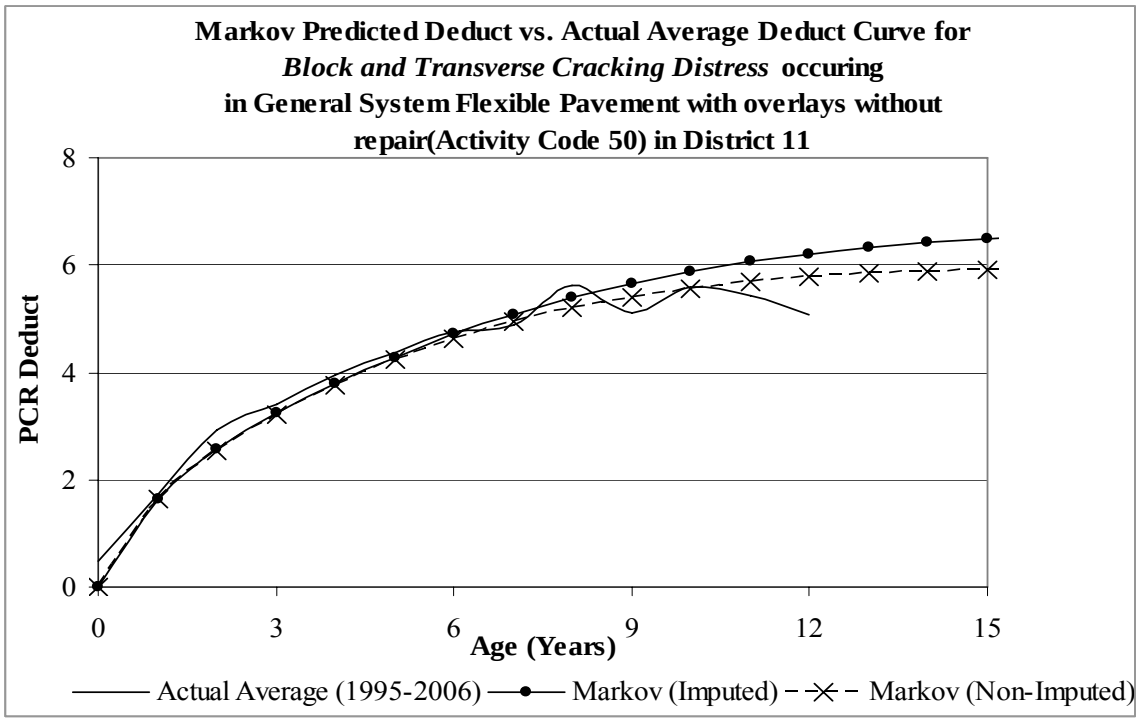


Figure 8. Predicted and Actual Average Block and Transverse Cracking Deducts in District 11

By summing up all the distress deducts for a pavement at a particular age, the PCR value can be determined. Figure 9 shows the average PCR deterioration trend and the Markov model predicted PCR trends (with and without imputation) for overlays on District 11 General system flexible pavements.

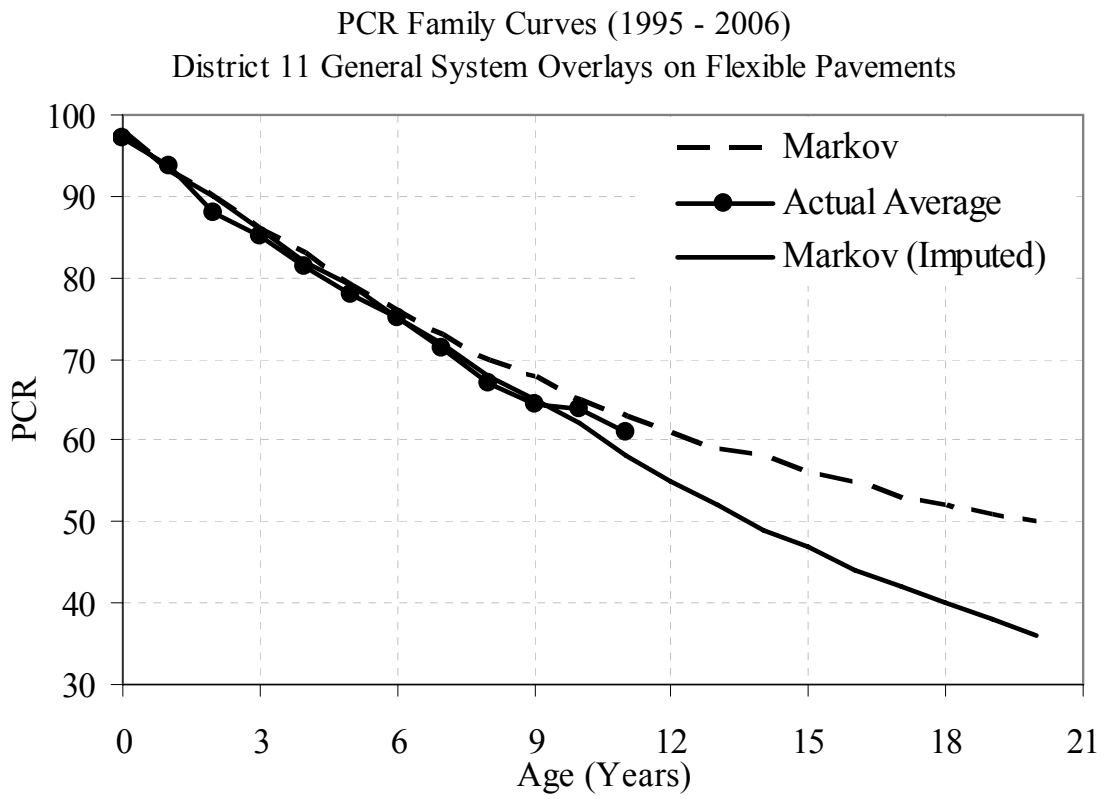


Figure 9. PCR Family Curves (District 11, General Flexible Overlays, 1995-2006)

Comparing the predicted distress and PCR curves with the average curves obtained from actual PCR measurements provides a good indication of the accuracy of the prediction model. It can be seen from Figures 7, 8, and 9 that the Markov model reproduces the actual deterioration trends very well, while smoothing out the actual average curves.

Figures 10-13 show the individual distress deduct trends for three major distresses and the PCR deterioration trend for District 2 overlays (Activity 50) on General flexible pavements constructed between 1995 and 2006. Again, the Markov model can reproduce the average deterioration trends very well.

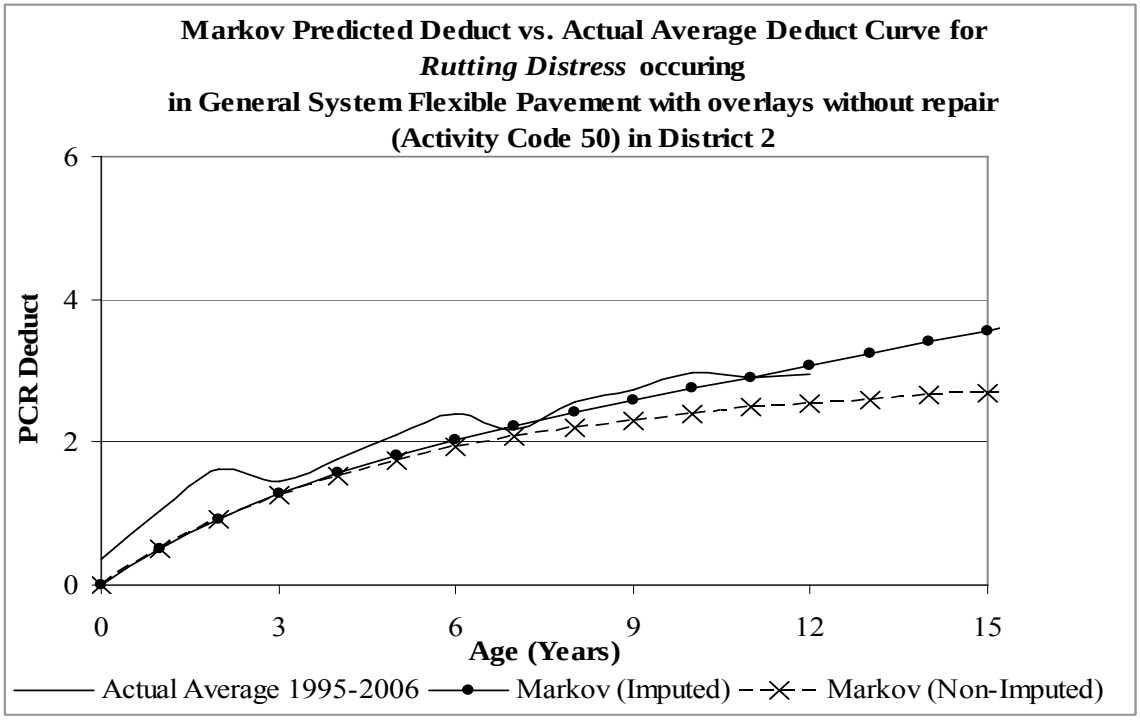


Figure 10. Predicted and Actual Average Rutting Deducts, District 2

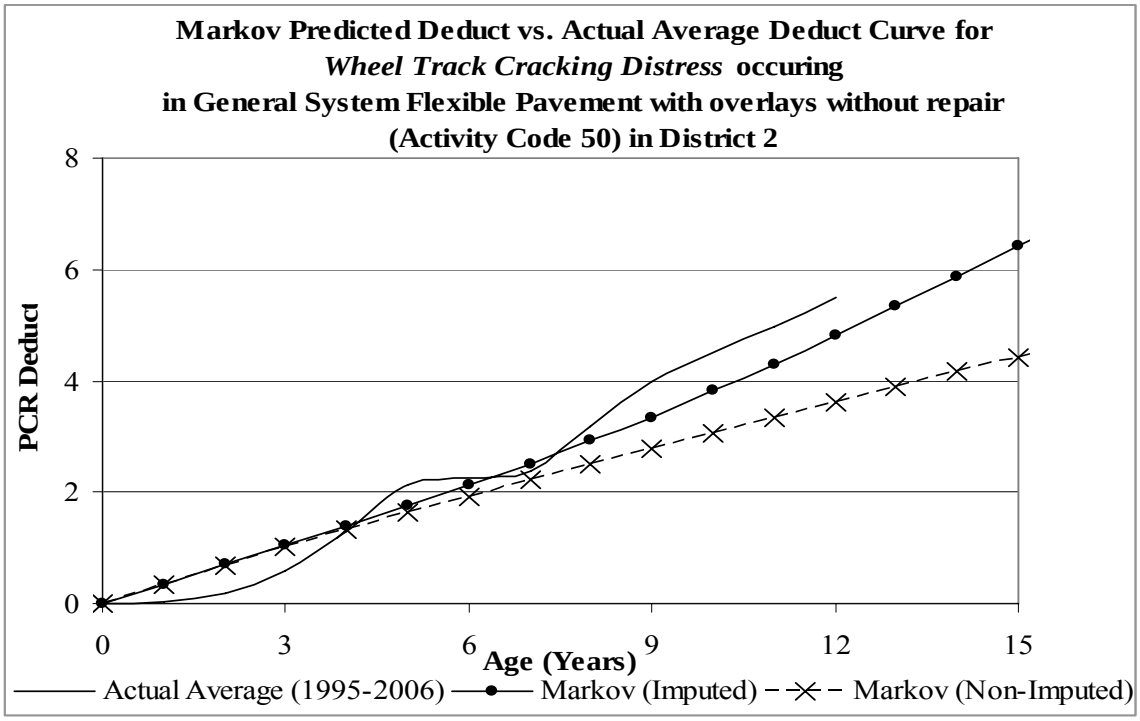


Figure 11. Predicted and Actual Average Wheel Track Cracking Deducts, District 2

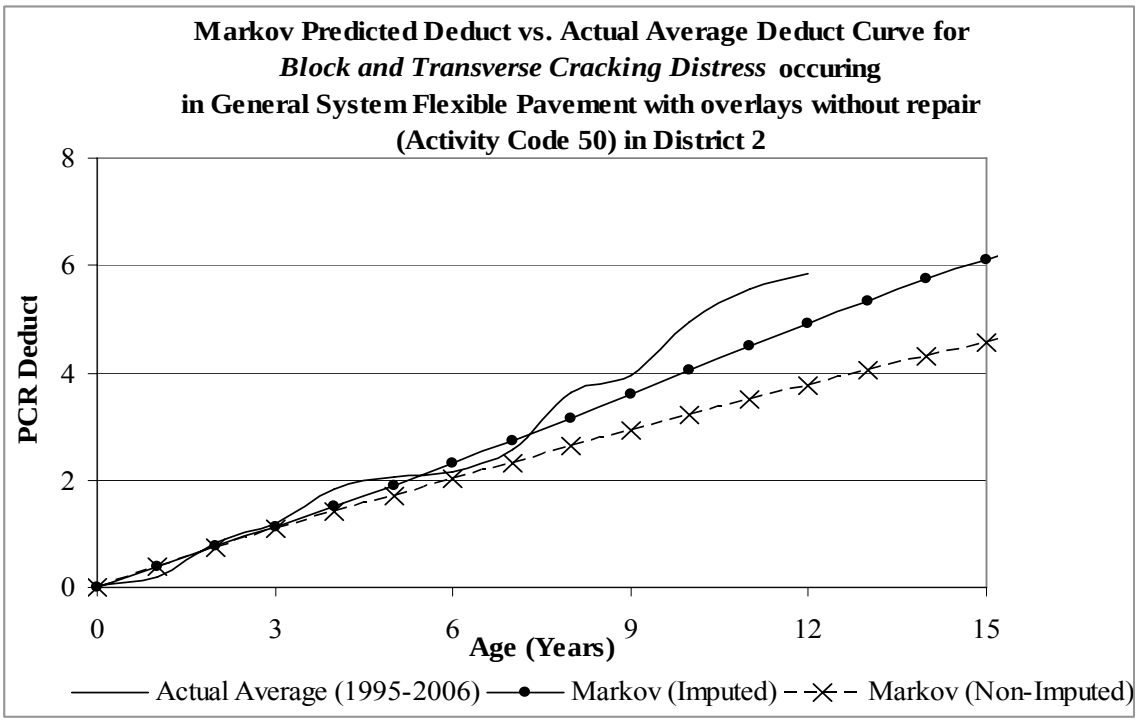


Figure 12. Predicted and Actual Average of Block and Transverse Cracking Deducts, District 2

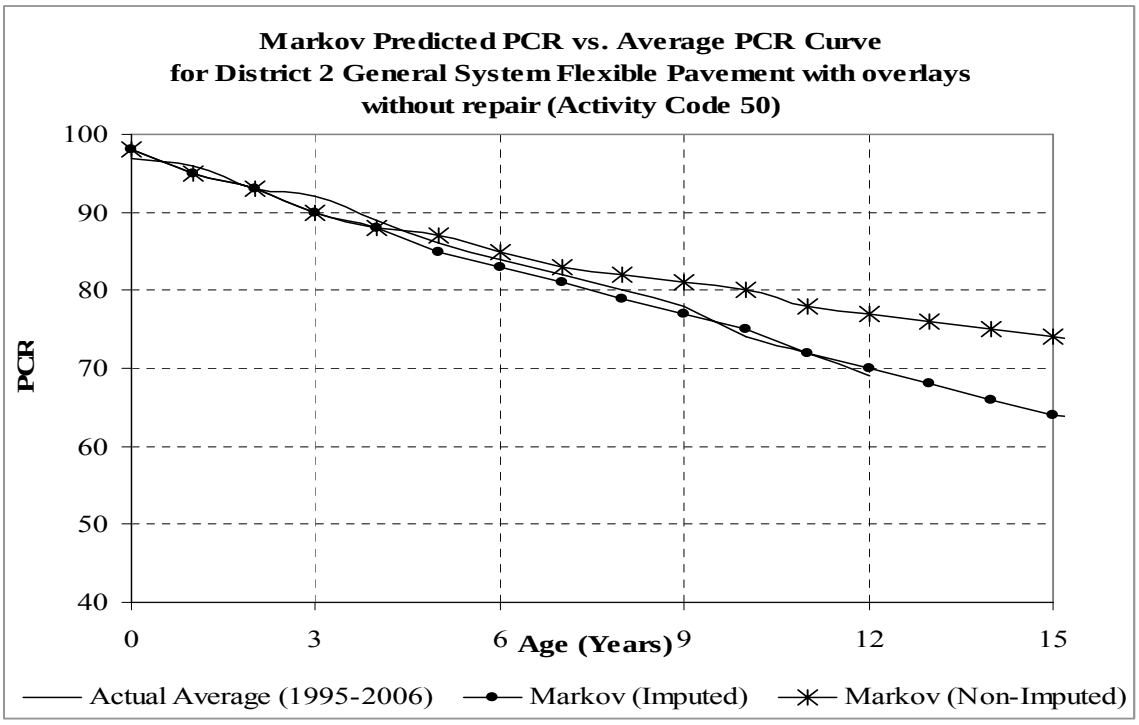


Figure 13. Predicted and Actual Average PCR Trends, District 2

Task 3 Determine Remaining Pavement Service Life Based on Appropriate Terminal Pavement Condition

The remaining service life (RSL) of a pavement can be defined as the time it takes for the pavement to deteriorate from its current condition to a specified terminal condition. The RSL provides important information for making various pavement management decisions. Based on the forecasted pavement conditions and a specified terminal condition, the remaining service life of a pavement is determined by counting the number of years from the present year until the year the predicted condition will fall below the specified terminal condition. The terminal condition of a pavement can include multiple criteria, as a pavement may be considered at the end of its service life due to various functional or structural deficiencies. Therefore, the terminal condition may be defined by not only a threshold PCR value, but by a critical distress level or a combination of several critical distresses. For example, a high severity of rutting or a severe and extensive wheel track cracking may both be considered as terminal. Some distresses may be repairable by a specific treatment, but other distresses require more significant rehabilitation. A tool to estimate the remaining service life was developed in this task. The user can specify different terminal conditions for different pavements. The default terminal condition for Priority system pavements is when the PCR value is below 65, and for General system pavements, below 60.

Task 4 Determination of Initial PCR Rating for Rehabilitated Pavements

Currently, a PCR value of 100 is assigned to pavement sections that are being rehabilitated. Even for pavement sections that are actually rated after a rehabilitation treatment, the PCR value may be overrated as some rehabilitation treatments can "mask" certain underlying distresses for a short period of time, but not eliminate them. As a result, depending on the rehabilitation treatment performed and the prior distresses presented, some distresses may resurface quickly within a few years after receiving rehabilitation.

A more realistic estimate of the initial PCR rating is necessary to avoid distorting the average PCR value caused by repair treatments that do not provide long term benefit. This distortion may prevent decision makers from having an unbiased impression of the overall pavement

network conditions. In addition, a more realistic initial PCR rating would avoid having many drastically different 'rates of deterioration' (or 'slopes') after the same repair treatment due to presence of different distresses prior to repair. The goal of this task was to determine a realistic estimation of initial PCR for newly rehabilitated pavements.

By comparing the distresses prior to repair and the distresses within a few years after repair, the effectiveness of the repair treatment to address a specific distress may be established. Certain distresses, such as transverse cracking, may not be entirely erased by a given treatment, but may only be 'masked' or delayed. Therefore, the distress condition is not entirely eliminated. Instead, the 'residual damage' may be carried over after a repair treatment. The amount of 'residual damage' depends on the repair treatment used and the degree of damage existed prior to repair. By summing up all the residual damages that can not be erased by the specific rehabilitation treatment, a more realistic initial PCR value of a rehabilitated pavement can be determined.

The rehabilitation treatments performed by ODOT can be grouped into three categories: maintenance, minor rehabilitation, and major rehabilitation. Maintenance activities include crack sealing, chip seal, micro-surfacing, etc. Minor rehabilitation treatments primarily involves asphalt concrete (AC) overlays (with or without repairs), and major treatments range from rubblized and roll, unbonded concrete overlay, to new flexible or new rigid pavement. Table 4 shows the complete list of treatment activities performed by ODOT.

Figures 14 and 15 show the distribution of treatments performed on all composite and flexible pavements since 1985. It can be seen that overlays with or without repair (activity codes 50 or 60) constitute the vast majority (85-90%) of treatments, for both composite and flexible pavements. The total length of pavement sections studied was 12104.2 miles. This total length includes multiple counts of the same pavement section that may have been repaired multiple times. Each time a pavement section is repaired, its length is added to the total in this analysis.

Table 4. Activity Codes

Treatment Class	Activity Code	Description
Maintenance	10	Reactive Maintenance
	20	Crack Sealing
	25	Chip Seal
	30	Micro-Surfacing
	31	Double Application Micro-Surfacing
	35	Nova-Chip Resurfacing
	38	Fine Graded Polymer AC Overlay
	40	CPR
Minor	45	Intermediate Coarse Recycled AC
	50	AC Overlay without Repairs
	52	AC Inlay
	55	Double Chip Seal
	60	AC Overlay with Repairs
Major	70	Crack and Seat
	73	Break and Seat
	77	Rubblize and Roll
	80	Whitetopping
	90	Unbonded Concrete Overlay
	95	Unbonded Composite Overlay
	100	New Flexible Pavement
	110	New Rigid Pavement
	120	New Composite Pavement

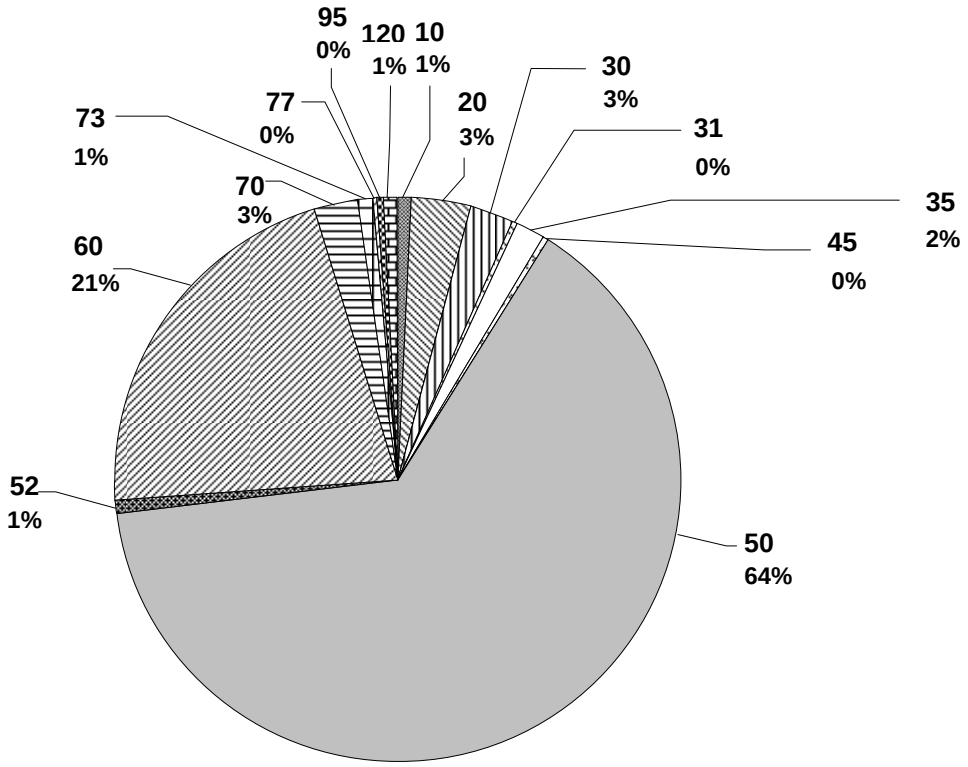


Figure 14. Mileage Distribution of Repair Type, for Composite Pavements

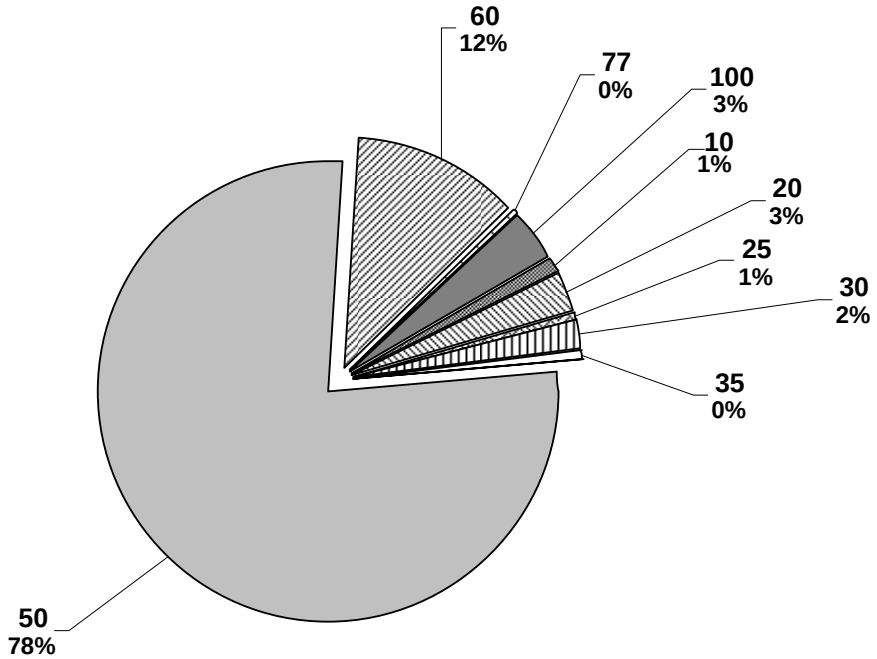


Figure 15. Mileage Distribution of Repair Type, for Flexible Pavements

Since the PCR is derived from a set of distresses, a study of the individual distresses was necessary to estimate the initial PCR. In order to deduct a fair and reasonable value for each initial individual distress and ultimately, the initial PCR data from 2, 3, and 4 years after a treatment were used to get an average intercept between the y axis (value at year 0) and the best linear fit between these three values. Figure 16 shows the initial value for raveling on priority system overlays on flexible pavements is 2.48, while the actual average from the data is 2.10.

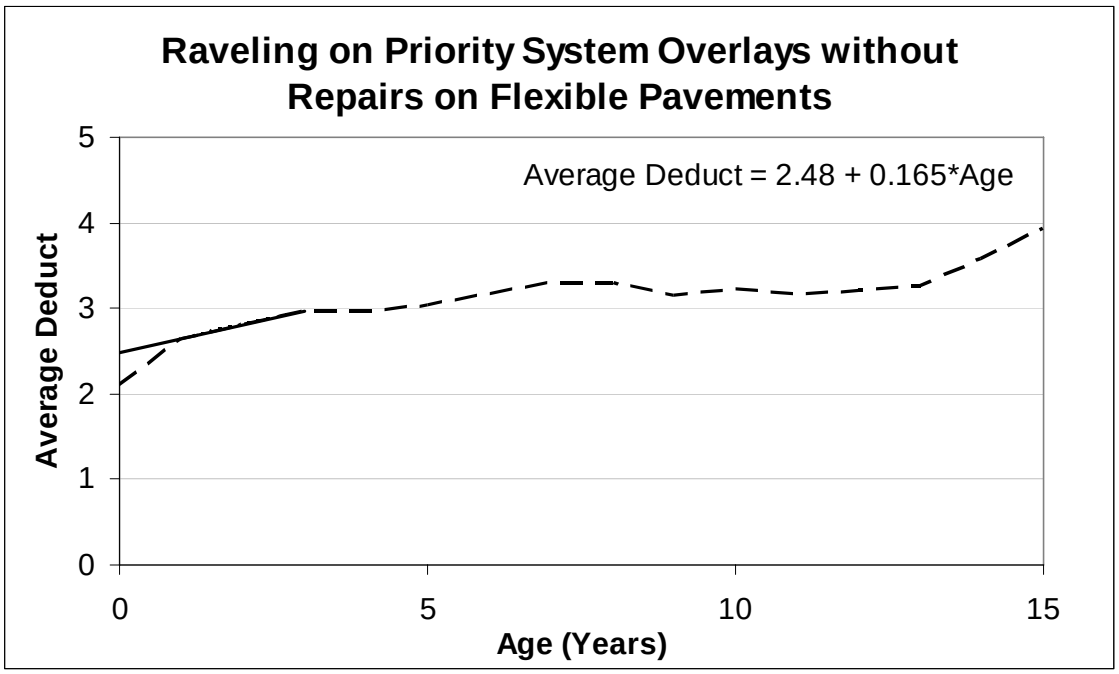


Figure 16. Initial Value of Raveling from Linear Fit of Years 2, 3, and 4

The same methodology is followed to calculate the initial value of each distress and ultimately the initial PCR value.

Based on the data available in the ODOT pavement database, the appropriate initial ratings for rehabilitated pavement sections are determined taking into account the type and level of distresses presented prior to repair and the repair treatment performed. Since a large number of data are available for overlays (Activity Codes 50 and 60), pavements are grouped according to distress deduct levels prior to the overlay, and within each group, the initial deduct value for each distress was determined. When the initial deduct values among

different groups are different for a specific distress, it indicates that the level of that distress prior to overlay will affect the initial PCR after overlay.

Each pavement type (Concrete, Flexible, and Composite) has 13 to 15 different distresses. These distresses can be structural or functional, or both. ODOT uses Structural Deducts and Cracking Deducts, in addition to overall PCR (which is 100 subtracting total deducts), to help engineers obtain a general impression of the pavement's condition. Table 5 shows the distresses included in the structural and cracking deducts for each of the pavement type.

Table 5. Distress Types Included in Structural and Cracking Deducts

Type of Deduct (1)	**Jointed Concrete Pavement (2)**	**Flexible Pavement (3)**	**Composite Pavement (4)**
Structural Deduct	• Pumping • Faulting (Joints & Cracks) • Transverse Cracking, Reinforced Concrete • Longitudinal Cracking • Corner Breaks • Transverse Cracking, Plain Concrete	• Rutting • Wheel Track Cracking • Edge Cracking • Random Cracking • Potholes	• Pumping • Shatter Slab (Jointed Base) • Tranverse Cracks (Unjointed Base) • Intermediate Transverse Cracks (Jointed Base) • Longitudinal Cracking • Corner breaks (Jointed Base) • Punchouts (Unjointed Base)
Cracking Deduct	• Transverse Cracking, Reinforced Concrete • Longitudinal Cracking • Longitudinal Joint Spalling • Transverse Cracking, Plain Concrete	• Wheel Track Cracking • Block and Transverse Cracking • Longitudinal Cracking • Edge Cracking • Random Cracking • Thermal cracking	• Transverse Cracks (Unjointed Base) • Joint Reflection Cracks (Jointed Base) • Intermediate Transverse Cracks (Joined Base) • Longitudinal Cracking • Corner breaks (Jointed Base) • Punchouts (Unjointed Base)

Task 5 Develop Decision Trees for Selecting Rehabilitation Strategies

A set of decision trees developed by the Office of Pavement Engineering staff for selecting the most appropriate maintenance and rehabilitation treatment based on pavement type, system, existing pavement condition and past performance, and traffic level were implemented within the pavement management information system. These decision trees were developed after several iterations of revisions to evaluate the various decision criteria. The entire set of decision trees is shown in Appendix B.

A work plan generating tool was developed to allow the rehabilitation decision trees to be applied to the current as well as predicted pavement conditions. ODOT decision makers can use this tool to determine the repair needs in the current and future years. After a specific work plan is provided by the user, the tool will produce the corresponding future pavement conditions and repair needs. As a result, the consequence of alternative work plans can be easily evaluated. The input work plan can be for a single year or multiple years.

Task 6 Revise PMIS to accommodate the PCR procedure updated in 2004

The ODOT PCR procedure was updated in 2004. Several additional distress types were added. At the same time, a few distress types that rarely occurred were abolished. Since this change took place after this study had started, it was not anticipated in the original study proposal. An addendum was approved to incorporate the changes in distress categories to allow the developed forecasting models to incorporate the updated distresses and PCR scores.

Tables 6 and 7 show the distress types and the corresponding maximum deduct values for flexible, composite, and concrete pavements.

The Markov model predicts future pavement conditions based on individual distresses. The distresses included in the 2004 updated PCR procedure are predicted based on the 2004-2006 PCR data.

Table 6. Flexible and Composite Pavements Distress Codes and Deducts Pre-2004 and Since 2004

Flexible Pavements				Composite Pavements			
		Maximum Deducts				Maximum Deducts	
Distress Code	Distress Name	Pre-2004	Since 2004	Distress Code	Distress Name	Pre-2004	Since 2004
1	Raveling	10	10	1	Raveling	10	10
2	Bleeding	5	5	2	Bleeding	5	5
3	Patching	5	5	3	Patching	5	5
4	Potholes/Debonding	10	5	4	Surface Disintegration/Debonding	5	5
5	Crack Sealing Deficiency	5	5	5	Rutting	10	10
6	Rutting	10	10	6	Pumping	10	10
7	Settlements	10	---	7	Shattered Slab (Jointed Base)	10	10
8	Corrugations	5	---	8	Settlements	5	---
9	Wheel Track Cracking	15	15	9	Transverse Cracks (Unjointed Base)	20	20
10	Block and Transverse Cracking	10	10	10	Joint Reflection Cracks (Jointed Base)	12	12
11	Longitudinal Joint Cracking	5	5	11	Intermediate Transverse Cracks (Joined Base)	8	8
12	Edge Cracking	5	10	12	Longitudinal Cracking	5	5
13	Random Cracking	5	---	13	Pressure Damage/Upheaval	5	5
14	Thermal cracking	---	10	14	Crack Sealing Deficiency	5	5
15	Potholes	---	10	15	Corrugations	5	---
				16	Corner breaks (Jointed Base)	---	10
				17	Punchouts (Unjointed Base)	---	15

Table 7. Concrete Pavements Distress Codes and Deducts Pre-2004 and Since 2004

Jointed Concrete Pavements				Continuously Reinforced Concrete Pavements		
Distress Code	Distress Name	Maximum Deducts		Distress Code	Distress Name	Maximum Deducts
		Pre-2004	Since 2004			Pre-2004 and Since 2004
1	Surface Deterioration	10	10	1	Surface Deterioration	10
2	Popouts	5	---	2	Popouts	5
3	Patching	5	10	3	Patching	5
4	Pumping	15	15	4	Pumping	15
5	Faulting (Joints & Cracks)	10	10	5	Settlements and Waves	10
6	Settlements	5	---	6	Transverse Crack Spacing	10
7	Transverse Joint Spalling	15	10	7	Longitudinal Cracking	10
8	Joint Sealant Damage	5	---	8	Punchouts or Edge Breaks	15
9	Pressure Damage	5	5	9	Spalling	15
10	Transverse Cracking	10	15	10	Pressure Damage	5
11	Longitudinal Cracking	5	10			
12	Corner Breaks	10	10			
13	Longitudinal Joint Spalling	---	5			
14	Transverse Cracking, Plain Concrete	---	15			

This task also implements the Pavement Quality Index (PQI) into the existing pavement database. Pavement Quality Index (PQI) combines the two existing measures employed by ODOT to characterize distress and roughness, namely PCR and International Roughness Index (IRI), into one single index. This index may be used for overall pavement condition assessment purpose.

The PQI is calculated by the following formula:

$$\mathrm{PQI} = \mathrm{PCR} - a\left(\mathrm{IRI}\right)^{b} \tag{9}$$

with a = 0.00003716, b = 2.4913 for priority systems and a = 0.00004915, b = 2.4230 for general systems.

Task 7 Incorporating Local Federal Aid Routes

In recent years, ODOT's Office of Pavement Engineering has begun collecting pavement condition data for local (county and municipality) routes that receive federal aid. These local routes were not part of the original pavement management database, which contains state highways only. A second addendum was approved to develop a management database for the local federal aid routes.

Pavement condition data for the local federal aid routes are available only since 2003, and no project date or treatment activity records are currently available. Therefore, the type of analysis allowed is much more limited compared with that for the state routes. Nevertheless, a database for local federal-aid routes was developed to support pavement management activities at the county and municipality level. Some of the functions available in the ODOTPMIS were redesigned or modified when appropriate, while others were disabled due to lack of data.

The following were accomplished during this task:

1. The available pavement condition data for local federal aid routes were imported from spreadsheet format into a MS Access database, LOCALPMIS. Besides the fields already

in the spreadsheet, additional fields were added, such as traffic categories, ADT, street names, etc, in anticipation of future data collection and local needs.

2. A method of importing new data and appending additional data to the LOCALPMIS database was developed. This method is described in detail in Appendix D.
3. Various analysis functions and reporting tools were modified for use with the local routes data. A separate menu of functions and tools were developed for the local routes database.
4. The pavement condition data for the local routes were collected on alternate years. Therefore, for most of the local route pavements, only two years of data are currently available. Pavement age information is also not available. Furthermore, pavement design, construction, and maintenance standards and practices vary significantly among counties and municipalities, as compared to that for state highways. Therefore, predicting future pavement condition becomes more difficult, as the Markov model requires a relatively large group of similarly performing pavements to generate a reliable transitional probabilities matrix, and the Family regression model requires pavement age information. A simplified approach of considering the current deterioration rate was chosen, which can predict both future PCR and distress. Since only two (or three) data points are currently available for each pavement, linear regression is used. As more local condition data become available, the prediction method may be refined.

FINDINGS OF THE RESEARCH EFFORT

The findings of this study are presented in this section. They include:

I. Forecasted pavement conditions,
II. Validation of the developed forecasting models,
III. Summary of the estimated remaining service life of pavements,
IV. Estimated initial PCR after various rehabilitation or maintenance treatments,
V. Rehabilitation decision trees and multiyear work plan tool, and
VI. Pavement management database for local routes.

I. Forecasted Pavement Conditions

Future pavement conditions can be forecasted using the developed models. As mentioned earlier, for the Markov model and the Family Regression model, the forecasted conditions are based on the latest available condition measurement, while for the Individual Regression model, a best fit curve for all know PCR values is used to predict future conditions. The Individual Regression model requires at least three PCR data from the same pavement to make a prediction. Therefore, it can not be used for newer pavements that have less than three years of PCR data.

Table 8 shows an example of the predicted PCR values for four pavement sections in District 11. Figure 17 illustrates the forecasted pavement conditions from the three models for a specific pavement section, COL-39-0-1.06.

For the Markov model, the predictions can also be made with a specified confidence interval. Figure 18 shows that when a 90% confidence interval is specified, the predicted pavement condition can be in a range. Generally, however, only the most likely value is reported.

Table 8. Predicted Pavement Conditions from the Three Models

District	County	Route	Station	Blog	Elog	Year	Priority	Pave Type	AC*	Model Type	PCR																
											2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
11	CAR	171R	UP	8.82	10.76	1995	G	3	50	Actual	86	87	85	82	78	70	70										
										I								69	66	63	60	57	54	50	47	46	44
										II								67	65	62	59	56	54	51	48	45	43
										III								69	69	68	68	67	66	66	65	65	65
11	CAR	332R	UP	6.48	10.31	1995	G	3	50	Actual	72	75	75	68	68	60	58										
										I								58	57	55	52	50	48	45	44	42	41
										II								55	53	50	47	44	42	39	36	33	31
										III								57	56	55	55	54	53	52	52	51	50
11	COL	039R	UP	0	1.06	1995	G	3	50	Actual	79	79	76	71	69	70	67										
										I								66	64	62	59	56	53	49	47	45	43
										II								64	62	59	56	53	51	48	45	42	40
										III								66	65	64	63	62	61	60	59	58	58
11	HOL	557R	UP	6.57	10.23	1995	G	3	50	Actual	74	71	71	76	74	66	66										
										I								65	63	60	58	55	52	47	45	43	42
										II								63	61	58	55	52	50	47	44	41	39
										III								65	64	63	63	62	61	61	60	60	59
11	TUS	039R	UP	23.92	24.92	1995	G	3	50	Actual	87	83	81	78	78	78	77										
										I								76	72	69	66	63	60	55	53	51	49
										II								74	72	69	66	63	61	58	55	52	50
										III								77	76	76	76	75	75	75	74	74	74

I – Markov Model
II – Family Regression Model
III - Individual Regression Model

*AC – Activity Code

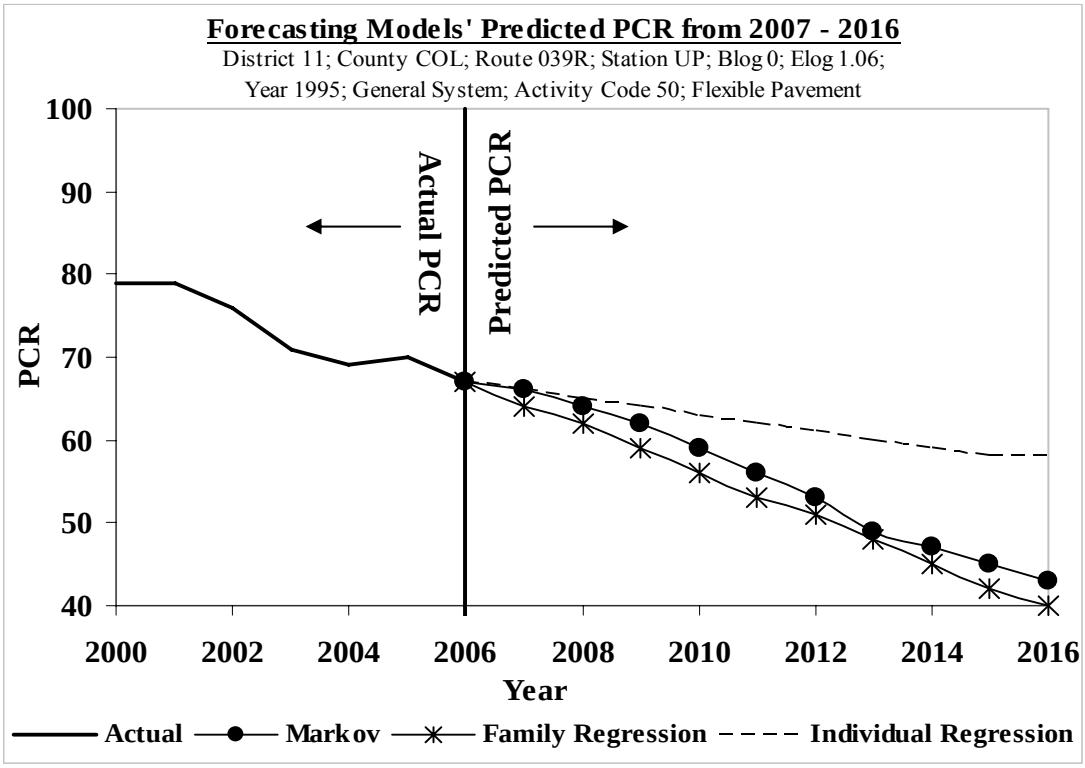


Figure 17. Markov Model Predicted PCR for an Individual Pavement Section

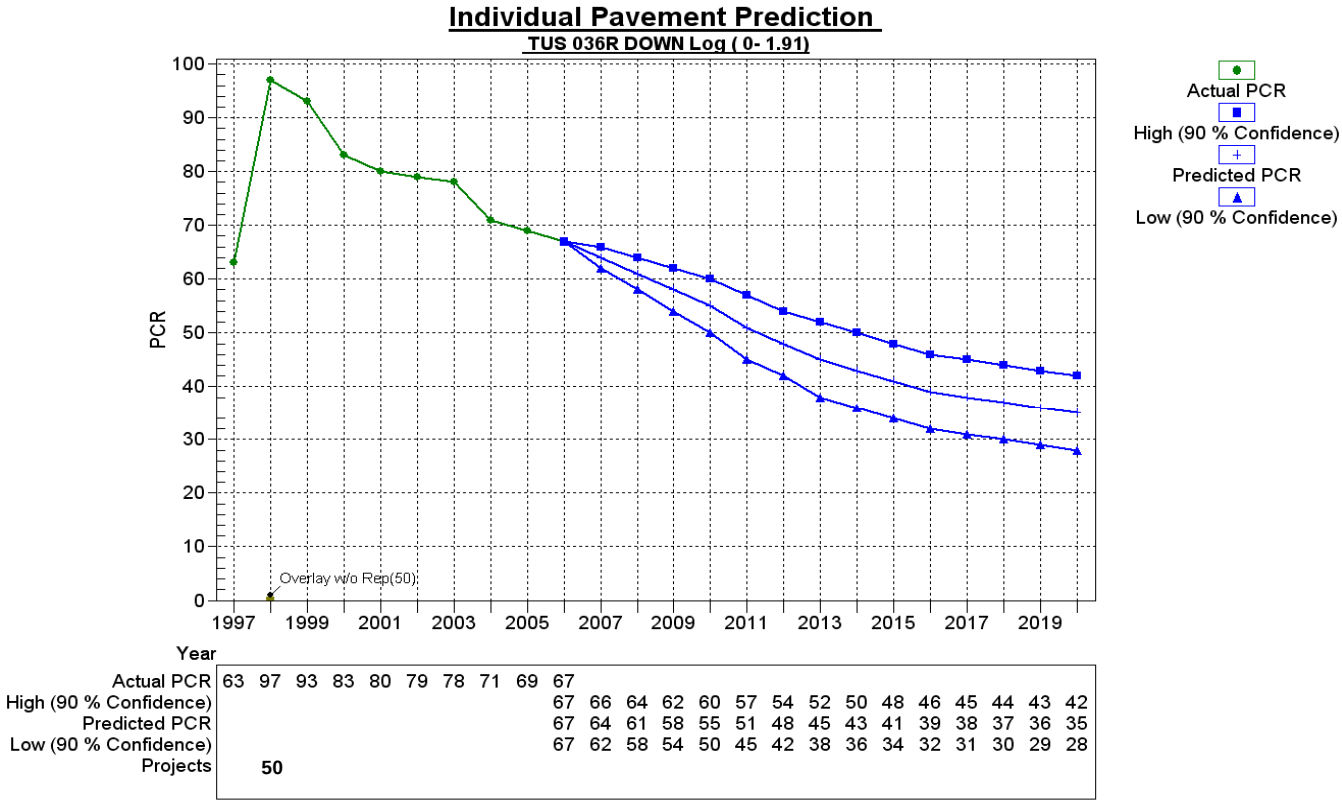


Figure 18. Predicted Conditions with Confidence Interval

II. Validation of the Developed Forecasting Models

The predicted results of the Markov and both regression models are validated through comparison with actual observed pavement conditions. For validation purpose, overlays on General system flexible pavements in District 11 were used as the test data set to verify the predicted results. PCR measurements from 1985 to 2001 were used to develop the models, and the predicted PCR values for the 2002 to 2006 period were compared to the actual measured PCR during that same period. If a pavement section was rehabilitated between 2002 and 2006, the initial PCR for that rehabilitation treatment was determined and subsequent PCR values predicted. Table 9 shows the amount of PCR data available for District 11 General System flexible and composite pavements from 1985 to 2001.

Table 9. Data Used for Validation
(District 11 General System Flexible Pavement Treated with Activity Code 50 or 60 between 1985 and 2001)

Pavement Type	Total Directional Miles	Total No. of Pavement Sections	Total No. of PCR Measurements
Flexible	634.18	372	1531

The Markov model needs a transition matrix to predict PCR values. In the present study, two sets of transition matrices were developed. The first set of transition matrices were generated using pavement sections that were repaired before 1994. The second set of transition matrices were generated using pavement sections that were repaired since 1994. It was determined that pavements repaired after mid 90's performed better than those repaired in previous years. Hence, pavement sections that were repaired before 1994 use the first set of transition matrices, while pavement sections repaired after 1994 use the second set of transition matrices. For the family regression model, data were divided into two sets based on the date of construction/rehabilitation (similar to Markov model). For the individual section regression model, since each pavement section has its own regression equation, there is no need for a separate model to account for improvements in pavement performance in more recent years.

Table 10 shows a sample of the validation data. The actual measured PCR between years 2002 and 2006 are compared to the predicted PCR during the same time period. Figure 19 illustrates the actual versus predicted PCR conditions for a specific pavement section.

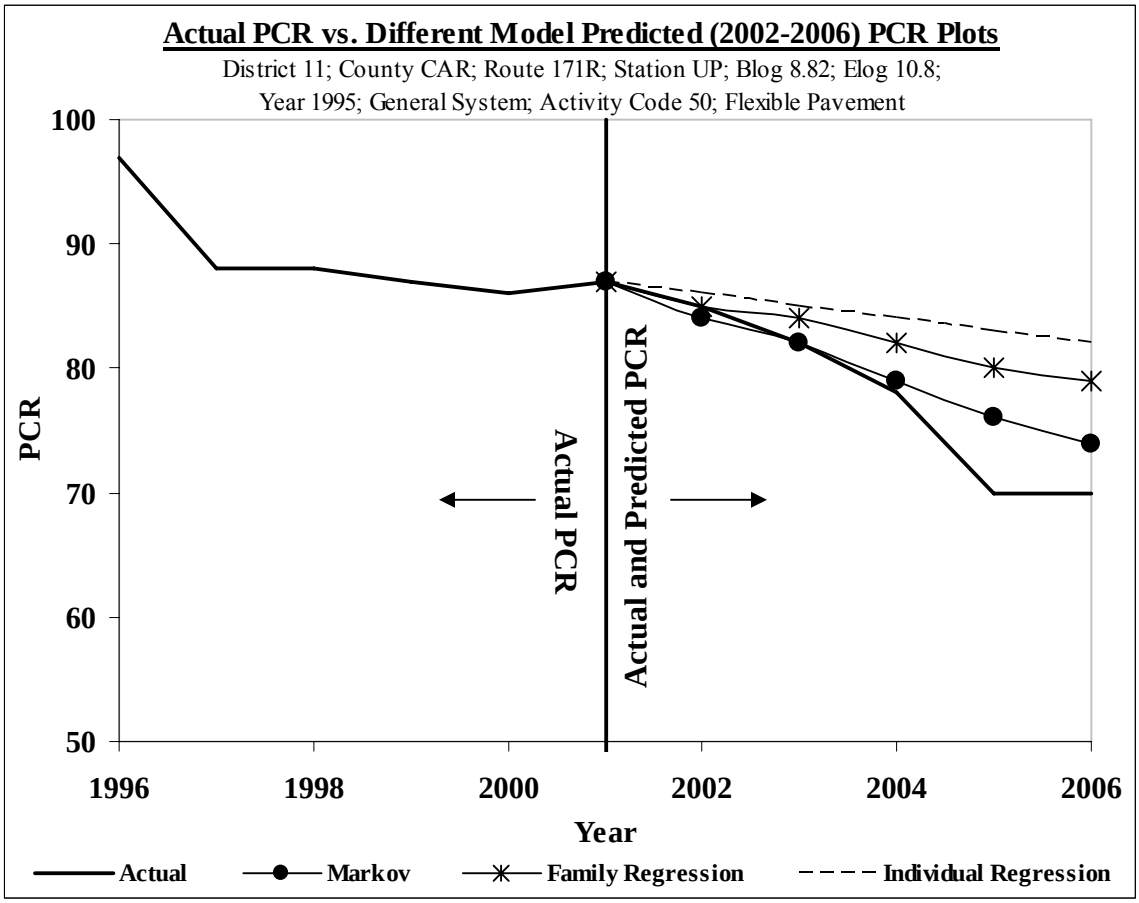


Figure 19. Actual PCR vs. Different Model Predicted PCR for a Pavement Section in District 11 treated with Activity Code 50

Table 10. Actual PCR vs. Different Model Predicted PCR

District	County	Route	Station	Blog	Elog	Year	Priority	Pave Type	AC*	Model Type	PCR										
											1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
11	CAR	171R	UP	8.82	10.8	1995	G	Flexible	50	Actual	97	88	88	87	86	87	85	82	78	70	70
										Markov							***84***	***82***	***79***	***76***	***74***
										Family Regression							**85**	**84**	**82**	**80**	**79**
										Individual Regression							**86**	**85**	**84**	**83**	**82**
11	COL	039R	UP	0	1.06	1995	G	Flexible	50	Actual	96	89	87	83	79	79	76	71	69	70	67
										Markov							***75***	***71***	***68***	***66***	***63***
										Family Regression							**76**	**72**	**69**	**65**	**72**
										Individual Regression							**77**	**75**	**74**	**63**	**71**
11	HAS	646R	UP	10.6	14.9	1995	G	Flexible	50	Actual	90	80	79	77	78	75	71	67	64	62	57
										Markov							***73***	***70***	***67***	***64***	***63***
										Family Regression							**73**	**70**	**68**	**66**	**70**
										Individual Regression							**74**	**72**	**71**	**63**	**69**
11	HOL	514R	UP	5.73	8.08	1995	G	Flexible	50	Actual	99	89	89	83	73	72	69	65	61	57	54
										Markov							***67***	***64***	***62***	***59***	***45***
										Family Regression							**67**	**61**	**56**	**50**	**63**
										Individual Regression							**69**	**67**	**65**	**57**	**61**

* AC – Activity Code

Markov Model Results

The predicted PCR values obtained from the Markov model versus the actual PCR values are plotted in Figure 20. Model accuracy is expressed by (1) root mean squared error (RMSE), and (2) coefficient of correlation (ρ). The RMSE is defined as:

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} \left(PCR_P - PCR_A\right)^2}{n}}, \tag{12}$$

where PCR_P is the predicted PCR value from the prediction model, PCR_A is the actual PCR measurement and n is the number of observations. Smaller RMSE value indicates a more accurate model.

The correlation coefficient signifies the degree of match between actual and predicted PCR. A perfect match would have a correlation coefficient of 1.0.

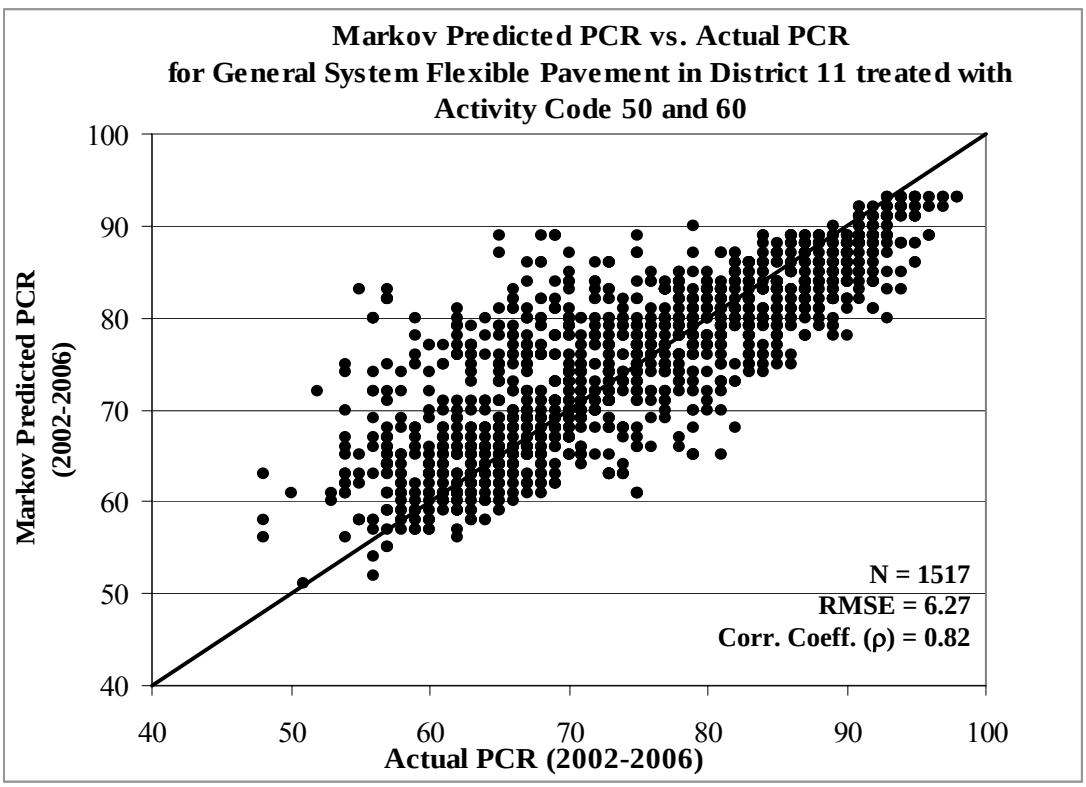


Figure 20. Markov Predicted PCR vs. Actual PCR (2002-2006)

It can be seen from Figure 20 that some of the predicted values are quite different from the measured values. After examining the corresponding PCR curves, it was determined that they were due to 'abnormal' deterioration trends such as (1) sudden decreases of measured PCR values, or (2) nearly flat or even gradually increasing PCR curves where a series of undocumented maintenance activities may have been performed.

Figure 21 shows an actual pavement section in the data. This is typical of the 'abnormal' trends where PCR drops in initial years are consistent, but the rate of deterioration increase significantly after a few years. The Markov and other models can not predict this type of sudden change.

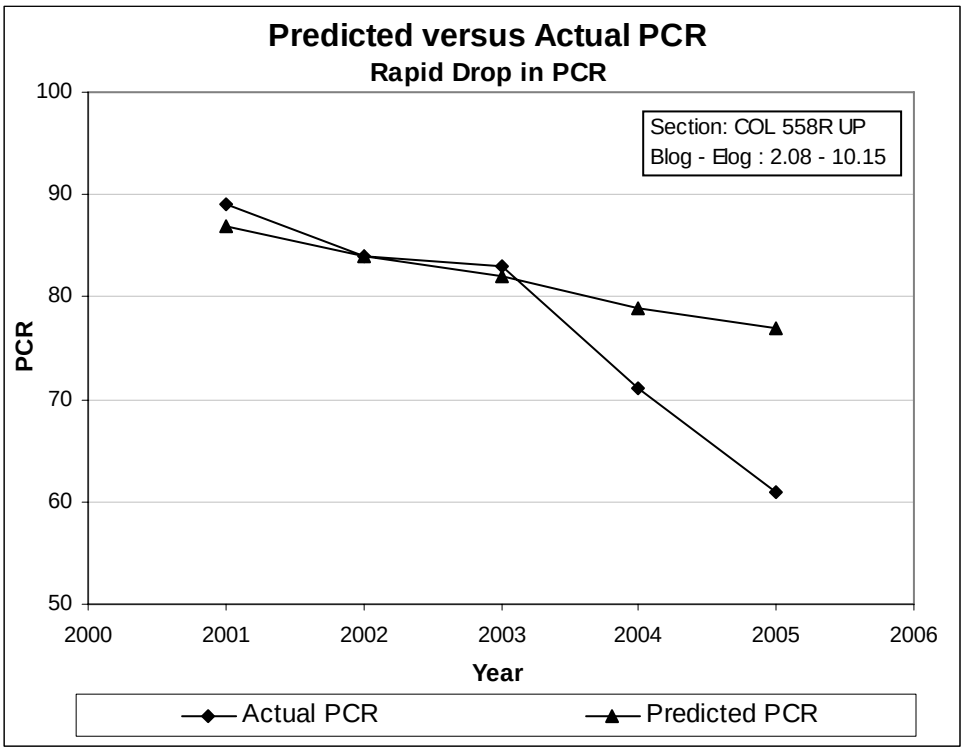


Figure 21. Sudden Drop in PCR

Figure 22 shows another actual case, where the pavement 'stops' deteriorating after initially deteriorating at a 'normal' rate. This is likely due to undocumented maintenance activities. None of the statistical-based prediction models can predict these abnormal trends.

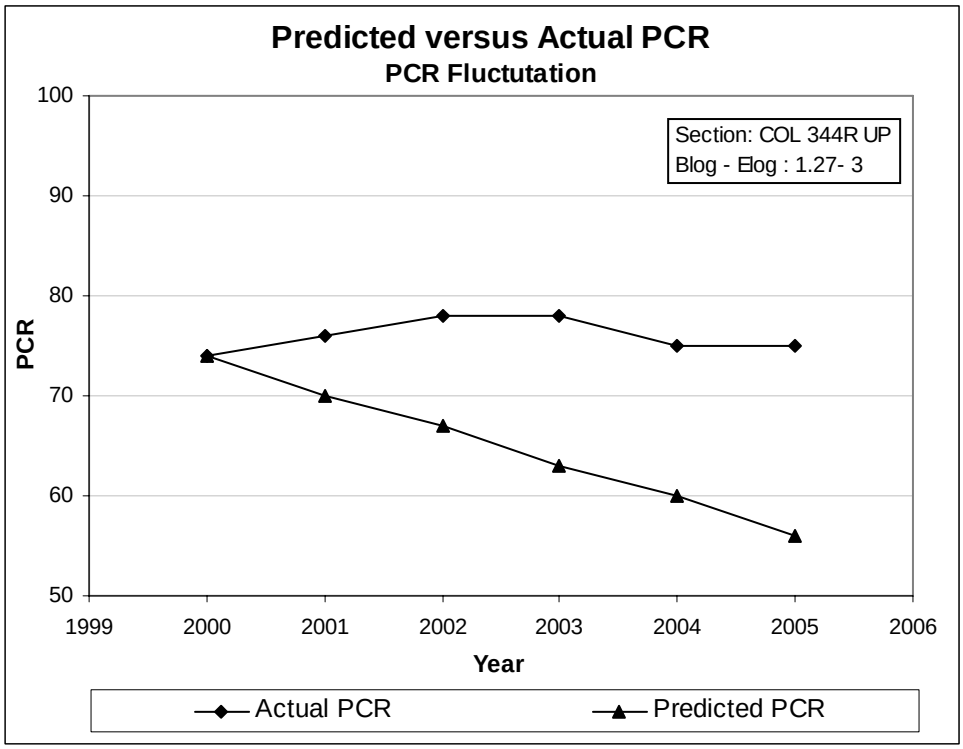


Figure 22. Fluctuation in PCR

Family Regression Model

Separate regression equations were developed for treatment 50 (overlay without repairs) and treatment 60 (overlay with repairs) for General system flexible pavements in District 11. The regression equations are:

Activity Code 50 (1985-1994):

$$\mathrm{PCR_P} = 86.634 - 5.438 \times [(\mathrm{Age}+1)^{0.728} - 1], \quad (17)$$
$$n = 3791, R^2 = 0.38$$

Activity Code 50 (1994-2001):

$$\mathrm{PCR_P} = 98.383 - 9.453 \times [(\mathrm{Age}+1)^{0.728} - 1], \quad (18)$$
$$n = 2803, R^2 = 0.72$$

Activity Code 60 (1985-2001):

$$\mathrm{PCR_P} = 98.401 - 6.142 \times [(\mathrm{Age}+1)^{0.728} - 1], \quad (19)$$
$$n = 1523, R^2 = 0.74$$

Similar to the Markov model, the last five years of data from 2001 to 2005 are removed. The predicted PCR values versus the actual PCR values during the same time period are shown in Figure 23.

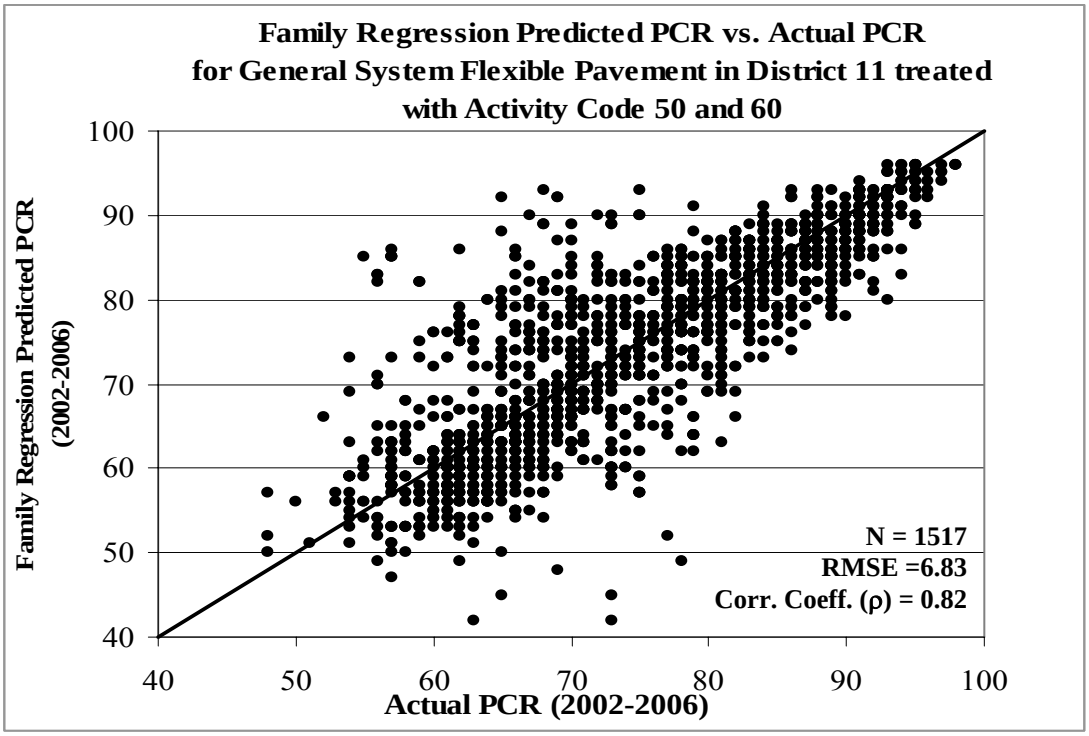


Figure 23. Family Regression Predicted PCR vs. Actual PCR (2002-2006)

Individual Section Regression Model

The individual section regression model is based on fitting a regression between PCR and age for each and every individual pavement section. In other words, each pavement section has its own regression equation. The regression equation has the following form:

$$PCR_P = \text{Intercept} + \text{Slope} \times [(\text{Age}+1)^{0.728} - 1] \ , \qquad (16)$$

where PCR_P is the predicted PCR value and $[(\text{Age}+1)^{0.728} - 1]$ is the age transformation used to account for the non linear deterioration trend between PCR and age. As with the Markov model, the last five years of data from 2002 to 2006 were removed for model development, and used for validation. The predicted PCR values versus the actual PCR values during the same time period are plotted in Figure 24.

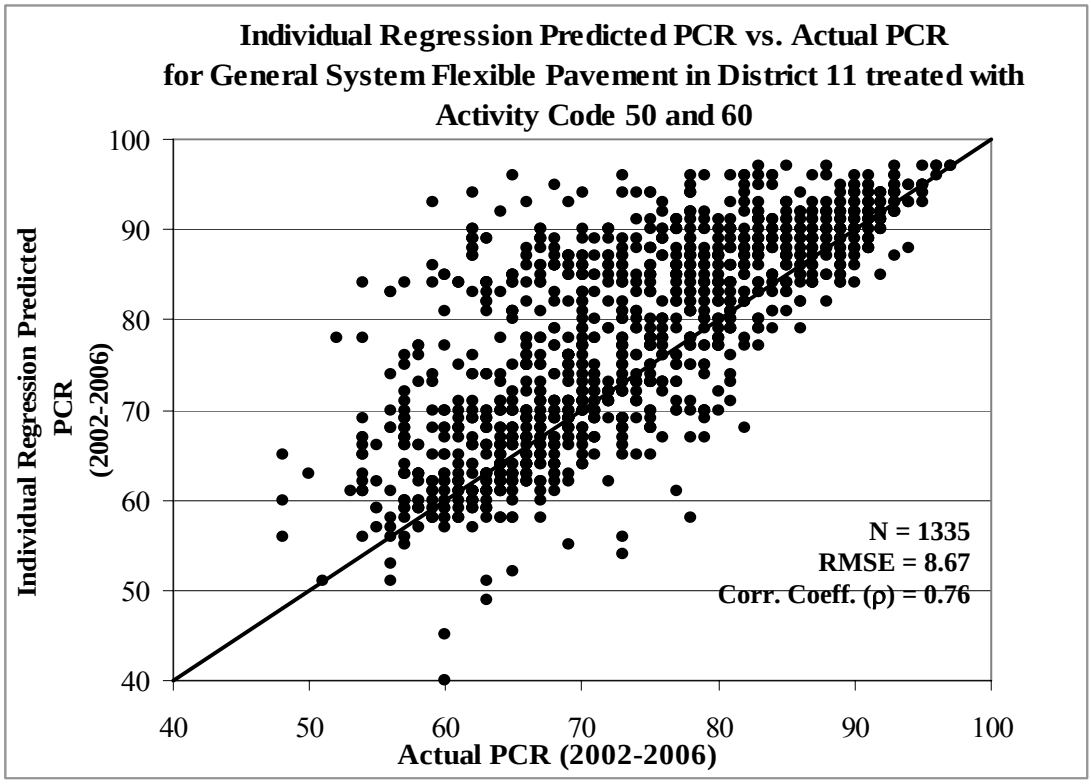


Figure 24. Individual Regression Predicted PCR vs. Actual PCR (2002-2006)

Table 11 summarizes the RMSE and correlation values for each of the models before and after removing the outliers. The number of PCR data points included in the individual regression model are fewer, because a minimum of three years of PCR data are required to develop the individual section regression equation. Therefore, those pavement sections with less than three years of PCR data are excluded from the analysis.

Table 11. Comparison of Model Accuracies

Forecasting Models	Total Directional Miles	Total No. of Sections	Data Points	RMSE	Correlation Coefficients
Markov Model	634.18	372	1531	6.55	0.81
Family Regression	634.18	372	1531	7.24	0.80
Individual Regression	570.91	336	1342	8.73	0.76

The error of prediction increases with the time frame of prediction, that is, prediction of near future is more accurate than prediction further into the future. Figure 25 shows the RMSE increases quickly with time period of prediction, especially for the individual regression model. Therefore, the individual regression model is not recommended.

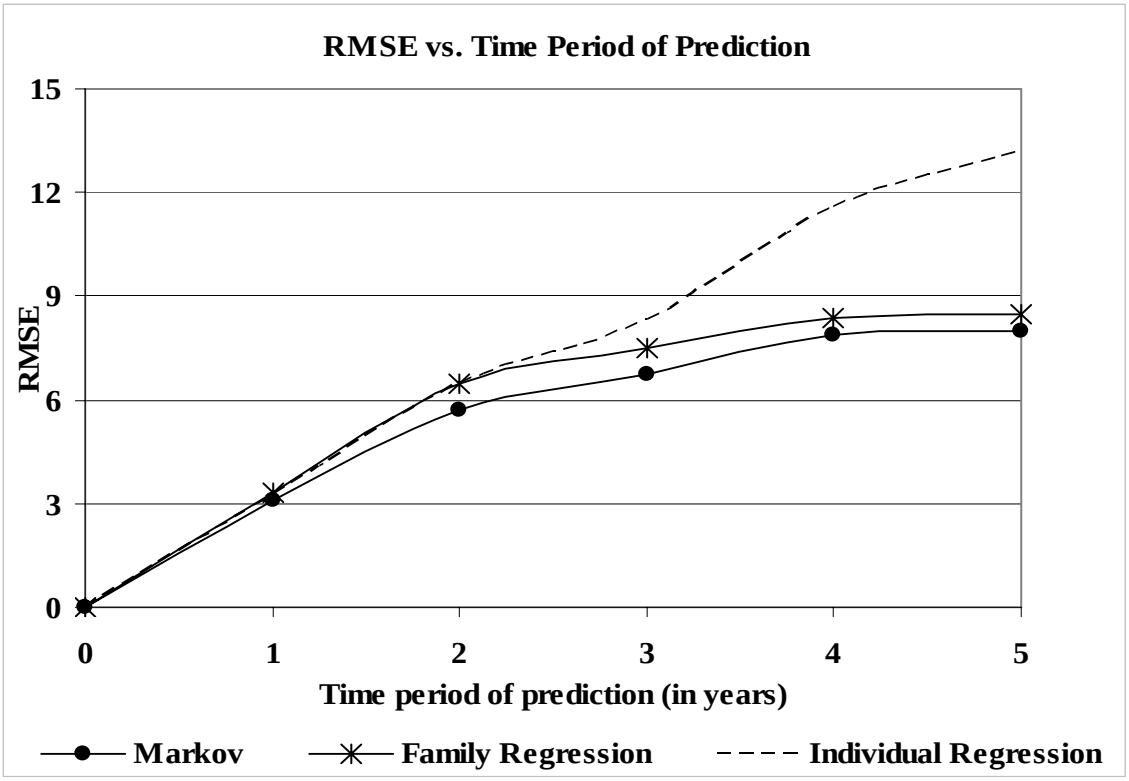


Figure 25. Prediction Error Increases with Time

From the above analysis, it can be concluded that overall, the Markov model provides better accuracy than the two types of regression models. An important benefit of the Markov model is that it can also predict individual distresses. The Markov model requires a sufficient number of pavements with similar deterioration trends in order to develop a reliable transitional probabilities matrix. Since the ODOT database contains a very large number of pavement sections, this does not present a problem, especially for overlays, which constitute the vast majority of the treatments performed. However, some treatment activities have not been used widely, and the number of pavements that have received the treatment is relatively small. For those cases, a family regression model is recommended.

III. Summary of Estimated Remaining Service Life of Pavements

The remaining service life of a pavement can be estimated based on its current and forecasted conditions. The terminal condition of a pavement, the condition at which a pavement is considered to reach the end of its useful service life, may be defined by several criteria, such as a minimum allowable PCR score and/or specific distress level; for example, rutting distress must be less than H (0.5 inch). A tool has been developed as part of this study to estimate the remaining service life of each pavement. The default terminal conditions are a PCR score below 65 for Priority system pavements, and a PCR score below 60 for General/Urban systems pavements.

Figure 25 summarizes the estimated remaining service life of pavements in each District as of 2007. Pavements with no remaining service life (0 years remaining) are those with current PCR scores already below the terminal thresholds. In other words, these pavements are considered as 'deficient'.

The Districts with large mileage of 'deficient' or 'near deficient' pavements are experiencing excessive rehabilitation needs. These include Districts 3, 4, 6, 9, 10, and 11. Note the majority of the pavements in District 12 are Priority system pavements, and a significant number of them require rehabilitation. In contrast, Districts 1 and 7 have notably fewer pavement sections that are deficient or near deficient.

The estimated remaining service life of pavements can be very useful in assessing the overall network condition, estimating rehabilitation needs and funding requirements, and planning and prioritizing rehabilitation projects.

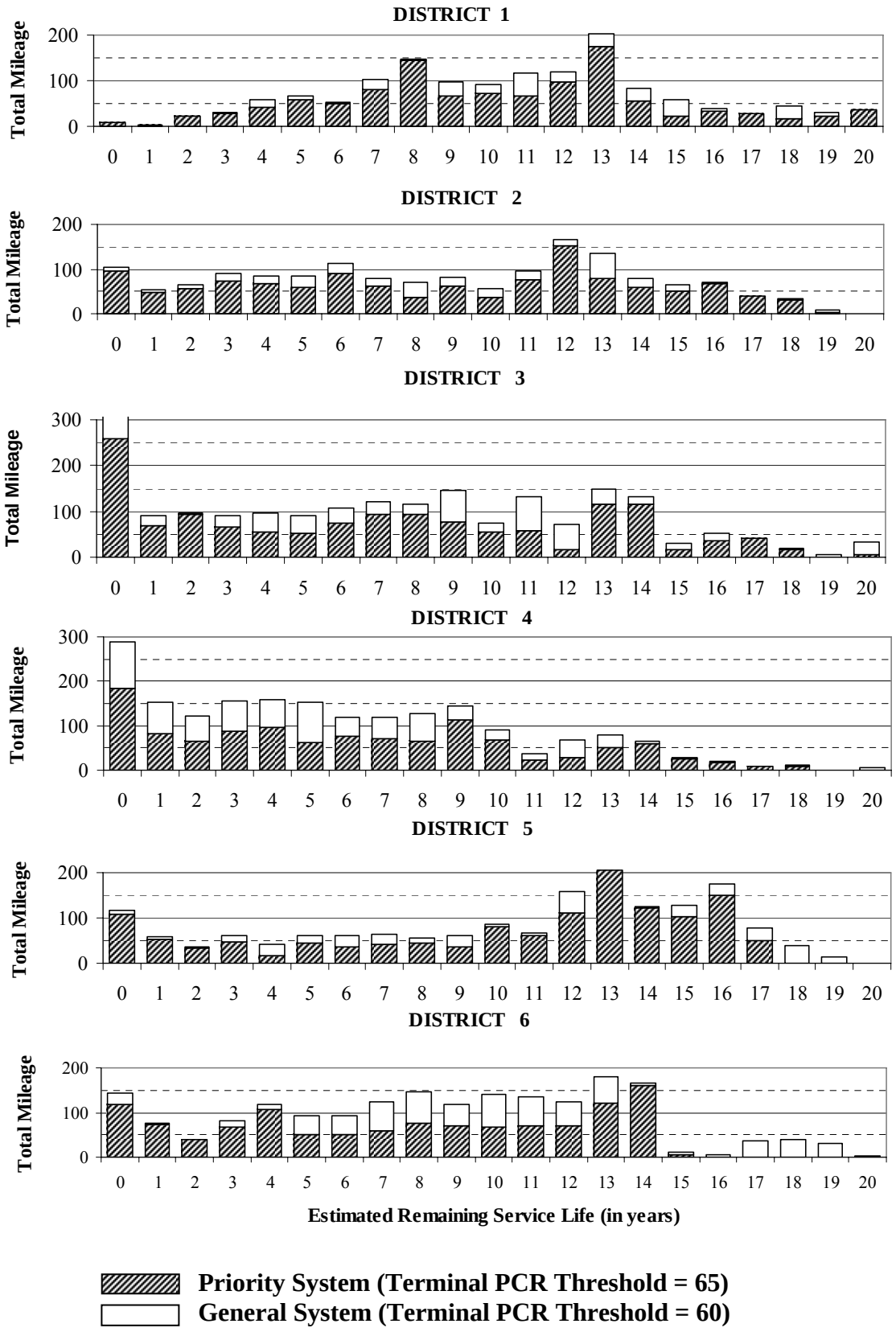


Figure 26-a Remaining Service Life of Pavements in each District

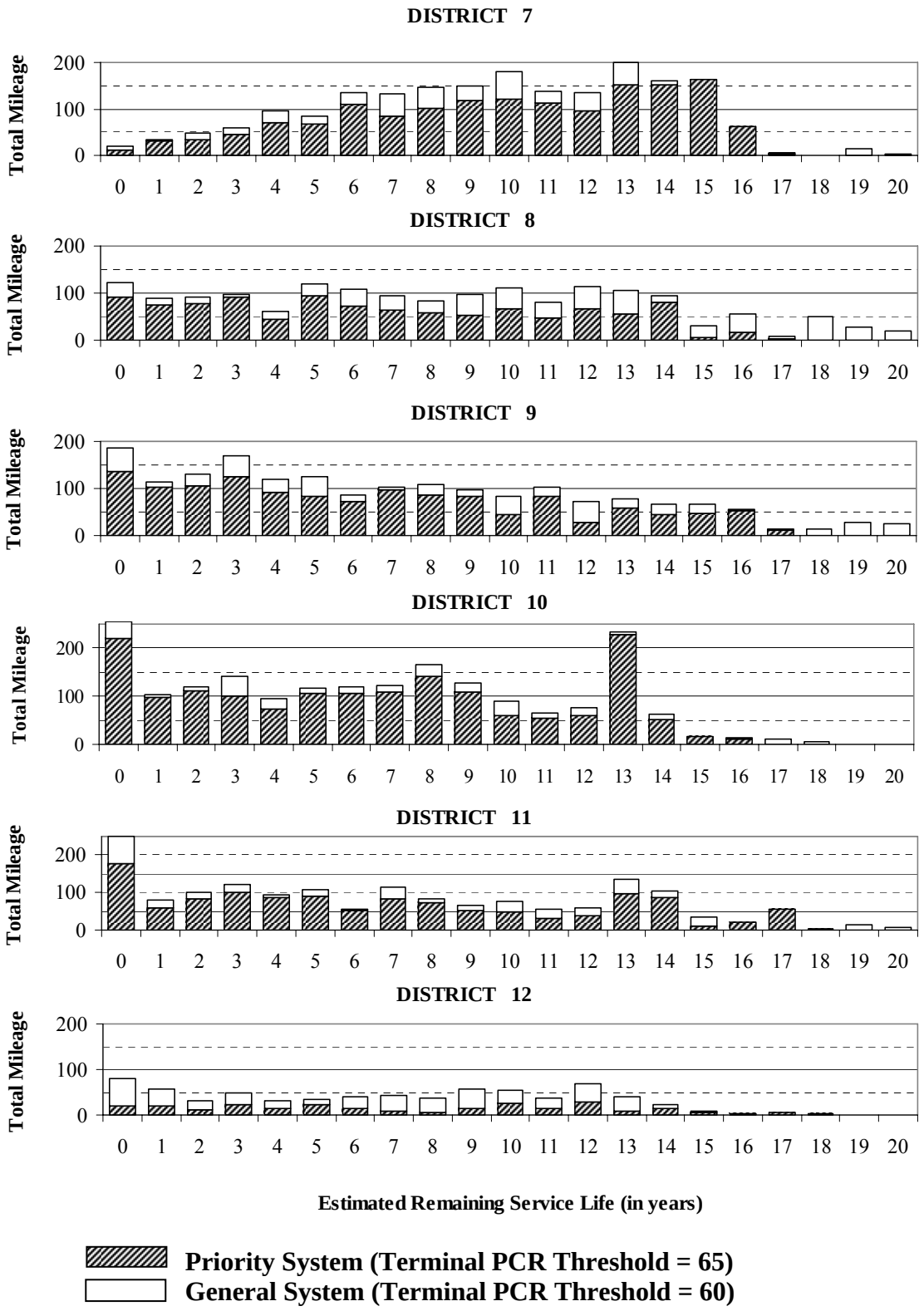


Figure 26-b. Remaining Service Life of Pavements in each District

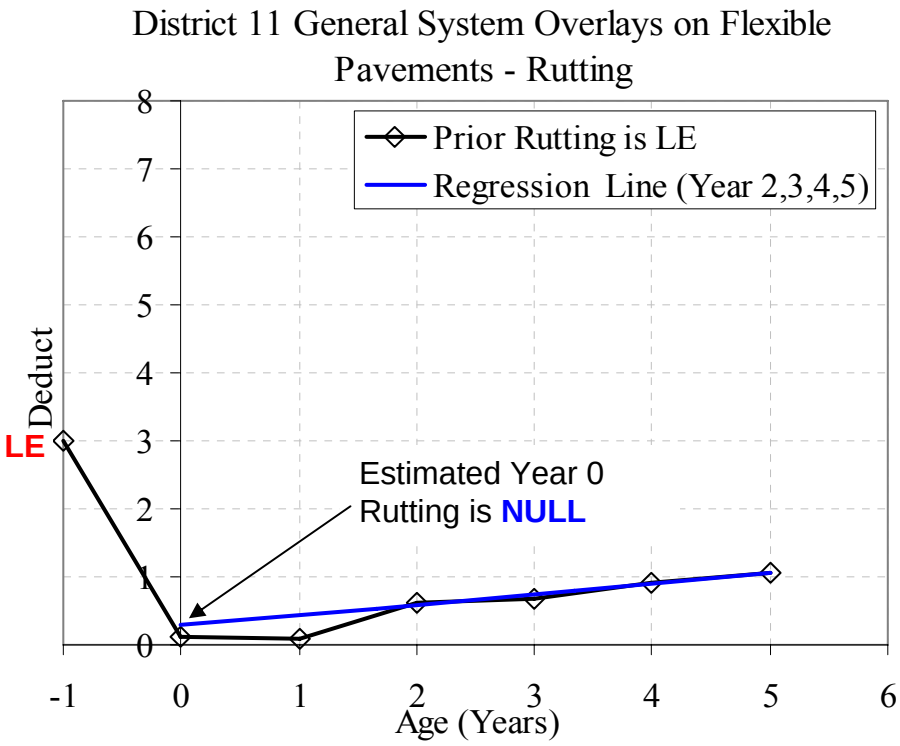
VI. Estimated Initial PCR after Various Rehabilitation or Maintenance Treatments

The initial PCR value of a pavement after a rehabilitation treatment will depend on the type and level of distress existing prior to the treatment and the effectiveness of that specific treatment's in addressing those distresses.

Figure 27 illustrates how the average deduct value of a particular distress at the initial year (Year 0) is obtained from the intercept of a linear regression of the average deducts of this distress from two to five years after the rehabilitation treatment. The resulting initial deduct value is then converted to the nearest distress level description. The average initial PCR value after a rehabilitation treatment is obtained by combining all the distress deducts.

Figure 28 shows that for a specific pavement section, the initial distress level is also a function of the level of the same distress prior to treatment. For example, after an overlay, the initial rutting level is likely to be NULL, if the rutting level prior to overlay was LO, LF, LE, or MO. However, if the rutting level prior to overlay was MF, ME, HO, HF, or HE, then the initial rutting level after overlay is likely LO. Initial levels of other distresses are determined in the same way. Therefore, the initial PCR value of each pavement section can be determined from the prior distress level and the treatment applied.

The average distress levels prior to and after various rehabilitation treatments for Concrete Pavements, Priority system flexible and composite pavements, and General system flexible and composite pavements, respectively, are shown in Table 12. The average PCR values before and after various treatment are also shown.



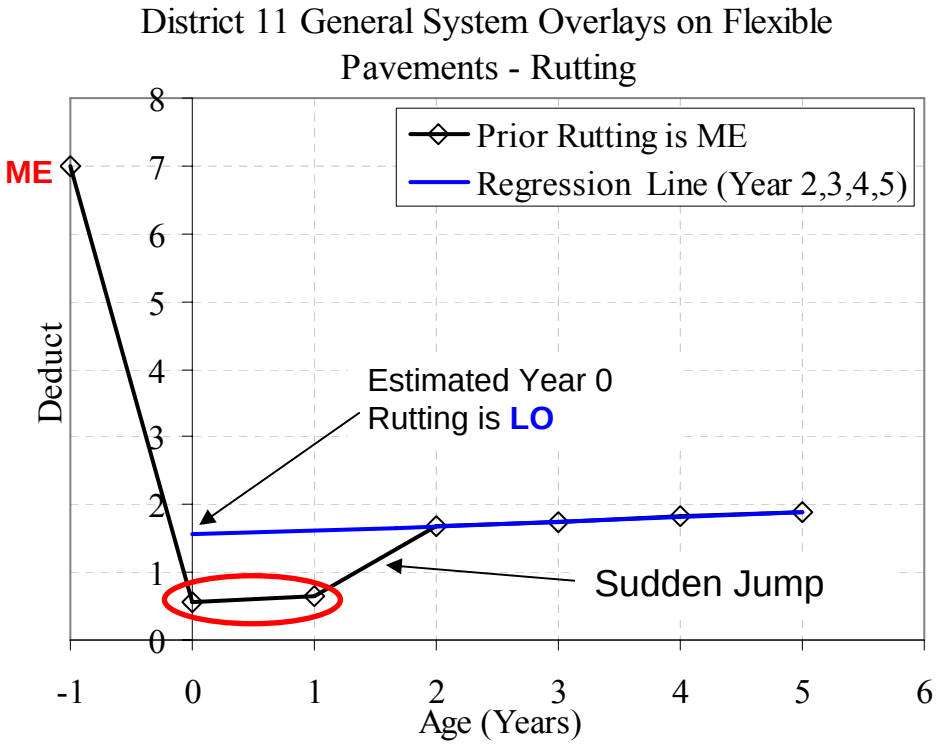
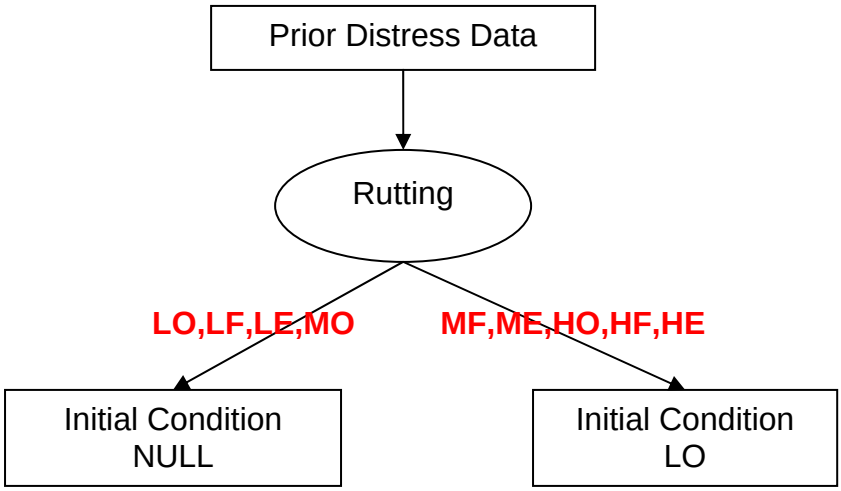


Figure 27. Determine Initial Distress Level from the Distress Levels in Years 2, 3, 4, 5



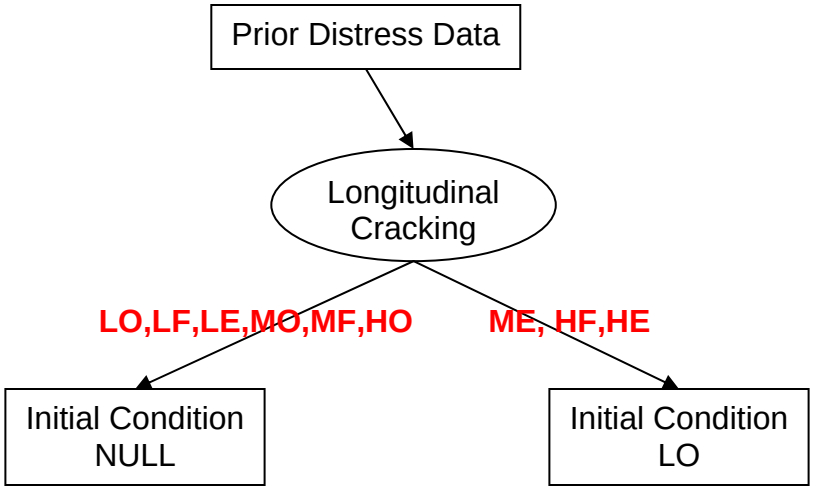


Figure 28. Initial Distress Level after Overlay as a Function of Prior Distress Level

Table 12. Average Distress Levels Before and After Treatment and Average Initial PCR Values

CONCRETE PAVEMENYTS

Activity Name	Activity Code	Prior / Immediately After Treatment	Average Distress Level Prior and After Treatment (* indicates NULL)														Average Cracking Deduct (CD)	Average Structural Deduct (SD)	Average / Initial PCR
			Surface Deterioration	Popouts	Patching	Pumping *SD*	Faulting Joints & Cracks) *SD*	Settlements	Transverse Joint Spalling	Joint Sealant Damage	Pressure Damage	Transverse Cracking, Reinforced Concrete *SD & CD*	Longitudinal Cracking *SD & CD*	Corner Breaks *SD*	Longitudinal Joint Spalling *CD*	Transverse Cracking, Plain Concrete *SD & CD*			
Reactive Maintenance	10	Prior	LE		LF	*	HF		*		O	HF	MO	LO	*	*	13.7	24.9	66
		After	LO		LO	*	*		LO		*	MO	*	*	*	*	4.8	5.5	89
Crack Sealing	20	Prior	LO		LO	*	*		*		O	LE	LO	*	*	*	2.8	4.4	89
		After	LO		LO	*	LO		*		*	LE	LO	*	*	*	3.1	5.0	89
Micro-Surfacing	30	Prior	HO		MF	*	ME		*		F	LF	*	MF	*	*	1.0	13.8	70
		After	**After treatment Pavement Type changes to Composite**														1.0	1.0	98
Fine Graded Polymer AC Overlay	38	Prior	LF		LO	*	*		*		*	LE	LO	*	*	*	3.0	4.6	91
		After	**After treatment Pavement Type changes to Composite**														0.3	0.3	97
CPR	40	Prior	LE		HO	*	LE		LO		*	MF	MO	HO	LO	*	13.7	23.0	64
		After	LF		LO	*	LO		LO		*	HO	*	LO	LO	*	9.3	11.2	82
AC Overlay Without Repairs	50	Prior	LE		LF	*	LE		*		*	MF	HO	LF	MO	O	21.5	27.4	62
		After	**After treatment Pavement Type changes to Composite**														1.7	2.5	95
AC Inlay	52	Prior	LF		MO	*	LF		*		*	LE	*	MO	LF	*	4.1	10.1	81
		After	**After treatment Pavement Type changes to Composite**														0.0	0.0	98
AC Overlay With Repairs	60	Prior	MO		HO	*	MF		*		*	HF	LE	MF	LE	F	29.2	40.0	49
		After	**After treatment Pavement Type changes to Composite**														0.6	0.9	96

CONCRETE PAVEMENYTS

Activity Name	Activity Code	Prior / Immediately After Treatment	Average Distress Level Prior and After Treatment (* indicates NULL)														Average Cracking Deduct (CD)	Average Structural Deduct (SD)	Average / Initial PCR
			Surface Deterioration	Popouts	Patching	Pumping *SD*	Faulting Joints & Cracks) *SD*	Settlements	Transverse Joint Spalling	Joint Sealant Damage	Pressure Damage	Transverse Cracking, Reinforced Concrete *SD & CD*	Longitudinal Cracking *SD & CD*	Corner Breaks *SD*	Longitudinal Joint Spalling *CD*	Transverse Cracking, Plain Concrete *SD & CD*			
Break And Seat	73	Prior	LE		LF	*	HO		*		*	HF	MO	MF	*	*	15.9	26.8	67
		After	**After treatment Pavement Type changes to Composite**														0.5	0.5	100
Rubblize And Roll	77	Prior	LE		MO	*	ME		LO		*	MF	MF	*	*	*	15.9	22.9	68
		After	**After treatment Pavement Type changes to Composite**														9.6	11.6	84
Whitetopping	80	Prior	LE		*	*	HF		*		*	HE	MF	MF	*	*	21.3	35.3	61
		After	*		*	*	*		*		*	*	*	*	*	*	0.5	0.5	98
Unbonded Concrete Overlay	90	Prior	MO		HO	*	HO		LO		*	HF	LE	HF	*	*	17.1	29.1	59
		After	*		*	*	*		*		*	*	*	*	*	*	0.0	0.3	99
New Rigid Pavement	110	Prior	MO		LE	O	HO		*		*	MF	LE	MF	LO	F	25.3	38.0	51
		After	LO		*	*	*		*		*	LO	*	*	*	*	1.5	2.6	95

PRIORITY SYSTEM **FLEXIBLE PAVEMENT**

Activity Name	**Activity Code**	**Prior / Immediately After Treatment**	**Average Distress Level Prior and After Treatment (* indicates NULL)**															**Average Cracking Deduct (CD)**	**Average Structural Deduct (SD)**	**Average / Initial PCR**
			Raveling	**Bleeding**	**Patching**	**Debonding**	**Crack Sealing Deficiency**	**Rutting** *SD*	**Settlements**	**Corrugations**	**Wheel Track racking** *SD & CD*	**Block and Transverse Cracking** *CD*	**Longitudinal Cracking** *SD & CD*	**Edge Cracking** *SD & CD*	**Random Cracking** *SD & CD*	**Thermal cracking** *CD*	**Potholes** *SD*			
Reactive Maintenance	10	Prior	MO	*	MF	*	E	*			LE	MF	MF	*		HF	*	20.4	9.2	69
		After	MO	*	LF	*	F	*			LO	LE	LE	*		MF	*	14.8	6.3	77
Crack Sealing	20	Prior	MO	*	LE	LO	O	LO			LF	LE	HF	LO		*	*	12.1	9.6	79
		After	LO	*	*	*	*	*			*	*	LO	*		*	*	1.5	1.0	96
Micro-Surfacing	30	Prior	MO	*	LF	*	O	LE			*	LE	MO	LO		*	*	8.4	7.9	81
		After	LF	*	*	*	*	*			*	*	LO	*		*	*	0.6	0.3	98
Double Application Micro-Surfacing	31	Prior	MO	*	*	*	O	LF			LO	MO	MF	*		*	*	9.4	7.8	83
		After	LO	*	*	*	*	*			*	*	LO	*		*	*	1.9	2.0	95
Nova-Chip Resurfacing	35	Prior	MO	*	*	*	O	LE			*	MF	LE	LO		LF	*	12.0	7.2	80
		After	MO	*	*	*	*	*			*	LF	*	*		*	*	0.5	0.1	98
Fine Graded Polymer AC Overlay	38	Prior	MO	*	*	*	O	LO			LO	MO	LE	*		LO	*	9.9	5.9	84
		After	LO	*	*	*	*	*			*	*	*	*		*	*	0.0	0.0	99
AC Overlay Without Repairs	50	Prior	MO	*	LE	*	F	LE			LO	HF	HF	LO		LO	*	15.2	11.2	72
		After	LF	*	*	*	*	*			*	*	*	*		*	*	0.4	0.3	98
AC Inlay	52	Prior	MO	*	LF	*	O	LF			LF	MF	MF	LF		HE	*	23.3	11.4	66
		After	LO	*	*	*	*	*			*	*	LO	*		*	*	0.0	0.0	99
Double Chip Seal	55	Prior																		
		After																		

PRIORITY SYSTEM **FLEXIBLE PAVEMENT**

Activity Name	Activity Code	Prior / Immediately After Treatment	Average Distress Level Prior and After Treatment (* indicates NULL)															Average Cracking Deduct (CD)	Average Structural Deduct (SD)	Average / Initial PCR
			Raveling	Bleeding	Patching	Debonding	Crack Sealing Deficiency	Rutting	Settlements	Corrugations	Wheel Track racking	Block and Transverse Cracking	Longitudinal Cracking	Edge Cracking	Random Cracking	Thermal cracking	Potholes			
								SD			*SD & CD*	*CD*	*SD & CD*	*SD & CD*	*SD & CD*	*CD*	*SD*			
AC Overlay With Repairs	60	Prior	MO	*	LE	*	F	MO			LF	HF	HO	LO		MO	*	18.7	12.6	68
		After	LF	*	*	*	*	*			*	*	*	*		*	*	0.3	0.1	98
New Flexible Pavement	100	Prior	MO	*	MO	*	F	LO			*	HF	MO	LE		HF	*	19.9	8.7	69
		After	LO	*	*	*	*	*			*	*	*	*		*	*	0.5	0.3	97

PRIORITY SYSTEM **COMPOSITE PAVEMENT**

Activity Name	Activity Code	Prior / Immediately After Treatment	Average Distress Level Prior and After Treatment (* indicates NULL)																	Average Cracking Deduct (CD)	Average Structural Deduct (SD)	Average / Initial PCR
			Raveling	Bleeding	Patching	Surface Disintegration/ Debonding	Rutting	Pumping *SD*	Shattered Slab (Jointed Base) *SD*	Settlements	Transverse Cracks (Unjointed Base) *SD & CD*	Joint Reflection Cracks (Jointed Base) *CD*	Intermediate Transverse Cracks (Joined Base) *SD & CD*	Longitudinal Cracking *SD & CD*	Pressure Damage/ Upheaval	Crack Sealing Deficiency	Corrugations	Corner Breaks (Jointed Base) *SD & CD*	Punchouts (Unjointed Base) *SD & CD*			
Reactive Maintenance	10	Prior	MF	*	MF	LO	LE	O	*		*	HF	HO	HO	LO	F		*	*	14.1	9.0	66
		After	MO	*	MO	*	LO	*	*		MO	MF	MO	MF	LO	O		*	*	13.2	10.0	75
Reactive Maintenance, None Contract	15	Prior	MO	*	HO	LO	MO	*	*		*	HF	HO	HO	LO	F		*	*	14.1	7.7	65
		After	MO	*	MF	*	MO	*	*		*	MF	LF	MO	*	F		*	*	8.1	3.1	79
Crack Sealing	20	Prior	MO	*	LE	*	LE	*	*		MO	ME	HO	HO	LO	F		*	*	17.8	10.8	67
		After	LF	*	LO	*	LO	*	*		LO	HO	LO	LF	*	O		*	*	6.7	2.9	87
Chip Seal	25	Prior	MO	O	HF	*	HO	*	O		*	ME	HO	HO	*	O		*	*	11.8	9.3	65
		After	MF	*	LF	*	MO	*	*		*	MF	*	LF	*	E		*	*	5.7	2.2	81
Micro-Surfacing	30	Prior	MO	*	MO	*	MO	*	*		*	HF	MO	MF	LO	F		*	*	13.1	5.2	72
		After	LF	*	*	*	LO	*	*		*	HO	LO	LE	*	O		*	*	3.8	1.3	90
Double Application Micro-Surfacing	31	Prior	MO	*	LF	*	LF	*	*		HO	MO	LO	HO	*	O		*	*	14.2	10.4	76
		After	LO	*	*	*	LO	*	*		*	LO	*	LO	*	*		*	*	1.8	0.9	97
Nova-Chip Resurfacing	35	Prior	MO	*	LO	*	MO	*	*		*	MF	LF	MO	*	O		*	*	8.3	2.7	81
		After	LF	*	*	*	*	*	*		*	LO	LO	LO	*	*		*	*	0.9	0.2	98

PRIORITY SYSTEM **COMPOSITE PAVEMENT**

Activity Name	Activity Code	Prior / Immediately After Treatment	Average Distress Level Prior and After Treatment (* indicates NULL)																	Average Cracking Deduct (CD)	Average Structural Deduct (SD)	Average / Initial PCR
			Raveling	Bleeding	Patching	Surface Disintegration/ Debonding	Rutting	Pumping *SD*	Shattered Slab (Jointed Base) *SD*	Settlements	Transverse Cracks (Unjointed Base) *SD & CD*	Joint Reflection Cracks (Jointed Base) *CD*	Intermediate Transverse Cracks (Joined Base) *SD & CD*	Longitudinal Cracking *SD & CD*	Pressure Damage/ Upheaval	Crack Sealing Deficiency	Corrugations	Corner Breaks (Jointed Base) *SD & CD*	Punchouts (Unjointed Base) *SD & CD*			
Fine Graded Polymer AC Overlay	38	Prior	MO	*	LE	*	LF	*	*		LF	HO	LO	HO	*	O		*	*	10.3	5.9	77
		After	LO	*	*	*	*	*	*		*	LF	*	*	*	*		*	*	1.8	0.7	97
AC Overlay Without Repairs	50	Prior	MO	*	MF	*	MO	*	*		LE	HF	MO	ME	LO	F		*	*	17.8	10.2	65
		After	LF	*	*	*	LO	*	*		*	LO	*	*	*	*		*	*	0.4	0.1	97
AC Inlay	52	Prior	MO	*	MO	LO	MO	*	*		LE	ME	MO	MF	LO	F		*	*	16.4	9.7	67
		After	LO	*	*	*	*	*	*		*	LO	*	*	*	*		*	*	0.6	0.1	98
AC Overlay With Repairs	60	Prior	MO	*	MO	*	MO	*	*		MO	HF	MO	MF	LO	F		*	*	19.6	12.5	64
		After	LF	*	*	*	*	*	*		*	*	*	*	*	*		*	*	0.3	0.1	98
Crack And Seat	70	Prior	MO	*	MF	*	MF	*	*		*	ME	LF	MF	LO	O		*	*	10.9	3.8	73
		After	LF	*	*	*	*	*	*		*	*	*	LO	*	*		*	*	0.2	0.0	97
Rubblize And Roll	77	Prior	LF	*	MO	LO	MO	*	*		*	ME	HO	HO	*	O		*	*	12.8	6.6	74
		After	LO	*	*	*	LO	*	*		*	LO	*	LO	*	*		*	*	0.8	0.3	96
New Composite Pavement	120	Prior	MO	*	LF	*	HO	O	*		*	MO	MF	LE	MF	O		*	*	8.4	8.6	72
		After	MO	*	*	*	LO	*	*		*	LE	*	LE	*	*		*	*	1.9	1.0	93

GENERAL SYSTEM **FLEXIBLE PAVEMENT**

Activity Name	Activity Code	Prior / Immediately After Treatment	Average Distress Level Prior and After Treatment (* indicates NULL)															Average Cracking Deduct (CD)	Average Structural Deduct (SD)	Average / Initial PCR
			Raveling	Bleeding	Patching	Debonding	Crack Sealing Deficiency	Rutting *SD*	Settlements	Corrugations	Wheel Track Cracking *SD & CD*	Block and Transverse Cracking *CD*	Longitudinal Cracking *SD & CD*	Edge Cracking *SD & CD*	Random Cracking *SD & CD*	Thermal cracking *CD*	Potholes *SD*			
Reactive Maintenance	10	Prior	MO	*	MO	*	F	LE			LF	HO	HO	MO		LO	*	18.4	14.0	68
		After	LF	*	LO	*	O	LO			LO	LE	MO	LO		LO	*	8.9	6.5	84
Reactive Maintenance, None Contract	15	Prior	MO	*	MO	LO	F	MO			MO	HF	HF	HO		HO	*	24.9	17.8	60
		After	LF	*	*	*	O	LF			LO	MO	MO	LF		*	*	9.8	8.8	82
Crack Sealing	20	Prior	MO	*	LF	*	O	LO			MO	LE	LF	LE		LO	*	16.1	12.0	75
		After	MO	*	*	*	*	LO			*	LF	*	LF		*	*	3.5	3.0	91
Chip Seal	25	Prior	MO	*	LO	*	F	LE			LF	MF	MF	MO		LO	*	15.5	12.9	74
		After	LF	O	*	*	*	LE			LO	LO	LO	LF		*	*	4.0	5.0	90
Micro-Surfacing	30	Prior	MO	*	LO	*	O	LF			LO	LE	MF	LF		LO	*	14.8	11.0	76
		After	LF	*	*	*	*	LO			LO	LO	LO	LO		*	*	5.2	3.3	91
Double Application Micro-Surfacing	31	Prior	MO	*	LF	*	O	LF			LO	MF	MF	LF		LO	*	14.0	10.2	76
		After	LO	*	*	*	O	LF			*	LE	MO	LO		*	*	4.4	3.3	92
Nova-Chip Resurfacing	35	Prior	MO	*	*	*	O	LO			*	LF	LF	LO		*	*	7.5	6.6	84
		After	MO	*	*	*	*	*			*	LO	*	*		*	*	2.5	0.4	95
Fine Graded Polymer AC Overlay	38	Prior	MO	*	LO	*	O	LO			LF	MO	LF	LF		*	*	13.5	10.8	78
		After	LF	*	*	*	*	*			*	LO	*	*		*	*	2.4	1.5	95
Intermediate Coarse Recycled AC	45	Prior	ME	*	MO	LO	E	MO			MF	HE	HF	HF		LF	*	30.1	21.1	51
		After	LO	*	*	*	*	*			*	*	*	*		*	*	0.0	0.0	99

GENERAL SYSTEM **FLEXIBLE PAVEMENT**

Activity Name	Activity Code	Prior / Immediately After Treatment	Average Distress Level Prior and After Treatment (* indicates NULL)															Average Cracking Deduct (CD)	Average Structural Deduct (SD)	Average / Initial PCR
			Raveling	Bleeding	Patching	Debonding	Crack Sealing Deficiency	Rutting	Settlements	Corrugations	Wheel Track Cracking	Block and Transverse Cracking	Longitudinal Cracking	Edge Cracking	Random Cracking	Thermal cracking	Potholes			
								SD			*SD & CD*	*CD*	*SD & CD*	*SD & CD*	*SD & CD*	*CD*	*SD*			
AC Overlay Without Repairs	50	Prior	MF	*	MO	*	F	MO			MO	HF	HF	LE		LE	*	23.3	16.6	61
		After	LF	*	*	*	*	LO			*	*	*	*		*	*	0.4	0.4	98
AC Inlay	52	Prior	MF	*	LE	LO	F	LE			MO	HF	HF	LE		MF	*	24.7	16.1	61
		After	LO	*	*	*	*	*			*	*	LO	*		*	*	0.8	1.0	98
Double Chip Seal	55	Prior	MO	*	MO	*	E	*			LO	HF	MF	MO		*	*	16.0	9.0	74
		After	MO	*	*	HO	*	*			*	LO	*	LO		*	*	4.0	2.0	91
AC Overlay With Repairs	60	Prior	MF	*	MO	*	F	MO			LE	HF	HO	LE		LE	*	23.1	16.6	62
		After	LF	*	*	*	*	*			*	*	*	*		*	*	0.3	0.2	98
New Flexible Pavement	100	Prior	MF	*	MO	LO	F	MO			LO	HF	HO	HO		HO	*	23.8	15.6	61
		After	LO	*	*	*	*	*			*	*	*	*		*	*	0.4	0.5	98

GENERAL SYSTEM **COMPOSITE PAVEMENT**

Activity Name	Activity Code	Prior / Immediately After Treatment	Average Distress Level Prior and After Treatment (* indicates NULL)																	Average Cracking Deduct (CD)	Average Structural Deduct (SD)	Average / Initial PCR
			Raveling	Bleeding	Patching	Surface Disintegration/ Debonding	Rutting	Pumping *SD*	Shattered Slab (Jointed Base) *SD*	Settlements	Transverse Cracks (Unjointed Base) *SD & CD*	Joint Reflection Cracks (Jointed Base) *CD*	Intermediate Transverse Cracks (Joined Base) *SD & CD*	Longitudinal Cracking *SD & CD*	Pressure Damage/ Upheaval	Crack Sealing Deficiency	Corrugations	Corner Breaks (Jointed Base) *SD & CD*	Punchouts (Unjointed Base) *SD & CD*			
Reactive Maintenance	10	Prior	MF	*	LF	*	MO	*	*		ME	ME	HO	ME	LO	F		*	*	25.3	17.9	58
		After	LF	*	*	*	LF	*	*		LE	HO	LF	MO	LO	O		*	*	9.0	4.8	84
Reactive Maintenance, None Contract	15	Prior	MF	*	MF	LO	MO	*	*		ME	HF	MF	HF	MO	E		*	*	29.5	21.1	51
		After	LF	*	LO	*	LF	*	*		LE	HO	LF	MO	LO	O		*	*	11.1	7.0	80
Crack Sealing	20	Prior	MO	*	MO	*	MO	*	*		ME	ME	MO	HO	*	F		*	*	23.7	15.9	61
		After	MO	*	LO	*	LE	*	*		HO	HO	LE	HO	*	O		*	*	15.6	11.4	76
Chip Seal	25	Prior	MO	*	*	*	LE	*	*		MF	ME	MO	HO	LF	F		*	*	21.7	13.7	66
		After	LF	*	*	*	LF	*	*		LE	LF	LO	MO	LO	*		*	*	7.0	5.0	86
Micro-Surfacing	30	Prior	MO	*	LO	*	LE	*	*		LF	ME	HO	HO	LO	F		*	*	15.0	8.9	72
		After	LF	*	*	*	LO	*	*		HO	LE	LO	LF	LO	*		*	*	10.4	7.9	84
Double Application Micro-Surfacing	31	Prior	HO	*	HO	*	MO	*	*		HO	HF	MF	ME	LO	F		*	*	25.2	15.6	56
		After	LF	*	*	*	LF	*	*		LO	LE	LO	LO	*	*		*	*	5.6	3.1	89
Nova-Chip Resurfacing	35	Prior	ME	*	HO	LO	LE	O	*		HO	ME	ME	ME	*	O		*	*	23.2	17.7	59
		After	MF	*	LO	*	LO	*	*		MO	*	*	HO	*	O		*	*	6.6	6.6	84
Fine Graded Polymer AC Overlay	38	Prior	MO	*	LO	*	LE	*	*		MF	HO	LF	HO	LO	O		*	*	16.8	12.2	71
		After	LO	*	*	*	*	*	*		LF	*	*	*	*	*		*	*	1.6	1.4	97

GENERAL SYSTEM **COMPOSITE PAVEMENT**

Activity Name	Activity Code	Prior / Immediately After Treatment	Average Distress Level Prior and After Treatment (* indicates NULL)																	Average Cracking Deduct (CD)	Average Structural Deduct (SD)	Average / Initial PCR
			Raveling	Bleeding	Patching	Surface Disintegration/ Debonding	Rutting	Pumping *SD*	Shattered Slab (Jointed Base) *SD*	Settlements	Transverse Cracks (Unjointed Base) *SD & CD*	Joint Reflection Cracks (Jointed Base) *CD*	Intermediate Transverse Cracks (Joined Base) *SD & CD*	Longitudinal Cracking *SD & CD*	Pressure Damage/ Upheaval	Crack Sealing Deficiency	Corrugations	Corner Breaks (Jointed Base) *SD & CD*	Punchouts (Unjointed Base) *SD & CD*			
Intermediate Coarse Recycled AC	45	Prior	HE	O	MF	LO	ME	*	*		*	HE	ME	HE	MF	E		*	*			
		After	MO	*	*	*	LE	*	*		*	MF	*	*	LO	F		*	*			
AC Overlay Without Repairs	50	Prior	MF	*	MO	*	MF	*	*		MF	HF	MF	ME	LF	E		*	*	27.0	17.4	55
		After	LF	*	*	*	LO	*	*		*	LO	*	*	*	*		*	*	0.8	0.4	97
AC Inlay	52	Prior	ME	*	LF	LO	LE	*	*		MF	HF	ME	HF	MO	F		*	*	28.4	19.4	54
		After	LO	*	*	*	*	*	*		*	*	*	LO	*	*		*	*	0.8	0.6	98
AC Overlay With Repairs	60	Prior	MF	*	MO	*	MO	*	*		ME	HF	MF	ME	LF	F		*	*	28.7	19.8	53
		After	LF	*	*	*	*	*	*		*	*	*	*	*	*		*	*	0.5	0.3	97
Rubblize And Roll	77	Prior	ME	*	MF	LO	LE	*	*		*	HE	MO	HE	*	E		*	*	18.9	6.9	64
		After	LO	*	*	*	*	*	*		*	*	*	*	*	*		*	*	0.0	0.0	99
New Composite Pavement	120	Prior	MO	*	HO	LO	LE	*	*		*	ME	MF	MF	*	E		*	*	13.4	6.4	72
		After	MO	*	*	*	LE	*	*		*	LO	*	MO	*	O		*	*	0.0	0.0	94

V. Rehabilitation Decision Trees and Multiyear Work Plan Tool

A set of rehabilitation treatment decision trees was developed in cooperation with the Office of Pavement Engineering. Separate decision trees were developed for Priority system major rehabilitation candidates, concrete pavements, Priority system composite and flexible pavements, General system composite and flexible pavements, General system low volume pavements, and poor performance and poor condition pavements. These recommended rehabilitation treatment decision trees are shown in Appendix B.

By applying the recommended treatment decision trees to the current and forecasted future pavement conditions, the rehabilitation needs for the current and future years can be obtained. As the available budgets are not likely to satisfy all rehabilitation needs, an actual work plan must be developed with consideration of budget and other constraints such as keeping the percentage of 'deficient' pavements below a certain limits.

A tool has been developed to evaluate and compare alternative multiple-year work plans based on their effect on predicted future conditions. Figure 29 shows the View Predicted Pavement Condition with Work Plan menu. The planned future projects are imported from a spreadsheet and saved in a table named DATA_FutureProjects.

Table 13 shows the resulting predicted PCR values after the effects of planned work have been incorporated for a group of selected pavements. Figure 30 shows the existing and predicted PCR trends with and without planned treatment for a specific pavement section.

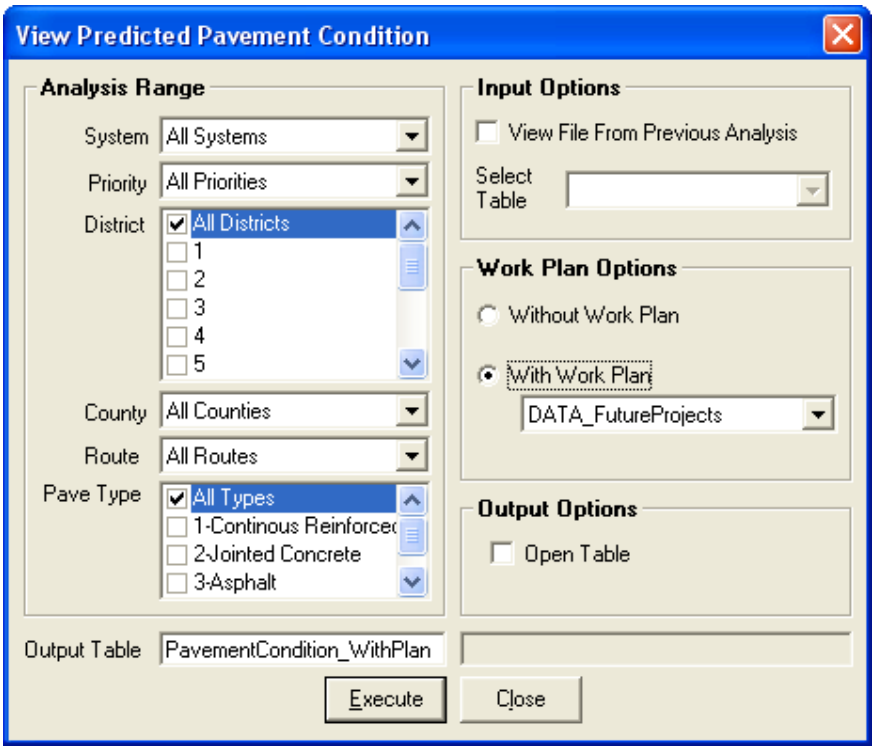


Figure 29. View Predicted Pavement Condition with Work Plan Tool

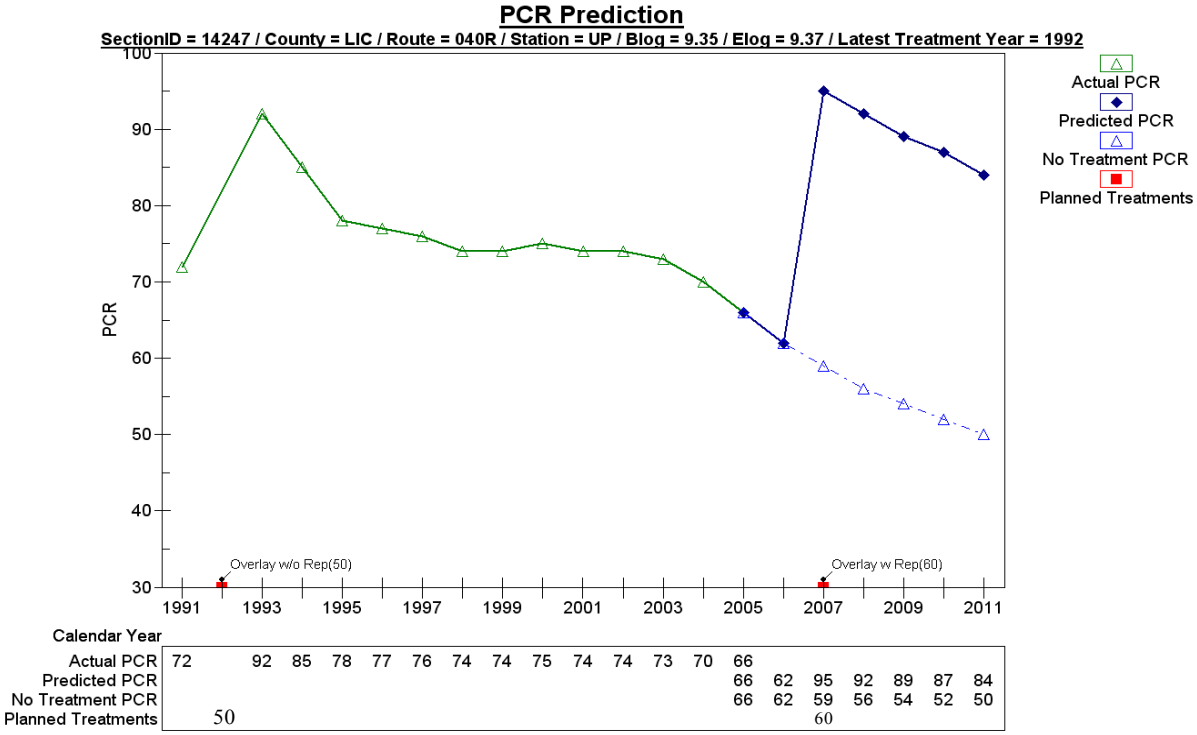


Figure 30. Predicted PCR Trend with and without Planned Treatment

Table 13. Effect of Planned Work Example

PaveID	District	County	Route	Blog	Elog	Pave Type	Activity Code			PCR								
							2008	2009	2010	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	11	BEL	007A	0	0.46	2				74	73	72	70	*66*	*62*	***58***	***54***	***50***
20	11	BEL	009R	16.26	20.4	3				89	81	79	70	*67*	*64*	*60*	***57***	***54***
21	11	BEL	009R	20.4	22.8	3				91	83	83	75	*71*	*67*	*63*	*60*	***56***
34	11	BEL	040R	19.72	20.13	4	60			62	99	96	93	*97*	*94*	*92*	*89*	*86*
66	11	BEL	147R	14.05	14.38	3			60	67	61	**59**	**59**	***55***	***52***	*96*	*91*	*86*
67	11	BEL	147R	14.38	19.19	3			60	67	61	61	**57**	***54***	***51***	*96*	*91*	*86*
195	11	CAR	009R	21.82	28.08	3				61	56	**54**	99	*96*	*93*	*90*	*87*	*85*
196	11	CAR	039R	0	4.5	3				60	57	**54**	**51**	***48***	***45***	***42***	***39***	***37***
200	11	CAR	039R	7.29	10.23	4				75	75	72	71	*68*	*66*	*64*	*61*	*60*
201	11	CAR	039R	10.23	14.25	3				99	93	92	89	*83*	*77*	*71*	*66*	*60*
203	11	CAR	039R	15.18	23.41	3		60		72	62	62	62	***59***	*96*	*91*	*86*	*82*
204	11	CAR	039R	23.41	25.92	3		60		68	62	62	**54**	***53***	*96*	*91*	*86*	*82*
205	11	CAR	039R	25.92	27.35	3		60		68	62	62	**54**	***53***	*96*	*91*	*86*	*82*
210	11	CAR	043R	14.1	16.19	4				67	61	60	61	***57***	***54***	***52***	***50***	***49***
283	11	COL	014R	6.41	8	4				91	80	78	76	*73*	*71*	*69*	*66*	*64*
285	11	COL	014R	8.83	8.89	4				75	75	95	93	*90*	*87*	*84*	*82*	*79*
286	11	COL	014R	9.33	9.41	4	50			68	62	60	60	*96*	*90*	*85*	*80*	*76*
287	11	COL	014R	12.67	19.26	4	60			72	66	71	70	*97*	*94*	*92*	*89*	*86*
291	11	COL	030R	0	7.33	4				78	67	67	68	*65*	*63*	*60*	***58***	***57***
292	11	COL	030R	7.33	8.87	4				77	71	71	68	*65*	*63*	*60*	***58***	***56***
466	11	HAS	009R	6.24	6.48	3	100		200	77	75	73	68	*97*	*93*	*90*	*88*	*85*
483	11	HAS	022R	9.24	9.27	4	200			73	71	70	98	*94*	*91*	*88*	*86*	*83*

75 **- Actual PCR** *85* **- Predicted PCR** ***58*** **- Predicted PCR below threshold**

VI. Pavement Management Database for Local Routes

Table 14 shows a summary of the data contained in the LOCAL PMIS database for local federal-aid routes and the current (or latest) condition based on the available PCR measurements. As can been from Table 14, Districts 1, 2, 6, 7, 8 have PCR data from 2003 and 2005, whereas the other Districts have data from 2003, 2004, and 2006.

Statewide, a total of 11,611 miles of local pavements are included in the database. Approximately 32.9 percent are in very good condition, 24.9 percent are in good condition, 21.7 percent are in fair condition, 12 percent are in poor condition, and 8.5 percent are in very poor (or deficient) condition. On average, local pavements in Districts 1, 6, 7, 8, 9 are in better conditions than the rest of the State. Figure 31 shows the condition distribution of local pavements in each District.

Some of the analysis functions and reporting tools available in the ODOTPMIS had to be disabled due to lack of project history data. The primary tools remaining include current condition report, condition forecasting for a single or a group of pavements, remaining service life estimation, and rehabilitation recommendations based on decision trees.

Forecasting Pavement Condition by Linear Regression

Since the database for local federal-aid routes contains only two or three years of PCR data in the most recent past, with no project history or construction dates, a linear regression model is used to calculate the average deterioration rate. The linear regression model predicts both individual distresses and overall PCR value for each pavement section. As more data become available in the future, a nonlinear regression or a Markov model may be adopted.

For pavement sections where the best fit line cannot be drawn from the data or where the resulting PCR slope is abnormal (e.g., positive slope which indicates non-deteriorating condition or PCR is decreasing by more than 10 points a year), prediction is done based on the statewide average. Figures 32 and 33 show the PCR trend based on the actual predicted PCR slope and on District average PCR slope respectively.

Table 14. Summary of Local Pavement PCR Data and Current Condition

District	County	Miles	Data Availability				Latest Pavement Condition in Percent Miles				
			2003	2004	2005	2006	PCR: > 90	PCR: 80-90	PCR: 70-80	PCR: 60-70	PCR: < 60
1	ALL	146.07	✔		✔		32.4	36.9	17	4.3	9.3
	DEF	42.56	✔		✔		36.9	37	19.9	6	0.2
	HAN	89.68	✔		✔		41.6	13.9	16.2	15.7	12.6
	HAR	34.28	✔		✔		49.2	40.9	7.9	2	0
	PAU	28.54	✔		✔		45.6	9.4	4.1	36.8	4.2
	PUT	30.85	✔		✔		76.8	17.3	1.6	4.2	0
	VAN	44.09	✔		✔		20.6	42.4	31.9	3.1	2.1
	WYA	44.38	✔		✔		36.4	35.3	23.9	1	3.3
1		**460.45**	**Average Condition**				**38.9**	**30.1**	**16.7**	**8.1**	**6.2**
2	FUL	149.14	✔		✔		32.7	13	25.6	19.6	9.1
	HEN	62	✔		✔		23	14.5	48.8	7.7	6.1
	LUC	430.19	✔		✔		30.9	25.3	26.1	9.6	8.1
	OTT	45.17	✔		✔		58.2	28.7	4.9	4.4	3.7
	SAN	111.96	✔		✔		32.3	13.2	41	10.2	3.3
	SEN	131.42	✔		✔		29.4	36.7	28.6	4.4	0.8
	WIL	50.1	✔		✔		16	30.2	26.5	27.2	0
	WOO	167.27	✔		✔		16.1	24.8	21.5	18.4	19.2
2		**1147.3**	**Average Condition**				**28.9**	**23.5**	**27.5**	**12.1**	**7.9**
3	ASD	51.06	✔	✔		✔	36.2	16.1	14.5	15.3	17.9
	CRA	67.87	✔	✔		✔	10	34.8	25.8	23	6.5
	ERI	96.64	✔	✔		✔	55.8	24.7	7.8	8.9	2.9
	HUR	69.38	✔	✔		✔	22	16.2	27.5	9.5	24.8
	LOR	248.64	✔	✔		✔	21.8	20.3	21.4	20.4	16.1
	MED	146.86	✔	✔		✔	24.4	22.6	20.4	17.9	14.7
	RIC	161.3	✔	✔		✔	23.7	25.3	18.3	23.3	9.3
	WAY	176.08	✔	✔		✔	34.3	33.2	16.8	4.5	11.2
3		**1017.8**	**Average Condition**				**27.8**	**24.6**	**19**	**15.8**	**12.8**
4	ATB	106.04	✔	✔		✔	38.2	16.9	17.7	12.7	14.6
	MAH	285.21	✔	✔		✔	18.4	11.6	24	19.5	26.5
	POR	142.69	✔	✔		✔	16.5	28.4	22.9	22.5	9.7
	STA	495.33	✔	✔		✔	29.2	28.9	19.1	14.8	8
	SUM	501.32	✔	✔		✔	28.4	23.7	29.1	13.6	5.1
	TRU	198.12	✔	✔		✔	20.9	13.8	20.6	28.4	16.3
4		**1728.7**	**Average Condition**				**25.8**	**22**	**23.2**	**17.3**	**11.7**

District	County	Miles	Data Availability				Latest Pavement Condition in Percent Miles				
			2003	2004	2005	2006	PCR: > 90	PCR: 80-90	PCR: 70-80	PCR: 60-70	PCR: < 60
5	COS	29.58	✔	✔		✔	42	23.2	24.6	7.8	2.4
	FAI	128.27	✔	✔		✔	37.8	24.8	22.2	9.1	6.1
	GUE	69.49	✔	✔		✔	58.3	10.5	20.1	9.5	1.5
	KNO	41.59	✔	✔		✔	28.3	19.5	14.5	33.6	4
	LIC	149.75	✔	✔		✔	29.7	12	29.3	14.6	14.4
	MUS	123.25	✔	✔		✔	37.7	19.1	22.1	8.4	12.6
	PER	16.49	✔	✔		✔	83.7	5.7	3.2	7.4	0
5		**558.42**	**Average Condition**				**39.1**	**17.3**	**22.8**	**12.2**	**8.6**
6	DEL	134.1	✔		✔		51.9	26.2	16.4	4.6	0.8
	FAY	34.81	✔		✔		43.3	39.8	3.9	12.7	0.3
	FRA	830.37	✔		✔		40.1	32.9	17.5	4	5.5
	MAD	22.85	✔		✔		4.8	19.4	27.8	8.4	39.6
	MAR	76.87	✔		✔		28.7	18	35.1	13.2	5
	MRW	22.25	✔		✔		23.3	5.4	6.3	64.9	0
	PIC	18.76	✔		✔		61.6	17.1	8.3	12	1
	UNI	86.24	✔		✔		33.2	26.7	24.4	13.2	2.5
6		**1226.3**	**Average Condition**				**39.6**	**30**	**18.4**	**6.9**	**5.1**
7	AUG	52.63	✔		✔		38.6	21.2	27.2	4.3	8.7
	CHP	34.68	✔		✔		47.6	33.6	7.5	7.1	4.2
	CLA	182.28	✔		✔		32.7	20.7	37.9	8.4	0.3
	DAR	69.18	✔		✔		38	39.9	21.8	0.4	0
	LOG	63.27	✔		✔		23.2	31.3	27	4.6	13.8
	MER	37.41	✔		✔		44.9	24	26.4	4.4	0.4
	MIA	119.04	✔		✔		35.8	18.8	14.3	17.6	13.5
	MOT	714.29	✔		✔		36.9	30.8	21.1	4.3	6.9
	SHE	51.23	✔		✔		31.8	43.4	7.7	7.6	9.5
7		**1324**	**Average Condition**				**36**	**28.8**	**22.6**	**6.1**	**6.5**
8	BUT	263.83	✔		✔		32.7	32.6	14.8	11.3	8.7
	CLE	104.48	✔		✔		37.5	23.6	15.8	22.3	0.8
	CLI	56.31	✔		✔		41.1	34.9	17.6	3.3	3
	GRE	198.92	✔		✔		31.4	17.4	26.3	21	3.9
	HAM	639.57	✔		✔		34.9	29.2	22.4	10	3.5
	PRE	36.24	✔		✔		46	24.9	18.6	7.6	3
	WAR	95.13	✔		✔		45.6	11	14.8	7.9	20.6
8		**1394.5**	**Average Condition**				**35.4**	**26.6**	**20.2**	**12.3**	**5.5**

District	County	Miles	Data Availability				Latest Pavement Condition in Percent Miles				
			2003	2004	2005	2006	PCR: > 90	PCR: 80-90	PCR: 70-80	PCR: 60-70	PCR: < 60
9	ADA	44.61	✔	✔		✔	46.1	40.1	12	0	1.7
	BRO	69.62	✔	✔		✔	60.5	39.3	0	0	0.1
	HIG	54.19	✔	✔		✔	78.3	17.9	2.1	1.2	0.6
	JAC	57.11	✔	✔		✔	16.7	17.4	25.3	25.4	15.3
	LAW	79.26	✔	✔		✔	33.7	20.1	11	21	14.2
	PIK	33.66	✔	✔		✔	2.2	4.5	33.3	47.7	12.2
	ROS	110.86	✔	✔		✔	27.8	35.1	12.1	19	6
	SCI	54.87	✔	✔		✔	26.6	31.8	26.7	12.6	2.2
9		**504.18**	**Average Condition**				**37.2**	**27.5**	**13.7**	**15**	**6.6**
10	ATH	80.73	✔	✔		✔	27.2	11.7	24.9	15.5	20.8
	GAL	48.9	✔	✔		✔	33.3	9.7	12.9	39.8	4.3
	HOC	28.06	✔	✔		✔	8	29.7	50.7	11.6	0
	MEG	51.28	✔	✔		✔	35.7	19.5	28.1	2.6	14.1
	MOE	45.14	✔	✔		✔	22	19.5	1.1	22.5	34.9
	MRG	21.36	✔	✔		✔	16.1	38.6	7.5	2.1	35.7
	NOB	13.3	✔	✔		✔	43.5	0	0	28.2	28.3
	VIN	38.63	✔	✔		✔	35.9	17.8	46.3	0	0
	WAS	83.83	✔	✔		✔	30.8	35.4	27.5	1	5.4
10		**411.23**	**Average Condition**				**28.6**	**20.9**	**23.8**	**12.6**	**14**
11	BEL	118.25	✔	✔		✔	19.1	4.5	17.9	29.2	29.4
	CAR	24.79	✔	✔		✔	30.9	51.1	12.9	4	1.3
	COL	134.49	✔	✔		✔	17	21.8	43.1	13.9	4.1
	HAS	46.7	✔	✔		✔	53	21.9	7.1	1.7	16.3
	HOL	50.32	✔	✔		✔	37.3	14.7	35.7	12.1	0.2
	JEF	103.72	✔	✔		✔	31.1	29	17.6	13	9.2
	TUS	158.1	✔	✔		✔	54.4	24.2	13.3	2	6
11		**636.37**	**Average Condition**				**33.8**	**21**	**22.5**	**12.2**	**10.6**
12	CUY	904.59	✔	✔		✔	37.5	20.8	21.6	11	9.2
	GEA	138.93	✔	✔		✔	24.3	38.2	27.7	5.9	3.9
	LAK	158.28	✔	✔		✔	8.1	23.2	31.6	29	8.2
12		**1201.8**	**Average Condition**				**32.1**	**23.1**	**23.6**	**12.8**	**8.4**
Statewide		***11611***	**Average Condition**				***32.9***	***24.9***	***21.7***	***12***	***8.5***

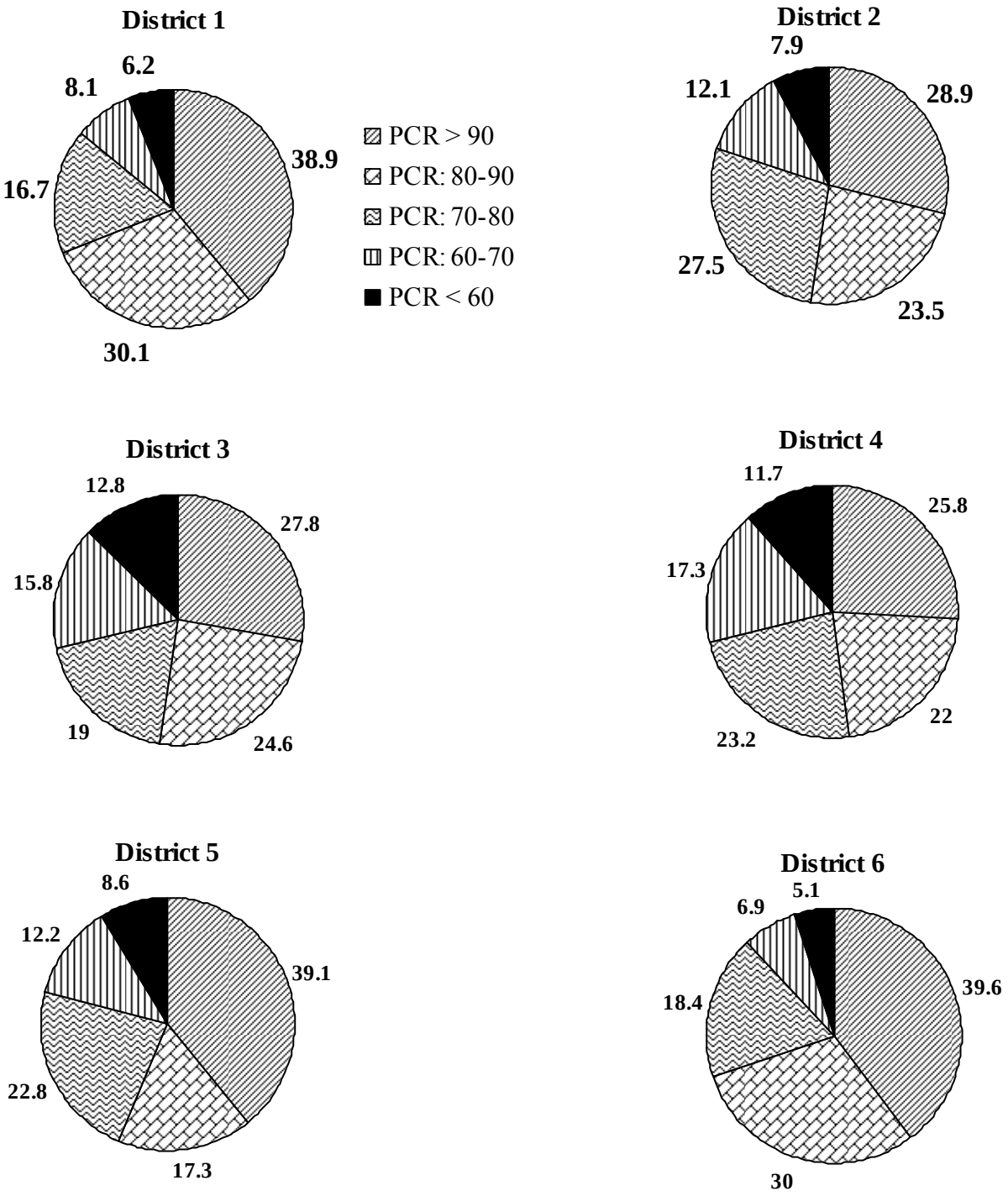


Figure 31-a. Condition Distribution of Local Pavements in Each District

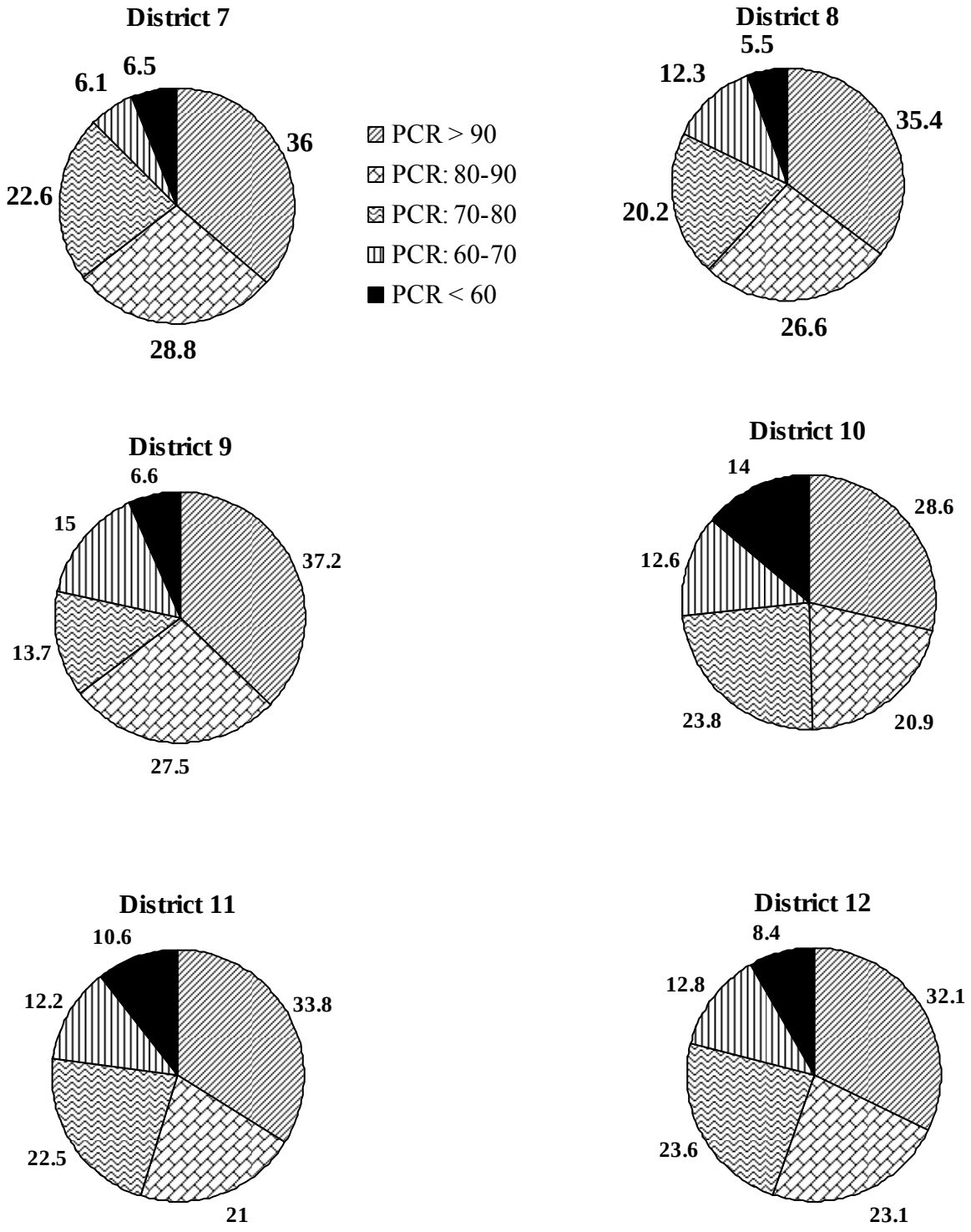


Figure 31-b. Condition Distribution of Local Pavements in Each District

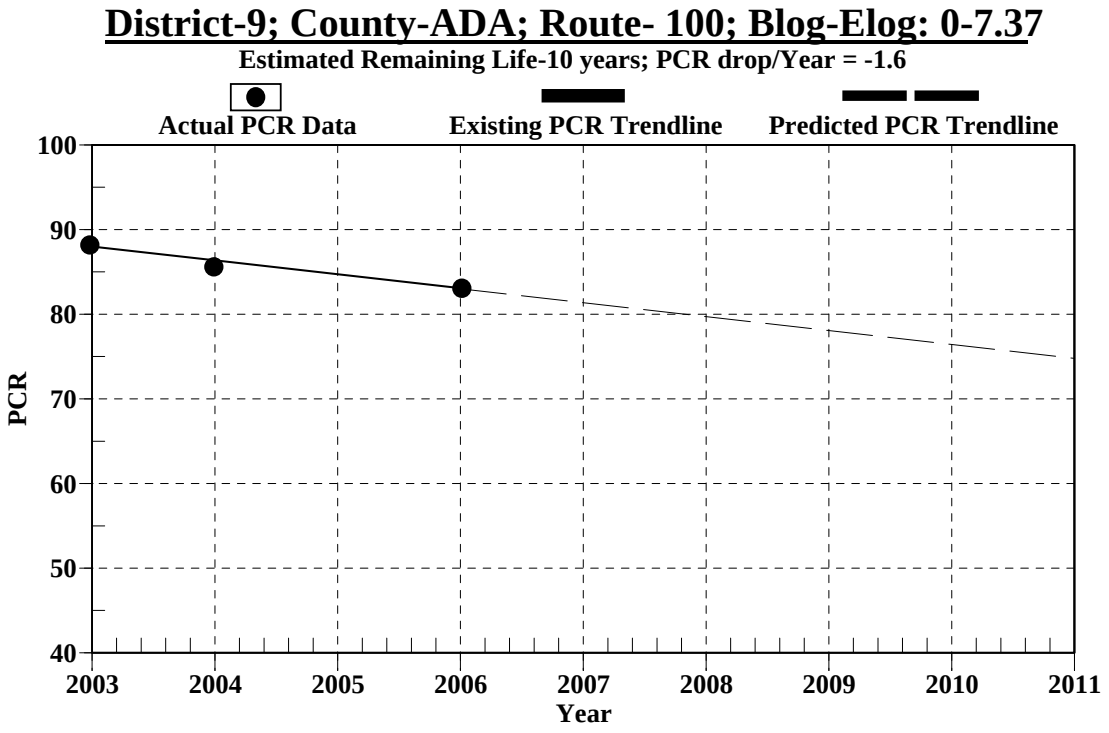


Figure 32. PCR Trend Based on Individual Slope for a Pavement Section

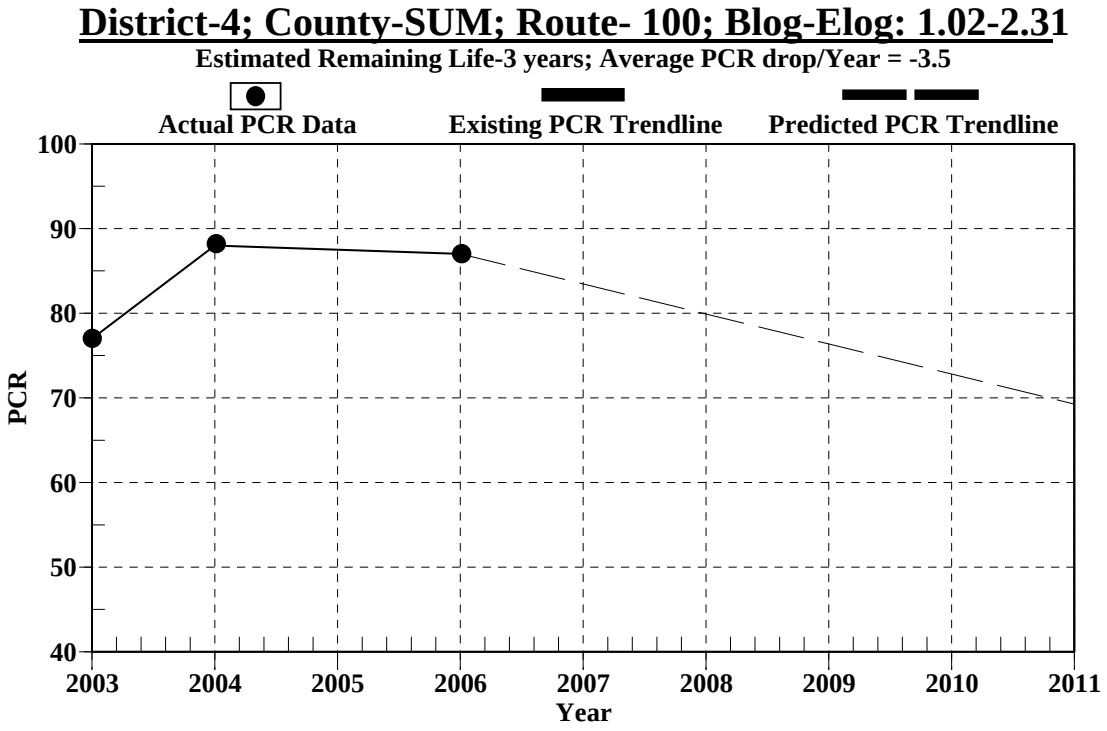


Figure 33. PCR Trend based on Average Sloped for a Pavement Section

Estimation of Remaining Life of Pavement

LOCALPMIS uses the predicted PCR and distress information to estimate the remaining life of the pavement. The terminal condition in terms of PCR or distress thresholds can be defined by the user. The default terminal condition is PCR value below 60.

Repair Candidates

The pavement database for federal aid local routes includes four types of pavements: Jointed Concrete Pavement (JCP), Local Pavement (Asphalt), Brick Pavement, and Gravel Pavement. The rehabilitation decision tree for Local Pavement was designed in cooperation with ODOT officials. For JCP, the same rehabilitation decision tree for state highways was used. Decision trees for the brick and gravel pavements are not available at this time.

Based on the repair decision tree and the current PCR and distress information, LOCALPMIS generates a report listing the pavement sections that require Preventive Maintenance (PM), Minor Rehabilitation, or Major Rehabilitation. The report also lists the pavement sections which do not require any repair.

Report

LOCALPMIS can generate both the existing and future pavement condition report and can also generate a graph displaying PCR trend for any individual pavement section. Both the existing and future condition reports contain the section-wise information of PCR and distresses.

More detailed information on the LOCALPMIS is presented in Appendix D.

CONCLUSIONS AND RECOMMENDATIONS

Transportation agencies around the Country must find ways to cope with rapidly rising construction costs, which are unlikely to be offset by highway budget increases in the foreseeable future. Prudent use of available rehabilitation budget is essential to maintain and preserve the existing highway infrastructure during this challenging period. Selection of the most beneficial projects among competing needs and determination of the most cost-effective rehabilitation strategies require knowledge regarding future system conditions. This research study has developed models and tools to forecast future conditions and estimate remaining service life of pavements. The results can be used to support pavement maintenance and rehabilitation planning and management decisions.

Based on the findings of this research study, the following conclusions can be made:

1. Pavement condition can be predicted using the models developed in this study. Having the capability to forecast future conditions and to estimate the remaining service life of pavements provides invaluable decision support in choosing the most cost-effective strategies
2. The following three forecasting models: the individual section regression, the "family" regression, and the Markov transition models were developed in this project. These statistical models were developed based on past performance data available in the ODOT pavement management database.
3. The family regression model and the Markov transition model require pavements to be grouped into "families" with similar characteristics. In this study, pavements within the same system, pavement type, or District, or those having received the same treatment activity are considered as in the same "family. However, there still can be fairly large variations in deterioration trends within the same "family". This "within family" variation is one of the sources of prediction errors.
4. A tool was developed to allow the user to define "families" with different characteristics. This provides more flexibility in choosing the "family" members yielding more accurate prediction. However, each family should include a significant number of pavements with

varying ages for the forecasting to be reliable. A minimum number of approximately 300 sections is recommended.

5. The prediction models were validated by comparing the predicted pavement distress and PCR conditions to the measured actual conditions. Predicted pavement conditions for the period of 2002-2006 were compared with measured actual conditions during the same period. In general, the predicted results matched reasonably well with measured data. The Markov model delivers the best overall accuracy, followed by the family regression model.
6. The individual regression model relies only on the available past deterioration trend to predict future conditions. It requires at least a few years of known PCR condition data for a specific pavement section. Therefore, it cannot be applied to newer pavements, where predictions of future conditions would be most useful.
7. Both the family regression and Markov models predict future conditions based on the known current (or latest available) condition. The prediction error increases as the time span increases. That is, prediction of the near future is more accurate. Therefore, condition forecasting should be performed each year based on the latest, most updated current condition.
8. The Markov model developed in this study first predicts the deduct trend of each individual distress. It then predicts the PCR value by summing up the total deducts from of the all distresses. The ability of the Markov model to predict the individual distress level (and the likely severity and extent) is an important benefit over the other forecasting models.
9. Attrition of pavement condition data due to fewer pavements with more advanced ages, also called "drop outs", can cause the average deterioration trend to appear to 'level off' and not deteriorate any further beyond a certain age. This can result in overestimation of pavement conditions and possibly cause under funding of the rehabilitation program. A technique called 'imputation' was used to address this problem for both the family regression and Markov models.
10. All three of the developed forecasting models can predict non-linear deterioration trends. The Markov model has the advantage of forming the best-fit non-linear deterioration curve without requiring the non-linear function to be specified.
11. The predictions provided by the forecasting models are not perfect. All three models fail to accurately predict pavement conditions when the deterioration trends are inconsistent,

such as pavements that deteriorate suddenly following a steady deterioration, pavements that stop deteriorating after relatively rapid deterioration, or pavements with fluctuating conditions but no apparent deterioration trend.

12. The Markov model requires a significant number of pavement sections with similar characteristics in order for the developed transition matrix to be reliable. Since the ODOT pavement database contains a large number of pavement sections, this does not present a major problem, especially for the more commonly performed treatment activities such as overlays. For treatment activities that do not have a sufficient number of pavement sections, the family regression model with Shahin's 'shift' method can be used.
13. The remaining service life of a pavement is estimated by counting the number of years between the current year and the year its predicted conditions fall below a specified terminal condition. The default terminal condition for Priority system pavements is PCR value of 65, and for General system pavements, PCR of 60.
14. Pavements with zero years of remaining service life are considered as 'deficient'. Based on the forecasted pavement conditions and the rehabilitation work planned by ODOT for the next five years, the number of pavements that will be in deficiency will rise substantially in the next few years.
15. Reasonable initial PCR values after various rehabilitation treatments were determined based to on average distress condition progressions after the same rehabilitation treatment. The type and level of distresses presented prior to the rehabilitation were also factored in. The resulting initial PCR values reflect more realistically the actual pavement condition than assigning a perfect score to all newly rehabilitated pavements.
16. A set of rehabilitation recommendation decision trees developed by the Office of Pavement Engineering was used to establish the most appropriate treatment for each pavement section. The recommended rehabilitation treatment, if any, was determined based on the type of pavement structure, traffic volume on the pavement, current pavement distress conditions, past performance, and treatment history.
17. Current and future maintenance and rehabilitation needs can be determined. The future needs are dependent upon the work being performed and planned. A tool has been developed to allow various multiple-year work plans to be evaluated as to their impact on forecasted future network conditions.

18. A separate pavement database for local federal-aid routes has been developed. The amount and type of data available to these local pavements are very different from that of the state highway pavements. Therefore, a separate database and different functions have been developed.

The following recommendations are made based on the findings of this study:

1. Overall, the developed forecasting models provide acceptable accuracy in predicting future pavement conditions. Therefore, it is recommended that ODOT use the predicted conditions to support pavement management decisions such as developing rehabilitation work plans.
2. The Markov transition model is the recommended model for predicting pavement conditions after overlay (with or without repair), which is the predominant rehabilitation treatment, accounting for 85-90 percent of total repair mileage.
3. When the number of pavements in a "family" group is relatively small (for example, less than 300 miles total), family regression model with 'shift' is recommended.
4. The individual regression model is recommended for local Federal-aid route pavements, since no pavement age data are currently available. The dependent variable is the PCR value, whereas the independent variable is the calendar year.
5. Further study to refine the "family group" definition is recommended to further improve the prediction accuracy.
6. The predicted pavement conditions and remaining service life estimations should be updated each year based on the latest pavement condition rating. The corresponding rehabilitation treatment recommendations for current and future years and the multiple-year work plan should also be updated on a yearly basis.
7. Continuing yearly collection of pavement condition data in a consistent manner is highly recommended.
8. The initial PCR value estimates after various rehabilitation treatments developed in this study are recommended to be used by ODOT to reflect more realistically the actual pavement conditions.

9. The statewide pavement network conditions are projected to worsen in the next several years based on the forecasted pavement conditions and the scheduled work. It is recommended that ODOT take countermeasures to preserve the existing pavement assets. Such countermeasures may include more careful selection of pavement sections for rehabilitation, applying more cost-effective rehabilitation treatments, and adopting best pavement management practices at both Central and District offices.

IMPLEMENTATION PLAN

The results of this research study can be implemented as follows:

1. The pavement condition forecasting models, the remaining service life estimation function, and the rehabilitation recommendation decision trees have been incorporated into the ODOT Pavement Management Database. Predicted future conditions, estimated remaining service lives, and rehabilitation treatment recommendations for a specified group of pavements or for the entire state highway network can be generated. Alternative multiyear rehabilitation work plans can be evaluated with regard to their impact on future network conditions. The Office of Pavement Engineering has taken a proactive role in leading the efforts to implement the results of this research study. Most of the tools developed in this study have been used by the Office to support pavement management activities.
2. The results of this study may be integrated with findings from other related research projects to support a comprehensive pavement management system. Such a system can fully support the various critical pavement management decisions routinely made by the Central Office as well as District Offices in a timely manner.
3. Local agencies (counties and municipalities) can use the local Federal-aid routes pavement database developed in this study to support local pavement management decisions. Since the same pavement condition rating system is used for both State highways and local roads, more consistency in the pavement management process is possible.

APPENDICES

A. References

B. Rehabilitation Decision Trees

C. PMIS User Manual

D. Local PMIS User Manual

APPENDIX A. REFERENCES

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Yu, J. (2005). Pavement Service Life Estimation and Condition Prediction. PhD. Dissertation, University of Toledo, Toledo, Ohio.

APPENDIX B. REHABILITATION DECISION TREES

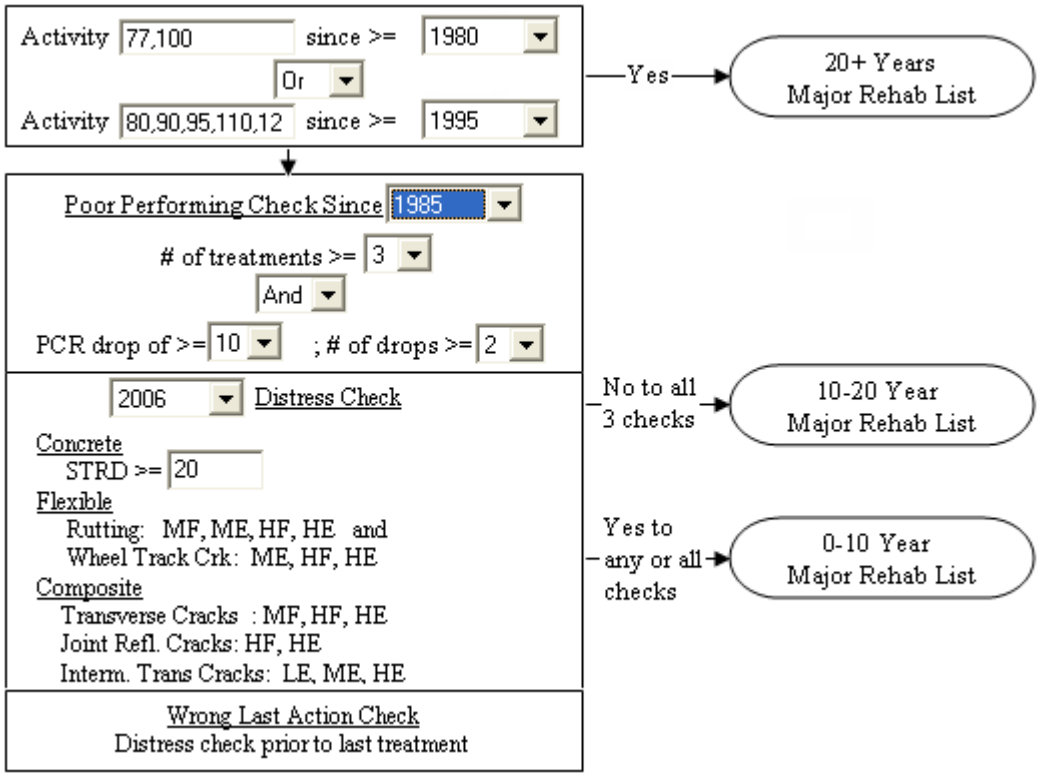

FIGURE B-1. Priority System Major Rehabilitation Candidates List

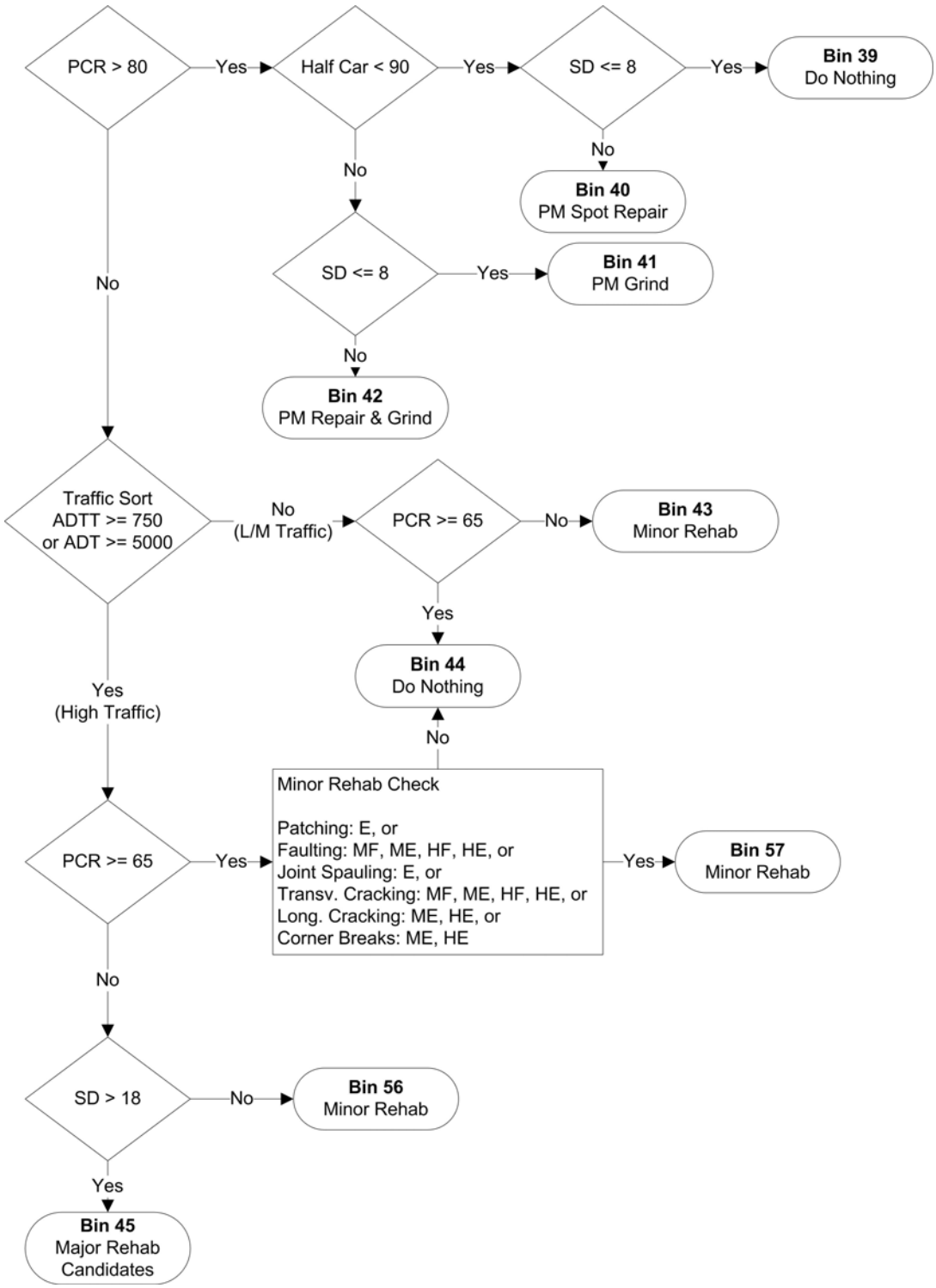

FIGURE B-2. Priority System Concrete Pavements Decision Tree

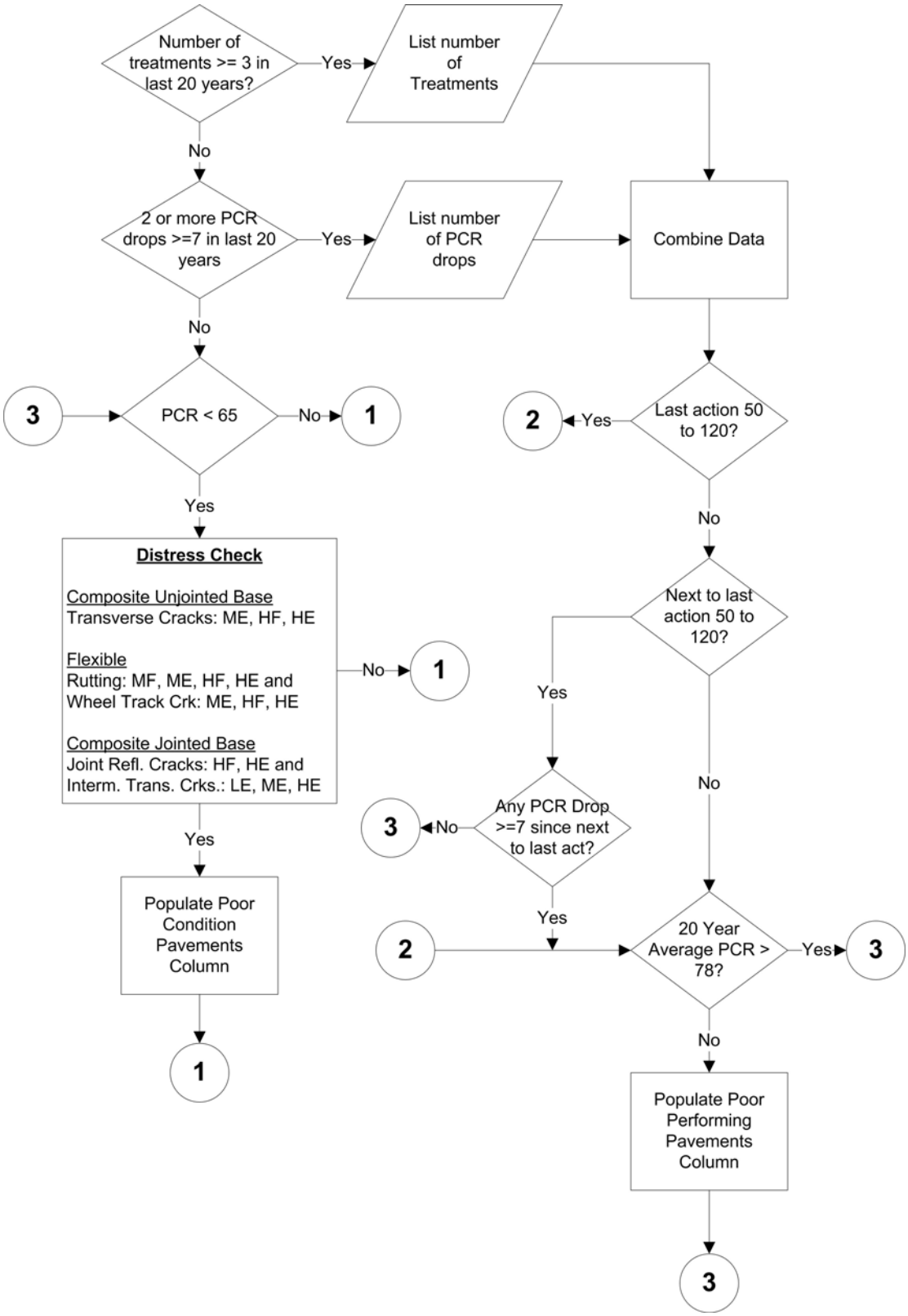

FIGURE B-3. Priority System Flexible and Composite Pavements Decision Tree

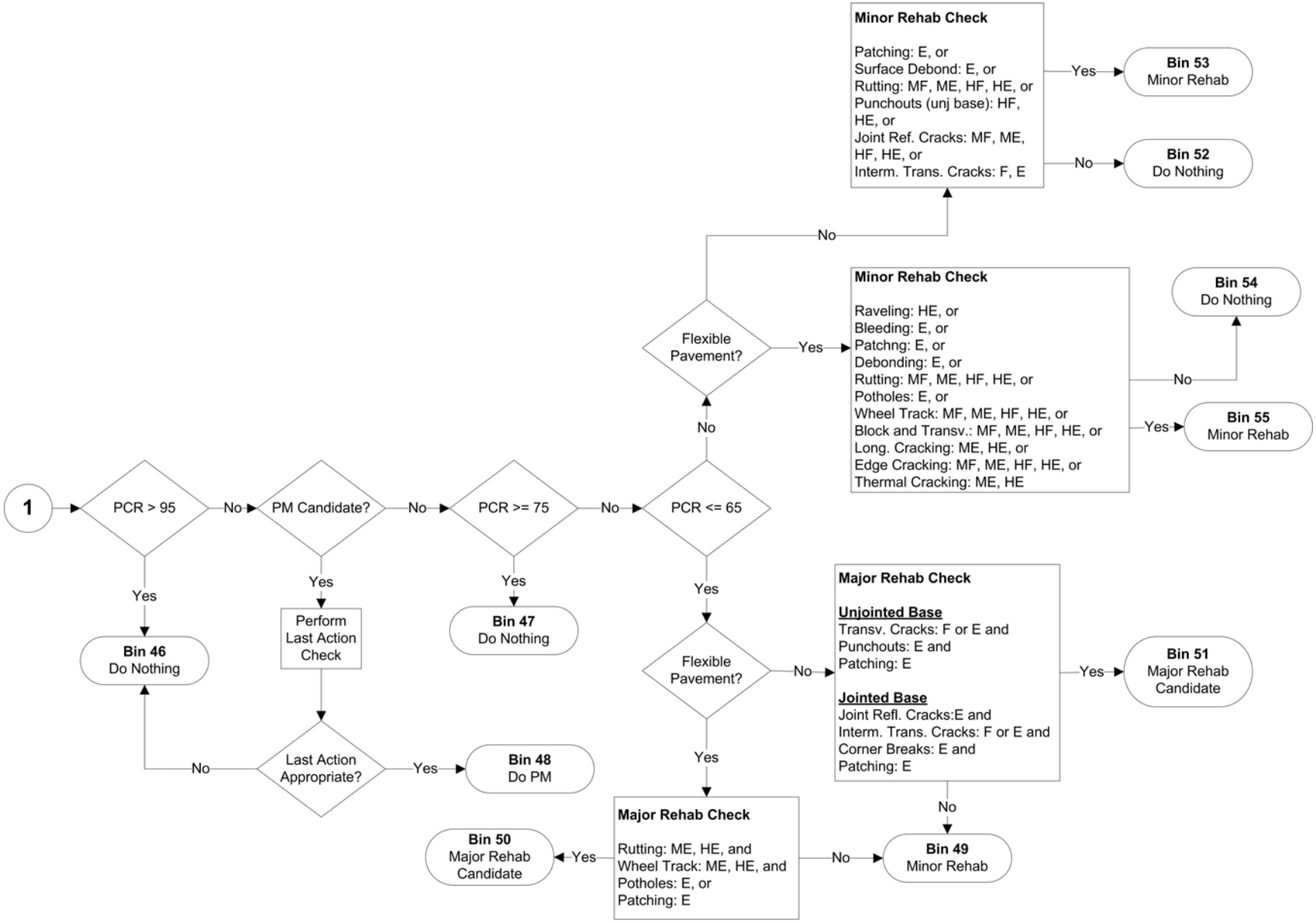

FIGURE B-4. Priority System Flexible and Composite Pavements Decision Tree (Continued)

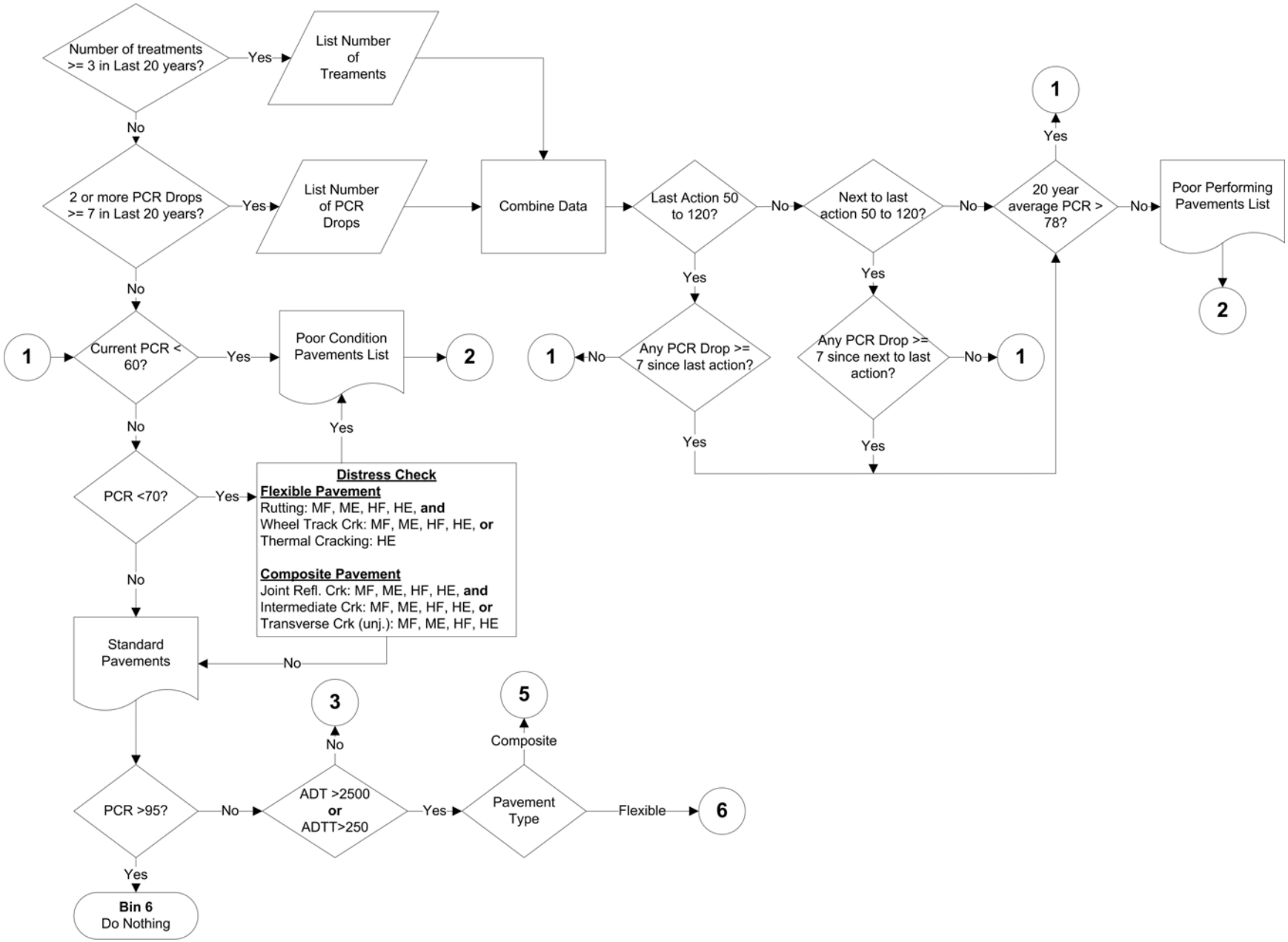

FIGURE B-5. General System Decision Tree

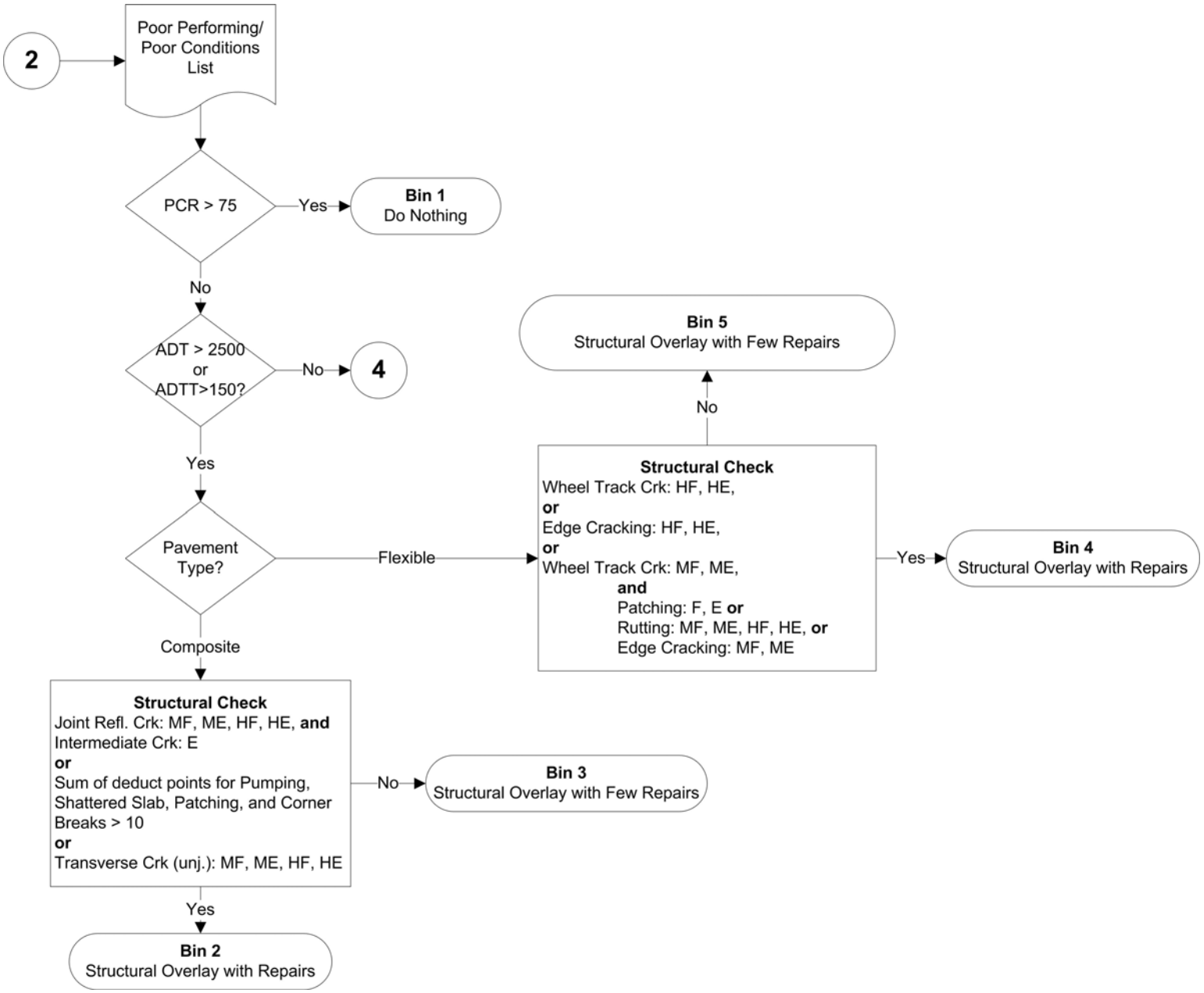

FIGURE B-6. General System Decision Tree for Poor Performing and Poor Condition Pavements

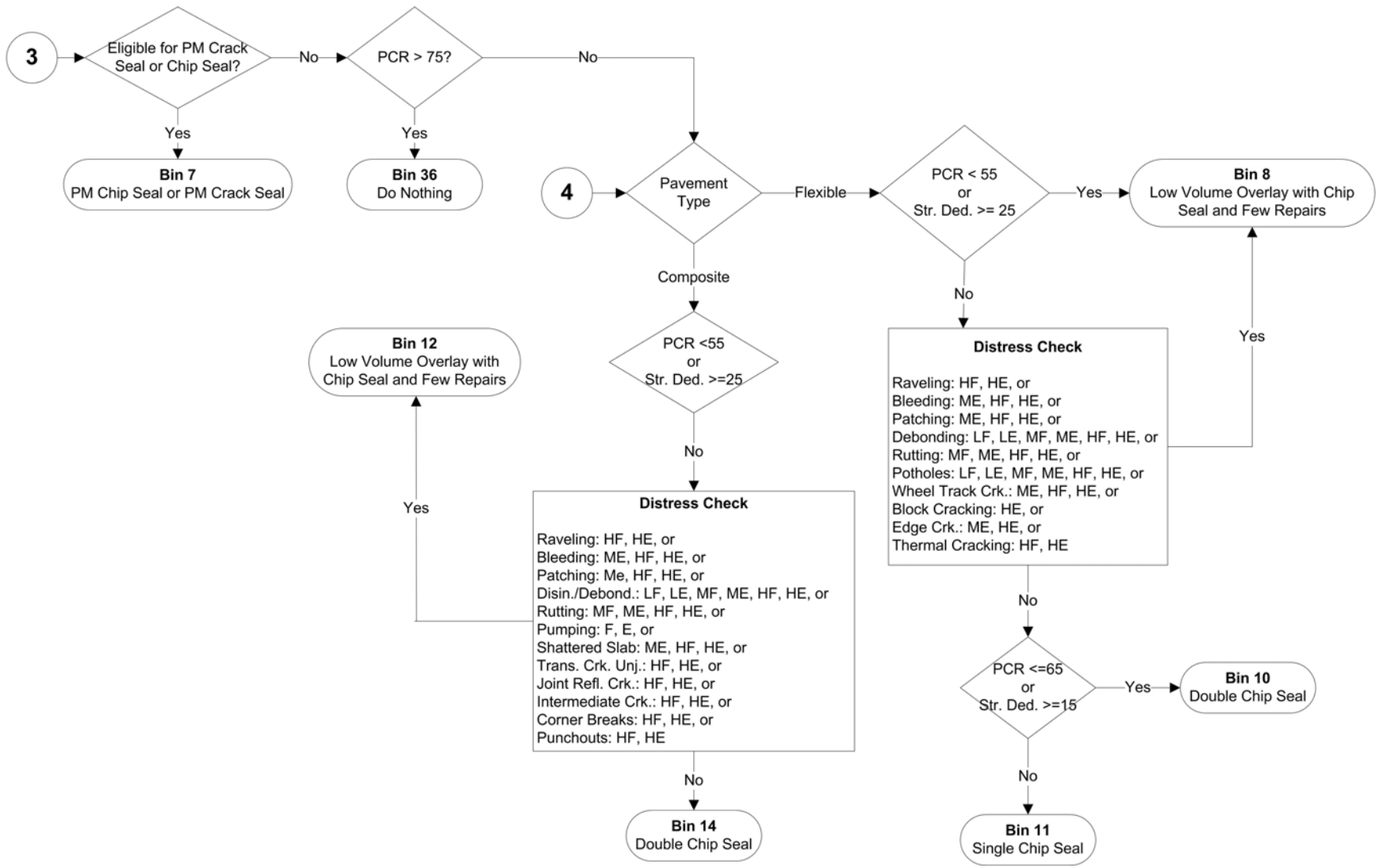

FIGURE B-7. General System Decision Tree for Low Volume Pavements

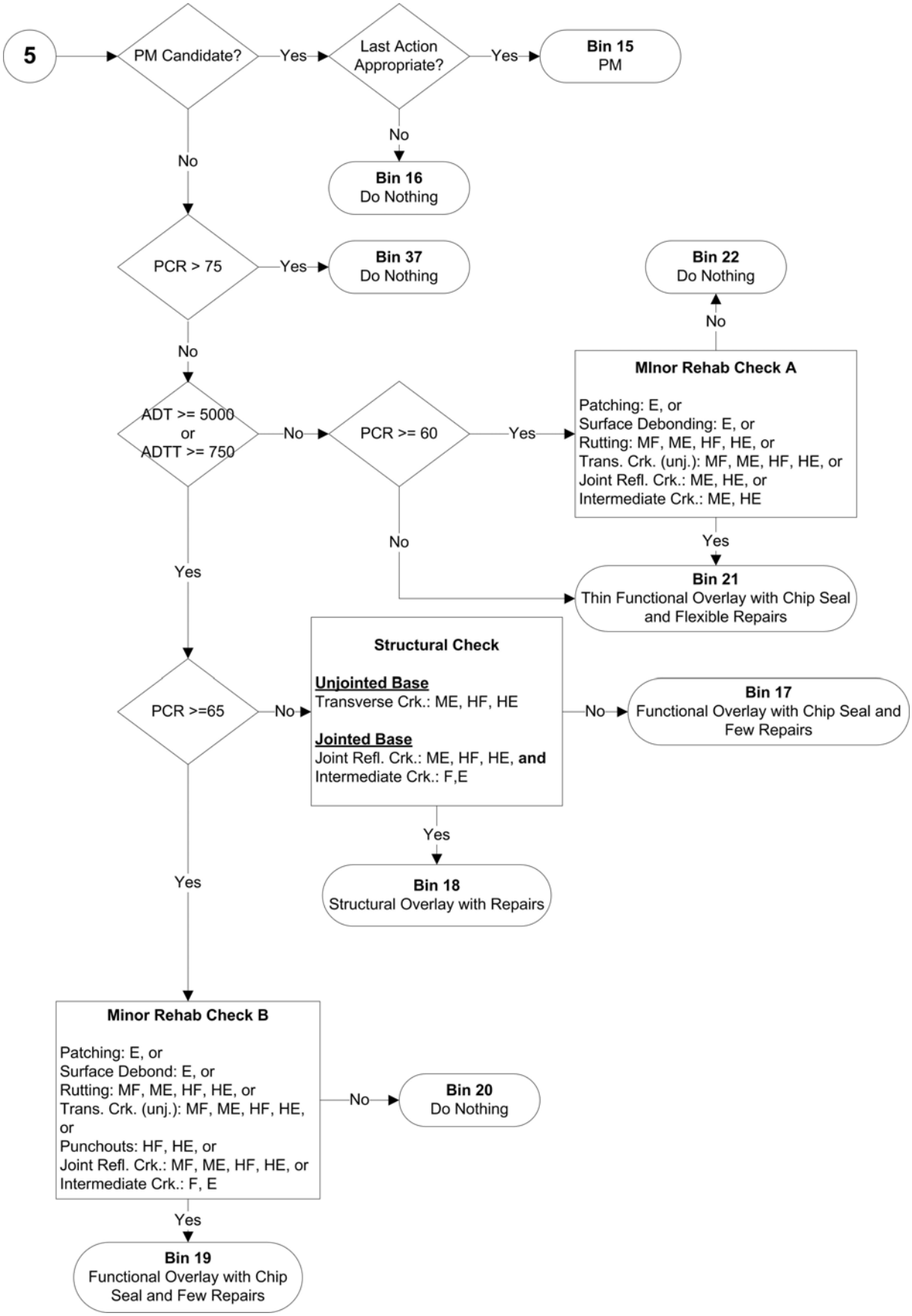

FIGURE B-8. General System Decision Tree for Composite Pavements

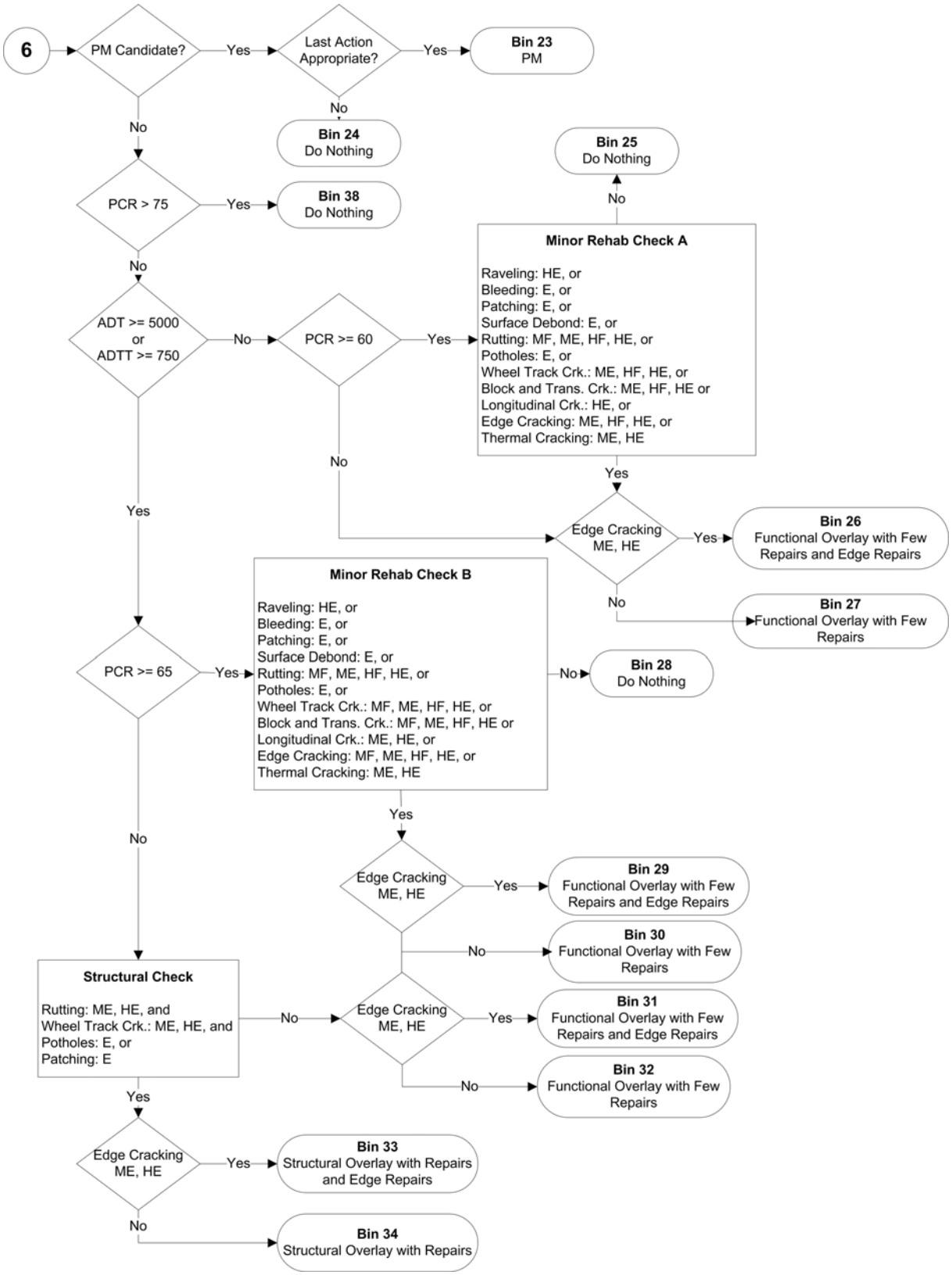

FIGURE B-9. General System Decision Tree for Flexible Pavements

APPENDIX C. ODOTPMIS USER MANUAL

The pavement management database (ODOTPMIS) has been extensively updated as part of this study. Several new tools were added and a few of the existing tools were revised. This Appendix provides a detailed user manual to the entire updated ODOTPMIS.

The new tools include: Generate Markov Predictions, Show Predicted Pavement Conditions, Estimate Remaining Life, and Import Planned Projects.

The tools that have been revised are: Derived Performance Trend, Rehabilitation Candidate Lists, Apparent Projects Determination, and Import Pavement Condition Data.

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INTRODUCTION

The Infrastructure Information System Laboratory at the University of Toledo has developed a Pavement Database for the Ohio Department of Transportation using the Microsoft Access database format. The ODOTPMIS includes the database and a set of reporting tools to extract the data necessary for pavement performance analysis.

This section of the user's manual includes installation procedures of the ODOTPMIS, an introduction to the menu items, and a brief overview of the basic operations.

1.1 System Installation

Three types of installations may be performed: full, lightweight, and executable file only. The full version includes the entire database, and is necessary for new users. The lightweight version is for users who have the database, but wish to update the program and the required runtime components. During installation, click the "Yes," "Next," and "OK," buttons to install ODOTPMIS successfully. The default directory where PMIS is installed is "C:\Program Files\ODOT Pavement Management Information System." Users can change this installation directory by selecting a different location. Figure C-1 shows the sequential steps in installing ODOTPMIS for the full and lightweight versions.

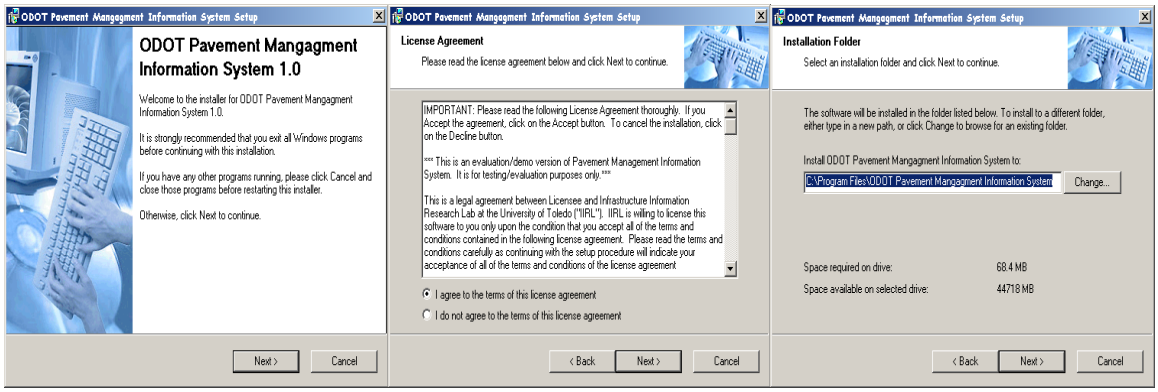


FIGURE C-1. Installation Procedure

Users requiring an executable file only installation should download the new executable file from the ODOTPMIS download page and replace the existing executable file (ODOTPMIS.exe) found in the installation directory.

Some program updates may also require updating tables in the database. To replace only these tables in the database:

1. Download the updated tables
2. Open the original database (odot.mdb) in Microsoft Access
3. Delete or rename the tables which will be replaced
4. Under the "File" menu choose "Get External Data" and click "Import"
5. Select the newly downloaded database
6. Select the updated tables
7. Click OK

Newer versions and updates of ODOT PMIS can be downloaded from http://www.eng.utoledo.edu/civil/chou/index.htm under the OdotPMIS Download Page link. Once ODOTPMIS is installed, it attempts to locate the most recently accessed database. If no database can be found, it prompts the user to locate the database manually. To store this path, go to the "File" menu, choose "Preference," check the "Load Last Database" and "Save Database Path" checkboxes, and click the "Apply" button. In the future, ODOTPMIS will use this saved path as the default database path.

1.2 Reinstallation

After each reinstallation of the ODOPMIS, the user must locate the path to the database.

1.3 Uninstallation

ODOTPMIS should be uninstalled before a full reinstallation. When uninstalling an older version of the ODOTPMIS, the database is not deleted automatically. If a database with the same name already exists in the same directory where a full version of ODOTPMIS is to be installed, the new database can not be copied into the same directory. The user must manually delete of the older database. This is done to prevent accidental overwriting of the existing database.

1.4 System Requirements

Recommended software platform requirements for running this package are:

1. Windows 98 / Me / 2000 / XP
2. Microsoft Access 2000

Recommended minimum hardware platform requirements for running this package are:

1. Pentium II 300Mhz CPU
2. 128MB RAM
3. 14" color monitor
4. 2GB free hard disk space
5. Mouse
6. Color printer
7. 4MB video memory
8. CD-ROM drive

1.5 Compact Database

Users may find it is necessary to compact the database when its size exceeds 1GB. The database can be compacted by the following process.

1. Choose "Compact and Repair Database" in the "File" menu
2. Open the Access database file "ODOT.MDB" and in the "Tools" menu, choose "Database Utilities," and click on "Compact and Repair Database"

This operation may take 5 – 10 minutes, depending on the size of the database and the specifications of the computer.

1.6 Required Tables

For the PMIS utility to operate, several Data and Look-Up tables are required in the database. The tables are:

TABLE C-1. PMIS Required Tables

DATA_Apparent Projects	LU_MarkovFamilyDistress	LU_Slope
DATA_FutureProjects	LU_MarkovFamilyPCR	LU_STD Base Class
DATA_InitialCondition	LU_MarkovTree	LU_STD Surface Class
DATA_ODOT	LU_Median Type	LU_Structural Number
DATA_PERF_Analysis	LU_NLFID	LU_Weather
DATA_PERF_BASE	LU_Parameter Range	LU_STD Surface Class
DATA_Project History	LU_PaveType	LU_Structural Number
DATA_Road Inventory	LU_PQIParameters	LU_Weather
LU Pavement Layer	LU_Priority	LU_STD Surface Class
LU_Activity	LU_Project AggType	LU_Structural Number
LU_Activity Modified	LU_RehabCost	LU_Weather
LU_AggType	LU_Repair Limits	LU_Structural Number
LU_BinSummary	LU_Repair Logic	LU_Weather
LU_Centerline Length	LU_Route_Suffix	LU_Color
LU_FHWA Surface Class	LU_Deduct_1998	LU_COST
LU_Functional Class	LU_Distress	LU_County
LU_Inflation	LU_Distress_1998	LU_Deduct
LU_Jurisdiction	LU_LAYER	

PMIS prevents all operations from being performed in the database if any of these tables are missing.

BASIC USER INTERFACE ELEMENTS

ODOTPMIS was developed using Microsoft Visual Basic 6.0 to replicate common window-based graphical user interfaces. As such, the PMIS interface utilizes drop down menus located at the top of the screen, a number of buttons located beneath the menus, and an object browser to list queries and tables stored in the pavement management database. The following is a screenshot of ODOTPMIS.

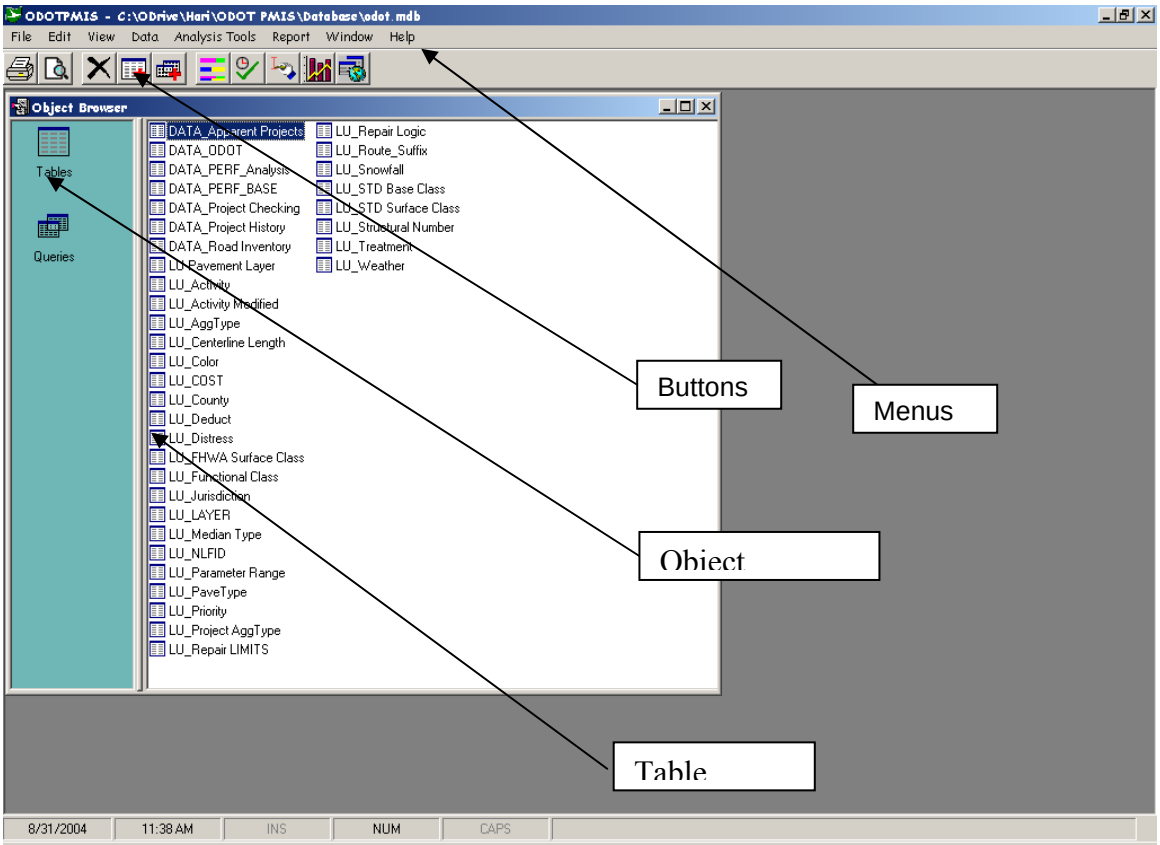


FIGURE C-2. ODOTPMIS User Interface

File Menu

The following figure shows the "File" menu options.

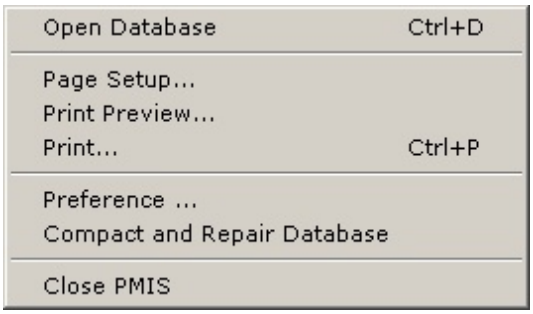


FIGURE C-3. ODOTPMIS File Menu

3.1 Open Database

This command is used to open the desired database for use within ODOTPMIS. The dialog box shown in Figure C-4 is shown when this option is clicked.

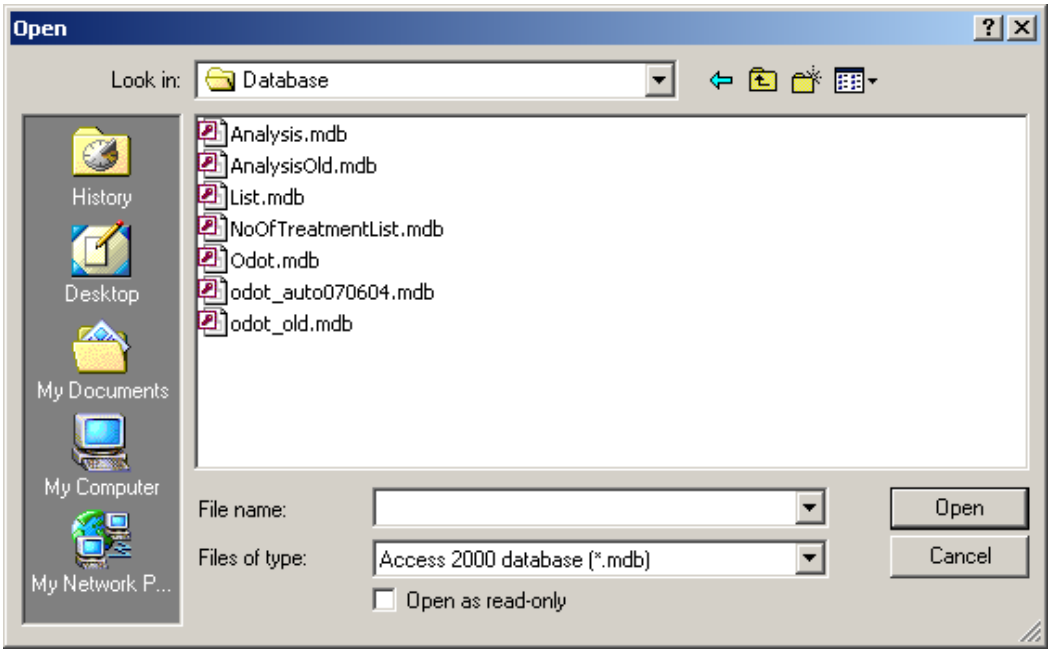


FIGURE C-4. Open Database Dialog Box

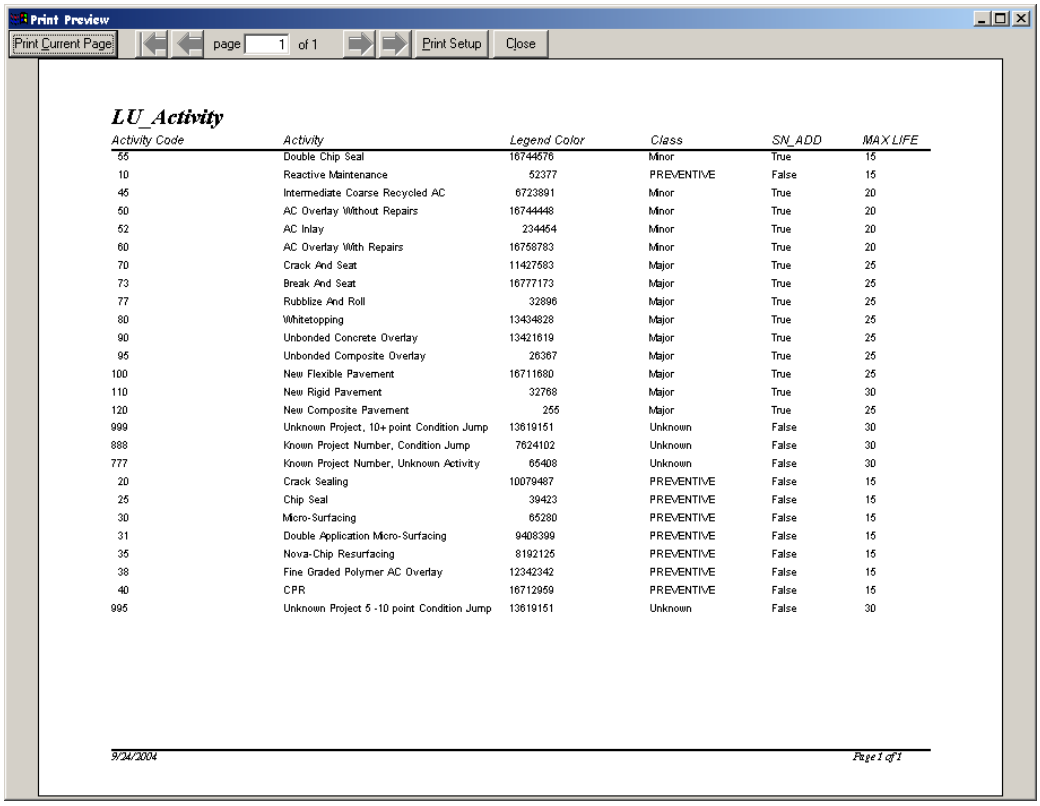
Choose the database file by selecting the directory from the drop down selector labeled "Look in." Select the file and click "Open."

3.2 Print Preview

All the tools in ODOTPMIS have a "Print Preview" option. Check this option to get a preview of the output obtained from the tools (reports, tables, or charts). Figure C-6 shows the preview of the lookup table "LU_Activity."

To preview the same table, use the following process:

1. In the object browser, select "LU_Activity"
2. In the "File" menu, select "Print Preview"
3. The preview shown in Figure C-6 will be generated

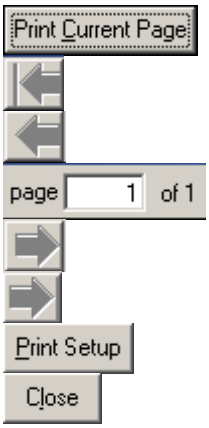


LU_Activity

Activity Code	Activity	Legend Color	Class	SN_ADD	MAX LIFE
55	Double Chip Seal	16744576	Minor	True	15
10	Reactive Maintenance	52377	PREVENTIVE	False	15
45	Intermediate Coarse Recycled AC	6723891	Minor	True	20
50	AC Overlay Without Repairs	16744448	Minor	True	20
52	AC Inlay	234454	Minor	True	20
60	AC Overlay With Repairs	16758783	Minor	True	20
70	Crack And Seat	11427583	Major	True	25
73	Break And Seat	16777173	Major	True	25
77	Rubblize And Roll	32896	Major	True	25
80	Whitetopping	13434828	Major	True	25
90	Unbonded Concrete Overlay	13421619	Major	True	25
95	Unbonded Composite Overlay	26367	Major	True	25
100	New Flexible Pavement	16711680	Major	True	25
110	New Rigid Pavement	32768	Major	True	30
120	New Composite Pavement	255	Major	True	25
999	Unknown Project, 10+ point Condition Jump	13619151	Unknown	False	30
888	Known Project Number, Condition Jump	7624102	Unknown	False	30
777	Known Project Number, Unknown Activity	65408	Unknown	False	30
20	Crack Sealing	10079487	PREVENTIVE	False	15
25	Chip Seal	39423	PREVENTIVE	False	15
30	Micro-Surfacing	65280	PREVENTIVE	False	15
31	Double Application Micro-Surfacing	9408399	PREVENTIVE	False	15
35	Nova-Chip Resurfacing	8192125	PREVENTIVE	False	15
38	Fine Graded Polymer AC Overlay	12342342	PREVENTIVE	False	15
40	CPR	16712959	PREVENTIVE	False	15
995	Unknown Project 5 -10 point Condition Jump	13619151	Unknown	False	30

FIGURE C-6. Print Preview of [LU_Actvity]

This preview page has the following options:



Print the current page only
Go to first page
Go to previous page
Current page number
Go to next page
Go to last page
Open the print setup window
Close the print preview

FIGURE C-7. Preview Page Options

The "Print Setup" window provides options to customize the document for printing. This allows users to change the layout, column widths, column orders, and other organizational aspects. Figure C-8 shows the "Print Setup" window.

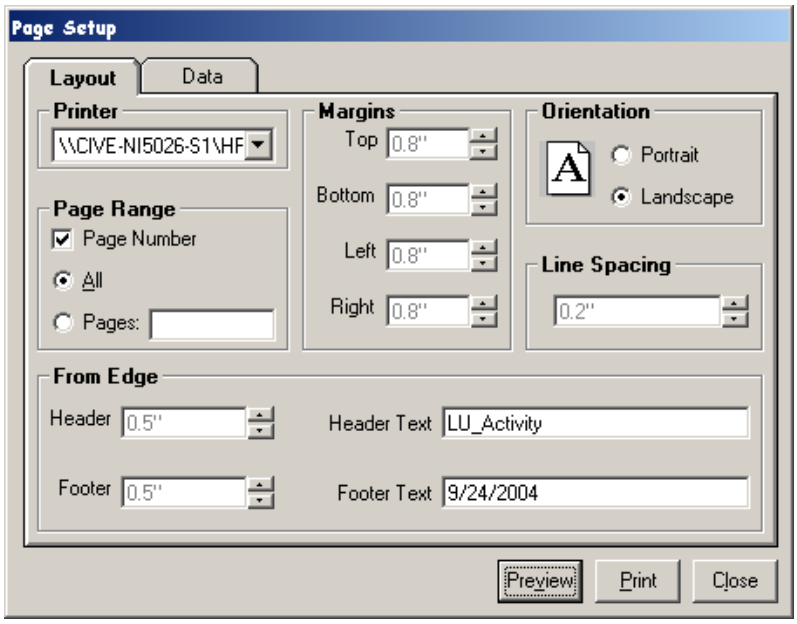


FIGURE C-8. Print Setup Dialog Box – Layout Tab

The "Print Setup" dialog has two tabs: layout and data. The layout tab, shown above in Figure C-8, provides options to select the printer, printed page range, orientation, layout, line spacing, and header and footer spacing and text.

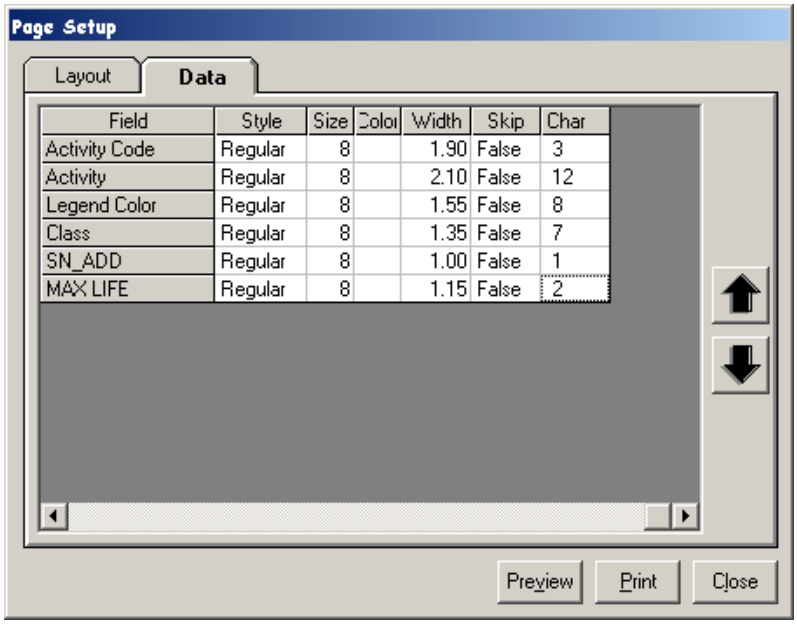


FIGURE C-9. Print Setup Dialog Box – Data Tab

The data tab, shown above in Figure C-9, lists the fields that will be printed, along with options to change their appearance.

Users can click on any of the first three columns to change the font, style, and size of the text as shown below in Figure C-10. The following dialog box will be displayed when one of the options is clicked. Users then select the required font, style, and size in the dialog and click "OK." The fields will reflect the new changes.

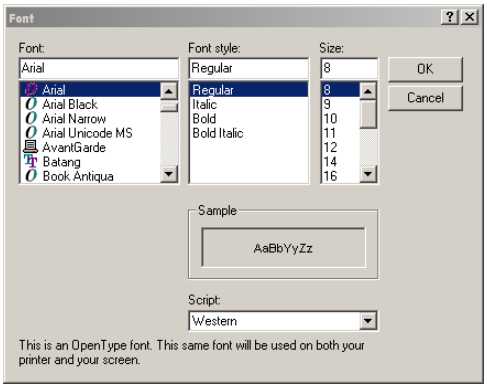


FIGURE C-10. Font Dialog Box

The main "Print Setup" window has additional options for users to customize the data printout. These options are explained below.

1. **Color**: Changes the text color of the data in selected column
2. **Width**: Columns are adjusted to a default width based on their length in the printout. The "Width" field allows users to enter a custom width length in inches
3. **Skip**: Select a column to hide or show in the printout
4. **Char**: Shows the character length of the field
5. The buttons on the right of the screen allow users to change the order of the fields that will be on the printout
6. **Preview**: Displays a mockup with the changes applied
7. **Print**: Print and close the "Print Setup" window
8. **Close**: Closes the "Print Setup" window without making any changes

3.3 Print

This command under the "File" menu is used for printing a table, chart or a grid.

3.4 Preference

This option is used to set the default options for ODOTPMIS as shown in Figure C-11. The presence or absence of a checkmark next to an option indicates its state.

Startup options appear when the application is opened. These are explained below.

1. **Show Splash Window**: Displays a window showing application information when ODOTPMIS is opened.
2. **Load Last Database**: Loads the last database opened on ODOTPMIS startup.

Exit options appear when the application is closed. These are explained below.

1. **Confirm Exit**: Displays a warning confirmation window when users attempt to close the application.
2. **Compact Database Before Exit**: Compacts the database before each close.
3. **Save Database Path**: Saves the current database path to allow users to open the same database without reentering the location the next time it is opened.

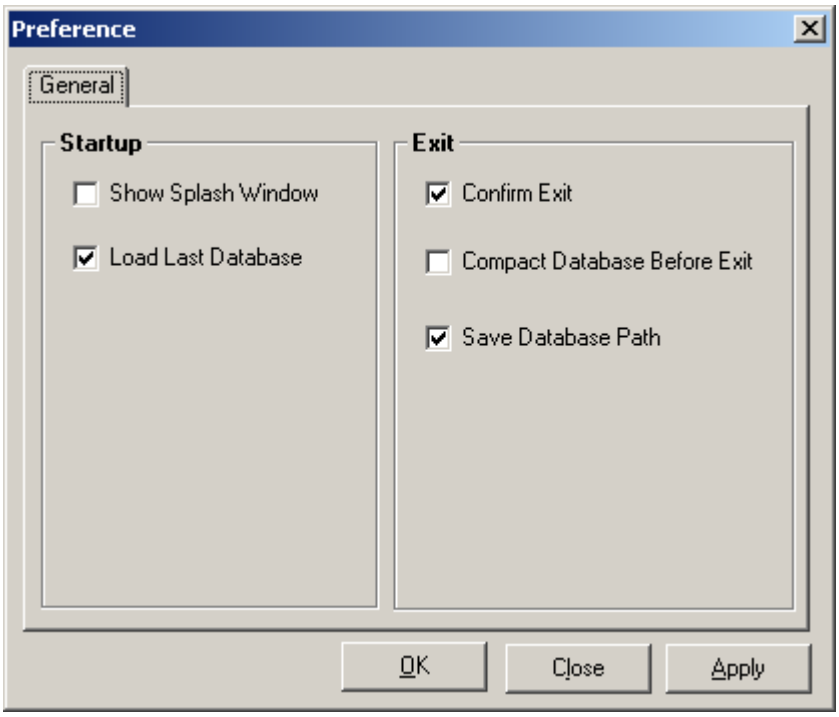


FIGURE C-11. Preference Setup Interface

3.5 Compact and Repair Database

The "Compact and Repair Database" command activates a utility that compresses the database, which increases the analysis speed. This command should be performed regularly to ensure optimal performance. ***WARNING: If the database is allowed to reach its maximum size of two gigabytes, none of the PMIS functions will function***. Furthermore, at two gigabytes, the database cannot be used for executing queries. To prevent or alleviate these problems, compact the database regularly.

3.6 Close PMIS

This option is used to exit from the PMIS application.

Edit Menu

The "Edit" menu contains commands for changing, creating, and deleting tables and queries. This menu will affect whichever data type is displayed in the object browser, either a query or table. The commands included on this menu are "Open," "Design," "Delete," and "New." The following figure shows the drop down menu

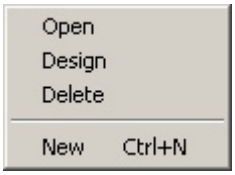


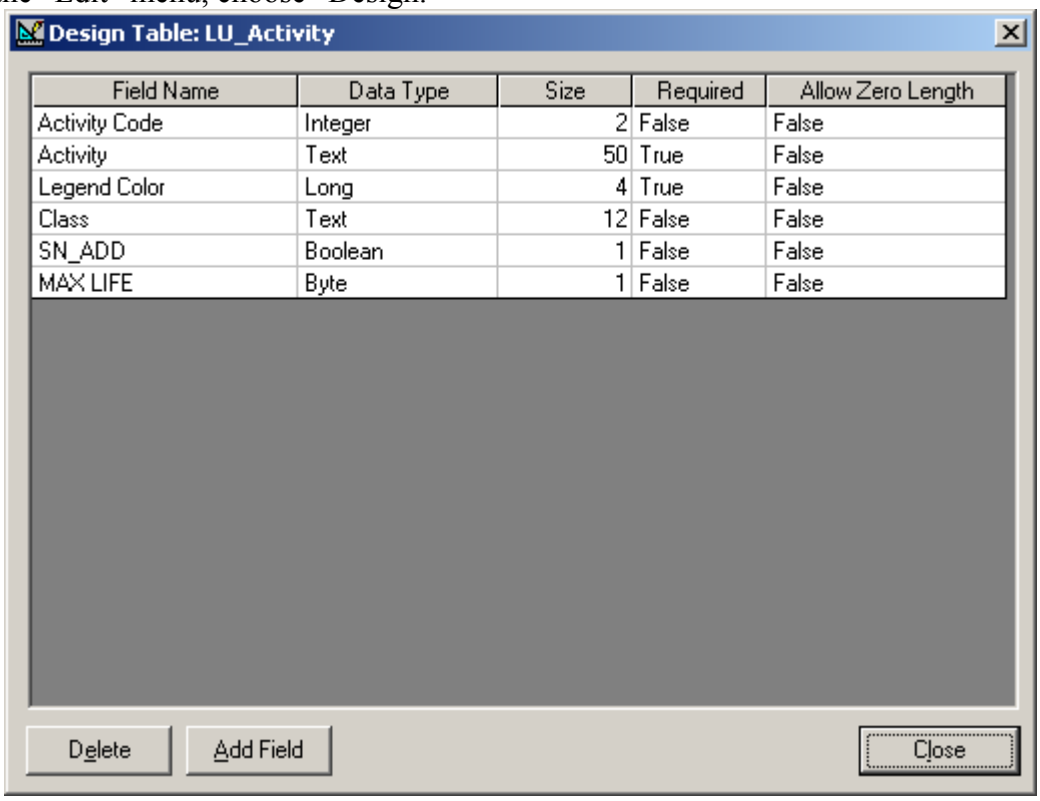
FIGURE C-12. ODOTPMIS Edit Menu

4.1 Open

This option opens a table for editing values. To open a table, highlight a table in the object browser and select "Open" in the edit menu.

4.2 Design

The "Design" command allows for the creation and deletion of columns in tables or modification of the SQL in queries. To modify a table or query, select it in the object browser and in the "Edit" menu, choose "Design."



Field Name	Data Type	Size	Required	Allow Zero Length
Activity Code	Integer	2	False	False
Activity	Text	50	True	False
Legend Color	Long	4	True	False
Class	Text	12	False	False
SN_ADD	Boolean	1	False	False
MAX LIFE	Byte	1	False	False

FIGURE C-13. ODOTPMIS Design Menu

To add, click on the “Add Field” radio button in the lower left corner of the window. To delete, select the field and click the “Delete” button in the lower left corner of the window. To modify, select the field. ODOTPMIS will allow users to make the changes directly in the table.

4.3 Delete

This command deletes the selected table or query from the database.

4.4 New

Creating a New Table:

1. Click “New” in the “Edit” menu
2. The dialog box as shown in Figure C-14 will appear
3. Enter the desired table name in the dialog and click “Create”
4. This will display the “Design Table Dialog” shown in Figure C-15. Users can add or delete fields, and set field properties like the field name, data type, and size, as well as toggle whether this field is required and whether a zero length is allowed

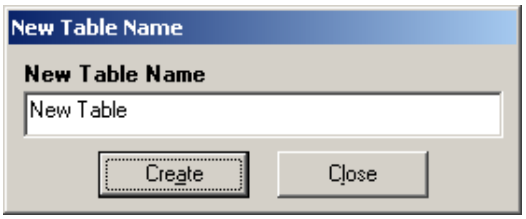


FIGURE C-14. New Table Name Input Interface

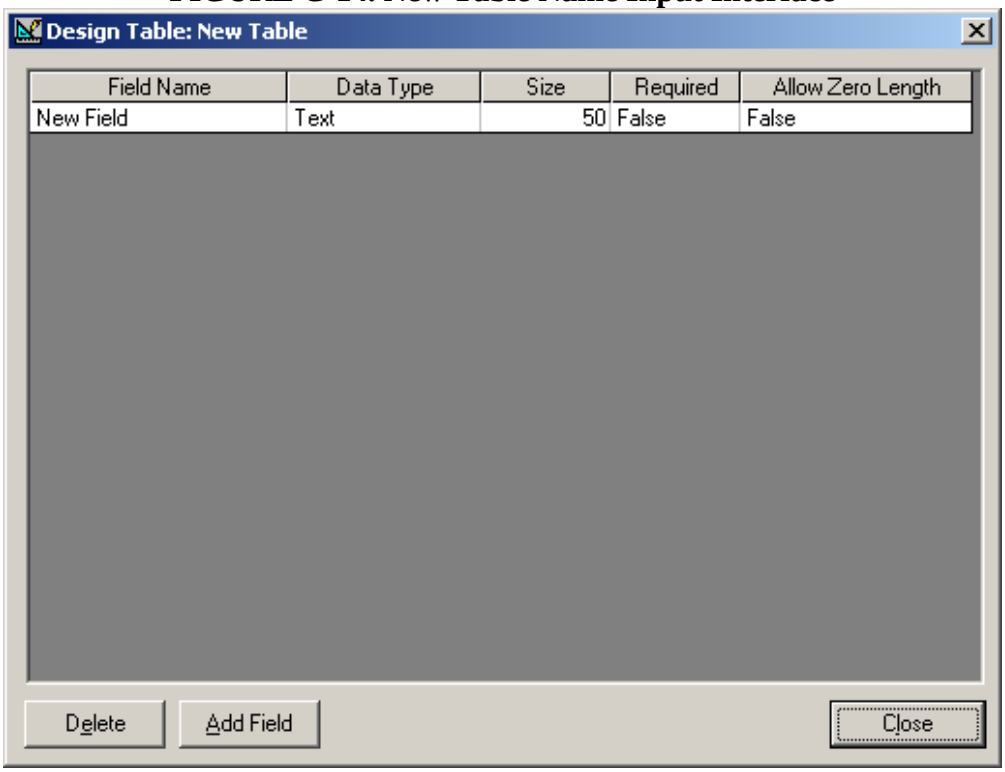


FIGURE C-15. New Table Name Input Interface

Creating a New Query:

1. Select “Queries” in the sidebar of the object browser
2. Click “New” in the “Edit” menu
3. A dialog box as shown in Figure C-16 will be displayed
4. Enter a name for the query in the “Query Name” text box
5. Type in a query. The typed query must follow the standard syntax as Access SQL
6. Close the dialog to auto-save

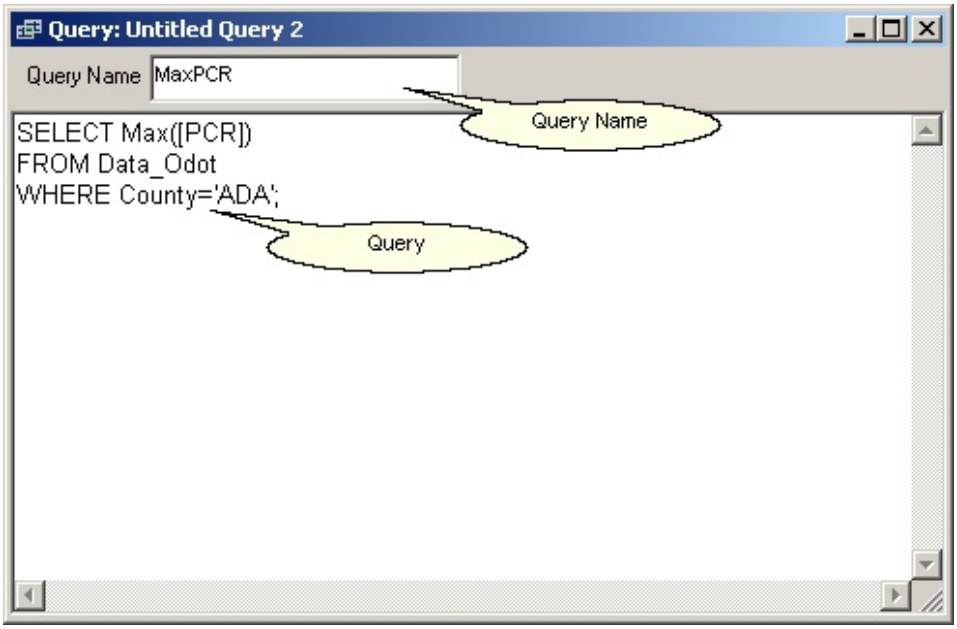


FIGURE C-16. Query Edit Interface

Modifying an Existing Query

1. Select a query in the object browser
2. In the “Edit” menu, click “Design”
3. A similar dialog box as above will appear displaying the selected query
4. Change the query and close the dialog box to auto-save

View Menu

The "View" menu contains commands for ensuring that the toolbars and the object browser are updated and visible. The commands include "Show Toolbar," "Show Object Browser," and "Refresh Object Browser."

FIGURE C-17. ODOTPMIS View Menu

5.1 Show Object Browser (Shortcut Key: CTRL+O)

This option is used to show the object browser. The presence of a check mark next to its name in the "View" menu indicates that the object browser will be displayed in the main ODOTPMIS window.

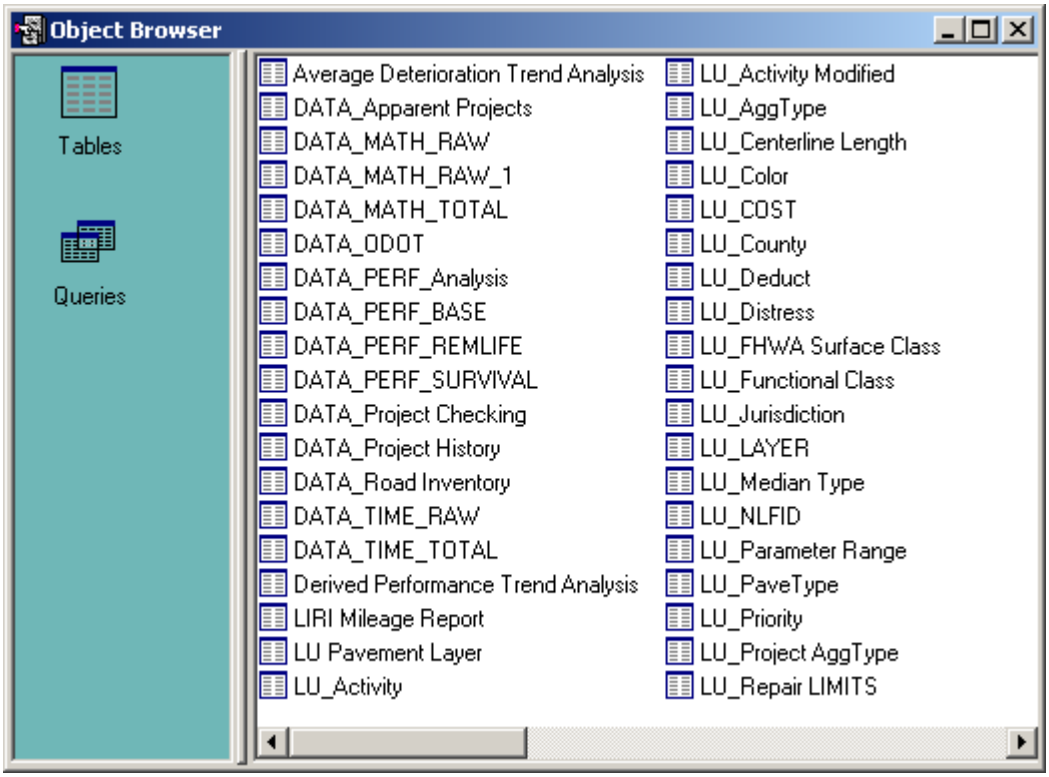


FIGURE C-18. Show Object Browser

The object browser displays a list of the tables and queries in the current database. The object browser contains two filters:

1. **Tables**: Displays a list of all the tables in the database
2. **Queries**: Displays a list of all the queries in the database

5.2 Show Toolbar (Shortcut Key: CTRL+T)

This option is used to show or hide the toolbar, which contains the following buttons:

Print

Print Preview

Delete Table or Query

New

New

Sort the records of a table in ascending order for selected column (this button appears only when a table is opened)

Sorts the records of a table in descending order for selected column (this button appears only when a table is opened)

Linear Superposition*

Project History Plot*

Project History

Statistical Report*

Map View of a Table*

**See Part IV: Advanced Features*

FIGURE C-19. Tool Bar Options

5.3 Refresh Object Browser (Shortcut Key: F5)

This option is used to refresh the object browser to display updated information.

Data Menu

The "Data" menu contains functions that add or modify tables needed for the successful operation of PMIS.

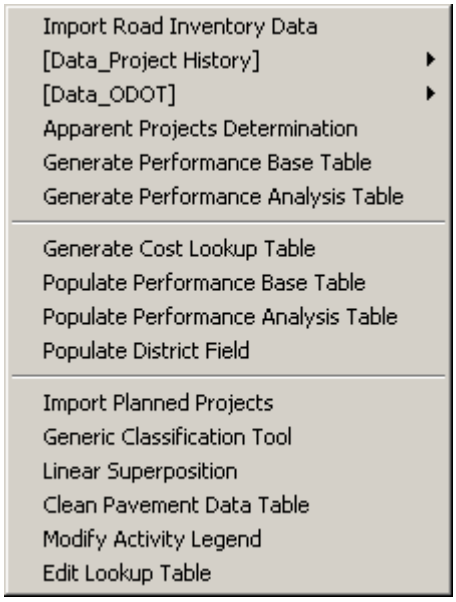


FIGURE C-20. ODOTPMIS Data Menu

6.1 Import Road Inventory Data

This tool allows users to update the road inventory table with new data from text files. Road inventory tables include the following information: road geometry, classification, priority, system, and traffic volume. These tables should be updated every year. The name of this table in ODOTPMIS is *DATA_Road Inventory*.

Table to Apply: [DATA_Road Inventory]
Data file type: Fixed column position text file
Data format:
[*Value 1*][*Value 2*] [*Value 3*] [*Value 4*] … [*Value 55*]
[*Value 1*][*Value 2*] [*Value 3*] [*Value 4*] … [*Value 55*]
[*Value 1*][*Value 2*] [*Value 3*] [*Value 4*] … [*Value 55*]
…

To import data, click on the "Data" menu and select "Import Road Inventory Data." The window shown in Figure C-21 will appear. Select the drive on which the file is stored using the "Drives" drop down menu, or use the "Network" button to select a network drive. Navigate to the directory of the data files using the "Folders" sub-window and use the "File name" sub-window to select the correct text file. Click "OK."

Users may or may not check the "Read only" box to prevent changes to the data, depending on their uses for this specific table.

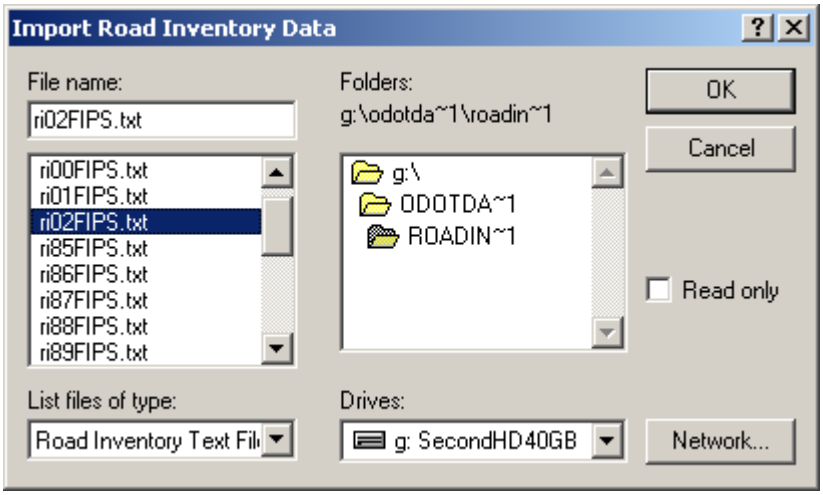


FIGURE C-21 Import Road Inventory Data

Note: Field values must be in the order specified in following table.

TABLE C-2. Field Order, Name and Data Format

Order	Field Name	Data Type	Column Position	Example
1	Jurisdiction	Text	1	S
2	County	Text	2-4	ADA
3	Route	Text	5-7	032
4	Route Suffix	Text	8	R
5	Blog	Text	10-13	0000
6	Log Point Suffix	Text	14	Space
7	Road Identification	Text	15	D
8	Data Type	Integer	16-19	PSTB
9	Data Status	Text	20	E
10	Transaction	Number	21	A
11	Inventory Perpetuation Date	Number	22-25	0100
12	FIPS Code	Number	27-29	Space
13	Mile Class	Byte	31	1
14	Section Length	Text	32-35	0035
15	System Class	Text	36	M
16	Standard Surface Classification	Text	38	G
17	Standard Base Classification	Text	39	L
18	Summary FHWA Surface Type	Text	40-41	I
19	Surface Width	Number	42-43	48
20	Summary Roadway Width	Number	44-45	64
21	Population (100's)	Number	46-49	0
22	Left Side Standard Surface Class	Text	50	G
23	Left Side Standard Base Class	Text	51	L
24	Left Side FHWA Surface Type	Text	52-53	I
25	Left Side Surface Width	Number	54-55	24
26	Median Width	Number	56-57	60
27	Right Side Standard Surface Class	Text	58	G
28	Right Side Standard Base Class	Text	59	L
29	Right Side FHWA Surface Type	Text	60-61	I
30	Right Side Surface Width	Number	62-63	24

31	Year in Inventory	Number	64-65	96
32	Federal-Aid Primary (FAP) Number	Number	66-69	0009
33	National Highway System (NHS)	Text	70	S
34	System	Text	71	SR
35	Highway Performance Monitoring System	Text	72	
36	Maintenance Route Type	Number	73-74	20
37	Population (over/Under 5000)	Number	75	
38	Municipality Name	Text	76-91	
39	Divided Highway Indicator	Text	92	*
40	Access Control	Text	93	L
41	Lanes	Number	94	4
42	District	Number	95-96	09
43	Number of Lanes (two character)	Number	97-98	
44	Station Equation Sort Field	Number	99	1
45	Elog	Number	100-103	0035
46	Priority	Text	104	P
47	Area Code	Number	105-107	000
48	Functional Class	Number	108-109	02
49	Car ADT	Number	111-116	4790
50	Truck ADT	Number	117-122	1370
51	Total ADT	Number	123-128	6160
52	ADT - Year of counts	Number	129-130	92
53	ESALx1000	Number	133-137	230
54	Year	Number	138-141	2000
55	NLFID	Text	142-155	SADASR00032**C

A typical road inventory text file will exhibit the data structure shown in Figure C-22.

```
SUNI033R 0000 DPSTBEA0106 000 10029M GLI 4896    GLI 2420GLI 24970011N2 20                *F4060410029P00002 01
SUNI033R 0029 DPSTBEA0106 000 10036M GLI 4872    GLI 2450GLI 24960011N2 20                *F4060410065P00002 01
SUNI033R 0065 DPSTBEA0106 000 10205M GLI 4872    GLI 2450GLI 24960011N2 20                *F4060410270P00002 01
SUNI033R 0270 DPSTBEA0106 000 10515M GLI 4872    GLI 2450GLI 24960011N2 20                *F4060410785P00002 02
SUNI033R 0785 DPSTBEA0106 000 10049M GLI 4872    GLI 2450GLI 24960011N2 20                *F4060410834P00002 02
SUNI033R 0834 DPSTBEA0106 000 10001M GLI 4872    GLI 2450GLI 24960011N2 20                *F4060410835P00002 02
SUNI033R 0835 DPSTBEA0106 000 10010M GLI 4872    GLI 2450GLI 24960011N2 20                *F4060410845P00002 02
SUNI033R 0845 DPSTBEA0106 000 10013M GLI 4872    GLI 2450GLI 24960011N2 20                *F4060410858P74712 02
SUNI033R 0858 DPSTBEA0106 000 10016M GLI 4872    GLI 2450GLI 24960011N2 20                *F4060410874P74712 02
SUNI033R 0874 DPSTBEA0106 000 10009M GPI 4878    GPI 2444GPI 24960011N2*20                *F4060410883P74712 02
SUNI033R 0883 DPSTBEA0106 000 20041M GPI 48780159GPI 2444GPI 24960011N2*20OMARYSVILLE      *F4060410924P74712 03
SUNI033R 0924 DPSTBEA0106 000 10061M GPI 4878    GPI 2444GPI 24960011N2*20                *F4060410985P74712 03
SUNI033R 0985 DPSTBEA0106 000 20051M GPI 48760159GPI 2444GPI 24960011N2*20OMARYSVILLE      *F4060411036P74712 03
SUNI033R 1036 DPSTBEA0106 000 20120M GPI 48760159GPI 2444GPI 24960011N2*20OMARYSVILLE      *F4060411156P74712 03
SUNI033R 1156 DPSTBEA0106 000 20034M GPI 48760159GPI 2444GPI 24960011N2*20OMARYSVILLE      *F4060411190P74712 03
SUNI033R 1190 DPSTBEA0106 000 20029M GPI 48760159GPI 2444GPI 24960011N2*20OMARYSVILLE      *F4060411219P74712 03
SUNI033R 1219 DPSTBEA0106 000 20018M GPI 48760159GPI 2444GPI 24960011N2*20OMARYSVILLE      *F4060411237P74712 03
SUNI033R 1237 DPSTBEA0106 000 20022M GPI 48800159GPI 2444GPI 24960011N2*20OMARYSVILLE      *F4060411259P74712 03
SUNI033R 1259 DPSTBEA0106 000 20026M GLI 48800159GLI 2444GLI 24990011N2*20OMARYSVILLE      *F4060411285P74712 03
SUNI033R 1285 DPSTBEA0106 000 20025M GLI 48720159GLI 2450GLI 24960011N2 20OMARYSVILLE      *F4060411310P74712 03
SUNI033R 1310 DPSTBEA0106 000 10022M GLI 4872    GLI 2450GLI 24960011N2 20                *F4060411332P74712 03
SUNI033R 1332 DPSTBEA0106 000 10097M GLI 4872    GLI 2450GLI 24960011N2 20                *F4060411429P74712 03
SUNI033R 1429 DPSTBEA0106 000 20070M GLI 48720159GLI 2450GLI 24980011N2 20OMARYSVILLE      *F4060411499P74712 03
SUNI033R 1499 DPSTBEA0106 000 10084M GLI 4872    GLI 2450GLI 24980011N2 20                *F4060411583P74712 03
SUNI033R 1583 DPSTBEA0106 000 10454M GLI 4872    GLI 2450GLI 24030011N2*20                *F4060412037P00002 03
```

FIGURE C-22 Snapshot of Road Inventory File

6.2 Data_Project History

The [Data_Project History] sub-menu contains tools that update the *Data_Project History* table. The tools available under this menu are *Project History Menu, Populate Structural Number Added, Populate Modified Activity Code, and Calculate Thickness Added.*

6.2.1 Project History Entry

Projects performed on pavement each year are recorded in the *DATA_Project History* table. This table can be updated by selecting "Project History Entry" under the "Project History Menu." This will launch the data entry form shown in Figure C-23 for users to view, edit, and input the data to be displayed in the *DATA_Project History* table.

Table to Apply: [DATA_Project History]
Data type and format: User input

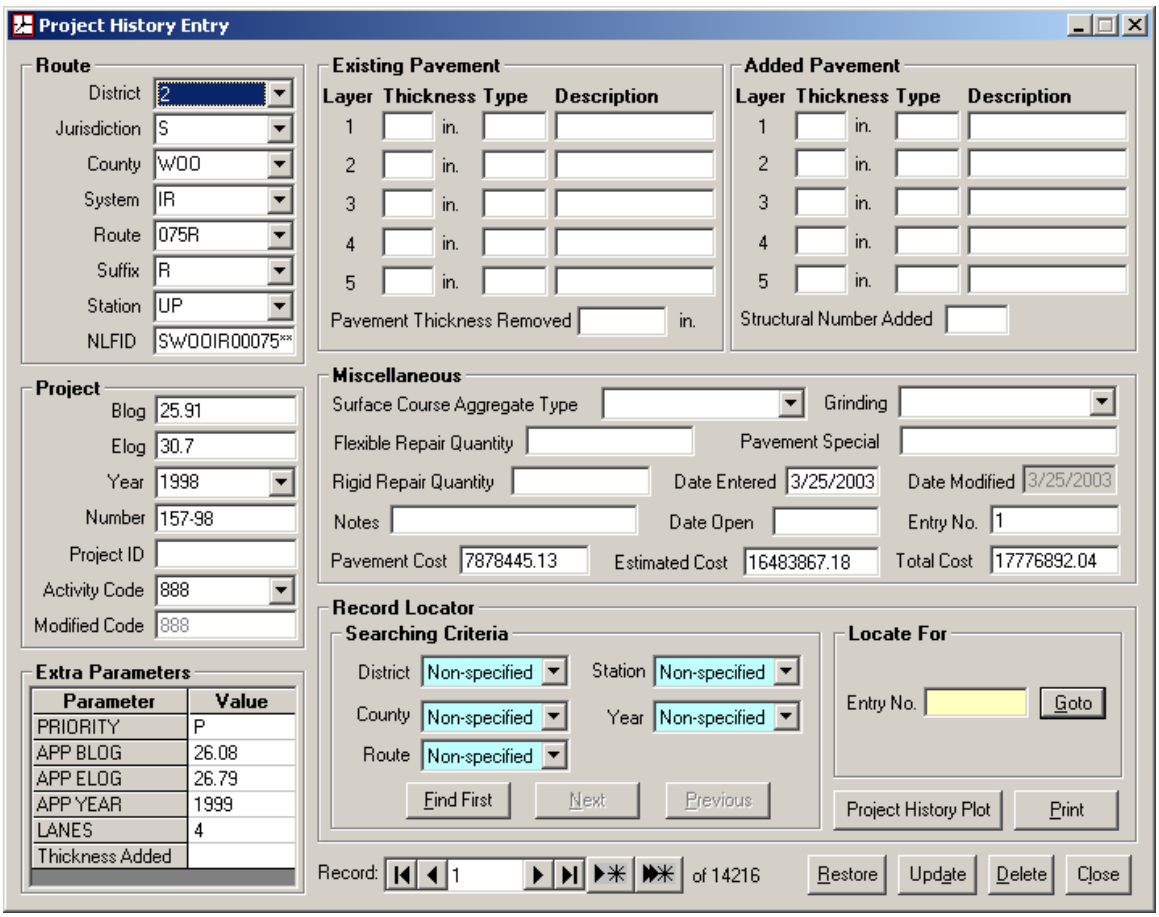


FIGURE C-23. Project History Entry

There are several options provided on the form for browsing, updating and deleting the records. These are as follows:

Record navigator

Add a new blank record

Copy the current record as a new record

Restore the current record to its original status

Update current record and make all changes permanent

Delete current record. The deleted record cannot be restored.

Close this tool

Comments:

Until the user leaves the input window,

button can be used to restore the current record to its original status and discard any changes. To permanently update the current record,

button must be clicked. To delete the current record, user can use

button. If a record is deleted, it cannot be restored. You can also locate a record by using the "Record Locator" search tool or the "Entry No." box. Any field not having a specific input box will appear in the "Extra Parameters" list. This means the user can input more fields into table [DATA_Project History]. However, the total number of fields in any table is limited to 256.

6.2.2 Populate Structural Number Added

This tool calculates the "Structural Number" of every entry in the *DATA_Project History* table and adds a new field [SN_Add]. The "Structural Number" is calculated according to the definitions in the table [LU_Structural Number].

6.2.3 Populate Modified Activity Code

This tool determines the "Modified Activity Code" for every entry in the *DATA_Project History* table. "Modified Activity Code" differs from "Activity Code" only in that it distinguishes between "Thin" and "Thick" overlays. If the thickness added of 50 or 60 is less than or equal to 2 inches, its "Modified Activity Code" becomes 41 or 42 correspondingly. This tool facilitates the analysis of thin and thick overlays.

6.2.4 Calculate Thickness Added

This tool calculates the "Total Thickness Added" and stores the result *DATA_Project History* table. A pavement can contain different layers. The thickness of each added layer is stored separately in the table. Sometimes it is useful to know the total thickness added to a pavement in a project. This tool calculates the total thickness added and stores the result in *DATA_Project History* table.

6.3 Data_ODOT

The Data_ODOT sub-menu contains tools that update the *Data_ODOT* table. The tools available under this menu are *Import Pavement Condition Data, Calculate PCR and Deducts, and Calculate PQI.*

6.3.1 Import Pavement Condition Data

This tool allows for updating of the *DATA_ODOT* table. In ODOTPMIS, pavement condition data such as PCR, RN, IRI, PSI, etc. are stored in *DATA_ODOT* table. This table also stores all road classification and distress data. This pavement condition data should be updated annually. To import condition data correctly, the source data file must have the required format.

Table to Apply: [DATA_ODOT]
Data file type: Coma delimited text file
Data format:
Value 1,Value 2,Value 3,Value 4,…
Value 1,Value 2,Value 3,Value 4, …
Value 1,Value 2,Value 3,Value 4,…

To import data, click on the "Data" menu and select "Import Pavement Condition Data." The window shown in Figure C-24 will appear. Select the drive on which the file is stored using the "Drives" drop down menu, or use the "Network" button to select a network drive. Navigate to the directory of the data files using the "Folders" sub-window and use the "File name" sub-window to select the correct text file. Click "OK." Checking the "Read only" box will prevent any changes to the data.

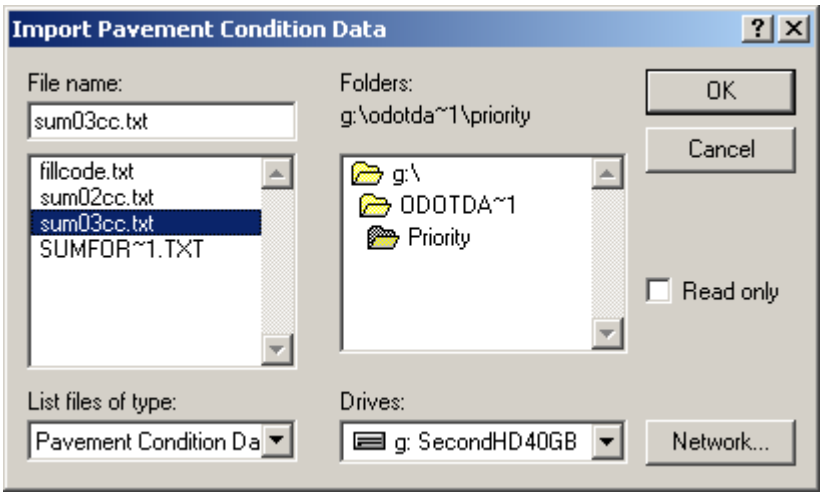


FIGURE C-24. Import Pavement Condition Data

Note: Field values must be in the order specified in Table C-3.

TABLE C-3. Field Order, Name and Data Format

Order	Field Name	Data Type	Example
1	NLFID	Text	SDARUS00036**C
2	District	Byte	7
3	County	Text	DAR
4	Route	Text	036R
5	Station	Text	UP
6	Blog	Single	13.41
7	Elog	Single	13.43
8	Year	Integer	1996
9	Priority	Text	G
10	PCR	Byte	97
11	TDC	Single	3
12	STRD	Single	0
13	Pavement Type	Byte	3
14	Project Number	Text	22871
15-39	Code 1 – Code 25	Text	Code 1 = LE
40	Rater 1	Text	RS
41	Rater 2	Text	
42	Divided - RI	Text	
43	Divided - PCR	Text	U
44	Mile Class	Text	1
45	Urban Area Code	Integer	735
46	Functional Class	Integer	14
47	NHS Field	Text	
48	National Highway System (NHS)	Text	
49	Route Type	Byte	2
50	MPC	Byte	6
51	Access Control	Text	N
52	Lanes	Byte	2
53	Surface Type	Text	I
54	Surface Width	Byte	24
55	Sum Road Width	Byte	44
56	Truck ADT	Long Integer	760
57	Total ADT	Long Integer	6210
58	ESALX1000	Long Integer	288
59	PSI	Single	3.69
60	LIRI	Integer	
61	RIRI	Integer	
62	HCS	Integer	
63	RN	Single	
64	PCR Date	Date	6/10/1996

A typical pavement condition text file exhibits the data structure shown in Figure C-25.

```
SADASR00032**C, 9,ADA,032R,UP  , 6.37, 6.56,2006,P, 91, 9.4, 4.4,3,078590,LE,  ,  ,  ,  ,  ,  ,LO,LO,LF,  ,
SADASR00032**C, 9,ADA,032R,UP  , 6.56, 6.67,2006,P, 91, 9.4, 4.4,3,078590,LE,  ,  ,  ,  ,  ,  ,LO,LO,LF,  ,
SADASR00032**C, 9,ADA,032R,UP  , 6.67,10.48,2006,P, 72,27.6,10.9,3,061590,MF,  ,LO,  ,F ,  ,LO,  ,MF,HF,HF,  ,
SADASR00032**C, 9,ADA,032R,UP  ,10.48,11.41,2006,P, 77,23.4,10.9,3,061590,LE,  ,  ,  ,O ,  ,LO,  ,MF,ME,HF,  ,
SADASR00032**C, 9,ADA,032R,UP  ,11.41,14.71,2006,P, 72,27.6, 9.9,3,061590,MF,  ,LO,  ,E ,  ,LO,  ,MF,HF,HO,  ,
SADASR00032**C, 9,ADA,032R,UP  ,14.71,14.72,2006,P, 79,21.4, 8.5,3,061690,MO,  ,  ,  ,E ,  ,  ,  ,LE,MF,HO,  ,
SADASR00032**C, 9,ADA,032R,UP  ,14.72,19.99,2006,P, 79,21.4, 8.5,3,061690,MO,  ,  ,  ,E ,  ,  ,  ,LE,MF,HO,  ,
SADASR00032**C, 9,ADA,032R,UP  ,19.99,23.35,2006,P, 99, 1.5, 0.0,3,061690,LO,  ,  ,  ,  ,  ,  ,  ,  ,  ,  ,  ,
SADASR00032**C, 9,ADA,032R,UP  ,23.35,24.85,2006,P, 99, 1.5, 0.0,3,061690,LO,  ,  ,  ,  ,  ,  ,  ,  ,  ,  ,  ,
SADASR00041**C, 9,ADA,041R,UP  , 0.00, 6.96,2006,G, 82,18.0, 9.8,3,074093,LE,MO,  ,  ,  ,  ,LO,  ,MO,LF,LO,MO,
SADASR00041**C, 9,ADA,041R,UP  , 6.96, 7.53,2006,G, 82,18.0, 9.8,3,074093,LE,MO,  ,  ,  ,  ,LO,  ,MO,LF,LO,MO,
SADASR00041**C, 9,ADA,041R,UP  , 7.53, 9.70,2006,G, 85,14.8, 9.8,3,017897,LE,  ,  ,  ,  ,  ,  ,  ,MO,LO,LO,MO,
SADASR00041**C, 9,ADA,041R,UP  , 9.70,10.85,2006,G, 85,14.8, 9.8,3,017897,LE,  ,  ,  ,  ,  ,  ,  ,MO,LO,LO,MO,
SADASR00041**C, 9,ADA,041R,UP  ,10.85,12.30,2006,G, 84,16.3, 8.3,3,017897,LE,  ,HO,  ,  ,  ,  ,  ,MO,LO,LO,LO,
SADASR00041**C, 9,ADA,041R,UP  ,12.30,12.45,2006,G, 84,16.3, 8.3,3,017897,LE,  ,HO,  ,  ,  ,  ,  ,MO,LO,LO,LO,
SADASR00041**C, 9,ADA,041R,UP  ,12.45,12.52,2006,G, 84,16.3, 8.3,3,017897,LE,  ,HO,  ,  ,  ,  ,  ,MO,LO,LO,LO,
SADASR00041**C, 9,ADA,041R,UP  ,12.52,12.66,2006,G, 82,18.2, 9.1,3,015699,MO,MO,LO,  ,  ,LO,  ,  ,MO,LF,  ,LO,
SADASR00041**C, 9,ADA,041R,UP  ,12.66,12.75,2006,G, 82,18.2, 9.1,3,015699,MO,MO,LO,  ,  ,LO,  ,  ,MO,LF,  ,LO,
SADASR00041**C, 9,ADA,041R,UP  ,12.75,12.81,2006,G, 82,18.2, 9.1,3,015699,MO,MO,LO,  ,  ,LO,  ,  ,MO,LF,  ,LO,
SADASR00041**C, 9,ADA,041R,UP  ,12.81,12.92,2006,G, 82,18.2, 9.1,3,015699,MO,MO,LO,  ,  ,LO,  ,  ,MO,LF,  ,LO,
SADASR00041**C, 9,ADA,041R,UP  ,12.92,13.24,2006,G, 82,18.2, 9.1,3,015699,MO,MO,LO,  ,  ,LO,  ,  ,MO,LF,  ,LO,
SADASR00041**C, 9,ADA,041R,UP  ,13.24,13.46,2006,G, 88,12.3, 7.3,3,015699,LE,  ,  ,  ,  ,  ,LO,  ,MO,LO,  ,LO,
SADASR00041**C, 9,ADA,041R,UP  ,13.46,14.03,2006,G, 88,12.3, 7.3,3,015699,LE,  ,  ,  ,  ,  ,LO,  ,MO,LO,  ,LO,
SADASR00041**C, 9,ADA,041R,UP  ,14.03,14.12,2006,G, 88,12.3, 7.3,3,015699,LE,  ,  ,  ,  ,  ,LO,  ,MO,LO,  ,LO,
SADASR00041**C, 9,ADA,041R,UP  ,14.12,14.15,2006,G, 88,12.3, 7.3,3,015699,LE,  ,  ,  ,  ,  ,LO,  ,MO,LO,  ,LO,
```

FIGURE C-25. Snapshot of Pavement Condition File

6.3.2 Calculate PCR and Deducts

This tool calculates the "PCR," "Structural Deduct," "Cracking Deduct," and "Rutting Deduct" as well as individual deducts. The original pavement condition data contains "PCR," "Distress" ratings, "TDC" (Total Deduct), "STRD" (Structural Deduct), and "CRD" (Cracking Deduct). However, individual distress deducts are not provided. This tool enables a user to calculate all necessary fields for future analysis. In fact, any table with distress information can be used with this tool. However, its main purpose is to populate *DATA_ODOT* table.

Figure C-26 shows the tool interface. Select the table in the "Tables" list box. Check the required deducts to be calculated fields in the "Options" frame, and select the year for which the PCR and deducts needs to be calculated. Click "Calculate" to fill the selected table with the selected fields.

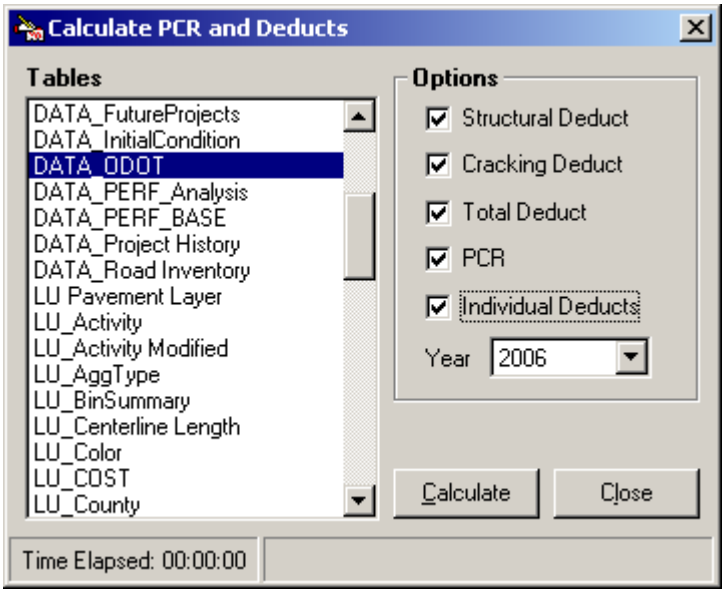


FIGURE C-26. Calculate PCR and Deducts

6.3.3 Calculate PQI

This tool is used to calculate the Pavement Quality Index (PQI). PQI represents a combination of PCR and IRI (average of LIRI and RIRI). PQI is calculated by Equation C-(1).

$$PQI = PCR - a \times IRI^{b}, \qquad \text{C-(1)}$$

Where a and b are read from *LU_PQIParameters* table.

6.4 Apparent Projects Determination

Note: This tool must be run before using the "Generating Performance Base Table" and "Generate Performance Analysis Table" functions.

This tool creates a new table called *DATA_Project History_Apparent* in the database that is similar to *DATA_Project History*. However, this table contains extra fields such as "App Blog," "App Elog," and "App Year" which are determined from matching PCR jumps with treatments. This tool also creates 999's and 995's if it finds a PCR jump of greater than or equal to 6, but does not find a corresponding matching treatment. DATA_PERF_BASE and DATA_PERF_ANALYSIS are generated based on this table.

6.5 Generate Performance Base Table

This tool generates the *DATA_PERF_BASE* table. The *DATA_PERF_BASE* table is the base of most analysis functions and should be generated before *DATA_PERF_ANALYSIS*. Note: It is recommended to perform a database compacting operation before and after using this function.

6.6 Generate Performance Analysis Table

This tool generates the *DATA_PERF_ANALYSIS* table from the *DATA_PERF_BASE* table. Most of the analysis tools in ODOTPMIS use this table. Note: It is recommended to perform a database compacting operation before and after using this function.

6.7 Generate Cost Lookup Table

To perform an "Average Cost" analysis of projects, a lookup table *LU_COST* is required to begin analysis. This tool is used to generate the *LU_COST* table.

6.8 Populate Performance Base Table

The "Populate Performance Base Table" function opens a window to display variances of user specified attributes in *DATA_ODOT* over time with respect to specified values of *DATA_Project History*.
This tool replaces the "Key" and "Entry" numbers in the *DATA_PERF_BASE* table. The keys are replaced with the selected values in the "DATA_ODOT" list box and entries are replaced with selected parameter values in "DATA_Project History" list box.

Note: The resultant table cannot exceed 256 columns in width. Thus, if many parameters are desired, the number of years selected should be decreased or conversely, if many years are selected, the number of parameters may need to be reduced.

Source Table: DATA_PERF_BASE, DATA_Project History_Apparent, DATA_ODOT
Output Table: The default name is *Result_Base*. However, the user can assign a different table name by changing the text in the "Output Table Name" textbox.

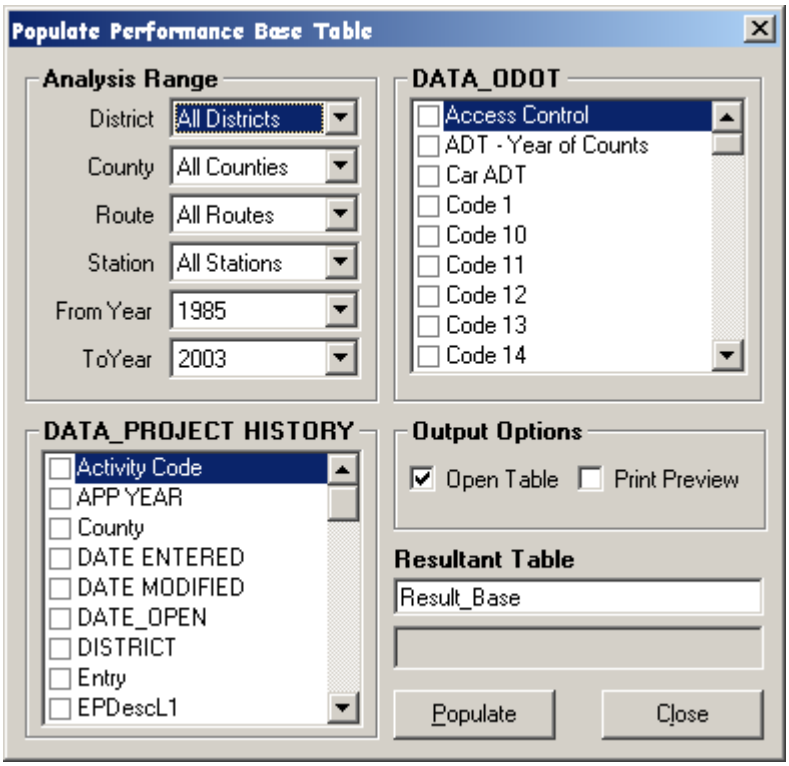


FIGURE C-27. Populate Performance Base Table

6.9 Populate Performance Analysis Table

The "Populate Performance Analysis Table" tool determines the changes of selected DATA_ODOT values between consecutive projects on the same pavement section with respect to data in DATA_Project History_Apparent.

This tool replaces the key and entry numbers in the *DATA_PERF_ANALYSIS* table with the selected values. The Fields Corresponding to Entry-1, Entry and Entry2 List boxes are used to select fields from *DATA_Project History_Apparent* table and Fields Corresponding to Key List box is used to select fields from *DATA_ODOT* table. Like the Populate Performance Base Table tool, the resultant table can support a maximum of 256 columns of data.

Source Table: DATA_PERF_ANALYSIS, DATA_Project History, DATA_ODOT
Output Table: The default name is *Result_Analysis*. However the user can assign a different table name by changing the text in the "Output Table Name" textbox.

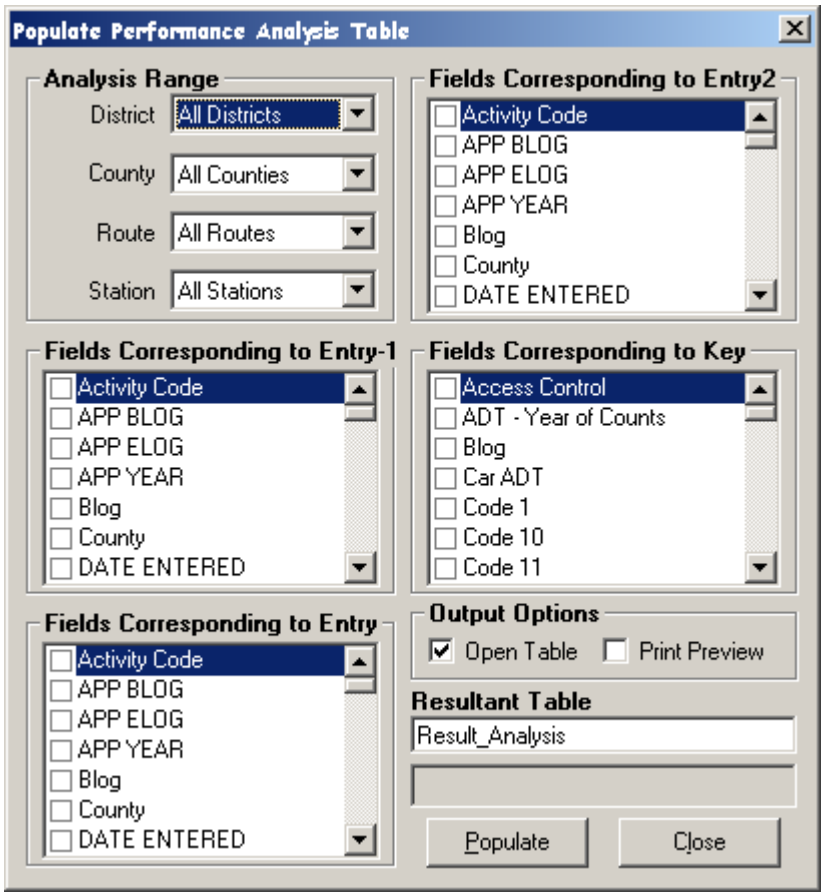


FIGURE C-28. Populate Performance Analysis Table

6.10 Populate District Field

This tool is used to populate the district field in a table, provided the selected table contains a "County" field.

6.11 Import Planned Projects

This tool allows the importing of a work plan into ODOTPMIS. Generally, the work plan file contains the planned treatments for the future, project cost, and location information. The imported file is stored in *DATA_FutureProjects*. Each time this tool is used to import a new work plan, the previous existing work plan in ODOTPMIS is overwritten. To import condition data correctly, the source data file must have the required format.

Stored Table: DATA_FutureProjects
Data file type: Microsoft Excel File
Data format: Shown in Table C-4.

In the work plan file, certain columns can be left empty if they do not contain data. However, the necessary fields (bolded) "PID," "NLF ID," "County Begin Number," "County End Number," and "Pavement Treatment Type" should contain values.

TABLE C-4. Work Plan File Format

Order	Field Name	Example
1	**PID**	21052
2	SUM Adjusted Total Amt	8300000
3	Sale Amount	
4	District	
5	Project Name (ie CRS)	
6	Primary Work Category	
7	Award Date Current	
8	Award Date Actual	
9	Requested STIP Yr	2009
10	**NLF ID**	SLUCSR00002**C
11	**County Begin Number**	30.23
12	**County End Number**	30.8
13	Actual Priority Miles	0
14	Actual Urban Miles	0
15	Actual General Miles	1.14
16	MAX Pvmt Treat Category Cd	
17	**Pavement Treatment Type**	60 - AC Overlay with Repairs

6.12 Generic Classification Tool

This tool, shown in Figure C-29, is used to classify numerical fields in a table. If the original field name in the table is [fieldname], a new field called [fieldname classification] will be added to the table.

If the table selected is [DATA_PERF_ANALYSIS], this field will automatically show in the "Group By" list box provided on most of the analysis tools, such as "Average Deterioration Trend," "Time To Treatment (Actual)," "Time To Treatment Survival Analysis" and "Derived Performance Trend."

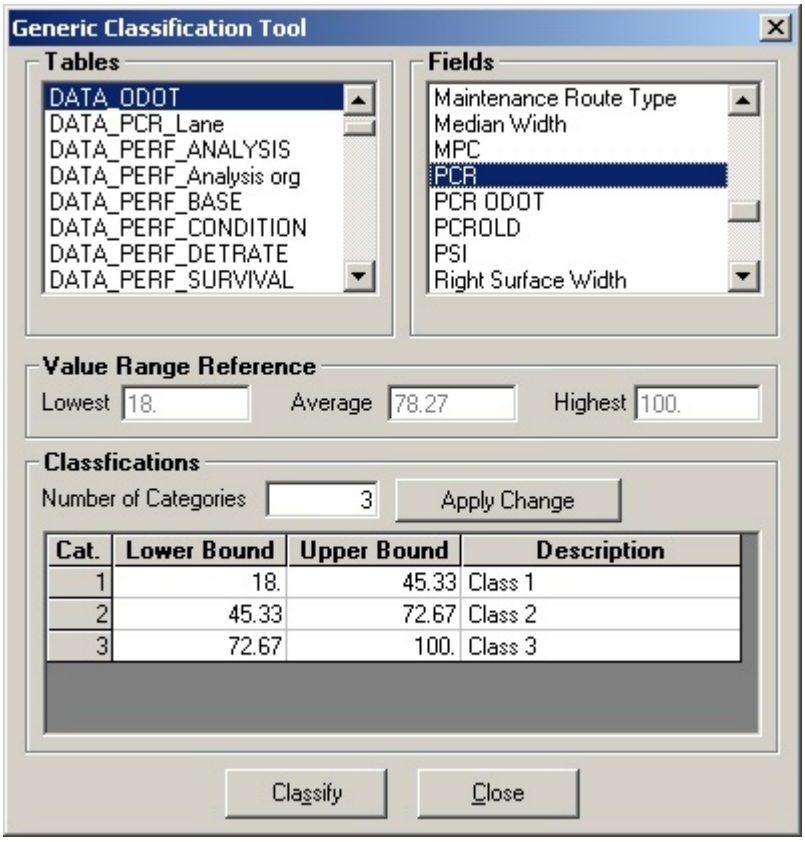


FIGURE C-29. Generic Classification Tool

Value Range Reference Options

Lowest: Lowest value of the parameter
Average: Average value of the parameter
Highest: Highest value of the parameter

Classifications Options

Number of Categories **: Number of categories to classify the selected "Fields"**
Apply Change **(button): Enter number of categories in the "Number of Categories" text box and click this button to change the categories**
Lower Bound **: Lower bound/limit of a category (This value cannot be changed.)**
Upper Bound **: Upper bound/limit of a category (This value can be changed. The changed value becomes the lower bound of the next category.)**
Description **: The description of each category. This description for each category of fields is stored as a new field in the table.**

Example:

The following example classifies AvgESAL in [DATA_PERF_ANALYSIS] into two categories: High, If ESAL ≥ 1500 and Low if ESAL < 1500.

1. Open the "Generic Classification Tool"
2. In the "Tables" list select "DATA_PERF_ANALYSIS"
3. In the "Fields" list select "AvgEsal"
4. Change the number of categories to 2 and click the "Apply Change" button
5. Change the Upper bound of Category 1 to 1500 and change its description to "Low"
6. Change the description of Category 2 to "High"
7. Click the "Classify" button
8. Close the tool and open the "Average Performance Trend" under the "Report" menu. "AvgEsal Classification" will be displayed in the "GroupBy" list.

6.13 Linear Superposition

The "Linear Superposition Operation" is a merge of multiple tables to obtain a single dynamically segmented table. The output is stored in the "Output Table." If the output table named in the input box already exists, the tool will ask the user to replace the existing table or exit from the tool. Figure C-30 shows the user interface.

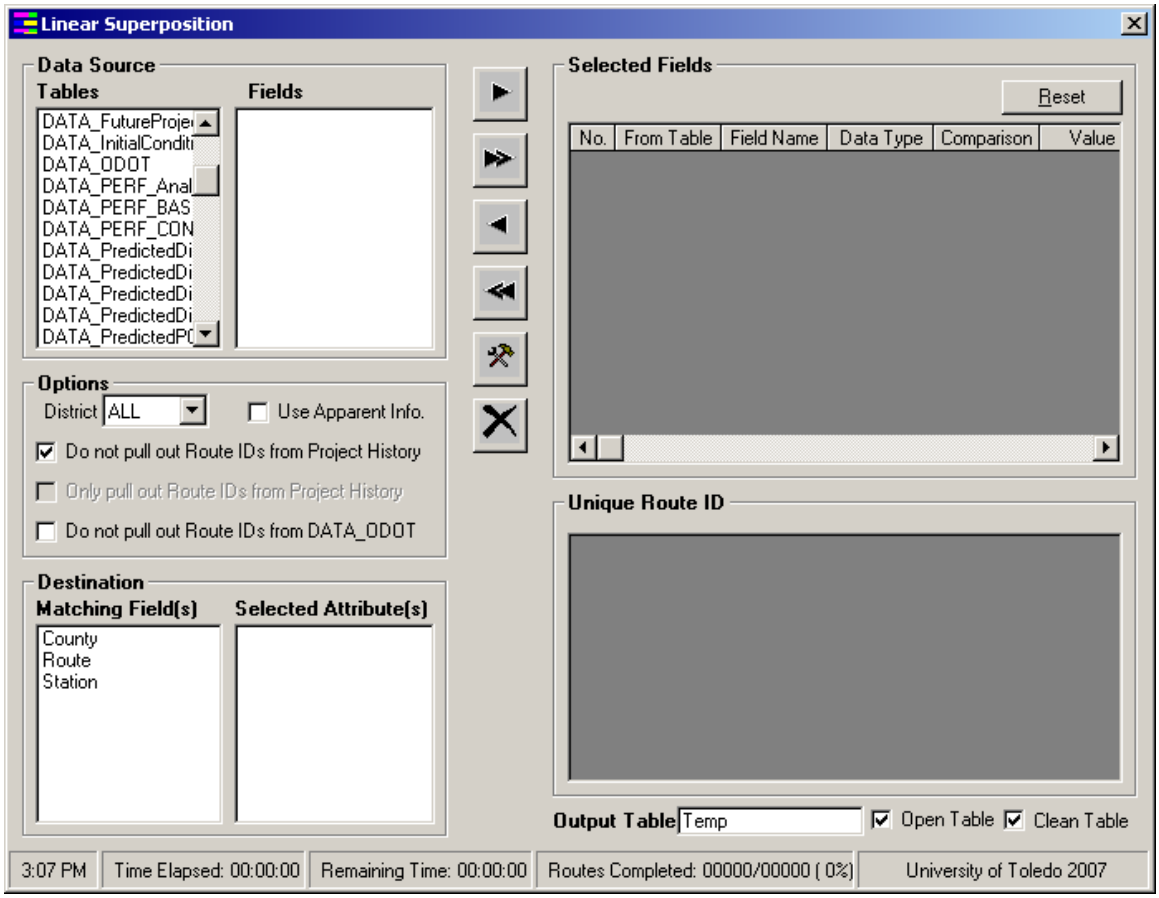


FIGURE C-30. Linear Superposition User Interface

Commands

Tables: Lists all the tables in the database
Fields: Lists all the fields of the table selected under "Available Tables"
Selected Fields: Lists all the selected fields from "Fields"

The attributes listed in the "Fields" list box can be added to the query in three ways:

1. Select a field in the "Fields" list and drag it into the "Selected Fields" list (a hand icon will appear when dragging and dropping)
2. Double click a field to be selected under "Fields"
3. Select a field under "Fields" and click

The "Selected Field" window also provides the option of constraining the records selected for merging. The comparison field in the "Selected Field" window provides a drop down list of how the constraint is to be implemented (≥, ≤, >, <, or =). The "Value" column specifies the desired value of the constraint.

Matching Fields

The "Matching Field" sub-window lists the fields required for merging. The default selections are "County," "Route," and "Station," as they typically specify a linear feature. In some situations, "Year" may also be included.

Adding Matching Fields

Two techniques exist for adding additional selections into the "Matching Field" box. To remove a matching field, double click a field in the "Matching Fields" sub-window.

1. Double click on field under "Selected Fields"
2. Select a field under "Selected Fields" and drag it to the "Matching Fields" box

The "Pull Out" option check boxes under "Options" limit the tables used to create internal program indices. Consequently, if DATA_Project History or DATA_ODOT is excluded in the analysis, its respective index should not be pulled out.

The "Unique Route ID" window displays all unique linear features specified in the merge. Each button is assigned a specific operation and described below.

	Add a selected field
	Add all fields from a table
	Remove a selected field
	Remove all the selected fields
	Run the linear superposition operation
	Stop the linear superposition operation
	Reset the values in the "Comparison" and "Value" columns of "Selected Fields"

Example 1:

The following example shows how to obtain the PCR History for Route 032R in Adams County.

1. Select DATA_ODOT in the "Tables" list
2. Select PCR in the "Fields" list, and double click it to include it in the "Selected Fields" list
3. Under the "Fields" list, add "County" and "Route"
4. In the "County" row, double click the "Value" column and enter "ADA"
5. In the "Route" row, double click the "Value" column and enter "032R"
6. Click the button

At this point, the "Linear Superposition" window should resemble Figure C-31.

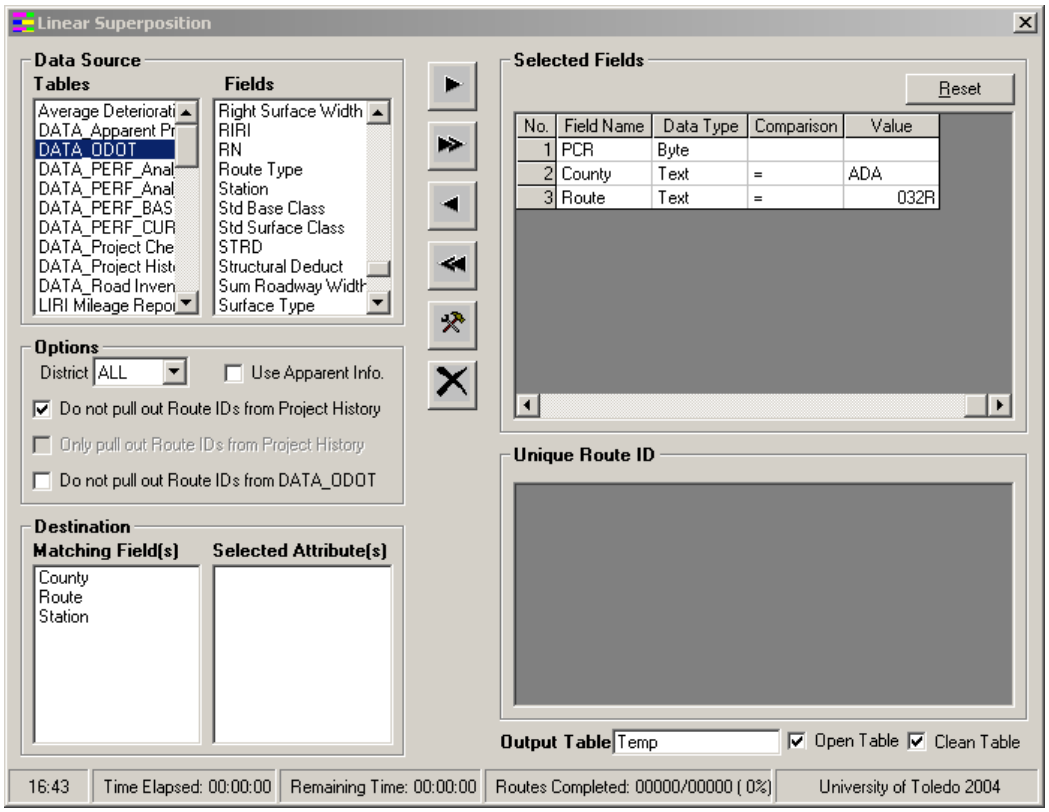


FIGURE C-31. Get PCR Series for Route 032R in Adams County

The result should resemble Figure C-32. Note: Not all PCRs are displayed because of the size of the window. Scroll to reveal the hidden PCRs.

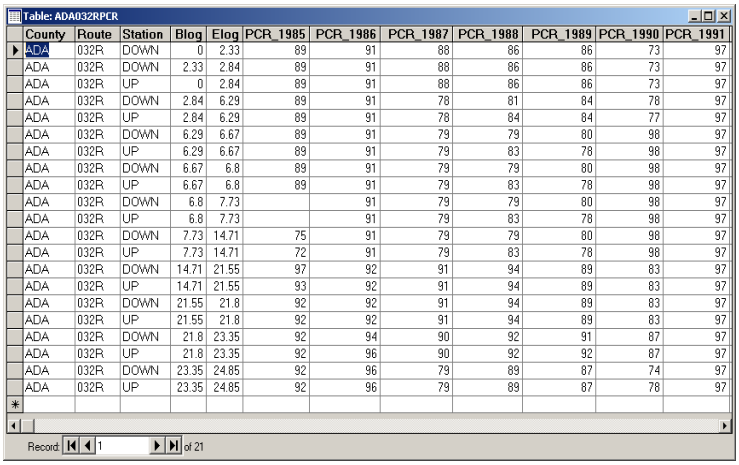


Table: ADA032RPCR

County	Route	Station	Blog	Elog	PCR_1985	PCR_1986	PCR_1987	PCR_1988	PCR_1989	PCR_1990	PCR_1991
ADA	032R	DOWN	0	2.33	89	91	88	86	86	73	97
ADA	032R	DOWN	2.33	2.84	89	91	88	86	86	73	97
ADA	032R	UP	0	2.84	89	91	88	86	86	73	97
ADA	032R	DOWN	2.84	6.29	89	91	78	81	84	78	97
ADA	032R	UP	2.84	6.29	89	91	78	84	84	77	97
ADA	032R	DOWN	6.29	6.67	89	91	79	79	80	98	97
ADA	032R	UP	6.29	6.67	89	91	79	83	78	98	97
ADA	032R	DOWN	6.67	6.8	89	91	79	79	80	98	97
ADA	032R	UP	6.67	6.8	89	91	79	83	78	98	97
ADA	032R	DOWN	6.8	7.73		91	79	79	80	98	97
ADA	032R	UP	6.8	7.73		91	79	83	78	98	97
ADA	032R	DOWN	7.73	14.71	75	91	79	79	80	98	97
ADA	032R	UP	7.73	14.71	72	91	79	83	78	98	97
ADA	032R	DOWN	14.71	21.55	97	92	91	94	89	83	97
ADA	032R	UP	14.71	21.55	93	92	91	94	89	83	97
ADA	032R	DOWN	21.55	21.8	92	92	91	94	89	83	97
ADA	032R	UP	21.55	21.8	92	92	91	94	89	83	97
ADA	032R	DOWN	21.8	23.35	92	94	90	92	91	87	97
ADA	032R	UP	21.8	23.35	92	96	90	92	92	87	97
ADA	032R	DOWN	23.35	24.85	92	96	79	89	87	74	97
ADA	032R	UP	23.35	24.85	92	96	79	89	87	78	97

Record: 1 of 21

FIGURE C-32. PCR Series for Route 032R in Adams County

Example 2:

To obtain the treatment history as well as the PCR history for Route 032R in Adams County, follow this procedure:

1. Select DATA_Project History in the “Tables” list

2. Double click “Activity Code” in the “Fields” list to include it in the “Selected Fields” list
3. Select DATA_ODOT in the “Tables” list
4. Double click “PCR” in the “Fields” list to include it in the “Selected Fields” list
5. Add “County” and “Route to the “Selected Fields” list
6. In the “County” row, double click the “Value” column and enter “ADA”
7. In the “Route” row, double click the “Value” column and enter “032R”
8. Click the button
9. After above 8 operations, the interface looks like the following figure

At this point, the “Linear Superposition” window should resemble Figure C-33.

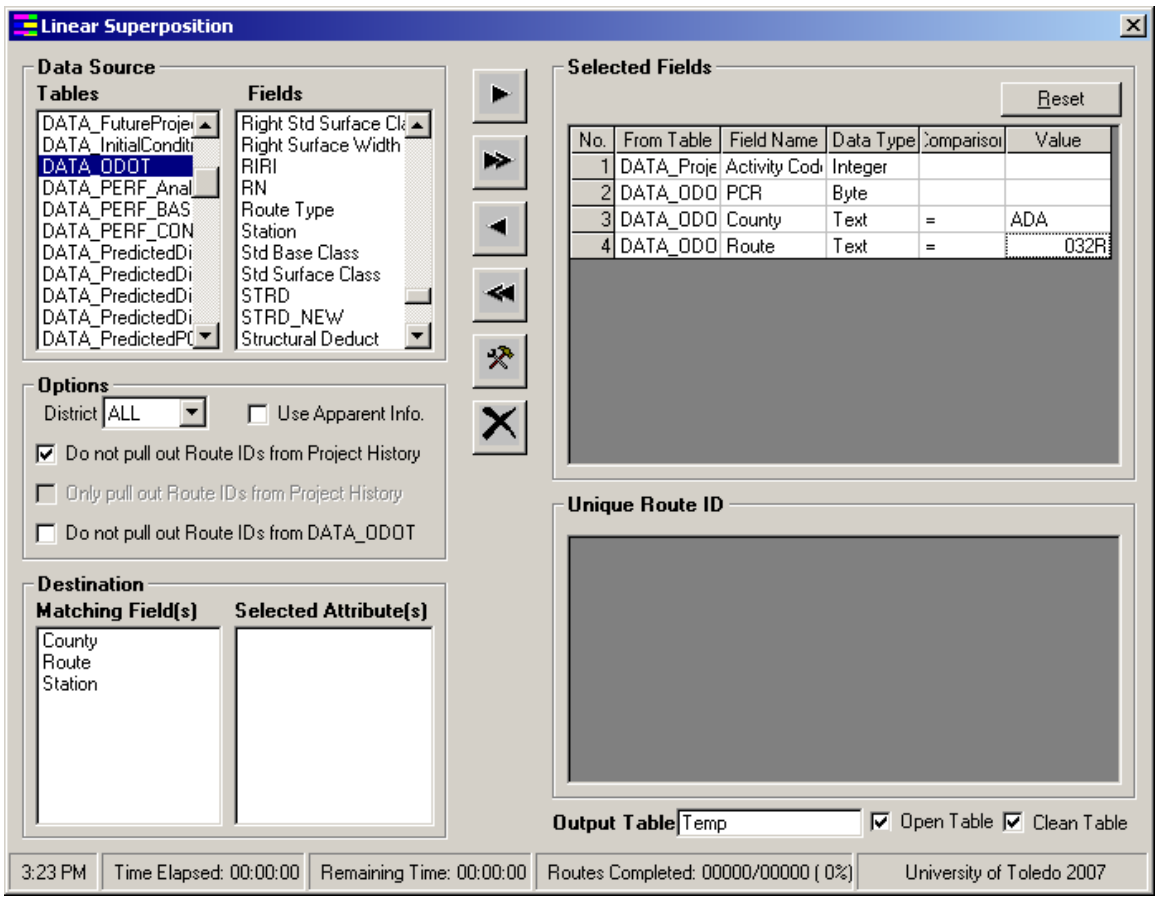


FIGURE C-33. Get PCR and Treatment History for Route 032R in Adams County

The result should resemble Figure C-34. Note: Not all PCRs are displayed because of the size of the window. Scroll to reveal the hidden PCRs.

Temp : Table

County	Route	Station	Blog	Elog	Activity Code_1971	Activity Code_1972	Activity Code_1978	Activity Code_1981	Activity Code_1982	Activi
ADA	032R	DOWN	0	0.35					100	
ADA	032R	DOWN	0.35	1.67					100	
ADA	032R	UP	0	1.67					100	
ADA	032R	DOWN	1.67	2.33					100	
ADA	032R	UP	1.67	2.33					100	
ADA	032R	DOWN	2.33	2.62					100	
ADA	032R	UP	2.33	2.62					100	
ADA	032R	DOWN	2.62	2.84						
ADA	032R	UP	2.62	2.84						
ADA	032R	DOWN	2.84	6.29				100		
ADA	032R	UP	2.84	6.29				100		
ADA	032R	DOWN	6.29	6.67			100	100		
ADA	032R	UP	6.29	6.67			100	100		
ADA	032R	DOWN	6.67	6.8			100	100		
ADA	032R	UP	6.67	6.8			100	100		

Record: 1 of 63

FIGURE C-34. PCR and Treatment History for Route 032R in Adams County

6.14 Clean Pavement Data Table

This tool is used to remove redundancy in dynamically segmented tables. For example, the two records in Table C-5 represent consecutive sections in a road and are identical except for the "Blog" and "Elog" figures. Therefore, these two records can be merged.

TABLE C-5. Original Data

County	Route	Station	Blog	Elog	Year	PCR
ADA	032R	Down	2.33	2.84	2002	91
ADA	032R	Down	2.84	6.29	2002	91

TABLE C-6. Data After Using Clean Pavement Data Table Function

County	Route	Station	Blog	Elog	Year	PCR
ADA	032R	Down	2.33	6.29	2002	91

6.15 Modify Activity Legend

This tool is used to add new activity codes, modify activity legend colors for project history checking, and ensure data integrity between the activity code and the modified activity code.

Modify Activity Legend: [LU_Activity]

Code	Color	Activity	Class	SN Item	Max Life
10		Reactive Maintenance	PREVENTI\	False	15
20		Crack Sealing	PREVENTI\	False	15
25		Chip Seal	PREVENTI\	False	15
30		Micro-Surfacing	PREVENTI\	False	15
31		Double Application Micro-Surfacing	PREVENTI\	False	15
35		Nova-Chip Resurfacing	PREVENTI\	False	15
38		Fine Graded Polymer AC Overlay	PREVENTI\	False	15
40		CPR	PREVENTI\	False	15
45		Intermediate Coarse Recycled AC	Minor	True	20
50		AC Overlay Without Repairs	Minor	True	20
52		AC Inlay	Minor	True	20
55		Double Chip Seal	Minor	True	15
60		AC Overlay With Repairs	Minor	True	20
70		Crack And Seat	Major	True	25
73		Break And Seat	Major	True	25
77		Rubblize And Roll	Major	True	25
80		Whitetopping	Major	True	25
90		Unbonded Concrete Overlay	Major	True	25
95		Unbonded Composite Overlay	Major	True	25
100		New Flexible Pavement	Major	True	25
110		New Rigid Pavement	Major	True	30
120		New Composite Pavement	Major	True	25
777		Known Project Number, Unknown Activity	Unknown	False	30
888		Known Project Number, Condition Jump	Unknown	False	30
995		Unknown Project 5 -10 point Condition Jun	Unknown	False	30
999		Unknown Project, 10+ point Condition Jum	Unknown	False	30

Add Delete

FIGURE C-35. Modify Activity Legend

To add a new activity code, click "Add." This will add a new row at the end of the window (Figure C-36). Enter the required information including the "Code" (numerical), "Color," "Activity," "Class," "SN Item," and "Max Life." Avoid entering duplicate data.

Modify Activity Legend: [LU_Activity]

Code	Color	Activity	Class	SN Item	Max Life
10		Reactive Maintenance	PREVENTI\	False	15
20		Crack Sealing	PREVENTI\	False	15
25		Chip Seal	PREVENTI\	False	15
30		Micro-Surfacing	PREVENTI\	False	15
31		Double Application Micro-Surfacing	PREVENTI\	False	15
35		Nova-Chip Resurfacing	PREVENTI\	False	15
38		Fine Graded Polymer AC Overlay	PREVENTI\	False	15
40		CPR	PREVENTI\	False	15
45		Intermediate Coarse Recycled AC	Minor	True	20
50		AC Overlay Without Repairs	Minor	True	20
52		AC Inlay	Minor	True	20
55		Double Chip Seal	Minor	True	15
60		AC Overlay With Repairs	Minor	True	20
70		Crack And Seat	Major	True	25
73		Break And Seat	Major	True	25
77		Rubblize And Roll	Major	True	25
80		Whitetopping	Major	True	25
90		Unbonded Concrete Overlay	Major	True	25
95		Unbonded Composite Overlay	Major	True	25
100		New Flexible Pavement	Major	True	25
110		New Rigid Pavement	Major	True	30
120		New Composite Pavement	Major	True	25
777		Known Project Number, Unknown Activity	Unknown	False	30
888		Known Project Number, Condition Jump	Unknown	False	30
995		Unknown Project 5 -10 point Condition Jun	Unknown	False	30
999		Unknown Project, 10+ point Condition Jum	Unknown	False	30
> 1		New Activity	DONOTHIN	False	

Add Delete

FIGURE C-36. Add New Activity

6.16 Edit Lookup Table

This tool updates the lookup tables necessary for all analyses in ODOTPMIS.

Table to Apply: [LU_XXXXX]
Tool to use: [Data] → [Edit Lookup Table]

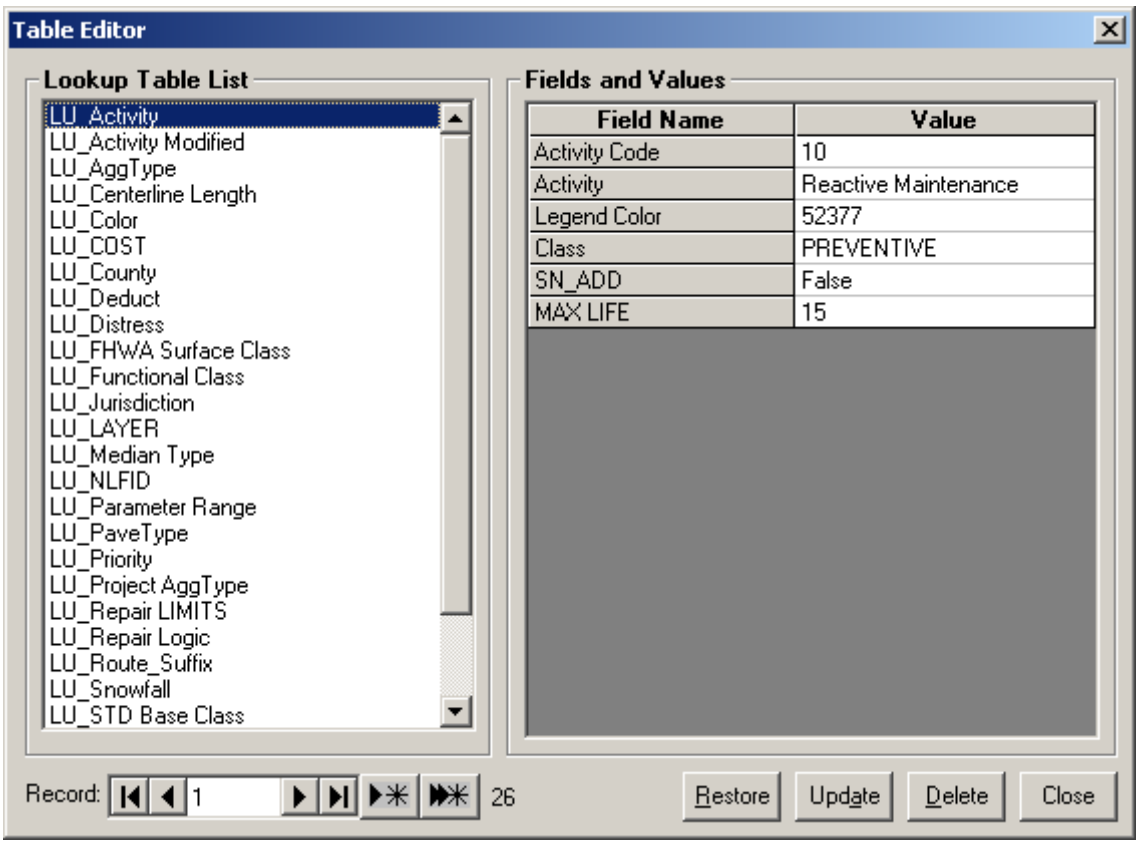


FIGURE C-37. Edit Lookup Table

Users can add, modify, or delete a current record in a lookup table. However, the user cannot change the field name or add/delete a field from a lookup table.

1	Record navigator
	Add a new blank record
	Copy the current record as a new record
Restore	Restore the original record
Update	Update and make all changes permanent
Delete	Delete current record. Deleted records cannot be restored.
Close	Close this tool

Example 1:

In the current ODOT database, only ten distresses are defined for Continuous Reinforced Concrete pavement. To change distress information for distress code 11 for pavement type 1 (Continuous Reinforced Concrete),

1. Select “Edit Lookup Table” under the “Data” menu
2. Select LU_Distress in the “Lookup Table” list

3. Go to "Pavement Type 1" and "Code 11" by using the button in the record navigator. The interface of the tool should resemble Figure C-38.
4. Click the "Field Name" to be changed

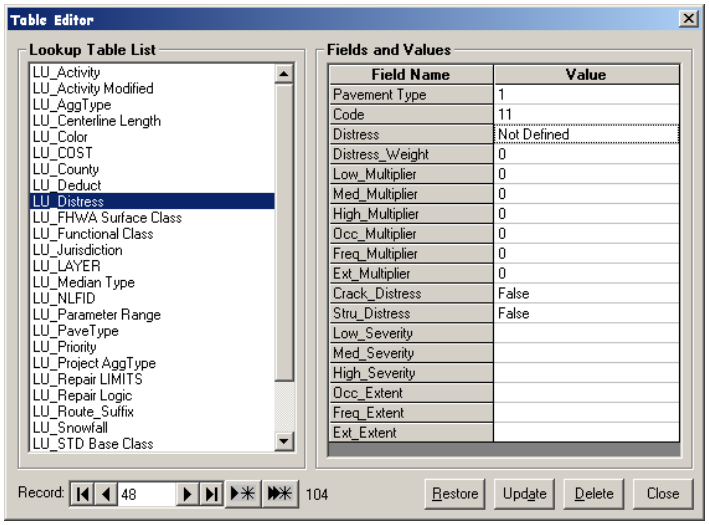


FIGURE C-38. LU_Distress Table

Figure C-39 demonstrates the valid format of the data to be entered.

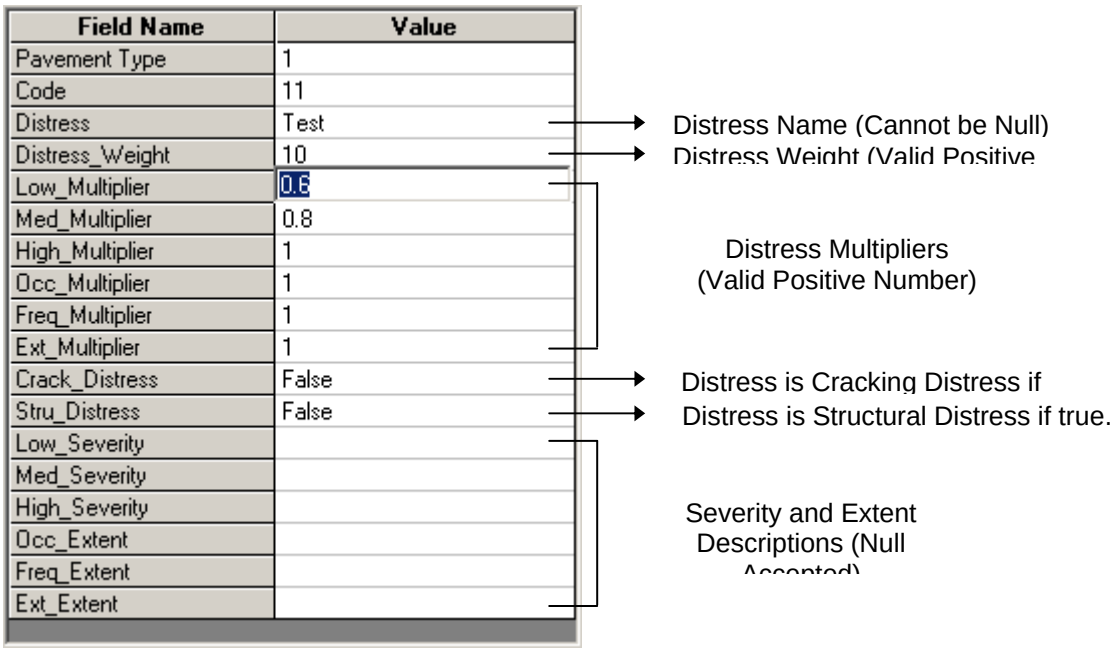


FIGURE C-39. Modifying LU_Distress

5. After entering the changes, click "Update"
6. The changes will be made in two tables: LU_Distress and LU_Deduct. ODOTPMIS uses LU_Deduct table to calculate "PCR," "Structural Deduct," "Cracking Deduct," and individual deducts.

7. To restore old values, click “Restore.” This only works if the user clicks the “Restore” button before closing the tool, and only restores one record at a time.

Analysis Tools Menu

This menu contains functions that perform analyses comparing time to treatment, condition deterioration, pavement condition prediction, and remaining life estimation.

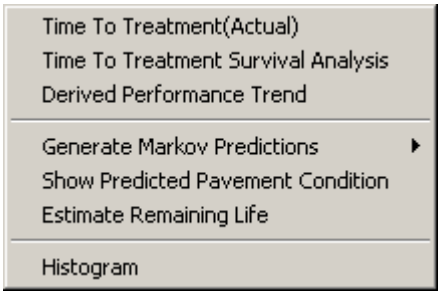


FIGURE C-40. ODOTPMIS Analysis Tools Menu

7.1 Exclude activity option

Analysis tools such as "Time To Treatment (Actual)," "Time To Treatment Survival Analysis," and "Derived Performance Trend" provide an option giving the user the ability to exclude certain activities from the analysis. For example, consider a pavement section with the treatment history as shown in Figure C-41.

FIGURE C-41. Example for Exclude Activity

This pavement section will not be included in the analysis if the "From Activity" is set to 50 and the "To Activity" to 50 because this tells the program to search for projects that are Activity 50 (overlay without repairs) and immediately followed by another Activity 50. However, this pavement section is included in the analysis, if both the "From Activity" and "To Activity" are set to 50, and Activity 20 is selected in the "Exclude Activity" list box.

7.2 Time To Treatment (Actual)

This tool is used to determine the average time between types of treatments or the average time to a certain PCR threshold.

Source Table: DATA_PERF_ANALYSIS
Intermediate Table Generated: DATA_PERF_AVGLIFE
Output Table: The default name for the output table is "Actual Time to Treatment Analysis." Users can update this table name by changing the text in the "Output Table name" text box.

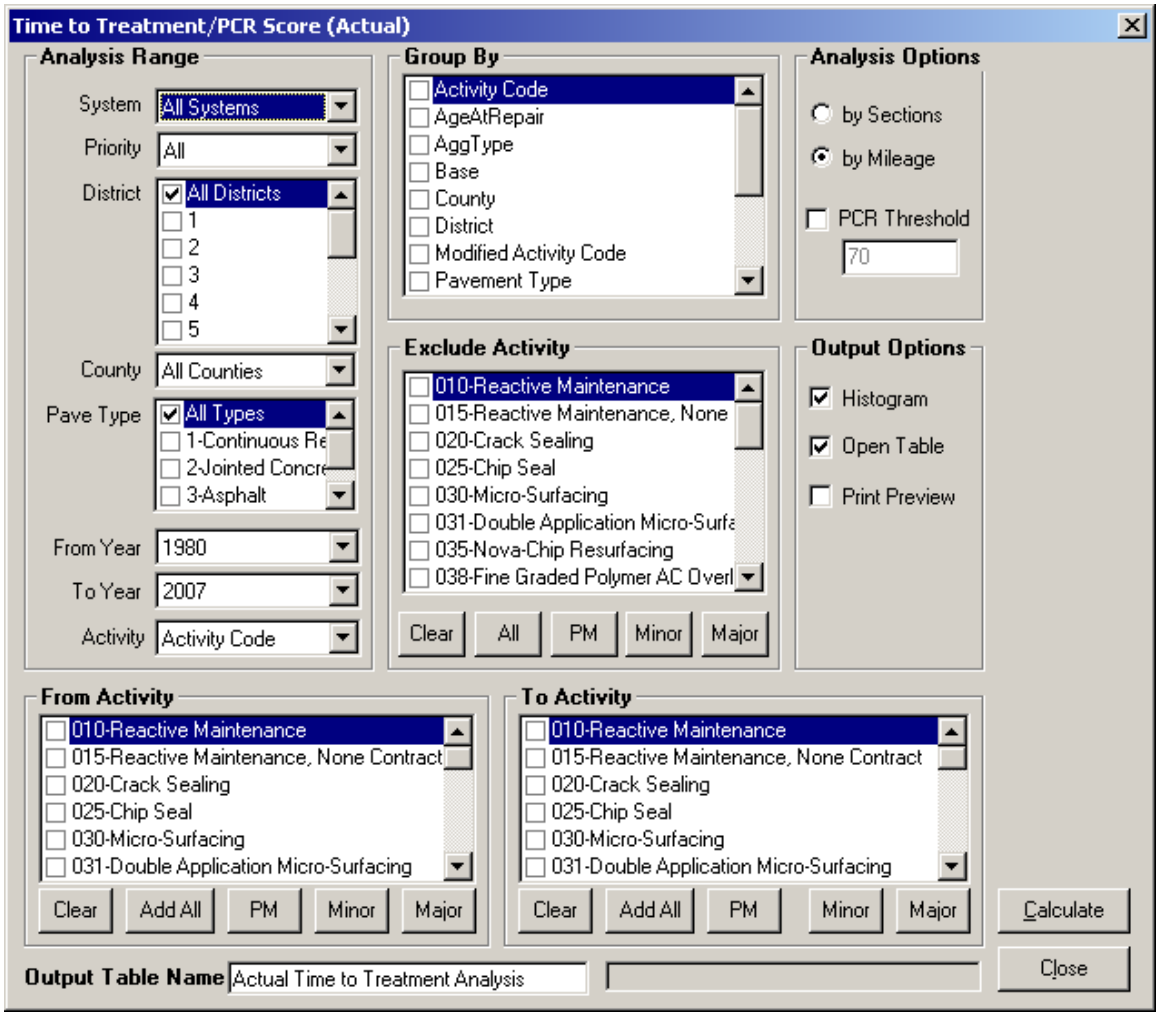


FIGURE C-42. Time to Treatment (Actual)

Example 1:

To generate the "Average Life of Overlay on Priority System Flexible Pavements," select the following options on the tool:

1. "All Systems" under "System"
2. "All" under "Priority"
3. "All Districts" under "District"
4. "All Counties" under "County"
5. "All Types" under "Pave Type"
6. "All Directions" under "System"
7. "1985" under "From Year," and "2006" under "To Year"
8. "Activity Code" under "Activity" list
9. "50" and "60" under "From Activity" list, and "Add All" under "To Activity" list
10. "By Mileage" under "Analysis Options"

Enter an output table name in the "Output Table Name" text box and click "Calculate."

Figure C-43 shows the mileage of pavements that failed or received treatment in each time period. The average life of an overlay on priority systems, according to the calculations, is 7.6 years.

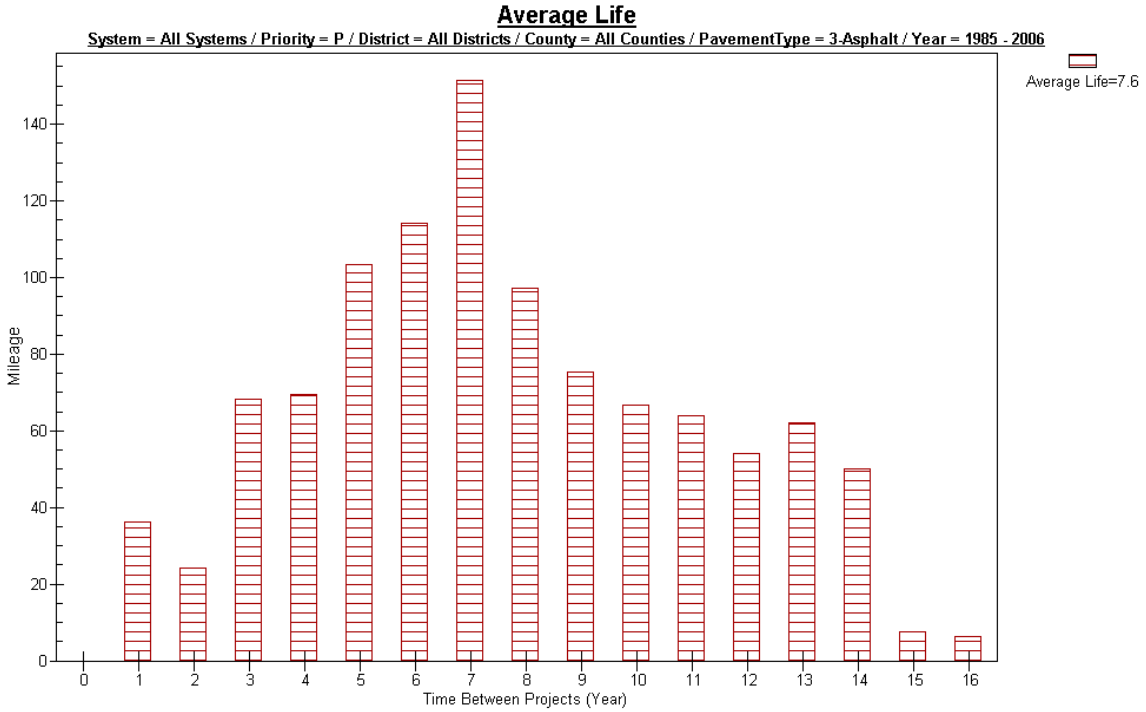


FIGURE C-43. Time to Treatment (Actual) Output for Flexible Overlays on Priority System

7.3 Time To Treatment Survival Analysis

This tool is used to calculate the time to the next treatment based on the Kaplan-Meier Survival Curve method. The advantage of Kaplan-Meier Survival Curve method is that it allows the inclusion of surviving pavement sections in the analysis.

Source Table: DATA_PERF_ANALYSIS
Intermediate Table Generated: DATA_PERF_REMLIFE
Output Table: The default name for the output table is "Pavement Survival Life Analysis." Users can update this table name by changing the text in the "Output Table name" text box.

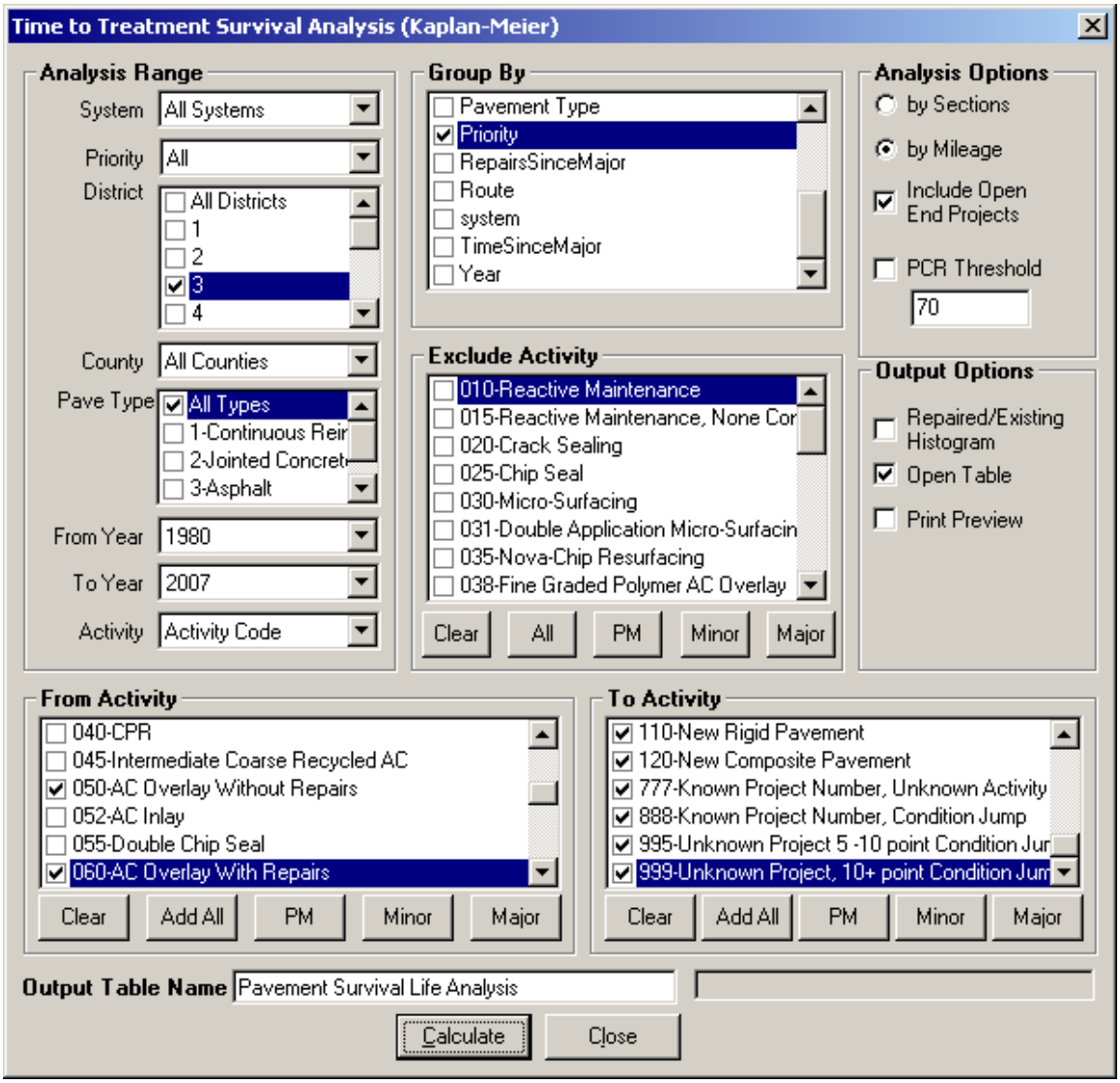


FIGURE C-44. Time to Treatment Survival Analysis User Interface

Analysis Options

Include Open End Projects: Checking this option will include open-ended projects (projects or pavements still in existence)

PCR Threshold: A pavement is considered failed if it undergoes treatment. Checking this option marks all pavements with PCR levels below the threshold as failed.

Output Options

Histogram: This option plots a histogram showing the number of censored and uncensored points for each section.

Survival Analysis Output

In certain scenarios including open ended projects, the survival curve will not reach zero percent surviving. This curve is called a stub survival curve. In the PMIS, a Weibull

survival function is used to complete the survival curve. The Weibull fit, along with the original survival curve, is shown in the output graph.

Example 1:

The following example shows the survival analysis of "Overlay on Priority System Flexible Pavements." Select the following options on the tool:

11. "All Systems" under "System"
12. "All" under "Priority"
13. "All Districts" under "District"
14. "All Counties" under "County"
15. "All Types" under "Pave Type"
16. "All Directions" under "System"
17. "1985" under "From Year," and "2006" under "To Year"
18. "Activity Code" under "Activity" list
19. "50" and "60" under "From Activity" list, and "Add All" under "To Activity" list
20. "By Mileage" under "Analysis Options"

Enter an output table name in the "Output Table Name" text box and click "Calculate."

Figure C-45 shows the "Survival Curve (Raw Data)," the survival curve obtained using the raw data. It can be seen that this survival curve does not reach 0% probability, and any estimates using this curve are not reliable. Hence a "Survival Curve (Weibull Fit)" is fitted to the original curve.

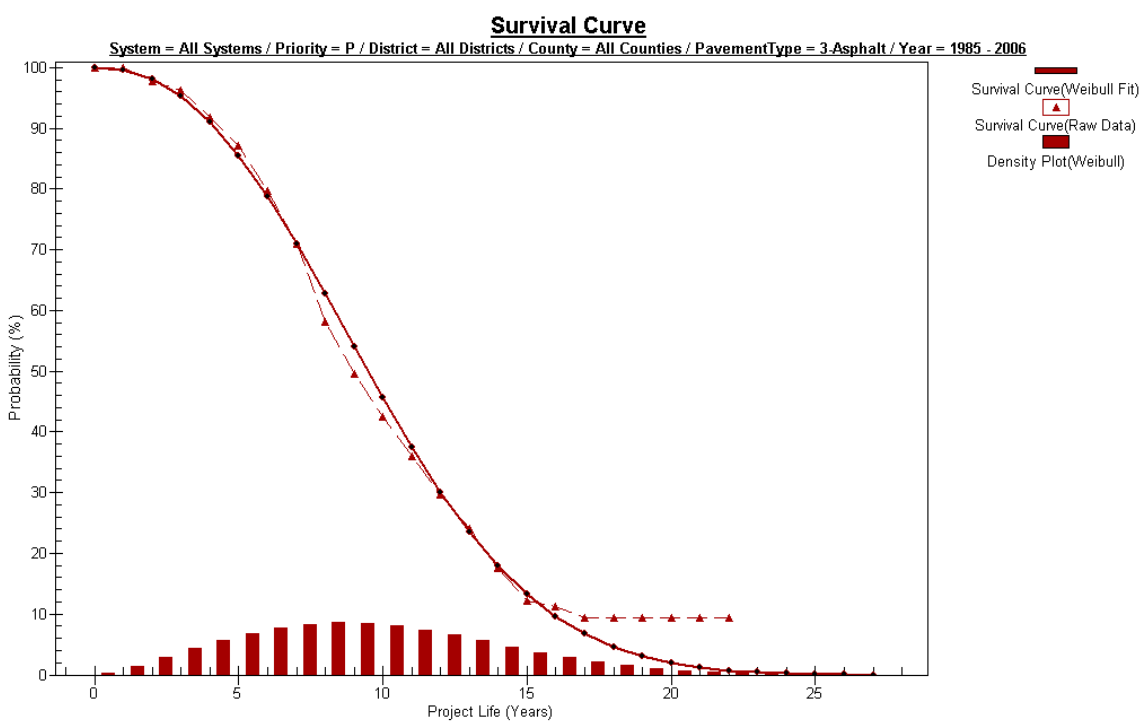


FIGURE C-45. Time to Treatment (Actual) Output for Overlays on Priority System

A histogram showing mileages of projects that have been repaired and still exist can also be generated by selecting "Histogram" under "Output Options." Figure C-46 shows the mileage histogram for the survival curve in Figure C-45.

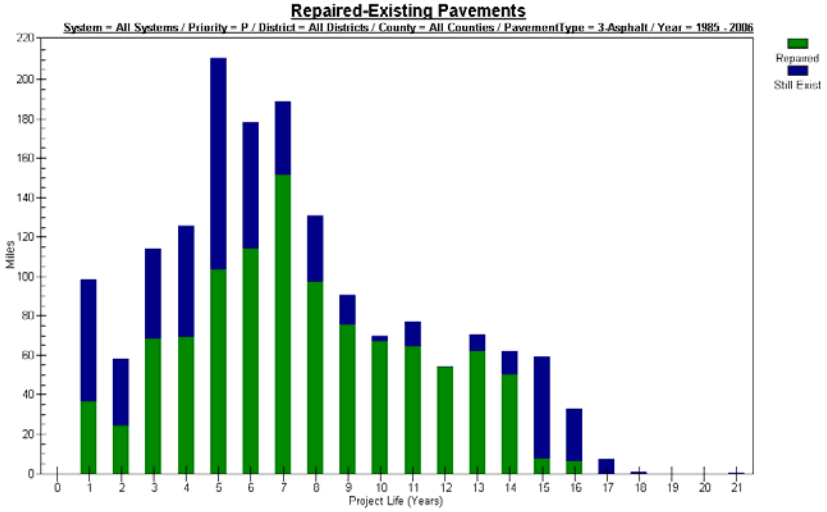


FIGURE C-46. Time to Treatment Survival Curve Mileage Histogram

7.4 Derived Performance Trend

This tool analyzes the series of survival curves to determine the pavement condition deterioration of a group of user specified pavement repairs.

Source Table: DATA_PERF_ANALYSIS, DATA_ODOT
Intermediate Table Generated: DATA_PERF_ SURVIVAL
Output Table: The default name for the output table is "Derived Performance." The user can change this table name by updating the text in the "Output Table Name" text box.

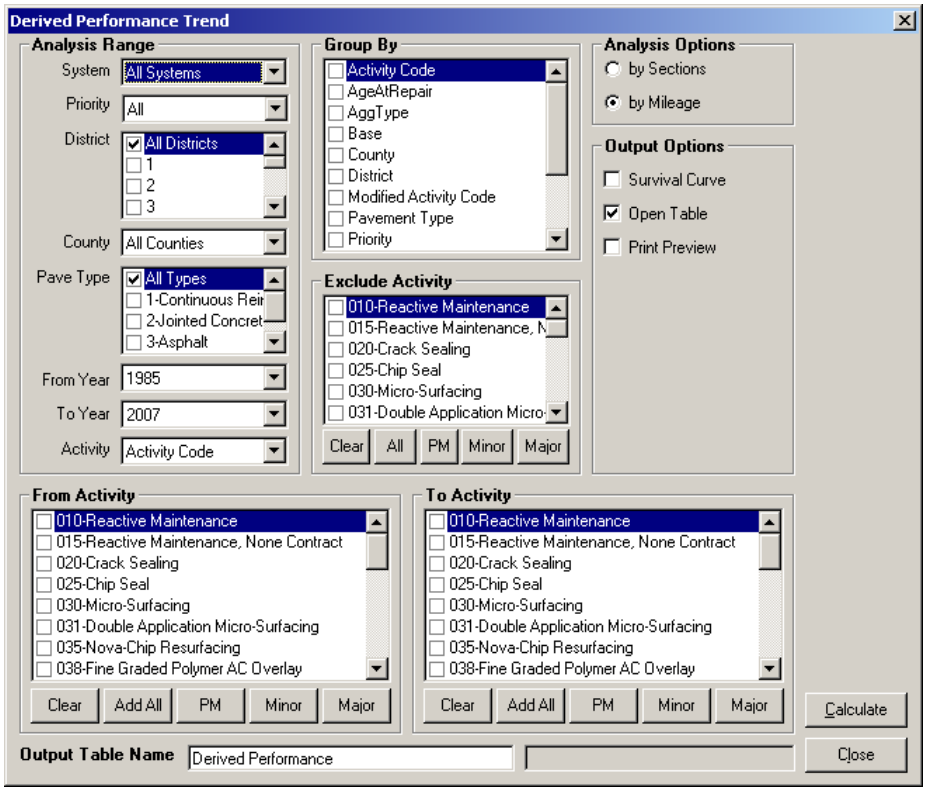


FIGURE C-47. Derived Performance Trend

Output Options

Survival Curve: Display survival curves for PCR from 100 to 50.

Example 1:

The following example shows the Derived Performance Trend for District 3 General System Flexible Pavements with Overlays. Select the following options on the tool:

1. "All Systems" under "System"
2. "G" under "Priority"
3. "All Districts" under "District"
4. "All Counties" under "County"
5. "All Types" under "Pave Type"
6. "All Directions" under "System"
7. "1985" under "From Year," and "2006" under "To Year"
8. "Activity Code" under "Activity" list
9. "50" and "60" under "From Activity" list, and "Add All" under "To Activity" list
10. "By Mileage" under "Analysis Options"
11. Check "Survival Curve" under "Output Options"

Enter an output table name in the "Output Table Name" text box and click "Calculate."

Figure C-48 shows the "Derived Performance Curve."

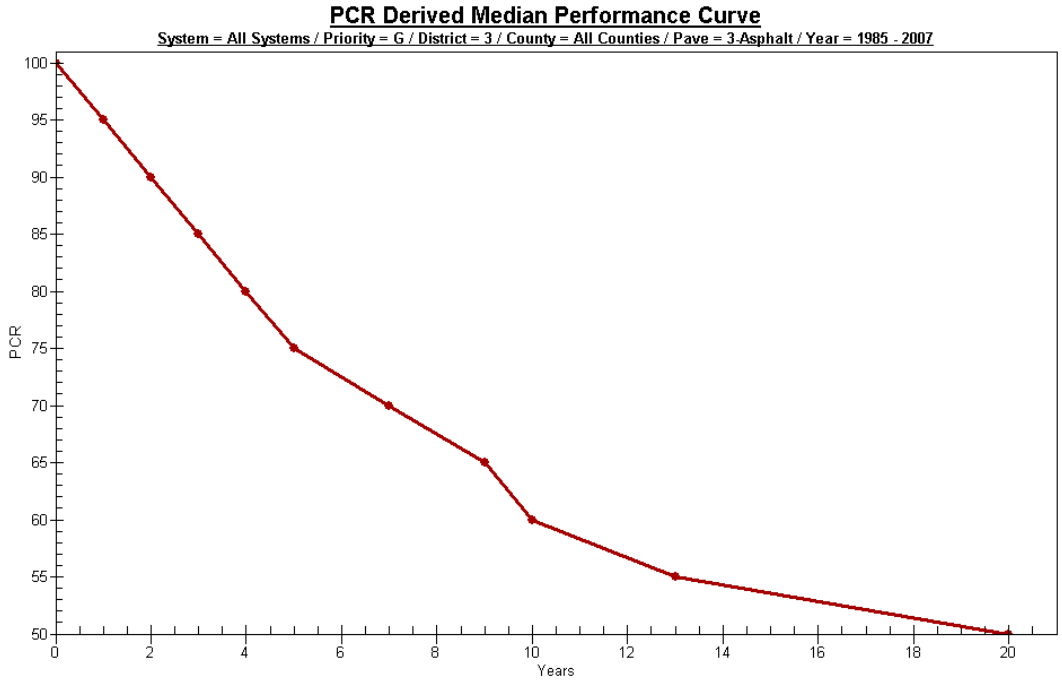


FIGURE C-48. Derived Median Performance Curve For District 3 General System Flexible Pavements with Overlays

This tool also generates the survival curves used for the "Derived Median Performance Curve" shown in the following figure. It can be seen that Weibull curves are used instead of stub survival curves.

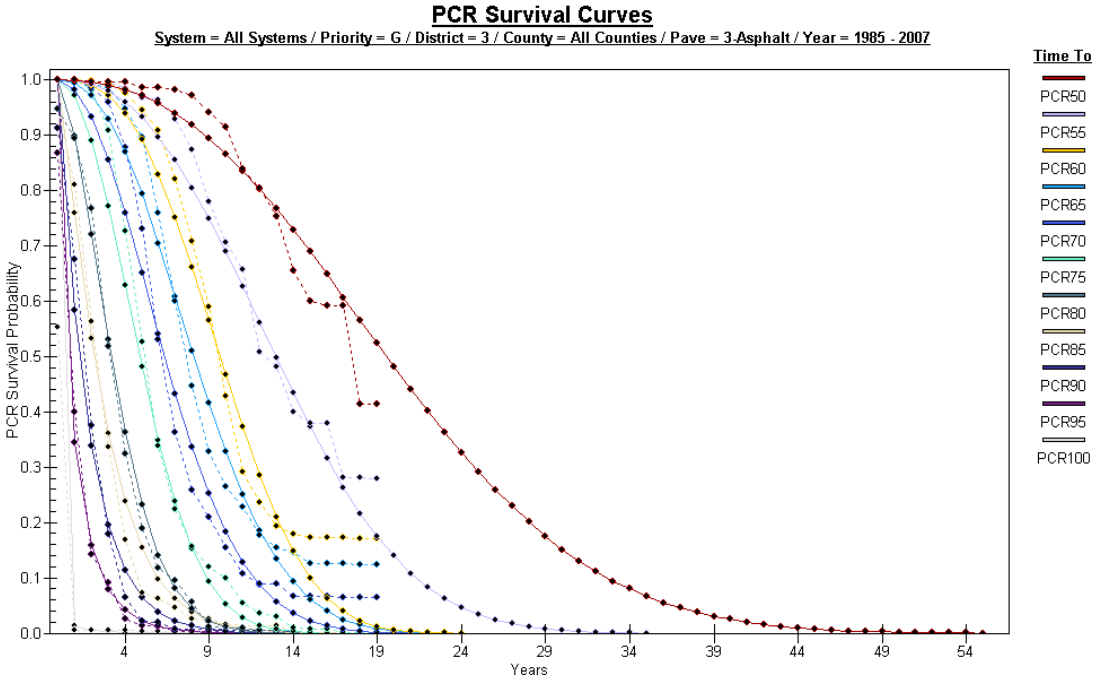


FIGURE C-49. PCR Survival Curves

7.5 Generate Markov predictions

This menu can be used to predict the PCR and distress for every pavement section in the database based on Markov process. However, for certain groups of pavements, the Markov transition matrix cannot be generated since only a few pavement sections are available. In that case, simple linear extrapolation is used for predicting distress and PCR.

The tools available under this menu are "Statewide Rigid Pavements," "Statewide Flexible Pavements," "Statewide Composite Pavements," "Individual Pavement Prediction," and "Selected Predictions."

The transition matrix table *DATA_TransitionMatrix* is created when using the "Statewide Rigid Pavements," "Statewide Flexible Pavements," and "Statewide Composite Pavements" options. Note: It is recommended that the user not delete this table, since it is used in the "Individual Pavement Prediction" and "Show Pavement Prediction" tools.

7.5.1 Statewide Rigid Pavements

This option generates statewide rigid pavement PCR and distress predictions for the next twenty years. Four tables will be generated. Note: It is recommended that the user not delete these tables unless new pavement condition data and/or project data are added in the database.

The tables created are: *DATA_PredictedPCR_JRC, DATA_PredictedDistress_JRC, DATA_PredictedPCR_CRC, and DATA_PredictedDistress_CRC.*

7.5.2 Statewide Flexible Pavements

This option generates statewide flexible pavement PCR and distress predictions for the next twenty years. Two tables will be generated. It is recommended that the user not delete these tables unless new pavement condition data and/or project data are added in the database.

The tables created are: *DATA_PredictedPCR_Flex, DATA_PredictedDistress_Flex.*

7.5.3 Statewide Composite Pavements

This option generates statewide composite pavement PCR and distress predictions for the next twenty years. Two tables will be generated. It is recommended that the user not delete these tables unless new pavement condition data and/or project data are added in the database.

The tables created are: *DATA_PredictedPCR_Comp, DATA_PredictedDistress_Comp.*

7.5.4 Individual Pavement Prediction

This tool can be used to view the predicted PCR of an individual pavement section. Markov prediction is combined with Monte-Carlo simulation to generate the PCR predictions and confidence intervals. The user has the ability to choose between various confidence intervals. Figure C-50 shows the user interface.

Source Table: DATA_Transition Matrix

Output Table: The default name for the output table is "Pavement Section Prediction." Users can update this table name by changing the text in the "Output Table name" text box.

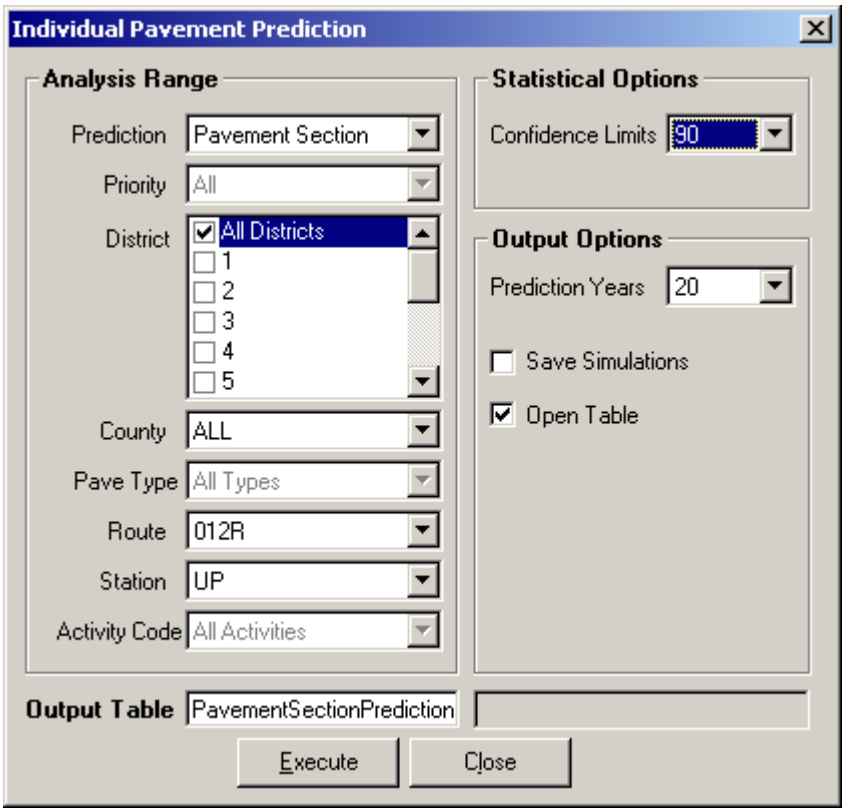


FIGURE C-50. Individual Pavement Section Prediction

Example 1:

To view the predicted PCR for Allen County, Route 030R Up Direction, for the next twenty years with an 80% confidence limit, select following options:

1. "All" under "County"
2. "030R" under "Route"
3. "UP" under "Station"
4. "80" under "Confidence Limits"
5. "20" under "Prediction Years"

Enter an output table name in the "Output Table" text box and click "Execute."

Figure C-51 shows the output grid which displays the results.

Individual Pavement Prediction - ALL 030R UP

Yr\Log	0	.53	1.08	1.09	1.12	1.13	1.18	7.41	13.16	13.29	13.58	14	17.95	18.91	19.01	19.68	20.16	20.35	20.42	20.52	24.05	24.1
U1998	84	84	84	84	84	92	92	92	69	69	69	69	69	69	69	69	75	75	75	75	75	
U1999	80	80	71	71	71	71	71	80	67	67	67	67	67						74	74	74	
U2000	79	79	68	68	68	68	68	76	100	100	100	100	100	100	100	100	100	100	100	100		
U2001	99	99	99	99	73	73	73	73	73	93	93	93	93	93	93	96	96	96	96	96		
U2002	99	99	99	99	70	70	70	70	70	89	89	89	96	96	96	93	93	93	93	93		
U2003	98	98	98	98	70	70	70	70	70	85	85	85	91	91	91	93	93	93	93	93		
U2004	95	95	95	95	65	65	65	65	65	84	84	84	88	88	88	98	98	98	98	98		
U2005	95	95	95	95	99	99	99	99	99	82	82	82	88	88	88	98	98	98	98	98		
U2006	94	94	94	94	98	98	98	98	98	86	86	86	91	91	91	98	98	98	98	98		
U2007	91	91	91	91	93	93	93	93	93	84	83	84	86	86	90	95	95	95	95	95		
U2008	89	88	88	88	89	88	88	89	89	81	81	81	83	83	88	92	92	92	92	92		
U2009	86	85	85	85	85	85	85	85	85	79	79	79	80	80	87	90	90	90	90	90		
U2010	83	83	83	82	81	81	81	82	81	76	76	76	77	77	86	87	87	87	87	87		
U2011	80	80	80	79	78	78	78	78	78	74	74	74	75	75	85	84	84	84	84	84		
U2012	77	77	76	76	75	76	76	76	75	71	71	71	72	72	84	82	82	82	82	82		
U2013	74	74	73	73	73	73	73	73	73	69	69	69	70	70	82	79	79	79	79	79		
U2014	71	71	70	70	70	71	70	70	70	67	67	66	68	68	81	76	76	76	76	76		
U2015	68	68	67	67	68	68	68	68	68	64	64	64	66	65	80	73	73	73	73	73		
U2016	65	65	64	64	65	66	66	66	66	62	62	62	63	63	79	72	72	72	72	72		
U2017	62	63	61	61	63	64	64	63	63	60	60	60	61	61	78	70	70	70	70	70		
U2018	59	60	59	58	61	62	62	61	61	58	58	58	59	59	77	69	69	69	69	69		
U2019	56	57	56	56	59	60	60	60	59	56	57	56	57	58	75	67	67	67	67	67		
U2020	54	55	53	53	57	58	58	58	58	55	55	55	56	56	74	66	66	66	66	66		
U2021	52	52	51	51	56	57	56	56	56	53	53	53	54	54	73	64	64	64	64	64		
U2022	49	50	49	49	54	55	55	54	54	52	52	52	53	53	72	63	63	63	63	63		
U2023	47	48	47	47	53	53	53	53	53	50	50	50	51	51	71	61	61	61	61	61		
U2024	46	46	45	45	51	52	51	51	51	49	49	49	50	50	69	59	59	59	59	59		
U2025	44	45	43	43	50	50	50	50	50	48	48	48	49	48	68	58	58	58	58	58		
U2026	43	43	42	42	48	49	49	49	49	46	47	47	47	47	67	56	56	56	56	56		

FIGURE C-51. PCR Prediction Grid

Click on any part of the grid to generate a PCR prediction plot that shows the confidence limits as shown in Figure C-52.

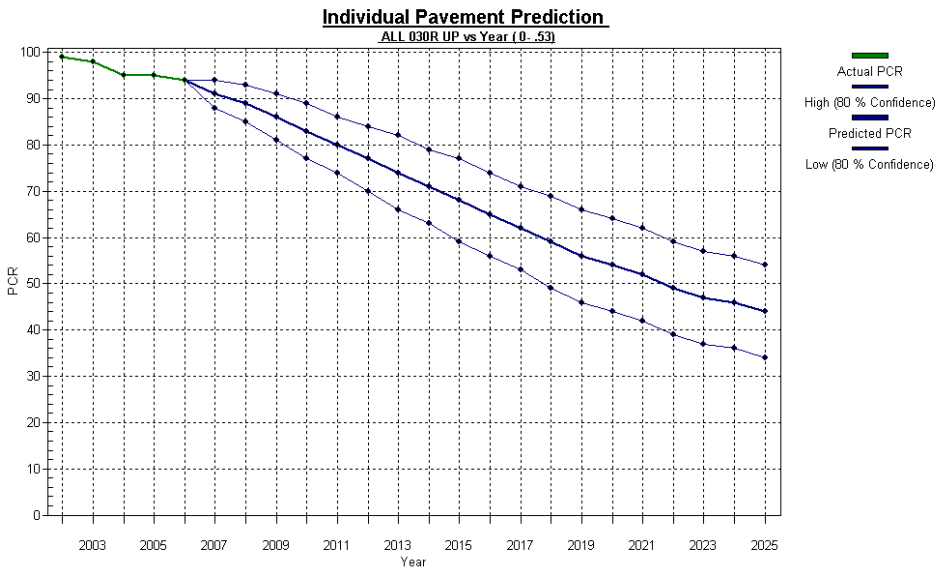


FIGURE C-52. PCR Prediction Confidence Limits

7.5.5 Selected Predictions

This tool has the same functionality as the Markov prediction tool, but is designed for more advanced users to select pavement families for transition matrices.

7.6 Show Predicted Pavement Conditions

This tool can be used to view the Markov predicted pavement conditions. Figure C-53 shows the user interface to view the predicted conditions.

Source Table: DATA_Transition Matrix, DATA_PredictedPCR_JRC, DATA_PredictedDistress_JRC, DATA_PredictedPCR_CRC, DATA_PredictedDistress_CRC, DATA_PredictedPCR_Flex, DATA_PredictedDistress_Flex, DATA_PredictedPCR_Comp, DATA_PredictedDistress_Comp, and DATA_FutureProjects

Output Table: The default name for the output table is "PavementCondition_WithPlan." Users can update this table name by changing the text in the "Output Table name" text box.

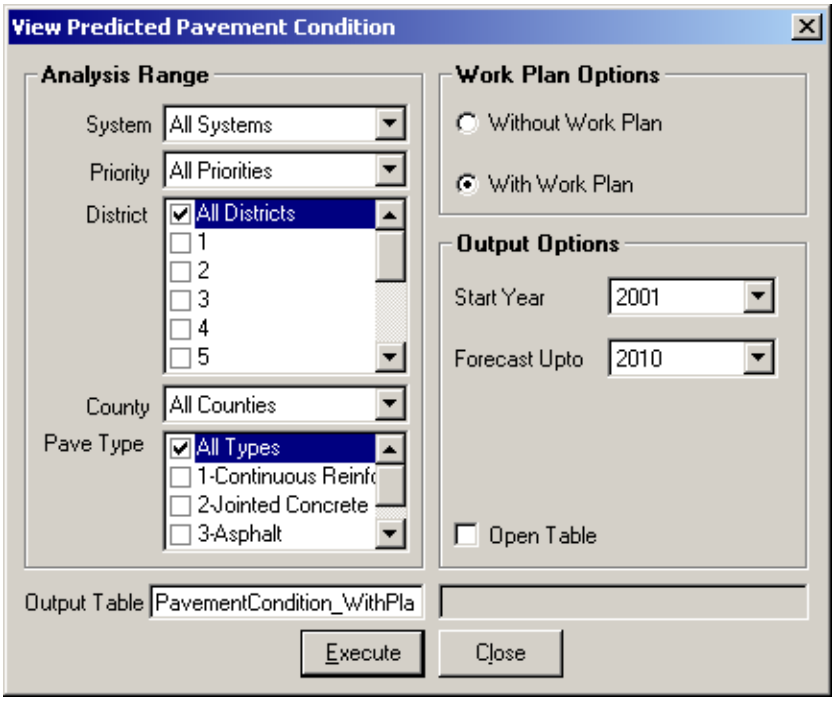


FIGURE C-53. View Predicted Pavement Condition

Work Plan Options

Without Work Plan: Analysis based on original PCR and distress predictions
With Work Plan: Analysis based on result from overlay of PCR and distress predictions with DATA_FutureProjects file

Output Options

Start Year: Start year of the analysis
Forecast Upto: End year of the analysis

Example 1:

To view pavement conditions with the plan for District 3, select the following options:

1. "3" under "District"
2. "With Work Plan" under "Work Plan Options"

3. “2001” under “Start Year”
4. “2010” under “Forecast Upto

Enter an output table name in the “Output Table Name” text box and click “Execute.”

This procedure generates two grids: (1) “view pavement condition with planned treatments,” which displays the predicted PCR overlaid with planned treatments and (2) “view pavement condition with planned treatments – recommended treatments,” which displays the recommended treatments from the current year until 2010.

View pavement condition with planned treatments

PaveID	County	Route	Station	Blog	Elog	Year	Activity Code	Pave Type	Priority	Activity Code				PCR									
										2007	2008	2009	2010	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
61	ASD	042R	UP	0.41	1.01	1997	50	4	G					78	74	73	72	68	68	64	60	57	53
62	ASD	042R	UP	1.01	1.21	1997	50	4	G					78	74	73	72	68	68	64	60	57	53
63	ASD	042R	UP	1.21	2.65	1997	50	4	G					78	74	73	72	68	68	64	60	57	53
64	ASD	042R	UP	2.65	3.02	1997	50	4	G					78	74	73	72	68	68	64	60	57	53
65	ASD	042R	UP	13.4	13.44	1997	31	4	G		60			79	72	68	64	60	67	62	91	89	86
66	ASD	042R	UP	13.44	15.17	1997	31	4	G		60			79	72	68	64	60	67	62	91	89	86
67	ASD	042R	UP	15.17	19.41	1997	31	4	G		60			71	67	64	61	56	54	48	91	89	86
68	ASD	042R	UP	9.43	13.4	2000	50	4	G		60			85	81	75	72	68	70	67	91	89	86
69	ASD	042R	UP	3.02	3.2	2005	20	4	G					78	74	73	72	68	68	65	62	59	57
70	ASD	042R	UP	3.2	3.4	2005	20	4	G					52	50	83	76	71	73	70	67	64	63
71	ASD	042R	UP	3.4	3.63	2005	20	4	G					52	50	83	76	71	73	70	67	64	63
72	ASD	042R	UP	3.63	3.92	2005	20	4	U					52	50	83	76	71	73	70	67	64	63
73	ASD	042R	UP	3.92	4.93	2005	20	4	U					54	54	84	78	74	77	74	71	68	66
74	ASD	042R	UP	4.93	6.56	2005	20	4	G					54	54	84	78	74	77	74	71	68	66
75	ASD	042R	UP	6.56	6.58	2005	20	4	G					54	54	84	78	74	77	74	71	68	66

FIGURE C-54. View Pavement Condition with Planned Treatments

Users can right click the above PCR grid and select “Generate PCR Summary” to generate a “PCR Summary” chart as shown in Figure C-55.

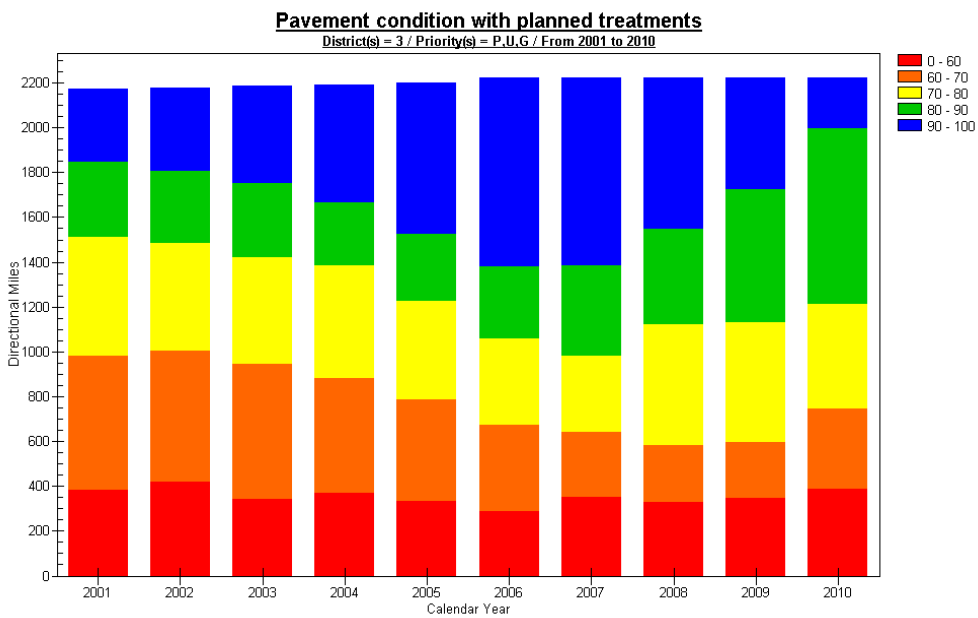


FIGURE C-55. PCR Summary

The second grid with recommended treatments is shown in Figure C-56.

View pavement condition with planned treatments - Recommended Treatments

PaveID	Route	Station	Blog	Elog	Year	Activity Code	Pave Type	Priority	Activity Code				Recommended Treatment				Recommended Cost in $			
									2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
61	042R	UP	0.41	1.01	1997	50	4	G					Bin2	Bin2	Bin2	Bin2	97,067	102,891	108,036	112,897
62	042R	UP	1.01	1.21	1997	50	4	G					Bin2	Bin2	Bin2	Bin2	48,533	51,446	54,018	56,449
63	042R	UP	1.21	2.65	1997	50	4	G					Bin2	Bin2	Bin2	Bin2	232,961	246,938	259,285	270,953
64	042R	UP	2.65	3.02	1997	50	4	G					Bin2	Bin2	Bin2	Bin2	89,787	95,174	99,933	104,430
65	042R	UP	13.4	13.44	1997	31	4	G		60			Bin3	Bin1	Bin1	Bin1	6,170	0	0	0
66	042R	UP	13.44	15.17	1997	31	4	G		60			Bin3	Bin1	Bin1	Bin1	266,850	0	0	0
67	042R	UP	15.17	19.41	1997	31	4	G		60			Bin3	Bin1	Bin1	Bin1	1,308,029	0	0	0
68	042R	UP	9.43	13.4	2000	50	4	G		60			Bin2	Bin1	Bin1	Bin1	642,260	0	0	0
69	042R	UP	3.02	3.2	2005	20	4	G					Bin2	Bin2	Bin2	Bin2	58,240	61,735	64,821	67,738
70	042R	UP	3.2	3.4	2005	20	4	G					Bin2	Bin3	Bin3	Bin3	64,711	65,401	68,672	71,762
71	042R	UP	3.4	3.63	2005	20	4	G					Bin2	Bin3	Bin3	Bin3	74,418	75,212	78,972	82,526
72	042R	UP	3.63	3.92	2005	20	4	U					Bin2	Bin3	Bin3	Bin3	93,831	94,832	99,574	104,055
73	042R	UP	3.92	4.93	2005	20	4	U					Bin3	Bin3	Bin3	Bin3	155,791	165,139	173,396	181,198
74	042R	UP	4.93	6.56	2005	20	4	G					Bin3	Bin3	Bin3	Bin3	251,425	266,511	279,837	292,429
75	042R	UP	6.56	6.58	2005	20	4	G					Bin3	Bin3	Bin3	Bin3	3,085	3,270	3,434	3,588

FIGURE C-56. View Pavement Condition with Planned Treatments – Recommended Treatments

Users can right click the above grid and select "Generate Cost Summary" to generate a "Cost Summary" chart as shown in Figure C-57.

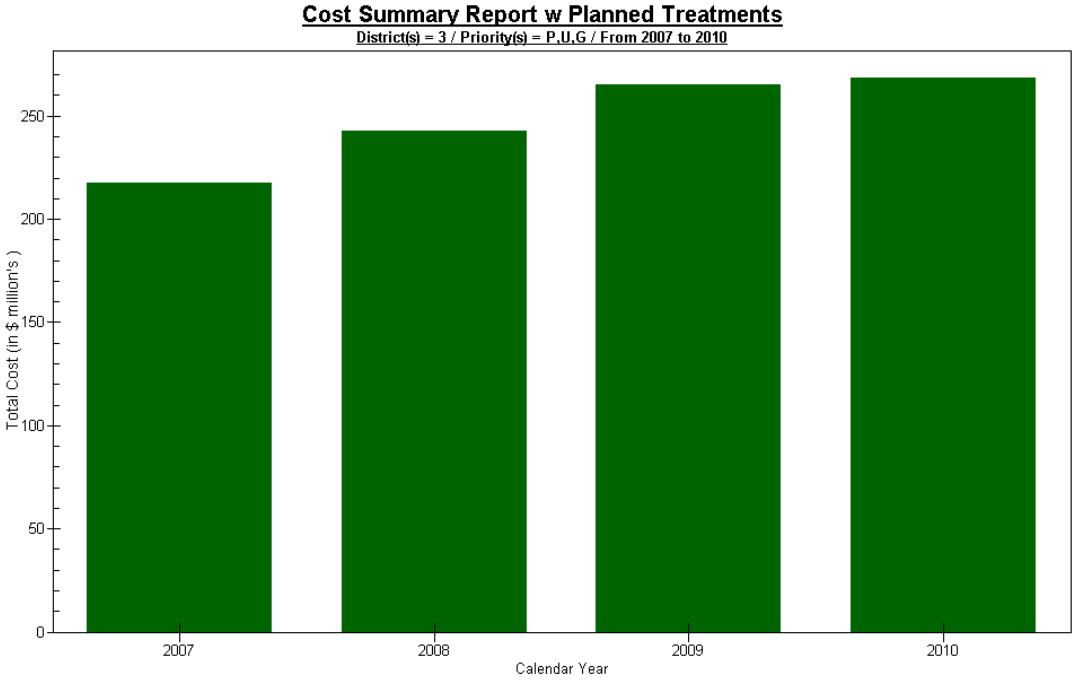


FIGURE C-57. Cost Summary

7.7 Estimate remaining life

This tool can be used to estimate the remaining life of pavement sections based on certain PCR and/or distress thresholds. Figure C-58 shows the user interface to view the predicted conditions.

Source Table: DATA_PredictedPCR_JRC, DATA_PredictedDistress_JRC, DATA_PredictedPCR_CRC, DATA_PredictedDistress_CRC,

DATA_PredictedPCR_Flex, DATA_PredictedDistress_Flex, DATA_PredictedPCR_Comp, DATA_PredictedDistress_Comp.

Output Table: The default name for the output table is "Remaining Life." Users can update this table name by changing the text in the "Output Table name" text box.

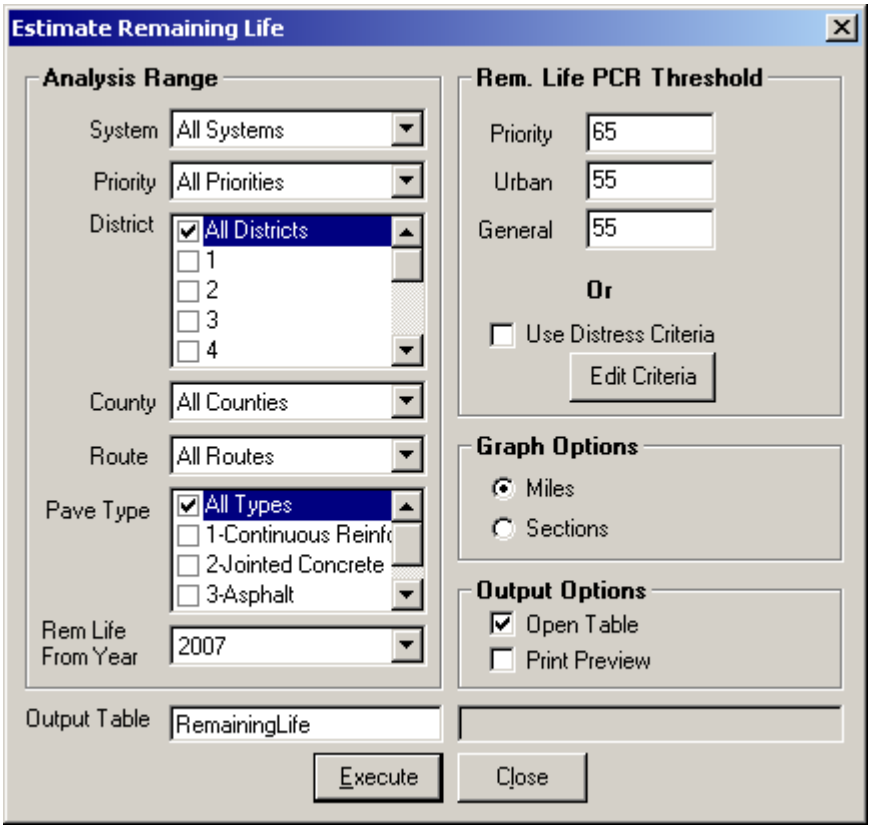


FIGURE C-58. Estimate Remaining Life

Rem. Life PCR Threshold

Enter PCR thresholds in the text boxes. The remaining life is calculated by the time until the current PCR reaches the specified PCR threshold.

Use Distress Criteria

Check this option and click "Edit Criteria" to display the window shown in Figure C-59. Users can then enter thresholds for individual distresses. The remaining life is calculated using both the PCR and distress thresholds, whichever occurs first.

Graph Options

Miles: Analysis will be based on the directional miles
Sections: Analysis will be based on the number of pavement sections

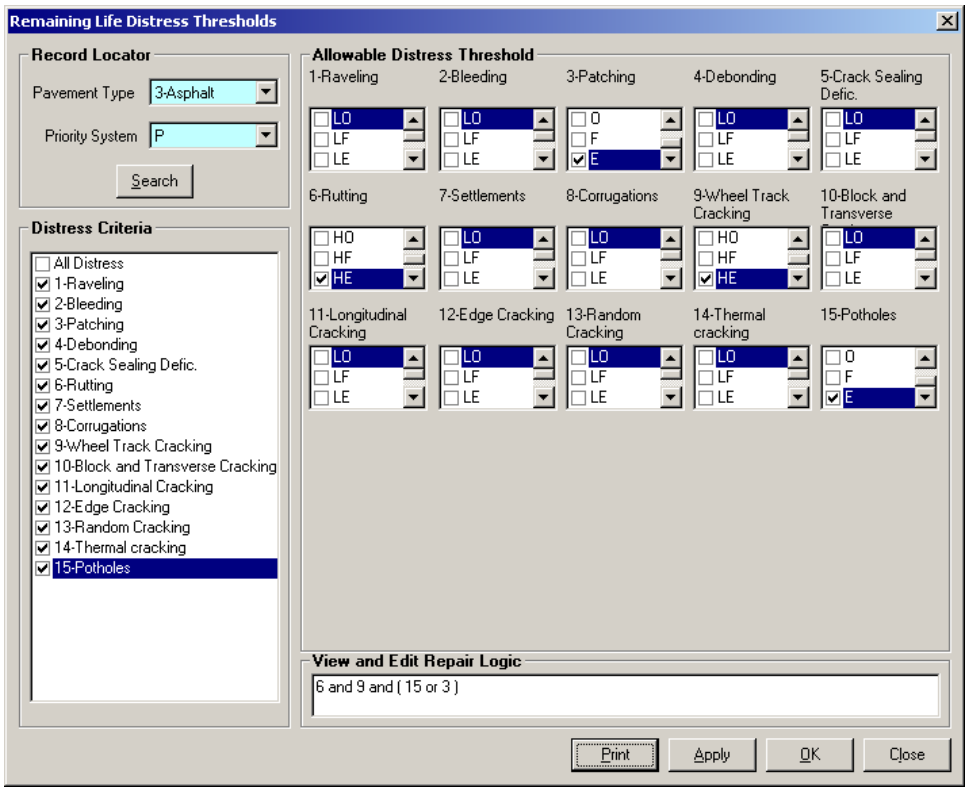


FIGURE C-59. Distress Thresholds

Example 1:

To view the remaining life for "General System Pavements" from 2007 based on a PCR threshold of 55, select the following options:

1. "G" under "Priority"
2. "2007" under "Rem Life From Year"
3. "55" in the "General" text box under "Rem. Life PCR Threshold"

Enter an output table name in the "Output Table Name" text box and click "Execute."

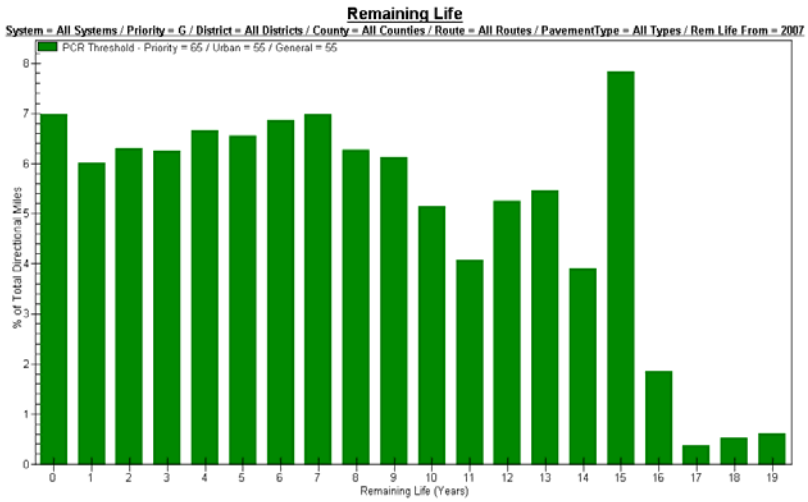


FIGURE C-60. Remaining Life on General Systems

7.8 Histogram

This tool is used to generate a histogram for a selected field in a table.

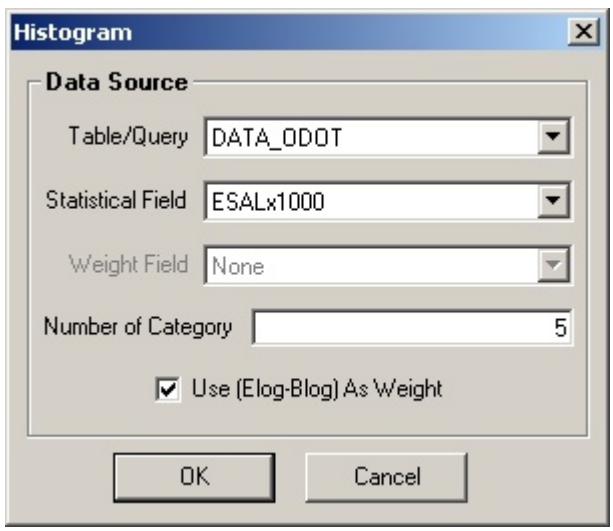


FIGURE C-61. Histogram Tool

Data Source

Table/Query: Table or query from which a field is selected to generate histogram
Statistical Field: Field from the selected table
Weight field: sum of selected field in each category of statistical field
Number of Category: Number of categories for histogram
Use (Elog-Blog): Total mileage under each category.

Example 1:

Figure C-62 shows the histogram for PCR, weighted by mileage from DATA_ODOT. This is generated by selecting "DATA_ODOT" in "Table/Query," "PCR" in "Statistical Field,"

"None" in "Weight Field," "5" in "Number of Category," and enabling "Use (Elog-Blog) As Weight."

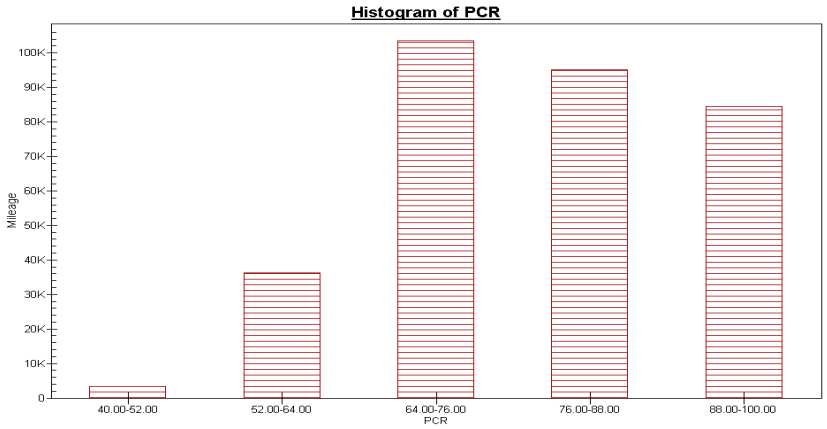


FIGURE C-62. Example of a PCR Histogram Tool

Report Menu

This menu contains tools to generate reports of the database.

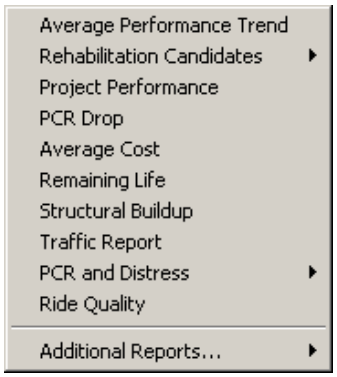


FIGURE C-63. ODOTPMIS Report Menu

8.1 Average Performance Trend

This tool generates an average performance report for parameters from DATA_ODOT.

Source Table: DATA_PERF_ANALYSIS, DATA_ODOT
Intermediate Table Generated: DATA_PERF_CURVE
Output Table: The default name for the output table is "Average Deterioration Trend Analysis." Users can update this table name by changing the text in the "Output Table name" text box.

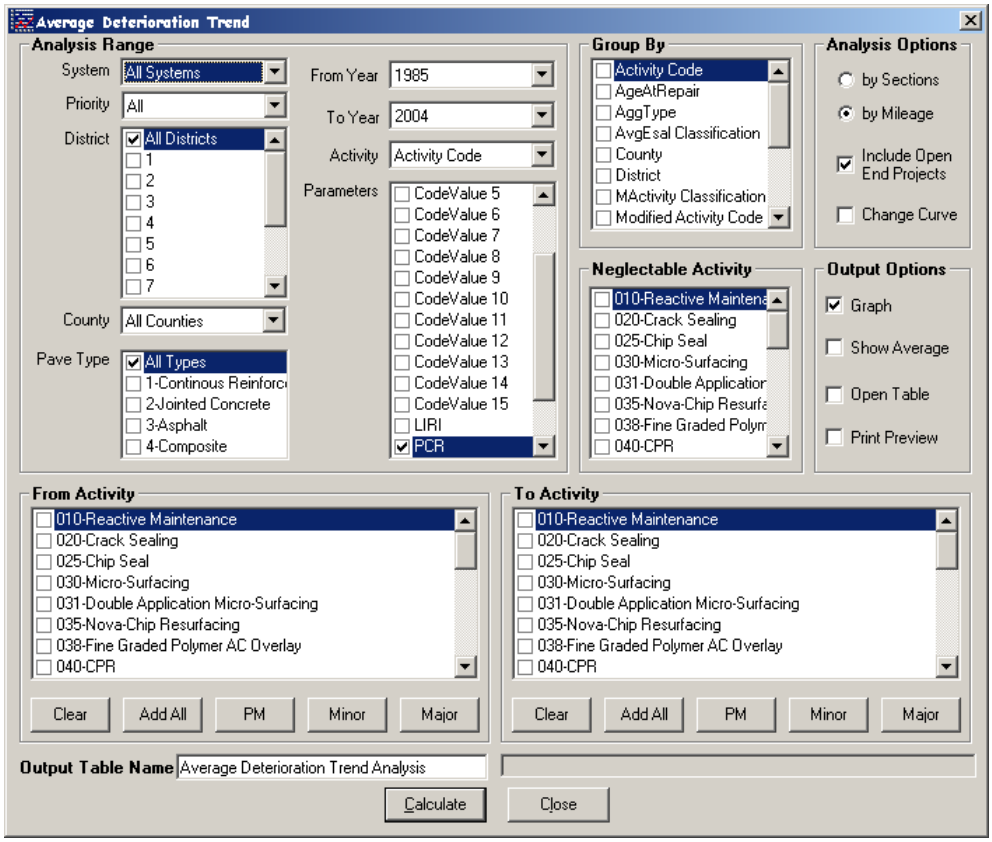


FIGURE C-64. Average Deterioration Trend User Interface

Analysis Options

Include Open End Projects: Enabling this option will include open-ended projects (projects/pavements which still exist)

Change Curve: Enabling this option will generate a graph based on the rate of deterioration.

Output Options

Show Average: Enabling this option calculates and displays an average category based on the current categories displayed on the chart. For example, if the average deteriorations of Districts 1 and 3 are displayed, checking this option will display an additional category that is the average of deterioration trends on Districts 1 and 3.

Example:

The following example shows the average deterioration trend report for PCR and RN for all systems, priorities, pavement types and counties in district 1 for Activity codes 50 and 60 and from 1985 to 2006. Select following options on the tool:

1. "All Systems" under "System"
2. "All" under "Priority"
3. "1" under "District"

4. “All Counties” under “County”
5. “All Types” under “Pave Type”
6. “All Directions” under “System”
7. “1985” under “From Year,” and “2006” under “To Year”
8. “Activity Code” under “Activity” list
9. “PCR” and “RN” under “Parameters”
10. “50” and “60” under **“**From Activity” list, and “Add All” under “To Activity” list

Enter an output table name in the “Output Table Name” text box and click “Execute.”

Figure C-65 shows the average deterioration trends for PCR and RN.

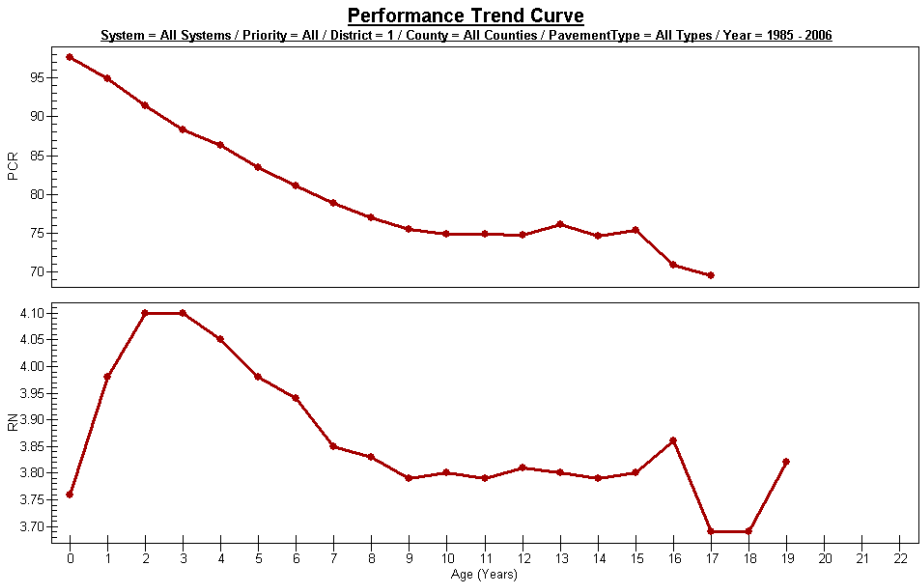


FIGURE C-65. Performance Trend Curve

This tool also generates a mileage chart as shown in Figure C-66.

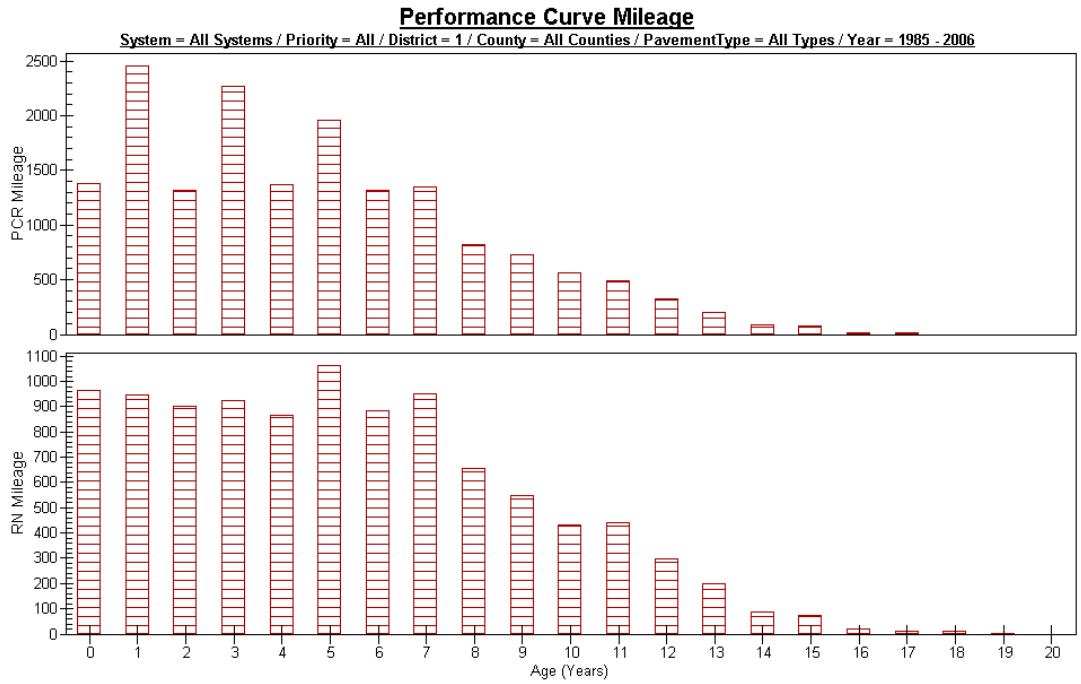


FIGURE C-66. Performance Curve Mileage

Figure C-67 is generated when the "Change Curve" option is checked in "Analysis Options" and shows the change curve for "PCR" and "RN." The change curve values are obtained by taking the difference of two consecutive average deterioration values. It represents the rate of deterioration.

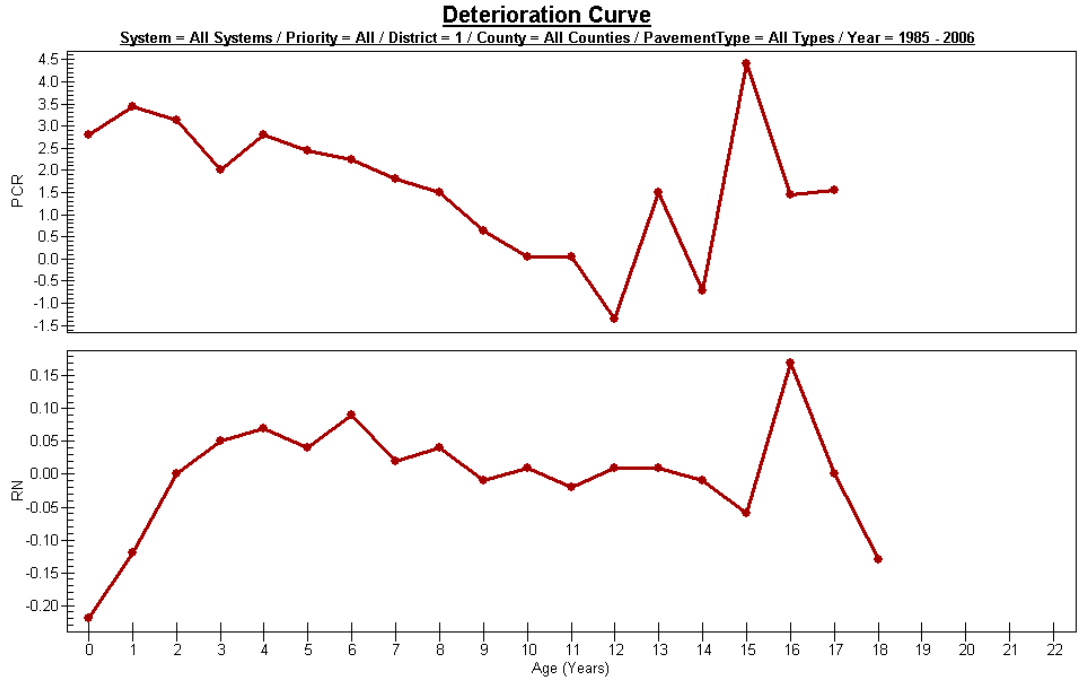


FIGURE C-67. Change Curve

8.2 Rehabilitation Candidates

This menu is used to generate a rehabilitation candidate list based on the treatment decision trees provided by ODOT. The tools available under this menu are "Generate Statewide Rehab List," "Generate U/G Rehab List," "Generate Priority Rehab List," "Priority System Major Rehab List," and "Modify Repair Logic." For all the tools under this menu, the following tables are used in the background:

Source Tables: DATA_ODOT, DATA_Project History_Apparent, DATA_PERF_BASE, LU_Repair Logic, LU_Repair Limits

8.2.1 Generate Statewide Rehab List

This tool generates the recommended treatments for all the pavement sections in the database for the latest available PCR. The user interface is shown in Figure C-68. The output is stored in the table name given in the "Output Table" text box. In addition to this output table, this tool also generates a bin summary table that contains the directional miles that fall under each bin category. If the output table name is [table name], the bin summary table created will be named [table name_Bin Summary].

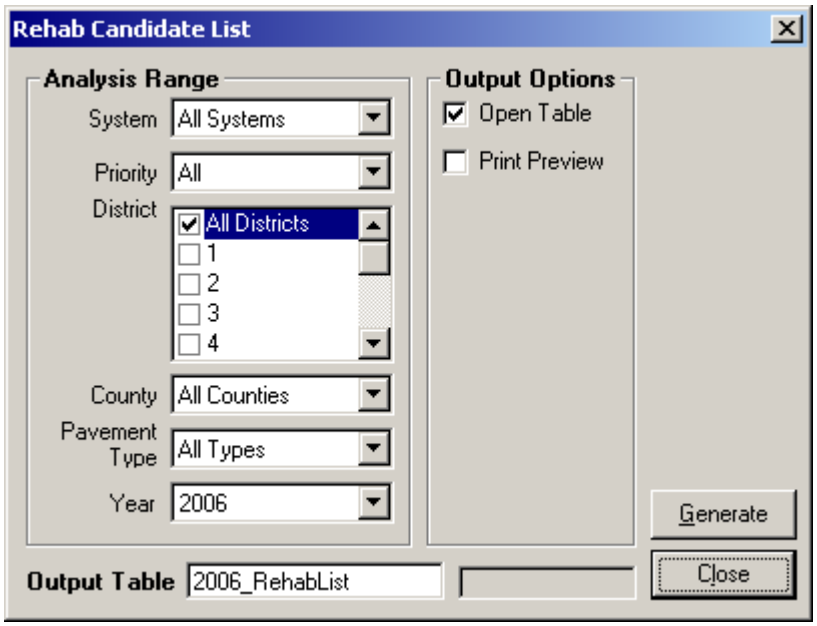


FIGURE C-68. Rehab Candidates

8.2.2 General U/G Rehab List

This tool generates the recommended treatments (bin's) list only for pavement sections on urban and general systems. The user interface is similar to above in Figure C-68, however, in the "Priority" combo box, the default value is "U/G."

8.2.3 General Priority Rehab List

This tool generates the recommended treatments (bin's) list only for pavement sections on urban and general systems. The user interface is similar to Figure C-68, however the "Priority" combo box is defaulted to "P."

8.2.4 Priority System Major Rehab List

This tool generates the candidate sections eligible for major rehab on priority systems based on the decision tree provided by ODOT. The user interface is shown in Figure C-69. The decision tree and repair logic are also shown in the user interface.

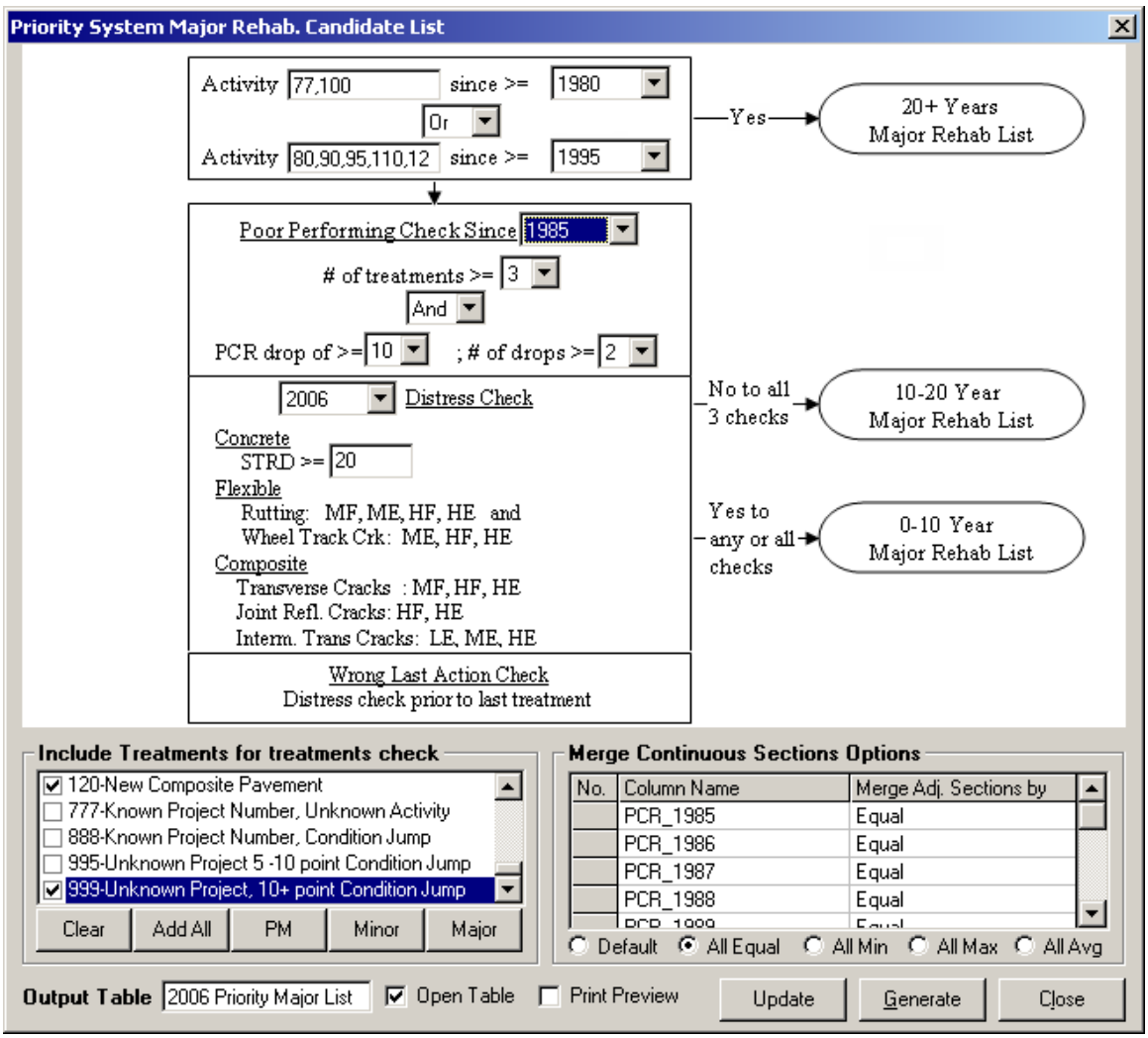


FIGURE C-69. Priority System Major Rehab List

Include Treatments for Treatments Check

This option allows the user to select the treatments that will be included in the "# of treatments" check in the decision tree.

Merge Continuous Sections Options

These options allow the user to control how continuous sections are merged. The options provided are

Default: Two continuous sections are merged into a single record by considering the "Minimum PCR," "Maximum Total ADT," and "Truck ADT" between the sections, provided the remaining fields are equal

All Equal: Two continuous sections are merged into a single record if all the fields are equal

All Min: Two continuous sections are merged into a single record by considering the "Minimum of PCR," "Total ADT," and "Truck ADT" between the sections provided the remaining fields are equal

All Max: Two continuous sections are merged into a single record by considering the "Maximum of PCR," "Total ADT," and "Truck ADT" between the sections provided the remaining fields are equal

All Avg: Two continuous sections are merged into a single record by considering the "Average of PCR," "Total ADT," and "Truck ADT" between the sections provided the remaining fields are equal

8.2.5 Modify Rehab Logic

This tool enables the user to change the decision tree and repair logic provided by ODOT. Figure C-70 shows the interface for modifying decision trees.

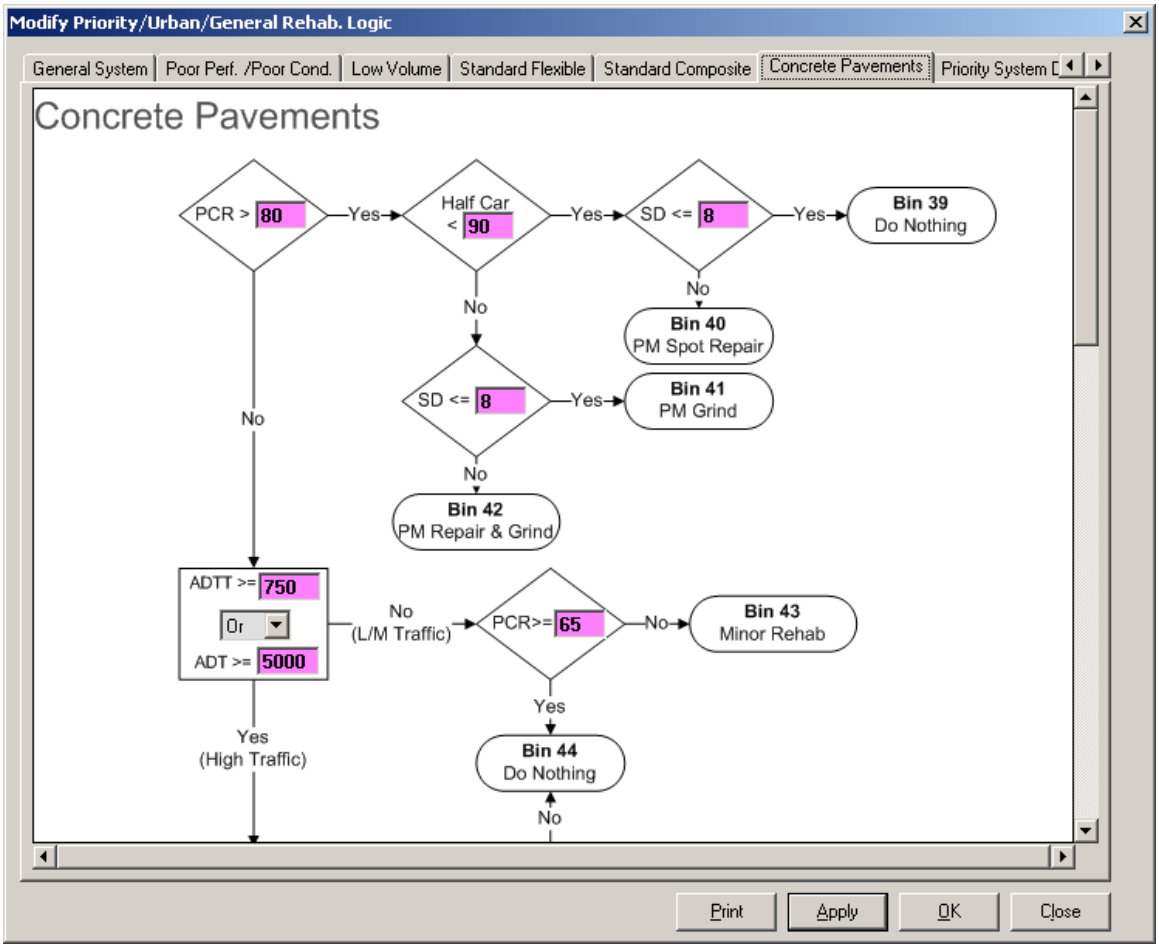


FIGURE C-70. Modify Decision Trees and Repair Logic

To modify a decision tree, choose the category by clicking on the appropriate tab in the "Modify Priority/Urban/General Rehab Logic" sub-window. Text boxes are provided at various stages (for PCR, traffic, etc.). Enter new values in the text boxes and click "Apply" to modify the decision tree.

To modify the repair logic ("Preventive Maintenance," "Major," "Minor," and "Priority Major Rehab"), click "Miscellaneous Criteria." Select the "Pavement Type," "Preservation," and "Priority System" in the "Record Locator" and click "Search." The "Miscellaneous Criteria" tab provides options to change the "Functional Class," "PCR Limits," and "Traffic" as shown in Figure C-71. This is the basic procedure:

Note: If the value for criteria is empty, it is not considered in the repair logic.

1. Change the "Functional Class" in the "Functional Class" list
2. Change the "PCR Limits" in the "PCR Lower Limit" and "PCR Upper Limit" text boxes
3. Change the "Traffic Limits" in the "Total ADT" and "Truck ADT" text boxes
4. Change the "Cracking Index Limit" in the "Max Cracking Index" text box
5. For two lanes, apply the "Two-Lane Only" option
6. Select appropriate distress levels for each code under "Allowable Distress"

7. Click “Apply” to save the changes

To change the logic for a repair check i.e., to include or remove any distress from the repair logic, use the “View and Edit Repair Logic” text box.

Figure C-71 shows the allowable distress for a structural check of a general system, flexible pavement. The repair logic is “6 and 9 and (15 or 3)”. The user can edit the text in this text box to add or remove any distress, however, the default syntax must be used to make any changes. This syntax is shown in Figure C-71.

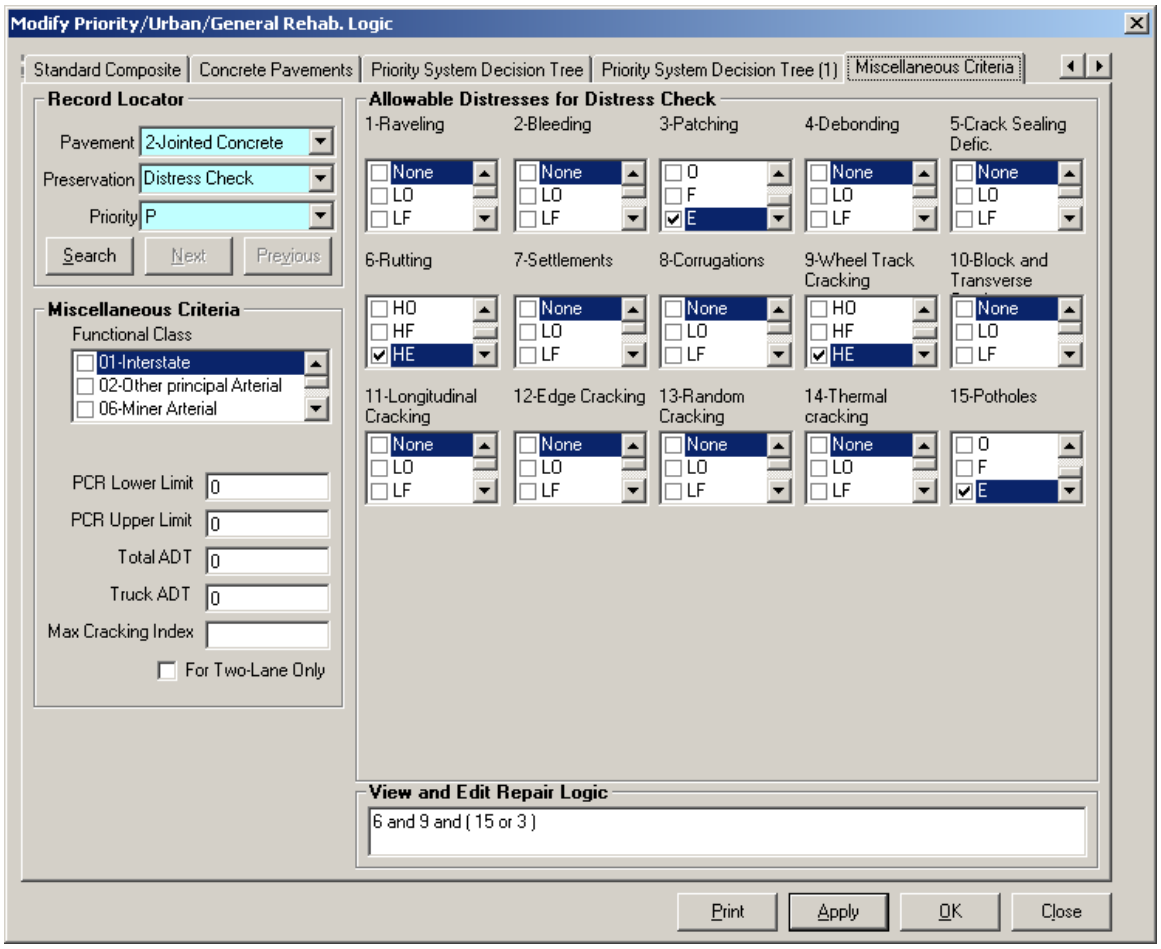


FIGURE C-71. Edit Repair Logic

Syntax for Editing Repair Logic

1. Enter any distresses by their code numbers
   Example: If the logic is “Rutting” or “Wheel Track Cracking” for flexible pavement, the user should input “6 or 9”

2. Separate text by spaces
   Example: The correct syntax for the command “1or2or3” is “1 or 2 or 3”

3. Separate brackets by spaces

Example: The correct syntax for the text "1or(2and3)or4" is "1 or (2 and 3) or 4"

8.3 Project Performance

In the "Report" menu, click "Project Performance." This tool generates the project performance reports.

Source Table: DATA_Project History_Apparent, DATA_ODOT
Output Table: The default name for the output table is "Project Performance." Users can update this table name by changing the text in the "Output Table name" text box.

Figure C-72 shows the window used for generating this report. The "Analysis Range" frame selects the project number and parameters to be used to generate the report.

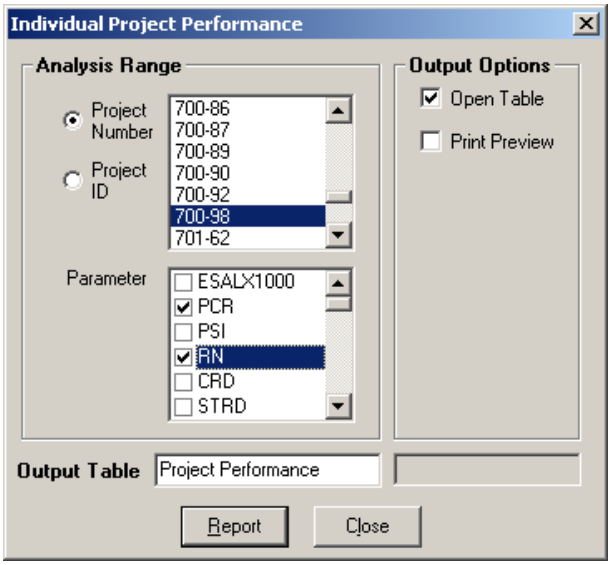


FIGURE C-72. Individual Project Performance

Example:

Figure C-73 shows the Project Performance Report for Project Number 701-99 for PCR and RN (Ride Number). This report is generated by selecting "Project Number 701-99" in the "Project Number" list box, and "PCR" and "RN" in the "Parameter" list box.

Individual Project Performance

Project Number = 701-99

County	Route	Station	BLog	ELog	Activity Code	PN	Year	PCR	RN
CHP	004R	DOWN	6.93	7.96	50	701-99	1999		
							2000		
							2001		
							2002		
							2003		
							2004		
							2005		
							2006		
CHP	004R	UP	6.93	7.13	50	701-99	2000	100.00	3.98
							2001	98.00	3.99
							2002	91.00	3.99
							2003	90.00	3.80
							2004	89.00	3.80
							2005	84.00	3.80
							2006	83.00	3.58
CHP	004R	UP	7.13	7.44	50	701-99	2000	100.00	3.85
							2001	98.00	3.99
							2002	91.00	3.99
							2003	90.00	3.63
							2004	89.00	3.63
							2005	84.00	3.63
							2006	83.00	3.12
CHP	004R	UP	7.44	7.96	50	701-99	2000	100.00	3.95
							2001	98.00	3.92
							2002	91.00	3.92
							2003	90.00	3.86
							2004	89.00	3.86
							2005	84.00	3.86
							2006	83.00	3.46

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FIGURE C-73. Example of Individual Project Performance Output

8.4 PCR Drop

This tool generates a list of pavement sections with a quantity of PCR drops greater than or equal to a specified value, and with specific treatments performed. PCR Drop for this tool is defined as decrease in PCR value between any two years.

Source Table: DATA_Project History_Apparent, DATA_ODOT, DATA_PERF_BASE
Output Table: The default name for the output table is "PCR Drop List." Users can update this table name by changing the text in the "Output Table name" text box.

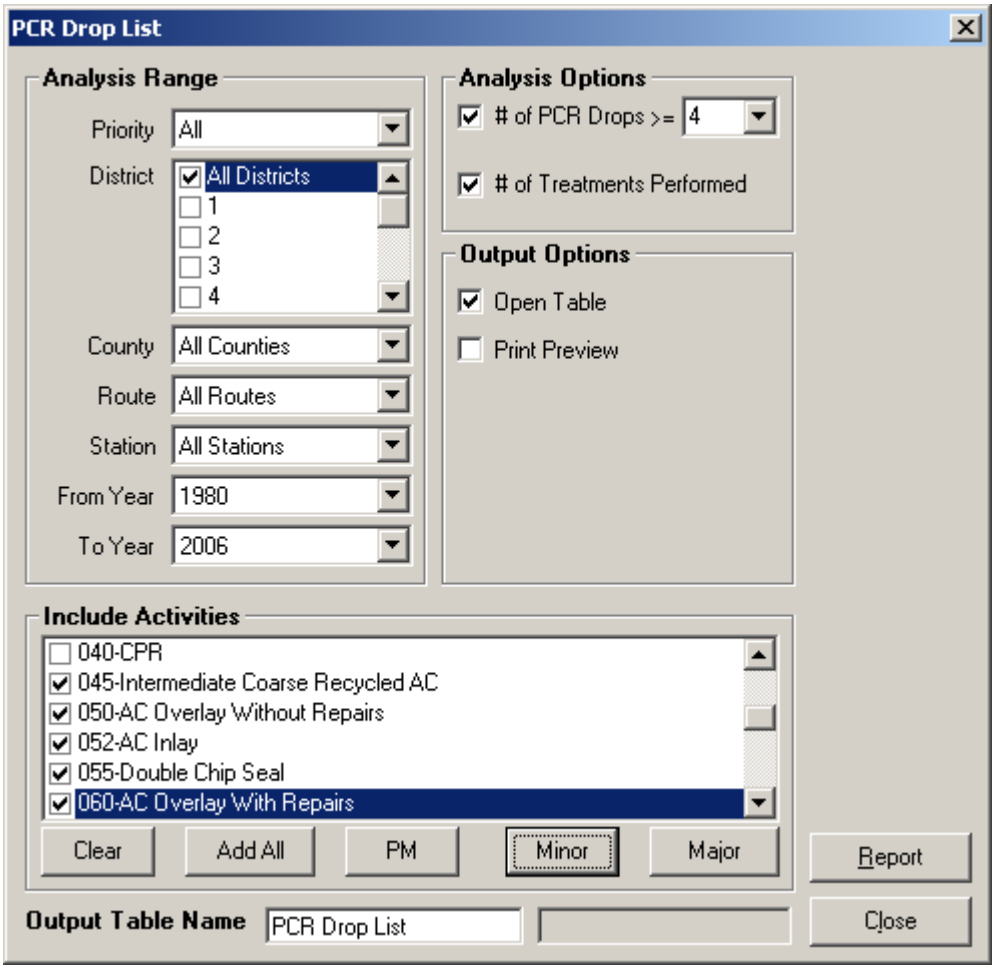

FIGURE C-74. PCR Drop Tool

Analysis Options

PCR Drop >=: When checked, this option will calculate the number of PCR Drops greater than or equal to the value selected in the drop down box and between the values selected in the "From Year" and "To Year" drop down boxes

 # Of Treatments Performed: When checked, this option will calculate the number of treatments performed between the values selected in the "From Year" and "To Year" drop down boxes. The treatments selected in "Include Activities" will be counted

8.5 Average Cost`

This tool generates an average cost report for each activity. To generate this report, the look up table LU_COST must exist in the database. In the "Data" menu, click "Generate Cost Lookup Table" to generate LU_COST.

Source Table: DATA_Project History, LU_COST
Output Table: The default name for the output table is "Unit Cost Analysis." Users can update this table name by changing the text in the "Output Table name" text box.

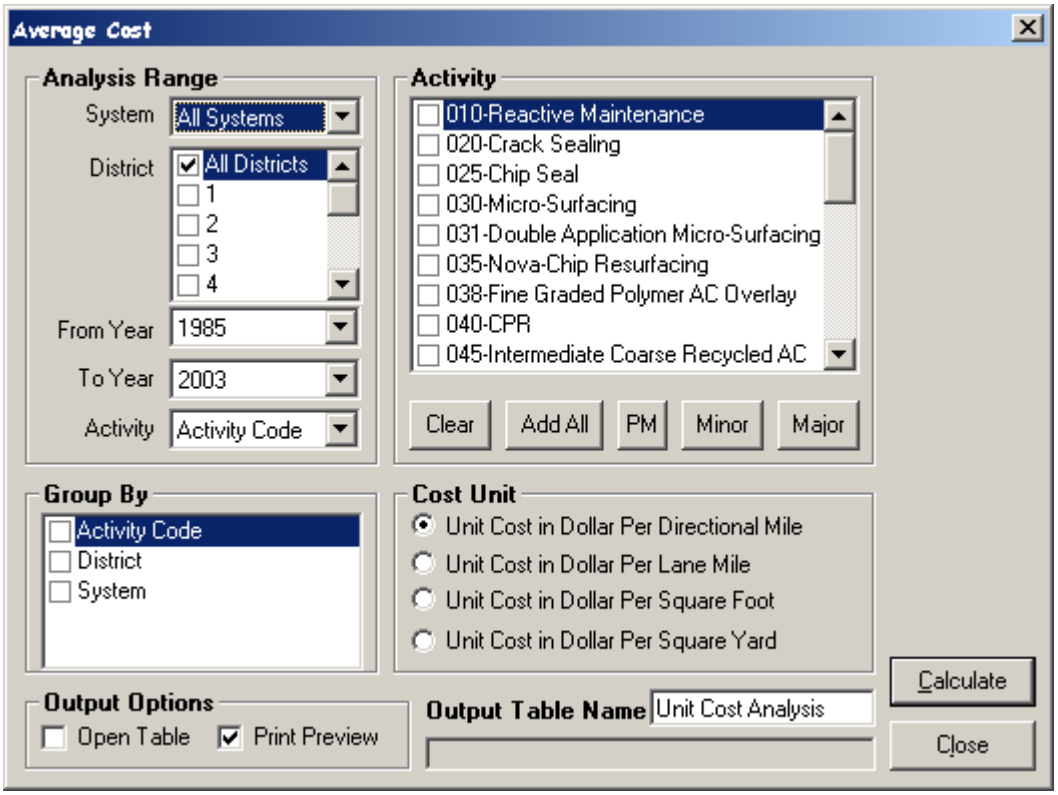

FIGURE C-75. Average Cost Analysis Interface User Interface

Example:

Figure C-76 shows the cost report for Activities 50 and 60 per lane mile, for all systems and in each district from 1985 to 2006.

This report is generated by selecting “All Systems” under “System,” “All” under “District,” “1985” under “From Year,” “2006” under “To Year,” “Activity Code” under “Activity,” “District” under “Group By,” “50” and “60” under “Activity,” and “Unit Cost in Dollar Per Lane Mile” under “Cost Unit.”

Unit Cost Analysis

District	Average Cost / Ln mi	Median Cost / Ln mi	Number of Projects
1	5975.99	5425.23	88
2	27751.52	30798.56	77
3	15053.34	15379.41	94
4	27722.08	27693.88	98
5	8832.71	7160.04	64
6	9241.30	7262.44	109
7	10045.35	9547.76	162
8	11781.96	9146.57	98
9	5168.19	4248.30	65
10	2255.64	807.18	102
11	15687.55	17691.35	100
12	30617.93	25113.67	81

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FIGURE C-76. Average Cost Per Lane Mile for Overlays

8.6 Structural Buildup

This tool generates a current pavement structure report.

Source Table: DATA_Project History, DATA_PERF_BASE
Output Table: The default name for the output table is "Recent Pavement Structure Report" Users can update this table name by changing the text in the "Output Table name" text box.

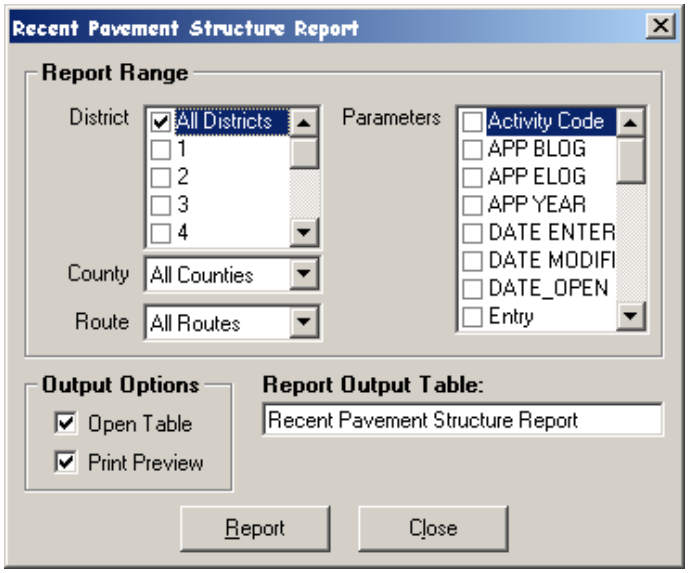

FIGURE C-77. Pavement Structure Report

Example:

Figure C-78 shows the current pavement structural buildup for Route 032R in Adams County. This report is generated by selecting "ADA" in the "County" list and 032R in the "Route" list.

Recent Pavement Structure Report

County = ADA
Route = 032R

Property	*Value*
Route ID	ADA 032R DOWN
Section (App)	0 - 6.29
App Year	1991
Pavement Removed	0-2.75 VAR
Added Layer 1	1" 448-AC
Added Layer 2	1.75" 448-AC
Section (Org)	0 - 6.29
Org Year	1991
Route ID	ADA 032R DOWN
Section (App)	6.29 - 6.67
App Year	2001
Section (Org)	6.29 - 6.67
Org Year	2001
Route ID	ADA 032R DOWN
Section (App)	6.67 - 14.71
App Year	1990
Added Layer 1	1" 404-AC
Added Layer 2	1.5" 402-AC
Section (Org)	6.67 - 14.71
Org Year	1990
Route ID	ADA 032R DOWN
Section (App)	14.71 - 24.85
App Year	1991
Added Layer 1	1" 404-AC
Section (Org)	14.71 - 19.99
Org Year	1991

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FIGURE C-78. Recent Pavement Structure Report Output

8.7 Traffic Report

This tool generates the average Traffic, ESAL, and summary statistics report.

Source Table: DATA_ODOT
Output Table: The default name for the output table is “Traffic Report” Users can update this table name by changing the text in the “Output Table name” text box.

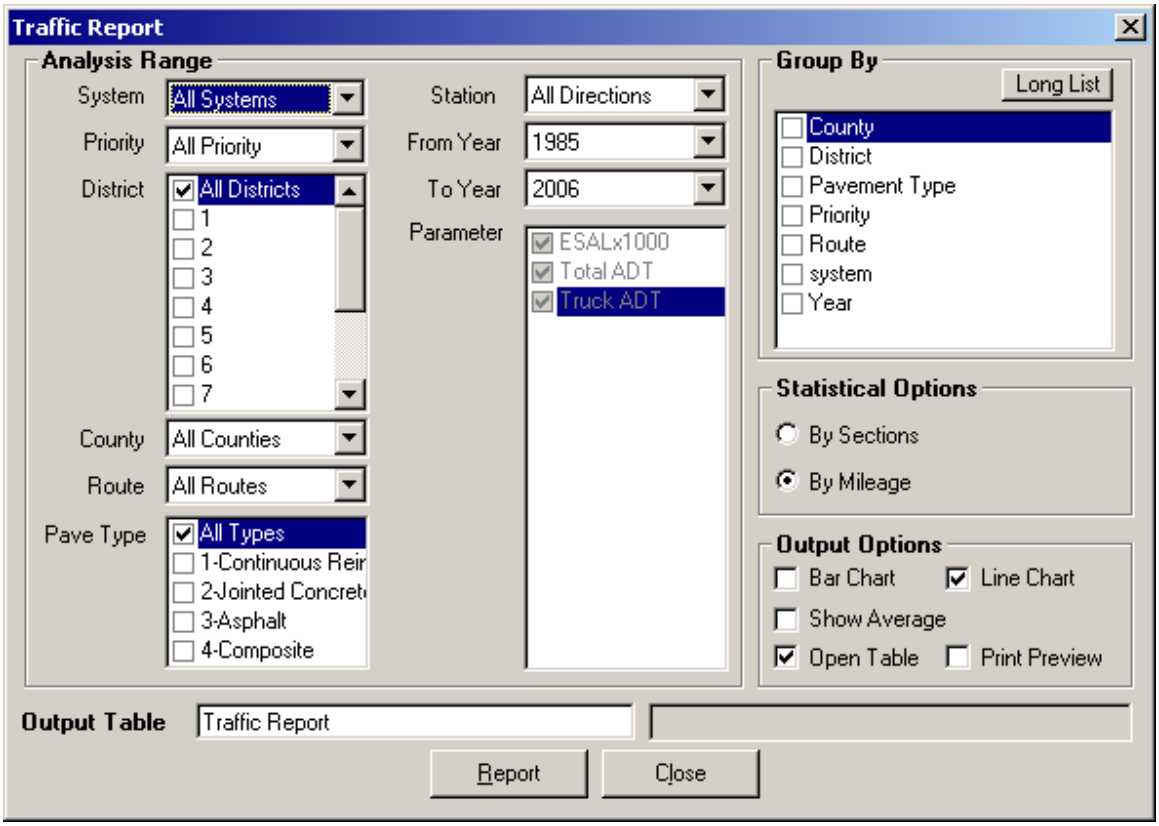
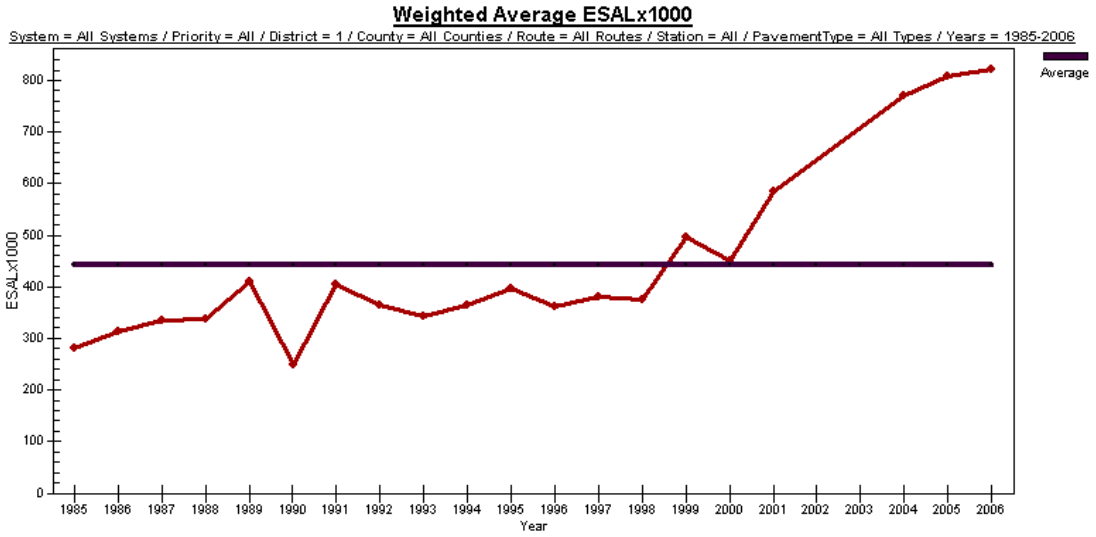


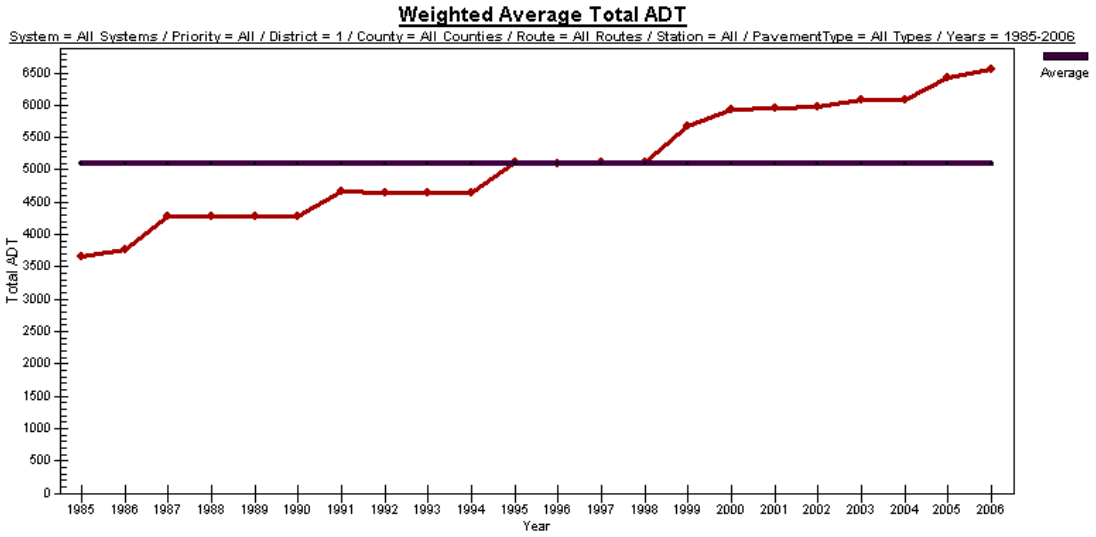
FIGURE C-79. Traffic Report User Interface

Example:

Figure C-80 shows the charts for ESALX1000, Total ADT, and Truck ADT for all systems, priorities, pavement types, and routes in District 1 from 1985 to 2006. The tool also generates a report, shown in Figure C-81.

The charts and report are generated by selecting "All Systems" under "System," "All" under "Priority," "1" under "District," "All Counties" under "County," "All Types" under "Pave Type," "All Directions" under "System," "1985" under "From Year," "2006" under "To Year," "Year" under "Group By," "By Mileage" under "Analysis Options," "Line Chart" under "Output Options," and "Show Average" under "Output Options."





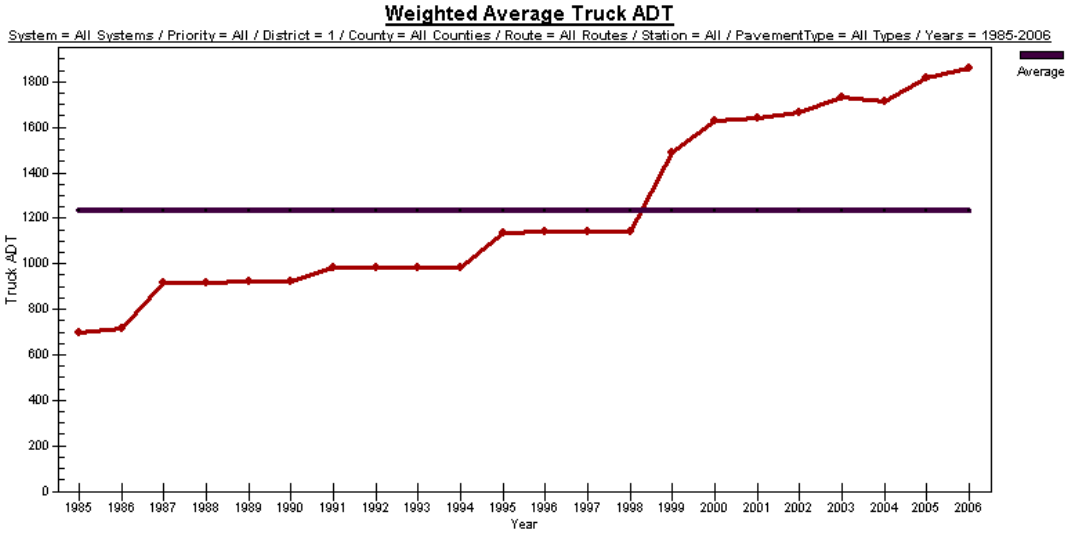


FIGURE C-80. Traffic Report Charts

Traffic Report (1985 - 2006)

System = All Systems
Priority = All Priorities
District = 1
County = All Counties
Route = All Routes
Pavement Type = All Types

State Average:
ESALx1000 = 545.46
Total ADT = 15202.06
Truck ADT = 1718.93

Highest:
ESALx1000 = 822,Year = 2006
Total ADT = 6560,Year = 2006
Truck ADT = 1861,Year = 2006

Lowest:
ESALx1000 = 250,Year = 1990
Total ADT = 3651,Year = 1985
Truck ADT = 696,Year = 1985

Year	*ESAL(1000)*	*Total ADT*	*Truck ADT*	*ADT Mileage*
1985	281	3651	696	1639.20
1986	314	3758	717	1655.01
1987	335	4278	919	1654.13
1988	337	4272	919	1653.16
1989	410	4276	920	1654.74
1990	250	4280	921	1657.38
1991	406	4657	985	1656.37
1992	364	4656	985	1655.79
1993	342	4656	985	1655.79

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FIGURE C-81. Traffic Report

8.8 PCR and Distress

This menu is used to generate the average PCR and distress by project age or calendar year.

Source Tables: DATA_ODOT, DATA_PERF_ANALYSIS

8.8.1 Average by Project Age

This tool generates the average distresses, CRD (cracking deduct), PCR, and STRD (structural deduct) for a project year. The user interface is shown in Figure C-82.

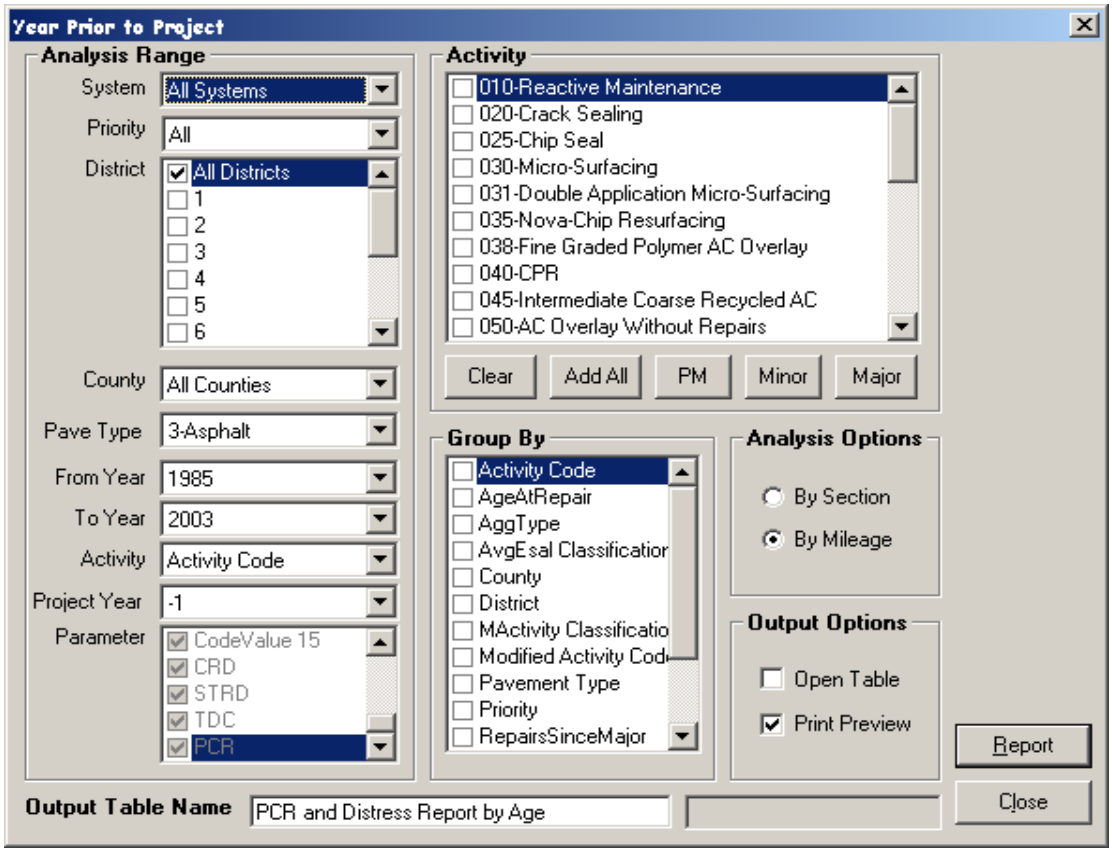

FIGURE C-82. Average PCR and Distresses by Project Age

Example:

Figure C-83 shows "Year 0" or the condition immediately after overlays, on priority system, flexible pavements. This report is generated by selecting "All Systems" under "System," "P" under "Priority," "All" under "District," "All Counties" under "County," "3-Asphalt" under "Pave Type," "1985" under "From Year," "2006" under "To Year," "50 and 60" under "Activity," "0" under "Project Year," "Add All" under "Activity," and "By Mileage" under "Analysis Options."

Year 0 of Project (1985 - 2006)

System = All Systems
Priority = P
District = All Districts
County = All Counties
Pavement Type = 3-Asphalt

PaveType	Age	Parameter	% Mileage Affected	WAvg Deduct of Affected	Overall WAvg
3	0	Raveling	83.09	2.10	1.74
3	0	Bleeding	.72	.03	.00
3	0	Patching	2.74	.04	.00
3	0	Debonding	1.54	.02	.00
3	0	Crack Sealing Defic.	4.78	.19	.01
3	0	Rutting	13.32	.55	.07
3	0	Settlements	.39	.04	.00
3	0	Corrugations	.00	.00	.00
3	0	Wheel Track Cracking	1.85	.10	.00
3	0	Block and Transverse Cracking	8.08	.34	.03
3	0	Longitudinal Cracking	7.45	.17	.01
3	0	Edge Cracking	1.48	.03	.00
3	0	Random Cracking	6.42	.15	.01
3	0	Thermal cracking	.07	.00	.00
3	0	Potholes	.00	.00	.00
3	0	CRD		.85	
3	0	STRD		1.14	
3	0	TDC		3.76	
3	0	PCR		96.38	
3	0	PCR Mileage		1236.45	

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FIGURE C-83. Average PCR and Distresses by Project Age Output

8.8.2 Average by Calendar Year

This function reports the average distresses, CRD (cracking deduct), PCR and STRD (structural deduct) by pavement type, district, and county for a given calendar year.

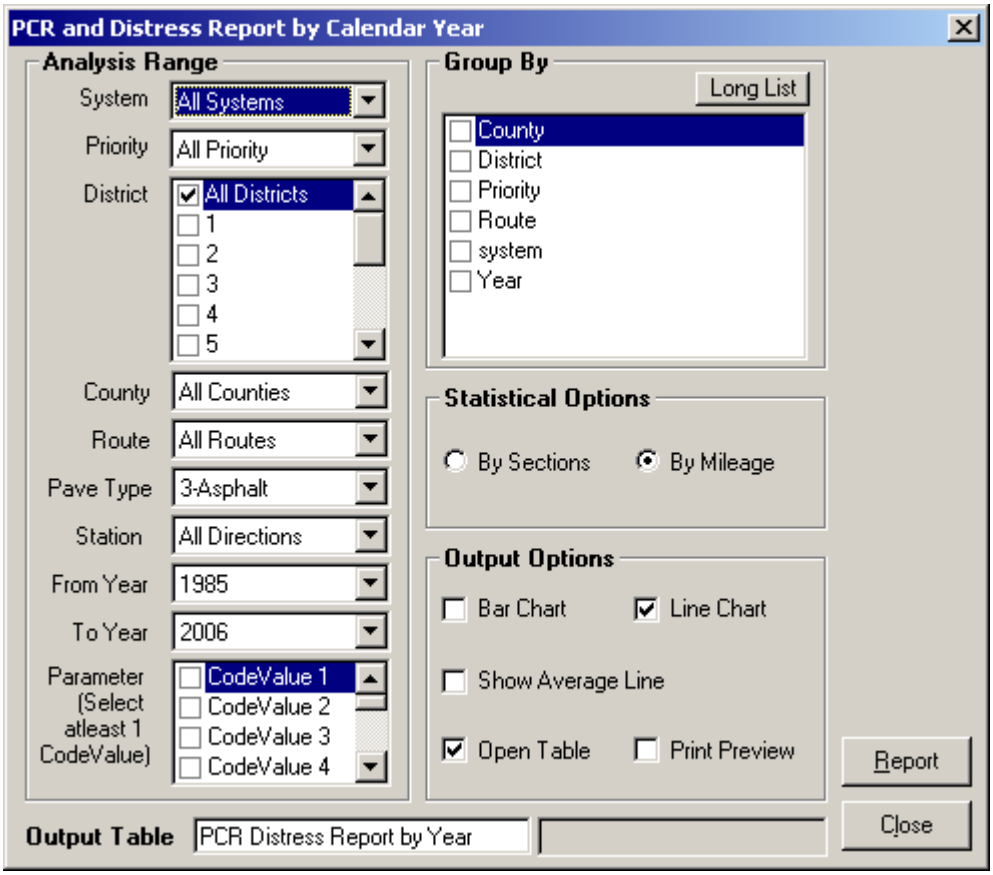

FIGURE C-84. Average PCR and Distresses by Calendar Year

Example:

Figure C-85 shows the PCR and Distress Average by Calendar Year report for all distresses in flexible pavements, for all systems, all priorities, in District 1 from 1985 to 2006.

PCR and Distress Report by Calendar Year (1985 - 2006)

```
System = All Systems
Priority = All
District = 1
County = All Counties
Route = All Routes
PavementType = 3-Asphalt
Station = All Stations
```

Parameter	*Total WAvg*	*WAvg of Affected*	*% Mileage Affected*
PCR	86.35		
Raveling	2.92	2.97	98.36
Bleeding	.55	3.19	17.32
Patching	.25	1.83	13.84
Debonding	.04	1.76	2.53
Crack Sealing Defic.	1.90	4.19	45.34
Rutting	2.48	3.31	74.93
Settlements	.03	3.15	1.07
Corrugations	.00	1.08	.20
Wheel Track Cracking	.91	3.85	23.58
Block and Transverse Cracking	1.42	3.88	36.56
Longitudinal Cracking	1.57	2.31	67.70
Edge Cracking	.56	1.87	29.96
Random Cracking	1.06	2.17	49.04
Thermal cracking	.05	2.62	1.81
Potholes	.00	2.00	.00
PCR Mileage	17826.50		

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FIGURE C-85. PCR and Distresses by Calendar Year Output

8.9 Ride Quality

This report gives the ride quality (in terms of LIRI, RIRI and RN) distribution in miles by pavement type, district, year, etc

Source Table: DATA_ODOT, LU_Parameter Range (parameter categories defined by ODOT)
Output Table: The default name for the output table is "LIRI Mileage Report." Users can update this table name by changing the text in the "Output Table name" text box.

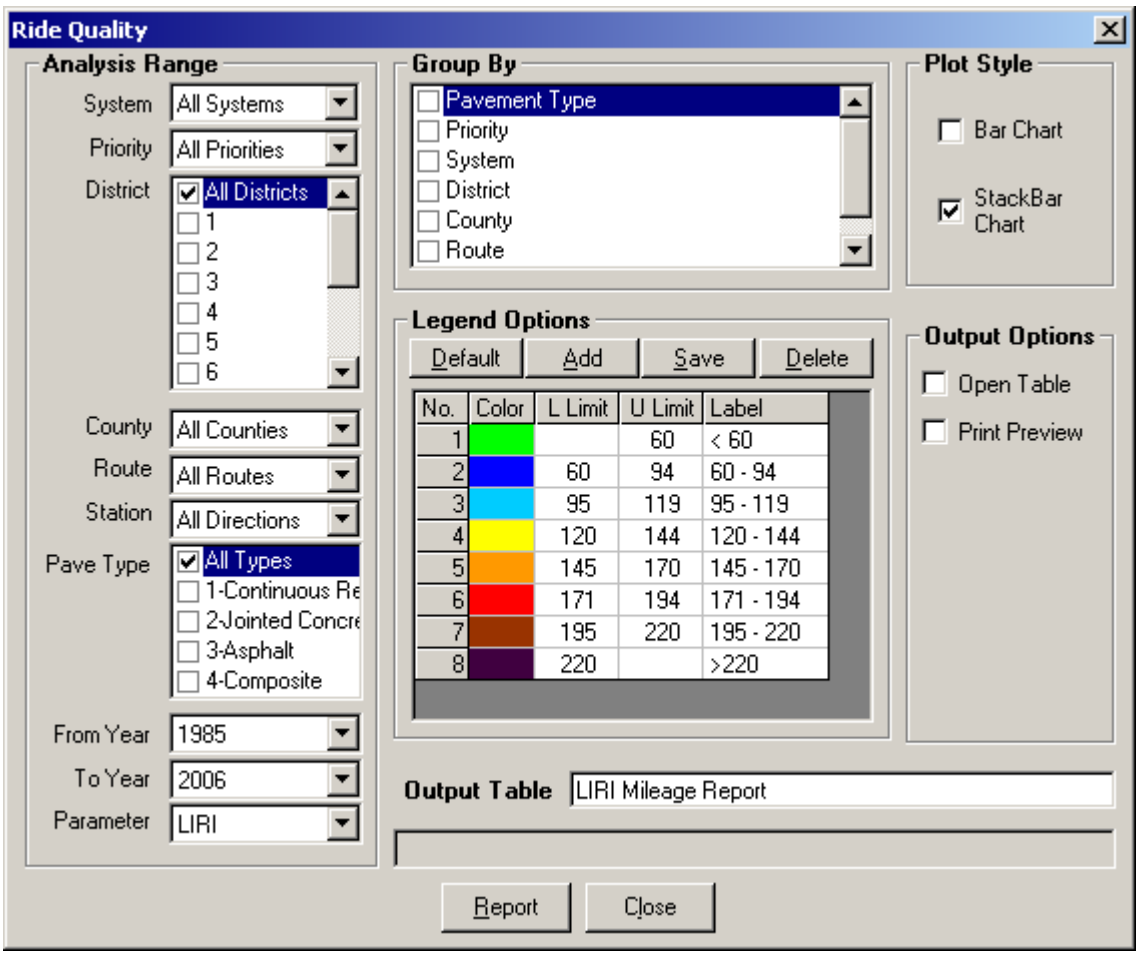


FIGURE C-86. Ride Quality Report

Example:

Figure C-87 shows the Ride Quality Report in miles for LIRI for categories defined by ODOT in District 1 for each year from 1998 to 2006.

This report is generated by selecting "All Systems" under "System," "All" under "Priority," "1" under "District," "All Counties" under "County," "All Types" under "Pave Type," "1985" under "From Year," "2006" under "To Year," "LIRI" under "Parameter," "Year" under "Group By," and "Stackbar Chart" under "Plot Style."

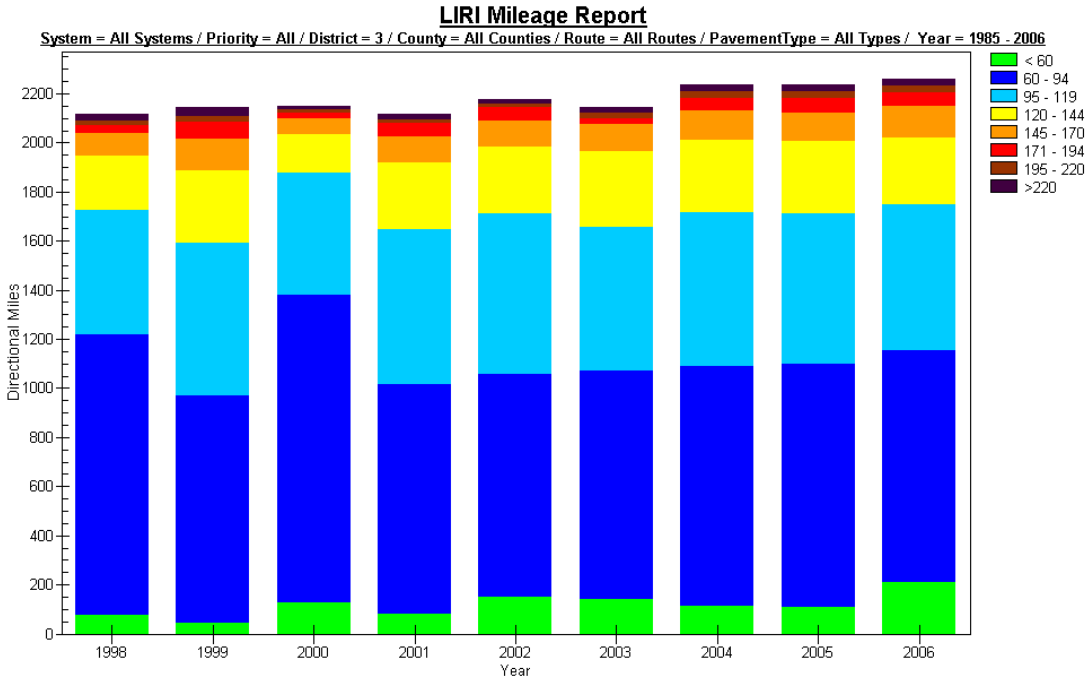


FIGURE C-87. Ride Quality Report Output (Left IRI)

8.10 Additional Reports

The tools under this menu are "Project History Plot," "Statistical Report," "General Mileage Report," and "Map View of a Table."

8.10.1 Project History Plot

This tool, shown in Figure C-88, is used for viewing the changes in data – PCR, for example – from DATA_ODOT over time for a particular route within a county based on the Original Record (Blog and Elog) from DATA_Project History, or Auto Detection (Blog and Elog) from DATA_Project History_Apparent. The tool also uses colored backgrounds to indicate the repair history of the selected route.

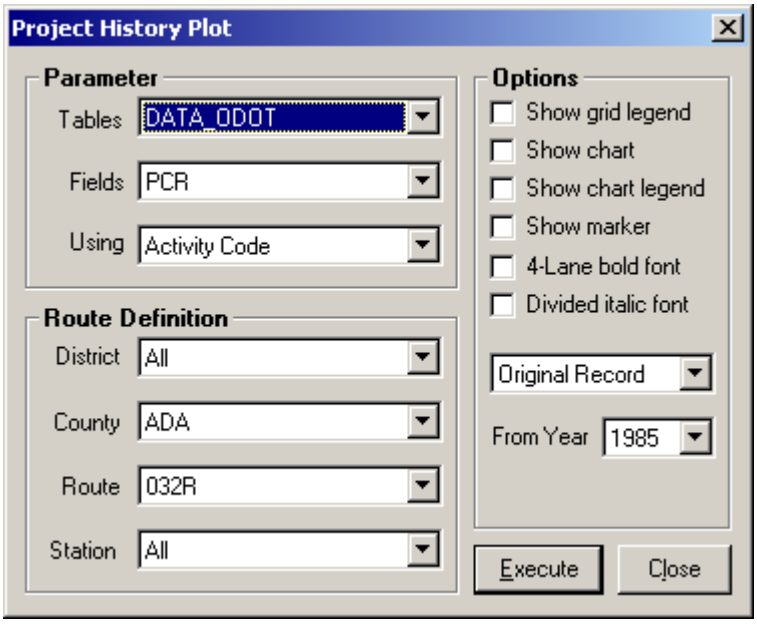
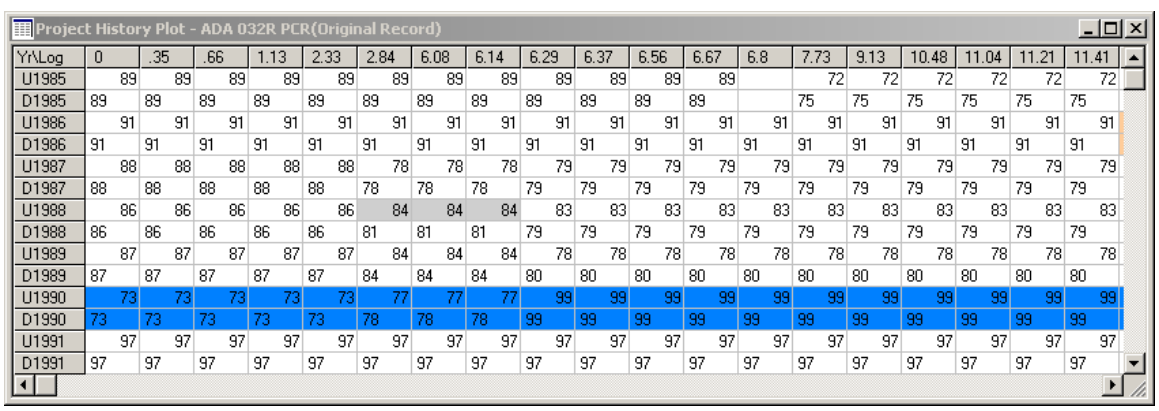


FIGURE C-88. Project History Plot

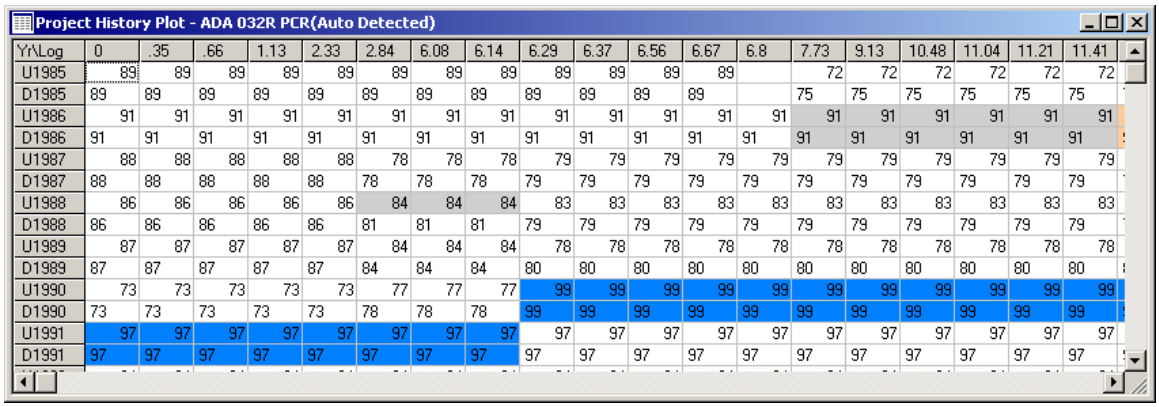
The plot shown in Figure C-89 was generated by selecting "ADA" under "County," "032R" under "Route," and "Original Record" under "Options." Figure C-90 was generated with the same settings but using "Auto Detected" under "Options." Figure C-90 demonstrates that the Activities are adjusted according to PCR jumps.



Project History Plot - ADA 032R PCR(Original Record)

Yr\Log	0	.35	.66	1.13	2.33	2.84	6.08	6.14	6.29	6.37	6.56	6.67	6.8	7.73	9.13	10.48	11.04	11.21	11.41
U1985	89	89	89	89	89	89	89	89	89	89	89	89		72	72	72	72	72	72
D1985	89	89	89	89	89	89	89	89	89	89	89	89		75	75	75	75	75	75
U1986	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91
D1986	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91
U1987	88	88	88	88	88	78	78	78	79	79	79	79	79	79	79	79	79	79	79
D1987	88	88	88	88	88	78	78	78	79	79	79	79	79	79	79	79	79	79	79
U1988	86	86	86	86	86	84	84	84	83	83	83	83	83	83	83	83	83	83	83
D1988	86	86	86	86	86	81	81	81	79	79	79	79	79	79	79	79	79	79	79
U1989	87	87	87	87	87	84	84	84	78	78	78	78	78	78	78	78	78	78	78
D1989	87	87	87	87	87	84	84	84	80	80	80	80	80	80	80	80	80	80	80
U1990	73	73	73	73	73	77	77	77	99	99	99	99	99	99	99	99	99	99	99
D1990	73	73	73	73	73	78	78	78	99	99	99	99	99	99	99	99	99	99	99
U1991	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97
D1991	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97

FIGURE C-89. Project History Plot Based on Original Record



Project History Plot - ADA 032R PCR(Auto Detected)

Yr\Log	0	.35	.66	1.13	2.33	2.84	6.08	6.14	6.29	6.37	6.56	6.67	6.8	7.73	9.13	10.48	11.04	11.21	11.41
U1985	89	89	89	89	89	89	89	89	89	89	89	89		72	72	72	72	72	72
D1985	89	89	89	89	89	89	89	89	89	89	89	89		75	75	75	75	75	75
U1986	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91
D1986	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91
U1987	88	88	88	88	88	78	78	78	79	79	79	79	79	79	79	79	79	79	79
D1987	88	88	88	88	88	78	78	78	79	79	79	79	79	79	79	79	79	79	79
U1988	86	86	86	86	86	84	84	84	83	83	83	83	83	83	83	83	83	83	83
D1988	86	86	86	86	86	81	81	81	79	79	79	79	79	79	79	79	79	79	79
U1989	87	87	87	87	87	84	84	84	78	78	78	78	78	78	78	78	78	78	78
D1989	87	87	87	87	87	84	84	84	80	80	80	80	80	80	80	80	80	80	80
U1990	73	73	73	73	73	77	77	77	99	99	99	99	99	99	99	99	99	99	99
D1990	73	73	73	73	73	78	78	78	99	99	99	99	99	99	99	99	99	99	99
U1991	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97
D1991	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97

FIGURE C-90. Project History Plot Based on Auto Detected

8.10.2 Statistical Report

This tool is used to calculate average or weighted average values for a user selected parameter. This tool is similar to Traffic Report explained earlier; however in this tool the user can select any parameter from ODOT in addition to traffic and ESAL.

Source Table**: DATA_ODOT**

Output Table**: The default name for the output table is "Statistical Report." Users can update this table name by changing the text in the "Output Table name" text box.**

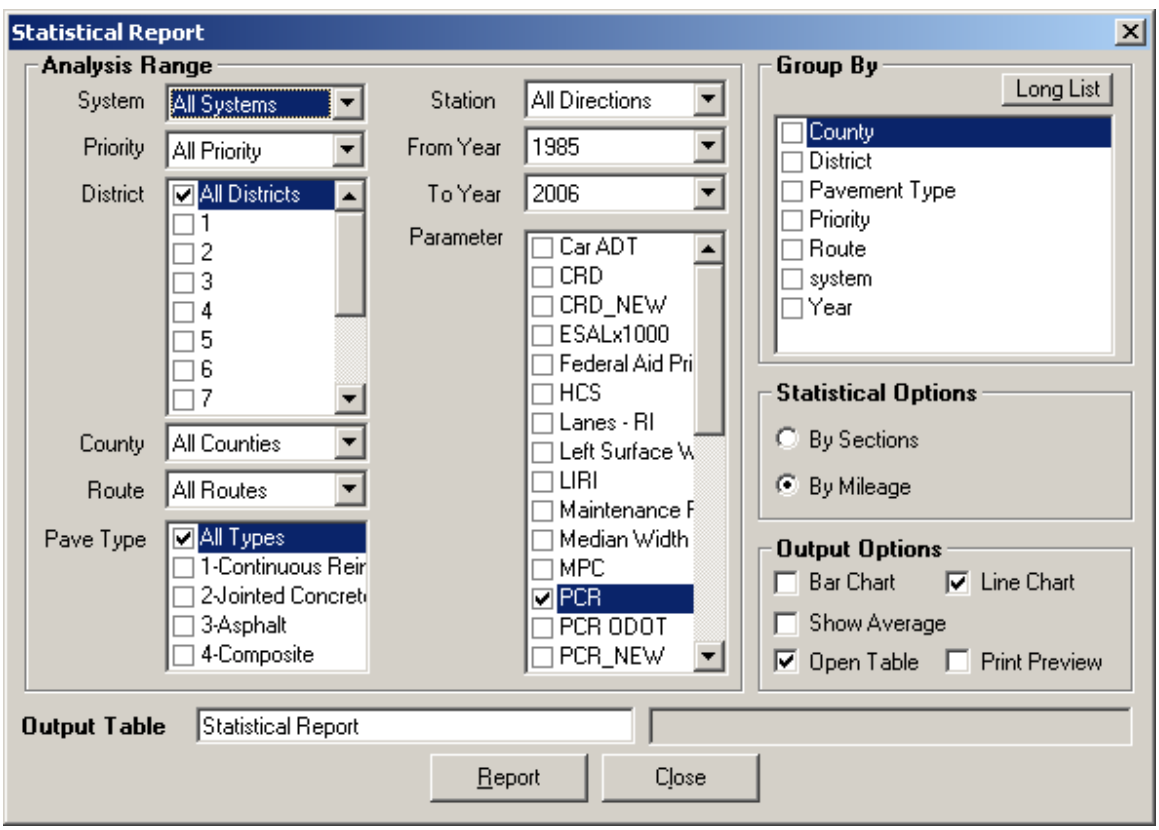


FIGURE C-91. Statistical Report User Interface

Output Options

Bar Chart	Output shown in bar chart format
Line Chart	Output shown in line graph format
Show Average	Average of all data shown on graph

Example:

Figure C-92 shows the Statistical Report for PCR and RN (Ride Number) for all systems, all priorities, all pavement types, in each county and on all routes in District 1, for each year from 1985 to 2006.

This report is generated by selecting "All Systems" under "System," "All" under "Priority," "1" under "District," "All Counties" under "County," "All Types" under "Pave Type," "1985" under "From Year," "2006" under "To Year," "PCR" and "RN" under "Parameter," "Year" under "Group By," "By Mileage" under "Analysis Options," and "Line Chart," Show Average" and "Print Preview" under "Output Options."

Figure C-92 shows the generated statistical report. ODOT began collecting RN (ride number) data in 1998, and hence RN data slots are empty prior to 1998.

Statistical Report (1985 - 2006)

System = All Systems
Priority = All Priorities
District = 1
County = All Counties
Route = All Routes
Pavement Type = All Types

State Average:
PCR = 79.50
RN = 3.40

Highest:
PCR = 89,Year = 1985
RN = 3.943477,Year = 2003

Lowest:
PCR = 77,Year = 1991
RN = 3.790172,Year = 1999

Year	*PCR*	*PCRMileage*	*RN*	*RNMileage*
1985	89	255.05		
1986	86	1602.96		
1987	84	276.48		
1988	85	1624.76		
1989	83	278.48		
1990	84	1650.75		
1991	77	281.90		
1992	85	1636.13		
1993	79	280.74		
1994	86	1633.32		
1995	80	380.46		
1996	83	1634.94		

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FIGURE C-92. Statistical Report Output

Figure C-93 shows the PCR chart with an average line.

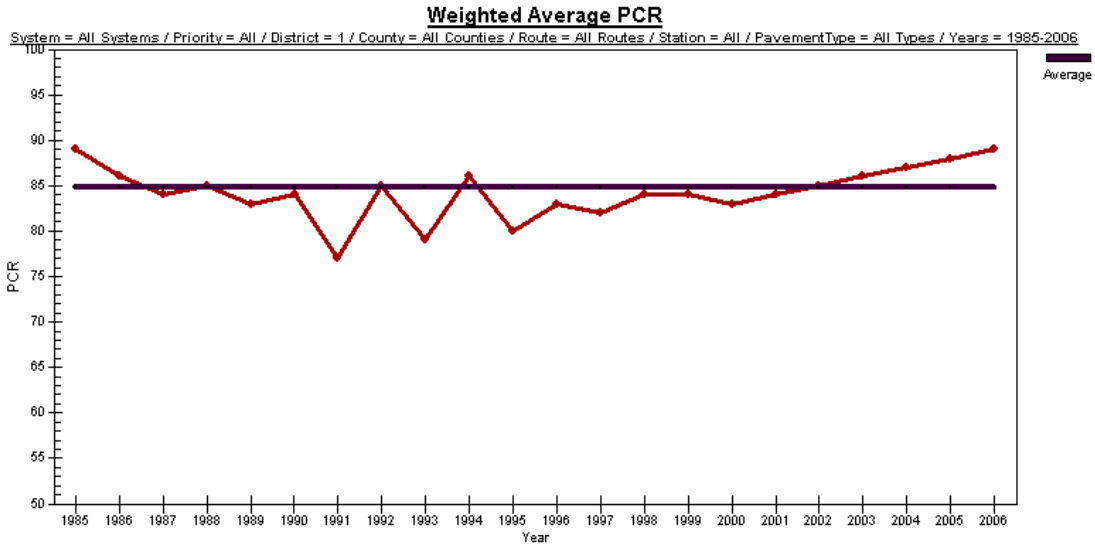

FIGURE C-93. PCR Chart

Figure C-94 shows the RN chart with an average line.

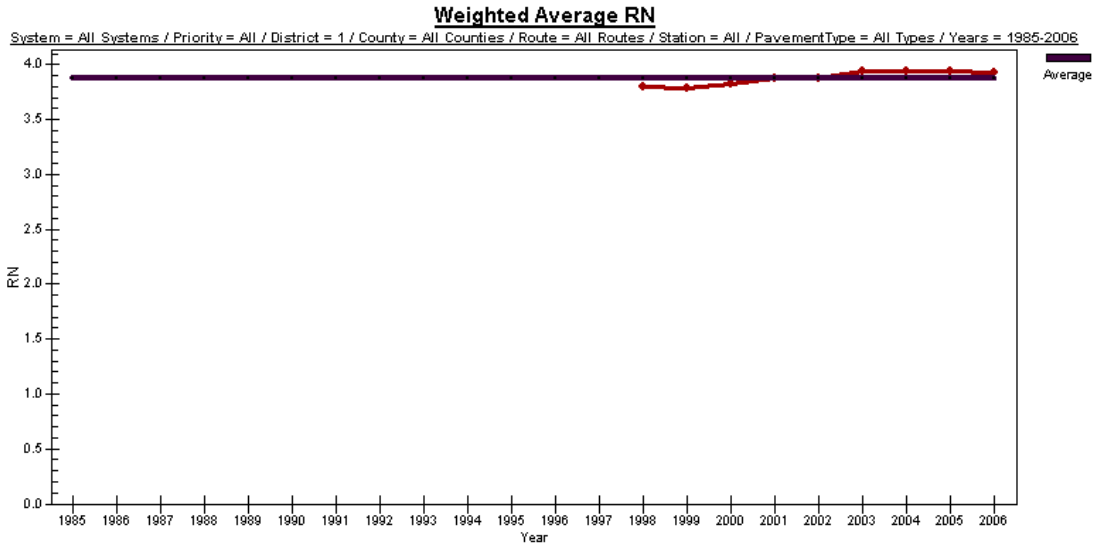

FIGURE C-94. RN (Ride Number Chart)

8.10.3 General Mileage Report

This tool calculates the amount of directional mileage covered for a user selected parameter.

Source Table: DATA_ODOT,
Output Table: The default name for the output table is "PCR Mileage Report." Users can update this table name by changing the text in the "Output Table name" text box.

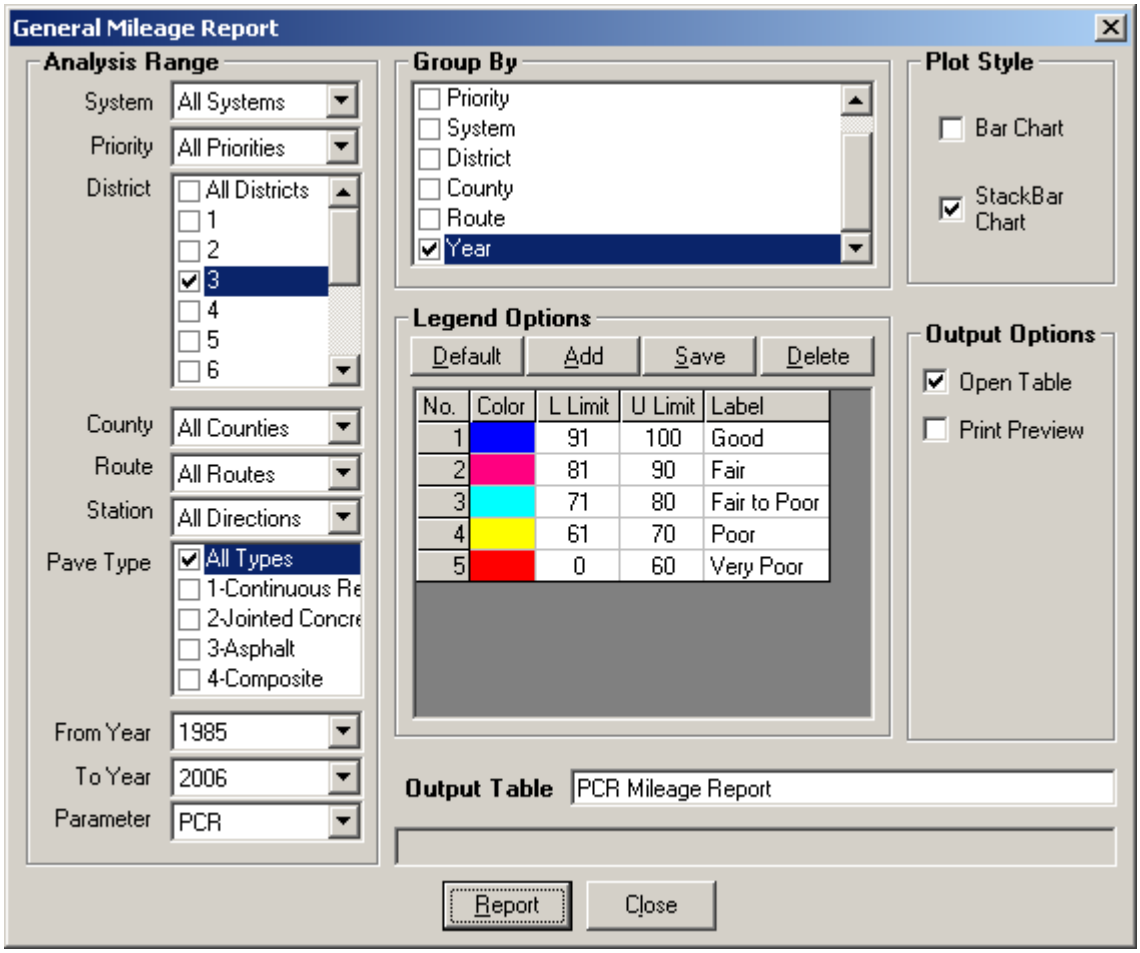

FIGURE C-95. General Mileage Report User Interface

Plot Style

Bar Chart	Output shown in bar chart format
Stack Bar Chart	Output shown in stacked bar chart format

Example:

This report is generated by selecting "All Systems" under "System," "All" under "Priority," "3" under "District," "All Counties" under "County," "All Routes" under "Route," All Directions" under "Station," "All Types" in "Pave Type," "1985" under "From Year," "2006" under "To Year," "PCR" under "Parameter," "Year" under "Group By," and "Stackbar Chart" under "Plot Style."

Figure C-96 shows the Mileage Report in directional miles for PCR, in categories defined by ODOT in District 3 for each year from 1985 to 2006.

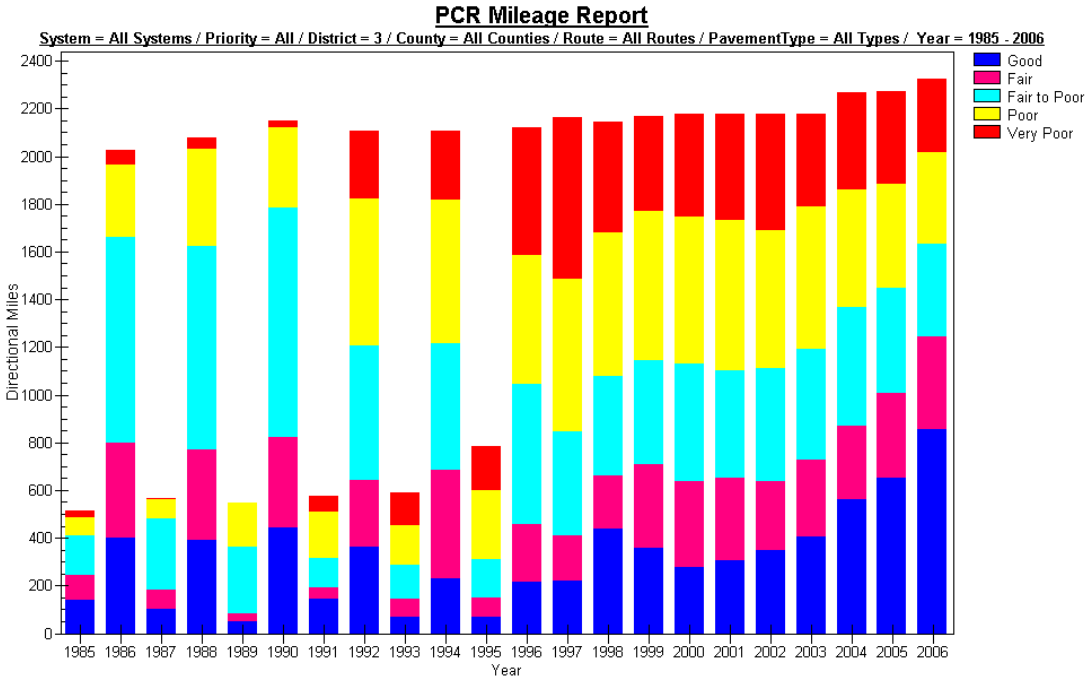

FIGURE C-96. PCR Mileage Report Output

8.10.4 Map View of a Table

This tool allows for mapping of attributes if the table includes “County,” “Route,” “Station,” “Blog,” and “Elog” fields.

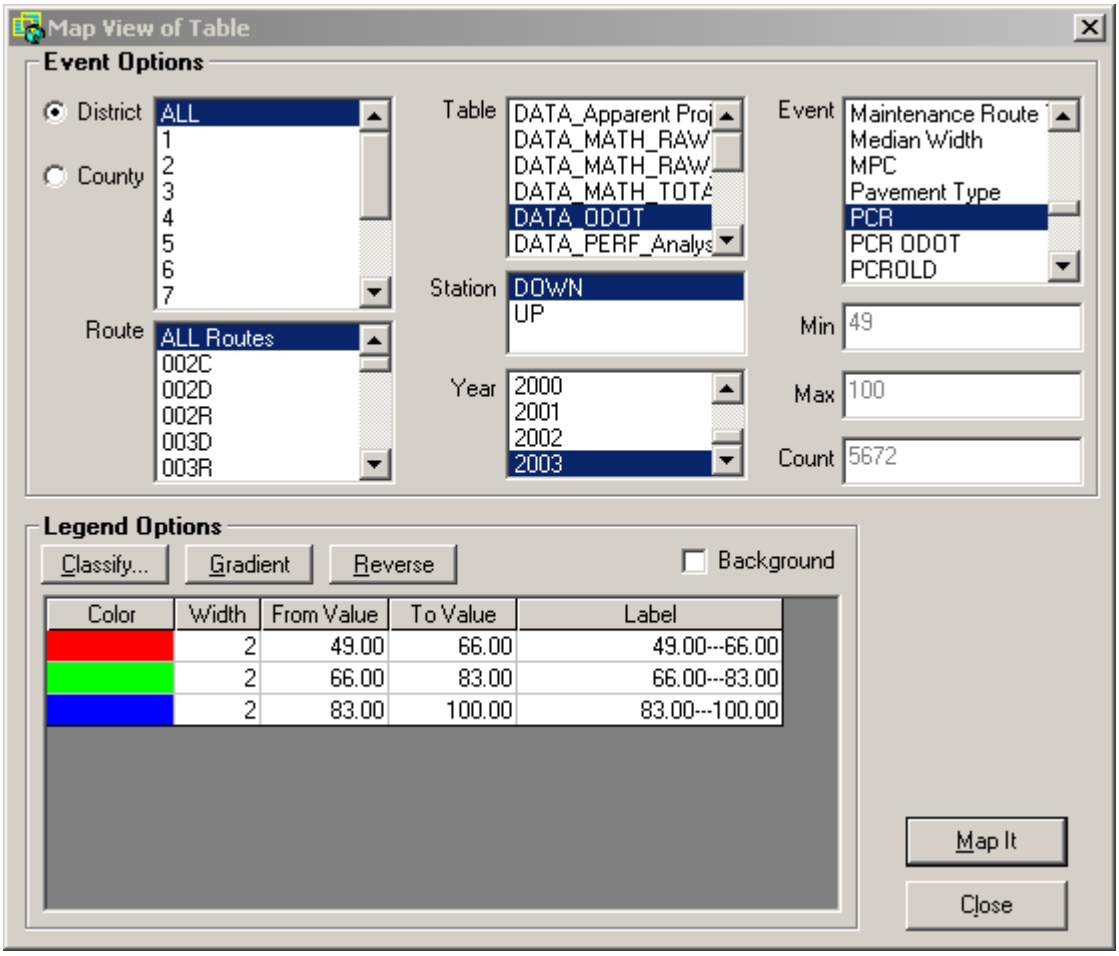

FIGURE C-97. Map View of Table User Interface

Legend Options

Classify: Set the number of categories
Gradient: Determine the middle category colors by grading the top and bottom category colors
Reverse: Flip the selected colors
Background: Superimpose map against Ohio geographical outline

Example:

Figure C-98 shows the map view of PCR data in DATA_ODOT for priority system routes in the entire state for 2006.

This report is generated by selecting "All" in the "District" list which appears when "District" is selected, "All Routes" under "Route," "DATA_ODOT" under "Table," "DOWN" under "Station," "2006" under "Year," and "PCR" under "Event."

The user can right click on the map to export it as an image.

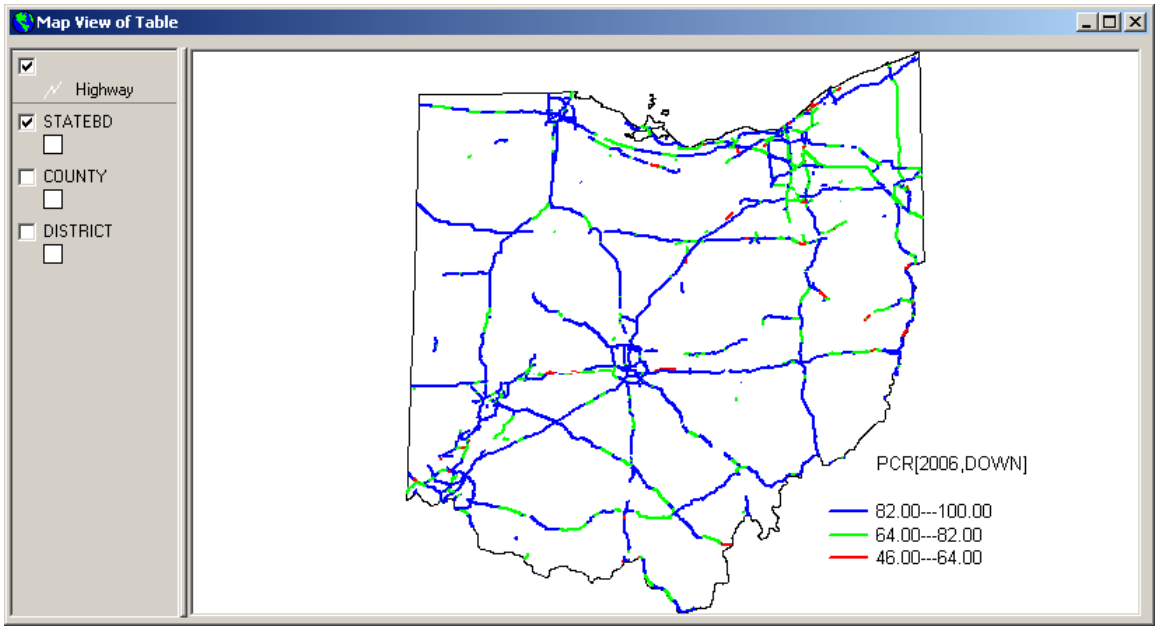

FIGURE C-98. Example of Map View

Window Menu

The "Window" menu includes normal Microsoft functions for controlling the simultaneous display of multiple open windows.

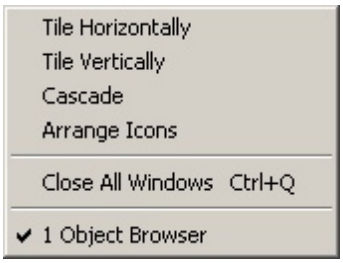

FIGURE C-99. ODOTPMIS Window Menu

9.1 Tile Horizontally

Horizontally tile all non-minimized windows.

9.2 Tile Vertically

Vertically tile all non-minimized windows.

9.3 Cascade

Cascade all non-minimized windows.

9.4 Arrange Icons

Arrange icons for minimized windows.

9.5 Close All Windows (Shortcut Key: CTRL+Q)

Close all opened tables and queries.

Help Menu

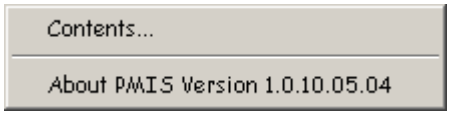

FIGURE C-100. ODOTPMIS Help Menu

10.1 Contents

Click this option to open the help file. The help file can also be activated by pressing the F1 key. Select the form or tool in question and press F1. Help for that topic will be displayed.

10.2 About

This option provides downloads of the latest updates for ODOTPMIS and specifies the current version number.

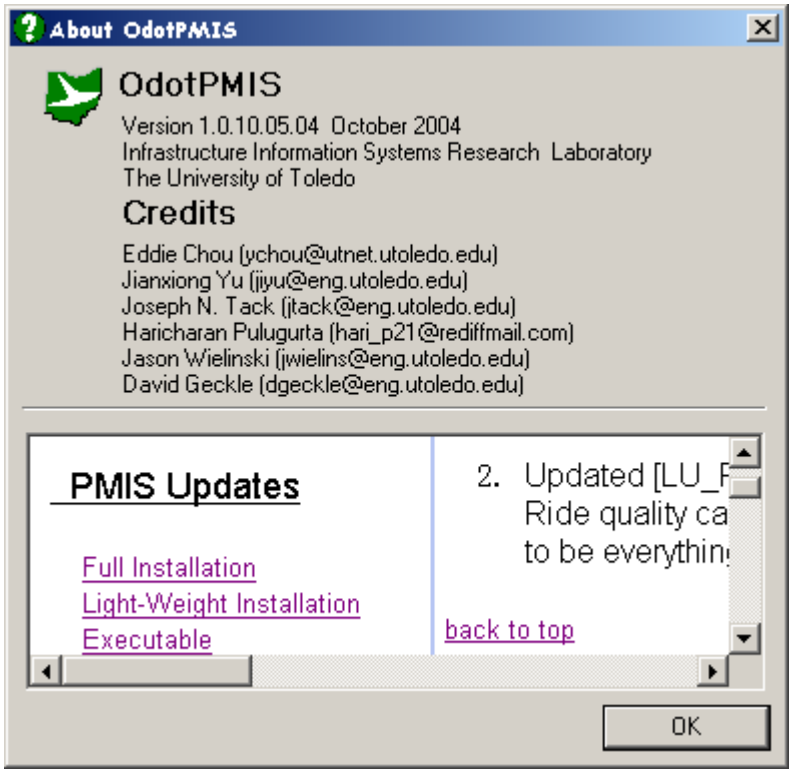

FIGURE C-101. ODOTPMIS About Dialog Box

APPENDIX D

LOCALPMIS USER MANUAL

D.1: INTRODUCTION

The Infrastructure Information System Laboratory at the University of Toledo has developed a database of pavements under local systems for the Ohio Department of Transportation. The database is in Microsoft Access database format. The LOCALPMIS includes the database and a set of reporting tools to extract the data necessary for pavement performance analysis.

All the basic operations of LOCALPMIS are similar to the ODOTPMIS. For more information, on the procedure for installation of LOCALPMIS, interface elements, *File* Menu, *Edit* Menu, *View* Menu, *Windows* Menu, *Help* Menu and *Index* Menu kindly refer Appendix-A.

However, the *Data* Menu, *Tools* Menu and *Report* Menu have been changed to synchronize the PMIS tool with the federal-aid local route pavement condition database. Therefore, this manual focuses solely on the detail descriptions of these three revised menus.

D.2: Data Menu

The Data Menu contains functions that add or modify various tables needed for operation of LOCALPMIS.

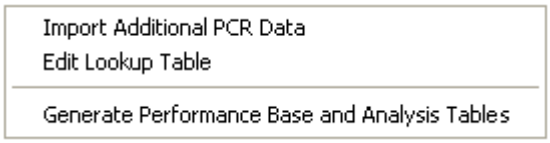

Figure D.2-1 LOCALPMIS Data Menu

D.2.1 IMPORT ADDITIONAL PCR DATA

Import Additional PCR Data sub menu is meant for importing or appending new pavement condition data and subsequently calculate PCR and deducts from the available distresses in the database.

In the Data menu choose and click the *Import Additional PCR Data*. A browser window as shown in Fig. D.2-2 appears. Select the required *.txt file(s) from the desired location(s) and click the OK button. This allows updating the [Local_PMIS] table. Pavement condition data in terms of Pavement Condition Rating (PCR) and severity and extent of each individual distress like raveling, rutting, settlements etc. are stored in [Local_PMIS] table. This table also stores road classification and all traffic information. Pavement condition data should be updated annually. To import condition data correctly, the source data file must have the required format.

Table to Apply: [Local_PMIS]
Data file type: Coma delimited text file
Data format:
First Line: *Field Name 1, Field Name 2, …, Field Name 64*
Second and after: *Value 1, Value 2, …, Value 64*

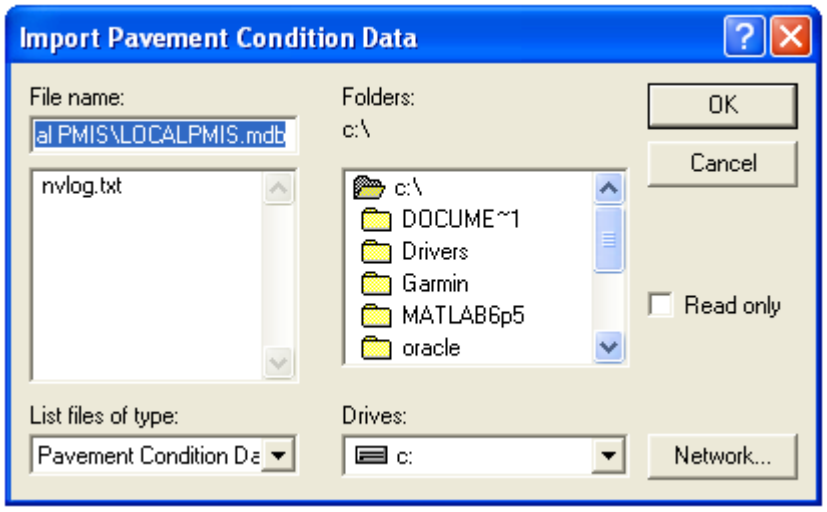

Fig. D.2-2 Import Pavement Condition Data

Comments

The first line of the input text file is for reference only. Actual field names are specified within the software. Field values must be in the order specified in Table D.1.

Table D.1 Field Order, Name and Data Format

Order	Field Name	Data Type	Example
1	NLFID	Text	TCOSTS00453**C
2	District	Number	5
3	County	Text	COS
4	Priority	Text	L
5	System	Text	Non-Federal Aid(Local)
6	Jurisdiction	Text	T
7	Route	Text	453
8	route_suffix	Text	
9	Station	Text	UP
10	Blog	Number	0.36
11	Elog	Number	0.93
12	begin_street	Text	
13	end_street	Text	
14	Length	Number	0.57
15	PCR	Number	80

16	Total Deduct	Number	23
Order	**Field Name**	**Data Type**	**Example**
17	Structural Deduct	Number	15
18	Rater	Text	RS
19	one_if_construction	Number	0
20	rated_date	Number	121503
21	form_number	Number	5
22	NHS	Text	No (write Yes/No)
23	PROJECT	Text	
24	Lanes	Text	
25	Lane Number	Text	
26	Plot Last Year	Text	No (write Yes/No)
27	Under Const	Text	No (write Yes/No)
28	Metric	Text	No (write Yes/No)
29-53	code 1 - code 25	Text	1 = LE
54	divided_undivided	Text	U
55	curb_rating	Text	N
56	sidewalk_rating	Text	N
57	utility_cut	Text	
58	drainage	Text	
59	Year	Number	2003
60	begin_description	Text	COSHOCTON CL
61	divided_RI	Text	
62	street_name_prefix	Text	
63	street_name	Text	T-453
64	street_name_suffix	Text	RD
65	street_name_suffix2	Text	
66	street_name_suffix3	Text	
67	surface_type	Text	I
68	surface_width	Number	20
69	roadway_width	Text	
70	pavement type	Number	5
71	functional_class	Number	17
72	muni_name	Text	
73	muni_street_number_suffix	Text	
74	Township_Name	Text	
75	mileage_class	Number	1
76	number_lanes	Text	
77	proposed	Text	
78	ADT Category	Text	M
79	ADT	Number	
80	Truck ADT Category	Text	L
81	Truck ADT	Number	
82	Base	Text	
83	Notes	Text	

After the new data is appended successfully to the existing [Local_PMIS] table, the PCR, Structural Deduct, Cracking Deduct, and Total Deducts are calculated for the entire database. The original pavement condition data contains PCR, and Distress ratings. After calculation of PCR and deducts, the tool checks for any mismatch between the imported PCR and the PMIS calculated PCR values. If any mismatch persists, the user is prompted to select either the calculated PCR or the imported PCR for all future analysis. The PMIS tool memorize this selected PCR and store it in a new field named *PCR_Ana* in the [Local_PMIS] table. All the analysis in LOCALPMIS is based on the PCR values stored under *PCR_Ana* field in [Local_PMIS] table.

D.2.2 Generate Performance Base AND ANALYSIS Table

In the Data menu click *Generate Performance Base and Analysis Table*. This tool first generates the [DATA_PERF_BASE] table and then generates the [DATA_PERF_ANALYSIS] table.

Both [DATA_PERF_BASE table] and [DATA_PERF_ANALYSIS] table are the basis of most of the pavement condition prediction analysis. Therefore, every time new data are added, user is recommended to generate and automatically update these two tables.

This entire procedure of preparing the base table and the analysis table is very time-consuming. Do not restart the computer while it is in progress. The database size could increase during this procedure. The user is encouraged to perform a database compacting operation before and after using this function.

D.3: Tools Menu

This menu contains functions that pavement condition prediction and remaining life estimation. This menu also contains an option to modify the decision tree to identify the repair of pavement based on the current condition.

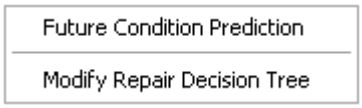

Figure D.3.1 LOCALPMIS Analysis Tools Menu

D.3.1 FUTURE CONDition prediction

This sub menu can be used for predicting future pavement condition using linear regression model. Both PCR and distress for every pavement section in the database are predicted for some chosen no. of years. Once the prediction of PCR and distress are

completed, the remaining life of the pavement is estimated based on either PCR or distress, as per the choice of the user.

In the Tools menu click on the submenu *Future Condition Prediction*. The form as shown in the Fig D.3.2 pops up. This form guides the user to do the prediction of pavement condition and estimate the remaining life. For each pavement type the user will have to do the prediction separately. Prediction of pavement can be done either based on system or district or county, as per the requirement of the user. However, if sufficient data which reveals certain drop in PCR in certain county or district is not available, then the results of doing district-wise or county-wise prediction can lead to misleading or no result. In that case, users are advised to include more data from other districts or counties for doing the prediction.

All the features in the prediction form as labeled in Fig D.3.2(a) are described as below:

Feature	Label as in Fig 3.1	Description
Analysis Range		
System	1	Includes either Federal Aid(Local) or Non-Federal Aid(Local) or both.
District	2	Lists all the 12 districts. The user can either select any particular district or can select *All Districts* to do the prediction.
County	3	Lists all the counties in the selected district(s). The user can either select any particular county or can select *All Counties* in the selected district (s) to do the prediction.
Pave Type	4	Lists all the 7 type of pavements. For each pavement type, the user will have to select the particular pavement and run the prediction separately. There is no option like "All Pavements" in this list.
From Year	5	The user can select the start of analysis year. The model includes the data starting from this selected year in the regression model. The default value is kept as 2003.
To Year	6	The user can select the end of analysis year. The model includes the data till this selected year in the regression model. The default value is kept as the latest data year available in the database.
Rem Life	7	The user can select any year from this

Feature	Label as in Fig 3.1	Description
from year		drop box. The remaining life of pavement is then estimated assuming this selected year as the base year. The default value is kept as the current year.
Prediction Option		
# of Years	8	The user can select any no. of years of doing the prediction from this drop box. The default value is kept as 5.
Rem. Life PCR Thresholds		
Local	9	This field cannot be left blank. The user will have to provide the threshold PCR value, below which the pavement section is deemed to be at the end of its life.
Use Distress Criteria	10	If the user desires to estimate the remaining life based on distress, then this field must be checked.
Edit Criteria	11	Clicking this button the user can define the threshold extent and severity of selected distress to estimate the remaining life. On clicking, another form as shown in Fig. D.3.2(a) will pop up. This form will guide the user to define the distress and its threshold extent and severity that influences the life of the pavement
Output Tables		
All output tables	12-15	It is advised to keep the Table Name unchanged. This table names are identified in some program to generate the reports and graphs
Generate	16	The prediction and estimation of life of pavement is initiated by clicking this button. This process is a bit time consuming. So users are asked to be patient while running this model.
Close	17	If this button is clicked the form as displayed in Fig D.3.2(a) is unloaded

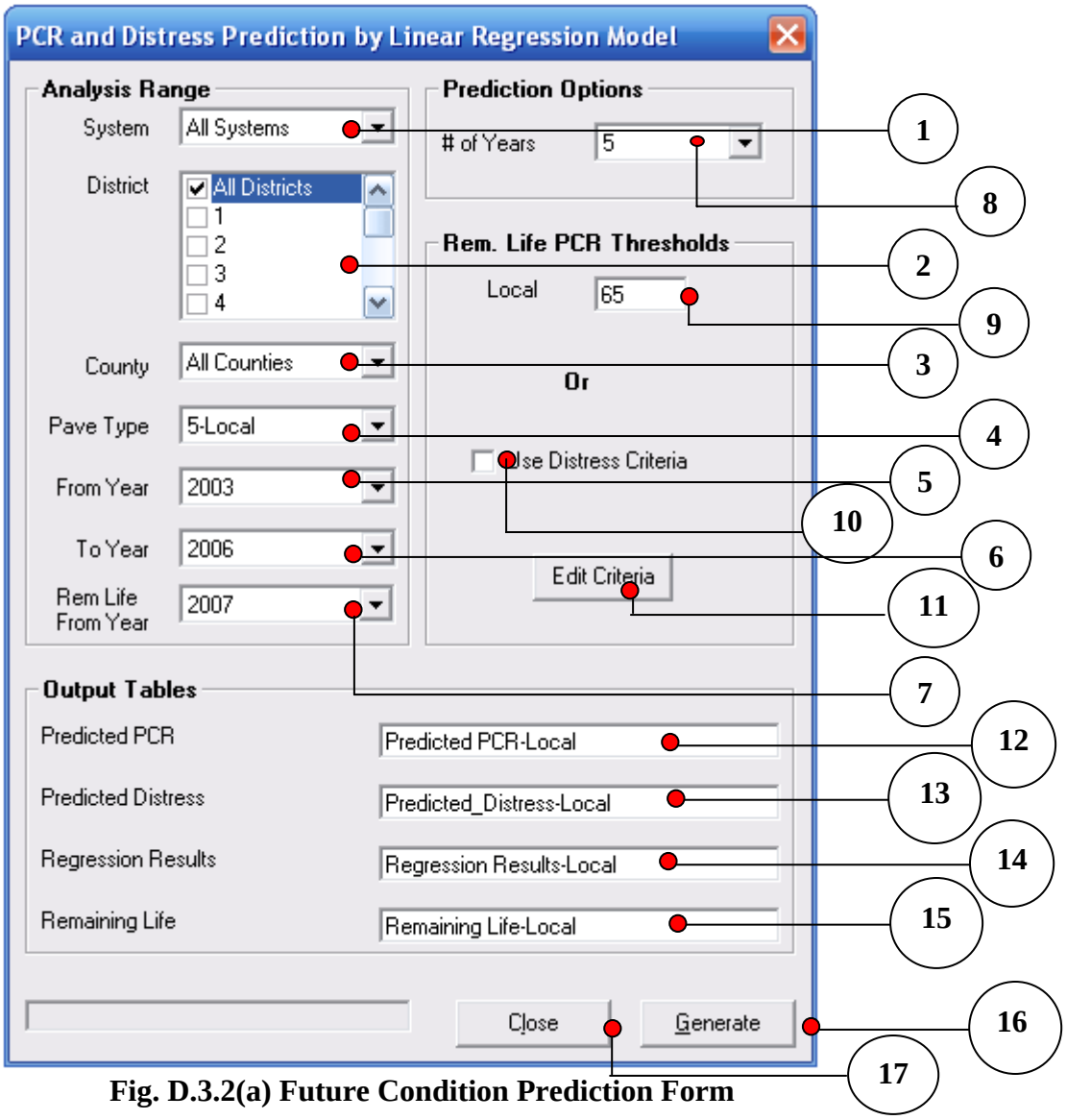

Fig. D.3.2(a) Future Condition Prediction Form

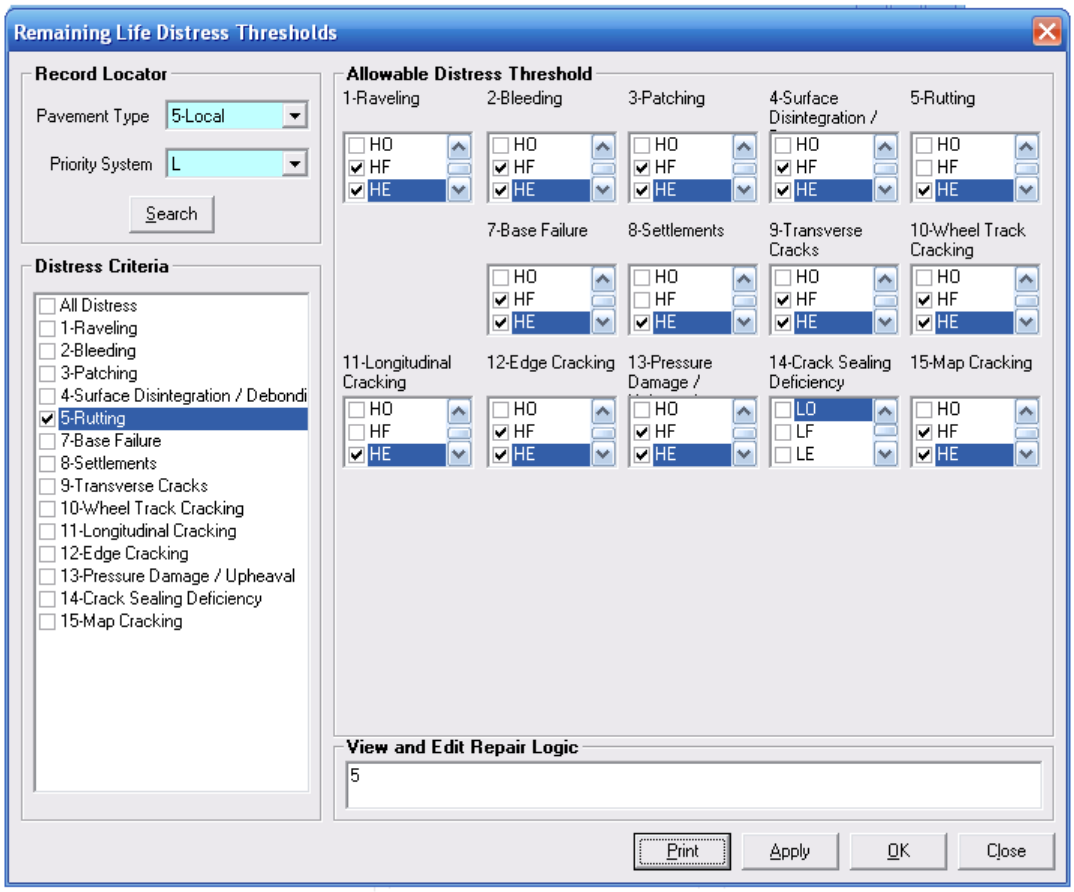

Fig D.3.2(b) Remaining Life Distress Thresholds form

D.3.2 MODIFY REPAIR DECISION TREE

This sub menu helps the user to modify the repair decision tree prior to determine the recommendations for repair for each pavement section. The treatment logic for Local Pavement is shown in Fig. D.3.3 (a) below. The user can change the threshold PCR and Structural Deduct in this logic form. As the decision tree for Brick and Gravel pavements are not available, currently the decision trees for Jointed Concrete Pavement and Local Pavement are only included. To modify the logic for distress, the user will have to click the *Miscellaneous Criteria*, labeled as "1" in Fig D.3.3 (a). The form for *Miscellaneous Criteria* is shown in Fig. D.3.3 (b). In this form the user can first find the default setup for the distress logic using the *record locator* option. Selecting the desired pavement type and clicking the *Search* button will help the user to get the *Allowable Distress.* User can then change the desired extent and level of each available distress for the selected pavement type. The repair logic to consider the distress types using "AND / OR" can be set up in the *View and Edit Repair Logic* field. After doing all the necessary changes, the user should either click the APPLY or the OK button to make the changes in the [LU_Repair Logic]. The recommendation of treatment is then based on this new logic setup by the user.

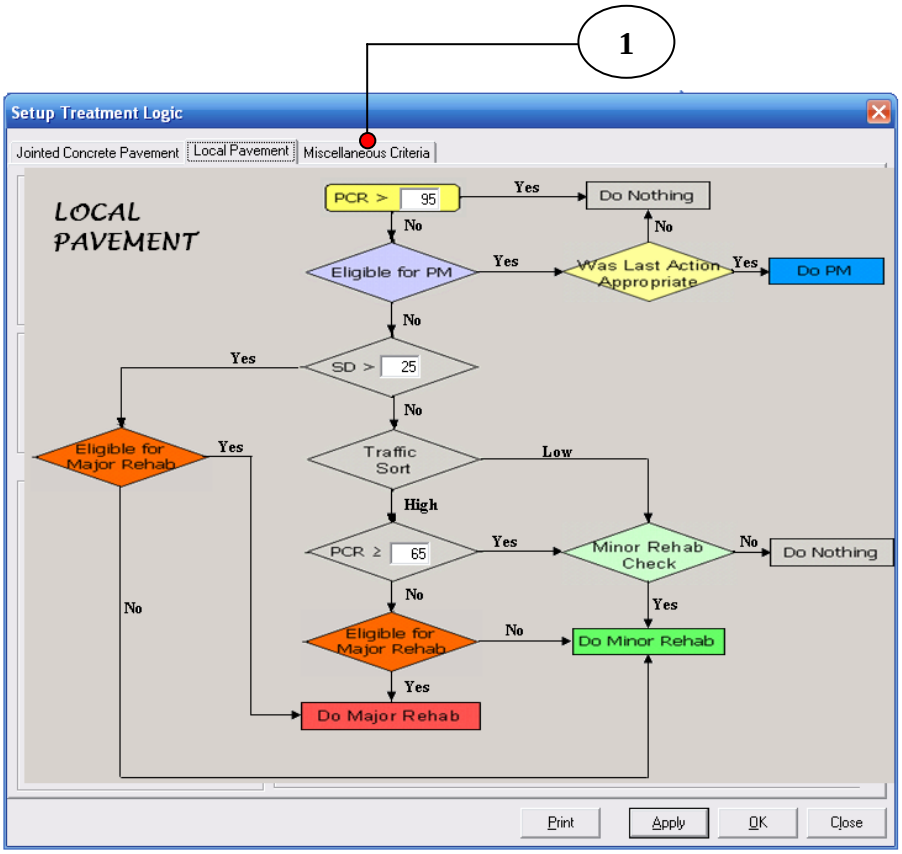

Fig D.3.3 (a) Treatment Logic form

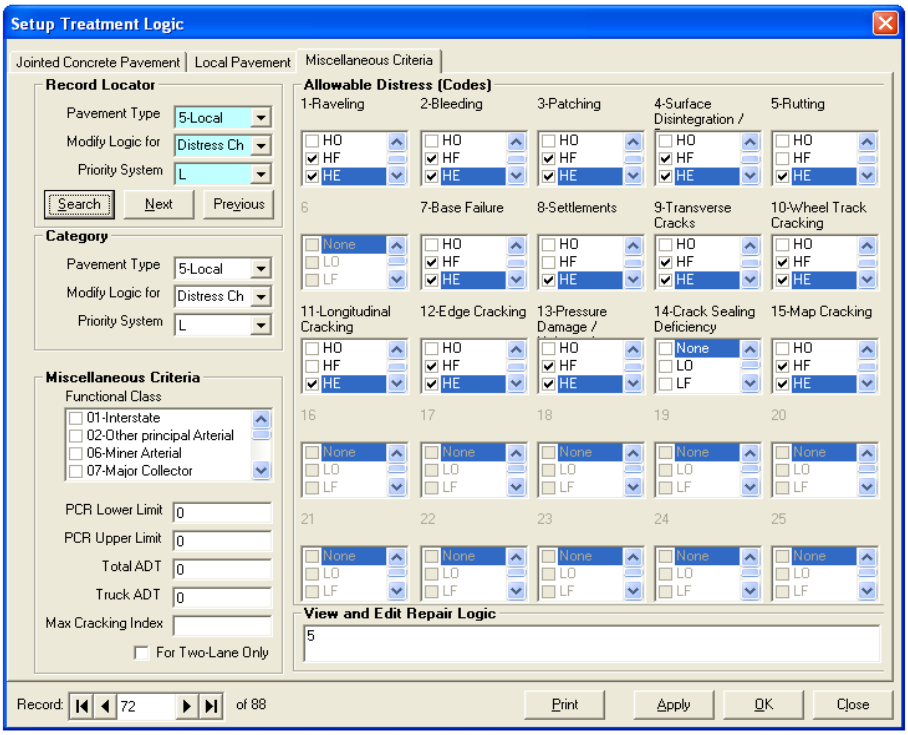

Fig D.3.3 (b) Treatment Logic for Distress

D.4: REPORT Menu

This menu contains tools for to generate specific reports and graphs of the database.

Figure D.4.1 LOCALPMIS Report Menu

D.4.1 GENERATE CURRENT PAVEMENT CONDITION REPORT

This submenu generates the existing pavement condition report. User can generate the report either district-wise or for any particular county. The form as shown in Fig. D.4.2 guides to generate this report. The grid table generated contains the existing PCR and distress for the pavement sections in the selected district or county. The grid table can be exported to Microsoft Excel® by clicking anywhere within the grid table.

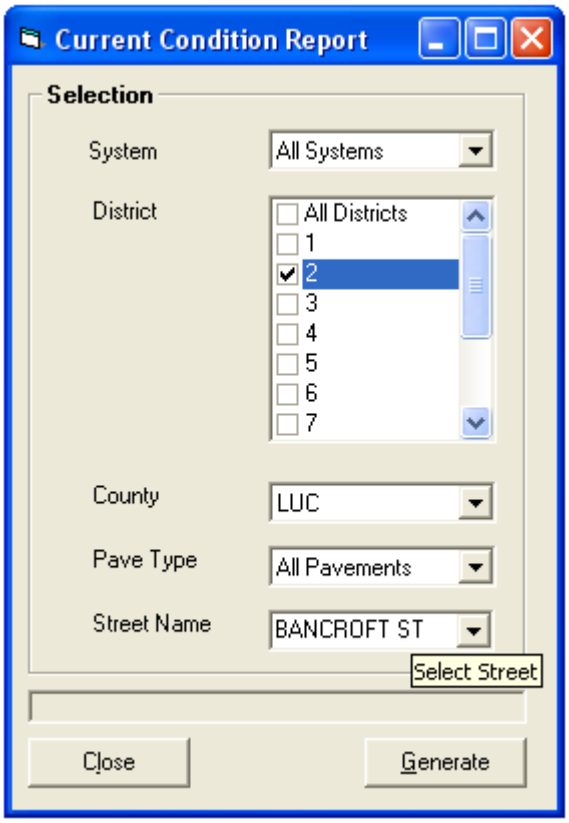

Fig. D.4.2 Current Pavement Condition Report Form

A glimpse of the generated grid table for existing pavement condition is shown in Fig D.4.3 below:

CURRENT PCR: DISTRICT-2

SectionID	NLFID	District	County	Route	Station	Blog	Elog	muni_name	Street_Name	Base	Pavement Type	PCR_Year	PCR	Code_1	Co
22	NCR0031	2	SAN	312	UP	0	0.03	BELLEVUE	NORTHWEST RD		5 - Local	2005	97	LF	
23	NCR0060	2	SAN	602	UP	0	0.03	BELLEVUE	YORK ST		5 - Local	2005	97	LF	
24	NCR0004	2	SEN	48	UP	0	0.03		C-48 RD		5 - Local	2005	72	LE	
74	CCR0051	2	LUC	518	UP	0	0.05	TOLEDO	ERIE ST		2 - Jointed Concrete	2005	69	LE	
75	CCR0054	2	LUC	542	UP	0	0.05	TOLEDO	GROVELAND RD		2 - Jointed Concrete	2003	87	LE	
118	CCR0051	2	LUC	518	UP	0.05	0.06	TOLEDO	ERIE ST		5 - Local	2005	88	LE	
119	CCR0054	2	LUC	546	UP	0	0.06	TOLEDO	SCOTTWOOD		5 - Local	2003	100		
170	CCR0009	2	LUC	98	UP	0	0.07		HOLLOWAY RD		5 - Local	2005	92	LF	
184	TCR0050	2	OTT	501	UP	0	0.07	PORT	LAY DR		5 - Local	2005	64	LE	
188	NCR0031	2	SAN	312	UP	0.03	0.07				5 - Local	2003	71	LE	
189	NCR0060	2	SAN	600	UP	0	0.07	BELLEVUE	EXCHANGE ST		5 - Local	2005	94	LE	
190	NCR0003	2	SEN	36	UP	0	0.07	TIFFIN	COE ST		5 - Local	2005	70	LE	
248	CCR0050	2	LUC	509	UP	0	0.08	TOLEDO	MILLARD AVE		2 - Jointed Concrete	2005	80	LE	
249	CCR0052	2	LUC	520	UP	0	0.08	TOLEDO	JACKMAN RD		5 - Local	2005	78	LE	
250	CCR0054	2	LUC	541	UP	0	0.08	TOLEDO	COLUMBUS ST		5 - Local	2003	100		
251	CCR0054	2	LUC	542	UP	0.05	0.08	TOLEDO	GROVELAND RD		2 - Jointed Concrete	2005	87	LF	
268	NCR0050	2	SAN	501	UP	0	0.08		RIVER ST		5 - Local	2005	96	LO	
321	CCR0055	2	LUC	552	UP	0	0.09	TOLEDO	ST CLAIR ST		5 - Local	2005	71	ME	
327	NCR0060	2	SEN	604	UP	0	0.09	TIFFIN	MONROE ST		5 - Local	2005	81	LE	
395	CCR0013	2	LUC	131	UP	0	0.1		SHERMAN-WHITE		5 - Local	2005	99	LO	
396	CCR0051	2	LUC	518	UP	0.06	0.1	TOLEDO	ERIE ST		5 - Local	2005	88	LE	
397	CCR0052	2	LUC	524	UP	0	0.1	TOLEDO	MULBERRY ST		5 - Local	2005	98	LO	
398	CCR0053	2	LUC	530	UP	0	0.1	MAUMEE	KEY ST		5 - Local	2005	76	LE	
399	CCR0054	2	LUC	549	UP	0	0.1		JEFFERSON AVE		5 - Local	2005	99	LO	
400	CCR0056	2	LUC	562	UP	0	0.1	TOLEDO	SUNRISE AVE		5 - Local	2005	99	LO	
401	CTR0007	2	LUC	77	UP	0	0.1	SYLVANIA	HARROUN RD		5 - Local	2005	83	LE	
415	TCR0050	2	OTT	503	UP	0	0.1	PORT	MONROE ST		2 - Jointed Concrete	2005	80	LE	
473	CCR0056	2	LUC	562	UP	0.1	0.11	TOLEDO	SUNRISE AVE		5 - Local	2005	99	LO	
474	CCR0080	2	LUC	801	UP	0	0.11	TOLEDO	BOWEN RD		5 - Local	2005	98	LO	
531	CCR0053	2	LUC	530	UP	0.1	0.12	MAUMEE	KEY ST		5 - Local	2005	86	LO	
532	CCR0054	2	LUC	549	UP	0.1	0.12		JEFFERSON AVE		5 - Local	2005	67	ME	
533	CCR0055	2	LUC	552	UP	0.09	0.12	TOLEDO	ST CLAIR ST		5 - Local	2005	71	ME	

Fig. D.4.3 Current Pavement Condition Grid Table

D.4.2 PCR DROP

This sub-menu lists all the pavement sections whose yearly change in PCR is more or equal to the selected PCR Drop value. Fig. D.4.4 below illustrates the PCR Drop form.

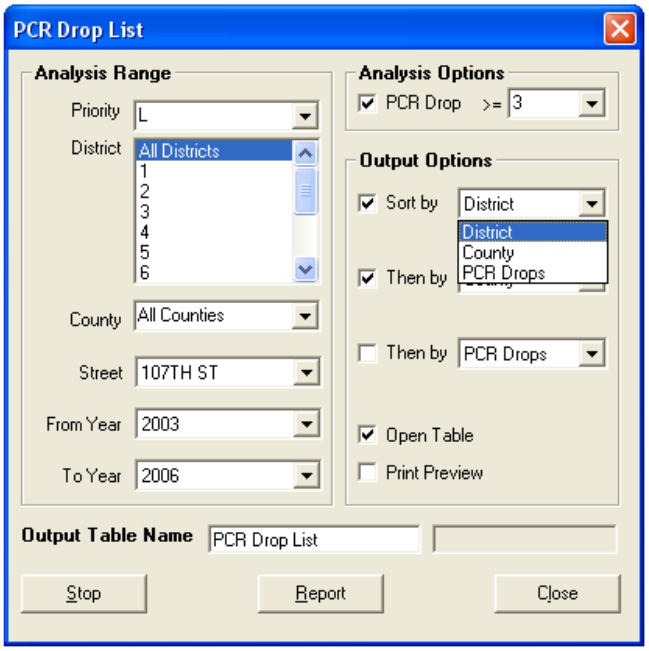

Fig. D. 4.4 PCR Drop List form

D.4.3 show predicted pavement condition

Under this sub-menu two more menus are available: *Generate PCR Grid Table* and *Show Section-wise PCR Trend*

Generate PCR Grid Table

This option helps the user to generate PCR grid table either district-wise or for any particular district. On clicking the form as in Fig D.4.5 will pop up.

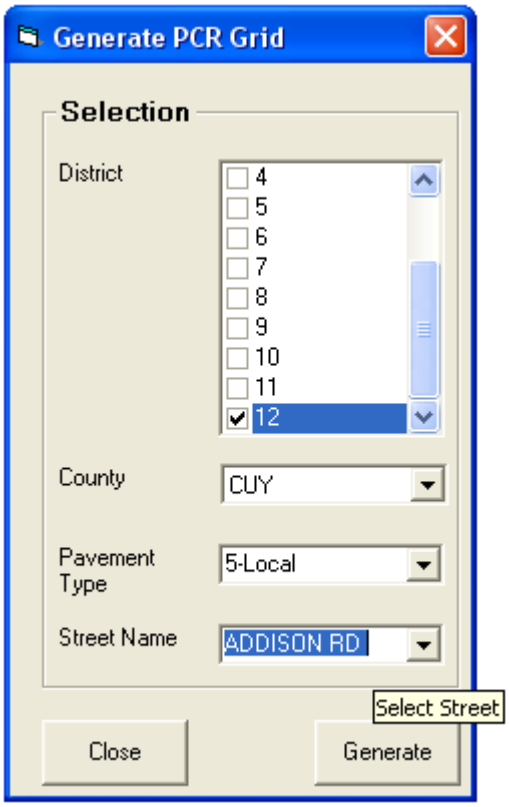

Fig. D.4.5 Generate Predicted PCR Grid form

The grid table contains all the following fields:

District	Pavement Type
County	Base
Route	Surface Type
Station	Remaining Life
Blog	Remarks
Elog	PCR

The surface type field lists whether the pavement section has asphalt or brick or concrete or gravel surface. The Remarks column in the grid table indicates whether the predicted distress predominates in the estimation of remaining life. If the cell under Remarks column is blank, then it indicates that the future PCR plays dominant role in estimation of remaining life.

The PCR field lists the year-wise existing and predicted PCR values. The predicted values are displayed till the year the prediction was done using the *Future Condition Prediction* submenu under Tools menu.

This grid table can also be exported to MS Excel ®.

A glimpse of the grid table generated for District – 5 can be seen in Fig D.4.6

LOCALPMIS - D:\DDatta\PMIS\Local PMIS\LOCALPMIS.mdb - [PREDICTED PCR: DISTRICT-5]

File Edit View Data Tools Report Window Help

SectionID	District	County	Route	Station	Blog	Elog	Pavement Type	Base	Surface Type	Remaining Life	Remarks	PCR								
												2003	2004	2005	2006	2007	2008	2009	2010	2011
18	5	LIC	821	UP	0	0.03	5		Asphalt	11		70	74		91	89	86	84	82	80
38	5	GUE	518	UP	0	0.04	5		Asphalt	7		83	83		84	82	79	77	75	73
43	5	LIC	832	UP	0	0.04	5		Asphalt	0	Distress Rules	50	62		98	96	93	91	89	87
73	5	LIC	302	UP	0	0.05	5		Asphalt	4			80	78	75	73	71	69	66	64
77	5	MUS	467	UP	0	0.05	5		Asphalt	0		77	77		63	58	53	48	43	38
116	5	KNO	506	UP	0	0.06	5		Asphalt	3	Distress Rules	69	75		98	96	93	91	89	87
166	5	KNO	508	UP	0	0.07	5		Asphalt	0		61	63		64	62	59	57	55	53
169	5	LIC	343	UP	0	0.07	5		Asphalt	3	Distress Rules	71	84		98	96	93	91	89	87
182	5	MUS	2006	UP	0	0.07	5		Asphalt	7		82	81		82	80	77	75	73	71
183	5	MUS	2015	UP	0	0.07	5		Asphalt	1		75	75		69	67	65	63	60	58
185	5	PER	6	UP	0	0.07	5		Asphalt	7			85		81	79	77	75	73	71
232	5	GUE	519	UP	0	0.08	5		Asphalt	11		89	90		92	90	87	85	83	81
240	5	KNO	508	UP	0.07	0.08	5		Asphalt	0		61	59	56	54	52	50	47	45	43
245	5	LIC	830	UP	0	0.08	5		Asphalt	3	Distress Rules	72	79		94	92	89	87	85	83
266	5	PER	501	UP	0	0.08	5		Asphalt	7		86	82		80	78	76	74	73	71
293	5	COS	16	UP	0	0.09	5		Asphalt	3		93	88		81	77	73	69	65	61
294	5	COS	504	UP	0	0.09	5		Asphalt	0		83	77		70	66	62	57	53	49
309	5	GUE	33	UP	0	0.09	5		Asphalt	36		94	94		92	91	91	90	89	88
310	5	GUE	516	UP	0	0.09	5		Asphalt	3	Distress Rules	97	98	96	93	91	89	87	84	82
315	5	LIC	800	UP	0	0.09	5		Asphalt	10		61	98		90	88	85	83	81	79
316	5	LIC	801	UP	0	0.09	5		Asphalt	10		61	98		90	88	85	83	81	79
317	5	LIC	825	UP	0	0.09	5		Asphalt	0		68	98		66	64	61	59	57	55
318	5	LIC	827	UP	0	0.09	5		Asphalt	0		65	63	60	58	56	54	51	49	47
368	5	FAI	510	UP	0	0.1	5		Asphalt	2	Distress Rules	85			84	84	83	83	83	82
386	5	LIC	260	UP	0	0.1	5		Asphalt	4	Distress Rules		94		91	90	88	86	85	84
387	5	LIC	302	UP	0.05	0.1	5		Asphalt	7			80		82	80	77	75	73	71

Fig D.4.6 Predicted PCR Grid Table

Show Section-wise PCR Trend

This option helps the user to generate PCR trendlines for any selected pavement section. On clicking this menu, the form as shown in Fig D.4.4 pops up. As seen in the form, user can select any particular route within any county and can then select the desired pavement section from the Blog-Elog list of the selected route. Both existing and predicted PCR trends are then plotted for the chosen section when the PLOT button is clicked. The graph depicting PCR trends for the section displayed in the Fig D.4.7 is shown in Fig. D.4.8.

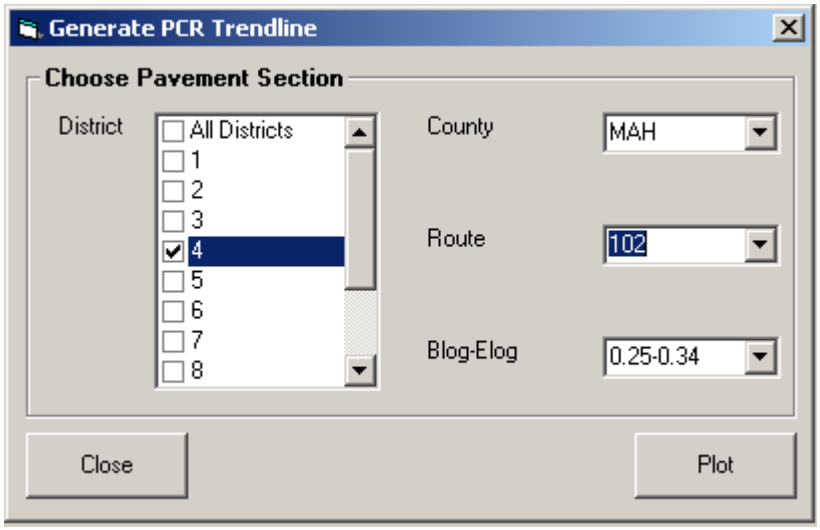

Fig D.4.7 Generate PCR Trendline form

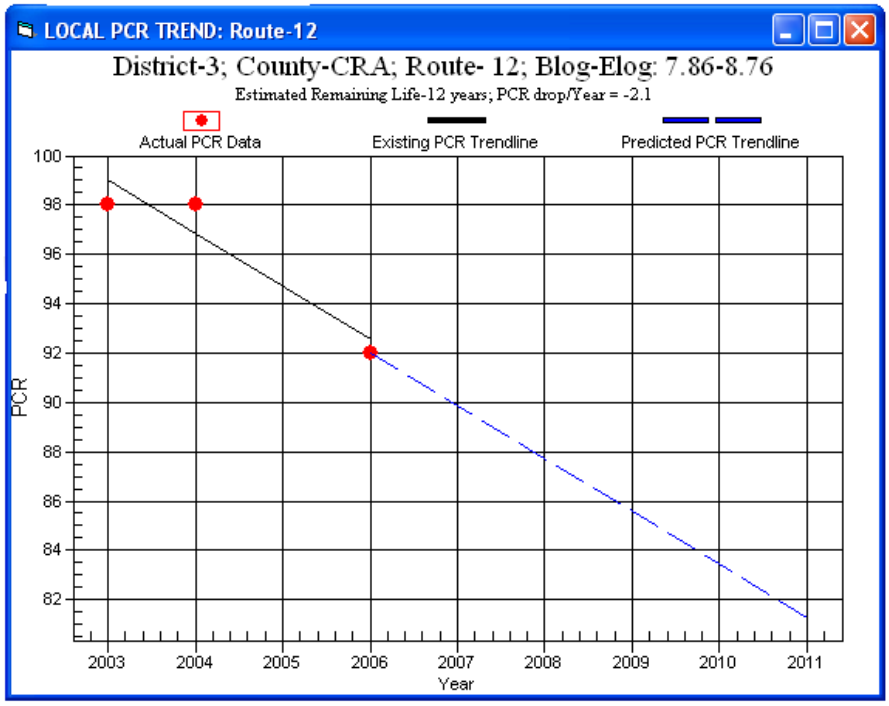

Fig D.4.8 Graph showing PCR Trend

For display purpose, the user can change some settings, as shown in Fig D.4.9 by clicking the right button of the mouse.

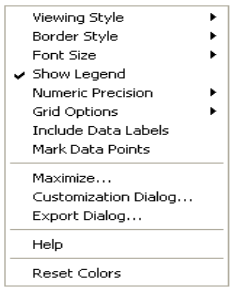

Fig D.4.9 Customizing PCR Trend Graph

The scale of the axes can be changed by clicking the Customization Dialog… option as seen in Fig D.4.9 and then going to the Axis option within the dialog form. The Max/Min options should be clicked to change the scale of PCR axis.

User can also use the Export Dialog…to export the graph in JPEG or PNG or BMP or txt format. The graph can also be printed by using the PRINT button available within the Export Dialog form.

D.4.4 REPAIR CANDIDATES

This submenu is used to generate the recommendation report of repair of the pavement sections. The recommendation is based entirely on the repair logic set up by the user. Currently there is no default logic set up for the Brick and the Gravel pavements. Therefore, the report displays the recommended repair for only local pavement and jointed concrete pavement sections.

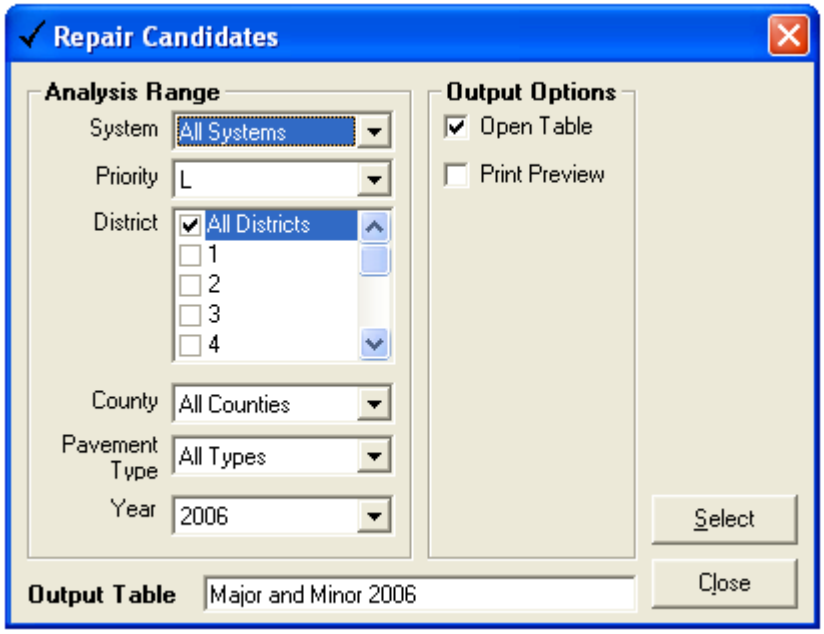

Fig. D.4.10 Repair Candidates Form