GIS-ILLINET Version 2.0
Pavement Management and Information System
User’s Guide

by

Ghulam H. Bham
Nasir G. Gharabeh
Michael I. Darter

A report of the findings of
Enhancements to Illinois Pavement Management

Project IHR-R24
Illinois Cooperative Highway Research Program

Conducted by the

Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign

and the
Illinois Department of Transportation

In cooperation with the
U.S. Department of Transportation
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## Abstract

GIS-ILLINET is interactive and user-friendly personal computer software developed to aid in managing the rehabilitation of Illinois pavements. GIS-ILLINET can provide vital information about pavement sections and the network and can also be used to answer a variety of "what if" questions about funding needs, effects of various policies, and pavement conditions. The main capability is to assist District staff to develop or update the multi-year pavement program for Interstate and non-Interstate systems. It can also display graphically the historic, current, and predicted health of the network.

## Key Words

Software, pavement management, pavement performance, pavement rehabilitation

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<tr>
<td>AADT</td>
<td>Average Annual Daily Traffic</td>
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<tr>
<td>AC</td>
<td>Asphalt Concrete</td>
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<tr>
<td>ACCP</td>
<td>Asphalt Concrete Overlay over Continuously Reinforced Concrete Pavement</td>
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<tr>
<td>ACJR</td>
<td>Asphalt Concrete Overlay over Jointed Reinforced Concrete Pavement</td>
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<tr>
<td>ADT</td>
<td>Annual Daily Traffic</td>
</tr>
<tr>
<td>CRCP</td>
<td>Continuously Reinforced Concrete Pavement</td>
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<td>CRS</td>
<td>Condition Rating Survey</td>
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<tr>
<td>ESAL</td>
<td>Equivalent Single Axle Load</td>
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<td>ESRI</td>
<td>Environmental Systems Research International</td>
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<td>GIS</td>
<td>Geographic Information Systems</td>
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<td>HMAC</td>
<td>Hot Mix Asphalt Concrete pavement</td>
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<td>IDOT</td>
<td>Illinois Department of Transportation</td>
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<td>ILLINET</td>
<td>Illinois Network Evaluation Technique</td>
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<td>IPFS</td>
<td>Illinois Pavement Feedback System</td>
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<td>IRI</td>
<td>International Roughness Index</td>
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<td>IRIS</td>
<td>Illinois Roadway Information System</td>
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<td>JPCP</td>
<td>Jointed Plain Concrete Pavement</td>
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<tr>
<td>JRCP</td>
<td>Jointed Reinforced Concrete Pavement</td>
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<tr>
<td>PMS</td>
<td>Pavement Management System</td>
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<tr>
<td>VMT</td>
<td>Vehicle-Miles Traveled</td>
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<td>WBRP</td>
<td>Weighted Benefit Ranking Procedure</td>
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CHAPTER 1—INTRODUCTION

Highway infrastructure facilities in the United States represent a large investment that is essential for the movement of people and goods. It stands to reason, then, that the quality of the highway network is an important factor in the economic growth of the country. Pavement surfaces are a major component of this infrastructure and greatly affect the comfort, costs, and safety of highway users.

The Illinois Interstate system includes over 1,400 different pavement sections, totaling about 2,000 centerline miles. Most of these sections were built during the 1960s and 1970s and have experienced much higher traffic loadings than those for which they were designed (approximately 4 to 5 times the design number of heavy axle loadings). Approximately 73 percent these pavements have been rehabilitated during the past two decades, some of them three times, and many will be rehabilitated again in the next 5 years (1).

In the 1980s, the Illinois Department of Transportation (IDOT) invested in research and other studies to develop pavement databases and software tools to allocate resources more effectively for rehabilitation and investigate the performance of these pavements. Figure 1 shows a timeline of these efforts. In the early 1980s, the Illinois Pavement Feedback System (IPFS) was developed to provide data for research studies. The implementation of the Illinois Roadway Information System (IRIS) in the early 1990's replaced the old Highway Inventory File and provided new roadway inventory data elements and better capabilities for data access. IDOT's first pavement management system (PMS), ILLINET, was completed in 1992, and a Microsoft® Windows® version was introduced in 1994. With the advent of geographic information systems (GIS), IDOT started major GIS effort in 1995 and developed several GIS-based prototypical applications. In 1997, InfraManage (2, 3), a prototype GIS-based highway asset management system for Champaign County, was developed. IDOT initiated the development of its own GIS-based PMS, called GIS-ILLINET, in 1998. In 2000, the scope of the project expanded to secondary and tertiary highway networks, and by 2003 the program included all highways in District 5. The following sections of this chapter provide an overview of the development of these systems. Appendix A provides more details about these efforts.

Figure 1. Evolution of IDOT's transportation information and management systems.
CHAPTER 3—USING GIS-ILLINET

This chapter provides information about input data and describes the system files.

### Input Data

To perform an analysis, GIS-ILLINET uses several different types of data files. The file types are differentiated by direction—“W” for increasing milepost direction and “O” for the opposite direction. The "shape" sub-directory contains the core of the data files. The format of these files is dbase, with a .dbf extension, and the files can be edited directly in ArcView by accessing the files using “Tables” and then clicking the file name. Microsoft Excel can be used for changing the values in these files, but no rows should be added or deleted. Each row in these files represents specific unidirectional data of the pavement network. Following is a description of the column headings (fields):

**Column Headings for Files: DistrictsZ-Opposite/DistrictsZ-With**

- **Roadname:** Name of route
- **Marked_rt:** Route No.
- **Route:** Classification of Highway route
- **Beg_sta:** Beginning milepost
- **End_sta:** End milepost
- **Length:** Length of section
- **Lns:** No. of lanes
- **Distress_opp:** Distresses in the opposite direction
- **Aadt-1999:** Annual average daily traffic (AADT) for the year 1999
- **Aadt_yr:** Year of AADT
- **Hcv:** Heavy commercial vehicles
- **Mu_vol:** Multiple unit vehicles
- **Fault_opp:** Faulting in the opposite direction
- **Crs_yr:** Year CRS data was collected
- **CrsO-2000:** CRS values for year 2000 in the opposite direction
- **IriO-2000:** IRI values for year 2000 in the opposite direction
- **RutO-2000:** Rutting values for year 2000 in the opposite direction
- **CrsW-2000:** CRS values for year 2000 in the with direction
- **IriW-2000:** IRI values for year 2000 in the with direction
- **RutW-2000:** Rutting values for year 2000 in the with direction
- **Surf_typ:** Type of surface according to IRIS classification
- **Latest:** Latest information on type of surface (construction/reconstruction/rehabilitation)
- **Types of pavement**
  - HMAC = hot-mix asphalt concrete (AC) pavement,
  - JPCP = jointed plain concrete pavement,
  - CRCP = continuously reinforced concrete pavement,
  - JRCP = jointed reinforced concrete pavement,
  - ACJR = AC overlay (ACOL) on JRCP,
  - ACCP = ACOL over CRCP
- **PatchO:** Counter used for number of years after patching in the opposite direction
- **PatchW:** Counter used for number of years after patching in the with direction
- **RrehabO:** Column used for updating type of pavement surface during prediction, the column shows the pavement type for the last year of prediction in the opposite direction

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5
RrehabW: Column used for updating type of pavement surface during prediction, the column shows the pavement type for the last year of prediction in the with direction
Ln-Length: Lane times length of the section
ObenO-2001: Overall benefits calculated for year 2001 in the opposite direction
NoO-2001: Sections numbered according to priority and rehabilitation
CostO-2001: Cost of rehabilitation for a section incurred in year 2001
RcostO-2001: Remaining cost of rehabilitation (Total Budget - Cost)
RehabW-2001: Rehabilitation performed in year 2001 in the with direction

System Files

GIS-ILLINET consists of program files, input files, output files, and temporary files, as described below.

Program files:
  *.apr
   Project file which stores all the work done in ArcView, contains views, tables, charts, scripts (most important file, always keep a backup of the latest program file)
  *.avl
   script files

Input/Output files:
  direct-iris.txt
  read.me
  tableiripred.dbf
  tablerutpred.dbf
  tableunitcost.dbf
  year.txt
  year2.txt
  yearcrrspred.dbf
  yeariri-rut.txt
  yearenhb.txt
  yeartrafpred.dbf
  lists the direction (Opposite, With) used in the User Dialog
  Latest information about GIS-ILLINET
  lists years for which IRI data is predicted, used in the User Dialog
  lists years for which rutting data is predicted, used in the User Dialog
  input table for unit costs, used in the User Dialog
  lists years for which CRS data is available, used in the User Dialog
  lists years for AADT and ESAL data, used in the User Dialog
  lists years for which CRS data is predicted, used in the User Dialog
  years for which IRI and rutting data is available, used in the User Dialog
  lists years for rehabilitation history, used in the User Dialog
  lists years for which traffic data is predicted, used in the User Dialog

Data Files
  *.dbf
dbase files, data files
  * .shp
  AutoCAD shape source file
  * .shx
  AutoCAD compiled shape file
CHAPTER 4—GIS-ILLINET FUNCTIONS

This chapter describes how to navigate and use features of GIS-ILLINET. The functions described can be found by clicking on "Edit Parameters" from the main screen in GIS-ILLINET window. Program execution can be accessed by clicking on "Rehab. Program." The committed rehabilitation (rehabilitation entered manually) can be entered using "Map Committed Rehabilitation." Detailed discussion of each menu item is presented in the following.

GIS-ILLINET Main Menus

When GIS-ILLINET is first opened, the user sees the following screen, which is called the Project Window. The side bar shows the Views, Charts, Tables, Layouts, Scripts and Dialogs. One view is shown in Figure 2, which contains data for opposite and with directions for Interstate and other marked routes.

![GIS-ILLINET main window called the Project Window.](image)

The menu bar at the top of the window displays eight choices. They can be used for accessing several submenus.

**File:**

The menu can be used for opening new and old projects and in closing projects. Projects can be saved, and the "Extensions" can be accessed through it. "Print" options and "Print Setup" is also available. Detail on printing is provided in Chapter 6. Data can also be exported in different formats using the "Export"
function. Furthermore, data files can be copied, renamed and deleted using “Manage Data Sources.” GIS-ILLINET can also be exited using the menu.

Project:
Provides access to several different features and changes according to what is selected in the side bar.

Map Historical Data: This menu can be used to access the nine districts of Illinois. Currently only District 5 is implemented.

Edit Parameters: Provides access to different input parameters for carrying out analysis in GIS-ILLINET.

Rehab Program: Two submenus are provided. “Execute” runs the algorithm for pavement management, and the “Display” is used to see the results of the analysis. Also provides access to predicted summary of CRS, IRI, rutting and rehabilitation for the district network, showing health of the network.

Map Committed Rehab: Allows selection of district, entering and removing rehabilitation data, and entering/removing cost data for an individual section on the highway network. Additionally, the network can be observed using thematic maps for distresses and traffic.

Window: Used for managing different frames tile, cascade, viewing different views, and charts that are open, and for accessing the “Symbol Window.”

Help: Contains detailed information about how to use ArcView.

Map Historical Data

The drop-down menu in Figure 3 enables the user to view databases for individual districts. Currently data are available for District 5 only. The data include the pavement type, CRS, IRI, and rutting for year 2000 and traffic (AADT) for 1999. More historical data can be added, if available.

Figure 4 shows the “User Interface” used for selecting and displaying CRS, IRI, rutting, AADT, and type of pavement. One of the buttons on the left is selected first, then “Year” and then “Direction” can be selected. The “Execute” button executes scripts, and the correct thematic map is displayed according to the selection. The four square buttons in the middle, on the right, are provided for displaying information on the district map. The “i” button is for directly extracting information from the interstate Highway. After clicking the “i” button and then clicking any section of the highway, information about a particular section or sections can be retrieved. A single section can be chosen by zooming in. Other buttons are currently disabled because of non-availability of data. Clicking the “Done” button quits the display routine and the user returns to the initial main screen.

Figure 4 shows a color-coded map of pavement types in District 5 on Interstate and other marked routes (U.S. and State routes). The legends are shown on the left which shows the different types of pavement in the “With” direction. Figure 5 shows the range of CRS in different colors used in the map. The range is divided into five categories as established by the IDOT.

Figure 6 shows the historical data in tabular form. The data can be observed by clicking on the “Open Theme Table” button on the button bar. The table shows all the columns, which were discussed in Chapter 3. Using the horizontal scroll button at the bottom, more columns that are not shown in the figure can be observed.
Figure 3. Submenus in historical data.

Figure 4. Type of pavement - With Direction for District 5.
Figure 5. CRS values for the With Direction, District 5.

Figure 6. Historical data in tabular form.
Edit Parameters

The menu allows the user to change system defaults and analysis parameters. The drop-down menu is shown in Figure 7. On the submenus, once the desired input has been entered, the user can close them by clicking on the “OK” button. In the following, the submenus are described in detail.

Figure 7. Drop-down menu for Edit Parameters.

CRS Prediction Model (Interstate Routes and Other Marked Routes)

This function allows the user to modify all the parameters that are used in forecasting CRS values. The current parameters are displayed by clicking on the “CRS Parameters” submenu, as shown in Figure 8. Two dialog boxes are available for input to the CRS prediction model. The first one is for Interstate highways only, and the second one (shown in Figure 9) is for other marked routes, which includes U.S. routes and State routes.

The default CRS parameters can be obtained by clicking on the “Use Default Values” button, otherwise users can input their desired values. Default values are based on Illinois’s pavement deterioration data provided by the IDOT for different pavement types. The predicted CRS of each pavement type is computed based on the equation shown at the top of the user interface.
Figure 8. CRS Prediction Model Parameters user interface for Interstate routes.

Figure 9. CRS Prediction Model Parameters user interface for other marked routes.

IRI Prediction Model

This function allows the user to modify all the parameters that are used to predict IRI. Clicking on the "IRI Parameters" submenu to obtain current parameters is shown in Figure 10.
The default IRI parameters can be obtained by clicking on the “Use Default Values” button, otherwise users can input desired values. The predicted IRI of each pavement type is computed based on the equation shown at the top of the interface. This IRI model should be considered as a “placeholder” until a more accurate model is developed.

**Rutting Prediction Model**

This function allows the user to modify all the parameters that are used to predict rutting in flexible pavements. Click on the “Rutting Parameters” submenu to obtain current parameters, as shown in Figure 10. The rutting model should be considered as a “placeholder” until a more accurate model is developed.

The default rutting parameters can be obtained by clicking on the “Use Default Values” button, or the user can input desired values. The predicted rutting of each pavement type is computed based on the equation shown at the top of the interface.

![IRI and Rutting Parameters Interface](image)

**Figure 10. User interface: IRI (left) and Rutting (right) Prediction Model Parameters.**

**Traffic Forecast**

Traffic growth rates for AADT can be entered by clicking on “Traffic Forecast.” Both simple and compound traffic growth rates can be selected using the drop-down menu, as shown in Figure 11. The predicted values of AADT and ESAL are computed based on the equation shown at the bottom of the interface.
Rehabilitation Program (Parameters)

Figure 12 shows the user interface for entering the multi-year rehabilitation program. The latest years for AADT, rutting, IRI, and CRS, base year, analysis period, yearly budget, and benefit backlog parameters are inputs to the weighted benefit ranking procedure (WBRP), which is discussed in greater detail in chapter 5. The system is flexible, as latest years for every input parameter can be modified as newer data is added to the system. Base year is also a variable. The year column is updated according to the base year and budget can be entered for individual years by clicking on the budget column.
Currently for District 5, data for ADT are available for 1999, and data for CRS, IRI, and rutting are available for 2000. Until new data are available, these years should be used as inputs to “Latest Year” for different variables in the “Rehab Program Parameters” box.

Two separate columns are provided for entering budget—combined or individual budgets. By entering the analysis period, the years are updated in the tables automatically. Additionally, by clicking the click box “Separate Budget,” either Separate or Combined (Comb.) budgets can be selected. “Separate Budget” allows the user to enter separate budgets for Interstate and Other Marked routes (indicated by “OM Routes”). A combined total budget for the Interstate and Other Marked routes can be used with “Comb. Budget.” Budget for a year can be entered by clicking on the amount under “Interstate,” “OM Routes,” or “Budget.” A user interface opens up, as shown in Figure 12, which provides easy entry of budget for a year.

**Rehabilitation Decision Process (Interstate and Other Marked Routes)**

The user interface allows the user to customize the rehabilitation decision tree. For Interstate and Other Marked routes, individual trigger values (CRS) for each pavement type and rehabilitation activity are entered. Type of rehabilitation is selected based on the CRS values in the user interface. The user interfaces are presented in Figure 13 for Interstate routes and in Figure 14 for Other Marked routes.

![Rehabilitation Decision Variables](image)

**Figure 13. Decision tree trigger values for Interstate routes.**
Figure 14. Decision tree trigger values for Other Marked routes.

The decision tree trigger values consider six main rehabilitation activities and six different pavement types. According to the values in the user interface shown in Figure 13, a JRCP section with a CRS ≥ 1.0 and CRS < 4.9 would require reconstruction. Similarly, a JPCP section with a CRS ≥ 4.9 and CRS < 6.0 would require a 5-inch asphalt overlay. The CRS trigger values determine the type of rehabilitation for a particular type of pavement section. The trigger values for each rehabilitation type should be entered to fit the following definitions:

- **Maintenance**: Trigger value for maintenance (lower limit of range),
- **Patching**: Trigger value for patching (lower limit of range),
- **1-1/2 in ACOL**: Trigger value for 1-1/2 in AC overlay (lower limit of range),
- **2-1/4 in ACOL**: Trigger value for 2-1/4 in AC overlay (lower limit of range),
- **3-1/4 in ACOL**: Trigger value for 3-1/4 in AC overlay (lower limit of range),
- **3-3/4 in ACOL**: Trigger value for 3-3/4 in AC overlay (lower limit of range),
- **5 in ACOL**: Trigger value for 5-in AC overlay (lower limit of range), and
- **Reconstruction**: Trigger value for pavement reconstruction.

If the user doesn’t like to carry out “Maintenance” and “Patching,” a value of 9.0 can be used. The “Maximum Rehab. CRS Value” restricts any rehabilitation above the user specified value. If “Maximum Rehab. CRS Value” is lower than the CRS value for the first overlay, which in the case of Interstate routes is 3-3/4 in ACOL, then no rehabilitation will be provided above the user-specified value (e.g., if the CRS value specified for the 3-3/4 in ACOL is 6.0 and the “Maximum Rehab. CRS Value” is 5.2, then a section having a CRS value of 5.4 will not get a rehabilitation). If a section has a CRS value of 6.4, and the “Maximum Rehab. CRS Value” is set at 7.0, then the section will get an overlay of 3-3/4 in. “Number of Years between Patching” is used to restrict patching for a user-specified minimum number of years between two consecutive patching events.

**Rehabilitation Unit Costs**

The user can enter the desired unit cost of each rehabilitation activity as shown in Figure 15. Cost is entered as dollars per lane mile, for the activity identified. Annual compound rate is also entered for
inflating all future costs. For maintenance and patching, a percentage of the cost entered for Interstate routes is used for Other Marked routes, which is entered in the box above the “Inflation Rate” as shown in Figure 15.

![Rehabilitation Unit Costs](image)

**Figure 15. Rehabilitation unit costs.**

**Rehabilitation Effects on CRS, IRI, and Rutting**

Figure 16 shows the effects of pavement rehabilitation on the values of CRS, IRI, and rutting. Again, default values can be used or user-specified values can be entered. The effect of rehabilitation depends on the type of surfacing (asphalt or concrete) and the type of activity (patching, thickness of asphalt overlay or reconstruction). For example, a pavement section with a CRS of 4, an IRI of 250, and rutting of 0.35 will be updated to a CRS value of 9, IRI of 60, and no rutting will be present, if it is reconstructed (see 7th column of the user interface). However, in the case of patching, only a relative change occurs in the condition of the section—the CRS increases by 0.5, whereas IRI and rutting values are reduced by 1 and 0.001, respectively, according to the values in the user interface.
Vehicle Miles Traveled

Figure 17 shows the user interface with default critical values for vehicle miles traveled (VMT). This parameter is useful in assessing the number or proportion of highway users traveling on good (or poor) highway pavements and can be understood easily by administrators and legislators. VMT for the section is calculated according to the equation at the top of the interface. For CRS, critical value indicates that VMT is calculated for sections with CRS greater than or equal to 6.5. For IRI, VMT is calculated for sections having IRI less than or equal to the critical value, and for rutting, VMT is calculated for sections having rutting less than or equal to the critical value.
Rehab. Program

Figure 18 shows the submenus under "Rehab. Program."

![Image: District Rehab Program showing submenus.](image)

**Initialize Tables**

This submenu initializes the table used in forecasting the state of the highway network. All types of rehabilitation and distress values are also removed from the table. Figure 19 shows the state of the network after initialization as observed using the "Map Committed Rehab." menu (explained in the following subsections).

**Execute: Weighted Benefit Ranking Procedure**

Clicking on the submenu "Execute: Weighted Benefit Ranking Procedure" starts the algorithm for forecasting the future state of the Interstate network using the WBRP. The steps involved in the procedure are described in chapter 5. The procedure selects type and time of rehabilitation for sections on the highway using the budget provided for a year. The condition of the network is also forecasted over the analysis period.

**Forecast State of the Network using Committed Rehab.**

After executing the WBRP, rehabilitation on the highway network can be modified as explained in the section on "Committed Rehab." This submenu can then be used to forecast the state of the highway network.
network using the new/modified rehabilitation selected by the user.

Figure 19. Initialized highway network for District 5.

Display Results throughout the Analysis Period

This submenu allows the user to view results of multiyear improvement plan in a variety of formats. The user interface shown in Figure 20 is used to display results. The user interface is very similar to the interface used in displaying "Historical Data" shown in Figure 4. Buttons on the right are enabled after selection of a parameter, year, and direction. The "Line Graph" symbol is used with a selected section on the map for displaying trend of CRS, rutting, IRI, ADT, or overall benefits over the years, depending on the parameter selected in the user interface. A graph is plotted showing data from the latest year to the last year of forecast.
Figure 20. User interface for displaying results of analysis period.

Figure 21 shows the type of rehabilitation provided in the year 2004 in the With direction. The legend identifies the color of the type of rehabilitation used in the map. The figure also shows information from the interface "Identify Results" for a section of the network. The information can be obtained by first clicking on the "i" button and then clicking on any section of the network. The information shows the overall benefits, CRS, IRI, rutting, cost of rehabilitation, type of rehabilitation, and remaining cost for 2004. Other information can also be observed by scrolling vertically up or down.

Figure 21. Rehabilitation for the year 2004 and information about a selected section of the network.
Figure 22 shows a thematic map of forecasted CRS for 2004. The chart shows the forecasted CRS of a selection section of the network. Similarly, Figure 23, 24, and 25 show the forecasted thematic map of rutting, IRI, and overall benefits respectively for 2004. The selected section in Figure 22 is also shown in Figures 23, and 24, and shows the increase in CRS, decrease in IRI and rutting values, respectively, when it is rehabilitated.

Figure 22. Chart and thematic map of forecasted CRS for 2004.
Figure 23. Chart and thematic map of forecasted rutting for 2004.

Figure 24. Chart and thematic map of forecasted IRI for 2004.
Figure 25. Chart and thematic map of forecasted overall benefits.

Predicted Summaries

The program generates summaries of predicted values for CRS, IRI, rutting, rehabilitation, and cost for every year of the analysis period.

Distresses

The submenu provides results for the network analyzed in terms of CRS, rutting, and IRI. The summaries can assist decision-makers in analyzing the results of rehabilitation decisions. Weighted average values for CRS, IRI, and rutting are calculated. The weighted average is calculated as:

\[
\text{Network Weighted Average Parameter} = \frac{\sum_{k=1}^{K} (\text{Parameter} \times \text{Length})}{\sum_{k=1}^{K} \text{Length}} \tag{1}
\]

where
- Parameter = CRS, IRI, or rutting values per section,
- K = total no. of sections, and
- Length = length of section, mile.

The network weighted average is calculated as it shows the state of the network without adding bias in any way. It is also useful in making quantitative comparisons between successive years of the analysis period. Figure 26 shows example charts of weighted averages for CRS, IRI, and rutting calculated for the highway network. The program also generates the forecasted summary in tabular format.
Figure 26. Example weighted average for CRS, IRI, and rutting.

Rehabilitation and Cost Summary

Figure 27 shows the rehabilitation summary, which is provided in miles, for different types of rehabilitation and aggregated for every year. The summary is also provided both in tabular and graphical format. Different colors are used to indicate the type of rehabilitation. 1-1/2 to 3-3/4 in ACOL are for U.S. and State routes, and 3-3/4 to 5 in ACOL are for Interstate highway. Localized repair is combined for all types of highways. A cost summary is shown in Figure 28 and is very similar in format to the rehabilitation summary.
Figure 27. Rehabilitation summary.

Figure 28. Cost summary.
Vehicle Miles Traveled

The submenu provides result for the network analyzed in terms of CRS, IRI, and rutting. VMT is calculated for a parameter using a user specified critical value, as shown in Figure 17. VMT is calculated using the following equation:

\[ \text{VMT}_p = \frac{\text{AADT}}{2} \times \text{Length} \times 365 \] \hspace{1cm} (2)

where

\( \text{VMT}_p \) = vehicle miles traveled for a parameter i.e. CRS, IRI, or rutting, and
\( \text{Length} \) = length of section, mile.

VMT provides the length of highway in miles, which is better than a specified value. It evaluates the quality of the highway network and provides it as a quantitative number. Years, different budgets, and strategies for a multi-year program can be compared using VMT for a single distress type or all three types together.

![Graph showing Vehicle Miles Traveled (VMT) for CRS >= 6.5, District 5]

*Figure 29. VMT for CRS on Interstate and Other Marked routes.*

Map Committed Rehab.

Committed rehabilitation allows the user to enter or modify the plan generated by the WBRP, or the user may start from an initialized map (with no rehabilitation) and build a multi-year plan to reflect IDOT's decision. An entire District's rehabilitation program can be entered using the program. The user can select the type of rehabilitation, its cost, year, and length of rehabilitation (constrained by the length of the section). This section presents the details of the committed rehabilitation process, from selecting the type of rehabilitation to visualizing the highway network.

Figure 30 shows the user interface and map for District 5 when accessed using the “Map Committed Rehab” menu. The lower left side of the user interface displays parameters that can be selected, direction,
year, and the “Update Map” button. The “Update Map” button runs the script and updates the map for display, after the parameter, direction, and year are selected. The “i” and “graph” buttons let the user click a section on the highway network and observe information in different formats. The “i” button displays information in a tabular form, and the “graph” button displays a chart showing the trend of the values from the latest year to the last year of forecast, as shown in Figure 31.

![Image of software interface]

Figure 30. Entering rehabilitation and cost of a project using the Commit. Rehab user interface.
In Figure 30, the arrow in the middle of the user interface allows a section to be selected for rehabilitation. After the section is selected, its color is updated and it is highlighted in magenta (purple). The "Remove" button can be used to remove rehabilitation, and the "Enter" button can be used to enter a selected rehabilitation or modify current rehabilitation based on the current selection. In this manner, a district engineer or manager can input IDOT's decision to the multi-year rehabilitation program. To enter rehabilitation, first the type of rehabilitation is selected from the "Select Rehab" list box. The list box has seven alternatives: patching, 1-1/2 in ACOL, 2-1/4 in ACOL, 2-3/4 in ACOL, 3-3/4 in ACOL, 5 in ACOL, and Reconstruction. The 1-1/2 in ACOL and 3-1/4 in ACOL are used for Other Marked routes (U.S. and State routes), and the others are for Interstate routes (note that patching applies to both). Correct rehabilitation needs to be entered based on the functional classification of the route, otherwise the program doesn't enter the selected rehabilitation. The "Unit Cost" ($/lane-mile) can be entered in the box provided, and the program calculates the total section cost when the "Enter" button is clicked. If the box is left blank, then the total cost is calculated using the cost provided in the "Rehab Unit Cost" interface explained in Figure 15. The "Close" button closes the user interface, as well as the "View" of the District. The top half of the user interface shows information of the section selected for rehabilitation. The horizontal scroll bar lets the user view the section properties. After entering the rehabilitation, the map can be updated to display the entered rehabilitation on the map. This is required when the type of rehabilitation is not currently displayed in the list of legend.
Rehabilitation can also be entered directly using the list box displaying the section properties by clicking the year of rehabilitation. For example, if the map is displaying rehabilitation for the year 2004, then rehabilitation can be entered under the column RehabW-2004 or RehabO-2004 by first selecting the type of rehabilitation and then double clicking the cell in the list box. The selected rehabilitation will appear in the cell after the list box is updated automatically. This is shown in Figure 32. Similarly, the rehabilitation can be removed by clicking the "Remove" button.

Figure 33 displays a thematic map and chart for rutting. The figure shows the drop in rutting after rehabilitation in 2004. Similarly, Figure 34 and Figure 35 show example thematic maps for forecasted CRS and IRI, respectively. Figure 36 shows example a thematic map and chart for forecasted ADT.
Figure 33. Displaying thematic map of rutting and trend for a selected section.

After rehabilitation is entered, the forecast of the network can be updated using "Forecast State of the Network using Committed Rehab." from the "Rehab Program" menu. This allows CRS, IRI, and rutting values to be forecasted, to reflect the change as a result of modification in the year of rehabilitation. The predicted summaries should also be updated to reflect the change in rehabilitation.
Figure 34. Displaying thematic map of CRS and section properties.

Figure 35. Displaying thematic map of IRI and section properties.
Figure 36. Thematic map and chart for forecasted ADT.
CHAPTER 5—DEVELOPMENT OF MULTI-YEAR IMPROVEMENT PROGRAM

GIS-ILLINET utilizes a weighted benefit ranking procedure (WBRP) to prioritize network-level pavement rehabilitation. The WBRP measures overall benefit of improving the condition of a pavement section based on changes in the CRS, IRI, average rut depth, and traffic. When the overall benefit exceeds a certain limiting value (1.0), the pavement is considered to be in a "backlog" condition and in need of improvement. The more the value is exceeded, the more critical the pavement backlog condition is and, therefore, the greater the need for improvement.

Pavement sections with an overall benefit greater than the limiting value are selected as candidates for rehabilitation. These sections are prioritized in the order of their overall benefit. The input parameters and algorithm for the WBRP are described in the following sections.

Weighted Benefit Ranking Procedure

Overall benefit is subdivided into individual benefits that depend on CRS, IRI, and rutting. The individual benefits are computed as:

\[
\begin{align*}
\text{CRS Benefit} &= \log \left( \frac{\text{AADT/Lanes}}{\text{AADT/Lanes}} \right) \times (9.0 - \text{CRS}) \quad \text{(3)} \\
\text{IRI Benefit} &= \log \left( \frac{\text{AADT/Lanes}}{\text{AADT/Lanes}} \right) \times (\text{IRI} - 50) \quad \text{(4)} \\
\text{Rut Benefit} &= \log \left( \frac{\text{AADT/Lanes}}{\text{AADT/Lanes}} \right) \times \text{Rut} \quad \text{(5)}
\end{align*}
\]

where

- CRS Benefit = benefit due to improvement in CRS,
- IRI Benefit = benefit due to improvement in IRI,
- Rut Benefit = benefit due to improvement in rutting,
- AADT = annual average daily traffic
- Lanes = number of lanes,
- CRS = Condition Rating Survey (range from 1 to 9),
- IRI = International Roughness Index, inches/mile, and
- Rut = rut depth, inches.

Figure 37 shows the relationship between CRS, IRI, and rutting and their respective benefit of pavement improvement. The figure shows individual benefits for a range of condition index. IRI shows the highest and rutting shows the lowest benefit for high values of IRI and rutting, respectively. IRI and rutting benefits increase as the pavement indices increase or as the pavement condition gets worse, whereas CRS benefits decreases as the CRS value increases or as the pavement condition gets better.

AADT per lane is plotted against log of AADT/lane to show their relationship. The AADT/lane increases logarithmically instead of linearly and is a better relationship that indicates the importance of AADT in calculating benefits in prioritizing pavement sections for rehabilitation.

For AC surfacing, the overall benefit is calculated as:

\[
\text{Overall Benefit} = 0.5 \frac{\text{CRS Benefit}}{a} + 0.25 \frac{\text{IRI Benefit}}{b} + 0.25 \frac{\text{Rut Benefit}}{c} \quad \text{(6)}
\]

where a, b, and c are parameters defined in the next section.
For PCC surfacing, the overall benefit is calculated as:

\[
Overall\ Benefit = 0.5 \frac{CRS\ Benefit}{a} + 0.5 \frac{IRI\ Benefit}{b}
\]  

In Equation 7, more weight is given to CRS benefit (0.5) in comparison to benefits calculated using IRI and rutting (0.25) for AC pavements, whereas equal weights are used for PCC pavements. This is carried out, since IDOT is more confident in using CRS, compared to both IRI and rutting for use in pavement management. CRS has been used extensively for the last 20 years for pavement rehabilitation. However, in concrete pavements equal weights were given to both CRS and IRI, as it was believed that these key indicators should have the same relative weight.

![Graphs showing CRS, IRI, and rutting benefits](image)

Figure 37. CRS, IRI, and rutting versus CRS, IRI and rutting benefits, and AADT/Lane versus Log(AADT/Lane).

Overall benefit of improvement is lower for pavement sections that are in better condition, showing low priority for rehabilitation. Similarly, overall benefits are higher for pavement sections that are in bad condition and require rehabilitation, showing higher priority. A pavement section with a high value of CRS will have a low overall benefit, compared to a pavement section with a lower value of CRS, when other variables remain constant. On the other hand, a pavement section with a high value of IRI will have a high value of overall benefit, compared to a section with a lower value of IRI, assuming other variables
remain the same. The sensitivity of overall benefit to CRS, IRI, rutting and AADT is discussed in the section on sensitivity analysis.

**Defining Parameters**

Parameters a, b, and c are defined based on AADT/lane, CRS, IRI, and rutting values. The parameters are selected so that a pavement section that requires rehabilitation has an overall benefit greater or equal to the limiting value, which was selected to be 1.0.

AADT/lane was first analyzed and its minimum value was used from the latest year’s data. The minimum value was chosen so that a section with even the lowest value of AADT would have an overall benefit greater or equal to 1.0, if backlogged and in need of rehabilitation.

To compute parameters a, b, and c in Equations 6 and 7, weighted average values of CRS, IRI, and rutting for the Illinois Interstate network were calculated. These values were found to be 7.0 for CRS, 115 inch/mile for IRI, and 0.1 inch for rutting for all types of pavements. These values were used in calculation of parameters by solving Equations 6 and 7 for an overall benefit of 1.0 and are presented in Table 2.

**Table 2. Parameters used in WBRP.**

<table>
<thead>
<tr>
<th>Pavement Surfacing</th>
<th>CRS in./mile</th>
<th>IRI</th>
<th>Rut Inch</th>
<th>(AADT/Lane)</th>
<th>Overall Benefit</th>
<th>A</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>7.0</td>
<td>115</td>
<td>0.1</td>
<td>787.5</td>
<td>1.0</td>
<td>5.73</td>
<td>188.25</td>
<td>0.29</td>
</tr>
<tr>
<td>Concrete</td>
<td>7.0</td>
<td>115</td>
<td>--</td>
<td>787.5</td>
<td>1.0</td>
<td>5.73</td>
<td>188.25</td>
<td>--</td>
</tr>
</tbody>
</table>

**Sensitivity Analysis**

Sensitivity analysis is carried out to show the effectiveness of overall benefit in selecting sections that require rehabilitation. Parameters a, b, and c presented in Table 2 were used in calculating the overall benefits. Pavement section data from the GIS-ILLINET database were used in the analysis. Sections were chosen such that one of the variables varied while the other variables had similar values.

Table 3 shows the sensitivity of overall benefit to CRS. A CRS value of 4.2 for the first section on Interstate 80 (I-80) shows that it is in bad condition and requires rehabilitation. The section has an IRI of 124 inch/mile and rutting of 0.14 inch. It shows a high overall benefit of 2.52. Similarly, a section on I-394 has similar IRI, rutting, AADT, and number of lanes. However, its CRS value is high and it is in better condition than the first section. These sections are selected as candidates for rehabilitation, and the type of rehabilitation will depend on the value of CRS in Figure 13. The overall benefit for the second section is lower than the first section, showing that a pavement section with low CRS value has higher priority over a section with high CRS value, when other variables are similar.

Table 4 shows the sensitivity of overall benefit to change in IRI. The section on I-74 shows a low value of IRI but a high value of rutting and, therefore, requires rehabilitation. Similarly, the second section on I-80 shows a similar value of rutting but has a higher IRI value than the first section. Its overall benefit is thus higher than the first section, showing sensitivity of overall benefit to change in IRI. Both sections are selected as candidates for rehabilitation since the overall benefit is greater than 1.0.

Table 5 shows sensitivity of overall benefit to rutting. Rutting in the second section is higher than the first section, and its overall benefit is higher as well. The section’s CRS value is slightly lower than the first section. The second section thus has higher priority over the first section because of higher overall
benefits.

Table 6 shows sensitivity of overall benefit to AADT. The I-57 sections lead into Chicago and the AADT increases with increase in milepost. The overall benefit increase with increase in AADT, showing sensitivity to AADT.

Table 3. Sensitivity of overall benefit to CRS.

<table>
<thead>
<tr>
<th>Rte</th>
<th>Dir</th>
<th>Bmp</th>
<th>Emp</th>
<th>Type</th>
<th>CRS</th>
<th>IRI (in/mile)</th>
<th>Rutting (inch)</th>
<th>AADT</th>
<th>Lanes</th>
<th>Over. Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-80</td>
<td>E</td>
<td>133.6 5</td>
<td>137.51</td>
<td>ACCR</td>
<td>4.5</td>
<td>124</td>
<td>0.14</td>
<td>28431</td>
<td>2</td>
<td>2.52</td>
</tr>
<tr>
<td>I-394</td>
<td>N</td>
<td>3.95</td>
<td>6.65</td>
<td>ACJR</td>
<td>6.2</td>
<td>128</td>
<td>0.13</td>
<td>27447</td>
<td>2</td>
<td>1.89</td>
</tr>
</tbody>
</table>

Table 4. Sensitivity of overall benefit to IRI.

<table>
<thead>
<tr>
<th>Rte</th>
<th>Dir</th>
<th>Bmp</th>
<th>Emp</th>
<th>Type</th>
<th>CRS</th>
<th>IRI (in/mile)</th>
<th>Rutting (inch)</th>
<th>AADT</th>
<th>Lanes</th>
<th>Over. Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-74</td>
<td>E</td>
<td>74.08</td>
<td>81.82</td>
<td>ACCR</td>
<td>6.0</td>
<td>93</td>
<td>0.24</td>
<td>8943</td>
<td>2</td>
<td>1.91</td>
</tr>
<tr>
<td>I-80</td>
<td>E</td>
<td>10.68</td>
<td>14.47</td>
<td>ACJR</td>
<td>6.0</td>
<td>125</td>
<td>0.22</td>
<td>8999</td>
<td>2</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Table 5. Sensitivity of overall benefit to rutting.

<table>
<thead>
<tr>
<th>Rte</th>
<th>Dir</th>
<th>Bmp</th>
<th>Emp</th>
<th>Type</th>
<th>CRS</th>
<th>IRI (in/mile)</th>
<th>Rutting (inch)</th>
<th>AADT</th>
<th>Lanes</th>
<th>Overall Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-80</td>
<td>E</td>
<td>10.68</td>
<td>14.47</td>
<td>ACJR</td>
<td>6.0</td>
<td>125</td>
<td>0.22</td>
<td>8999</td>
<td>2</td>
<td>2.00</td>
</tr>
<tr>
<td>I-80</td>
<td>E</td>
<td>5.23</td>
<td>9.68</td>
<td>ACCR</td>
<td>5.7</td>
<td>126</td>
<td>0.30</td>
<td>8718</td>
<td>2</td>
<td>2.35</td>
</tr>
</tbody>
</table>

Table 6. Sensitivity of overall benefit to AADT.

<table>
<thead>
<tr>
<th>Rte</th>
<th>Dir</th>
<th>Bmp</th>
<th>Emp</th>
<th>Type</th>
<th>CRS</th>
<th>IRI (in/mile)</th>
<th>Rutting (inch)</th>
<th>AADT</th>
<th>Lanes</th>
<th>Over. Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-57</td>
<td>N</td>
<td>347.48</td>
<td>348.48</td>
<td>ACCR</td>
<td>6.5</td>
<td>198</td>
<td>0.13</td>
<td>40495</td>
<td>3</td>
<td>2.17</td>
</tr>
<tr>
<td>I-57</td>
<td>N</td>
<td>353.25</td>
<td>354.24</td>
<td>ACCR</td>
<td>6.5</td>
<td>198</td>
<td>0.13</td>
<td>57199</td>
<td>3</td>
<td>2.19</td>
</tr>
<tr>
<td>I-57</td>
<td>N</td>
<td>355.09</td>
<td>356.18</td>
<td>ACCR</td>
<td>6.5</td>
<td>198</td>
<td>0.13</td>
<td>63274</td>
<td>3</td>
<td>2.21</td>
</tr>
</tbody>
</table>

Weighted Benefit Ranking Algorithm
The WBR algorithm produces a prioritized set of pavement sections for rehabilitation every year in the analysis period. The following steps are carried out in selecting a prioritized set of pavement sections:

Step 1. Set \( y = y_1 \), where \( y \) represents a year and \( y_1 \) is the first year in the analysis period.

Step 2. Compute CRS, IRI, and rutting benefits for each section for the first year in the analysis period using Equations 1, 2 and 3.

Step 3. Compute the overall benefit for each section using Equations 4 or 5, depending on the surface type.

Step 4. Select backlog sections (overall benefit \( \geq 1.0 \)) and prioritize by sorting them in descending order of the overall benefit.

Step 5. For each backlog section \( j \), where \( j = 1 \) to \( J \) and \( J \) represents total number of backlog sections, perform the following tasks:
- Determine type of rehabilitation required for section \( j \) based on the project-level decision tree
Compute cost of rehabilitation for the candidate section as:
Cost of section = unit cost (in $/lane-mile) * no. of lanes * length of section (in mile)

**Step 6.** From the backlogged sections select candidate ones for rehabilitation, as:
- If cost of section ≤ remaining budget (for an analysis year)
  - Select section for rehabilitation
  - Update budget: Remaining budget = total budget – cost of section
- Else, select next section in the prioritized list of backlogged sections, until all backlog sections are selected for rehabilitation or the budget is less than the lowest section cost (i.e. no budget is left to fund remaining sections).

**Step 7.** Update CRS, IRI, and rutting values for the sections selected for rehabilitation using Figure 16 and the prediction models for the remaining sections.

**Step 8.** Update pavement type based on selected type of rehabilitation (AC overlay or CRCP reconstruction). Patching and routine maintenance do not affect pavement type.

**Step 9.** Update AADT using predefined growth rate for the network.

**Step 10.** Repeat Steps 1 to 10, until \( y = y_n \).
Else \( y = y_1 + 1 \) (i.e. move to next year in the analysis period).
where, \( y \) = year,
\( y_1 \) = first year,
\( y_n \) = last year in the analysis period, and
\( n \) = total no. of years in the analysis period.
CHAPTER 6—PRINTING

In ArcView, printing of views, table of contents, and tables can be performed using the "Print" option provided under the "File" menu or the "Layout" option provided under the "View" menu. These printing and plotting options are shown in Figure 38 and Figure 39.

Figure 38. Print options for current view and table of contents.

Figure 39. Printing or plotting using the layout option.
Alternatively, the user can use [Alt]+[Print Screen] or [Print Screen] on the keyboard to copy screens to the clipboard and then use them with other applications (e.g. MS Word, PowerPoint, PhotoEditor, etc.) for printing. The figures provided in the report were captured using [Print Screen] and then pasted to MS Photo Editor. From there, the required user interfaces were pasted in MS Word as pictures.
REFERENCES


APPENDIX A: ILLINOIS EFFORTS IN ROADWAY INFORMATION AND MANAGEMENT SYSTEMS

Illinois Roadway Information System

To develop the most effective highway improvement program possible, IDOT anticipates and prioritizes highway rehabilitation needs. Required improvements are projected using information from IRIS. The IRIS database includes inventory information for the entire 138,995 miles of public owned roadways in Illinois, including those under State and local jurisdiction (4).

The implementation of IRIS in the early 1990's provided new roadway inventory data elements and better capabilities for data access. Roadway information is collected for the entire width (i.e., between right-of-way lines) of all highways that are open for public travel. The IRIS pavement data consists of pavement Condition Rating Survey (CRS), International Roughness Index (IRI), rutting, faulting, other distresses, and surface type. Key traffic data in the IRIS consist of Average Daily Traffic (ADT), volume of heavy commercial vehicles, and multiple units. Information on the number of lanes and shoulder width (both inner and outer) is also available.

IRIS uses Key Route/milepost as its primary location identifier but also includes a reference to Marked Route. A major component of IRIS is the annual creation of a year-end file that provides a method to develop a history for individual road segments for information such as changes in ADT. In 1995, the IRIS data was directly linked to the IDOT's GIS.

Illinois Pavement Feedback System

A joint team of University of Illinois and IDOT personnel was formed to develop the IPFS in 1985. The IPFS is a comprehensive database that includes detailed inventory and condition monitoring data for Interstate highways and supplemental freeways in Illinois. The IPFS provides the data required for a variety of purposes—planning, design, rehabilitation, maintenance, materials, and construction (1). The objective of the IPFS was to provide a formalized data processing structure and process that will collect, store, retrieve, and analyze design, materials, traffic, condition, and performance data for existing pavements (4).

A major objective of the IPFS database was to provide IDOT districts and central offices with the information needed for pavement management purposes. The IPFS project also includes development of analysis routines and reporting capabilities for special studies, research in prediction models, and answers to "what if" questions to help improve management strategies. The database was intended to provide all the information required for the analysis routines. It contains detailed, long-term, historical information on the pavement surface, traffic loading history, construction history, and pavement condition (4). The pavement condition data in the IPFS consists of CRS data collected every 2 years. Information about the presence of D-cracking is also available, as are pavement construction, rehabilitation, reconstruction, and repair data. Historic traffic data dating back to 1955 are also available in the IPFS. The traffic data include ADT, equivalent single axle loads (ESALs), and truck traffic (single and multiple units). The number of lanes and traffic growth rates are also available.

ILLINET PMS

The objective of the ILLINET pavement rehabilitation and management program was to provide network
analysis and reporting capabilities to aid IDOT personnel in developing multi-year rehabilitation program. ILLINET is equipped with a wide variety of project-level rehabilitation selection routines, network-level analysis algorithms, and benefit functions to identify which projects in the pavement network should receive funding, what treatments are best for those sections, and when the treatments should be applied. It uses data from IPFS; only the major elements considered necessary for pavement management are used.

ILLINET for DOS® (5, 6) was developed in 1992 by a joint team of personnel from the University of Illinois and IDOT. It included a mathematical algorithm based multi-year pavement preservation program generator and utilized priority and optimization models to allocate funding or to predict the total rehabilitation needs and costs to meet performance standards.

In 1994, IDOT pavement engineers felt that more human–interaction/input was needed. They wanted the ability to input their own knowledge into the decision-making process of generating a satisfactory multi-year highway pavement improvement program. Secondly, the output from the system was not very easy to understand, and more graphical data interpretation was required. Furthermore, there was no way to evaluate overall pavement performance, and the pavement engineer was not able to decide which multi-year program was better suited when the system generated more than one program. Thus, IDOT decided to upgrade and improve ILLINET for DOS to ILLINET for Windows.

The Microsoft Windows 3.1 version of ILLINET (1, 7) involved a new methodology that was more flexible and interactive. It combined the advantages of both the manual and mathematical processes. Pavement performance and network quality evaluation capabilities were added in the new methodology, in order to evaluate rehabilitation decisions and to compare different long-range rehabilitation programs. This improved newer version was based more on graphical data interpretation. A multi-functional and flexible program generator was used to predict the pavement performance, rehabilitation costs, and long-term benefits obtained from rehabilitation. Human-computer interaction technology was used in the rehabilitation program development process to allow the pavement manager to be involved in the decision making process.

Windows ILLINET offers several different decision making options: 5 network-level algorithms, 6 project-level rehabilitation selection algorithms, and 3 different types of benefits (7). The system can run the algorithms only or can combine the algorithms with a user-defined committed rehabilitation plan, in which the user identifies specific rehabilitation projects that must be performed at specific years (7).

Despite its useful features, Windows ILLINET became outdated because of the change in how data are spatially and temporally represented, and operating systems and platforms. With the advent of GIS, the system needed additional capabilities in terms of visualization of data, mapping, and access to the Internet. In addition, it requires a simpler user interface that is fairly self-explanatory and does not require training for engineers and managers. Furthermore, it was designed for Interstate routes and no provision was made for non-Interstate routes.

**Highway Asset Management System**

Highway asset/infrastructure management is essentially a set of activities associated with the process of maintaining, rehabilitating, and reconstructing/replacing highway assets in a cost-effective way (2). It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more logical approach to decision making. Thus, highway agencies need tools that allow them to perform coordinated management of their assets and to provide the services that the community expects of them within funding limits (2).
Researchers at the University of Illinois developed a methodology for integrating highway infrastructure management activities. The main objective of the research was to provide highway agencies with a methodology for performing trade-off analysis among various highway infrastructure improvement projects and coordinate project implementation to reduce traffic disruptions. The methodology consists of analytical procedures, and data integration and presentation tools, along with a GIS-based software program called InfraManage that integrates and implements these procedures and tools.

A GIS-based prototype software tool that implements this asset management methodology was developed using Champaign County's roadway network (Interstate and non-Interstate). The prototype called InfraManage and can be used in managing five highway components (pavements, bridges, culverts, signs, and intersections) in a coordinated and cost-effective manner. The system was developed using ARC/INFO® (8) (Environmental Systems Research International [ESRI]).

**Illinois GIS-based PMS System**

The Illinois Pavement Information and Management System (called GIS-ILLINET) has been developed in ESRI's ArcView® GIS 3.2 (9). However, the base map was developed using ESRI's ARC/INFO®. The system is built on the experience of ILLINET. The current version uses the data from IRIS.

Work on GIS-ILLINET was carried out in stages. The first stage consisted of data acquisition from the IPFS and the IRIS databases. The second stage involved implementation of prediction capabilities in the system. The third stage involved incorporating analysis procedures for developing multi-year rehabilitation programs. The final stage incorporated non-Interstate roadway network, implementation of the system in District 5 (as a prototype) and making it possible to enter a committed rehabilitation program manually.

GIS-ILLINET is able to display, analyze, modify, report, and predict pavement and traffic information for District 5 in central Illinois. The system can display information spatially as well as temporally. Spatial information on traffic, type of pavement rehabilitation, or pavement performance (CRS, IRI, rutting) is presented for both directions (with the milepost increasing direction and opposite to the milepost increasing direction) for the entire Interstate and non-Interstate highway system in district 5. Directional information is available in the form of different themes. Temporal information is displayed based on user selection on a yearly basis. Thus, thematic maps can be generated for variables such as average ADT, CRS, IRI, and rutting for each year in the database. With a touch of a button, any section on the Interstate/freeway map can be selected and its graph plotted showing the historical trend of the data. The prediction models built into the system can predict 20 years in the future. The pavement performance prediction models are user modifiable. The user also has the option of selecting traffic growth rates for the future. Both simple and compound growth rates can be used.

GIS-ILLINET is unique because of its graphing and data displaying capabilities. Almost all information is displayed either in a map, a graph, or a chart. Color-coded dynamic legends are used to display and provide information to the user. Additionally, it is possible to zoom in and out to a particular section or highlight it by selecting it from an attribute table. Similarly, by selecting a section, its attributes can be highlighted in a table.

The GIS-ILLINET system is equipped with engineering and economic methods and models that predict future traffic, rehabilitation, and pavement condition. In addition, it can generate multi-year pavement rehabilitation programs. IDOT can use this system to help make more cost-effective decisions, increase staff productivity, and increase customer (public) satisfaction.
The system is easy to use and does not require prior training in ArcView GIS. The user interface was developed using the "Dialog Designer" extension of ArcView, in which dialogs are created and then simple scripts written in Avenue (ArcView’s object oriented programming language) attached with label and tool buttons, lists, and combination boxes.
APPENDIX B: EXAMPLE APPLICATION

This appendix presents a detailed example application of GIS-ILLINET using the WBRP. The procedure is used in analyzing District 5 for different levels of budget to observe network conditions for CRS, IRI, rutting, and rehabilitation. The analysis is performed for four different levels of budget: 1) High Budget - 75 million 2) Medium Budget - 50 million 3) Low Budget - 25 million and 4) Zero Budget. The impact of trigger values on the state of the network is also analyzed. Default values of parameters are used as inputs to “Edit Parameters.” Traffic function and growth rates are simple and 2%, respectively. A 10-year analysis period with the base year as 2002 is used. For CRS, IRI, and rutting, the latest year is 2000 and for ADT it is 1999, based on data provided by the IDOT. Benefit backlog parameters used for CRS, IRI, and rutting are 5.7925, 188.256, and 0.2896, respectively. The same backlog parameters are used for AC and PCC pavements. The parameters were calculated as explained in chapter 5. The default parameters for Interstate and Other Marked routes for decision trees are shown in Figure 13 and Figure 14, respectively.

Impact of Different Levels of Budget on the State of the Network

Different budgets are used to analyze the state of the network for weighted average values of CRS, IRI, and rutting, calculated using Equation 1. The length of different types of rehabilitation (in miles) is also calculated for Interstate highways and Other Marked routes.

High Budget - 75 million

Using a budget of $75 million causes significant improvement in the condition of District 5, which can be observed in Figure 40 and Figure 41. CRS in Figure 40 shows significant improvement and an increase to around 8.1 for the last 7 years of the analysis. Similarly, IRI shows a significant decrease to around 72 in/mile for the last 7 years. Rutting decreases, then increases, then stabilizes around 0.3 in. Rutting is high since the number of asphalt surfacing increases because of overlays on deteriorated pavements. This can also be observed in Table 7 which shows the number of lane miles for different types of rehabilitation. For marked routes, greater use is made of the 1-1/2 in overlay. Similarly, for Interstate routes, greater use is made of the 3-3/4 in overlay. This shows that the WBRP provides for a thinner overlay, which shows that the technique prevents deterioration of the network at an early stage.

Table 8 shows the amount spent for various levels of budget. For a high budget, total amount spent is around $564 million out of a total of 750 million that were available, which shows a saving of around $186 million. Compared to a budget allocation of $50 million a year, $64 million of additional funding was spent; however, the network conditions were much better with an average weighted CRS of around 8.1.
Figure 40. Weighted average CRS and IRI for the 10 years of analysis using different budgets.

Medium Budget - 50 million

Using a medium budget of $50 million/yr, CRS and IRI in Figure 40 show continuous improvement of the network. CRS improved from 6 to 8 in 10 years. Similarly, IRI improved from around 120 in/mile to 72 in/mile. Hence, a budget of $50 million proves to be adequate for the network. It can be observed in Table 8 that most of the budget was spent every year.

Figure 41. Weighted average rutting for the 10 years of analysis, using different budgets.

Table 9 shows the usage of different types of overlays used on Interstate and Other Marked routes. Figure 42 shows the comparison of different types of rehabilitation by miles for several years. Overlays of 1-1/2 in and 3-3/4 in are selected most often for rehabilitation, which shows that the WBRP prevents the network from deteriorating to an extent that a higher portion of thicker overlays are required. This can also be observed from the decision tree, as sections with a CRS value equal to and greater than 5.2 were rehabilitated with thinner overlays. The user can change the input from 5.2 to a higher value to select lesser number of thinner overlays, whereas using a lower value of CRS can increase the number of thinner overlays.
Table 7. Rehabilitation length (miles) for a $75 million/year budget.

<table>
<thead>
<tr>
<th>Year</th>
<th>1-1/2 in OL</th>
<th>2-1/4 in OL</th>
<th>3-1/4 in OL</th>
<th>3-3/4 in OL</th>
<th>5 in OL</th>
<th>Recons.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>52.05</td>
<td>24.53</td>
<td>19.03</td>
<td>229.11</td>
<td>205.08</td>
<td>137.04</td>
</tr>
<tr>
<td>2004</td>
<td>232.33</td>
<td>44.22</td>
<td>44.22</td>
<td>645.94</td>
<td>--</td>
<td>46.28</td>
</tr>
<tr>
<td>2005</td>
<td>368.46</td>
<td>254.43</td>
<td>254.43</td>
<td>289.27</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2006</td>
<td>580.20</td>
<td>232.25</td>
<td>232.25</td>
<td>232.25</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2007</td>
<td>399.72</td>
<td>--</td>
<td>--</td>
<td>0.12</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2008</td>
<td>169.66</td>
<td>--</td>
<td>--</td>
<td>335.76</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2009</td>
<td>365.91</td>
<td>--</td>
<td>--</td>
<td>368.60</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2010</td>
<td>637.51</td>
<td>--</td>
<td>--</td>
<td>271.08</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2011</td>
<td>940.80</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2012</td>
<td>616.29</td>
<td>--</td>
<td>--</td>
<td>4.32</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>4,362.93</td>
<td>555.43</td>
<td>549.93</td>
<td>2,376.45</td>
<td>205.08</td>
<td>183.32</td>
</tr>
</tbody>
</table>

Table 8. Amount not spent and spent every year.

<table>
<thead>
<tr>
<th>Year</th>
<th>Not spent (25M)</th>
<th>Spent (25 M)</th>
<th>Not spent (50 M)</th>
<th>Spent (50 M)</th>
<th>Not spent (75 M)</th>
<th>Spent (75 M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>85.3</td>
<td>24,999,914.7</td>
<td>145.1</td>
<td>49,999,854.9</td>
<td>86.5</td>
<td>74,999,913.5</td>
</tr>
<tr>
<td>2004</td>
<td>551.9</td>
<td>24,999,448.2</td>
<td>89.7</td>
<td>49,999,910.3</td>
<td>1,003.1</td>
<td>74,998,996.9</td>
</tr>
<tr>
<td>2005</td>
<td>112.9</td>
<td>24,999,887.2</td>
<td>116.0</td>
<td>49,999,884.0</td>
<td>997.9</td>
<td>74,999,002.2</td>
</tr>
<tr>
<td>2006</td>
<td>7.8</td>
<td>24,999,992.2</td>
<td>604.7</td>
<td>49,999,395.4</td>
<td>189.3</td>
<td>74,998,810.8</td>
</tr>
<tr>
<td>2007</td>
<td>299.9</td>
<td>24,999,700.1</td>
<td>245.0</td>
<td>49,999,755.0</td>
<td>52,307,942.1</td>
<td>22,692,057.9</td>
</tr>
<tr>
<td>2008</td>
<td>582.9</td>
<td>24,999,417.1</td>
<td>658.0</td>
<td>49,999,342.0</td>
<td>37,506,130.0</td>
<td>74,993,870.0</td>
</tr>
<tr>
<td>2009</td>
<td>373.6</td>
<td>24,999,626.4</td>
<td>657.4</td>
<td>49,999,342.7</td>
<td>31,675,043.3</td>
<td>43,324,956.7</td>
</tr>
<tr>
<td>2010</td>
<td>598.6</td>
<td>24,999,401.4</td>
<td>38.0</td>
<td>49,999,962.0</td>
<td>16,958,590.6</td>
<td>58,041,409.4</td>
</tr>
<tr>
<td>2011</td>
<td>778.2</td>
<td>24,999,221.8</td>
<td>604.5</td>
<td>49,999,395.6</td>
<td>9,359,325.6</td>
<td>65,640,674.4</td>
</tr>
<tr>
<td>2012</td>
<td>1,047.1</td>
<td>24,998,952.9</td>
<td>402.2</td>
<td>49,999,597.8</td>
<td>37,921,126.1</td>
<td>37,078,873.9</td>
</tr>
<tr>
<td>Total</td>
<td>4,438.0</td>
<td>249,995,562.0</td>
<td>3,560.5</td>
<td>499,996,439.6</td>
<td>185,730,434.4</td>
<td>564,269,565.6</td>
</tr>
</tbody>
</table>

Table 9. Rehabilitation length (miles) for a $50 million/year budget.

<table>
<thead>
<tr>
<th>Year</th>
<th>1-1/2 in OL</th>
<th>2-1/4 in OL</th>
<th>3-1/4 in OL</th>
<th>3-3/4 in OL</th>
<th>5 in OL</th>
<th>Recons.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>26.89</td>
<td>20.57</td>
<td>15.07</td>
<td>128.03</td>
<td>160.68</td>
<td>88.36</td>
</tr>
<tr>
<td>2004</td>
<td>94.34</td>
<td>26.40</td>
<td>26.40</td>
<td>223.04</td>
<td>10.68</td>
<td>93.08</td>
</tr>
<tr>
<td>2005</td>
<td>101.16</td>
<td>24.40</td>
<td>18.52</td>
<td>416.36</td>
<td>13.72</td>
<td>46.28</td>
</tr>
<tr>
<td>2006</td>
<td>128.87</td>
<td>89.09</td>
<td>89.09</td>
<td>228.29</td>
<td>4.08</td>
<td>--</td>
</tr>
<tr>
<td>2007</td>
<td>88.22</td>
<td>33.90</td>
<td>33.90</td>
<td>34.02</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2008</td>
<td>72.36</td>
<td>--</td>
<td>--</td>
<td>194.24</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2009</td>
<td>116.28</td>
<td>63.74</td>
<td>63.74</td>
<td>263.50</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2010</td>
<td>276.88</td>
<td>0.44</td>
<td>0.44</td>
<td>347.16</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2011</td>
<td>566.64</td>
<td>13.42</td>
<td>13.42</td>
<td>203.74</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2012</td>
<td>704.18</td>
<td>--</td>
<td>--</td>
<td>0.12</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>2,175.82</td>
<td>271.96</td>
<td>260.58</td>
<td>2,038.50</td>
<td>189.16</td>
<td>227.72</td>
</tr>
</tbody>
</table>
Figure 42. Comparison of type of rehabilitation by miles for medium budget.

Low Budget - 25 million

Using a low budget of $25 million/yr, CRS and IRI in Figure 40 show slight deterioration of the network. CRS decreased from above 6 to below 6 in 10 years. Similarly, IRI increased from below 120 in/mile to around 130 in/mile. Rutting increased significantly to around 0.5 (from less than 0.2). Hence, a budget of $25 million proves to be inadequate for the network. Table 8 also shows that most of the budget was spent every year. The level of budget chosen for this example shows a significant cut in budget for the district analyzed.

Table 10 indicates the deterioration of the network since a high total value of reconstruction lane miles can be found for Interstate routes. Similarly, for Other Marked routes, thicker overlays were required compared to thinner overlays (1-1/2in). This can be observed from the pie charts in Figure 43, which shows the percentage length of different types of rehabilitation for the analysis period.

Charts in ArcView are dynamic, which means that rows in tables can be selected (highlighted in magenta) and the chart manipulated to show only selected years. Deselecting the rows return the charts to the original display. This can be seen in Figure 42, in which years from 2003 to 2008 are displayed.

Table 10. Rehabilitation length (miles) for a $25 million/year budget.

<table>
<thead>
<tr>
<th>Year</th>
<th>1-1/2 in OL</th>
<th>2-1/4 in OL</th>
<th>3-1/4 in OL</th>
<th>3-3/4 in OL</th>
<th>5 in OL</th>
<th>Recons.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>13.83</td>
<td>18.47</td>
<td>12.97</td>
<td>62.09</td>
<td>87.32</td>
<td>43.20</td>
</tr>
<tr>
<td>2004</td>
<td>9.48</td>
<td>2.52</td>
<td>2.52</td>
<td>51.92</td>
<td>--</td>
<td>83.64</td>
</tr>
<tr>
<td>2005</td>
<td>6.26</td>
<td>31.06</td>
<td>31.06</td>
<td>126.62</td>
<td>28.32</td>
<td>36.28</td>
</tr>
<tr>
<td>2006</td>
<td>2.38</td>
<td>8.38</td>
<td>7.86</td>
<td>45.30</td>
<td>--</td>
<td>67.32</td>
</tr>
<tr>
<td>2007</td>
<td>9.48</td>
<td>2.66</td>
<td>5.20</td>
<td>19.52</td>
<td>51.24</td>
<td>53.88</td>
</tr>
<tr>
<td>2008</td>
<td>14.24</td>
<td>1.64</td>
<td>19.00</td>
<td>105.36</td>
<td>36.36</td>
<td>28.84</td>
</tr>
<tr>
<td>2009</td>
<td>34.04</td>
<td>1.28</td>
<td>2.12</td>
<td>3.12</td>
<td>2.48</td>
<td>91.96</td>
</tr>
<tr>
<td>2010</td>
<td>0.51</td>
<td>0.52</td>
<td>0.88</td>
<td>137.08</td>
<td>--</td>
<td>55.08</td>
</tr>
<tr>
<td>2011</td>
<td>32.06</td>
<td>1.72</td>
<td>3.20</td>
<td>119.64</td>
<td>--</td>
<td>25.84</td>
</tr>
<tr>
<td>2012</td>
<td>6.86</td>
<td>4.40</td>
<td>--</td>
<td>46.36</td>
<td>--</td>
<td>58.84</td>
</tr>
<tr>
<td>Total</td>
<td>129.14</td>
<td>72.65</td>
<td>84.81</td>
<td>717.01</td>
<td>205.72</td>
<td>544.88</td>
</tr>
</tbody>
</table>
Zero Budget

Since no rehabilitation is performed for the network under zero budget, network deterioration rate for CRS and IRI can be observed in Figure 40. Average weighted CRS for the network decreases from a "Good" condition to a "Poor" condition. Similarly, IRI increases from below 120 in/mile to more than 170 in/mile, which shows considerable deterioration in the state of the network. Since rutting increased appreciably during high levels of budget, during zero budget it increases to an unacceptably high average value of more than 0.6 in.

![Pie charts for low budget, showing percentage length of different types of rehabilitation.](image)

Figure 43. Pie charts for low budget, showing percentage length of different types of rehabilitation.

Impact of Trigger Values on the State of the Network

This section shows the impact of trigger values on the state of the network. The network is evaluated in terms of average weighted values of CRS, IRI, rutting, and percentage miles of highway rehabilitation. The objective is to present how different analyses can be carried out using the program.

The base year for the analysis is selected as 2000, and the network will be predicted from 2001 to 2007. The latest values available for CRS, IRI, and rutting were from 2000, and for AADT they were from 1999. A budget of $50 million/yr and benefit backlog parameters as used in the above analysis are used. Traffic parameters also remain the same as used in the above analysis.

Default Decision Tree Values

Table 11 shows the impact on the network using default values from the submenus in the “Edit Parameters” menu. CRS and IRI show improvement to the network. Rutting first shows an increase in the network for the first 3 years of the analysis and then decreases to almost the starting value in year 2007.
This also shows improvement in the overall network as the number of asphalt overlays increases for the network. Overall, the network shows improvement.

### Table 11. State of network using default values.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRS</td>
<td>6.9</td>
<td>7.1</td>
<td>7.4</td>
<td>7.7</td>
<td>8.0</td>
<td>8.2</td>
<td>8.2</td>
<td>8.2</td>
<td>7.7</td>
</tr>
<tr>
<td>IRI in/mile</td>
<td>104</td>
<td>94</td>
<td>88</td>
<td>84</td>
<td>79</td>
<td>74</td>
<td>73</td>
<td>72</td>
<td>84</td>
</tr>
<tr>
<td>Rutting in</td>
<td>0.12</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.14</td>
<td>0.13</td>
<td>0.13</td>
<td>0.14</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Table 12 shows the percentage length of pavement rehabilitation performed using the default decision variables. The program also provides a bar and pie chart for rehabilitation by miles and percentage length, as shown in Figure 42 and Figure 43, which can be accessed using “Predicted Rehabilitation Summary” under the “District Rehab Program” menu. Table 12 also shows that no thick overlays or reconstruction was required on the network.

### Table 12. Percentage length (miles) of pavement rehabilitation.

<table>
<thead>
<tr>
<th>Year</th>
<th>Combined</th>
<th>Other Marked Routes</th>
<th>Interstate Routes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loc. Rep</td>
<td>1-1/2in</td>
<td>2-1/4in</td>
</tr>
<tr>
<td>2001</td>
<td>--</td>
<td>16.93</td>
<td>14.33</td>
</tr>
<tr>
<td>2002</td>
<td>--</td>
<td>38.90</td>
<td>11.68</td>
</tr>
<tr>
<td>2003</td>
<td>--</td>
<td>53.23</td>
<td>4.71</td>
</tr>
<tr>
<td>2004</td>
<td>--</td>
<td>63.40</td>
<td>10.97</td>
</tr>
<tr>
<td>2005</td>
<td>--</td>
<td>76.29</td>
<td>3.79</td>
</tr>
<tr>
<td>2006</td>
<td>--</td>
<td>46.75</td>
<td>--</td>
</tr>
<tr>
<td>2007</td>
<td>--</td>
<td>55.78</td>
<td>--</td>
</tr>
</tbody>
</table>

**Decision Tree to Restrict Reconstruction as a Rehabilitation Alternative**

Decision tree variables were selected, such that reconstruction will not be used on Interstate routes and 3-1/4 inch overlay will not be used on Other Marked routes. The decision tree for Interstate routes is shown in Figure 44, and the decision tree for Other Marked routes is shown in Figure 45. The decision tree makes sure that for Interstate routes having CRS values greater than and equal to 5.7, 3-3/4 in overlay is used and for CRS greater than or equal to 1.0, but less than 5.7, a 5 in AC overlay is selected for rehabilitation. This type of decision tree blocks use of “reconstruction” as an alternative. Similarly, the decision tree in Figure 45 avoids used of 3-1/4 in AC overlay on Other Marked routes. This example shows how the decision tree can be used effectively to select the type of rehabilitation on the network. The state of the network is shown in Table 13, and the percentage of miles of different pavement rehabilitation alternatives is shown in Table 14.
Figure 44. Decision tree for Interstate routes to restrict use of reconstruction.

Figure 45. Decision tree for Other Marked routes to restrict use of 3-1/4 in AC overlay.

Table 13. State of network for restricted rehabilitation alternatives.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRS</td>
<td>6.9</td>
<td>7.0</td>
<td>7.3</td>
<td>7.6</td>
<td>7.8</td>
<td>8.1</td>
<td>8.1</td>
<td>8.2</td>
<td>7.6</td>
</tr>
<tr>
<td>IRI in/mile</td>
<td>104</td>
<td>96</td>
<td>90</td>
<td>86</td>
<td>82</td>
<td>77</td>
<td>74</td>
<td>73</td>
<td>85</td>
</tr>
<tr>
<td>Rutting (in)</td>
<td>0.12</td>
<td>0.15</td>
<td>0.16</td>
<td>0.16</td>
<td>0.16</td>
<td>0.15</td>
<td>0.14</td>
<td>0.14</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Table 14. Percentage length (miles) of pavement rehabilitation for restricted rehabilitation alternatives.

<table>
<thead>
<tr>
<th>Year</th>
<th>Loc. Rep</th>
<th>1-1/2in</th>
<th>2-1/4in</th>
<th>3-1/4in</th>
<th>3-3/4in</th>
<th>5in</th>
<th>Reconst.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>--</td>
<td>8.35</td>
<td>23.82</td>
<td>--</td>
<td>32.40</td>
<td>35.42</td>
<td>--</td>
</tr>
<tr>
<td>2002</td>
<td>--</td>
<td>16.60</td>
<td>37.83</td>
<td>--</td>
<td>40.43</td>
<td>5.14</td>
<td>--</td>
</tr>
<tr>
<td>2003</td>
<td>--</td>
<td>16.98</td>
<td>55.93</td>
<td>--</td>
<td>27.09</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2004</td>
<td>--</td>
<td>13.88</td>
<td>64.71</td>
<td>--</td>
<td>21.41</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2005</td>
<td>--</td>
<td>44.07</td>
<td>42.38</td>
<td>--</td>
<td>13.56</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2006</td>
<td>--</td>
<td>55.75</td>
<td>0.31</td>
<td>--</td>
<td>43.93</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2007</td>
<td>--</td>
<td>45.84</td>
<td>--</td>
<td>--</td>
<td>54.16</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Decision Tree to Avoid Rehabilitation of Sections with CRS ≥ User Defined Value

The decision tree variables shown in Figure 46 and Figure 47 were used to avoid rehabilitation of the network above a defined CRS value. For the Interstate route, a section with CRS ≥ 6.1 was rehabilitated with dummy patching. Similarly, sections in Other Marked routes having CRS ≥ 5.6 were rehabilitated with dummy patching. The cost used for patching was zero, and the effect of dummy patching was minimal, as can be observed in Figure 48.

This scheme minimizes the use of most rehabilitation alternatives, as shown in Table 15. Localized repair is selected, but the cost and its effect are not existent on the network. The state of the network is presented in Table 16.

![Rehabilitation Decision Variables](image)

Figure 46. Decision tree for Interstate routes.
Figure 47. Decision tree for Other Marked routes.

Figure 48. Rehabilitation effect variables to avoid rehabilitation above a specified CRS value.
Table 15. Percentage length (miles) of pavement rehabilitation when rehabilitation is avoided above a specified CRS value.

<table>
<thead>
<tr>
<th>Year</th>
<th>Loc. Rep</th>
<th>1-1/2in</th>
<th>2-1/4in</th>
<th>3-1/4in</th>
<th>3-3/4in</th>
<th>5in</th>
<th>Reconst.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>66.94</td>
<td>12.01</td>
<td>1.00</td>
<td>--</td>
<td>20.05</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2002</td>
<td>37.16</td>
<td>38.12</td>
<td>--</td>
<td>--</td>
<td>24.72</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2003</td>
<td>32.9</td>
<td>55.76</td>
<td>--</td>
<td>--</td>
<td>11.34</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2004</td>
<td>23.58</td>
<td>62.2</td>
<td>--</td>
<td>--</td>
<td>14.22</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2005</td>
<td>30.12</td>
<td>49.45</td>
<td>--</td>
<td>--</td>
<td>20.43</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2006</td>
<td>67.53</td>
<td>26.79</td>
<td>--</td>
<td>--</td>
<td>5.67</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2007</td>
<td>15.33</td>
<td>27.76</td>
<td>--</td>
<td>--</td>
<td>56.92</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 16. State of the network when rehabilitation is avoided above a specified CRS value.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRS</td>
<td>6.9</td>
<td>7.2</td>
<td>7.6</td>
<td>7.9</td>
<td>8.2</td>
<td>8.1</td>
<td>8.0</td>
<td>8.0</td>
<td>7.7</td>
</tr>
<tr>
<td>IRI in/mile</td>
<td>104</td>
<td>92</td>
<td>84</td>
<td>78</td>
<td>74</td>
<td>74</td>
<td>76</td>
<td>76</td>
<td>82</td>
</tr>
<tr>
<td>Rutting (in)</td>
<td>0.12</td>
<td>0.13</td>
<td>0.13</td>
<td>0.12</td>
<td>0.12</td>
<td>0.13</td>
<td>0.15</td>
<td>0.17</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Summary

GIS-ILLINET is a powerful software package that can provide IDOT District and central office staff the tools needed to manage the highway pavements in their districts. It can also be used to manage the entire Interstate highway system. This program is built upon the original version of ILLINET but incorporates the full GIS capabilities of ArcView 3.2. GIS-ILLINET has many capabilities, but it is essentially a tool for use for managing the IDOT highway pavement network into the future.

The program provides various tools to analyze the state of the network using different strategies for rehabilitation. Sensitivity analysis can also be carried for the selected strategies. The applications presented show the usage of the program for a district engineer to manage the network to meet the policies of IDOT. The program is easy to use and learn, and it requires only a short time to run different types of analysis. Using the program effectively can increase the efficiency of staff members involved in managing Illinois's highway network.