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RUTGERS PAVEMENT RESOURCE CENTER

OVERHAUL PAVEMENT MANAGEMENT SYSTEM

January 2011

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Abstract

The primary objective of the 2006 RPRC program is to utilize the extensive laboratory and field pavement testing equipment and staff expertise of the Rutgers Pavement Resource Center to assist the New Jersey Department of Transportation (NJDOT) in developing a pavement program that optimizes network condition with available capital resources. The primary goals of this project include the enhancement of the NJDOT's Pavement Management System and ongoing support for implementation of Mechanistic-Empirical Pavement Design Guide (MEPDG) as needed to support the Department's $280 million FY07 pavement investment. The condition of New Jersey's pavement has declined steadily over the past decade as available resources have been consumed by other needs. The significant backlog of pavement maintenance has resulted in significant increase in vehicle operating costs to NJ motorists, reportedly twice the national average. A new approach to pavement management utilizing leading edge technology is needed to help restore New Jersey's highway infrastructure to a state of good repair with available resources. The Rutgers Pavement Resource Center is an extension of the NJDOT Pavement Technology Unit and functions as the primary research and technology arm. It is organized to rapidly respond to the Department's need for implementation of advanced pavement engineering and asset management technologies. The products identified in this proposal will include asset management tools, database design, data processing and data storage systems, material testing and evaluation, validation and implementation of new technologies, methodologies and materials. The program will work closely with NJDOT staff and its consultants to fulfill its mission.

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EXECUTIVE SUMMARY

The primary objective of the 2006 RPRC program was to use the extensive laboratory and field pavement testing equipment and staff expertise of the Rutgers Pavement Resource Center to assist the New Jersey Department of Transportation (NJDOT) in developing a pavement program that would optimize the network condition with available capital resources. The primary goals of the project were the enhancement of the NJDOT's Pavement Management System and to support for implementation of Mechanistic-Empirical Pavement Design Guide as needed to support the Department's $280 million FY07 pavement investment.

The condition of New Jersey's pavement has declined steadily over the past decade as available resources have been consumed by other needs. The significant backlog of pavement maintenance resulted in an increase in vehicle operating costs to NJ motorists – reportedly twice the national average. A new approach to pavement management using leading edge technology was needed to help restore New Jersey's highway infrastructure to a state of good repair through its available resources.

The Rutgers Pavement Resource Center (RPRC) served as an extension of the NJDOT's Pavement Technology Unit and functioned as the primary research and technology arm. It was organized to rapidly respond to the Department's need for implementation of advanced pavement engineering and asset management technologies. The goal of the program was to provide asset management tools, database design, data processing and data storage systems, material testing and evaluation, and the validation and implementation of new technologies, methodologies and materials. The program worked closely with NJDOT staff and its consultants to fulfill its mission.

INTRODUCTION

The Rutgers Pavement Resource Center (RPRC) and the New Jersey Department of Transportation (NJDOT) developed a list of deliverables and services that would be both research based and implementable for the New Jersey Department of Transportation.

The detailed descriptions of the services provided under laboratory and field categories are described in the following sections.

INFORMATION TECHNOLOGY AND OVERHAUL OF PAVEMENT MANAGEMENT SYSTEM

Background

Pavement condition data enables the NJDOT's Pavement Technology Unit to achieve its task of developing multi-year pavement programs and reporting annually to the Governor and Legislature on the status of pavements on the state highway system. The equipment is also utilized to precisely measure the profile of new pavement surfaces for ride quality assurance. Recent technological advancements in the equipment have generated enormous volumes of data that requires processing, analysis and storage utilizing various proprietary software packages. A comprehensive analysis of the proprietary software and the related databases was required to improve data processing and loading time. In addition, the Department desired the ability to store and access the PMS data and digital images from generic PC based workstations rather than expensive proprietary workstations.

Pavement Management is charged with the annual collection and analysis of pavement information, development of pavement programs and reporting the current condition of New Jersey's highway network. Each data collection cycle generates three terabytes of data to be analyzed and stored. The volume of data and the complexity of the system lead to difficulty in storing, sorting and analyzing the data. The Pavement Management Unit requires robust asset management software with complete documentation. Changes in pavement management strategies, treatments, costs and data collection methods and equipment require periodic software updating and New Jersey's current software has reached an stage where overhaul is required to meet current objectives. A significant cost savings would be realized if the Department adopted a comprehensively documented software application that could be operated with minimal consultant support. It is planned that Rutgers University would assist in the development and provide support and a knowledge base. The Deighton Associates "dTIMS" asset management software is the most widely utilized and thoroughly documented Pavement Management software available. At the beginning of this project, only New Jersey and New York were not currently using dTIMS in the Northeast.

Understanding pavement management systems and related asset management software is of primary interest to the Pavement Management Unit. Using notable field experts is one method that presents a better understanding of pavement management systems.

Work Performed

Early in the process in the summer of 2007, the PRP team performed a migration of the Deighton dTIMS Pavement Management software from Stantec's HPMA software. The process was time intensive and provided a unique opportunity for the PRP team. They initiated a special training session with members of the Deighton team, which provided a quick tutorial on the system and capabilities, but also provided contacts of other state agencies who were currently using the same PMS software.

The fourth quarter of 2007 brought new challenges as the PRP continued to provide Deighton with data models, and assistance in facilitating the transition from HPMA. The PRP developed models to replace the current Surface Distress Index (SDI) model with enhanced models to represent load associated distress and rutting into a new Load Related Distress Index (LDI) index and more traditional distresses into a Non-load associated Distress Index (NDI) index. The work also saw the PRP develop a new SDIm to combine NDI and LDI into a combined index for the new Dighton Asset Management System. The documentation for the development of the models was delivered to the NJDOT.

In 2008, the PRP team continued to work with Deighton to provide them with the appropriate data, models, and assistance in facilitating the transition from HPMA. The bridge structure data from the NJDOT Bridge Maintenance System (BMS) was introduced and sent to Deighton. The PRP developed models to replace the current default prediction models for the IRI and SDI – based upon NJDOT and SHRP LTPP program data. The documentation was prepared and delivered to the NJDOT. (Appendix A)

The second half of 2008 was busy for the PRP team as it continued to work with Deighton by providing data, models, and assistance in facilitating the transition from HPMA. In addition, the PRP was able to perform some budget scenarios at the request of CIS. Late in the year, Deighton delivered its draft of the dTIMS CT PMS for NJDOT and provided training to NJDOT staff.

In 2009, the PRP was able to spend a significant amount of time evaluating the Deighton CT software and identifying areas that needed further information and instruction from the Deighton support staff. All of this work was performed as an extension of the NJDOT itself. Part of the process included delivering more timely data and information so that the information being run through the appropriate models would provide relevant information. Committed projects for the 2008-2009 construction seasons were provided for additional analysis runs. By the end of 2009, the Deighton dTIMS CT software was developed and implemented. Further refinements continued to be conducted under the original 2008 PRP task order.

DEVELOPMENT OF A TRACKING SYSTEM TO MONITOR PAVEMENT NETWORK STATUS

Background

The task involved the development of a software application that would mine and track pavement-related items primarily from existing databases within the NJDOT. The NJDOT has an enormous amount of pavement-related sources of information that reside in various formal and informal databases. The Pavement Tracking System will use the information from the various databases to report information regarding the status of state owned pavements. This will provide the Department with information that can provide information such as:

- Real time status of pavement projects.
- Initial project cost compared to as-built construction cost.
- Costs benefit ratios for the various pavement treatments, strategies and projects.
- Database of completed pavement projects
    - Construction Type (resurfacing, rehabilitation, reconstruction)
    - Material Designation and Thickness (polymer, OGFC, etc.)
    - Design Parameters (traffic, subgrade classification)
    - Material Supplier and Contractor
    - Initial Ride Quality Reported in IRI

Work Performed

The development of a Project Tracking System was initiated in the winter of 2008 through the development of a partnership between the Pavement Resource Program and Advanced Infrastructure and Design (AID). The team held a series of meetings throughout the department to begin the identification of all the databases currently being used throughout. Meetings were called with groups such as the Pavement and Drainage Management Unit, Maintenance & Operations, and Capital Projects Management.

The PRP/AID team worked diligently with the Pavement and Drainage Management Unit staff to develop the database field summary and the process of selection from the PMS needs selection to the final pavement paving project list. Over several meetings, the PRP/AID team began to develop the prototype conflict detection and tracking system. The final database for the tracking system was eventually coded and at the end of 2009, the final Project Tracking System software and User Manual were delivered to the NJDOT. (Appendix B)

NJDOT RIDE QUALITY SPECIFICATION AND DEVELOPING A DRAFT RIDE QUALITY SPECIFICATION

Background

The condition of New Jersey's pavement investment has declined steadily over the past decade as available resources have been committed to other needs. The significant backlog of pavement maintenance has resulted in significant vehicle operating costs to NJ motorists, reportedly twice the national average. A fresh approach to pavement management utilizing the latest technology is needed to help restore New Jersey's highway infrastructure to a state of good repair with limited available resources. The Rutgers Pavement Resource Center is an extension of the NJDOT Pavement Technology Unit and functions as the primary research and technology arm

One way to measure the quality of a road's performance is through a ride quality or smoothness specification measured through the International Roughness Index (IRI). The NJDOT wanted to join with it neighboring states by developing and instituting a smoothness specification that contractors would have to meet in order to be paid in full. The PRP team was tasked with this challenge in the middle of 2008.

Work Performed

The PRP and Advanced Infrastructure & Design (AID) worked together to perform this task. The work began with a thorough literature search that included a review of all the state specifications already implemented throughout the country. The task required that the team developed a specification for both roadways and bridges. In the Spring of 2009, the team delivered an interim ride quality specification to the NJDOT and continued to develop on for bridge surfaces. Eventually, a specification for bridge surfaces was also delivered to the NJDOT for review. (Appendix C)

TECHNICAL SUPPORT FOR THE MECHANISTIC-EMPIRICAL PAVEMENT DESIGN GUIDE (MEPDG)

Background

The currently used 1993 AASHTO Design Guide uses statistical regressions based on test track studies conducted in the late 1950's to early 1960's. Pavement layer thicknesses were determined as a function of structural coefficients for different materials, pavement types, and ESAL's. However, it is well known among pavement design professionals that these concepts are outdated and do not represent the type of loading and traffic volumes carried by today's pavements.

At the time, the recently released Mechanistic-Empirical Pavement Design Guide (MEPDG) was a comprehensive methodology for designing pavement structures utilizing material stresses and strains and advanced climatic models. However, most pavement and traffic engineers are not familiar with the required material and traffic input parameters. Issues with material and traffic inputs, along with the need to recalibrate global model parameters and distress predictions to represent regional/state specific conditions, will discourage implementation of the design guide on an already overburdened pavement designer's workload.

Work Performed

Throughout this project, the PRP remained at the forefront of developing inputs and models for the MEPDG. They also performed a good deal of preparation work and the development of the materials database for the MEPDG. To support these activities, the PRP also collected and analyze Ground Penetrating Radar (GPR) data to be incorporated into the database.

In the Fall of 2009, the PRP and NJDOT staff presented a Pavement Training Course for CPM and Operations staff members. Additional training has been held as needed.

DEVELOP AND PROVIDE TRAINING FOR "INPUTS TO THE MEPDG"

Background

The FHWA's Design Guide Implementation Team (DGIT) has designed a two day training course to help teach state agencies the concepts, testing methods, and analysis needed to provide the necessary inputs for the MEPDG. Unfortunately, the courses will only be held a total of five times next year, with the closest two locations being either in Connecticut or Virginia. RAPL has arranged to have the DGIT provide the training materials so NJDOT can have a staff training session in New Jersey allowing a greater number of NJDOT personnel and design consultants to attend. The course encompasses the testing and analysis of unbound, bituminous, and PCC materials. The course is also set up to provide computer time to show the engineers how to properly input the parameters. Tentatively, the course is scheduled to occur over Rutgers University's spring break so as to allow for the use of the larger computer labs. After the initial class, it is anticipated that another will be held for NJDOT highway design consultants. RAPL will also provide training to the NJDOT, other state agencies in NJ and NJ design consultants once or twice times a year to refresh and update after the initial workshops. It is hopeful that NJDOT will eventually approve the course as a NJDOT certification-type course that all pavement design consultants must take. The actual determination of the material inputs will also be conducted in two main phases: 1) developing a material database library and 2) determined on an as needed basis. The benefit of the NJDOT having a material database library is that new pavement designs determined from the MEPDG will be conducted using material properties of actual materials used in New Jersey, not default properties or properties based on empirical equations. The as-needed basis is essential to fine-tuning the mechanistic models. This encompasses testing all materials prior to the opening of the roadway to construction. The materials (asphalt, PCC, unbound materials) would be sampled directly from the site and compacted and reconstructed at RAPL in a manner that represents the in-situ condition of the roadway.

Work Performed

A Two-Day training course was provided to the NJDOT pertaining to traffic inputs for the Mechanistic Empirical Pavement Design Guide. The PRP and the FHWA resource Center developed a software intensive training course to encompass both quality data collection/analysis and how to input those parameters in the MEPDG for analysis. Approximately 10 participants from NJDOT, consultants, and members from Rutgers participated in the workshop.

CONCLUSION

The Pavement Resource Program at the Center for Advanced Infrastructure and Transportation at Rutgers University was pleased to participate as an extension and partner with the New Jersey Department of Transportation to perform a variety of tasks put before them.

APPENDIX A

Rutgers The State University of New Jersey

Center for Advanced Infrastructure and Transportation

Development of Enhanced Pavement Index Prediction Models

For:

State of New Jersey
Department of Transportation

Pavement & Drainage Management

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March 27, 2008

Overview

This report outlines analyses performed to develop enhanced pavement index prediction models for IRI and SDI for use in NJDOT PMS Budget Analyses as requested by the Pavement and Drainage Management Unit. The NJDOT HPMA uses default prediction models to predict the condition of the State highway network pavements to identify when a pavement will be in need of repair based on IRI or SDI condition parameters.

Pavement Index Prediction Models

The HPMA has different default IRI and SDI prediction models for various treatment activities on bituminous, composite and concrete pavements.

The sigmoidal model form used for predicting increasing IRI functions is shown in Equation [1].

$IRI = IRI_O + e(A - B*C^{\ln(Age)})$ Eq 1

Where:
IRI_O is the Index value at age zero (set to IRI of 70 inch per mile),
Age is the number of years since the last rehabilitation or construction activity, and
A, B, and C are the model coefficients.

Table 1 provides a summary of the IRI coefficient values for various treatments listed in the HPMA.

The sigmoidal model form used for predicting decreasing SDI functions is shown in Equation [2].

$SDI = SDI_O - e(A - B*C^{\ln(1/Age))}$ Eq 2

Where:
SDI_O is the Index value at age zero (set to SDI of 5.00),
Age is the number of years since the last rehabilitation or construction activity, and
A, B , and C are the model coefficients.

Table 2 provides a summary of the SDI coefficient values for various treatments listed in the HPMA. Figures 1 and 2 provide an illustration of the default prediction models for IRI and SDI for the Mill 2"/ Overlay 2" activity.

Table 1 Summary of default equation IRI coefficients for various treatment activities.

Bituminous:

activity	coef_a	coef_b	coef_c	coef_o
Mill 2"+Overlay 2"	13.959	13.596	0.844	70
Mill 2"+Overlay 4"	25.886	25.463	0.928	70

Overlay 2" over AC	18.949	20.153	0.847	90
Mill 2"+Overlay 6"	25.886	26.057	0.928	70
Mill 2"+J Repr+Ov 4"	25.886	25.463	0.928	70
Mill(2-4")+J Replace	25.886	25.463	0.928	70
Micro Surf(NovaChip)	18.949	18.379	0.847	90
Mill2+Ovly4(Poly.)	25.886	25.781	0.928	70
Partial Recon (BC)	13.209	18.065	0.755	70
Full Recon (BC)	13.209	18.557	0.755	60
Patching	18.949	20.153	0.847	90
4" Overlay over AC	18.949	20.685	0.847	70
6" Overlay over AC	18.949	21.694	0.847	70
Mill(3-4")Ovly(3-4")	25.886	25.463	0.928	70

Composite:

activity	coef_a	coef_b	coef_c	coef_o
Mill 2"+Overlay 2"	13.959	13.015	0.844	70
Mill 2"+Overlay 4"	25.886	25.086	0.928	70
Overlay 2" over AC	18.949	19.066	0.847	90
Mill 2"+Overlay 6"	25.886	25.781	0.928	70
Mill 2"+J Repr+Ov 4"	25.886	25.463	0.928	70
Mill(2-4")+J Replace	25.886	25.463	0.928	70
Micro Surf(NovaChip)	18.949	19.647	0.847	90
Mill2+Ovly4(Poly.)	25.886	25.463	0.928	70
Partial Recon (BC)	13.209	18.065	0.755	70
Full Recon (BC)	13.209	18.557	0.755	60
Patching	18.949	19.066	0.847	90
Rumble Strip	18.949	19.066	0.847	90
4" Overlay over AC	18.949	19.915	0.847	75
6" Overlay over AC	18.949	20.685	0.847	70
Mill(3-4")Ovly(3-4")	25.886	25.086	0.928	70

Concrete:

activity	coef_a	coef_b	coef_c	coef_o
Micro Surf(NovaChip)	18.949	19.647	0.847	90
Ovly2 over PCC (I)	13.959	13.325	0.844	90
Partial PCC Reconstr	13.209	16.862	0.755	90
Surface Texturing	13.209	16.435	0.755	70
Ovly4 over PCC (I)	25.886	25.781	0.928	70
Rubb. PCC + OV 10"	13.209	18.758	0.755	70
Patching	18.949	19.066	0.847	90

Table 2 Summary of default equation SDI coefficients for various treatment activities.

Bituminous:

activity	coef_a	coef_b	coef_c	coef_o
4" Overlay over AC	28.08	28.79	1.023	5
6" Overlay over AC	28.08	28.98	1.023	5
Full Recon (BC)	13.05	13.592	1.038	5
Micro Surf(NovaChip)	28.08	28.527	1.023	5
Mill 2"+J Repr+Ov 4"	13.05	13.35	1.038	5
Mill 2"+Overlay 2"	28.08	28.625	1.023	5
Mill 2"+Overlay 4"	28.08	28.79	1.023	5
Mill 2"+Overlay 6"	28.08	28.98	1.023	5
Mill(3-4")Ovly(3-4")	28.08	28.79	1.023	5
Mill2+Ovly4(Poly.)	28.08	28.923	1.023	5
Overlay 2" over AC	28.08	28.527	1.023	5
Partial Recon (BC)	13.05	13.509	1.038	5
Patching	13.05	13.408	1.038	5

Composite:

activity	coef_a	coef_b	coef_c	coef_o
Mill 2"+Overlay 2"	28.08	28.625	1.023	5
Mill 2"+Overlay 4"	28.08	28.79	1.023	5
Overlay 2" over AC	28.08	28.527	1.023	5
Mill 2"+Overlay 6"	28.08	28.98	1.023	5
Mill 2"+J Repr+Ov 4"	13.05	13.35	1.038	5
Mill(2-4")+J Replace	13.05	13.284	1.038	5
Micro Surf(NovaChip)	28.08	28.527	1.023	5
Mill2+Ovly4(Poly.)	28.08	28.923	1.023	5
Rubb. PCC + OV 10"	28.08	29.082	1.023	5
Partial Recon (BC)	13.05	13.509	1.038	5
Full Recon (BC)	13.05	13.592	1.038	5
Patching	13.05	13.408	1.038	5
4" Overlay over AC	28.08	28.79	1.023	5
6" Overlay over AC	28.08	28.98	1.023	5
Mill(3-4")Ovly(3-4")	28.08	28.86	1.023	5

Concrete:

activity	coef_a	coef_b	coef_c	coef_o
Micro Surf(NovaChip)	28.08	28.527	1.023	5
Ovly2 over PCC (I)	13.9	13.855	1.025	5
Partial PCC Reconstr	13.9	14.097	1.025	5
Ovly4 over PCC (I)	13.9	13.98	1.025	5
Rubb. PCC + OV 10"	28.08	29.082	1.023	5
Patching	13.05	13.408	1.038	5
PCC Construction	13.05	13.592	1.038	5

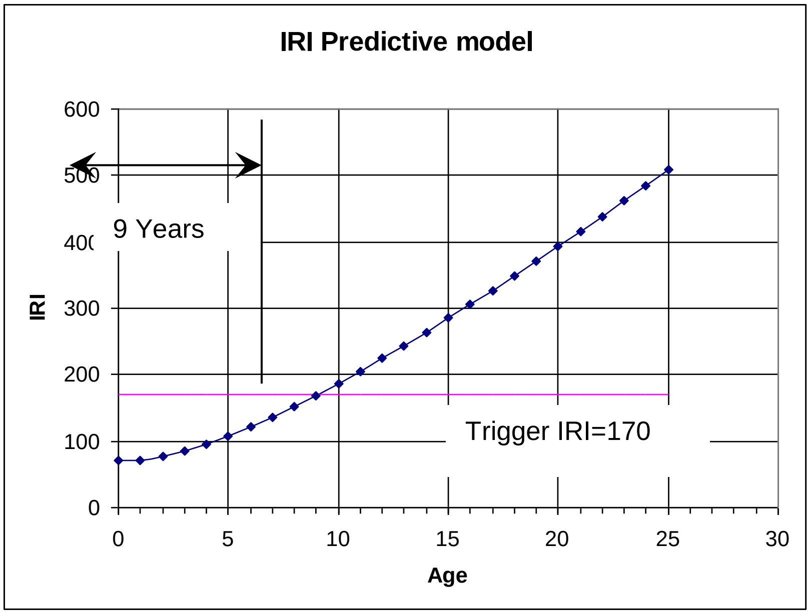


Figure 1 HPMA IRI Predictive Model for the Mill 2”/ Overlay 2” activity

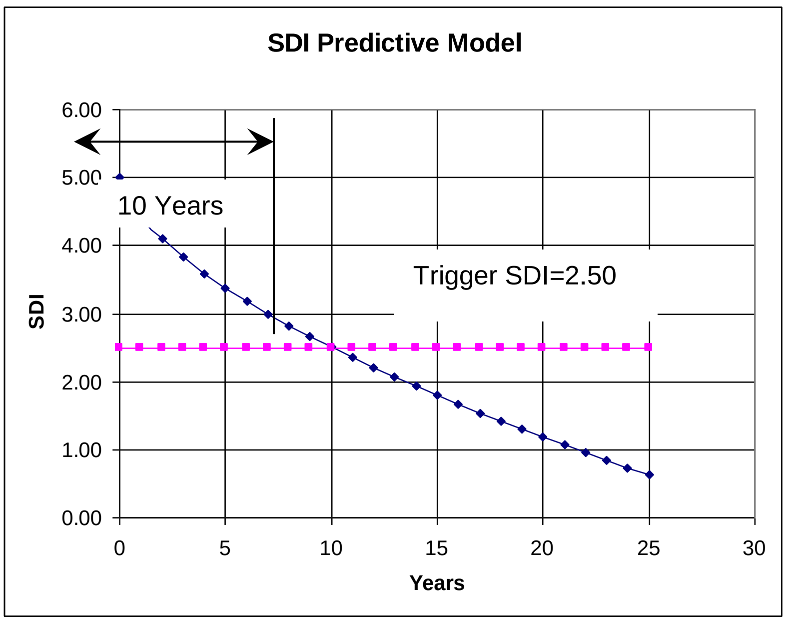


Figure 2 HPMA SDI Predictive Model for the Mill 2”/ Overlay 2” activity

These model coefficients were developed based on the best engineering judgment to estimate life of the treatment before it reached the trigger value. The analyses that follow evaluates these model coefficient based on actual pavement condition data collected by the NJDOT PMS group and SHRP LTPP contractor.

NJDOT Site Specific Model Development

To develop site specific models using NJDOT PMS data, the HPMA was used to identify construction projects completed in 1999. The 1999 construction year was used to maximize the number of IRI and SDI data points that could be used in the analyses. The IRI and SDI condition data for 2001-2002, 2002-2003, 2004, 2005 and 2006 was used to develop actual performance histories of the construction projects completed in 1999.

The 1999 construction projects were divided into groups according to the treatment activities:

Mill 2"+Overlay 2"
Mill 2"+Overlay 4"
4" Overlay over AC

Table 3 provides an example of one Mill 2"+Overlay 2" construction project identified

Table 3 Mill 2"+Overlay 2" construction project completed in 1999

Route type	Route number	Direction	Begin milepost	End milepost
US	1	S	14	14.1
US	1	S	14.1	14.12
US	1	S	14.12	14.7
US	1	S	14.7	14.8

The IRI and SDI condition history data for each year between 2000 and 2006 was extracted based on the direction and limits of construction project. Table 4 provides an example of the IRI and SDI data for this construction project.

Table 4 IRI and SDI data for the Route 1 Mill 2"+Overlay 2" construction project

IRI

Route	Dir	MP Start	Pave	2000 - 2001 AIRI	2002 - 2003 AIRI	2004 AIRI	2005 AIRI	2006 AIRI
001	S	14	BC	187	147	190	159	171
001	S	14.1	BC	156	182	191	257	285
001	S	14.2	BC	289	170	181	166	218
001	S	14.3	BC	146	193	210	246	287
001	S	14.4	BC	179	157	192	222	242
001	S	14.5	BC	138	144	185	202	218
001	S	14.6	BC	207	226	345	279	231
001	S	14.7	BC	152	155	180	163	194
001	S	14.8	BC	92	108	145	137	149
			Avg	172	165	202	204	222
			year	2000	2002	2004	2005	2006
			Age	1	3	5	6	7

SDI

Route	Dir	MP Start	Pave	2000 - 2001 SDI	2002 - 2003 SDI	2004 SDI	2005 SDI	2006 SDI
001	S	14	BC	3.62	2.64	1.70	2.23	2.28
001	S	14.1	BC	3.90	2.64	1.37	1.32	2.28
001	S	14.2	BC	3.90	2.64	1.37	1.32	2.28
001	S	14.3	BC	3.90	2.64	1.37	1.32	2.39
001	S	14.4	BC	3.90	2.64	1.59	1.32	2.51
001	S	14.5	BC	3.90	2.64	1.59	1.32	2.51
001	S	14.6	BC	3.90	2.64	1.59	1.32	2.51
001	S	14.7	BC	3.90	2.64	1.59	1.32	2.51
001	S	14.8	BC	3.90	2.84	2.48	2.21	2.65
			Avg	3.87	2.66	1.63	1.52	2.43
			year	2000	2002	2004	2005	2006
			Age	1	3	5	6	7

This exercise was repeated for the following 1999 construction projects:

Route Type	Route Number	Dir	Begin Milepost	End Milepost	Activity
US	1	S	14	14.8	M2/Ov2
US	9	B	42.5	43.8	M2/Ov2
NJ	23	B	0.007	2.058	M2/Ov2
NJ	29	B	29	31.4	M2/Ov2
NJ	70	B	36.8	37.8	M2/Ov2
US	30	E&W	1.3	2.5	M2/Ov4
NJ	35	S	35.6	36.1	4" OV over AC
I	78	E&W	30.9	42.7	4" OV over AC
I	287	N&S	5.9	14.2	4" OV over AC
US	46	E&W	57.7	58.2	4" OV over PCC

The size of the dataset for each activity project list proved to be insufficient. The IRI data was normalized to an initial 70 inch/mile and then the data for each activity was combined to examine the overall performance history for each activity. Figure 3 and 4 provide an illustration of the overall IRI and SDI performance histories. The model based on actual NJDOT PMS IRI condition data is far flatter than the HPMA default prediction model.

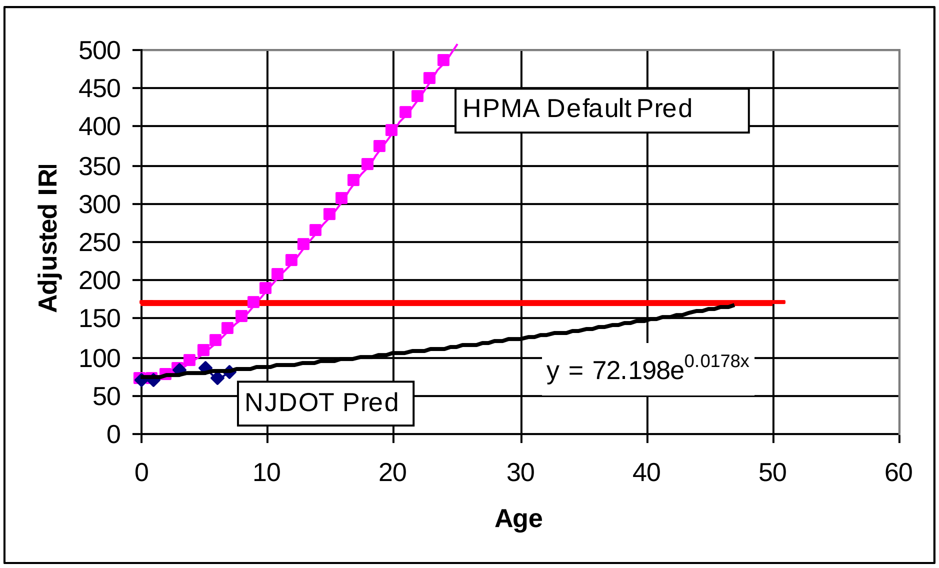


Figure 3 Overall IRI Performance History for the Mill 2"/ Overlay 2" Activity

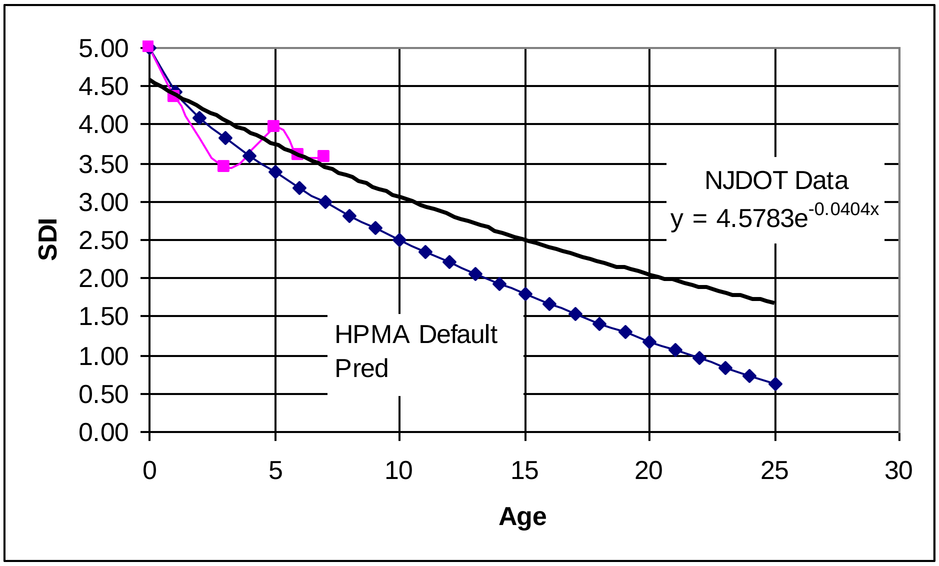


Figure 4 Overall SDI Performance History for the Mill 2”/Overlay 2” Activity

The model based on actual NJDOT PMS SDI condition data is similar to the HPMA default prediction model.

Figure 5 illustrates the results of the overall individual treatment IRI Performance Histories. Comparing the Performance Histories of the overall dataset for the individual treatments showed counter intuitive results. Based on the regression model, Mill2”/Overlay 2” would last more than 10 years longer than Mill2”/Overlay 4. However, all IRI Performance Histories showed that the performance prediction models to be flatter than the current HPMA default models, i.e., pavements last longer in terms of IRI ranging from 30-45 years. The dataset for individual treatments proved to be too small to provide accurate IRI performance models.

Figure 6 shows the results of the individual treatment SDI Performance Histories. Comparing the Performance Histories of the overall dataset for the individual treatments showed reasonable results. Based on the regression model, Mill2”/Overlay 4” would last longer than Mill2”/Overlay 2. All SDI Performance Histories showed that the SDI performance prediction models were similar to the current HPMA default models.

In an effort to improve the IRI and SDI models, the datasets were combined to provide data for overall IRI pavement prediction models for HMA overlays.

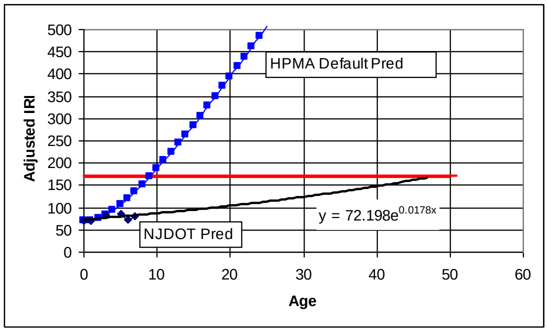
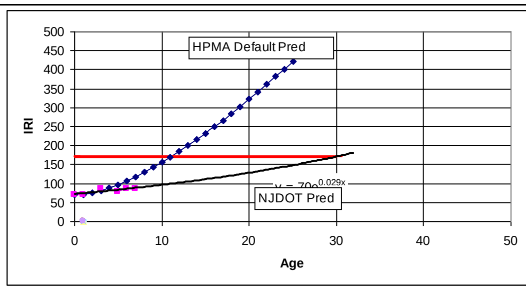
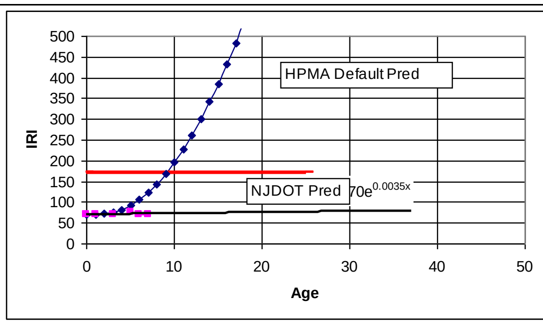
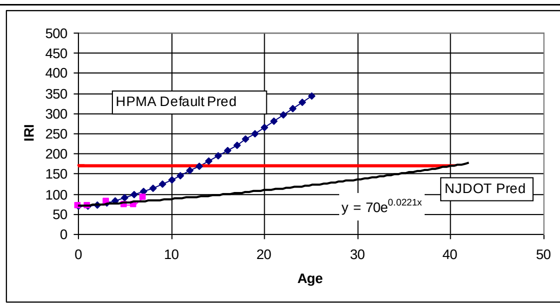
	Mill 2”/Overll 2”
	Mill 2”/Overlay 4”
	4” Overlay over AC
	4” Overlay over PCC

Figure 5. Comparison of IRI Performance Histories for various treatments

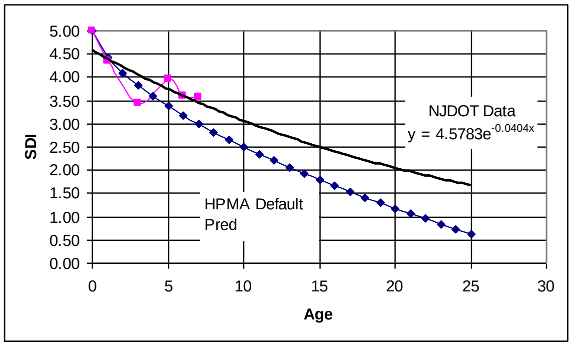
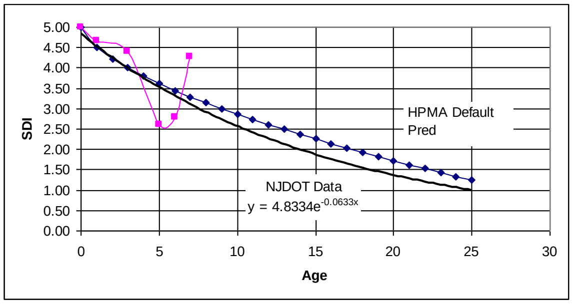
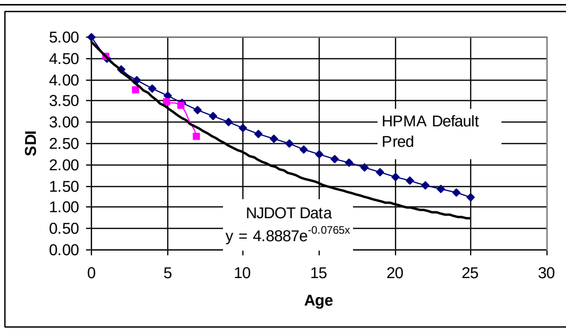
	Mill 2"/Overll 2"
	Mill 2"/Overlay 4"
	4" Overlay over AC

Figure 6. Comparison of SDI Performance Histories for various treatments

By combining the individual treatment datasets, the regression analysis produced an overall IRI and SDI Performance History for HMA overlays. Figure 7 illustrates the HMA overlay pavement prediction models.

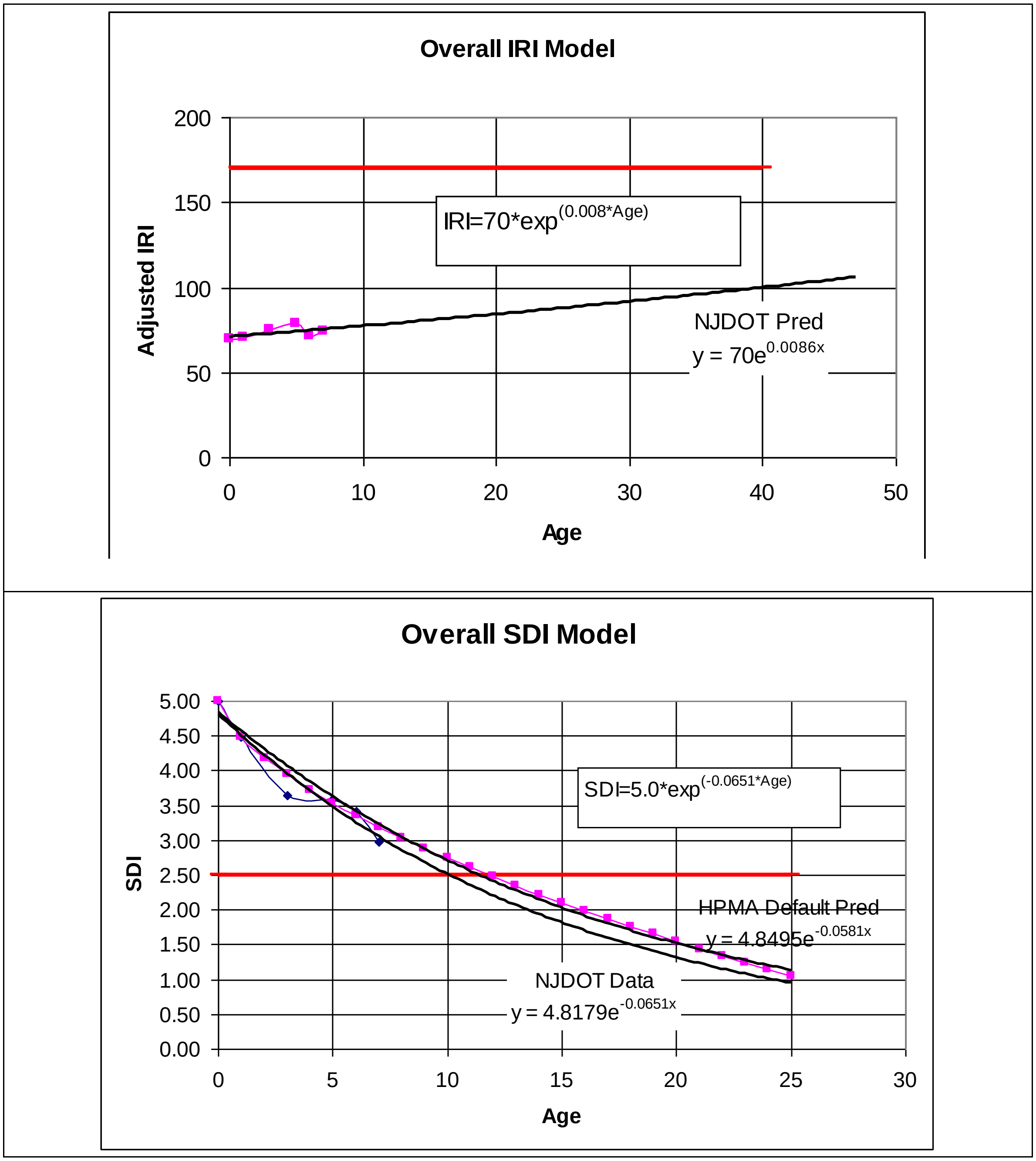


Figure 7 HMA overlay IRI and SDI pavement prediction models.

SHRP LTPP IRI Pavement Condition Prediction Models

The SHRP LTPP data from DATAPAVE for NJ's SPS-5, SPS-9, and GPS sites was used to validate the overall IRI pavement prediction model. The SPS-5 sites were special test sites that examined the performance of HMA overlays. The SPS-9 sites were special test sites that examined the performance of Superpave HMA overlays with different performance-graded binder types. The GPS test sites monitored the performance of in-service pavement sections. Figure 8 illustrates the IRI performance of the various SPS-5 HMA overlay sites.

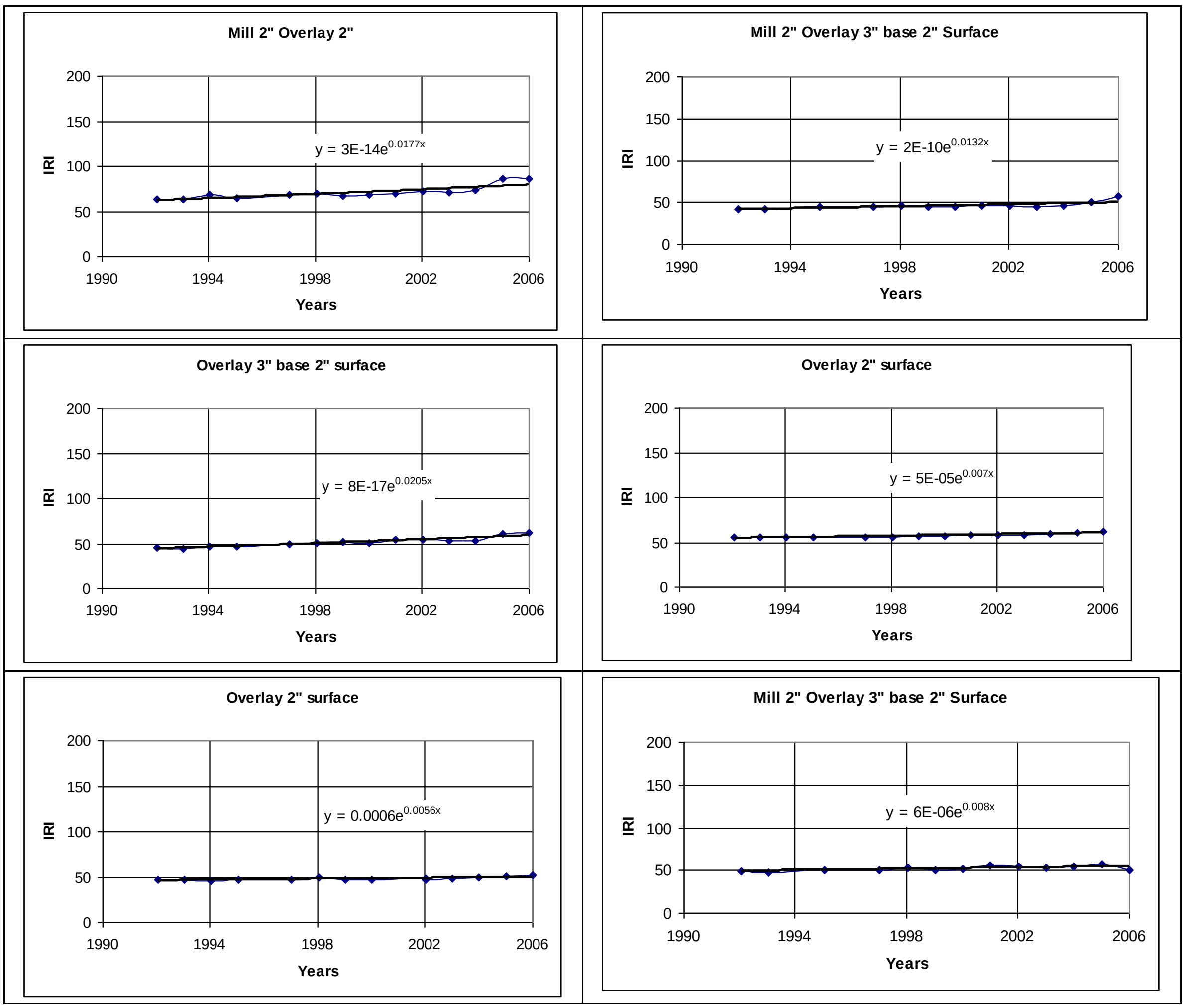


Figure 8 IRI Performance Histories of the various SPS-5 HMA overlay sites.

Figure 9 illustrates the IRI performance of the various SPS-9 HMA overlay sites.

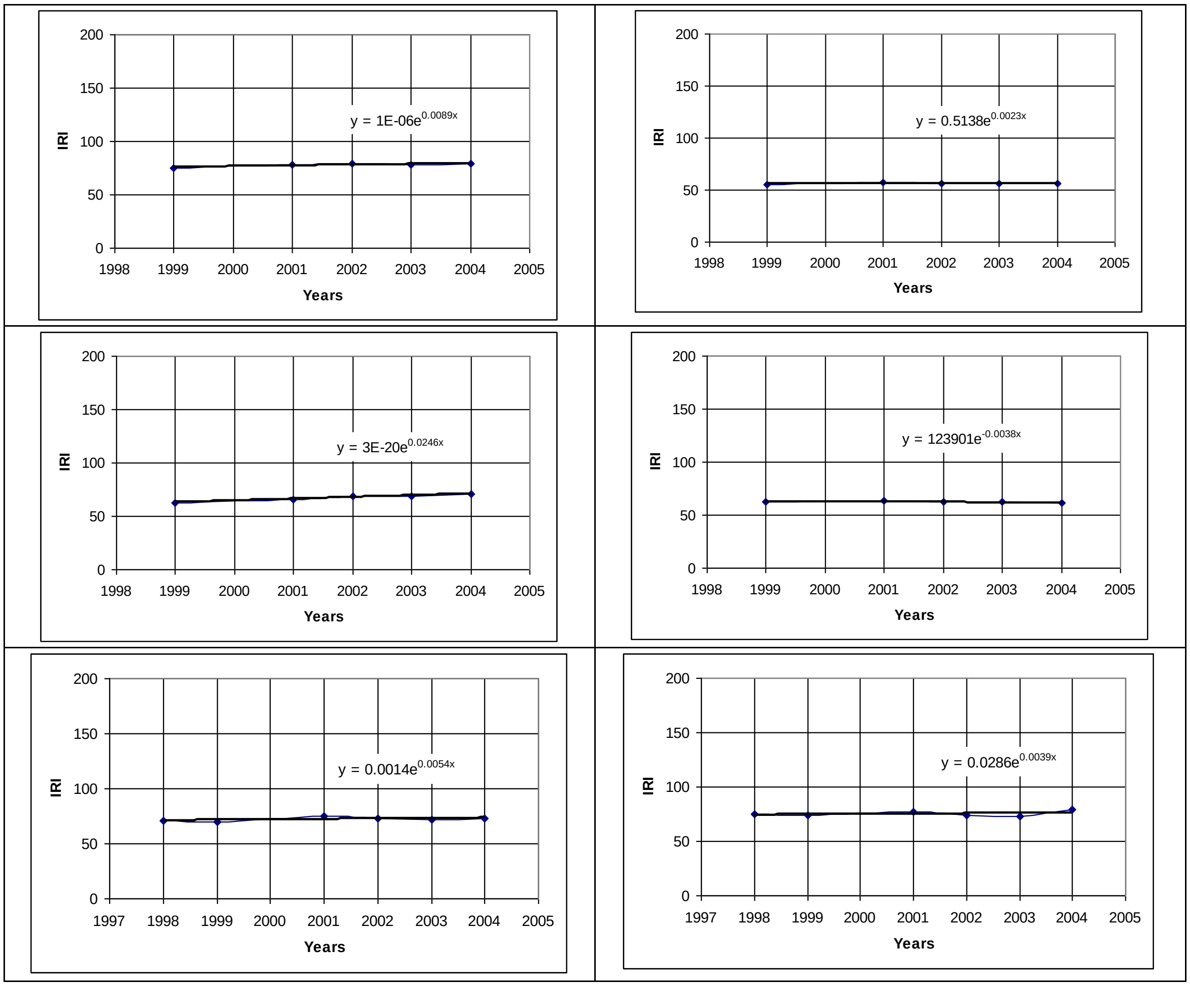


Figure 9 IRI performance of the various SPS-9 HMA overlay sites.

Figure 10 illustrates the IRI performance of the various HMA GPS sites

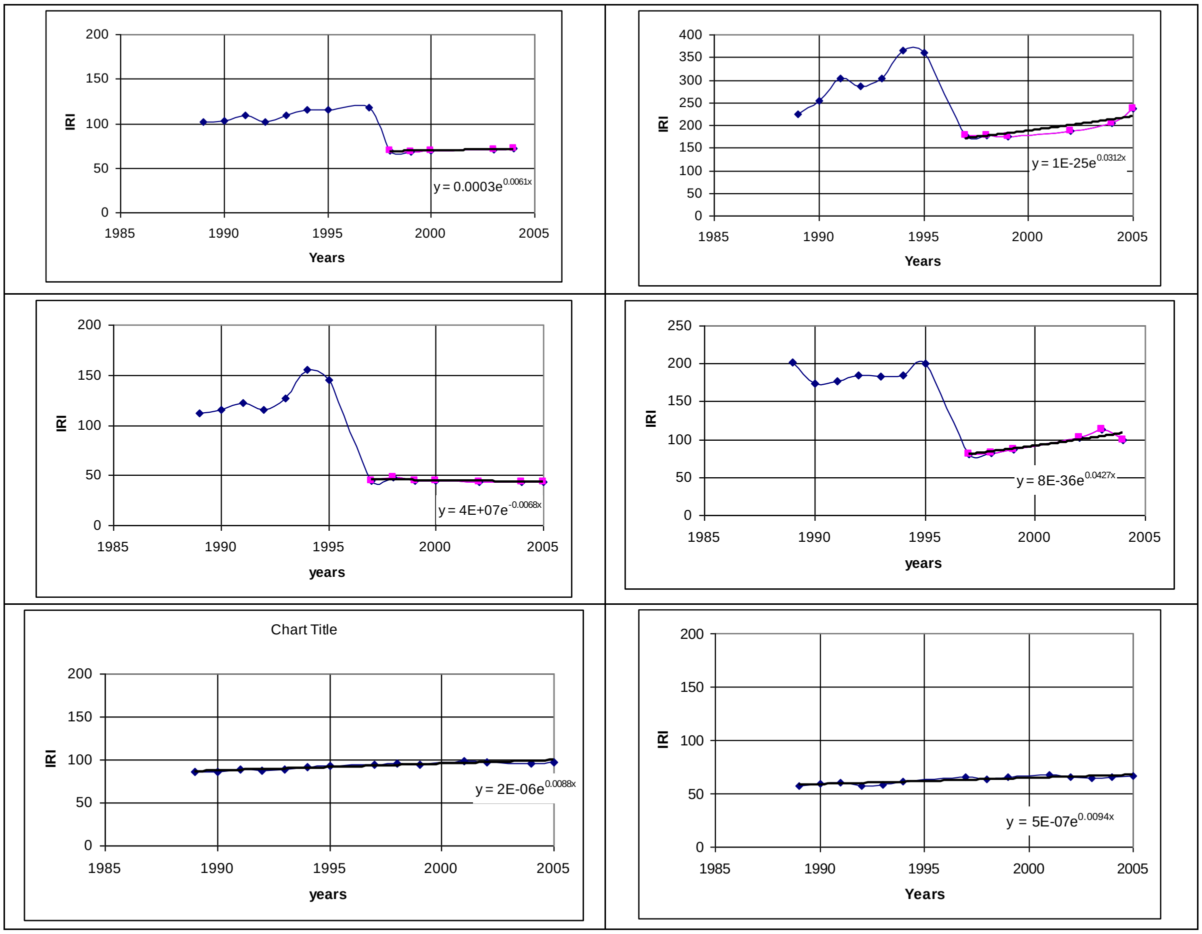


Figure 10 IRI Performance Histories of the various HMA GPS sites

The first four GPS sites above were overlaid. The IRI condition data for the sites after the rehabilitation (from 1997-1998) was used to develop IRI pavement prediction model equations. The last two sites were not overlaid.

As can be seen from the data plots for the SPS-5, SPS-9 and GPS sites, the IRI Performance Histories indicate that the IRI condition remains relatively flat over the early years since the rehabilitation.

After normalizing the condition data to an initial IRI value of 70 inch/mile, the data was plotted against the age since the rehabilitation or construction. Figure 11 provides an comparison of the various SPS-5 and SPS-9 sites. The plot for SPS-5 (501) and SPS-5 (560) were plots for routine maintenance and rubber Open-graded Friction Course respectively. The data points for the 501 and 560 sites were not used in the analyses that follow.

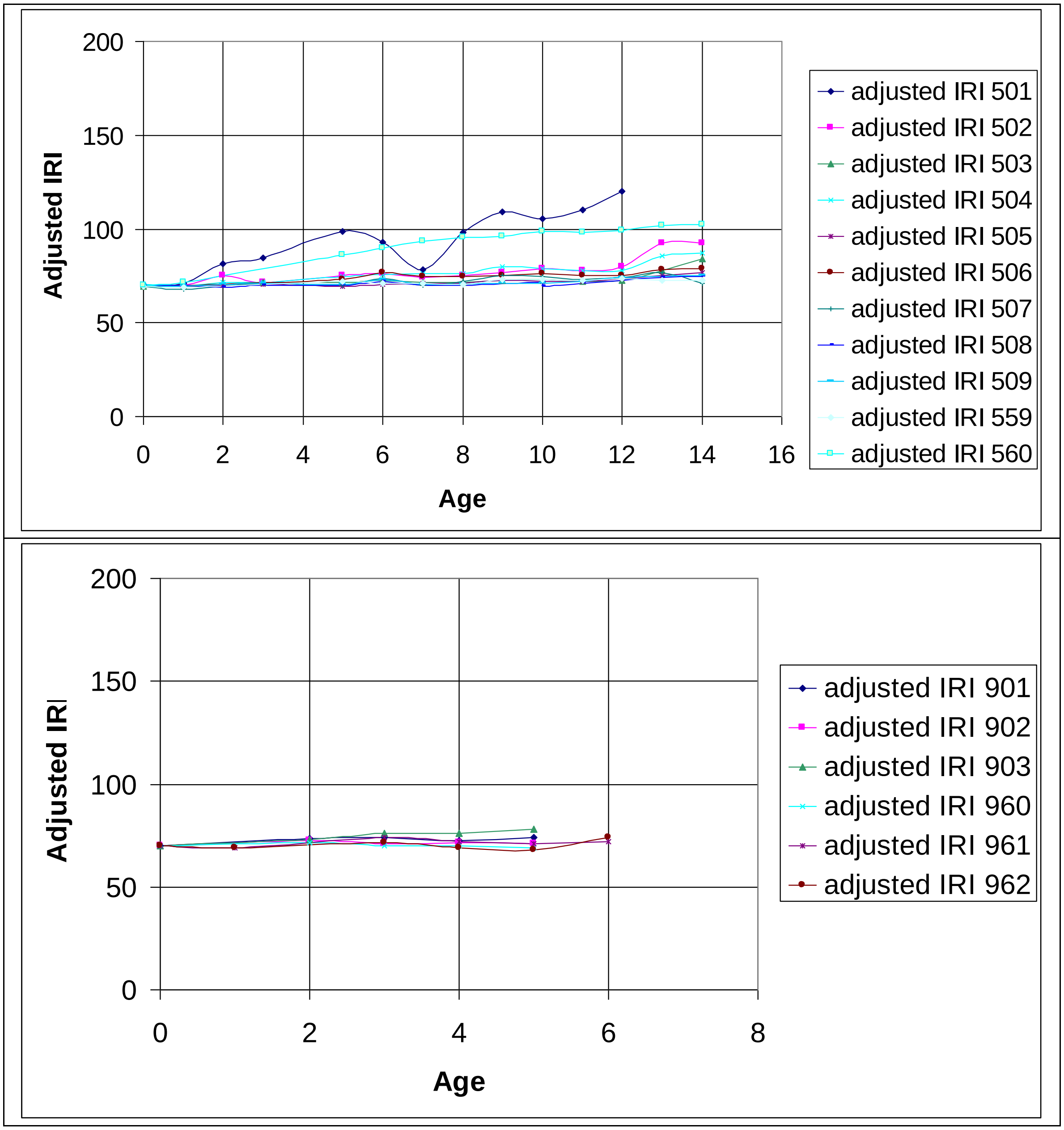
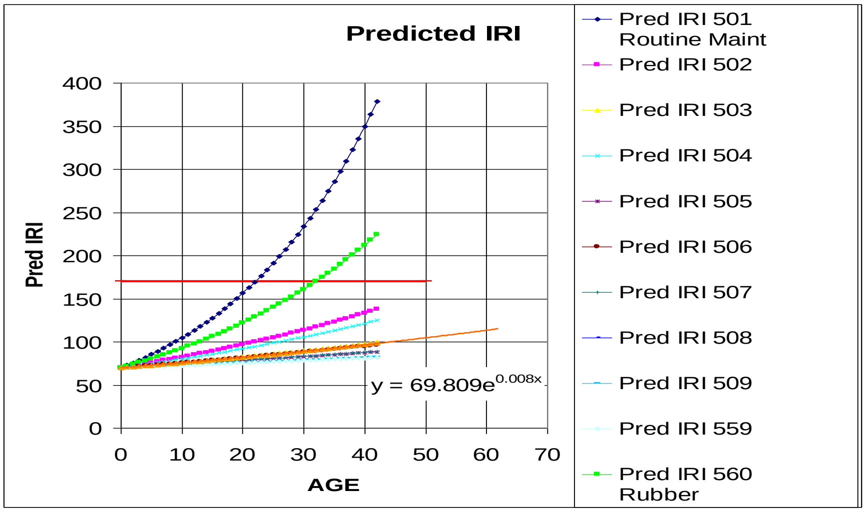


Figure 11 Comparison of the Normalized IRI data for various SPS-5 and SPS-9 sites

By averaging the predicted values for each SPS-5 and SPS-9 site, the analysis was able to develop an overall prediction model for the SPS-5 and SPS-9 sites. This analysis is illustrated in Figure 12, below.



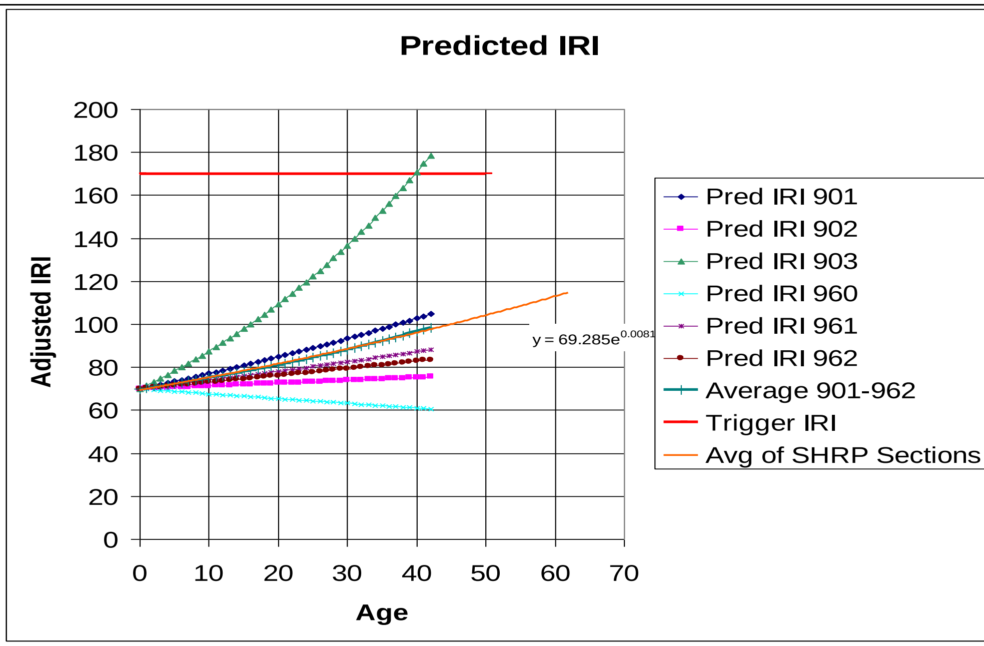


Figure 12 Comparison of Predictive Curves for SPS-5 and SPS-9 sites

The IRI regression model equations from the prediction curves from the average of the SPS-5 and SPS-9 sites are:

SPS-5 $IRI = 69.809exp^{(0.008*Age)}$ Eq 3

SPS-9 $IRI = 69.285exp^{(0.0081*Age)}$ Eq 4

Validation of NJDOT IRI Prediction Model

The analysis compared the IRI prediction models developed from the SHRP LTPP sites to the NJDOT IRI prediction models as a validation of the model form and coefficients.

SPS-5 $IRI = 69.809exp^{(0.008*Age)}$ Eq 3

SPS-9 $IRI = 69.285exp^{(0.0081*Age)}$ Eq 4

NJDOT $IRI = 70.0exp^{(0.008*Age)}$ Eq 5

The models developed from the NJDOT IRI data and the SHRP SPS-5 and SPS-9 site data are extremely similar.

Refinement of IRI Models

The IRI models developed above were base on pavement ages from 6 to 14 years. As cracking distresses and patches in the wheel paths increase in severity and extent, the ride quality will begin to deteriorate at an accelerated rate. Figure 14 illustrates possible IRI prediction models after the 14 years of data that are currently available from the SHRP LTPP dataset.

To refine the above models, the research examined the age of the SHRP LTPP sections since the last rehabilitation to estimate the point at which the pavement section would reach the IRI trigger value. On the average, the SHRP LTPP sections lasted 25 years.

Based on this rough analysis, the IRI prediction mode could be forced to pass through the 170 inch/mile trigger at 25 years.

The IRI prediction model based on this condition would be

NJDOT $Pred\ IRI = 0.0099\ Age^3 - 0.1014\ Age^2 + 0.3659\ Age + 71.144$ Eq 6

Figure 14 Illustrates the model.

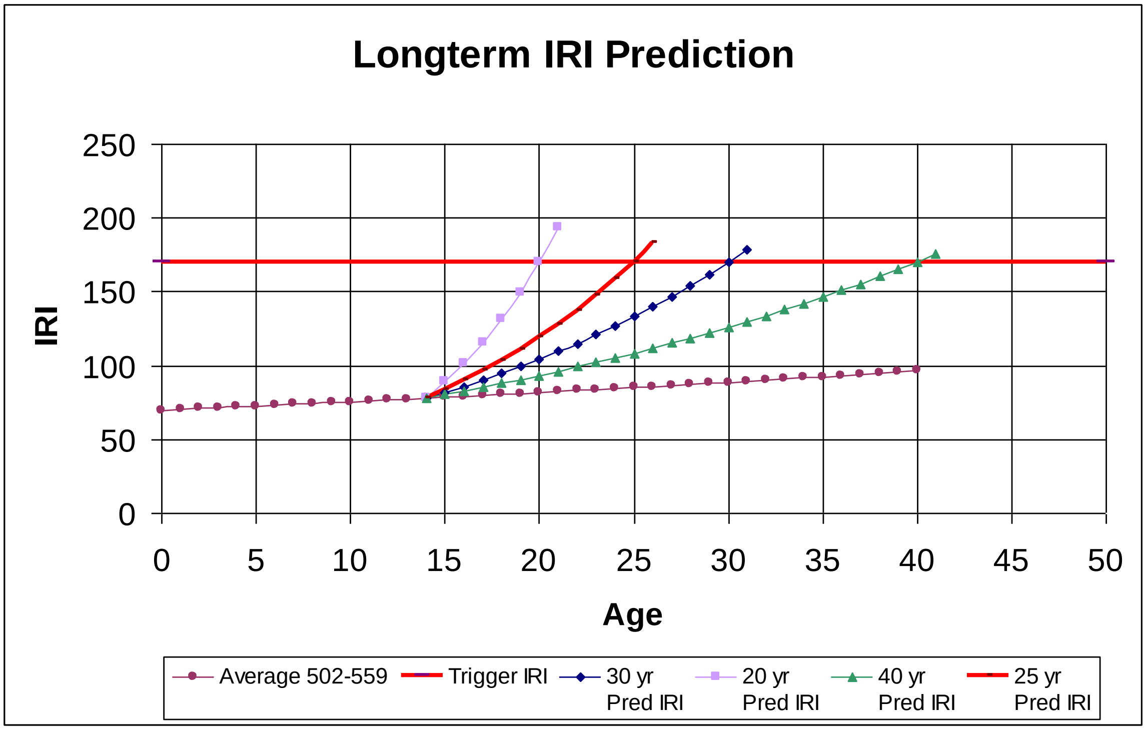


Figure 13 Illustrates possible IRI prediction models based data collected after the current 14 years of data

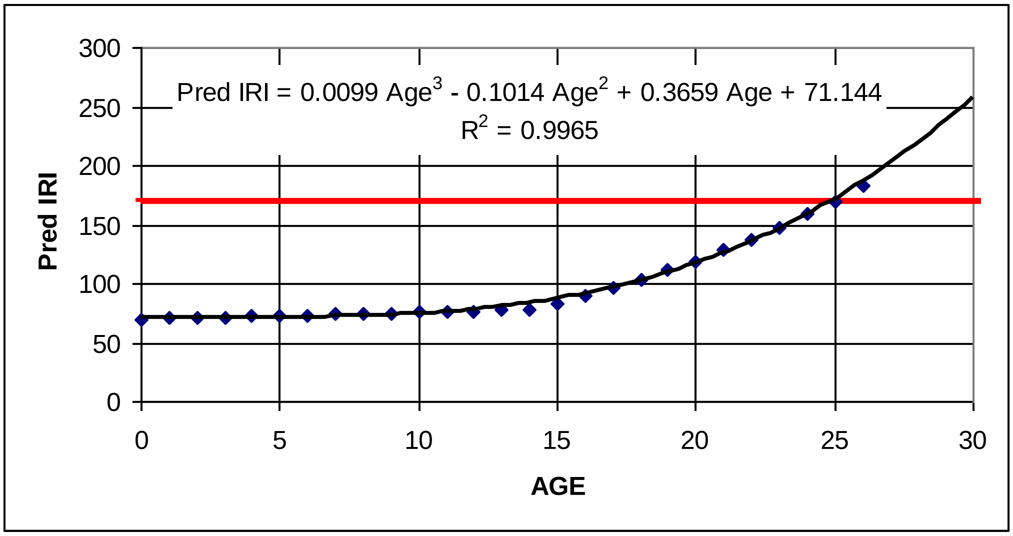


Figure 14 Recommended IRI Prediction Curve Based on SHRP LTPP data

New IRI and SDI Pavement Condition Models

Based on the analyses conducted and the IRI refinement, it is recommended that the following IRI and SDI models be considered as interim models to replace the current HPMA models for use in the Deighton PMS.

NJDOT $\quad$ Pred IRI = $0.0099\ Age^3 - 0.1014\ Age^2 + 0.3659\ Age + 71.144$ $\quad$ Eq 6

NJDOT $\quad$ SD I= $5.0 * exp^{(-0.0651*Age)}$ $\quad$ Eq 7

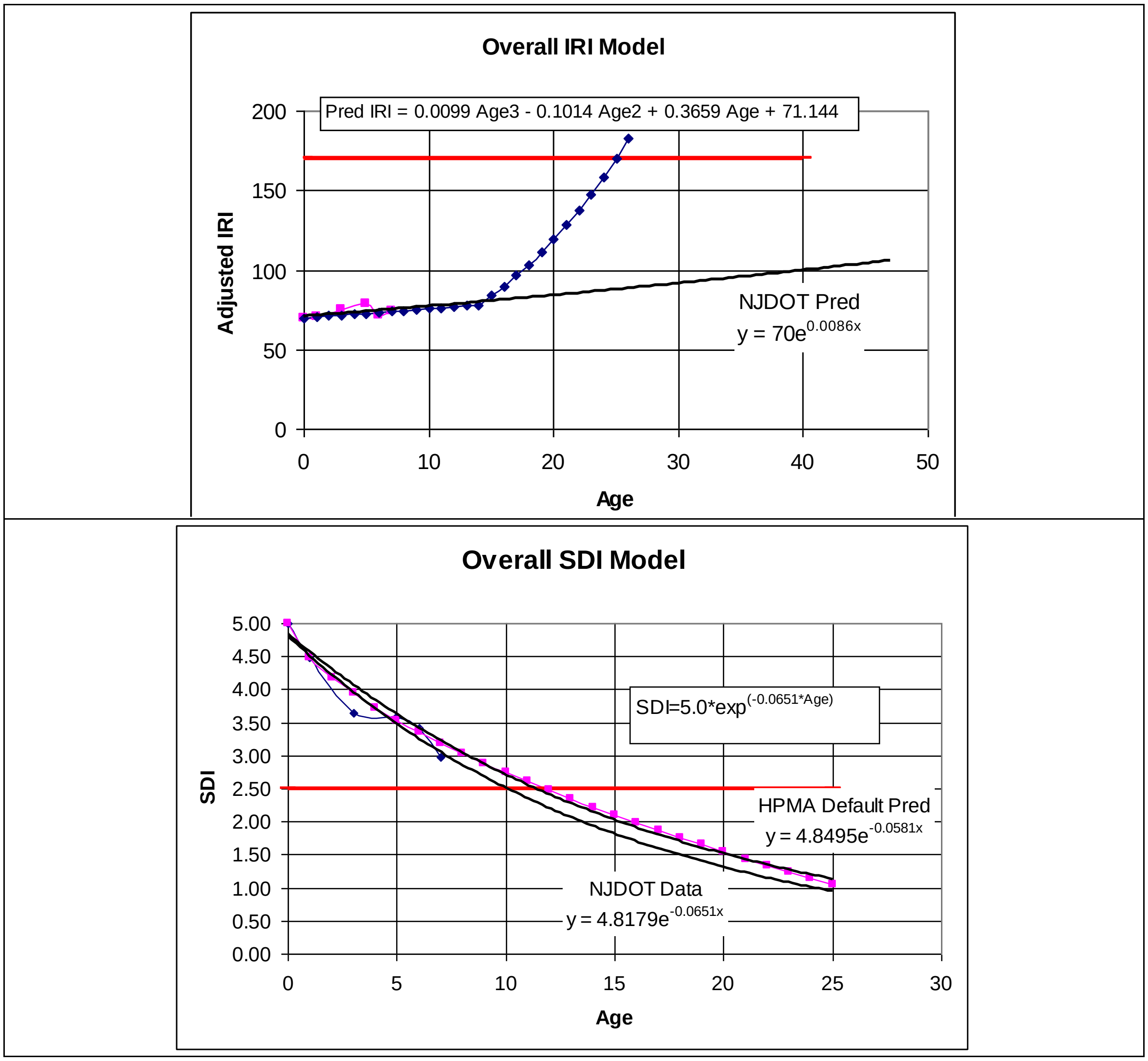


Figure 15 Illustrates the suggested IRI and SDI pavement performance models.

Conclusion

These analyses compared the current HPMA Pavement Index Prediction Models with those developed from actual NJDOT data on various types of pavement rehabilitation. While the SDI models developed closely agreed with the default HPMA models, the IRI models developed were far flatter than the default HPMA prediction models.

SHPR LTPP data for NJ SPS-5, SPS-9 and GPS test sites were used to develop IRI pavement index prediction models. These models proved to have similar performance histories to the NJDOT performance models.

Using the SHPR LTPP SPS-5 and SPS-9 as a validation of the NJDOT models, and SHPR LTPP GPS for-refinement of IRI prediction models based on observed age of SHRP LTPP test sites before failure based on IRI, final model equations were suggested to replace the current HPMA default prediction models.

Based on the analyses that were conducted in this effort, It is estimated that an additional 15-30 years of pavement condition data on 30 or more miles of pavements (of each rehabilitation activity type) would be needed to develop definitive (average) IRI and SDI Pavement Index Prediction Models for each rehabilitation activity type. The 15 years should be sufficient for the development of SDI models, however based on the observed longevity of pavement smoothness, closer to 30 years would be needed for definitive IRI models. This may prove difficult to collect 30 years of pavement IRI condition data for model development, if the pavement fails in 10-15 years based on SDI. It is suggested that the SHRP LTPP sites be preserved as long as possible to provide the needed IRI conditions data for refined model development.

APPENDIX A

ADVANCED INFRASTRUCTURE DESIGN

Advanced Infrastructure Design, Inc.

NJDOT Project Tracking System

User Manual

12/28/2009

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1. INTRODUCTION

The NJDOT Project Tracking System provides a set of tools which stores, analyzes, and reports on the process of NJDOT Pavement Projects from conception to completion.

The software modules provide the NJDOT Pavement and Drainage Management staff with the ability to identify potential conflicts between the Pavement Management System's Needs-List and ongoing project work documented in Maintenance Operations, CPM's PRS (design), and Construction's SCN. The software also provides the means of storing each year's paving program project information as a status report of location, costs, and materials.

2. STARTING THE PROJECT TRACKING SYSTEM

To start the Project Tracking System click on the DOT Track Icon 

in tracking directory, or the installation folder/directory. The Project Tracking System will be loaded.

2.1 MAIN MENU

Five drop-down menus are presented at the top of the main screen.

1- **File Menu:** (Figure 1A)

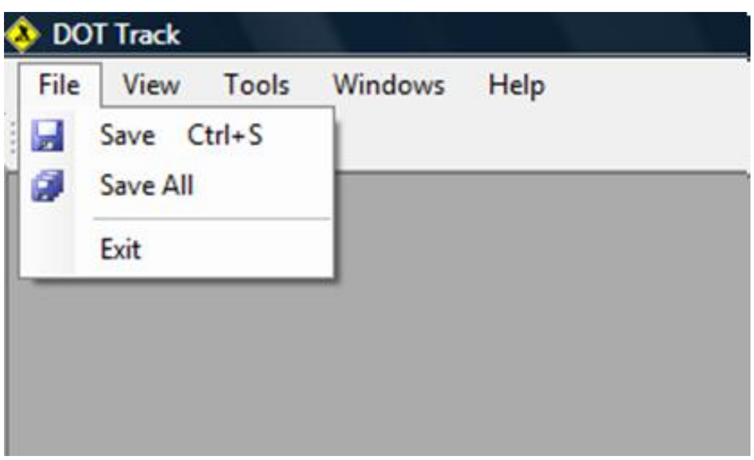


Figure 1A: File Menu Sub Items

File Menu depicts three options:

- "**Save**" option is not available. (faded out)

- "**Save All**" operation is similar to the MultipleDisk Icon which allows the user to save the detected conflicts to the DB or an Excel sheet. (Please refer to Figure 1G)
- "**Exit**" option closes the software system.

2- **View Menu:** Provides the user with ability to invoke one of the main modules of Tracking System (Conflict Detection, Project Search, and Recommended) (Figure 1B). The All Conflict Report option produces a Crystal report of conflicted route segments. The Status Bar option currently does not serve any function. It is currently used as a place holder for additional functionality. The Toolbar – selecting (check marking) the Tool bar option displays the icons under the menu bar (Please refer to Section 2.2) and deselecting (Figure 1B-1) it hides the menu bar.

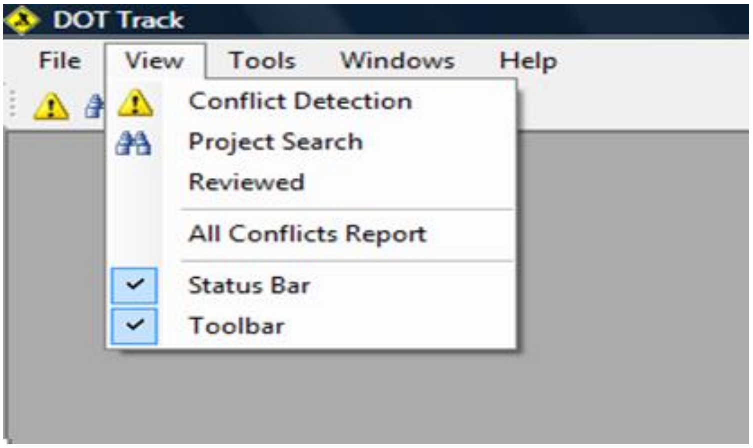


Figure 1B: View Menu Sub Items

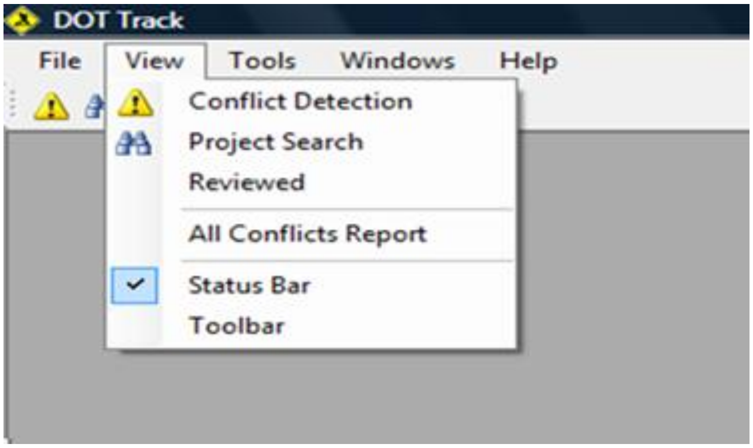


Figure 1B-1: Tool Bar deselected

3- **Tools Menu:** Provides the user access to the Tracking DB (Figure 1C)

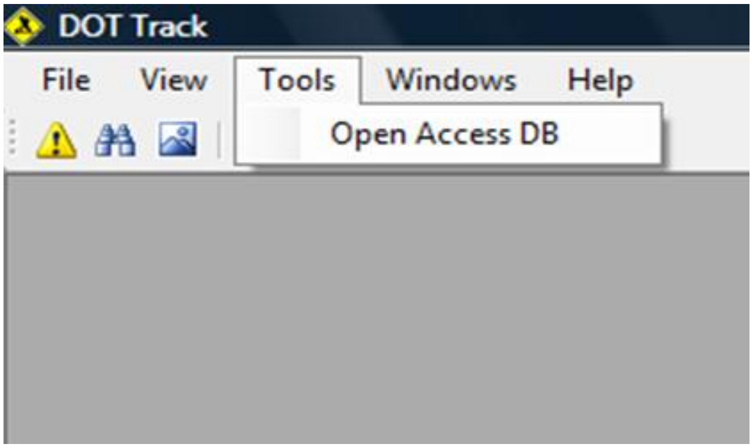


Figure 1C: Tools Menu Sub Items

4- **Windows Menu:** Gives the user various window/View options
5- **Help Menu:** Give user access to the user manual documentation (Figure 1D)

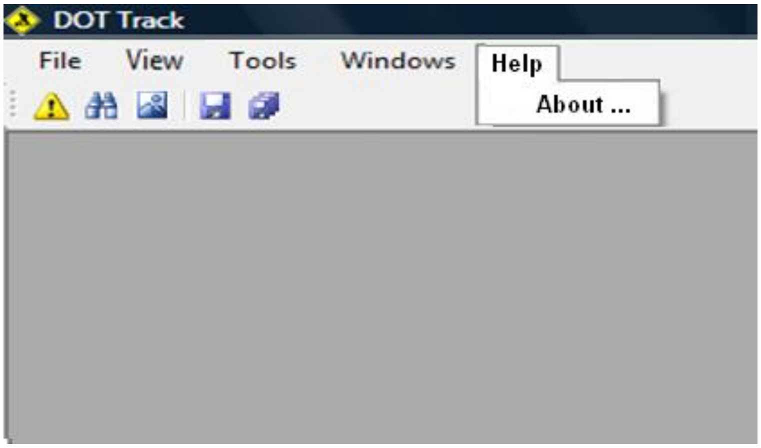
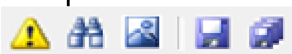


Figure 1D: Help Menu Sub Items

2.2 TOOL BAR

On the LEFT top side of the screen under the menu bar, there are five icons presented to the user  (Figure 1E).

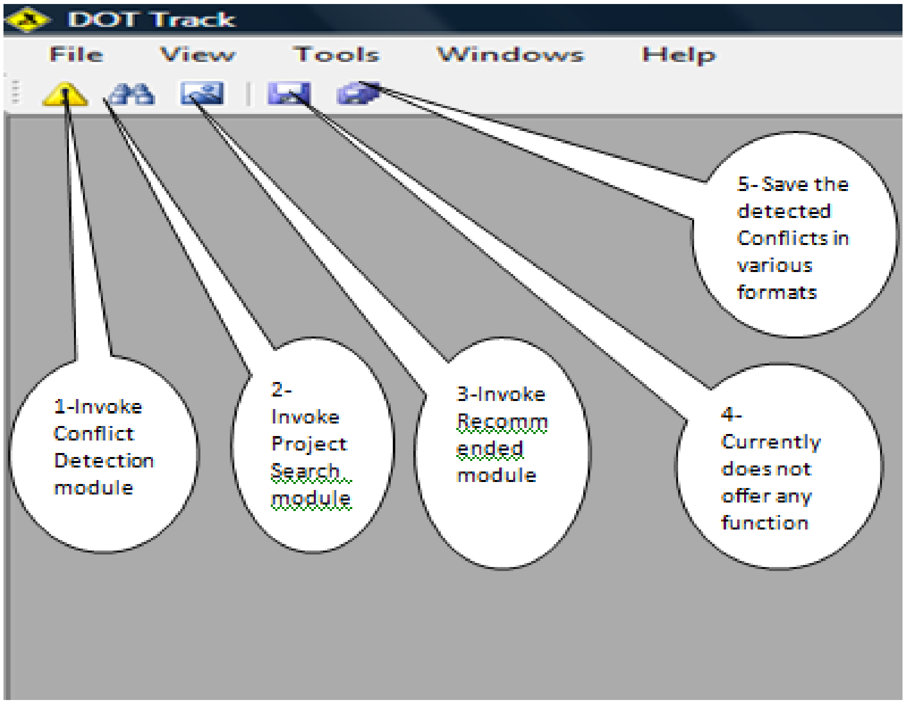


Figure 1E: DOT Track System

1- **Yellow Triangle** : Activates the Conflict Detection module

2- **Binocular** : Activates the Project Search Recommended module

3- **Mountain with Sun** : Activates the Recommended module

4- **Single Disk** : This option currently is not available (faded).

5- **Multiple Disks** : Allows the output to be stored in either an Excel Workbook, Access database, or SQL database (not currently available). Once this icon is double clicked, user will be prompted by three options as presented in Figure 1F.

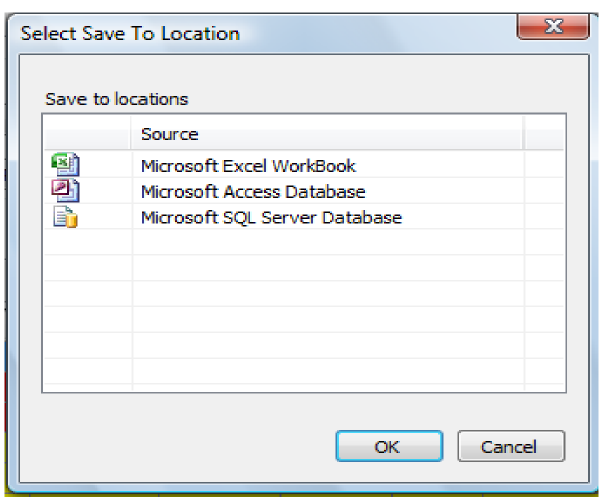


Figure 1F: Save Options

- Microsoft Excel WorkBook: Saves the conflict report as an excel sheet sorted by Project IDs at the user specified location
- Microsoft Access Database: Saves the conflict in an ACCESS table in Tracking DB (Called dbo_ConflictResut Table).
- Microsoft SQL Server database: This option is not currently available.

3. MODULES OF PROJECT TRACKING SYSTEM

The Project tracking system consists of three modules:

1- Conflict Detection
2- Project Search
3- Recommended

3.1 CONFLICT DETECTION MODULE

Click on the Yellow Triangle  to activate the Conflict Detection module (Figure 2).

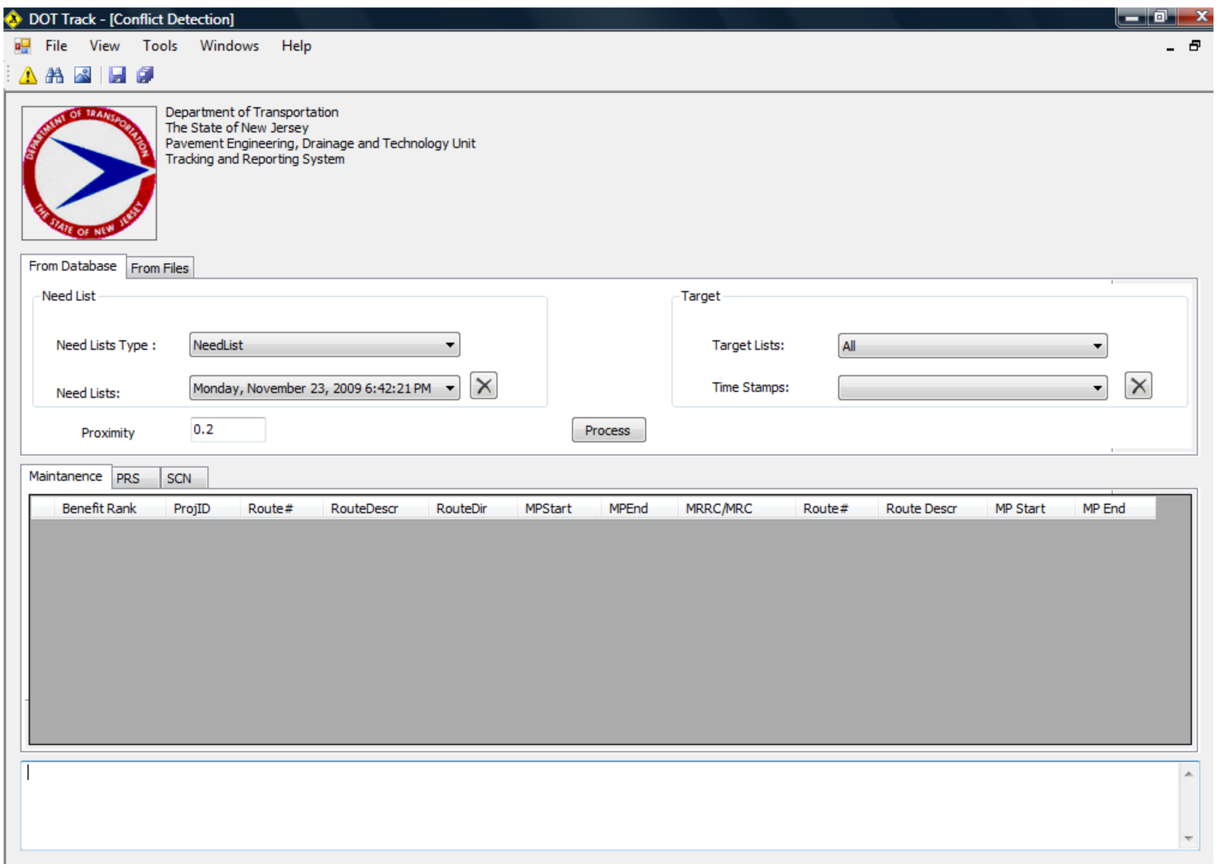


Figure 2: Conflict Detection Module

Project Tracking System input data is inserted into the system through Conflict Detection Module and Recommended Module. Each data set uploaded to the system receives a time stamp added to the file name, which distinguishes that data set from previously loaded and future uploads.

The execution of the Project Tracking system starts with Conflict Detection module. This module allows for the loading of the PMS Needs-List and comparison input files from Maintenance Operations, CPM (PRS), and Construction (SCN). The module then uses an execution of conflict detection algorithm. Once the Conflict Detection module is selected, the user is given the option to either upload new input files, or to process the data currently exists in the DB (previously uploaded).

The following summarizes the capabilities this module provides to the users:

3.1.1 NEED-LIST

Before using the Conflict Detection module, one needs to upload Need-List excel data set into Project Tracking DB (Figure 2A). Under “Need List” section user has the option to input a new data set or use a previously loaded data file. Consequently a version of Need-List can be deleted by selecting the file and pressing the Delete button  Next to the download “date stamp” field.

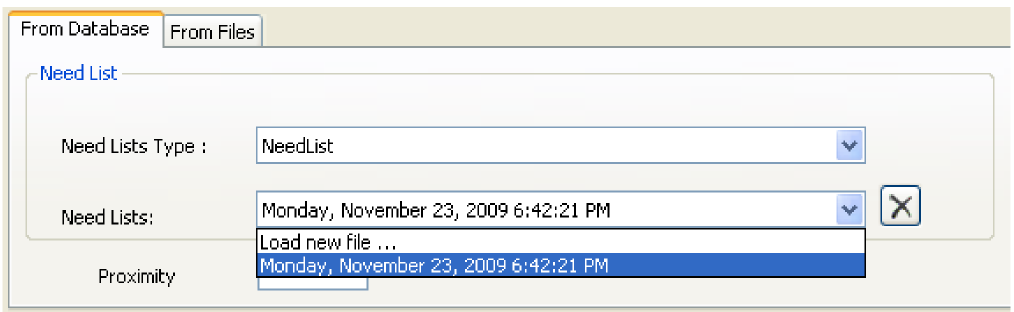


Figure 2A: Conflict Detection: Need List

3.1.2 COMPARISON PROJECT DATA FILES

Maintenance, PRS and SCN data files are loaded utilizing the Target-List option on the right hand side of the screen. (Figures 2B, 2C, 2D). User may upload a new version or utilize a previously uploaded version. Consequently a version of any data set can be deleted by selecting the file and pressing the Delete button  Next to the download “date stamp” field.

The “ALL” option loads the latest version of Maintenance, PRS and SCN data files**.** Individual Maintenance, PRS and SCN data files may be loaded by selecting the individual options in the dropdown menu.

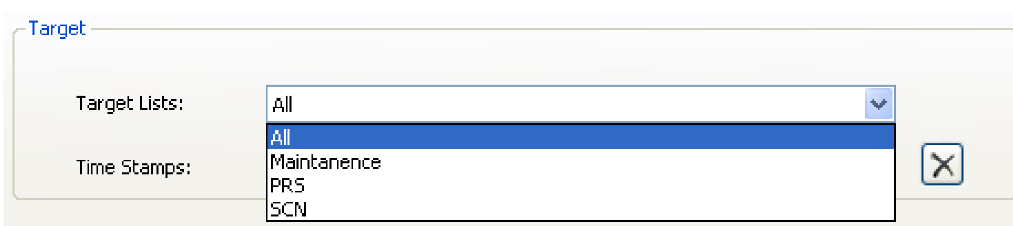


Figure 2B: Conflict Detection: Target List

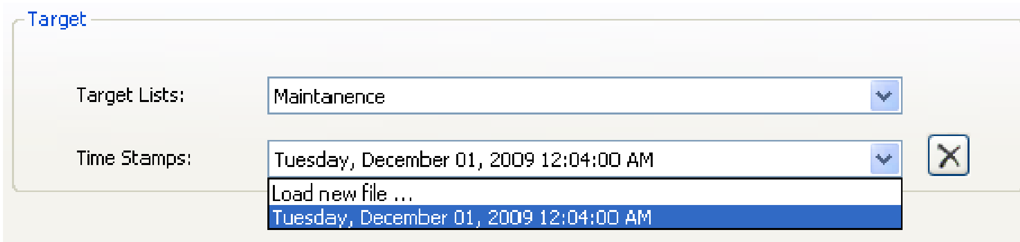


Figure 2C: Conflict Detection: Target Time Stamps

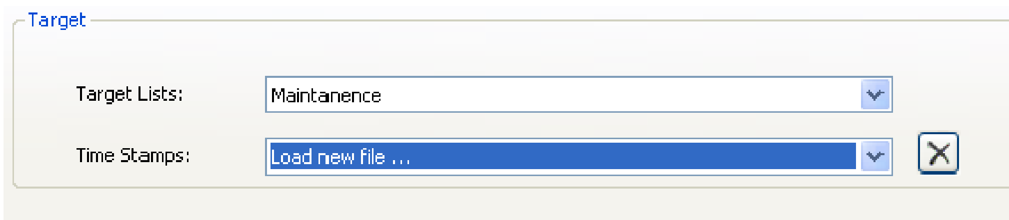


Figure 2D: Conflict Detection: Load New File

3.1.3 <u>CONFLICT RESOLUTION ANALYSIS</u>

The conflict resolution analysis compares the data in the PMS Needs-List with the ongoing projects stored in the Maintenance operations, CPM (PRS), or Construction (SCN) databases.

Execute the conflict algorithm / compare the Need List to one or more of the input data sets (Maintenance, PRS, SCN) and display those records that conflict or are in close proximity. Comparison is done by selecting “ALL” or one of the data sets available through Target List, and then clicking the Process button (Figure 2E, Figure 2F).

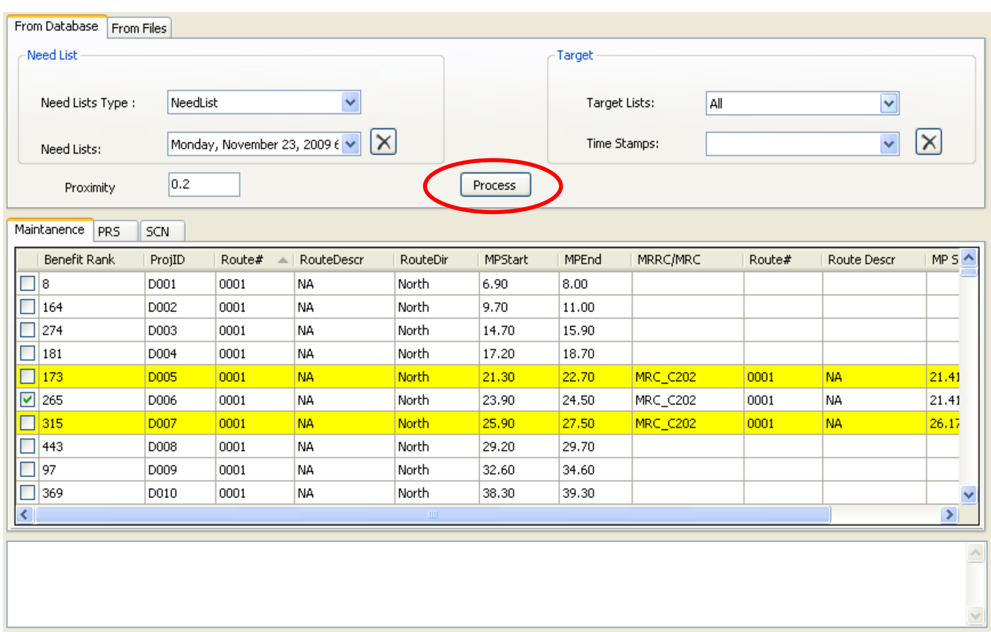


Figure 2E: Maintenance Conflict

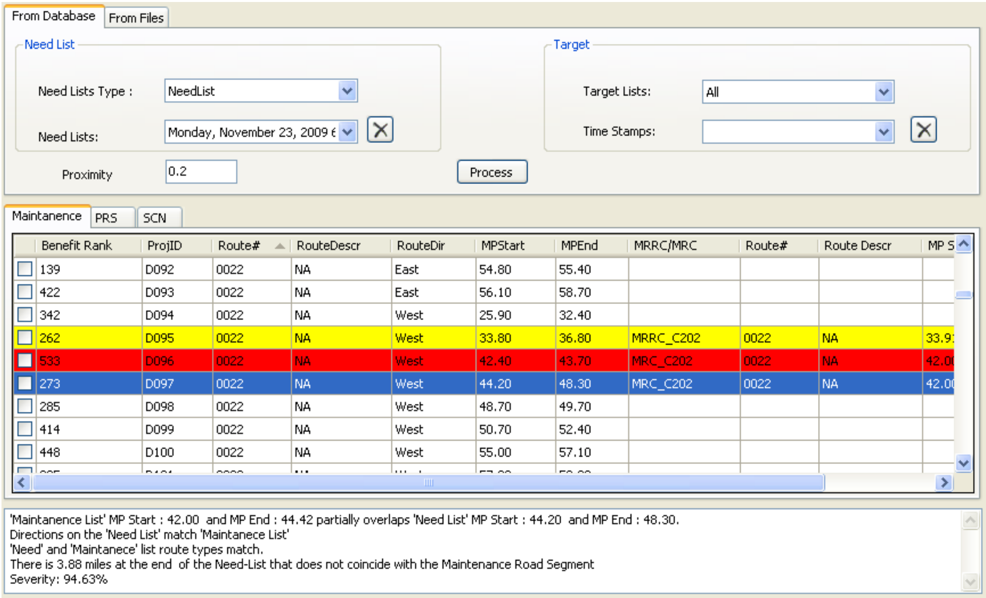


Figure 2F: Result of Conflict Detection

If the "ALL" option is selected, the data in Need-List will be compared against all loaded input data sets (most recent version of Maintenance, PRS and SCN). The result will be displayed in the lower part of the screen under three tabs: Maintenance, PRS and SCN.

Each tab displays pertinent conflicted route segments with the Need-List. Conflicts are colored based on the level of severity. Those with the highest level of severity (100% conflict) are colored Red. The lower conflict levels are colored Yellow. As it has been displayed in Figure 2F, once a particular record is highlighted, the color changes to Blue and a description capturing the nature of the conflict appears at the bottom of the screen.

3.1.4 CONFLICT OUPUT FILE

The Conflict Detection module captures all Need-List road segments along with their pertinent conflict, if any. The identified conflicts can then be stored to an Excel spreadsheet, an Access database or a SQL Server database (This option is currently not available). User can press the multidisc icon (on the tool bar) or the "Save All" menu item (on the "File" drop down menu) to save the results. Then user will be prompted to specify a location to save the conflict report in Excel format (Figure 2G). The format of this Excel report is identical to the original Need-List, however it is sorted by the Need-List's Proj_ID (Project Identifier).

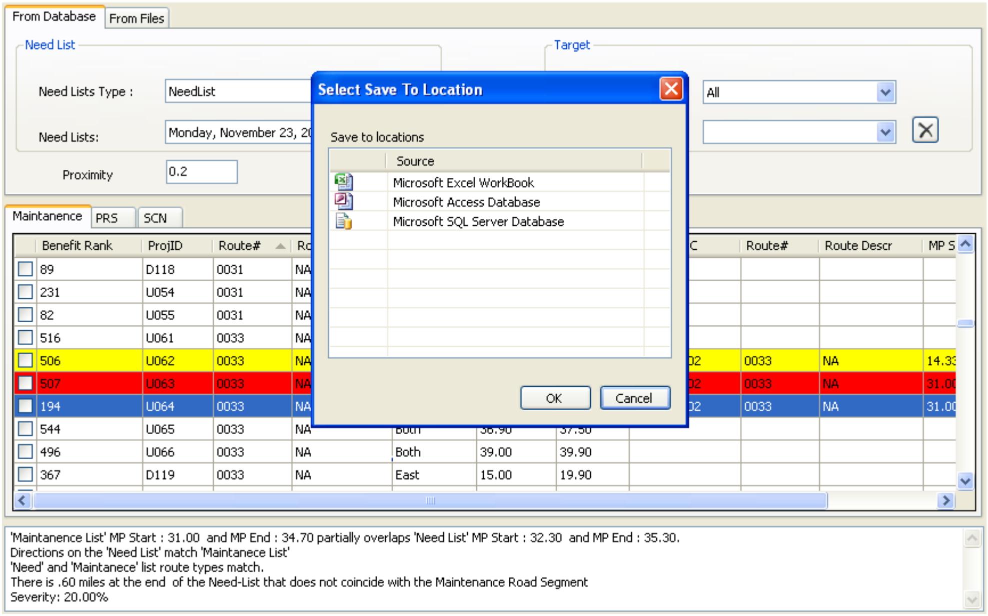


Figure 2G: Saving Conflict Report to Excel, Access Database, or SQL Server Database

The Conflict Detection module can also produce a Crystal report which captures only those road segments of Need-List that are in conflict with one or more of records in Maintenance, PRS and SCN input data files. A sample Crystal report is shown in Figure 2H. To generate a Crystal report, a user needs to select the "All Conflict Report" option under the View drop down menu (Please refer to Figure 1B in Section 2.1).

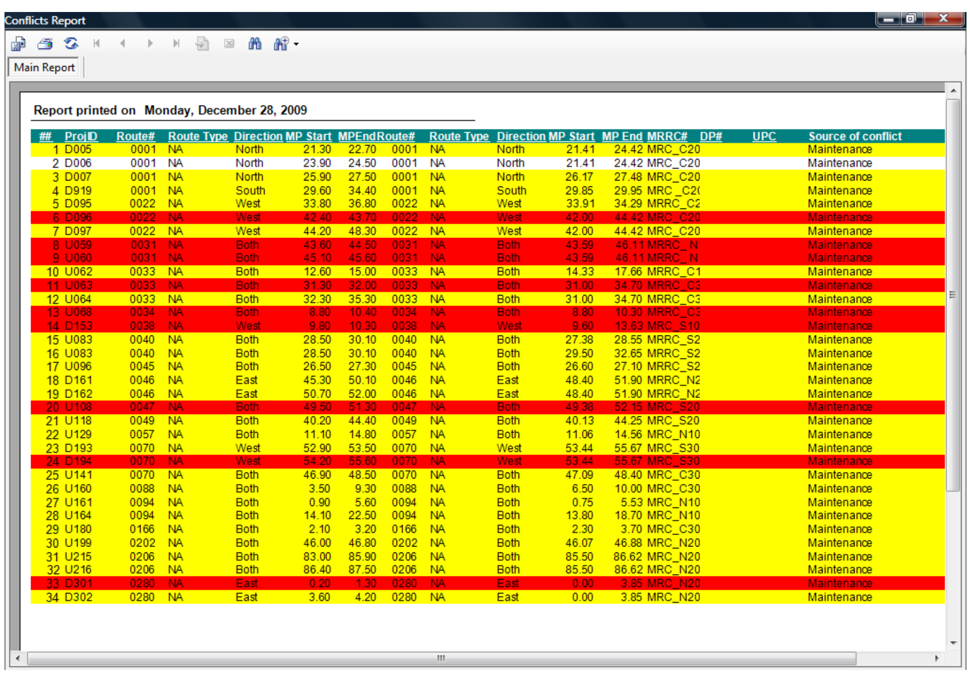


Figure 2H: Crystal Report

*The Conflict Detection module allows users to save a detected conflict as a non-conflict record***:** The boxes next to the road segments allow the user to notify the Project tracking system that a "potential conflict" detected by the system is actually recognized as a non-conflict by the expert engineer. In other words, once a conflict is check marked by the expert, the system will treat that conflict as non-conflict in the reports, by coloring it white. In Figure 2E, the Proj-ID D006 is check marked. The corresponding record in Crystal report (Figure 2H) is colored white.

IMPORTANT:

It is important to save the detected conflicts and newly check marked or un-check marked conflicts to the data base regularly, particularly before any attempt to create a report. To save the conflicts in the database, press the multidisc icon (on the tool bar) or the "Save All" option (on the "File" drop down menu), then select Microsoft Access Database (Figure 2G). This will update the database related records. Then click the process Button (Figure 2E).

3.2 PROJECT SEARCH MODULE

The Project Search module allows the user to search for ongoing work project in the PMS Needs-List, Construction (SCN), CPM (PRS), Maintenance Operations, or Recommended-List

Click on the binocular icon  to activate the Project Search module (Figure 3)

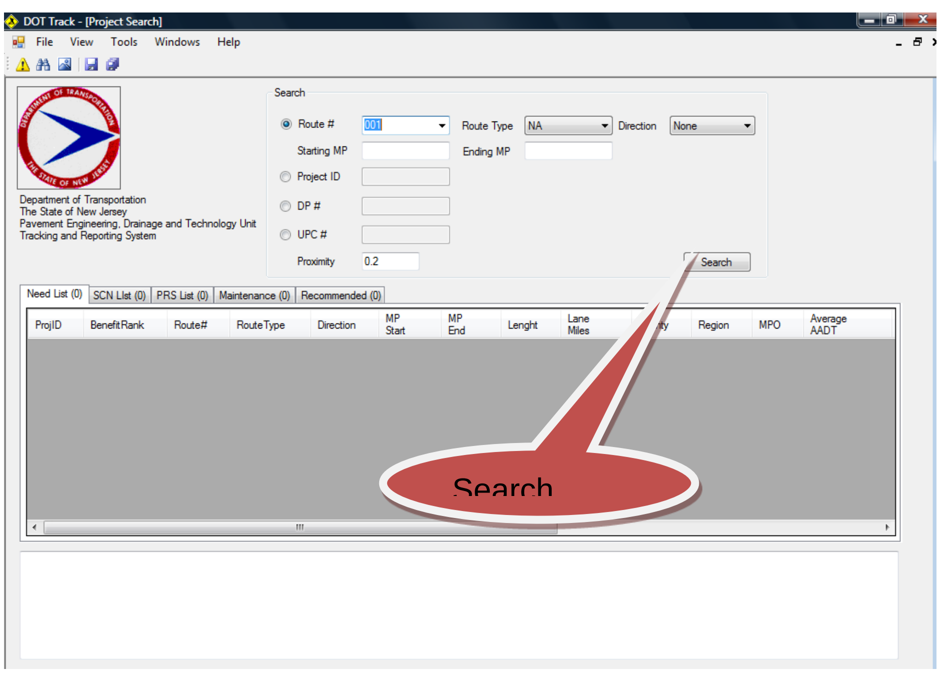


Figure 3: Searching for a Route Segment

A route segment can be searched for using any one of the following search criteria:

- Route name: You can alternative for a route name identify the followings (optional)
    - Route direction (North, South, East or west),
    - Route Type (Truck, Business, Upper, …..)
    - Beginning and ending mile post
- Project ID (Need-List Project ID or Recommended List (approved Project) Project ID)
- UPC
- DP Number

Once a search criterion is specified, the system will search within five data sets for a match. These data sets as specified in tabs of Figure 3 are 1- Need-List, 2- SCN, 3- PRS, 4 - Maintenance, 5- Project Recommendation and its associated route segments. To start the search process, after selecting search criteria, click on the "Search" button (Figure 3). Upon the completion of the search, the number of detected matches will appear next to tab name (Figure 3A, Figure 3A-1, Figure 3A-2).

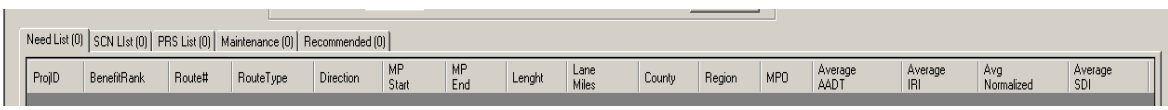


Figure 3A Tab counts before search

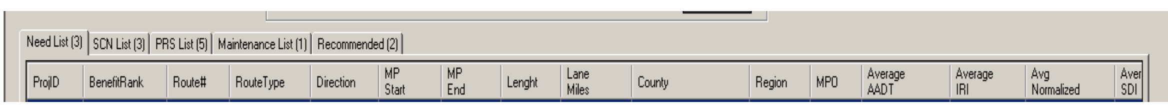


Figure 3A-1 Tab counts after search

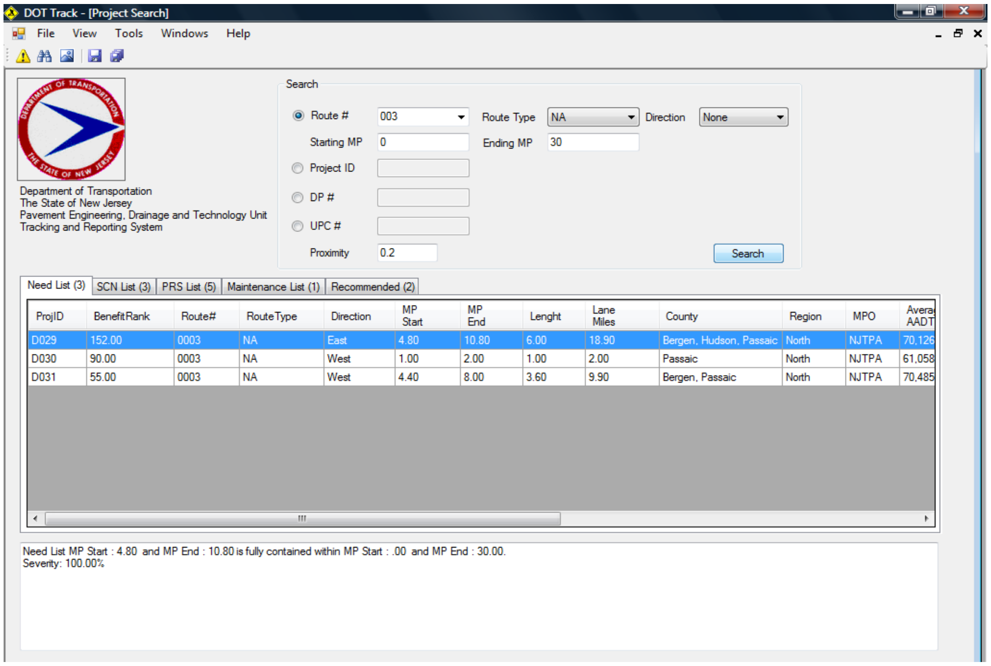


Figure 3A-2 Result of a Search

By selecting a tab, the associated records will be displayed in the grid. Each tab has a set of attributes associated to that of the input data sets (Figure 3B).

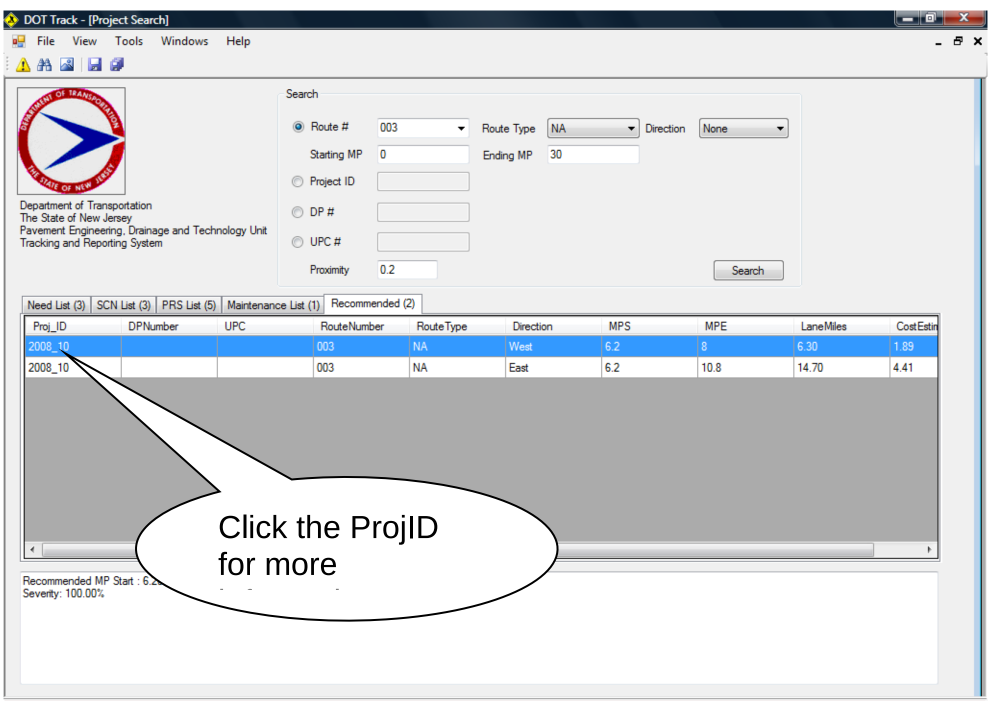


Figure 3B Selecting a Tab

Under the Recommended tab, user can obtain more information by double clicking on the Proj_ID. Subsequently a new window will be displayed which provides detail information with regards to the selected project (Figure 3C).

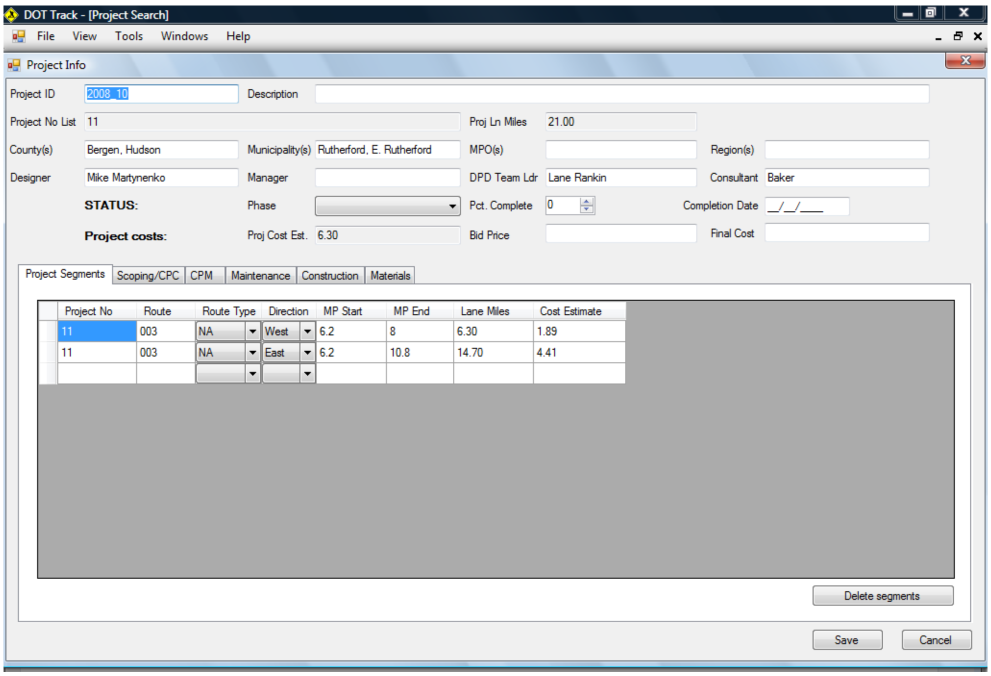


Figure 3C: Detail Information of an Approved Project

3.3 RECOMMENDED MODULE

Click on Mountain with Sun  icon to activate the Recommended module, and the Project Summary screen of the approved Project will be displayed (figure 4). Each Project is associated with one or more route segments.

3.3.1 PROJECT SUMMARY SCREEN

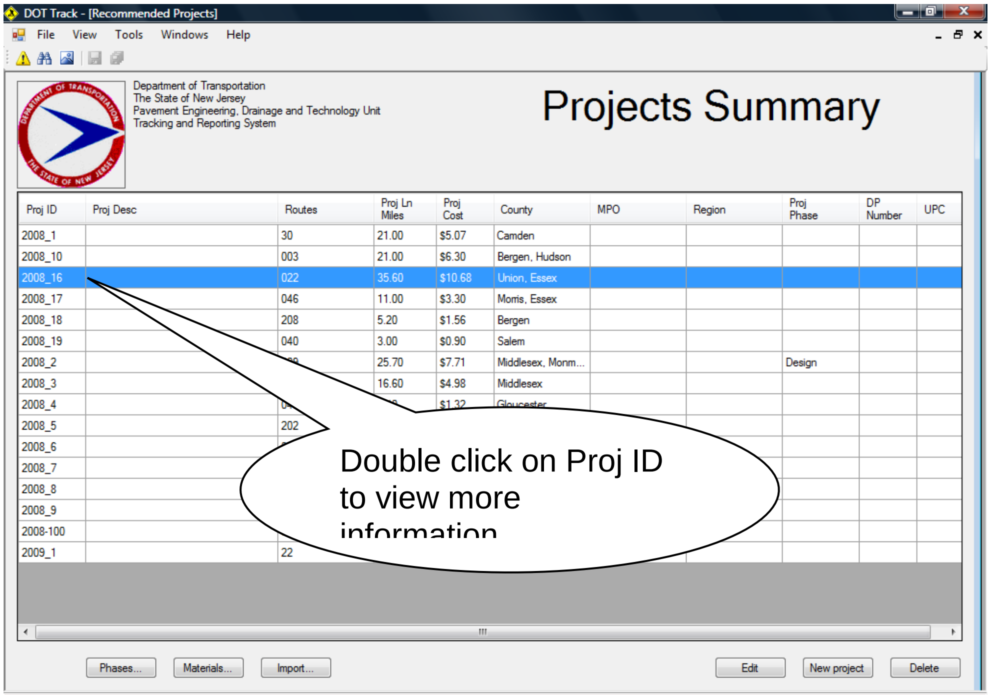


Figure 4 Approved Projects Summary

- <u>To Insert a New Project:</u> Click on the "New Project" button at the bottom of the screen (Figure 4).
- <u>To Edit an Existing Project:</u> Select the project by clicking on the row, or by clicking on the Edit button at the bottom of the screen (Figure 4). Project Information window will pop on the screen (Please refer to Figure 4B in Section 3.3.2). In this window, users can add new road segments as well as change or delete existing information related to a project.
- <u>To Modify the list of available project Phases:</u> Click on the Phases button at the bottom of the screen (Figure 4).
- <u>To Modify the list of available Materials:</u> Click on the Materials button at the bottom of the screen (Figure 4).
- <u>To Import the list of approved Projects and Project Segments:</u> Click on the Import button at the bottom of the screen (Figure 4). Figure 4A will be displayed. Use the "Browse" utility to locate the input files, and press the "Import" of figure 4A. In case of duplicate project or duplicate road segment, the user will be prompted by appropriate error messages and associated records will not be uploaded to the Tracking data base.

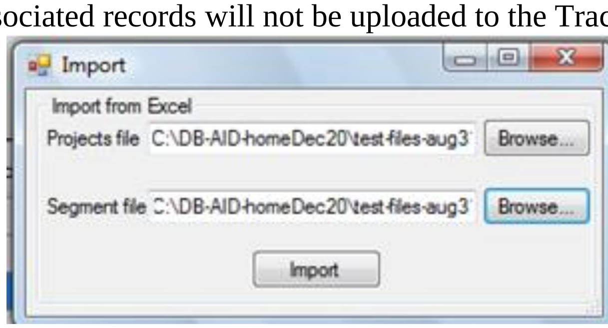


Figure 4A: Import Approved Projects and Segments

- To Delete a Project: Select the project by clicking on the row. Click on the Delete button at the bottom of the screen (Figure 4).

3.3.2 PROJECT AND SEGMENT INFORMATION

The header information at the top of the screen provides a summary of the individual project. The Project Lane-miles, and Project Cost Estimate are a summary of the individual segment lane miles and project cost estimates. Change the lane miles and estimated cost information in the header by modifying the information in the project segments. All other information can be inserted or edited.

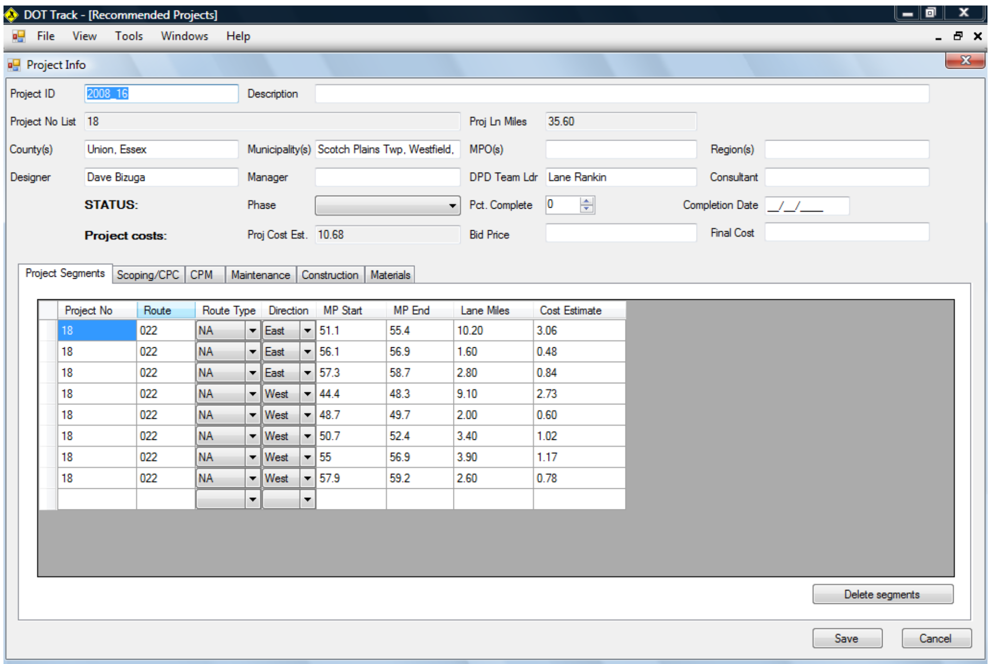


Figure 4B: Project 2008_16 Road segment information

- To Upload the Project Information and Associated Route Segments: From the bottom of the page click on the Import button (Figure 4). Import Window will be displayed in the middle of Project Summary view (Figure 4A). Specify the location of the files and press the import button on the newly displayed window. In case of duplicate project or duplicate road segment, the user will be prompted by appropriate error messages and associated records will not be uploaded to the Tracking data base.
- To Delete a Project Segment: Select the project segment by clicking on the row. Click on the "Delete Segment" button at the bottom of the screen (Figure 4B).

3.3.3 OBTAINING PROJECT INFORMATION

To display complete information with regards to a project, double click on the ProjID in Project Summary Screen.

To acquire more information with regards to a project, let say ProjID 2008_16, double click on the project. Project Info menu will be displayed (figure 4B).

Project Info menu provides comprehensive view of a specific project. In this menu all information pertaining to a project can be altered by the user, except “Project Lane Miles” and “Project Cost Estimate” fields. The value of these fields is automatically calculated and is the sum/aggregate of individual “Lane Miles” and “Cost Estimate” associated with individual route segments.

A new road segment can be added to the project list of road segments or a road segment can be deleted from the list.

3.3.4 PROJECT TABS

Project Information Menu captures information with regards to the various stages as a project traverses within its organizational life cycle. Information regarding the project stage and its progress disposition is captured under one of the Tabs (Scoping/CPC, CPM, Maintenance, Construction) in the Project Information window. Each tab captures a set of fields/attributes pertaining to its nature and all such fields are subject to change and modification.

3.3.4.1 Project Segments Tab

This has been discussed in the section 3.3.2. Please refer to Figure 4B.

3.3.4.2 Scoping/CPC Tab

Jobs that are routed to CPM track will be sent to Scoping for scope definition and CPC (Capital Programming Committee) for budget approval (Figure 4C).

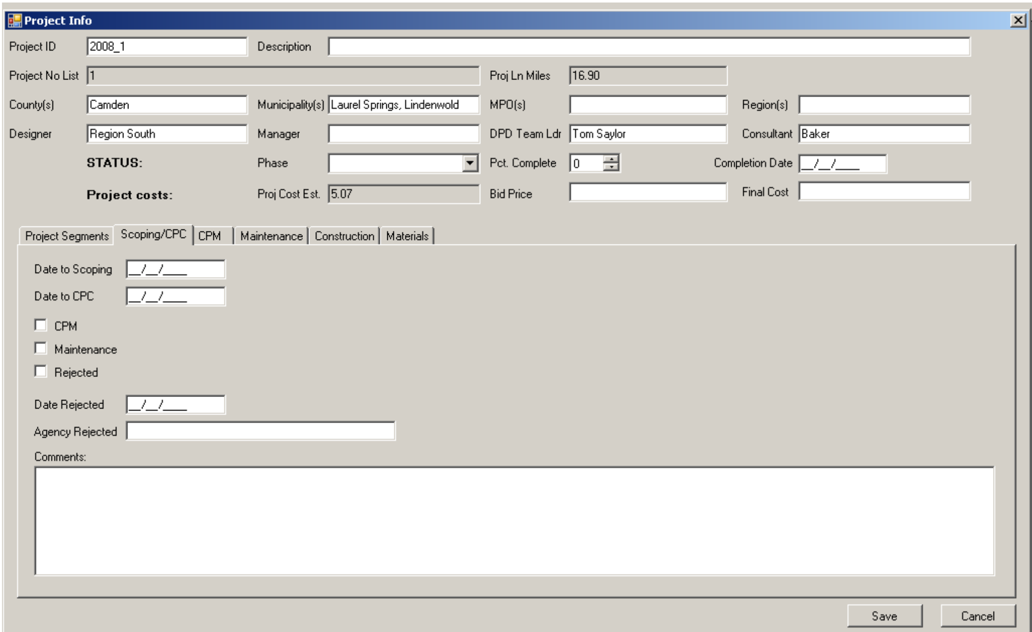


Figure 4C Scoping/CPC Tab

Field-Name	**Field Type**	**Field Description**
Date To CPC	Date	Date that project was sent to CPC
Date To Scoping	Date	Date that project was sent to Scoping
Maintenance	Boolean	Checked if job is sent to Maintenance
CPM	Boolean	Checked if job is sent to CPM
Rejected	Boolean	Checked if job is Rejected
Date Rejected	Date	Date that a project is rejected (if it has been rejected)
Agency Rejected	Char(50)	Name of the agency who rejected the project (Ex, CPC, Scoping..)
Scoping-comment	Comment	Comments inserted by the user with regards to the project while in Scoping/CPC

Table 4.1 Scoping/CPC Fields

3.3.4.3 CPM Tab:

After job graduates from CPC (approved by CPC) then it will be assigned a UPC prior a job reaches the CPM (Figure 4D).

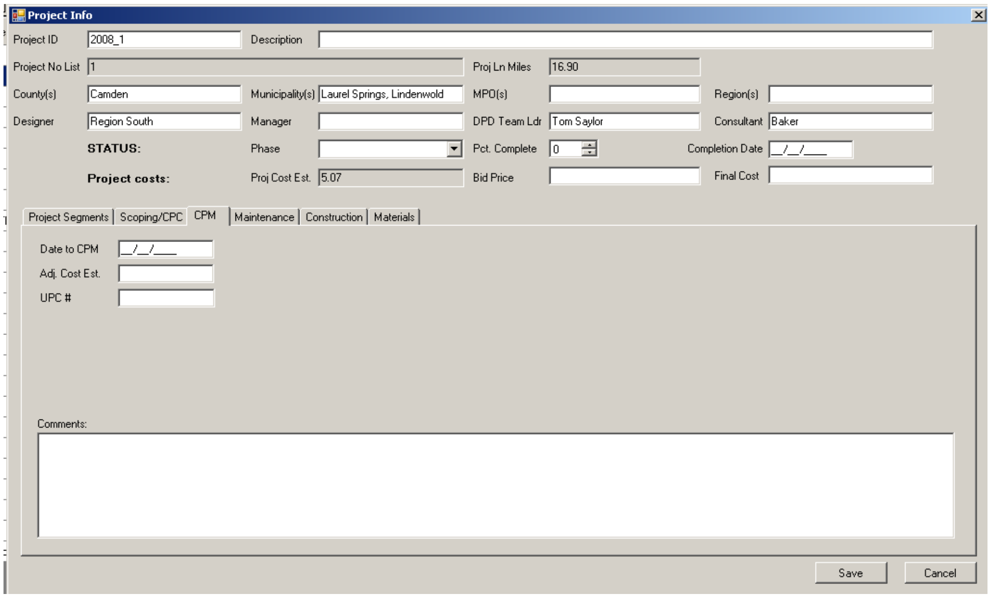


Figure 4D CPM Tab

Field-Name	Field Type	Field Description
Date To CPM	Date	Date that project was sent to CPM
Adj Cost Est	Currency	CPC makes an adjustment to the project cost estimate in reviewed-list. For CPM jobs only
UPC	Char(10)	Universal Project Code #. for CPM jobs only
CPM-Comment	Comment	Comments inserted by the user with regards to the project while in CPM

Table 4.2 CPM Fields

3.3.4.4 Maintenance Tab:

Project which graduate from Pavement Unit either directed to Maintenance or CPM Track.

Those jobs that are directed to Maintenance are required to have MRC or MRRC (Maintenance Contract) numbers (Figure 4E).

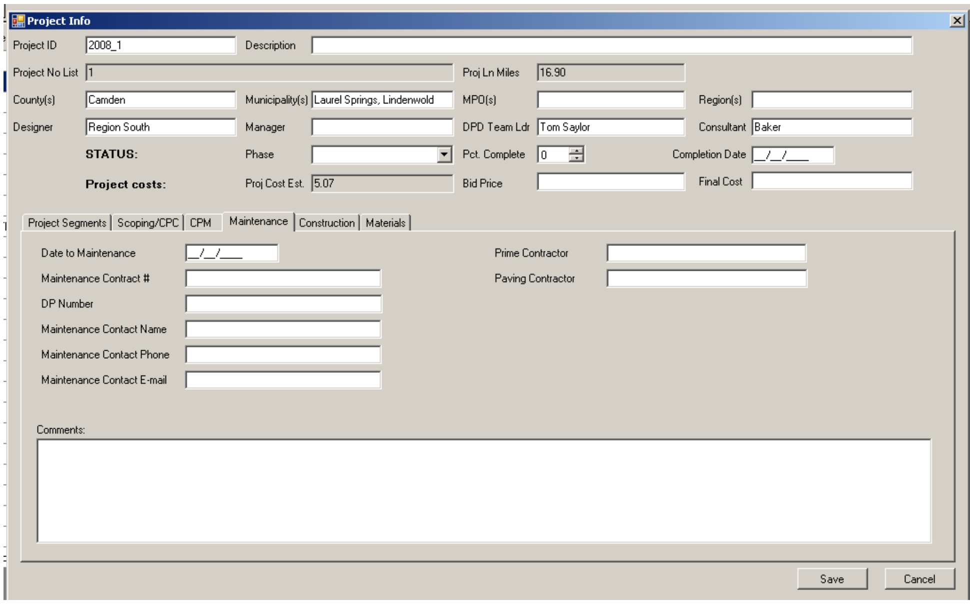


Figure 4E Maintenance Tab

Field-Name	Field Type	Field Description
Date To Maintenance	Date	Date that project was sent to Maintenance
Maintenance Contract Number	Char(8)	Maintenance unique identifier
DP Number	Char(8)	DP number. When a contract is packaged for advertisement then, the contract is assigned a DP#.
Maintenance Contact Name	Char(50)	Maintenance Contact Name
Maintenance Contact Phone	Char(20)	Maintenance Contact Phone#
Maintenance Contact E mail	Char(100)	Maintenance Contact Email
Prime contractor	Char(50)	Prime contractor name
Paving Contractor	Char(50)	Paving Contractor Name
Maintenance Comment	Comment	Comments inserted by the user with regards to the project while in Maintenance

Table 4.3 Maintenance Fields

3.3.4.5 Construction Tab:

Once a project enters the construction phase, the user enters data into the Construction Tab (Figure 4F).

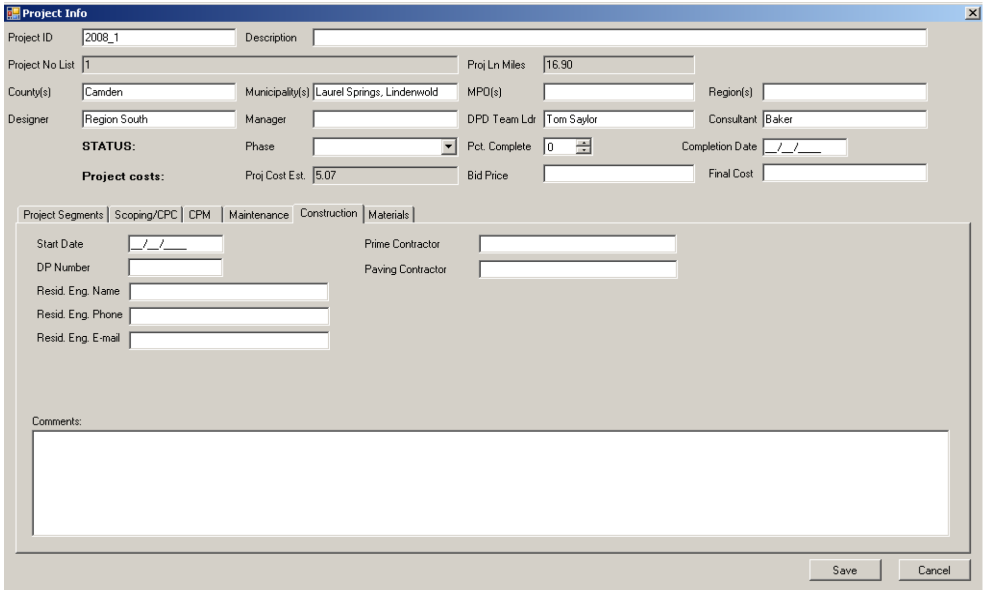


Figure 4F Construction Tab

Field-Name	Field Type	Field Description
Start Date	Date	Starting data of construction
DP Number	Char(8)	DP number. When a contract is packaged for advertisement then, the contract is assigned a DP#.
Resid. Eng. Name	Char(50)	Resident Engineer Name
Resid. Eng. Phone	Char(20)	Resident Engineer Phone#
Resid. Eng. Email	Char(100)	Resident Engineer Email
Prime contractor	Char(50)	Prime contractor name
Paving Contractor	Char(50)	Paving Contractor Name
Construction Comment	Comment	Comments inserted by the user with regards to the project while in Construction

Table 4.4 Construction Fields

3.3.4.6 Material Tab:

This tab tracks of all the material used or will be used in a project. All the material used for a specific project is specified under the Material Tab (Figure 4G).

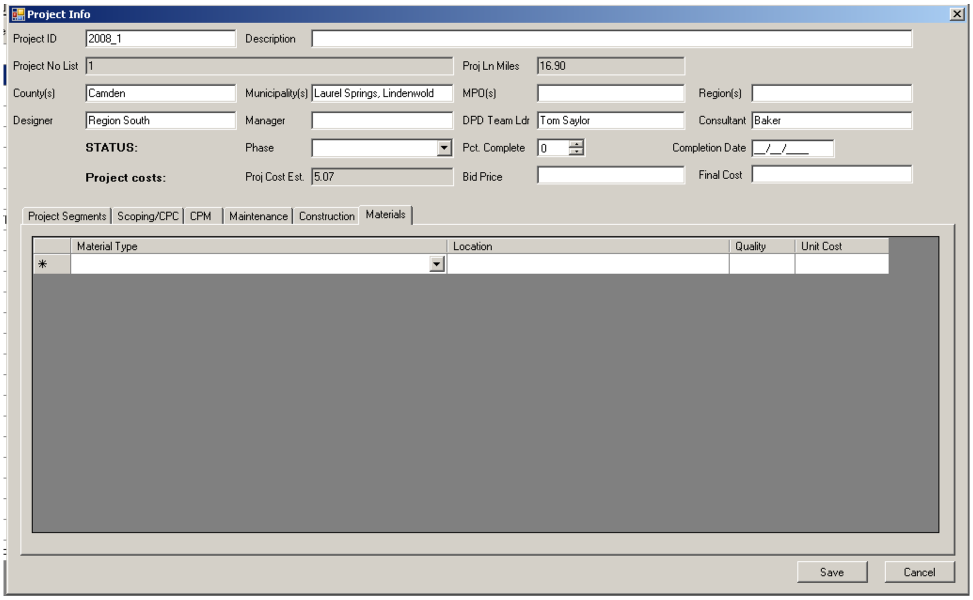


Figure 4G Material Tab

Field-Name	Field Type	Field Description
Material Type	Char(20)	Type of material used. A material ID which uniquely identifies a specific type of material. A drop down menu is used to select a material type
Location	Char(100)	Location that material is used. Consists of Route, Direction, MPS, MPE
Quality	single	Quality of the material used
Unit Cost	Currency	Price of one unit of material

Table 4.5 Material Fields

3.3.5 PROJECT AND SEGMENT DATA INPUT

The project information data and route segment data is uploaded into the Recommended database using the project and project segment Excel input files. The formats for the files are shown below:

Project ID	Designer	Proj Mgr	DPD Team Ldr	County	Municipality	Pavement Screening Consultant
2008_1	Region South		Tom Saylor	Camden	Laurel Springs, Lindenwold Boro, Clementon Boro, Berlin Boro	Consultant1
2008_2	Region Central		Bob Marshall	Middlesex, Monmouth	Sayreville Boro, So. Amboy City, Freehold Twp, Howell Twp	Consultant1, Consultant2
2008_3	Mike Martynenko		Bob Marshall	Middlesex	No. Brunswick Twp, Plainsboro Twp, So. Brunswick Twp	Consultant1
2008_4	Region South		Tom Saylor	Gloucester	Clayton Boro, Glassboro Boro	Consultant1
2008_5	Mike Martynenko		Bob Marshall	Hunterdon	Raritan Twp	Consultant1
2008_6	Region Central		Bob Marshall	Monmouth	Ocean Twp, Eatontown Boro, Wall, Neptune	Consultant2
2008_7	Region North		Lane Rankin	Passaic, Morris	Wayne Twp, Pequannock Twp	Consultant1
2008_8	Region North		Lane Rankin	Sussex	Andover Twp, Newton Town, Hampton Twp, Frankford Twp, Branchville Boro	Consultant2
2008_9	Mike Martynenko		Bob Marshall	Monmouth	Colts Neck Twp, Wall Twp	Consultant2
2008_10	Mike Martynenko		Lane Rankin	Bergen, Hudson	Rutherford, E. Rutherford Boro, Secaucus Town, No. Bergen Twp	Consultant1

Table 4.6: Project Information/Data

Project ID	Project No	Route	Dir(B=Both	MP Start	MP End	Lane Miles	Cost Estimate (Millions)
2008_2	2	009	N	128.0	129.8	4.7	$1.41
2008_2	2	009	S	128.0	129.8	4.6	$1.38
2008_2	5	009	N	111.9	112.4	1.0	$0.30
2008_2	5	009	S	111.7	112.2	1.0	$0.30
2008_2	19	009	N	104.2	104.7	1.0	$0.30
2008_2	19	009	N	106.4	107.2	2.0	$0.60

2008_2	19	009	S	103.4	104.3	1.8	$0.54
2008_2	19	009	S	105.7	110.5	9.6	$2.88

Table 4.7: Project Route Segment

APPENDIX C

401.03.03

J. Ride Quality Requirements. The Department will evaluate the final riding surface using the International Roughness Index (IRI) according to ASTM E 1926. The Department will use the measured IRI to compute the appropriate pay adjustment (PA). The PA will be positive for superior quality work or negative for inferior quality work.

The Department will calculate the PA as specified in Table 401.03.03-7(A) & Table 401.03.03-7(B) and will base PA on lots of 0.01 mile length for each lane, ramp, and shoulder and 0.005 mile for each overlaid bridge structure.

1. **Smoothness Measurement.** The Department will test the longitudinal profile of the final riding surface for ride quality with a Class 1 Inertial Profiling System according to AASHTO MP 11. The Department will not measure locations where the traffic striping includes turn lanes that cause the through traffic lane to cross over a longitudinally paved joint. Ramps and lanes such as acceleration and deceleration lanes of less than 1000′ of continuous through treatment will not be measured. If project conditions preclude the use of the Class 1 Inertial Profiling System, the Department will use a Class 1 walking profiler or lightweight profiler.

   The Department will test the full extent of each wheel path of each lane in the longitudinal direction of travel. The wheel path is defined as being located approximately 3 feet on each side of the centerline of the lane and extending for the full length of the lane. For the purposes of this specification, lanes are defined by striping.

   The IRI value reported for each lot is the average of 3 runs of each wheel path, unless otherwise directed by the Department.

2. **Control Testing.** Perform control testing during material placement to ensure compliance with the ride quality requirements specified in Table 401.03.03-7(A) and Table 401.03.03-7(B).

3. **Preparation for IRI Testing.** Provide traffic control when the Department performs IRI testing. Perform mechanical sweeping of the surface before IRI testing. To facilitate auto triggering on laser profilers, place a single line of preformed traffic marking tape perpendicular to the roadway baseline 300 feet before the beginning and after the end of each lane, shoulder, and ramp to be tested or at the direction of the Department. Submit the actual stationing for each traffic marking tape location to the RE.

4. Acceptance. The Department will determine acceptance and provide PA based on the following:

a. Pay Adjustment. The pay equations in Table 401.03.03-7(A) and Table 401.03.03-7(B) express the PA in dollars per lot of 0.01 mile and 0.005 mile respectively. IRI numbers are in inches per mile. The number of lots for final pay adjustment will be reduced by the number of lots representative of a length equal to the total length of the impediments that are present within the areas to be tested. Lots excluded from final PA will be those with the highest recorded IRI numbers for respective roadway and bridge deck segments. The number of lots to be excluded for each segment is shown in Table 401.03.03-7(A) and Table 401.03.03-7(B).

Impediments include the following:

1. Metal impediments, such as utility covers, manholes, catch basins and inlets, located in the lane and in shoulders within 5 LF of the lane. The exclusion length for metal impediments is 20 LF each.

2. Transverse joints that separate the new pavement from an existing pavement, intersections, railroad crossings, and other features in the pavement deemed by the designer to be a potential impediment to achieving a smooth ride quality. The exclusion length is the length of the feature plus 10 LF before and 10 LF after each feature.

3. Bridge decks, approach slabs and transition slabs on structures which are not overlaid.

****** EXAMPLE EQUATIONS *******

Table 401.03.03-7(A)

	Excluded Lots	**Pay Equation(s) for Pavement Ride Quality for 0.01 Mile**	
Route 00 NB MP 6.3 to MP 7.1 **----------** **Route 00 SB MP 7.1 to MP 6.3**	1 in Lane 1 1 in Lane 2 -------- 1 in Lane 1 1 in Lane 2	IRI < 28	PA = $50
		28 ≤ IRI <48	PA = $120.00 – ($2.50 × IRI)
		48 ≤ IRI ≤ 58	PA = $0
		58 < IRI ≤ 128	PA = (IRI − 58) × (−$7.1429)
		IRI > 128	Remove & Replace
Route 00 SB MP 8.8 to MP 7.3 **-------** **Route 00 NB MP 7.3 to MP 8.3**	1 in Lane 1 1 in Lane 2 ------- 1 in Lane 1 1 in Lane 2	IRI < 25	PA = $50
		25 ≤ IRI < 45	PA = $112.50 − ($2.50 × IRI)
		45 ≤ IRI ≤ 55	PA = $0
		55 < IRI ≤ 125	PA = (IRI − 55) × (−$7.1429)
		IRI > 125	Remove & Replace
Route 00 NB MP 17.9 to MP 21.4 **------** **Route 00 SB MP 21.4 to MP 17.9** **--------** **Route 00 NB MP 8.3 to MP 8.8**	1 in Lane 1 39 in Lane 2 ---------- 1 in Lane 1 26 in Lane 2 --------- 1 in Lane 1	IRI < 41	PA = $50
		41 ≤ IRI < 61	PA = $152.50 − ($2.50 × IRI)
		61 ≤ IRI ≤ 71	PA = $0
		71 < IRI ≤ 141	PA = (IRI − 71) × (−$7.1429)
		IRI > 141	Remove & Replace

	1 in Lane 2		

Table 401.03.03-7(B) – Pay Equation for Overlaid Bridge Deck Ride Quality for 0.005 Mile – Includes length of overlaid bridge deck plus 50' on each end of deck		
Overlaid Bridge Decks on Route 400 Between MP 100.0 and MP 105.5	**MP 102.2 to MP 102.5**	
	IRI = 120	PA = $0
	120 < IRI ≤ 170	PA = (IRI − 120) × (−$5.00)
	IRI > 170	Remove & Replace
	MP 103.5 to 103.8	
	IRI = 120	PA = $0
	120 < IRI ≤ 170	PA = (IRI − 120) × (−$5.00)
	IRI > 170	Remove & Replace

b. **Retest provision.** After testing, if the IRI exceeds the Remove and Replace values (RRV) in Table 401.03.03-7(A) and Table 401.03.03-7(B), and there is definitive evidence that the test is invalid, the Department will disregard the test and will retest.

c. **Removal and Replacement.** If the final IRI is greater than the RRV, remove and replace the lot. Replacement work is subject to the same requirements as the initial work.

If less than 8 percent of paving lots exceeds the RRV, submit a plan for corrective action. If the corrective action plan is not approved by the RE, remove and replace the designated lots. If the corrective action plan is approved and the lots are reworked, the lots are subject to the requirements of section 401.03.03.J Ride Quality Requirements except the lots are not eligible for positive PA. The RE may allow the lots to remain in place and apply the pay adjustment as computed in Table 401.03.03-7(A) and Table 401.03.03-7(B).