Pavement Management Manual

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(Updated Annually)

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For the Pavement Management Unit
Materials and Geotechnical Branch

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Executive Summary

The goal of the Colorado Department of Transportation's (CDOT) Pavement Management Program is to provide the Regions with tools that optimize the use of public dollars and assist in project selection for the purposes of maintaining and improving overall system quality.

The Pavement Management Manual documents the criteria, procedures, and processes that are used by the Pavement Management Program to achieve the goal and to provide the following annual deliverables, to be used by the Colorado Transportation Commission, CDOT Executive Management Team, Regional Transportation Directors, as well as other CDOT departments:

- Statewide Surface Condition Reports (to include Good/Fair/Poor maps)
- Future Surface Condition Projections
- Project Recommendations
- Regional Budget Allocation Recommendations
- Annual Pavement Management Report
- Annual Preventive Maintenance/Surface Treatment Report

The manual also describes the roles and responsibilities of staff in both the Headquarters Staff Materials Pavement Management Section and the Region Materials Sections. Through the Pavement Management Technical Committee, ideas are exchanged and specific issues are discussed and resolved utilizing task forces. Several task forces meet on as-needed and/or recurring basis, and include participation from the Staff Pavement Management Program, Region Materials Engineers, and Region Pavement Managers.

1 INTRODUCTION

1.1 Updates for 2008

- Addition of an *Executive Summary*.

- Section 1.4 *Pavement Management Controlling Documents* added. This section defines the hierarchy and precedence of various Pavement Management documents.

- Clarification added to Section 4.5 regarding preventive maintenance's impact on RSLs.

- Added language to Section 4.7 that explains the Good/Fair/Poor Map review cycle.

- Removed the Definition of a Project Match from the appendices.

- Added Section 9.3, Staff Services and Regions. This section defines the rolls of Staff Services and the Regions.

1.2 Limited Historical Perspective (1998-2008)

It was a dark and stormy night in 1998 whereas, The Pavement Management responsibilities were transferred from the Research/ DTD branch to Staff Materials of the Colorado Department of Highways. Here the Overall Pavement Index (*OPI*), Remaining Service Life (RSL) and Pavement Management models were implemented. Deighton, the chief math modeling consultant, was brought on board to assist in the loading and analysis of data. Prior to Deighton, Quantum was the database vendor.

Prior to 1999, the Pavement Management Program (*PMP*) operated under the auspices of the Materials and Geotechnical Section. Directing the *PMP* were three distinct committees consisting of a Steering Committee, a Technical Committee, and the Materials Advisory Committee. The Steering Committee disbanded from lack of participation from its membership. In 1999, each of the Regions were asked to designate a Pavement Management Engineer. Each Pavement Management Engineer serves on the Technical Committee which functions with oversight from the Materials Advisory Committee. The Technical Committee is described in more detail in Section 9.1

In April 2002, a 70% matching criteria was implemented as core service performance criteria. This measure lent legitimacy to the PMS. The tools were being utilized to recommend surface treatment projects and to aid selection at a level beneficial to the Regional Materials Engineers (*RME*). The recommendations maximized the effectiveness of the funds available in a climate of never ending needs. The residual 30% still allows the *RME*s the flexibility to make necessary decisions based upon engineering judgment as well as the political realities of their region.

Policy Memo 18 (2003) dedicated 5% of the surface treatment funds to preventative maintenance. Being a minimum requirement, this guaranteed 5% of the resurfacing budget would be dedicated to preventative maintenance treatments where the greatest good could be derived. It is theorized that a 4:1 to 10:1 return is realized by this action.

The Pavement Management Program comprised of Staff and Regional personnel have labored through the last decade to produce numerous empirical and mathematical models. These efforts attempt to accomplish a model that mimics the status of Colorado roads and highways. The weighted affects of ride, rut, cracking and other criteria are reduced to a measure of residual life. Models such as OPI have yielded to RSL. In (2008) we have Scenario 6 which focuses on apparent age to rate the system of highways. One could say this is a virtual age as opposed to actual age.

The Pavement Management System (*PMS*) as currently utilized, allows examination of multiple funding scenarios by administrators and political divisions. The system lends advice and repercussions for both funded and do nothing options. This makes the system a political necessity where funds are scrutinized and transparency is demanded.

For historical perspectives other than recent CDOT, see *http://www.tfhrc.gov/pubrds/julaug98/pavement.htm*.

1.3 Purpose

The purpose of this manual is to document the processes that the PMP conducts annually. These products include:

- Condition Data (approved by July Technical Committee)
- Provide *Condition Data Quality Assurance Review* report.
- Investigate and report the *Remaining Service Life Field Investigation*.
- Pavement Management Manual updates.
- Good/Fair/Poor Maps and Graphs (completed end of August)
- Project Recommendations / Percent Project Matching (completed 1st week in December / April Technical Committee)
- 20-Year Network Projections (See Policy Memo #20)
- Regional Budget Allocation Recommendations (See Policy Memo #19)
- Annual Pavement Management report.
- Annual Preventive Maintenance/Surface Treatment report.

1.4 Pavement Management Controlling Documents

The Pavement Management Program will be governed by the appropriate CDOT Procedural and Policy Directives, Chief Engineer Policy Memos, and the current approved version of the Pavement Management Manual. The order of precedence is such:

1. Procedural and Policy Directives
2. Chief Engineer Policy Memos
3. Pavement Management Manual

In the event that there is a discrepancy between documents on the same level of precedence, the Pavement Management Program Manager will make an interim decision on how to proceed until the discrepancies can be discussed with the Pavement Management Technical Committee. The Technical Committee will make appropriate changes in the documents and elevate the documents to the proper signature levels.

2 CONDITION DATA (FEBRUARY – JULY)

2.1 Annual Condition Data

The PMP collects annual condition data for every highway on the CDOT's network. Condition data collection begins in January and finishes in June. These efforts date back to 1991 and old databases are archived for historical and research purposes. Condition data includes an inventory of every pavement crack, the rutting depth for every highway, the International Roughness Index (IRI) for every highway, pavement types, and various forms of shoulder observations. All pavement distresses are reported in 1/10-mile increments and are collected in accordance with the *Distress Identification Manual for the Long-Term Pavement Performance Project* (FHWA

2003), which subcategorizes all cracking distress into severity levels of low, moderate, and high. See Appendix A for a comprehensive list of condition data collected for the PMP.

As condition data is collected in the field, a continuous highway image log is also collected. Pictures of the windshield view, as well as left and right shoulder views, are collected every 26-feet. When the shoulder pictures and windshield pictures are aligned properly, a 120-degree panoramic view of the highway is created. In addition to these pictures, pictures are taken of the highway surface itself. The surface photos are taken every 5-feet and are stitched together to create a complete and continuous image of the data collection lane. From these pavement images, all cracking distress is categorized and catalogued. All highway images are high-resolution digital jpegs.

For all two-lane highways (one lane in each direction), the primary (or increasing milepost) direction is collected one year and the secondary (or decreasing milepost) direction is collected the following year. This biennial cycle allows for roadway data that adequately characterizes the overall road condition while highlighting variances between the primary and secondary directions. For all four-lane highways (two lanes in each direction), the far right lane is collected in both directions. For instances when a direction takes up a third or fourth lane, data collection remains in the second lane from the right, excluding any on/off ramps or continuous acceleration/deceleration lanes. When a concrete gutter pan extends into an asphalt driving lane, data collection is performed in the next lane over. Truck climbing lanes are not counted when determining which lane is the data collection lane. These basic guidelines ensure that larger highways are represented consistently in both directions every year. By restricting data collection to the same lane from year to year, the pavement degradation is reported with more consistency. This leads to better historical records of roadway deterioration and better predictions of future conditions. Jumping from one lane to another from year to year will not reveal the natural, progressive breakdown of the road. These rules define an economical and representative approach to determining how much of Colorado's highways need to be rated.

The annual condition data is received and loaded into the PMP software the last week of June.

2.2 Quality Assurance

All condition data results are verified via both office and field reviews. The in-office quality control includes reviewing the digital pictures for clarity and ID flag/counter continuity. The condition data is also compared side-by-side with the pavement images to insure that cracking information has been reported accurately. While the highway images are being spot checked, the raw condition data is also being processed and checked via a computer program developed internally by the PMP. The computer program checks for items such as duplicated records, missing roadway segments, wrong highway limits, missing highways, wrong pavement types, highways not in the network, and wrong raw data values. Furthermore, once the in-office spot checks are complete, PMP conducts field reviews of the condition data with the Regional Pavement Mangers. The field reviews include a detailed recording of amounts of cracking as well as severity of each crack. The field data is then compared with the condition data generated from the pavement images for consistency. If a major discrepancy is found between the data received for the vendor and that recorded by PMP in the field, the PMP will make adjustments to the vendor's data to insure that the most accurate information is being loaded into the pavement management software. A more detailed explanation of the quality control efforts made by the

PMP is identified in the *Quality Assurance Protocol for Verifying Pavement Management Condition Data* (Appendix B). The results of the quality assurance/control efforts are reported three weeks after the final delivery of the condition data is received.

In summary:

- Party Responsible for Deliverable: Condition Data Collection Contract Manager and Regional Pavement Managers
- Deliverable: *Condition Data Quality Assurance Review*
- Due Date: Prepared and ready for the July Technical Committee
- Deliverable Location: Pavement Management Program's Internal Website.

2.3 Data Access

The amassed data illustrates the current state of the roadway system and is delivered to the Department of Transportation Development (DTD) for inclusion on CDOT’s intranet. Once posted on DTD’s website all CDOT employees have the capability of retrieving current condition data for any segment of Colorado’s vast highway network. Each CDOT employee also has the ability to access the most recent two years of videolog jpegs via a program called VisiData. Archived highway image inventory older than 2-years is maintained by the Traffic and Safety Group. This program can be obtained by contacting the Information Technology Office and requesting installation.

In summary:

- Party Responsible for Deliverable: Contracted Data Collection Vendor (Currently Roadware Group.)
- Deliverable: Annual Roadway Condition Data
- Due Date: Collected and Processed from February to June
- Deliverable Location: The raw condition data can be acquired by contacting the PMP. VisiData can be acquired by contacting ITO.

3 PROJECT INVENTORY DATABASES

Successfully managing CDOT's highways requires a comprehensive list of maintenance, resurfacing, and reconstruction projects across the state. Each Region's Pavement Manager maintains a database that includes all projects performed on all of their highways for as far back historically as records allow. Every year during data collection season (April through June) the Regions send their maintenance databases to the HQ Pavement Management Program(PMP). The HQ PMP then imports all records into the Pavement Management software. Guidance on managing Project Inventory Databases includes:

- Regions to send their updated inventories to HQ including all Projects that already started or scheduled for the current year construction season.
- If the project Completion Date is unknown, the default date may be entered as 12/31 of the current year.
- At the beginning of each year HQ will provide theRegions with the previous year Project Inventory Database.
- Any changes and additions must be entered in this database and submitted to HQ by the established deadline, typically in May.
- The inventory database contains four tables: BAMS_Prj, BAMS_Mtc, Prj_WT and Mtc_WT.
- BAMS_Prj table contains projects with pavement depth >= 2in.
- Projects considered as design projects with pavement depth < 2in may be entered in this table as well.
- BAMS_Mtc table contains only maintenance projects with depth < 2in.
- Two reference tables Prj_WT and Mtc_WT contain four letter work type codes for construction and maintenance activities.

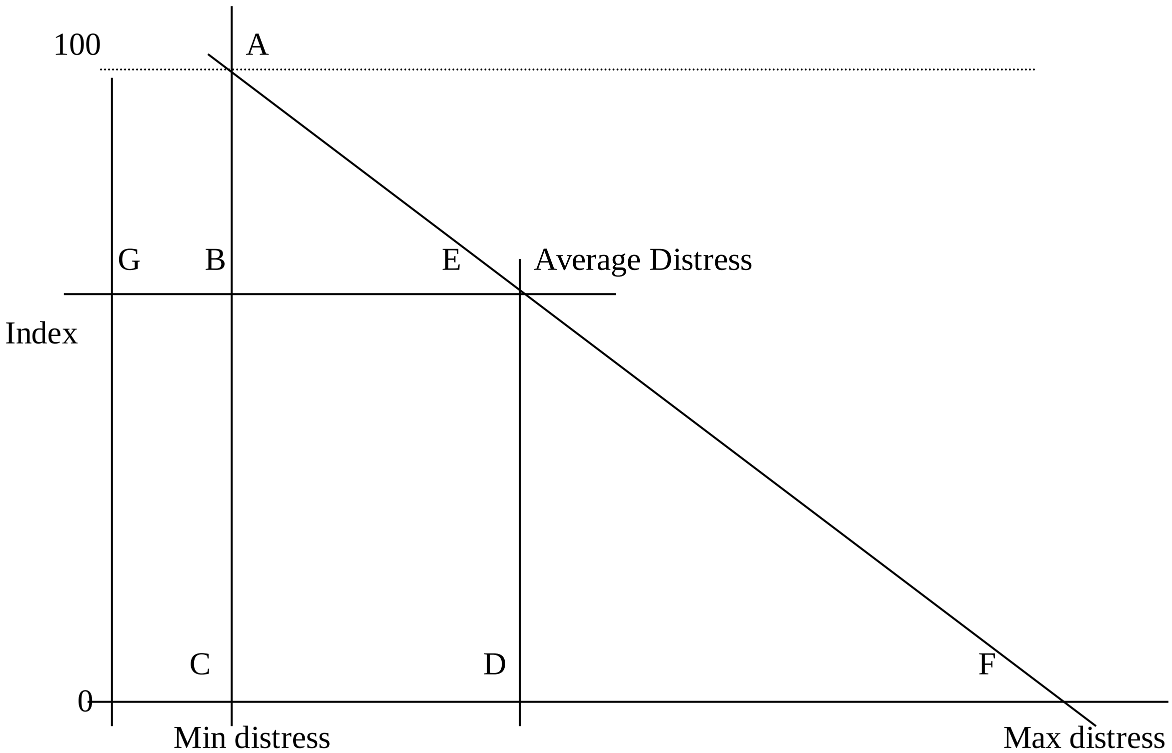
In summary:

- Party Responsible for Deliverable: Regional Pavement Manager
- Deliverable: Region's Project Inventory Database
- Due Date: Delivered to HQ PMP in May.
- Deliverable Location: All Project Inventory Databases from the Regions are loaded into the Pavement Management software and can be accessed as such. Additionally, the most current Project Inventory Database for any Region can be obtained from the Region's Pavement Manager.

4 GOOD/FAIR/POOR SUMMARY (JULY - AUGUST)

4.1 History of how RSL is calculated

On an annual basis the PMP reduces the raw condition data into a series of reports and maps classifying CDOT highways into one of three condition categories, Good, Fair, or Poor. To arrive at the Good/Fair/Poor classifications, the current raw condition data (IRI, rut, fatigue cracking, transverse cracking, longitudinal cracking, and corner breaks) is first manipulated through equations and normalized into an index value on a scale of 0 to 100, where 100 indicates a pavement free of distress. The general form of the individual index equations is based upon similar triangles as follows:



By similar triangles:

AB / AC = BE / FC

Substituting value definitions:

(100 – Index) / 100 = (Average distress – Min distress) / (Max distress – Min distress)

Solving for index:

Index = 100 – [(Average distress – min distress) * 100] / (max distress – min distress)

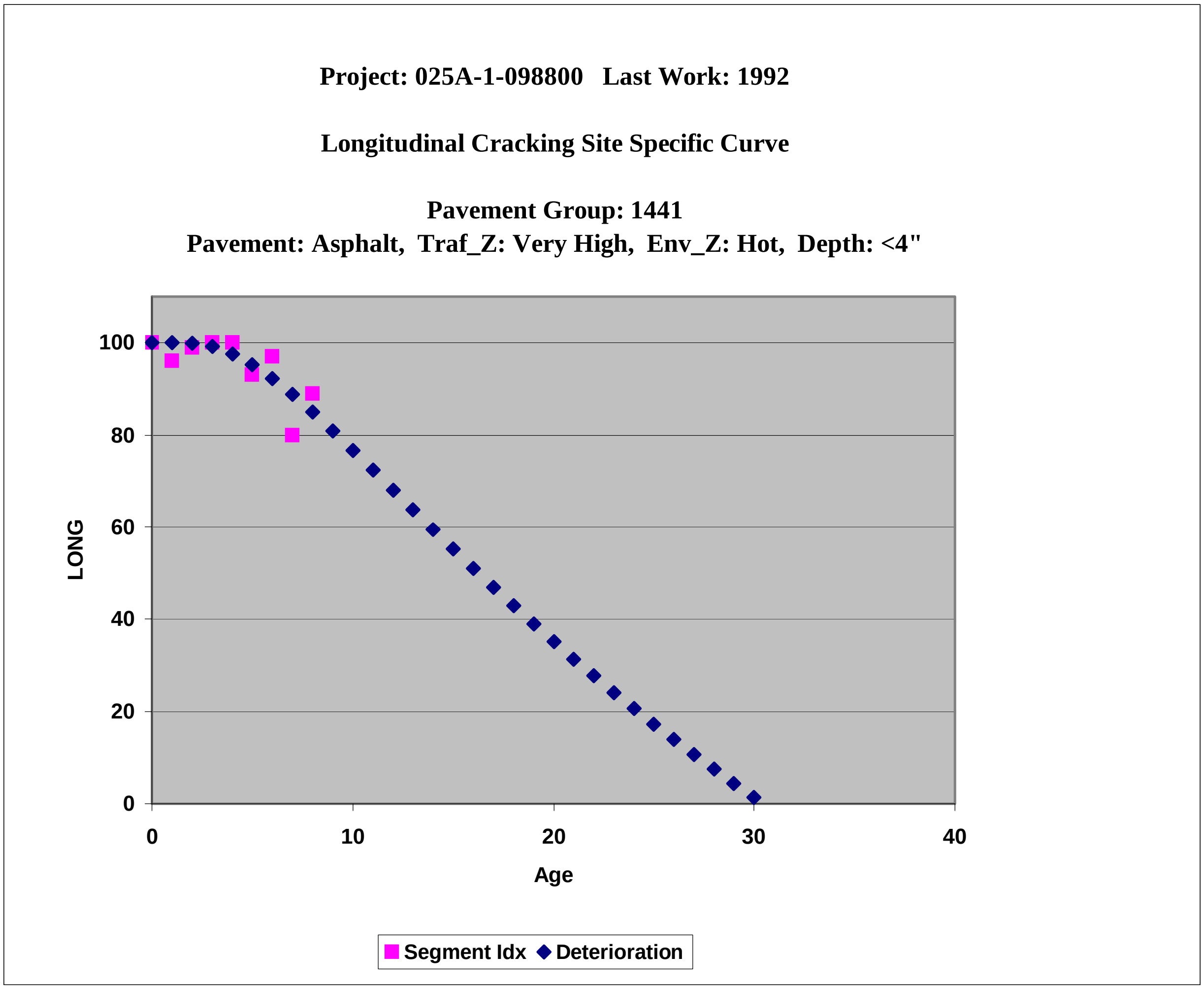
Where:

Average distress is the average of raw data for the selected segment.
Min distress is the statewide minimum raw data.
Max distress is the statewide maximum raw data.

These index values are then loaded into the Pavement Management Software, which compiles all of the data and generates performance curves for all CDOT highways. From these regression curves the software models the life and deterioration of the pavement. A performance curve is required for each distress type. The performance curve models the deterioration of the index value for a specific distress versus time. There are three levels of performance curves, site-specific, pavement family, and expert opinion curves. The most desirable of these is the site-specific curve, however, if one is not available a pavement family curve will be used, and if a pavement family curve cannot be generated then the default curve will be assigned.

4.2 Site-Specific Curves

Site-specific curves are generated on a project segments basis, the length of which can range from 0.5 mile to 5 miles. Site-specific curves are the most desirable form of performance curves because they inherently address the infinite number of variables for the unique stretch of road. These curves are regressed using historical index values for the road section. For site-specific regression, there must be at least 5 years of historical data (index values need to be greater than zero) available since the last rehabilitation or the site-specific curve cannot be used. Moreover, any section whose index standard deviation is greater than 10 is automatically assigned a family curve. If the site-specific regression is being performed, the user must specify the minimum acceptable coefficient of regression (R^2, current value = 0.5) for the curve. If the desired coefficient of regression cannot be attained, the site-specific curve is not used. The ultimate goal for the pavement management system is to have a unique performance curve for each index on each project section. This goal is often not fully attainable, as there are many factors that influence the performance index and raw data for each section. Below is an example of a site-specific curve:

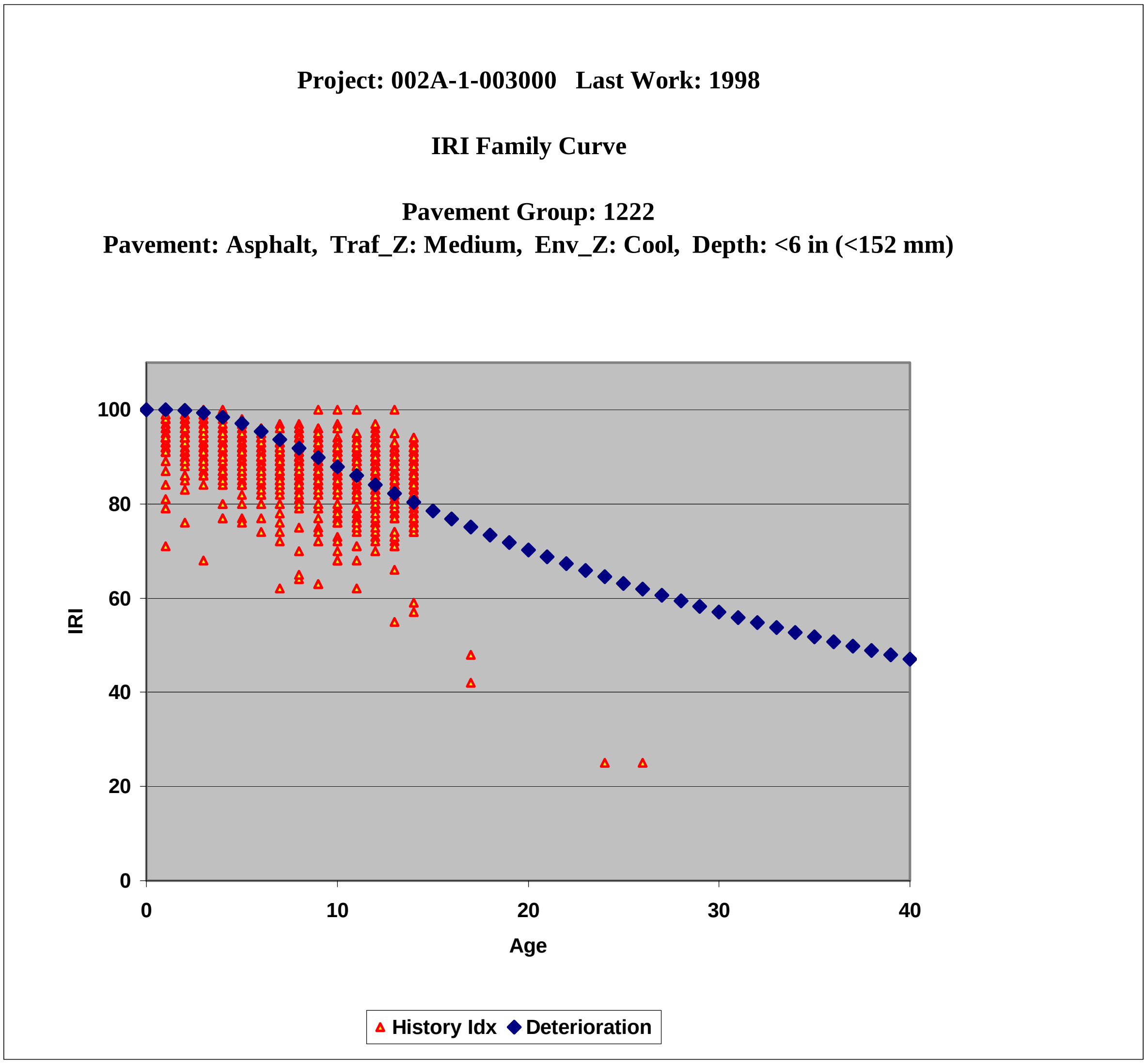


4.3 Family of Curves

When site-specific curve criteria cannot be met the system will check for a pavement family curve. Pavement families are used to group pavements together that have similar characteristics. Pavements that have similar composition, traffic patterns, climate, and thickness generally have the same performance. CDOT uses the following criteria to define the family curves:

- Pavement type (asphalt, asphalt over concrete, concrete, concrete over asphalt)
- Traffic (low, medium, high, very high, very very high)
- Climate (very cool, cool, moderate, hot)
- Pavement thickness (Asphalt: 0 – < 4 inches, 4 – < 6 inches, and >= 6 inches) (Concrete: pavements < 8 inches and >= 8 inches)

For example, all asphalt pavement sections with high traffic, cool climate, and an existing thickness between 0 – < 4 inches will be grouped together as a family. Theoretically these sections should perform similar to one another. Using these variables allows for 200 pavement families. Similar to site-specific curves, pavement family curves are regressed from individual distress index values that are separated per pavement family. Within the pavement family regression module, any pavement sections with an invalid year of last work or age will be excluded from the family regression. This means that the points are not used; this does not mean that a family performance curve will not be regressed. If the number of points for any family is less than or equal to 9 after the points have been reduced, a family curve will not be generated. Below is an example of a family of curves:



4.4 Default (Expert Opinion) Curves

When neither site-specific nor pavement family regression curves are available, a default curve is assigned. Default curves are based upon the same pavement family criteria mentioned above, which means 200 default curves have been established. Default curves are not regressed from data, but are derived from the expert opinion as to how individual pavement groups will deteriorate. Because default curves are based on expert opinion they are the least desirable performance curve; however, in cases of inconsistent or lacking data default curves must be used.

4.5 Calculation of RSL

Once a pavement segment has been assigned a performance curve, a threshold age can be determined for each distress type and the RSL can then be calculated. The threshold age is the age at which the only cost-effective pavement treatment is reconstruction. Knowing that pavements require reconstruction at an index value of 50, the threshold age can be determined from the regression curves. In the previous illustration (Project: 025A-1-09800, Section 4.2), the site-specific performance curve deteriorates to an index value of 50 at year 16; hence, the threshold age is 16 years. The RSL is the difference between the threshold age and the current age of the pavement. If the pavement is 9 years old then the threshold age minus the current age yields an RSL of 7 years.

For a particular asphalt pavement segment an RSL is determined for each of these distresses: IRI/ride, rutting, fatigue cracking, longitudinal cracking, and transverse cracking. For a particular concrete pavement, RSLs are determined for each of these distresses: IRI/ride, rut, longitudinal cracks, transverse cracks, and corner breaks. At this point the RSL is adjusted based maintenance activity was performed in the past year. If the depth of the treatment is less than 1-inch, the RSL will be increased by one year, otherwise two years. The final RSL for the particular segment is reported as the lowest of the individual distress RSLs are rounded to the nearest whole number. Next, the RSLs are grouped into categories:

- >10 years RSL is Good
- 6-10 years RSL is Fair
- < 6 years RSL is Poor

Poor pavements with an RSL of zero or less are placed into a special poor category which is referred to as “RSL-0”.

4.6 RSL Quality Control and Quality Assurance

Quality control and quality assurance measures are taken at each step of the RSL process in order to ensure reasonable RSLs and Good/Fair/Poor ratings. These efforts include field review of Region-selected projects and field review (or VisiData review) of randomly selected projects for each Region. The *Quality Assurance Protocol for Verifying Pavement Management Remaining Service Life*, which details the steps involved in field-reviewing RSLs, can be found in Appendix C. Furthermore, *Tracking Year to Year Changes in Remaining Service Life (RSL)*, documents the in-house process that headquarters follows to ensure that the annual changes in RSL are accurate and consistent before the results are distributed to the Regions. (See Appendix F).

In summary:

- Party Responsible for Deliverable: Headquarters Pavement Manager and Regional Pavement Managers
- Deliverable: *Remaining Service Life Field Investigation Summary Report*
- Due Date: Prepared and ready for the August Technical Committee
- Deliverable Location: Pavement Management Program's Internal Website.

4.7 Good/Fair/Poor Results

The Good/Fair/Poor results are displayed graphically in map form and sorted by system type (i.e., overall network, National Highway System [NHS], Interstates, and other). These reports are presented to the Transportation Commission and EMT to illustrate the current conditions of the CDOT highway system.

The annual production of the Good Fair Poor (GFP) maps is an iterative process between HQ Pavement Management Program (PMP) and the regions. The process has three rounds of review:

Round 1- The PMP delivers 1st draft of GFP maps to the region pavement managers during the 3rd week of July for initial review and comment. The PMP makes appropriate changes identified and submitted by the regional pavement managers and reloads and reruns the model. The review period is approximately 2 weeks and is intended to reconcile approximately 90% of required modifications.

Round 2- The PMP delivers the revised GFP maps to region pavement managers and RMEs at approximately the end of July of each year for second round of review. This is the final opportunity for regions to submit their recommended changes that require the model to be reloaded. This review period is approximately one week and is intended to address the remaining 10% of required modifications.

Round 3- The PMP delivers the Draft-"Final" Maps to regions for final review/comment by Region Management Staff during the 2nd week of August. If there are changes, accompanied with acceptable supporting documents, those changes will be made on the map only. Any changes made during this period are made by changing the colors on the maps of the affected areas; this process is called painting. The PMP reviews painting requests on a case by case and either makes the recommended changes or responds to the regions in the comment resolution form attached to the final GFP maps. This review period is approximately one week.

The GFP Maps are approved by the PMTC by e-vote at the end of August. Final GFP maps are presented to the Region Transportation Directors (RTD) at the September RTD meeting and to the Transportation Commission (TC) at the September TC meeting.

The Final maps approved by the RTD's and TC are maintained by the PMP. Regions have the ability to generate their own versions of the GFP maps for their presenting purposes.

The Transportation Commission has identified an overall network goal that 60% of all CDOT highways be rated Good or Fair (G/F). Additional goals include 85% G/F for Interstate Highways, 70% G/F for highways on the National Highway System (NHS) not including Interstate Highways, and 55% G/F for all other highways. The Good/Fair/Poor maps and reports are used to determine whether CDOT is progressing toward or regressing away from these goals.

Additionally, these analyses are performed on a Regional basis and distributed to the Regional Pavement Managers (RPM), Regional Material Engineers (RME), and Regional Transportation Directors (RTD). When developing their resurfacing strategies and projects, the Regions use these Good/Fair/Poor maps and reports as an additional tool. The maps and reports are sent to the Transportation Commission in September.

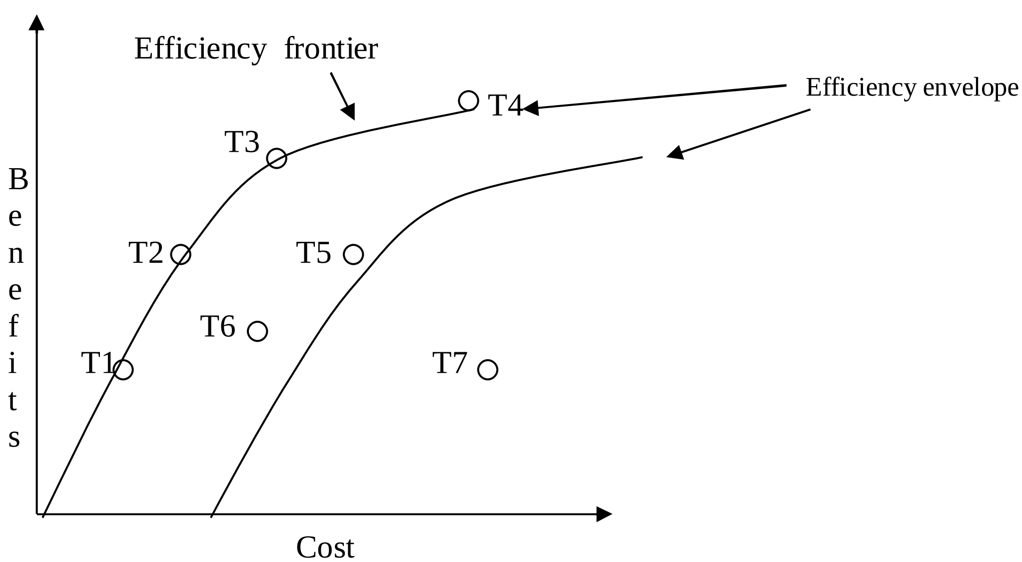
In summary:

- Party Responsible for Deliverable: PMP/Regions
- Deliverable: Good/Fair/Poor Maps and Graphs
- Due Dates (PMP Manager to coordinate PMP schedule to meet the following approval milestones):
    - Technical Committee Ratification by the third Thursday in August.
    - PMP Manager to transmit Maps and Reports to Director of Staff Branches in time for the September RTDs' Meeting, so that the RTDs, the Chief Engineer, the Chief Financial Officer, and the Director of DTD can approve the maps and reports.
    - PMP Manager to transmit approved Maps and Reports to the Transportation Commission office to be included in the September Transportation Commission Mailing so that the Maps and Reports can be presented at the September Transportation Commission Meeting for Transportation Commission Approval.
- Deliverable Location: CDOT's internal website, Policy Memo #02

5 PROJECT RECOMMENDATIONS (NOVEMBER – DECEMBER)

5.1 Benefit/Cost Calculation

After the data has been loaded into the pavement management software and the Good/Fair/Poor percentages calculated, PMP then uses the Deighton Associates dTIMS software to generate a list of resurfacing recommendations or strategies for each region. To generate these lists, PMP annually reviews and updates costs, benefits (added RSL), and triggers for each surface treatment. The PMP software then uses a heuristic optimization technique called Incremental Benefit Cost (IBC). Deighton defines the IBC as, "…the ratio between the increase in benefit to the increase in cost between successive strategies." (Deighton 1998). The IBC's goal is to select the strategies that maximize the user-defined benefit to the entire statewide network while not exceeding the budget available. A simplified example of the IBC analysis is shown below:



5.2 Project Selection Process

A list of possible strategies (T1-T7) is generated and plotted based on the cost and associated benefit for each strategy. The upper most strategies on the graph are joined together with a segmented line. Each segment is drawn by starting at the do-nothing strategy, located at the origin, segments are created in such a way that no strategy points exist above the line and no line segment has a bigger slope than the previous segment. This segmented line is called the Efficiency Frontier. The slope of each successive line segment is called the incremental benefit cost of going from one strategy to the next. The recommended strategy will most likely fall on the Efficiency Frontier because the treatment will have the highest benefits for the lowest cost. Furthermore, a second parallel line can be plotted to create the Efficiency Envelope. Deighton defines the Efficiency Envelope as, "The efficiency envelope is used… to expand the efficiency frontier. Without an efficiency envelope only the strategies on the efficiency frontier would be used in selecting strategies during optimization…"(4) Currently CDOT has selected an Efficiency Envelope of 10%. An example of the strategy selection process is located below:

Highway	IBC	Benefit	Cost (thousands)	Treatment
1	0.18	18	100	T3
2	0.16	12	75	T2
3	0.14	7	50	T1
1	0.10	20	200	T4
4	0.10	12	125	T5
2	0.09	9	100	T6
3	0.04	8	200	T7

1. An agency has a budget of $500,000.

2. All of the acceptable strategies for the network are sorted from highest to lowest IBC.

3. The strategy with the highest IBC (T3 = 0.18) is evaluated first. Does the agency have enough budget to support this strategy? If the answer is yes, the strategy is recommended for HWY 1 and the cost is deducted from the budget. Revised Budget = $400,000.

4. The next highest IBC (T2 = 0.16) is evaluated. Since there is enough money remaining in the budget T2 is recommended for HWY 2 and the cost is deducted from the budget. Revised budget = $325,000.

5. The next highest IBC (T1 = 0.16) is evaluated. Since there is enough money remaining in the budget T1 is recommended for HWY 3 and the cost is deducted from the budget. Revised budget = $275,000.

6. The next highest IBC (T4 = 0.10) is evaluated. Because both T3 and T4 are possible strategies for HWY 1 and since T3 has already been recommended T4's benefit is evaluated first. If T4's benefit (20) is higher than T3's (18), T4's cost is then reviewed; if T4's benefit was lower the strategy would be rejected and the next strategy is reviewed. Since the revised budget is $275,000 and T4 costs $200,000, T4 will be selected for HWY 1 because the benefit is higher than T3 and there is still enough money in the budget to perform this strategy. The revised budget = $275,000 - $200,000 (T4) + $100,000 (T3) = $175,000.

7. T5 for HWY 4 is next to be recommended. Revised budget = $50,000.

8. T6 for HWY 2 is compared against T2 that has already been recommended for this same highway. Since the benefit for the previously recommended strategy T2 (12) is higher than T6 (9), T6 is rejected and the budget remains $50,000.

9. T7 for HWY 3 is compared against T1. The benefit for T7 (8) is greater than T1 (7) therefore, the cost of T7 is reviewed against the current budget. Since the cost of T7 ($200,000) is greater than the current budget ($50,000) T7 is rejected and T1 remains the recommended strategy for HWY 3.

10. Thus, the recommended strategies would be T4 for HWY 1, T2 for HWY 2, T1 for HWY 3, T5 for HWY 4, and a remaining $50,000 in the budget.

11. The process continues until all of the budget is spent.

Furthermore, project recommendation lists are also used to determine the percentage of project match as required by the Chief Engineer's Objectives. Each region creates a multi-year construction plan using various sources of information including the PMP project recommendations. The regional construction plan is then compared to the PMP list of project recommendations to determine the percentage of project matching. The current goal of the Chief Engineer is that 70% of the projects on a region's construction plan match recommendations generated via the PMP software (see Policy Memo 10). Pavement Management annually reviews and updates the rules and assumptions that outlines how a project match is determined. The lists of project recommendations are distributed to the regions by from December to April, depending on the individual Region's needs, and the Technical Committee votes to accept the percent of projects matching at the June meeting.

In summary:

- Party Responsible for Deliverable: PMP/Regions

- Deliverable: Project Recommendations / Percent Project Matching

- Due Date: Project recommendations delivered to RPMs mid December. PMP Technical Committee approval of percent project matching at May Technical Committee meeting, percent project matching delivered to Chief Engineer end of June.

- Deliverable Location: Regional Pavement Managers and HQ PMP,

6 20-YEAR NETWORK PROJECTIONS (JANUARY)

6.1 Network Goals

While the Chief Engineer requires pavement management to report the current percentages of project matching, the Transportation Commission further requests that CDOT provide 20-year Good/Fair surface condition projections are developed. As noted previously, the Transportation Commission has set a goal for CDOT to have 60% of the state's roads in either Good or Fair condition. Pavement management reports the current roadway condition and projects future conditions using various network budgets. The budget used to predict 20-year conditions given CDOT's current funding levels comes from the *Colorado Department of Transportation 2035 Revenue Forecast and Resource Allocations*. Additional budget scenarios are included in the prediction to identify the funding needed to meet or exceed the Transportation Commission's condition goals. The 20-year network projections are delivered to the Technical Committee mid January and then forwarded to the Transportation Commission by the last week of January.

In summary:

- Party Responsible for Deliverable: PMP
- Deliverable: 20-Year Good/Fair Projections
- Due Date: PMP Technical Committee approval mid January, delivered to Transportation Commission in March, Chief Engineer and RTD review first week in February.
- Deliverable Location: PMP

7 REGIONAL BUDGET ALLOCATION RECOMMENDATIONS (JANUARY)

7.1 Regional Funding

Starting fiscal year 2007 the regional funding will be determined as outlined in CDOT Policy Memo #19. Furthermore, each region is required to spend at least 5% of their resurfacing budget on preventive maintenance.

In summary:

- Party Responsible for Deliverable: PMP
- Deliverable: Regional Budget Allocation Recommendations
- Due Date: Delivered to Chief Engineer as per current Policy Memo #19.
- Deliverable Location: CDOT Policy Memo #19

7.2 Preventive Maintenance Status Report

As noted, the Regions are required to spend at least 5% of their resurfacing budget on preventive maintenance. To track these preventive maintenance efforts, the PMP collects project data from the Regions and reports the results in the *Preventive Maintenance Status Report*.

In summary:

- Party Responsible for Deliverable: PMP Manager
- Deliverable: *Preventive Maintenance Status Report*
- Due Date: the report is transmitted to the Director of Staff Branches the last week of March.
- Deliverable Location: PMP Internal Website

8 ANNUAL PAVEMENT MANAGEMENT CYCLE

8.1 Annual Pavement Management Report

On an annual basis, the PMP compiles all completed tasks, on-going tasks, and planned future tasks. These tasks are summarized in the *Annual Pavement Management Report*.

In summary:

- Party Responsible for Deliverable: PMP Manager
- Deliverable: *Annual Pavement Management Report*
- Due Date: First week of July.
- Deliverable Location: PMP Internal Website

9 PAVEMENT MANAGEMENT ORGANIZATIONAL STRUCTURE

9.1 Technical Committee

The Pavement Management Program is comprised of a large Technical Committee that guides the evolution of Pavement Management. The voting members of the Technical Committee include two members of HQ Pavement Management Program, all regional materials engineers (RME), a representative from DTD, and a representative from the Federal Highways Administration. The Technical Committee identifies subjects for investigation or clarification and then assigns a task force to delve into the subject. The Technical Committee typically meets every-other month in conjunction with the Materials Advisory Committee.

9.2 Task Forces

Task forces generally include one or two members from HQ Pavement Management Program, and the RPMs. After a task force investigates an issue, the resolution is passed on to the Technical Committee. The Technical Committee then reviews the issue and votes to accept or reject the task force's proposal. *The Decision Making Process for the Pavement Management System Policy Memo #6* (Appendix D) details the organizational flow and the responsibilities of all participating parties.

9.3 Staff Services and Regions

The HQ Pavement Management Program will provide technical, procedural and policy guidance and assistance to the Regions, to ensure proper implementation and execution of the CDOT Pavement Management Program.

10 CONCLUSION

10.1 PMP Products and Due Dates

- Condition Data (completed mid July)
  - *Condition Data Quality Assurance Review* (July Technical Committee)
- Good/Fair/Poor Maps and Graphs (completed end of August)
  - *Remaining Service Life Field Review* (August Technical Committee)
- Project Recommendations / Percent Project Matching (completed 1st week in December / June Technical Committee)
- 20-Year Network Projections (completed last week of January)
- Regional Budget Allocation Recommendations (completed last week of November)
- Preventive Maintenance Status Report (Last week of March)
- Annual Pavement Management Report (First week in July)

11 REFERENCES

Colorado Department of Transportation. Policy Memos. CDOT External Website: http://www.dot.state.co.us/DesignSupport/Policy%20Memos/Policy%20Memos%20Index.htm

Colorado Department of Transportation. Pavement Management Internal Website: http://internal/PMPTC/

Deighton Associates Limited, from Deighton's software dTIMS V6.1 Found by searching for help on "Incremental Benefit Cost Analysis", 1998.

Federal Highway Administration. *Distress Identification for the Long-Term Pavement Performance Project*, FHWA-RD-03-031. McLean, VA: 2003.

APPENDIX A
Condition Data Collected

Pavement Management Condition Data Dictionary

Field	Description
HWY	Highway Number
DIR	Survey Direction 1=Increasing 2=Decreasing
REFPOST	Milepost Number
SEGMENT	Segment Number (1/10 mile)
LENGTH	Length of Segment (Thousandths of Mile)
BEGREFPT	Beginning Ref Point=Refpost + Segment
DATE	Date of Survey (MM/DD/YY)
ENGREGION	Engineering Region
SPEED	Vehicle Test Speed
PAVETYPE	Pavement Type 1 = Asphalt 2 = Concrete 3 = Other
SHLDRT	Shoulder Type N=No Observation F=Flexible Surface Type C=Curb and Gutter R=Rigid Surface type G=Gravel
SHLDRW	Shoulder Width 0=No Shoulder 1=0-4 ft 2=4-6 ft 3=>6 ft
SHLDR_COND	Shoulder Condition (Same/Better/Worse)
IRIAVG	Average Left & Right IRI (in/mile)
IRILEFT	Left IRI (in/mile)
IRIRIGHT	Right IRI (in/mile)
IRILEFTSD	Left IRI Standard Deviation
IRIRIGHTSD	Right IRI Standard Deviation
RUTAVG	Average Left & Right Rutting (hundredths of an inch)
RUTLEFT	Left Rut (hundredths of an inch)
RUTRIGHT	Right Rut (hundredths of an inch)
RUTLEFTSD	Left Rut Standard Deviation
RUTRIGHTSD	Right Rut Standard Deviation
RUTMAX	Maximum Rut (hundredths of an inch)
FATIGUE_L	Fatigue Cracking-Low Severity (square feet) (Maximum value=7,000 sqr. ft.)
FATIGUE_M	Fatigue Cracking-Moderate Severity (square feet) (Maximum value=7,000 sqr. ft.)
FATIGUE_H	Fatigue Cracking-High Severity (square feet) (Maximum value=7,000 sqr. ft.)
FATIGUE	Sum of all FATIGUE severities (square feet) (Maximum value=7,000 sqr. ft.)
BLOCK_L	Block Cracking-Low Severity (square feet) (Maximum value=9,000 sqr. ft.)
BLOCK_M	Block Cracking-Moderate Severity (square feet) (Maximum value=9,000 sqr. ft.)
BLOCK_H	Block Cracking-High Severity (square feet) (Maximum value=9,000 sqr. ft.)
BLOCK	Sum of all BLOCK severities (square feet) (Maximum value=9,000 sqr. ft.)

TRANSCOUNT_L	Transverse Cracking-Low Severity (count) (Maximum value=150)
TRANSCOUNT_M	Transverse Cracking-Moderate Severity (count) (Maximum value=150)
TRANSCOUNT_H	Transverse Cracking-High Severity (count) (Maximum value=150)
TRANSCOUNT	Sum of all TRANSCOUNT severities (count) (Maximum value=150)
LONG_L	Longitudinal Cracking-Low Severity (length ft) (Maximum value=3,000 ft.)
LONG_M	Longitudinal Cracking-Moderate Severity (length ft) (Maximum value=2,500 ft.)
LONG_H	Longitudinal Cracking-High Severity (length ft) (Maximum value=1,000 ft.)
LONG	Sum of LONG severities (length ft) (Maximum value=3,000 ft.)
CORNER_L	Corner Cracking-Low Severity (count) (Maximum value=50)
CORNER_M	Corner Cracking-Moderate Severity (count) (Maximum value=30)
CORNER_H	Corner Cracking-High Severity (count) (Maximum value=20)
CORNER	Sum of CORNER severities (count) (Maximum value=50)
STOP	Complete Stop (count)
RUMBLE	Rumple Strip (distance from pavement edge) 0=No Rumble Strip 1=<6 in 2=>6 in

APPENDIX B
Quality Assurance Protocol
For Verifying Pavement Management Condition Data

Quality Assurance Protocol for Verifying Pavement Management Condition Data

1 SCOPE

This protocol identifies and defines the procedure for reviewing Pavement Management's roadway surface condition data.

2 REFERENCED DOCUMENTS

Federal Highway Administration, *Distress Identification Manual for the Long-Term Pavement Performance Project* (FHWA-RD-03-031). McLean, VA: 2003.

3 TERMINOLOGY

Condition data – Roadway surface condition data is collected annually for the Pavement Management Unit by a contracted vendor. Collected data includes ride as IRI, depth of rutting, quantities of various cracking distresses, and the corresponding severity of the cracking distresses. All cracking distresses are identified and categorized in accordance with FHWA-RD-03-031. Data is presented as 1/10-mile segment totals.

Condition data test sites – Field sites selected by the Regional Pavement Manager that are visited annually and rated in accordance with FHWA-RD-03-031. Test sites are 1/10-mile long in an effort to mimic the contractor's segmentation. Each Region has 3 – 6 test sites, which have been chosen to reflect different pavement variables such as pavement type, age, prevalent distress types/severities, traffic, climate, etc. Condition data test sites are fairly constant, but they can be altered as the Regional Pavement Manager sees fit.

Correlation site – A pre-assigned segment of road on which the contractor is required to prove the repeatability of the ride and rut instruments by driving the data collection van over it multiple times. The contractor will drive the correlation sites prior to data collection, during data collection, and after data collection to ensure that the ride and rut readings remain constant throughout the entire schedule. Each site was picked to represent specific types of surface conditions such as smooth asphalt or rough concrete. One site is designated for speed correlation, and the contractor is required to run this site at varying speeds to ensure that ride and rut measurements are not dependent upon the velocity of the data collection van.

4 PROTOCOL

CDOT conducts two quality assurance (QA) protocols to accurately verify the quality of the condition data. One protocol is necessary for office review of data and one protocol is necessary for field review of data. It should also be noted that the contractor conducts quality control in accordance with their internal procedures and policies.

4.1 Office QA Protocol

1. The Condition Data Contract Manager, in association with the annual Pavement Management Condition Data Task Force, reviews ride and rut data repeatability for

all 1/10-mile segments on each correlation site and ensures that the variance between the lowest values and the highest values do not vary intolerably. If excessive variance is revealed the contractor is compelled to recalibrate his instruments and rerun specific correlation sites.

2. The Condition Data Contract Manager randomly checks digital jpeg images of the highways for picture clarity and ID flag/counter continuity. Thoroughly review images for the initial 500-miles of data. After that, randomly spot check picture clarity and continuity for subsequent data deliveries. Any images that are found to have unacceptable flaws in quality, clarity, or continuity are returned to the contractor for repair or replacement.

3. The Condition Data Contract Manager spot-checks 1/10-mile condition data records against the digital jpeg images of the highway surface. Randomly select a 1/10-mile segment and review it in slow motion. Quantify all cracks displayed on the video and determine their severity in accordance with FHWA-RD-03-031. Compare quantified results with those reported by the contractor to ensure that they correlate well. Any spot-checks that reveal poor correlation between the digital jpeg images and the condition data database are investigated further to determine the extent of the error and are then reported to the contractor for reconciliation.

4. The Condition Data Contract Manager and Database Manager verifies condition data by running a QA computer program that checks for duplicate records, missing segments, wrong highway limits, missing highways, wrong pavement types, highways not in network, and wrong raw data values. Any significant errors that cannot be mended at CDOT are returned to the contractor for their investigation and restoration. The logical evaluations for these processes are as follows:

    - **Duplicated Records:** Multiple records with the same highway, direction, and beginning milepost.
    - **Missing Segments:** Missing records within highway.
    - **Wrong Highway Limits:** Wrong beginning and/or ending in each highway direction.
    - **Missing Highways:** No data for entire highway.
    - **Wrong pavement type:** Presence of any asphalt distress values (fatigue and/or block cracking) in concrete segments. Presence of corner break values in asphalt segments.
    - **Highway Not In Network:** Unknown highway number.
    - **Wrong Raw Data Value:** Distress values exceed expected maximum as defined in the table below:

Table: Expected Data Value Maximums	
Ride 800 inches/mile	Longitudinal (total) 3,000 feet
Rut 1.5 inches	Longitudinal Low 3,000 feet
Fatigue (total) 7,000 square feet	Longitudinal Moderate 2,500 feet
Fatigue Low 7,000 square feet	Longitudinal High 1,000 feet
Fatigue Moderate 7,000 square feet	Corner Break (total) 50
Fatigue High 7,000 square feet	Corner Break Low 50
Transverse (total) 150	Corner Break Moderate 30
Transverse Low 150	Corner Break High 20
Transverse Moderate 150	
Transverse High 75	

4.2 Field QA Protocol

1. Regional Pavement Managers review last year's list of condition data test sites and add, remove, or modify any specific sites.

2. The Condition Data Task Force chooses one section as an orientation site. All attending Regional Pavement Managers and staff from Headquarters Pavement Management Unit will rate the cracking distress on this section together as a committee. All distresses will be measured as accurately as possible in accordance with FHWA-RD-03-031.

3. Field-rate the remainder of the test sites. Two-person teams (preferably the Regional Pavement Manager and a representative from Headquarters Pavement Management Unit) will perform rating in accordance with FHWA-RD-03-031.

4. The Condition Data Contract Manager, in association with the Condition Data Task Force, compiles all test site data and compares it with the contractor's data to ensure the quality of the condition data. Any sites that do not reasonably correlate are investigated. If unexplainable and unexpected differences are still prevalent the data can be returned to the contractor for re-collection or the data can be rejected.

5 SCHEDULE

The vendor typically begins data collection the first week of February and delivers the finalized data by the end of June. The vendor submits weekly batches of data. After each batch the Condition Data Contract Manager, in association with the Condition Data Task Force, has one week to analyze the data per the *Office QA Protocols* and report all errors back to the vendor. Subsequently, the vendor has one week to repair the errors and return the data to CDOT. For the *Field QA Protocols*, the test site field rating should be completed before the finalized data is received from the vendor.

All condition data must be error free by the first week of July so that the data can be loaded into the Pavement Management software. This is the latest the data can be loaded in order to have the current network conditions available for the September Transportation Commission workshop.

The Pavement Management Technical Committee must approve the annual condition data at the July meeting. Once the condition data is approved for use in the Pavement Management software, the results of the QA protocols can be compiled and a draft version of the annual *Condition Data Quality Assurance Protocol* report will be produced shortly thereafter for review by the Condition Data Task Force. A finalized version of that report will be available by the end August.

6 CONCLUSION

All data and decisions resulting from this protocol are summarized in the annual *Condition Data Quality Assurance Protocol*, which is produced by the Condition Data Task Force and ratified by the Pavement Management Technical Committee. At any time, data may be rejected or sent back to the contractor for re-collection. It should be noted that the Condition Data Task Force is not compelled to accept any or all data. It is quite possible for all data to be rejected and the Pavement Management Program could continue without one year's worth of condition data. Due to the subjective nature of pavement rating all results should be considered as a whole. If the overall results of this protocol are good then the condition data is considered acceptable.

APPENDIX C
Quality Assurance Protocol
For Verifying Pavement Management Remaining Service Life

Quality Assurance Protocol for Verifying Pavement Management Remaining Service Life

1 SCOPE

This protocol identifies and defines the procedure for reviewing Pavement Management's calculated Remaining Service Lifes (RSLs).

2 TERMINOLOGY

Pavement Family – Pavement families are used to group pavements together that have similar characteristics. Theoretically, pavements that have similar composition, traffic patterns, climate, and thickness generally have the same performance.

Project – A 0.5-5.0 mile segment of roadway with that is defined by the Pavement Management Software.

Regional Project Inventory Database – A database maintained by each Regional Pavement Manager that contains a history of all projects performed in the Region. These databases are updated and kept current with ongoing projects.

Remaining Service Life (RSL) – The estimated number of years, from a specified date in time, until a pavement section reaches the threshold distress index. RSL is a function of the distress level and rate of deterioration.

Remaining Service Life Report – An annual tabular report generated by the Pavement Management Unit for the Regions. The report identifies the RSL for all highway segments as well as associated pavement families, current distress index values, and recent maintenance activities.

Technical Committee - A group of individuals that represents the various departmental entities impacted by the Pavement Management Program. These individuals provide guidance, expert input, and direction for the development of the Pavement Management System. The Technical Committee includes Regional Materials Engineers, Regional Pavement Managers, Staff Pavement Management Unit, representatives from DTD, and representatives from FHWA.

3 PROTOCOL

Quality Assurance of Pavement Management RSLs is divided into two independent yet similar investigations. The first is an immediate check of RSL to be completed prior to the August Technical Committee meeting, at which the annual Good/Fair/Poor Maps and RSL Reports are approved. The second investigation is a long-term check of random projects throughout each Region. The data from this random investigation will be used to quantify overall RSL accuracy by May.

3.1 Immediate RSL QA

1. The Regional Pavement Manager chooses approximately ten Pavement Management projects for his or her Region. **Recommendations** for choosing test segments could include:
    - Minimize overlap of pavement families; thus, maximizing pavement family representation.
    - Pick test sites that are at least 5-years old.
    - Select sites within a reasonable proximity so that they can all be reviewed in one day.
    - Choosing test projects less than 2-miles in length.

2. The Regional Pavement Manager reviews the Regional Project Inventory Database to determine the project history for each test site. Using information from the Project Inventory Database, the Regional Pavement Manager fills in the pertinent data on the *Remaining Service Life Field Verification Form*: year of last work, depth of treatment, pavement type, and recent maintenance activities.

3. Upon receipt of the Remaining Service Life Report from headquarters, the Regional Pavement Manager determines the RSL for each test site. Using information from this report, the Regional Pavement Manager verifies the accuracy of the Pavement Management information by filling in the pertinent data on the *Remaining Service Life Field Verification Form*: year of last work, depth of treatment, pavement type, environmental zone, traffic zone, recent maintenance activities, pavement distress indices, and RSL.

4. After the Regional Project Inventory Database and Remaining Service Life Report is reviewed, the Regional Pavement Manager visits each test site with the *Remaining Service Life Field Verification Form*. At the test site, the Regional Pavement Manager confirms the information on the *Remaining Service Life Field Verification Form* by writing “yes” or “no” in the *Field Check* column. If a “no” is written in the Field Check column, then the Regional Pavement Manager writes an abbreviated description of the discrepancy in the *Notes* area. Pavement Management RSLs are considered acceptable if they are within ±3 years of the Pavement Manager's RSL estimation.

5. Once the *Remaining Service Life Field Verification Form* is completely filled out the Regional Pavement Manager sends the forms to HQ.

6. HQ will review the completeness and accuracy of the submitted *Remaining Service Life Field Verification Forms.* HQ will then format the results from the Regions and use the results to approve or reject the annual Good/Fair/Poor Maps and RSL Reports at the August Technical Committee Meeting.

3.2 Random RSL QA

1. Headquarters Pavement Management Unit will generate ten random Pavement Management projects for each Regional Pavement Manager to review. If the random

list provided by HQ contains projects unsuitable for RSL review (e.g. projects under construction, etc.) then the Regional Pavement Manager can request alternate random projects.

2. The Regional Pavement Manager reviews the Regional Project Inventory Database to determine the project history for each test site. Using information from the Project Inventory Database, the Regional Pavement Manager fills in the pertinent data on the *Remaining Service Life Field Verification Form* (this is the same form used in section 3.1 Immediate RSL QA): year of last work, depth of treatment, pavement type, and recent maintenance activities.

3. The Regional Pavement Manager determines the RSL for each test site using information from the RSL Report. The Regional Pavement Manager verifies the accuracy of the Pavement Management information by filling in the pertinent data on the *Remaining Service Life Field Verification Form*: year of last work, depth of treatment, pavement type, environmental zone, traffic zone, recent maintenance activities, pavement distress indices, and RSL.

4. After the Regional Project Inventory Database and Remaining Service Life Report is reviewed, the Regional Pavement Manager visually reviews each test site with the *Remaining Service Life Field Verification Form*. Visual reviews can be done by visiting the site in the field or using alternate means such as photo documentation, video review, roadway condition data tools, etc. During the visual review, the Regional Pavement Manager confirms the information on the *Remaining Service Life Field Verification Form* by writing “yes” or “no” in the *Field Check* column. If a “no” is written in the Field Check column, then the Regional Pavement Manager writes an abbreviated description of the discrepancy in the *Notes* area. Pavement Management RSLs are considered acceptable if they are within ±3 years of the Pavement Manager's RSL estimation.

5. Once the *Remaining Service Life Field Verification Form* is completely filled out the Regional Pavement Manager sends the forms to HQ.

6. HQ will review the completeness and accuracy of the submitted *Remaining Service Life Field Verification Forms.* HQ will then format the results from the Regions and compile the results to determine the overall confidence in the Pavement Management RSLs.

4 SCHEDULE

4.1 Immediate RSL QA

The Regional Pavement Managers can begin selecting RSL test sites (3.1 step 1) as soon as they submit their finalized Regional Project Inventory Databases, which occurs at the end of June. To maximize the field review timeframe, the RSL test site selection (3.1 step 1) and Regional Project Inventory Database reviews (3.1 step 2) are completed prior to HQ delivery of the Remaining Service Live Reports, which occurs about the third week of July.

Once the Regional Pavement Managers have received their RSL Reports, they have one week to verify the information in the report (3.1 step 3), perform the field review (3.1 step 4), and deliver completed *Remains Service Life Field Verification Forms* to headquarters (3.1 step 5).

After receipt of the completed *Remains Service Life Field Verification Forms* HQ compiles and formats all data for the August Technical Committee Meeting, which usually takes place the third Thursday of August.

4.2 Random RSL QA

Headquarters can generate the random project lists in July after the RSL Reports have been generated. Once the Regional Pavement Managers have their random samples they can begin the review process. All random projects should be reviewed in full and submitted to Headquarters by the end of April. This will allow Headquarters to compile and format all results by the end May.

5 CONCLUSION

Data from the Immediate RSL QA review is used at the August Technical Committee Meeting to determine whether or not the Good/Fair/Poor Maps and RSL Reports should be ratified.

Data from the Random RSL QA review is used, in conjunction with the Immediate RSL QA results, to determine the overall confidence level in the Pavement Management System RSLs.

All data resulting from this protocol is further used to identify areas for improvement within the Pavement Management software and program. Through ongoing long-term quality assurance efforts, the Pavement Management Program can track the evolution of RSL accuracy and precision.

APPENDIX D
Decision Making Process
For the Pavement Management System

Decision Making Process for the Pavement Management System

Pavement Management Task Forces are made up of volunteers working toward the common goal of improving the Pavement Management System.

- Issues brought up in meetings or through other channels are investigated by the Task Force. Adequate documentation of the issue should be provided to evaluate prioritization and need for establishing a Task Force. The person or persons presenting the issue will be expected to chair the task force.
- Progress of the Task Force will be provided through meeting minutes to the Pavement Management Technical Committee. Additional Task Force updates will be given at the bi-monthly Pavement Management Technical Committee meeting.
    - Questions, comments, clarifications, or other input on any issues must be provided at this time.
- Task Force recommendations will be provided to the Technical Committee for ratification and any additional actions necessary. Consensus should be reached by the Task Force prior to providing recommendations to the Technical Committee. Results of any task force votes will be provided to the Technical Committee, with explanation for dissenting votes and comments.
- For task force items determined to be critical by the Technical Committee the following additional process will be utilized:
    - A vote of the Technical Committee will designate a task force critical or non-critical. Deadlines, effect on the current system, etc… should be considered for this designation.
    - All critical task forces will be assisted by the Pavement Management Program Manager in establishing an action plan, setting schedules, and reviewing progress.
    - The Task Force chairman will be responsible for scheduling meetings, creating agendas, and distributing minutes to effectively meet appropriate deadlines.
    - The Pavement Management Program Manager will prioritize critical task forces, approve revised deadlines, dissolve task forces, and provide direction to the chairperson. Task forces being dissolved or postponed due to lack of progress or prioritization will be reviewed with the Region Materials Engineers prior to making the decision.

Pavement Management Technical Committee is made up of the Region Materials Engineers, the Region Pavement Managers, the Pavement Management Program, the Materials and Geotechnical Branch Manager, DTD, and FHWA.

- At the Technical Committee meetings any issues approved by the Task Force will be presented for ratification.

  - The reasons why the Task Force approved/rejected the issue will be presented, along with a brief recap of the history behind the issue.
- Technical Committee ballots are allotted as such:
  - One ballot for the Materials and Geotechnical Branch Manager
  - One ballot for each Regional Materials Engineer.
  - One ballot for the Pavement Management Program Manager.
  - One ballot for the Department of Transportation Development.
- All voting members must stay informed on all Pavement Management issues as they develop so that they can cast responsible, informed ballots.
- All voting members must provide timely comments and criticisms so that Pavement Management can continue to progress and move forward.

<u>Voting Process</u>

1) Voting will occur at the scheduled Technical Committee meeting. If a voting member is to be absent, they should provide their vote in advance or delegate a proxy for voting. Any E-votes will be discussed at the previous Technical Committee meeting. The results of E-votes will be included in the next agenda and meeting minutes.
2) Any E-votes are due by the stated deadline.
3) A “Yes” vote is a vote of acceptance or in favor of changing current practice or procedure. A “No” vote is a vote against accepting the proposed item. An Abstention is allowed with a reason for abstaining.
4) Any ballots not cast at the meeting or by the stated deadline will be recorded as “Did not vote.”
5) A majority vote is required to ratify an issue. A majority will be based upon total votes cast. An “Abstention” or “Did not vote” will not count toward the total number of votes cast.
6) Any “No” votes require a stated objection. An attempt should be made to resolve any objections prior to voting, but this may not be possible in all cases. Objections to an approved issue may be considered for future Task Force investigation.

■

APPENDIX E
Pavement Management
Definitions

AADT – Average Annual Daily Traffic. It is the number of vehicles that pass a particular point on a roadway during a period of 24 consecutive hours averaged over a period of 365 days.

Apparent age – The age of a pavement based on projections from performance curves and the current distress levels.

Beginning Mile Point (BMP) – The numerical value of beginning mile point for a project segment or highway.

Condition data – Roadway surface condition data is collected annually for the Pavement Management Unit by a contracted vendor. Condition data includes ride as IRI, depth of rutting, quantities of various cracking distresses, and the corresponding severity of the cracking distresses. All cracking distresses are identified and categorized in accordance with SHRP-P-338. Data is presented as 1/10-mile segment totals.

Condition data test sites – Field sites selected by the Regional Pavement Manager that are visited annually and rated in accordance with SHRP-P-338. Test sites are 1/10-mile long and are used to verify the data collection vendor's results.

Corner Break Index (CRBK) - An index used by CDOT that quantifies the number and severity of corner breaks on a concrete pavement. It is reported in 1/10 mile increments. The scale starts at 100 and decreases numerically as the number and/or severity of corner breaks increase.

Correlation site – A pre-assigned segment of road on which the contractor is required to prove the repeatability of the ride and rut instruments by driving the data collection van over it multiple times. The data collection vendor can be compelled to run the correlation sites prior to data collection, during data collection, and after data collection to ensure that the ride and rut readings remain constant throughout the entire schedule.

dROAD – dROAD is a proprietary software package purchased by CDOT for the purpose of analyzing the pavement condition. dROAD is a set of software tools for organizing and maintaining a collection of infrastructure related data in a database. dROAD is a database management system designed specifically for infrastructure management applications like pavement management systems. If dROAD is linked to dTIMS, it can supply the source data for dTIMS through database extraction.

dTIMS - dTIMS is a proprietary software package purchased by CDOT for the purpose of calculating benefit/cost analyses used to recommend projects. dTIMS provides assistance in making funding decisions by finding the optimal set of strategies to apply to a network under a given set of constraints such as costs. dTIMS provides a mechanism for analyzing a variety of maintenance, rehabilitation, and reconstruction treatments over a period of time and assists in the selection of the most cost-effective treatments for a range of budget scenarios.

Data Collection Miles – The number of miles traveled by the data collection vendor during the annual process of collecting condition data.

Default Curve – See Expert Opinion Curve.

Depth – The thickness of the last treatment applied to the pavement.

Design Life - The anticipated life of the pavement section at the time of initial construction. Design life does not include any additional life estimates provided by anticipated future preventive maintenance. This term is also used to define the number of years for which design Equivalent Single Axle Loads are calculated as an input parameter for formal pavement design calculations.

Direction (DIR) – The direction traffic flows on a state highway. Direction 1 (primary) is increasing mile point (North or East) and Direction 2 (secondary) is decreasing mile point (South or West).

Distress Index - An index that quantifies the level of distress based on condition data collected on a 1/10th mile pavement segment. The scale starts at 100 and decreases numerically as distress level increases (pavement condition worsens).

Efficiency Envelope – Used in dTIMS to expand the efficiency frontier. Without an efficiency envelope only the strategies on the efficiency frontier would be used in selecting strategies during optimization. The efficiency envelope was added to dTIMS to recognize the imprecise nature of calculating the benefits. With it dTIMS allows strategies which are slightly below the efficiency frontier to be included in optimization.

Ending Mile Point (EMP) – The numerical value for the ending mile point for a project segment or highway.

ESAL – Equivalent Single Axle Load. This is the basic measure of traffic loading on a road section. The effect on pavement performance of any combination of axle loads of varying magnitude expressed in terms of the number of 18,000 lb single-axle loads required to produce an equivalent effect.

Environmental Zone (ENV_Z) – There are four categories used to group the various pavement sections into similar climates. Climate zones are determined by average high air temperature data;

Very Cool – high mountains; <27 deg C (<81 deg F)

Cool – mountains; 27 – 31 deg C (81 – 88 deg F)

Moderate – Denver, plains and west; >31 - 36 deg C (>88 - 97 deg F)

Hot – SE and west; >36 deg C (>97 deg F)

Expert Opinion Curve (Default Curve) – A performance curve based on engineering experience and not the collected data. These curves are used in the absence of Site Specific or Family curves.

Family Curve – Pavement family curves are groups of pavements with similar characteristics. Pavements that have similar composition, traffic patterns, climate, and thickness are assumed to have the same performance. Data from roadway sections in the same family are used to develop a family curve.

Fatigue Cracking Index (FATG) - An index used by CDOT that quantifies the area (sf) and severity of fatigue cracking on an asphalt pavement. It is reported in 1/10 mile increments. The scale starts at 100 and decreases numerically as the area and/or severity of fatigue cracking increases.

Functional Class (FUN_CL) – A functional class is the process by which streets and highways are grouped into systems according to the character of traffic service that they are intended to provide.

Good/Fair/Poor (G/F/P) – The G/F/P designation is a categorization of a pavement's RSL. A Good pavement section has an RSL greater than or equal to 11 years. A Fair pavement section has an RSL equal to 6 and less than or equal to 10 years. A Poor pavement section has an RSL of 5 years or less.

Good (RSL >= 11 years)

Fair (RSL >= 6 years and RSL =< 10 years)

Poor (RSL =< 5 years)

Incremental Benefit Cost (IBC) – The ratio of the increase in benefit to the increase in cost between successive strategies. The IBC's goal is to select the strategies that maximize the user defined benefit to the whole network while not exceeding the budget available.

IRI – International Roughness Index – Represents the impacts of road roughness on vehicle operations, operating costs, riding quality, and safety.

K-Factor - The exponent that the AADT for a segment is raised to for calculating the area-under-the-curve benefit of a surface treatment. The equation used to calculate benefit is as follows:

$$\text{Benefit} = (\text{Area Under the Curve}) * (\text{AADT})^k.$$

Length – The length in miles of a highway segment or project segment. Typically EMP – BMP.

Longitudinal Cracking Index (LONG) - An index used by CDOT that quantifies the length (ft) and severity of longitudinal cracking on a pavement. It is reported in 1/10 mile increments. The scale starts at 100 and decreases numerically as the length and/or severity of longitudinal cracking increases.

National Highway System (NHS) – The National Highway System (NHS) includes the Interstate Highway System as well as other roads important to the nation's economy, defense, and mobility. The NHS was developed by the Department of Transportation in cooperation with the states, local officials, and metropolitan planning organizations.

Pavement Group (P_GRP) – A pavement group or pavement family assumes that pavements with similar characteristics such as composition, traffic patterns, climate, and thickness should have the same performance.

Pavement Type (P_TYP) – The pavement type is considered to be the first characteristic that determines which family a pavement is in. Current pavement types are, asphalt, asphalt over concrete, concrete, and concrete over asphalt.

Performance Curves – The performance curve is a deterioration model based on data collected over a period of time.

Preventive Maintenance – "Preventive maintenance is a planned strategy of cost effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system without (significantly) increasing structural capacity." AASHTO

Project – A 0.5-5.0 mile segment of roadway as defined by the Pavement Management Software

Project Match – A project match is a project selected by a Region for construction that is also recommended by the pavement management software. Each Region is required to meet a minimum percentage of matching projects as identified in the annual Chief Engineer's objectives (see policy memo #)

Reactive Maintenance - Reactive maintenance is an activity that must be done in response to events beyond the control of the Department. Reactive maintenance cannot be scheduled over a long period of time. Examples of reactive maintenance activities include pothole patching or removing and patching pavement blowups (which may extend for miles). Reactive maintenance treatments are not credited in the pavement management system.

Reconstruction - Reconstruction treatments add 20 years or more of life to a roadway section.

Regression Curve – See Performance Curve.

Rehabilitation – A level of work that is applied to an existing pavement structure, extending the life by 10 or more years. Not as extensive as Reconstruction, but more involved than Preventative Maintenance. Treatments include recycling, overlays, milling, white topping of asphalt pavements, and black topping of concrete pavements.

Remaining Service Life (RSL) - The estimated number of years, from a specified date in time, until a pavement section reaches the threshold distress index. When a pavement reaches the threshold distress, reconstruction and/or major rehabilitation is the only cost-effective treatment. RSL is a function of the distress level and rate of deterioration.

RSL = 0 – The point where a pavement's condition has reached a remaining service life of zero years due to distresses and age. The Remaining Service Life pertains to the last treatment and not necessarily the entire pavement. An RSL of 0 indicates that the only cost-effective treatment is a reconstruction and/or major rehabilitation, although a project level investigation of the pavement is necessary to determine the best, most cost-effective treatment.

Ride Index (Ride) - An index used by CDOT that quantifies the pavement ride quality in accordance with the International Roughness Index (IRI) which is measured in inches/mile. It is reported in 1/10 mile increments. The scale starts at 100 and decreases numerically as ride quality decreases.

Routine Maintenance - Routine maintenance is the day-to-day maintenance activities that are scheduled or whose timing is within the control of maintenance personnel.

RSL Indicator (RSL_IDX) – The lowest RSL value calculated from the various distress indices which is used to predict the current remaining service life of a pavement.

Rut Index (RUT) - An index used by CDOT that quantifies the depth of rutting in inches. It is reported in 1/10 mile increments. The scale starts at 100 and decreases numerically as depth of the rut increases.

Service Life (Analysis Period) - The anticipated life of a rehabilitation or new/reconstruction, including additional pavement life provided by anticipated future preventive maintenance. This term is used to describe the number of years from the initial new construction, reconstruction or rehabilitation of a pavement to a subsequent rehabilitation or reconstruction. A service life or analysis period equals the sum of the original design life plus any additional pavement life provided by future anticipated preventive maintenance. Analysis period is the term typically used to describe the time used in a life cycle cost analysis.

Site Specific Curve – A performance curve generated on a project segment basis. These curves are regressed using the historical index values for the road section. There must be at least 5 consecutive years of historical data, including the current year, available since the last treatment. The standard deviation cannot be greater than 10 and a correlation coefficient (R^2 value) of 0.5 must be achieved.

Strategy – A strategy is a course of action to be taken over the analysis period which consists of one or more treatments applied on the segment at a specific point in time during the analysis period.

Threshold Age – The age at which the pavement is predicted to fail based on a performance curve.

Threshold Distress Index - A pavement condition indicator where a rehabilitation or reconstruction should be considered. The threshold distress index is equal to 50.

Traffic Zone (TRAF_Z) – There are 5 ranges for traffic loading used to define pavement groups. Traffic loading is calculated using the 20-year ESAL values as described in CDOT's *Pavement Design Manual* (CDOT Pavement Design Unit).

Low – <0.3 million ESALs

Medium – 0.3 to 3 million ESALs

High – 3 to 10 million ESALs

Very High – > 10 to 30 million ESALs

Very, Very High - > 30 million ESALs

Transverse Cracking Index (TRAN) - An index used by CDOT that quantifies the number and severity of transverse cracks on a pavement. It is reported in 1/10 mile increments. The scale starts at 100 and decreases numerically as the amount and/or severity of transverse cracking increases.

Year – The calendar year denoting when construction on a project is completed.

Treatment descriptions:

- ABLD (Asphalt Blade Patch) – An asphalt patch applied using a motor grader.
- ACHP (Asphalt Chip Seal) – A treatment that seals the surface with an asphalt emulsion. Crushed rock chips add surface friction and provide a wearing course.
- ACIP (Asphalt Cold in Place Recycle) – The existing HMAis milled, mixed with recycling agent, then placed and compacted.
- ACKS (Asphalt Crack Seal) – The application of rubber and/or asphalt material to cracks in the existing pavement to reduce water infiltration.
- AHSO (Asphalt Heater/Scarify/Overlay) – The existing HMA is heated in place, milled, mixed with rejuvenating agent, then placed, compacted and overlaid.
- AHIP (Asphalt Hot in Place Recycle) – The existing HMA is heated in place, milled either in 1” or 2” lifts, mixed with virgin material and rejuvenating agent if required, then placed and compacted.
- AMJO (Asphalt Major Overlay) – Standard HMA mix. Typically 4 to less than 6 inches thick.
- AMDO (Asphalt Medium Overlay) – Standard HMA mix. Typically 2 to less than 4 inches think.
- AMCS (Asphalt Microsurface) – A leveling and rut filling mix of polymer modified emulsified asphalt, fine aggregate, mineral filler, water and additives.
- AMFL (Asphalt Mill & Fill) – The existing asphalt is milled (typically up to 2” deep, but may vary based on the project), and the millings are removed. Then an overlay is

placed over the milled surface.

- AREC (Asphalt Reconstruction) – Asphalt reconstruction.
- ASND (Asphalt Sand Seal) – Similar to a chip seal, except sand is used in place of rock chips.
- ASMA (Stone Mastic Asphalt) – A gap graded mix having essentially no voids and requiring more asphalt in the mix. Normally placed on the top surface of a pavement structure and acts as a wearing course. May also include milling of the existing surface.
- ATHO (Asphalt Thin Overlay) – Standard HMA mix. Typically less than 2 inches thick.
- ACOV (Asphalt White Topping) – The placement of concrete pavement over existing asphalt pavement.

Concrete:

- CAOV (Concrete Black Topping) – The placement of asphalt over existing concrete pavement.
- CCKS (Concrete Crack Seal) – The sealing of cracks in the concrete pavement to reduce water infiltration.
- CJTS (Concrete Joint Seal) – Removal and replacement of joint sealant in the existing expansion joints.
- CSLB (Concrete Slab Replacement) – Replacement of failed concrete slabs.
- CDMG (Concrete Diamond Grinding) – Grinding of existing concrete to remove rutting and increase friction.

  CREC (Concrete Reconstruction) – The complete replacement of existing concrete, or new concrete construction.

APPENDIX F

Tracking Year to Year Changes in Remaining Service Life

Tracking Year to Year Changes in Remaining Service Life

6 INTRODUCTION

6.1 History

The Colorado Department of Transportation (CDOT) has been working to implement a pavement management system since the late 1980's. CDOT has historically used a composite index, known as the overall pavement index (OPI), as the reporting criteria for the condition of the state highway network. OPI was comprised of a weighted combination of ride quality, rutting, and cracking.

Because OPI had a tendency to skew the apparent condition of the network towards ride and relied heavily on the apparent surface condition of the pavement, CDOT began shifting from a composite index to remaining service life (RSL) as the reporting criteria in 1999. For example, if a road element has 5 years of RSL, theoretically the pavement will reach the end of its serviceable life in 5 years, assuming no rehabilitation treatments are performed. It is believed the shift to RSL will provide a more accurate and understandable representation of the pavement network condition for both elected/appointed officials and engineers.

6.2 Purpose

The purpose of this *Tacking Year to Year Changes in RSL Report* is to:

- Document the various methods and means that are utilized by the headquarters pavement managers to check the reasonableness of the RSLs that are generated on a yearly basis.
- Identify reoccurring issues identified during RSL field and office reviews.
- This report assumes that the reader is familiar with pavement management terms and methodology and should be used in conjunction with the various other reports and manuals created by the Pavement Management Unit.

7 YEARLY RSL CALCULATIONS

7.1 Goal

The Pavement Management Program is responsible for reporting the condition of CDOT's roadway network annually. The percentage Good, Fair, and Poor roads is used as the rating criteria. Where a Good road is considered to have an RSL of 11 years or greater, a Fair road has 6 to 10 years of RSL, and a Poor road has 5 years or less RSL; any road with an RSL of zero is noted as such by using the term "RSL-0". Each year, usually late August, multiple data bases are loaded into CDOT's pavement management software. These databases include updated regional inventories, roadway condition data, traffic data, and other pavement management related databases. The end result is a RSL report that lists each CDOT roadway broken down into segments in length from 0.5-5.0 mile increments. Each segment has a calculated RSL. It is the responsibility of the Pavement Management Program and Regional Pavement Managers to check the RSL calculations for reasonableness and to correct any errors that may have occurred during the data loading process.

7.2 Pavement Managers

The list of pavement managers as of 2008 are:

- Janet Minter Region 1
- Frank Walters Region 2
- Bob Heidelmeier Region 3
- Gary Strome Region 4
- Robert Shanks Region 5
- Bob Mero Region 6
- Stephen Henry Headquarters
- Ali Farrokhyar Headquarters
- Mike Keleman Headquarters

8 RSL CHECKS PERFORMED BY HEADQUARTERS

8.1 Percentage of Good/Fair/Poor/Poor-0

The first check that is performed on the RSL calculations is to compare the percentage of Good, Fair, Poor, and Poor-0 roads from year to year (Appendix F1). The goal at this level of checking is to identify major fatal errors that may have occurred during the loading of the data. The overall network percentages are compared as well as the breakdowns of interstate (non-NHS), NHS, “Other”, and finally the regional break downs for all the above categories as well. If the percentages are within +/- 10% the data is deemed acceptable at this point and HQ moves onto the next stage of RSL checking.

8.2 Statewide and Regional Good/Fair/Poor/Poor-0 Maps

The next level of RSL checks is performed on the Statewide and Regional Good/Fair/Poor maps (Appendix F2). The headquarters pavement management program is responsible for generating statewide and regional maps that uses a color coding system to identify the RSL category for each roadway segment where; Good = green, Fair = Yellow, Poor = pink, and Poor-0 = red. Much like the percentages of Good/Fair/Poor listed in item 3.1 above, the maps are compared from year to year. The pavement management program looks for major changes on a roadway segment such as a road that was listed as Good (green) one year and Poor (pink) or Poor-0 (red) the next year or vice versa. Minor shifts such as a road that was Fair (yellow) one year and Poor (pink) the next year are not reviewed in detail at this level. After all the major shifts in RSL have been identified the pavement management unit moves on to the next level of checking, the RSL Report.

8.3 RSL Report

Once the roadway segments with major shifts in RSL have been identified from the RSL maps the pavement management unit then tries to identify the cause of the change via the RSL Report (Appendix F3). The RSL Report lists detailed roadway segment information such as year of last work, pavement group, index values for IRI, rut, fatigue cracking, transverse cracking, longitudinal cracking, corner breaks, RSL, the index that was used to determine the RSL, and which performance curve was used to calculate the RSL. This information can be used in the following ways to determine the cause in the shift of RSL from one year to the next:

- Year of Last Work (Year) – It is the regional pavement manager's responsibility to update the year of last work field. If a new project has been completed or if a construction project is anticipated on a highway segment during the current calendar year the pavement managers have been instructed to list the current year in the year of last work field for that roadway segment. Furthermore, if additional information is found regarding a project segment's year of last work the pavement manager will update the year of last work field with the new information. The year of last work greatly impacts the RSL calculation and, therefore, is one of the first fields that is checked when a major shift in RSL has occurred. For example, the 2004 RSL Report listed a year of last work for a roadway segment as 1972 (32 years old and an RSL in the Poor or Poor-0 range) and in 2005 a construction project was completed on this segment. The new year of last work on the 2005 RSL Report would be listed as 2005 and the RSL should be in the Good range. The end result would be a major shift in RSL from 2004 (Poor or Poor-0) to 2005 (Good).

  The new year of last work should be verified by the regional pavement manager.

- Pavement Group (P_Grp) – The pavement group field is another area that can have major impacts on the calculation of RSLs. The pavement group field can direct the pavement manager to performance curves that may have changed from one year to the next. If a major shift in RSL has occurred the pavement manager should compare the performance curves for each distress from one year to the next. For example, in 2005 a pavement group had the following threshold ages; IRI = 10 years, RUT = 12 years, FATG = 15 years, TRAN = 17 years, and LONG = 20 years. In 2006, the threshold ages for this same pavement group have changed based upon the new data that was loaded into the pavement management software to: IRI = 20 years, RUT = 20 years, FATG = 18 years, TRAN = 19 years, and LONG = 25 years. The new performance curves in 2006 show a projected increase in RSL and, therefore, the RSL for this segment might show a major shift in RSL from 2005 to 2006.

  The new performance curves should then be checked for reasonableness.

- IRI, RUT, FATG, TRAN, LONG, CRBK indices – If a major shift in RSL has occurred on a roadway segment, another area to compare are the distress index fields. Again, significant changes in distress index values, up or down, may be the cause of a shift in RSL.

  The raw condition data should then be checked for that segment either by viewing the digital images and data bases provided by the condition collection vendor or by performing a visual survey of the segment in the field.

- RSL Index (RSL_IDX) – The RSL index field is used to identify which of the distress performance curves was used to calculate the minimum RSL for that roadway segment. As noted in the index field description above, there is a possibility that the performance curves will change from year to year and, thus, the performance curve that generates the lowest RSL for a roadway segment may change from one year to the next. For example, in 2005 the FATG performance curve generates a threshold age of 15 years and is the controlling index. Also, in 2005, the RUT performance curve has a threshold age of 17 years. In 2006, new performance curves are generated for both distresses and now RUT has a threshold age of 10 years while FATG remains unchanged at 15 years. In 2006, RUT becomes the controlling index which may result in a significant change in RSL from 2005 to 2006

The controlling index performance curve should be compared from year to year and the current controlling performance curve should be checked for reasonableness.

- Performance Curve Type (Curve) – This field is used to identify which type of curve, family (F), site specific (SS), or default (D) was used to calculate the RSL. As noted above, a change in performance curve (from family to site specific, etc) may result in a major shift in RSL from one year to the next. For example, in 2005 the controlling index was FATG and the FATG family curve was used which generated a threshold age of 20 years. In 2006 additional data is collected and now a site specific FATG curve is generated and the threshold age is now 10 years. This change may result in a significant shift in RSL.

  The performance curve type should be compared from year to year and the current controlling performance curve should be checked for reasonableness.

8.4 Regional Feedback

As soon as the percentages of Good/Fair/Poor/Poor-0 have been checked for reasonableness and no fatal flaws have been found in the loading of the new data bases the pavement management unit emails a copy of the Good/Fair/Poor/Poor-0 percentages, maps, and RSL reports to each regional pavement manager. It is then each regional pavement manager’s responsibility to distribute the information to the appropriate people within their respective regions for their review and comment. If the regional pavement manager cannot answer a question then the question is forwarded to headquarters for their review. It is very important that the regional pavement manager include a detailed description of what they think is incorrect with the RSL and why. For example, the segment is listed as Good with and RSL = 12 years, the region believes it to be Poor with an RSL of 2-3 years due to deep ruts. The more information that the regional pavement manager can provide to HQ the easier it will be for HQ to research the problem. It is then the responsibility of headquarters to provide a clear, written explanation to each of the submitted regional comments.

Furthermore, it is the responsibility of headquarters to identify trends in the feedback provided by the regions. Statewide trends may lead to errors in the pavement management software that need to be identified before the results are sent to the RTDs and other CDOT upper management.

9 CONCLUSION

9.1 Summary

Changes in RSL and the resulting Good/Fair/Poor/Poor-0 percentages from year to year are inevitable and should be expected as the network deteriorates and as new construction improvements are completed. The goal of checking the RSL from year to year is to identify any human or data related errors that occurred during the loading to the pavement management software that is used to generate the RSLs. Furthermore, it is necessary to research and clearly explain any regional feedback on the yearly RSLs so that confidence and integrity in the pavement management system is retained throughout all of CDOT.

Pavement management is a perpetual cycle of making improvements and reviewing the results for reasonableness. Checking the RSLs from year to year is a source that provides the roadmap for future areas of improvement and should be performed on a yearly basis when the new data is loaded as well as when major changes are considered that may affect performance curves, regional inventory, or the calculation of RSLs.

9.2 Future Task Force Considerations

9.2.1 Combining this document with the "Quality Assurance Protocol for Verifying Pavement Management Remaining Service Life"

The pavement managers have began development of the Quality Assurance Protocol for Verifying Pavement Management Remaining Service Life which outlines how to field review RSL. The combination of these two reports would then cover both the actions taken in the office as well as in the field to verify that the calculated RSLs are reasonable.

Appendix "F1"

Sample 2005 Good/Fair/Poor/Poor-0 Percentages

	GOOD	FAIR	POOR	RSL_0 Miles	RSL_0 %
Statewide	44%	21%	35%	1992	18%
Interstate	53%	19%	28%	173	9%
NHS	51%	25%	24%	311	10%
Other	38%	19%	43%	1509	25%

R - 1	GOOD	FAIR	POOR	RSL_0 Miles	RSL_0 %
Network	52%	19%	29%	276	17%
Interstate	67%	13%	20%	27	5%
NHS	48%	23%	29%	27	10%
Other	45%	21%	34%	222	25%

R - 2	GOOD	FAIR	POOR	RSL_0 Miles	RSL_0 %
Network	40%	21%	39%	442	19%
Interstate	37%	18%	45%	6	2%
NHS	67%	20%	13%	26	4%
Other	28%	23%	49%	410	30%

R - 3	GOOD	FAIR	POOR	RSL_0 Miles	RSL_0 %
Network	46%	24%	30%	233	10%
Interstate	54%	25%	21%	2	1%
NHS	55%	30%	15%	1	0%
Other	39%	21%	40%	230	18%

	GOOD	FAIR	POOR	RSL_0 Miles	RSL_0 %
Statewide	44%	21%	35%	1992	18%
Region1	52%	19%	29%	276	17%
Region2	40%	21%	39%	442	19%
Region3	46%	24%	30%	233	10%
Region4	41%	16%	43%	652	28%
Region5	42%	23%	35%	273	18%
Region6	49%	23%	28%	116	14%

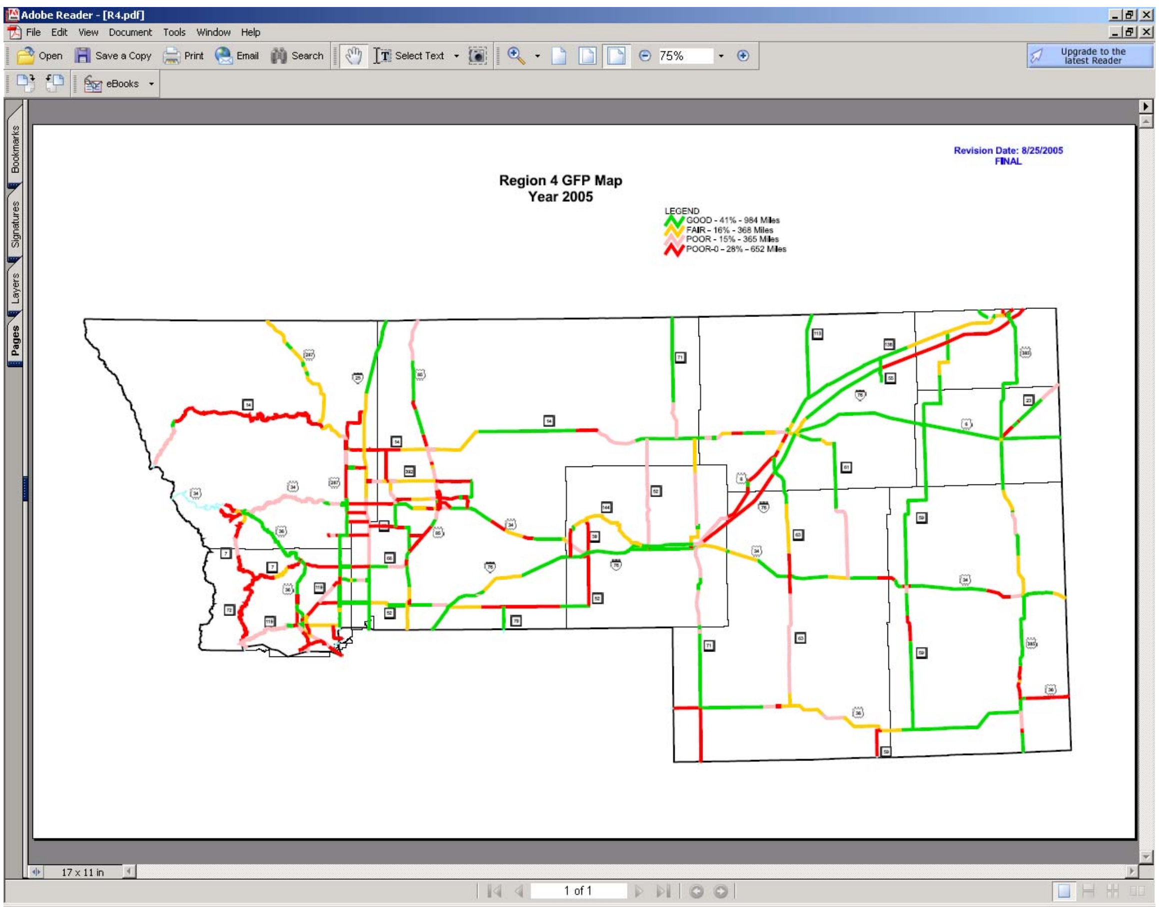
R - 4	GOOD	FAIR	POOR	RSL_0 Miles	RSL_0 %
Network	41%	16%	43%	652	28%
Interstate	52%	16%	32%	113	25%
NHS	31%	17%	52%	137	26%
Other	42%	15%	43%	402	29%

R - 5	GOOD	FAIR	POOR	RSL_0 Miles	RSL_0 %
Network	42%	23%	35%	273	18%
Interstate					
NHS	46%	33%	21%	81	12%
Other	38%	15%	47%	192	23%

R - 6	GOOD	FAIR	POOR	RSL_0 Miles	RSL_0 %
Network	49%	23%	28%	116	14%
Interstate	44%	26%	30%	25	10%
NHS	56%	25%	19%	39	10%
Other	42%	18%	40%	53	26%

Appendix "F2"

Sample 2005 Region 4 Good/Fair/Poor/Poor-0 Map



Appendix "F3"

Sample Page from Region 3 RSL Report

Microsoft Excel - R3 RSL Report 8_3_05.xls

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Hwy	Dir	BMP	Emp	Length	Year	Fun_Cl	P_Typ	Traf_Z	Env_Z	Depth	P_Grp	Nhs	Iri	Rut	Fatg	Tran	Long	Crbk	Rsl	Rsl_Idx	Curve	Mtc_Y	Mtc_D	Cond
2	006A	1	11.2	16.3	5.1	1985	07	1	2	4	4	1242	0	86	95	94	51	89	0	2	TRAN	F	-1	-1	POOR
3	006A	1	16.3	19	2.7	1981	07	1	2	4	4	1242	0	87	96	92	56	97	0	0	TRAN	F	-1	-1	POOR-0
4	006A	1	19	22.3	3.3	2005	16	1	2	4	6	1243	0	99	99	99	99	99	0	16	FATG	F	-1	-1	GOOD
5	006A	1	22.3	25.48	3.18	2002	06	1	2	4	2	1241	0	95	100	98	99	94	0	22	TRAN	F	-1	-1	GOOD
6	006A	1	25.48	26	0.52	1989	06	1	2	4	4	1242	0	93	100	96	77	95	0	13	FATG	F	-1	-1	GOOD
7	006B	1	30.3	34.4	4.1	2001	14	1	2	4	2	1241	0	88	100	99	97	99	0	21	TRAN	F	-1	-1	GOOD
8	006B	2	30.3	34.4	4.1	2001	14	1	2	4	2	1241	0	87	100	99	96	98	0	21	TRAN	F	-1	-1	GOOD
9	006C	1	37.5	42.5	5	2004	16	1	2	4	2.5	1241	0	94	100	100	99	100	0	24	TRAN	F	-1	-1	GOOD
10	006C	1	42.5	45.8	3.3	2004	07	1	1	4	2.5	1141	0	94	100	100	98	100	0	19	TRAN	F	-1	-1	GOOD
11	006D	1	92	93.9	1.9	1996	17	1	2	3	2	1231	0	90	97	99	94	99	0	4	LONG	D	-1	-1	POOR
12	006D	1	93.9	97.1	3.2	1976	07	1	2	3	4	1232	0	82	79	95	94	100	0	0	TRAN	F	1996	0.5	POOR-0
13	006D	1	97.1	102.1	5	1978	07	1	2	3	4	1232	0	84	88	96	91	99	0	0	TRAN	F	1995	0.5	POOR-0
14	006D	1	102.1	107.1	5	1978	07	1	2	3	4	1232	0	82	89	98	86	99	0	0	TRAN	F	-1	-1	POOR-0
15	006D	1	107.1	107.3	0.2	1978	07	1	1	3	4	1132	0	84	100	100	96	100	0	0	FATG	F	-1	-1	POOR-0
16	006D	1	107.3	110.8	3.5	1979	07	1	1	3	4	1132	0	85	99	99	94	99	0	0	FATG	F	-1	-1	POOR-0
17	006E	1	142	147.1	5.1	1991	07	1	3	3	4	1332	0	85	95	96	89	94	0	5	TRAN	F	1994	1.75	POOR
18	006E	1	147.1	150.5	3.4	1990	07	1	3	3	4	1332	0	84	94	99	85	92	0	4	TRAN	F	1994	1.75	POOR
19	006E	1	150.5	155.5	5	1996	07	1	2	3	2	1231	0	84	97	98	81	97	0	4	LONG	D	-1	-1	POOR
20	006E	1	155.5	159.7	4.2	1996	07	1	2	3	2	1231	0	85	97	94	84	97	0	4	LONG	D	-1	-1	POOR
21	006E	1	159.7	164	4.3	1998	07	1	2	3	2	1231	0	88	95	91	83	94	0	6	LONG	D	1997	0.25	FAIR
22	006E	1	164	169	5	1996	17	1	2	3	2	1231	0	87	89	95	86	92	0	4	TRAN	D	1998	0.25	POOR
23	006E	1	169	170.1	1.1	1996	17	1	2	3	2	1231	0	83	85	93	87	90	0	4	LONG	D	-1	-1	POOR
24	006E	1	170.1	172.09	1.99	1984	17	1	2	3	4	1232	0	90	97	100	99	98	0	5	TRAN	F	-1	-1	POOR
25	006E	1	172.09	173.79	1.7	1997	17	1	2	3	2	1231	0	88	96	96	90	95	0	5	LONG	D	-1	-1	POOR
26	006E	1	173.79	174.4	0.61	1990	07	1	2	3	4	1232	0	92	98	99	98	95	0	11	TRAN	F	-1	-1	GOOD
27	006K	1	0	0.4	0.4	1988	17	1	2	3	4	1232	0	86	91	98	87	94	0	12	RUT	F	-1	-1	GOOD
28	006L	1	88.6	91	2.4	1996	17	1	2	3	2	1231	0	92	99	99	94	98	0	4	LONG	D	-1	-1	POOR
29	006M	1	65.4	70.4	5	1985	07	1	2	4	4	1242	0	79	65	99	96	99	0	2	TRAN	F	-1	-1	POOR
30	006M	1	70.4	75.4	5	1985	07	1	2	4	4	1242	0	77	71	99	93	98	0	2	TRAN	F	-1	-1	POOR
31	009D	1	127.4	132.4	5	2004	06	1	2	2	3	1221	0	96	100	100	100	100	0	12	LONG	D	-1	-1	GOOD
32	009D	1	132.4	137.4	5	2004	06	1	2	2	3	1221	0	94	100	100	100	100	0	12	LONG	D	-1	-1	GOOD
33	009D	1	137.4	138.9	1.5	2004	06	1	2	2	3	1221	0	92	100	100	97	99	0	12	LONG	D	-1	-1	GOOD
34	013A	1	0	5	5	2005	14	1	2	3	1	1231	0	99	99	99	99	99	0	13	LONG	D	1997	0.5	GOOD
35	013A	2	0	3.1	3.1	2005	14	1	2	3	1	1231	0	99	99	99	99	99	0	13	LONG	D	-1	-1	GOOD
36	013A	1	5	6	1	2005	06	1	2	3	1	1231	0	99	99	99	99	99	0	13	LONG	D	-1	-1	GOOD
37	013A	1	6	11	5	2001	06	1	2	3	1.5	1231	0	94	100	100	92	98	0	9	LONG	D	2001	1.5	FAIR
38	013A	1	11	16	5	2001	06	1	2	3	1.5	1231	0	94	100	97	91	96	0	9	LONG	D	2001	1.5	FAIR
39	013A	1	16	18.5	2.5	2001	06	1	2	3	1.5	1231	0	96	100	98	92	93	0	9	LONG	D	2001	1.5	FAIR
40	013A	1	18.5	23.5	5	2005	06	1	2	3	3	1231	0	99	99	99	99	99	0	13	LONG	D	2001	1.5	GOOD
41	013A	1	23.5	26.5	3	2005	06	1	2	3	3	1231	0	99	99	99	99	99	0	13	LONG	D	-1	-1	GOOD
42	013A	1	26.5	30.3	3.8	1986	06	1	2	3	4	1232	0	93	98	76	90	99	0	7	TRAN	F	-1	-1	FAIR
43	013A	1	30.3	33.581	3.281	1985	06	1	2	3	4	1232	0	87	95	78	77	96	0	9	RUT	F	-1	-1	FAIR
44	013A	1	33.581	36.228	2.647	2005	06	1	2	3	5.5	1232	0	99	99	99	99	99	0	25	LONG	F	-1	-1	GOOD
45	013A	1	36.228	39.3	3.072	2000	06	1	2	3	4.5	1232	0	95	100	98	99	98	0	25	LONG	F	-1	-1	GOOD
46	013A	1	39.3	42.8	3.5	2003	06	1	2	3	2	1231	0	95	100	100	100	100	0	11	LONG	D	-1	-1	GOOD
47	013A	1	42.8	47.8	5	2000	06	1	2	3	3	1231	0	95	100	99	100	99	0	8	LONG	D	-1	-1	FAIR

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Ready NUM