DEPARTMENT OF TRANSPORTATION

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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1   INTRODUCTION

1.1   Updates for 2005

- The roadway condition data collection vendor changed from Pathway Services to Roadware Group. With this change in vendor, SVHS videos of the highway have been replaced with digital jpeg photographs.

- In 2005 Policy Memo #19 was adopted which eliminated the "Hold Harmless" method of funding the regional resurfacing program.

- A comprehensive list of pavement management definitions has been added as an appendix to this manual. The purpose of this list is to standardize common pavement management terms as well as document new definitions at the need arises.

1.2   History

The Colorado Department of Transportation (CDOT) has been working to implement a pavement management program (PMP) since the late 1980's. The goal for CDOT's PMP is to provide the regions with tools that optimize the use of public dollars and assist in project selection. CDOT 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. 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.

The shift to remaining service life has forced CDOT to completely revamp the pavement management system, starting with basic inventory information, through the candidate project identification process. CDOT selected Deighton Associates to provide the pavement management software and to act as a consultant during the system update.

The Pavement Management Program (PMP) uses this software to generate statewide surface condition reports, future surface condition projections, recommended project lists, and recommended regional budget allocations to be used as planning tools by the Transportation Commission, Regional Transportation Directors, CDOT Executive Management Team (EMT), as well as various other CDOT departments. Furthermore, in accordance with CDOT's total asset management philosophy pavement management provides a measure of accountability for how public funds are spent via the annual roadway surface condition report.

1.3   Purpose

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

- Condition Data (approved by July Technical Committee)

- 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 #19)

- Regional Budget Allocation Recommendations (See Policy Memo #19)

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 February 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 ever 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"). A Task Force convenes on an annual basis to review the current quality assurance procedures for technical improvements. 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 year of highway images are stored on 2-Terrabytes of external hard drives that can be accessed through shared drives Stephen Henry's computer (henrys/). Individual pictures can be viewed and analyzed with a simple image viewer such as Microsoft's Picture Manager. With the purchase of a $600 VisiData software license any CDOT employee can view these picture in

rapid succession, thus giving the illusion of moving video. Currently, CDOT has seven licenses one for headquarters' Pavement Management Unit and one for each of the six Regional Pavement Managers. Currently, CDOT is reviewing internal options for wider and more convenient highway image access. Ongoing plans currently include 4-Terrabytes of internal server space for faster image access and a user interface built into DTD's GeoMaps program.

Archived highway image inventory older than 2-years is maintained by the Traffic and Safety Group.

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.

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

3.1   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:
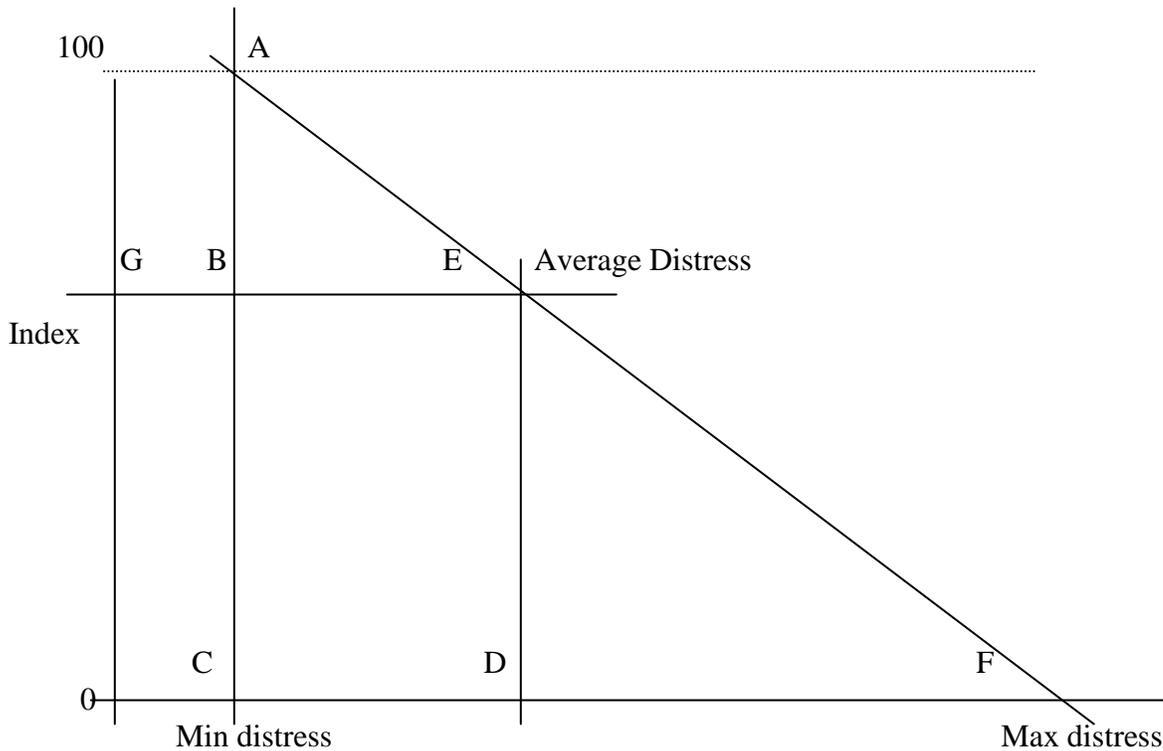
By similar triangles:

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.

3.2   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:
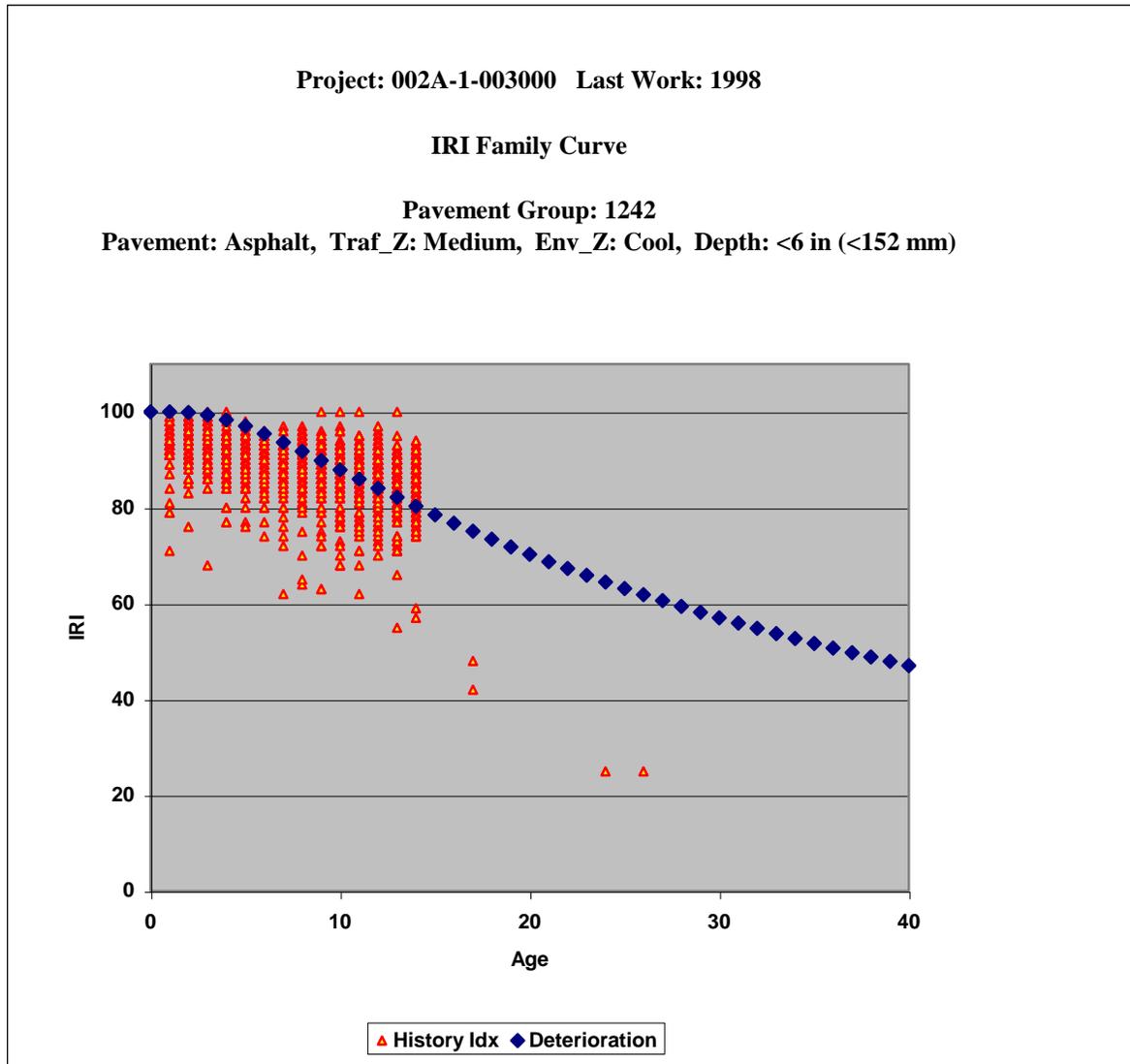
Project: 025A-1-098800   Last Work: 1992

Longitudinal Cracking Site Specific Curve

Pavement Group: 1431
Pavement: Asphalt, Traf_Z: Very High, Env_Z: Hot, Depth: <4"
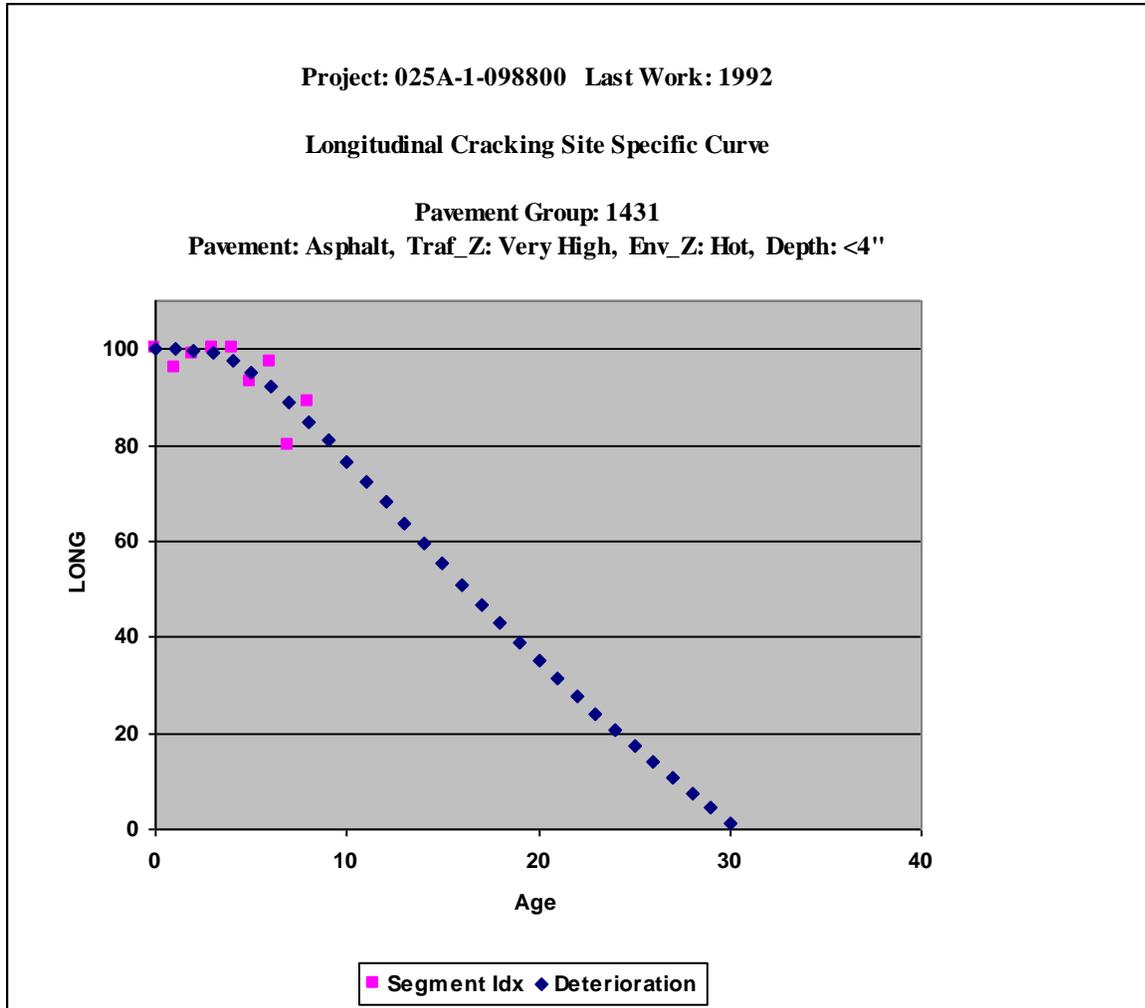
3.3   Family of Curves

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:

Project: 002A-1-003000   Last Work: 1998

IRI Family Curve

Pavement Group: 1242
Pavement: Asphalt, Traf_Z: Medium, Env_Z: Cool, Depth: <6 in (<152 mm)

3.4   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.

3.5   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 pavement is predicted to fail based on a performance curve. Knowing that pavements fail at an index value of 50, the threshold age can be determined from the regression curves. In the following illustration, 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. The final RSL for the particular segment is reported as the lowest of the individual distress RSLs 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

3.6   RSL Quality Control and Quality Assurance

Quality control and quality assurance measures are taken at each step of the process in order to ensure reasonable RSLs and Good/Fair/Poor ratings. The PMP is currently reviewing the quality control and quality assurance protocols for checking RSLs. Initially in 1999 each region was asked to review the generated RSLs for their highways and determine if, based upon their expert opinion, the values accurately depicted the condition of their region. As the software was refined the PMP determined that, much like the condition data QC/QA, field spot checks of the RSL could provide important feedback as to how accurately the RSLs generated by the pavement management software accurately reflected the existing field condition. The *Quality Assurance Protocol for Verifying Pavement Management Remaining Service Life* can be found in Appendix "C".

In summary:

- Party Responsible for Deliverable: Headquarters Pavement Manager and Regional Pavement Managers

- Deliverable: *Remaining Service Life Field Investigation*

- Due Date: Prepared and ready for the August Technical Committee

- Deliverable Location: Pavement Management Program's Internal Website.

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

Additionally, identical 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 by the end of August.

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 Services in time for the August RTDs' Meeting, so that the RTDs can approve the maps and reports.

  ➢ PMP Manager to transmit RTD-approved Maps and Reports to Chief Engineer to be included in the August Transportation Commission Mailing so that the Maps and Reports can be presented at the August Transportation Commission Meeting for Transportation Commission Approval.

- Deliverable Location: CDOT's internal Policy Memo #02

4   PROJECT RECOMMENDATIONS (NOVEMBER – DECEMBER)

4.1   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 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 (See Appendix "E"). 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 whole network while not exceeding the budget available. A simplified example of the IBC analysis is shown below:
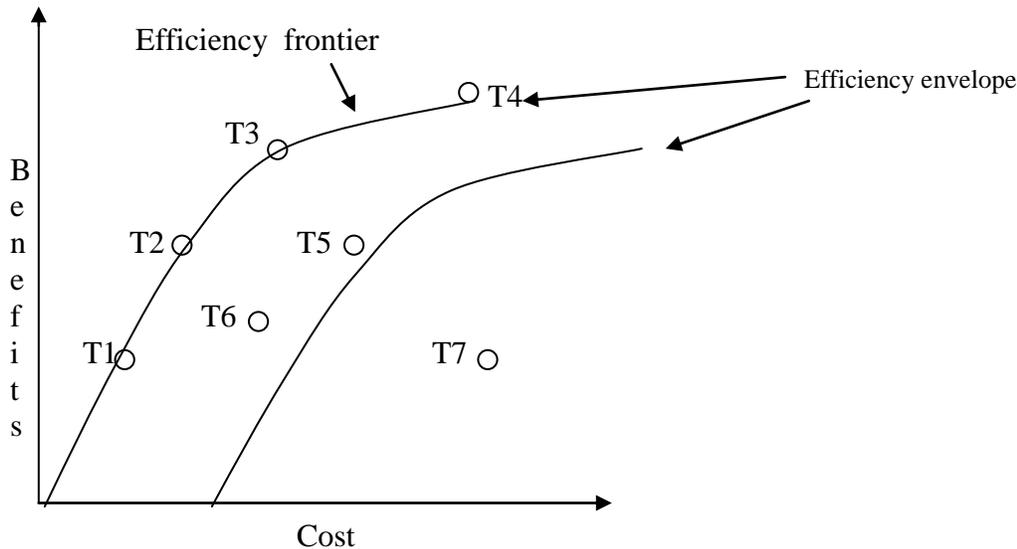
4.2   Project Selection Process

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 a recommendation generated via the PMP software. Pavement Management annually reviews and updates the rules and assumptions that outlines how a project match is determined (See Appendix "F"). The lists of project recommendations are distributed to the regions by the second week in December 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 mid April, percent project matching delivered to Chief Engineer end of June.

- Deliverable Location: Regional Pavement Managers and HQ PMU, Chief Engineer's Objectives Performance Report.

5   20-YEAR NETWORK PROJECTIONS (JANUARY)

5.1   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. 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. This way CDOT can calculate the funding level required to meet the Transportation Commissions' goal of 60% Good/Fair (See Appendix "G"). The 20-year network projections are delivered to the Technical Committee mid January and then forwarded to the Transportation Comission 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 the end of January, Chief Engineer review first week in February.

- Deliverable Location: PMP

6   REGIONAL BUDGET ALLOCATION RECOMMENDATIONS (JANUARY)

6.1   Regional Funding

Starting fiscal year 2007 the regional funding will be determined as outlined in CDOT Policy Memo #19. Furthermore, each region will still be required to spend 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 end of November.

- Deliverable Location: CDOT Policy Memo #19

6.2   Preventive Maintenance Status Report

As noted, the Regions are required to spend 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 Services the last week of March.

- Deliverable Location: PMP Internal Website

7   ANNUAL PAVEMENT MANAGEMENT CYCLE

7.1   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

8   PAVEMENT MANAGEMENT ORGANIZATIONAL STRUCTURE

8.1   Technical Committee

The Pavement Management Program is comprised of a large Technical Committee that guides the growth of Pavement Management. The voting members of the Technical Committee include two members of the Staff Pavement Management Program, all fulltime regional pavement managers, all regional materials engineers, 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.

8.2   Task Forces

Task forces generally include one or two members from the Staff Pavement Management Unit, and the RPMs. Several task forces reoccur yearly to provide quality assurance and quality control throughout the annual Pavement Management process. The Condition Data Task Force convenes annually to review the *Quality Assurance Protocol for Verifying Pavement Management Condition Data* (completed three weeks after final condition data is received) and to ensure the processes outlined in the document are fulfilled. The Index Equation/Performance Curve Task Force assembles once a year to validate the index equation and to review the myriad of performance curves (completed mid July). This Task Force also reviews the *Quality Assurance Protocol for Verifying Pavement Management Remaining Service Life* (completed the first week of August). Similarly, the annual Treatment Triggers and Cost Task Force reviews and updates the triggers and costs for each treatment. This Task Force also reviews the *Quality Assurance Protocol for Verifying Pavement Management Recommended Project Treatments* (completed the last week of August). The Systems Task Force also convenes annually to review the current Pavement Management performance measures, which includes investigating the project match definition and percentage (completed the first week of October).

After a task force investigates an issue, the resolution is passed on to the Technical Committee. The Pavement Management 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* (Appendix "I") details the organizational flow and the responsibilities of all participating parties.

9   CONCLUSION

9.1   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)

10   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

2003 Data Collection Season

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
	01=Old Asphalt
	02=New Asphalt
	03=Milled Surface
	04=Gravel Surface
	11=Old Concrete
	12=New Concrete
	21=Old Chipseal
	22=New Chipseal
SHLDRT	Shoulder Type
	N=No Observation
	F=Flexible Surface Type
	C=Curb and Gutter
	R=Rigid Surface type
SHLDRW	Shoulder Width
	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)
FAULTCOUNT_L	Number of Faults-Low Severity (>1/8" <1/4")
FAULTCOUNT_M	Number of Faults-Moderate Severity (>1/4" <1/2")
FAULTCOUNT_H	Number of Faults-High Severity (>1/2")
TEXRMS	Root Mean Square of Texture Depth (millimeters) (RWP)
TEXMTD	Mean Texture Depth (millimeters) (RWP)

2003 Data Collection Season
SPALL_L	Transverse Joint Spalling-Low Severity (count)
SPALL_M	Transverse Joint Spalling-Moderate Severity (count)
SPALL_H	Transverse Joint Spalling-High Severity (count)
SPALL	
FATIGUE_L	Fatigue Cracking-Low Severity (square feet) (Default width=1.5 ft)
FATIGUE_M	Fatigue Cracking-Moderate Severity (square feet) (Default width=4.0 ft)
FATIGUE_H	Fatigue Cracking-High Severity (square feet) (Default width=12.0 ft)
FATIGUE	
TRANSCOUNT_L	Transverse Cracking-Low Severity (count)
TRANSCOUNT_M	Transverse Cracking-Moderate Severity (count)
TRANSCOUNT_H	Transverse Cracking-High Severity (count)
TRANSCOUNT	
TRANS_L	Transverse Cracking-Low Severity (length ft)
TRANS_M	Transverse Cracking-Moderate Severity (length ft)
TRANS_H	Transverse Cracking-High Severity (length ft)
TRANS	
LONG_L	Longitudinal Cracking-Low Severity (length ft)
LONG_M	Longitudinal Cracking-Moderate Severity (length ft)
LONG_H	Longitudinal Cracking-High Severity (length ft)
LONG	
CORNER_L	Corner Cracking-Low Severity (count)
CORNER_M	Corner Cracking-Moderate Severity (count)
CORNER_H	Corner Cracking-High Severity (count)
CORNER	
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 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. 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 consistently exceed the preset thresholds. The variance threshold for ride is 50 inches/mile and the variance threshold for rut is 0.1 inch. 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 Remaining Service Life (RSL) as computed by the Pavement Management software and comparing those RSLs to field conditions.

2   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.

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

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

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.

3   PROTOCOL

1. The Regional Pavement Manager chooses ten Pavement Management projects for his or her Region. Ensuring that each Region is represented will account for environmental differences statewide.

2. The Regional Pavement Manager and Headquarters Representative will review the current history of the project to ensure that the highway segment is accurately reflected in the Pavement Management software. Specific factors to investigate include the year of last work, the traffic volume, and pavement thickness.

3. The Regional Pavement Manager visits the chosen projects and review the Pavement Management software RSL estimation of the project. Based upon the historical research and the field condition of the project, the Regional Pavement Manager determines whether or not the RSL is appropriate. If the RSLis deemed unsuitably inaccurate then the Regional Pavement Manager must determine the root cause of the misrepresentation. Factors that may contribute to bad results include, deficient historical data (i.e., year of last work, environmental zone, traffic volumes, and pavement thickness) within the Pavement Management

software, misrepresented pavement distress conditions, flawed index equations, imperfect performance curves, etc.

4. The Headquarters Representative analyzes the data to identify the percent of acceptable RSLs. This analysis will be done on a per project basis. Any projects with unreasonable RSLs will be listed with the reasons for the inaccuracy.

4   SCHEDULE

The office research and subsequent field investigations cannot commence until after the annul loading of the Pavement Management software, usually in mid-July. After the software has been loaded, the Regional Pavement Managers and Headquarters Representative can begin reviewing the historical data of the chosen QA project. Field investigation should begin in early August and are estimated to take a month to perform.

Once the research is completed, the reporting process can begin. A draft version of the annual *RSL Field Investigation* report will be circulated for comment and presented at the September Pavement Management Technical Committee. This report will summarize the findings of this protocol and identify any areas for improvement within the Pavement Management Program. A final *RSL Field Investigation* report will be ratified at the October Pavement Management Technical Committee.

5   CONCLUSION

All data and decisions resulting from this protocol are summarized in the annual *Remaining Service Life Field Investigation*, which is produced by the Index Equation/Performance Curve Task Force and ratified by the Pavement Management Technical Committee.

If the overall results of this protocol are good then the Pavement Management Program will proceed with the current components (i.e., historical data, condition data, index equations, and performance curves) of the Pavement Management software. If, however, the results of this protocol are egregiously inconsistent then the Pavement Management Program will have to develop a corrective action plan and determine how to proceed for the current year. It should be noted the restrictive nature of Pavement Management's annual schedule may be severely impacted if the results of this field investigation necessitate a corrective action plan.

APPENDIX D
Definition of a Project Match

Definition of a Project Match

1. Any length of overlap recommended by the Pavement Management Software and the actual projects that the regions are constructing will be constituted as a match. For example, a region has a project scheduled for highway 070A from milepost 300 to 310. The Pavement Management Software recommends a project on 070A from 308 to 312. Since there is a 2-mile overlap from 308 to 310 this project will be considered a match thus far and the next criteria will be checked.

2. The recommended project year from the Pavement Management Software must be within +/- 4 years. For example, a region has a project scheduled for 070A from milepost 300 to 310 starting construction in 2004. The Pavement Management Software recommends a project on 070A from 308 to 312 starting in 2007. As defined above this project will be considered a match thus far and the next criteria will be checked.

3. The level of treatment recommended by the region must match the level of treatment recommended by the Pavement Management Software. For example, a region has scheduled a stone mastic asphalt project for 070A from milepost 300 to 310 in 2004. The Pavement Management Software recommends a mill and fill project on 070A from milepost 308 to 312 in 2007. Since both treatments are rehabilitation type treatments this project will be considered a 100% match as long as items 1 and 2 above are satisfied.

Assumptions:

- Currently dTIMS recommends projects based on direction 1 or direction 2. Therefore, the chance of a recommended dTIMS project matching the region's multi year plan is increased. For example. dTIMS recommends a project for 070A direction 1 from MP 308 to 312 in 2003 and another project for 070A direction 2 from the same mileposts in 2007. Following rule number 2 above (+/- 4 years) our range of matching a project is now 1999 to 2011. So multi directional recommendations increase the chance of a project match.

- For 2002 the regional pavement managers will create a reasonable list of projects that their region intends to construct within the next 3 years starting with projects being built in calendar year 2004.

- PMP software optimized using the current regional budgets.

- Matching projects will be recorded as committed treatments in the future dTIMS. This will insure that dTIMS will recommend the same treatments in future years.

- Only projects constructed with surface treatment program funds will be considered for a project match. Therefore, if a project is funded from a source other than the surface treatment budget, i.e. 7th Pot, the software will be programmed such that surface treatment dollars will not be spent on that project.

- Use region specific costs in calculating treatment costs.

- If a region is constructing a project within another region's boundaries, the region funding the project will get the project match.

- If a project number consists of work being performed on multiple highways only one of these highways needs to match for the entire project number to be considered a project match.

APPENDIX E
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.
- Progress of the Task Force will be provided through meeting minutes to the Region Pavement Managers and the Region Materials Engineers. Additional Task Force updates will be given at the monthly Pavement Management Technical Committee meeting.
  - Questions, comments, clarifications, or other input on any issues must be provided at this time.
- Once the Task Force finalizes an issue, a unanimous vote of members present is required to pass the issue to the Technical Committee for ratification.
- The result of the Task Force vote will be sent to the Region Pavement Managers and the Region Materials Engineers.

Pavement Management Technical Committee is made up of representatives from all Regions and Head Quarters.

- At the Technical Committee meetings any issues approved by the Task Force will be presented for ratification.
  - The reasons why the Task Force approved 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 each Regional Pavement Manager.
  - One ballot for each Regional Materials Engineer.
  - One ballot for the Headquarters Pavement Management Program.
  - One ballot for the Headquarters staff member who is sponsoring the issue.
  - One ballot for the Department of Transportation Development.
  - One ballot for the Federal Highway Administration.
- All voting members have an inherent obligation to the Technical Committee to perform their duty responsibly in the best interests of the State of Colorado.
  - 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 the Pavement Management can continue to progress and move forward.
- All votes are due one week from the date of the Technical Committee meeting minutes.
  - Any votes not turned in by this time will be recorded as "Did not vote."
- A majority vote is required to ratify an issue.
- Any "No" votes will require a stated objection.
  - Any noted objections or comments attached to an approved issue will be the starting point for next year's Task Force investigation.

APPENDIX F
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 $1/10^{th}$ 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;

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 project 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 Cost Benefit (ICB) – 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 benefits. (Benefit = Area Under the Curve x 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).

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. 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. 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 an 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 volume used to define pavement groups.

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 HBP is 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 HBP is heated in place, milled, mixed with rejuvenating agent, then placed, compacted and overlaid.
- AHIP (Asphalt Hot in Place Recycle) – The existing HBP 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 superpave HBP mix. Typically 4 to less than 6 inches thick.
- AMDO (Asphalt Medium Overlay) – Standard superpave HBP 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 HBP is typically milled up to 2" deep, and the millings are removed. Then an HBP overlay of the same depth 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 HBP mix having more voids and requiring more asphalt in the mix. Placed on the top surface of a pavement structure and acts as a wearing course.
- ATHO (Asphalt Thin Overlay) – Standard superpave HBP 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