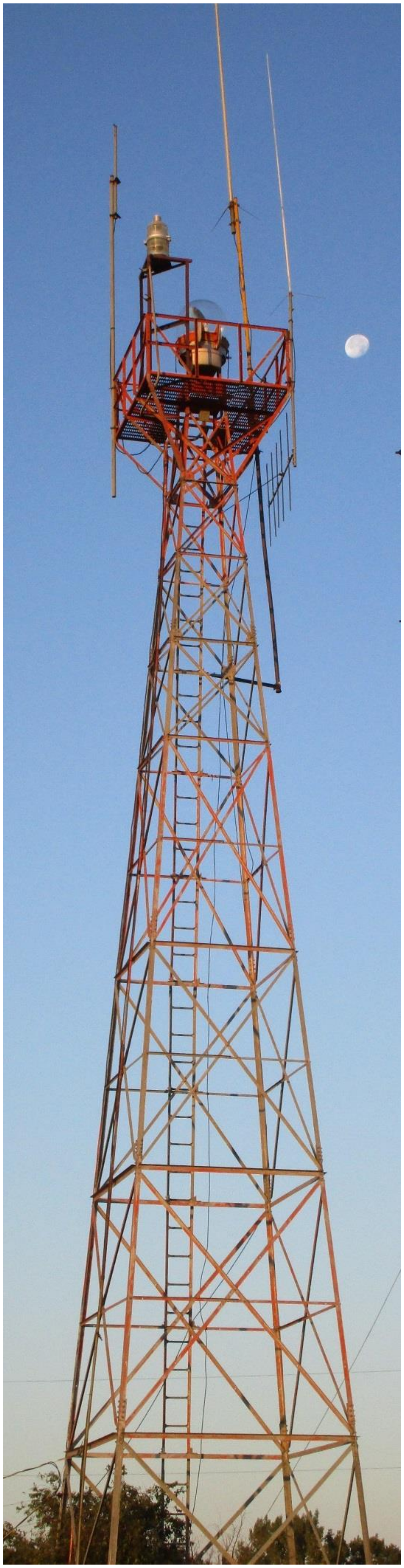

MONTANA

AVIATION SYSTEM PLAN - 2015 UPDATE

PAVEMENT CONDITION INDEXES

A.I.P. 3-30-0000-013-2015

Prepared for

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ABBREVIATIONS

AAC	Pavement surface type - structural asphalt overlays of asphalt
AC	Pavement surface type - asphalt / hot mix / plant mix bituminous surface course
ACAH	Pavement Family - asphalt aprons with higher than 30,000 lb. load rating
ACAM	Pavement Family - asphalt aprons with load rating from 12,500 to 30,000 lb.
ACPL	Pavement Family - asphalt pavements with less than 12,500 lb. load rating
ACPS	Pavement Family – asphalt pavements experiencing only seasonal operation (dormant during winter)
ACRH	Pavement Family - asphalt runways & taxiways with higher than 30,000 lb. load rating
ACRML	Pavement Family - asphalt RWs & TWs, load rating 12,500 to 30,000 lb, 5000 or fewer ops.
ACRMU	Pavement Family - asphalt RWs & TWs, load rating 12,500 to 30,000 lb, over 5000 ops.
Agg	Aggregate / gravel as a manufactured structural layer of a pavement section
AIP	Airport Improvement Program - FAA funding for airport maintenance and construction
APC	Pavement surface type - structural asphalt overlays of concrete
BST	Pavement surface type - bituminous surface treatments / single shot / double shot / triple shot
FAA	Federal Aviation Administration
FAA AC	Federal Aviation Administration, Advisory Circular
FOD	Foreign object debris. Loose material on a pavement surface that could cause aircraft damage
Form 5320-1	FAA-format for an airport pavement map with construction and maintenance history
GA	General Aviation
Global	Maintenance policy applied to the whole pavement (e.g. fog seals, overlays)
H	High - degree of severity for an asphalt defect
HLN/ADO	FAA's Helena Airports District Office
L	Low - degree of severity for an asphalt defect
L & T CR	Longitudinal and transverse cracking
LF	Linear foot (unit of length)
Local	Maintenance policy applied to small sections of a pavement (e.g. crack seal, patching)
M	Medium - degree of severity for an asphalt defect
M&R	Maintenance and rehabilitation
MAD	Montana Aeronautics Division
Major<Crit	Reconstruction of a pavement after its condition has dropped below the critical PCI
Major>Crit	Reconstruction of a pavement before its condition has dropped below the critical PCI
MDT	Montana Department of Transportation
N	No degree of severity for an asphalt defect is defined, the defect is either present or not
NWM	FAA's Northwest Mountain Region
Ops	Aircraft operations (takeoff or landing)
P-152	FAA designation for compacting native soils
P-154	FAA designation for subbase gravel
P-208	FAA designation for basecourse gravel
P-209	FAA designation for crushed basecourse gravel
P-401	FAA designation for plant-mix bituminous pavement (asphalt)
P-403	FAA designation for small quantities of plant-mix bituminous pavement (asphalt) with less testing
P-501	FAA designation for Portland cement concrete surface course
P-609	FAA designation for an application of asphalt binder / emulsion to a pavement surface
PCAA	Pavement Family - Portland Concrete Cement - All sections
PCC	Pavement surface type - Portland cement concrete
PCI	Pavement condition index
PFC	Porous Friction Course
PREV.	Preventative maintenance
RW	Runway
SF	Square foot (unit of area)
ST	Pavement surface type - bituminous surface treatments / single shot / double shot / triple shot
STA	Station - formatted distance with implied direction used by surveyors
STPA	Pavement Family - bituminous surface treated pavements of all load ratings
TW	Taxiway
USACERL	U.S. Army Corps of Engineers Construction Engineering Research Laboratory
XX	Indicates an inspection and PCI rating were completed for a pavement previous to its reconstruction

CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 PROJECT DESCRIPTION

This project, the 2015 Update to the Montana Aviation System Plan, continues development of a Pavement Management System for Montana's general aviation airports. This is an ongoing process begun in 1988 and updated on a three-year cycle since then. The Aeronautics Division of the Montana Department of Transportation, in coordination with the Federal Aviation Administration, Helena Airports District Office, contracted with Robert Peccia and Associates (RPA) to provide the surveys and analysis required for the on-going development of the State’s airport pavement management system. RPA subcontracted with Applied Research Associates, Inc. (ARA) to complete PAVER database manipulations.

The pavement management system is designed to be a systematic, and objective tool for determining maintenance and rehabilitation needs and priorities. It is intended to provide better information to airport and aviation officials, so that Federal, State, and local resources can be more efficiently allocated toward maintaining and improving airport pavements. Primary airports complete their own inspections and planning. The Pavement Condition Index (PCI) provides a standard scale for comparing the existing operational condition and structural integrity of airport pavements. The pavement management system’s PCI provides a rational basis for justifying pavement replacement or rehabilitation projects. It can also provide feedback on pavement performance to validate or revise pavement design, construction, and maintenance procedures.

The project consists of airport pavement records updates, map updates (FAA Form 5320-1), pavement condition surveys, PCI calculations, PCI analyses, PCI predictions, maintenance suggestions, and maintenance budget projections. This final report documents work completed, assesses system-wide conditions and potential, and recommends work for future updates to the pavement management system. Inspection results, PCI values, predictions, maintenance suggestions, and a brief interpretation of the results are provided directly to the sponsor for each airport. Results are provided to the Montana Aeronautics Division and the Federal aviation Administration (FAA).

RPA updated airport maps and pavement records (FAA Form 5320-1) for all fifty-nine (59) general aviation airports in Montana’s database. RPA personnel completed intensive field inspections of pavement samples and collected data at fifty (50) of these airports to identify current and estimate future pavement conditions. ARA forecast pavement deterioration at all Montana database airports at 1-, 5-, and 10-years using the Pavement Condition Index.

RPA completed field surveys in accordance with the criteria specified in Federal Aviation Administration (FAA) Advisory Circular AC 150/5380-6 "Guidelines and Procedures for Maintenance of Airport Pavements". Calculations, analysis, and predictions were completed using the U.S. Army Corps of Engineers Construction Engineering Research Laboratory’s (USACERL) "MicroPAVER" software system (version 6.5.7).

Table 1.1 and Figure 1.1 show the airports surveyed and analyzed in this project.

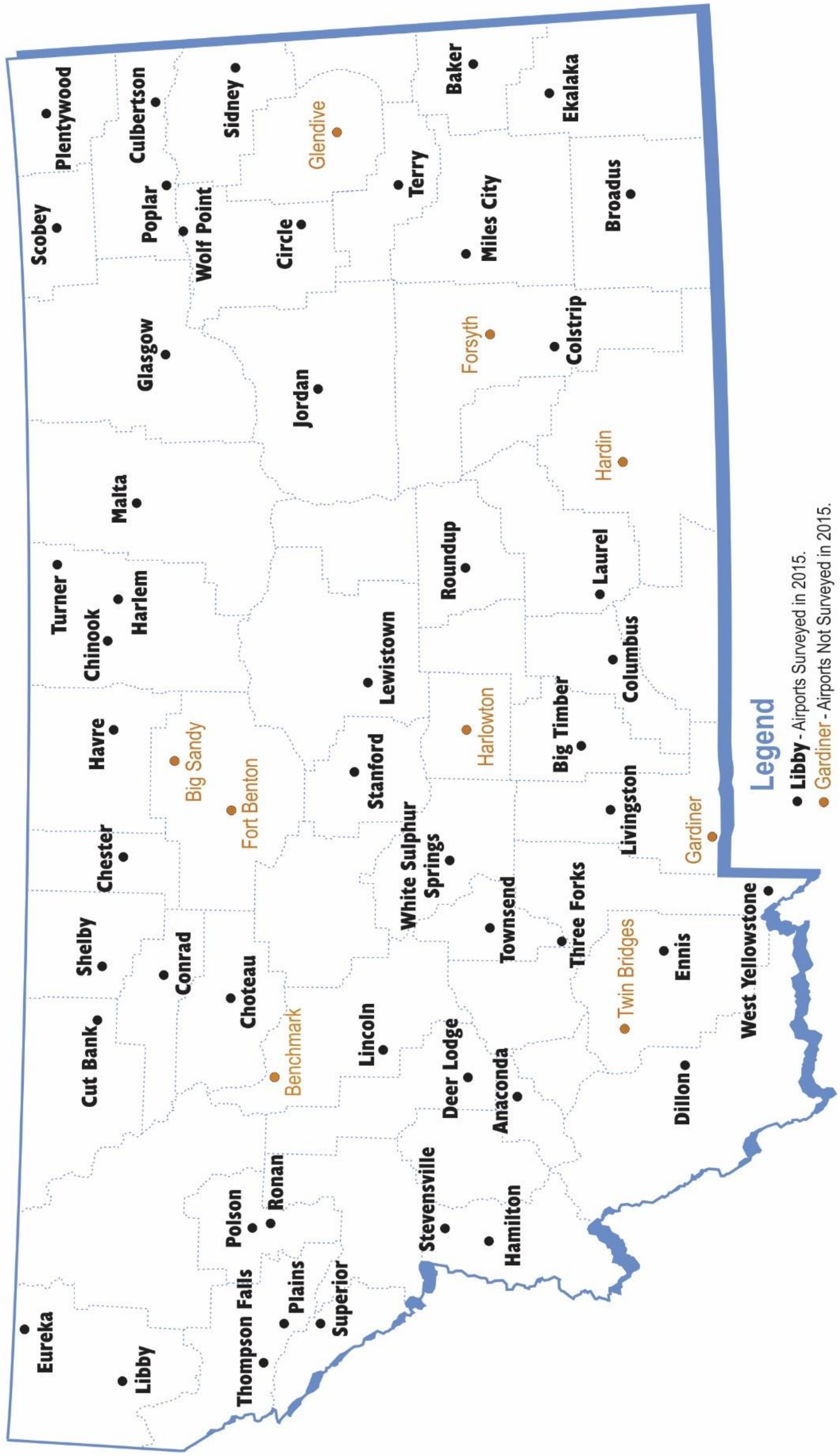
TABLE 1.1
MONTANA'S PAVEMENT MANAGEMENT SYSTEM - 2015 UPDATE

Airport (Database Branch Number)	**2015 Inspection Report**	**2015 Inspection Photos**	**FAA Form 5320-1 Update**	**PCI Predict.**
Anaconda Airport (09)	X	X	X	X
Baker Airport (56)	X	X	X	X
Benchmark Airport (11)			X	X
Big Sandy Airport (18)			X	X
Big Timber Airport (25)	X	X	X	X
Broadus (62)	X	X	X	X
Chester, Liberty County Airport (15)	X	X	X	X
Chinook Airport (58)	X	X	X	X
Choteau Airport (19)	X	X	X	X
Circle, McCone County Airport (38)	X	X	X	X
Colstrip Airport (48)	X	X	X	X
Columbus (59)	X	X	X	X
Conrad Airport (46)	X	X	X	X
Culbertson Airport, Big Sky Field (34)	X	X	X	X
Cut Bank Airport (13)	X	X	X	X
Deer Lodge City-County Airport (08)	X	X	X	X
Dillon Airport (52)	X	X	X	X
Ekalaka Airport (57)	X	X	X	X
Ennis Big Sky Airport (50)	X	X	X	X
Eureka Airport (54)	X	X	X	X
Forsyth Airport, Tillit Field (43)			X	X
Fort Benton Airport (60)			X	X
Gardiner Airport (64)			X	X
Glasgow International Airport (31)	X	X	X	X
Glendive, Dawson Community Airport (40)			X	X
Hamilton, Ravalli County Airport (06)	X	X	X	X
Hardin (66)			X	X
Harlem Airport (17)	X	X	X	X
Harlowton, Wheatland County Airport (22)			X	X
Havre City-County Airport (16)	X	X	X	X

TABLE 1.1 (contd.)
MONTANA'S PAVEMENT MANAGEMENT SYSTEM - 2015 UPDATE

Airport (Database Branch Number)	2015 Inspection Report	2015 Inspection Photos	FAA Form 5320-1 Update	PCI Predict.
Jordan Airport (37)	X	X	X	X
Laurel Municipal Airport (27)	X	X	X	X
Lewistown Airport (21)	X	X	X	X
Libby Airport (01)	X	X	X	X
Lincoln Airport (12)	X	X	X	X
Livingston Airport (24)	X	X	X	X
Malta Airport (61)	X	X	X	X
Miles City Airport, Frank Wiley Field (42)	X	X	X	X
Plains, Penn Stohr Field (63)	X	X	X	X
Plentywood, Sherwood Airport (36)	X	X	X	X
Polson Airport (03)	X	X	X	X
Poplar Airport (65)	X	X	X	X
Ronan Airport (53)	X	X	X	X
Roundup Airport (47)	X	X	X	X
Scobey Airport (35)	X	X	X	X
Shelby Airport (14)	X	X	X	X
Sidney-Richland Municipal Airport (39)	X	X	X	X
Stanford Airport (20)	X	X	X	X
Stevensville Airport (05)	X	X	X	X
Superior, Mineral County Airport (04)	X	X	X	X
Terry Airport (41)	X	X	X	X
Thompson Falls Airport (02)	X	X	X	X
Three Forks Airport (49)	X	X	X	X
Townsend Airport (55)	X	X	X	X
Turner Airport (29)	X	X	X	X
Twin Bridges Airport (51)			X	X
West Yellowstone Airport (10)	X	X	X	X
White Sulphur Springs Airport (23)	X	X	X	X
Wolf Point Airport (32)	X	X	X	X

FIGURE 1.1
MONTANA AIRPORTS' PAVEMENT DATABASE MAP



1.2 THE PAVEMENT MANAGEMENT SYSTEM

A pavement management system begins with an objective, repeatable method for determining present pavement condition. This project uses the Pavement Condition Index (PCI) developed at the US Army Corps of Engineering Research Lab (USACERL). The PCI is a numerical index from 0 to 100 that describes the pavement's overall structural integrity and operational condition, with 100 assigned to a flawless pavement and zero to a highly degraded pavement. The PCI is based on the types, severities, and quantities of pavement distresses identified during on-site visual inspections.

A computerized database called PAVER is used to store, manipulate, and present data that generates PCI values. This program was developed at USACERL specifically for use with the PCI. The PAVER system is continually being improved and upgraded by Engineered Management Systems Software and is periodically reissued in a new version. Montana's pavement management system typically uses a recent release of the software. The newer software has strived to enhance analysis and reporting tools, refine analysis routines, and improve the operator-computer interface. The current upgrade is a Windows-based program with reasonably easy data transfer and query routines. For this report PAVER output was refined and supplemented using Microsoft Word, Microsoft Excel, and Microsoft Access to improve readability and formatting.

As with any pavement management system, the following tasks are required to adequately document the process, obtain the required data, and generate meaningful results.

- ✈ Assemble background data about the pavements to be studied.
- ✈ Prepare and update base maps, define the study areas.
- ✈ Conduct field inspections of random samplings of the pavement surface.
- ✈ Process the field inspection and background data.
- ✈ Analyze the data and generate appropriate reports.

The process begins with reviewing airport records to locate the pavements to be studied. Background information such as materials, thicknesses, construction dates, primary use (runway/taxiway/apron), surface area, and related data is assembled. This data is then used to divide pavements into a successively refined network by geographic location, functional use, consistency of characteristics, and manageable inspection size.

Each airport is considered a separate “zone” in Montana's airport database. Each zone (airport) is then divided by function or primary use into “branches.” All aprons are grouped into a single branch, all taxiways into another branch, and each runway is placed in a separate branch. Branches are further divided into “sections” with similar characteristics. Each section is defined as a pavement of consistent age, construction materials, and maintenance history. Finally, since sections are generally still large pavement areas, each is divided as evenly as possible into “sample units.” This last division of asphalt-surfaced areas into near 5000 square foot samples, and concrete-surfaced areas into near 20-slab samples is designated for convenient, manageable, and statistically valid pavement inspection.

After obtaining background information and dividing the pavements into zones, branches, sections, and sample units, the database network is created and base maps are drawn to document this network structure. FAA Forms 5320-1, "Pavement Strength Survey" are revised and used as guides during field surveys. Base map layout is confirmed (or adjusted) on-site during visual pavement inspection.

As field inspections are completed, distress data is loaded into the PAVER program. Pavement Condition Indexes are calculated providing a numerical rating of present condition by section. Sections are grouped by similar construction, strength, and primary use into "families" of pavements which should experience similar wear, deterioration, and useful lives. The PCI inspection history of all pavements in a family are used to generate a pavement life cycle curve which can then be used to forecast PCI's for all member pavements in the family.

Finally, when the desired analyses have been completed, numerous reports can be generated to describe the pavement systems, their existing conditions, their approximate future conditions, and potential costs to improve performance and extend pavement life.

1.3 SCOPE OF SERVICES

The scope of services required for this phase of the pavement management system development consists of the following:

- ✈ Collecting and updating airport geometric and pavement condition information for fifty (50) airports. The FAA recommended skipping airports with new or impending construction, including: Big Sandy, portions of Cut Bank, Forsyth, Fort Benton, Glendive, Harlowton, portions of Miles City, and Twin Bridges. Benchmark and Gardiner were left out due to their advanced age. Striving to make the most efficient use of the available inspection budget, the following three rules were applied to select pavement sections at each remaining airport:
  - Sections smaller than 30,000 square feet were not inspected, since they typically do not "trigger" a paving project.
  - Pavement sections with a 2009 PCI value less than 55 were not surveyed, assuming that they would now be in need of reconstruction.
  - If applying the previous two rules eliminated all aprons or taxiways from the airport, one representative apron and/or taxiway was inspected at the airport.

  All omitted sections are listed in Table A.5 in Appendix A.

- ✈ Locating Construction or Record Drawings and updating base maps (FAA Form 5320-1) for the 50 inspection airports. Maps for the remaining 9 airports were revised where possible, and included in the report. These maps were produced in AutoCAD and transferred to the more readily accessible Adobe PDF format. Hard copy and digital format maps are project deliverables.

- ✈ Defining pavement zones, branches, sections, and sample units for any reconstruction, or new construction of airside pavements.

- Conducting visual condition surveys at 50 general aviation airports located throughout the State of Montana, loading the survey data into PAVER, and obtaining current PCI values for each section.

- Developing "Family Analysis Curves" that allow modeling of pavement performance by grouping similar pavements, then using the group's behavior to predict future pavement conditions.

- Updating the State's PAVER database, analyzing pavements, and producing summary reports for each airport studied.

- Delivering ten copies of a Final Report, organized and bound in a three-ring binder with cover graphics, table of contents, and appendices.

- Producing Adobe PDF versions of the project report for inclusion on MDT Aeronautics Division's website.

- Mailing pavement analysis results and recommendations for individual airports directly to airport managers.

CHAPTER 2
PROJECT APPROACH

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Work on this project began with a review of previous reports produced for the Montana Aviation System Plan – PCI Updates. Since consistency is extremely important to periodic pavement condition surveys, the pavement definitions, naming conventions, and recommendations from previous studies were incorporated into this project to the extent possible.

2.1 PROJECT DESCRIPTION

Airport construction information was collected for airports within the project scope that received FAA Airport Improvement Program (AIP) funds in fiscal years 2009-2015. Pavement information was reviewed and updated for construction since 2009 for each of the study airports. This information was obtained from airport layout plans (ALP), construction plans, FAA Form 5320-1, design reports, the 2015 Montana Airport Facility Directory, airport sponsors, and in some cases, directly from the engineer in charge of construction. When available records did not agree with completed construction, our inspection teams collected as-built dimensions in the field to update maps and re-defined sample sections on the fly.

All of the information obtained was used to prepare and/or update schematic maps for each airport, using FAA Form 5320-1 as a base. The maps show pavement locations, dimensions, composition, and dates of construction.

2.2 NETWORK AND SAMPLE DEFINITION

Each airport's pavement network consists of airside pavements that the Owner is responsible for maintaining. In each case, the airport's pavement was assigned to a zone. It was then divided into branches (facilities), sections (features), and sample units as defined by PAVER procedures and those of FAA Advisory Circular, AC 150/5380-7, "Airport Pavement Management Program (PMP)".

Once the updated base maps depicting the location of sections and sample units were prepared, the minimum number of sample units (n) that needed to be surveyed to obtain an adequate estimate of the section PCI was determined. The required number of sample units was estimated using the procedure defined in Attachment A of the Northwest Mountain Region (NWM) handout, entitled "Selection of Minimum Number of Sample Units". This is reproduced in Table 2.1. The number of sample units selected provides for a 92% probability that the estimate of the mean section PCI is within +/- 5 points of the true mean PCI.

At least one sample more than the NWM recommendation was inspected on each runway section. This provided additional accuracy for the sections most likely to drive airport maintenance or improvement projects. Samples were selected with the intent of overlapping one sample with a recent previous survey to aide in verifying consistent inspection techniques.

TABLE 2.1
SELECTION OF MINIMUM NUMBER OF SAMPLE UNITS

Flexible Pavement		Rigid Pavement	
N=1	n=1	N=1	n=1
N=2	n=2	N=2	n=2
N=3-6	n=3	N=3-4	n=3
N=7-13	n=4	N=5-6	n=4
N=14-38	n=5	N=7-8	n=5
N>38	n=6	N=9-11	n=6
		N=12-14	n=7
		N=15-19	n=8
		N=20-27	n=9
		N=28-38	n=10
		N=39-58	n=11
		N=59-104	n=12
		N=105-313	n=13
		N>313	n=14

N = Number of sample units in a pavement section or feature
(±5,000 sq. ft. per sample unit for asphalt pavements, ±20 slabs for Portland Cement Concrete pavements)
n = Number of sample units to be surveyed

Reference: Northwest Mountain Region handout, "Pavement Condition Survey Program", (6/11/88 HLN/ADO)

After the number of sample units to inspect was determined, particular sample units to inspect were chosen using "systematic random sampling". The method is described here, followed by an example in Table 2.2.

1) All the sample units within a section are numbered consecutively.

2) The sampling interval (I) is computed with the equation I=N/n, where N = total number of sample units in a section, n = the minimum number of sample units to be surveyed (from Table 2.1). The sampling interval (I) can be rounded up or down to a whole integer.

3) The first sample unit "s", is selected at random from numbers 1 through sampling interval (I).

4) Sample units to be inspected are identified as s, s+I, s+2I, s+3I, etc..

Sample units were selected before arriving at the site and inspections were conducted on the preselected sample units to avoid biasing the sample. In some cases systematic random sampling was not used either due to a decidedly "non-random" interaction of sample numbers and systematic survey points that concentrated sampling in a small area, or due to an effort to sample previously un-sampled areas. The Anaconda example below illustrates the most common sample selection variations. Runway 16-34, designated "R-1", has few previously sampled areas, so the recommended systematic random sampling is used. Standard systematic random sampling is also used for T-1 in 2015. A variant "paired sample" systematic random sampling was used on taxiway T-1 in 2006 to pick-up several samples with no historical inspection. Section A-1 had samples selected entirely at random, for a good geometric distribution. Finally, on apron area A-2, samples were selected to include several previously uninspected samples, then completing the selection with geometrically disbursed samples. On aprons and other areas where some locations may see much more wear than others, it is more important to get a good geometric distribution of samples, than to get a numerically random sampling.

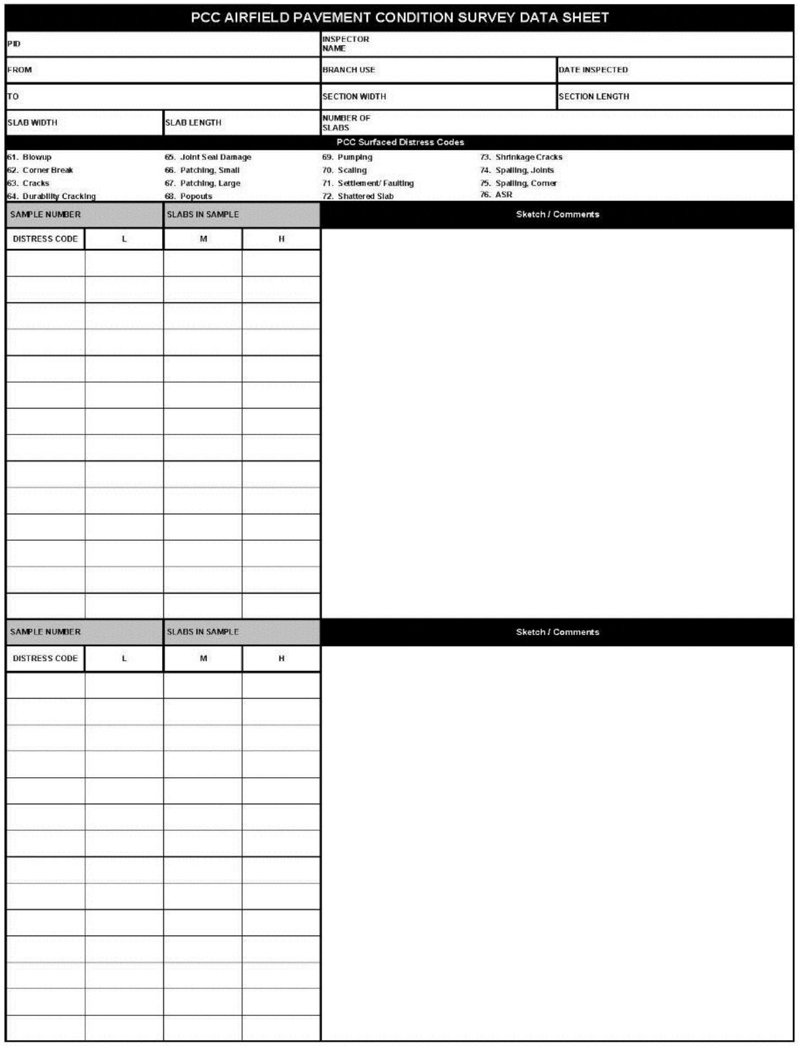
TABLE 2.2
EXAMPLE SAMPLE UNIT SELECTION

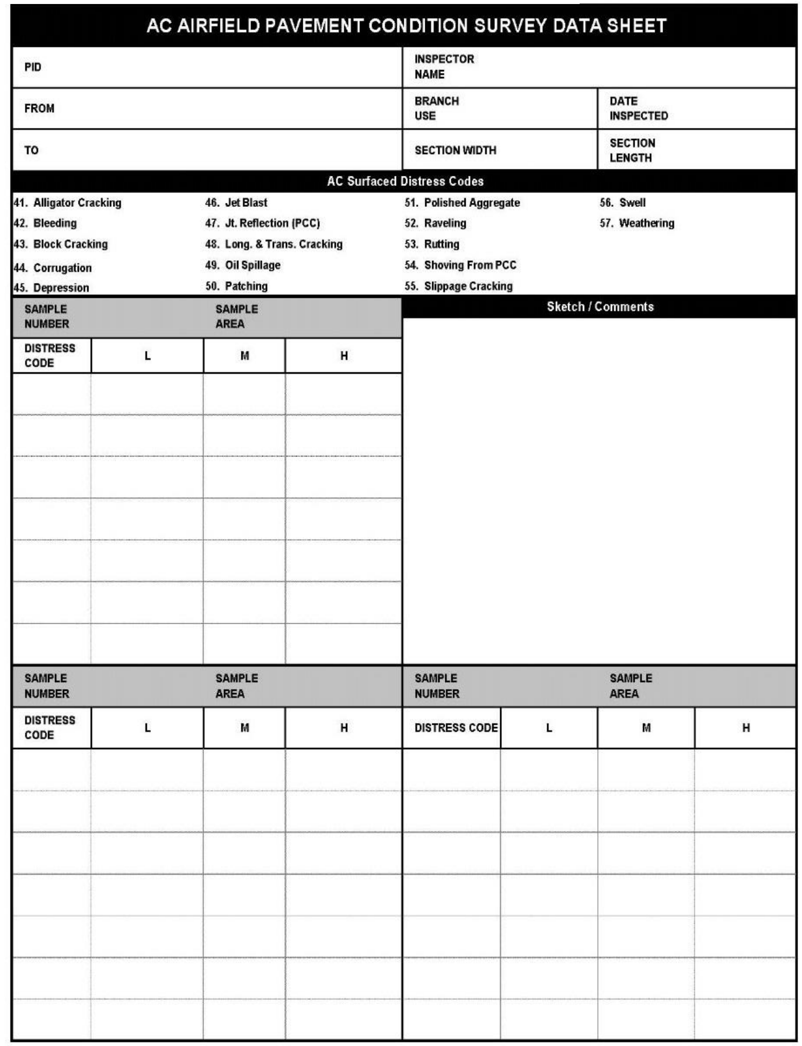
Section Number	**Total # of Sample Units** (N)	**Minimum # of Units to Inspect *** (n)	**Sample Spacing**** (I = N/ n)	**Random Start #** (s)	**Sample Units to Survey** (s,s+i,s+2i, etc.)	**Actual Sample Units Surveyed**
R-1	92	6 + 1 = 7†	13		8,21,34,47,60,73,86	8,21,34,47,60,73,86
			or		or	
			14		8,22,36,50,64,78,92	
T-1	20	5	3	2	2,5,8,11,14,17	
			or			
			4	1	1,5,9,14,18	1,5,9,14,18
			or			
		Paired sample variant used in 2006			4,5, 9,10, 16	
A-1	9	4	2	1	1,3,5,7,~~9~~ (used in '97)	1,3,7,9
				2	2,4,6,8 (used in '94)	
			or			
			3	1	1,4,7,~~10~~ (along one edge - not used)	
A-2	17	5	3	3	3,6,9,12,15 (along one edge – not used)	
			or			
			4	2	2,6,10,14,18,17 (variant used in '03)	
			or			
		Selecting mostly un-inspected samples that are spread out across the section				2,4,8,12,16

* Table 2.1, or engineer's judgement
** Rounded up or down to a whole number
† Robert Peccia & Associates' engineers chose to increase sampling frequency by 1 on all runways, to provide a higher probability of an accurate PCI assessment on this most critical airport pavement.

The airport base maps (FAA Form 5320-1) show the sections and sample units defined for each airport. Sample units selected for evaluation in the various project years are marked with different hatch patterns as shown in the map legend. Sample units selected for evaluation in the 2015 Update are marked with a dot pattern.

FIGURE 2.1
CONCRETE AND ASPHALT PAVEMENT INSPECTION SHEETS





2.3 PAVEMENT CONDITION SURVEYS

Visual condition inspections were conducted in general accordance with the procedure outlined in Appendix C of the FAA Advisory Circular 150/5380-7, "Airport Pavement Management Program (PMP)". The survey confidence level was reduced from 95% to 92% in accordance with the Northwest Mountain Region handout, "Pavement Condition Survey Program", (6/11/88 HLN/ADO).

Detailed visual inspections were conducted on paved surfaces at each of the airports selected for this project during the period August 2015 through October 2015. The sections defined on base maps were verified, or revised if necessary. Sample units to be surveyed were temporarily marked on the pavement. Visual inspections were conducted measuring types, severities, and quantities of pavement distresses while walking over each selected sample unit. Distresses were recorded on inspection sheets like those shown in Figure 2.1. Individual pavement distress types and severities were identified using USACERL generated PCI Field Manuals for asphalt surfaced airfields and jointed concrete airfields (see Appendix C of the FAA Advisory Circular 150/5380-7). Photographs documenting overall condition and/or specific distresses were taken during the field surveys and are included in Chapter 4. Sample selection strives to select “representative” areas, *but photos were often selected to show extreme (and possibly atypical) distresses.*

After consulting with M. Y. Shahin, MicroPaver’s lead development engineer, two adjustments to previous field inspections were initiated beginning in 2000. Alligator cracking within one foot of the pavement edge was recorded as longitudinal cracks, and distresses recorded as “block cracking” in 1997 were reduced to longitudinal /transverse cracks. On larger airports, sections can be chosen to separate runway edge conditions from the center with separate PCI’s produced for heavily used center and seldom used edges. With smaller GA airports, it’s impractical to subdivide runway width, so edge failure can drive the PCI of a runway significantly below what its center section would warrant. Down-grading the type of distress recorded for edge failure better represents the quality of the commonly used portion of the pavement. Large, rectangular blocks seen on a few of Montana’s airports were judged to be just off the block cracking continuum, and recording them as Block Cracking was excessively harsh on the section PCI. SEI’s 2012 inspections recorded block cracking at multiple airports. RPA’s 2015 inspections found no block cracking at any Montana airports. These two changes brought Montana’s pavement management system more in line with PAVER’s empirical research.

In 2010 the PCI Inspection Manuals and ASTM pavement inspection standards changed, splitting the previous asphalt “weathering/raveling” distress into two separate distresses, and adding Alkali-Silica Reactivity (ASR) to PCC distresses. The modification to “weathering” resulted in a PCI increase of around 5 points at numerous locations.

2.4 PAVEMENT CONDITION INDEX (PCI)

The pavement condition index (PCI) is an objective, repeatable numerical rating or “grade” that describes the overall condition of a pavement section on a scale of 0 (failed pavement) to 100 (perfect pavement). It is based on visual inspections of manageable sample pavement areas for types, severities, and quantities of a number of specific distresses. “Field verification of the PCI inspection method has shown that the index gives a good indication of a pavement’s structural integrity and operational condition. It has also been shown that, at the network level, the observation of existing distress in the pavement provides a useful index of both the current condition and an indication of future performance under existing traffic conditions."[1]

2.5 PCI CALCULATIONS

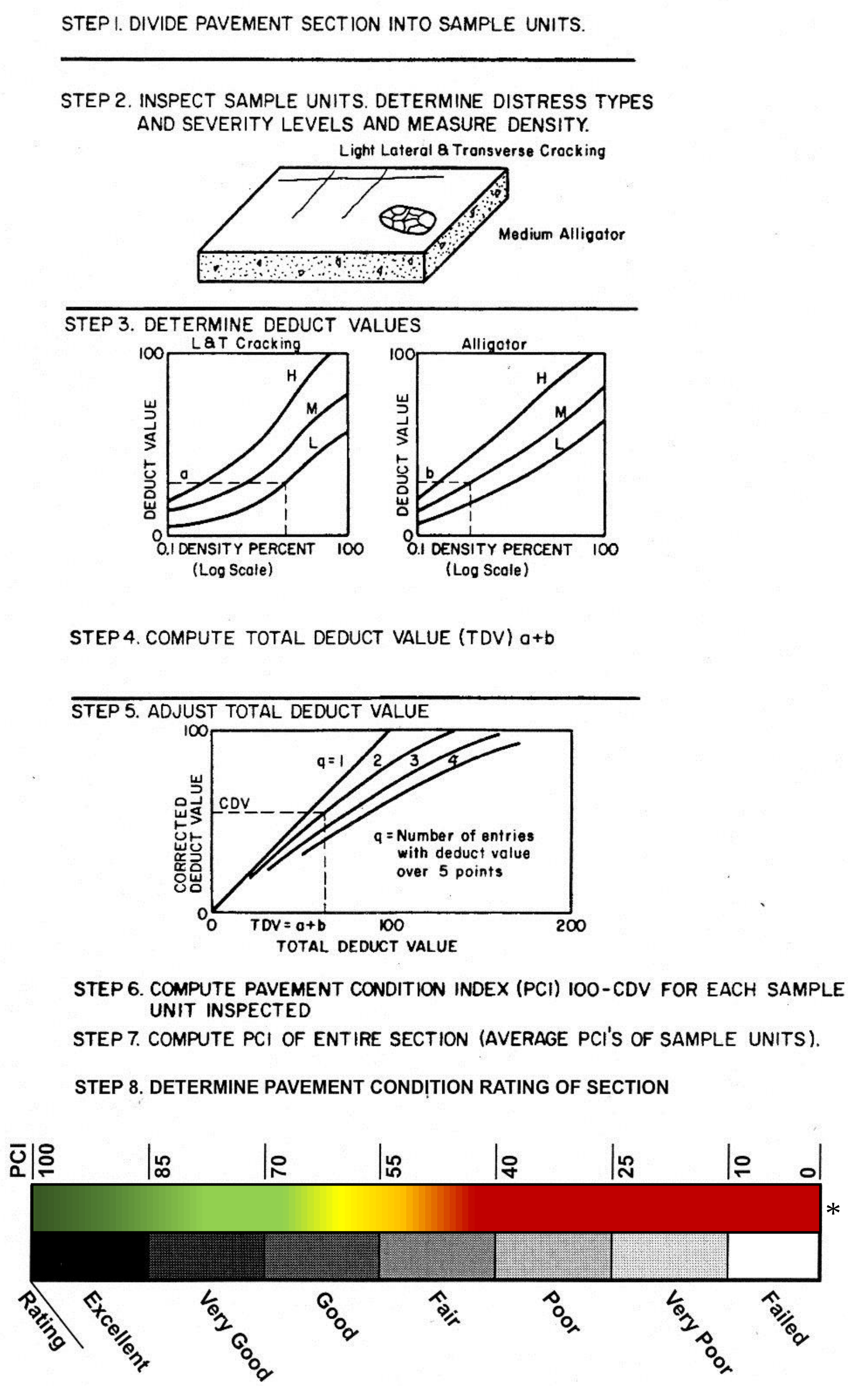
The PCI is produced for each surveyed sample unit with a series of calculations using the area of the sample and quantities of standard distress types as summarized in Figure 2.2. Pavements are divided into manageable sample areas and a random selection of these are intensively inspected (Figure 2.2, Step 1). Quantities of standardized distress types (descriptions and example photos in Appendix B) and severities are recorded during visual inspections by trained inspectors (Figure 2.2, Step 2). Quantities divided by the sample area give distress density for each type and severity of distress present. Distress densities are transferred to deduct values using composite curves generated from US Army Corps of Engineers pavement research (Figure 2.2, Step 3). The total deduct value is the sum of deducts due to individual distress types and severities (Figure 2.2, Step 4). To reflect the empirical fact that numerous minor defects are not as detrimental to a pavement's condition as a few major defects, this total deduct is scaled back when there are a large number of deducts recorded (Figure 2.2, Step 5). The Pavement Condition Index (PCI) is simply a perfect 100 pavement less the adjusted total deduct value (Figure 2.2, Step 6). The area-weighted average of the sample PCI's is taken as the section PCI (Figure 2.2, Step 7). There are seven discrete groupings of PCI values that describe the overall pavement quality with Pavement Condition Ratings (Figure 2.2, Step 8). The current version of PAVER allows user-defined rating titles & ranges, and suggests that only PCI's above 55 are acceptable, with sub-55 PCI's rated as "poor" to "failed."

In addition to extrapolating PCI's from selected sample areas to larger sections of pavement, distress densities, distress quantities, and deducts are extrapolated for each section and included in the Inspection Report Summary. Extrapolated distress densities are the sum of distress quantities divided by the sum of the sampled areas. Distress densities are both scaled up by the section area to get extrapolated distress quantities, and also fed into the deduct curves to get extrapolated deducts for the section.

While these calculations can be completed by hand, the vast quantity of data collected for Montana's general aviation airports makes it much more feasible to use the PAVER software package developed by USACERL expressly for PCI calculations. PCI's in this report were produced with PAVER 6.5.7 for Windows.

[1] USACERL Technical Report M-90/05, July 1990, Paver Update, "Pavement Maintenance Management for Roads and Streets Using the PAVER System," by M. Y. Shahin & J. A. Walther, p 40.

FIGURE2.2
PCI CALCULATIONS



*RPA supplemental color chart

Source: USACERL Technical report M-90/05, July 1990, Paver Update, "Pavement Maintenance Management for Road & Street Using the Paver System," by M.Y. Shahin & J.A. Walther, P41

2.6 PAVEMENT FAMILIES

In order to make sound management decisions, it is necessary to project the future condition of a pavement rather than just calculate the present PCI condition. Comparing the ten airport pavement surveys spanning the last twenty-seven years, it is apparent that a pavement's PCI degrades over time. By grouping pavements with similar properties, it is possible to distill an "average" behavior for the group. The PAVER system calls groupings of like pavements "families." The intent is that grouped pavements will tend to perform similarly as they age. If this grouping is performed successfully, documented behavior of older pavements can be used to project probable behavior for younger pavements as they age. In other words, pavements within the same family should have PCIs that are roughly the same when their ages are the same. The choice of what properties, and ultimately which pavements are used to build a family are determined by the engineer. The number of families needs to be sufficiently large to cover different pavement types while preserving a statistically significant data set from the available survey data.

The database of Montana airports was configured in 1991 for sorting of families by parameters: surface type, primary use, pavement strength, rank, and asphalt thickness to total thickness ratio. In 1997 the medium strength asphalt runways were split into two families by approximate usage, or "operations count". In 2015, two airports that typically spend the winter months under an insulating blanket of snow were pulled out of other families into a family of their own.

Surface types include: asphalt (AC), structural asphalt overlays of asphalt (AAC) or concrete (APC), bituminous surface treatments (ST), and Portland cement concrete (PCC). Concrete pads at the surface were designated "PCC," while those overlaid with asphalt were labeled "APC." When a pavement contained 1" or more of screed-applied asphalt cement coated aggregate it was called "AC," unless it was upgraded to an asphalt overlay of asphalt (AAC) by being overlaid with 1" or more of AC or with greater than 1" of porous friction course (PFC). Single-, double-, and triple-shot surfaces were designated as surface treatments (ST). These bituminous surface treatments (BST) were upgraded to structural strength similar to asphalt and called "AC" when overlaid with 1" or more of P-401, or with greater than 1" of porous friction course (PFC).

Primary uses for airport pavements are aprons, runways, and taxiways. Sections were assigned as "Apron", "Runway", or "Taxiway" based upon their use, and designated on FAA form 5230-1.

Pavement strengths are split into single wheel loads (SWL) of less than 12,500 pounds, 12,500 pounds up to and including 30,000 pounds, and over 30,000 pounds (light, medium, and heavy). Asphalt to total pavement section thickness ratio is set at less than 30%, between 30% and 70% inclusive, and over 70%. Design strength and asphalt thickness/total thickness ratio were encoded into a single character and stored into the database "Section Category" and updated for new construction. While asphalt thickness to total thickness ratio was not used in the final analysis of this report, it facilitated exploration of potential family groupings and could be used in future projects, so was not removed from the database. Pavement sections were assigned to one of ten section categories based on information shown on existing FAA Form 5320-1 for each airport. Unspecified P-609's (BST) were assumed to be double shots and assigned a nominal thickness of 1". Bituminous surface treatments (BST) and porous friction coats (PFC) were given credit for only half their nominal thickness in equivalent asphalt depth. Table 2.3 presents the section categories used and the requirements for each.

TABLE 2.3
SELECTION CATEGORY CRITERIA

Section Category	AC/Total Depth Ratio	Design Strength (Single Wheel Load)
A	< 30%	< 12.5K
B	30% - 70%	< 12.5K
C	> 70%	< 12.5K
D	< 30%	12.5K - 30K
E	30% - 70%	12.5K - 30K
F	> 70%	12.5K - 30K
G	< 30%	> 30K
H	30% - 70%	> 30K
I	> 70%	> 30K
P	PCC, non-asphalt surface	

"Rank" is used to describe a pavement's status in the database and its use on the airfield. Current database members that remain in use on the airport are designated with an "O". Non-federally funded, abandoned, or demolished pavements are labeled with a rank of "N" or "A". Those sections excluded from inspections and the database by contractual agreement are ranked "E". Only pavements with a rank of "O" were included in the 2015 update calculations and reports, dropping data for abandoned pavements from the era before preventative maintenance. Ranking could be used to prioritize funding allocation to heavy use airfields over lighter use fields, or to apply external budget priorities to maintenance and rehabilitation planning.

In 2000, medium strength runway/taxiways were subdivided by operations estimates into those having 5000 or fewer annual operations (L), and heavy use strips averaging over 5000 ops (U). This separation into "light use" versus "busy" was explored with other groupings, but each lacked sufficient samplings (mostly of older pavements) to produce reliable forecasting. Operations estimates were updated using 2015 FAA 5010-1 forms and rounded to the nearest thousand up to fifteen thousand, then to the nearest 5000 for annual estimates exceeding 15,000.

In 2006, the two families of surface treatment pavements were combined, as were the two primary usages associated with low strength pavement. There were no longer enough pavements in these dwindling families to produce statistically significant groups, nor to require separate estimations.

In 2015, there was sufficient data in the families ACAH and ACRH to identify a collection of PCI points that did not fit the remaining cluster of data. Closer inspection revealed the anomalous data belonged exclusively to Benchmark and West Yellowstone Airport pavements. These two airports are distinguished from other Montana airports in that they are used only seasonally, spending the winter months under an insulating blanket of snow. It is likely that the snow layer protects the pavements from repetitive freeze-thaw cycling and extends their life significantly. In any event, these pavements were pulled out into their own "seasonal" pavement family.

While a number of other parameters are currently available in the database, few if any would be reasonable sort criteria. There are user definable fields for refining or redefining families as the available data set grows and it becomes possible to use additional delimiters such as "Maintained" vs. "Unmaintained", "Harsh"/"Moderate"/"Minimal" to describe freeze-thaw cycle exposure at the site, or "Below average"/"Average"/"Above Average" historical performance.

2.7 FAMILY ANALYSES

Families were assigned according to surface type, primary use, design strength (using section category values), and operations counts. These selection criteria made the most sense and produced results that fit well with common engineering judgement and measured data. Numerous grouping variations were explored with inferior results. Retaining the majority of the families used in earlier years allows meaningful comparisons with previous surveys. Family curves for all PCI system plans since 1991 are included in Appendix A. The following eight families were defined, and are coded to indicate the combination of selection criteria used for each.

FAMILY NAMES:
ACPL, ACAM, ACRML, ACRMU, ACAH, ACRH, STPA, PCAA, ACPS

FAMILY NAME CODING:
1st two letters = surface type
- AC = all asphalt cement pavements
- PC = all Portland cement pavements
- ST = surface treatment

3rd letter = primary use
- A = aprons
- R = runways and taxiways
- P = all primary uses (aprons, runways, and taxiways)

4th letter = design strength / unique exposure
- A = all strengths
- L = low strength (< 12.5K, single wheel)
- M = medium strength (12.5K - 30K, single wheel)
- H = high strength (> 30K, single wheel)
- S = seasonal use airport

5th letter = operations count (where applicable)
- L = light use (≤ 5000 annual estimated operations)
- U = busy (over 5000 annual estimated operations, or more than 1 op./daylight hour)

While there is scatter in the data that PCI families are based on, it is well within the limits expected from nearly sixty airports spread across a wide geographic region, with varying traffic loads and maintenance practices. While maintenance is great for airport pavements, the inspections that follow produce an upward spike in the pavements' "life cycle curve." These increases in PCI's over historical values create a certain amount of unavoidable "scatter" in the data. Likewise, a thin overlay, or crack sealant will likely acquire distresses (or "age") much more quickly than the original pavement; this steeper rate of decline also generates data scatter. There are a few pavement sections that exhibit an increase in successive PCI's, as well as a few with precipitous drops due to failed sealant, a transition from "cracking" to "alligator cracking", or use by a heavy vehicle that produces "rutting".

To compensate for the scatter we must realistically expect from the variations in the airport system, the database of accumulated PCI inspection results is "screened" by removing statistical outliers and large deviations from known "typical" aging behavior. PAVER performs statistical analysis and can be directed to remove "outliers" from data prior to constructing a family curve. Pavement sections that are at the extremes of the pavement performance spectrum were removed from the data set used to construct the representative family curves. Engineers at ASA used engineering judgement acquired over years of experience to filter out abnormal pavement wear, maintenance spikes, and lapses in construction records. A combination of factors may conspire to rapidly degrade a specific pavement -- excess moisture destabilizing the subgrade, poor construction practices, abuse, or overloading. Another branch could have all the luck (and care) - solid subgrade, conscientious construction, light usage, and wintering the freeze-thaw cycles under an insulating blanket of snow. The Engineer used experience and judgement to select from the current data set to produce families that are well-suited to predicting future PCIs.

Table 2.4 on the following pages summarizes pavement section data from FAA 5320-1 forms, uses it to assign section categories and surface types, and then determines the family assignment for each section in the Montana airports database. This table has been updated to include approximate annual operations counts and documents the use of geotextiles in the pavement section. Table 2.4 includes all the information used to construct the current family groups, and additional data that could be used for future groupings.

PAVER gives the user great flexibility in defining families. The user is also free to redefine families at any time, since family definition plays a very important part in PCI predictions. As the pavement management system continues to develop, better family definitions may become apparent, and they should be revised accordingly.

After families have been defined and each pavement section is assigned to the appropriate family, PAVER generates "Family Analysis Curves." These are PCI verses Age curves derived from a least-squares adjustment of all data points selected to form the family. Graphically speaking, each time a PCI evaluation of a section is completed, that section's PCI is plotted against its Age, forming a single data point (or observation) on that section's family analysis curve. The model is further constrained by insisting that a pavement cannot improve its condition over time (without outside intervention), so a family curve can never rise in PCI with age. The least squares adjustment then yields a single curve that is most representative of the data. In lieu of better information, the life cycle curve for pavement ages greater than any sampled in the family group is assumed to continue at the same rate of decay as at the last data point. In other words, the PCI predictions follow the straight-line tangent to the curve at the oldest pavement life.

TABLE 2.4
SECTION PROPERTIES AND FAMILY ASSIGNMENTS

Branch Name (Airport City)	**Section**	**Approx. Annual Operations** (1000)	**Geo-Grid/ Fabric** (g / f)	**Sub-base** (Inches) (Agg)	**Base Course** (Inches) (Agg)	(AC)	**Surface Course** (Inches) (BST)	(AC)	(PCC)	**Overlay** (Inches) (BST)	(AC)	(PFC)	**Gravel Depth**	**Asphalt Depth**	**% Asphalt Depth**	**Pavement Strength** (1000 lbs.)	**Section Category**	**Branch Use**	**Surface Type**	**Family**
Anaconda	A-1	5			9			3					9	3	25%	12.5	D	Apron	AC	ACAM
Anaconda	A-2	5			9.7			4					9.7	4	29%	12.5	D	Apron	AC	ACAM
Anaconda	R-1	5			9			3			2.8		9	5.75	39%	16	E	Runway	AAC	ACRML
Anaconda	R-2	5			9			4			3		9	7	44%	18	E	Runway	AAC	ACRML
Anaconda	T-1	5			9			3			2.8		9	5.8	39%	16	E	Taxiway	AAC	ACRML
Anaconda	T-6	5	g		9			4					9	4	31%	12.5	E	Taxiway	AC	ACRML
Baker	A-2A	7			11			2			5.3		11	7.25	40%	12.5	E	Apron	AAC	ACAM
Baker	A-5	7	f	18	16			4					34	4	11%	12.5	D	Apron	AC	ACAM
Baker	R-1	7		12	12			5			4		24	9	27%	17.5	D	Runway	AAC	ACRMU
Baker	R-2	7			10			5					10	5	33%	17.5	E	Runway	AC	ACRMU
Baker	T-1	7			11			2			3		11	5	31%	12.5	E	Taxiway	AAC	ACRMU
Baker	T-2	7			6		1	2			3		6	5.5	48%	12.5	E	Taxiway	AAC	ACRMU
Baker	T-3	7			11			2			4.5		11	6.5	37%	12.5	E	Taxiway	AAC	ACRMU
Baker	T-4	7	f,g	18	16			4					34	4	11%	12.5	D	Taxiway	AC	ACRMU
Baker	T-5	7	g	18	10			4					28	4	13%	12.5	D	Taxiway	AC	ACRMU
Benchmark	A-1B	0			6			3					6	3	33%	45	H	Apron	AC	ACPS
Benchmark	R-1	0			5			2					5	2	29%	45	G	Runway	AC	ACPS
Benchmark	T-1	0			6			3					6	3	33%	45	H	Taxiway	AC	ACPS
Big Sandy	A-2	6			13			3					13	3	19%	12.5	D	Apron	AC	ACAM
Big Sandy	R-11	6			13			3					13	3	19%	12.5	D	Runway	AC	ACRMU
Big Sandy	T-12	6	f		13			3					13	3	19%	12.5	D	Taxiway	AC	ACRMU
Big Timber	A-1	5		6	4			2.5		1			10	3	23%	12.5	D	Apron	AC	ACAM
Big Timber	R-1	5		6	9.5			2.5		1			15.5	3	16%	12.5	D	Runway	AC	ACRML
Big Timber	R-2	5			4			2.5		1			4	3	43%	12.5	E	Runway	AC	ACRML
Big Timber	T-2	5			4		2				2		4	3	43%	12.5	E	Taxiway	AC	ACRML
Big Timber	T-4	5		30	6			4					36	4	10%	12.5	D	Taxiway	AC	ACRML
Big Timber	T-5	5		30	6			4					36	4	10%	12.5	D	Taxiway	AC	ACRML
Broadus	A-1	5		6	4			3.5					10	3.5	26%	12.5	D	Apron	AC	ACAM
Broadus	R-1	5		6	4			3.5					10	3.5	26%	12.5	D	Runway	AC	ACRML
Broadus	T-1	5		6	4			3.5					10	3.5	26%	13.5	D	Taxiway	AC	ACRML
Chester	A-11	5		6	12			3					18	3	14%	12.5	D	Apron	AC	ACAM
Chester	T-13	5		6	12			3			2		18	5	22%	12.5	D	Taxiway	AAC	ACRML
Chester	R-3	5		6	13			3			2		19	5	21%	12.5	D	Runway	AAC	ACRML

TABLE 2.4 (contd.)
SECTION PROPERTIES AND FAMILY ASSIGNMENTS

Branch Name (Airport City)	Section	Approx. Annual Operations (1000)	Geo-Grid/ Fabric (g / f)	Sub-base (Inches) (Agg)	Base Course (Inches)		Surface Course (Inches)			Overlay (Inches)			Gravel Depth	Asphalt Depth	% Asphalt Depth	Pavement Strength (1000 lbs.)	Section Category	Branch Use	Surface Type	Family
					(Agg)	(AC)	(BST)	(AC)	(PCC)	(BST)	(AC)	(PFC)								
Chinook	A-1B	8			10			3			2		10	5	33%	12.5	E	Apron	AAC	ACAM
Chinook	R-1	8			10			3			2		10	5	33%	12.5	E	Runway	AAC	ACRMU
Chinook	T-1	8			10			3			2		10	5	33%	12.5	E	Taxiway	AAC	ACRMU
Choteau	A-1	3		6	12			3					18	3	14%	24	D	Apron	AC	ACAM
Choteau	R-11	3		6	13			2					19	2	10%	24	D	Runway	AC	ACRML
Choteau	R-2	3	f	7.5	6.5			3					14	3	18%	24	D	Runway	AC	ACRML
Choteau	T-1	3			12			3					12	3	20%	24	D	Taxiway	AC	ACRML
Choteau	T-2	3	f	7.5	6.5			3					14	3	18%	24	D	Taxiway	AC	ACRML
Circle	A-2	4		10	4			2					14	2	13%	16	D	Apron	AC	ACAM
Circle	R-11	4		8	8			3					16	3	16%	30	D	Runway	AC	ACRML
Circle	T-1	4		6	13			3					19	3	14%	21	D	Taxiway	AC	ACRML
Colstrip	A-1	3			9			3			3.5		9	6.5	42%	12.5	E	Apron	AAC	ACAM
Colstrip	R-1	3			9			3			3.5		9	6.5	42%	12.5	E	Runway	AAC	ACRML
Colstrip	T-1	3			9			3			3.5		9	6.5	42%	12.5	E	Taxiway	AAC	ACRML
Columbus	A-1	9	f		13			3					13	3	19%	12.5	D	Apron	AC	ACAM
Columbus	R-1	9	f		13			3					13	3	19%	12.5	D	Runway	AC	ACRMU
Columbus	T-1	9	f		13			3					13	3	19%	12.5	D	Taxiway	AC	ACRMU
Columbus	T-3	9	f		13			3					13	3	19%	13.5	D	Taxiway	AC	ACRMU
Conrad	A-1	4			10			2			2.5		10	4.5	31%	12.5	E	Apron	AAC	ACAM
Conrad	R-3	4	f	8	3			3.5					11	3.5	24%	12.5	D	Runway	AC	ACRML
Conrad	T-4	4			10			2			2.5		10	4.5	31%	12.5	E	Taxiway	AAC	ACRML
Culbertson	A-1	5			8		1				3		8	3.5	30%	12.5	E	Apron	AC	ACAM
Culbertson	R-1	5			8		1				3		8	3.5	30%	12.5	E	Runway	AC	ACRML
Culbertson	R-2	5			8		1	3					8	3.5	30%	12.5	E	Runway	AC	ACRML
Culbertson	T-1	5			8		1				3		8	3.5	30%	12.5	E	Taxiway	AC	ACRML
Cut Bank	R-21	8	f	8	12			3					20	3	13%	27.5	D	Runway	AC	ACRMU
Cut Bank	T-4	8		6	3			3				1	9	3.5	28%	12.5	D	Taxiway	AC	ACRMU
Cut Bank	T-5	8	f		11			3					11	3	21%	12.5	D	Taxiway	AC	ACRMU
Deer Lodge	A-3	4			6			2.5			1.5		6	4	40%	30	E	Apron	AAC	ACAM
Deer Lodge	A-5	4			4			4					4	4	50%	30	E	Apron	AC	ACAM
Deer Lodge	R-3	4			6			2.5			2		6	4.5	43%	30	E	Runway	AAC	ACRML
Deer Lodge	R-4	4			4			4					4	4	50%	30	E	Runway	AC	ACRML
Deer Lodge	T-2	4			10			2.5					10	2.5	20%	12.5	D	Taxiway	AC	ACRML

TABLE 2.4 (contd.)
SECTION PROPERTIES AND FAMILY ASSIGNMENTS

Branch Name (Airport City)	Section	Approx. Annual Operations (1000)	Geo-Grid/ Fabric (g / f)	Sub-base (Inches) (Agg)	Base Course (Inches) (Agg)	Base Course (Inches) (AC)	Surface Course (Inches) (BST)	Surface Course (Inches) (AC)	Surface Course (Inches) (PCC)	Overlay (Inches) (BST)	Overlay (Inches) (AC)	Overlay (Inches) (PFC)	Gravel Depth	Asphalt Depth	% Asphalt Depth	Pavement Strength (1000 lbs.)	Section Category	Branch Use	Surface Type	Family
Dillon	A-3	11		10	4			1.5			1.5		14	3	18%	16	D	Apron	AAC	ACAM
Dillon	A-4	11	f	13	6			4					19	4	17%	33	G	Apron	AC	ACAH
Dillon	A-11	11			11.5			3					11.5	3	21%	22	D	Apron	AC	ACAM
Dillon	R-3	11			15			3					15	3	17%	30	D	Runway	AC	ACRMU
Dillon	R-4	11	f	24	15			3					39	3	7%	30	D	Runway	AC	ACRMU
Dillon	R-21	11			17			3					17	3	15%	30	D	Runway	AC	ACRMU
Dillon	T-3	11		7	4			3					11	3	21%	12.5	D	Taxiway	AC	ACRMU
Dillon	T-5	11			15			3					15	3	17%	30	D	Taxiway	AC	ACRMU
Ekalaka	A-1	3		11.5	2		1				3.5		13.5	4	23%	12.5	D	Apron	AC	ACAM
Ekalaka	R-1	3		11.5	2		1				3.5		13.5	4	23%	12.5	D	Runway	AC	ACRML
Ekalaka	R-11	3	g,f		12			4					12	4	25%	12.5	D	Runway	AC	ACRML
Ekalaka	T-1	3		11.5	2		1				3.5		13.5	4	23%	12.5	D	Taxiway	AC	ACRML
Ennis	A-2	12			8			3					8	3	27%	12.5	D	Apron	AC	ACAM
Ennis	R-11	12			7			3					7	3	30%	13.5	E	Runway	AC	ACRMU
Ennis	T-1	12			8			3					8	3	27%	12.5	D	Taxiway	AC	ACRMU
Ennis	T-2	12			8			3					8	3	27%	12.5	D	Taxiway	AC	ACRMU
Eureka	A-1	2		6	4			3			3		10	6	38%	12.5	E	Apron	AAC	ACAM
Eureka	R-1	2		6	4			3			3		10	6	38%	12.5	E	Runway	AAC	ACRML
Eureka	T-1	2		6	4			3			3		10	6	38%	12.5	E	Taxiway	AAC	ACRML
Eureka	T-3	2			6			3			3		6	6	50%	12.5	E	Taxiway	AAC	ACRML
Forsyth	A-1	8			4			3			2.5		4	5.5	58%	12.5	E	Apron	AAC	ACAM
Forsyth	R-1	8			7			3					7	3	30%	12.5	E	Runway	AC	ACRMU
Forsyth	T-1	8			7			3					7	3	30%	12.5	E	Taxiway	AC	ACRMU
Forsyth	T-2	8			3			6			2.5		3	8.5	74%	12.5	F	Taxiway	AAC	ACRMU
Fort Benton	A-1	5	f	6	6			3			2		12	5	29%	16	D	Apron	AAC	ACAM
Fort Benton	R-1	5	f	6	6			3			2		12	5	29%	16	D	Runway	AAC	ACRML
Fort Benton	T-1	5	f	6	6			3			2		12	5	29%	16	D	Taxiway	AAC	ACRML
Fort Benton	T-2	5	f	6	6			3					12	3	20%	12.5	D	Taxiway	AC	ACRML
Fort Benton	T-13	5			11			2					11	2	15%	9	A	Taxiway	AC	ACPL
Gardiner	R-1	8						4					0	4	100%	4	C	Runway	AC	ACPL
Gardiner	T-1	8						4					0	4	100%	4	C	Taxiway	AC	ACPL

TABLE 2.4 (contd.)
SECTION PROPERTIES AND FAMILY ASSIGNMENTS

Branch Name (Airport City)	**Section**	**Approx. Annual Operations**	**Geo-Grid/ Fabric**	**Sub-base** (Inches)	**Base Course** (Inches)		**Surface Course** (Inches)			**Overlay** (Inches)			**Gravel Depth**	**Asphalt Depth**	**% Asphalt Depth**	**Pavement Strength**	**Section Category**	**Branch Use**	**Surface Type**	**Family**
		(1000)	(g / f)	(Agg)	(Agg)	(AC)	(BST)	(AC)	(PCC)	(BST)	(AC)	(PFC)				(1000 lbs.)				
Glasgow	A-7	8	f	25	5			3					30	3	9%	12.5	D	Apron	AC	ACAM
Glasgow	R-13	8		8		5		4					8	9	53%	25	E	Runway	AC	ACRMU
Glasgow	R-14	8	g,f	11	4			3					15	3	17%	25	D	Runway	AC	ACRMU
Glasgow	R-15	8		11	8			4					19	4	17%	55	G	Runway	AC	ACRH
Glasgow	T-1	8		8		5		4			2	2.6	8	12.3	61%	75	H	Taxiway	AAC	ACRH
Glasgow	T-3	8		8		5		4			2	2.6	8	12.3	61%	75	H	Taxiway	AAC	ACRH
Glasgow	T-5	8		6	6			4			5		12	9	43%	75	H	Taxiway	AAC	ACRH
Glendive	A-1	6		6	6			4			2		12	6	33%	44	H	Apron	AAC	ACAH
Glendive	A-2	6						5			2.5		0	7.5	100%	12.5	F	Apron	AAC	ACAM
Glendive	R-1	6		6	6			4			2		12	6	33%	53	H	Runway	AAC	ACRH
Glendive	R-2	6		5	5			3			2		10	5	33%	38	H	Runway	AAC	ACRH
Glendive	R-3	6			6			3			2		6	5	45%	12.5	E	Runway	AAC	ACRMU
Glendive	T-1	6		6	6			4					12	4	25%	44	G	Taxiway	AC	ACRH
Glendive	T-2	6						5			2.5		0	7.5	100%	12.5	F	Taxiway	AAC	ACRMU
Glendive	T-5	6	f	6	12			5					18	5	22%	30	D	Taxiway	AC	ACRMU
Glendive	T-7	6		6	10			4					16	4	20%	30	D	Taxiway	AC	ACRMU
Hamilton	A-2	25			9		1						9	0.5	5%	17	A	Apron	ST	STPA
Hamilton	R-1A	25		4	7		1			1		1.5	11	1.75	14%	17	D	Runway	AC	ACRMU
Hamilton	R-2	25	f	40	4			2				1	44	2.5	5%	17	D	Runway	AC	ACRMU
Hamilton	T-5	25		12	8			4					20	4	17%	17	D	Taxiway	AC	ACRMU
Hardin	A-1	0		36	5			3					41	3	7%	18.5	D	Apron	AC	ACAM
Hardin	R-1	0		36	5			3					41	3	7%	18.5	D	Runway	AC	ACRML
Hardin	T-1	0		36	5			3					41	3	7%	18.5	D	Taxiway	AC	ACRML
Harlem	A-11	4		10.5	6			3					16.5	3	15%	12.5	D	Apron	AC	ACAM
Harlem	R-11	4		10.5	6			3					16.5	3	15%	12.5	D	Runway	AC	ACRML
Harlem	T-11	4		10.5	6			3					16.5	3	15%	12.5	D	Taxiway	AC	ACRML
Harlowton	A-21	2			9			3					9	3	25%	12.5	D	Apron	AC	ACAM
Harlowton	R-21	2			12.5			3					12.5	3	19%	12.5	D	Runway	AC	ACRML
Harlowton	T-21	2			9			3					9	3	25%	12.5	D	Taxiway	AC	ACRML
Havre	A-5	9		16	3			4				1	19	4.5	19%	45	G	Apron	AC	ACAH
Havre	R-15	9			7			4					7	4	36%	30	E	Runway	AC	ACRMU
Havre	R-22	9		30	6	2		2				1	36	4.5	11%	12.5	D	Runway	AC	ACRMU
Havre	T-4	9		11.5	6			3				1	17.5	3.5	17%	30	D	Taxiway	AC	ACRMU

TABLE 2.4 (contd.)
SECTION PROPERTIES AND FAMILY ASSIGNMENTS

Branch Name (Airport City)	**Section**	**Approx. Annual Operations** (1000)	**Geo-Grid/ Fabric** (g / f)	**Sub-base** (Inches) (Agg)	**Base Course** (Inches) (Agg)	(AC)	**Surface Course** (Inches) (BST)	(AC)	(PCC)	**Overlay** (Inches) (BST)	(AC)	(PFC)	**Gravel Depth**	**Asphalt Depth**	**% Asphalt Depth**	**Pavement Strength** (1000 lbs.)	**Section Category**	**Branch Use**	**Surface Type**	**Family**
Jordan	A-11	2	g, f	11	4			3					15	3	17%	12.5	D	Apron	AC	ACAM
Jordan	R-1	2		7	5		1.5				3.5		12	4.25	26%	12.5	D	Runway	AC	ACRML
Jordan	T-1	2		7	5		1.5				3.5		12	4.25	26%	12.5	D	Taxiway	AC	ACRML
Laurel	A-3	40	f		12			4					12	4	25%	12.5	D	Apron	AC	ACAM
Laurel	R-4	40	f		12			4					12	4	25%	12.5	D	Runway	AC	ACRMU
Laurel	T-8	40	f		12			4					12	4	25%	12.5	D	Taxiway	AC	ACRMU
Laurel	T-9	40	f		12			4					12	4	25%	12.5	D	Taxiway	AC	ACRMU
Lewistown	A-2	15			6			2				1	6	2.5	29%	8	A	Apron	AC	ACPL
Lewistown	R-23	15			11			3					11	3	21%	12.5	D	Runway	AC	ACRMU
Lewistown	R-32	15			10.5			5			5.5		10.5	10.5	50%	40	H	Runway	AAC	ACRH
Lewistown	R-33	15			10			2			2.5		10	4.5	31%	40	H	Runway	AAC	ACRH
Lewistown	R-34	15			10	7		1			2.5		10	10.5	51%	40	H	Runway	AAC	ACRH
Lewistown	T-1	15			6.25			5.8				3	6.25	7.25	54%	45	H	Taxiway	AAC	ACRH
Lewistown	T-5	15			10			3				1	10	3.5	26%	40	G	Taxiway	AC	ACRH
Lewistown	T-7	15		6	4			3					10	3	23%	12.5	D	Taxiway	AC	ACRMU
Lewistown	T-8	15		6	4			3					10	3	23%	12.5	D	Taxiway	AC	ACRMU
Lewistown	T-11	15	f		9			3					9	3	25%	18	D	Taxiway	AC	ACRMU
Libby	A-2	5		6	2			4			2		8	6	43%	23	E	Apron	AAC	ACAM
Libby	A-3	5		6	6			3			2		12	5	29%	60	G	Apron	AAC	ACAH
Libby	R-1	5		8		2		2				1.3	8	4.625	37%	23	E	Runway	AAC	ACRML
Libby	R-2	5		6	2			3.6				1.3	8	4.225	35%	23	E	Runway	AAC	ACRML
Libby	T-2	5		6	6			3					12	3	20%	60	G	Taxiway	AC	ACRH
Libby	T-5	5	f		8			4					8	4	33%	23	E	Taxiway	AC	ACRML
Lincoln	A-11	4		29	6.75			3					35.75	3	8%	12.5	D	Apron	AC	ACAM
Lincoln	R-11	4		29	6.75			3					35.75	3	8%	12.5	D	Runway	AC	ACRML
Lincoln	T-11	4		29	6.75			3					35.75	3	8%	12.5	D	Taxiway	AC	ACRML
Livingston	A-11	15			6			4					6	4	40%	38	H	Apron	AC	ACAH
Livingston	R-11	15			6			4					6	4	40%	39	H	Runway	AC	ACRH
Livingston	T-5	15		8	6			3			1		14	4	22%	40	G	Taxiway	AAC	ACRH
Malta	A-1	6	g, f	14		2		2			4		14	8	36%	12.5	E	Apron	AAC	ACAM
Malta	R-1	6	g, f	14				4			4		14	8	36%	12.5	E	Runway	AAC	ACRMU
Malta	T-1	6	g, f	14				4			4		14	8	36%	12.5	E	Taxiway	AAC	ACRMU
Miles City	R-12	11			19	9		4					19	13	41%	38	H	Runway	AC	ACRH
Miles City	T-2A	11			6			2.5		1	3		6	6	50%	20	E	Taxiway	AAC	ACRMU
Miles City	T-3	11	f	11	4			3					15	3	17%	38	G	Taxiway	AC	ACRH
Miles City	T-6	11	f		8			2.5					8	2.5	24%	24	D	Taxiway	AC	ACRMU

TABLE 2.4 (contd.)
SECTION PROPERTIES AND FAMILY ASSIGNMENTS

Branch Name (Airport City)	**Section**	**Approx. Annual Operations** (1000)	**Geo-Grid/ Fabric** (g / f)	**Sub-base** (Inches) (Agg)	**Base Course** (Inches) (Agg)	(AC)	**Surface Course** (Inches) (BST)	(AC)	(PCC)	**Overlay** (Inches) (BST)	(AC)	(PFC)	**Gravel Depth**	**Asphalt Depth**	**% Asphalt Depth**	**Pavement Strength** (1000 lbs.)	**Section Category**	**Branch Use**	**Surface Type**	**Family**
Plains	A-1	4	f	8	3			3					11	3	21%	12.5	D	Apron	AC	ACAM
Plains	R-1	4	f	8	3			3					11	3	21%	12.5	D	Runway	AC	ACRML
Plains	T-1	4	f	8	3			3					11	3	21%	12.5	D	Taxiway	AC	ACRML
Plentywood	A-11	11			8			3			3		8	6	43%	12.5	E	Apron	AAC	ACAM
Plentywood	R-11	11	f		9			4					9	4	31%	12.5	E	Runway	AC	ACRMU
Plentywood	T-11	11	f		9			4					9	4	31%	12.5	E	Taxiway	AC	ACRMU
Polson	A-11	10			12			3					12	3	20%	12.5	D	Apron	AC	ACAM
Polson	R-11	10	f		13			3					13	3	19%	12.5	D	Runway	AC	ACRMU
Polson	T-11	10	f		13			3					13	3	19%	12.5	D	Taxiway	AC	ACRMU
Polson	T-12	10	f		13			3					13	3	19%	12.5	D	Taxiway	AC	ACRMU
Poplar	A-1	11	f	9	6			3					15	3	17%	4	A	Apron	AC	ACPL
Poplar	R-1	11	f	9	6			3					15	3	17%	4	A	Runway	AC	ACPL
Poplar	T-1	11	f	9	6			3					15	3	17%	4	A	Taxiway	AC	ACPL
Ronan	A-11	10	f	8.5	6			2.5					14.5	2.5	15%	20	D	Apron	AC	ACAM
Ronan	A-12	10	f	8.5	6			2.5					14.5	2.5	15%	20	D	Apron	AC	ACAM
Ronan	R-11	10	f	8.5	6			2.5					14.5	2.5	15%	20	D	Runway	AC	ACRMU
Ronan	T-11	10	f	8.5	6			2.5					14.5	2.5	15%	20	D	Taxiway	AC	ACRMU
Roundup	A-1	5			10		1				2		10	2.5	20%	14	D	Apron	AC	ACAM
Roundup	R-1	5			10			2			2		10	4	29%	22	D	Runway	AAC	ACRML
Roundup	T-1	5			10		1				2		10	2.5	20%	14	D	Taxiway	AC	ACRML
Roundup	T-4	5		12	6			3					18	3	14%	12.5	D	Taxiway	AC	ACRML
Scobey	A-11	4		8	6			4					14	4	22%	12.5	D	Apron	AC	ACAM
Scobey	R-11	4		6	6			4					12	4	25%	12.5	D	Runway	AC	ACRML
Scobey	R-12	4			14			4					14	4	22%	12.5	D	Runway	AC	ACRML
Scobey	T-11	4		6	6			4					12	4	25%	12.5	D	Taxiway	AC	ACRML
Shelby	A-21	8		18	6			3					24	3	11%	12.5	D	Apron	AC	ACAM
Shelby	R-21	8		18	14			3					32	3	9%	12.5	D	Runway	AC	ACRMU
Shelby	R-22	8		18	14			3					32	3	9%	12.5	D	Runway	AC	ACRMU
Shelby	T-6	8		8	4			3			2		12	5	29%	12.5	D	Taxiway	AAC	ACRMU
Shelby	T-17	8		18	4			3					22	3	12%	12.5	D	Taxiway	AC	ACRMU
Shelby	T-21	8	f	18	6			3					24	3	11%	12.5	D	Taxiway	AC	ACRMU
Shelby	T-22	8	f	18	6			3					24	3	11%	12.5	D	Taxiway	AC	ACRMU

TABLE 2.4 (contd.)
SECTION PROPERTIES AND FAMILY ASSIGNMENTS

Branch Name (Airport City)	**Section**	**Approx. Annual Operations** (1000)	**Geo-Grid/ Fabric** (g / f)	**Sub-base** (Inches) (Agg)	**Base Course** (Inches) (Agg)	(AC)	**Surface Course** (Inches) (BST)	(AC)	(PCC)	**Overlay** (Inches) (BST)	(AC)	(PFC)	**Gravel Depth**	**Asphalt Depth**	**% Asphalt Depth**	**Pavement Strength** (1000 lbs.)	**Section Category**	**Branch Use**	**Surface Type**	**Family**
Sidney	A-3A	13	f		10			4					10	4	29%	25	D	Apron	AC	ACAM
Sidney	A-11	13	f		8				8				PCC	PCC	PCC	PCC	P	Apron	PCC	PCAA
Sidney	A-13	13	f		10			4					10	4	29%	40	G	Apron	AC	ACAH
Sidney	R-11	13		6	3		2	4			4.5		9	9.5	51%	40	H	Runway	AAC	ACRH
Sidney	R-12	13		6	6		2	4			4.5		12	9.5	44%	40	H	Runway	AAC	ACRH
Sidney	T-4	13		16	6			3.5			3.5		22	7	24%	40	G	Taxiway	AAC	ACRH
Sidney	T-6	13	g	24	4			5					28	5	15%	40	G	Taxiway	AC	ACRH
Stanford	A-2	4			8			3					8	3	27%	12.5	D	Apron	AC	ACAM
Stanford	R-2	4			12		1				3		12	3.5	23%	12.5	D	Runway	AC	ACRML
Stanford	R-3	4			8			3					8	3	27%	12.5	D	Runway	AC	ACRML
Stanford	T-2	4			8			3					8	3	27%	12.5	D	Taxiway	AC	ACRML
Stevensville	A-1	14			5.5		1.8					1	5.5	1.4	20%	12.5	D	Apron	ST	STPA
Stevensville	A-2	14			6			2					6	2	25%	12.5	D	Apron	AC	ACAM
Stevensville	R-1	14			5.5		1.8					1	5.5	1.4	20%	12.5	D	Runway	ST	STPA
Stevensville	T-3	14			6			2					6	2	25%	12.5	D	Taxiway	AC	ACRMU
Stevensville	T-5	14		8	4			3					12	3	20%	12.5	D	Taxiway	AC	ACRMU
Superior	A-11	4		9	6			3					15	3	17%	30	D	Apron	AC	ACAM
Superior	R-11	4		9	6			3					15	3	17%	30	D	Runway	AC	ACRML
Superior	T-11	4		9	6			3					15	3	17%	30	D	Taxiway	AC	ACRML
Terry	A-11	1			11.5			2.5					11.5	2.5	18%	12.5	D	Apron	AC	ACAM
Terry	R-11	1			11.5			2.5					11.5	2.5	18%	12.5	D	Runway	AC	ACRML
Terry	T-11	1			11.5			2.5					11.5	2.5	18%	12.5	D	Taxiway	AC	ACRML
Thompson Falls	A-2	7			4			2.5					4	2.5	38%	12.5	E	Apron	AC	ACAM
Thompson Falls	R-1	7			6		1.5				2		6	2.75	31%	12.5	E	Runway	AC	ACRMU
Thompson Falls	R-2	7			4			2.5					4	2.5	38%	12.5	E	Runway	AC	ACRMU
Thompson Falls	T-4	7			4			2.5					4	2.5	38%	12.5	E	Taxiway	AC	ACRMU
Thompson Falls	T-5	7			4			2.5					4	2.5	38%	12.5	E	Taxiway	AC	ACRMU
Three Forks	A-1	12			4			2.5			2		4	4.5	53%	12.5	E	Apron	AAC	ACAM
Three Forks	R-1	12			4			2.5			2		4	4.5	53%	12.5	E	Runway	AAC	ACRMU
Three Forks	R-2	12			4			2.5			2		4	4.5	53%	12.5	E	Runway	AAC	ACRMU
Three Forks	T-2	12			4			2.5			2		4	4.5	53%	12.5	E	Taxiway	AAC	ACRMU
Three Forks	T-3	12			4			2.5			2		4	4.5	53%	12.5	E	Taxiway	AAC	ACRMU
Three Forks	T-4	12			4			2.5					4	2.5	38%	12.5	E	Taxiway	AC	ACRMU

TABLE 2.4 (contd.)
SECTION PROPERTIES AND FAMILY ASSIGNMENTS

Branch Name (Airport City)	**Section**	**Approx. Annual Operations** (1000)	**Geo-Grid/ Fabric** (g / f)	**Sub-base** (Inches) (Agg)	**Base Course** (Inches) (Agg)	(AC)	**Surface Course** (Inches) (BST)	(AC)	(PCC)	**Overlay** (Inches) (BST)	(AC)	(PFC)	**Gravel Depth**	**Asphalt Depth**	**% Asphalt Depth**	**Pavement Strength** (1000 lbs.)	**Section Category**	**Branch Use**	**Surface Type**	**Family**
Townsend	A-1	5			4			3			2		4	5	56%	12.5	E	Apron	AAC	ACAM
Townsend	R-1	5			4			3			2		4	5	56%	12.5	E	Runway	AAC	ACRML
Townsend	T-1	5			4			3			2		4	5	56%	12.5	E	Taxiway	AAC	ACRML
Turner	A-1	7	f	22	6			3					28	3	10%	12.5	D	Apron	AC	ACAM
Turner	R-1	7	f	22	6			3					28	3	10%	12.5	D	Runway	AC	ACRMU
Turner	T-3	7	f	22	6			3					28	3	10%	12.5	D	Taxiway	AC	ACRMU
Twin Bridges	A-11	3		11	6			4					17	4	19%	60	G	Apron	AC	ACAH
Twin Bridges	R-11	3		11	6			4					17	4	19%	60	G	Runway	AC	ACRH
Twin Bridges	T-11	3		11	6			4					17	4	19%	60	G	Taxiway	AC	ACRH
West Yellowstone	A-4	11			6		1					2	6	1.5	20%	30	D	Apron	AC	ACPS
West Yellowstone	R-1	11				7		2.5			3		0	12.5	100%	105	I	Runway	AAC	ACPS
West Yellowstone	R-2	11				8		3			3		0	14	100%	90	I	Runway	AAC	ACPS
West Yellowstone	T-1	11				8		3					0	11	100%	90	I	Taxiway	AC	ACPS
White Sulphur Springs	A-11	5			10			3.5					10	3.5	26%	16.5	D	Apron	AC	ACAM
White Sulphur Springs	R-11	5			10			3.5					10	3.5	26%	16.5	D	Runway	AC	ACRML
White Sulphur Springs	R-12	5			5			4			3		5	7	58%	16.5	E	Runway	AAC	ACRML
White Sulphur Springs	T-12	5			5			2					5	2	29%	16.5	D	Taxiway	AC	ACRML
Wolf Point	A-5	6			15			3			1.5		15	4.5	23%	18	D	Apron	AAC	ACAM
Wolf Point	R-11	6		9	14			4					23	4	15%	38	G	Runway	AC	ACRH
Wolf Point	T-4	6			15			3			1.5		15	4.5	23%	18	D	Taxiway	AAC	ACRMU

NOTES:
Italic font indicates the airport was neither inspected nor mapped for this report, as such the included information is suspect. If construction has occurred, it will not be reflected in this report.
Section Properties and families are assumed from the most current pre-2015 pavements.

(Agg) = Aggregate (AC) = Asphalt Cement Concrete (BST) = Bituminous Surface Treatment (PCC) = Portland Cement Concrete (PCF) = Porous Friction Course

Figures 2.3 through 2.11 illustrate the family analysis curves for the nine families defined in this project. These curves are based on actual data from pavement condition surveys spanning 1988-2015. In some cases, pavements were filtered out of the curve analyses when they fit poorly with the other data within the family, when there was a known atypical repair to specific pavements, or simply using good engineering judgement about the possible quality versus pavement age.

Figures 2.3 through 2.11 show life cycle curves for each family, selected data points used to construct the curve, and non-contributing "outliers" not used in the curve fit. Note that PAVER uses the dashed linear projection rather than the curve for ages greater than sampled ages in the family. The lower right corner of each graph contains the family curve equation, as well as the "critical PCI" where the rate of deterioration increases markedly.

FAMILY LIFE CYCLE CURVES

FIGURE 2.3

ACPL - ASPHALT PAVEMENTS WITH LESS THAN 12,500 LB. LOAD RATING

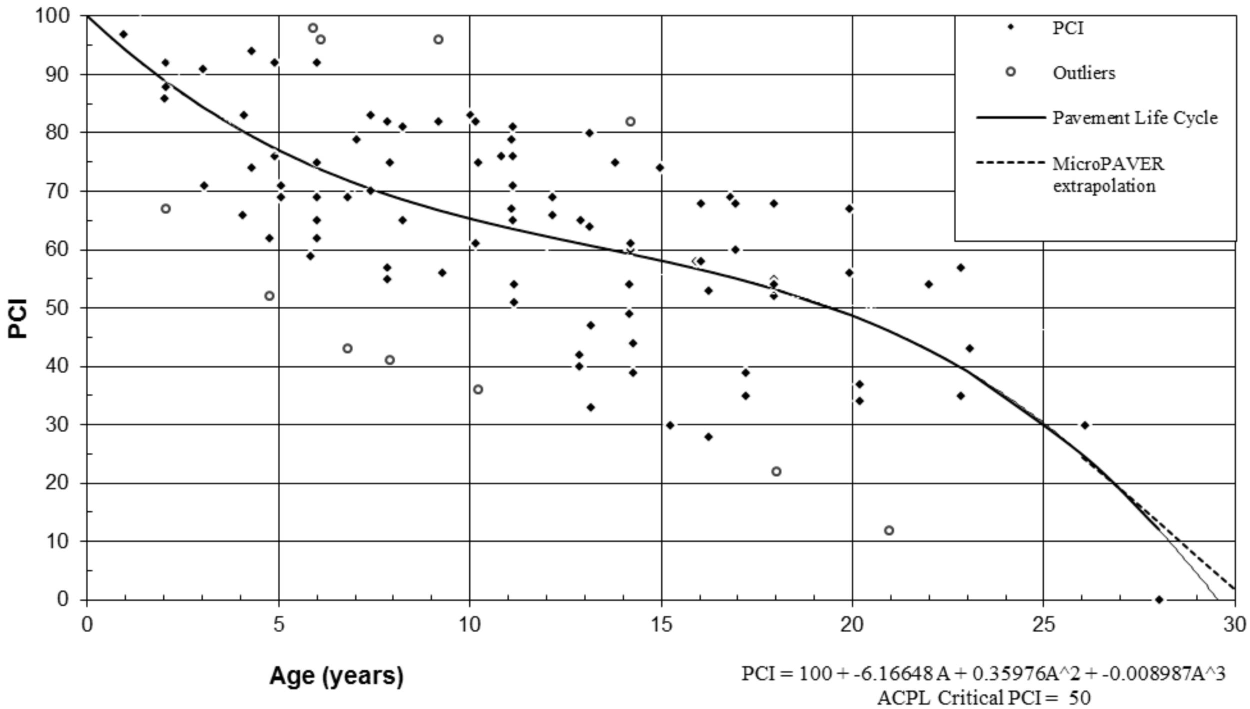


FIGURE 2.4

STPA - BITUMINOUS SURFACE TREATED PAVEMENTS OF ALL LOAD RATINGS

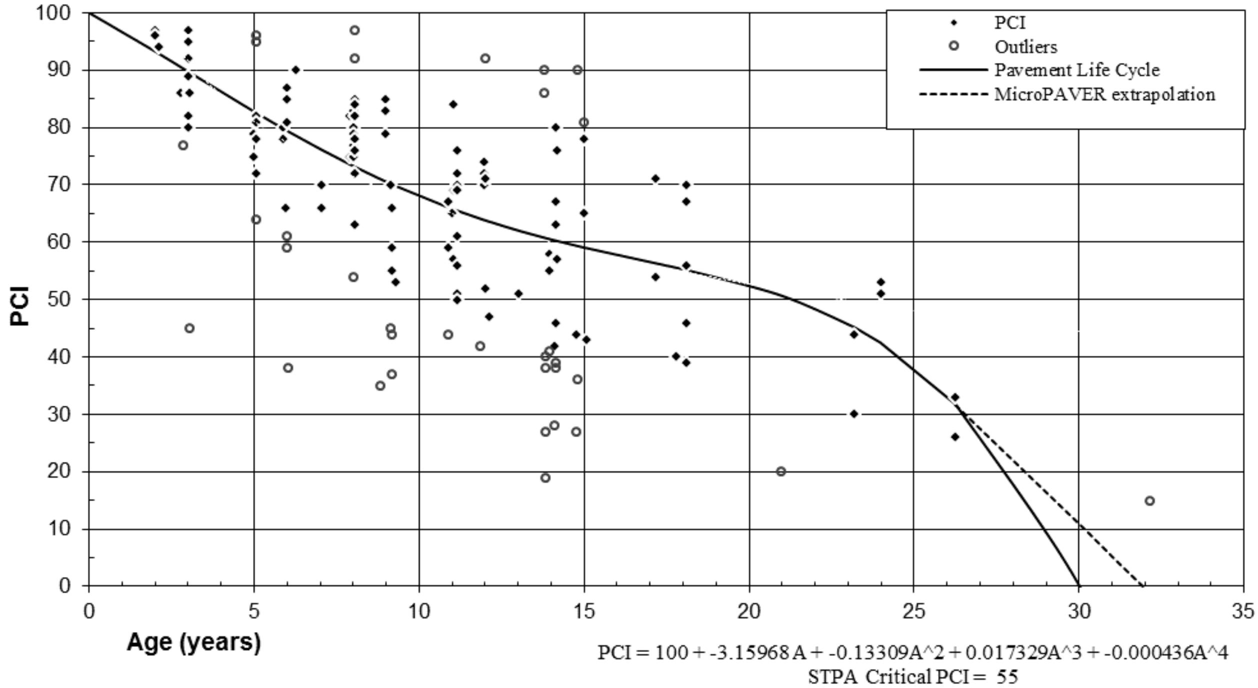


FIGURE 2.5

ACAH - ASPHALT APRONS WITH HIGHER THAN 30,000 LB. LOAD RATING

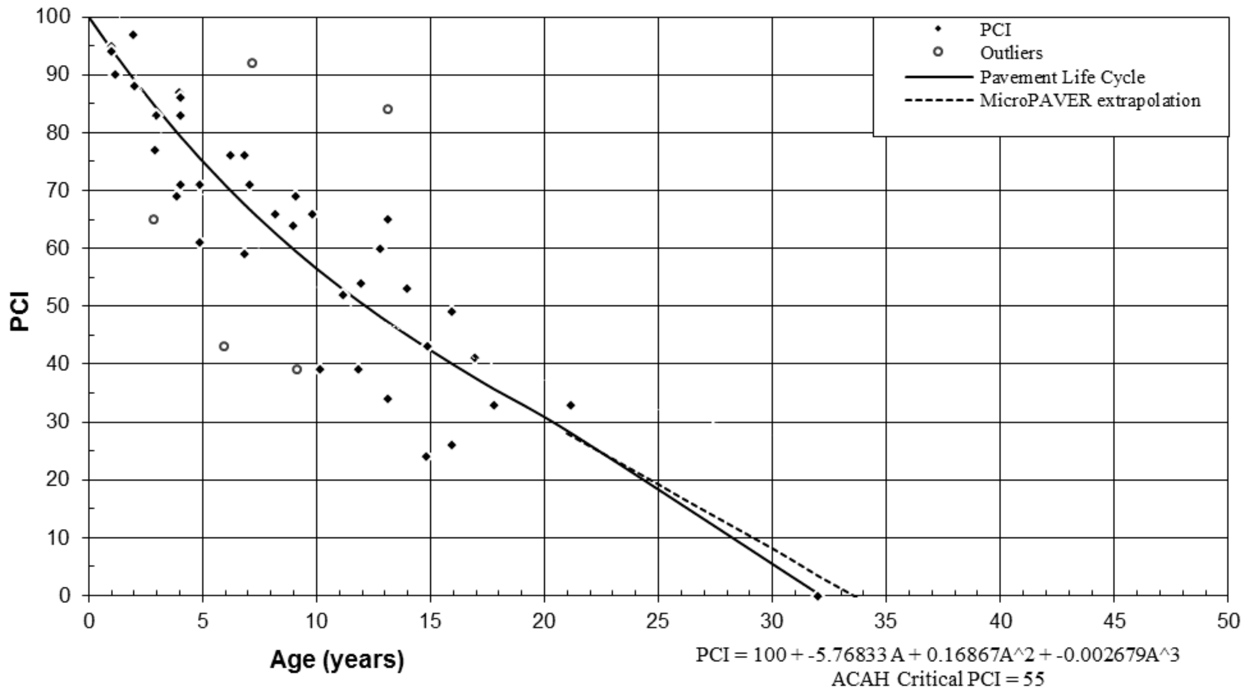


FIGURE 2.6
ACRH - ASPHALT RUNWAYS AND TAXIWAYS WITH HIGHER THAN 30,000 LB. LOAD RATING

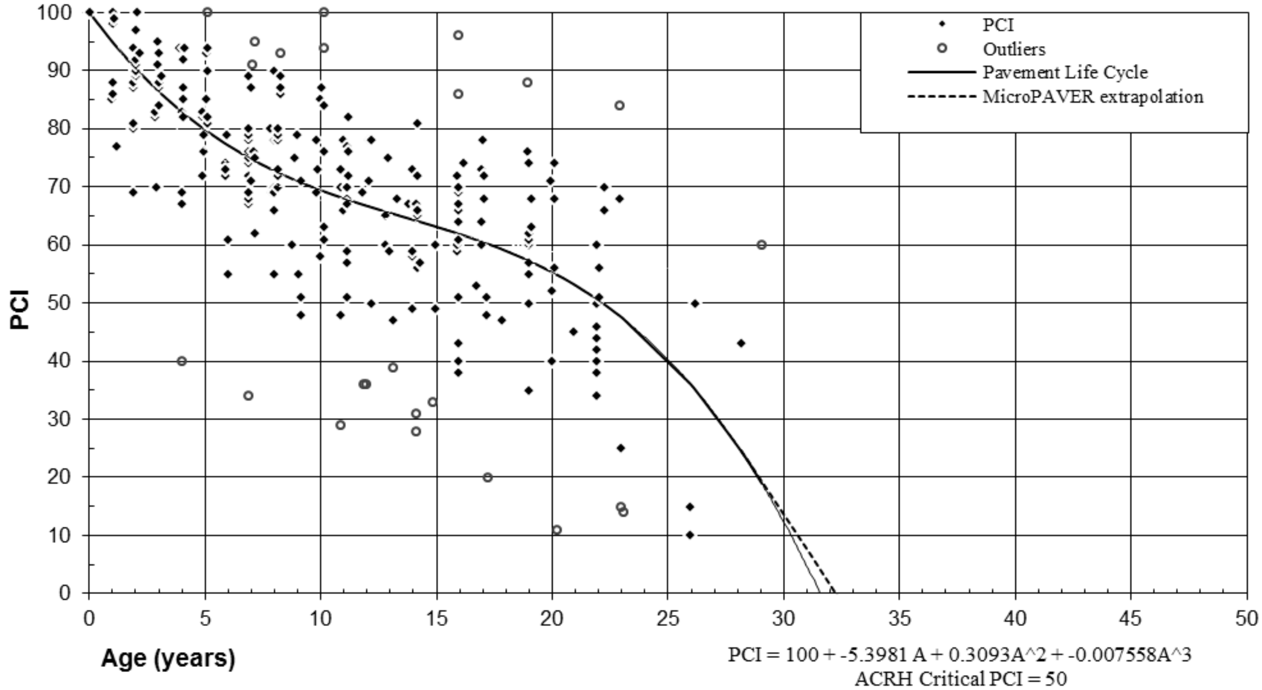


FIGURE 2.7
ACRML - ASPHALT RWS AND TWS, LOAD RATING 12,500 TO 30,000 LB., 5000 OR FEWER OPS.

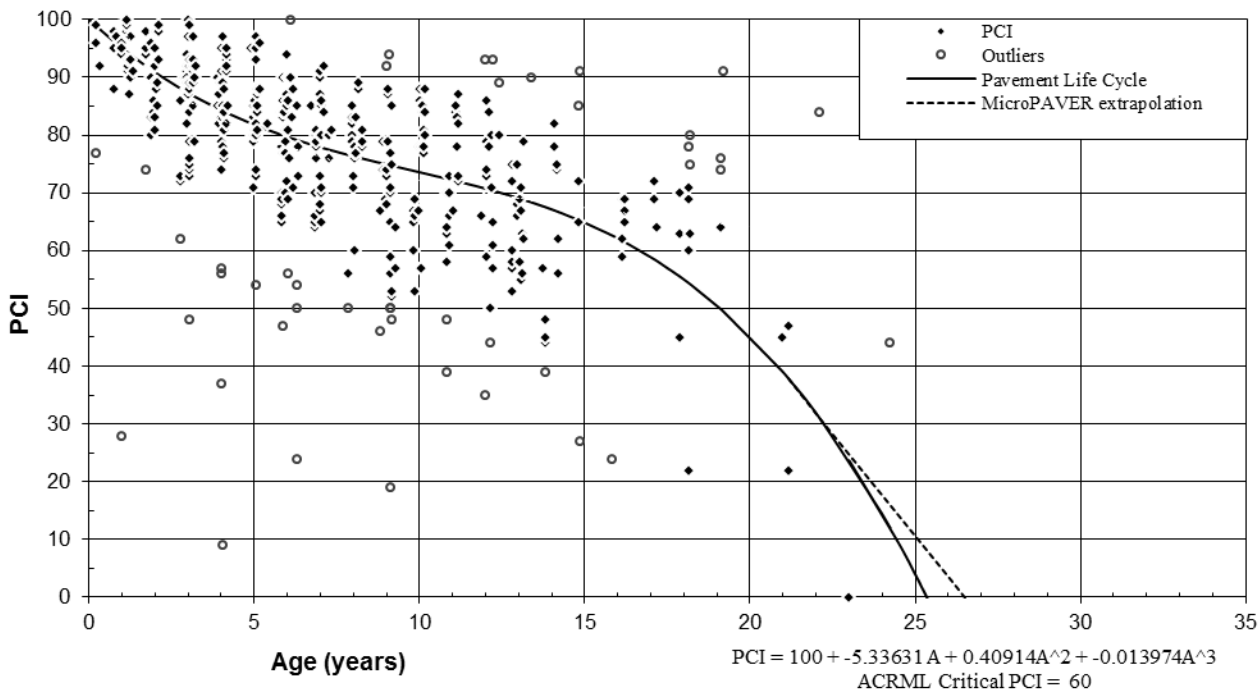
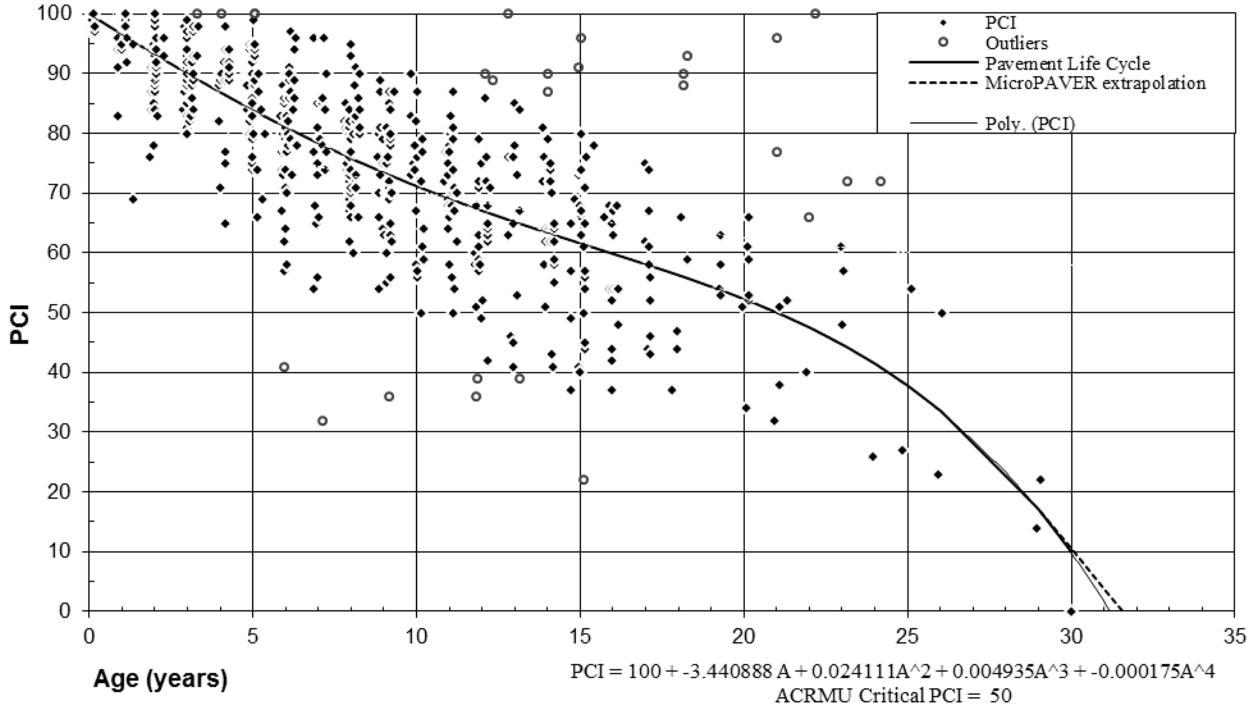
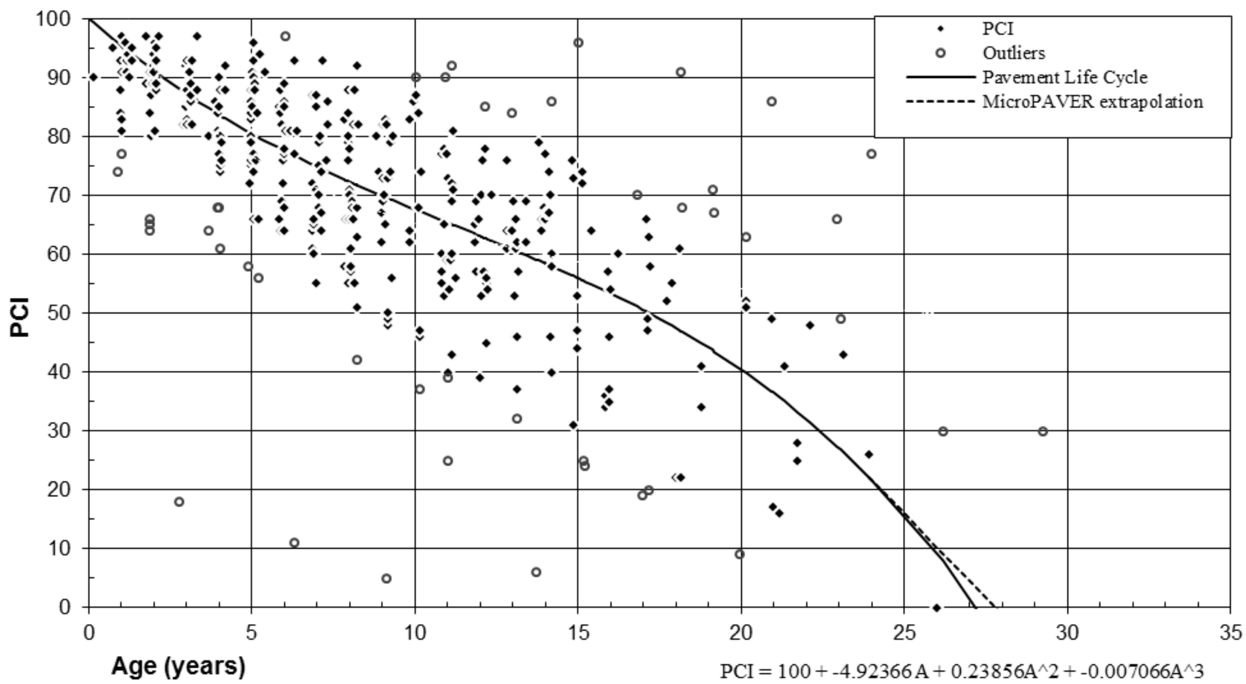


FIGURE 2.8
ACRMU -ASPHALT RWS AND TWS, LOAD RATING 12,500 TO 30,000 LB., OVER 5000 OPS.



PCI = 100 + -3.440888 A + 0.024111A^2 + 0.004935A^3 + -0.000175A^4
ACRMU Critical PCI = 50

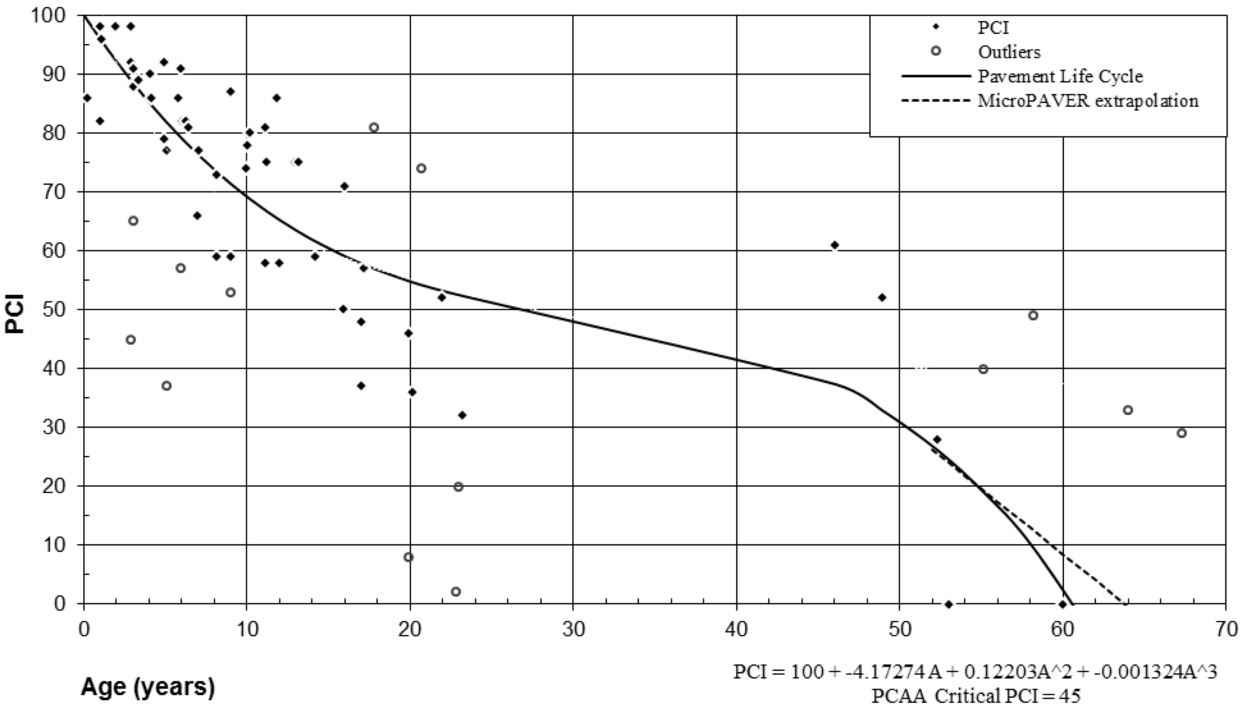
FIGURE 2.9
ACAM - ASPHALT APRONS WITH LOAD RATING FROM 12,500 TO 30,000 LB.



PCI = 100 + -4.92366 A + 0.23856A^2 + -0.007066A^3
ACAM Critical PCI = 50

FIGURE 2.10

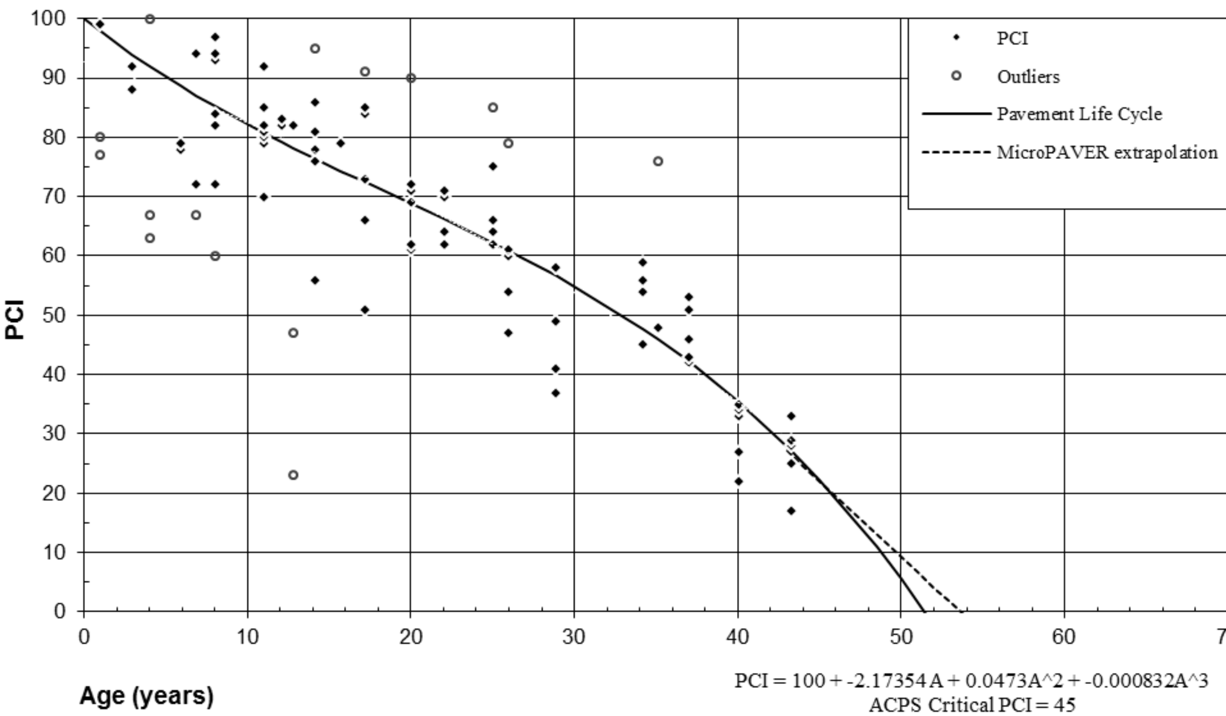
PCAA - PORTLAND CONCRETE CEMENT - ALL SECTIONS



PCI = 100 + -4.17274 A + 0.12203A^2 + -0.001324A^3
PCAA Critical PCI = 45

FIGURE 2.11

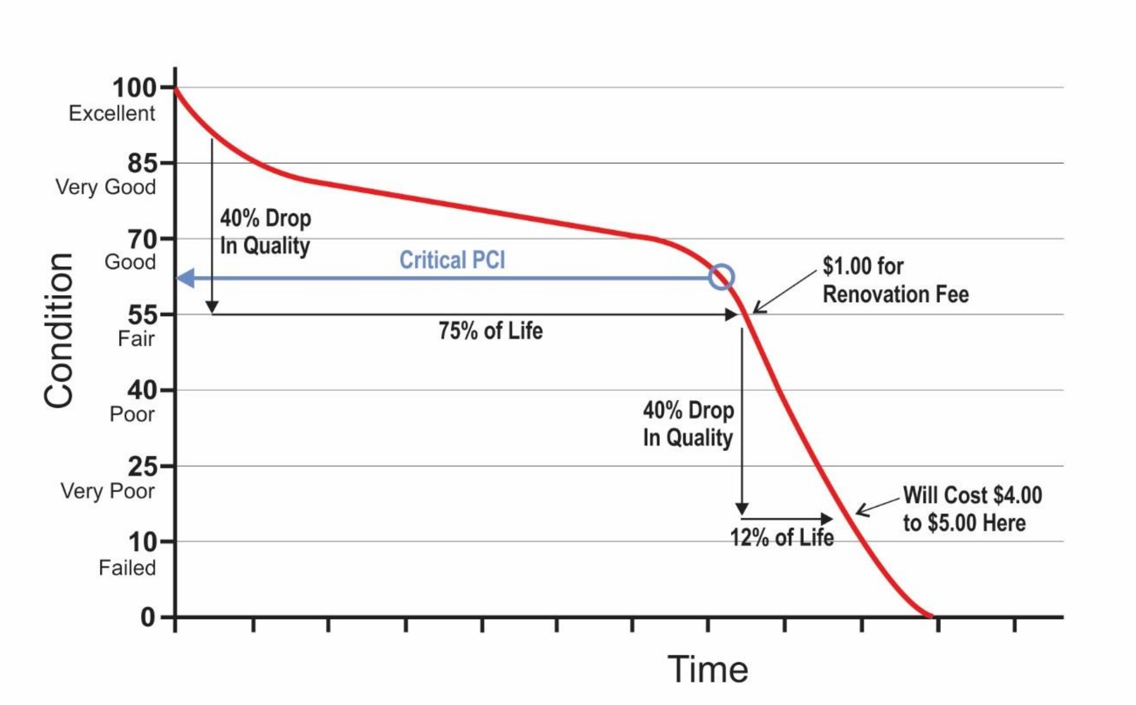
ACPS - ASPHALT PAVEMENTS WITH SEASONAL USAGE



PCI = 100 + -2.17354 A + 0.0473A^2 + -0.000832A^3
ACPS Critical PCI = 45

Figure 2.12 illustrates a theoretical pavement life cycle, and some very general observations about renovation costs throughout the pavement's life. The critical PCI is at the crest of the curve where continued maintenance begins to be less economical than reconstruction.

FIGURE 2.12
PAVEMENT LIFE CYCLE



CHAPTER 3
RESULTS AND RECOMMENDATIONS

CHAPTER 3 RESULTS AND RECOMMENDATIONS

3.1 FAMILY ANALYSIS CURVES

Pavement families for this analysis are slowly evolving from the consistent 1988-1997 family groups. The families are designed to group similar pavements based on material type, primary use, design strength, and annual operations within the context of the current pavement design and maintenance norms. The core of the original family groupings have been retained since they are providing increasingly stable and accurate predictors of Montana airport pavement behavior. With pavement maintenance norms changing, the database's oldest pavement's behavior is no longer an accurate predictor of future condition. So, inspection data from abandoned, demolished, and non-maintained sections are no longer included in the family curve determinations. These dropped inspections are no longer representative "typical" sections and there are sufficient inspections to provide statistical validity without these data points. The two original surface treatment families were combined into a single family in 2006, and remain so this year, since very few of these pavements remain. Likewise, pavements with design loads under 12,500 pounds are now rarely constructed, so the dwindling remnants of these "light" pavements have been grouped into a single family, regardless of their use. Comparison of the family curves from 1991 to the present provides some insight into the appropriateness of the family definition criteria, and the likely long-term usefulness of the curves. (See Figure A.1of the Appendix A)

2015 family ACPL (Asphalt Concrete, All Pavements, Low Strength) combined former families ACAL and ACRL, light duty asphalt aprons and runway/taxiways, respectively. FAA policies no longer encourage constructing asphalt pavements with design loads less than 12,500 pounds, so the remaining members of this shrinking family are upgraded to medium strength whenever reconstruction or maintenance is required. The family exhibits about 7 years of rapid aging followed by 10 years of slower decline. After approximately 17 years of acceptable performance, the family curve passes through a critical PCI of 50 and begins a rapidly accelerating decline in pavement quality. A good deal of scatter in ACPL data indicate variations in construction quality, maintenance, use, and climate. Improving maintenance practices are documented by a raised graph in the 5-15 year range. This family shows excellent stability in 2006, 2009, and 2015.

2015 family STPA (Surface Treatment, All Pavements, All Strengths) was adjusted slightly from previous years to reduce the very flat mid-life plateau that contributed to prediction volatility. The bulk of the data for this family comes from pavements 15-years old or less, with only two airports continuing to contribute data for pavement over 20-years of age. These relatively low-strength pavements exhibit a fairly uniform rate of deterioration through their first 10 years, followed by another 10 years of more rapid deterioration, projecting approximately 20-years of usable life before rapidly declining to an unserviceable condition. Double- and triple-shot surfaces continue to be replaced by dense-grade mixes, decreasing the pool of family members. The critical PCI remains at "55".

2015 family ACAH (Asphalt Concrete, Aprons, High Strength) made the largest change of any family in 2015 with the removal of all Benchmark and Yellowstone Airport pavements. The formerly long predicted life (30 years of above-critical service) is just not supported by the aging at any of the remaining airport pavements. Other pavements in this family have finally reached 15-20 years of age, and deteriorated to well below critical, similar to other AC families. Family ACAH predicts about 12 years of good, usable pavement life before reaching critical PCI of 55. Beyond the critical PCI, this family curve actually shows a slowing of aging, as if maintenance intensifies to stretch the aprons' life until piggy-backing onto a runway replacement project. Accuracy of the end of life predictions for this family will benefit greatly from the next couple of inspection cycles, since the remaining data is a bit sparse. ACAH predicts poor, but serviceable use out to about 25 years.

2015 family ACRH (Asphalt Concrete, Runways/Taxiways, High Strength) also makes a significant departure from past predictions with the removal of Benchmark and Yellowstone data. The first 15 years of prediction has been extremely consistent since 1994, in large part due to the large number of sections in the family, but the projected service life decreased by about 15 years. ACRH pavements can expect about 22 years above their critical PCI of 50, before beginning rapid deterioration.

2015 family ACRML (Asphalt Concrete, Runways/Taxiways, Medium Strength, Light Use) show better than average performance over the first 10 years of life, the results of preventative maintenance programs in common application across the State. Most of the pavements in this family have been crack sealed and fog sealed, or overlaid since the previous inspection. This is one of the largest sets in the database and it has minimal scatter. ACRML has a very slow initial aging rate, plus more than typical time in the over-70 PCI range. These pavements can expect about 17-years of useable life above their critical PCI of 60.

2015 family ACRMU (Asphalt Concrete, Runways/Taxiways, Medium Strength, Busy Use) was revised in 2015 to a simpler, less "bumpy" curve to provide more regular predictions. There remains periodic increases in data scatter indicative of periodic application of preventative maintenance common at Montana's most-used airports. This is a data-rich family that should not show much variation in the first 15 years over future inspection cycles. ACRMU pavements, as a group, are the busiest and best maintained pavements in the GA airport system. Changes in maintenance strategies and funding resulted in nearly every ACRMU pavement that was inspected showing signs of recent preventative maintenance. This maintenance appears to be producing a consistently better quality pavement, in addition to significantly extending the pavements' usable life. This family projects about 22 years of good service before passing the critical PCI of 50 and beginning rapid aging.

2015 family ACAM (Asphalt Concrete, Aprons, Medium Strength) has good, high-density data for 20-years of pavement behavior. This data has consistently shown a near-linear decline in quality with age, but the 2015 family accentuates the mid-life "plateau" separating more rapid aging. A linear decline in quality typically indicates heavy wear and hard use. The data in this family exhibits increasing scatter with age. An increasing dispersion of data points with age suggests that pavements within these families have differences in construction quality, maintenance practices between airports, or varied wear and traffic loads. The critical PCI remains at 50, with a predicted 17 years of above-critical service.

2015 family PCAA (Portland Cement, Aprons, All Strengths) was adjusted from previous years to have less of a mid-life plateau that results in volatile projections. This family doesn't have many sections, and only one over 25-years of age. Engineering judgement would indicate a PCAA life span for concrete regularly exposed to its design loads to be about 40 years. PCAA predicts 40 years of usable life above the critical PCI of 45, then rapid deterioration.

2015 family ACPS (Asphalt Concrete, All Pavements, Seasonal) collected pavements primarily from families ACAH and ACRH that had significantly longer pavement life than other elements of those families. The "anomalous" data was from Benchmark and Yellowstone Airports, which alone among the Montana airports, see only seasonal use. These two airports spend much of the winter season insulated under snow cover, and are potentially spared some of the freeze-thaw cycling that other Montana airport pavements are exposed to, resulting in a longer expected life. In early development of Montana airport families, these two airports did not provide enough points for a well-defined family. Now they have enough points to be reasonably robust, and stand alone as a family. ACPS predicts about 35 years of usable life above the critical PCI of 45.

3.2 PCI PREDICTIONS

Pavement Condition Index values were predicted for one, five, and ten years into the future for all pavements in the database, using the previously discussed pavement families: ACPL, ACAM, ACRML, ACRMU, ACAH, ACRH, STPA, PCAA, and ACPS. The PAVER software predicts PCI's by taking the last inspected PCI value, finding the corresponding PCI value on the family curve for that pavement, and assuming the particular pavement ages in the same way the family curve declines. Graphically, the family curve is moved *horizontally* until it lies on top of the last inspected PCI-verses-age point, then the family curve is followed forward.

FIGURE3.1
PAVER PCI PREDICTION PROCESS

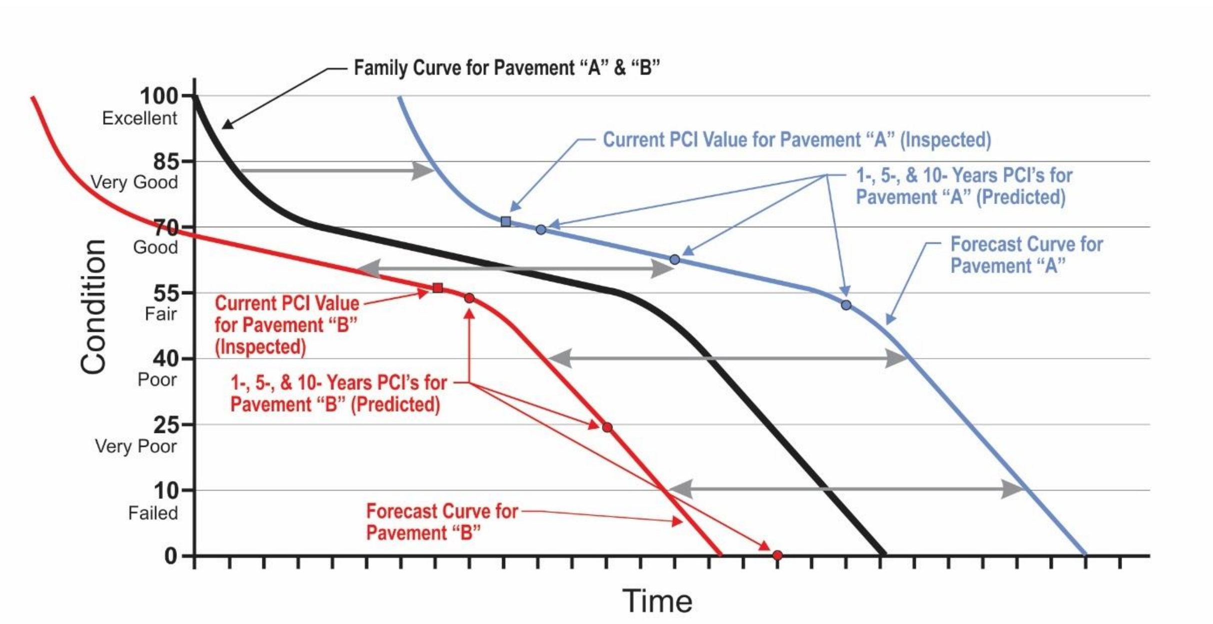


Table 3.1 shows inspected PCI values for all pavement sections included in the Montana airport pavement database. It also includes predicted PCI values for the years 2016, 2020, and 2025, based on the last inspected PCI-verses-age for each airport and the 2015 family curves. PCI's calculated from inspections are separated from projected estimates by a "critical PCI" unique to the pavement family. Pavements above their critical PCI can be economically maintained, while those "below critical" have begun rapid decay and are typically reconstructed. The "critical PCI" is the pavement condition rating (PCI value) shortly before the family curve predicts a dramatic decrease in pavement quality.

Older PCI values for a pavement section are replaced with "XX" whenever the pavement is demolished and reconstructed. 2015 PCI inspections were not conducted on a number of airports that were recently reconstructed or rehabilitated, nor were inspections completed on a few airports with an extended period of maintenance inactivity. Airports not inspected in 2015 are shown in italics - please realize that predictions for these airports may not reflect their current conditions.

TABLE 3.1
SUMMARY OF PCI RATINGS

Airport City (Branch Name)	Section	Section Area (sq. feet)	Constr. Year	Family Group	Surveyed PCIs 2000	2003	2006	2009	2012	2015	Critical PCI	Predicted PCIs 2016	2020	2025
Anaconda	A-1	49,140	1992	ACAM		81	77	58	64	43	**50**	40	21	0
Anaconda	A-2	84,000	1993	ACAM		74	64	61	41	48	**50**	45	29	0
Anaconda	R-1	450,000	2009	ACRML		XX	XX	99	90	90	**60**	87	78	71
Anaconda	R-2	271,200	2011	ACRML		XX	XX	XX	85	84	**60**	82	75	67
Anaconda	T-1	108,800	2009	ACRML		XX	XX	96	83	90	**60**	87	78	71
Anaconda	T-6	35,840	2010	ACRML			XX	XX	95	80	**60**	78	73	63
Baker	A-2A	120,000	1992	ACAM	83	77	79	70	72	66	**50**	64	55	38
Baker	A-5	40,000	1997	ACAM	88	86	62	66	66	61	**50**	59	48	28
Baker	R-1	367,500	2012	ACRMU	XX	XX	XX	XX	100	94	**50**	91	79	68
Baker	R-2	75,000	2012	ACRMU					100	99	**50**	96	84	71
Baker	T-1	33,750	2001	ACRMU	XX	88	74	69	75	72	**50**	70	63	53
Baker	T-2	137,200	2001	ACRMU	XX	85	75	73	73	75	**50**	74	66	57
Baker	T-3	53,620	2001	ACRMU	XX	94	76	79	85	75	**50**	73	65	56
Baker	T-4	45,415	1997	ACRMU	88	87	79	75	72	66	**50**	64	57	46
Baker	T-5	45,850	2012	ACRMU					100	97	**50**	94	82	70
Benchmark	*A-1B*	*45,000*	*1966*	*ACPS*	*45*	*42*	*22*	*17*			**45**	*0*	*0*	*0*
Benchmark	*R-1*	*465,000*	*1966*	*ACPS*	*59*	*51*	*35*	*29*			**45**	*12*	*1*	*0*
Benchmark	*T-1*	*13,500*	*1966*	*ACPS*	*56*	*42*	*34*	*33*			**45**	*16*	*5*	*0*
Big Sandy	*A-2*	*31,488*	*2010*	*ACAM*					89		**50**	*76*	*67*	*55*
Big Sandy	*R-11*	*214,200*	*2010*	*ACRMU*					*100*		**50**	*87*	*76*	*65*
Big Sandy	*T-12*	*46,261*	*2015*	*ACRMU*							**50**	*97*	*84*	*71*
Big Timber	A-1	40,000	1996	ACAM	90	87	86	61	78	71	**50**	69	60	46
Big Timber	R-1	348,750	1996	ACRML	91	87	78	67	58	76	**60**	75	69	55
Big Timber	R-2	47,625	1996	ACRML	95	90	86	71	79	74	**60**	73	66	48
Big Timber	T-2	39,600	1996	ACRML	83	73	67	55	68	64	**60**	62	44	8
Big Timber	T-4	85,365	2003	ACRML			93	83	76	93	**60**	90	79	72
Big Timber	T-5	35,020	2003	ACRML			89	76	73	84	**60**	82	75	67
Broadus	A-1	99,855	2005	ACAM				86	95	84	**50**	81	71	59
Broadus	R-1	330,000	2005	ACRML				85	92	85	**60**	83	76	68
Broadus	T-1	45,500	2005	ACRML				89	94	84	**60**	82	75	67
Chester	A-11	42,706	2010	ACAM					100	90	**50**	87	75	63
Chester	T-13	17,600	1997	ACRML					95	86	**60**	84	76	69
Chester	R-3	345,000	1997	ACRML	91	81	79	65	87	85	**60**	83	76	68
Chinook	A-1B	39,000	2006	ACAM				82	86	73	**50**	71	62	49
Chinook	R-1	300,000	2006	ACRMU	XX	XX		87	85	80	**50**	78	69	60
Chinook	T-1	103,075	2006	ACRMU	XX	XX		92	89	87	**50**	85	74	64
Choteau	A-1	46,336	2001	ACAM		91	88	82	83	70	**50**	68	59	45
Choteau	R-11	198,000	2001	ACRML		92	85	78	76	75	**60**	74	68	52
Choteau	R-2	375,000	2001	ACRML		83	81	78	78	75	**60**	74	68	52
Choteau	T-1	38,760	2001	ACRML		81	84	81	76	75	**60**	74	68	52
Choteau	T-2	35,560	2001	ACRML		89	87	79	78	74	**60**	73	66	48
Circle	A-2	34,860	2007	ACAM	XX	XX		66	68	68	**50**	66	57	42
Circle	R-11	307,500	2007	ACRML				90	88	83	**60**	81	74	66
Circle	T-1	2,900	2007	ACRML	XX	XX		84	78	77	**60**	76	70	57
Colstrip	A-1	66,000	2008	ACAM	XX	XX	XX	90	91	74	**50**	72	63	50
Colstrip	R-1	382,500	2008	ACRML	XX	XX	XX	97	92	92	**60**	89	79	71
Colstrip	T-1	27,300	2008	ACRML	XX	XX	XX	93	94	84	**60**	82	75	67
Columbus	A-1	77,012	1998	ACAM		79	80	59	68	49	**50**	46	30	1
Columbus	R-1	285,000	1998	ACRMU		85	81	67	72	43	**50**	40	21	0
Columbus	T-1	76,575	1998	ACRMU		92	84	57	77	46	**50**	44	27	0
Columbus	T-3	45,275	2001	ACRMU		88	83	60	75	43	**50**	40	21	0
Conrad	A-1	95,000	2002	ACAM		77	76	76	75	57	**50**	55	43	20
Conrad	R-3	345,000	2002	ACRML		95	76	76	72	62	**60**	60	40	4
Conrad	T-4	23,040	2002	ACRML		86	88	80	62	62	**60**	60	40	4

2012 numbers by SEI, remaining data by RPA.

TABLE 3.1 (contd.)
SUMMARY OF PCI RATINGS

Airport City (Branch Name)	Section	Section Area (sq. feet)	Constr. Year	Family Group	Surveyed PCIs 2000	2003	2006	2009	2012	2015	Critical PCI	Predicted PCIs 2016	2020	2025
Culbertson	A-1	47,000	2009	ACAM	XX	XX	XX		96	89	50	86	74	62
Culbertson	R-1	180,000	2009	ACRML	XX	XX	XX		99	86	60	84	76	69
Culbertson	R-2	48,000	2009	ACRML	XX	XX	XX		98	90	60	87	78	71
Culbertson	T-1	25,000	2009	ACRML	XX	XX	XX		91	85	60	83	76	68
Cut Bank	R-21	437,850	2007	ACRMU	XX		XX	93	93	83	50	81	71	61
Cut Bank	T-4	156,800	1991	ACRMU	84		68	59	57	72	50	70	63	54
Cut Bank	T-5	104,013	2000	ACRMU	100		67	72	37	63	50	62	54	42
Deer Lodge	A-3	55,310	1996	ACAM	88	82		62	41	67	50	65	56	40
Deer Lodge	A-5	75,312	2009	ACAM				100	88	97	50	93	79	66
Deer Lodge	R-3	330,000	1996	ACRML	85	80		90	77	91	60	88	78	71
Deer Lodge	R-4	59,987	2006	ACRML				92	80	92	60	89	79	71
Deer Lodge	T-2	31,000	1997	ACRML	81	74		80	67	80	60	78	73	63
Dillon	A-3	92,250	1994	ACAM	84	79	65	96	97	86	50	83	72	60
Dillon	A-4	78,200	2002	ACAH		95	87	92	85	84	50	80	64	48
Dillon	A-11	193,569	2008	ACAM				94	82	80	50	78	68	56
Dillon	R-3	467,400	1998	ACRMU	91	90	81	81	72	75	50	73	65	56
Dillon	R-4	58,500	1998	ACRMU	76	84	82	83	69	75	50	73	65	56
Dillon	R-21	187,440	2009	ACRMU				98	90	91	50	78	66	51
Dillon	T-3	212,275	1998	ACRMU	84	88	85	80	68	62	50	61	53	39
Dillon	T-5	33,288	2009	ACRMU				97	89	89	50	86	76	65
Ekalaka	A-1	100,000	2004	ACAM	XX	XX	89	86	89	81	50	79	68	57
Ekalaka	R-1	249,150	2004	ACRML	XX	XX	92	83	90	84	60	82	75	67
Ekalaka	R-11	35,850	2004	ACRML	XX	XX	84	79	90	85	60	83	76	68
Ekalaka	T-1	73,500	2004	ACRML	XX	XX	92	85	90	85	60	83	76	68
Ennis	A-2	88,128	1992	ACAM	88	78	66		68	49	50	46	30	1
Ennis	R-11	495,000	2008	ACRMU					90	86	50	84	73	63
Ennis	T-1	96,425	1990	ACRMU	87	85	66		76	54	50	52	41	17
Ennis	T-2	117,775	1992	ACRMU	77	77	58		50	57	50	56	46	27
Eureka	A-1	76,125	2010	ACAM	XX		XX	XX	93	77	50	75	65	53
Eureka	R-1	315,000	2010	ACRML	XX		XX	XX	93	88	60	86	77	70
Eureka	T-1	56,700	2010	ACRML	XX		XX	XX	97	89	60	86	77	70
Eureka	T-3	60,000	2010	ACRML			XX	XX	69	79	60	78	72	62
Forsyth	*A-1*	*89,640*	*1994*	*ACAM*	*69*	*74*	*69*	*25*	*26*		50	*3*	*0*	*0*
Forsyth	*R-1*	*36,000*	*1994*	*ACRMU*	*71*	*81*	*71*	*56*	*54*		50	*45*	*29*	*0*
Forsyth	*T-1*	*53,120*	*1994*	*ACRMU*	*78*	*81*	*63*	*45*	*42*		50	*25*	*0*	*0*
Forsyth	*T-2*	*95,550*	*1994*	*ACRMU*	*73*	*73*	*57*	*45*	*45*		50	*30*	*5*	*0*
Fort Benton	*A-1*	*98,784*	*1999*	*ACAM*		*79*	*79*	*68*	*78*		50	*68*	*59*	*45*
Fort Benton	*R-1*	*322,500*	*1999*	*ACRML*		*84*	*85*	*77*	*73*		60	*67*	*54*	*22*
Fort Benton	*T-1*	*45,640*	*1999*	*ACRML*		*81*	*86*	*81*	*88*		60	*79*	*73*	*63*
Fort Benton	*T-2*	*31,745*	*1999*	*ACRML*		*77*	*80*	*78*	*85*		60	*77*	*71*	*60*
Fort Benton	*T-13*	*101,500*	*2015*	*ACPL*							50	*94*	*77*	*65*
Gardiner	*R-1*	*165,015*	*1996*	*ACPL*				*42*	*45*		50	*30*	*5*	*0*
Gardiner	*T-1*	*3,823*	*1996*	*ACPL*				*41*	*50*		50	*38*	*17*	*0*
Glasgow	A-7	68,675	2002	ACAM		83	79	71	69	66	50	64	55	38
Glasgow	R-13	101,250	2003	ACRMU		100	93	86	84	86	50	84	73	63
Glasgow	R-14	298,125	2003	ACRMU		100	92	86	80	90	50	87	76	65
Glasgow	R-15	500,100	2012	ACRH					100	93	50	89	77	68
Glasgow	T-1	58,500	1986	ACRH		78	71	68	47	60	50	59	50	30
Glasgow	T-3	70,900	1996	ACRH		71	58	59	65	63	50	62	55	41
Glasgow	T-5	74,250	1996	ACRH		87	85	68	53	68	50	67	62	53

2012 numbers by SEI, remaining data by RPA.

TABLE 3.1 (contd.)
SUMMARY OF PCI RATINGS

Airport City (Branch Name)	Section	Section Area (sq. feet)	Constr. Year	Family Group	Surveyed PCIs 2000	2003	2006	2009	2012	2015	Critical PCI	Predicted PCIs 2016	2020	2025
Glendive	*A-1*	*145,700*	*2003*	*ACAH*	*XX*	*XX*	*83*	*69*	*62*		**50**	*50*	*39*	*28*
Glendive	*A-2*	*50,000*	*2002*	*ACAM*	*XX*	*93*	*81*	*60*	*57*		**50**	*46*	*30*	*0*
Glendive	*R-1*	*465,000*	*2007*	*ACRH*	*XX*	*XX*		*81*	*74*		**50**	*68*	*63*	*55*
Glendive	*R-2*	*105,400*	*2007*	*ACRH*	*XX*	*XX*		*80*	*77*		**50**	*70*	*64*	*57*
Glendive	*R-3*	*174,000*	*2003*	*ACRMU*	*XX*	*XX*	*88*	*74*	*71*		**50**	*63*	*56*	*45*
Glendive	*T-1*	*31,000*	*2007*	*ACRH*	*XX*	*XX*	*XX*	*69*	*63*		**50**	*57*	*48*	*26*
Glendive	*T-2*	*38,000*	*2002*	*ACRMU*	*XX*	*94*	*82*	*68*	*58*		**50**	*50*	*38*	*11*
Glendive	*T-5*	*59,220*	*2007*	*ACRMU*				*94*	*94*		**50**	*82*	*72*	*62*
Glendive	*T-7*	*88,200*	*2012*	*ACRMU*					*100*		**50**	*87*	*76*	*65*
Hamilton	A-2	145,800	1983	STPA	71		44	34	39	15	**55**	8	0	0
Hamilton	R-1A	165,000	1992	ACRMU	95		87	67	62	61	**50**	60	52	37
Hamilton	R-2	150,000	1992	ACRMU	93		90	74	62	61	**50**	60	52	37
Hamilton	T-5	53,912	2002	ACRMU			89	90	80	84	**50**	82	72	62
Hardin	*A-1*	*106,000*	*2014*	*ACAM*							**50**	*91*	*78*	*65*
Hardin	*R-1*	*336,750*	*2014*	*ACRML*							**60**	*91*	*80*	*72*
Hardin	*T-1*	*88,370*	*2014*	*ACRML*							**60**	*91*	*80*	*72*
Harlem	A-11	65,320	2003	ACAM			92	84	81	85	**50**	82	71	60
Harlem	R-11	288,750	2003	ACRML			90	84	77	80	**60**	79	73	63
Harlem	T-11	28,174	2003	ACRML			87	77	74	71	**60**	70	60	35
Harlowton	*A-21*	*49,505*	*2016*	*ACAM*	*XX*	*XX*	*XX*	*XX*	*XX*		**50**	*100*	*84*	*70*
Harlowton	*R-21*	*252,000*	*2016*	*ACRML*	*XX*	*XX*	*XX*	*XX*	*XX*		**60**	*100*	*84*	*75*
Harlowton	*T-21*	*42,660*	*2016*	*ACRML*	*XX*	*XX*	*XX*	*XX*	*XX*		**60**	*100*	*84*	*75*
Havre	A-5	109,350	1994	ACAH	76	64	54	43	67	33	**50**	31	22	10
Havre	R-15	530,000	2015	ACRMU	XX	XX	XX	XX	XX	100	**50**	97	85	72
Havre	R-22	171,600	2010	ACRMU	XX	XX	XX	XX	98	96	**50**	93	81	69
Havre	T-4	31,500	1993	ACRMU	79	73	76	66	64	66	**50**	65	58	47
Jordan	A-11	50,000	2003	ACAM			90	88	88	76	**50**	74	64	52
Jordan	R-1	322,500	2003	ACRML	XX		91	83	80	78	**60**	77	71	60
Jordan	T-1	24,538	2003	ACRML	XX		94	90	94	78	**60**	77	71	60
Laurel	A-3	171,360	2001	ACAM		93	84	69	81	67	**50**	65	56	40
Laurel	R-4	390,000	2000	ACRMU		93	81	70	79	61	**50**	60	52	37
Laurel	T-8	98,550	2000	ACRMU		91	81	75	87	71	**50**	69	62	53
Laurel	T-9	67,060	2001	ACRMU		95	86	80	91	70	**50**	68	61	52
Lewistown	A-2	30,744	1993	ACPL	79	83	65	58	49	54	**50**	53	42	17
Lewistown	R-23	246,000	1996	ACRMU	89	77	72	67	62	54	**50**	52	42	18
Lewistown	R-32	327,000	2010	ACRH	XX	XX	XX	XX	100	81	**50**	79	70	64
Lewistown	R-33	205,000	2010	ACRH	XX	XX	XX	XX	100	82	**50**	80	71	64
Lewistown	R-34	78,000	2010	ACRH	XX	XX	XX	XX	100	80	**50**	78	70	64
Lewistown	T-1	299,000	1993	ACRH	91	87	75	72	65	51	**50**	49	33	7
Lewistown	T-5	88,200	1989	ACRH	82	81	72	74	63	50	**50**	48	31	6
Lewistown	T-7	183,706	1999	ACRMU	96	94	81	76	70	68	**50**	67	59	49
Lewistown	T-8	68,272	1999	ACRMU	92	92	66	57	62	54	**50**	52	42	18
Lewistown	T-11	36,781	2006	ACRMU				82	56	69	**50**	68	60	51
Libby	A-2	110,700	2002	ACAM		91	80	75	87	57	**50**	55	43	19
Libby	A-3	107,040	2002	ACAH		90	87	71	79	65	**50**	62	50	37
Libby	R-1	285,000	1999	ACRML		82	67	57	95	59	**60**	56	34	0
Libby	R-2	90,000	1999	ACRML		82	68	57	89	62	**60**	60	40	4
Libby	T-2	82,600	1987	ACRH		74	62	56	62	43	**50**	40	20	0
Libby	T-5	68,501	1999	ACRML		91	80	78	87	69	**60**	68	56	25
Lincoln	A-11	54,954	2005	ACAM				80	81	90	**50**	87	74	63
Lincoln	R-11	318,000	2005	ACRML				85	79	86	**60**	83	76	69
Lincoln	T-11	62,575	2005	ACRML				84	75	88	**60**	85	77	70

2012 numbers by SEI, remaining data by RPA.

TABLE 3.1 (contd.)
SUMMARY OF PCI RATINGS

Airport City (Branch Name)	Section	Section Area (sq. feet)	Constr. Year	Family Group	Surveyed PCIs 2000	2003	2006	2009	2012	2015	Critical PCI	Predicted PCIs 2016	2020	2025
Livingston	A-11	183,600	2011	ACAH						83	**50**	79	63	48
Livingston	R-11	427,575	2011	ACRH						82	**50**	80	71	64
Livingston	T-5	89,775	2005	ACRH			85	85	83	74	**50**	72	66	60
Malta	A-1	95,800	2010	ACAM		XX	XX	XX	93	91	**50**	88	75	64
Malta	R-1	337,500	2010	ACRMU		XX	XX	XX	92	88	**50**	86	75	64
Malta	T-1	37,100	2010	ACRMU		XX	XX	XX	92	90	**50**	88	76	66
Miles City	R-12	560,100	2008	ACRH	XX		XX	98	84	76	**50**	74	68	61
Miles City	T-2A	63,000	1998	ACRMU	84		72	73	75	61	**50**	60	52	37
Miles City	T-3	43,750	2001	ACRH	XX		76	66	76	67	**50**	66	61	52
Miles City	T-6	50,400	1998	ACRMU	89		80	73	80	58	**50**	57	48	29
Plains	A-1	141,750	2006	ACAM				86	88	82	**50**	80	69	58
Plains	R-1	348,750	2006	ACRML				89	84	75	**60**	74	68	52
Plains	T-1	47,775	2006	ACRML				88	88	85	**60**	83	76	68
Plentywood	A-11	73,348	2001	ACAM	XX	81	72	66	77	66	**50**	64	55	38
Plentywood	R-11	292,500	2001	ACRMU	XX	89	83	75	76	68	**50**	66	59	49
Plentywood	T-11	141,080	2001	ACRMU		88	85	74	81	73	**50**	71	63	54
Polson	A-11	199,475	1998	ACAM		76	66	56	61	47	**50**	44	27	0
Polson	R-11	315,000	1998	ACRMU		74	66	62	53	56	**50**	55	45	24
Polson	T-11	170,450	1999	ACRMU		75	73	64	47	54	**50**	52	42	17
Polson	T-12	32,925	1999	ACRMU		65	56	59	56	48	**50**	46	31	0
Poplar	A-1	78,380	2009	ACAM					98	95	**50**	91	75	64
Poplar	R-1	330,000	2009	ACRMU					99	92	**50**	88	73	63
Poplar	T-1	58,500	2009	ACRMU					97	95	**50**	92	80	68
Ronan	A-11	162,800	2000	ACAM		87	85	79	68	74	**50**	72	63	50
Ronan	A-12	41,600	2000	ACAM		89	78	74	83	72	**50**	70	61	48
Ronan	R-11	360,000	2000	ACRMU		86	71	62	56	65	**50**	64	57	45
Ronan	T-11	192,675	2000	ACRMU		92	74	70	61	71	**50**	69	62	53
Roundup	A-1	36,400	2002	ACAM	XX	83	75	66	79	62	**50**	60	50	31
Roundup	R-1	382,500	2002	ACRML	XX	96	84	76	78	56	**60**	53	27	0
Roundup	T-1	36,720	2002	ACRML	XX	95	84	79	77	63	**60**	61	42	6
Roundup	T-4	82,600	2013	ACRML						93	**60**	90	79	72
Scobey	A-11	46,500	1998	ACAM			88	53	69	66	**50**	64	55	38
Scobey	R-11	255,000	1998	ACRML			80	70	78	72	**60**	71	62	39
Scobey	R-12	46,500	1998	ACRML			82	73	81	69	**60**	67	56	25
Scobey	T-11	40,640	1998	ACRML			83	61	67	69	**60**	67	56	25
Shelby	A-21	97,273	2003	ACAM			83	77	85	78	**50**	76	66	54
Shelby	R-21	375,000	2004	ACRMU			83	80	89	70	**50**	68	61	52
Shelby	R-22	222,000	2003	ACRMU			81	78	83	64	**50**	63	56	43
Shelby	T-6	115,000	1994	ACRMU	83		63	50	100	77	**50**	75	67	58
Shelby	T-17	71,330	2012	ACRMU					100	84	**50**	82	72	62
Shelby	T-21	89,250	2003	ACRMU			86	78	88	69	**50**	67	60	51
Shelby	T-22	64,400	2004	ACRMU			78	69	77	54	**50**	52	42	17
Sidney	A-3A	55,000	2007	ACAM	XX		XX	84	86	66	**50**	64	55	38
Sidney	A-11	80,156	2004	PCAA			99	92	72	81	**45**	79	69	60
Sidney	A-13	114,774	2006	ACAH				77	81	69	**50**	66	52	39
Sidney	R-11	402,000	2003	ACRH			91	73	81	71	**50**	70	65	58
Sidney	R-12	570,500	2003	ACRH			95	72	82	78	**50**	76	69	63
Sidney	T-4	338,250	2012	ACRH	XX		XX	XX		84	**50**	81	72	65
Sidney	T-6	58,450	2012	ACRH						89	**50**	86	74	67
Stanford	A-2	60,000	1997	ACAM	93	81	82	70	78	68	**50**	66	57	42
Stanford	R-2	52,500	1997	ACRML	93	86	88	79	75	69	**60**	68	56	26
Stanford	R-3	262,500	1997	ACRML	92	81	79	73	75	60	**60**	57	36	0
Stanford	T-2	13,100	1997	ACRML	97	90	87	86	90	71	**60**	70	60	35

2012 numbers by SEI, remaining data by RPA.

TABLE 3.1 (contd.)
SUMMARY OF PCI RATINGS

		Section	Constr.	Family	Surveyed PCIs						Critical	Predicted PCIs		
Airport City (Branch Name)	**Section**	**Area** (sq. feet)	**Year**	**Group**	**2000**	**2003**	**2006**	**2009**	**2012**	**2015**	**PCI**	**2016**	**2020**	**2025**
Stevensville	A-1	70,000	1991	STPA	79	70	65	70	80	51	**55**	49	35	0
Stevensville	A-2	90,425	1994	ACAM	93	80	70	64	82	40	**50**	37	16	0
Stevensville	R-1	228,000	1991	STPA	83	72	78	67	60	53	**55**	52	41	6
Stevensville	T-3	161,448	1994	ACRMU	96	87	89	78	93	52	**50**	50	38	11
Stevensville	T-5	71,505	2013	ACRMU						92	**50**	90	78	67
Superior	A-11	37,284	2004	ACAM	XX		92	74	68	69	**50**	67	58	44
Superior	R-11	270,979	2004	ACRML	XX		92	84	91	83	**60**	81	75	67
Superior	T-11	72,413	2004	ACRML	XX		89	80	81	78	**60**	77	71	60
Terry	A-11	52,234	2001	ACAM		94	75	76	76	74	**50**	72	63	50
Terry	R-11	322,500	2001	ACRML		95	83	79	75	82	**60**	80	74	65
Terry	T-11	23,463	2001	ACRML		92	71	73	66	78	**60**	77	71	60
Thompson Falls	A-2	52,490	1995	ACAM	93	88	77	67	67	63	**50**	61	51	33
Thompson Falls	R-1	252,000	1995	ACRMU	93	88	83	79	83	61	**50**	60	52	37
Thompson Falls	R-2	63,000	1995	ACRMU	88	82	67	64	64	52	**50**	50	38	11
Thompson Falls	T-4	66,300	1995	ACRMU	93	91	78	75	68	53	**50**	51	40	14
Thompson Falls	T-5	50,090	2000	ACRMU	99	97	90	81	86	76	**50**	74	66	57
Three Forks	A-1	63,800	2000	ACAM		91	82	70	81	73	**50**	71	62	49
Three Forks	R-1	246,000	2000	ACRMU		89	78	70	64	66	**50**	64	57	46
Three Forks	R-2	60,000	2000	ACRMU		93	87	80	77	71	**50**	69	62	52
Three Forks	T-2	74,150	2000	ACRMU		93	87	79	88	80	**50**	78	68	59
Three Forks	T-3	33,300	2000	ACRMU		90	80	65	63	67	**50**	65	58	48
Three Forks	T-4	70,344	2000	ACRMU		97	87	78	67	74	**50**	72	64	55
Townsend	A-1	105,000	2002	ACAM	XX	94	84	72	76	69	**50**	67	58	43
Townsend	R-1	240,000	2002	ACRML	XX	91	87	81	81	58	**60**	54	31	0
Townsend	T-1	34,700	2002	ACRML	XX	93	87	80	70	69	**60**	67	55	24
Turner	A-1	33,800	1995	ACAM	94	70	59	64	80	51	**50**	49	34	6
Turner	R-1	216,000	1995	ACRMU	84	79	75	72	78	59	**50**	58	49	32
Turner	T-3	20,000	1995	ACRMU	87	74	69	76	83	66	**50**	65	58	47
Twin Bridges	*A-11*	*86,040*	*2014*	*ACAH*							***50***	89	71	53
Twin Bridges	*R-11*	*360,000*	*2014*	*ACRH*							***50***	90	77	68
Twin Bridges	*T-11*	*105,880*	*2014*	*ACRH*							***50***	90	77	68
West Yellowstone	A-4	75,000	1980	ACPS	90		79	58	65	76	**45**	75	70	63
West Yellowstone	R-1	1,012,500	2003	ACPS	XX		92	78	82	83	**45**	82	76	70
West Yellowstone	R-2	247,500	2003	ACPS	XX		88	79	85	82	**45**	81	75	69
West Yellowstone	T-1	750,000	1980	ACPS	63		54	41	44	48	**45**	46	38	26
White Sulphur	A-11	78,951	2010	ACAM	XX	XX	XX		96	91	**50**	88	75	63
White Sulphur	R-11	367,500	2010	ACRML	XX	XX	XX		99	82	**60**	80	74	66
White Sulphur	R-12	105,000	2009	ACRML	XX	XX	XX		96	84	**60**	82	75	67
White Sulphur	T-12	26,915	2010	ACRML					100	95	**60**	92	80	72
Wolf Point	A-5	106,363	2010	ACAM	XX	XX	XX		98	90	**50**	87	75	63
Wolf Point	R-11	509,100	2010	ACRH					99	79	**50**	77	69	63
Wolf Point	T-4	28,200	2010	ACRMU	XX	XX	XX		93	80	**50**	78	69	59

TOTAL SURFACED AREA: 37,226,178 (sq. feet)
2015 SURVEY AREA: 32,783,687 (sq. feet) = 88%

NOTES:

"XX" in PCI columns indicates previous PCI values have been voided to account for new construction.

No entry in PCI columns indicates no inspection of the pavement section for the given year.

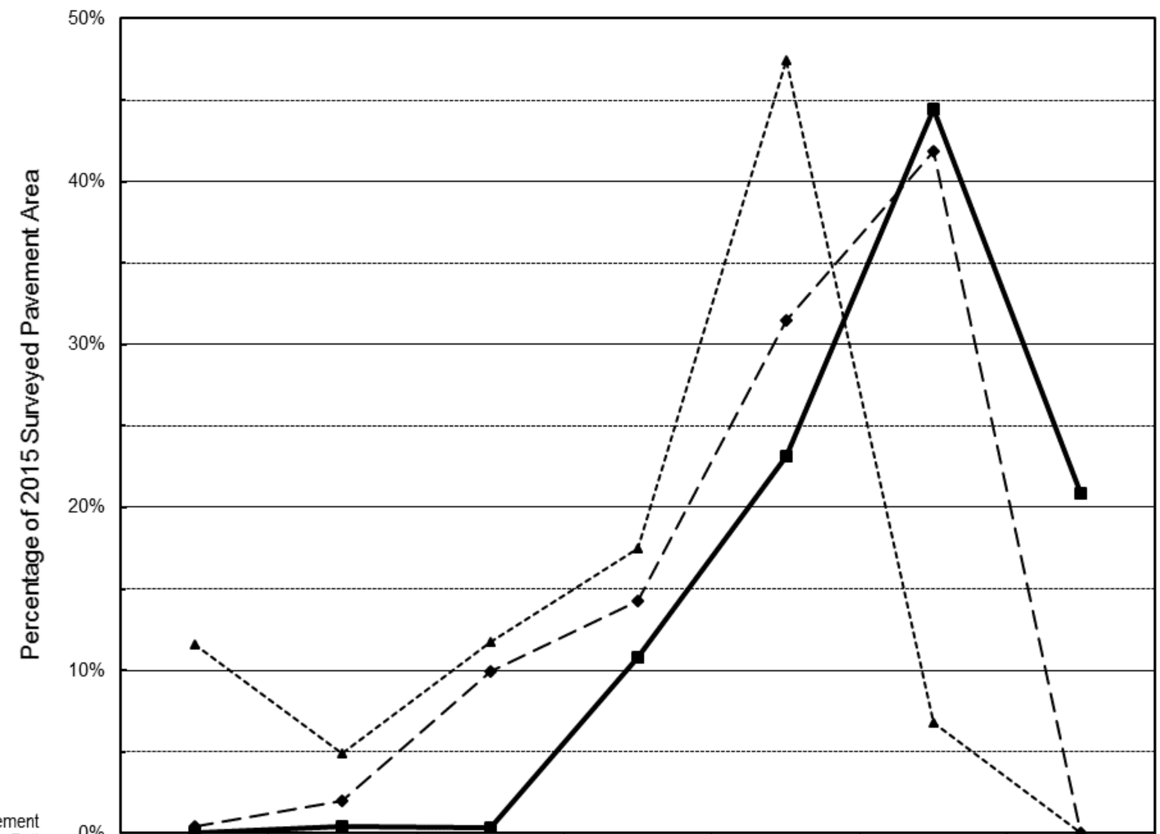
Italics indicates the airport was not inspected for this report, as such the included information is suspect. If construction has taken place it will not be reflected in this report. Families and PCI predictions are assumed from pre-2015 pavements.

2012 numbers by SEI, remaining data by RPA.

3.3 SYSTEM-WIDE PAVEMENT CONDITIONS

PAVER uses current PCI values as a starting point on the pavement section's family curve, then continues down the family curve to project PCI's in the future. The constrained "best-fit" life cycle curves generated for each family are valid only to the age for which there is survey data, after which they assume a straight-line projection of the curve's slope (shown with dashed lines on the family curves). An Excel spreadsheet was used to summarize, organize, and enhance the presentation of PAVER-processed information into system-wide pavement condition ratings (Figure 3.2). The Pavement Condition Ratings shown are area-weighted to portray the percentage of 2015-surveyed Montana airport pavement area falling into each rating class. Square footages for each pavement section were accumulated into one of seven Pavement Condition Ratings, based on their inspected or predicted PCI values, and the rating scale shown in Figure 2.2, Step 8. The pavement area in each condition rating was then converted to percentages by dividing by the total 2015-surveyed area. The resulting distribution of Pavement Condition Ratings shown in Figure 3.2 projects a representative aging of all inspected airport pavements given continued maintenance practices, but no major rehabilitation or reconstruction.

FIGURE 3.2
SYSTEM-WIDE PAVEMENT CONDITION RATINGS
"No Action" Alternative for Pavements Surveyed in 2015



Pavement Condition Ratings:	Failed	Very Poor	Poor	Fair	Good	Very Good	Excellent
2015	0.0%	0.4%	0.3%	10.8%	23.2%	44.4%	20.8%
2020	0.4%	2.0%	9.9%	14.3%	31.5%	41.9%	0.0%
2025	11.6%	4.9%	11.7%	17.5%	47.5%	6.8%	0.0%

The data in Table 3.1 and Figure 3.2 both show unequivocally that if reconstruction programs on Montana airports were suspended or discontinued, airport pavements would degrade to marginal serviceability within about 10 years. While there are many finer points to be gleaned from the graph of system-wide pavement condition ratings (Figure 3.2), splitting the pavement ratings into three groups (below fair, fair, and above fair) will help translate the extensive data set to more comprehensible insights.

Pavements rated as "Fair" are generally in a state of transition on two fronts: surface defects are beginning to be noticeable in both type and frequency, and the expense of reconstruction is becoming more economical than continued preventative maintenance. While surface distresses indicating deterioration of the pavement/base course system are visible, they are subtle enough to not have major effects on ride quality nor are they generating significant foreign object debris (FOD). Studies continue to indicate that reconstruction of "good" to "fair" quality asphalt surfacing is more economical than waiting until major distresses appear. While it may seem counterintuitive to reconstruct good-looking pavement, reconstruction before the gravel base deteriorates is much less expensive. The area of transitional pavements in the absence of reconstruction is projected to escalate from 11% to 14% to 18% in the years 2015, 2020, and 2025, respectively.

Those pavements rated above "Fair" are high-quality surfaces providing trouble-free use and relatively low maintenance costs. Currently, lower-cost preventative maintenance is the recommended course of action for 88% of the pavement area in the PCI database. Without investments in (re)construction, the area of pavement in this high service/low cost maintenance class drops to 73% in five years and 54% in 10 years.

Pavements assessed as below "Fair" condition provide increasing maintenance headaches, growing probabilities of damaging aircraft, decreasing ride quality, and escalating repair and reconstruction costs. "Below fair" pavements range from showing noticeable defects, all the way to near gravel surfaces. These serviceable, but low quality pavements grow from 1% (by area) of the database pavement area to 12% and 28% of the State-wide system pavements in 2020 and 2025, respectively.

This prediction is based on the assumption that current maintenance practices, aircraft activity, and loadings will continue, and that no new construction or major reconstruction will occur. In other words, they show what would happen if Montana airports discontinued pavement construction / reconstruction programs.

3.4 MAINTENANCE PRIORITIES

As an aid to pavement maintenance project prioritization three summary tables have been constructed using PCI projections from Table 3.1. These tables consider project prioritization from a system-wide approach, a community-based vantage, and a "maintain vs. reconstruct" option. These summary tables are meant only as an "early warning indicator" and should not be misconstrued as being an absolute authority. Where a rehabilitation or reconstruction project has been completed since the most recent PCI inspection, projections are shown with a ~~strike out~~.

TABLE 3.2
PAVEMENT PROJECTED TO GO SUBCRITICAL
By Pavement Area

2015-2020

City	(sq. ft.)
West Yellowstone	750,000
Polson	485,450
Lewistown	345,016
~~Fort Benton~~	~~322,500~~
Libby	286,241
Turner	216,000
Ennis	214,200
Stevensville	161,448
Thompson Falls	129,300
Conrad	95,000
Scobey	87,140
Roundup	73,120
Stanford	70,000
Glendive	69,000
Shelby	64,400
Glasgow	58,500
Miles City	50,400
Baker	40,000
Big Timber	39,600
Townsend	34,700

2020-2025

City	(sq. ft.)
Choteau	693,656
Laurel	561,360
Big Timber	436,375
Ronan	401,600
Plentywood	365,848
Plains	348,750
Jordan	347,038
Three Forks	343,100
Hamilton	315,000
Thompson Falls	304,490
Scobey	301,500
Dillon	290,475
Shelby	222,000
Lewistown	183,706
Livingston	183,600
Glendive	174,000
Sidney	169,774
Baker	165,415
Glasgow	139,575
Superior	109,697
Townsend	105,000
Cut Bank	104,013
~~Fort Benton~~	~~98,784~~
Stanford	73,100
Miles City	63,000
Deer Lodge	55,310
Chinook	39,000
Circle	37,760
Havre	31,500
Harlem	28,174
Terry	23,463
Turner	20,000

2015-2025

City	(sq. ft.)
West Yellowstone	750,000
Choteau	693,656
Laurel	561,360
Lewistown	528,722
Polson	485,450
Big Timber	475,975
Thompson Falls	433,790
~~Fort Benton~~	~~421,284~~
Ronan	401,600
Scobey	388,640
Plentywood	365,848
Plains	348,750
Jordan	347,038
Three Forks	343,100
Hamilton	315,000
Dillon	290,475
Shelby	286,400
Libby	286,241
Glendive	243,000
Turner	236,000
Ennis	214,200
Baker	205,415
Glasgow	198,075
Livingston	183,600
Sidney	169,774
Stevensville	161,448
Stanford	143,100
Townsend	139,700
Miles City	113,400
Superior	109,697
Cut Bank	104,013
Conrad	95,000
Roundup	73,120
Deer Lodge	55,310
Chinook	39,000
Circle	37,760
Havre	31,500
Harlem	28,174
Terry	23,463

~~strike out~~ indicates a pavement rehabilitation/replacement project has taken place since the previous PCI inspection.

Preserving the current investment in Montana's general aviation (GA) airport pavements may include prioritizing maintenance projects as in Table 3.2. Fog seals/seal coats, crack sealing, and thin-lift overlays *applied before the pavement crosses its critical PCI* are the most economical way of extending pavement life. By prioritizing projects by their square footage, it's possible to allocate State and Federal dollars to best extend the life of the greatest pavement area. Table 3.2 can be used to guide a *system-wide approach to economical pavement maintenance.*

When inconvenience and/or the future rehabilitation burden on local communities is of prime importance, maintenance can be prioritized by the percent of each airport's pavement forecasted to drop below the critical PCI. Table 3.3 is a ranking of airport communities that could be investing most economically in pavement maintenance. These communities can get their biggest "bang for the buck" if available maintenance dollars are spent before the critical PCI transition. Table 3.3 can help establish a *community-based emphasis to economical pavement maintenance*.

Tables 3.2 and 3.3 each provide three different time frames to consider in the project prioritization scenario, the first and second five-year period following inspection, and a ten-year overview. Please note that critical PCI transition tables do not give an indication of the type of maintenance that would be most beneficial, only the timing of the application. Inspection Summary Reports and Maintenance Reports are better indicators of the need for thin lift overlays, fog seals, crack sealing, localized patching, or other remediation.

Airports listed in Table 3.4 are candidates for reconstruction or repairs. Continued investments in maintaining these pavements produce diminishing returns, and are not the best investment of funds. The airports with greater than 75% of their pavements subcritical should be targeted for complete reconstruction, while those in the 25% range just need a section or two of pavement reconstructed.

The break-out of pavement ratings ("fair", "poor", etc.) can be used to determine the need for action. For example, since 100% of Benchmark's pavements have subcritical PCI's, and all are rated "very poor" to "failed", Benchmark Airport should be encouraged to reconstruct as soon as possible to avoid accelerating degradation, continued loss of base course structural strength, and rising reconstruction costs. Columbus is showing 100% subcritical pavements, but all above a PCI of 40. While Columbus's airport will remain serviceable with only localized "safety" repairs for quite a number of years, the monies invested would be better directed toward acquiring an AIP local match for a reconstruction project. Libby shows up in the partial reconstruct list, but a quick consideration of their remaining sections show they are all near-critical, bumping this airport into a recommended complete reconstruction. Anaconda and Havre have an overall high quality pavement with an isolated "historical" section in need of repairs. A significant number of airport operations combined with "poor", or "very poor" pavement conditions should boost an airport to the top of the reconstruction list.

These tables are provided only as an aid in the larger framework of GA airport funding allocation. Used judiciously, they can simplify and improve the airport improvement prioritization process.

TABLE 3.3
PAVEMENT PROJECTED TO GO SUBCRITICAL
By % of Each Airport's Pavement Area

2015-2020

City	
Polson	68%
~~Fort Benton~~	~~54%~~
Libby	38%
West Yellowstone	36%
Ennis	27%
Thompson Falls	27%
Stevensville	26%
Scobey	22%
Lewistown	22%
Conrad	21%
Stanford	17%
Roundup	14%
Townsend	9%
Miles City	7%
Big Timber	7%
Shelby	6%
Glendive	6%
Glasgow	5%
Baker	4%

2020-2025

City	
Jordan	87%
Scobey	78%
Laurel	77%
Big Timber	73%
Plentywood	72%
Plains	65%
Thompson Falls	63%
Three Forks	63%
Hamilton	61%
Ronan	53%
Superior	29%
Townsend	28%
Livingston	26%
Dillon	22%
Shelby	21%
Stanford	18%
Baker	18%
Fort Benton	16%
Glendive	15%
Cut Bank	15%
Glasgow	12%
Lewistown	12%
Circle	11%
Sidney	10%
Deer Lodge	10%
Chinook	9%
Miles City	9%
Turner	7%
Harlem	7%
Terry	6%
Havre	4%

2015-2025

City	
Turner	87%
Townsend	37%
Three Forks	63%
Thompson Falls	90%
Terry	6%
Superior	29%
Stevensville	26%
Stanford	35%
Choteau	100%
Scobey	100%
Jordan	87%
Big Timber	80%
Laurel	77%
Plentywood	72%
~~Fort Benton~~	~~70%~~
Polson	68%
Plains	65%
Hamilton	61%
Ronan	53%
Libby	38%
Lewistown	34%
Shelby	28%
Ennis	27%
Livingston	26%
Baker	22%
Dillon	22%
Glendive	21%
Conrad	21%
Glasgow	17%
Miles City	16%
Cut Bank	15%
Roundup	14%
Circle	11%
Sidney	10%
Deer Lodge	10%
Chinook	9%
Harlem	7%
Havre	4%

~~strike out~~ indicates a pavement rehabilitation/replacement project has taken place since the previous PCI inspection.

TABLE 3.4
% OF EACH AIRPORT'S PAVEMENT WITH 2016 SUBCRITICAL PCI

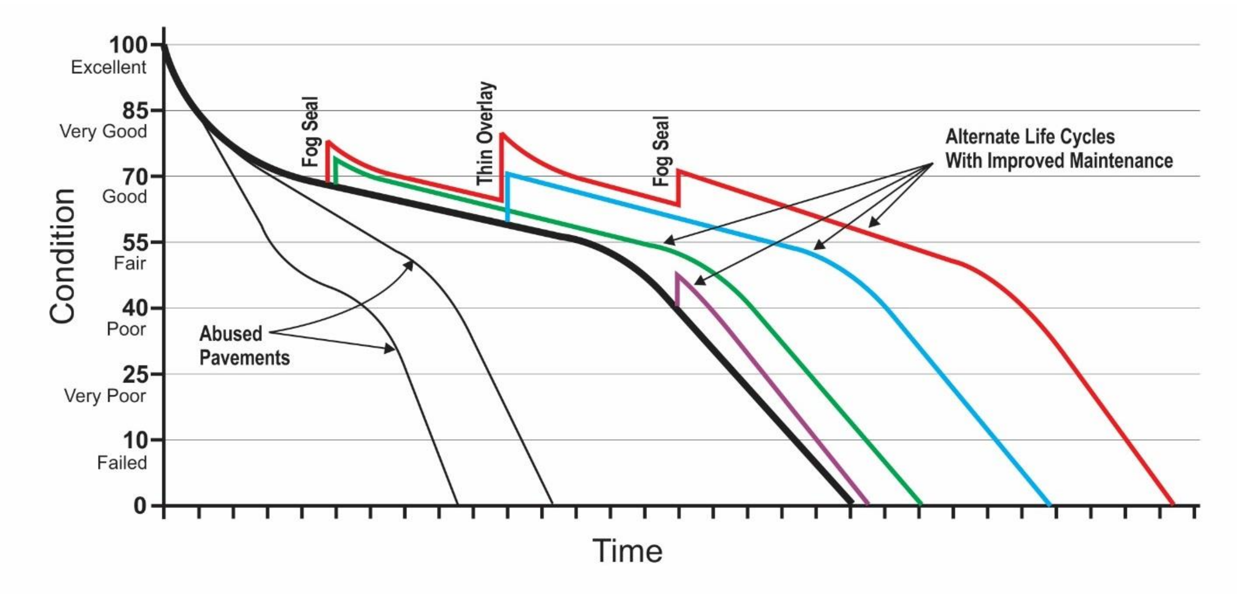
Category	Airport City	Subcritical 0-55	Failed 0-10	Very Poor 11-25	Poor 26-40	Fair 41-critical PCI
Complete Reconstruct when Appropriate	Benchmark	100%	9%	91%		
	Forsyth	100%	33%		54%	13%
	Gardiner	100%			100%	
	Columbus	100%				100%
	Conrad	79%				79%
	Roundup	71%				71%
Partial Reconstruct when Appropriate	Hamilton	28%	28%			
	Stevensville	63%			15%	48%
	Libby	62%			11%	50%
	Stanford	65%				65%
	Townsend	63%				63%
	Polson	32%				32%
	Lewistown	25%				25%
Localized Repair / Reconstruct	Havre	13%			13%	
	Anaconda	13%			5%	8%
	Glendive	17%				17%
	Turner	13%				13%
	Ennis	11%				11%

~~strike out~~ indicates a pavement rehabilitation/replacement project has taken place since the previous PCI inspection.

3.5 MAINTENANCE PRACTICES

All of the results obtained from this analysis are affected by maintenance practices. In general, improved maintenance raises all points of the curve, produces a "bump up" in quality, and/or extends the "flat" portion of the pavement life cycle, providing a longer usable pavement life before dropping off at the critical condition. Figure 3.3 revisits the pavement life cycle curve from Figure 2.12 showing the benefits of improved maintenance practices. While occasional maintenance extends pavement life, regular preventative maintenance clearly extends the usable life of pavement well beyond its non-maintained expected usable life. Most pavements around the State are already benefitting from recent increases in federal airport funding and improved maintenance policies. Families have more data scatter than previous years, due in large part to new maintenance policies mixed with the old data. Future analyses may be able to quantify these effects by studying maintenance practices more closely along with the PCI evaluations, and redefining pavement families to account for maintenance practices.

FIGURE 3.3
EXTENDED PAVEMENT LIFE CYCLE



3.6 MAINTENANCE AND REHABILITATION PLANNING

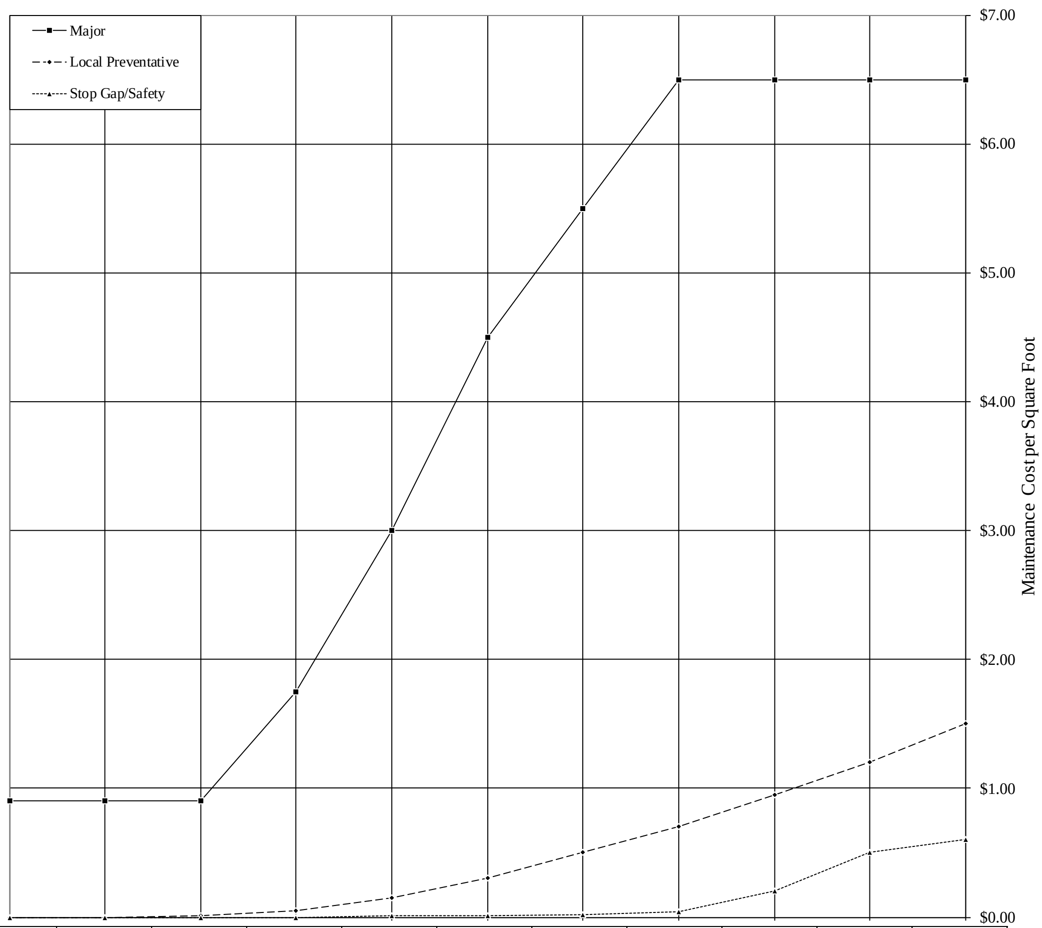
PAVER for windows consolidates the Maintenance & Rehabilitation (M&R) planning into a single work plan with a number of application, modeling, and reporting options. The scope of policy application is set by a sort routine, just like that used to set families. The sort can be structured to report on all database members, currently maintained pavements, one airport, or even a single section of an airport pavement. Once the scope of the M&R plan has been defined a choice of three modeling routines is available: Minimum Condition Report, Consequence Model Report, and Limit to Budget Report. These three reports take dramatically different approaches to modeling pavement aging and its effect on budgeting for optimum pavement quality. The final option of establishing an M&R routine is to set-up the table(s) specific to each model. These range from target minimum PCI's for future years, simple cost by condition tables, to elaborate webs of costs and consequences of specific remedies to be applied to specific grades of distress.

The first step in establishing a work plan is to determine the scope of application. This scope may be restricted for such reasons as reducing computing time, or exploring optimum repair strategy at a single airport. Within the Selection Criteria option of the work plan, the user may select "All Items" to get past and present pavement sections stored in the database, or choose "Build Selection" to construct a smaller group. To choose currently maintained pavements filter using "Rank = O," i.e. select all pavements that have been classified as "current" (This is the same as previous PAVER versions' "Network Report"). Airports can be addressed individually by setting "Zone" equal to the airport's four-character code **and** setting "Rank = O." Smaller selections are filtered out using "BranchID" or "SectionID."

The **Minimum Condition Report** is the simplest of the modeling routines. This report allows the user to set a single PCI minimum for each future year, then calculates the cost to repair any pavement that falls below these predetermined minimums. Costs of improvements increase with decreasing PCI and chosen to be typical PAVER airfield values (see Figure 3.4). These PCI-based repair cost estimates are a systematic reflection of increasing repair costs for decreasing pavement quality. The minimum allowable PCI can be set for each year in the future to phase in repairs acceptable to available funding. For example, budget constraints might only allow raising the system-wide minimum PCI to 35 the first year, but this could then be raised to 41, 46, and 50 in successive years. Major M&R budgeting is predicted reasonably well for any number of years with little change in the validity of the results.

The **Consequence Model Report** treats extrapolated distress quantities with specific remedies (see Table 3.5) to remediate pavement distresses and increase the overall section PCI. For a preset cost (see Table 3.6) the pavement distress associated with the treatment replaces the original more severe distress in PCI calculations (see Table 3.7). For example, crack sealing AC pavements costs about two dollars per linear foot and fills medium- and high-severity cracks, reducing them to low-severity cracks. Costs are estimated for a stand-alone FAA-assisted project, and may be higher than a contractor's quote. If an airport owner paid for recommended repairs to each pavement distress on their pavement and had their airport inspected immediately after completion of the repairs, the airport's new PCI and the bill for improvements would be approximately that predicted by the Consequence Model Report. The Consequence Model Report uses only localized repair options and makes no attempt to increase quantity or severity of distresses to account for the natural aging process nor to project distresses that have not already been recorded during an inspection. This report is designed to provide projections of the localized repair costs and consequences *only when repairs are applied within a year of the airport inspection.*

FIGURE 3.4
COST BY PCI ASSUMPTIONS



CATEGORY \ PCI	100	90	80	70	60	50	40	30	20	10	0
Major	$0.9000	$0.9000	$0.9000	$1.7500	$3.0000	$4.5000	$5.5000	$6.5000	$6.5000	$6.5000	$6.5000
Local Preventative	$0.0000	$0.0000	$0.0100	$0.0500	$0.1500	$0.3000	$0.5000	$0.7000	$0.9500	$1.2000	$1.5000
Stop Gap/Safety	$0.0000	$0.0000	$0.0000	$0.0000	$0.0100	$0.0100	$0.0200	$0.0400	$0.2000	$0.5000	$0.6000

The **Limit to Budget Report** optimizes pavement quality using a set budget cap and four targeted maintenance policies: Localized Safety, Localized Preventative, Global, and Major Reconstruction. Localized Safety treatments attempt to keep an airport pavement safe for operation using only local treatments while waiting for funds to replace the entire pavement section. For example, a high severity depression could be patched to eliminate hydroplaning potential, but underlying subgrade problems could still necessitate eventual reconstruction. Local Preventative treatments are applied to above-critical-PCI pavements to prolong the pavement life and reduce the effect of nonstructural and minor structural local defects. Crack sealing is a common Local Preventative repair that will stop moisture penetration into the subgrade and preserve subgrade integrity and extend pavement life. Global Preventative measures are applied to above-critical-PCI pavements when defects affect the whole surface. For example, raveling can be slowed significantly by applying a surface seal, rebinding the aggregate into a high quality surface at a fraction of the cost of a new surface. Major M&R is a total reconstruction of a pavement section applied when that section is below the critical PCI for its family curve, or if alligator cracking, rutting, and the like, indicate structural failure even above the critical PCI. The “Major Under-Critical” case of Major M&R assumes that the critical PCI was chosen such that reconstruction is a more economical option than continued maintenance once a section has passed below its critical PCI. While it is very rare, structural failure of parts of a section (like a culvert crossing of a runway settling) may produce an unusable pavement with a PCI rating above critical. This “Major Above-Critical” special case can only be treated effectively by reestablishing a sound foundation for the surface layer, hence its inclusion in the Major M&R policy.

The Limited to Budget Report is a hybrid report which makes the best use of detailed inspection data for short-range predictions then switches to a more general, empirically verified long-range scheme. The first year predictions are based on a Consequence Model Report plus Global and Major repair options, while successive years use the same costs (see Table 3.6) as the Minimum Condition Report. First year predictions of costs for local maintenance and conditions are determined from Localized Safety and Localized Preventative Maintenance Policies (Table 3.5) and their associated cost and consequence tables (Tables 3.6 and 3.7). In succeeding years, both Localized Safety and Preventative Maintenance costs are determined from the Cost by PCI table illustrated in Figure 3.4. Global M&R always takes its costs and consequences from user-defined values irrespective of pavement PCI’s (see Table 3.8). In other words, fog seals/seal coats will have the same cost and useful life regardless of the quality of pavement they’re applied to. Major Rehabilitation costs for all projection years are used from the Cost by PCI table in Figure 3.4. Localized Safety and Localized Preventive Maintenance Policies are applied only when the annual budget is limited. Localized policies are only applied while waiting for a section’s “turn” in the funding cycle.

TABLE 3.5
FIRST YEAR LOCALIZED MAINTENANCE POLICIES

LOCALIZED SAFETY OR "STOP-GAP"

Description	Severity	Treatment
Alligator Cracking	H	Patching–AC Deep
Block Cracking	H	Crack Sealing – AC
Depression	H	Patching – AC Deep
Jt. Ref. Cracking	H	Crack Sealing – AC
L & T Cracking	H	Crack Sealing – AC
Patching	H	Patching – AC Deep
Weathering	H	Patching – AC Shallow
Raveling	H	Patching – AC Shallow
Rutting	H	Patching – AC Deep
Shoving	H	Patching – AC Shallow
Slippage Cracking		Patching – AC Shallow
Swelling	H	Patching – AC Deep
Blow-Up	M or H	Patching – PCC Full Depth
Corner Break	H	Patching – PCC Full Depth
Linear Cracking	H	Crack Sealing – PCC
Durability Cracking	H	Slab Replacement – PCC
Small Patch	H	Patching – PCC Partial Depth
Large Patch/ Utility	H	Patching – PCC Full Depth
Scaling	H	Slab Replacement – PCC
Shattered Slab	H	Slab Replacement - PCC
Joint Spalling	H	Patching – PCC Partial Depth
Corner Spalling	H	Patching – PCC Partial Depth

LOCALIZED PREVENTATIVE

Description	Severity	Treatment
Alligator Cracking	M or H	Patching–AC Deep
Block Cracking	M or H	Crack Sealing – AC
Depression	M or H	Patching–AC Deep
Jt. Ref. Cracking	M or H	Crack Sealing – AC
L & T Cracking	M or H	Crack Sealing – AC
Oil Spillage		Patching – AC Shallow
Patching	M or H	Patching–AC Deep
Rutting	M or H	Patching–AC Deep
Shoving	M or H	Patching – AC Shallow
Slippage Cracking		Patching – AC Shallow
Swelling	M or H	Patching–AC Deep
Blow-Up	L	Patching – PCC Full Depth
Blow-Up	M or H	Slab Replacement – PCC
Corner Break	H	Slab Replacement – PCC
Corner Break	M	Patching – PCC Partial Depth
Linear Cracking	M or H	Crack Sealing – PCC
Durability Cracking	H	Crack Sealing – PCC
Durability Cracking	M	Patching – PCC Full Depth
Small Patch	M or H	Patching – PCC Full Depth
Large Patch/ Utility	H	Slab Replacement – PCC
Large Patch/ Utility	M	Patching – PCC Full Depth
Scaling	M or H	Slab Replacement – PCC
Settlement	H	Slab Replacement – PCC
Shattered Slab	M or H	Slab Replacement – PCC
Joint Spalling	M or H	Patching – PCC Partial Depth
Corner Spalling	M or H	Patching – PCC Partial Depth

TABLE 3.6
FIRST YEAR LOCALIZED MAINTENANCE COSTS

Repair Description	Cost
Crack Sealing - AC	$2/ft
Patching - AC Deep	$44/sf
Patching - AC Shallow	$18/sf
Crack Sealing - PCC	$2/ft
Patching - POC Full Depth	$80/sf
Patching - POC Partial Depth	$100/sf
Slab Replacement - PCC	$80/sf

TABLE 3.7
EXAMPLE FIRST YEAR REPAIR CONSEQUENCES

CRACK SEALING - AC

Distress Description	Severity	New Distress Description	New Severity
Block Cracking	M	Block Cracking	L
Block Cracking	H	Block Cracking	L
Jt. Ref. Cracking	M	Jt. Ref. Cracking	L
Jt. Ref. Cracking	H	Jt. Ref. Cracking	L
L & T Cracking	M	L & T Cracking	L
L & T Cracking	H	L & T Cracking	L

TABLE 3.8
GLOBAL MAINTENANCE COSTS AND CONSEQUENCES

Repair Description	Cost	Application Interval	Years for PCI to Return to Pre-application Value
Overlay - AC Thin (Global)	$1.95/sf	10	6
Surface Seal – Seal Coat	$0.28/sf	5	2

Money is first allocated to sub-critical PCI sections for "stop gap" Localized Safety treatments. If it's determined later that funding is available for major reconstruction of a section, then its stop-gap funds are redistributed. The second fiscal priority is to prolong the life of above-critical-PCI pavements with Local, then Global Preventative treatments. Local and Global Preventative funds are the example $1 invested near the critical PCI as shown in Figure 2.12 to avoid the necessity of spending $4 to $5 later. This investment in pavements before rapid deterioration produces an extended pavement life cycle as shown in Figure 3.2 and optimizes pavement quality per dollar spent. Major Under Critical and Major Above Critical repair treatments are prioritized for replacement by PCI and primary use as shown in Table 3.9.

TABLE 3.9
EFFECTIVE MAJOR M&R PRIORITIES

M&R Policy	PCI Range	Runways	Taxiways	Aprons
Major Above Critical	100 - 70	2	4	6
	70 - Critical	1	3	5
Major Under Critical	Critical - 40	1	3	5
	40 - 0	2	4	6

3.7 OTHER PAVER REPORTS (Available, but not included in this System Plan Update)

PAVER provides several reporting options that are not included in this report since they do not directly address the intent of this project. They are briefly discussed here to provide insight on the potential advantages of implementing the pavement management system.

The **Inspection Schedule Report** allows the user to plan which pavements need to be inspected based on their current and expected conditions. This allows the user to time inspections for maximum effectiveness in identifying pavements in critical need of maintenance and/or reconstruction.

The **Condition History Report** allows the user to plot a specific pavement's history of PCI values through all of its existing PCI inspections. This option gives the user an at-a-glance assessment of an individual airport pavement's performance over time. This is available in graphical and tabular form under the heading "Condition Table" as part of the M&R Report, but was not included in this text. A 1-, 5-, and 10-year sampling are included in Table 3.1.

The MS Excel spreadsheets included in this report as Tables 2.4 and 3.1 can also be manipulated to perform many of the tasks possible in the PAVER database. Depending on the computer equipment available and the expertise of the user, this spreadsheet format may be more convenient for some types of analysis.

PAVER provides several other analysis routines to help the user decide among various maintenance and repair alternatives. These analysis and reporting options provide decision making information that may be useful for evaluating system-wide programs or for individual airport planning.

3.8 CONTINUED MOCROPAVER IMPLEMENTATION

In addition to this report, the product for this 2015 Update to the Montana Aviation System Plan includes an up-to-date copy of the pavement database, and a current licensed copy of the PAVER software. This will allow the MDT Aeronautics staff to use the software and database in their planning and budgeting efforts. Inspection reports and airport maps will be provided to MDT in a pdf-format for inclusion on their web site where they will be available to the public. Excerpts of the information contained in the reports are provided directly to airport managers, so they have a current indication of their pavement conditions and needs.

The continued success of this pavement management system is dependent on keeping the database up to date. PCI surveys, conducted on a regular three-year cycle beginning in 1988, have collected pavement condition information for 65 of Montana's airports. Continued implementation of the current family models need not include surveys of each airport each time an update is completed. Instead, the frequency of inspections at each airport should be based on the likelihood of significant change since the last inspection. If previous survey results indicate an approaching PCI plateau, an airport could be skipped for a phase or two, allowing additional airports to be surveyed on available funds. Conversely, survey frequency should increase as conditions approach the critical

PCI. The frequency of inspections at any given airport may also be based on the importance of that airport to the system, or the sponsor's needs for information to assess their maintenance and construction programs.

The PCI survey program depends on consistent inspection information to provide accurate and reliable estimates of condition and predictions of future condition. This is best achieved through strict compliance with the requirements of FAA Advisory Circular 150/5380-7 with the modifications from the Northwest Mountain Region handout "Pavement Condition Survey Program", since PAVER is designed to work with these procedures. Personnel selected to conduct the PCI visual inspections should be well-trained, and experienced in the procedures outlined in these documents, to ensure the needed quality and consistency of data.

The program also benefits from close attention to detail in documenting the inspection and analysis processes. The PAVER database, if properly maintained, preserves much of this data. FAA Forms 5320-1 also provide much of the needed information about pavement design criteria, and the definitions of sections and sample units. It is very important that these forms and the information they contain for Montana airports continue to be updated as changes occur, and that the information is updated in the PAVER database. Coordination with the FAA, airport sponsors, and engineers working on airport improvement projects is essential in maintaining up-to-date records of the pavement systems in the database. Additional information, such as the spreadsheet summaries provided in this report should be carefully updated or noted as obsolete when database updates occur. Additionally, the PAVER database may be compatible with other airport information management systems, providing a powerful combination of information in convenient formats. Because of the architecture of the database, it can be coordinated with other programs. Such efforts may require direct coordination with the developers of the program at the United States Army Corps of Engineers Research Labs.

Predictions developed for this update use a slowly evolving set of families. As noted earlier in this chapter, family analysis curves can be re-defined in any way the user desires. Results obtained in this update suggest that maintenance practices actually occurring on Montana's airports may play an increasingly important role in slowing pavement aging. As a result, future updates to the plan may be improved by increased attention to actual maintenance on each pavement section, and revised family analysis curves that account for differences in maintenance. Changes to the family analysis curves should not be undertaken without careful analysis however, since consistency of results is of great importance to the success of the program. Five rounds of inspections under a new maintenance regimen and increased federal investment in Montana's airport infrastructure is getting close to providing enough data to split families into "well-maintained" and "poorly-maintained" groups. Most of the current families do not have enough survey points to divide without compromising the statistical validity of the data, especially on the aged end of the graph. In fact, should excellent maintenance continue, the database will not add any "below critical PCI" information; and while this will be good news to airport users, it adds more uncertainty to end-of-cycle PCI predictions.

Even with Montana's current wealth of data (using all inspections from 1988-2015; roughly 3000 PCI determinations from 40,000 recorded distresses) we are probably limited to 5-15 families. It is a very fine line between having enough types of families to fairly accurately model the different pavements in the State, and having too many families to be accurately defined by the existing data. To be "well-defined" a family must have inspections of representative pavements at a good range of ages. If pavements are less representative of the group, or data is lacking for a cluster of ages (especially the downward curve after critical PCI) a family can only be constructed with a good deal of engineering judgement, and as such, it may represent that judgement, more than the empirical reality. The challenge becomes choosing which few of the numerous common-sense delimiters create families with good statistical properties.

As this pavement management system evolves, it may be appropriate to slowly phase in one or more new criteria (maintenance practices, freeze-thaw cycling, insolation, etc.) in place of, or in addition to the current five criteria (pavement type, functional use, design strength, operations counts, seasonal use) while trying to maintain approximately 10 families. For example, operations counts were phased into the most data-rich family in 2003 as a way to split an overly large set (ACRM became ACRML and ACRMU). Functional usage was dropped from the light-duty design load pavements in 2006 creating two families where formerly there were four. There were not nearly enough "under 12,500 lb. design load" or "surface treatments" remaining in the State to warrant four families, so ACAL and ACRL were combined into ACPL, while STAA and STRA were lumped into STPA. There are no families with an excess of data, ripe for dividing into meaningful subsets. The families STPA and ACPL represent very few active pavements, but enough to keep around for a few more iterations. In short, the set of families are currently functioning very well with slow evolution.

Appendix A Figure A.1 is included to illustrate that the current set of families is fairly robust, although it also hints at how the high-age end of the graphs (with the least data) can show significant variation from year to year. Note how slight raising of the 0-5 year portions of each graph reflect a number of reconstructed airports and improving early preventative maintenance.

Finally, the Montana airport pavement database and associated software systems can only provide benefits if they are actively used to help manage Montana's airport pavements. The entire purpose of the program is to provide information to decision makers. Whether it is used by the MDT Aeronautics Division, the Federal Aviation Administration, airport sponsors, planners, or engineers, the system can be used to provide meaningful information about pavement conditions, performance, policies, and budget allocations.

CHAPTER 4
AIRPORT REPORT SUMMARIES

CHAPTER 4 AIRPORT REPORT SUMMARIES

4.1 INTRODUCTION

This chapter contains the airport inspection report summaries, maintenance reports, inspection photos, and updated FAA forms 5320-1 (Airport Layout Maps with Pavement Strength Survey / Pavement Condition Survey) for each airport surveyed in the 2015 Update to the Montana Aviation System Plan.

Airports are arranged alphabetically by the name of the city in which they are located and maps are folded so that the city name sticks out to provide a convenient locating tab. The city name also appears in large, bold print at the top left corner of each inspection report and maintenance report page. Inspection and summary data is grouped by section and samples which are called out on the included map. The first character of a section name is coded to its primary use, so **A-3** will be an apron, **R-1** a runway, and **T-5A** a taxiway. These section designations are in large, bold print at the top right corner of each inspection report page.

4.2 INSPECTION REPORT SUMMARIES

The Airport Inspection Report Summaries are presented for each airport using PAVER's "Inspection Report" to compile the 2015 PCI survey project data and perform calculations, then refined and reformatted using MS Access. A variety of descriptive information about the section is listed immediately below the header on the left three quarters of the page, while the database classification codes for the section are on the right margin. The Inspections section presents first and foremost the section PCI in a medium-sized, bold print, followed by the sampling rate and date of inspection. The specific, recorded distresses for a number of samples completes the documentation of the field surveys. The Extrapolated Distress Quantities section approximates the distresses present in the entire section from those measured in the sampled areas, and shows values for intermediate steps in the PCI calculation routine. The Distresses are listed in order of decreasing "deducts," so the distresses listed first are those causing most damage to the pavement. Maintenance concerns should be prioritized to address these distresses in the order they appear. The classification by distress mechanism may point to the most significant force in pavement deterioration. Finally, no entry in a given section of an inspection report simply means there were no measurable distresses in the sample inspected.

4.3 MAINTENANCE REPORT SUMMARIES

The Maintenance Report Summaries are presented for each airport using PAVER's Budget Constrained M&R Report with Unlimited Budget to project the 2015 survey data into a fifteen year budgeting projection. The results are refined and reformatted using MS Access. Fifteen Year Projections estimate an annual budget necessary to keep all airport pavements above their critical PCI's, as well as detailing a time line of suggested repairs. The section designation requiring work and an abbreviated treatment suggestion are located along the left edge of the page, with total cost and resulting change in PCI along the right page edge. The detailed breakdown of cost by treatment is listed in the center. A section is not called out in parts of the maintenance report if it is in satisfactory condition and needs no repairs.

4.4 INSPECTION PHOTOS

One or more pages of inspection photos are provided for each airport to illustrate specific pavement distresses identified in the 2015 survey, or to show the overall appearance of pavement sections. We have increased the number and size of the photos, typically providing both an overview and close-up detail of each pavement section. This “virtual tour” of Montana’s airports will provide the report reader with a clearer understanding of the conditions that contributed to our evaluations.

While inspections are completed for typical representative sample areas, photos often strive to document the worst pavement distresses of a section - *they often show the exception, not the rule*. These photos document the extremes of our evaluation and instruct airport managers and others charged with maintaining Montana’s pavements what to look for on an airport pavement. Copies of these photos will be provided for inclusion on MDT’s web site.

4.5 FAA FORM 5320-1

The FAA form 5320-1 for each airport is a standard form that describes the components of each pavement section, and identifies pavement improvement dates. The form has been adapted to also show sample units defined for each pavement section. This allows the field-inspected sample units to be precisely located on the airport, and allows consistent sampling from PCI project to project.

4.6 REPORTS

The information presented in this chapter for individual airports is also provided directly to each airport's manager, for their use in planning improvements to their airport pavements.

Some pavement sections were not included in the current survey, either because they were brand new and assumed to be in "perfect" condition, or because they are abandoned, not maintained, not part of the federally financed system, T-hangar taxiways, or too small to significantly affect the program. A few sections were left out of the 2015 scope of work since they have deteriorated well below the critical PCI, so no significant information could be gained from their inspection. These omitted pavement sections are listed in Table A.5 in the Appendix A along with reasons for omission.

Individual airport reports for 2015 surveyed airports follow:

APPENDIX A

TABLE A.1
ASPHALT PAVEMENT DISTRESSES

Distress Name	Description
Alligator Cracking	Load related - a major distress
Bleeding	Excess asphalt cement on surface reduces traction - design or construction defect
Block Cracking	Rectangular, interconnected cracks - related to climate, age, durability
Corrugation	Closely spaced ridges & valleys, perpendicular to traffic, caused by braking action & unstable pavement base.
Depression	Low spots by settlement or load, cause roughness and future deterioration
Jet Blast	Asphalt has been burned by jet engines
Joint Reflection	Caused by movement of Portland cement under an asphalt overlay - will cause future problems
Longitudinal & Transverse Cracking (L & T Crack)	Random cracks, usually not load related, but due to poor construction joints or climate/age/durability
Oil Spillage	Usually on aprons - softens asphalt and speeds aging process
Patching	A defect no matter how well-done
Polished Aggregate	Aggregate is worn smooth - poor traction
Raveling	Loss of aggregate from the paved surface
Rutting	Surface depression in wheel path - almost always from snowplows and sand trucks
Shoving from PCC	Asphalt is crushed from adjacent PCC movement
Slippage Cracking	Minor cracks - caused by braking or turning wheels
Swell	Upward bulge - usually from frost heave or expansive clays below pavement
Weathering	Loss of asphalt binder and/or fines

TABLE A.2
PORTLAND CEMENT PAVEMENT DISTRESSES

Distress Name	Description
Blow-Up	Slabs expand in hot weather and crush each other
Corner Break	Poor support at corner of slab, combined with loading
Longitudinal/Transverse/ Diagonal Cracks	Cracks extend clear across a slab dividing it into two or three pieces
"D" Crack	Durability Cracks - climate related
Joint Seal Damage	Poor or missing crack sealant - lets water and incompressible materials between slabs - can cause blow-up, pumping, spalling
Patching < 5 ft ^{2}	A defect no matter how well-done
Patching / Utility Cuts	A defect no matter how well-done
Popouts	Small piece of pavement dislodged from surface - freeze / thaw or poor aggregate
Pumping	Subgrade materials are liquefied and then "pumped" up through cracks when loaded
Scaling/Map Cracking/Crazing	Hairline cracks in surface - usually caused by over-finishing the surface, or by climate factors
Settlement Fault	Slabs move up/down at joint with respect to each other
Shattered Slab	Cracked into four or more pieces
Shrinkage Crack	Short, fine surface cracks, usually a construction defect
Spalling - Joints	Edges broken along slab joints, usually near surface only - due to incompressible materials in joints
Spalling - corners	Breaks in slab at joint corners, usually near surface only - due to incompressible materials in joints
Alkali Silica Reaction	Chemical reaction causing map cracking and popouts from aggregate expansion. Colored gel or staining at the cracks

TABLE A.3
ASPHALT PAVEMENT DISTRESSES BY CAUSES

Load	Climate/Durability	Other
Alligator Cracking	Block Cracking	Bleeding
Rutting	Joint Reflection Cracking	Corrugation
	Longitudinal/Transverse Cracking	Depression
	Patching	Jet Blast
	Weather	Oil Spillage
	Raveling	Polished Aggregate
		Shoving
		Slippage Cracking
		Swelling
		Mechanical Raveling

TABLE A.4
CONCRETE PAVEMENT DISTRESSES BY CAUSES

Load	Climate/Durability	Other
Corner Break	Blow-Up	Small Patch
Linear Cracking	Durability Cracking	Large Patch/Utility
Shattered Slab	Joint Seal Damage	Popouts
		Pumping
		Scaling/Crazing
		Faulting
		Shrinkage Cracking
		Joint Spalling
		Corner Spalling
		Alkali Silica Reactivity

TABLE A.5
SECTIONS OMITTED FROM 2015 PCI SURVEY

Airport	Omitted Section	Reason for Omission
Anaconda	T-4	Sub-critical
	T-1A, T-2, T-5	Area < 30,000 sf
Baker	A-3A, A-6, A-7, A-9	Area < 30,000 sf
Benchmark	All	Sub-critical
Big Sandy	All	Per FAA direction
Big Timber	T-1	Sub-critical
	A-2, T-3	Area < 30,000 sf
Broadus		
Chester	A-5	Sub-critical
	T-2, T-3, T-4	Area < 30,000 sf
Chinook	A-1A	Sub-critical
Choteau	R-12	Area < 30,000 sf
Circle	A-1, T-2	Area < 30,000 sf
Colstrip	T-2	Area < 30,000 sf
Columbus	T-2	Area < 30,000 sf
Conrad		
Culbertson	A-2, T-2	Area < 30,000 sf
Cut Bank	A-1, R-1, T-1,T-2	Per FAA direction
	T-6	Area < 30,000 sf
Deer Lodge	A-4, T-1B	Area < 30,000 sf
Dillon	T-2, T-4	Area < 30,000 sf
Ekalaka	T-2, T-11	Area < 30,000 sf

TABLE A.5 (contd.)
SECTIONS OMITTED FROM 2015 PCI SURVEY

Airport	Omitted Section	Reason for Omission
Ennis	A-1	Sub-critical
Eureka	T-2	Sub-critical
	T-4, T-5	Area < 30,000 sf
Forsyth	All	Per FAA direction
Fort Benton	All	Per FAA direction
Gardiner	All	Sub-critical
Glasgow	A-4, A-6, T-4, T-7, T-9	Sub-critical
	A-3, T-10, T-11, T-12	Area < 30,000 sf
Glendive	All	Per FAA direction
Hamilton	A-1, ~~A-2~~, T-2, T-3	Sub-critical
Hardin	All	Per FAA direction
Harlem	R-12	Area < 30,000 sf
Harlowton	All	Per FAA direction
Havre	A-3, A-4, ~~A-5~~, R-21, T-2, T-3	Sub-critical
	T-3	Area < 30,000 sf
Jordan	T-12	Area < 30,000 sf
Laurel	T-1, T-2	Sub-critical
Lewistown	A-1, A-3A, T-4, T-9, R-1	Sub-critical
	T-10	Area < 30,000 sf
Libby	A-4	Sub-critical
	A-1, A-5, T-6	Area < 30,000 sf
Lincoln	A-2	Area < 30,000 sf

TABLE A.5 (contd.)
SECTIONS OMITTED FROM 2015 PCI SURVEY

Airport	Omitted Section	Reason for Omission
Livingston	T-11	Area < 30,000 sf
Malta	A-3, A-4, T-2	Area < 30,000 sf
Miles City	A-2, A-3, A-3A, A-4, A-5, ~~R-12~~, R-21	Per FAA direction
	T-1B	Sub-critical
	T-3B	Area < 30,000 sf
Plains	T-2	Area < 30,000 sf
Plentywood		
Polson	T-14	Area < 30,000 sf
Poplar		
Ronan	T-5	Area < 30,000 sf
Roundup	A-2, T-3	Area < 30,000 sf
Scobey	A-12, T-12, T-13	Area < 30,000 sf
Shelby	A-22, T-7	Area < 30,000 sf
Sidney	T-3, T-4	Sub-critical
	A-12, A-14, A-15, T-2	Area < 30,000 sf
Stanford		
Stevensville	T-1, T-4	Area < 30,000 sf
Superior	A-12, A-13	Area < 30,000 sf
Terry		
Thompson Falls	A-1, T-6	Area < 30,000 sf
Three Forks	A-2	Sub-critical
	T-1	Area < 30,000 sf

TABLE A.5 (contd.)
SECTIONS OMITTED FROM 2015 PCI SURVEY

Airport	Omitted Section	Reason for Omission
Townsend	T-2	Area < 30,000 sf
Turner	T-2	Area < 30,000 sf
Twin Bridges	All	Per FAA direction
West Yellowstone	A-1, A-2, A-3, ~~T-1~~ A-5, T-2	Sub-critical Area < 30,000 sf
White Sulphur Springs	T-1 T-2, T-11	Sub-critical Area < 30,000 sf
Wolf Point	T-11, T-12, T-13	Area < 30,000 sf

TABLE A.6
AC – FIRST YEAR REPAIR CONSEQUENCES

CRACK SEALING

Distress / Description	Severity	New Distress / Description	New Severity
Block Cracking	H	Block Cracking	L
Block Cracking	M	Block Cracking	L
Jt. Ref. Cracking	H	Jt. Ref. Cracking	L
Jt. Ref. Cracking	M	Jt. Ref. Cracking	L
L & T Cracking	H	L & T Cracking	L
L & T Cracking	M	L & T Cracking	L

PATCHING – DEEP

Distress / Description	Severity	New Distress / Description	New Severity
Alligator Cracking	H	Patching	L
Alligator Cracking	M	Patching	L
Depression	H	Patching	L
Depression	M	Patching	L
Patching	H	Patching	L
Patching	M	Patching	L
Rutting	H	Patching	L
Rutting	M	Patching	L
Swelling	H	Patching	L
Swelling	M	Patching	L

PATCHING – SHALLOW

Distress / Description	Severity	New Distress / Description	New Severity
Oil Spillage		Patching	L
Weathering	H	Patching	L
Raveling	H	Patching	L
Shoving	H	Patching	L
Shoving	M	Patching	L
Slippage Cracking		Patching	L

TABLE A.7
PCC – FIRST YEAR REPAIR CONSEQUENCES

CRACK SEALING

Distress / Description	Severity	New Distress / Description	New Severity
Linear Cracking	H	Linear Cracking	L
Linear Cracking	M	Linear Cracking	L

SLAB REPLACEMENT

Distress / Description	Severity	New Distress / Description	New Severity
Blow-Up	H	None	
Blow-Up	M	None	
Corner Break	H	None	
Durability Cracking	H	None	
Large Patch/Utility	H	None	
Scaling	H	None	
Scaling	M	None	
Faulting	H	None	
Shattered Slab	H	None	
Shattered Slab	M	None	

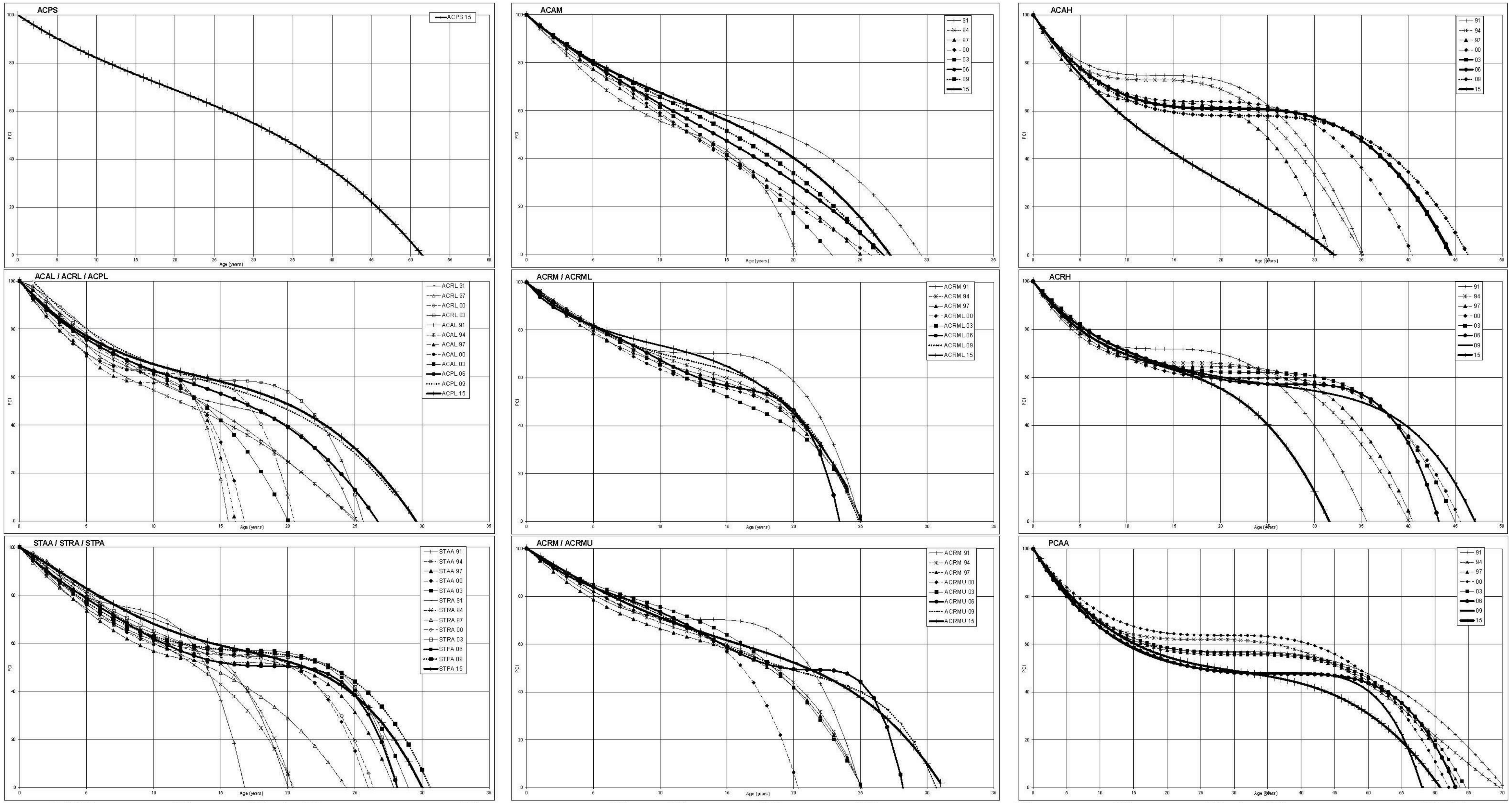
PATCHING – FULL DEPTH

Distress / Description	Severity	New Distress / Description	New Severity
Blow-Up	H	Large Patch/Utility	L
Blow-Up	M	Large Patch/Utility	L
Blow-Up	H	Large Patch/Utility	L
Corner Break	M	Large Patch/Utility	L
Corner Break	H	Large Patch/Utility	L
Durability Cracking	M	Large Patch/Utility	L
Small Patch	H	Small Patch	L
Small Patch	M	Small Patch	L
Large Patch/Utility	H	Large Patch/Utility	L
Large Patch/Utility	M	Large Patch/Utility	L

PATCHING – PARTIAL DEPTH

Distress / Description	Severity	New Distress / Description	New Severity
Small Patch	H	Small Patch	L
Joint Spalling	H	Large Patch/Utility	L
Joint Spalling	M	Large Patch/Utility	L
Corner Spalling	H	Large Patch/Utility	L
Corner Spalling	M	Small Patch	L

FIGURE A.1 FAMILY COMPARISONS



coefficients	ACPS	ACAL					ACRL				ACPL		
constant	100	100	100	100	100	100	100	100	100	100	100	100	100
linear	-2.174	-7.783	-8.537	-2.07	-7.764	-6.997	-6.663	-3E-07	-3.217	-3.721	-6.487	-6.28	-6.17
quadratic	0.0473	0.64	0.62	-2.02	0.0854	0.5327	0.158	-2.468	-0.745	-0.314	0.379	0.35	0.36
cubic	-8E-04	-0.032	-0.025	0.297	0.0725	-0.022	0.011	0.3478	0.1037	0.0405	-0.01	-0.01	-0.01
quartic		5E-04	3E-04	-0.01	-0.004		-5E-04	-0.014	-0.003	-9E-04			
quintic										-9E-06			
critical PCI	45				55	55			55	55	50	50	50
outlier	90%				90%	90%			90%	80%	90%	90%	90%
corr coeff	-0.118				0.78	0.85			0.71	0.90	0.77	-0.07	0.75
Std of err	5.99				13.60	12.50			14.44	7.90	13.80	11.26	12.40
year	15	A 91	A 94	A 97	A 00	A 03	R 94	R 97	R 00	R 03	P 06	P 09	P 15

coefficients	ACAM							
constant	100	100	100	100	100	100	100	100
linear	-4.891	-5.402	-4.85	-4.198	-4.493	-4.672	-4.55	-4.924
quadratic	-0.056	-0.192	0.0567	0.0057	0.109	0.133	0.166	0.239
cubic	0.0238	0.047	0.0024	0.0008	-0.005	-0.004	-0.005	-0.007
quartic	-8E-04	-0.002	-1E-04	-2E-05				
quintic								
critical PCI				50	55	50	50	50
outlier				90%	90%	90%	90%	90%
corr coeff				0.85	0.88	0.84	-0.14	0.81
Std of err				11.11	9.60	9.97	8.04	10.28
year	91	94	97	00	03	06	09	15

coefficients	ACAH							
constant	100	100	100	100	100	100	100	100
linear	-5.81	-6.91	-7.63	-5.92	-5.664	-5.686	-5.735	-5.768
quadratic	0.461	0.62	0.529	0.323	0.276	0.275	0.262	0.169
cubic	-0.014	-0.02	-0.01	-0.01	-0.004	-0.004	-0.004	-0.003
quartic	8E-05	2E-04						
quintic								
critical PCI				60	60	60		55
outlier				90%	90%	90%		90%
corr coeff				0.63	0.68	0.78		0.92
Std of err				12.44	12.91	11.82		9.29
year	91	94	97	00	03	06	09	15

coefficients	ACRM			ACRML				
constant	100	100	100	100	100	100	100	100
linear	-4.1	-3.648	-5.259	-3.428	-4.497	-7.368	-4.293	-5.336
quadratic	-0.093	-0.058	0.182	-0.287	0.276	1.434	0.059	0.409
cubic	0.033	0.0177	0.005	0.037	-0.033	-0.188	0.013	-0.014
quartic	-0.001	-6E-04	-4E-04	-0.001	0.002	0.011	-6E-04	
quintic					-4E-05	-2E-04		
critical PCI				50	50	55	60	60
outlier				90%	90%	99%	99%	99%
corr coeff				0.83	0.83	0.70	-0.06	0.76
Std of err				9.07	8.48	11.40	8.44	8.73
year	M 91	M 94	M 97	L 00	L 03	L 06	L 09	L 15

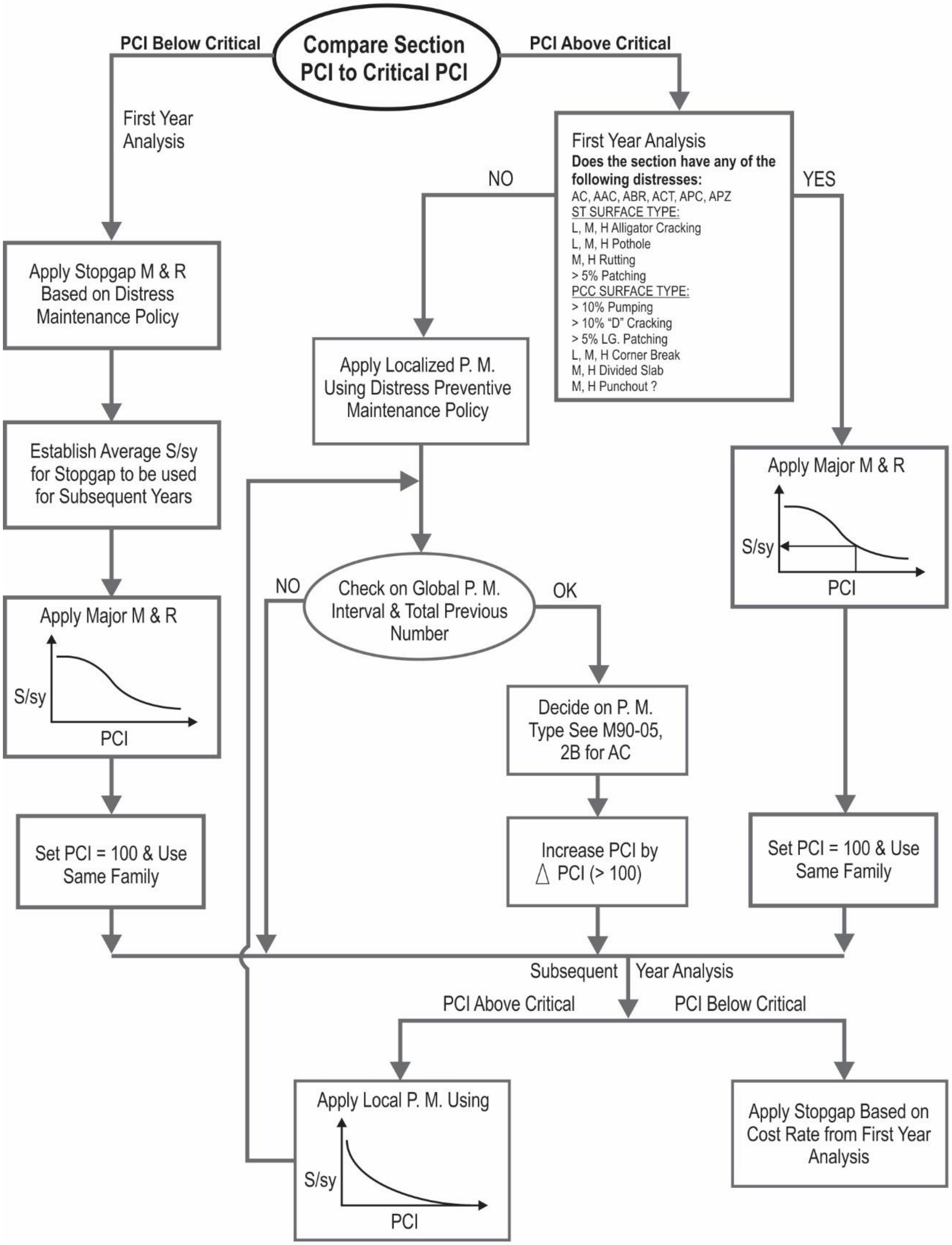
coefficients	ACRMU				
constant	100	100	100	100	100
linear	-3.528	-4.14	-4.434	-5.163	-3.441
quadratic	-0.178	0.277	0.142	0.648	0.024
cubic	0.041	-0.01	0.049	-0.064	0.005
quartic	-0.002		-0.008	0.003	-2E-04
quintic			4E-04	-4E-05	
			-6E-06		
critical PCI	55	60	50	50	50
outlier	90%	90%	99%	99%	99%
corr coeff	0.73	0.76	0.73	-0.04	0.82
Std of err	9.55	7.52	10.49	7.93	9.20
year	U 00	U 03	U 06	U 09	U 15

coefficients	ACRH							
constant	100	100	100	100	100	100	100	100
linear	-6.4	-6.48	-5.625	-4.643	-4.109	-5.257	-4.925	-5.4
quadratic	0.504	0.428	0.2865	0.1501	0.1076	0.3976	0.2887	0.309
cubic	-0.02	-0.01	-0.004	-1E-05	0.0015	-0.022	-0.011	-0.01
quartic	1E-04	6E-05	-2E-05	-5E-05	-7E-05	0.0007	0.0003	
quintic						-8E-06	-3E-06	
critical PCI				55	60	55	50	50
outlier				90%	90%	90%	90%	90%
corr coeff				0.74	0.81	0.82	-0.09	0.79
Std of err				9.74	8.49	8.92	6.76	10.16
year	91	94	97	00	03	06	09	15

coefficients	STAA					STRA					STPA		
constant	100	100	100	100	100	100	100	100	100	100	100	100	100
linear	-5.967	-3.011	-5.504	-3.962	-5.052	-4.184	-3.445	-6.82	-1.946	-6.204	-5.534	-5.16	-3.16
quadratic	0.234	-0.341	-0.069	-0.359	-0.035	-0.004	-0.382	0.4	-0.602	0.691	0.427	0.069	-0.133
cubic	0.042	0.039	0.0264	0.048	0.022	0.0266	0.0576	-0.01	0.056	-0.073	-0.048	0.011	0.017
quartic	-0.003	-0.001	-8E-04	-0.001	-6E-04	-0.001	-0.002		-0.001	0.0038	0.003	-4E-04	-4E-04
quintic										-7E-05	-6E-05		
critical PCI				50	55				50	55	50	55	55
outlier				90%	(90%)				95%	90%	90%	90%	90%
corr coeff				0.76	0.76				0.82	0.76	0.80	0.01	0.84
Std of err				12.78	10.60				10.26	10.25	10.31	8.85	9.54
year	A 91	A 94	A 97	A 00	A 03	A 91	A 94	A 97	A 00	A 03	A 06	A 09	A 15

coefficients	PCCA							
constant	100	100	100	100	100	100	100	100
linear	-4.674	-4.948	-4.34	-3.864	-4.182	-4.864	-4.374	-4.173
quadratic	0.179	0.2296	0.142	0.138	0.135	0.2038	0.094	0.122
cubic	-0.003	-0.004	-0.002	-0.002	-0.001	-0.005	0.003	-0.001
quartic	1E-05	3E-05				9E-05	-2E-04	
quintic						-7E-07	4E-06	
critical PCI				60	55	50	45	45
outlier				90%	80%	90%	90%	90%
corr coeff				0.86	0.86	0.77	-0.29	0.88
Std of err				9.58	9.83	12.78	9.86	11.33
year	91	94	97	00	03	06	09	15

FIGURE A.2
PAVER 3.21 "LIMIT TO BUDGET" FLOW DIAGRAM



Adapted from *Pavement Management: The PAVER System,* by M.Y. Shahin, September 1989, p 5-71 and *USACERL Technical Report M-90/05*, July 1990, Paver Update, *Pavement Maintenance Management for Roads and Streets Using the PAVER System*, by M.Y. Shahin & J.A. Walther, p 69.

APPENDIX B

PRIMER

PAVEMENT DISTRESSES – DESCRIPTIONS, CAUSES, CLASSIFICATION, & REPAIR

The following pavement distresses commonly found on Montana's airport pavements are included in this "primer":

Asphalt (AC) Pavement Distresses:
Alligator Cracking
Bleeding
Block Cracking
Depression
Joint Reflection Cracking from PCC
Longitudinal & Transverse Cracking (Filled)
Longitudinal & Transverse Cracking (Non-Filled)
"Oil" Spillage
Patching
Raveling
Rutting
Shoving from PCC
Swell
Weathering

Concrete (PCC) Pavement Distresses:
Corner Break
Cracks: Longitudinal, Transverse, & Diagonal
Joint Seal Damage
Scaling, Map Cracking, and Crazing
Settlement or Fault
Shattered Slab
Spalling (Corner)
Spalling (Joints)

Technical material in this section is based on the following sources:

Pavement Maintenance Management for Roads and Streets Using The PAVER System, US Army Construction Engineering Research Laboratory, Technical Report M-90/05, July 1990, M.Y. Shahin and J.A. Walther.

Pavement Management for Airports, Roads and Parking Lots, M.Y. Shahin, 1994, Chapman and Hall.

Guidelines and Procedures for Maintenance of Airport Pavements
FAA AC 150/5380-6, 1982.

All photos are taken by employees of Robert Peccia & Associates.

Development of the pavement condition index (PCI) and the "PAVER" system is conducted by the US Army Construction Engineering Research Laboratory with support from: American Public Works Association, Federal Aviation Administration, Federal Highway Administration, US Air Force Engineering and Services Center, US Army Corps of Engineers, and US Navy.

Pavement Maintenance Management Systems like PAVER® have been developed to:

- ❖ Assess overall pavement condition based on accumulated pavement distress.
- ❖ Set standard repair practices for common pavement distresses.
- ❖ Determine maintenance and rehabilitation needs and priorities.
    - Project life-cycle costs of repair and replacement options.
    - Decide when replacement is more economical than continued repair.
    - Optimize timing of repairs to preserve the infrastructure investment.
- ❖ Optimize pavement performance with available funds.
- ❖ Project future pavement conditions and maintenance requirements.

Alligator Cracking

AC

Description: A series of interconnecting cracks caused by fatigue failure on the asphalt concrete surface under repeated traffic loading.

Causes: Loads in excess of the current pavement strength. Heavy aircraft, snow plows, fuel trucks, delivery trucks. Substandard installation or degradation of subgrade, subbase, and/or base course.

Light

Fine parallel hairline cracks with few or no interconnecting cracks. No spalling.
Repair: Do nothing / Surface seal / Overlay

Medium

Pattern or network of cracks that may be lightly spalled.
Repair: Partial or full depth patch / Overlay / Reconstruct

High

Pattern or network of cracks with well defined pieces and spalled edges.
Repair: Partial or full depth patch / Overlay / Reconstruct

Bleeding

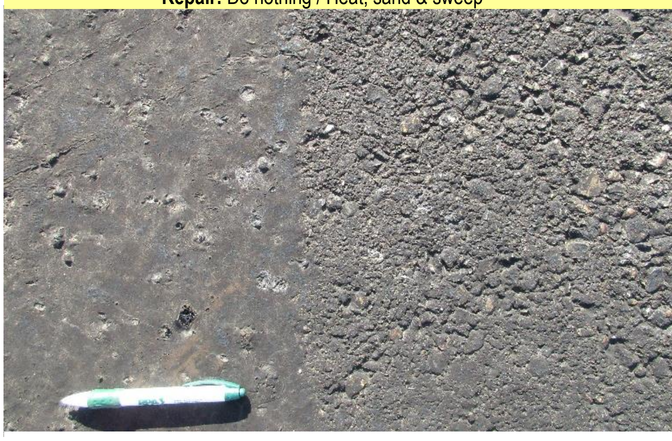
AC

Description: A film of bituminous material on the pavement surface that usually becomes sticky when hot and can cause hydroplaning when wet.

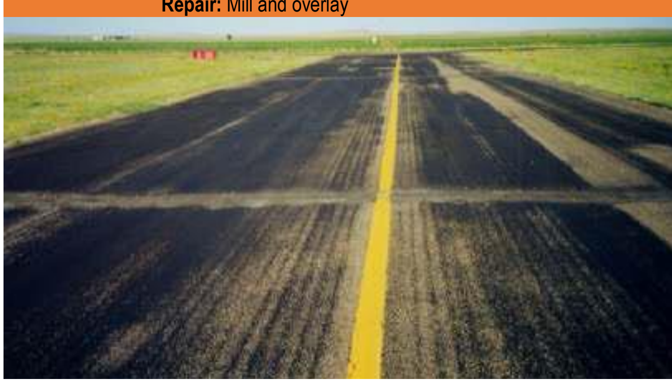
Causes: Excessive amounts of asphalt cement or tars in the mix and/or low air void content.

Yes/No

Extensive enough to cause reduced skid resistance.
Repair: Do nothing / Heat, sand & sweep



Severe global bleeding excessive enough to cause traction safety issues.
Repair: Mill and overlay



Block Cracking

AC

Description: 1 x 1 foot to 10 x 10 feet interconnected cracks that divide the pavement into approximately rectangular pieces.

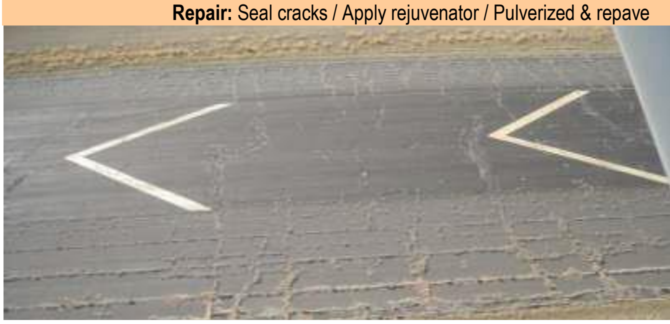
Causes: Shrinkage of the asphalt concrete and daily temperature cycling coupled with significant asphalt hardening.

Light

Non- or only lightly spalled blocks with no foreign object debris (FOD) potential. Nonfilled cracks have ¼ inch or less mean width and filled cracks have filler in satisfactory condition.
Repair: Do nothing / Apply rejuvenator

Medium

Filled or nonfilled cracks that are moderately spalled. Nonfilled cracks with mean width greater than approximately ¼ inch. Filled medium cracks with failed sealant.
Repair: Seal cracks / Apply rejuvenator / Pulverized & repave



High

Severely spalled cracks with a definite FOD potential.
Repair: Seal Cracks / Recycle surface / Pulverize and repave

Depression

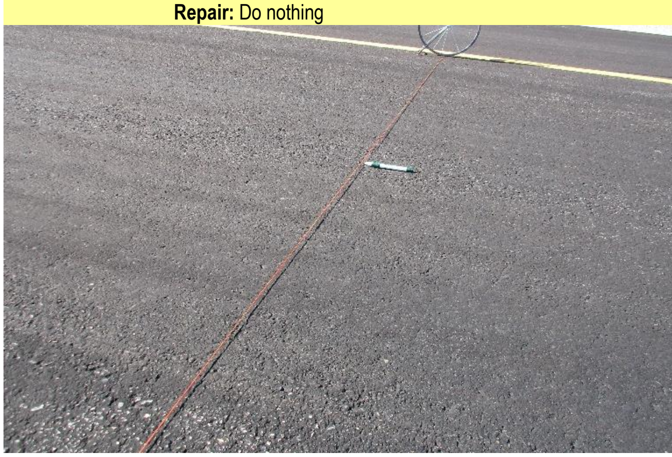
AC

Description: Localized pavement surface areas having elevations slightly lower than those of the surrounding pavement, “birdbath” areas; could cause hydroplaning & accelerate pavement decay.

Causes: settlement of the foundation soil or improper construction

Light

Mean depth: Runways and High-speed Taxiways: ⅛ to ½ inch,
Taxiways and Aprons: ½ – 1 inch.
Repair: Do nothing



Medium

Mean depth: Runways and High-speed Taxiways: ½ - 1 inch,
Taxiways and Aprons: 1 - 2 inches.
Repair: Partial or full depth patch

High

Mean depth: Runways and High-speed Taxiways: > 1 inch,
Taxiways and Aprons: > 2 inches.
Repair: Partial or full depth patch

AC

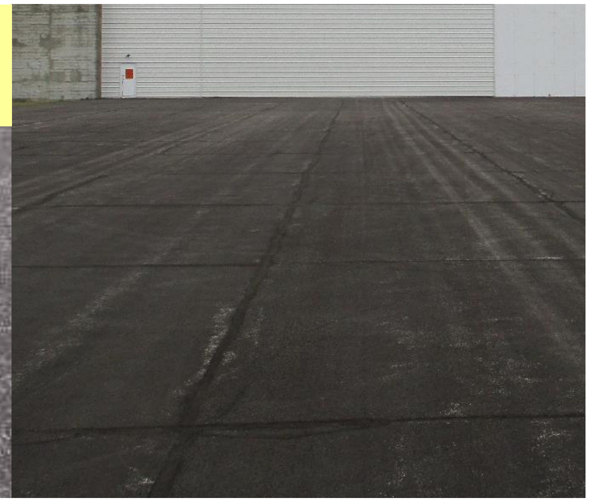
Joint Reflection Cracking From PCC

Description: Cracks translated upward through an asphalt surface overlaid a Portland cement concrete (PCC) slab at the slab joints.

Causes: Loads in excess of the current pavement strength. Heavy aircraft, snow plows, fuel trucks, delivery trucks. Substandard installation or degradation of subgrade, subbase, and/or base course.

Light

Filled or nonfilled cracks have light or no spalling, nonfilled cracks have a mean width of ¼ inch or less. Filled cracks are of are of any width but with filler material in satisfactory condition.
Repair: Do nothing / Seal cracks over ⅛ inch



Medium

Filled or nonfilled cracks are moderately spalled. Filled cracks are not spalled or are only lightly spalled but with failed filler. Nonfilled cracks have mean crack width greater than ¼ inch with light or no spalling.
Repair: Partial depth patch / Seal cracks

High

Cracks are severly spalled (definate FOD potential).
Repair: Mill and repave

Longitudinal & Transverse Cracking (Non-Filled)

AC

Description: Asphalt pavement cracking along or across the laydown direction.

Causes: Poorly constructed paving lane joint, shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or a reflective crack caused by cracks beneath the surface course.

Light

Nonfilled cracks have a mean width of ¼ inch or less, cracks have no or minor spalling (little or no FOD potential).
Repair: Do nothing / Seal cracks over ⅛ inch / Surface seal

Medium

Nonfilled cracks have mean crack width greater than ¼ inch possibly with light spalling. Cracks are moderately spalled (some FOD potential).
Repair: Seal cracks

High

Cracks are severly spalled, causing definite FOD potential. They're usually greater than 1 inch wide.
Repair: Seal cracks / Partial depth patch

Longitudinal & Transverse Cracking (Filled)

AC

Description: Asphalt pavement cracking along or across the laydown direction.

Causes: Poorly constructed paving lane joint, shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or a reflective crack caused by cracks beneath the surface course.

Light

Filled cracks are of any width but their filler material is in satisfactory condition. Cracks have no or minor spalling (little or no FOD potential).
Repair: Do nothing / Seal cracks over ⅛ inch / Surface seal

Medium

Filled cracks are moderately spalled (some FOD potential). Filled cracks have failed sealant with possible light spalling.
Repair: Seal cracks

High

Cracks are severly spalled, causing definite FOD potential. They're usually greater than 1 inch wide.
Repair: Seal cracks / Partial depth patch

"Oil" Spillage

AC

Description: Deterioration or softening of the pavement surface caused by the spilling of oil, fuel, or other solvents.

Causes: Spills, leaks, accidents, etc.

Yes/No Spillage exists.
Repair: Do nothing / Partial or full depth patch

AC

Patching

Description: An interruption in the continuous pavement mat, which reduces mat strength and may provide a path for moisture intrusion or adversely affect ride quality. A patch is considered a defect, no matter how well it is performing.

Causes: Tiedown anchors, pavement cores, utility cuts, and other pavement removal and replacement.

Light

Patch is in good condition and performing satisfactorily.
Repair: Do nothing

Medium

Patch and/or patch joint has deteriorated and/or affects riding quality.
Repair: Seal cracks / Repair distress in patch / Replace patch

High

Patch and/or patch joint has badly deterirated resulting in high FOD potential and poor ride quality.
Repair: Replace patch

Raveling

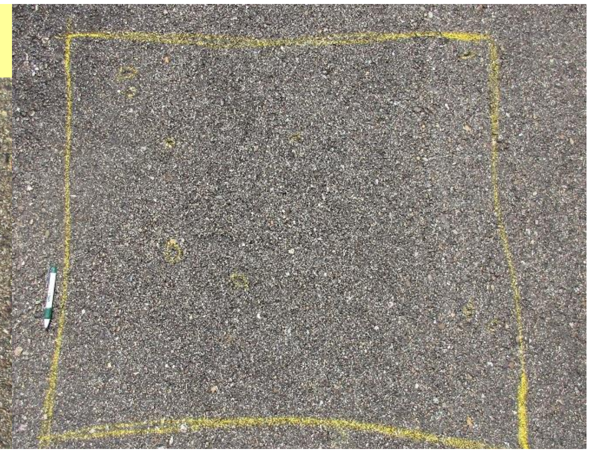
AC

Description: The dislodging of coarse aggregate particles from the pavement surface.

Causes: Asphalt oil not binding well to the aggregate, and/or physically tearing aggregate out of the surface.

Light

In a square yard, the number of aggregate particles missing is between 5 and 20. There is little to no FOD potential.
Repair: Do nothing

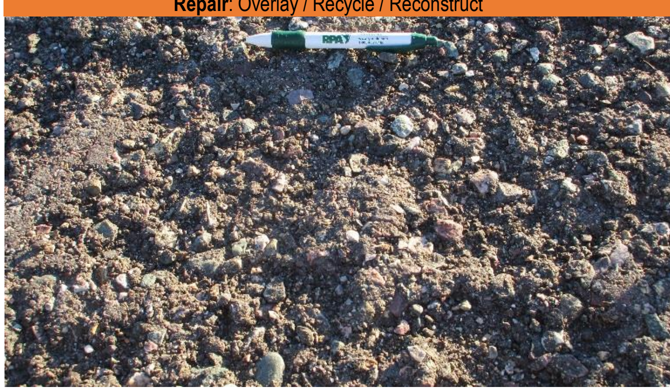


Medium

In a square yard, the number of aggregate particles missing is between 21 and 40. There is some FOD potential.
Repair: Surface seal

High

In a square yard, the number of aggregate particles missing is over 40. There is significant FOD potential.
Repair: Overlay / Recycle / Reconstruct



Rutting

AC

Description: A surface depression in the wheel path indicating structural failure of the pavement. Pavement uplift may occur along the sides of the rut.

Causes: Traffic loads exceeding the pavement section's strength, resulting in a permanent consolidation or lateral movement of the pavement layers or subgrade. A heavily loaded plow on wet spring subgrades may be the most common cause of rutting.

Light

¼ - ½ inch mean depth.
Repair: Do nothing

Medium

Medium > ½ inch ≤ 1 inch mean depth.
Repair: Partial or full depth patch / Patch and overlay

High

High > 1 inch mean depth.
Repair: Partial or full depth patch / Patch and overlay

Shoving From PCC

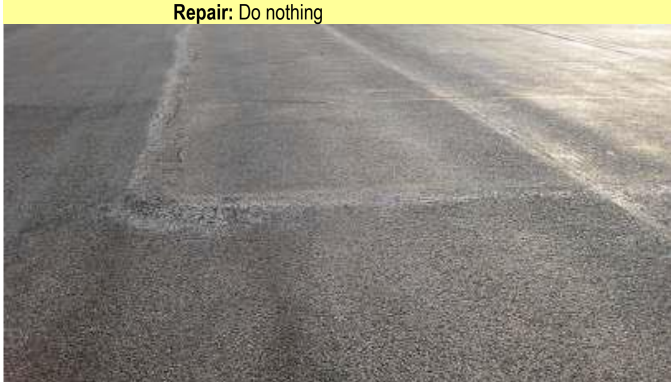
AC

Description: A swelling and cracking of asphalt pavements where they adjoin concrete slabs.

Causes: Concrete pavements grow in size as the joints between slabs fill with debris. The increasing size of the slabs shoves and deforms adjacent asphalt pavements.

Light

A slight amount of shoving has occurred with little effect on ride quality and no asphalt break-up.
Repair: Do nothing



Medium

A significant amount of shoving has occurred causing moderate roughness and little or no asphalt break up.
Repair: Surface grind / Partial depth patch / Full depth patch

High

A large amount of shoving has occurred causing severe roughness or break-up of the asphalt pavement.
Repair: Surface grind / Partial depth patch / Full depth patch

Swell

AC

Description: An upward bulge in the pavements surface, sharply over a small area, or as a longer, gradual "wave" possibly accompanied by surface cracking.

Causes: Frost action in the subgrade or construction errors.

Light

< ¾ inch height differential.
Repair: Do nothing

Medium

¾ - 1 ½ inches height differential.
Repair: Reconstruct / Patch / Surface grind

High

> 1 ½ inch height differential.
Repair: Reconstruct / Patch / Surface grind

AC

Weathering

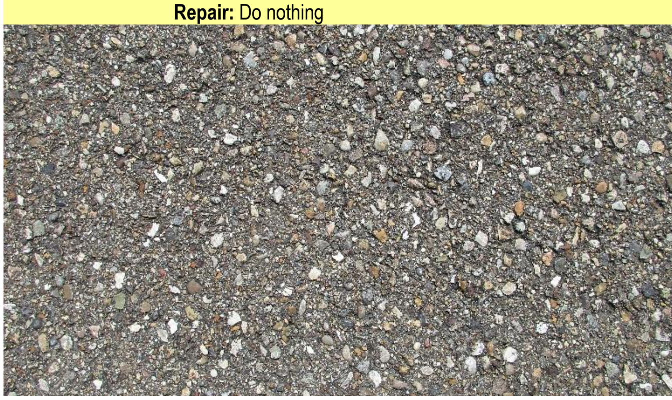
Description: Wearing away of the asphalt binder and fine aggregate matrix from the pavement surface.

Causes: Aging, or ultraviolet exposure that oxidizes & hardens the asphalt binder.

Light

Beginning to show signs of aging, loss of fine aggregate matrix is noticeable and loss of color.

Repair: Do nothing



Medium

Loss of fine aggregate matrix is noticeable and edges of coarse aggregate are exposed up to ¼ width (of the longest side) of the coarse aggregate.

Repair: Surface seal

High

Edges of coarse aggregate have been exposed greater than ¼ width (of the longest side) of the coarse aggregate and considerable loss of the fine aggregate matrix.

Repair: Overlay / Recycle / Reconstruct

Corner Break

PCC

Description: A crack that intersects the joints at a distance less than or equal to one-half the slab length on both sides, measured from the corner of the slab. The crack extends vertically through the entire slab thickness.

Causes: Load repetition combined with loss of support and curling stresses.

Light

Crack has either no spalling or minor spalling (no FOD potential) with a mean width less than approximately ⅛ inch.
Repair: Do nothing / Seal cracks / Undersealing project

Medium

A nonfilled crack has a mean width between ⅛ and 1 inch, moderately spalled, failed filler.
Repair: Seal cracks / Full depth patch / Slab replacement / Undersealing project

High

A nonfilled crack has a mean width greater than 1 inch, severely spalled.
Repair: Seal cracks / Full depth patch / Slab replacement / Undersealing project

PCC

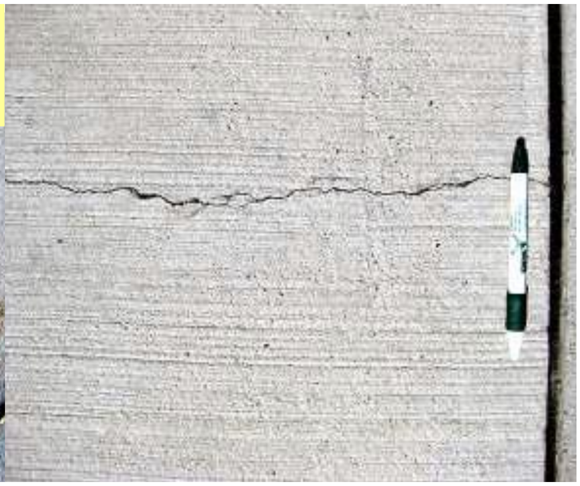
Cracks: Longitudinal, Transverse, & Diagonal

Description: Cracks that divide the slab into two or three pieces.

Causes: Load repetition, curling stresses and shrinkage stress.

Light

Crack has either no spalling or minor spalling (no FOD potential) with a mean width less than approximately ⅛ inch. Filler in unsatisfactory condition or slab is divided into three pieces by low severity cracks.
Repair: Do nothing / Seal cracks



Medium

Moderately spalled, a nonfilled crack has a mean width between ⅛ inch and 1 inch. Filler in unsatisfactory condition or slab is divided into three pieces by two or more cracks, one of which is at least medium severity.
Repair: Seal cracks

High

Severely spalled and a nonfilled crack has a mean width approximately greater than 1 inch.
Repair: Seal cracks / Full depth patch / Slab replacement / Undersealing project

Joint Seal Damage

PCC

Description: Any condition that allows significant infiltration of water or enables soil or rocks to accumulate in the joints preventing the slabs from expanding (may result in slab buckling, shattering, or spalling). Sealant hardens and cracks, loses edge bond, doesn’t fill the joint, or has weed penetration.

Causes: Reduced pliability from weathering, or poor construction practices. .

Light

Sealant is performing well with minor, if any, damage.
Repair: Do nothing

Medium

Joints sealer is in generally fair condition with some moderate damage.
Repair: Sealant needs replacement within 2 years

High

Joint sealer is in generally poor condition or lacking over the entire surveyed section.
Repair: Sealant needs immediate replacement or application

Popouts

PCC

Description: A small inverted cone of concrete that breaks loose from the surface ranging from 1 to 4 inches in diameter and ½ to 2 inches deep.

Causes: Freeze thaw action and/or expansive aggregate.

Yes/ No Average density should exceed over 3 per square yard over the entire slab.
Repair: Do nothing / Replace slab

PCC

Scaling

Description: A network of shallow, fine, or hairline cracks tending to intersect at angles of 120 degrees, which extend only through the upper surface of the concrete. May lead to "scaling" of the surface (the breakdown of the slab's top approximate ¼" – ½").

Causes: Reduced pliability from weathering, or poor construction practices.

Light

Crazing or map cracking exists over most of the slab area; the surface is in good condition with no scaling.
Repair: Do nothing

Medium

Slab is scaled over approximately 5 percent or less of the surface causing some FOD potential.
Repair: Partial depth patch / Slab replacement

High

Slab is severely scaled causing a high FOD potential. Usually more than 5 percent of the surface is affected.
Repair: Slab replacement

Settlement

PCC

Description: A difference of elevation at a joint or crack.

Causes: Water intrusion into expansive subgrades, base course leach-out and consolidation or contamination, and/or poor construction practices.

Light

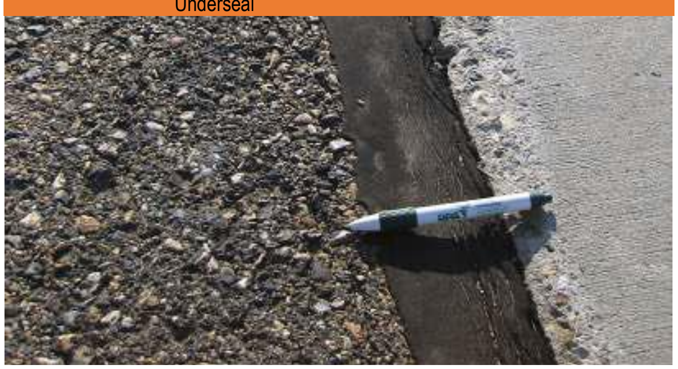
Edge elevation difference: Runways and Taxiways: ¼ inch, Aprons ⅛ - ½ inch.
Repair: Do nothing / Joint seal / Injection-fill under slab / Underseal

Medium

Edge Elevation Difference: Runways and Taxiways: ¼ - ½ inch, Aprons: ½ - 1 inch.
Repair: Slab grinding / Joint seal / Injection-fill under slab / Underseal

High

Edge Elevation Difference: Runways and Taxiways: > ½ inch Aprons: > 1 inch.
Repair: Slab grinding / Joint seal / Injection-fill under slab / Underseal



Shattered Slab

PCC

Description: The slab is broken into four or more pieces, not all contained in a corner break

Causes: Overloading or inadequate support of the slab.

Light

The slab is broken into 4 or 5 pieces with over 85% of the cracks of low severity.
Repair: Seal cracks

Medium

The slab is broken into 4 or 5 pieces with over 15% of the cracks of medium severity or the slab is broken into 6 or more pieces with over 85% of the cracks of low severity.
Repair: Seal cracks / Full depth patch / Slab replacement

High

The slab is broken into 4 or 5 pieces with some or all of the cracks of high severity or the slab is broken into 6 or more pieces with over 15% of the cracks of medium or high severity.
Repair: Slab replacement

Spalling (Corner)

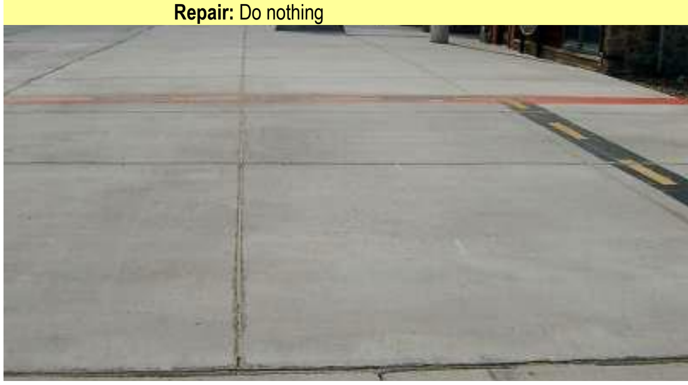
PCC

Description: The raveling or breakdown of the slab within approximately 2 feet of the corner. Spalls angle downward to intersect the joint, not vertically through the slab.

Causes: Infiltration on incompressible materials, excessive traffic loads, or weak (overworked) concrete at the joint.

Light

Corner edges are lightly frayed with few pieces (little or no FOD potential).
Repair: Do nothing



Medium

Moderately frayed edge, fractured pieces may be loose or absent (some FOD or tire damage potential).
Repair: Partial depth patch

High

Severely frayed, high severity cracks, fractured pieces absent (high FOD or tire damage potential).
Repair: Partial depth patch

PCC

Spalling (Joint)

Description: The raveling or breakdown of the slab within approximately 2 feet of the edge. A joint spall usually does not extend vertically through the slab, but intersects the joint at an angle.

Causes: Infiltration of incompressible materials, excessive traffic loads, or weak (overworked) concrete at the joint.

Light

Joint is lightly frayed with few pieces (little or no FOD potential).
Repair: Do nothing

Medium

Moderately frayed edge, fractured pieces may be loose or absent (some FOD or tire damage potential).
Repair: Partial depth patch

High

Severely frayed, high severity cracks, fractured pieces absent (high FOD or tire damage potential).
Repair: Partial depth patch