Pavement Management for Local Agencies

How to Justify M&R Budgets?

Northwest Conference

Seattle, WA

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Pavement Management in the “Good Old Days”

(Ref LA)

- Routine Maintenance Cycles.
- Prioritize On A “Worst First” Basis.
- Citizen Complaint.
- Political Priority.
- Recommendation From The “Old Superintendent”.

However, today things have changed…

Pavement Management

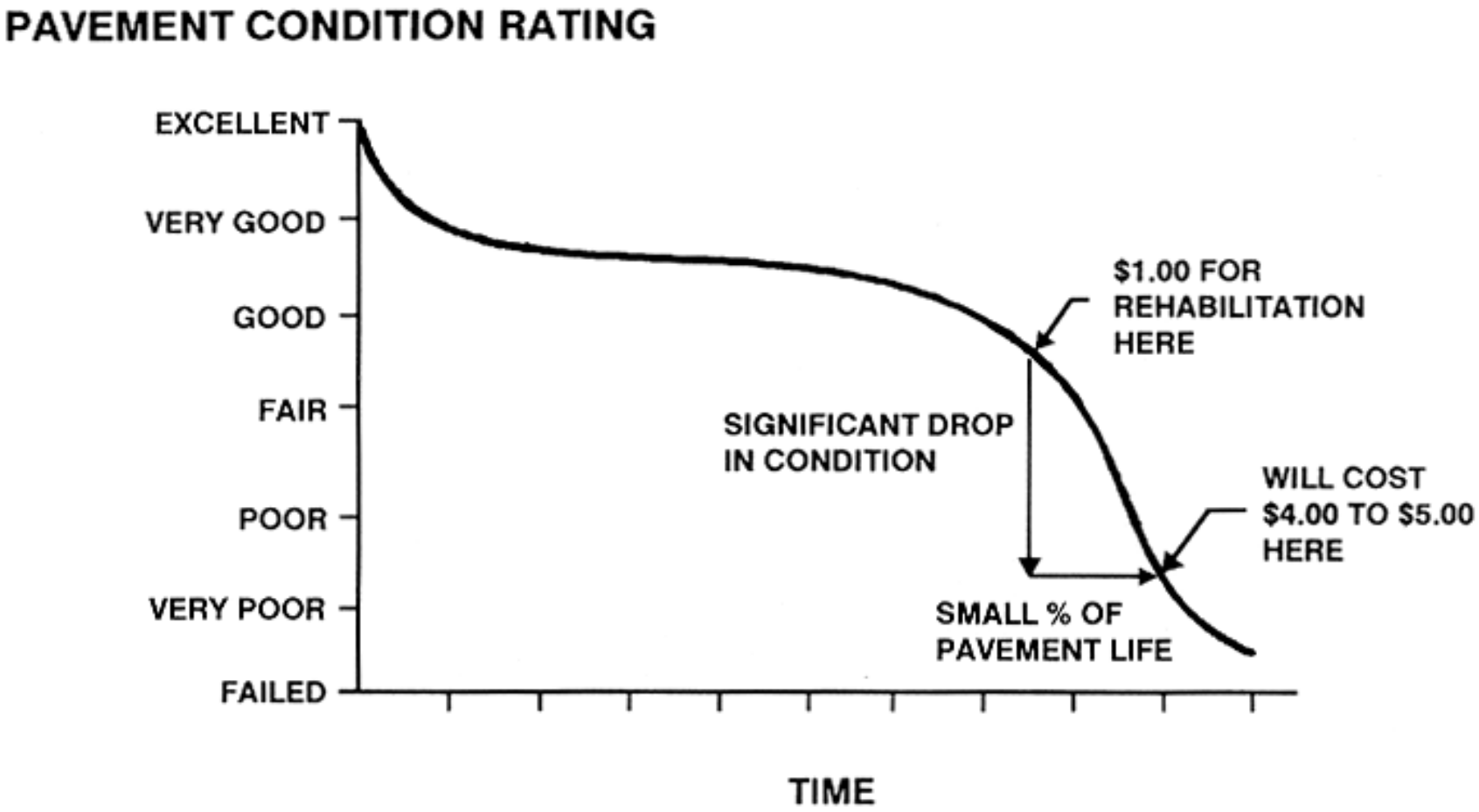
- **Network-Level**:

  A systematic approach to inventory the pavement network, analyze pavement performance, ensure optimum return on investment, meet mission requirements, and identify M&R requirements.

- **Project-Level**:

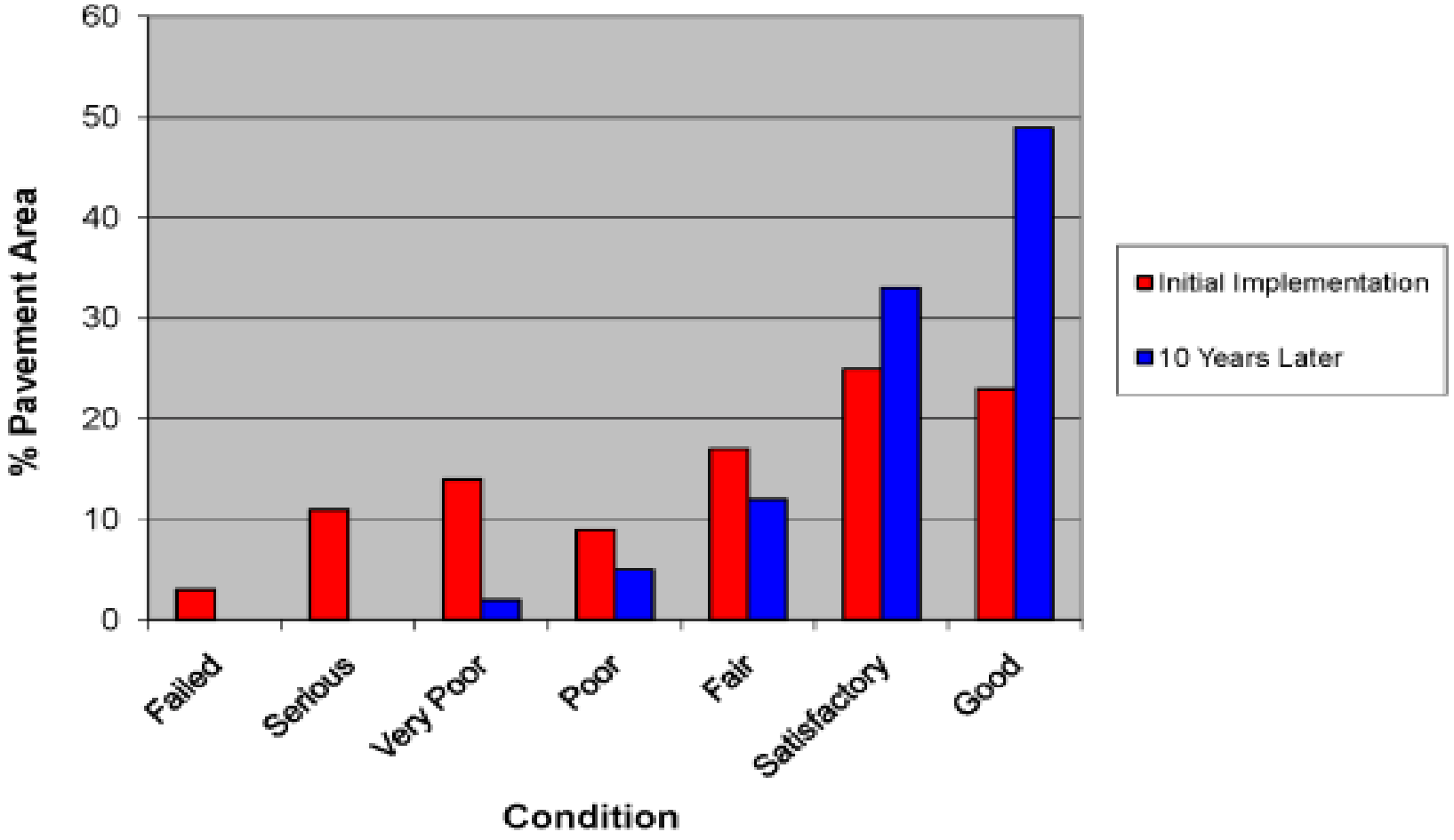
  Detailed project definition that may include in-depth pavement evaluation (often structural). It includes the selection and design of specific M&R type(s), such as overlay or surface reconstruction.

Why Use Pavement Management?



Pavements need to be managed, not simply maintained.

Benefits of Pavement Management?



Pavement Management Components

- Inventory Definition
- Condition Assessment
- Condition Prediction
- Performance Analysis
- Annual M&R Category Assignment for each Section
- Project Formulation using M&R Types
- Risk Analysis

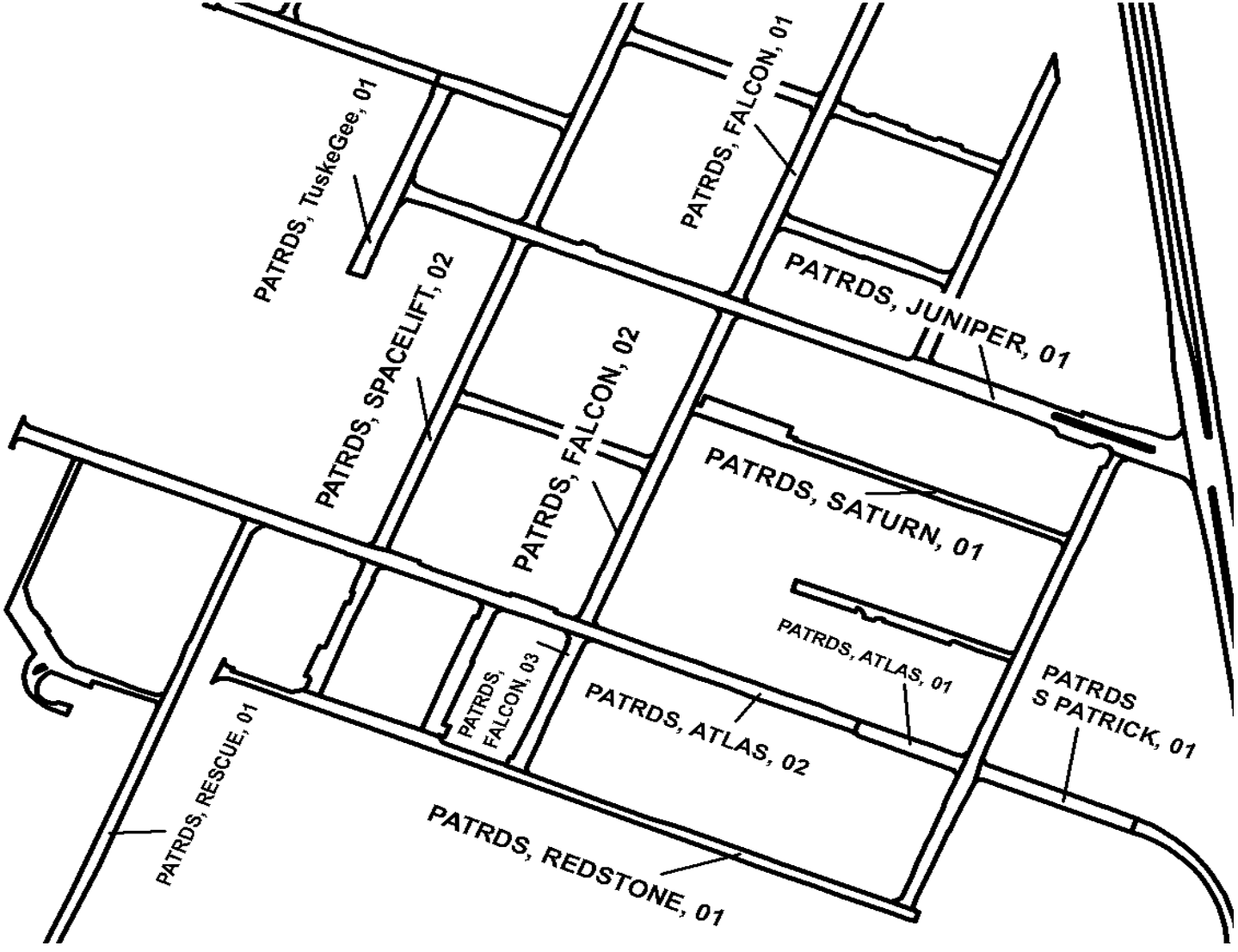
Network Definition

- **Network**: A logical grouping of pavements that will usually be managed together.

- **Branch**: A readily identifiable part of the pavement network that has a distinct use.

- **Section**: The smallest management unit when considering the application of Major M&R.

Example Road Network Definition



Inventory

1::43RDPL::6523000
1::SNTNDRWSPL::4681600
1::VERNONAV::5671500
1::WERNAV::5895400
1::HOBARTBL::2623200
1::VERNONAV::5671300
1::HARVARDBL::2472200
1::LASALLEAV::3035800
1::VERNONAV::5671100
1::DENKERAV::1554100
1::45THST::6531700
1::45THST::6531600
1::45THST::6531500
1::45THST::6531400
1::46THST::6534500
PCI = 67
1::SNTNDRWSPL::4681800
1::46THST::6534600
1::46THST::6534400
1::46THST::6534300
1::WERNAV::5895600
1::HARVARDBL::2472500
1::47THST::6539000
1::47THST::6538900
1::47THST::6538800
1::47THST::6538700

GIS Network Definition

GIS Attribute Table

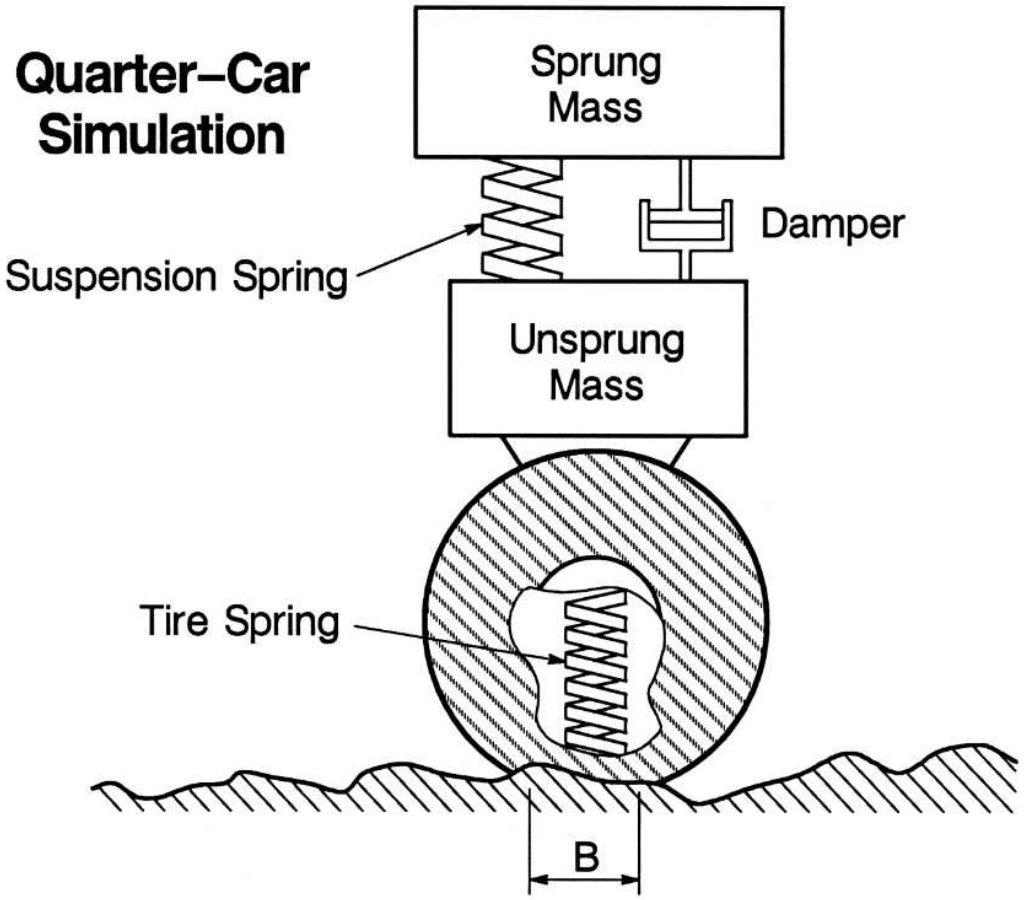
FID	Shape *	OBJECTID	NETWORKID	BRANCHID	SECTIONID	FROM_	TO	LENGTH	WIDTH	RANK	SURFACE	STRUEAREA
0	Polygon ZM	63	JBLMH	REDWOOD	01	BIRCH ST	FIR ST	1435	22	T	AC	39325.11069
1	Polygon ZM	53	JBLMH	N12TH	04	VIEW DR	N 9TH RD	937	17	T	AC	20521.78956
2	Polygon ZM	58	JBLMH	EAGLE	01	BLAINE AV	EAGLE CIR	2138	25	T	AC	57034.60084
3	Polygon ZM	60	JBLMM	SI	01	JACKSON AV	PERRY AV	2942	51	P	AC	207258.06428
4	Polygon ZM	40	JBLMH	N5TH	01	CRARY AV	IDAHO AV	927	30	S	AC	34175.33447
5	Polygon ZM	0	JBLMN	DUPONT	01	END	DUPONT	3680	38	P	AC	161903.19529
6	Polygon ZM	67	JBLMN	NORTHGATE	01	EAST DR	END	8376	23	P	AC	206419.96804
7	Polygon ZM	67	JBLMN	NCOBEACH	01	SAN FRANCISCO AV	END	5286	48	S	AC	211472.61012
8	Polygon ZM	67	JBLMN	EAST	03	DUPONT-STEILACOOM	NORTH GATE RD	2295	43	P	AC	80952.65707
9	Polygon ZM	67	JBLMN	20TH	01	DUPONT-STEILACOOM	32ND DIVISION DR	1912	20	S	AC	40930.113

Condition Assessment

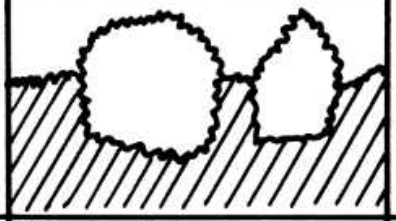
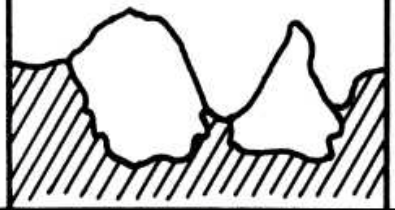
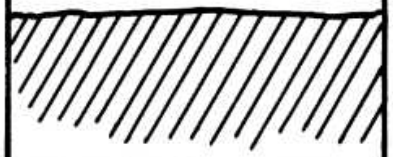
Condition Indicators:

- **Roughness**
- **Skid**
- **Structural**
- **Distress**

Roughness Evaluation, IRI

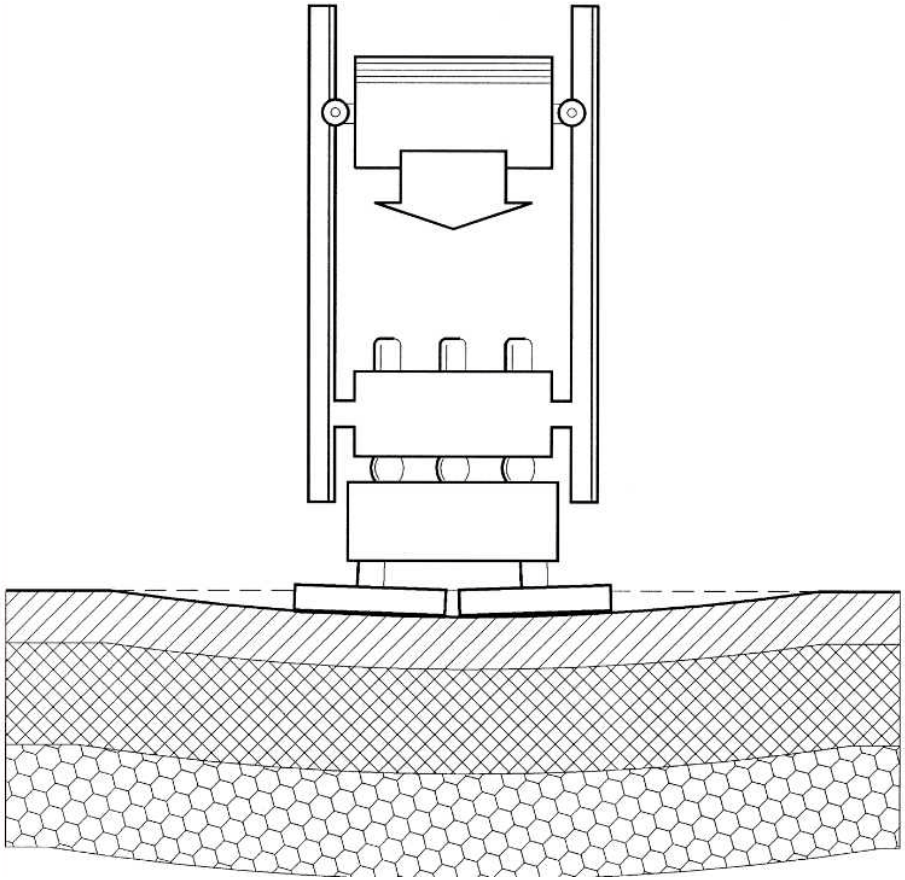


Skid Resistance

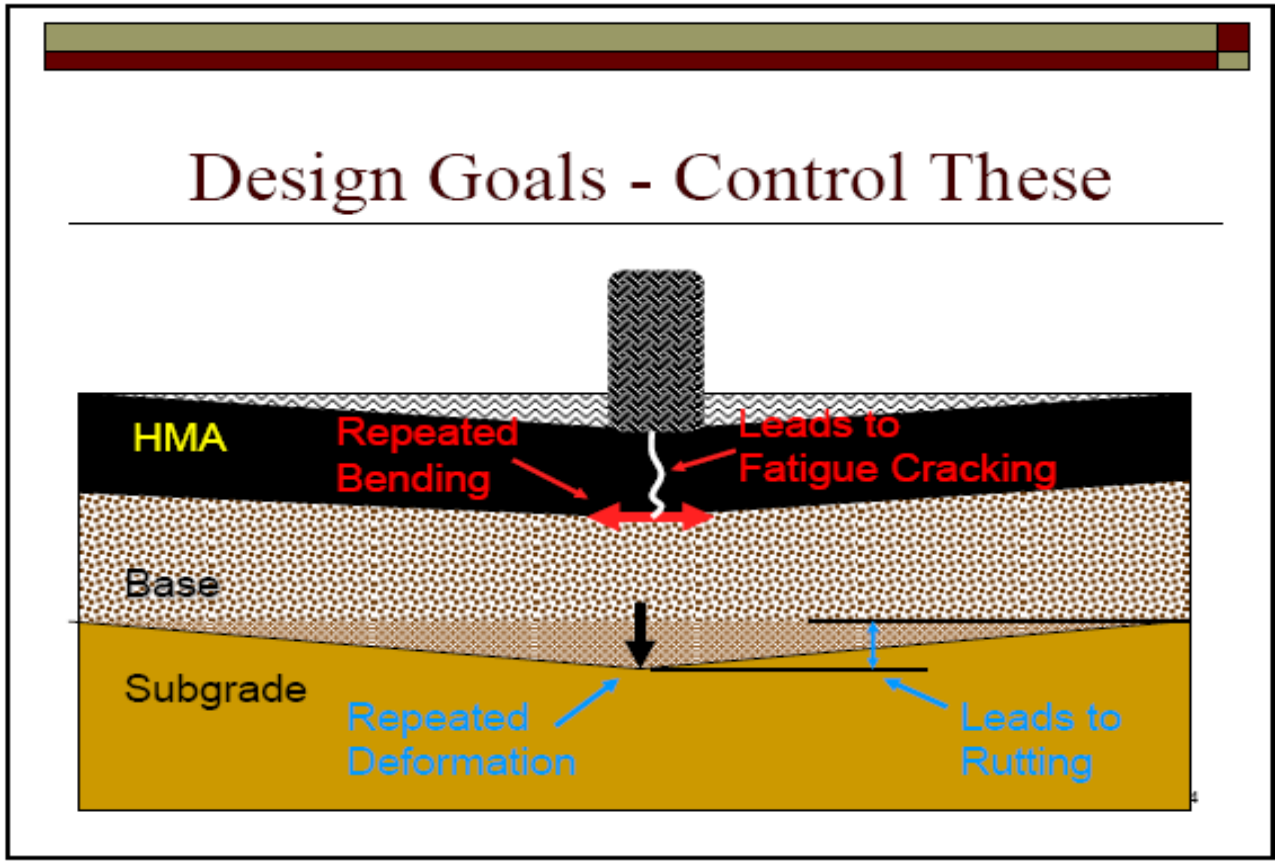
SURFACE		Scale of Texture	
		Macro (Large)	Micro (Fine)
A		Rough	Harsh
B		Rough	Polished
C		Smooth	Harsh
D		Smooth	Polished

City Falling Weight Deflectometer (FWD)

Structural Evaluation

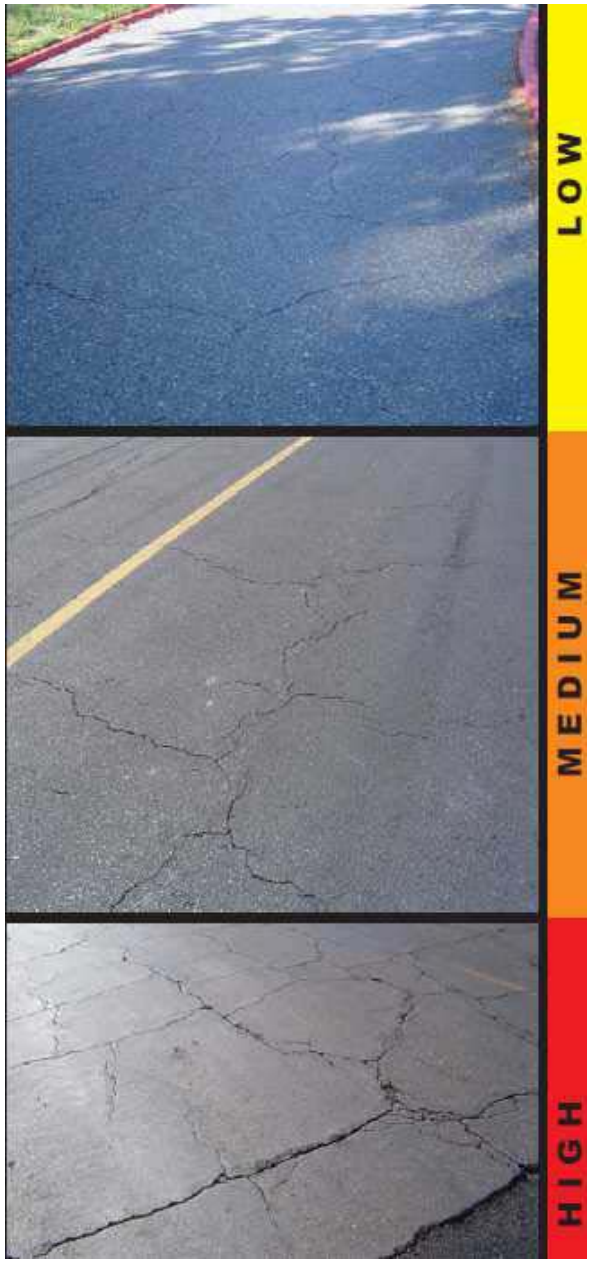


Cause of Pavement Fatigue

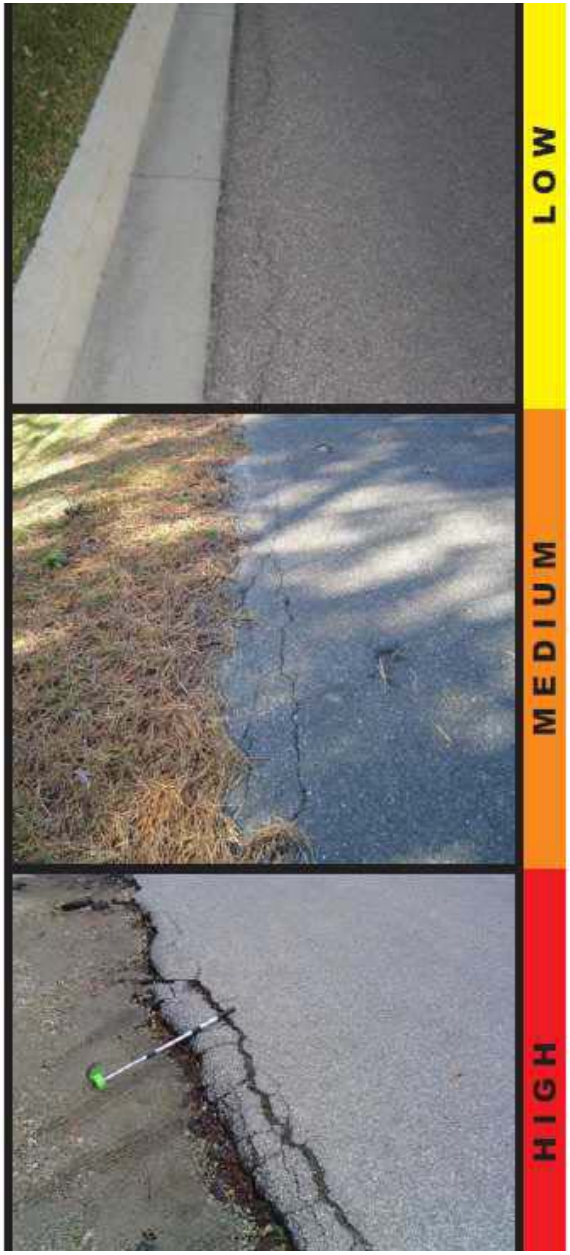


Alligator Cracking

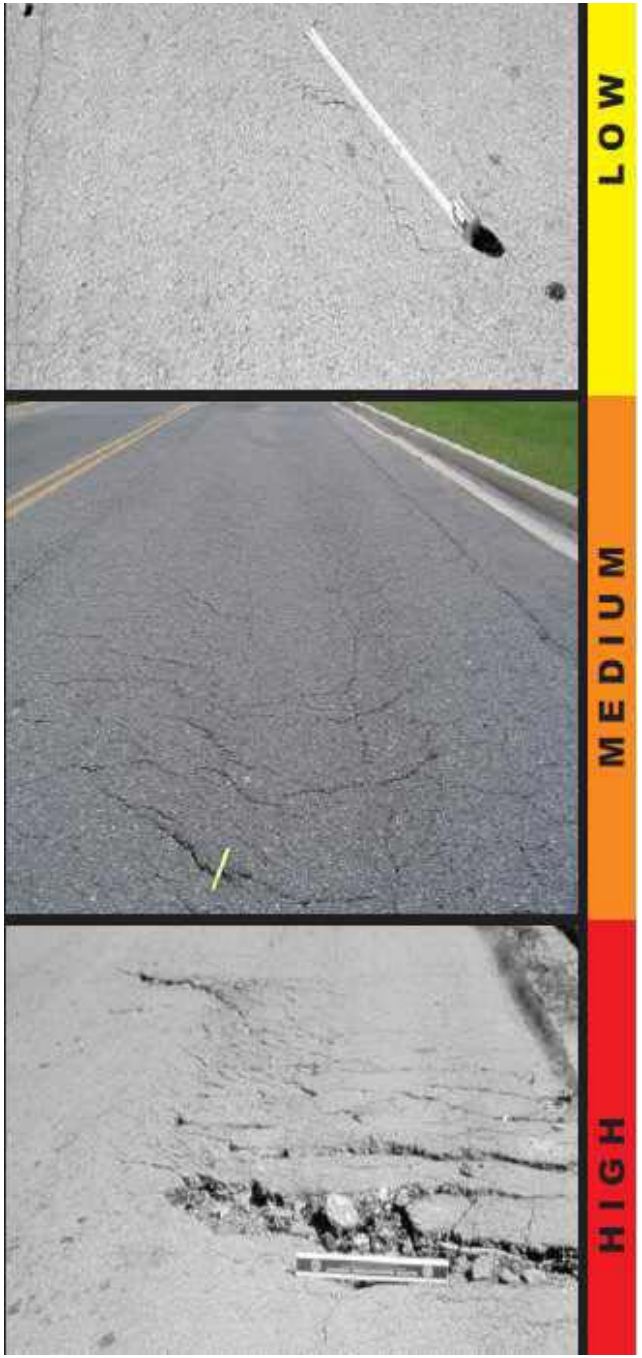
Block Cracking



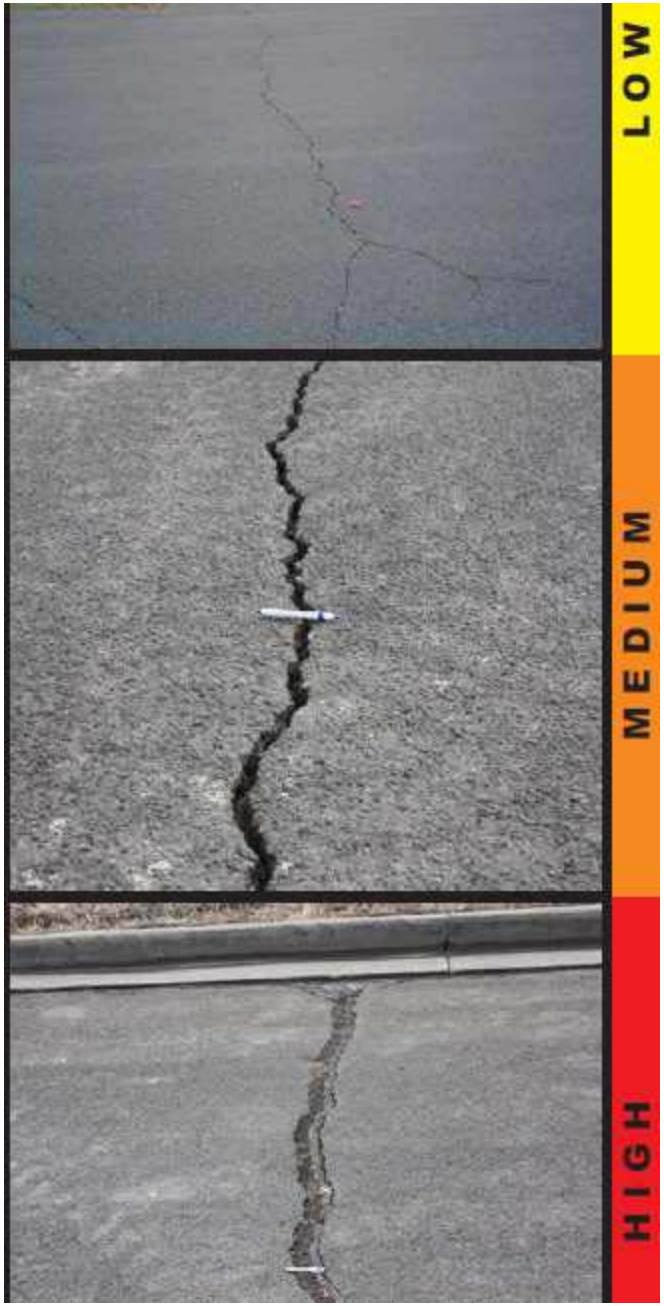
Edge Cracking



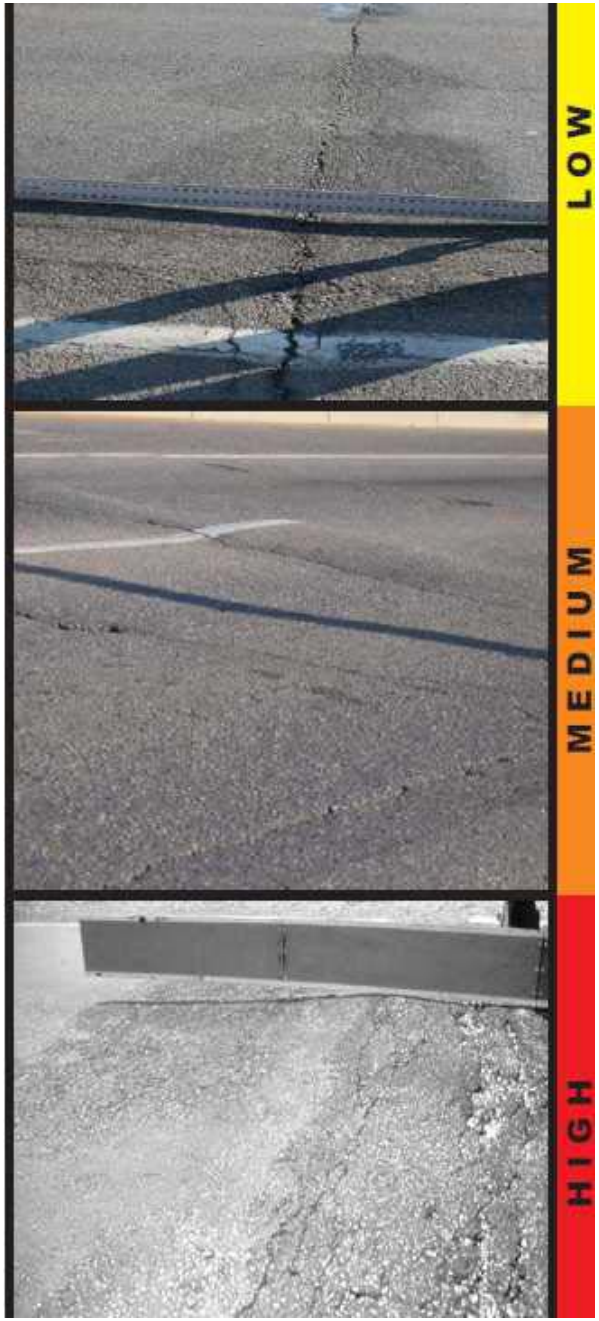
Slippage Cracking



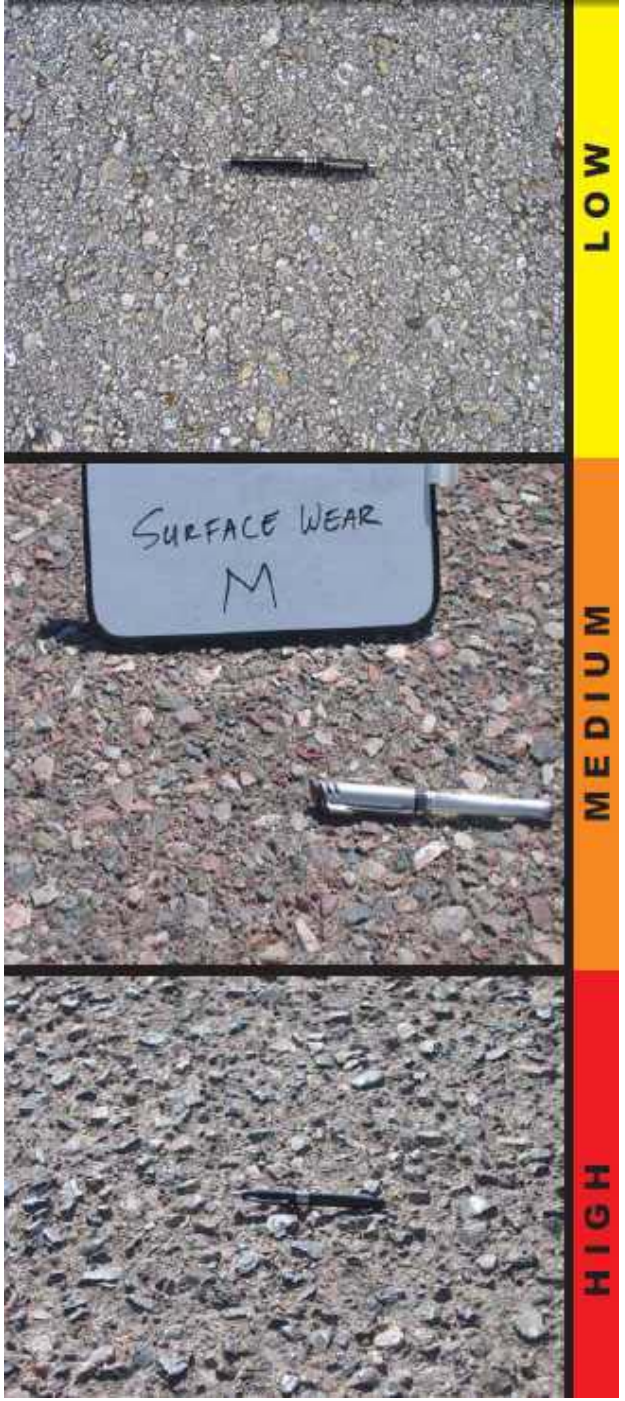
Linear Cracking



Bumps and Sags

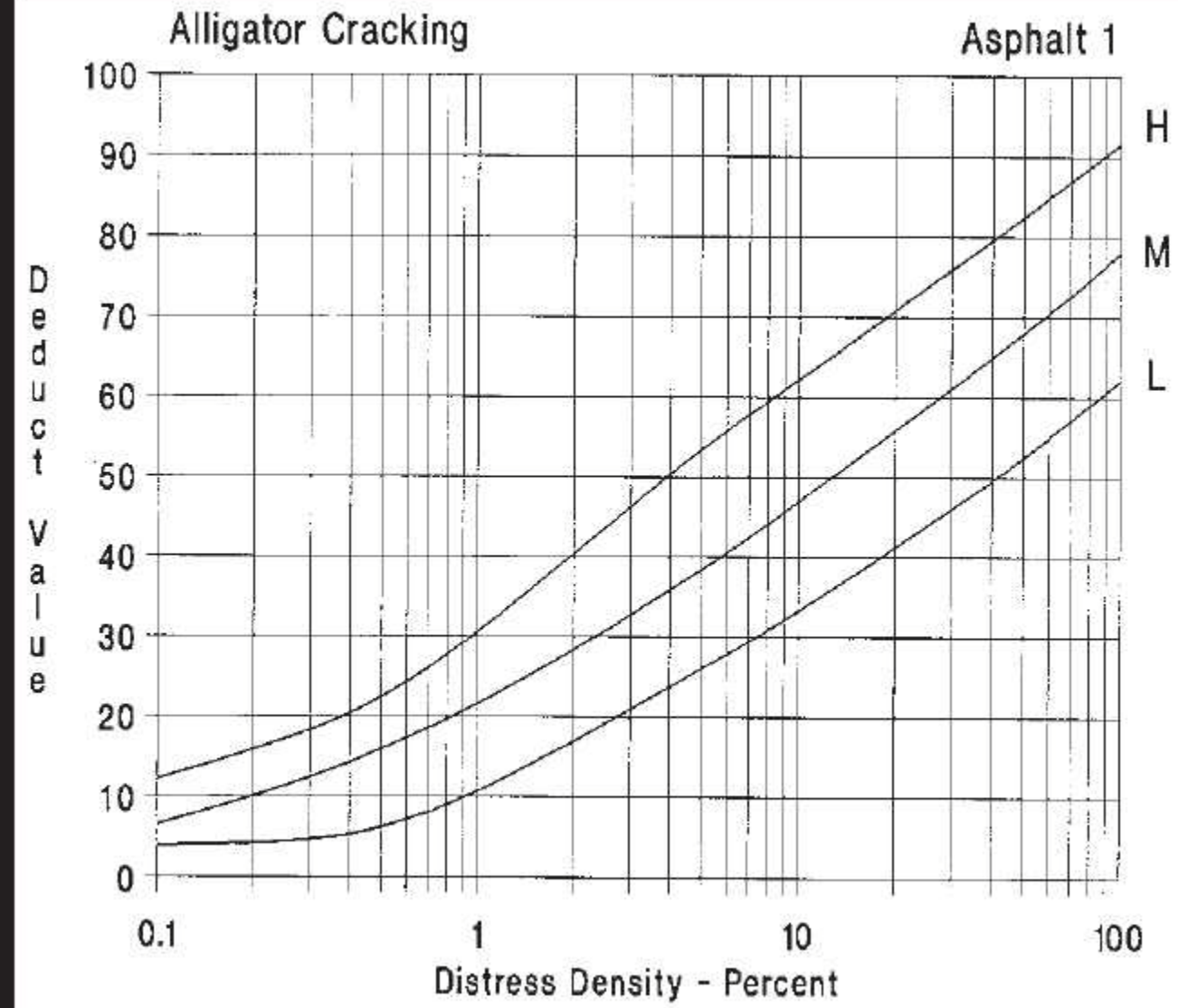


Weathering

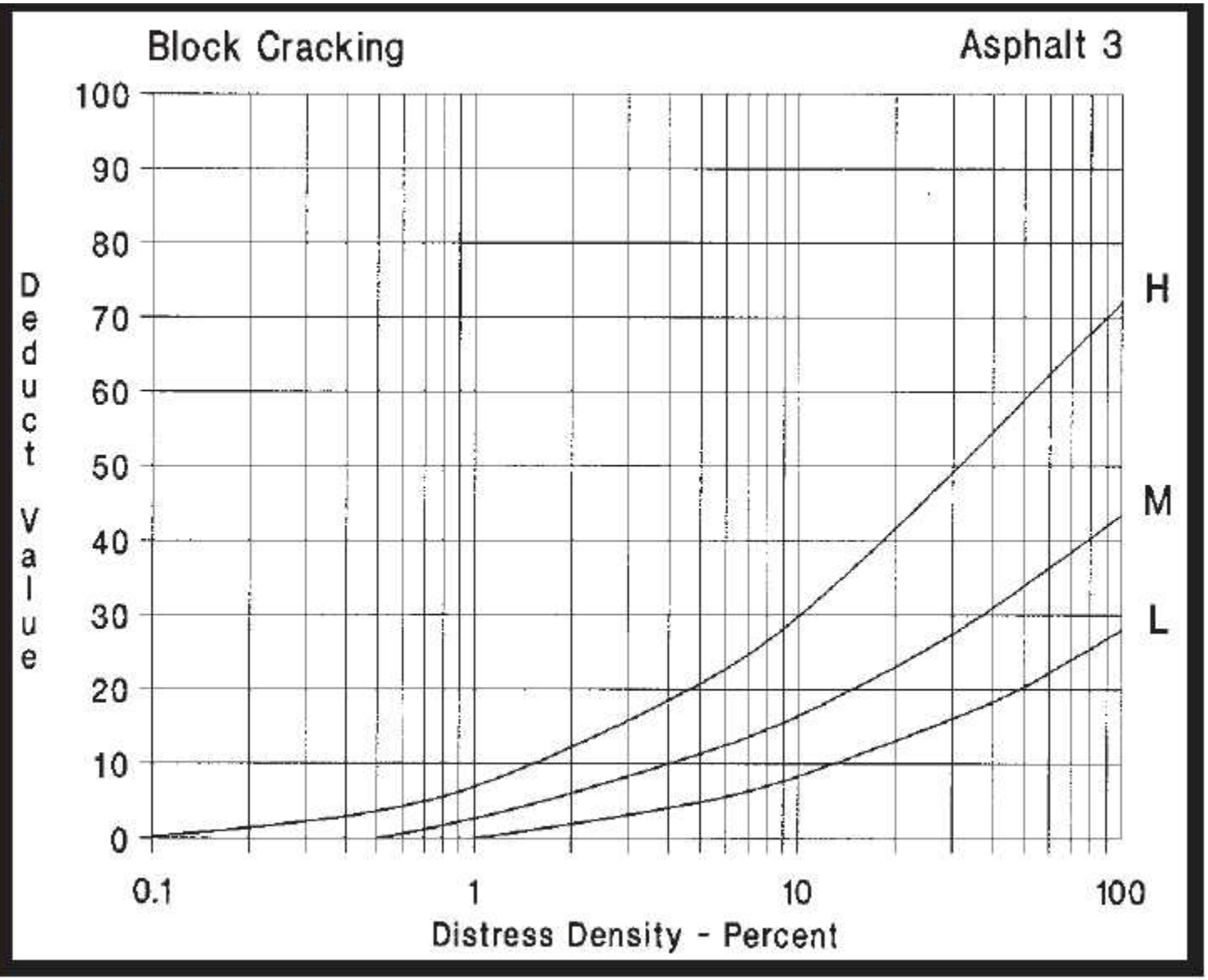


Patching / Utility Cut

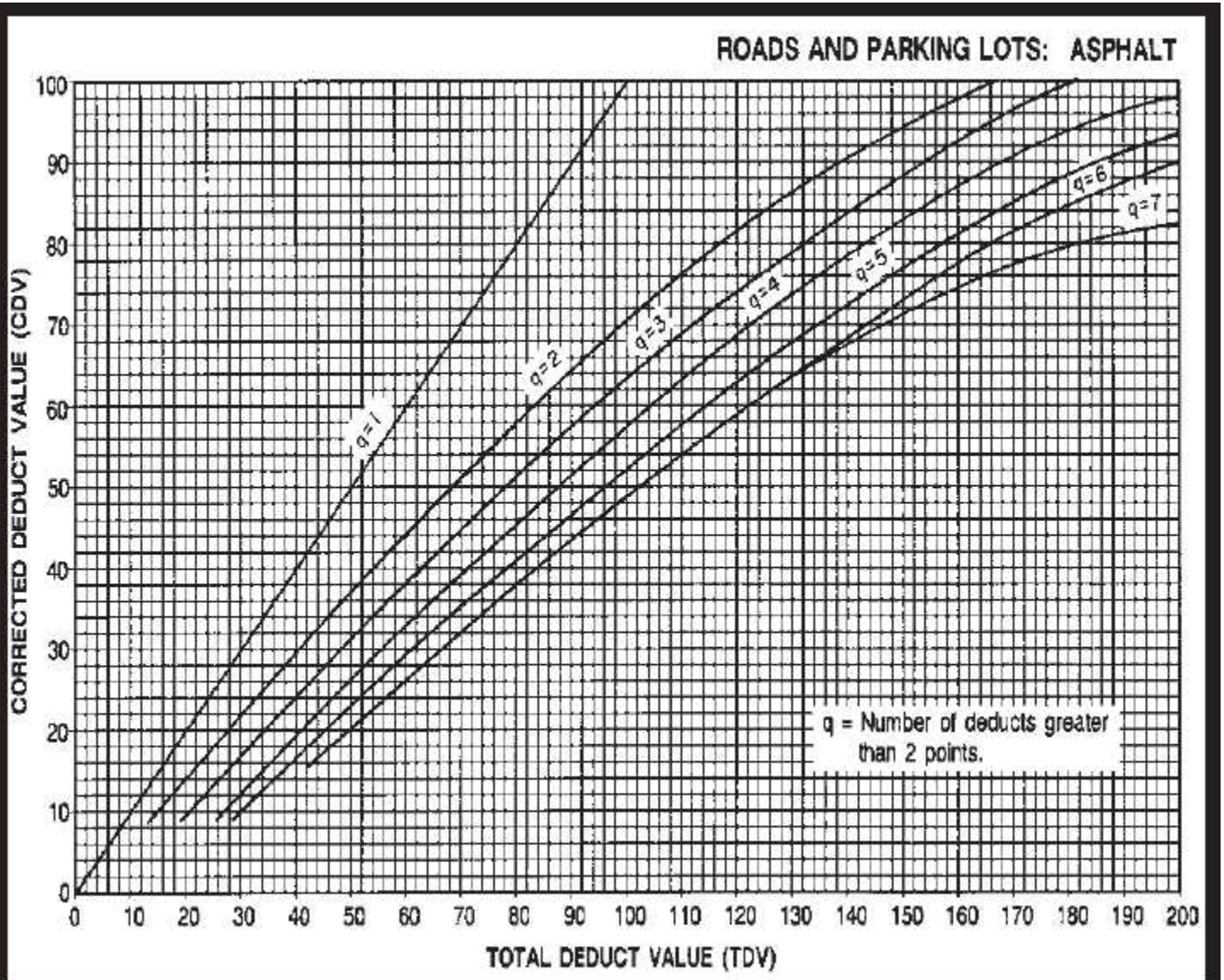
ALLIGATOR (1)


Alligator Cracking
Asphalt 1
100
90
80
70
60
50
40
30
20
10
0
Deduct Value
H
M
L
0.1
1
10
100
Distress Density - Percent

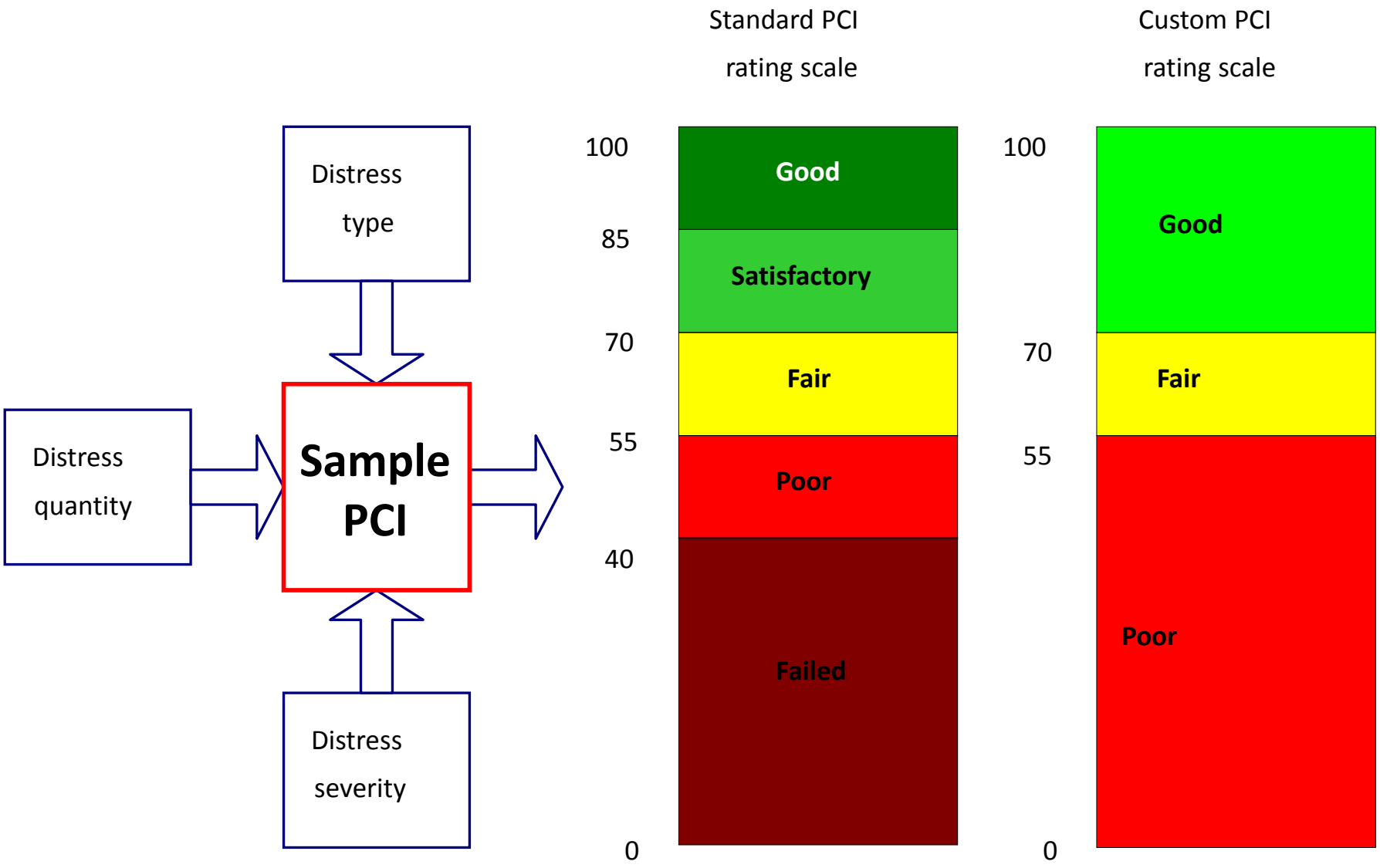
BLOCK CRACKING (3)



CORRECTED DEDUCTS



Pavement Condition Index (PCI)



ASTM Standards

PCI for:

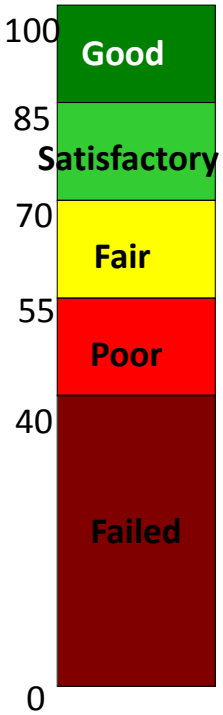
- Airfields: D 5340 11

- Roads & Parking Lots: D 6433 11

Example Pavement Conditions

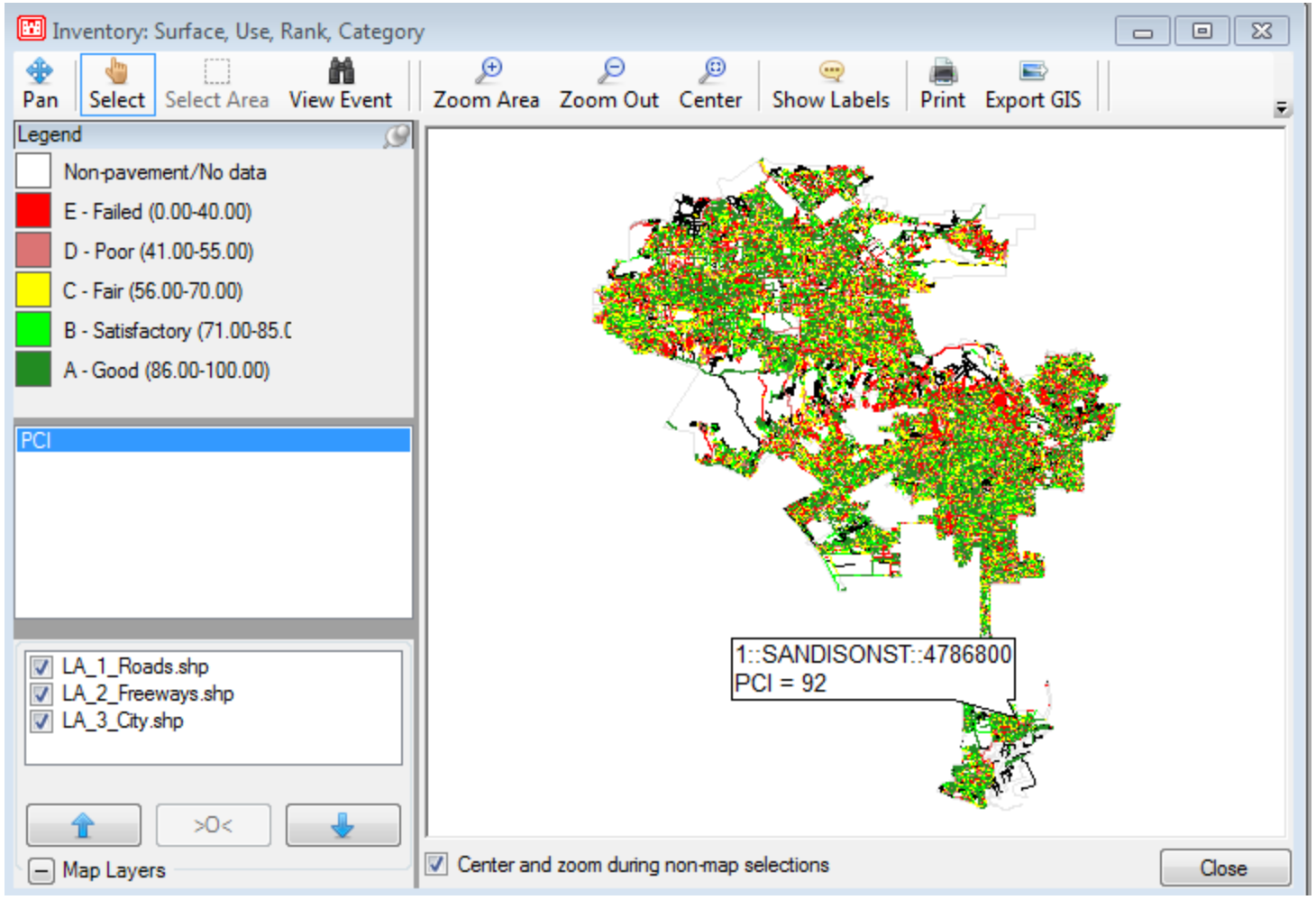
(Ref. LA)

PCI: 71- Satisfactory
07/12/2013



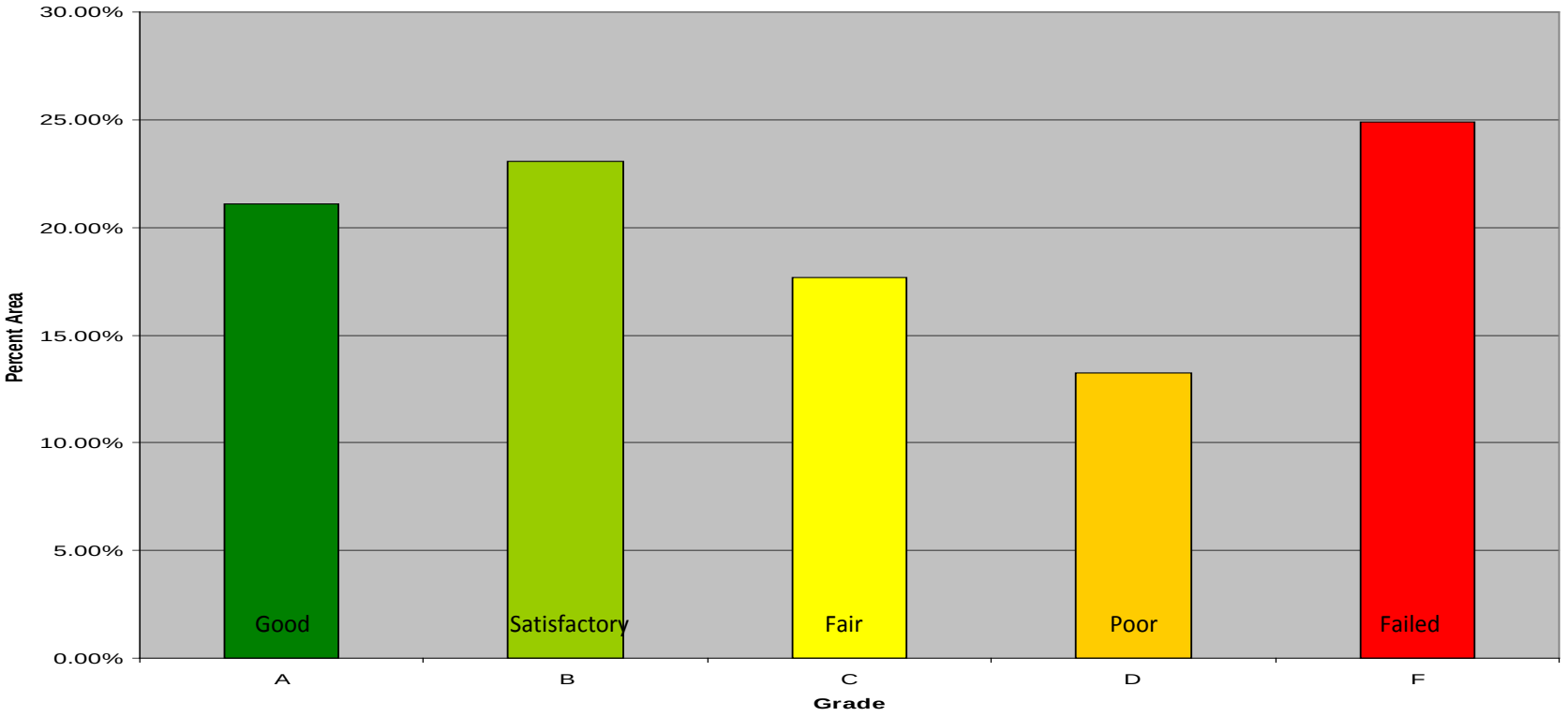
PCI: 51 - Poor
07/12/2013

Condition Map

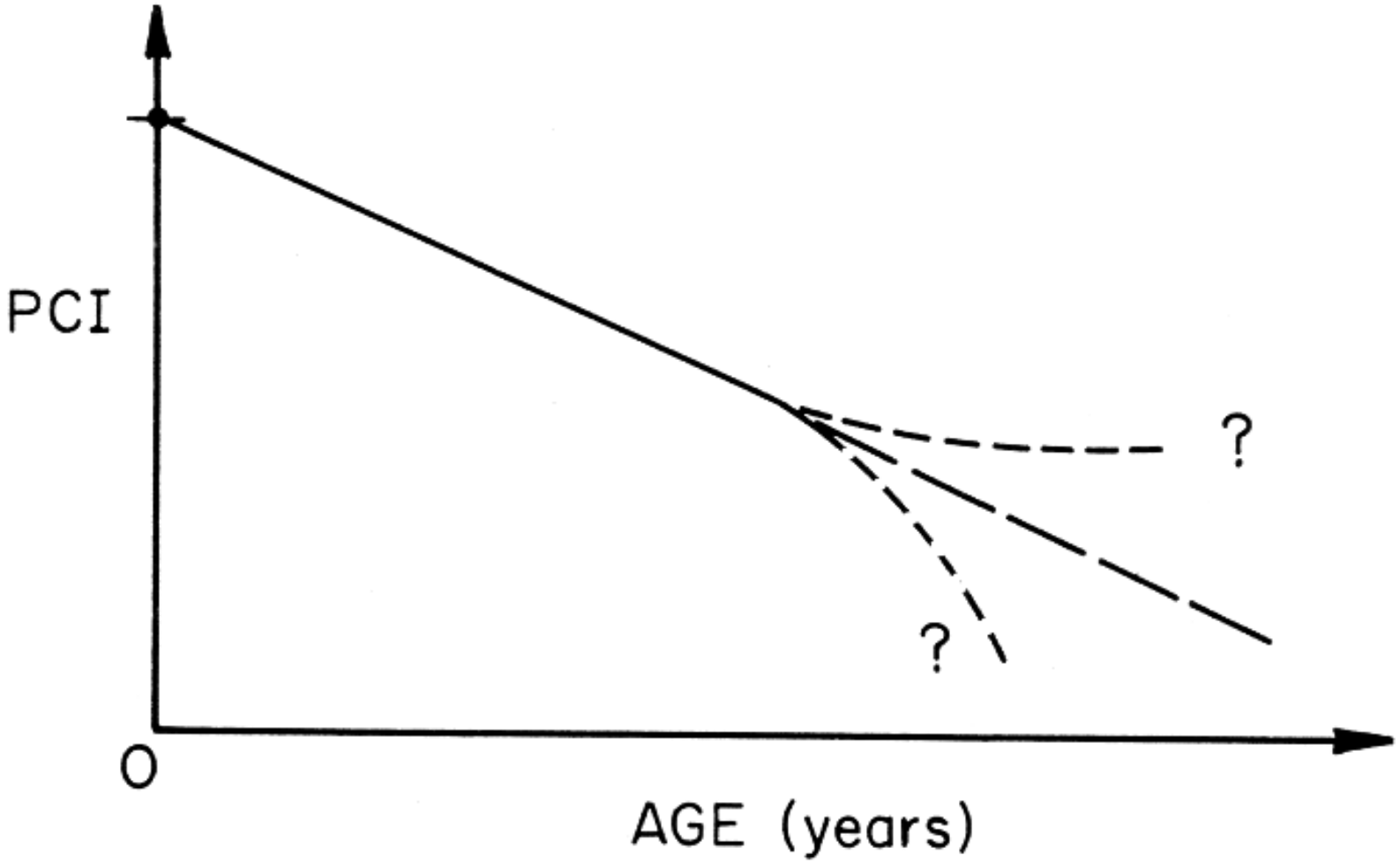


Current Condition of Los Angeles Streets

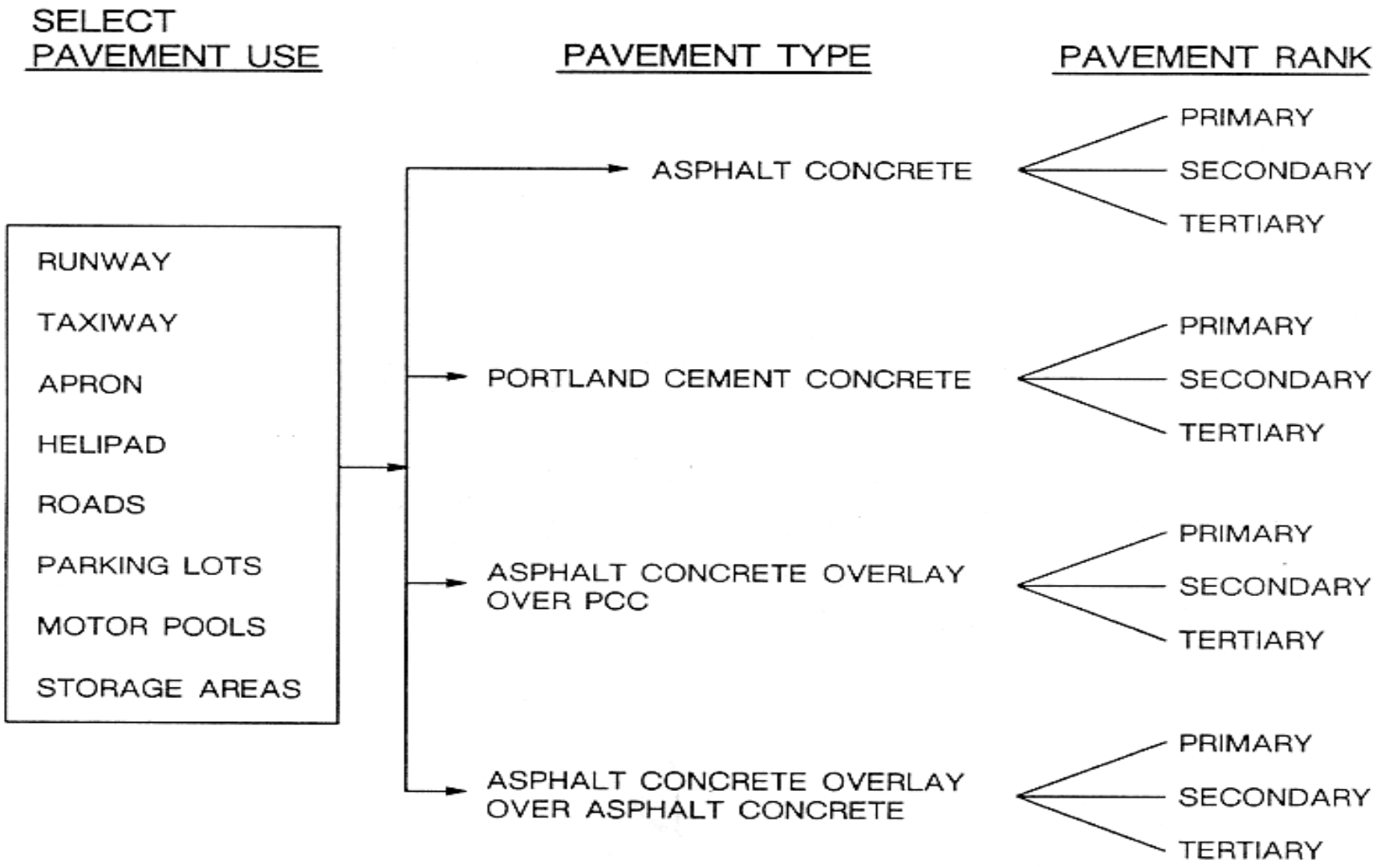
Decades of deferred maintenance created a street network that currently has approximately 25% of our streets in a failed condition (Grade F), where they will cost up to five times more to reconstruct and rebuild than normal resurfacing.



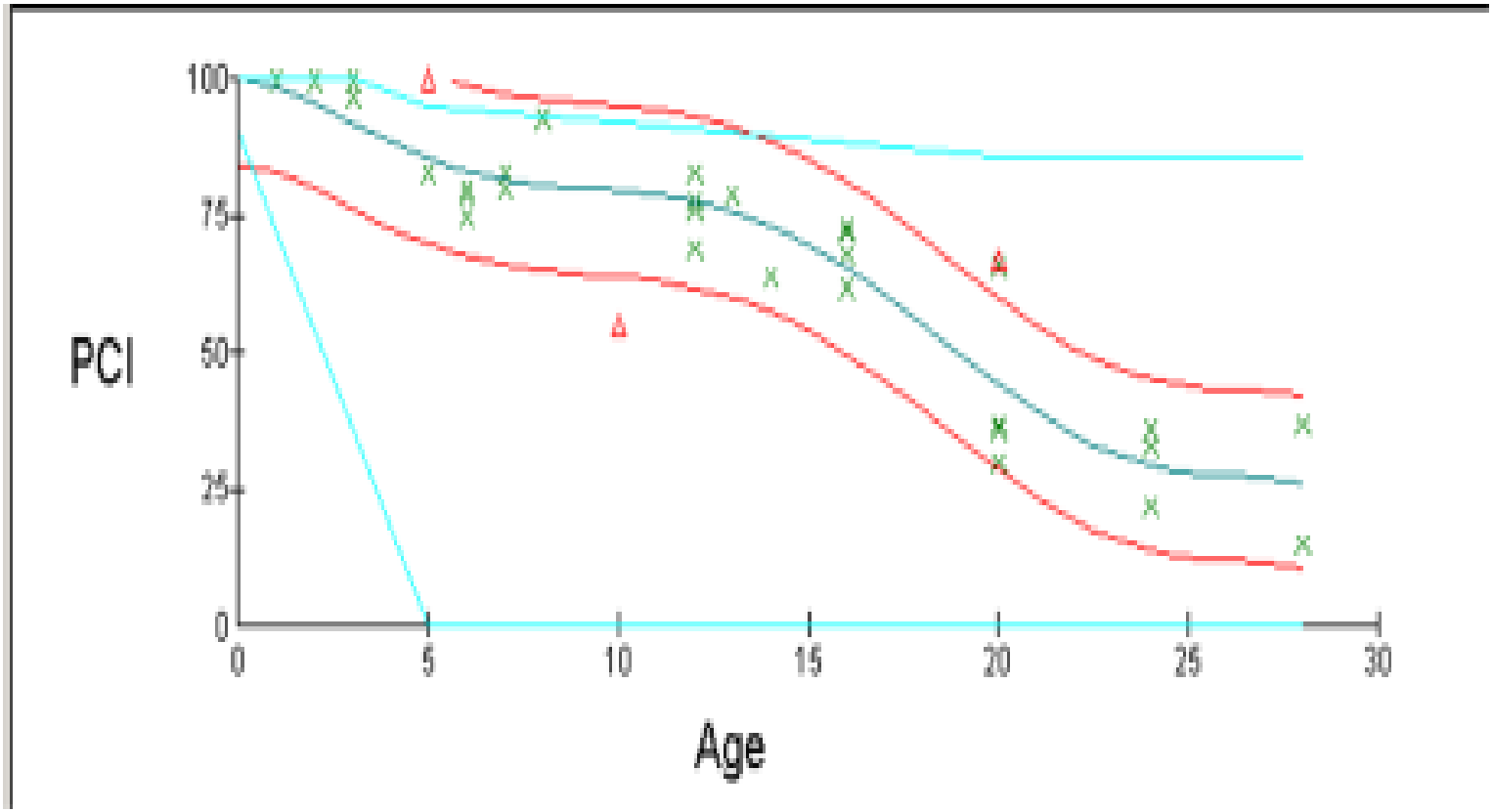
Condition Prediction



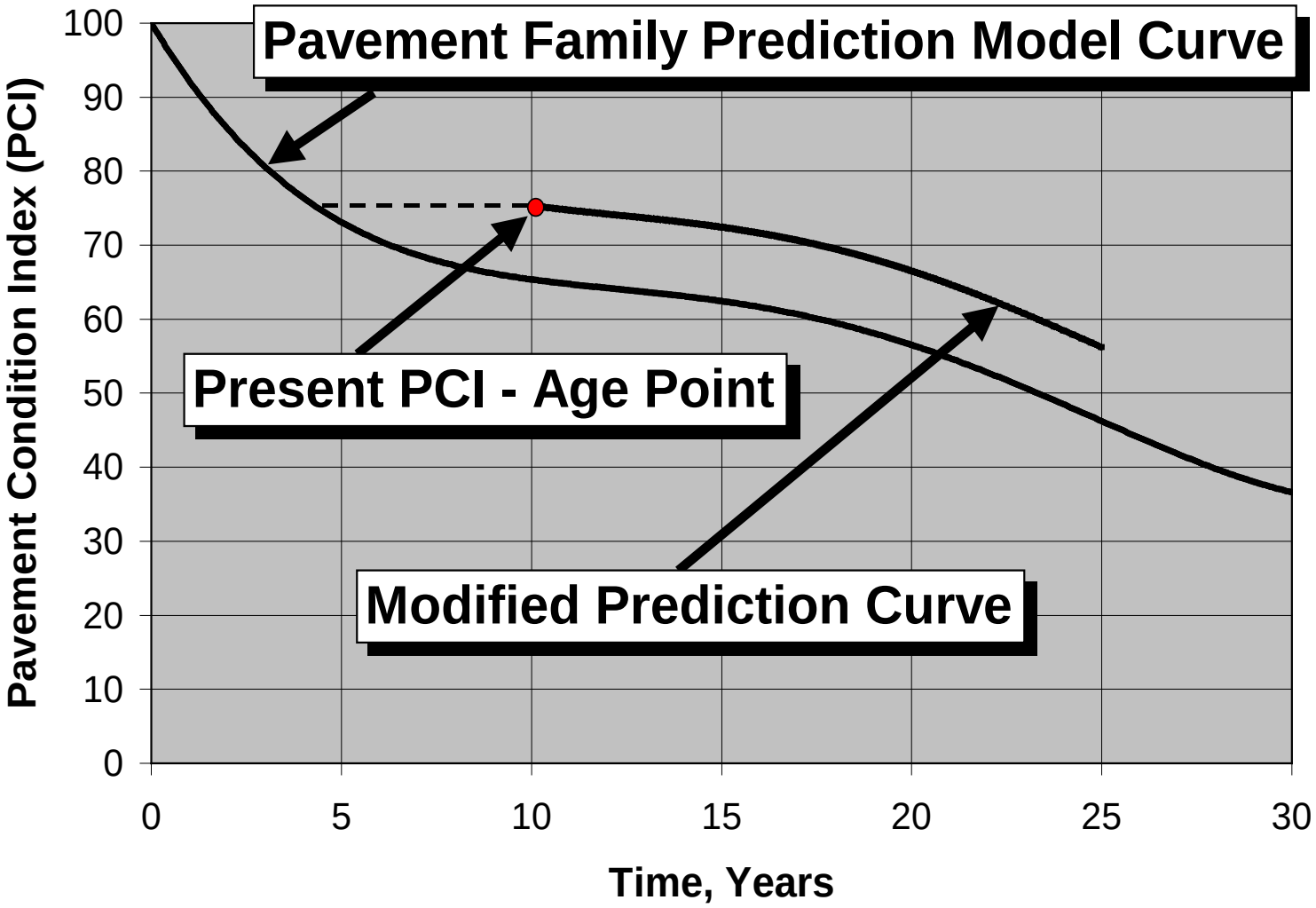
Group Similar Pavements (Create Families)



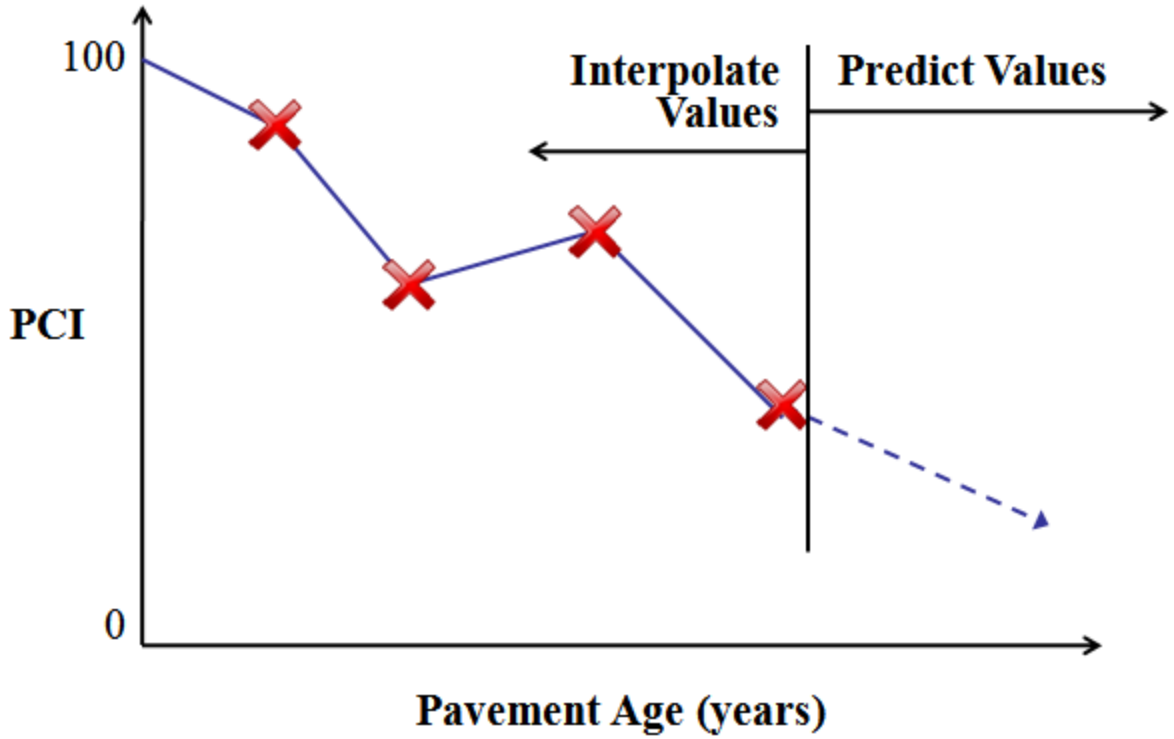
Develop Family Trend



Predict Section Condition based on Family

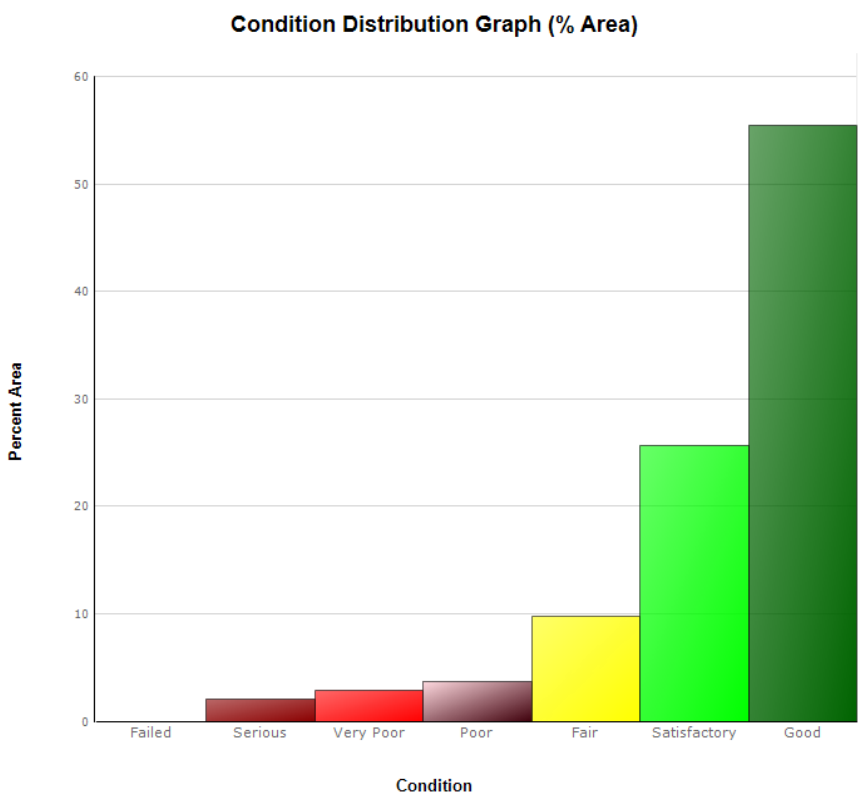


Performance Analysis

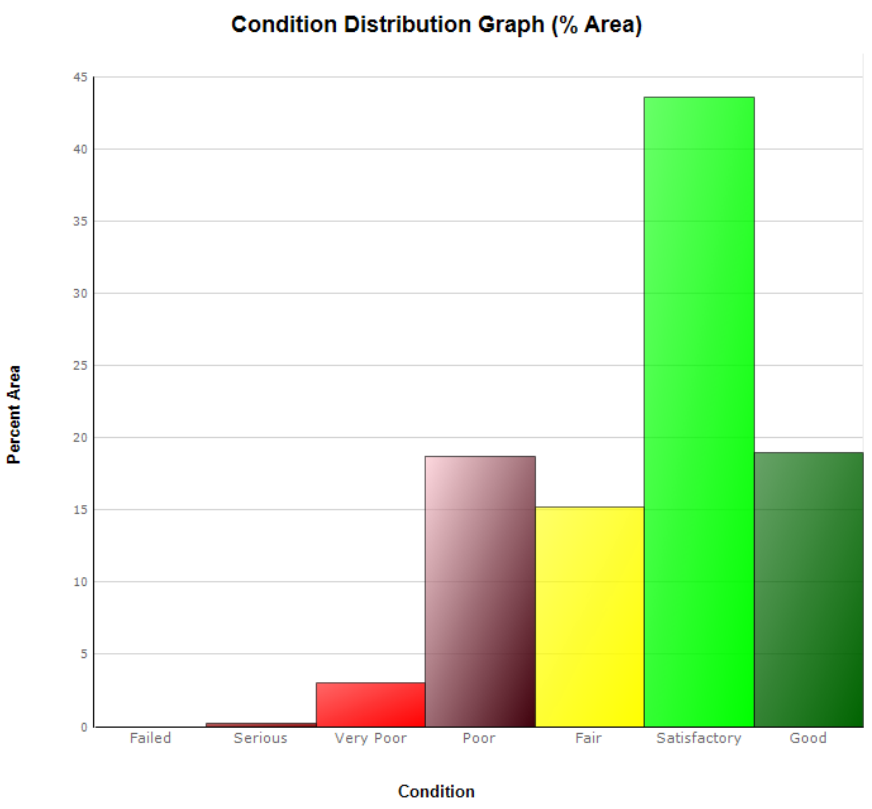


Condition Distribution

2007



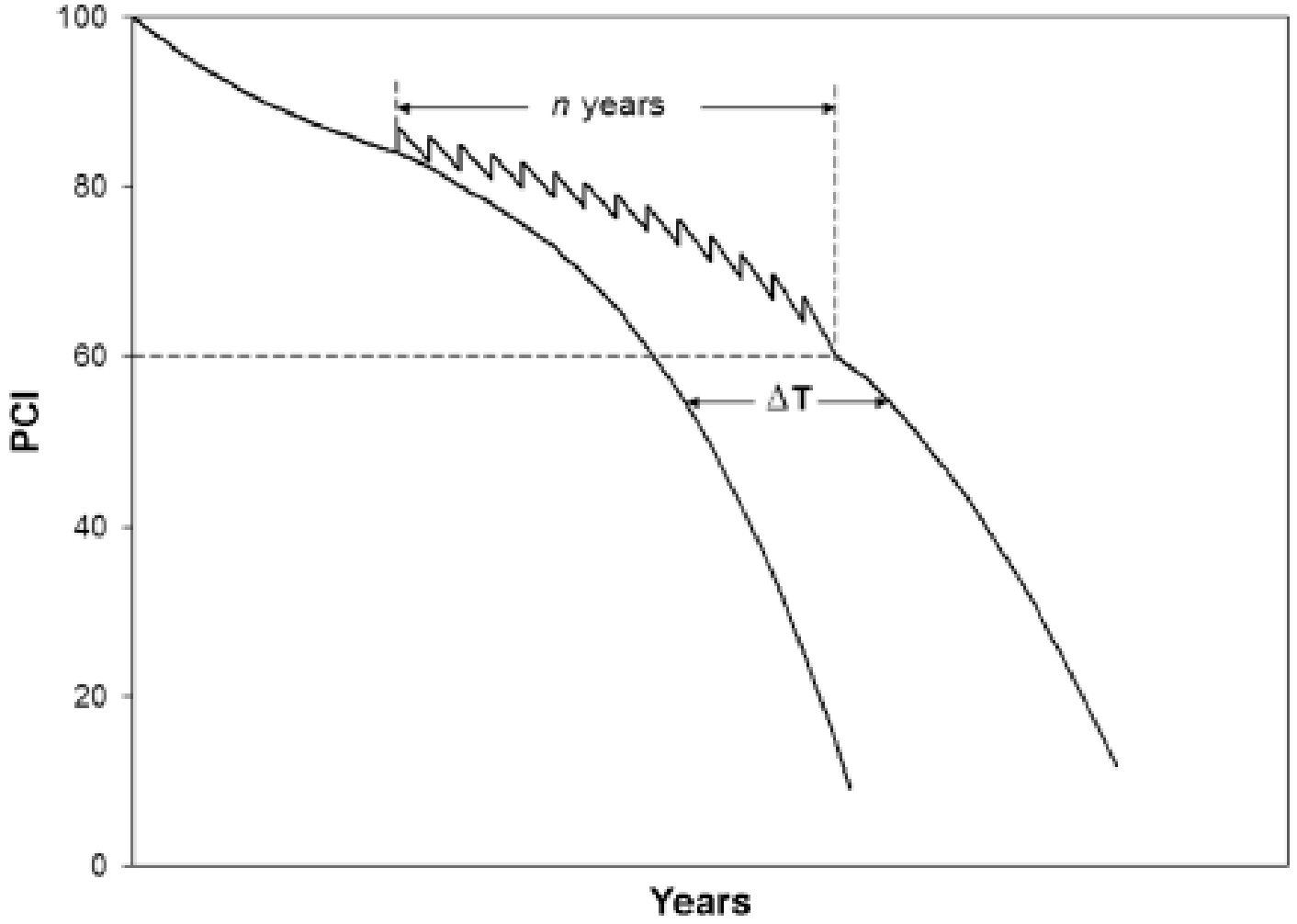
2016



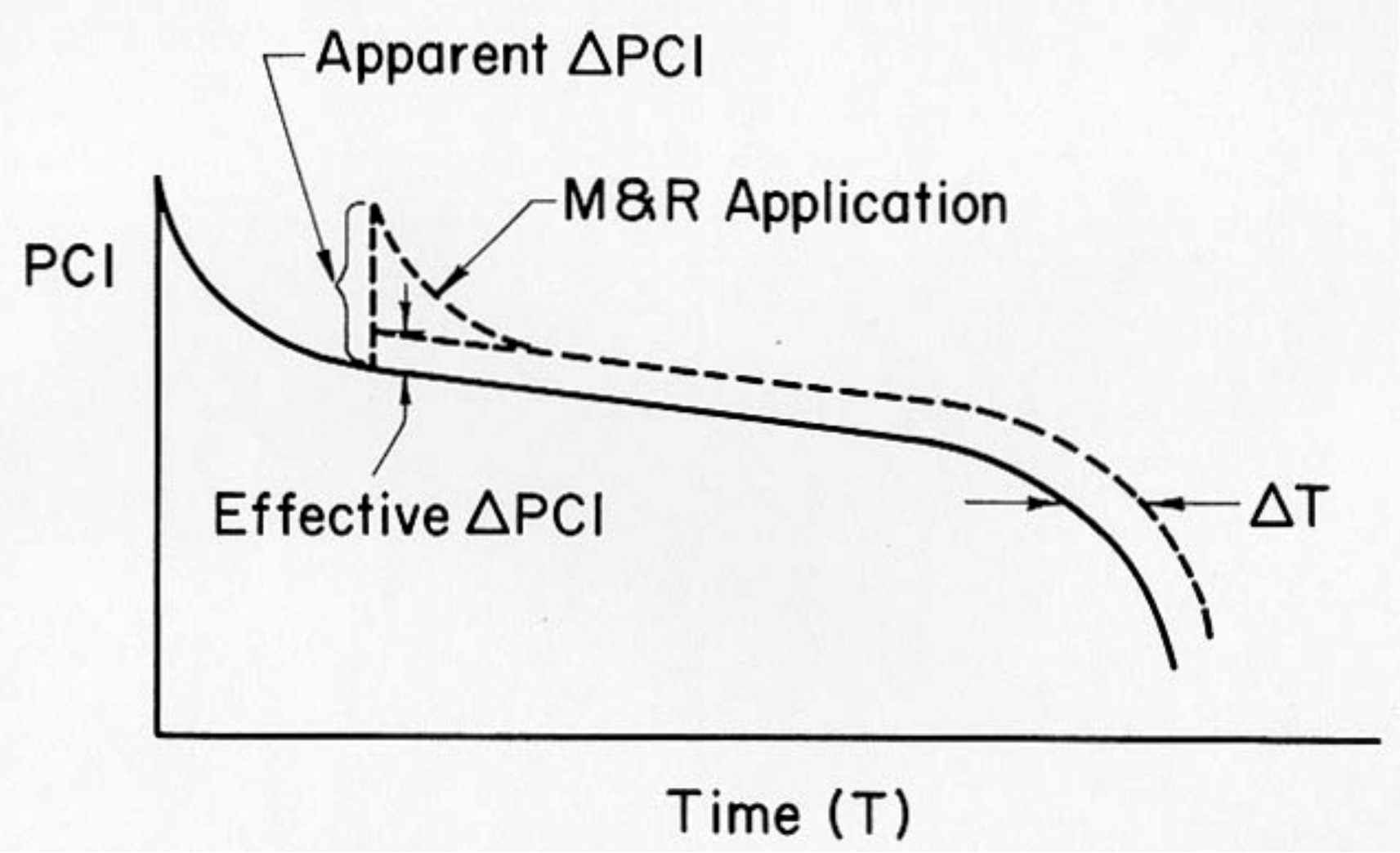
M&R Categories

- **Localized:**
  - **Preventive, PCI > critical**
  - **Localized Safety, PCI < critical**
- **Global: Micro Surfacing, etc.**
- **Major:**
  - **PCI > critical**
  - **PCI < critical**

Effect of Localized Preventive M&R on PCI



Effect of Global M&R on PCI

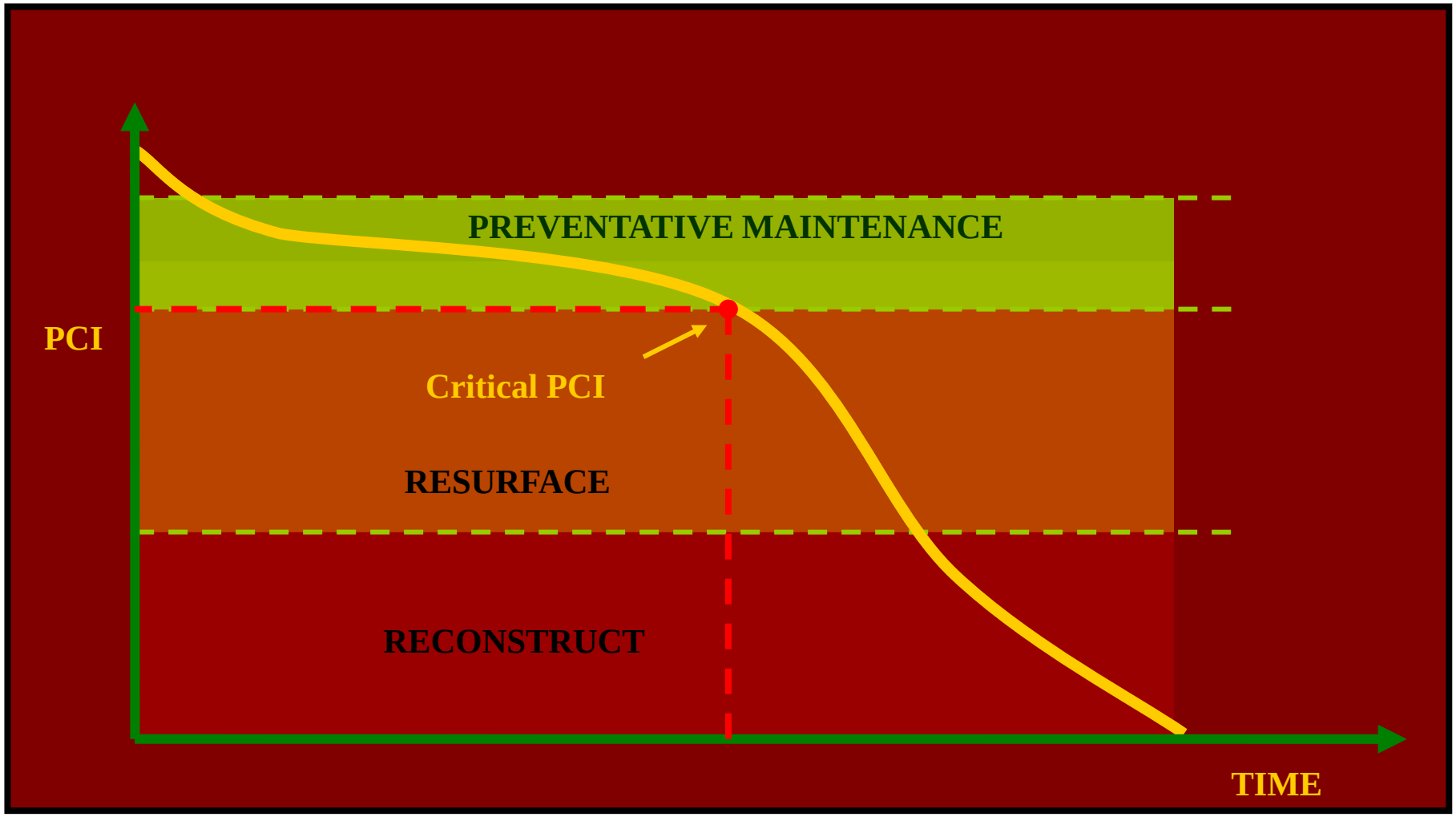


Rubberized Slurry Seal Application

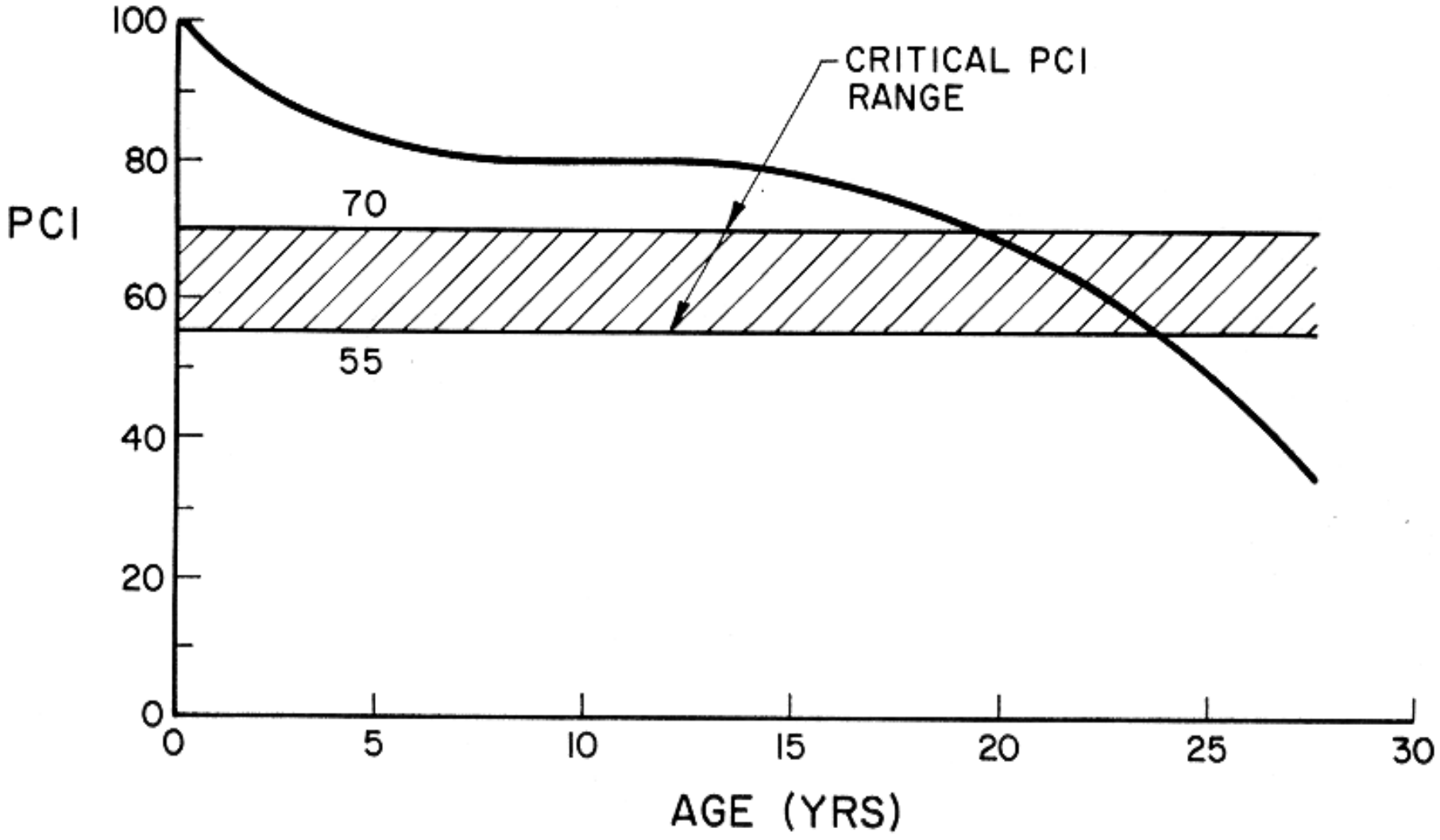
Major M&R

Resets PCI to 100

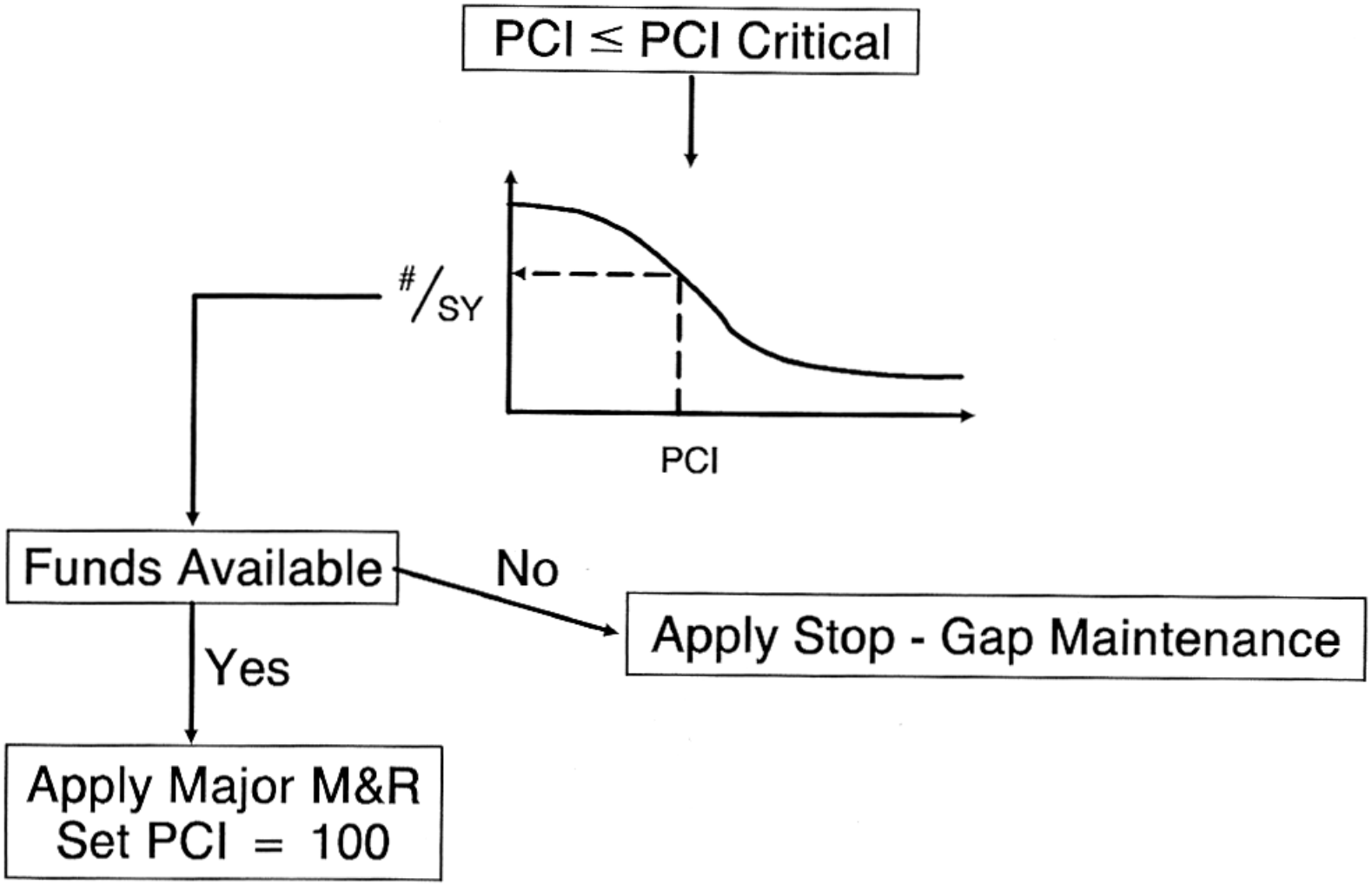
M&R Rehabilitation Policy



Critical PCI



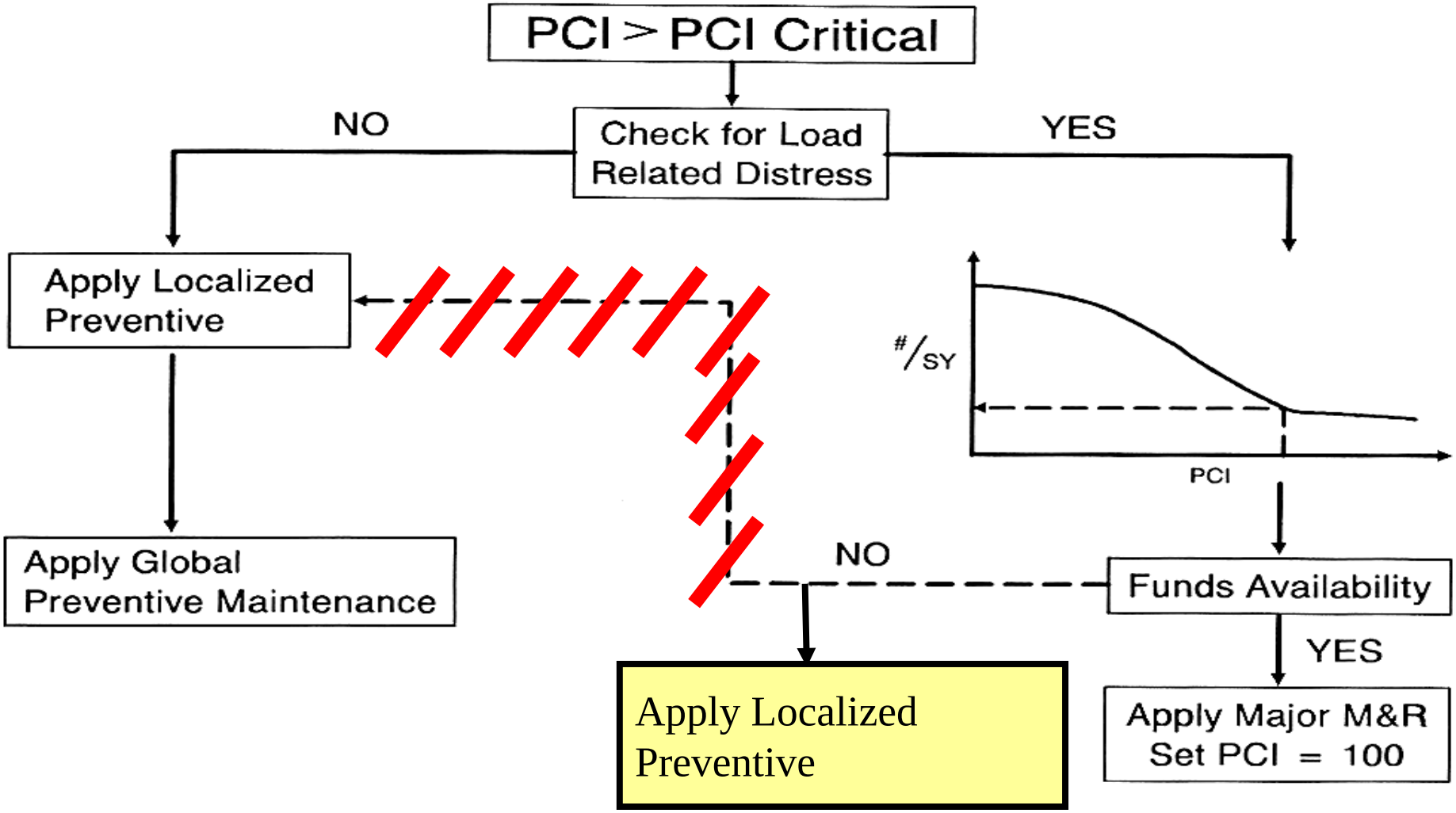
M&R Assignment *Below Critical PCI*



List of Structural Distresses

Asphalt Pavement				
Alligator Cracking		L + M + H		> 0.5%
Patching		M + H		> 10%
Potholes		L + M + H		> 0.1%
Rutting	M + H		> 1.0%	
Concrete Pavement				
Large Patching	M + H		> 10%	
Corner Break		L + M + H		> 5%
Divided (shattered) Slab				
Punchout				

M&R Assignment *Above Critical PCI*



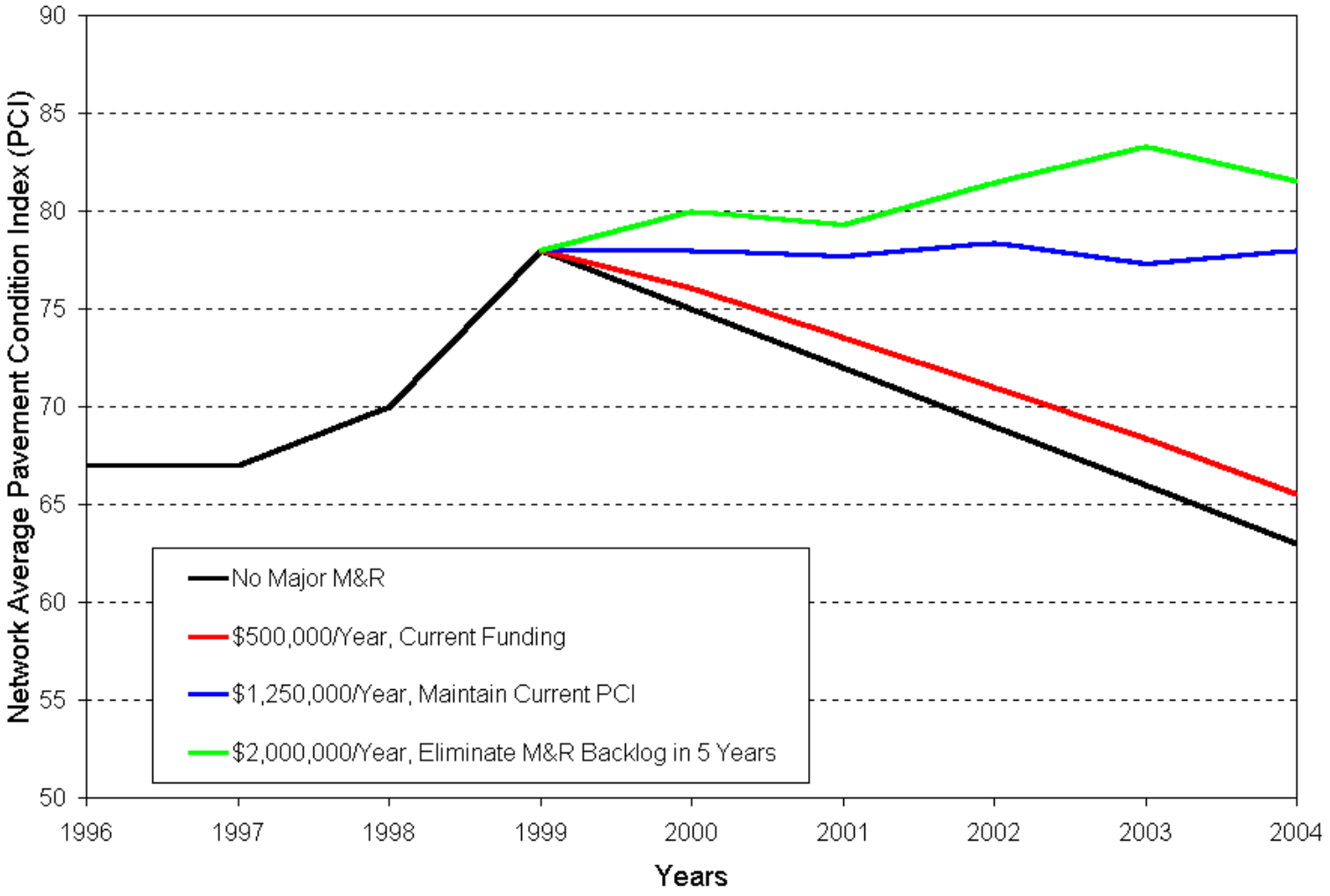
Work Planning Options

Determine Budget Consequence: Consequence of different budgets on condition and backlog of M&R

Determine Budget Requirement:

Eliminate backlog of major M&R in a specified period of time
Maintain current area-weighted PCI over a specified period of time
Reach desired area-weighted PCI in a specified period of time

Work Planning



Priorities of M&R Categories

A> B> C

A. M&R Category

1. Localized Safety
2. Localized Preventive
3. Global
4. Major >= Critical
5. Major < Critical

B. Example Use/Rank Priority Table

RANK / USE	Arterial	Collector	Residential
Roadway	1	3	6
Parking	2	5	8
Other	4	7	9

C. Proximity to the Critical PCI

- Example:
  - Assuming a critical PCI 0f 60, a pavement with PCI of 55 will have a higher priority than Pavement with a PCI of 20.

Work Planning Options

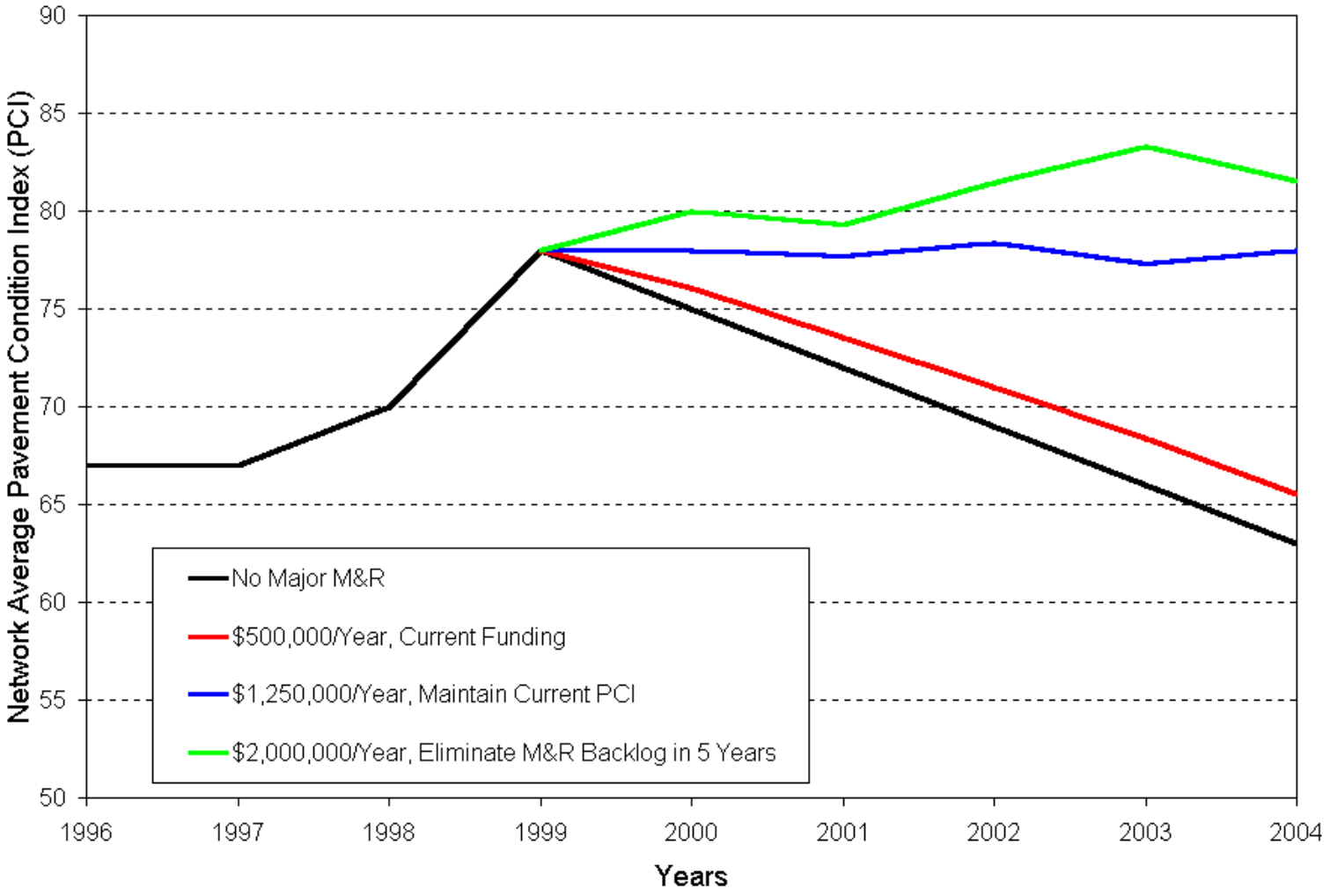
Determine Budget Consequence:

Consequence of different budgets on condition and backlog of M&R

Determine Budget Requirement:

- Eliminate backlog of major M&R in a specified period of time
- Maintain current area-weighted PCI over a specified period of time
- Reach desired area-weighted PCI in a specified period of time

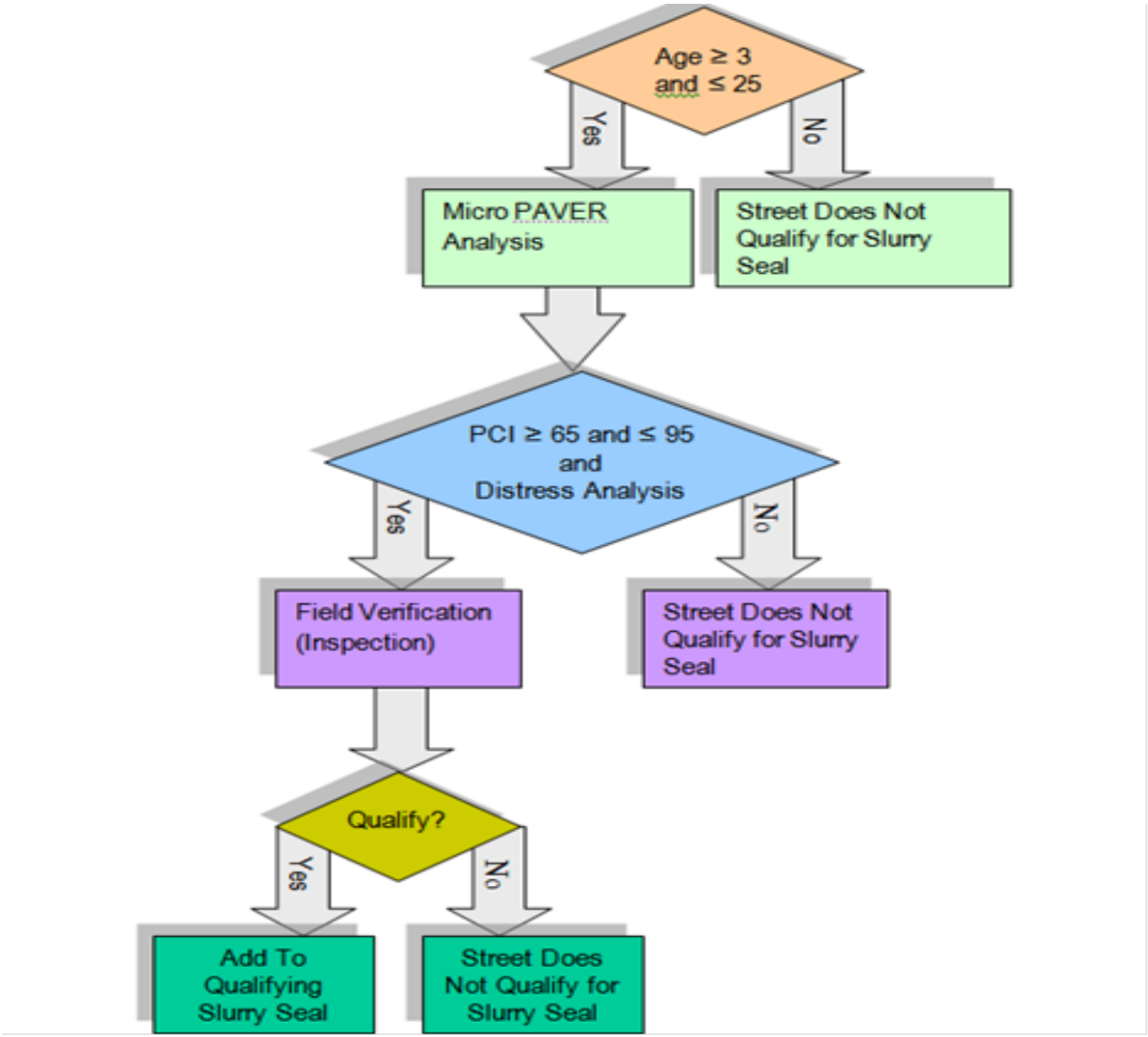
Work Planning



Project Formulation

- ✓ Select section to be included in the project using any of the selectors based on condition, proximity, etc.
- ✓ Select work items to be performed and assign work date and unit costs.
- ✓ Add/delete work items for individual sections.
- ✓ Re-execute the work plan

Slurry Seal Decision Flow Chart

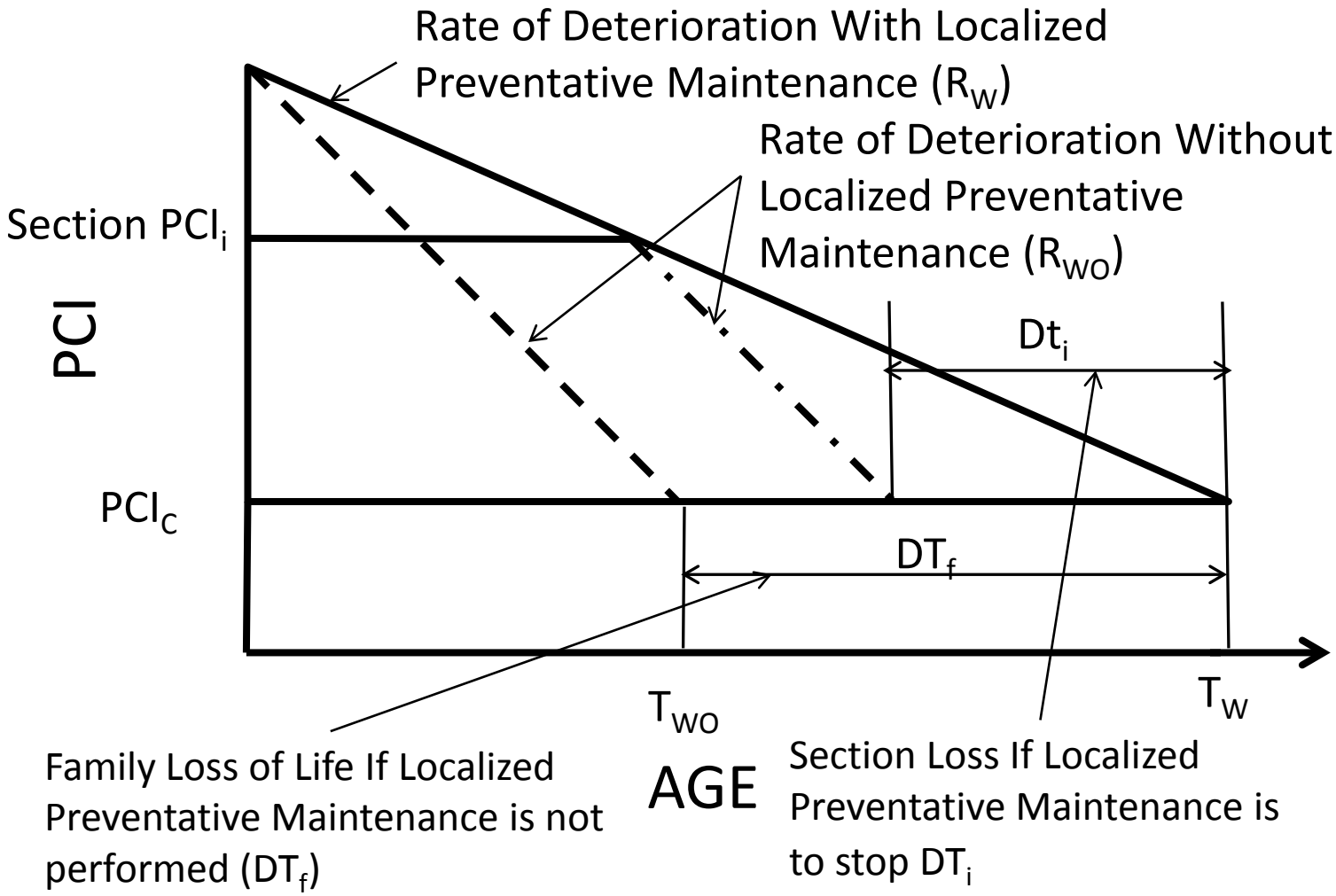


Cold In-Place Recycling (CIR)

Risk of Not Performing Preventive Localized Repair

- Defined as the decrease in pavement life and thus increase in the overall pavement M&R cost as a result of not performing the required localized preventative M&R

Background: Pavement Deterioration



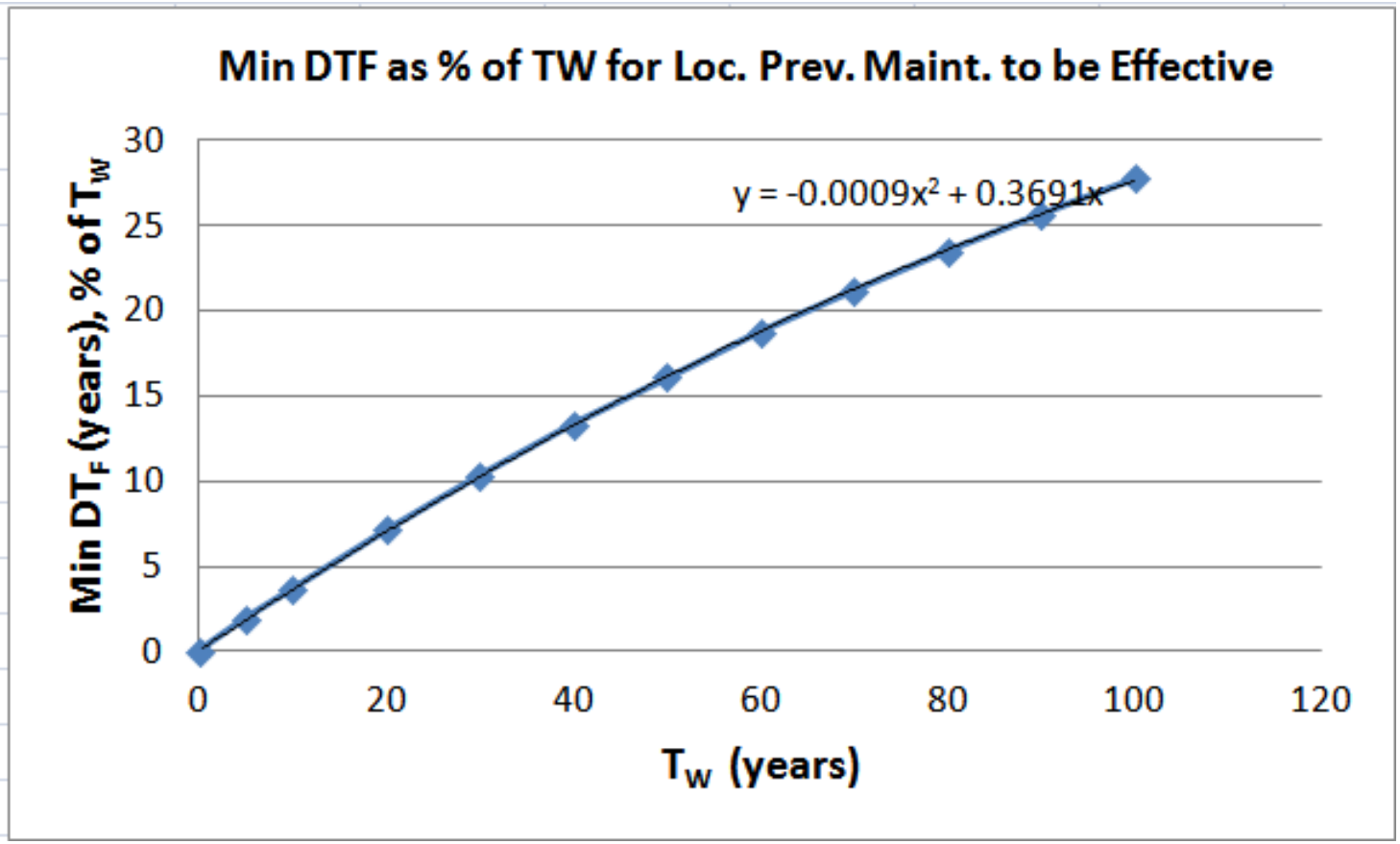
Procedure: Loss in Pavement Family Life

- The value of DT_f depends on several factors including; pavement life with localized preventative maintenance (T_w), pavement type (i.e. asphalt vs. concrete), climate, and traffic
  - Recommended DT_f when T_w is 20 years:

Climate	DT_{f20}, years
Dry/No Freeze	5
Wet/No Freeze-Dry/ Freeze	7.5
Wet/Freeze	10

Procedure: DT_f for any other T_w

- $DT_f @ T_W = DT_{f20} * (.3691\ T_W - .0009\ T_W^2) / 7.13$



Procedure: DT_f Calculation Example

- For example, if T_w = 25 years, then DT_f for Dry/No Freeze is calculated as:

$$DT_{f20} *(.3691\ T_W - .0009\ T_W^2)/\ 7.13,$$

$$= 5 * (.3691 * 25 - .0009 *(25^2))/\ 7.13$$

$$= 6.08 \text{ years}$$

Cost Due to Loss of Pavement Life
$EUAC_{Loss}$

$$EUAC_{LOSS} = EUAC_{Alt2} – EUAC_{Alt1,}$$

Where,

$$EUAC_{Alt2} = (\$_{Annual\text{-}Major\text{-}Alt2}) + \$_{Annual\text{-}operational,}$$

$$EUAC_{Alt1} = (\$_{Annual\text{-}Major\text{-}Alt1}) + \$_{Annual\text{-}Preventive}$$

$EUAC_{LOSS}$ Example - Localized Preventive

Given:

- Major M&R = $ 20/ SM
- Annual Preventive = $0.09/ SM
- Annual Operational, Safety = $0.04/ SM

Then:

✓ $\$_{Annual\text{-}Major\text{-}Alt1} = \$ 20/ 25 = \$ 0.8/ SM/ YR$

✓ $\$_{Annual\text{-}Major\text{-}Alt2} = \$ 20/ (25 - 6.08) = \$ 1.0571/ SM/ YR$

✓ $EUAC_{Alt2} = \$ 1.0571 + \$ 0.04 = \$ 1.0971/ SM/ YR$

✓ $EUAC_{Alt1} = \$ 0.8 + \$ 0.09 = \$ 0.89/ SM/ YR$

✓ $EUAC_{LOSS} = \$ 1.0971 - \$ 0.89 = \$ 0.2071/ SM/ YR$

Loss in Cost For Each Section (C_i)

$C_i = EUAC_{Loss} * T_W *$ section area in SM, where

Dt_i = loss in life for section i

In the example,

- $EUAC_{Loss}$ = \$0.2071/ SM/ YR
- Dt_i = 3.04 years
- Assume section area = 5000 SM

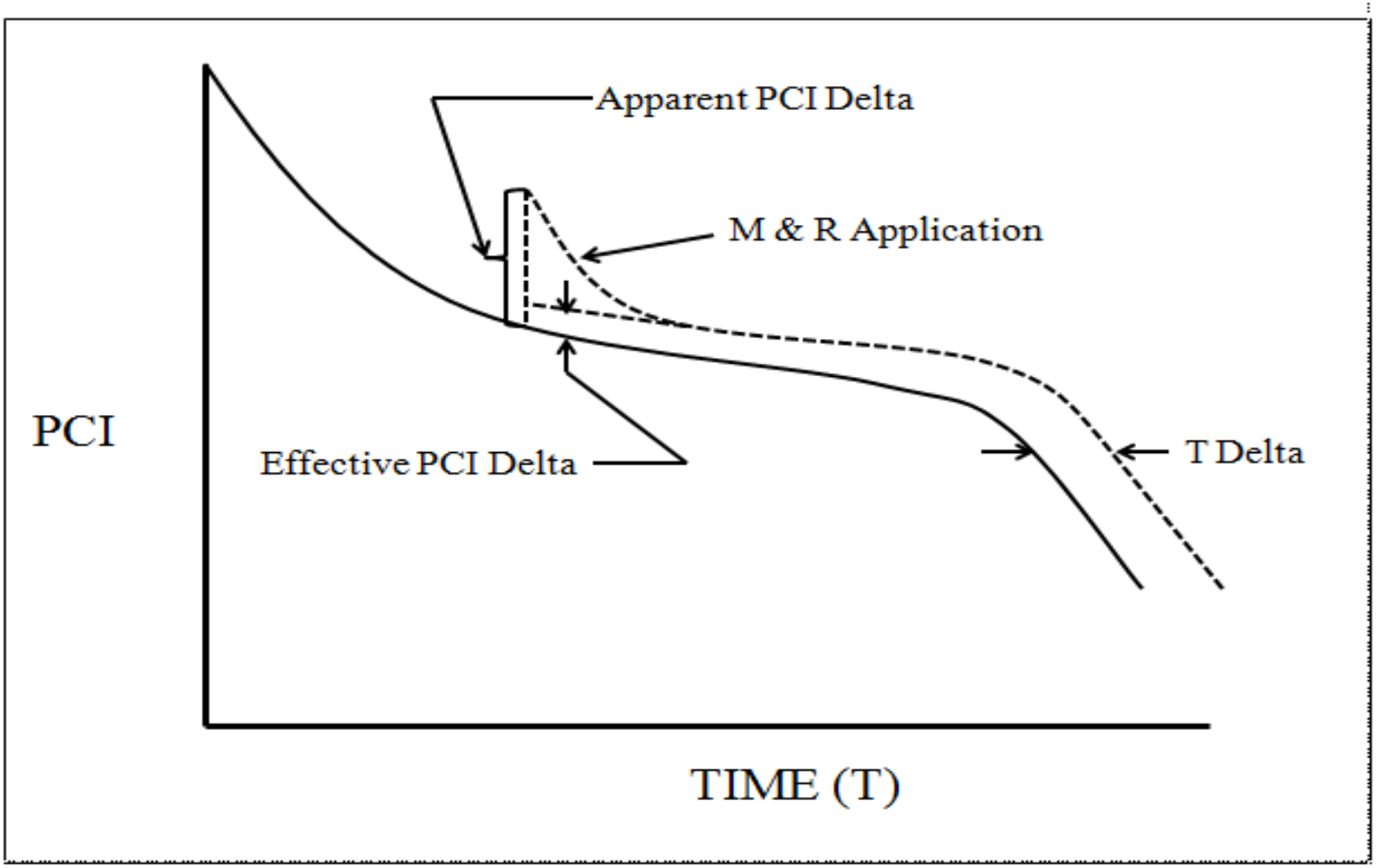
✓ C_i = \$ 0.2071 * 25* 5000 = \$ 25,887

Risk of Not Performing Global Preventive Maintenance

Background: Global Preventative M&R

- Typically, global preventative maintenance is applied for pavements above the Critical PCI at an appropriate frequency throughout the life of pavement
- Examples of global preventive types are: fog seals, rejuvenators, and slurry seals
- Risk is defined as the decrease in pavement life and thus increase in the overall section M&R cost as a result of not performing the required global preventative M&R.
- The procedure presented is for determining the risk for a single application.

Background: Effect of Global Preventive M&R on Pavement Condition



Procedure: Calculate Age to PCI_C Assuming No Global (T_{WO_G})

$$T_{WO_G} = (100 - PCI_C) / R_{WO_G}$$

Example,

- $PCI_C = 60$
- $R_{WO_G} = 2$ PCI Points per Year,

$$T_{WO_G} = (100 – 60) / 2 = 20 \text{ years.}$$

Procedure: Estimate Delta (D_T)

- Delta T (D_T) is the effective increase in pavement life due to the application of the global treatment

- The value of D_T is a function of a variety of factors including pavement condition, climatic conditions (such as solar radiation), as well as the type of treatment being applied. It normally ranges from 2 to 7 years.

Procedure: Guidelines for Estimating D_T

- Use the midpoint of the range unless local experience and condition indicate other values within the range are more appropriate

Type of Seal Coat	D_T, years
Fog Seal	2-3
Rejuvenator	3-5
Slurry Seal/ Chip Seal	4-6
Microsurfacing	5-7

Procedure: Calculate Age to PCI_C Assuming Global(T_{W_G})

$$T_{W_G} = T_{WO_G} + D_T$$

- In the example above, assuming DT = 5years,

$$T_{W_G} = 20 + 5 = 25 \text{ years.}$$

Cost Due to Loss of Pavement Life $EUAC_{Loss}$

$$EUAC_{LOSS} = EUAC_{Alt2} – EUAC_{Alt1},$$

Where,

- $EUAC_{Alt2} = \$_{Major\text{-}critical} / T_{WO_G}$
- $EUAC_{Alt1} = (\$_{Major\text{-}critical} / T_{W_G}) + \$_{Global}$
- $\$_{Major\text{-}critical}$ = Major M&R cost at critical PCI
- T_{WO_G} = Pavement life without Global
- T_{W_G} = Pavement life with Global
- $\$_{Global}$ = Treatment Unit cost/T_{W_G}

$EUAC_{Loss}$ Example - Global Preventive

Given:

- $\$_{Major\text{-}critical}$ = $ 20/ SM
- T_{WO_G} = 20 years
- T_{W_G} = 25 years
- Global Treatment Cost= $2/ SM

Then:

✓ $EUAC_{Alt2}$ = 20 / 20 = $ 1.0/ SM/ YR

✓ $EUAC_{Alt1}$ = (20 / 25) + (2/ 25) = $ 0.88/ SM/ YR

✓ $EUAC_{LOSS}$ = $ 1.0 - $ 0.88= $ 0.12/ SM / YR

Loss in Cost For Each Section (C_i)

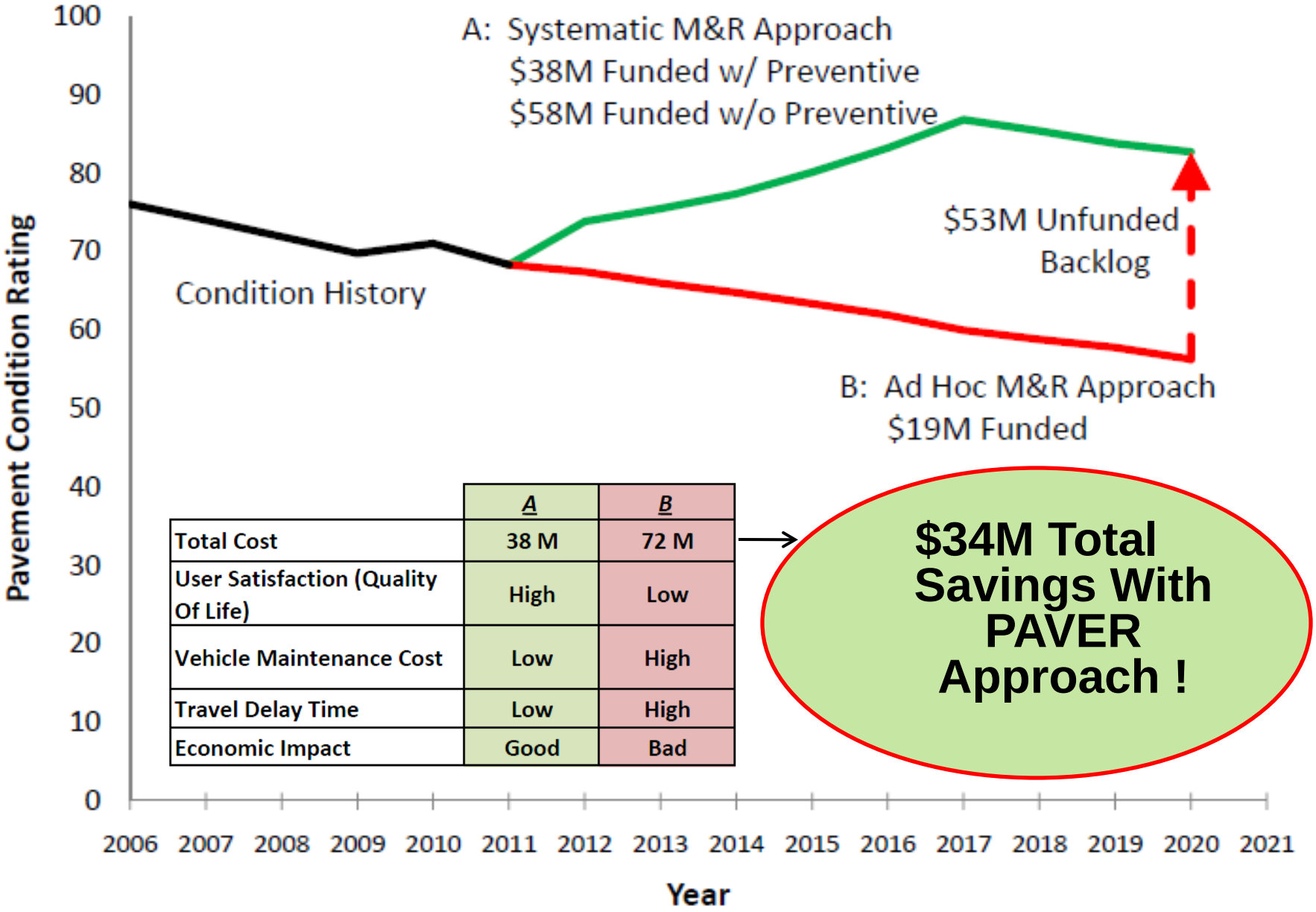
$$C_i = EUAC_{Loss} * T_{W_G} * \text{Section area in SM}$$

In the example,

- D_T = 5 years
- $EUAC_{Loss}$ = \$0.12/ SM/ YR
- Assume sectioni is 5000 SM

✓ C_i = \$ 0.12 * 25* 5000 = \$ 15,000.00

Quantifying the Benefits of Pavement Management



	A	B
Total Cost	38 M	72 M
User Satisfaction (Quality Of Life)	High	Low
Vehicle Maintenance Cost	Low	High
Travel Delay Time	Low	High
Economic Impact	Good	Bad

$34M Total Savings With PAVER Approach !

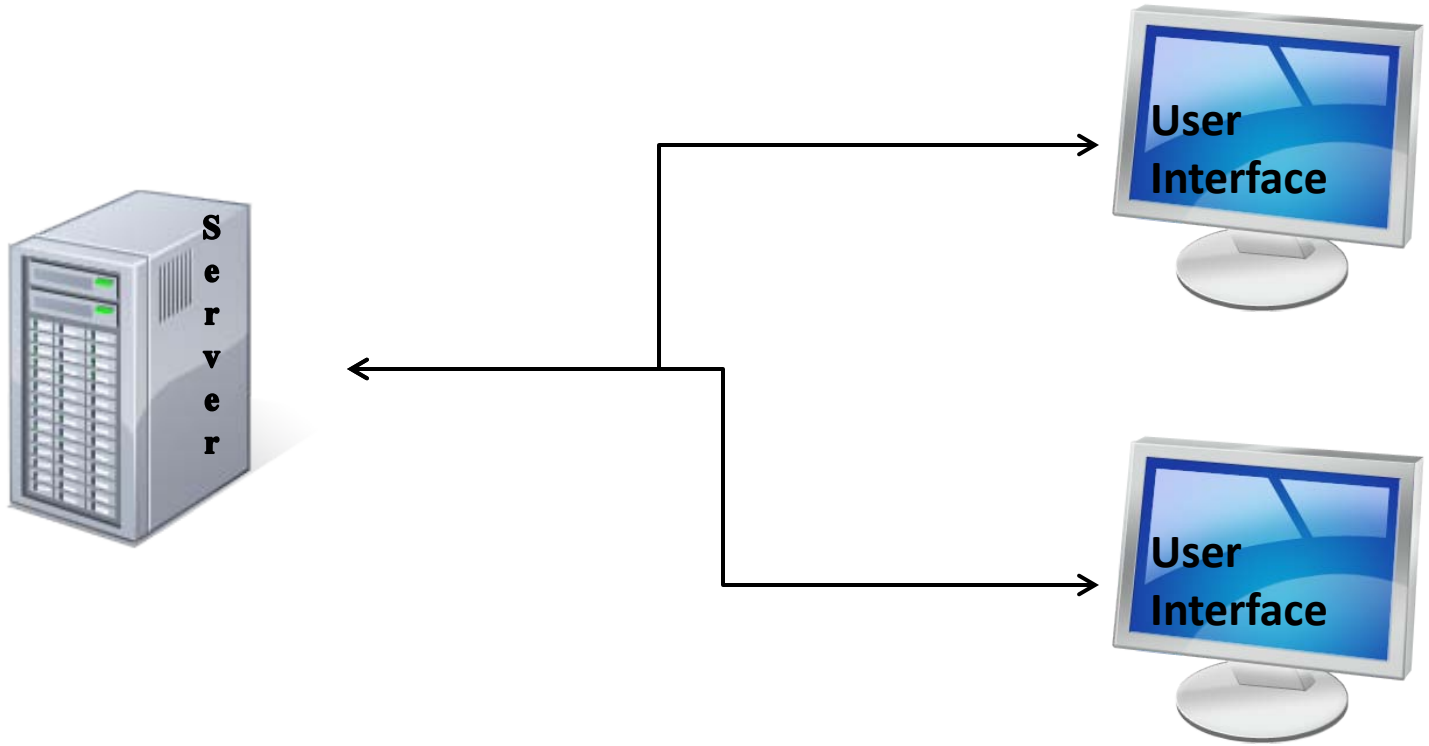
PAVER™ version 7.0

V7 - Personal PC Install

PAVER™ is installed onto a single machine just as it is in version 5 and 6 currently.

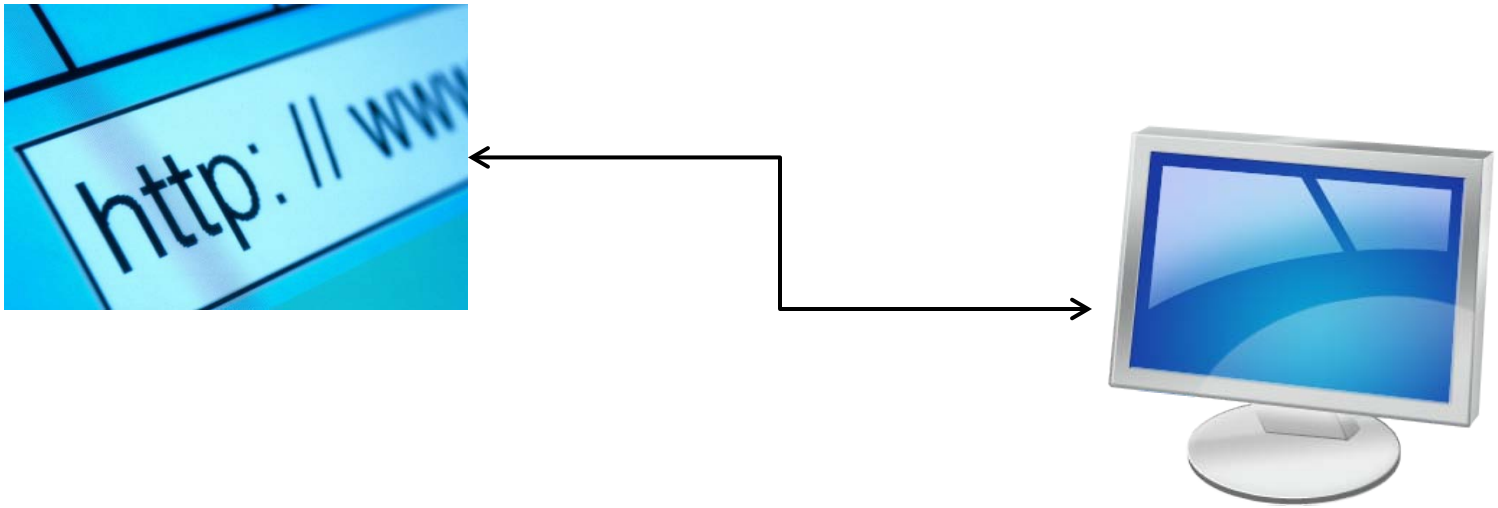
V7 - Client – Server Install

The engineering rules and PAVER™ data are installed on a server, and users access it via individual computers that have the user interface installed on it ("thick client").

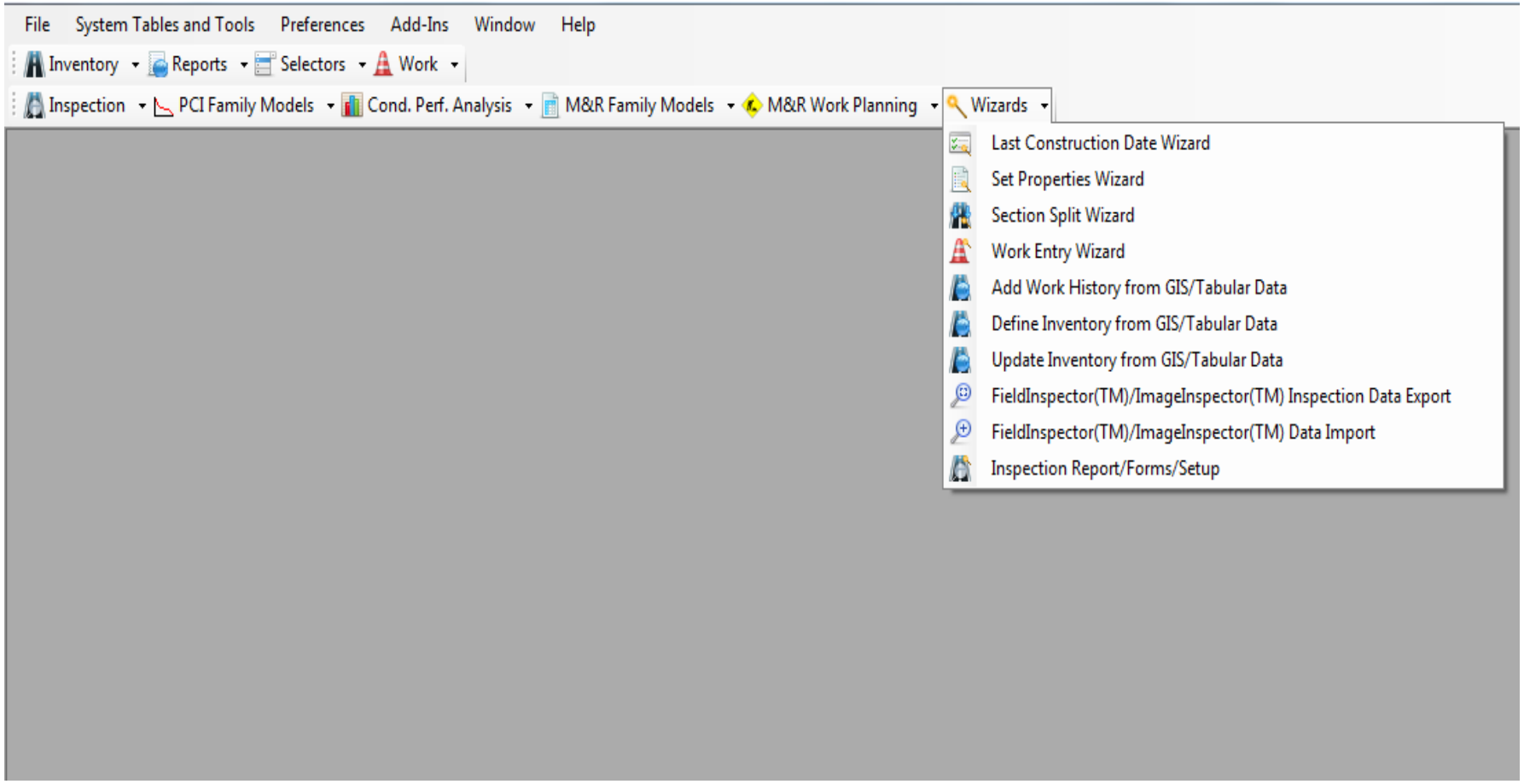


V7 - WebPAVER™ Install

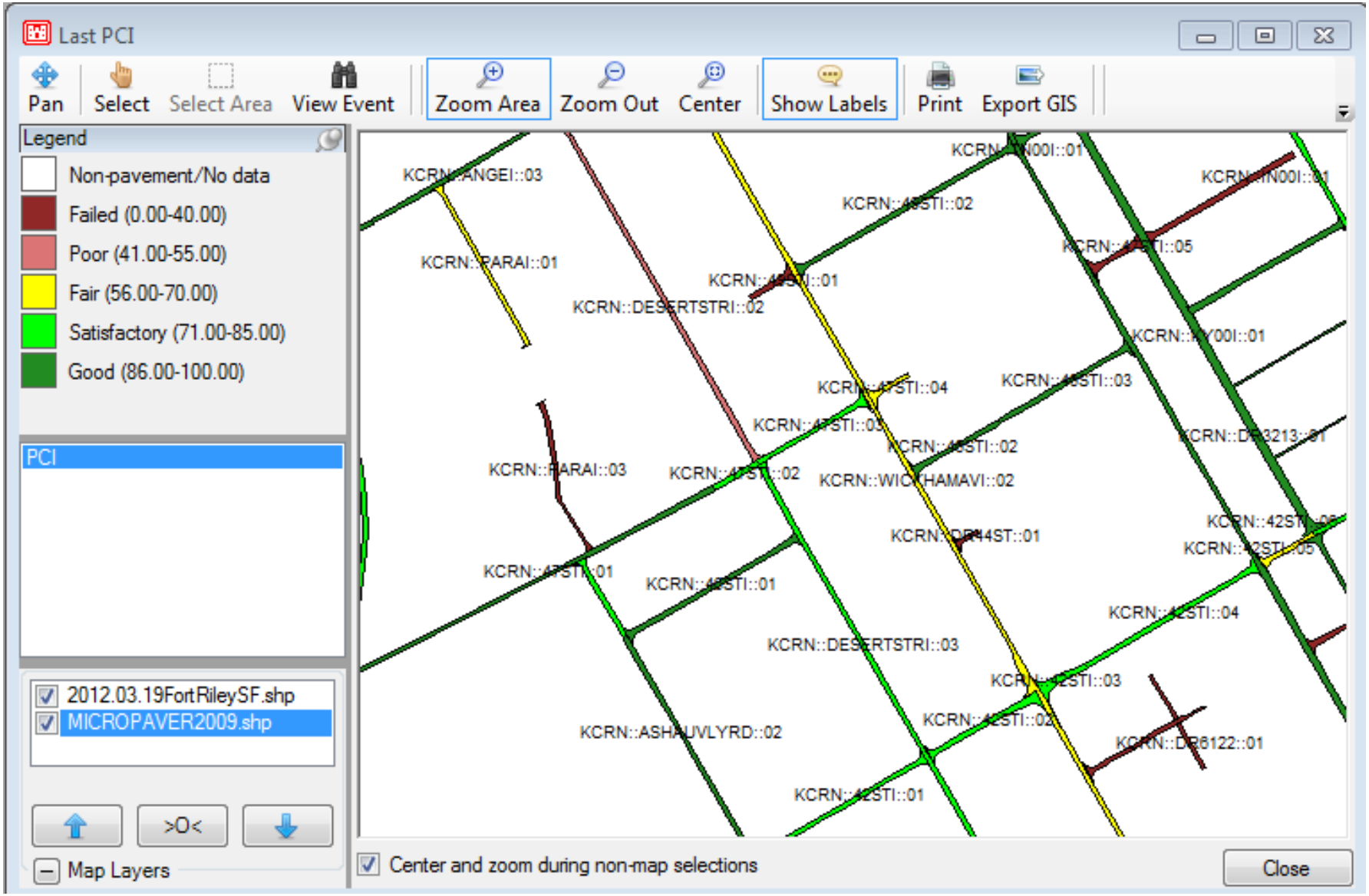
PAVER™ is accessed over the internet so that the thick client, or user interface does not need to be present on the computer in use.



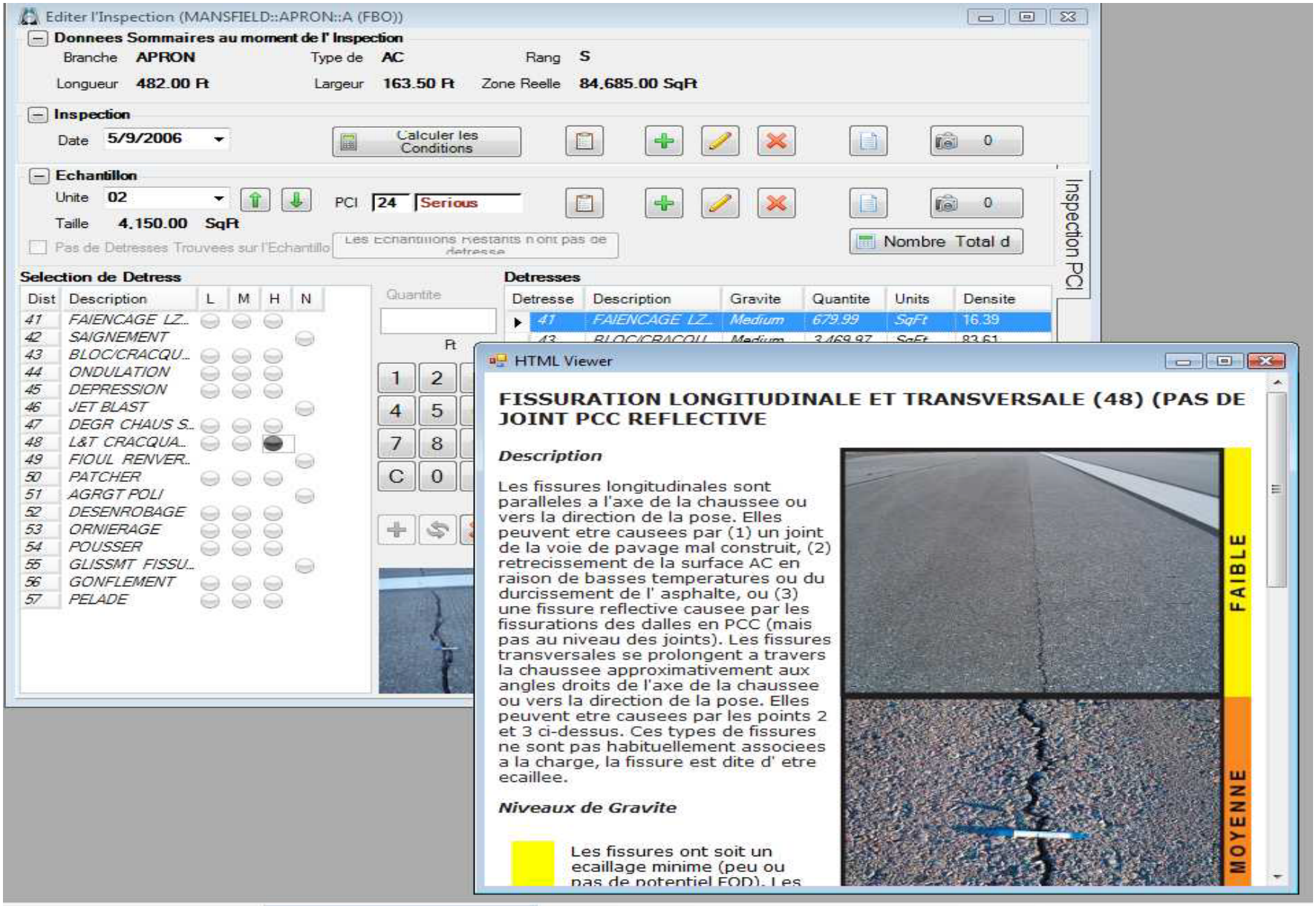
PAVER 7 Desktop – Menu Driven



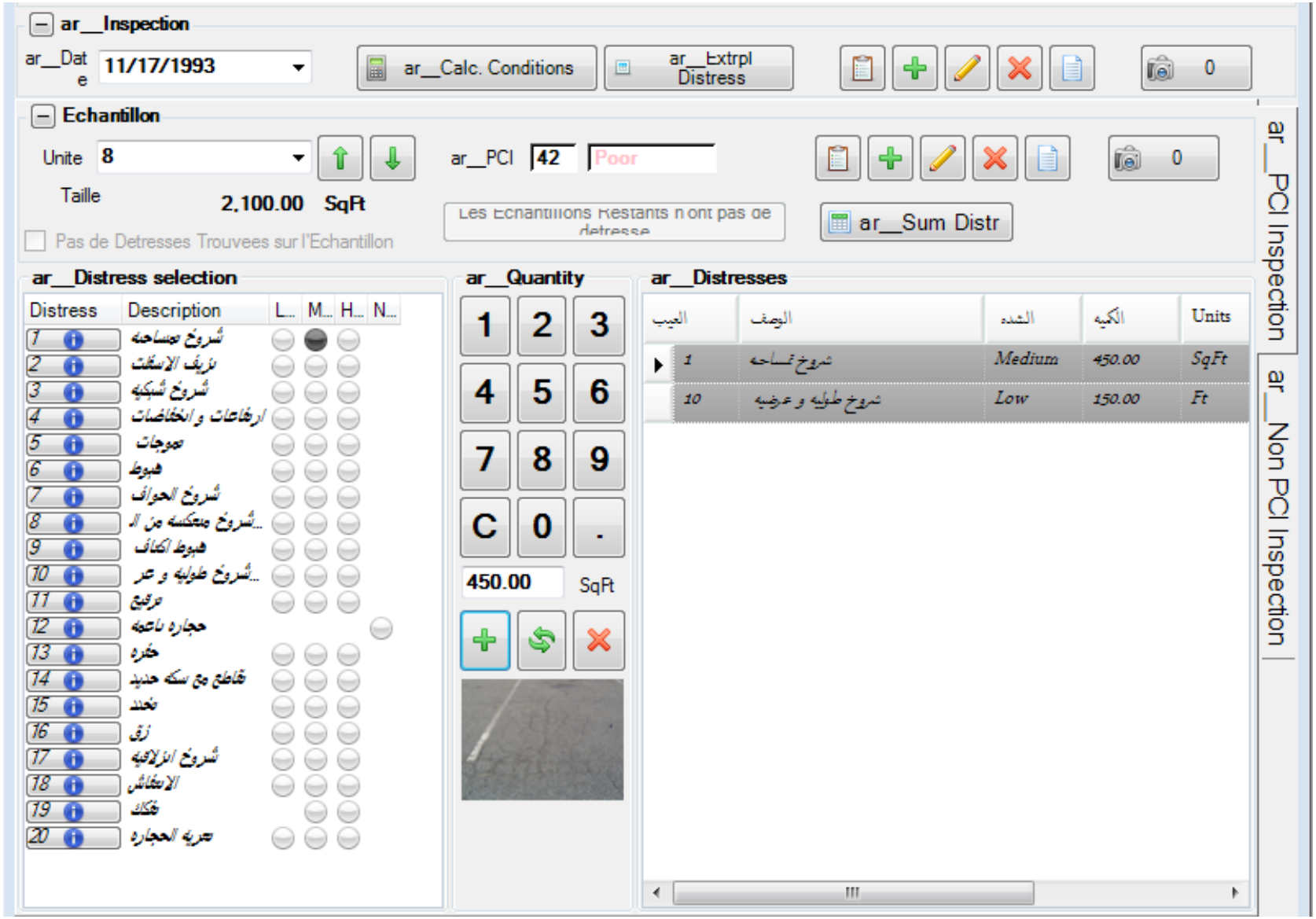
Example GIS PCI Condition Report



French Translation



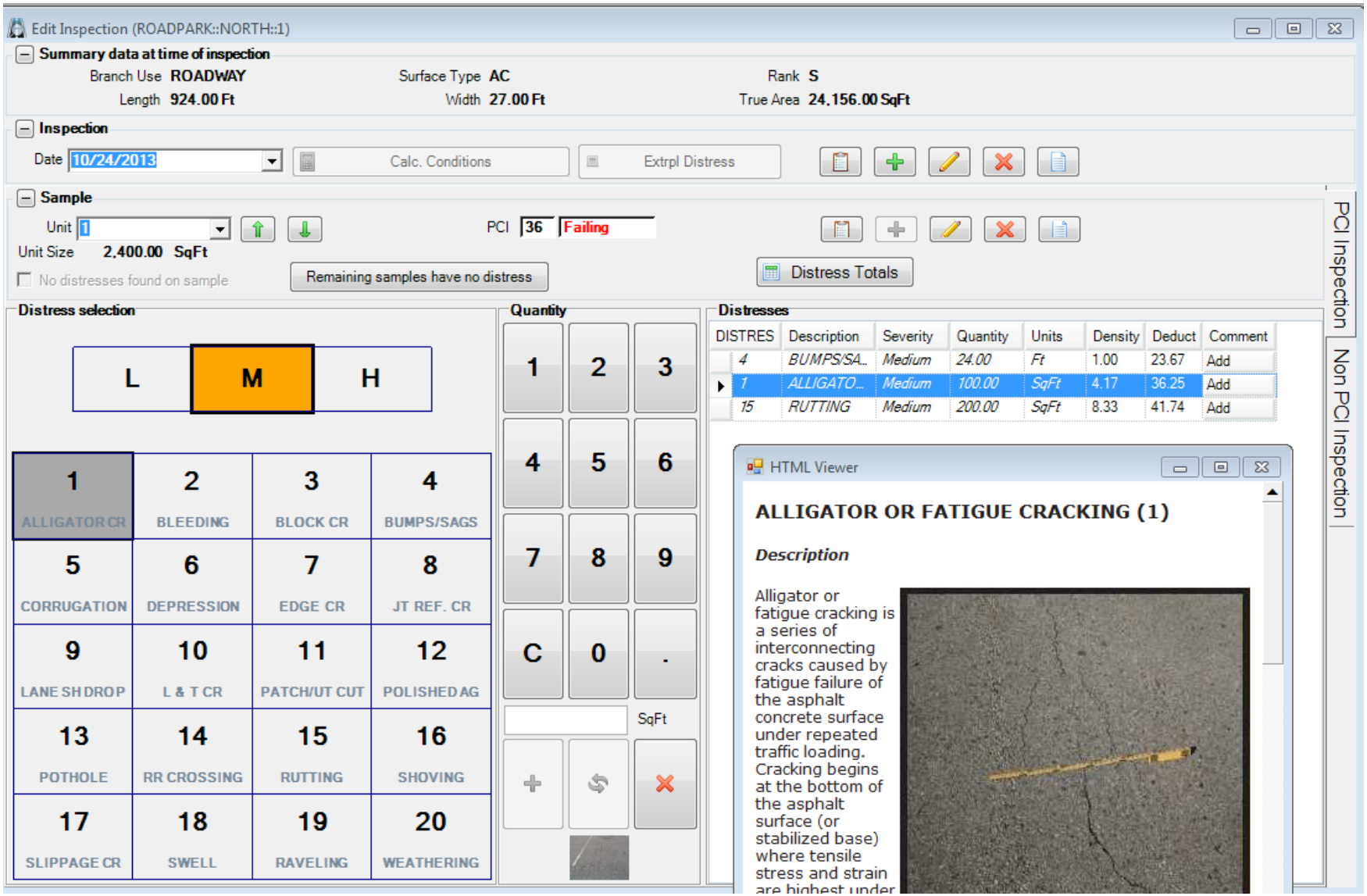
Arabic Translation



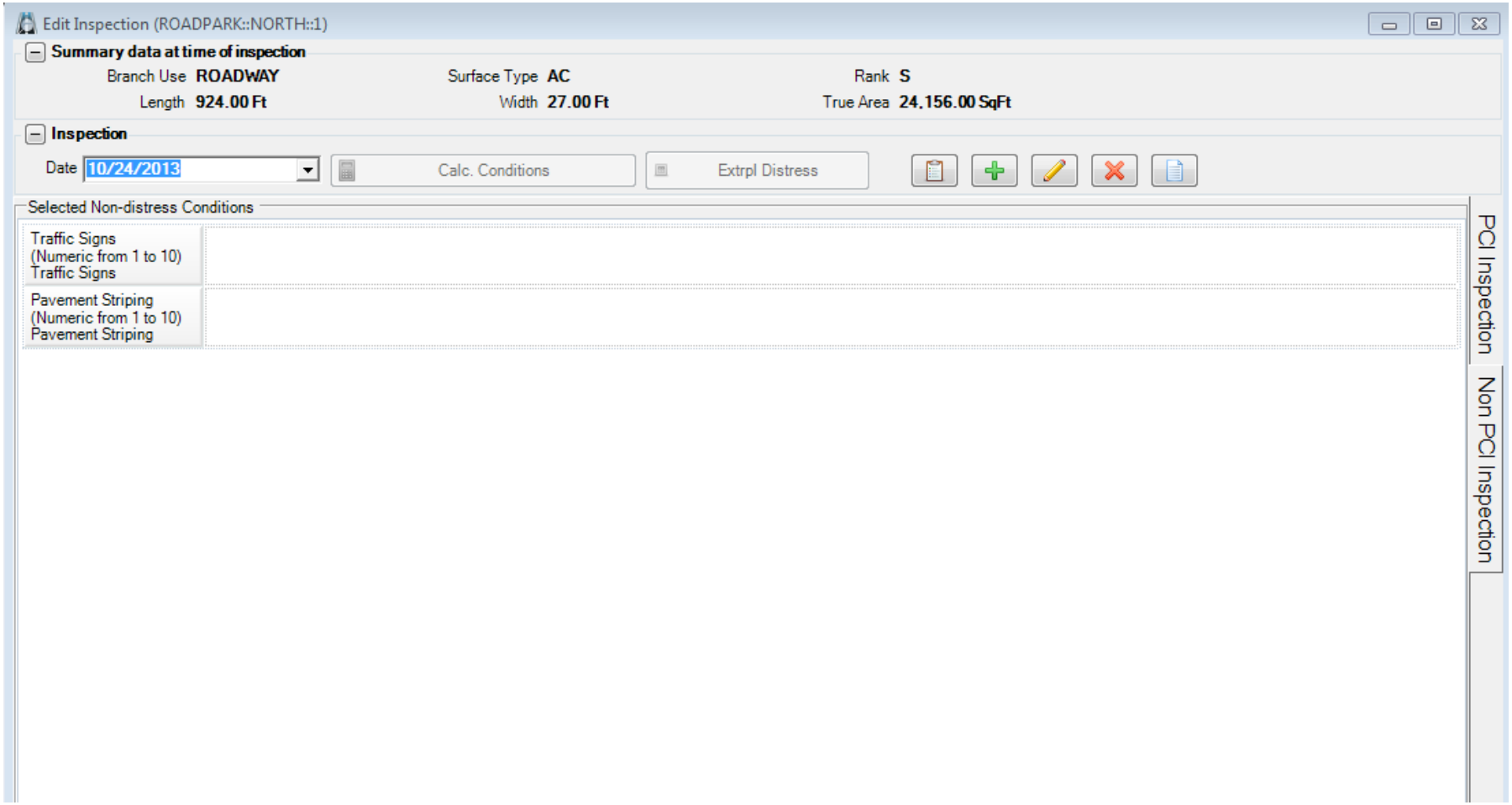
PAVER™ FieldInspector™

PAVER Field Inspector - Asphalt PCI

PAVER™

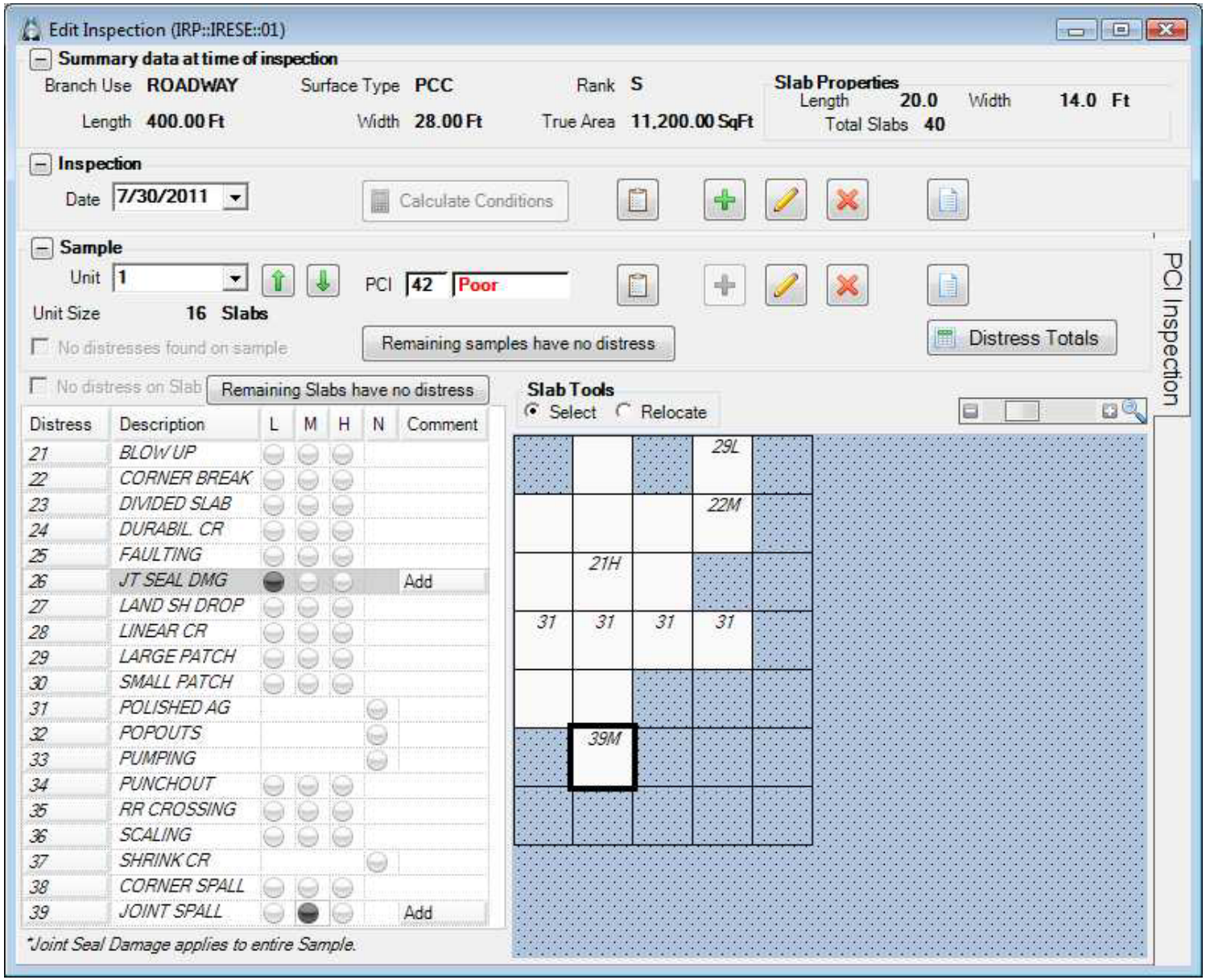


Asphalt Non PCI Inspection



Concrete PCI Inspection

PAVER™



PAVER™ ImageInspector™

PAVER™

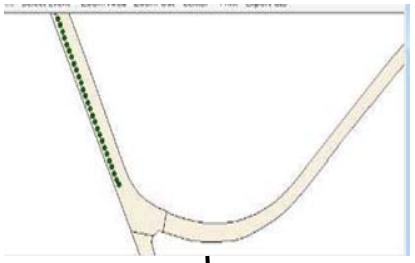
Image Interpretation Workstation

Inventory from PAVER (.i70)

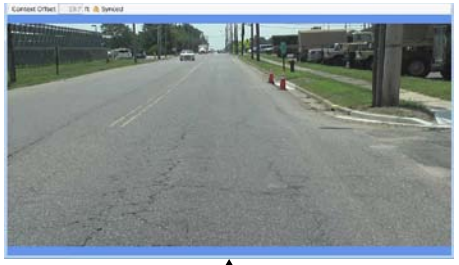
Images and GPS Data

XML Distress Data to PAVER (Import Tool)

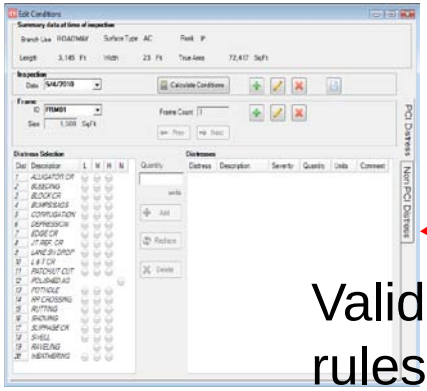
Assign Images to PID



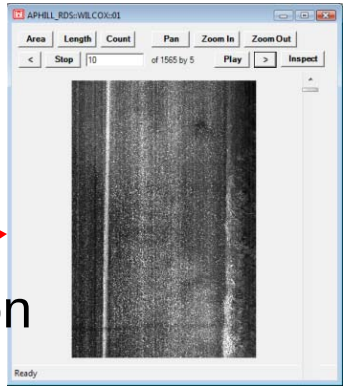
Right of way Image



Inspection

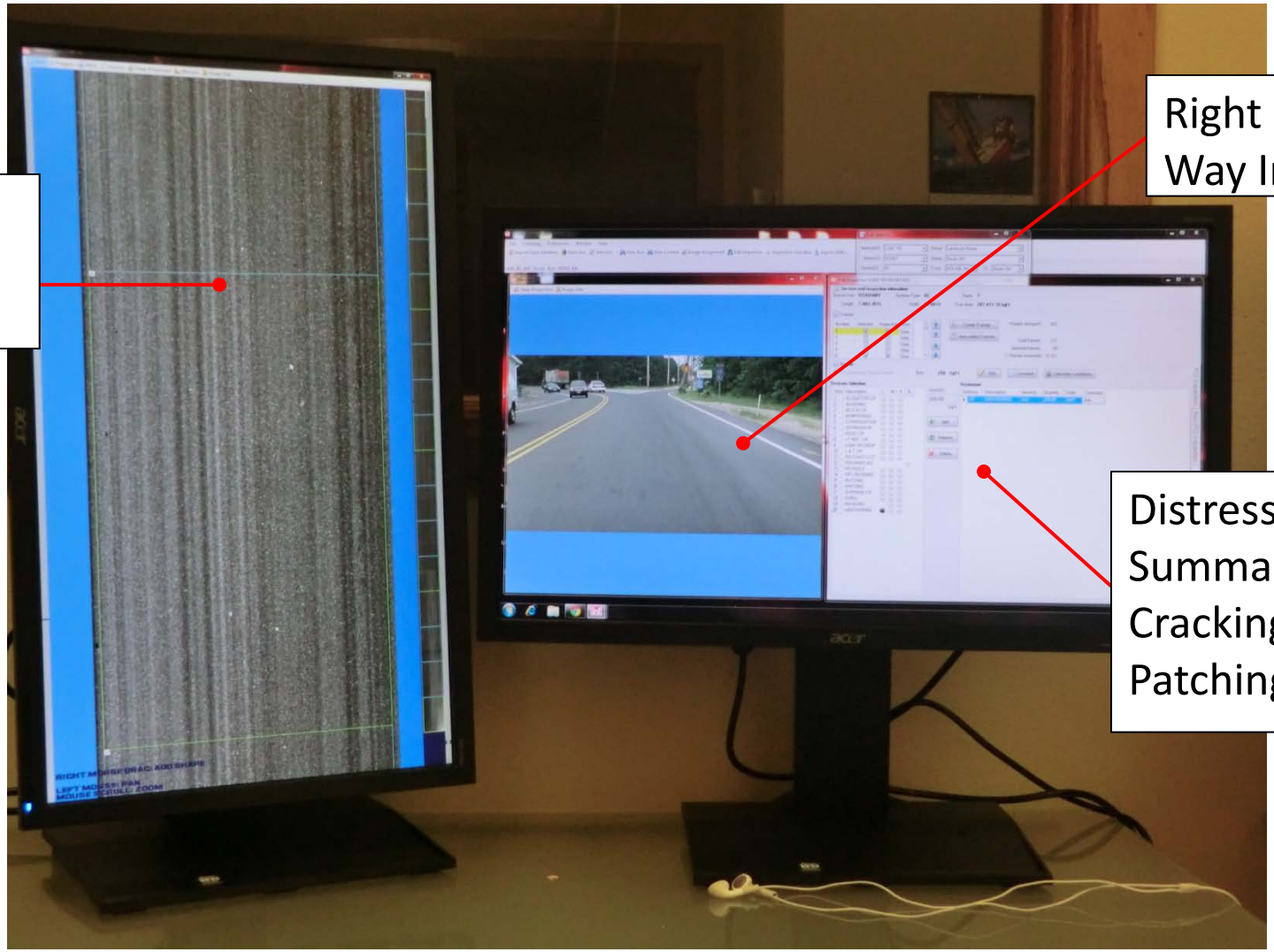


Downward View



Validation rules

Pavement Distress Interpretation



PAVER Users

Consultants
Airports/DOT
Universities
Cities/Counties
Iceland
Finland
Sweden
Norway
Russia
Poland
Ukraine
Kazakhstan
Mongolia
France
Spain
Turkey
China
Japan
South Korea
Afghanistan
Iraq
Iran
Pakistan
Algeria
Libya
Egypt
Saudi Arabia
India
Thailand
Mali
Niger
Chad
Sudan
Nigeria
Ethiopia
Kenya
DR Congo
Tanzania
Angola
Namibia
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Australia
New Zealand
Canada
Mexico
Venezuela
Colombia
Brazil
Peru
Bolivia
Chile
Argentina
North Atlantic Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean

Universities