Pavement Management Program 101

Roger E. Smith, P.E., Ph.D.
Professor Emeritus
Zachry Department of Civil Engineering
Texas A&M University

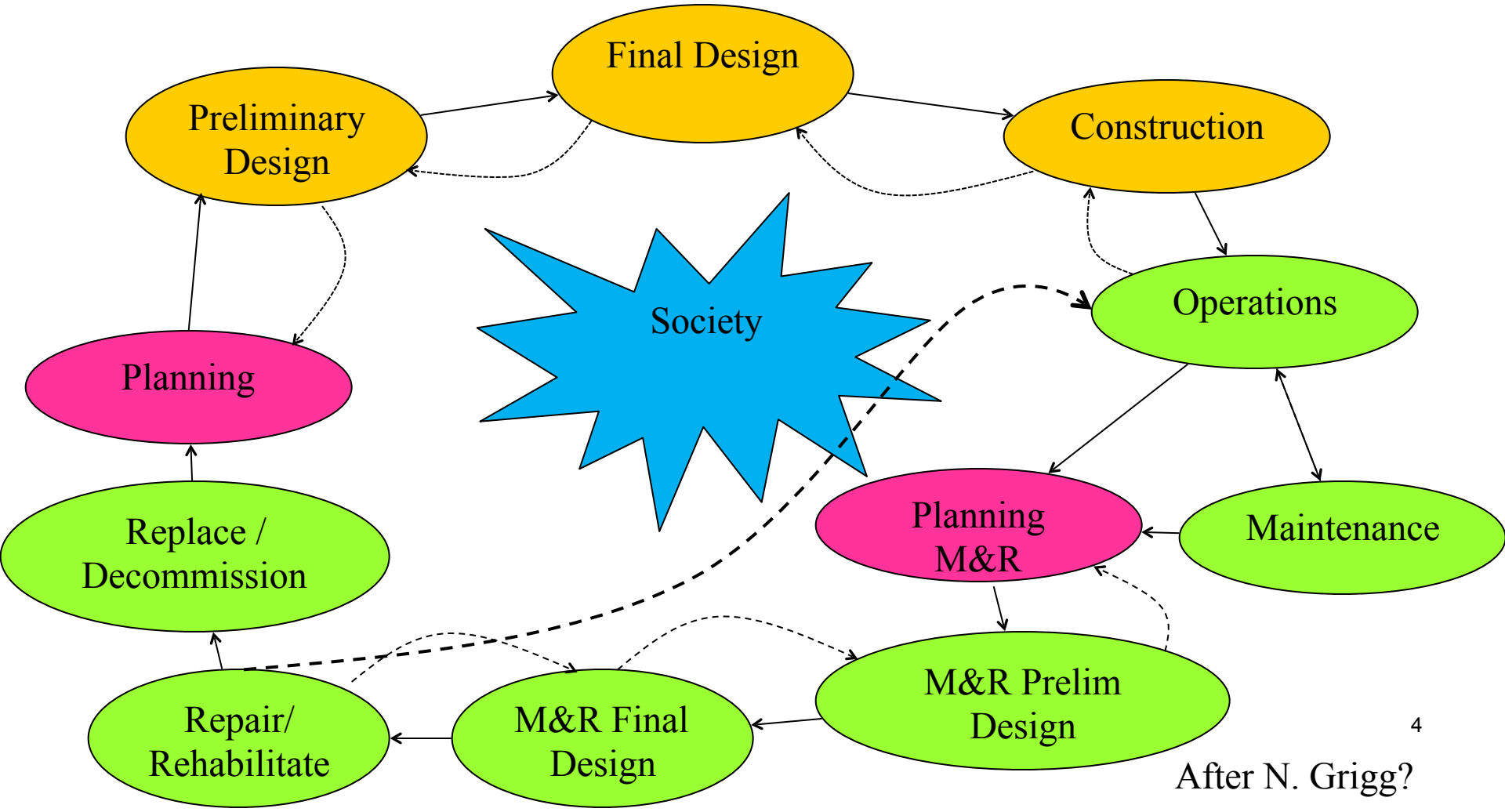
Pavements

- Often the most expensive asset that most public agencies own and manage
- Begin deteriorating as soon as they are built
- Must be kept is serviceable condition to support economic competitive ness

Pavement Management

- A ***Decision Making Process***
- Used to assist in making cost-effective decisions about
  - Design
  - Construction
  - Maintenance
  - Rehabilitation
  - Retrofit or
  - Abandonment

Infrastructure Life Cycle



After N. Grigg?

In Concept

Pavement Management Covers

- Planning
- Programming
- Analysis
- Design
- Construction
- Research

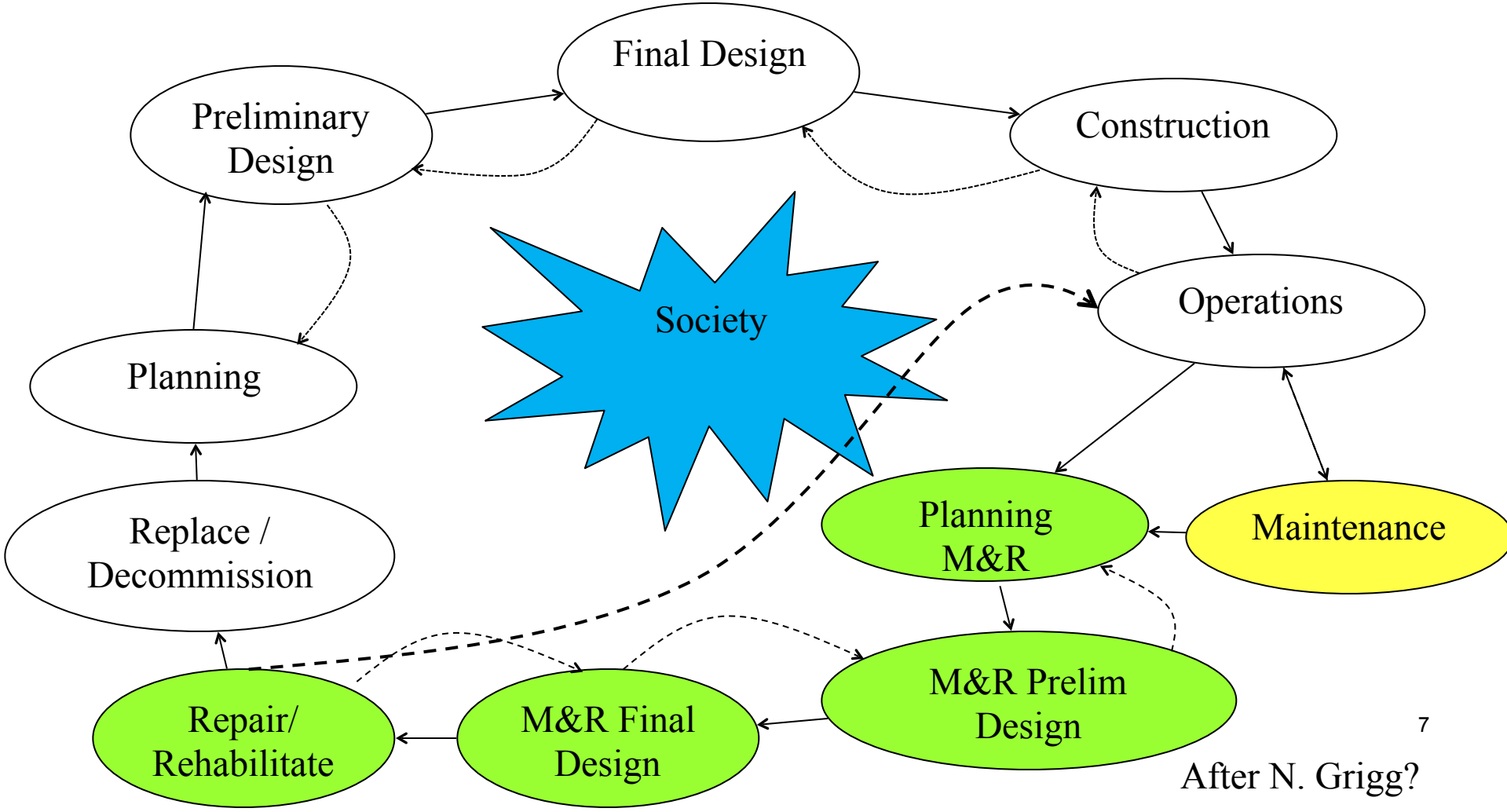
As Implemented

Pavement Management Systems Primarily Address:

- Maintenance
- Rehabilitation
- Reconstruction

of the *Existing Pavement System*

Network Level PMS Primary Focus



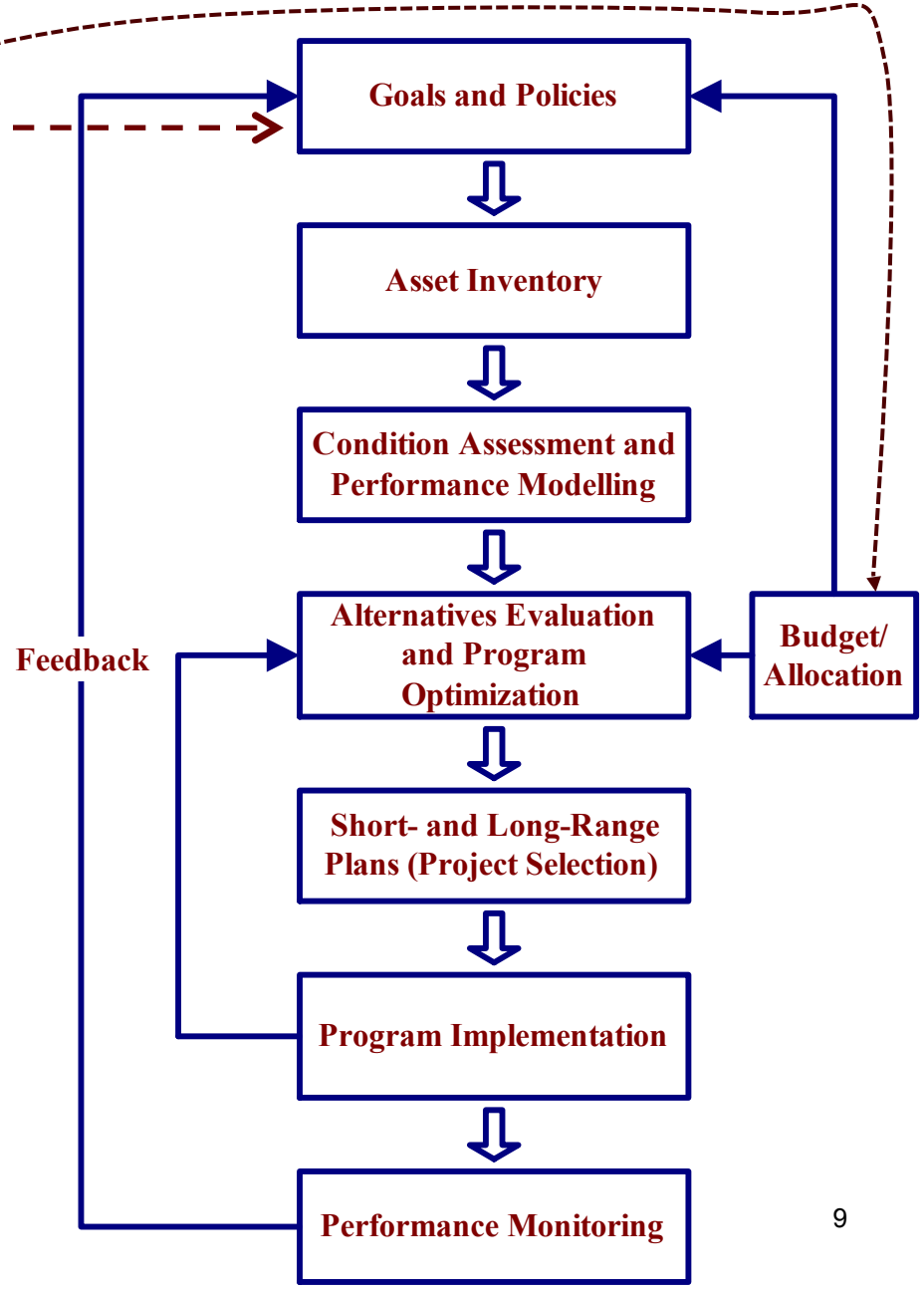
After N. Grigg?

Pavement Management System or PMS Software

- Decision support tool
  - Store data
  - Provide information
  - Prepare reports & graphs
- Help make cost-effective decisions
  - Primarily at network-level
    - Some assistance in project-selection
  - Addresses existing pavement system
    - Does not address need for additional roads & streets

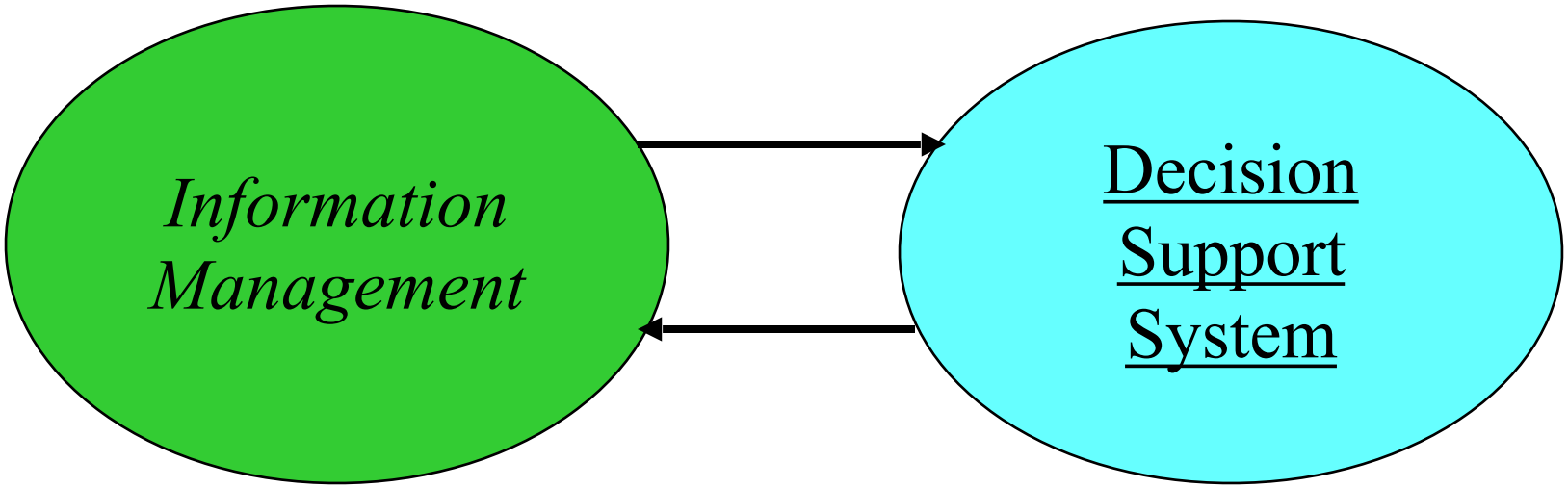
Input from Elected Officials & Citizens

Infrastructure Asset Management Framework

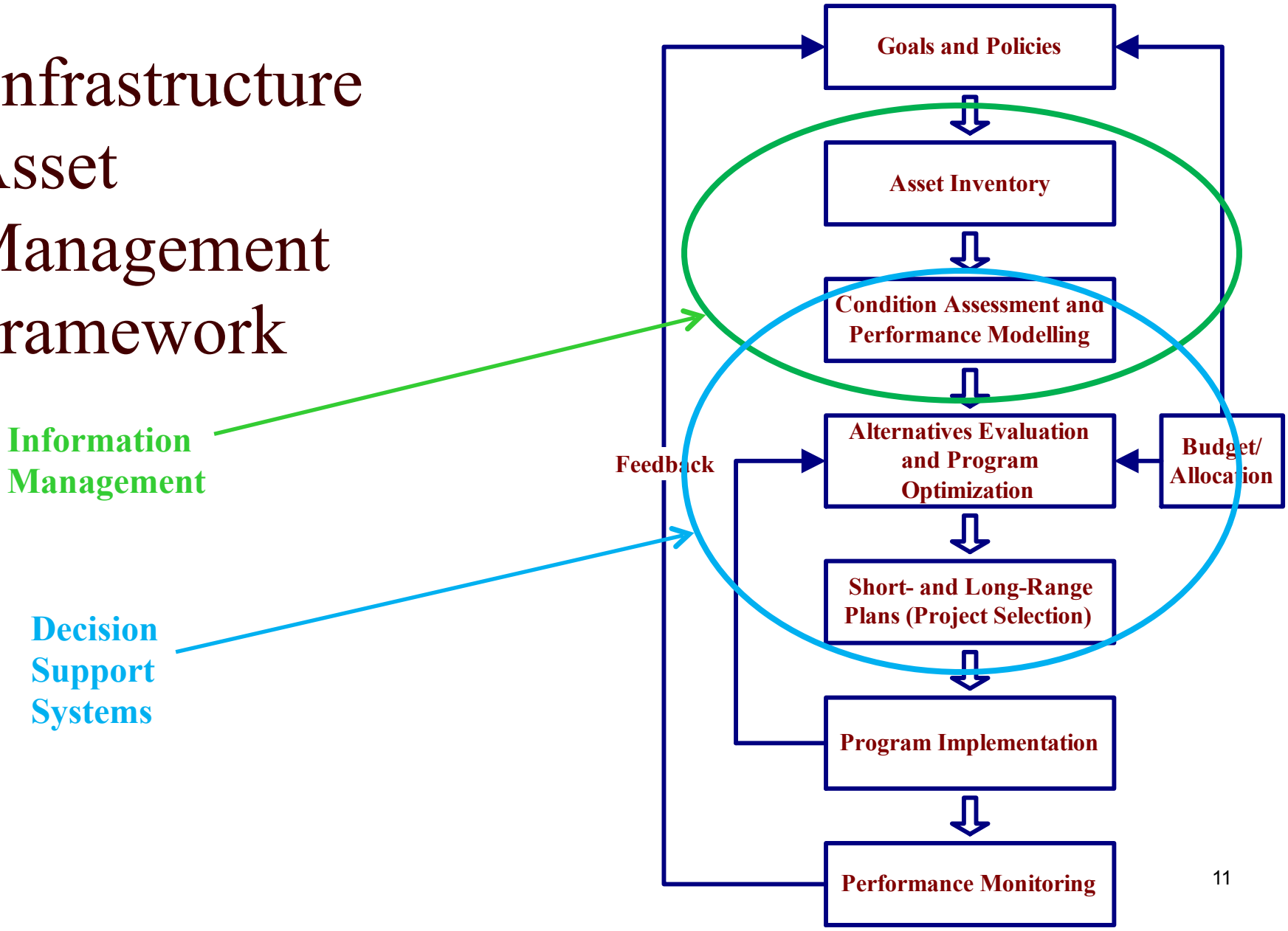


Infrastructure Asset Management

Major Sub-Components



Infrastructure Asset Management Framework



Operates in Management Levels

- ***Strategic (Asset) – Planning, Programming & Allocation for All Systems***
- ***Network - Planning & Programming for Entire Set of Type Facility Managed***
- *Project Selection - Programming a Subset*
- Project
  - Designing a Specific Section
  - Constructing Specific Section

Important to Consider Management Levels

- Need different detail in data to support decisions at different levels
- Need different information to effectively communicate with decision makers at different levels

Strategic – Level

- Related to investment analysis & fund allocation
  - Total funds needed and allocation of funds for each type facility to meet established goals
  - Show impact of funding options
  - Justification of funds
- Communicate with funding authorities
  - Level of service desired (goals & policies)
  - Investment needed to provide that service
- Previously considered planning activities

Network-Level Pavement Management

- Related to the budget process for pavements
  - Long-term plans
  - Identify pavement maintenance and rehabilitation needs
  - Funds needed to complete pavement M&R
  - Prioritized listings of pavement segments needing work
- Allocation to
  - Sub-organizations (maintenance or political districts)
  - Funding categories (maintenance, rehabilitation, safety, etc.)
- Show impact of funding options
  - Preservation vs new construction
  - Distribution among sub-organizations
- Communicate within agency

Input from Strategic-level

Project-Selection-Level

- Short-term plans
- Identify constraints not previously considered
  - Physical
  - Financial
- Refine alternative treatments
- Improve cost estimates
- Select segments for funding & project-level analysis, design & construction in near term
- Show impact of deviation from network-level plans

Input from Network-level

Project-Level

- For sections selected for immediate work
- Develop cost-effective strategy for:
  - Original construction
  - Maintenance
  - Rehabilitation
  - Reconstruction
- Within imposed constraints
- Complete design
- Construct project

Input from Project Selection-level

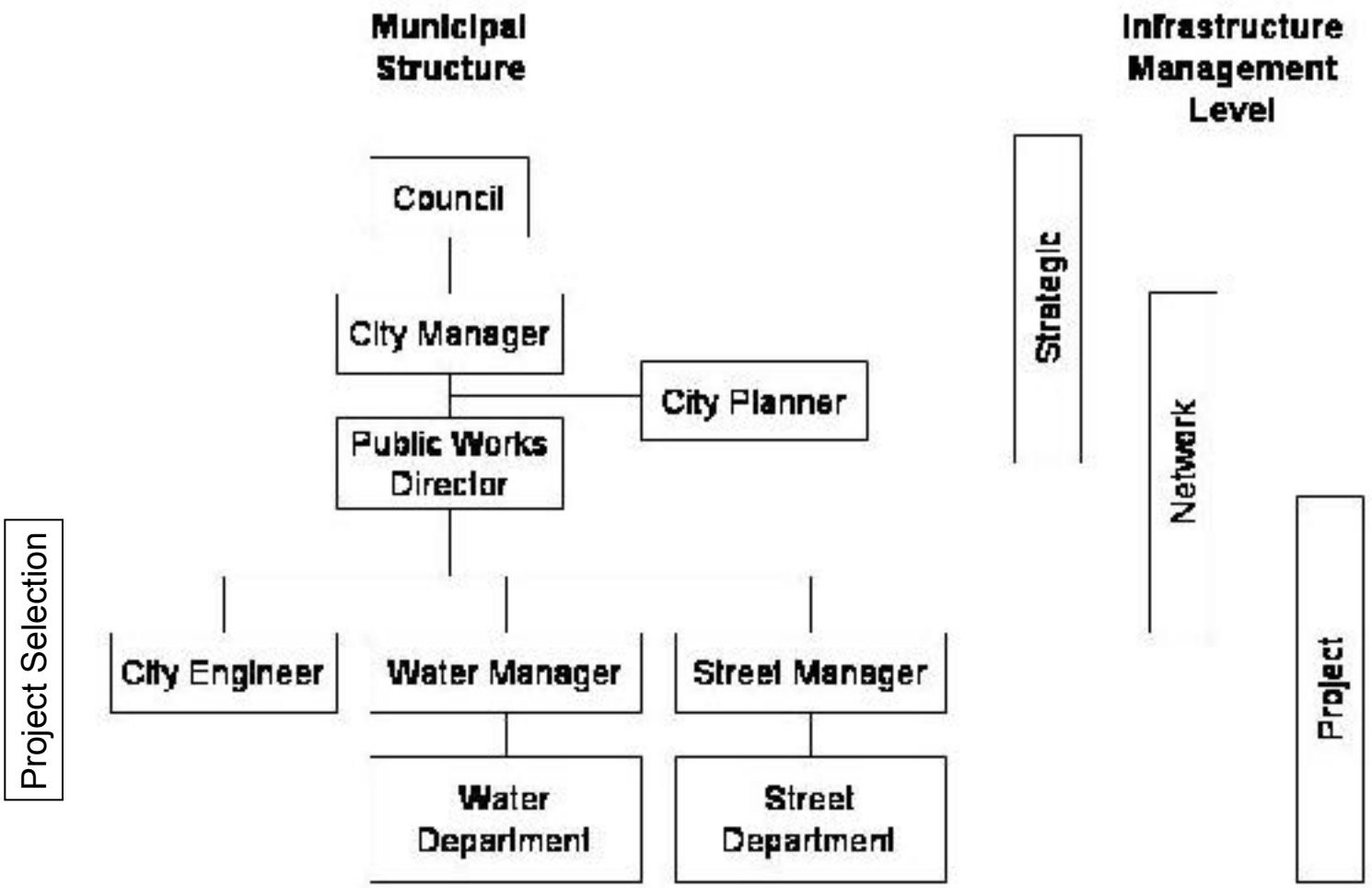
Post Project-Level Analysis & Design

- Complete required work
- Monitor construction
- Monitor performance

Differences in Those Responsible

- Project-level
  - Engineers/technical staff
- Project-selection level
  - Senior management and/or department/district managers
  - Department/district staff
- Network-level
  - Senior management & funding authorities
  - District/department managers
- Strategic-level
  - Funding authorities
  - Senior management

Typical Municipal IM Organization



Those Responsible Vary

- Differences Depend on:
  - Centralized, Decentralized, Public Private Partnerships or Privatized
  - Funding Source
    - Capital vs Maintenance
    - Enterprise vs General vs Dedicated Funds
  - Importance of Facility
  - Organizational & Historical Relationships

Differences in Data Needed

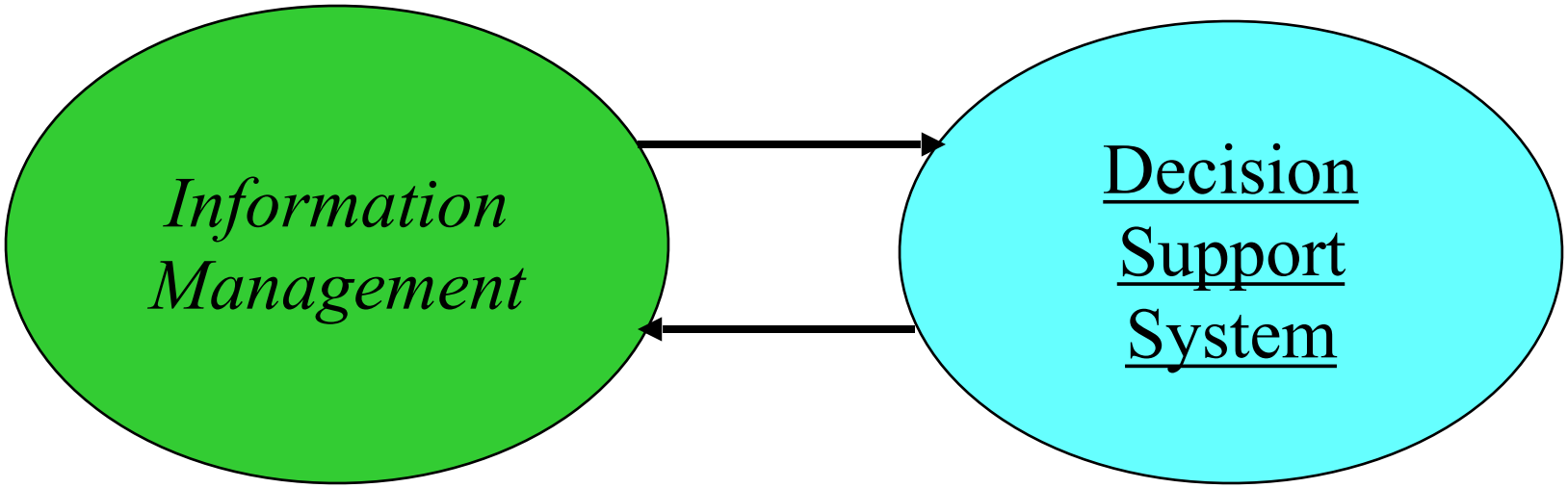
- Project-level
  - Detailed data needed to complete design
  - For very small % of network
- Project selection-level
  - Enough data to select projects to be funded
  - For small % of network
- Network-level
  - Enough data to identify candidates & support allocation
  - For entire network
- Strategic-level
  - Data from network-level (entire network)
  - Data that funding authorities can use
  - Indicators of work performed and results achieved

Network-Level

- Data on *every segment in the network*
- Enough to identify:
  - *Best group of candidate segments* or
  - Number & type of segments that need to be addressed
  - Funding impacts of different alternatives
  - Optimization, prioritization, or simulation using empirical models that connect *condition, or changes in condition,* of type facility to changes to *funds invested*
    - Network-level condition
    - Network inventory
    - Past M&R, etc.

Infrastructure Asset Management

Major Sub-Components



Network-Level Activities

- *Inventory*
- *Condition Assessment*
- Determination of Needed Work & Funds
- Identification of Candidate Projects
- Determination of Impacts of Funding Alternatives
- Feedback & Upkeep

Inventory

- What agency is responsible for
  - What it “owns”
- Where it is located
  - Location referencing
  - How is it connected to other sections
  - Political subdivision in which it is located
- Importance of section
  - Functional classification
  - Etc.

Basic Information

- Length, width, area, etc.
- Layers & materials
  - Records
  - Work completed
  - Coring
  - Ground penetrating radar
- Usage
  - Especially heavy wheel (truck) loads

- Work completed
  - Construction
  - Rehabilitation
  - Maintenance
- Dates of completed work

Issues

- How much data to collect and store at network level
- How to interface data with other databases in agency
- What level of detail must be kept current
- How to store and manage data

Approaches

- Requiring too much data to begin may result in abandonment
- Too little data will not provide support needed
- “Collect on the data you need when you need it”
- “History begins now”
- Stage data collection over time

Condition Assessment

- Health of individual segments
  - Engineering
  - Functional
  - Safety
  - Noise generated by traffic
- Collectively define health of network

Engineering

- What do engineers think of pavement?
- Surface condition
  - Measure of observable distress
    - Manual surveys &
    - Vehicle mounted Semi-automated
- Structural integrity
  - Deflection testing with back-calculation
  - Supplemented with coring & lab testing

Functional

- What do users think of pavement when driving/riding on it?
- Primarily
  - Roughness
  - Ride
- Standard vehicle mounted testing equipment

Safety

- How safe is pavement to drive on?
- Primarily
  - Surface friction
  - Skid
  - Hydroplaning potential
- Vehicle/trailer mounted equipment
  - Portable equipment for spot tests

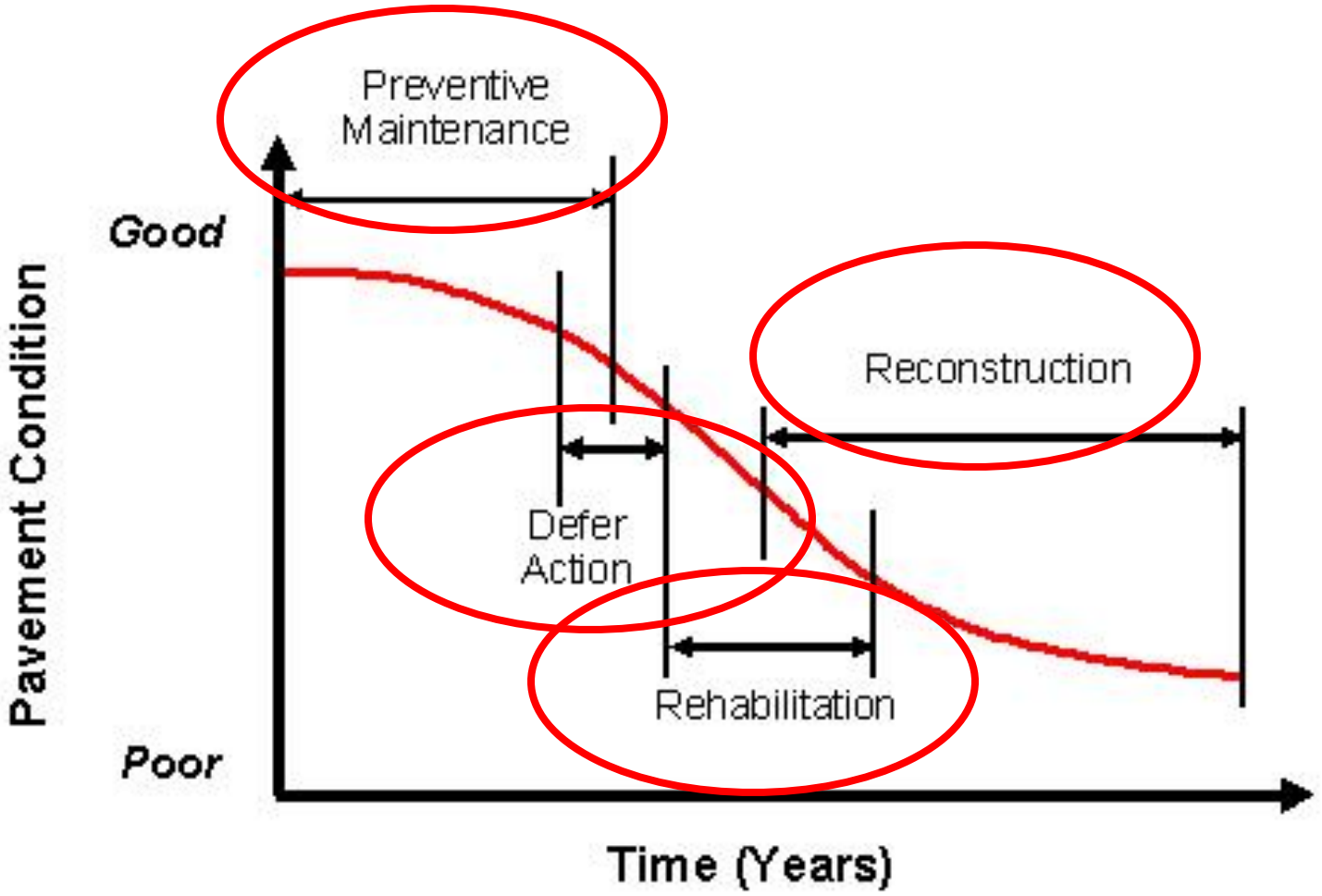
Noise

- USA – noise greater than ~70 decibels
- Generated by tire interaction with pavement surface
- Primarily a problem on higher volume-higher speed pavements in urban areas
- Cannot control tires
- Can select surface types used
- Standardized measurements still being developed

Common Data for Local Agencies

- Observable Surface Distress (when to intervene)
  - Network - a Sample
  - Project Selection Level Verification
  - Project Design - Quantities
- Structural (is it strong enough)
  - Deflection and coring
  - Project Selection Level Verification
  - Project Design

Network-Level Treatment Selection Normally Based on Pavement Condition



Structurally Adequate

- At network level - often overlay required
  - Presence of major load-related distress
- At project selection level and especially at project level
  - Coring
  - Deflection testing

Other Types of Data in Local Agencies

- Roughness – do I need to address ride
  - NHS
  - Arterials
  - Local – impacted by speed, obstructions
- Skid – is this an issue
  - Intersections where skid related accidents are frequent
- Noise – mostly high speed-high volume
  - Seldom

Distress Types

- Distress types caused by
  - loads
  - material problems or deterioration
  - climatic factors

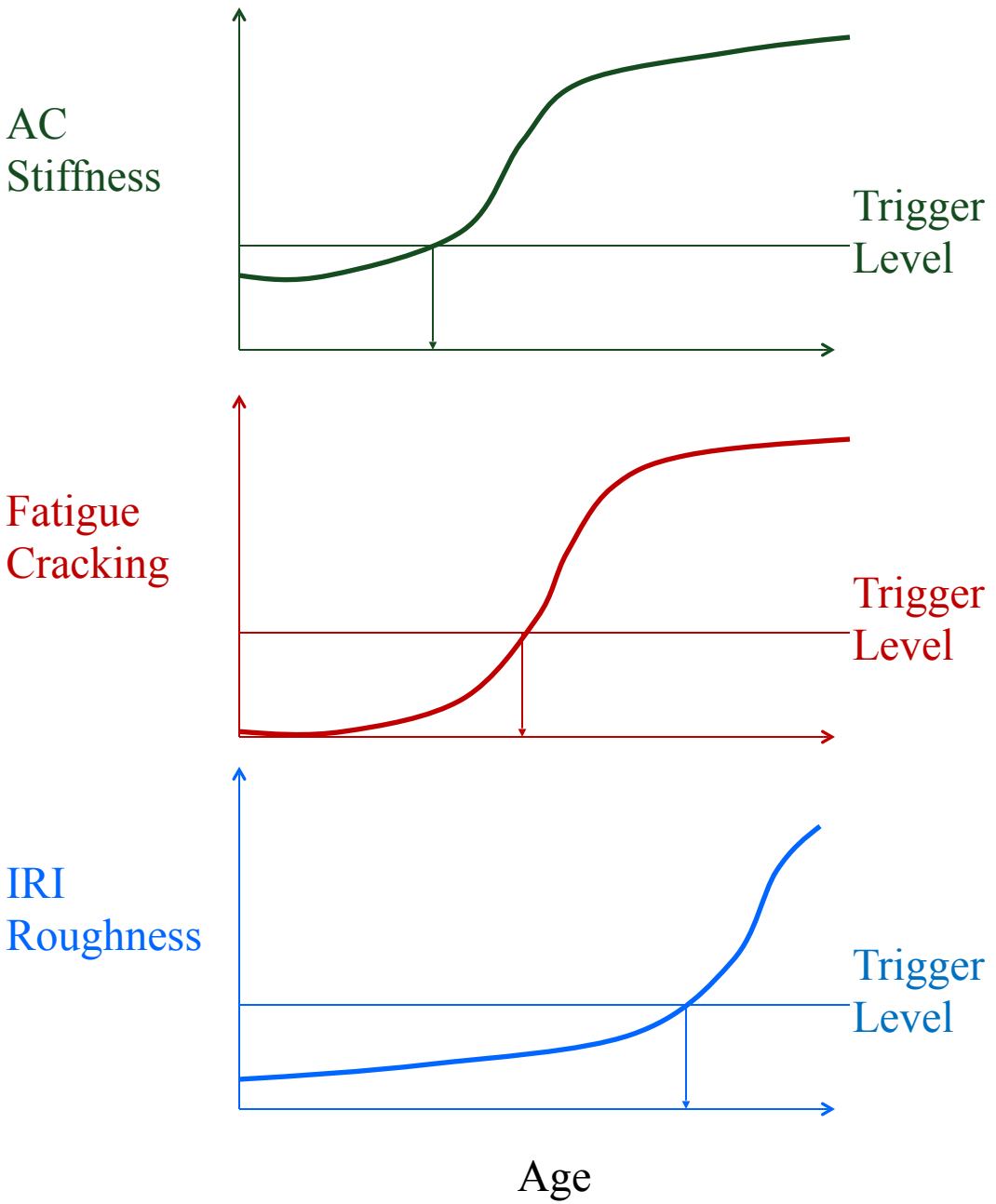
- Distress types lead to roughness

Distress to Roughness

- Distress will lead to roughness
- Better to set intervention based on distress
- Better yet to set intervention based on changes in material properties - not currently possible

Pavement Condition & Performance Measures

Provide safe & smooth pavement surface for traveling public



Other Issues Impacting Decisions

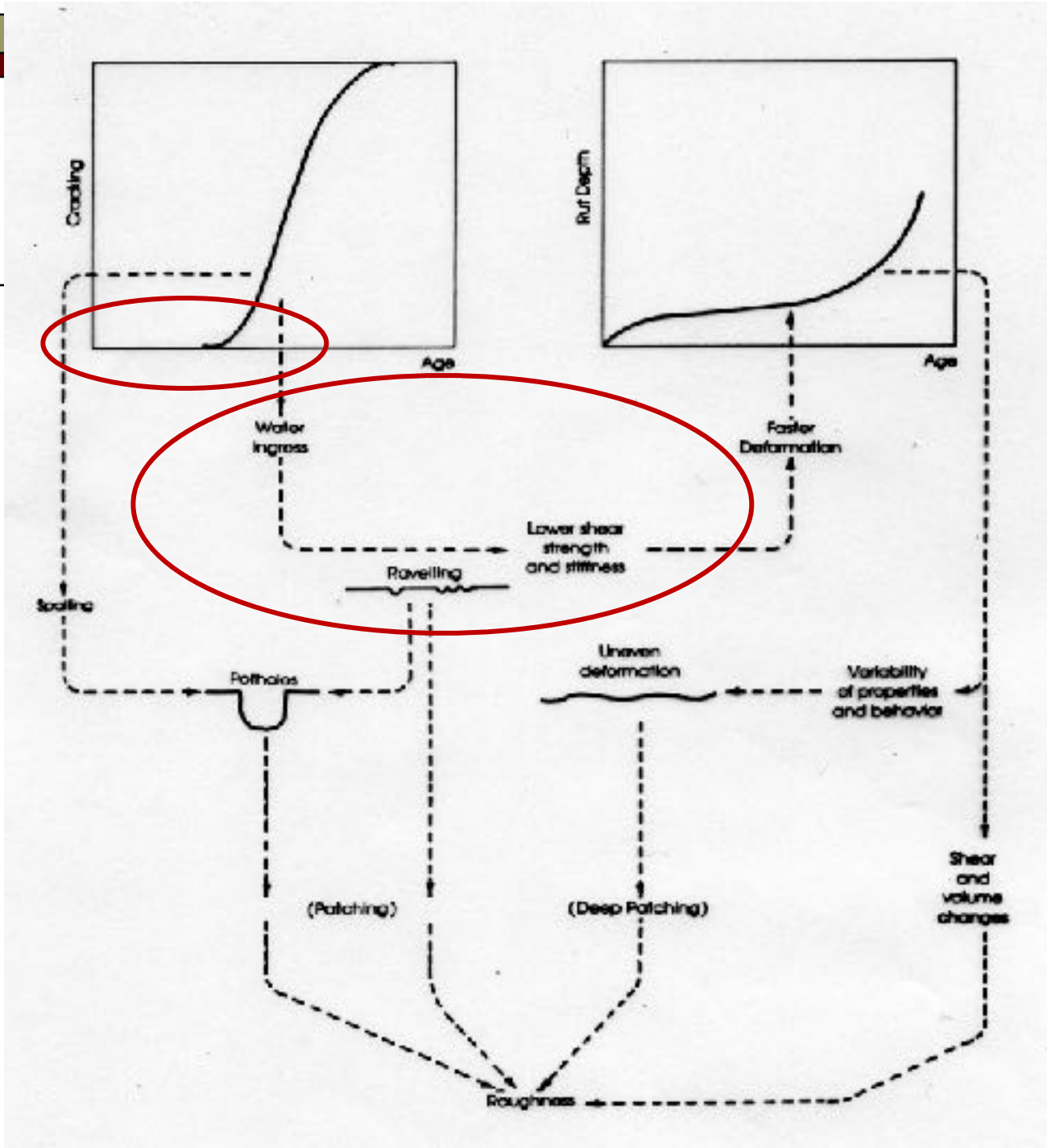
- Are pavement layer materials durable?
  - Premature weathering & raveling
  - Slippage cracks & double wheel ruts
- Is drainage adequate?
  - Standing water
  - Water seeps
  - Wet spots & saturated materials
- Has previous maintenance been abnormal?
  - Excessive patching & repairs

Preventive Maintenance

Prevent development of extensive distress

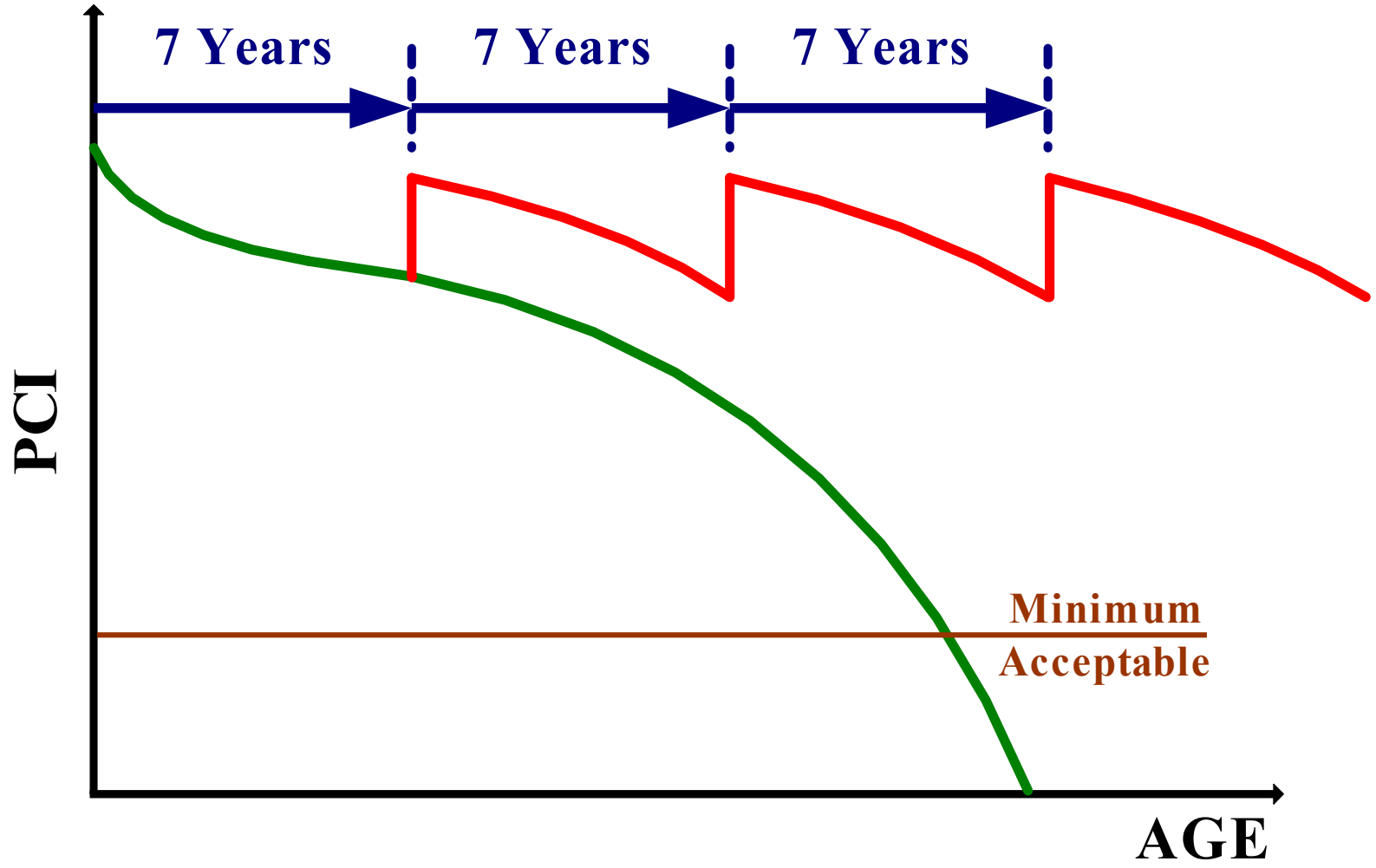
Primarily addresses environmental caused deterioration

Preserves existing structure so that it can resist traffic loadings



Preventive Maintenance

Keep cracking & other distress from developing



Collecting Condition Data

- One of the most costly parts of:
  - IMS implementation
  - Keeping IMS operating
- Manual (still used extensively)
- Automated (a few specific types)
- Semi-automated (collected by machines, interpreted by people)
- Remote Sensing (developing field)

Collection Methodologies

- Affect:
  - Accuracy ↑
  - Precision ↑
  - Resolution ↑
  - Cost ↑
- Select procedure to meet needs and match resources

Data Collection Advances

- New technologies are allowing us to collect more at lower cost
  - Operating systems
  - Monitoring systems
  - Observation data
- This will increase
  - Old data is often not equivalent to new data

Data Collection & Management Levels

- Network Level
  - Often indicators
- Project-Selection Level
  - More complete info
- Project Design Level
  - Design level data

Collect only the data you need
At the level you need it

Stage Data Collection

- Some amount of a damage indicator triggers another data collection effort
  - Load related surface distress triggers structural evaluation
  - Wet weather accidents trigger surface friction testing

Collect only the data for
the Sections that need it

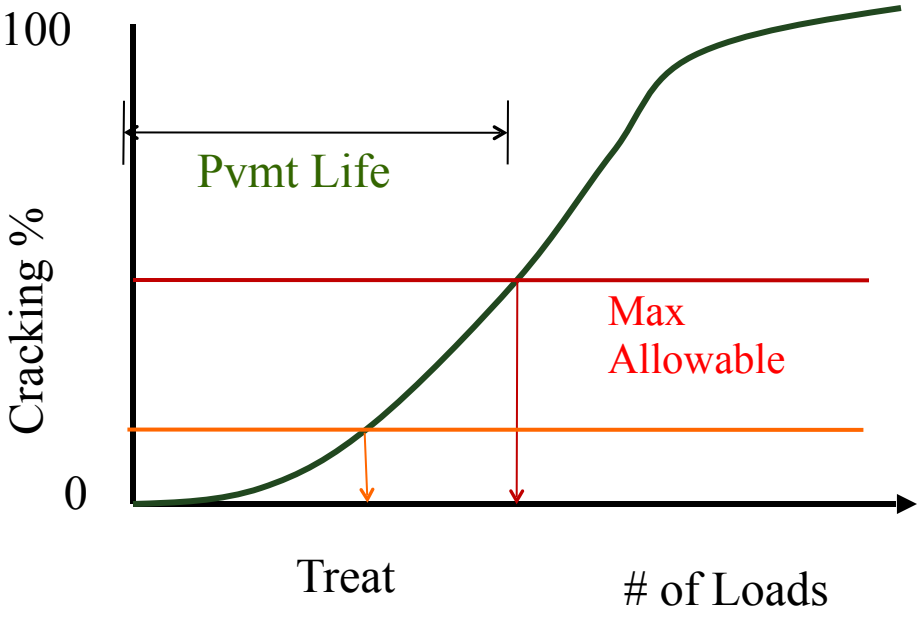
Staged Data

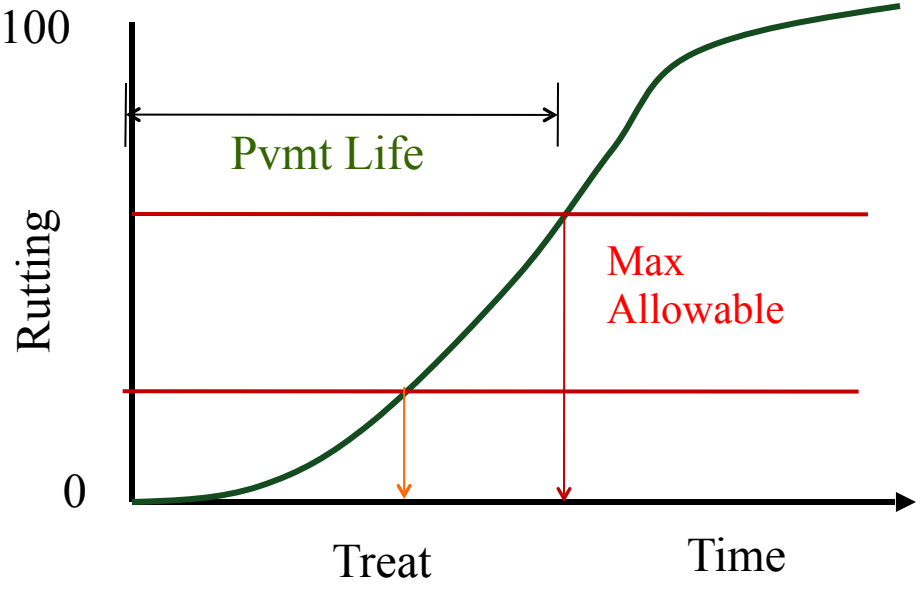
- Network-level – distress on every section
- Project-Selection – more distress, maybe deflection, maybe roughness (seat-o-meter?)
- Project-level – detailed materials and structural data for major rehabilitation/ reconstruction

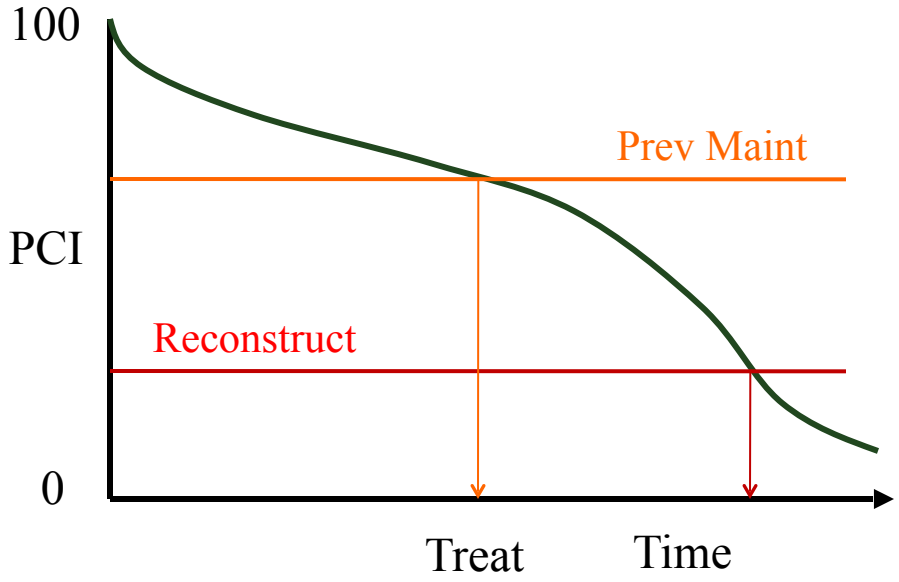
Interpreting Data

- Individual measures
- Individual indexes
- Combination indexes
- Mostly network-level engineering/public works communication number

Indexes Often Used at Network & Strategic Levels







Multiple indexes and Measures can be

Automated Collection of Distress

- Improve safety of personnel
- Decrease traffic interruptions
- Funds to contract but limited staff
- Will not collect “same” data

- Don’t switch back and forth between manual and automated

Manual Collection of Distress

- Requires commitment of trained personnel
- Develops expertise within agency
- Can improve understanding of pavement performance
- Can help develop confidence in PMS
- Can help develop communication with agency

Quality Data

- Develop quality control & quality assurance plans for data
- Define what is required
  - Type of data
  - Accuracy
  - Precision
  - Resolution

Contracting for Data Collection

- Define:
  - Data to be collected
  - Accuracy needed
  - Precision desired
- Let economics tell how to collect
- Require data quality plan from collecting firm

Quality Control Plan for Contracted Data Collection

- Prequalification of inspection agency
- Description of the training and experience of the inspectors
- Certifications of inspectors
- Data verification processes completed by the contractor which can include:
  - Periodic re-inspection of "control" sections
  - Re-inspection of sections previously inspected
  - Re-inspection of inspected sections by a supervisor
  - Re-inspection of inspected sections by independent evaluation
- Define what will considered acceptable
- Describe what be required if the re-inspection data is not acceptable

Quality Acceptance Plan for Contracted Data Collection

- Verification that Quality Control plans are conducted
- Check Quality Control results to ensure that the required tolerances were met or appropriate corrective actions completed
- Inspection of small percent of sections inspected by contractor
  - Define acceptance criteria
  - Define requirements imposed on contractor when acceptance criteria is not met
- Data checks
  - Check against prior inspection data for same section if no treatment has been applied since last inspection
  - Check against projected PCI

Quality Control is Worth the Cost

- You wouldn't spend money on construction without quality checks

- Don't spend money on inspection without quality control !!

Needs Analysis

- Determines
  - What segments (or group of segments) need work
    - All segments needing work to provide selected level-of-service
  - Cost to complete work
    - That is needed without regard to funds available
  - During designated analysis period

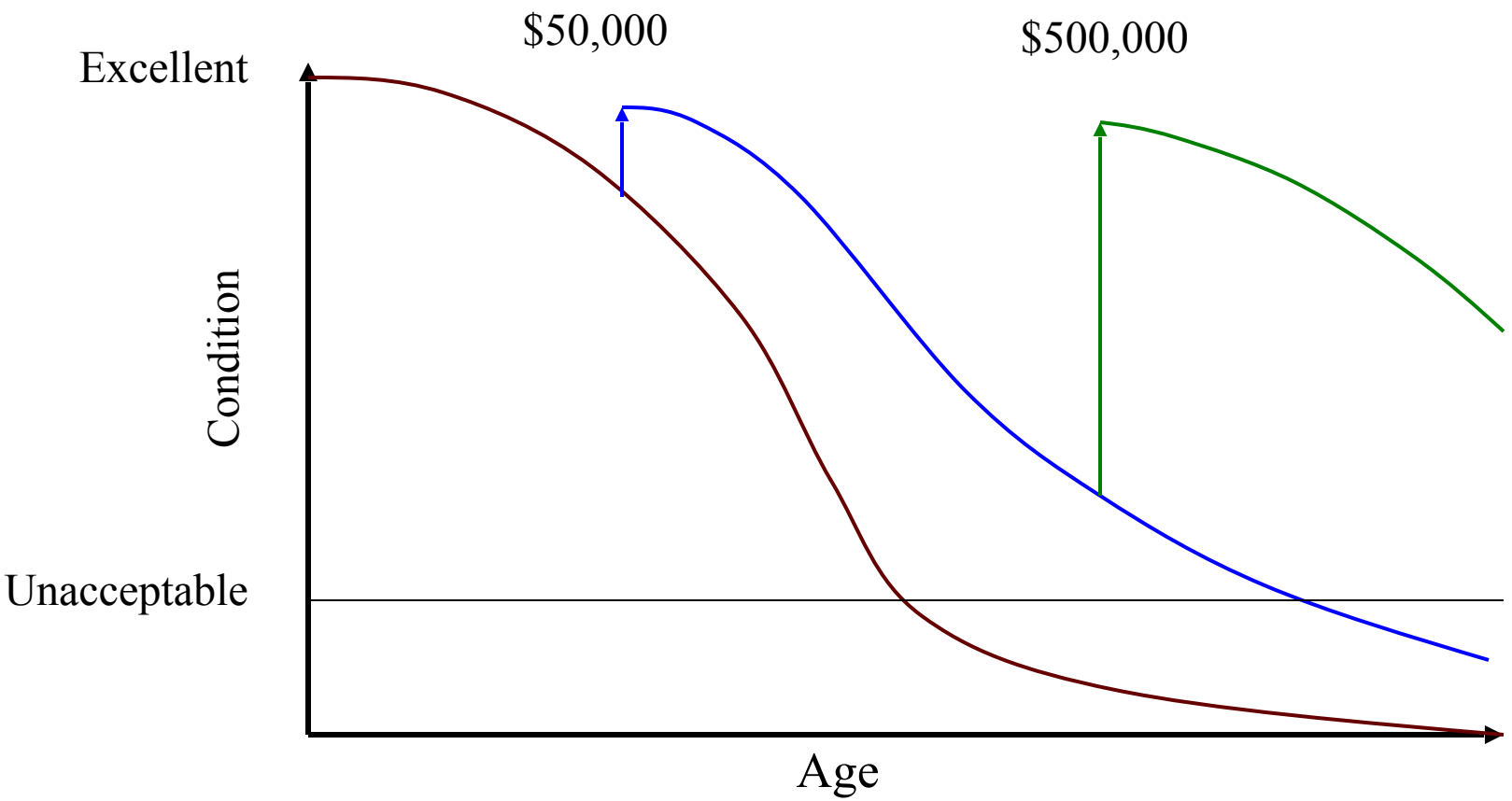
Decision Support Systems

- Computerized decision support systems
- Decision support tools used by agency personnel to
  - Provide quantified information to support cost-effective decisions
- ***Key elements*** include *models that connect funding to levels of service provided over time*

Model

- Theoretical construct representing processes by a set of variables and a set of logical and/or quantitative relationships between them
- Simplified framework designed to illustrate complex processes

Condition vs Expenditure Model



Future Needs and Actions

- Require projecting condition into future
  - Project for individual segments with curves adjusted for individual segment performance
    - Modified deterministic
  - Project percent of families that will change condition categories
    - Stochastic

Changes Due to Actions

- How treatments change:
  - Condition
  - Future life
  - Treatment alternatives

Treatment Assignment Used in

- Inventory
- Condition Assessment
- ***Determination of Needed Work & Funds***
- ***Identification of Candidate Projects***
- ***Determination of Impacts of Funding Alternatives***
- Feedback

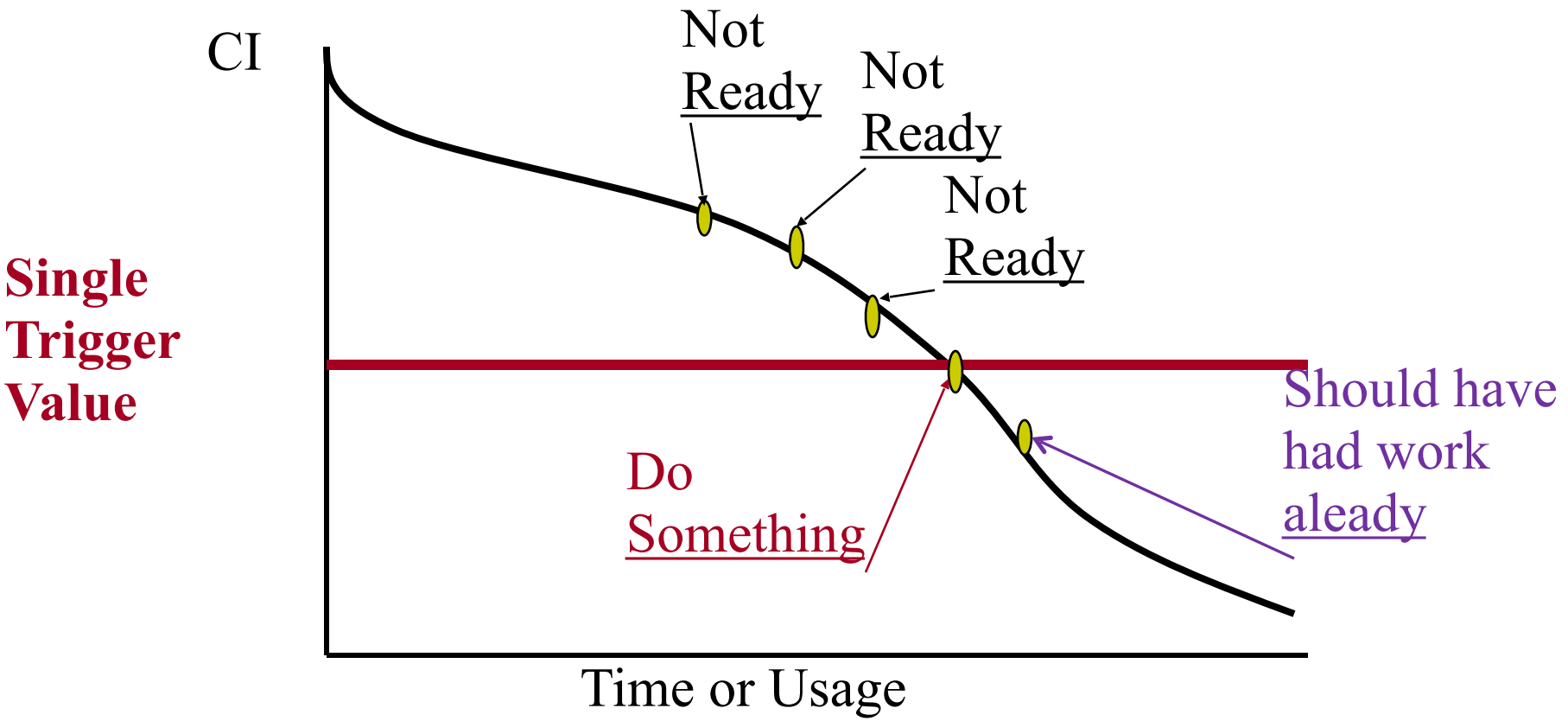
Assignment Procedure

- Connects inventory & condition data to treatment levels & costs
- Typically a decision tree or matrix
  - Treatment cost category
  - Assigned by type facility
  - In one of several condition categories
  - (Family analysis)
- Impacts treatment approach
  - Preservation
  - Worst first

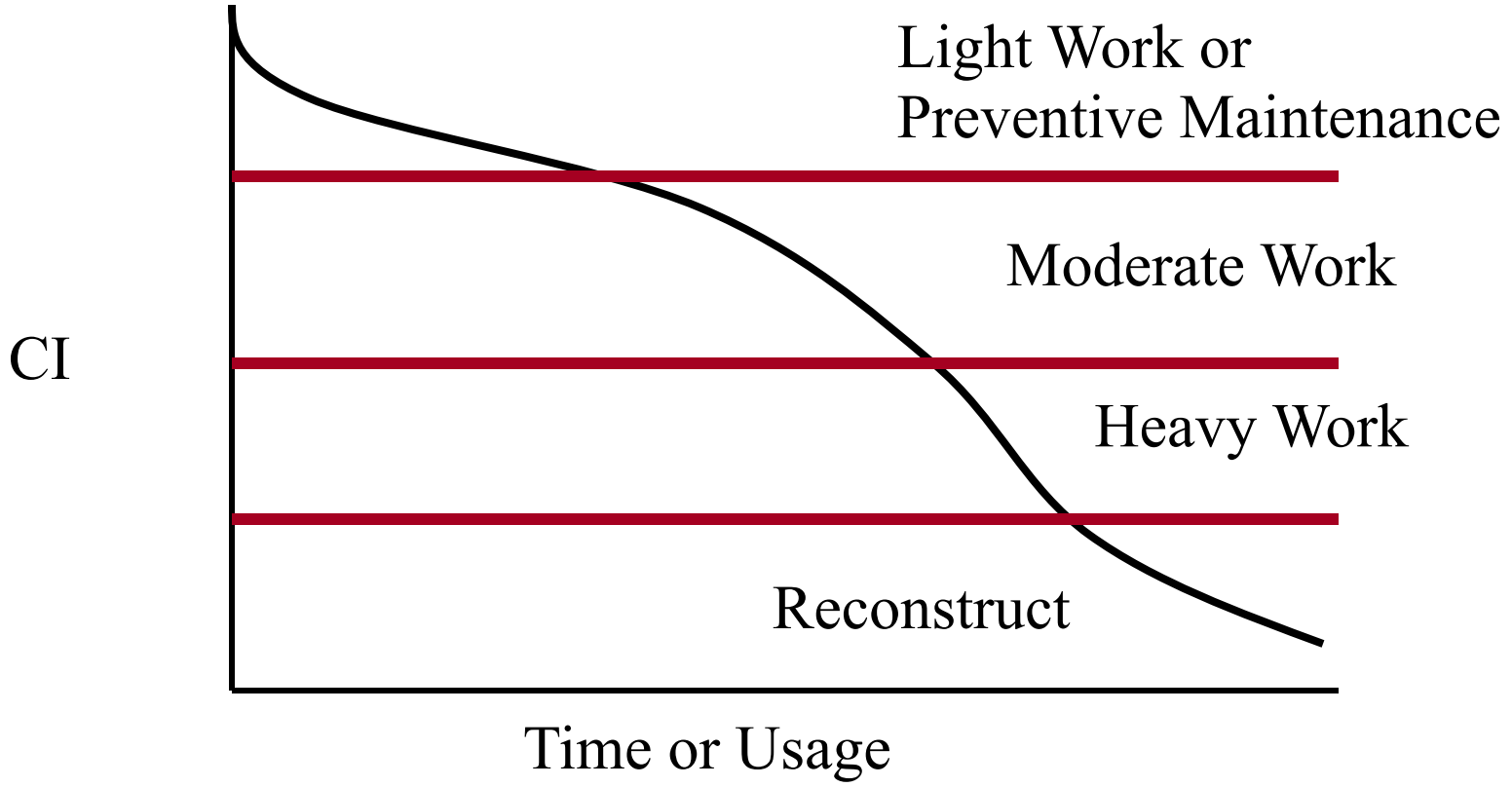
Network-Level Methods

- Identify intervention (Treatment) levels
  - Combine with projected condition for each segment
- Often use “Trigger Values”
  - Trigger a treatment

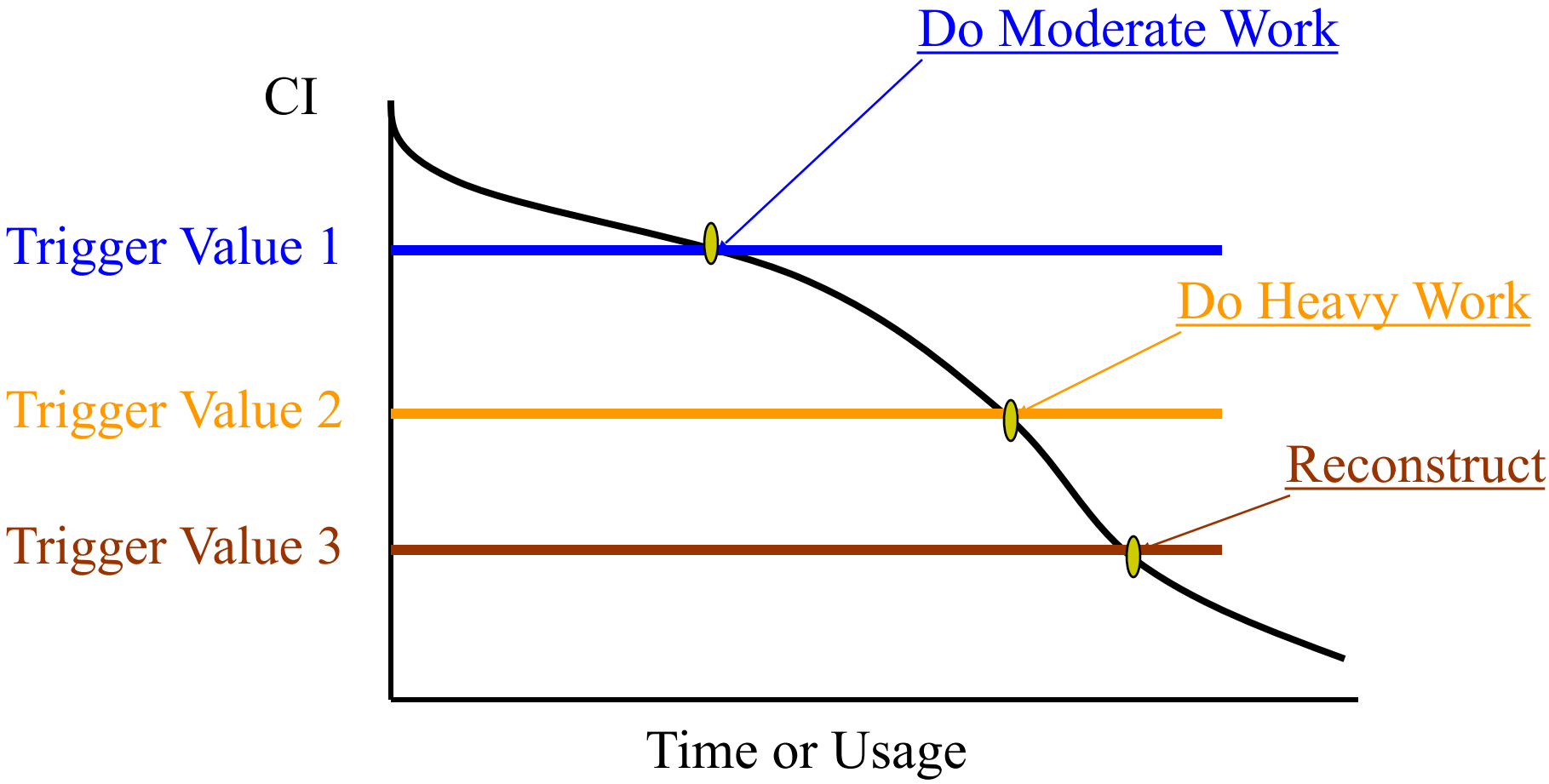
Condition at Time to Intervene Often Reflected in "Trigger Values"



Multiple Possible Treatment Levels



Multiple Trigger Value Levels



Advantages of Multiple Values

- Allows multiple intervention points

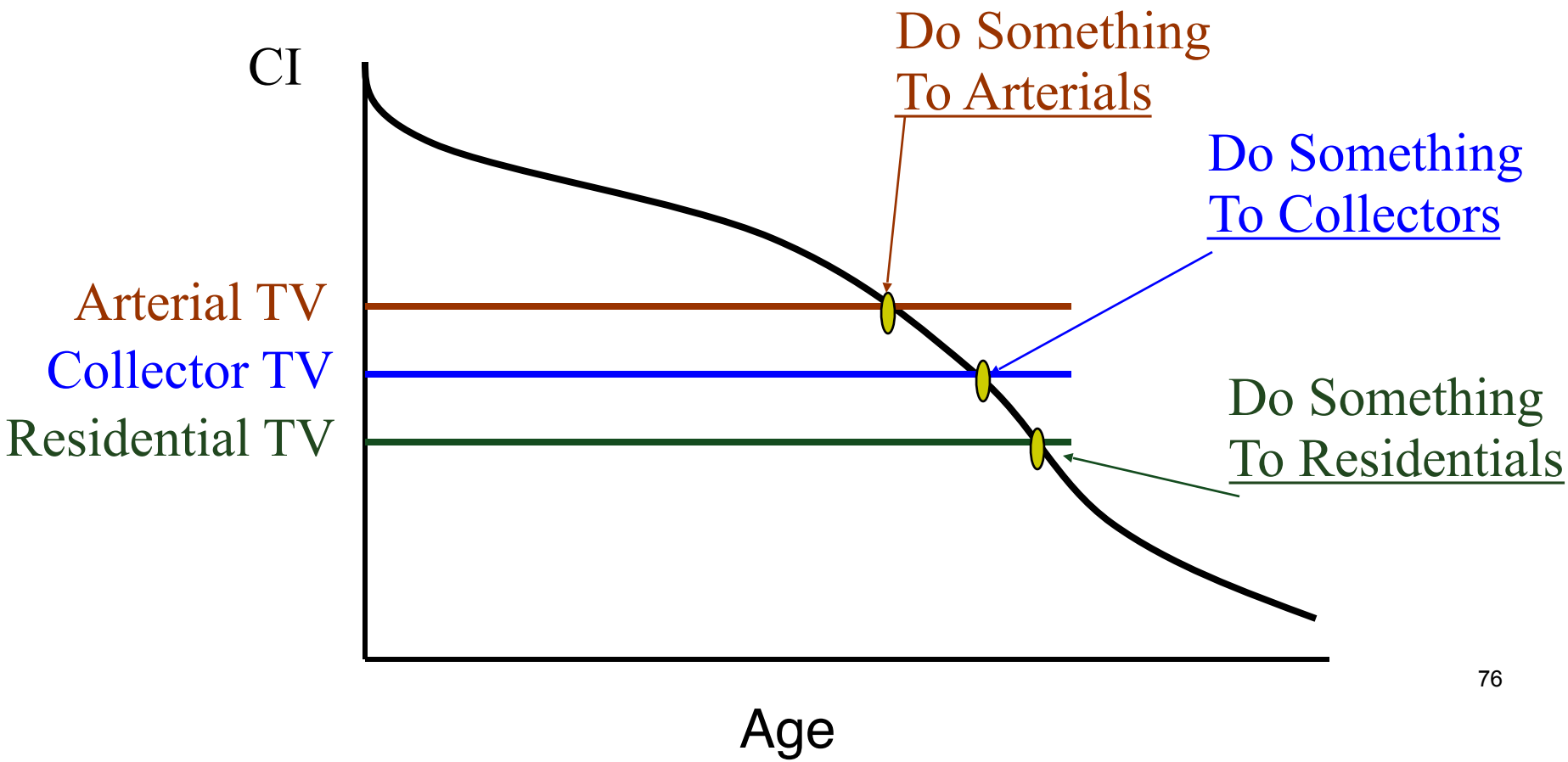
- When a PM treatment is not applied, moderate treatment can be identified before reconstruction is required

Factors to Consider in Setting Values

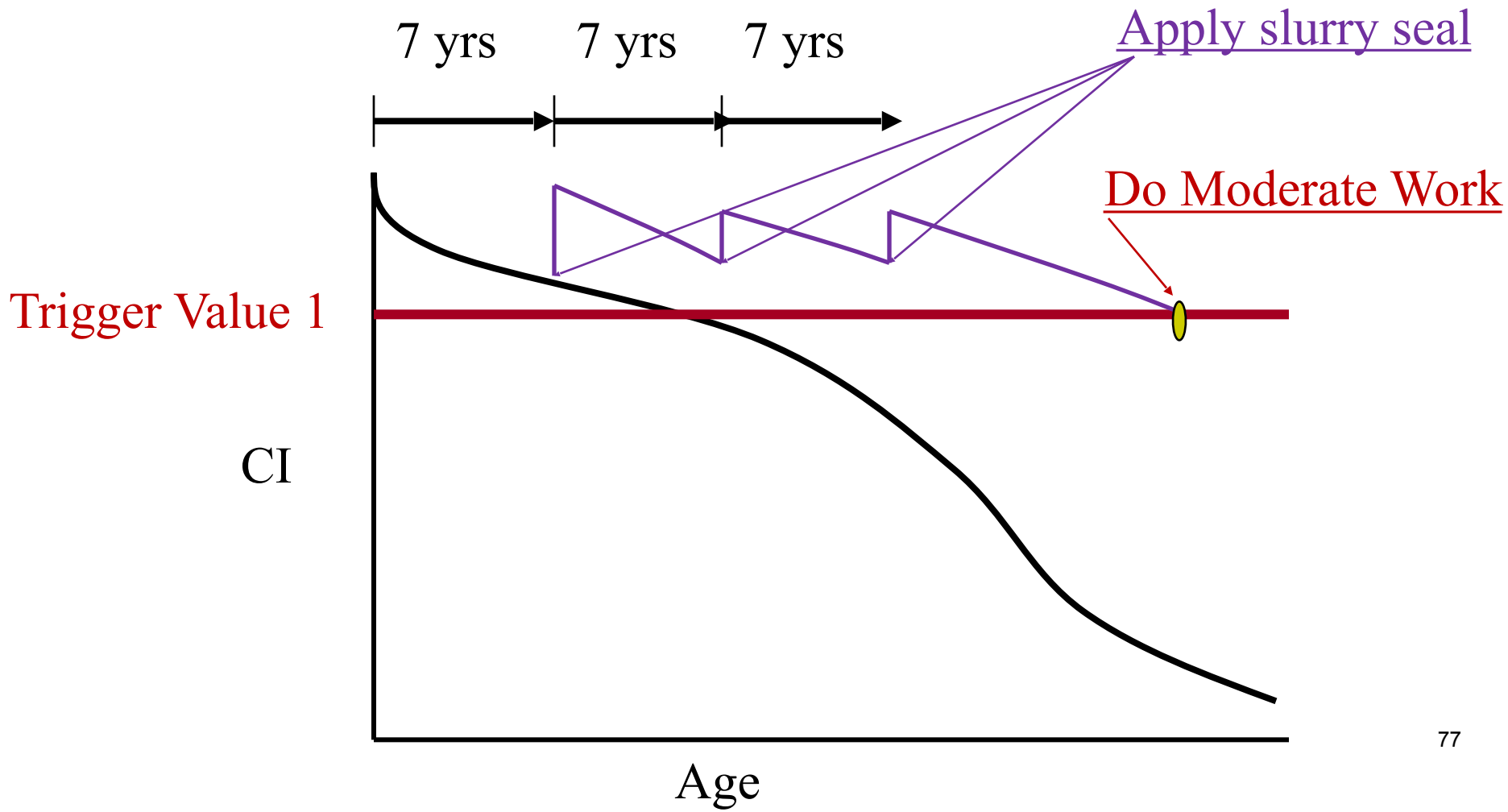
- Distress ID system & CI calculation method
- Type of pavement surface
  - AC vs PCC
- Importance of road/street
  - Arterial vs residential
- Usage/load level
  - AADT
  - AADTT

Adjust Levels For Importance/Usage

Moderate Level Trigger Value (TV)



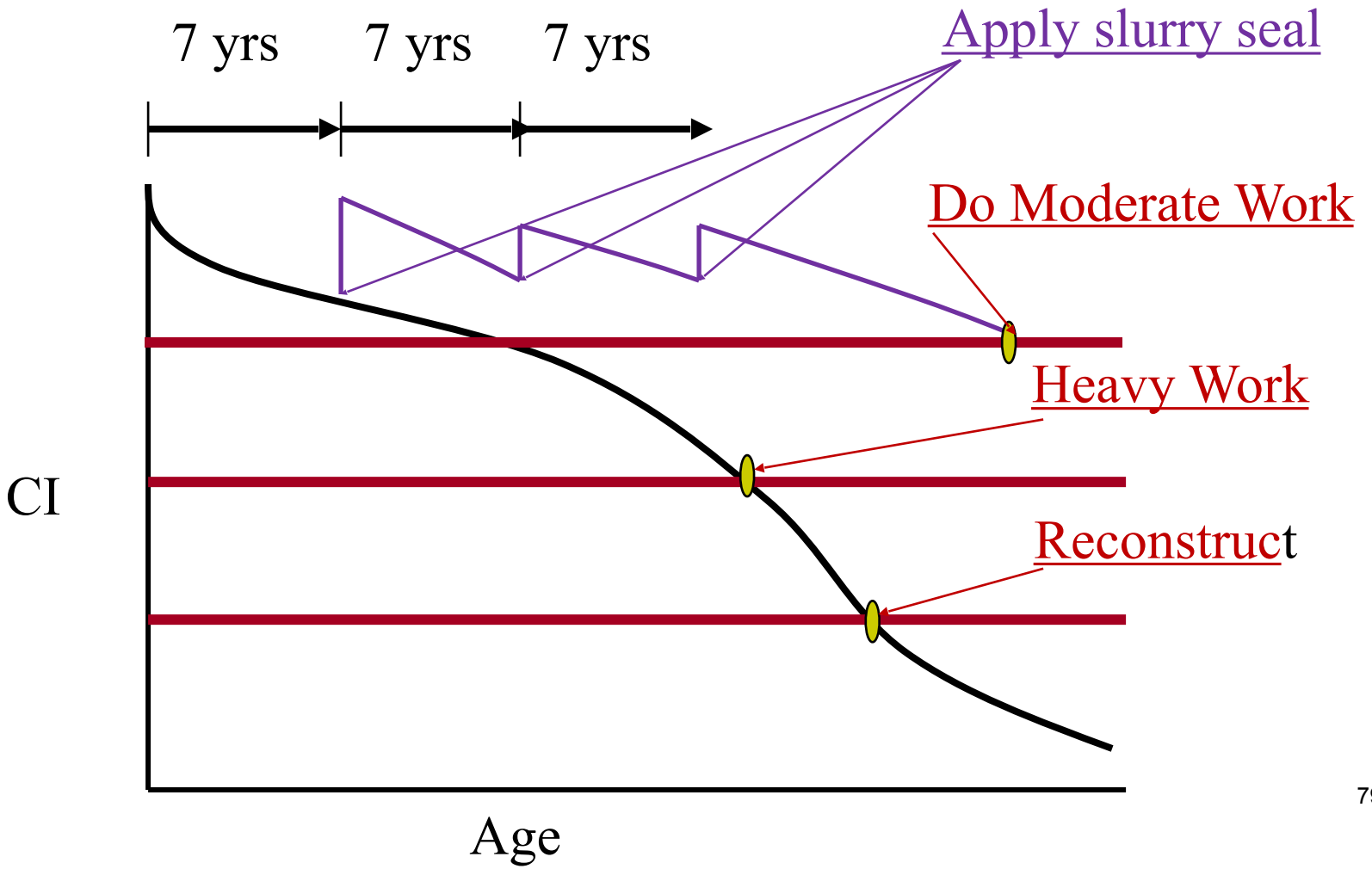
Preventive Maintenance - Time Driven?



Combine Trigger Values with Other Factors

- Inventory Data
  - Importance (functional classification, etc.)
  - Usage level (high vs low)
  - Material types (PCC vs HMAC)
  - Construction dates

One of These for Every Combination



Methods for Combining Factors

- Rules
- Decision Trees
- Decision Matrices
- Artificial Neural Networks
- Etc.

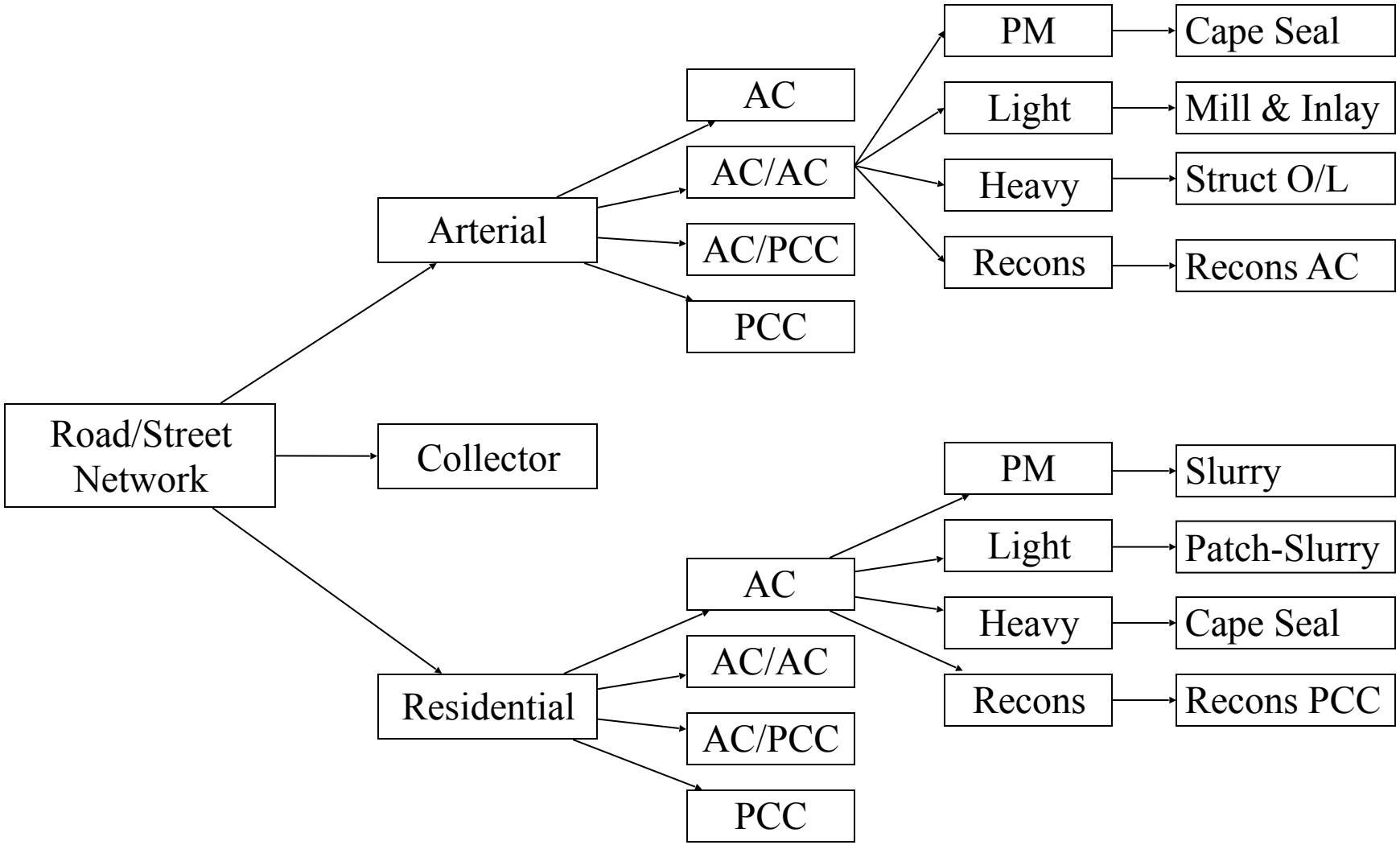
Rules

- Rules of thumb from decision makers
- Sounds simple
- Often develops conflicts
- Difficult to maintain
- Difficult to check/validate

Decision Tree

- Method of combining information to choose between several options
- Structured method to identify appropriate options
  - Assign appropriate treatment
- Allows visualization of complex process
- Often end up with several final branches and resulting decision recommendations

Example Decision Tree



Decision Matrices

- Decision trees become difficult to visually represent when there are many branches
- Decision matrices similar to decision tree
  - May be easier to visualize with many branches
- Uses sequences of imbedded matrices
- Allows multiple treatments

Treatment Matrix for Pavements

	Functional Classification			
		Art	Col	Res
Surface Type	AC	Con AA	Con AC	Con AR
	AC/PCC	Con CA	Con CC	Con CR
	PCC	Con PA	Con PC	Con PR

Con CC – Condition Matrix for Composite Collector

Condition Matrix for Composite Collector (Con CC) Imbedded in Prior Matrix

PM	Light	Mod Rehab	Heavy Rehab	Reconst ruct
Chip Seal	Thin Overlay	Patch & O/L	Struct O/L	Rec-AC
Slurry Seal	O/L w Fabric	Hot Inplace Recycle	Mill & Struct O/L	Rec-PCC
Cape Seal	Mill & Thin O/L	Mill & O/L	Cold Recycle & O/L	

Decision Matrix

Treatment Matrix

Functional Classification

Surface Type

	Art	Col	Res
AC	Con AA	Con AC	Con AR
AC/PCC	Con CA	Con CC	Con CR
PCC	Con PA	Con PC	Con PR

Condition Matrix for Composite Collector

PM	Light	Mod Rehab	Heavy Rehab	Recon struct
Chip Seal	Thin Overlay	Patch & O/L	Struct O/L	Rec-AC
Slurry Seal	O/L w/ Fabric	Hot Inplace Remix	Mill & Str O/L	Rec-PCC
Cape Seal	Mill & O/L	Mill & Overlay	Cold Rec & O/L	

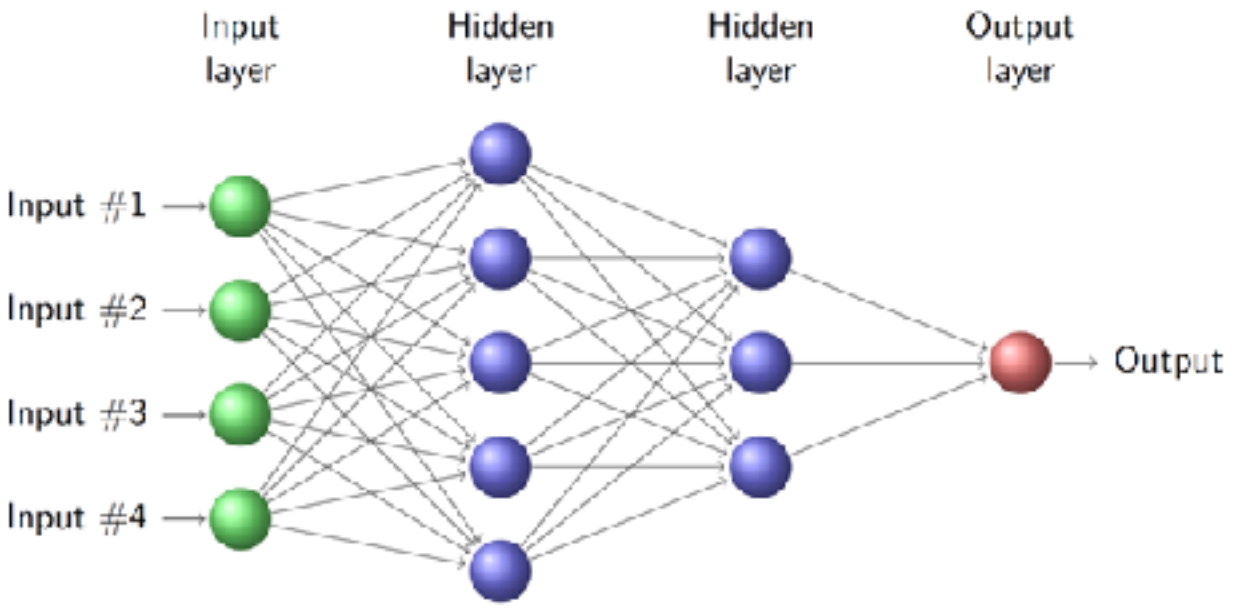
LCCA is performed during each run of the software to select most cost-effective treatment

Decision Matrices

- With many combinations
- Decision appear to be more of a black box
- More complex to set up
- More complex to maintain
- More difficult to check/validate

Artificial Neural Networks

Allows unlimited combinations



http://www.siiv.net/site/sites/default/files/Documenti/firenze/firenze61.pdf

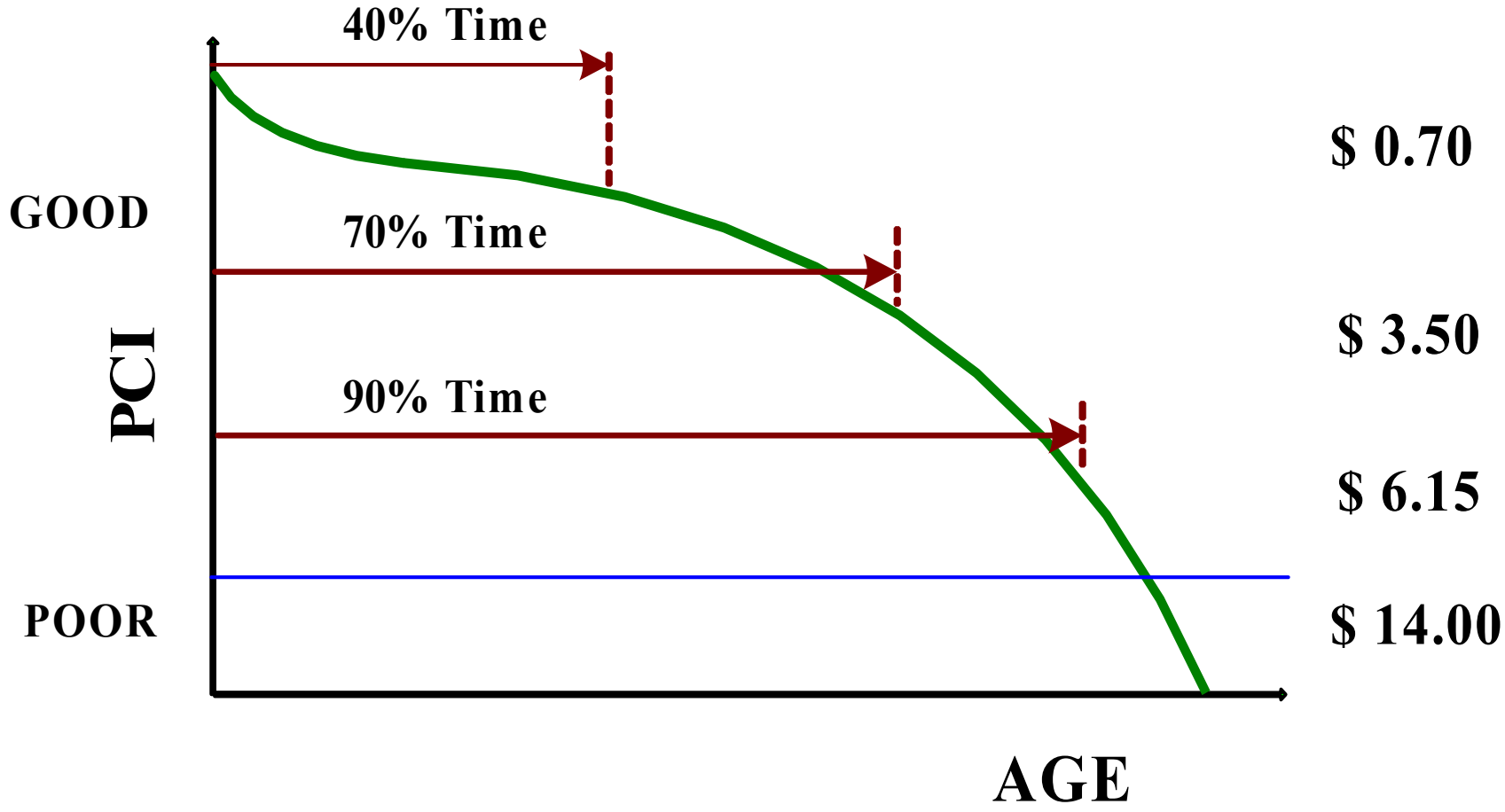
Artificial Neural Networks

- Require special expertise
- Require many (hundreds or thousands) of training runs
- Generally black box to most users
- Very difficult to maintain
- Very difficult to check/validate

Treatment Assignment

- Reflects how the agency plans to manage their network
- If PM and light treatments are not included
  - Only major rehabilitation and reconstruction will be assigned
- Selecting PM and light treatments allows a preservation approach

Pay Me Now or Pay Me Later



Pay Me Now

- 3 Seal Coats at $ 0.70 /sy - 24 yrs
- 1 Overlay at $ 3.50 /sy - 8 yrs
- 2 Seal Coats at $ 0.70 /sy - 16 yrs

- Total $7.00 /sy for 56 yrs

Pay Me Later

- 2 Remove & Replace at $ 14.00 /sy
  - 54 yrs
- Total $28.00 /sy for 54 yrs

Compare

- Pay Me Now
  - Total $7.00 /sy for 56 yrs
- Pay Me Later
  - Total $28.00 /sy for 54 yrs
- Which Gave Better Service?

Treatment Assignment

- Agency policy must be established
- Can use different decision trees/matrices to show impacts of applying different treatment approaches

Pavement Preservation Strategies

- Apply:
  - The right treatment
  - To the right pavement
  - At the right time
- Focuses on preventive maintenance
  - Dedicate funds to preventive maintenance

Worst First

- Many agencies have backlog of sections that need major rehabilitation of reconstruction
- On approach - fix those in worst condition first
- To address backlog, best approach is:
  - Retain good roads
  - While repairing some percent of poor roads each year

To Address Backlog

- Agencies must retain good roads
- While repairing poor roads

Good Roads Cost Less than Bad Roads

- It costs the maintaining agencies less to have good roads than bad roads - Over the long term
- Providing:
  - Reasonable level of service provided
  - Pavements will respond to preventive maintenance, e.g. they must be structurally adequate
- Pavement preservation approach provides best roads for the least cost

Back to Network-Level Questions

- Funds needed – long-term
  - To provide selected level-of-service
  - Impact of spending less or more
  - Impact of spending differently
- Funds set – short-term
  - Which segments give best potential return on funds
  - Impact of repairing different segments
  - Impact of applying different treatments
  - Impact of applying treatments at different times

Treatment vs Treatment Category

- At network level
  - ***Treatment category*** rather than actual treatment
  - Cost estimating treatment
- Level of funding more important than actual treatment
  - Treatment refined in project selection-level
  - Treatment selected in project-level
- Treatment Name needed to develop costs

Needs Analysis Results

- List of sections needing work
- Approximate funds needed
- Based on agency goals
- Over an analysis period

Issues

- Developing and maintaining models
  - Deterministic vs stochastic
  - Quasi-stochastic
- Specificity of treatments at management levels vs cost category
- Keeping costs reasonable and current

Identification of Candidate Projects

- Prioritization/Optimization
- Identifies segments for repair
  - Best candidates to give
  - Highest return for
  - Available funds
- Various ranking and optimization procedures used
  - Some allow analysis of benefits

Basic Approaches

- Minimize funds needed to provide desired service

- Maximize return on set funding levels

Cost-Benefit Analysis

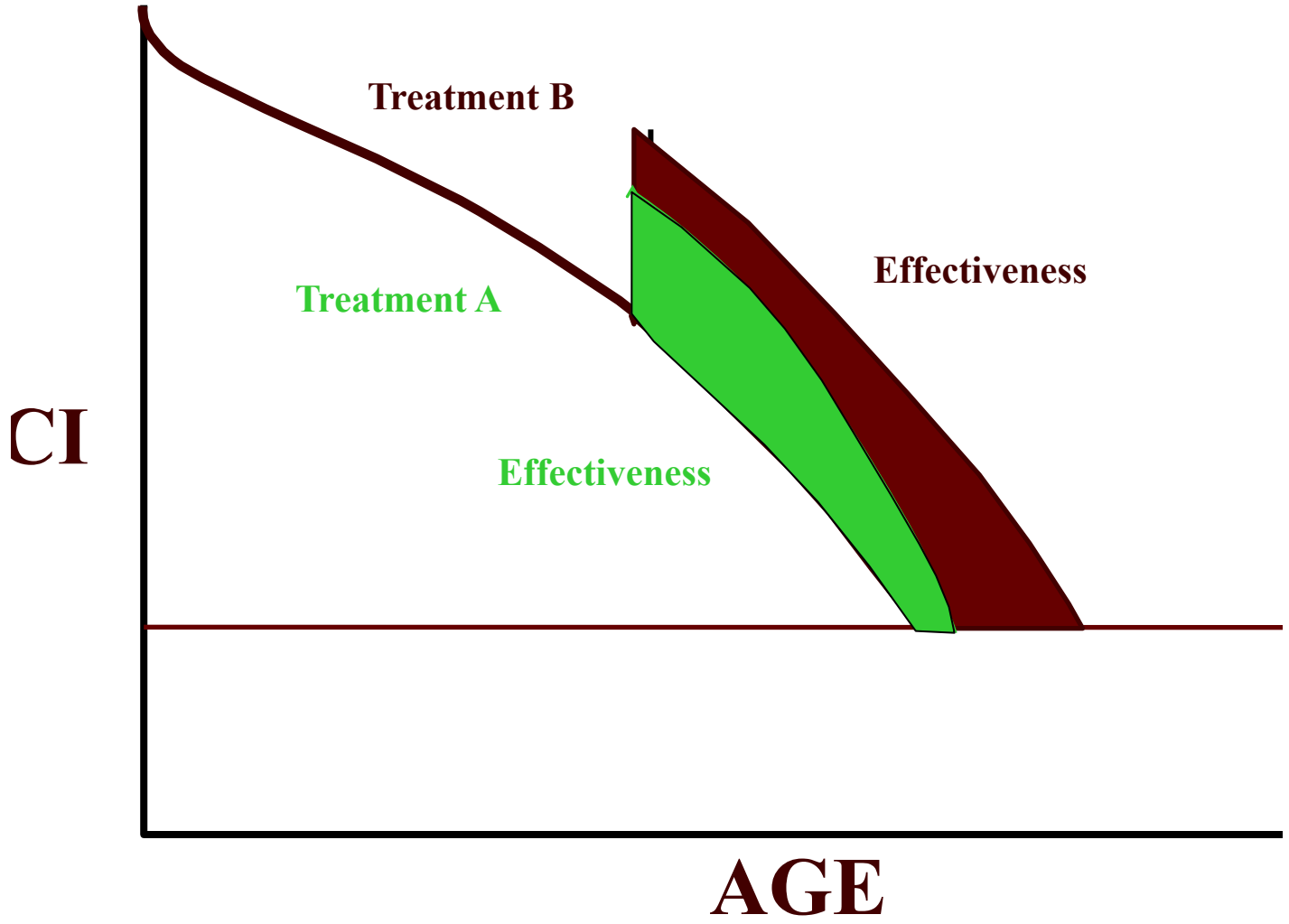
- Often uses reduction in
  - Costs incurred by public as the benefit of the treatment
- Primary issue
  - How to calculate dollar value of work to public or "benefit to society"

Alternatives to Cost-Benefit Analysis

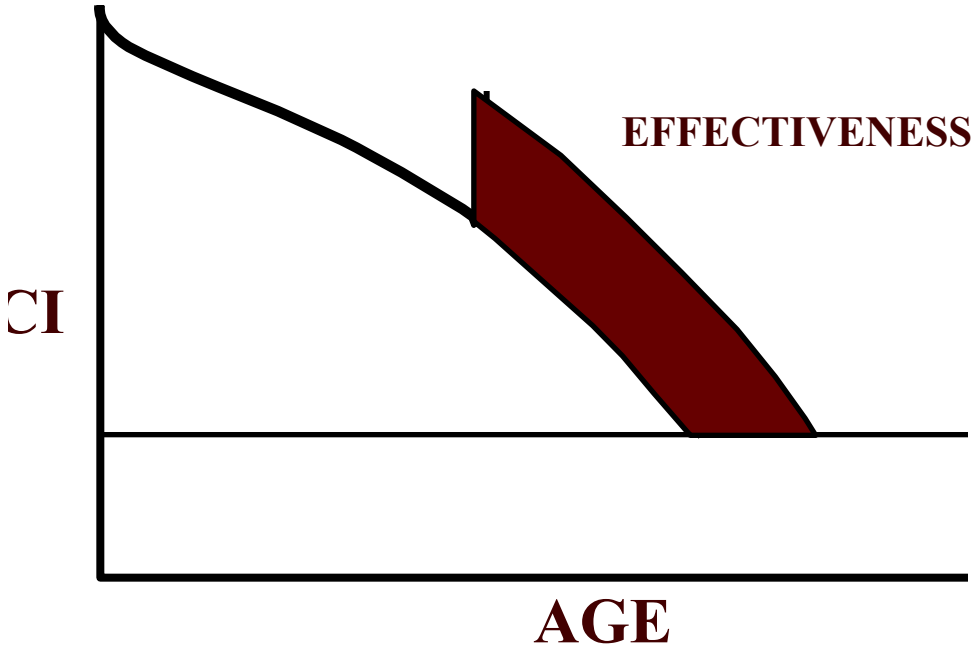
- Cost-effectiveness analysis
- Used like cost-benefit analysis

- Surrogate used for benefit
  - Commonly the area under
  - A performance curve

Greater Area indicates Greater Effectiveness



Costs Change with Importance, Effectiveness Does Not



$$\text{Weighted Cost-Effectiveness Ratio} = \frac{\text{AREA}}{\text{EUAC / SY}} \times \text{WF}$$

Should Allow

- Comparison of policies such as
  - Preventive maintenance
  - Versus
  - Worst first
- May have to run different analyses with different decision trees/matrices

Prioritization/Optimization Approaches

- Set level-of-service
  - Identify the candidate projects and funds needed to provide some condition indicator over time
  - How much money needed to reach a set condition level?
- Fix the funds
  - Identify the candidate projects that give the best return on the money
  - Which segments are the best candidates for funding?

Issues

- Prioritization/optimization approach
  - Stochastic vs deterministic
- Addressing large data sets over long time periods
  - True optimization vs “near optimization”
- Understanding that considerable changes will occur due to other factors not considered in decision support tools

Run Series of Long-term Scenarios

- Establish best treatment approach that will be supported by funding authorities
- Develop funding plan to provide, or reach, the level-of-service to be provided to citizens and driving/riding public
- Funding levels for next few years are established

Run Series of Short-Term Scenarios

- Funds available have been established
- Identify how to get best return on funds allocated
  - Which sections to fund first

Prioritization/Optimization

- Provides a list of candidate segments
  - That can be funded with available funds.

- Cannot give best treatment for each segment
  - Only provides a treatment or cost category

Project Selection-level Analysis

- Used to develop improved cost estimates for each individual segment
- Consider constraints & cost elements not included in network-level analysis
- May require more data and more analysis

Project-Level Analysis

- Used to determine the best treatment and to develop final cost estimates for each individual segment
- Requires more detailed data and more extensive analysis
- Some help from software
  - Run Analysis with Selected Projects

Impact Analysis

- Develop information to communicate impacts of infrastructure funding and policies with
  - Senior management/funding authorities
  - Elected officials
  - Primary constituents
- Not generally a different set of decision support tools
  - Extracting information in terms of report, graphs, etc.

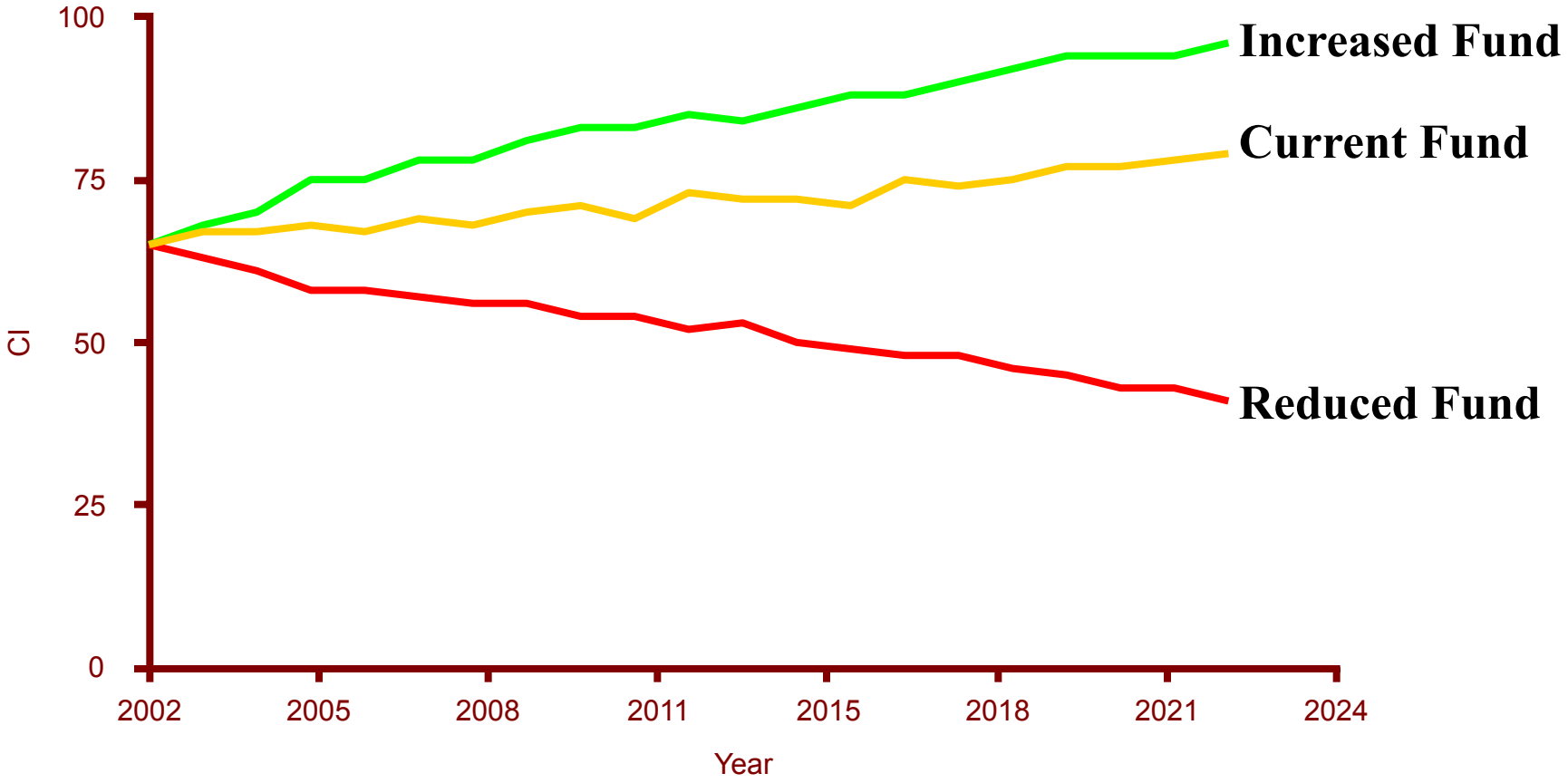
Funding Decisions

- Funding decisions controlled by non-engineers (politicians)
- Public works spends (cost-effectively)
- Public works staff must explain effects of funding recommendations
- Impact analysis is the connection of PMS to the budget process

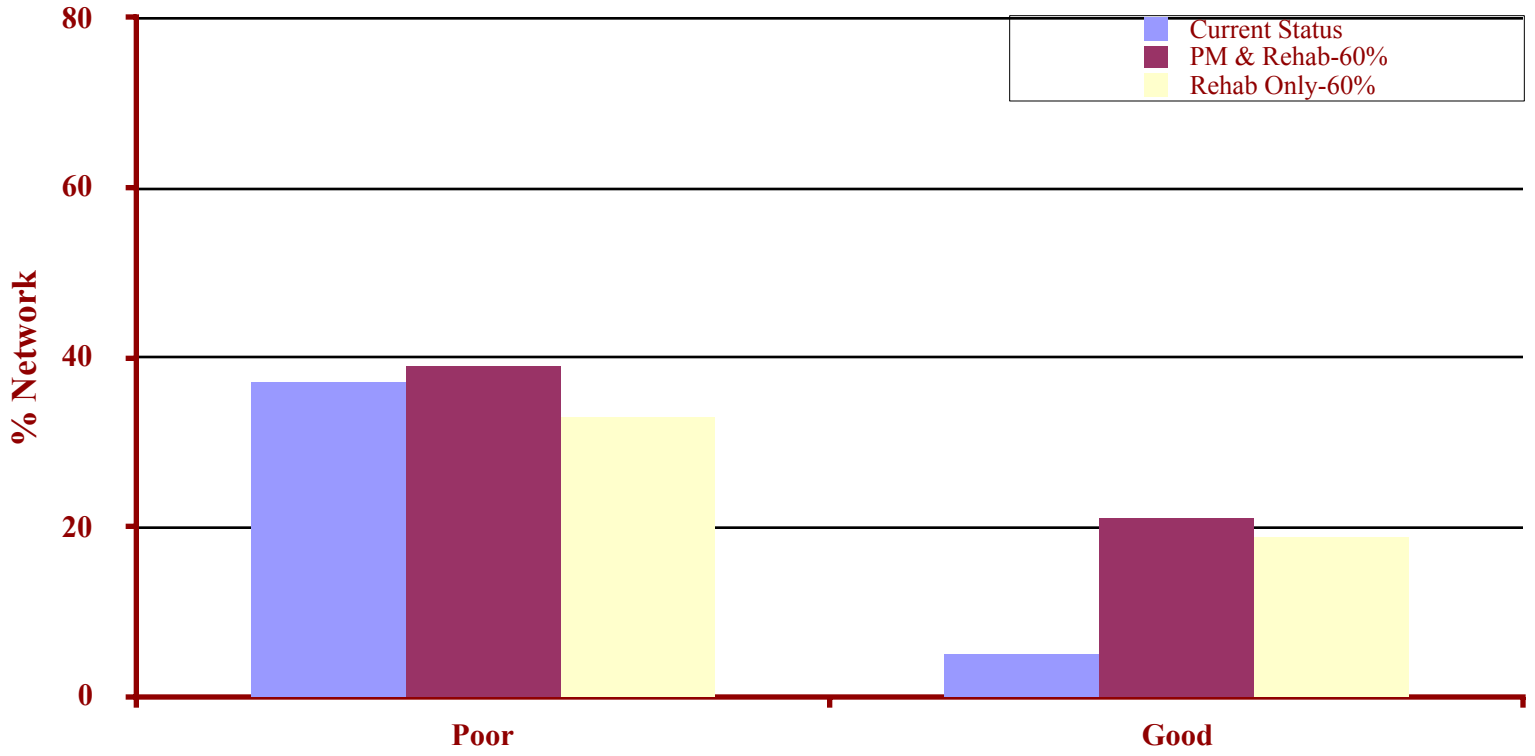
Impact of Funding Decisions

- Future facility/network condition
- Future fund needs
- Segments with deferred needs
- Segments with stop-gap treatments
- Remaining life of segments & system
- User costs
- Other impacts

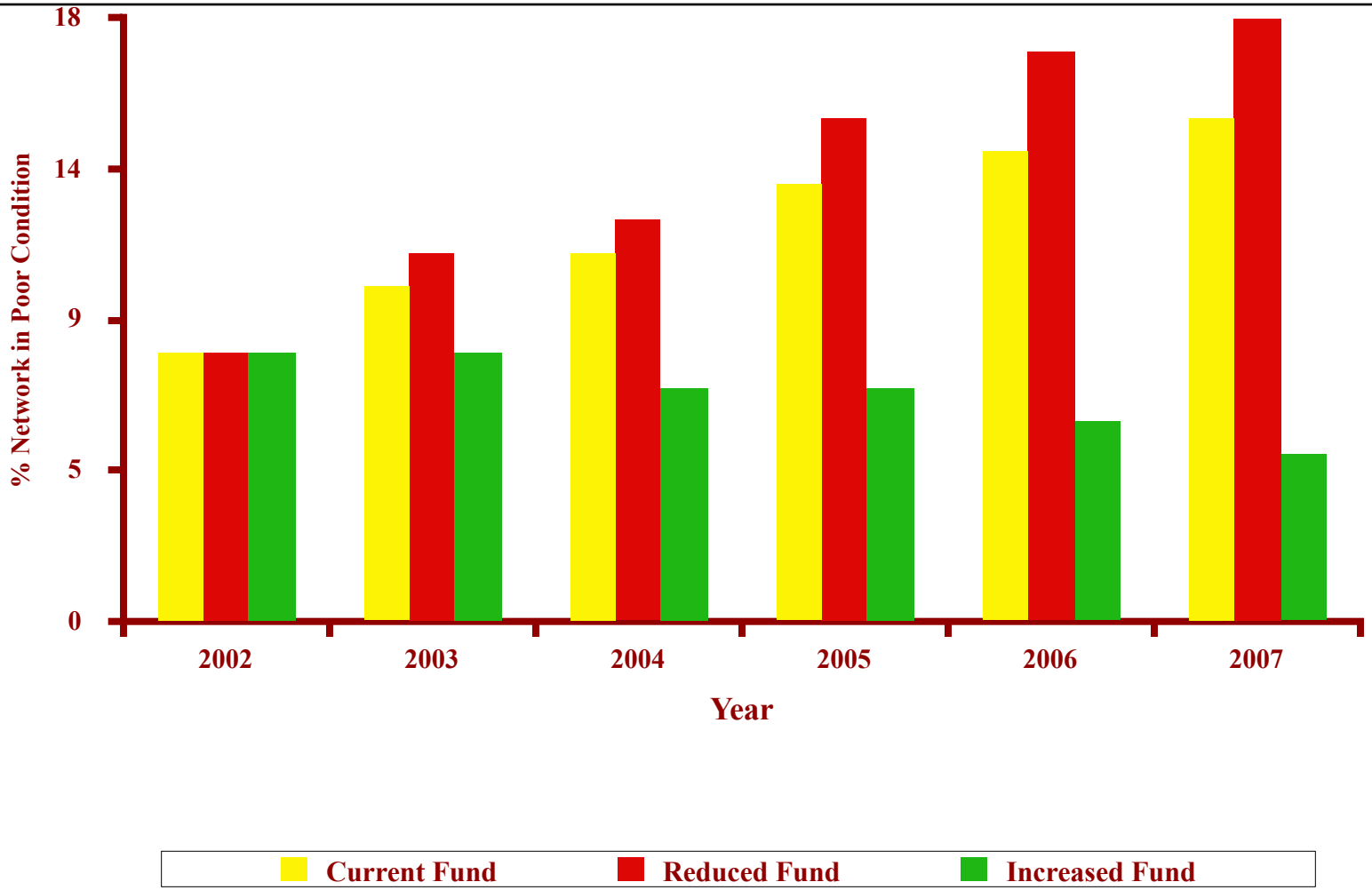
Projected Condition



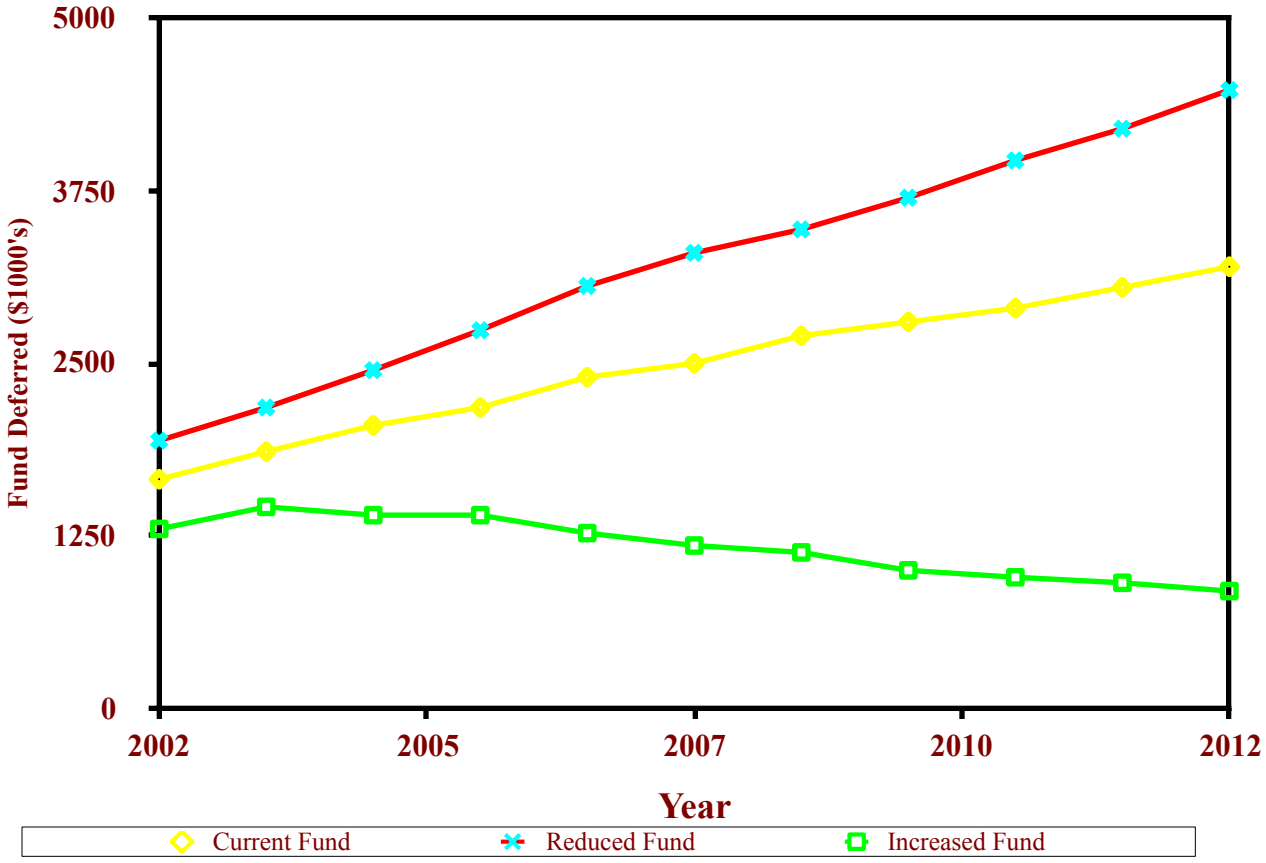
Impact of PM on Average CI



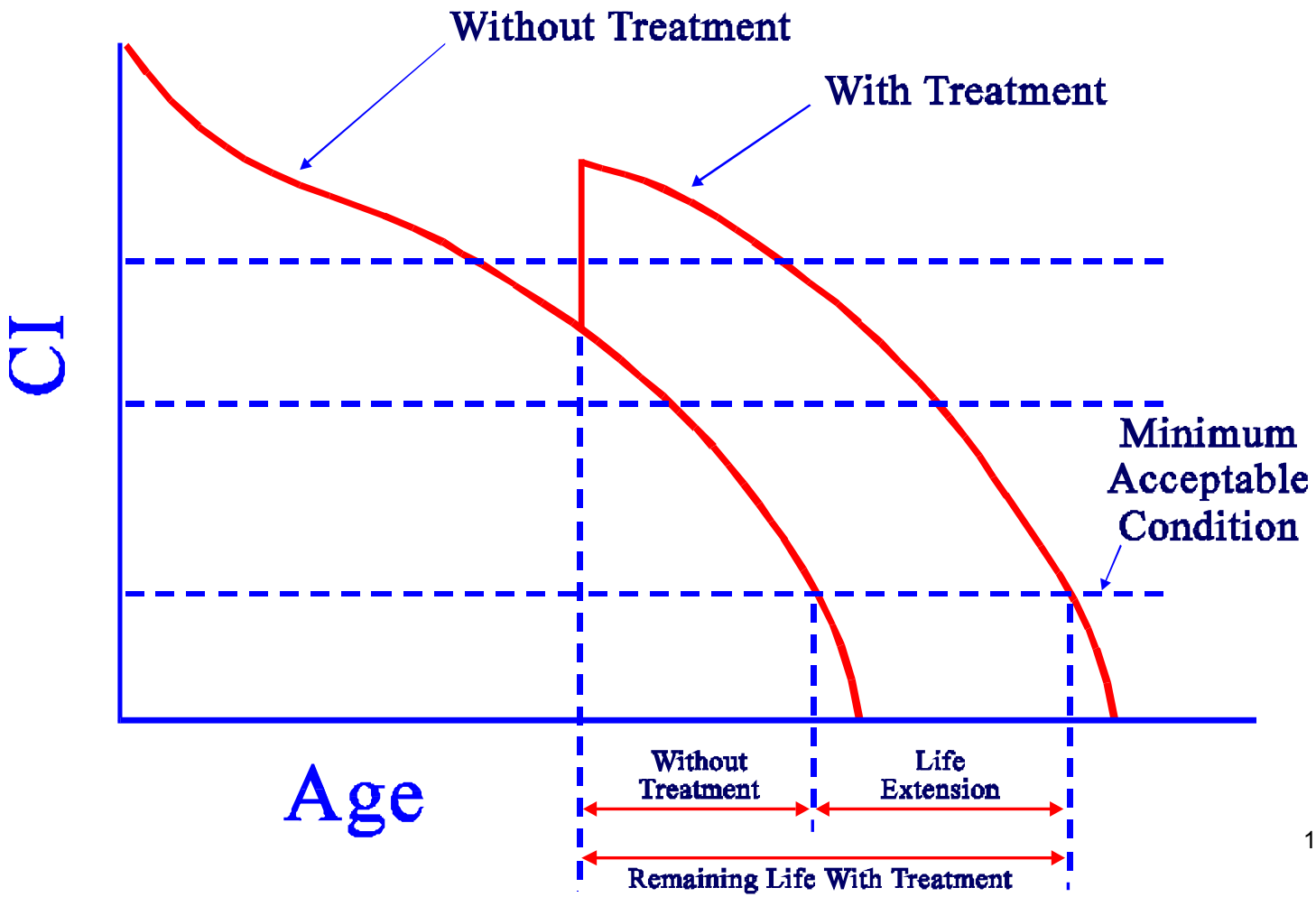
Poor Condition Category



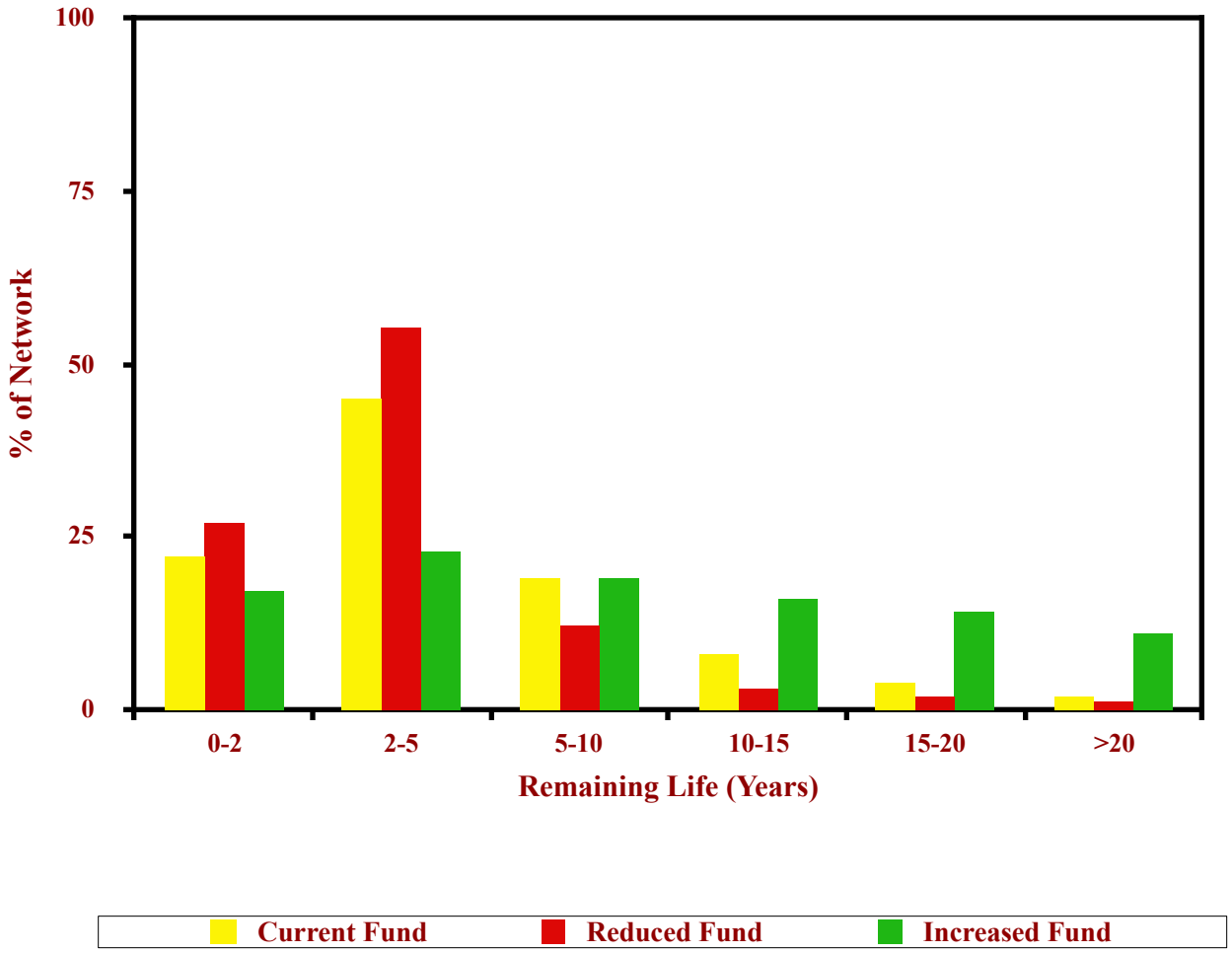
Deferred Fund Needs



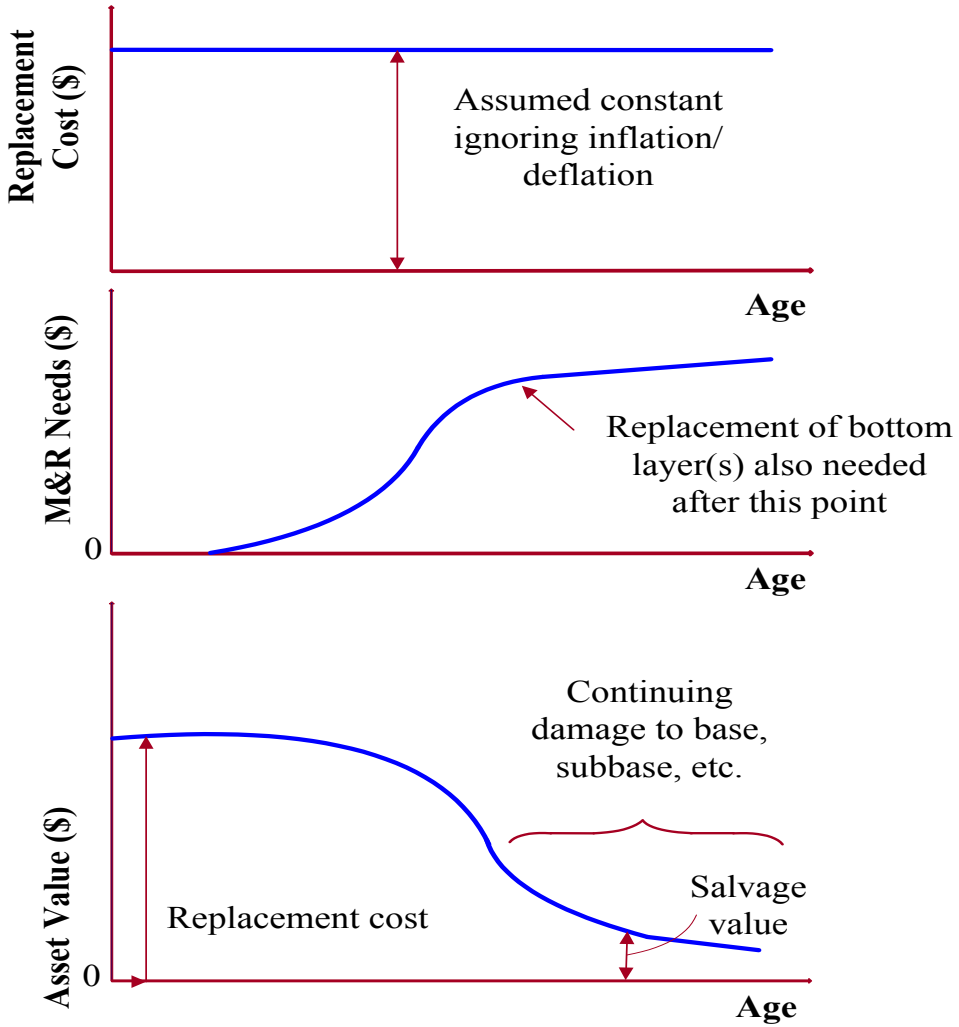
Remaining Life Definition



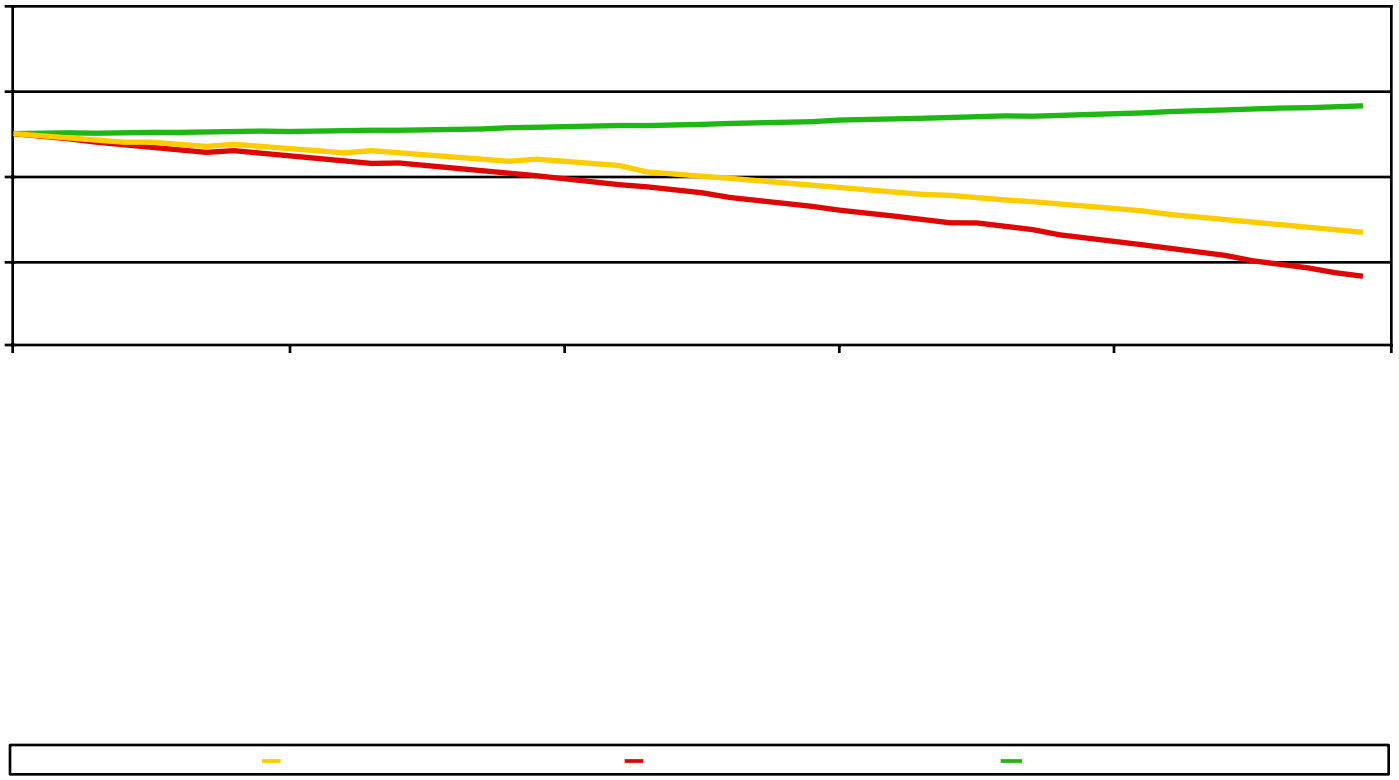
Large Amount of Short Remaining Life



Asset Value Calculation



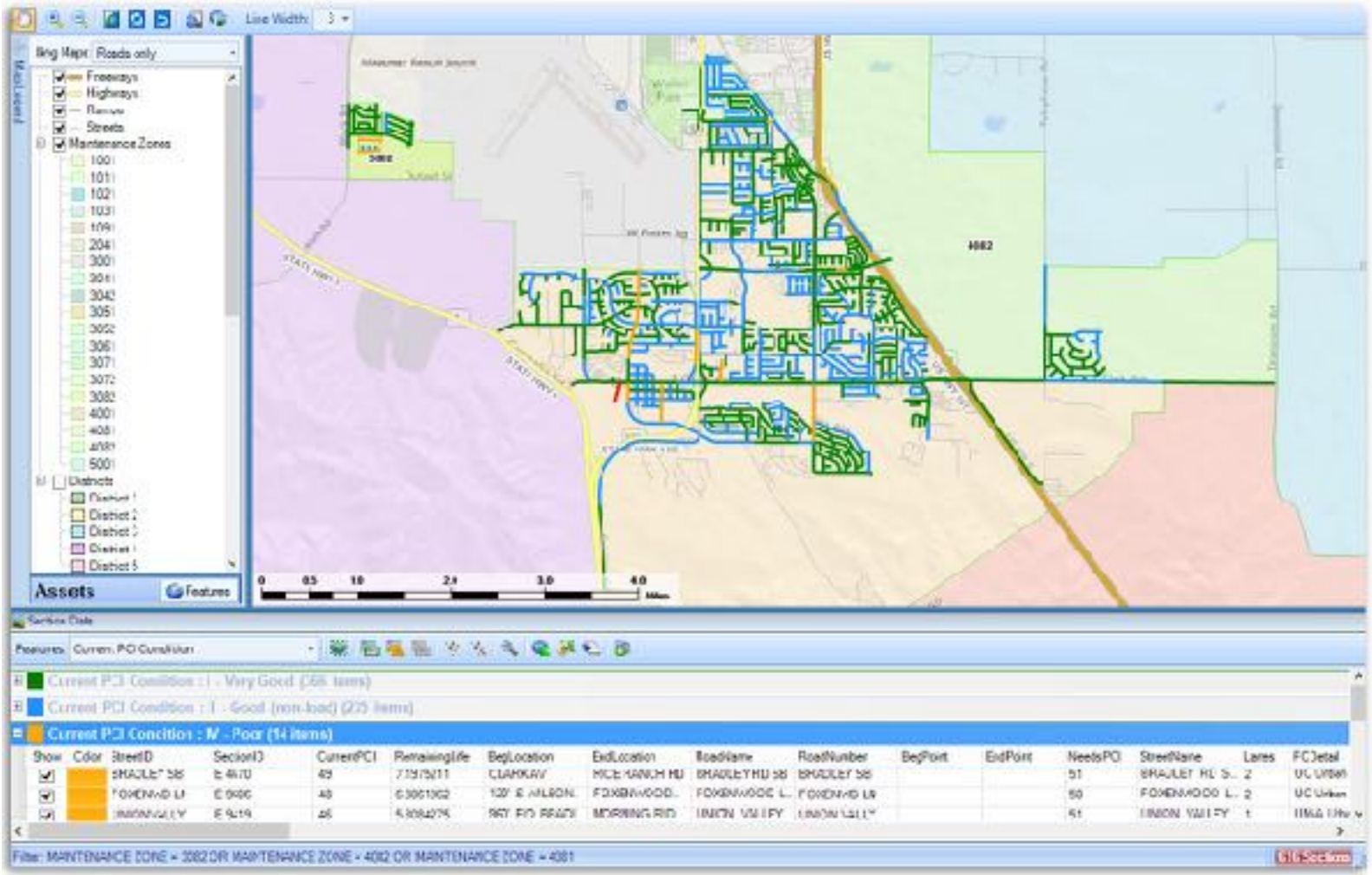
Projected Change in Asset Value



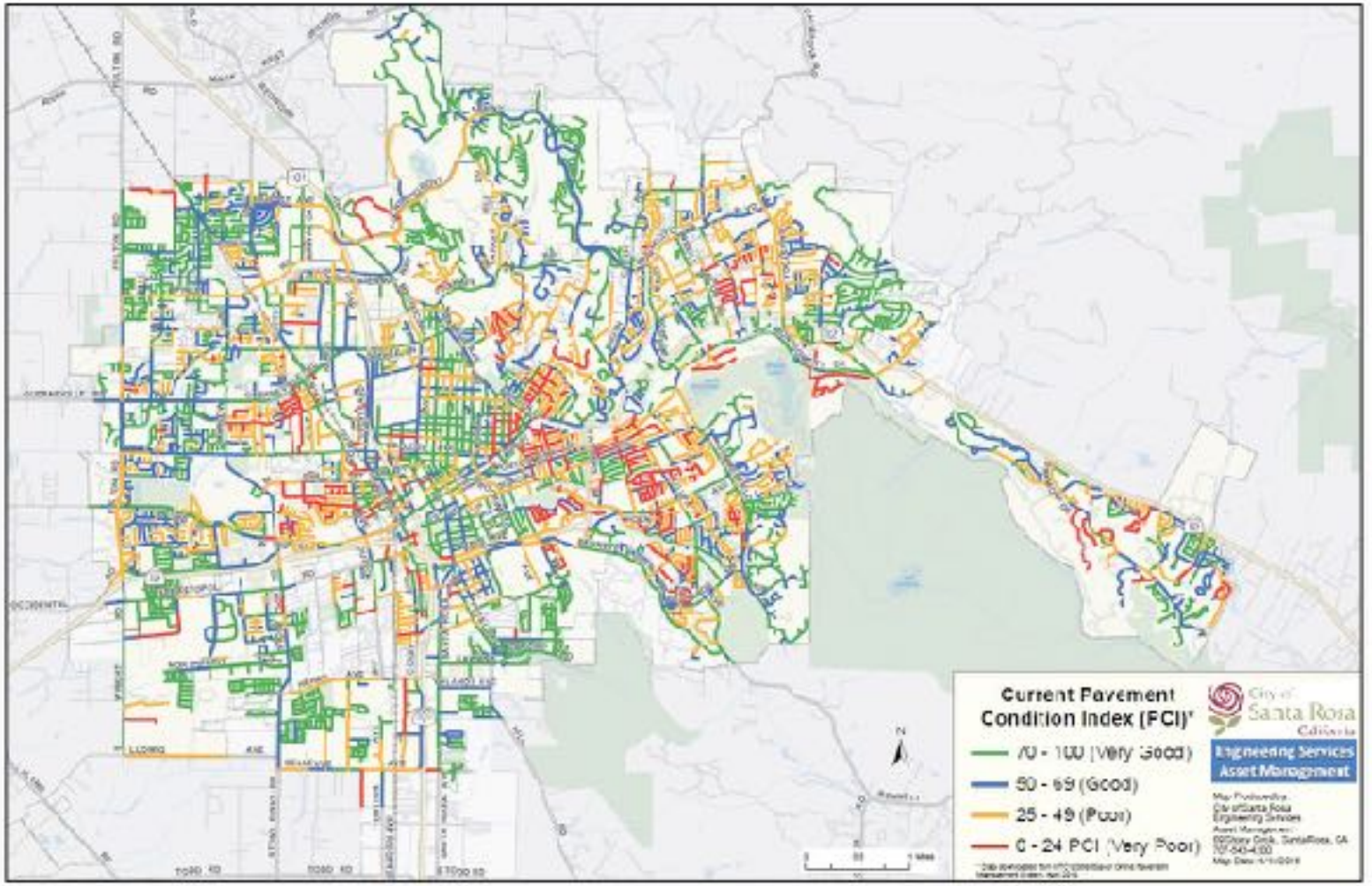
GIS

- Use StreetSaver® Plus with GIS or export data to in-house GIS
- Produce map based reports to communicate with
  - Agency personnel
  - Funding authorities
  - Citizens

GIS Based Reports



Street Condition Map



Funding Decisions

- Funding decisions controlled by non-engineers (politicians)
- Public works spends (cost-effectively)
- Public works staff must explain effects of funding recommendations
- Impact analysis is the connection of PMS to the budget process

Results of Network-Level

- Maintenance and Rehabilitation Needs
  - List of Sections
  - Planning Treatment
  - Average Costs
- Prioritized Listing of Candidate Projects
- Impact of Funding Options

Project Selection-level Analysis

- Select sections for near term work from candidate sections identified network-level analysis
- Small percent of network
  - PM
  - Rehab/reconstruct

Project Selection-level Analysis

- Develop more specific treatment and improved cost estimate for sections to be funded in near term
- Consider constraints & cost elements not included in network-level analysis
- May require more data and more analysis
  - Deflection testing/structural evaluation
  - Need to address roughness

Project-Selection Level

- Software used to evaluate results
  - Most work requires staff input
  - Finalize candidate project list
    - Add & Remove projects
    - Combine projects
  - Consider constraints - other work
  - Change dates
  - Adjust limits of projects
  - Revise cost estimates

Contract package

- Set same date and treatment to a group of sections needing similar treatment over some period of time (slurry seal program)
- User must know sections
  - Set sections, treatment type and date
- Sections 001, 006, and 011

Construction package

- Set same, or similar, treatment to a group of adjacent sections
- User must know sections
  - Set sections, treatment type and date
- Sections 004, 048, & 060

Treatment over multiple years

- Large segment of street, or group of streets, will have worked sequenced over a number of years
- User must know sections
  - Set sections, treatment type and date
- Sections 028-04, 033-05, & 038-06

Conflict analysis

- Avoid treatment until after utility work completed

- User must know conflicts
  - 1. Designate date after which work is allowed
    - or
  - 2. Set treatment type and date

- Section 009 – No work until 2008

Delay work

- The section needs reconstruction, but work will be delayed until some future date (parabolic section)

- User must know sections and dates
  - 1. Designate date after which work is allowed
    - or
  - 2. Set treatment type and date

- Section 023 – Delay work until after 2010

Required Section

- Improve street because of agency commitment
- User must know section
  - Set treatment type and date
- Section 026 – Thick overlay 2007

Changed Treatments

- Treatments for individual sections may be designated and better defined
  - Are structural improvements needed
  - Does roughness need to be addressed
  - Will roadway noise be a consideration
  - Does treatment need to be adjusted because of adjacent section treatment needs

Rerun Short-term Scenario Analysis

- Sections identified in project-selection are identified for treatment at the time, with the treatment, and with the cost identified in project selection.
- Those sections can then be placed back into the regular assignment process.
- Those not established in project-selection are funded through the regular analysis process if the funds area adequate to address them

Caution

- This analysis will not complete designs

User Responsible

- Must have completed appropriate
  - Data collection
  - Analysis
- Must have appropriate costs
- Must make decisions about adjustments

Results of Project Selection-Level

- Prioritized Listing of Candidate Projects
- Adjusted for User Selected Sections
  - Constraints Considered
  - Construction Packages
  - Contract Packages
  - Refined & Alternative Treatments
  - Adjusted Treatment Times
  - Improved Estimates

Project-Level

- Start with project selection level list
- Develop cost-effective strategy for:
  - Original construction
    - Maintenance
    - Rehabilitation
    - Reconstruction
  - Within imposed constraints

Complete Project Level Analysis

- With level and causes of damage known
- Final selection of feasible treatments (Evaluation of more complete information)
- Preliminary design
- Life cycle cost analysis
- Final design
- Construction

Structurally Adequate

- Coring
- Deflection testing
- Structural analysis
  - With and without removing localized damage

Distress Collection

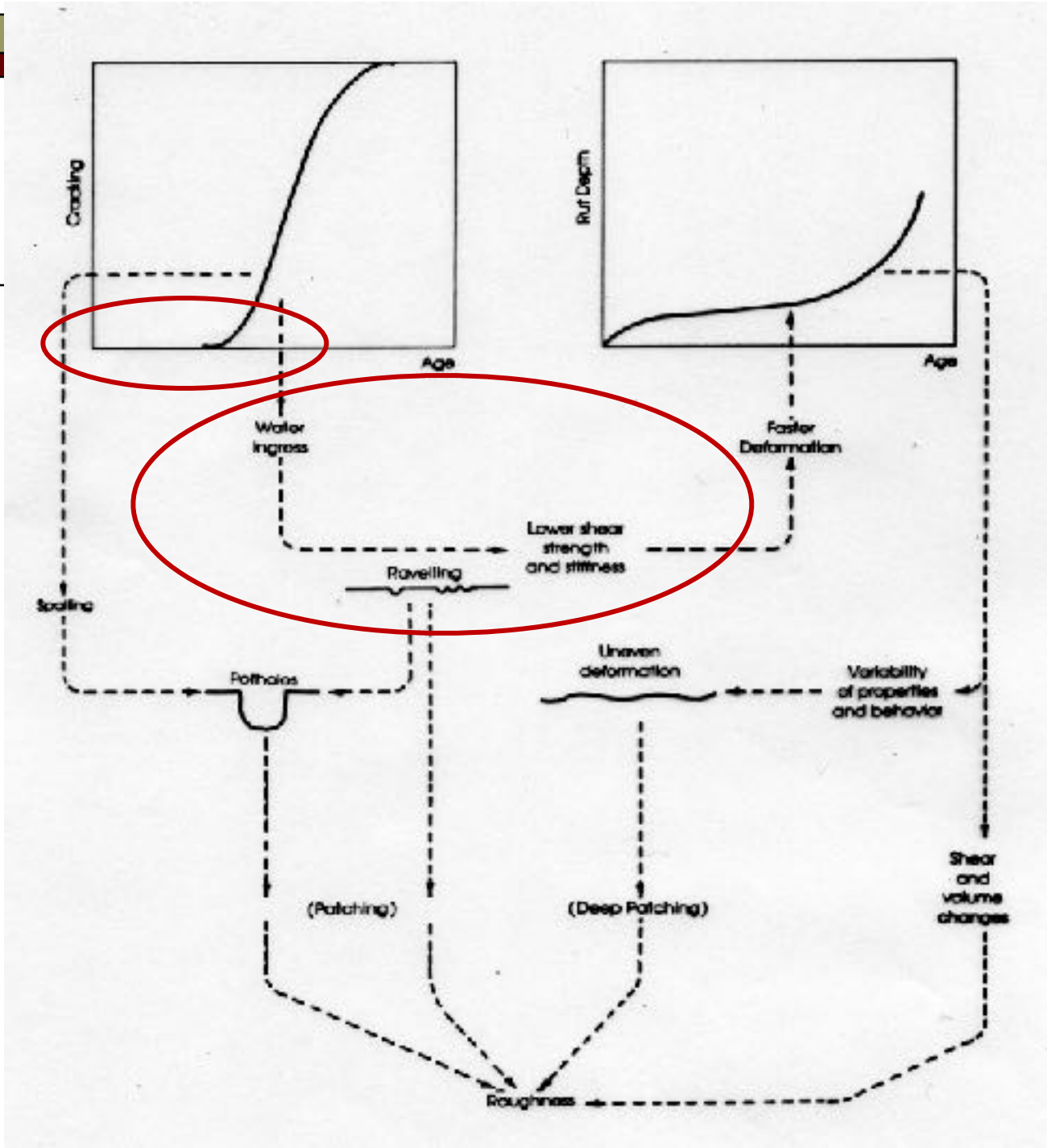
- May need distress on entire section
  - Should I do localized with a seal coat/localized with thin overlay

Preventive Maintenance

Prevent development of extensive distress

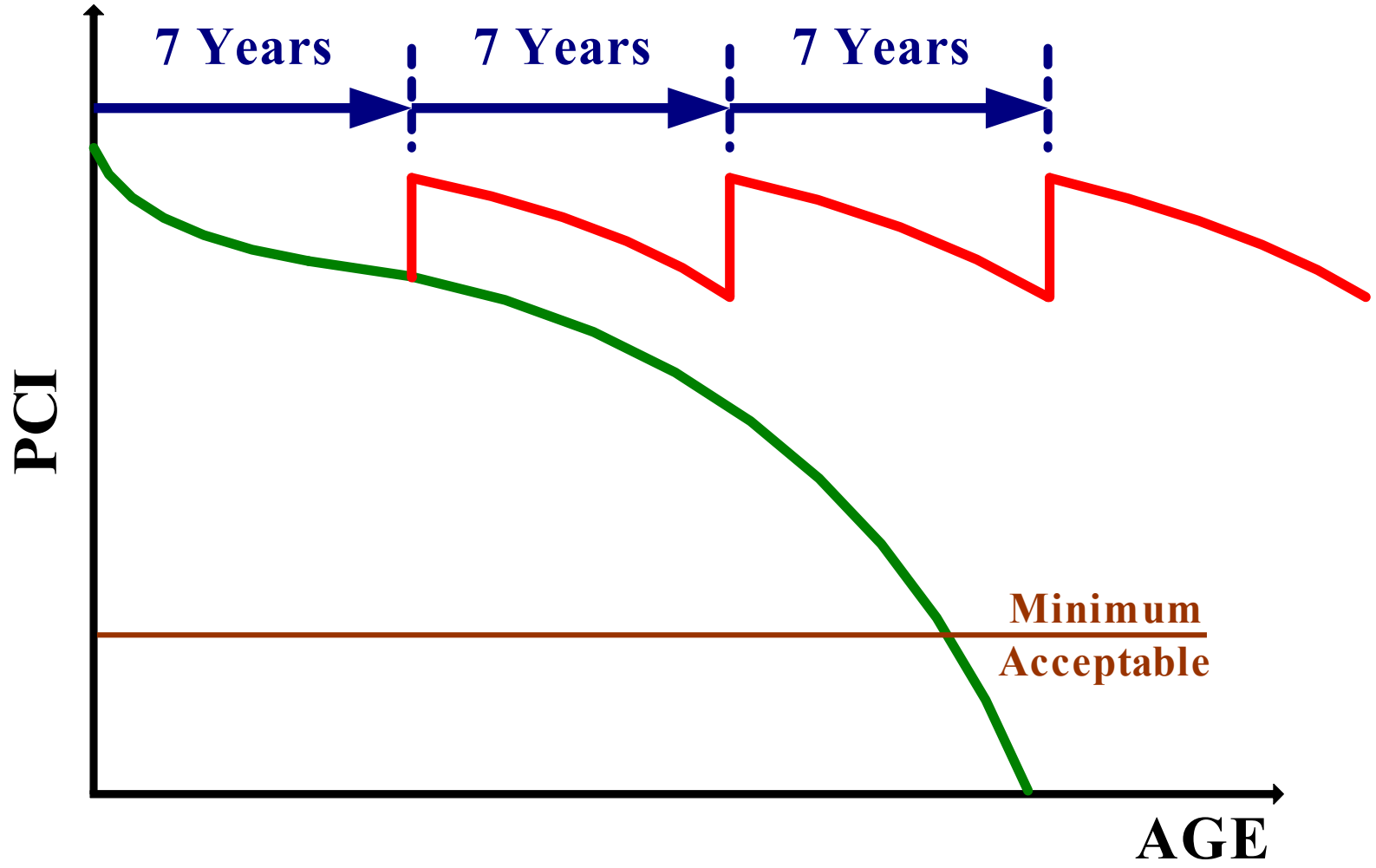
Primarily addresses environmental caused deterioration

Preserves existing structure so that it can resist traffic loadings



Preventive Maintenance

Keep cracking & other distress from developing



PM Analysis

- Often completed by Public Works Personnel
- Generally not much structural or other analysis unless conditions warrant it

Pavements Must be Designed

- Pavements not structurally adequate to support traffic loads will fail no matter the preventive maintenance applied
- Many existing local pavements not designed
- Many agencies have a large backlog of more extensive/expensive work

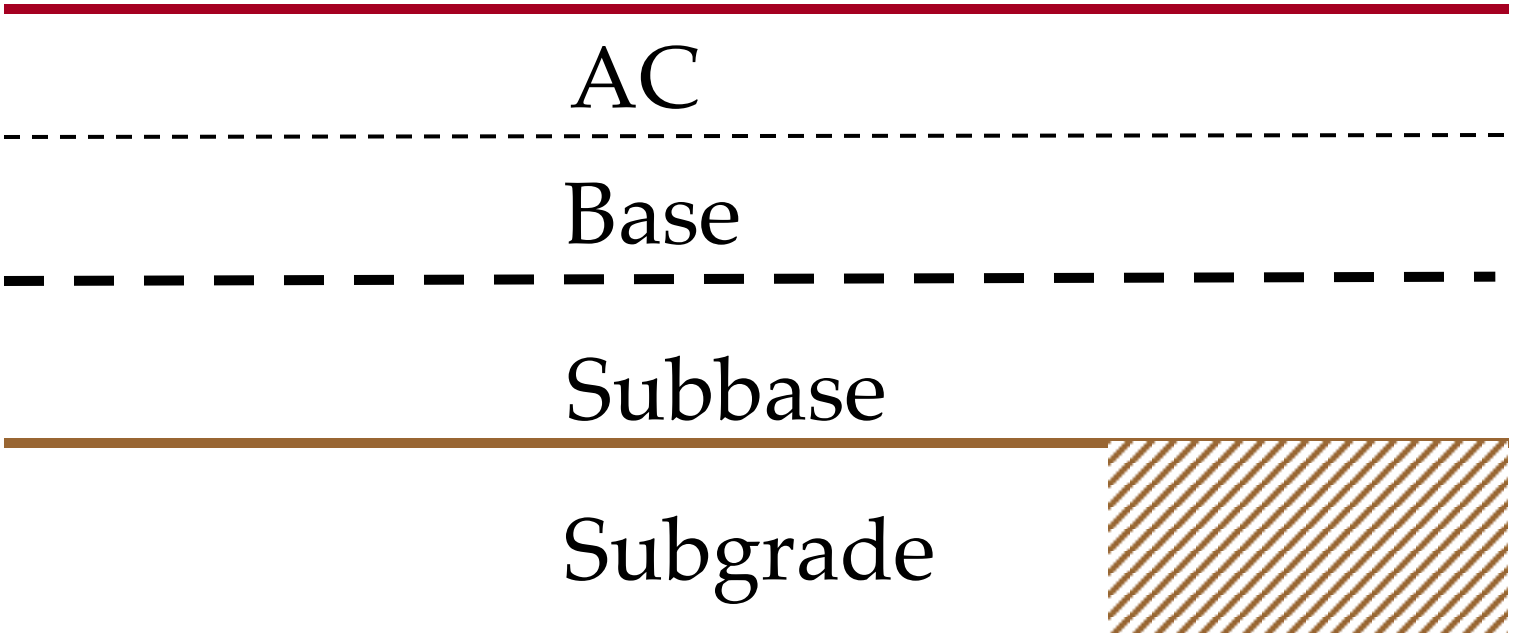
Project-Level Analysis

- Used to determine the best treatment and to develop final cost estimates for each individual segment
- Requires more detailed data and more extensive analysis
- Some help from software
  - Run Analysis with Selected Projects

Structurally Inadequate?

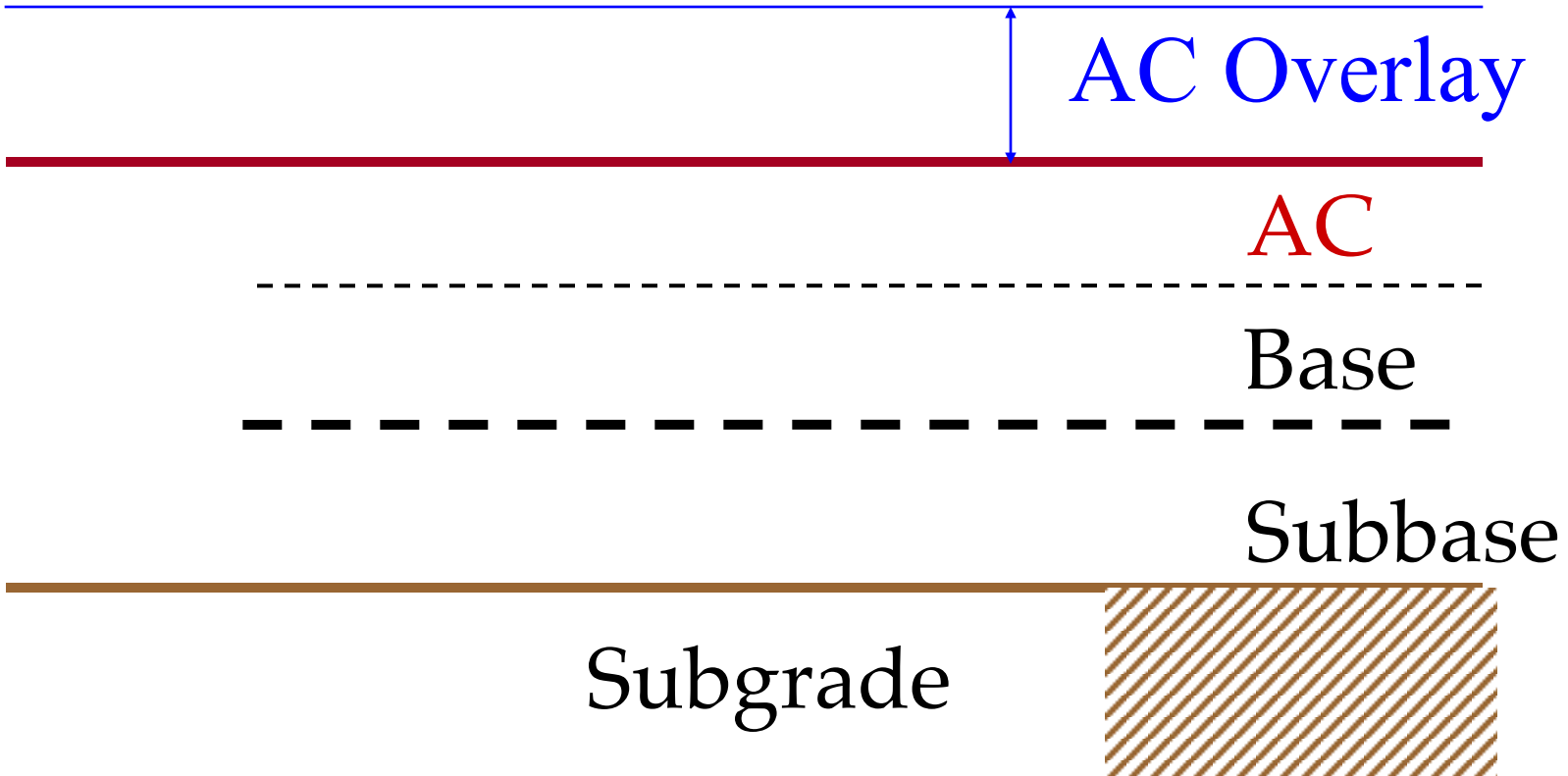
- Overlay or other strengthening approach required
  - More later
- Reconstruction - remove & replace
  - Use new design procedure
- Overlay - add additional surface layer
  - Use overlay design procedure
  - Use in-place material property values for layers left in place

Typical Flexible Pavement Layers



Overlay

Add Layer Above
Existing Pavement Layers



Properties

- Typical characteristics
  - Dense graded HMA
  - Rubberized Hot Mix Asphalt (RHMA)
  - Applied to flexible or rigid surface
  - 0.1 to 0.75 ft (25 to 225 mm) thickness
- Options
  - Mill and Fill
  - Interlayers (SAMI, Fabrics, etc.)

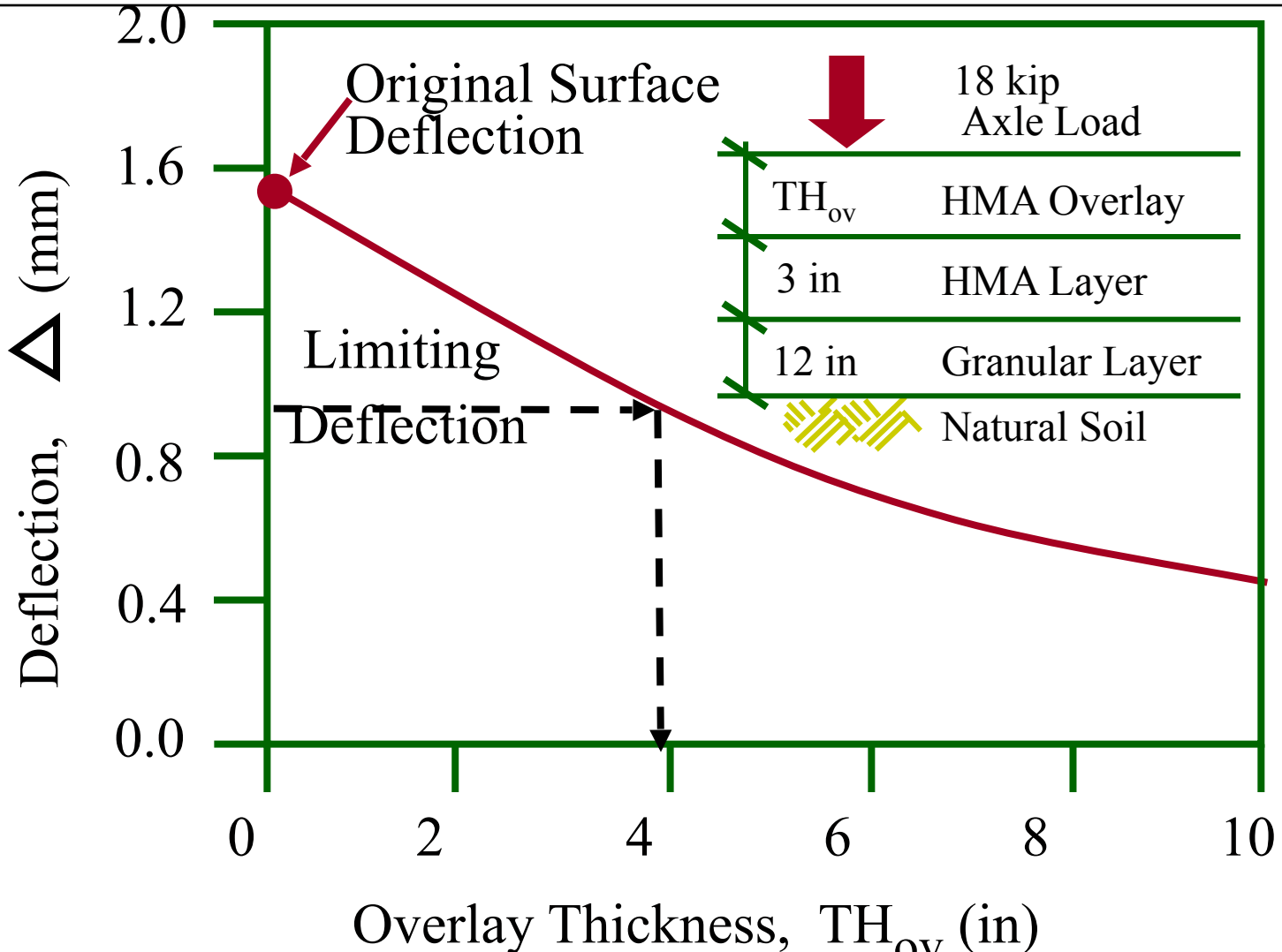
Purpose and Applications

- Improve
  - Structural capacities (structural overlay)
    - and/or
  - Functional characteristics (non-structural overlay)
- Select approach based on pavement conditions at time of overlay

Deflection Approach to Overlay Design

- Determine deflection needed to carry current and future traffic (Limiting Deflection)
- Determine current deflection
- Find added asphalt thickness required to reduce deflection to Limiting Deflection

CALTRANS Deflection Approach



Design Approach

- Follow local design method
  - WSDOT Pavement Policy – Sep 2018
  - ODOT Pavement Design Guide
  - ITD Roadway Design Manual
  - NTD Road Design Guide
- Most rehabilitation/reconstruction designed by:
  - Agency engineers
  - Consulting engineers under contract

Selecting Appropriate Treatments

- Engineering knowledge & Engineering economics
- Life Cycle Cost Analysis (LCCA)
  - Uses economic principles to compare investment in competing treatments & strategies
  - Among candidate treatments for a specific segment type
  - Determine which is generally most cost effective
- Based on historical data for similar work

Project-Level Results

- Cost-effective design for:
  - Original construction
  - Maintenance (PM & Preservation)
  - Rehabilitation
  - Reconstruction
- Within imposed constraints
- For each selected section

Following Design

- Construction
  - Monitoring and reporting
  - Recording work and important information from construction
- Performance
  - Monitoring

Upkeep

- Update inventory data based on work completed
- Periodically re-inspect pavements

Feedback System

- Accuracy of past estimates
  - Treatments applied
  - Cost of treatments applied
- Improve future estimates based on observed performance
  - Improve condition projections

Update For Work Completed

- Computer does not know work completed until data entered
- Will recommend work on wrong projects unless data updated

Update Condition Information

- State or GASB requirements
- Inspect arterials/collectors once every 2 years?

How to Select Sections for Reinspection

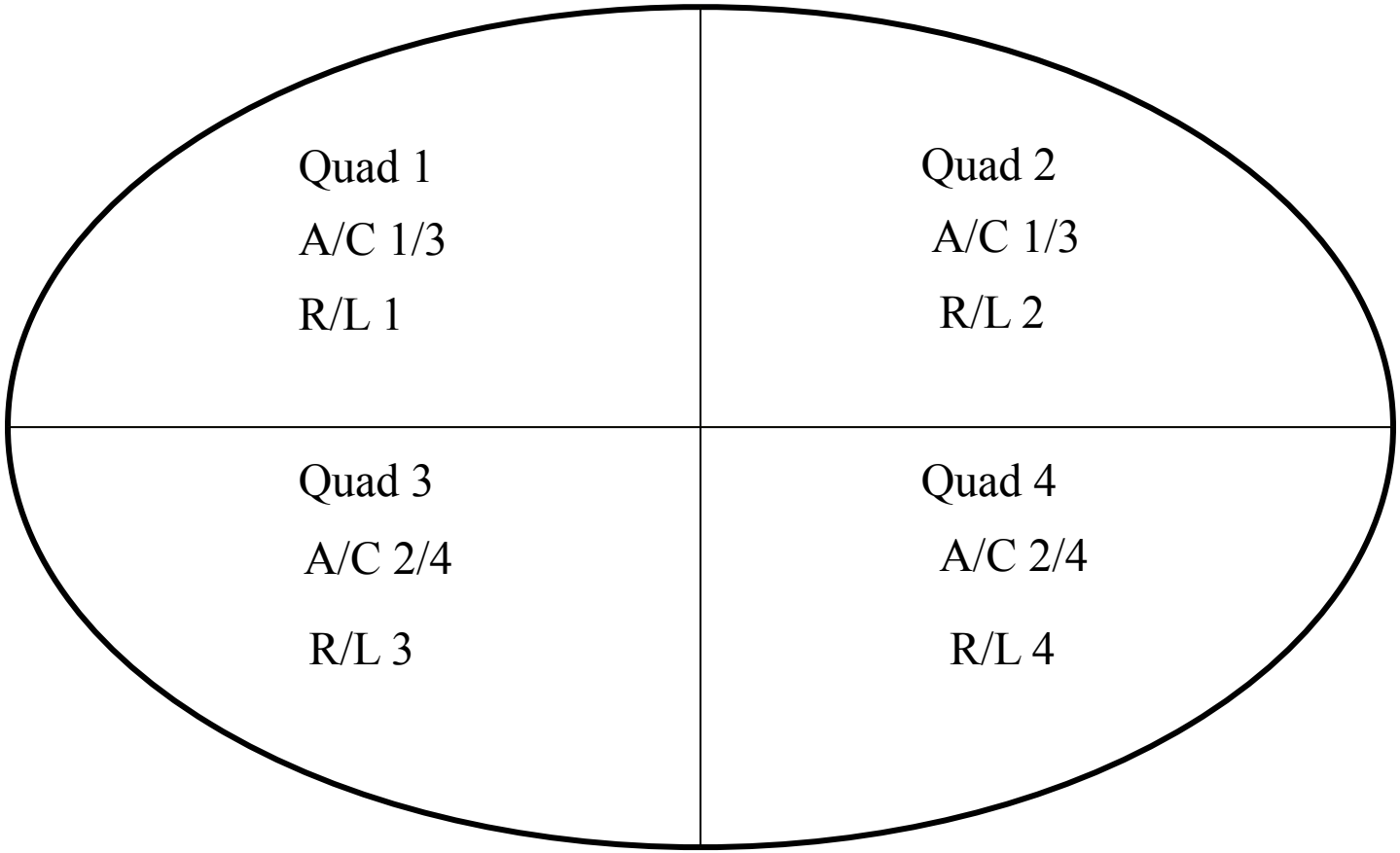
- Rate of deterioration
- Sections in designated area
- Consider not Inspecting those with Recent (less than 1 year old) Surface Seals

Distributed Inspection

- Year 1
  - Inspect all arterial & collector sections in north half
  - Inspect all residential/local & others in north-east quadrant
- Year 2
  - Inspect all arterial & collector sections in south half
  - Inspect all residential/local & others in south-east quadrant

- Year 3
  - Inspect all arterial & collector sections in north half
  - Inspect all residential/local & others in north-west quadrant
- Year 2
  - Inspect all arterial & collector sections in south half
  - Inspect all residential/local & others in south-west quadrant

Reinspection by Quadrant



Concentrated Inspection

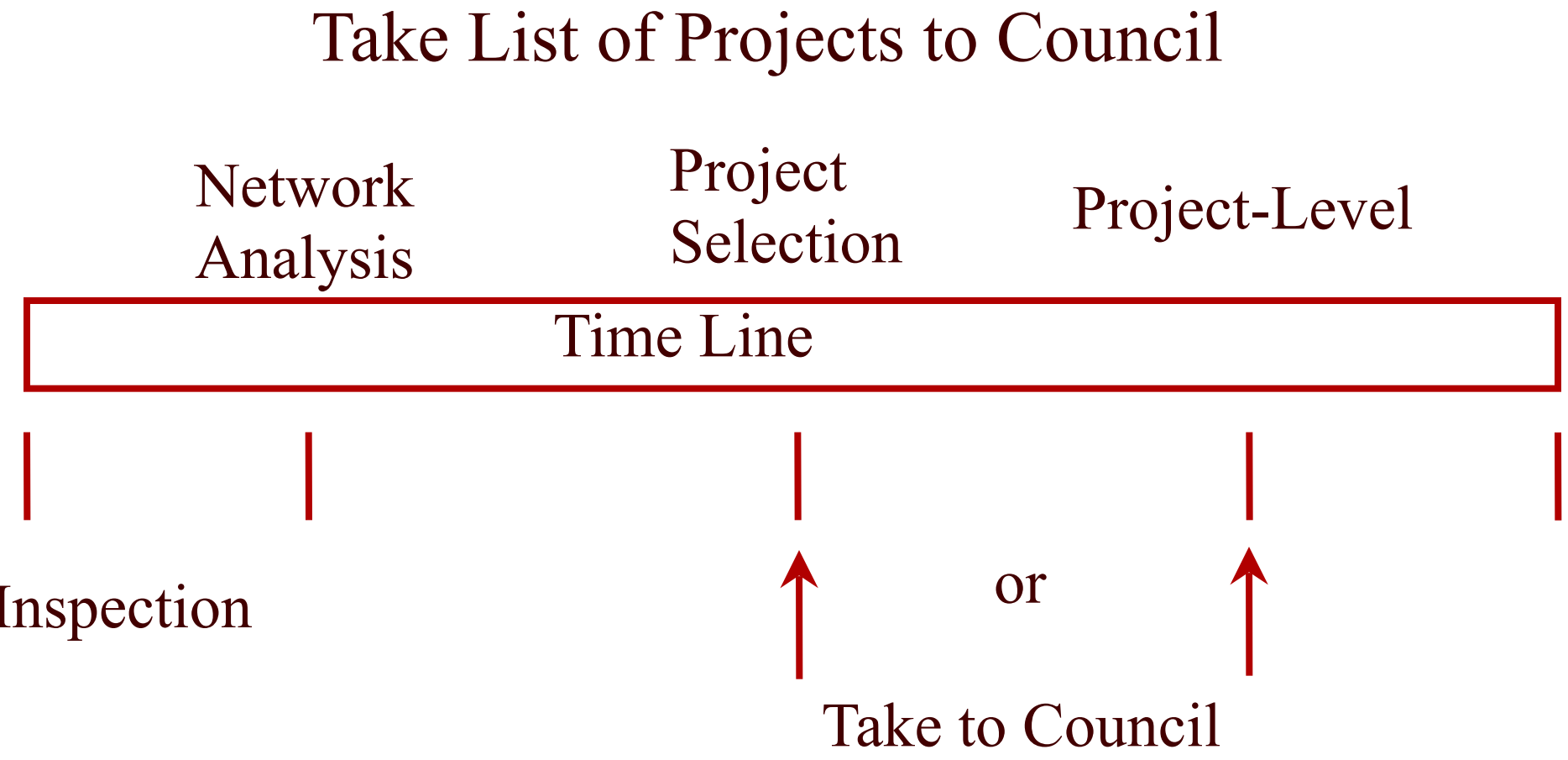
- Year 1
  - Inspect all arterial & collector sections
  - Inspect all residential/local & others in north half
- Year 3
  - Inspect all arterial & collector sections
  - Inspect all residential/local & others in south half

Training

- For all affected by PMS
- At several levels
- Upper management

- MTC training for
  - Basic concepts
  - Distress
  - Software use
  - Analysis

Timing of Analysis Actions



Elected Funding Authorities

- Politicians often more interested in less expensive short-term solutions
- Need justification to approve funding for expensive long-term solutions
- Typically are not engineers

Questions?