Knowledge – based Condition Assessments

Presentation for:

Predicting Outcomes of Investments in Maintenance and Repair of Federal Facilities Report Dissemination Forum

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Presentation Outline

This presentation encompasses:

- A defining of terms
- An explanation of what a knowledge – based condition survey is and how it compares to a "traditional" approach
- A listing of condition survey objectives
- A discussion of the different types of condition survey inspection types
- A look at a building component-section life cycle, including M&R needs, condition zones, and condition survey inspection needs at different periods in the life-cycle
- A discussion regarding creating a condition survey plan
- Some experiences from the field
- A note on sampling
- Some thoughts regarding costs

Terms

Component-section (a.k.a. section): The basic "management unit." Buildings are a collection of components grouped into systems. Sections define the component by material or equipment type and age.

Condition Survey Inspection (a.k.a. Condition Survey; Inspection): The gathering of data for a given component-section for the primary purpose of condition assessment.

Condition Assessment: The analysis of condition survey inspection data.

Component Section Condition Index (CSCI): An engineering – based condition assessment outcome metric (0 – 100 scale) and part of the Building Condition Index (BCI) series.

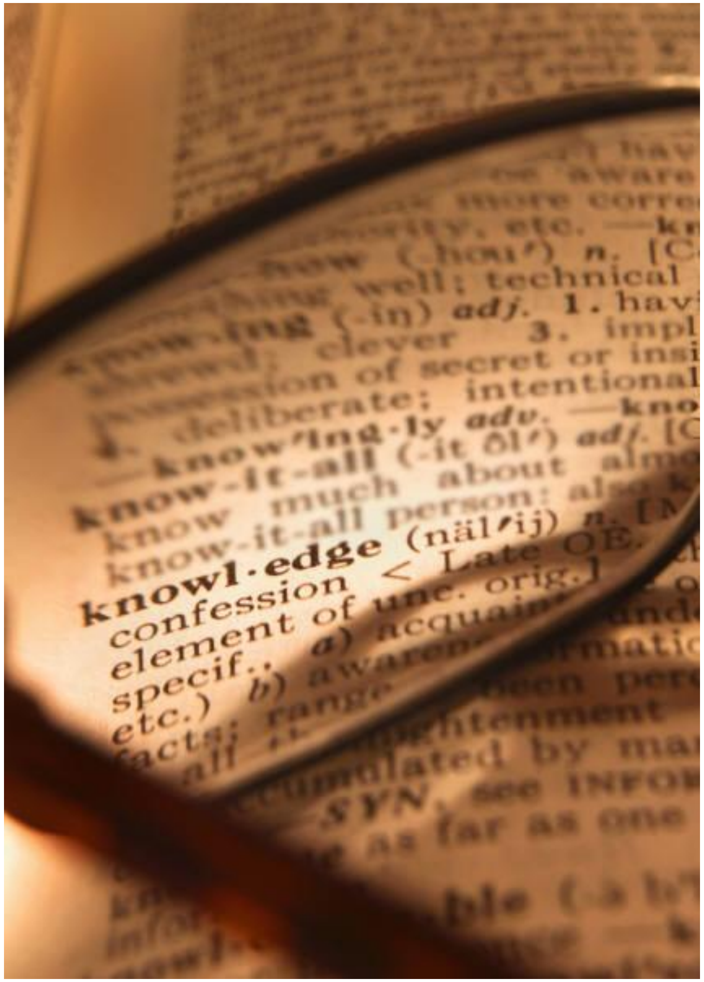
"Traditional" Condition Survey Inspection and Condition Assessment

- Identify and record condition related problems (deficiencies) that need to be (or should be) fixed
- Inspectors may provide an evaluation regarding priority (in a given priority class) and/or estimate of remaining service life, and perhaps flag other factors such as life – safety risk
- A scoping quantity and cost estimate is usually provided
- Inspections are usually planned and scheduled based on calendar and available budget

- Resulting condition assessment is usually monetary based and "backward" looking due to "as of" estimate date

Knowledge – based Condition Survey Inspection - KBCSI (a.k.a. KBI) and Condition Assessment

(rethinking the inspection and condition assessment process)



- Asset management decision making information needs vary over time
- “No data before its time” (get more detail, when, where needed)
- Use “knowledge” (quantifiable information about a building’s inventory, such as: component-section condition history, expected condition, importance, etc.) to determine what to inspect, how often, and what inspection type (i.e. inspection intensity) to do

Knowledge – based Condition Survey Inspection and Condition Assessment (con't)

- Recognizing that component-section life-cycles vary, tailor the frequency and level of inspection detail to the condition assessment objectives (i.e. why are we conducting an assessment?), expected component-section condition at the time of the inspection (determined from condition prediction model), importance, and risk tolerance
- Component-sections are planned (by year) for a given inspection type based on a logical set of business rules
- Will result in the various component-sections in a given building being inspected on different frequencies
- Goals are to manage risk, increase the utility of inspection data and condition assessment results, and reduce inspection costs
- Condition assessment is "forward" looking

Condition Survey Inspection Objectives

1. Determine Condition (i.e. CSCI) of Component-Section
2. Determine Roll-Up Condition of System, Building, etc.
3. Provide a Condition History
4. Compute Deterioration Rates
5. Calibrate/Re-calibrate Condition Prediction Model Curves
6. Compute/Re-compute Remaining Maintenance Life
7. Determine Broad Scope of Work for Planning Purposes
8. Quantify/refine Work Needs (incl root cause analysis, if needed)
9. Establish when Cost Effective to Replace (vs. Repair)
10. Compute/Re-compute Remaining Service Life
11. QC/QA (Post-work Assessment)

Condition Survey Inspection Types

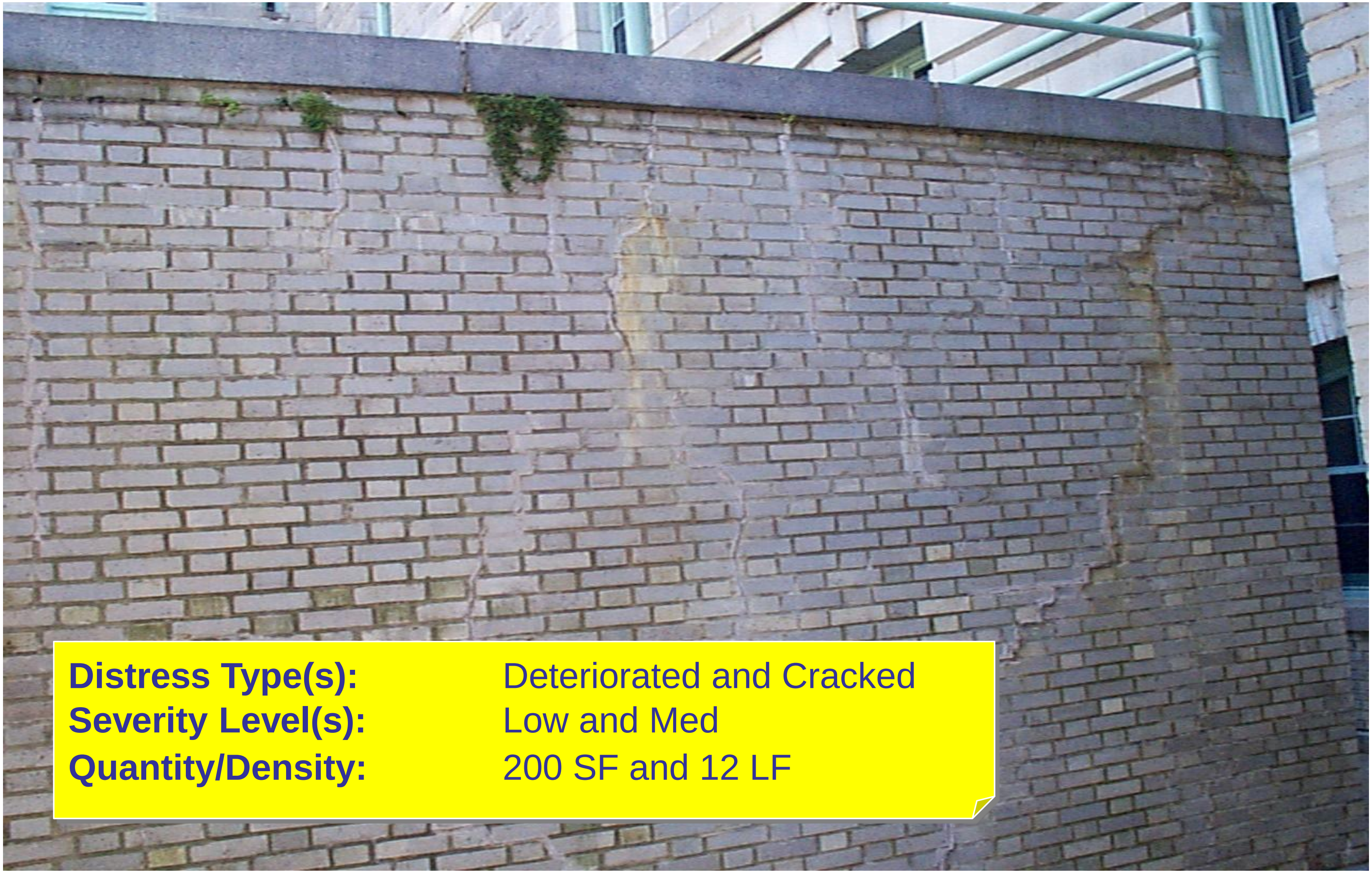
Deficiency: The “traditional” inspection discussed previously.

Distress Survey: The identification of distress types (i.e. crack, damage, etc.), severity (low, medium, high) and density (percentage) present. Data directly used in the calculation of the CSCI. No estimate of cost or priority.

Distress Survey with Quantities: Same as distress survey except that distress quantities are measured or counted. The resulting density is more accurate than a distress survey, thus the CSCI is more precise.

Direct Rating: A one-step process that combines inspection and condition assessment. An alphanumeric rating (three categories, three subcategories each) is assigned to the component-section by the inspector. Rating is directly correlated to a CSCI value, but is less accurate than a CSCI derived from a distress survey. Quick, but no record of what’s wrong.

Distress Survey with Quantities

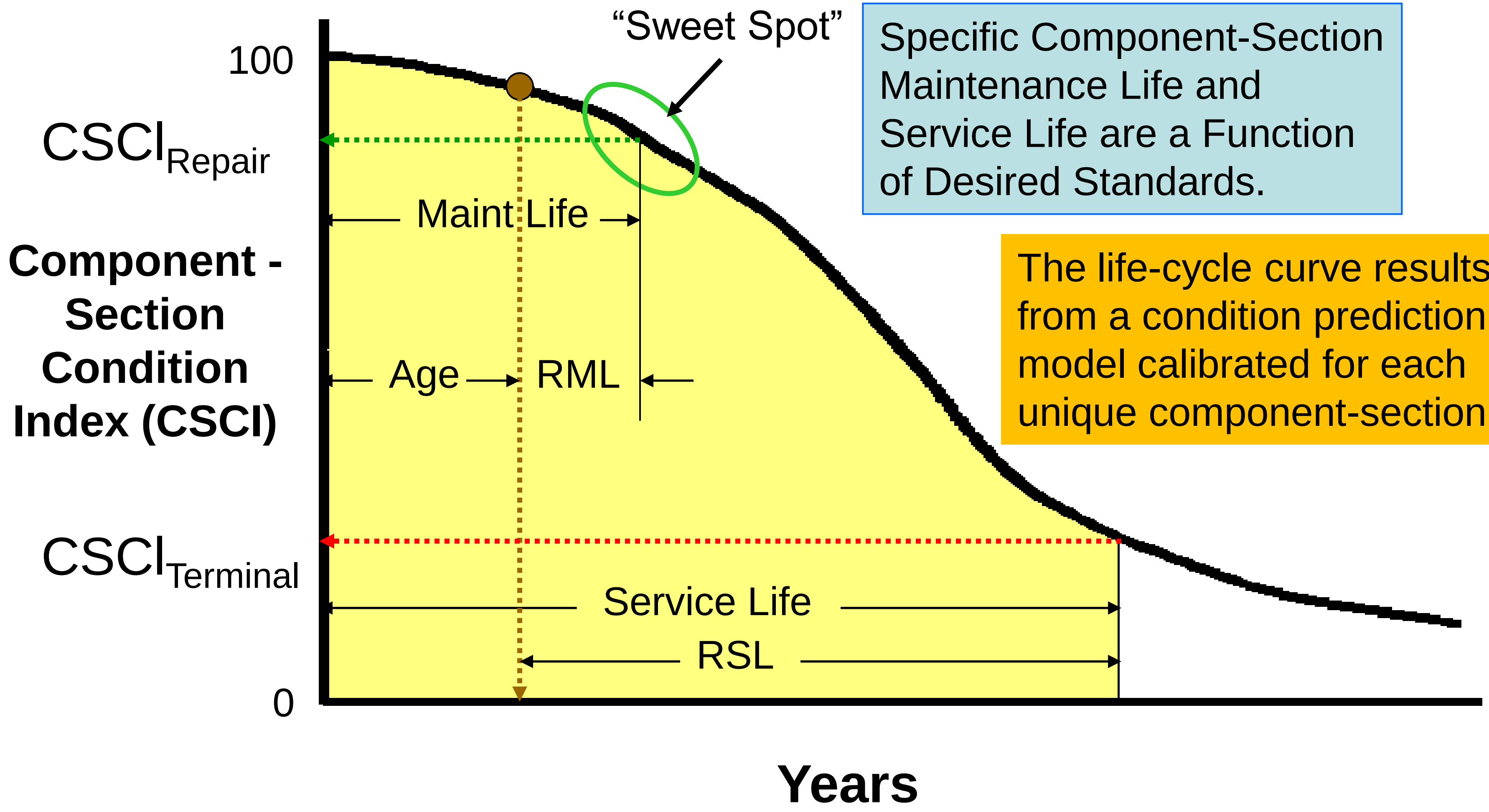


Distress Type(s): Deteriorated and Cracked
Severity Level(s): Low and Med
Quantity/Density: 200 SF and 12 LF

Direct Condition Rating Definitions
(partial)

Rating	Work Needs	Rating Definition
Amber (+)	Maintenance or repair to any of the following: Minor repairs to several subcomponents; or Significant repair, rehabilitation, or replacement of one or more subcomponents, but not enough to encompass the component-section as a whole; or Combinations thereof.	Component-section or sample serviceability or reliability is degraded, but adequate. A very few, major (critical) subcomponents may suffer from moderate deterioration with perhaps a few minor (non-critical) subcomponents suffering from severe deterioration.
Amber		Component-section or sample serviceability or reliability is definitely impaired. Some, but not a majority, major (critical) subcomponents may suffer from moderate deterioration with perhaps many minor (non-critical) subcomponents suffering from severe deterioration.
Amber (-)		Component-section or sample has significant serviceability or reliability loss. Most subcomponents may suffer from moderate degradation or a few major (critical) subcomponents may suffer from severe degradation.

Condition/Maintenance Life/RML/ Service Life/RSL Relationships for a Given Component -Section

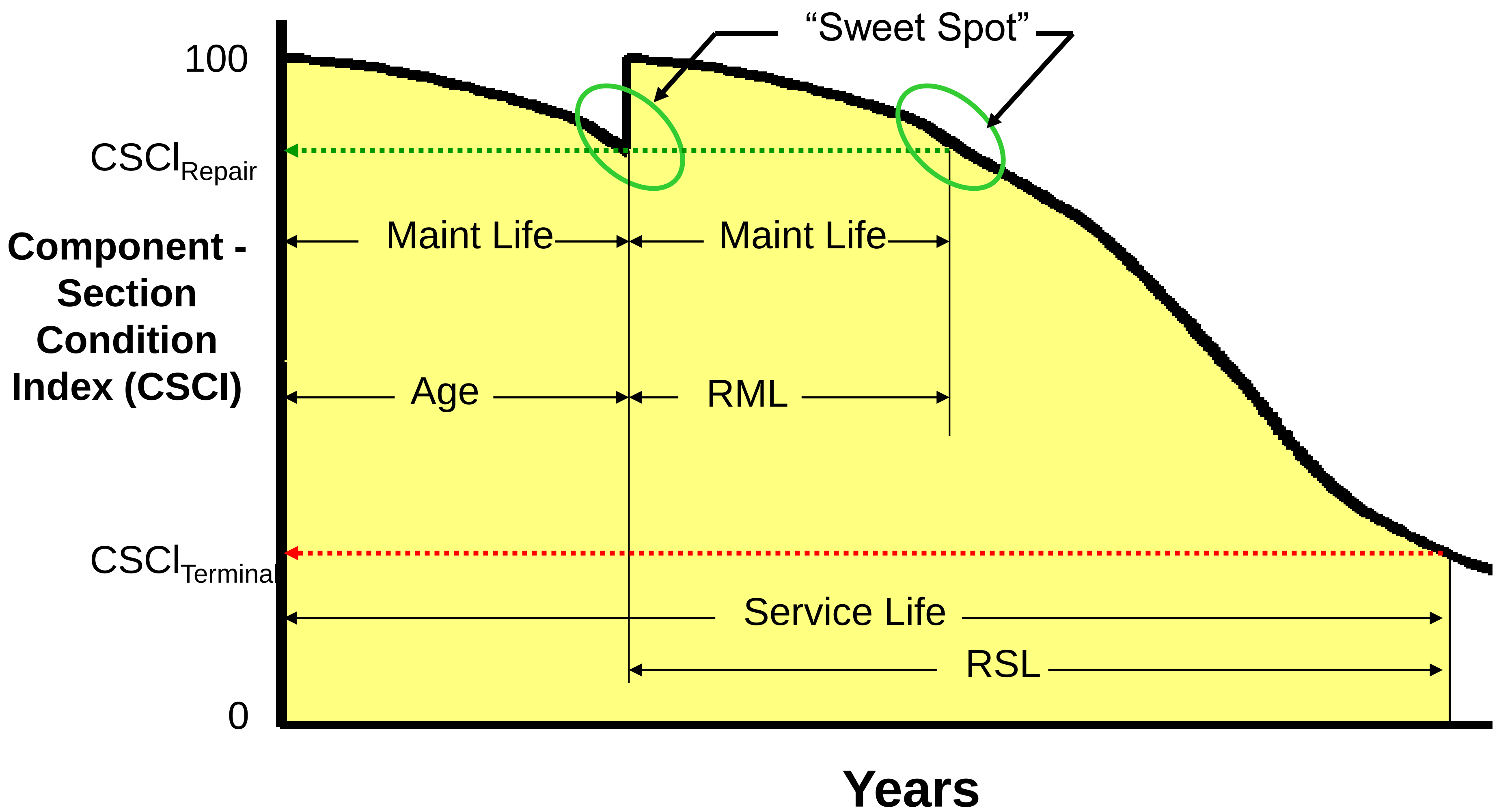


Specific Component-Section Maintenance Life and Service Life are a Function of Desired Standards.

The life-cycle curve results from a condition prediction model calibrated for each unique component-section.

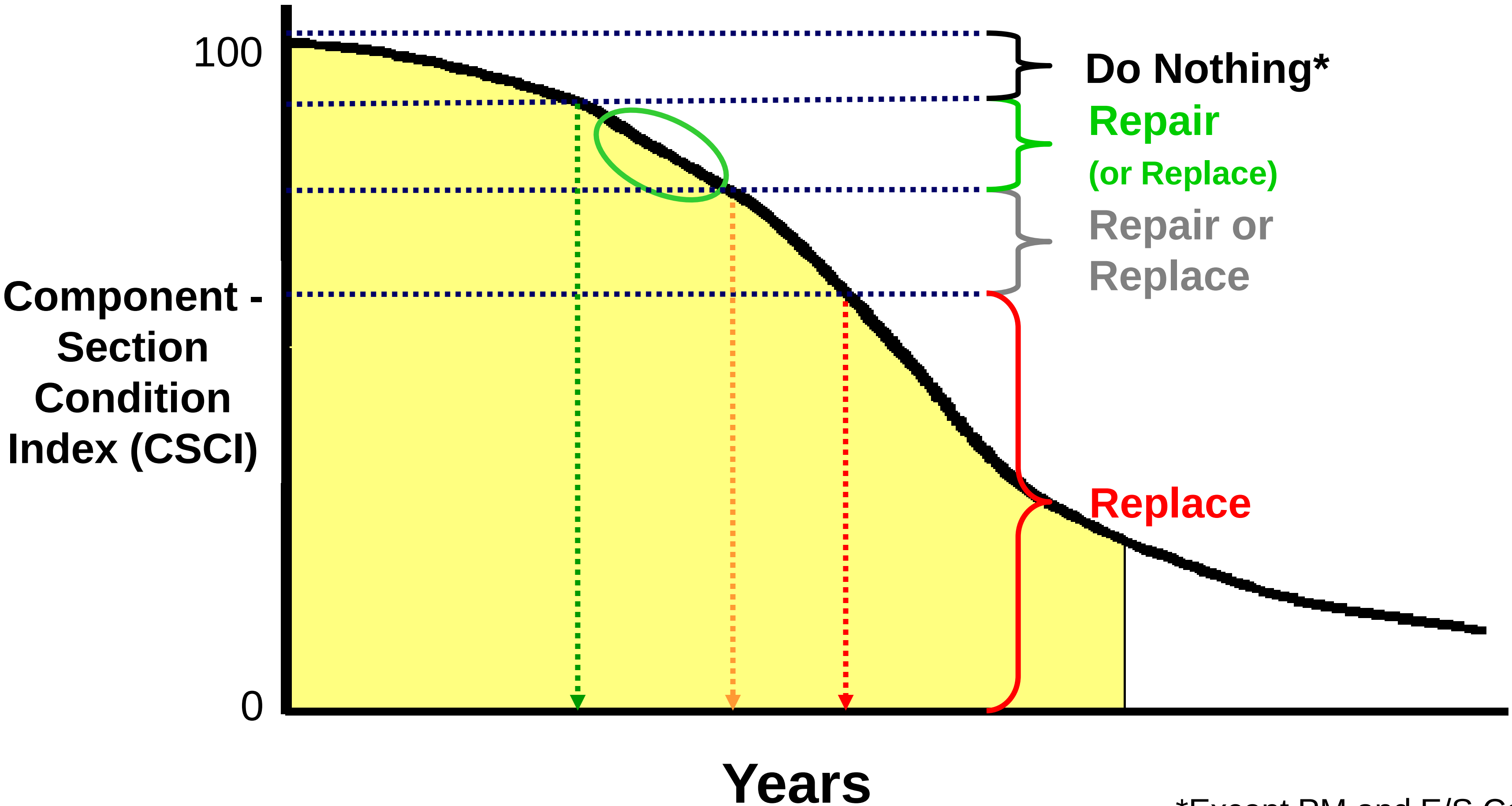
Source: D.R. Uzarski, Ph.D., P.E.

Component-Section Life Cycle Condition Curve After Maintenance/Repair



Source: D.R. Uzarski, Ph.D., P.E.

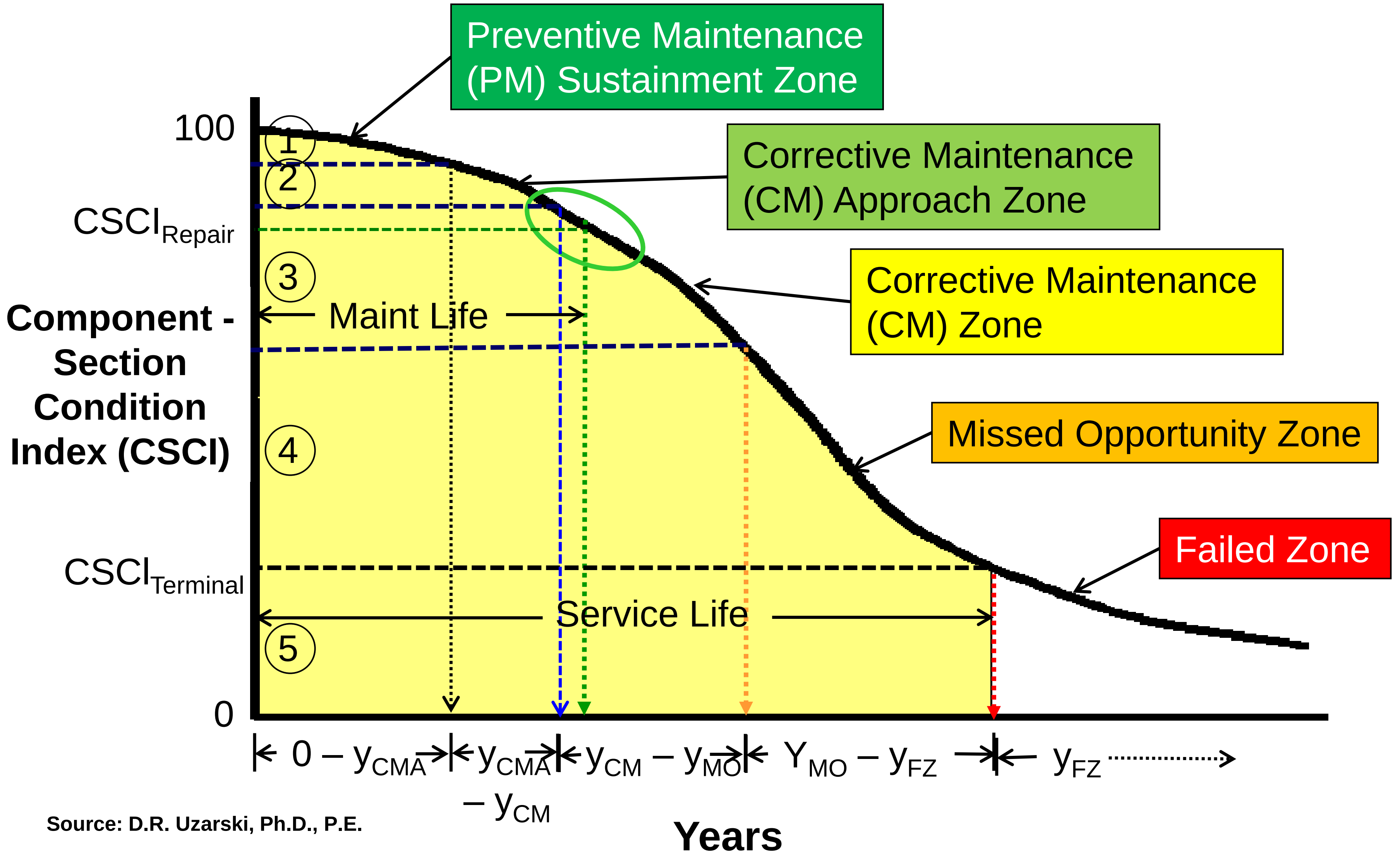
Component-Section Maintenance/Repair Needs vs. Condition



*Except PM and E/S Calls

Source: D.R. Uzarski, Ph.D., P.E.

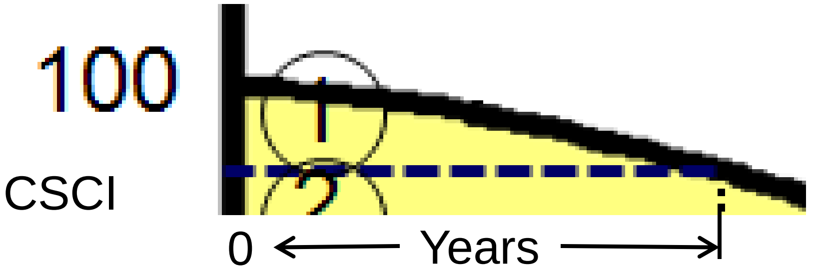
Condition Zones for a Component-Section Life-Cycle



Source: D.R. Uzarski, Ph.D., P.E.

Condition Zones

Zone 1 – Preventive Maintenance (PM) Sustainment Zone

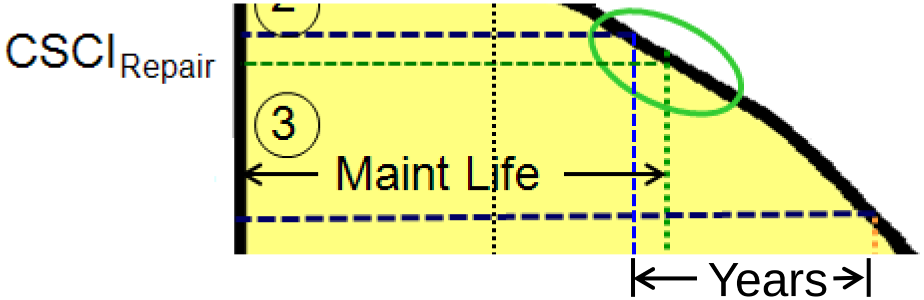


- Little, if any, corrective work needed
- Condition surveys needed to satisfy objectives 1 – 6, 11
    1. Determine Condition of Component-Section
    2. Determine Roll-Up Condition of System, Building, etc.
    3. Provide a Condition History
    4. Compute Deterioration Rate
    5. Calibrate/Re-calibrate Condition Prediction Model Curve
    6. Compute/Re-compute Remaining Maintenance Life
    11. QC/QA (Post-work Assessment)

Zone 2 – Corrective Maintenance (CM) Approach Zone

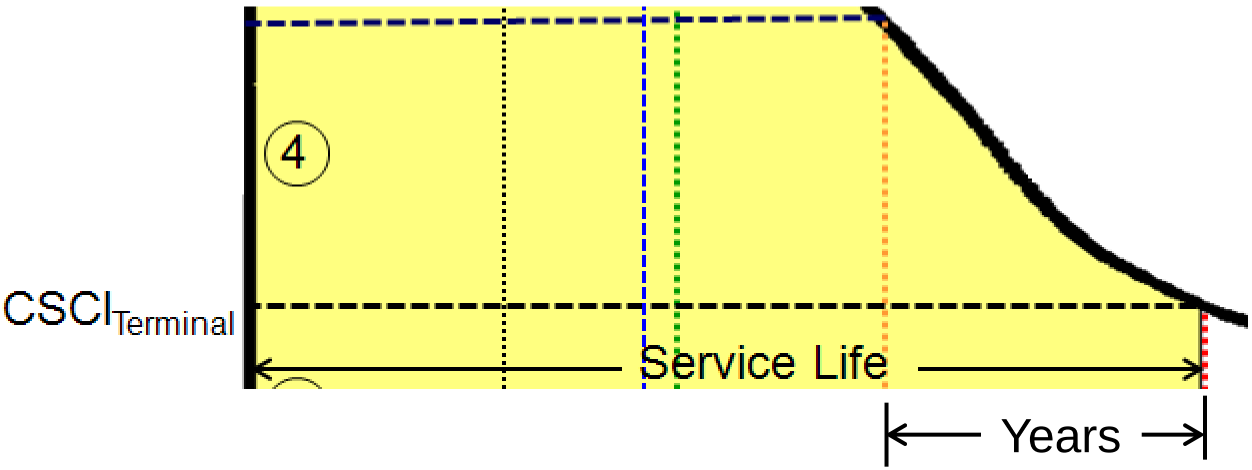
- Corrective maintenance usually not planned for this zone
- Approaching the “Sweet Spot”
- CSCI “Sweet Spot” value, rate of deterioration, and planning horizon set the upper limit for this zone
- Condition surveys needed to satisfy objectives 1 – 7
  1. Determine Condition of Component-Section
  2. Determine Roll-Up Condition of System, Building, etc.
  3. Provide a Condition History
  4. Compute Deterioration Rate
  5. Calibrate/Re-calibrate Condition Prediction Model Curve
  6. Compute/Re-compute Remaining Maintenance Life
  7. Determine Broad Scope of Work for Planning

Zone 3 – Corrective Maintenance (CM) Zone



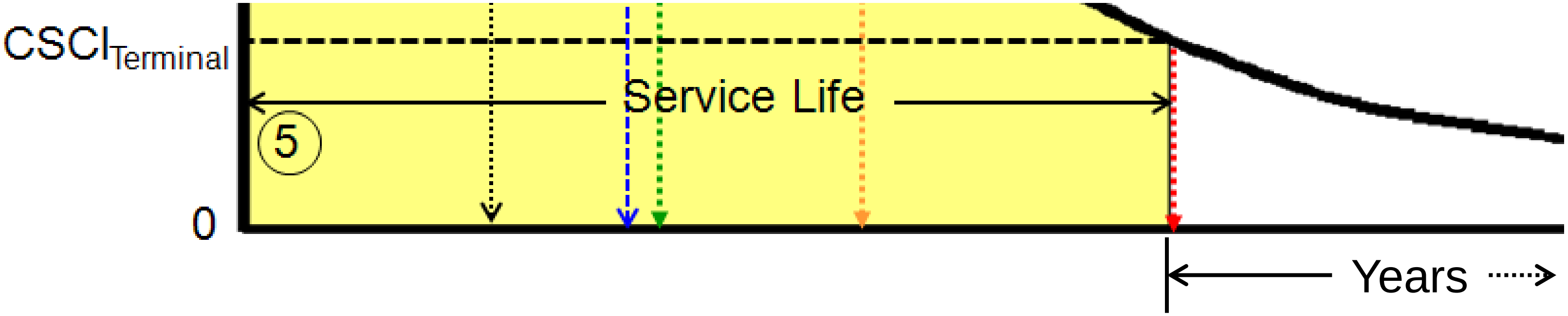
- Zone defined by the "Sweet Spot"
- Begins one year prior to "Sweet Spot" year
- Zone extends beyond "Sweet Spot" because needs will likely exceed funding in a given year and work is often deferred
- Condition surveys needed to satisfy objectives 1 – 9 (6 – 9 are main focus)
  6. Compute/Re-compute Remaining Maintenance Life
  7. Determine Broad Scope of Work for Planning
  8. Quantify/refine Work Needs
  9. Establish when Cost Effective to Replace
- 100% of component-section should be inspected (if sampling conducted previously)
- However, condition survey may be skipped in lieu of a "Just-in-time (JIT)" detailed job plan field survey to finalize scope and quantities (if important and funding is assured).

Zone 4 – Missed Opportunity Zone



- "Missed Opportunity" because penalty costs are incurred
- Replacement (or major rehab/reconstruction) generally is the most economical option
- Condition surveys needed to satisfy objective 10
  10. Compute/Re-compute Remaining Service Life
- Objectives 1 – 5 and 7 – 9 are less important in this zone
- Objective 6 is meaningless
  6. Compute/Re-compute Remaining Maintenance Life

Zone 5 – Failed Zone



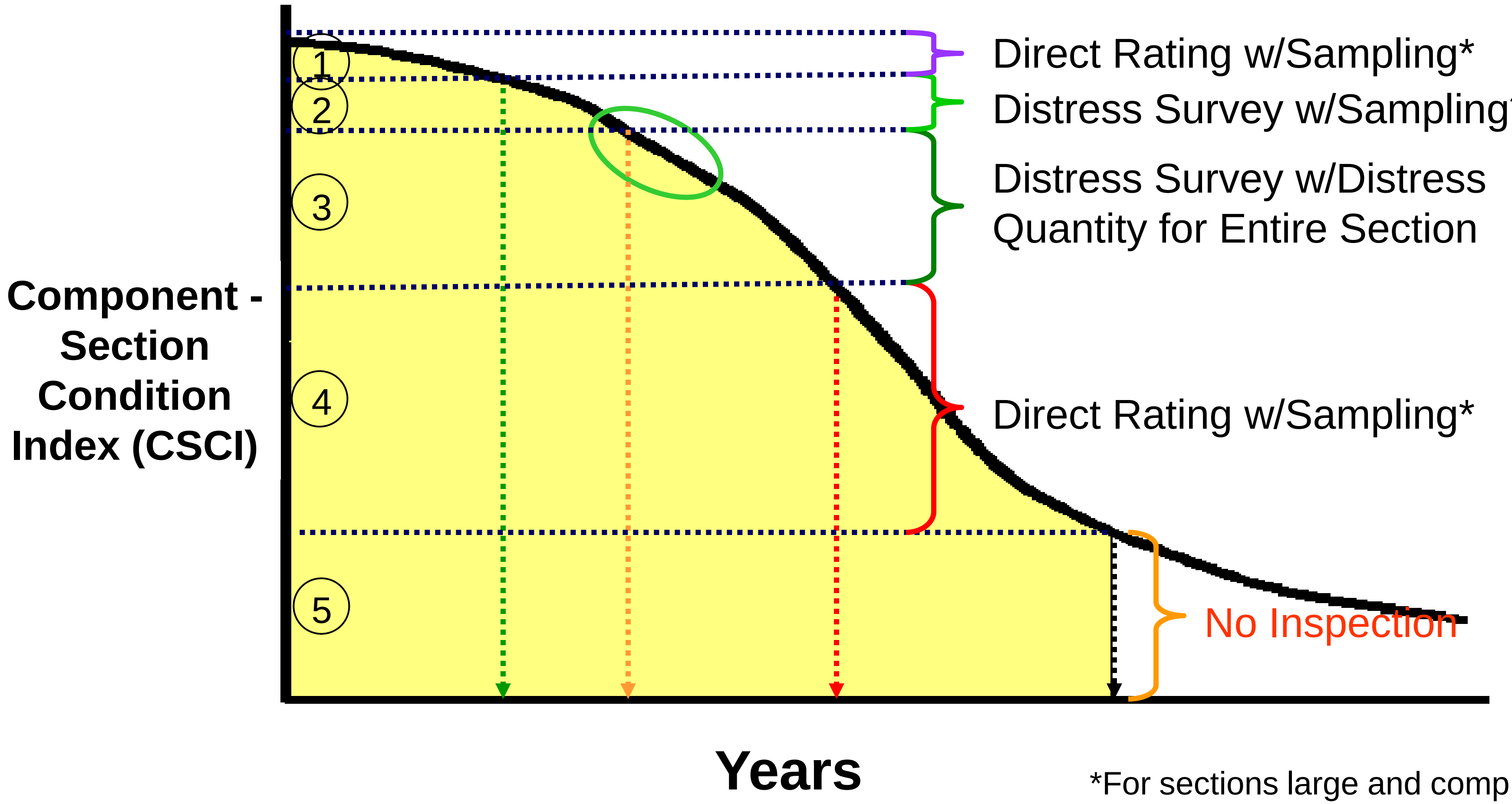
- Replacement (or major rehab/reconstruction) only viable option
- Condition surveys no longer needed
- Estimated CSCI values will satisfy objectives 1 – 3
  1. Determine Condition of Component-Section
  2. Determine Roll-Up Condition of System, Building, etc.
  3. Provide a Condition History
- All other objectives either can be met though model estimation or they are meaningless

Ability of Condition Survey Inspection Types to Meet Condition Survey Objectives

Objective	Direct	Distress	Distress w/Qty
1. Determine Condition of Component-Section	Good	Better	Best
2. Determine Roll-Up Condition of System, Building, etc.	Good	Better	Best
3. Provide a Condition History	Good	Better	Best
4. Compute Deterioration Rates	Limited	Better	Best
5. Calibrate Condition Prediction Model Curves	Limited	Better	Best
6. Compute/Re-compute Remaining Maintenance Life	Limited	Better	Best
7. Determine Broad Scope of Work for Planning	Limited	Better	Good
8. Quantify/refine Work Needs	No	No	Good
9. Establish when Cost Effective to Replace	No	Good	Better
10. Compute/Re-compute Remaining Service Life	Good	Better	Best
11. QC/QA (Post-work Assessment)	Limited	Good	Better

Matching of Condition Survey Inspection Type to Specific Condition Zones

(balancing objectives and cost)



*For sections large and complex enough to warrant sampling. Sampling to be discussed later.

Source: D.R. Uzarski, Ph.D., P.E.

Exceptions

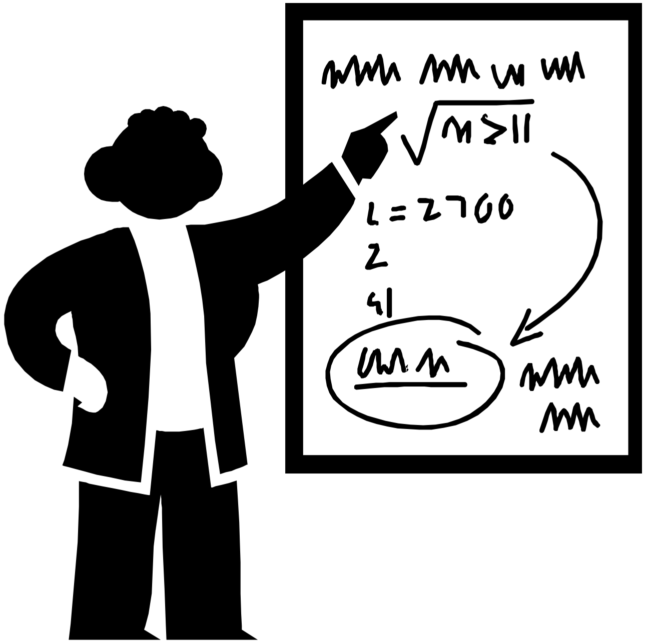
Exceptions exist that may warrant a different condition survey strategy for a given component-section

- Non-maintainable
  - Do not maintain/repair
  - Replace when needed
  - Two cases:
    - Run-to-failure with minimal disruption
      - Low risk case
      - No condition surveys needed
    - Replace prior to failure
      - High risk or “no surprises” case
      - Perform a condition survey at some point prior to end of expected service life
      - Additional condition surveys may be scheduled to mitigate disruption risk
      - *Or*, simply replace prior to end of expected service life

Exceptions (con’t)

- Catastrophic Event
  - Event, large or small, may affect life-cycle in an unpredictable way
  - Often, some type of a condition survey is needed
- Computerized Maintenance Management System (CMMS) Trend Analysis
  - Service call analysis may flag a problem
  - Condition survey may be needed to verify component-section condition
- Rapid Deterioration Rate or Short Service Life
  - Zones 1 and 2 may be compressed and combined with Zone 3
  - “Sweet Spot” rapidly approaching
- Certifications

Knowledge – Based Condition Survey Inspection Planning



- Brings together the ideas of what to inspect, how often, and what inspection type to use for scheduling condition surveys in a given year
- Consider risk
- Establish a set of business rules using:
  - Building importance (based on, for example, the Mission Dependency Index – MDI)
  - Component-section importance
  - Service life
  - Remaining service life
  - Maintenance life
  - Remaining maintenance life
  - Rate of deterioration
  - Condition zone
  - Condition standards and policies
  - Max interval between condition surveys

Example Knowledge – based Condition Survey Inspection Plan

Knowledge-Based Inspection with MDI Criteria

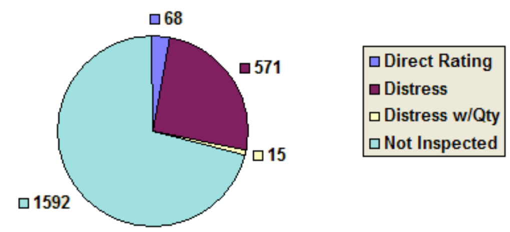
Knowledge-based Condition Survey Inspection Plan

Inspection Parameters For: MDI 85-71

	CI Lower	Max Insp Interval	# Insp's in Zone	Degradation Factor
Zone 1	70	20	1	2
Zone 2	60	20	2	2
Zone 3	50	20	2	2
Zone 4	40	20	1	2
Zone 5	0	20	1	2

Recalculate Data

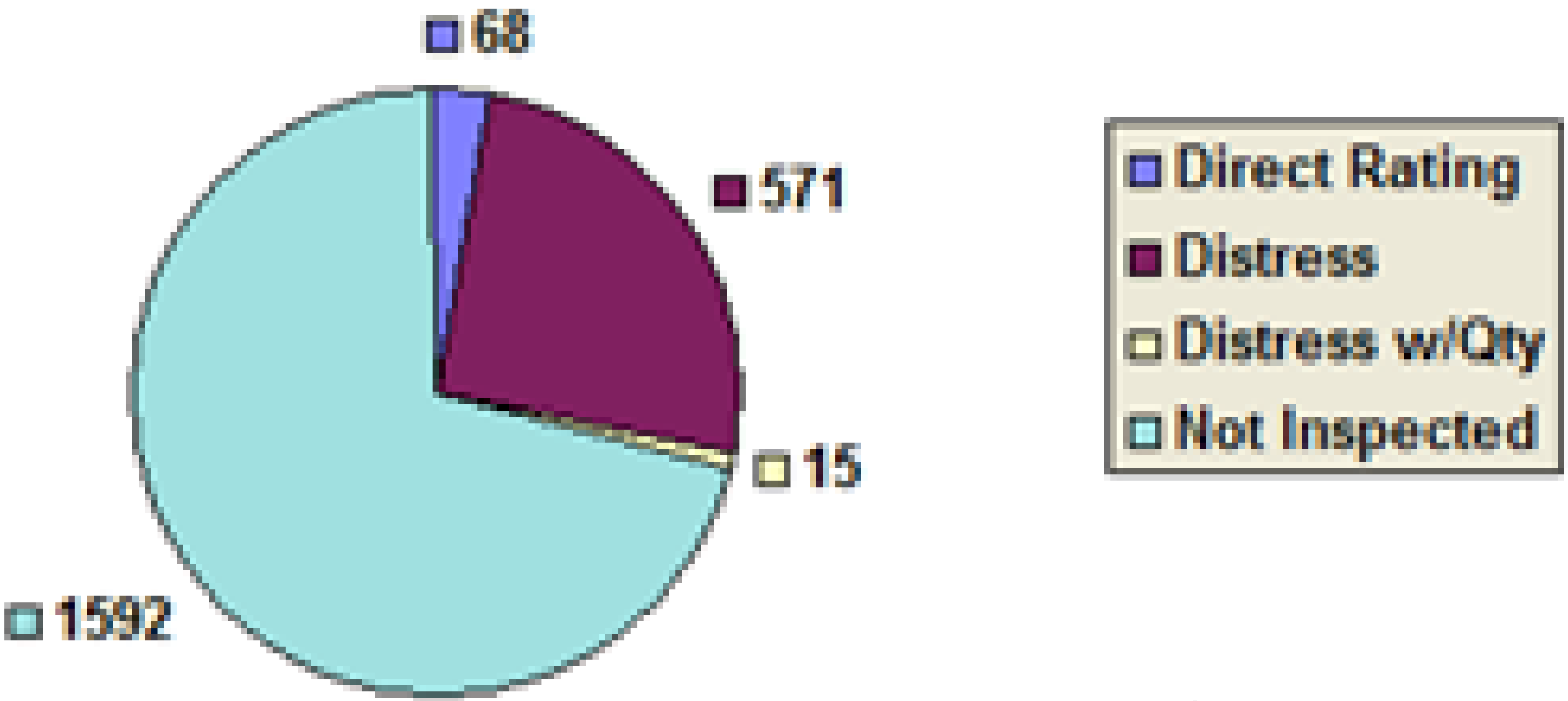
Inspection Breakdown



Bldg No	System	Component	Material	Comp Type	Section	Installed	RSL	Pro CI	Quantity	UM	Last Insp	Inspecti
00601	HVAC	Cooling Unit/Plant	Condenser (R	Air-Cooled 6	N/A	1996	9	89	2	EA	11/7/2002	Distress
00207	HVAC	Cooling Unit/Plant	Heat Pump	Water-to-Air	SC-5	1997	13	89	1	EA	11/4/2001	Direct
00205X	HVAC	Heating Unit/Plant	Baseboard	Hydronic 1/2	2nd floor	1974	0	40	24	EA	6/30/1974	Direct
00205X	HVAC	Heating Unit/Plant	Baseboard	Hydronic 1/2	3rd flr library	1974	0	40	15	EA	6/30/1974	Direct
00205	HVAC	Heating Unit/Plant	Baseboard	Hydronic 1/2	3rd Floor Library	1975	1	42	15	EA	6/30/1975	Direct
00205	HVAC	Heating Unit/Plant	Baseboard	Hydronic 1/2	2nd Floor Library	1975	1	42	24	EA	6/30/1975	Direct
00108	HVAC	Heating Unit/Plant	Furnace	Oil 95-134 M	HU 108-2	2003	14	95	1	EA	6/30/2003	Direct
00406	HVAC	Heating Unit/Plant	Unit Heater	Hot Water/Ste	UH-1	1976	2	44	1	EA	6/30/1976	Direct
00103	HVAC	Heating Unit/Plant	Unit Heater	Hot Water/Ste	UH 103-34	1974	30	84	1	EA	3/7/2002	Distress
00103	HVAC	Heating Unit/Plant	Unit Heater	Hot Water/Ste	UH-0052	1974	30	84	1	EA	3/7/2002	Distress
00112	HVAC	Other HVAC Equipm	Heat Exchang	Shell and Tube	N/A	1995	13	92	2	EA	11/7/2002	Direct
00103	HVAC	Other HVAC Equipm	Heat Exchang	Shell and Tube	N/A	1974	20	75	1	EA	3/7/2002	Detailed Ins
00112	HVAC	Other HVAC Equipm	Humidifier	<11 lbs/hr	N/A	1995	5	84	1	EA	11/7/2002	Distress
00406	HVAC	Other HVAC Equipm	Humidifier	50-100 lbs/hr	N/A	1976	0	0	1	EA	6/30/1976	Direct
00500	HVAC	Other HVAC Equipm	Pump	Industrial	Recirculation Boiler	2002	18	94	1	EA	11/13/2002	Distress
00112	HVAC	Other HVAC Equipm	Pump	Industrial	Hot Water	1995	13	92	2	EA	11/7/2002	Direct
00112	HVAC	Other HVAC Equipm	Pump	Industrial	Cold Water	1995	13	92	2	EA	11/7/2002	Direct
00500	HVAC	Other HVAC Equipm	Pump	Industrial	PCS500-1 (Reheat)	2002	18	93	1	EA	6/30/2002	Direct
00103	HVAC	Other HVAC Equipm	Pump	Industrial	Reheat	1998	13	90	1	EA	3/7/2002	Direct
00500	HVAC	Other HVAC Equipm	Pump	Industrial	PCS500-1	2002	18	94	1	EA	11/13/2002	Distress

Record: 1 of 1417

Knowledge – based Inspection Plan Inspection Type Summary



Note: The percentages of each condition survey inspection type will vary by year and by portfolio.

Knowledge – based Inspection Plan Inspection Type Detail

Bldg No	System	Component	Material	Comp Type	Section	Installed	RSL	Pro CI	Quantity	UM	Last Insp	Inspecti
00601	HVAC	Cooling Unit/Plant	Condenser (R	Air-Cooled 6	N/A	1996	9	89	2	EA	11/7/2002	Distress
00207	HVAC	Cooling Unit/Plant	Heat Pump	Water-to-Air	SC-5	1997	13	89	1	EA	11/4/2001	Direct
00205X	HVAC	Heating Unit/Plant	Baseboard	Hydronic 1/2	2nd floor	1974	0	40	24	EA	6/30/1974	Direct
00205X	HVAC	Heating Unit/Plant	Baseboard	Hydronic 1/2	3rd flr library	1974	0	40	15	EA	6/30/1974	Direct
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00112	HVAC	Other HVAC Equipn	Heat Exchang	Shell and Tub	N/A	1995	13	92	2	EA	11/7/2002	Direct
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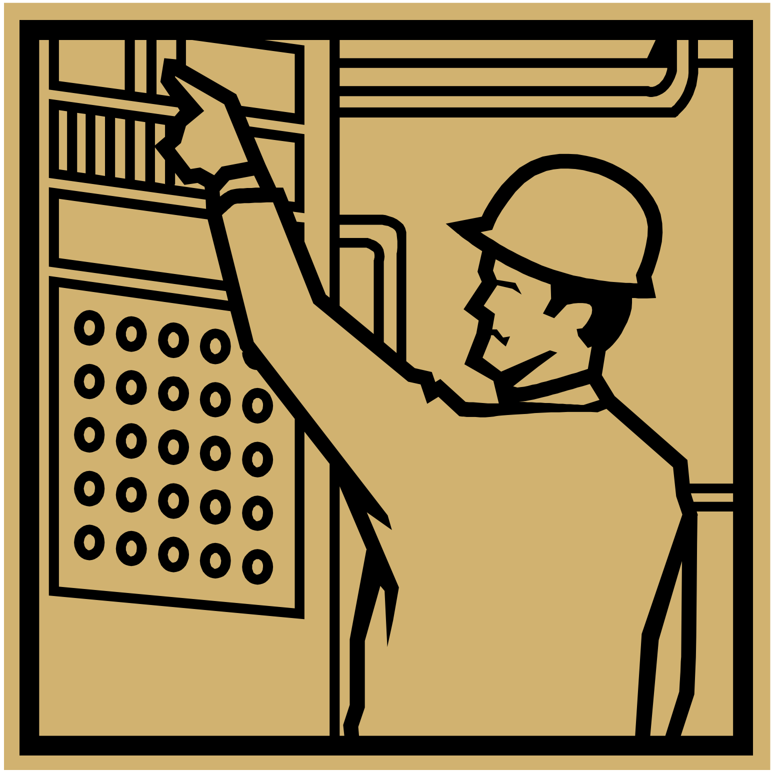
00112	HVAC	Other HVAC Equipn	Humidifier	<11 lbs/hr	N/A	1995	5	84	1	EA	11/7/2002	Distress
00406	HVAC	Other HVAC Equipn	Humidifier	50-100 lbs/h	N/A	1976	0	0	1	EA	6/30/1976	Direct

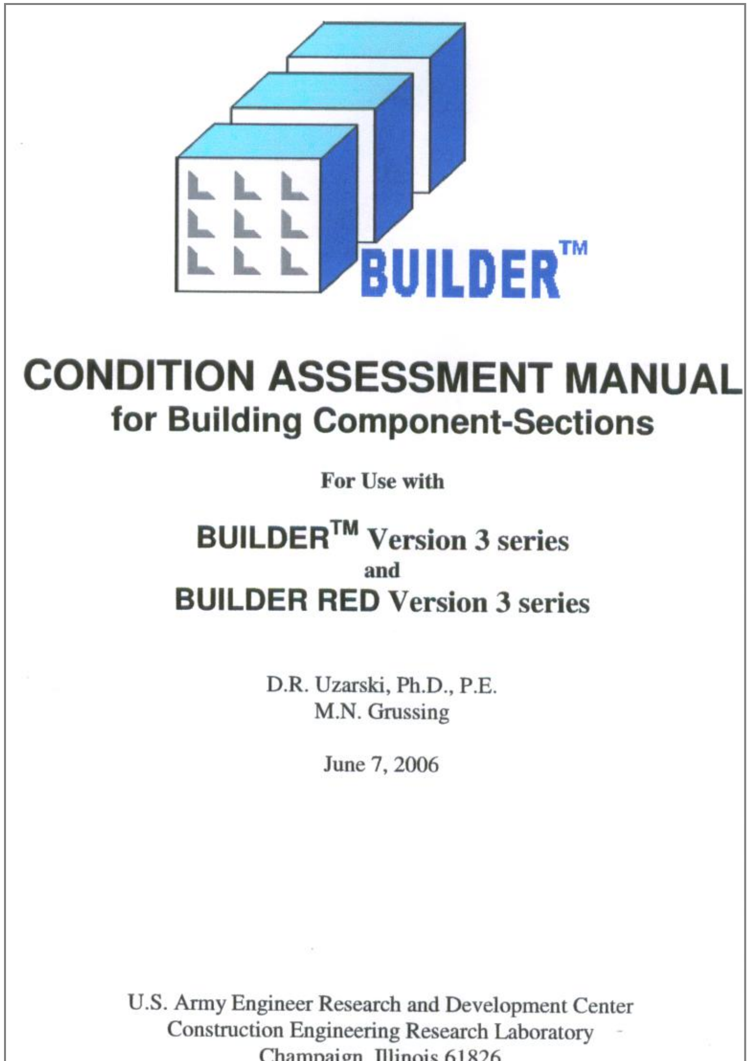
Recall, a current estimate of each CSCI is always known based on the prediction model calibrated for each unique component-section. So, all component-sections receive either a real or simulated condition assessment and all metrics are normalized to the same timeframe.

From Experience…

- Combining condition surveys with preventive maintenance (PM) work is logical and beneficial
  - Equipment is likely shut down (at least for a little while) and PM crews have both the experience and opportunity to conduct the surveys
  - A condition survey is not required at every PM
  - The appropriate condition survey inspection type should be used
- High security building access issues may alter the condition scheduling
- Local situations will alter the condition survey plan
- Clustering may be practical and beneficial in some cases
- Be flexible!



Condition Survey Sampling



BUILDER™

CONDITION ASSESSMENT MANUAL
for Building Component-Sections

For Use with

BUILDER™ Version 3 series
and
BUILDER RED Version 3 series

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M.N. Grussing

June 7, 2006

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- Use when component-section is complex, separated, or very large (exceeds field of vision)
- Can sample with either the distress survey or the direct rating method
- In general, sampling reduces inspection effort and cost, but some accuracy regarding quantities may be lost. If larger sampling percentages are used, quantity accuracy is improved
- CSCI accuracy may actually be improved
- Use discreet discontinuities to delineate sample boundaries
- Condition assessment manual addresses sampling

What About the Cost?

Or

Do We Save Any Money?

"It Depends…"

Recall, the "Predicting Outcomes" report cited condition assessment costs ranging from $0.07 - $0.60 per SF. KBCSI field experience is still evolving, but testing conducted during the KBCSI development showed an approximate 75% reduction in cost when compared to a baseline of 100% annual inspection. But…

- Each portfolio will be somewhat different
- Baselines differ
- Costs per year will vary depending on "mix"

Rather…

The KBCSI provides a targeted approach

- Address risk
- Focus on what's important
- Some component - sections are inspected sooner and some later
- Maximize value for inspection dollar spent

Is There More to the KBCSI Story?

YES

- This presentation focused on knowledge-based inspection and condition assessment ("Predicting Outcomes" Report Finding 5 and Recommendation 6.)
- However, what about setting risk-based project priorities (Report Recommendation 3)? KBCSI data can be used not only to prepare an inspection plan, but also to assist in assigning Component Probability of Failure Ratings and Component Failure Consequence Ratings as addressed in Chapter 7 (another discussion for another time…)

Questions?