Fundamentals of Asset Management

Step 3. Determine Residual Life

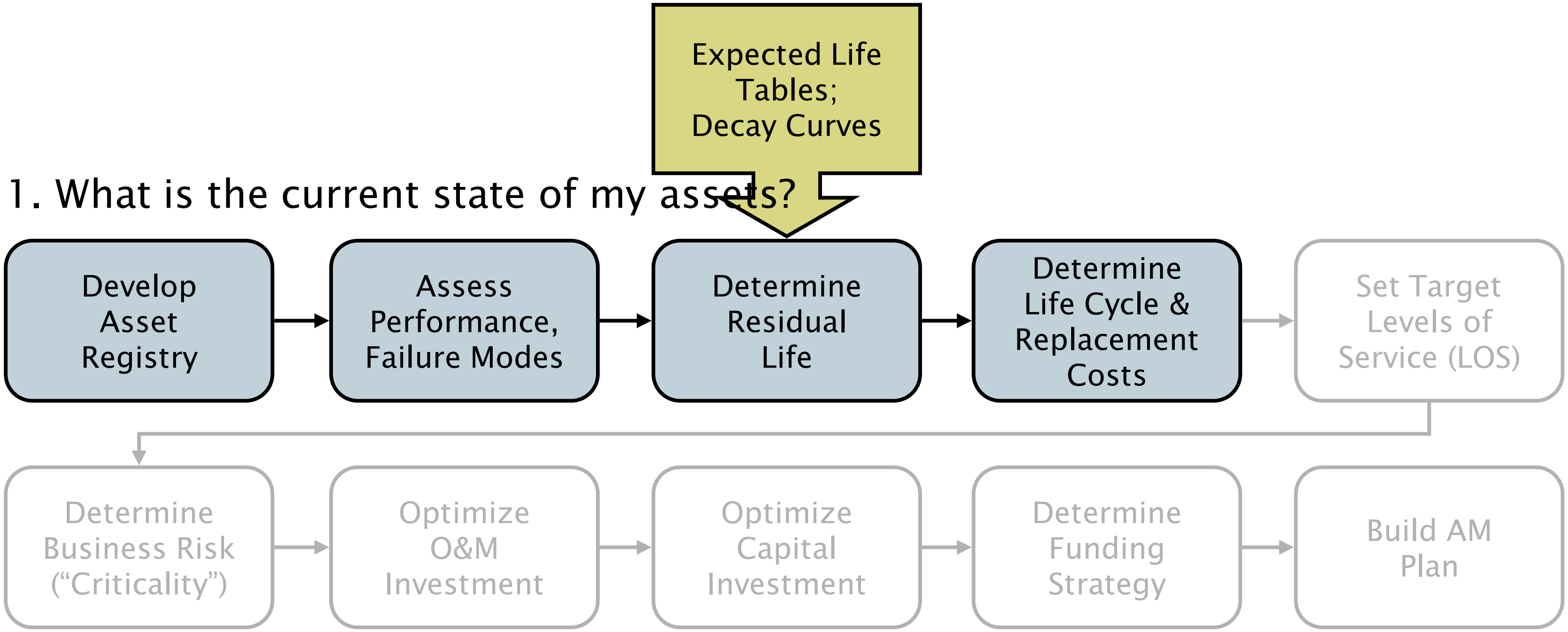
A Hands-On Approach

Tom’s bad day…

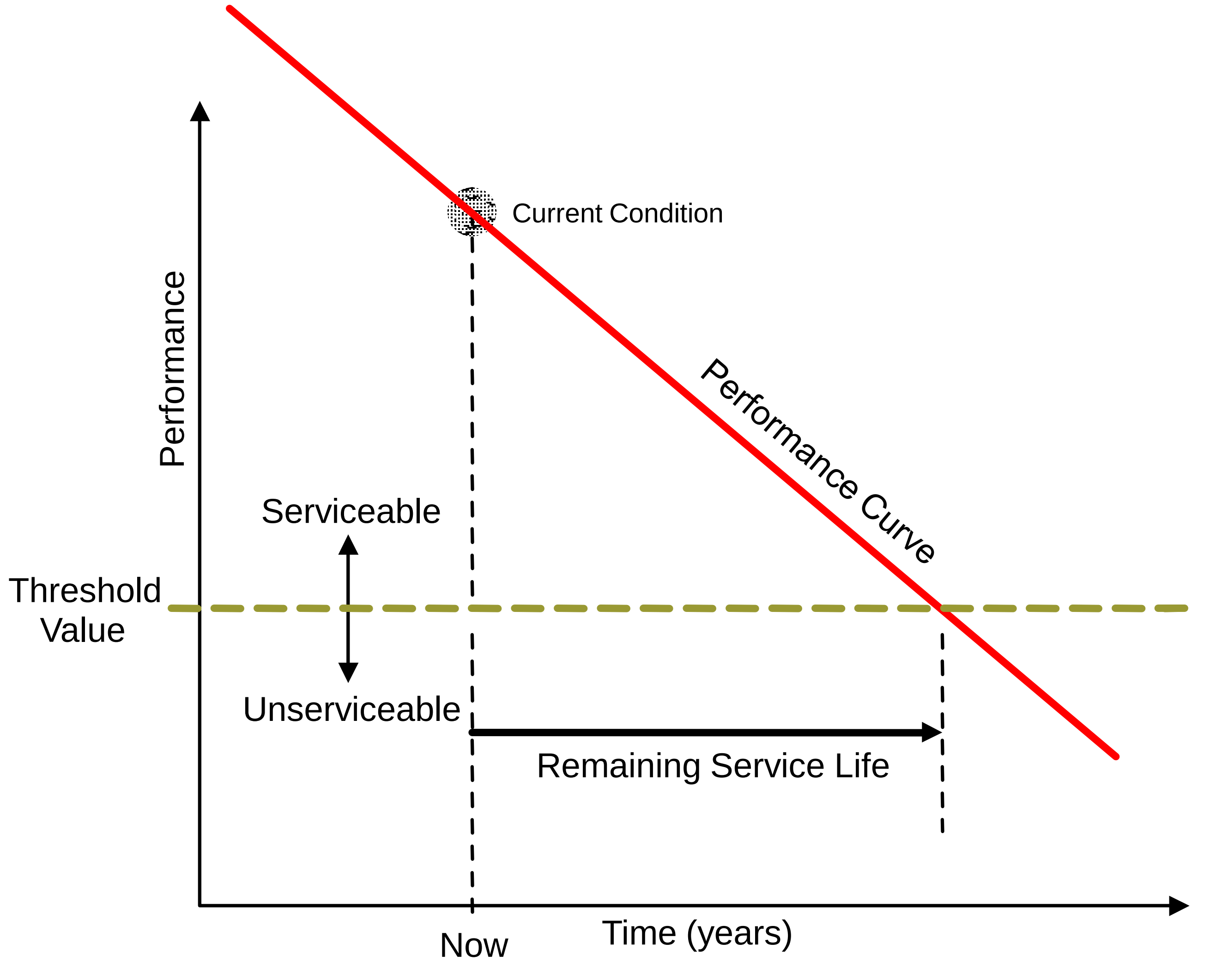
First of 5 core questions, continued

1. What is the condition of my assets? How well do they perform?
   - What is the *importance* of *remaining useful life*?
   - How might we *determine* remaining useful life?

AM plan 10-step process



Determining Residual Life



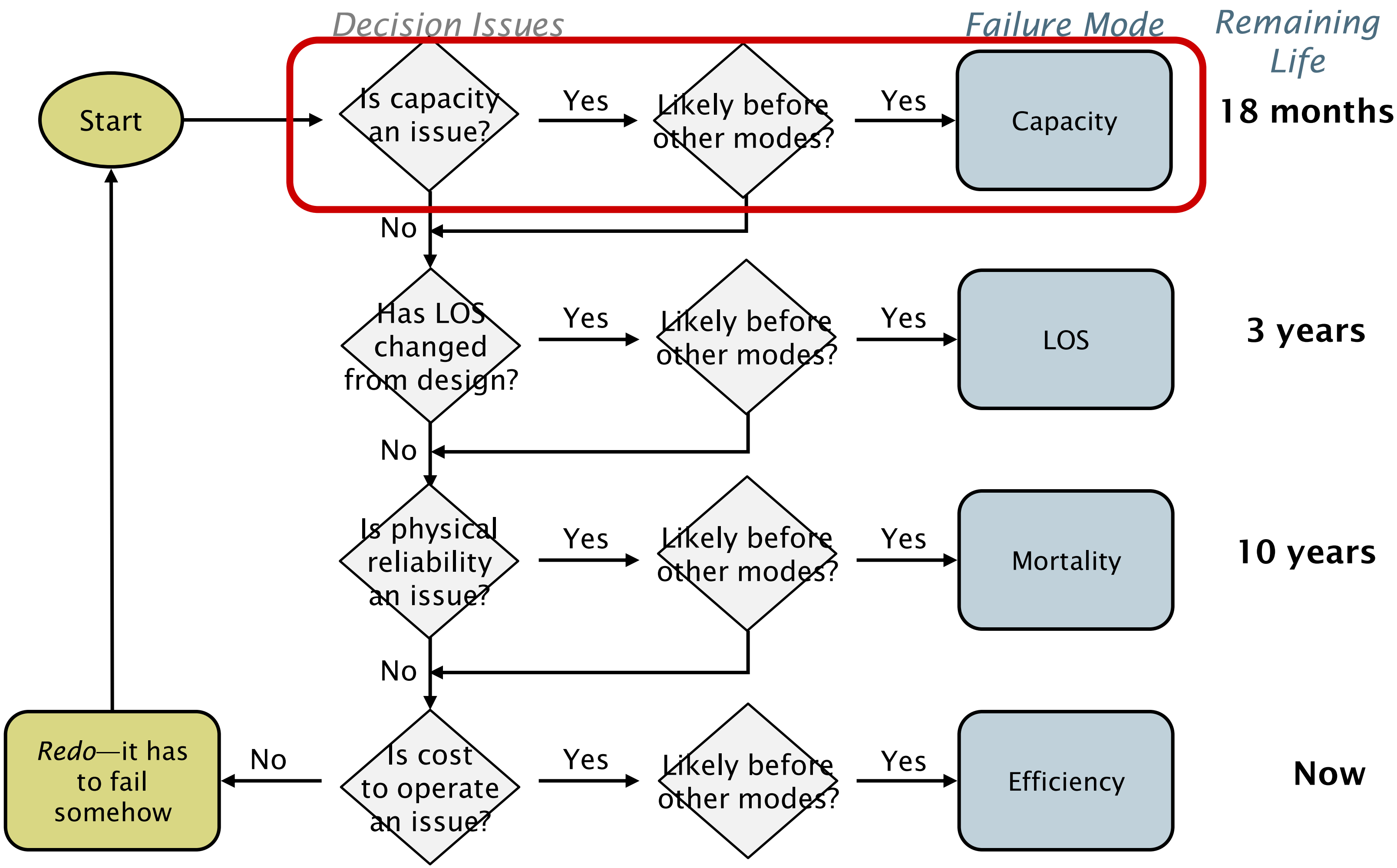
But – when has an asset “failed”?

- When it cannot do what it is required to do
- Technical perspective – when the asset is not “available”:
  - When the asset stops functioning or does not function when called on
  - When performance deteriorates to point of insufficient service
  - When it is taken out of service (maintenance, renewal)
- Does your maintenance management business process (think work order) identify when an asset goes out of service and when service is restored?
- Thought exercise: when exactly has a sewer pipe “failed”?

What do we mean by "remaining asset life"?

- *End of financial life* – when an asset is fully financially depreciated on the "books"
- *End of physical life* – when an asset is physically non-functioning (e.g., failed, collapsed, stopped working)
- *End of service level/capacitylife* – when an asset can no longer do what we/our customers/stakeholders require it to do
- *End of economic life* – when an asset ceases to be the lowest cost alternative to satisfy a specified level of performance or service level

The role of failure modes in determining residual life



Key definition: "effective asset life"

- "Effective asset life" is the lowest expected life for a selected asset given its operating environment where that life is derived from a determination of the most imminent trigger among the three asset life triggers (service level life, capacity life, physical life, economic life).
- Example (remaining life):
  - service level/capacitylife – 3 breaks, estimated 2 years to next break ("no more than 4 breaks in 5 years")
  - Physical life – 30 years
  - Economic life – 10 years

Determining remaining physical life

Age Based

- *Approach 1* Effective life table
- *Approach 2* Effective life table, plus modification factors
- *Approach 3* Direct observation table
- *Approach 4* Condition and decay curve table

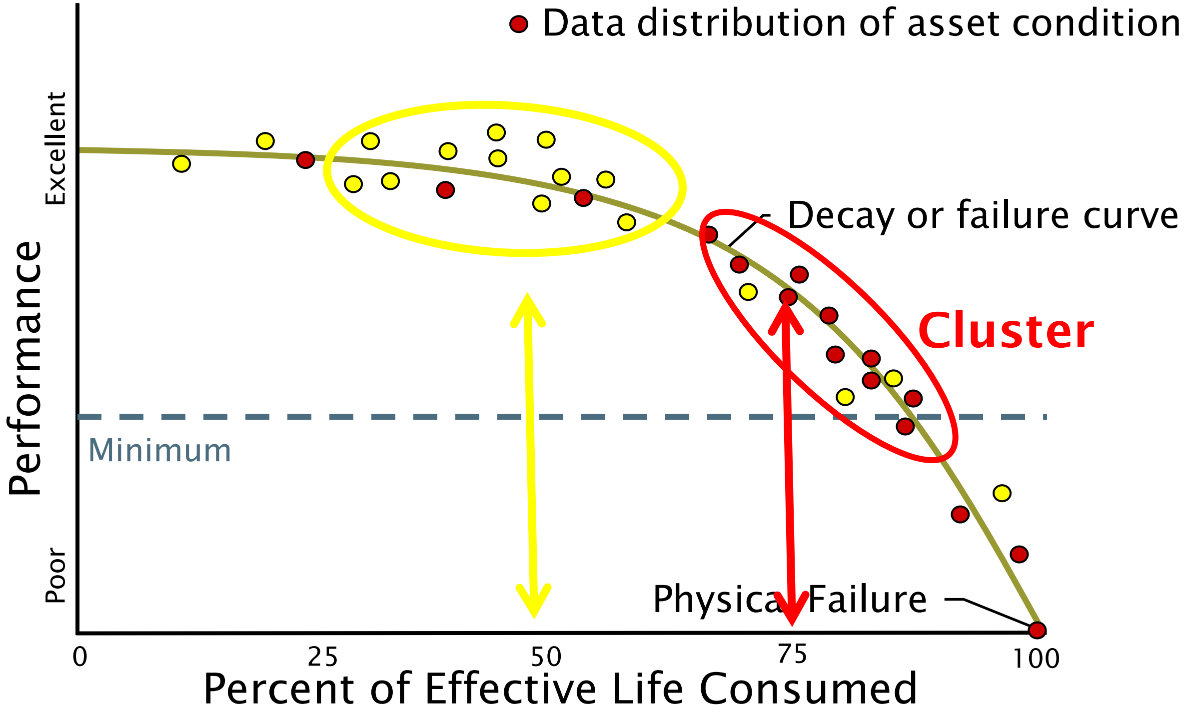
Condition Based

Approach 1, effective life table (“design life”)

Class	Asset Type	Effective Life	Class	Asset Type	Effective Life
1	Civil	75	6	Motors	35
2	Pressure pipework	60	7	Electrical	30
3	Sewers	100	8	Controls	25
4	Pumps	40	9	Building assets	30
5	Valves	30	10	Land	NA

Sources: manufacturers, industrial associations, GASB, colleagues, consulting engineers, research (professional associations, universities), international community

So, how do we move forward - review: “Percent of effective life consumed” concept



Example: simple determination of "% remaining physical life"

1. Calculate physical life consumed

$$\text{\% physical life consumed} = \frac{\text{Life to date}}{\text{Estimated useful life}}$$

2. Determine % remaining physical life

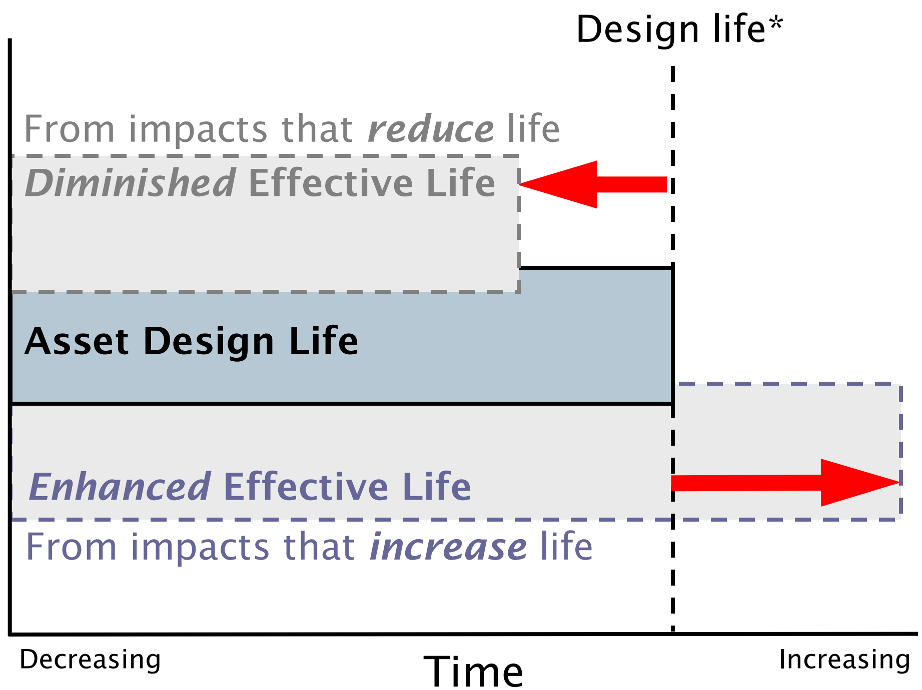
$$\text{\% remaining physical life} = 1.0 - \text{\% physical life consumed}$$

Example calculation - % remaining physical life

Asset acquired 1992; current year 2012; useful life 25 years

$$\text{20\% remaining physical life} = 1.0 - (\text{20 yr. LTD / 25 yr. EUL})$$

Approach 2, amending standard effective lives



*Asset *design life* is from average effective life tables

Modification factors for effective life tables

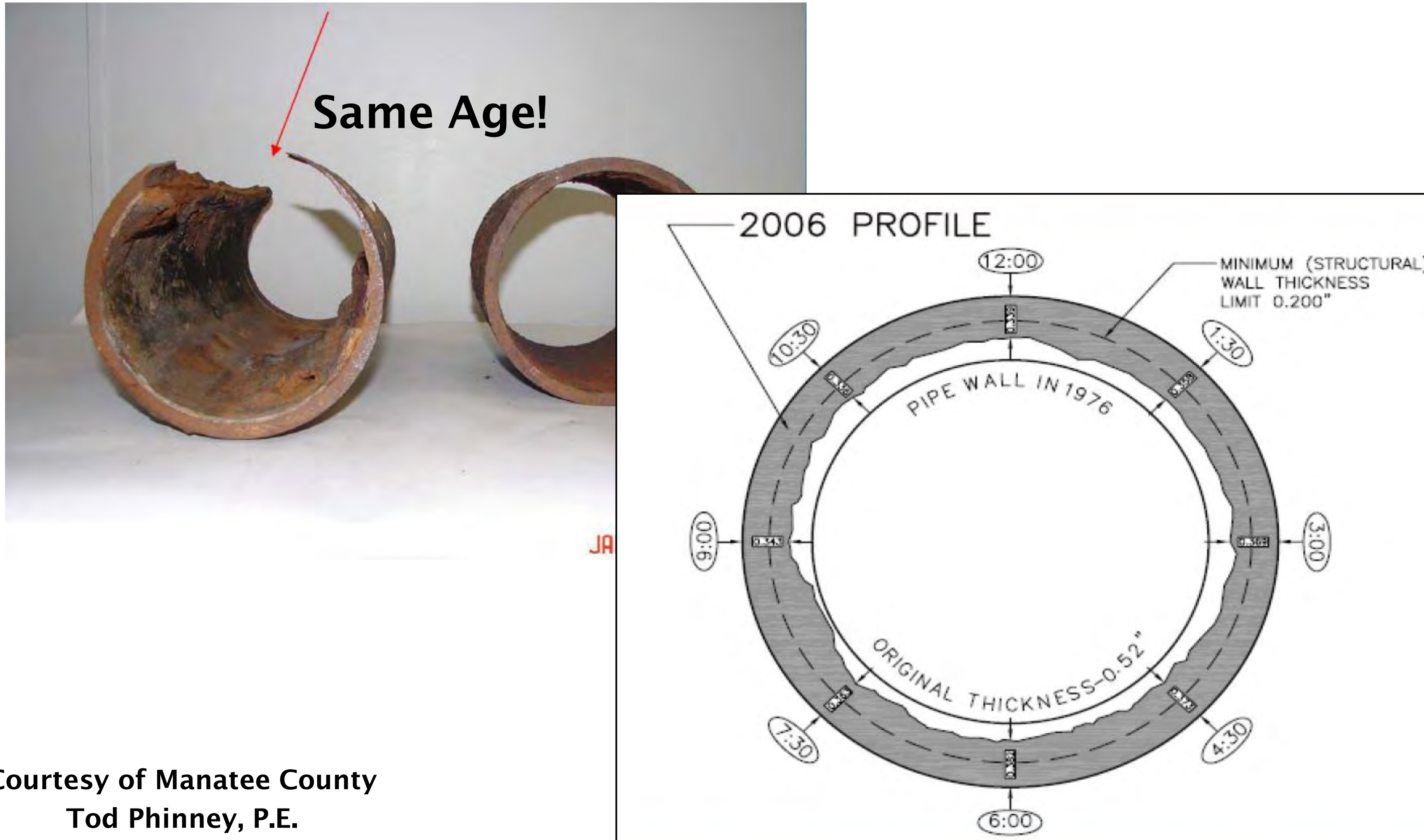
	Impact Rating Factor				
Condition Variables	1	2	3	4	5
Design standards	+10%	+5%	0	-5%	-10%
Construction quality	+10%	+5%	0	-5%	-10%
Material quality	+10%	+5%	0	-5%	-10%
Operational history	+10%	+5%	0	-5%	-10%
Operating environment	+10%	+5%	0	-5%	-10%
External stresses	+10%	+5%	0	-5%	-10%

Values are for example purposes only

Approach 3: “Direct observation” table

Assessment (Likelihood of Occurrence within One Year	*Description*
Almost certain	Expected to occur within 1 year
Very high	Likely to occur within 1 year
High	Estimated 50% chance of occurring within any year
Quite likely	Expected to occur within 5 years; estimated 20% chance of occurring in any year
Moderate	Expected to occur within 10 years; estimated 10% chance of occurring in any year
Low	Expected to occur within 50 years
Very low	Expected to occur within 100 years

Challenge: Age versus condition based renewal



Courtesy of Manatee County
Tod Phinney, P.E.
John Paterson, Ph.D., P.E., BCEE

Strategy: Condition based rather than age based

- Assess condition of targeted cast iron and ductile iron force mains using sonar technology
- Conduct failure analysis to understand failure modes
- Focus only on assessment of those (short) sections of force main that are likely in worst condition (high points where pipes rise)
- Use work orders and GIS to locate candidate sections
- Assess condition in one day or less

In the trenches…

Courtesy of Manatee County
Tod Phinney, P.E.
John Paterson, Ph.D., P.E., BCEE

Results: Manatee County, Florida

Courtesy of Manatee County
Tod Phinney, P.E.
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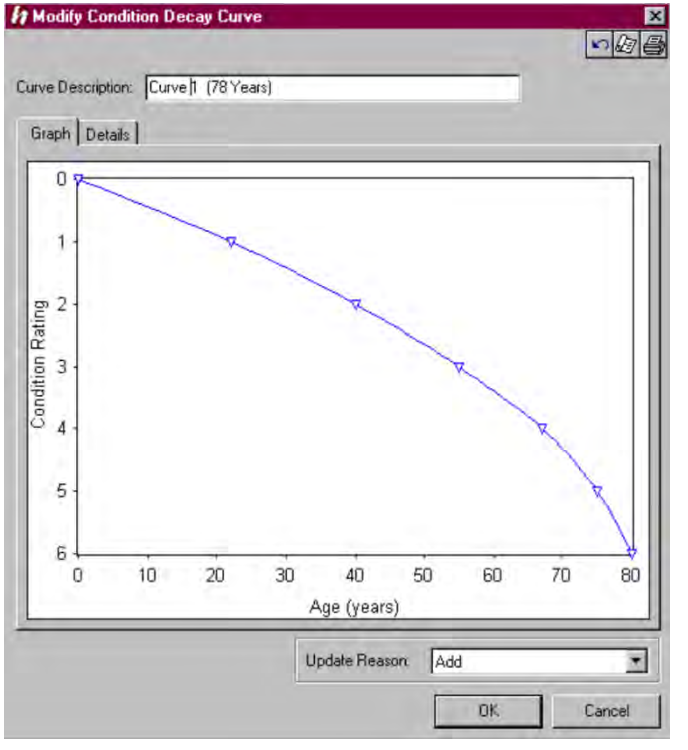
- Condition assessments were programmed for 14 force mains that were already programmed for replacement (combined total length – 12 miles)
- Immediate replacement *was not required for 90%* (by length); stately alternatively – 90% of pipe scheduled for replacement based on age had useful service life left.
- Reduced CIP by $5.5 million
- Delayed an additional $2 million pending condition assessment in lieu of replacement

Approach 4, Condition assessment and the decay curve

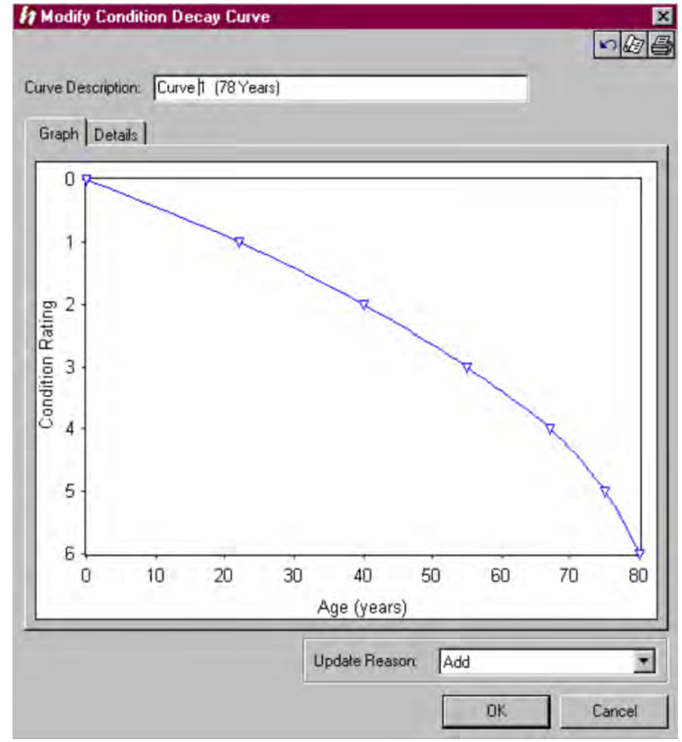
Condition assessment assists in recognizing…

- *Nature* and *shape* of the failure or decay (or deterioration) curve
- *Where* on the curve is asset's current condition
- Asset's *remaining useful life*, an estimate



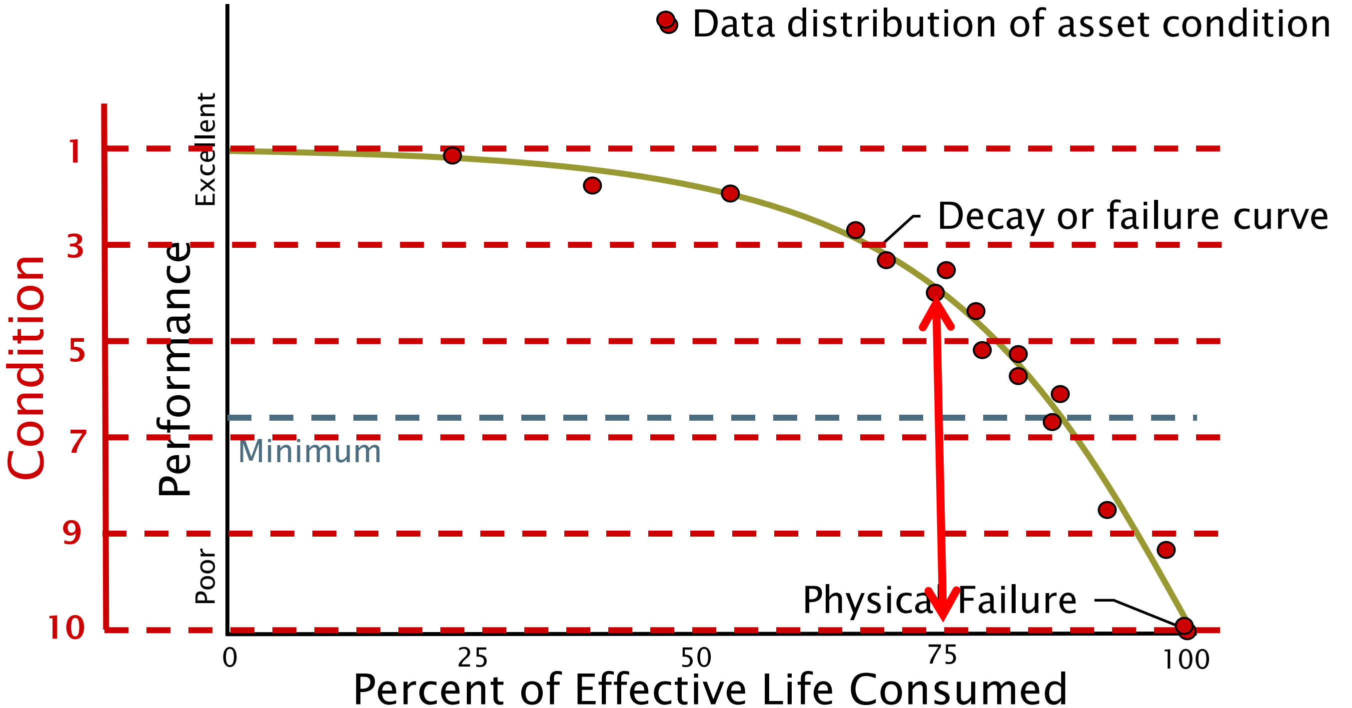
Developing a decay curve

- *Longitudinal* study—uses data collected *over the life* of a *single* asset (or set of assets)
- *Latitudinal* study—uses data collected from *multiple* assets of the same type but of different ages

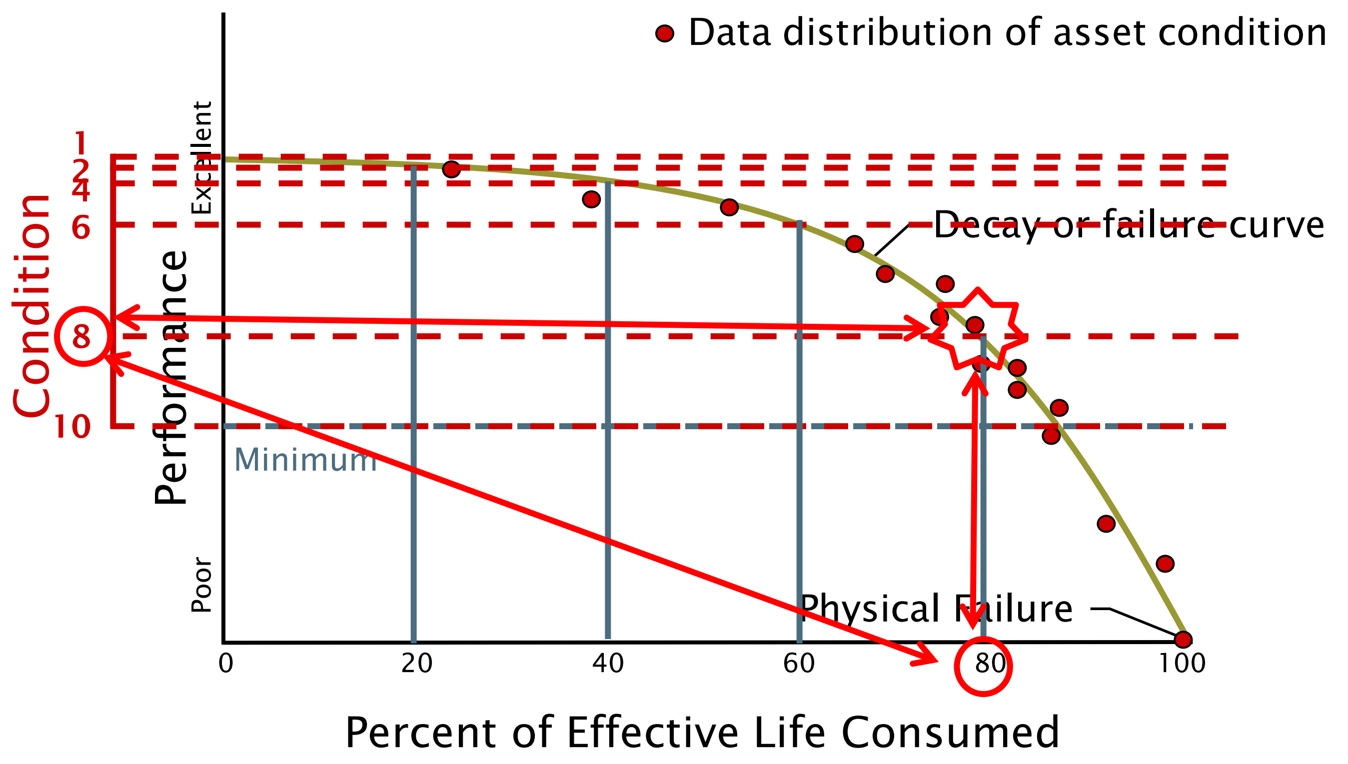


Challenge: tying condition score and % physical life consumed

Relating asset condition to percent of physical life consumed



Alternative: tying condition score to asset failure



Alternative: tying condition to remaining life using % Physical Life Consumed

% of Physical Life Consumed	*Condition*
<10%	1
20%	2
30%	3
40%	4
50%	5
60%	6
70%	7
80%	8
90%	9
Failed	10

Enter: “management strategy groups”

- Grouping of assets with similar renewal / behavioral patterns
- Purpose - to assist:
  - Assigning asset lives and decay curves
  - Calculating current replacement costs
  - Calculating risk
    - Consequence of failure
    - Probability/likelihood of failure
  - Developing life-cycle management plans
- Examples
  - Gravity Pipes, RCP, Built < 1950, in High H_2S areas
  - Submersible sewage pumps, ABC Co., 123 series, 1983 - 1995

Key points from this session

What is its remaining life?

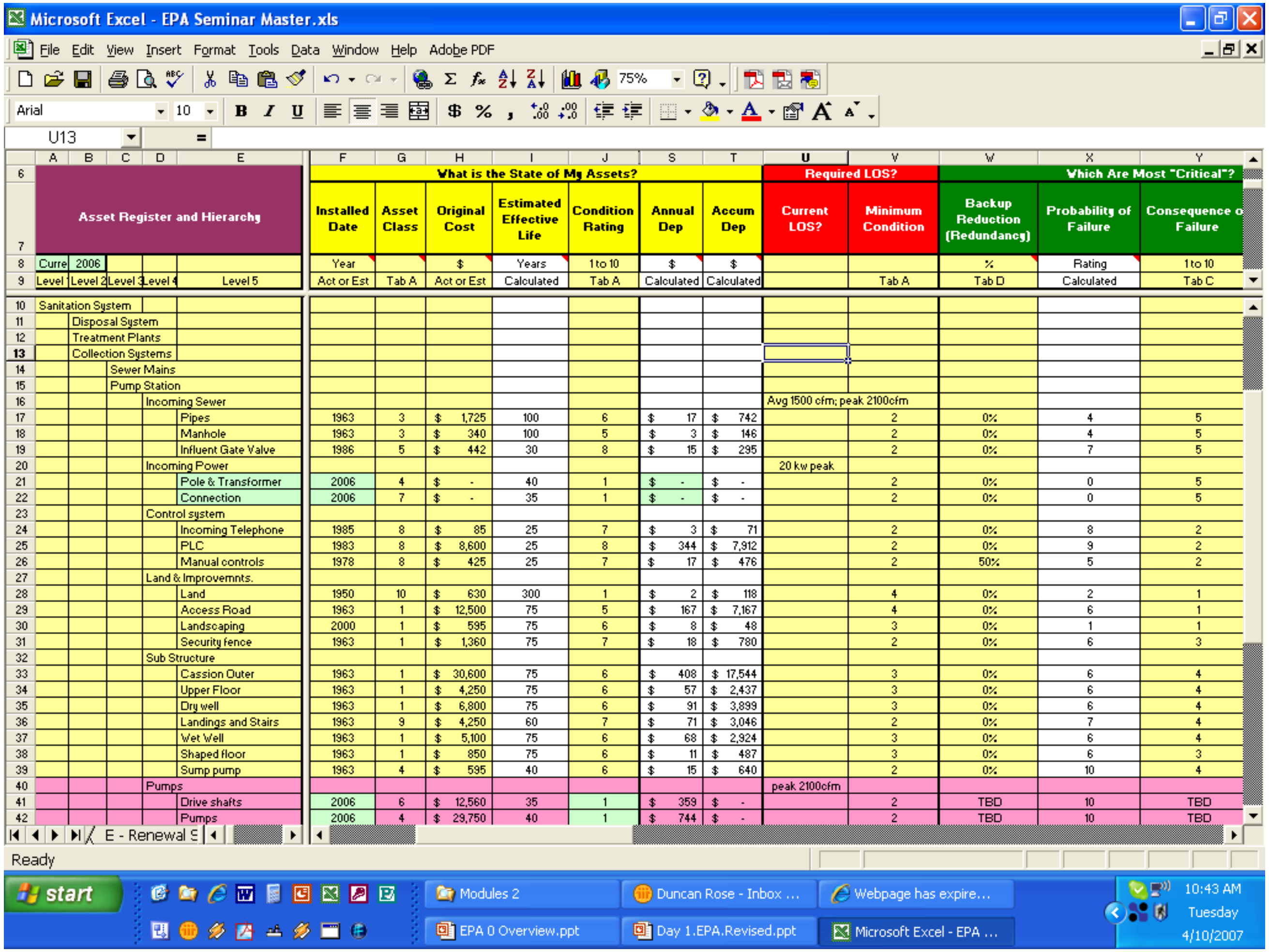
Key Points:

- Determining remaining useful life is as much art at this point as science
- Although good information is better, asset “decay curves” need not be highly detailed to be useful.
- Good CMMS data is key to building agency specific failure curves
- Good condition information is vital to assigning remaining useful life
- Incorporating good failure codes into the work order is important to building good failure curves

Associated Techniques:

- Remaining useful life assessment·
- Decay curves, useful-life tables
- Survivor curves
- Major failure modes

Tom’s spreadsheet



Row	Asset Register and Hierarchy	Installed Date (F)	Asset Class (G)	Original Cost (H)	Estimated Effective Life (I)	Condition Rating (J)	Annual Dep (S)	Accum Dep (T)
6		What is the State of My Assets?						
8	Curre 2006	Year		$	Years	1 to 10	$	$
9	Level 1 / Level 2 / Level 3 / Level 4 / Level 5	Act or Est	Tab A	Act or Est	Calculated	Tab A	Calculated	Calculated
10	Sanitation System							
11	Disposal System							
12	Treatment Plants							
13	Collection Systems							
14	Sewer Mains							
15	Pump Station							
16	Incoming Sewer							
17	Pipes	1963	3	$ 1,725	100	6	$ 17	$ 742
18	Manhole	1963	3	$ 340	100	5	$ 3	$ 146
19	Influent Gate Valve	1986	5	$ 442	30	8	$ 15	$ 295
20	Incoming Power							
21	Pole & Transformer	2006	4	$ -	40	1	$ -	$ -
22	Connection	2006	7	$ -	35	1	$ -	$ -
23	Control system							
24	Incoming Telephone	1985	8	$ 85	25	7	$ 3	$ 71
25	PLC	1983	8	$ 8,600	25	8	$ 344	$ 7,912
26	Manual controls	1978	8	$ 425	25	7	$ 17	$ 476
27	Land & Improvemnts.							
28	Land	1950	10	$ 630	300	1	$ 2	$ 118
29	Access Road	1963	1	$ 12,500	75	5	$ 167	$ 7,167
30	Landscaping	2000	1	$ 595	75	6	$ 8	$ 48
31	Security fence	1963	1	$ 1,360	75	7	$ 18	$ 780
32	Sub Structure							
33	Cassion Outer	1963	1	$ 30,600	75	6	$ 408	$ 17,544
34	Upper Floor	1963	1	$ 4,250	75	6	$ 57	$ 2,437
35	Dry well	1963	1	$ 6,800	75	6	$ 91	$ 3,899
36	Landings and Stairs	1963	9	$ 4,250	60	7	$ 71	$ 3,046
37	Wet Well	1963	1	$ 5,100	75	6	$ 68	$ 2,924
38	Shaped floor	1963	1	$ 850	75	6	$ 11	$ 487
39	Sump pump	1963	4	$ 595	40	6	$ 15	$ 640
40	Pumps							
41	Drive shafts	2006	6	$ 12,560	35	1	$ 359	$ -
42	Pumps	2006	4	$ 29,750	40	1	$ 744	$ -

Row	Current LOS? (U)	Minimum Condition (V)	Backup Reduction (Redundancy) (W)	Probability of Failure (X)	Consequence of Failure (Y)
6	Required LOS?		Which Are Most "Critical"?		
8			%	Rating	1 to 10
9		Tab A	Tab D	Calculated	Tab C
16	Avg 1500 cfm; peak 2100cfm				
17		2	0%	4	5
18		2	0%	4	5
19		2	0%	7	5
20	20 kw peak				
21		2	0%	0	5
22		2	0%	0	5
24		2	0%	8	2
25		2	0%	9	2
26		2	50%	5	2
28		4	0%	2	1
29		4	0%	6	1
30		3	0%	1	1
31		2	0%	6	3
33		3	0%	6	4
34		3	0%	6	4
35		3	0%	6	4
36		2	0%	7	4
37		3	0%	6	4
38		3	0%	6	3
39		2	0%	10	4
40	peak 2100cfm				
41		2	TBD	10	TBD
42		2	TBD	10	TBD