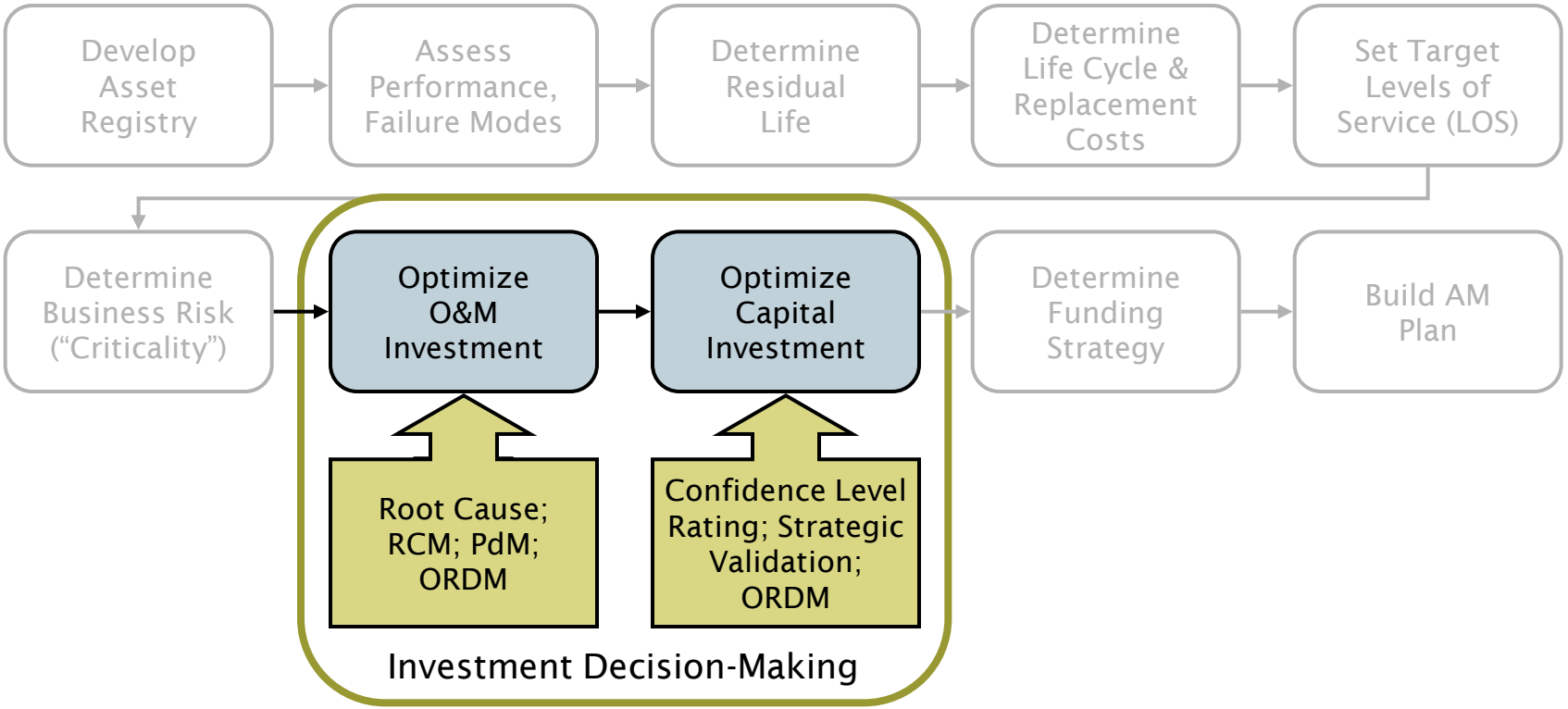
Fundamentals of Asset Management

Background: Optimized Investment Decision Making

A Hands-On Approach

View 6: AM plan 10-step process



Three fundamental management decisions

1. What are my work crews doing, where are they doing it—*and why*?
2. *What* CIP projects should be done—*and when*?
3. When should I *repair*, when should I *rehab*, when should I *replace*?

These decisions typically account for *over 80%* of a utility's annual expenditures

Asset decision framework

Big picture

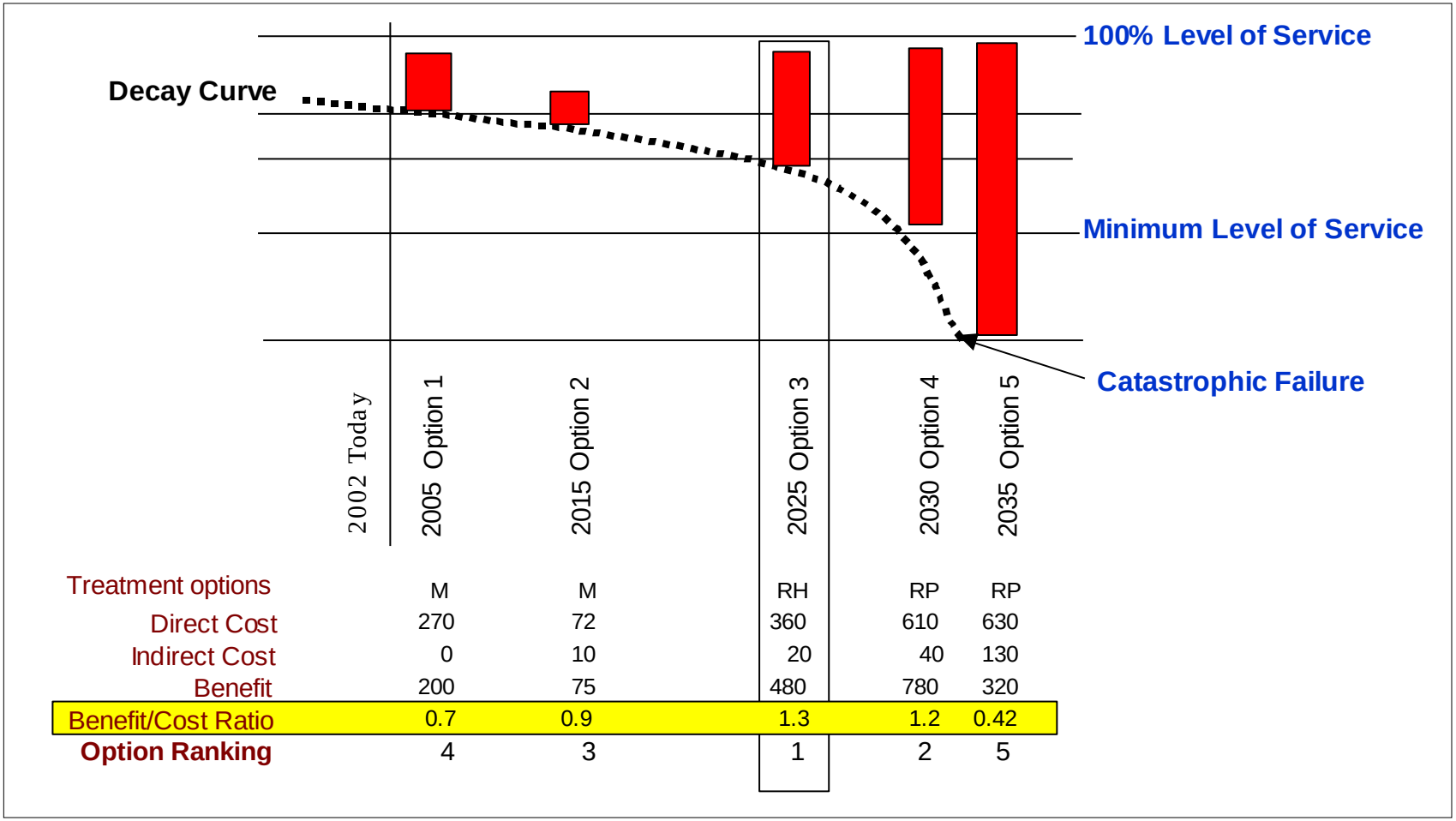
- Whole portfolio perspective
  - Trends
  - Macro forces
- Policy framework
- Budget arena

Micro view

- Event based
- Specific asset focus
- Case-by-case decision points

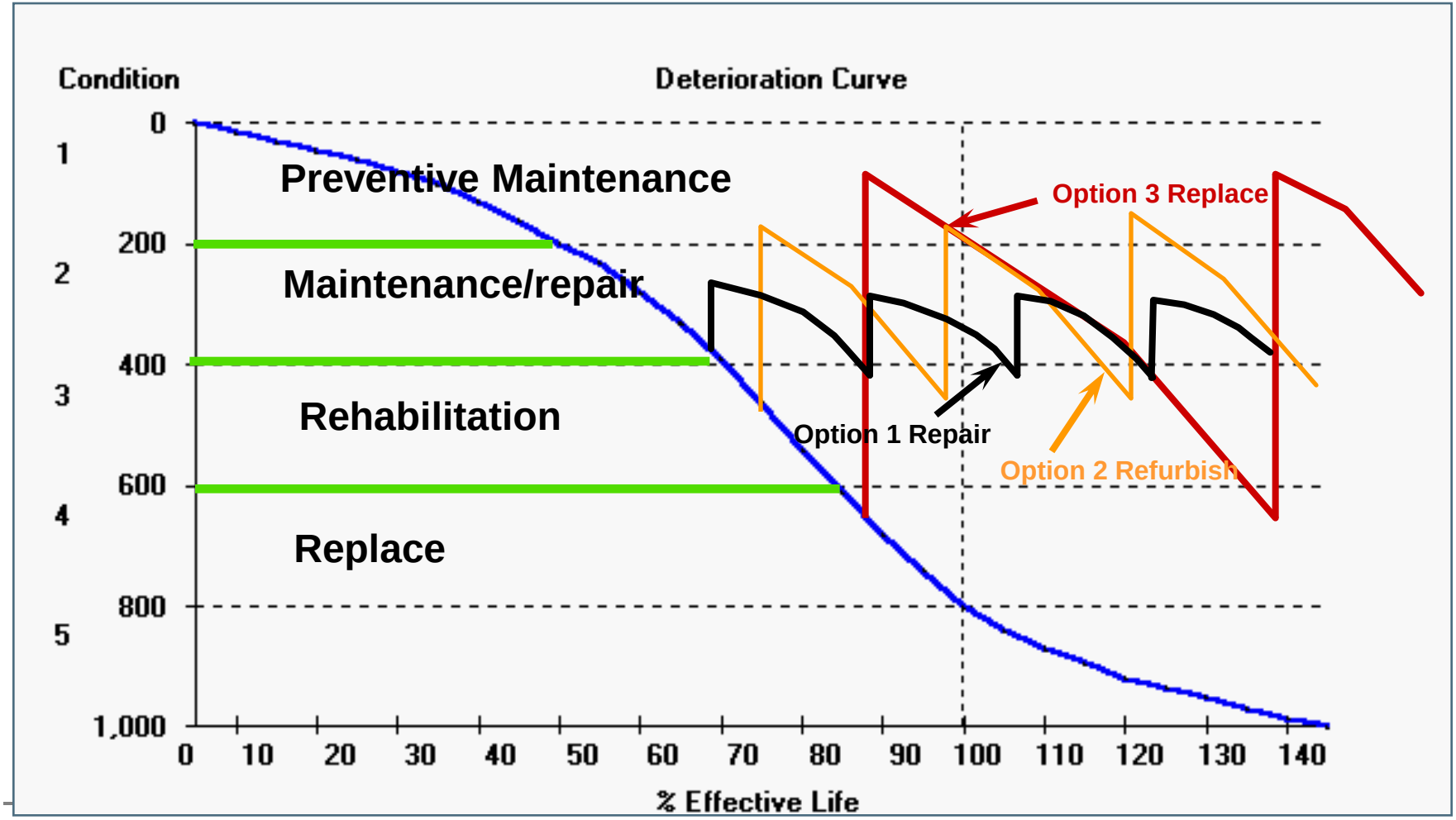
Maintain? Repair? Refurbish? Replace? Augment?

There exists for every asset, a theoretical “best” investment



	2005 Option 1	2015 Option 2	2025 Option 3	2030 Option 4	2035 Option 5
Treatment options	M	M	RH	RP	RP
Direct Cost	270	72	360	610	630
Indirect Cost	0	10	20	40	130
Benefit	200	75	480	780	320
Benefit/Cost Ratio	0.7	0.9	1.3	1.2	0.42
Option Ranking	4	3	1	2	5

Managing the “asset consumption” process



Bringing it all together

Repair-refurbish-replace decision

1. Fix when broken (run to failure)
2. End of prescriptive life
   - 12 years old
   - 3,000 run-time hours
   - 35,000 miles
3. Rule of thumb
   - 3 breaks per mile or in 24 hours
   - Poor condition (and worst first)
   - FCI > 6% (Facility condition index—O&M as a percentage of replacement cost)
4. Optimized renewal decision making (ORDM)

What is optimized decision making?

- Systematic search for lowest-cost renewal investment
- Based on interaction of
  - Cost trends (direct O&M, indirect)
  - Condition trends (decay/survivor curve)
  - Risk-consequence trends
- Three major approaches
  - Valued expert judgment
  - Lowest projected average life-cycle cost per year of residual life;
    - Operational costs
    - Risk-weighted, full economic costs
  - Intervention factors; condition, performance, reliability, Business Risk Exposure, etc.

Three levels of ORDM

- *Level 1* Decision tables/trees
  - Structured, often substantially qualitative, value judgment-based
  - Event-focused, scenario-based
- *Level 2* Lowest average PV life cycle cost scenario analysis
  - Specific decision event-focused
  - Spreadsheet-driven
  - Can be used to refine decision tables/trees
- *Level 3* Integrated intervention and full economic life cycle cost optimization
  - Sophisticated modeling
  - Objective function-driven
  - Both portfolio- and event-driven

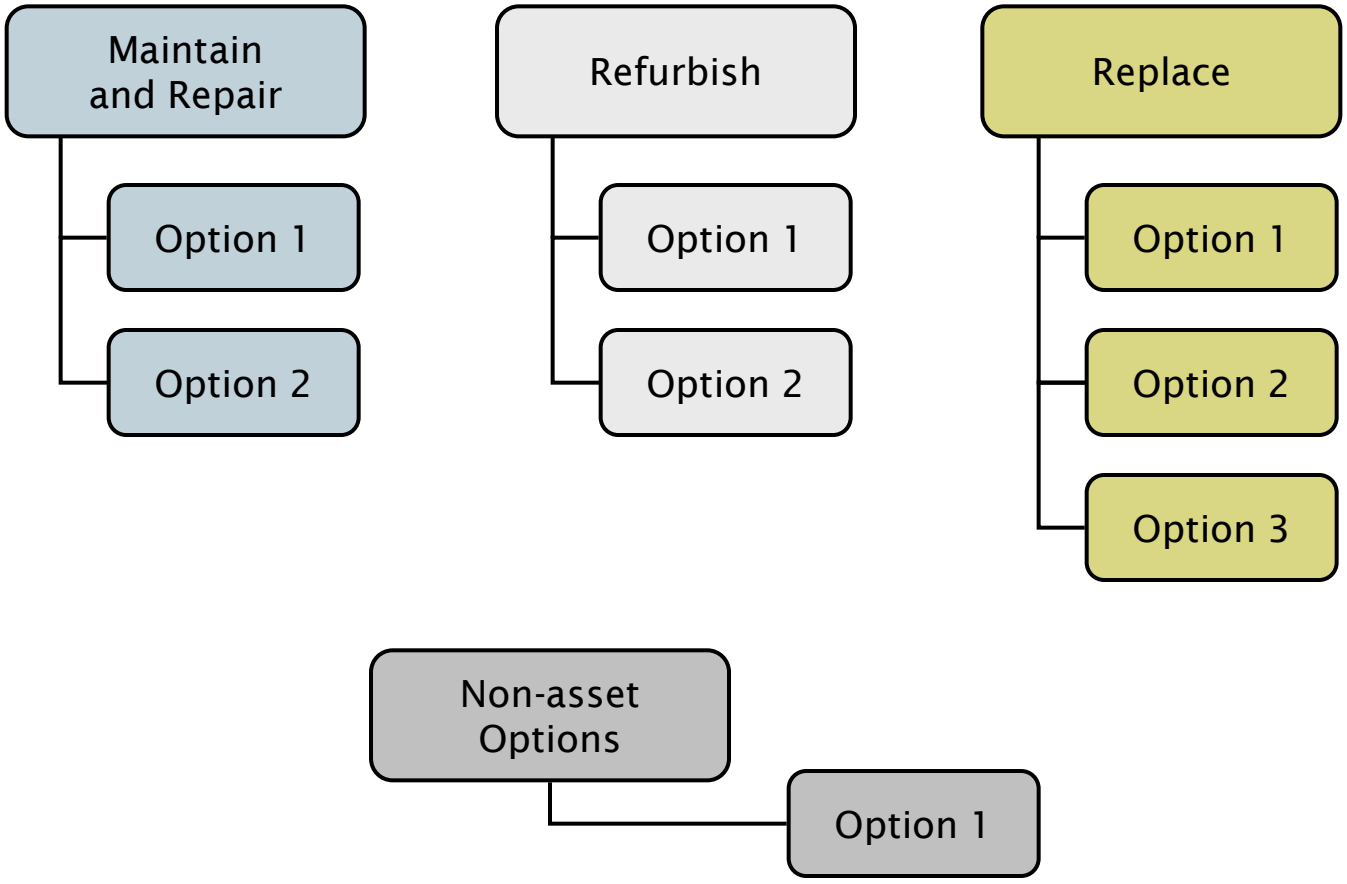
So, what to we mean by…

Minimum life cycle cost strategies

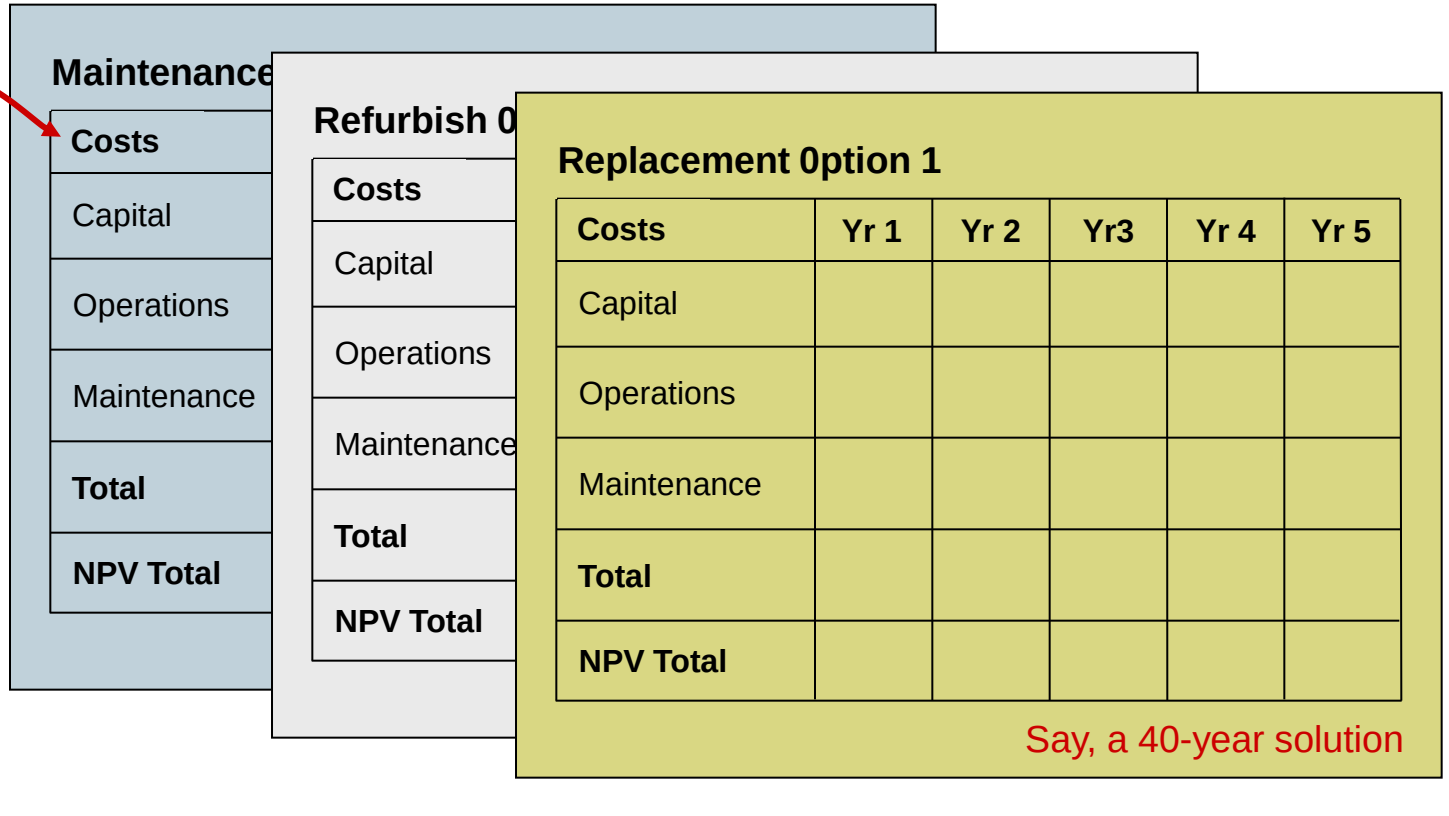
- Fundamental asset management options available to the management team are:
  - Do nothing (zero-based strategy)
  - Status quo
  - Operate differently
  - Maintain differently—run to failure, preventive-based, predictive-based (condition, usage)
  - Repair
  - Refurbish/rehabilitate
  - Replace
  - Decommission
  - Non asset-based
- Which strategy for each asset?
- Combinations over life cycle

It's *all* investment!

What do we mean by “alternative (management) treatment options”?



Our “decision rule”



Estimated total costs for the effective life of the solution (capital, operations, & maintenance)

Look for “alternative treatment” with lowest *average annual* (present value) cost (average annual cost = total annual cost/year)

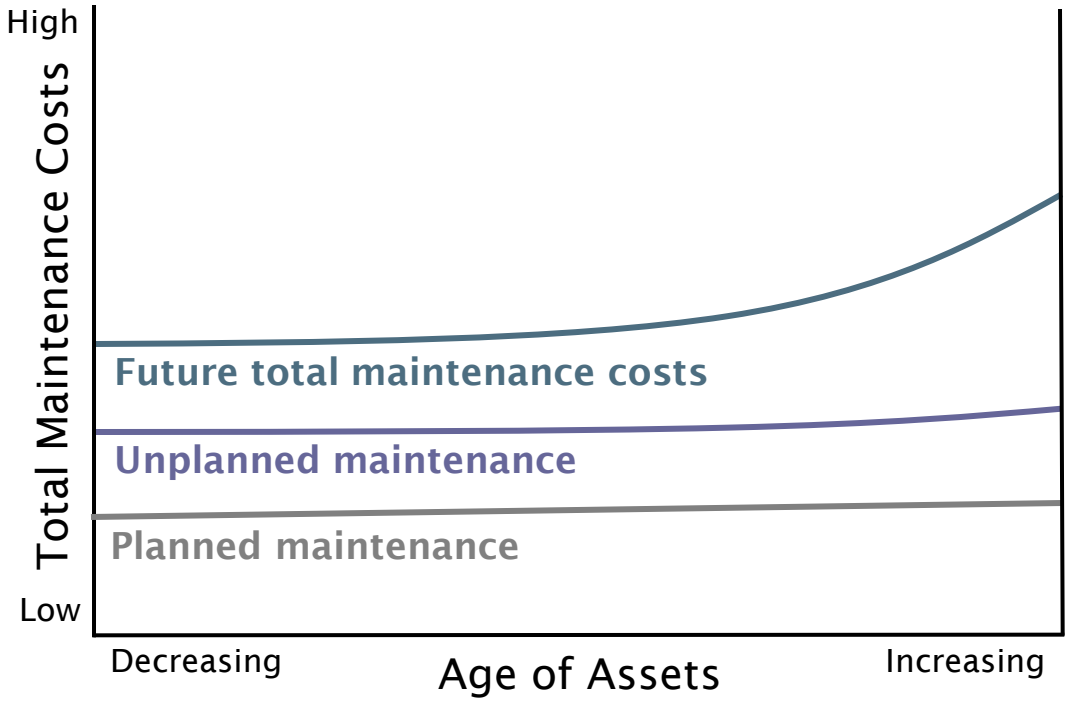
ORDM decision rules

- *Which* strategies are most cost effective here?

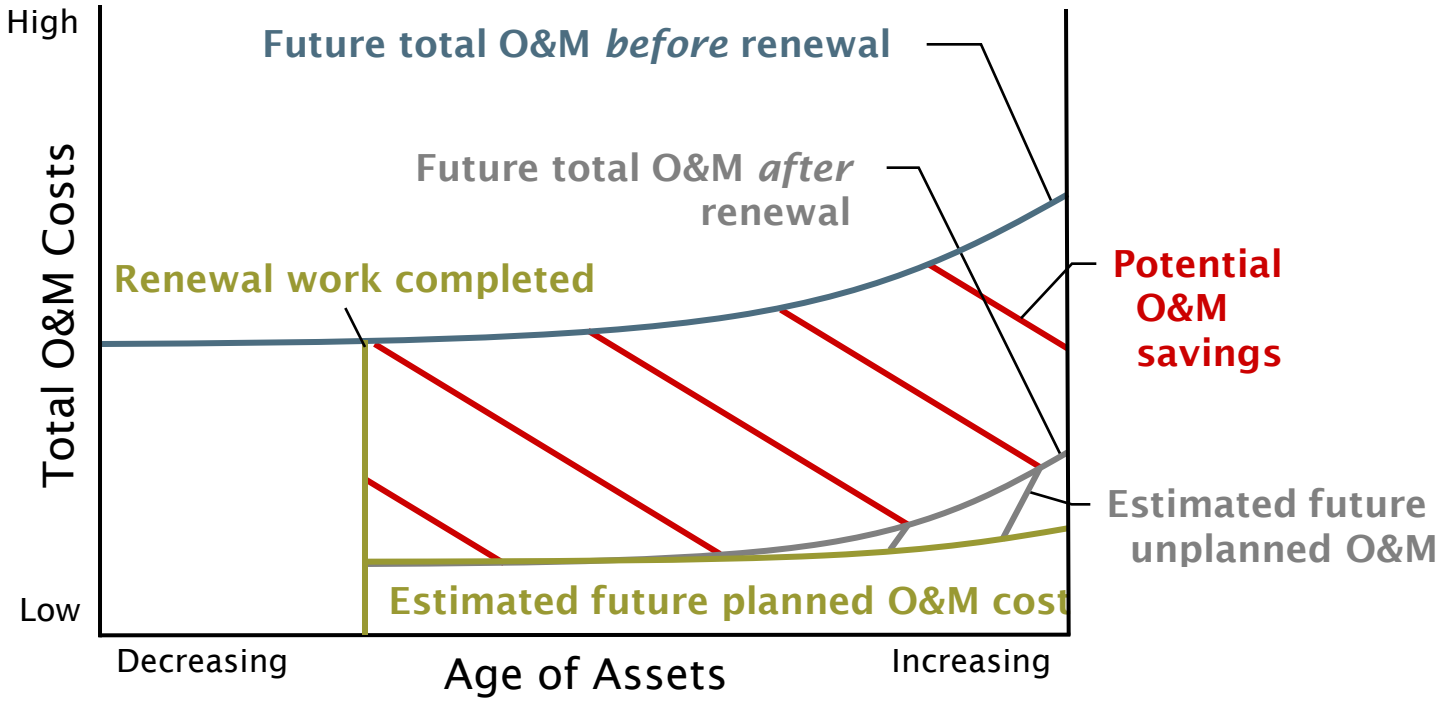
  Lowest average annual cost (PV) is used to determine which strategies to use
- *When* to change strategies?
  - Lowest marginal cost is used to determine when to transition to the next strategy, or
  - When an intervention point is triggered by interaction of “constraint” trend lines (maximum business risk exposure, minimum tolerable condition, etc.)

PV is present value

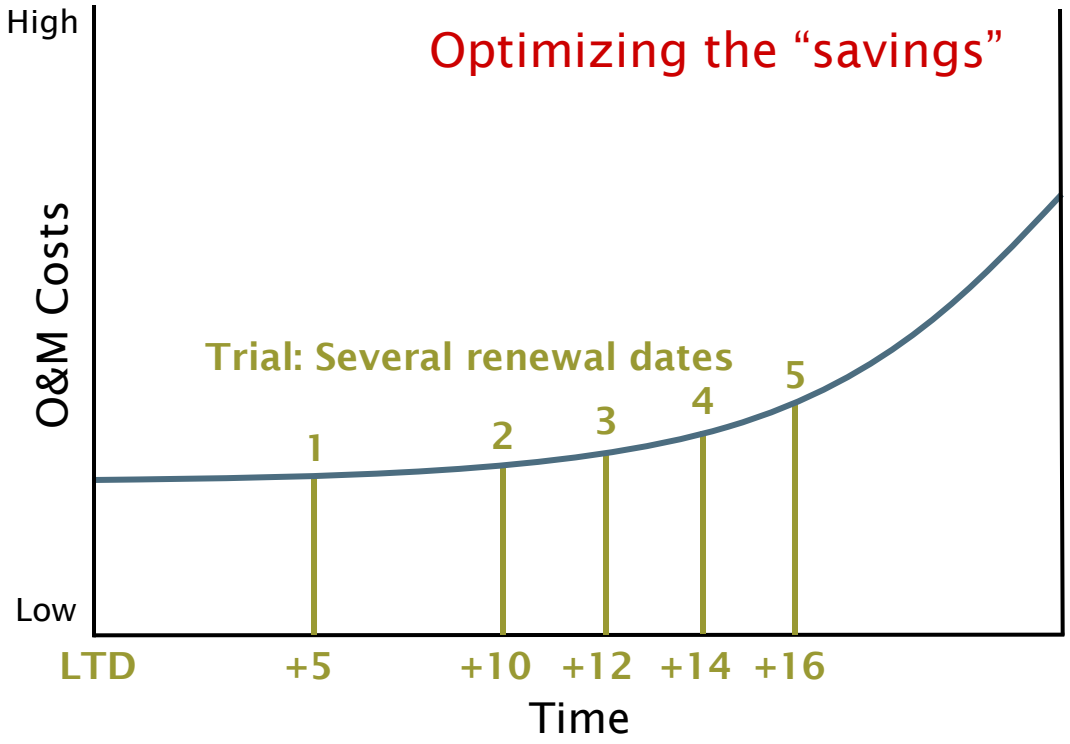
ORDM future costs



ORDM - where do the savings come from?



ORDM - timing the renewal



ORDM is optimized renewal decision-making, LTD is life to date

Setting up the basic analysis: lowest annual life cycle cost

Discount Rate	5.0%	Avg Annual $										
Repair/Maintenance	**Total**		**1**	**2**	**3**	**4**	**5**					
Capital	$ 4,500		$ 4,500	$ -	$ -	$ -						
Operations	$ 2,034		$ 350	$ 403	$ 415	$ 427	$ 440					
Maintenance	$ 1,803		$ 350	$ 355	$ 361	$ 366	$ 371					
Total Costs	$ 8,337	$ 1,667	$ 5,200	$ 758	$ 775	$ 793	$ 811					
PV Total Costs	$ 7,977	$ 1,595	$ 5,200	$ 722	$ 703	$ 685	$ 667					
Refurbish			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital	$ 35,500		$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775
Operations	$ 7,515		$ 325	$ 330	$ 335	$ 340	$ 345	$ 350	$ 355	$ 361	$ 366	$ 372
Maintenance	$ 6,888		$ 275	$ 279	$ 283	$ 288	$ 292	$ 296	$ 301	$ 305	$ 310	$ 319
Total Costs	$ 49,903	$ 2,495	$ 2,375	$ 2,384	$ 2,393	$ 2,402	$ 2,412	$ 2,421	$ 2,431	$ 2,441	$ 2,451	$ 2,466
PV Total Costs	$ 32,329	$ 1,616	$ 2,375	$ 2,270	$ 2,171	$ 2,075	$ 1,984	$ 1,897	$ 1,814	$ 1,735	$ 1,659	$ 1,589
Replace			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital	$ 61,000		$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525
Operations	$ 10,854		$ 200	$ 203	$ 206	$ 209	$ 212	$ 215	$ 219	$ 222	$ 225	$ 229
Maintenance	$ 12,244		$ 200	$ 200	$ 200	$ 200	$ 200	$ 225	$ 228	$ 232	$ 235	$ 239
Total Costs	$ 84,097	$ 2,102	$ 1,925	$ 1,928	$ 1,931	$ 1,934	$ 1,937	$ 1,965	$ 1,972	$ 1,979	$ 1,986	$ 1,992
PV Total Costs	$ 36,707	$ 918	$ 1,925	$ 1,836	$ 1,752	$ 1,671	$ 1,594	$ 1,540	$ 1,472	$ 1,406	$ 1,344	$ 1,284

Setting up the basic analysis: lowest annual life cycle cost

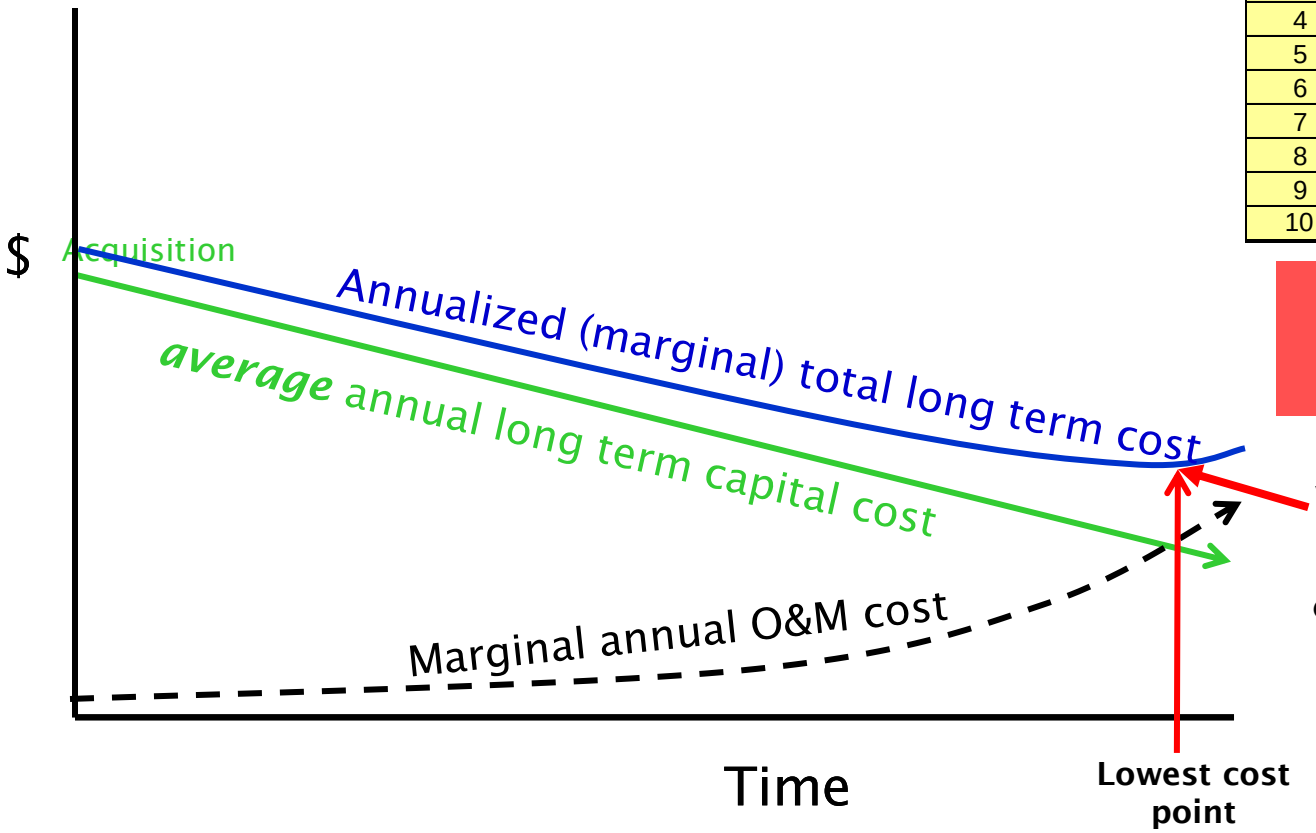
Discount Rate	1.0%	Avg Annual $										
Repair/Maintenance	**Total**		**1**	**2**	**3**	**4**	**5**					
Capital	$ 4,500		$ 4,500	$ -	$ -	$ -						
Operations	$ 2,034		$ 350	$ 403	$ 415	$ 427	$ 440					
Maintenance	$ 1,803		$ 350	$ 355	$ 361	$ 366	$ 371					
Total Costs	$ 8,337	$ 1,667	$ 5,200	$ 758	$ 775	$ 793	$ 811					
PV Total Costs	$ 8,259	$ 1,652	$ 5,200	$ 750	$ 760	$ 770	$ 780					
Refurbish			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital	$ 35,500		$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775	$ 1,775
Operations	$ 7,515		$ 325	$ 330	$ 335	$ 340	$ 345	$ 350	$ 355	$ 361	$ 366	$ 372
Maintenance	$ 6,888		$ 275	$ 279	$ 283	$ 288	$ 292	$ 296	$ 301	$ 305	$ 310	$ 319
Total Costs	$ 49,903	$ 2,495	$ 2,375	$ 2,384	$ 2,393	$ 2,402	$ 2,412	$ 2,421	$ 2,431	$ 2,441	$ 2,451	$ 2,466
PV Total Costs	$ 45,382	$ 2,269	$ 2,375	$ 2,360	$ 2,346	$ 2,332	$ 2,318	$ 2,304	$ 2,290	$ 2,277	$ 2,263	$ 2,254
Replace			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital	$ 61,000		$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525	$ 1,525
Operations	$ 10,854		$ 200	$ 203	$ 206	$ 209	$ 212	$ 215	$ 219	$ 222	$ 225	$ 229
Maintenance	$ 12,244		$ 200	$ 200	$ 200	$ 200	$ 200	$ 225	$ 228	$ 232	$ 235	$ 239
Total Costs	$ 84,097	$ 2,102	$ 1,925	$ 1,928	$ 1,931	$ 1,934	$ 1,937	$ 1,965	$ 1,972	$ 1,979	$ 1,986	$ 1,992
PV Total Costs	$ 69,241	$ 1,731	$ 1,925	$ 1,909	$ 1,893	$ 1,877	$ 1,862	$ 1,870	$ 1,858	$ 1,846	$ 1,834	$ 1,822

Decision rule: minimize "annualized (marginal) total long term costs"

15. Is proactive reinvestment cost effective?

Numbers are illustrative only

Capital Cost	$ 2,000	O&M Costs	
Year	Avg Annual Cost	Annual O&M	Annualized (Marginal) Total Costs
1	$ 2,000	$ 200	$ 2,200
2	$ 1,000	$ 220	$ 1,220
3	$ 667	$ 242	$ 909
4	$ 500	$ 266	$ 766
5	$ 400	$ 293	$ 693
6	$ 333	$ 322	$ 655
7	$ 286	$ 354	$ 640
8	$ 250	$ 390	$ 640
9	$ 222	$ 429	$ 651
10	$ 200	$ 472	$ 672



Look for that point in time where average annual total costs begins to increase

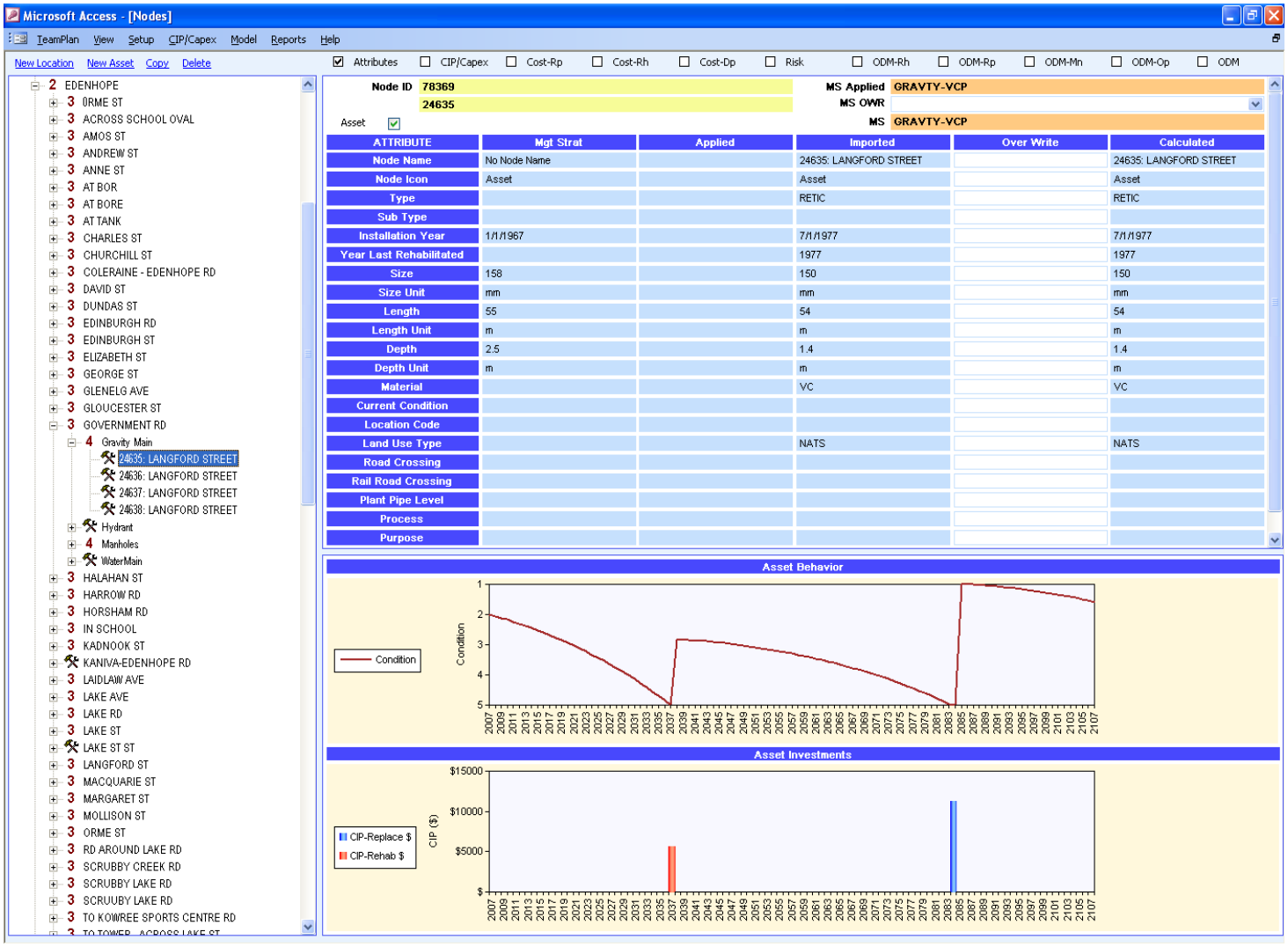
Here's where the extra value in capital investment gained by operating one more year starts to be eaten up by the increase in O&M associated with keeping it performing during that additional year

Adding non-financial decision elements: weighted decision tables

		Repair		Refurbish	
Criteria	*Weight*	*A**	*Weight A*	*B**	*Weight B*
Life cycle cost**	3	10	30	8	24
Safety	1	8	8	8	8
Environmental impact					
Noise	1	7	7	8	8
Odor	1	7	7	9	9
Performance					
Level of service	1	7	7	9	9
Reliability	2	7	14	10	20
Availability	1	8	8	7	7
Total	10		81		85

* Scored 1 (poorest) to 10 (best)
** Based on estimated $

ORDM modeling: TEAM-Plan main screen



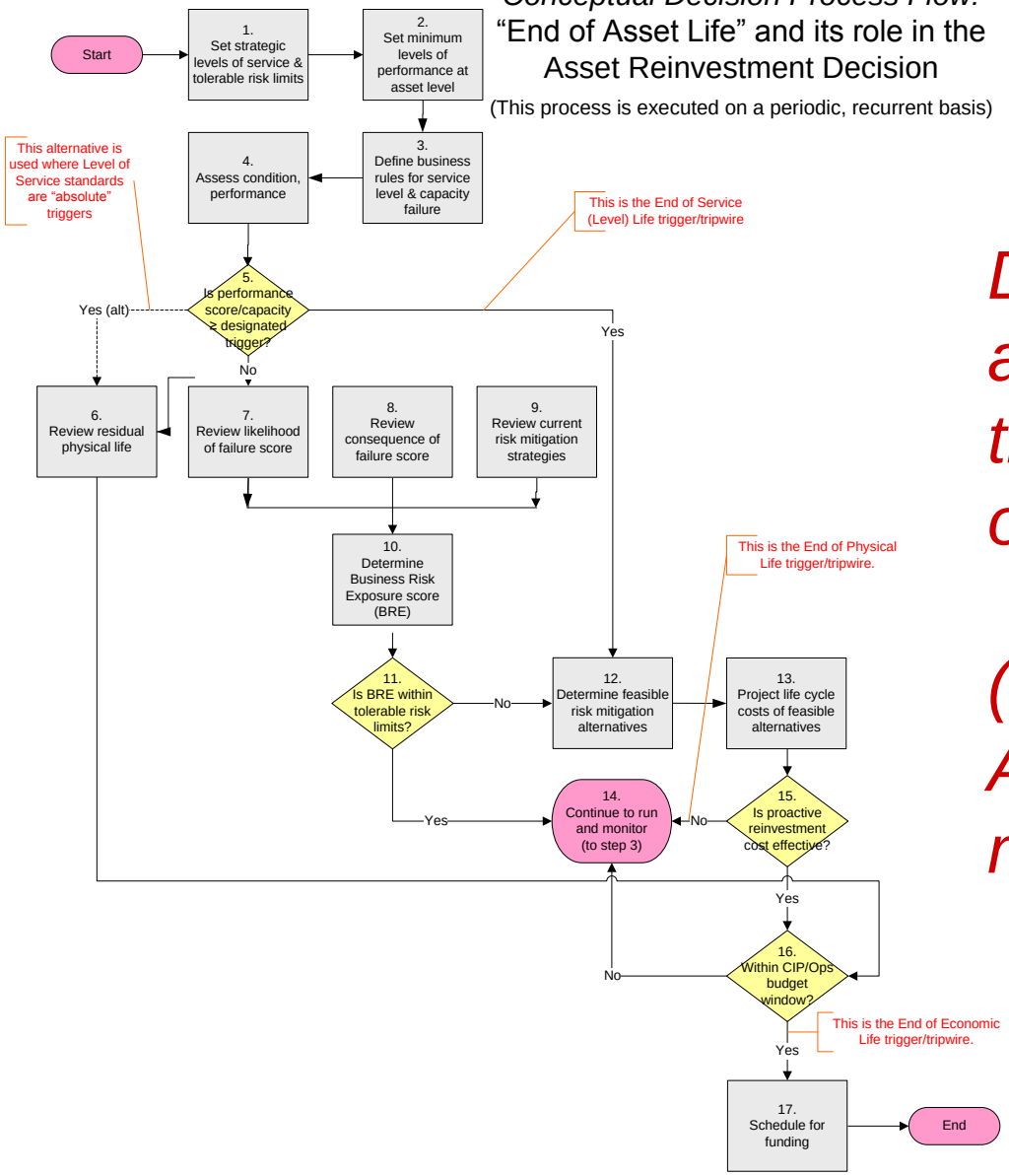
Management strategy groups

- Grouping of assets with similar renewal and behavioral patterns
- Purpose
  - Allocate defaults to assets (missing data)
  - Assign asset lives and decay curves
  - Calculate current replacement costs
  - Calculate business risk
    - Consequence of failure
    - Probability of failure
  - *Determine appropriate investment intervention*
- Example

  Gravity pipes, RCP, built <1950, high H_2S

Conceptual Decision Process Flow:
"End of Asset Life" and its role in the Asset Reinvestment Decision

(This process is executed on a periodic, recurrent basis)



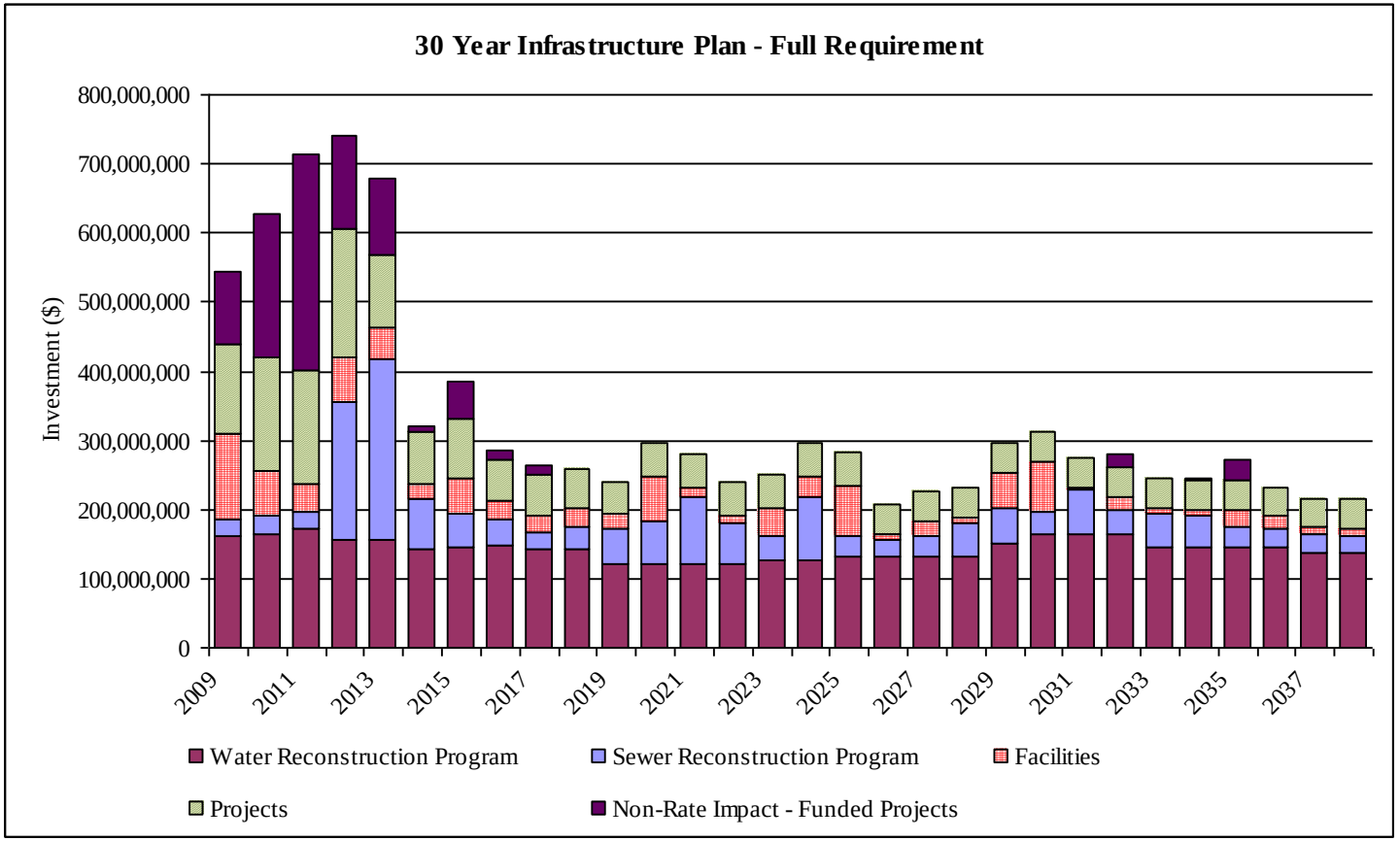
Determining the end of asset life - the heart of the investment optimization process

(the focus of the Advanced Workshop materials)

From the strategic AM funding perspective

- From a strategic AM funding perspective, two separate fundamental management questions:
  - How many/when – how many assets of a particular class are likely to fail within a specific timeframe? (used to build the "nessie curve – a projection of future expected costs)
  - Which/when – which specific assets are likely to fail in a given timeframe? (used to build the detailed CIP budget)

Strategic level - *how many/when* assets in timeframe period and at what cost each (this sets the funding framework)



Which/when tactical level – *which/when* assets within a CIP cycle (list of capital projects)

ID	District	Facility	Process Area	Involved Assets	BRE of Asset	Description of Project	Source
DISTRICTS 1, 4 AND 5							
1	1	Collection System	Various	Collection System		I/I Rehabiliation	Existing CIP
2	1	Pump Station	Industrial Parkway	Ind Pkwy PS - Below Ground Structure	63	Perform vibration analysis, pumping evaluation, design new pumps, replace pumps, evaluate control system	At-Risk Assets
3	1	Pump Station	Cayuga	Cayuga PS - HVAC	45	Replace Wet well Roof AHU	At-Risk Assets
		Pump Station	Industrial Parkway	Ind Pkwy PS - HVAC	45	Replace Wet and Dry Well Roof AHU	
4	1	Pump Station	Cayuga	Wet Well Chain Pull	50	Redesign wet well chain pull to remove comminutors	At-Risk Assets
	4	Pump Station	Depew	Cranes	21	Redesign crane system	
		Pump Station	Vanderbilt	Cranes	30	Redesign crane system	
		Pump Station	Broadway East	Cranes		Redesign crane system	
5	4	Pump Station	Depew	ORF Chlorine Chamber/Gates	30	Add additional gates to drain CCT	At-Risk Assets
				ORF Washwater Fill Pump Station	30	Redo submersible pump station and creek intake	
				ORF Washwater Pumps	21	Replace ORF washwater pump	
				Flow meters/Force Main Ball Valve	30	Remove and replace valve stem, repair flow meter, modify valve chamber so valve can be easily lifted out	
				Flow Meters/ORF Ball Valve	30	Repair flow meter, modify valve chamber so valve can be easily lifted out	
6	4	Pump Station	Bowmansville	Wastewater Pumps	20	Evaluate pumps and piping and replace as necessary	At-Risk Assets
7	4	Pump Station	Vanderbilt	Pumping System/Force Main Evaluation	40	Evaluate capacity of pumping system, resize pumps if necessary.	At-Risk Assets
8	4	Pump Stations	Aurora N/Aurora S	Pump Stations		Various Improvements	Existing CIP
9	5	Pump Station	Eastern Hills	EHPS - Below Ground Structures	81	Replace below-ground steel structures with FRP	At-Risk Assets
10	5	Collection System	Transit Road	Collection System		Replacement of ACP	Existing CIP
11	5	Collection System	Goodrich Road	Collection System		Various Improvements	Existing CIP
12	5	Collection System	Spaulding Lakes	Collection System		Various Improvements	Existing CIP

Key points from this session

How do I optimize O&M and capital investment?

Key Points:

- Follow a logical best practice process – Optimized Decision Making or Life Cycle Costing Analysis.
- Get the best information and data you have, consider all feasible alternatives, and generate your best strategy.
- Consider non-asset solutions!

Associated Techniques:

- Optimized renewal decision-making
- Life-cycle costing (including projections)
- Decision-tree analysis
- Weighted decision tables