WELCOME
TO THE JUNE EDITION
OF THE 2014
M&R SEMINAR SERIES
BEFORE WE BEGIN

• PLEASE SILENCE CELL PHONES & SMART PHONES

• QUESTION AND ANSWER SESSION WILL FOLLOW PRESENTATION

• PLEASE FILL EVALUATION FORM

• SEMINAR SLIDES WILL BE POSTED ON MWRD WEBSITE

• STREAM VEDIO WILL BE AVAILABLE ON MWRD WEBSITE
  (www.MWRD.org: Home Page ? MWRDGC RSS Feeds)
Tim Skeel

Current: (retiree) Principal Economist, City of Seattle, Washington

Experience: - Over 30 years in applied economics including capital asset management, triple bottom line evaluation, life cycle cost analysis, benefit/cost analysis, risk assessment, integrated resource planning, supply and demand forecasting, utility rates, finance and value engineering.
- With Seattle Public Utilities and Seattle Department of Transportation, conducting project business cases, developing economic decision models, conducting risk assessments, creating asset management plans for optimal maintenance, repair and renewal strategies, educating staff on asset management principles, and managing its formal Value Management Program.
- Worked as a consultant for CH2M Hill,
- Taught Economics courses at North Seattle Community College and at the University of Washington.
- Worked as an economist for the Montana Department of Natural Resources.

Education: BA from the University of Montana
Master from the University of Washington
Ph.D. Candidate, the University of Washington
Fig. 34. The trend toward farm mechanization is indicated by the rapid increase in the number of tractors on the farm and the steady decline in the number of horses and mules used for farm power.
• Universe of Value

Public, Non-market Goods
Value = ?

Private, Market Goods
Value = $
• How can you deliver the best value for money to customers and the community?

• Well, first, make the right capital investments at the right time. Minimize life cycle cost by implementing cradle-to-grave asset strategies that balance renewal and rehab against preventive and corrective maintenance. Optimize risk exposure by understanding the likelihood and consequences of failure, and employing the most cost-effective risk mitigation measures. Ensure that expenditures are made efficiently and effectively. Understand the full financial, social and environmental impacts on the community.

• Optimizing expenditures and providing best value for money means you need to analyze cost and performance data, you need to know the value customers put on your services, and you need appropriate analytical tools and models. You need an effective decision management structure to turn the analysis, evaluation and resulting optimal strategies into efficient projects and programs. It’s not rocket science, but, you could call it asset management science.

• A decision management structure incorporating business case analysis is a powerful tool in delivering the best value for money to customers and the community. Business case analysis and review of expenditure decisions has saved Seattle Public Utilities’ customers millions of dollars in capital and O&M expenses while providing them with equal or better service.

• This talk will provide an overview of the business case tools, analysis and decision making structures that help SPU to provide the most value for money to its customers and community, including the triple bottom line of financial, social and environmental impacts.
Benefit/Cost Analysis: Theory and Practice at a Public Utility

Tim Skeel, Principal Economist, Asset Management and Economic Services, Seattle Public Utilities
What is Benefit/Cost Analysis and Why do We Do It?
We consume a lot of scarce resources to deliver utility services to the community.

We should strive to maximize the net benefits to society in our use of resources.
Guiding Light:

Focus on Long-Run Value and Life-cycle Cost

... to the Customer and the Community
The Essential Mission of Public Agency

Scarce community resources → Valuable community services → Community well-being
Lack of Incentives in Public Agencies: 4 ways to spend $ 

- Whose money?
  - Your own
  - Someone else’s

- Spent On?
  - Yourself
  - Someone else

- Benefit/Cost Analysis
  - Careful on both value and cost
  - Careful on cost, not so much on value
  - Not that careful on either cost or value
  - Careful on value, not so much on cost
Why B/C Analysis on Public Expenditure?

Policy on Resource Allocation

More public goods, fewer private

More private goods, fewer public

Social Welfare

Weak incentives to be efficient

Externalities tend to be ignored
Benefit/Cost Analyses demonstrate greatest net value to the community to:

- 1) maintain or improve utility service, and/or
- 2) reduce long-run life-cycle cost
- 3) reduce financial/social/environmental risk
- 4) meet regulatory requirements
- 5) improve social/environmental outcomes
Benefit/Cost Analysis Guides
Decisions
Transparent, objective, decisions based on sound data and analysis to return the best value to the community.
Value of B/C Analysis

• Improve Expenditure Decisions – Better Net Value for the Community
• Provide Transparent Documentation of Decisions
• Make Decisions Corporate – Risk and Accountability becomes Executives’
Benefit/Cost Analysis: What and Why

Value for cost target

Improving aim
Best Value to Society/Community

“Full” benefit and cost accounting –
Market Values: $, labor, capital, energy, materials, inputs, land (market priced)
Social: service, aesthetics, time, convenience, health, recreation (no market price)
Environmental: habitat, ecosystem services, green space, air and water quality (no market price)
Guiding Light:

Focus on Long-Run Value and Life-cycle Cost

... to the Customer and the Community
What Are the Issues with Benefit/Cost Analysis?
Methodologies

- Valuing public goods and externalities
- Indirect market and non-market valuation
  
  Travel cost, revealed preference, hedonic estimation, willingness to pay, contingent valuation, etc.

- Reasonable person test
Two Approaches

• Valuing triple bottom line
  Indirect market and non-market valuation techniques, willingness-to-pay, set of agreed values

• Application of “reasonable person test”
  Shortcut to direct valuation, executive judgement
Guide for TBL Valuation

• When available, use agreed values for non-market (social and environmental) benefits and costs, otherwise:
• When justified, use agreed non-market valuation techniques to estimate value, otherwise:
• Use “reasonable person test” to determine “break-even” value of non-market benefits or costs
Risk Cost

• Risk Cost = % Likelihood times $ Consequence
• 10% Chance of Failure x $10,000 Cost of Failure = $1,000 Risk Cost of Failure
• Actuarial value – expected long run average cost of failure
Elements for Success

How much analysis?

Gains from analysis

Analysis effort

Personal decision w/in organizational norms - BAU
Answer a few key questions about $ value and $ cost
Peer-reviewed $ WTP study on color of recycling can
Discounting to Present Value

Present Value of Cash Flow From Year 1 to Year 10 =

The “Miracle of Compound Interest” in Reverse!
Fitting the target to the arrow – NOT!
Why B/C Analysis on Public Expenditure?

Other reasons:

- CYA – re-direct accountability
- Sales job
- Process is our product
- Another hoop to jump through
- Economists like to do analyses
Other Issues

• Cost shifting
  Traffic costs, cleaning grease traps, maintaining pressure pumps, legal liability,

• Benefits beyond core business
  Aesthetics, open space, safety, security, protection of private property, habitat

• Who counts, who pays
  Region, ratepayers, citizens, direct beneficiaries
Defining the Base Case

• Each business case should clearly define what will be used as the “Base Case”. This could vary across analysis so key here is to explain exactly what is meant for that particular business case.

• Economic analysis of the options should “always” be done relative to the base case.

• The costs and the benefits will therefore be changes in costs and changes in benefits from the base case.
Some barriers to effective B/C Analysis

Conflict of interest: Vested interests put in charge of analyses

Decision makers personal B/C at odds with social B/C analysis

Analysts with skills not suited to B/C analysis
What is Triple Bottom Line?

Financial

✓ Costs: (capital) design, materials, construction, permitting, disposal, operation and maintenance
✓ Benefits: capital and O&M cost reductions (over base case)

Social

✓ Costs: traffic disruption, lost aesthetics, outages
✓ Benefits: improved aesthetics, recreation, convenience, safety

Environmental

✓ Costs: negative impacts on air, water, habitat, etc.
✓ Benefits: improved water quality, wildlife and fish species enhancement, ecosystem services
“Willingness to Pay” Surveys
Example 1

SPU Recently Asked it’s Customers:

“How Much More Would You be Willing to Pay to Ensure that All Customers Receive an Acceptable Level of Sewer Backup Service?”
“Willingness to Pay” Surveys Example 1 (Cont’d)

Study Design:

- **Conjoint Analysis** (i.e. Compelling Survey Respondents to make Tradeoffs Between Alternative Service Levels at Differing Costs)

- **Detailed Phone Survey of 354 SPU Customers**

- **Statistically Acceptable Sample Was Achieved** Across Gender, Geography, Own vs. Rent, Household Size, Race, and Income
“Willingness to Pay” Surveys
Example 1 (Cont’d)

What Our Customers Said:

• Forty-Two% of Those Sampled were Unwilling to Pay any Additional Monthly Expense
• However...75% of Those Willing to Incur Added Expenses Agreed to Pay an Additional 5% Per Year for the Next 20 Years
• The Median (Consultant Recommended) Amount of All Respondents was to Pay an Additional $0.35 per Month to Achieve a Minimum Sewer Backup Level of Service

<table>
<thead>
<tr>
<th></th>
<th>All Respondents N=354</th>
<th>Respondents Willing to Pay N=206</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>$</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>2.39</td>
<td>0.84</td>
</tr>
<tr>
<td>Median</td>
<td>1.00</td>
<td><strong>0.35</strong></td>
</tr>
</tbody>
</table>
“Willingness to Pay” Surveys
Example 1 (Cont’d)

We Also Calculated the Cost to Meet These Alternative Service Level Options:

<table>
<thead>
<tr>
<th>Service Level Options</th>
<th>Maximum Cost Above Do-Nothing Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once in 2 years</td>
<td>$23.9 million</td>
</tr>
<tr>
<td>Once in 5 years</td>
<td>$36.9 million</td>
</tr>
<tr>
<td>Once in 10 years</td>
<td>$40.8 million</td>
</tr>
<tr>
<td>Once in 20 years</td>
<td>$59.1 million</td>
</tr>
</tbody>
</table>

The Service Level Most Closely Resembling That Chosen by Customers in our Survey (1.0% or $0.35 Additional Cost Per Month) Equated to a 5-year Level of City-Wide Sewer Backup Service When Converted from CIP to an Average Monthly Sewer Rate
“Willingness to Pay” Surveys
Example 2

SPU Recently Asked it’s Customers:

“We Have Estimated that Your Bill Will
Increase by $4.62 per Month for the Next
Five Years to Pay for Combined Sewer
Overflow Projects to Meet Regulations. How
Supportive are You of This?”
“Willingness to Pay” Surveys Example 2 (Cont’d)

Study Design:

• **Simple Question and Answer** with Respondents Typically Responding on a 1 (Low) to 7 (High) Scale in Regards to System Knowledge and Willingness to Pay.

• **Detailed Phone Survey of 402 SPU Customers** was Performed

• **Statistically Acceptable Sample Was Achieved** Across Gender, Geography, Own vs. Rent, Household Size, Race, and Income
“Willingness to Pay” Surveys
Example 2 (Cont’d)

What Our Customers Said:

• There was a Fairly Low Degree of Knowledge about SPU’s CSO Program (24%)
• Those Who Knew of CSOs Mostly Became Aware via Reading Local Newspaper Articles
• When Informed of the Problem, 68% Felt “Supportive” or “Very Supportive” of SPU’s Efforts to Reduce CSOs
• When Informed of the Cost ($4.62 Extra Per Month) Only 49% Felt “Supportive” or “Very Supportive”
# U-bridge Watermain Break

<table>
<thead>
<tr>
<th>Time</th>
<th>Cost</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>$440,000</td>
<td>47%</td>
</tr>
<tr>
<td>Transit</td>
<td>$130,000</td>
<td>14%</td>
</tr>
<tr>
<td>Walkers, Bicyclists</td>
<td>$32,000</td>
<td>3%</td>
</tr>
<tr>
<td>Blocked access to houseboats</td>
<td>$800</td>
<td>&lt;1%</td>
</tr>
<tr>
<td><strong>SPU Response</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contracted Repairs</td>
<td>$200,000</td>
<td>21%</td>
</tr>
<tr>
<td>Other Response Costs</td>
<td>$117,000</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Service Outage</td>
<td>$2,000</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Lost Water</td>
<td>$300</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Other Property Damage (cars)</td>
<td>$4,000</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Environmental Costs</td>
<td>$5,000</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Lost Business</td>
<td>$10,000</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$940,000</td>
<td></td>
</tr>
</tbody>
</table>
Life Cycle Cost Including Risk Cost, Capital and O&M (20 Year Present Value)

- Status Quo
- Option 1 – Improve Procedures and Training
- Option 2 – Install Public Address System
- Option 3 – Replace and Upgrade Full Alarm System

- Present Value of Option Cost over 20 Years at 2% Real Discount Rate
- Present Value of Annual Risk Cost over 20 Years at 2% Real Discount Rate
1 of 3 Charts: Flood Reduction

Estimated Reduction in Flooding Damages
(In $ Millions over 50 years at 5%)

Risk Reduction from current $18.7 million to $.4 million is benefit of conveyance project
PV Costs Comparison - Rainier

- **Do Nothing Hi**
- **Do Nothing Low**
- **Do Project Hi**
- **Do Project Low**

Legend:
- SPU Costs
- SDOT Costs
- Private Risks
Triple Bottom Line Justifies Early Replacement of Plastic Service Pipes

Discounted Present Value of Cost

Risk Category | Probability | Consequence | Risk Cost
---|---|---|---
Service Interruption | 10% | 1 hr x 10 cust x $100/hr/cust | $100
Property Use Impact | 1% | $2,000 | $20
Surface Water Discharge | 0.1% | $1,000 | $1
Traffic Delay | 10% | 1 hr x 400 cars/hr x $5/car | $200
Total | | | $321

Social and Environmental Risk Cost
Financial Cost
Comparison of Annualized Life Cycle Cost (incl. Risk Cost)

PV of All Costs = $3.1m

PV of All Costs = $1.8m

PV of All Costs = $2.8m

- Replace Affected Pipe
- Leak Repair, Expansion Joints
- Monitoring
- Environmental Damage Level 2
- Environmental Damage Level 1
- Repair
- Curtailment

No Action
Fix Leaks, Add Exp Joints
Replace Pipe, Add Exp Joints
Economic Analysis - NPV

Figure 6.3: Net present value of South Park Water Quality Facility, excluding pump station costs, millions of dollars.

- 8 percent increase in property values due to water quality facility needed to make NPV = 0

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Costs</th>
<th>Benefits</th>
<th>Net</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Stormfilter with increased maintenance</td>
<td>$32.500</td>
<td>$15.300</td>
<td>($17.100)</td>
</tr>
<tr>
<td>4a. CESF with pressure sand, Single level</td>
<td>$28.300</td>
<td>$16.100</td>
<td>($12.200)</td>
</tr>
<tr>
<td>7. Delay WQ Facility</td>
<td>$15.900</td>
<td>$10.600</td>
<td>($5.300)</td>
</tr>
<tr>
<td>8. Delay Both</td>
<td>$11.600</td>
<td>$10.600</td>
<td>($1.000)</td>
</tr>
</tbody>
</table>
Evaluating Risk Improves Performance and Reduces Life Cycle Cost

SPU Wastewater Force Mains Risk Ranking

Consequence of Failure Score

Likelihood of Failure Score

Sewer bills likely to triple in 5 years
Benefit of Optimal Intervention

1) Old practice based on service life of 100 years; actual economic life averaged 150 years.

2) Cost of intervening too early = green area.

3) Typical PV of savings due to optimal timing = $17 million per pipe.
Water Service Pipes Program

2007 Units & Spending

Reactive Failure Renewals
570 $4,772,000

More of this now = Less of this in future

Proactive Renewals
320 $936,000
Comparing Option Costs

Annualized Life-cycle Cost of Options

- **Option 1**:
  - Payment to TCC: $50,000

- **Option 2**:
  - Pierce Transit Agency: $400,000
  - Transit Riders: $50,000
  - Street Vehicle Traffic: $50,000

- **Option 3**:
  - Cost of New Transit Center: $500,000
  - Cost to Restore TCC Site: $300,000

See Chart "Option 2 Cost Detail"
Option 2 Details

Option 2 Cost Detail

- Increased Bus Driver Time Cost
- Increased Cost for SHUTTLE Program
- Avoided Transit Center O&M
- Avoided Transit Center Security
- Increased Rider Safety
- Risk
- Rider Added Time

Cost Offsets:
- Pierce Transit Agency
- Transit Riders
- Street Vehicle Traffic

Costs:
- Restore Site to Original Construction
- New Stops O&M
- New Stops Construction
- Lost Trip Revenue
- Increased Traffic Delays

Costs and Offsets are represented in the chart.
# Watershed Bridges

<table>
<thead>
<tr>
<th>Steps</th>
<th>Traditional Approach</th>
<th>BCE Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Problem Statement</td>
<td>Failing bridges need to be replaced</td>
<td>Access to sections of watershed threatened by failing bridges</td>
</tr>
<tr>
<td>2. Options Analysis</td>
<td>None</td>
<td>None, some or all bridges replaced; various designs</td>
</tr>
<tr>
<td>3. Economic Analysis</td>
<td>None</td>
<td>Compare TBL value and cost of options over full life cycle</td>
</tr>
<tr>
<td>4. Recommendation</td>
<td>Replace all failing bridges with concrete design appropriate for major urban arterial at a cost of $7-8 million</td>
<td>Best value is replace highest value bridges with steel design appropriate for limited mountain road use at a cost of $2-3 million; decommission low valued bridges</td>
</tr>
</tbody>
</table>
# Maple Leaf Tank

<table>
<thead>
<tr>
<th>Steps</th>
<th>Traditional Approach</th>
<th>BCE Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Problem Statement</td>
<td>Tank needs to be upgraded to meet SPU seismic design standards; also, neighborhood receives low pressure</td>
<td>Neighborhood is exposed to risk cost due to seismic vulnerability of existing tank; minimum pressure service levels in neighborhood are being met, but lower than system average</td>
</tr>
<tr>
<td>2. Options Analysis</td>
<td>None</td>
<td>Tank, pipeline, pump, storage and operational solutions</td>
</tr>
<tr>
<td>3. Economic Analysis</td>
<td>None</td>
<td>Compare TBL value and cost of options over full life cycle</td>
</tr>
<tr>
<td>4. Recommendation</td>
<td>Replace tank with higher elevation tank meeting current seismic design standards at a cost of $7 million</td>
<td>Best value is connect neighborhood distribution network to higher head transmission line in vicinity and eliminated tank from service at a cost under $100K</td>
</tr>
</tbody>
</table>
Elmore Trestle

• 75 year old 30” clay sewer main

• On wooden trestle crossing ravine

• Conveys collected waste water from 2,000 customers to treatment interceptor line

• Trestle shows signs of structural weakness

• Pipe has some dripping leaks from joints
## Elmore Trestle

<table>
<thead>
<tr>
<th>Steps</th>
<th>Traditional Approach</th>
<th>BCE Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Problem Statement</td>
<td><em>Old, leaking sewer line on failing trestle needs to be replaced</em></td>
<td>?</td>
</tr>
<tr>
<td>2. Options Analysis</td>
<td><em>None</em></td>
<td>?</td>
</tr>
<tr>
<td>3. Economic Analysis</td>
<td><em>None</em></td>
<td>?</td>
</tr>
<tr>
<td>4. Recommendation</td>
<td><em>Replace sewer line in new alignment around ravine through neighborhood streets at a cost of $3 million</em></td>
<td>?</td>
</tr>
</tbody>
</table>
# Elmore Trestle

<table>
<thead>
<tr>
<th>Option</th>
<th>Present Value of Cost @ 5% Discount Rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do Nothing</td>
<td>$1,531,000</td>
</tr>
<tr>
<td>2. Re-align in 35th Ave. W.</td>
<td>$1,900,000</td>
</tr>
<tr>
<td>3. Re-route to 36th Ave. W.</td>
<td>$3,000,000</td>
</tr>
<tr>
<td>4. Reline pipe and Rebuild Trestle with wood timbers</td>
<td>$584,000</td>
</tr>
<tr>
<td>5. Reline pipe and Rebuild Trestle with reinforced recycled plastic timbers</td>
<td>$776,000</td>
</tr>
</tbody>
</table>

*Includes risk cost of failure and periodic rehabilitation over 100 years
Triple Bottom Line “Reasonable Person” Test Helps Choose Best Value Option

Environmental Risk Cost Required to Make Lowest Financial Cost Option "Break Even" with No Environmental Risk Option

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Environmental Consequence</th>
<th>Environmental Risk Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>$2,500,000</td>
<td>$2,500,000</td>
</tr>
</tbody>
</table>

Likelihood and consequence required to “break even” with no risk option judged unreasonably high.
Economic Principles

- Marginal Cost
- Average Cost
- Average Fixed Cost
- Average Variable Cost

Minimum Cost

Output of Asset
Replace Assets at end of Economic Life – Minimum Average Life Cycle Cost
Economic Life Models: Optimal Asset Replacement

Replace when retention exceeds cost of replacement

- Life Cycle Cost of Asset Replacement
- Actual Cost of Retaining Existing Asset
- Optimal Time to Replace
- Too Soon
- Too Late
# Pipe Replacement Model

**Scenario:** W Cremona St: 8th Ave W to 7th Ave W  
(model modification, 10% contingency, 8" DI replacement option)

<table>
<thead>
<tr>
<th>Option</th>
<th>Data Class</th>
<th>Input Variables</th>
<th>Input Values</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Net Present Value of Replacement @ 3%</td>
<td>$130,533</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Net Present Value of Replacement @ 5%</td>
<td>$64,874</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Net Present Value of Replacement @ 7%</td>
<td>$16,597</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Pipe</td>
<td>Pipe Length Miles</td>
<td>0.063</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Pipe</td>
<td>Leaks per Mile per Year in Year 1</td>
<td>25.4</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Pipe</td>
<td>Pipe Age</td>
<td>76.0</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Construction</td>
<td>Leak Repair Hours</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Construction</td>
<td>Persons per Repair</td>
<td>3</td>
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<tr>
<td>Leak Repair</td>
<td>Construction</td>
<td>Cost per Person per Hour</td>
<td>$50</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Construction</td>
<td>Equipment Pieces per Repair</td>
<td>3</td>
<td></td>
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<tr>
<td>Leak Repair</td>
<td>Construction</td>
<td>Cost per Equipment Piece per Hour</td>
<td>$75</td>
<td></td>
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<tr>
<td>Leak Repair</td>
<td>Construction</td>
<td>Material Cost</td>
<td>$625</td>
<td></td>
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<tr>
<td>Leak Repair</td>
<td>Construction</td>
<td>Total Cost per Leak</td>
<td>$2,500</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Service</td>
<td>Hours Service Interruption per Leak</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Service</td>
<td>Customers Impacted per Leak</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Service</td>
<td>% Leak Repairs w/ Water Shutoff</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Service</td>
<td>Cost per Customer per Hour</td>
<td>$5</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Traffic</td>
<td>Hours Traffic Interruption</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Traffic</td>
<td>Traffic Flow Cars per Hour</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Traffic</td>
<td>Cost per Car</td>
<td>$2</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Lost Water</td>
<td>Hours of Water Loss per Leak</td>
<td>168</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Lost Water</td>
<td>Gallons Lost per Hour</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Lost Water</td>
<td>Cost per Gallon Lost</td>
<td>$0.002</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Damage</td>
<td>Number of Damage Claims per Leak</td>
<td>0.167</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Damage</td>
<td>Settlement Cost per Claim</td>
<td>$2,000</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Fire Risk</td>
<td>Customers Impacted Fire Flow</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Fire Risk</td>
<td>Property Value per Customer</td>
<td>$500,000</td>
<td></td>
</tr>
<tr>
<td>Leak Repair</td>
<td>Fire Risk</td>
<td>Probability each Year Fire w/ Inadequate Fire Flow</td>
<td>0.00001</td>
<td></td>
</tr>
</tbody>
</table>

- Total Leaks per Year in Year 1: 1.60
- Total Leaks per Year in Year 20: 4.89

**Construction % of Leak Repair Option Cost**: 52%

**Service % of Leak Repair Option Cost**: 7%

**Traffic % of Leak Repair Option Cost**: 8%

**Lost Water % of Leak Repair Option Cost**: 0%

**Damage % of Leak Repair Option Cost**: 7%
A better balanced maintenance strategy results in lower life cycle cost and higher service levels.

Optimizing Life Cycle Cost

- Preventive Maintenance
- Corrective maintenance
- Reactive Maintenance
- Risk Cost
- Rehab/Replacement
- Total life cycle cost

Suboptimal
Optimal
Multiple Options and Complex Systems

Optimizing Value over Cost

Complete a *Demand Management Potential Assessment*

[Graph showing levelized cost in dollars per gallon versus gallons per day, with arrows pointing to avoided cost of supply, and noting the addition of showerheads, toilets, and washers.]
Multiple Options and Complex Systems

Optimizing Value over Cost

Including Triple Bottom Line in Costs

Levelized Cost: $/Gal

Gallons/day

Further Demand Management is Cost Effective

Plus Avoided Social and Environmental Cost of Supply (e.g., x% “adder”)

Avoided Financial Cost of Supply
Optimizing Cost and Service Level

- Customer Value
- Suboptimal Utility Cost and Service Level
- Optimal Balancing of O&M, Capital and Risk Cost
- Minimum Life Cycle Cost