Value of Water – Application of Economics in Decision-Making

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Value of water presentation outline

1. Water project benefits = Value of water = Willingness-to-pay for water
2. Water value justifies water projects
3. How to estimate water value
4. Recommendations
1. Water project benefits =
   Value of water =
   Willingness-to-pay for water

Value of water is customer maximum willingness-to-pay for certain quantity and quality

Water value depends on how water is used
Water values estimated for U.S. utilities apply to discretionary uses only

Essential uses – 6 basic needs
1. Drinking
2. Sanitation
3. Cooking
4. Food production – Water needed to produce crops and process food where water applied efficiently
5. Electricity production – Where water used efficiently
6. Supports employment - Industrial production where water used efficiently

Discretionary uses – all other uses
- Long showers and other household uses beyond essential
- Lawn irrigation
- Car washing
- All production activities where it is privately or socially economically feasible to increase water use efficiency
- Production activities that are artificially supported by the government that are economically inefficient.

Water value per 1,000 gallons falls as amount of water consumed increases

Water Demand Equation - Single Family Household Annual Water Use
(Price varies and all other factors are constant)

Only this part of demand curve can be estimated using customer data
This is the part needed to make investment decisions

Value of Water = Consumer Surplus + Water (& Sewer) Bill
Example of water value - Bonita Springs household

Demand equation plotted:
Quantity per Household = 22 – 0.70 x Price
Price at last usage block = P₁ = $8.92 per kgal
Q₁ = Total water use = 15.65 kgal / month

Discretionary Water Use Value per Household at 11,000 Gallons per Month

Value of Discretionary Water Use
Value of use that customer keeps.

Water value justifies water supply projects
Benefits of water supply projects

- Avoid water shortage declarations by utility and water management districts
- Water shortage restrictions target discretionary water use:
  - Lawn watering restrictions
  - Outdoor use restrictions – car wash, pool filling, sidewalk cleaning
  - Small % cutbacks with suggestions to reduce indoor use
- In practice, essential uses supplied during water shortage
- Value of additional water supply is customer’s value of preserving discretionary uses
- Discretionary use has value to customers

Customer value of avoided water shortage using estimated water demand equations for Florida

<table>
<thead>
<tr>
<th>% Cutback in Water Use</th>
<th>Probability of Water Cutback</th>
<th>1%</th>
<th>5%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>100%</th>
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<tbody>
<tr>
<td></td>
<td>1% Once in 100 years</td>
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<td>10% Once in 5 years</td>
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<td>3 out of 10 years</td>
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<td>4 out of 10 years</td>
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<td>10 out of 10 years</td>
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<tr>
<td>10%</td>
<td>$5</td>
<td>$11</td>
<td>$16</td>
<td>$21</td>
<td>$53</td>
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<tr>
<td>15%</td>
<td>$9</td>
<td>$19</td>
<td>$27</td>
<td>$37</td>
<td>$92</td>
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<tr>
<td>20%</td>
<td>$15</td>
<td>$28</td>
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<td>$144</td>
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<tr>
<td>30%</td>
<td>$32</td>
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<td></td>
<td>$322</td>
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<tr>
<td>40%</td>
<td>$37</td>
<td>$76</td>
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<td>50%</td>
<td>$19</td>
<td>$93</td>
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<td>60%</td>
<td>$56</td>
<td>$276</td>
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</table>

Household willing to pay as much as:
- $276 per year to avoid a 60% water shortage once every 20 years ($23 per month).
- $322 per year to avoid a 30% water shortage every year ($27 per month).
Customer value to avoid cutbacks used to estimate breakeven cost (benefits = costs) of new water supply

Breakeven Annualized Capital and O&M Cost Per 1,000 Gallons of Additional Water Supply
To Avoid Water Shortage Scenario and Have No Shortages
Dollars per 1,000 Gallons of New Water Produced When Project is Producing Water, 2019 dollars

<table>
<thead>
<tr>
<th>% Cutback in Water Use</th>
<th>Probability of Water Cutback</th>
<th>1%</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Once in 100 years</td>
<td>Once in 20 years</td>
<td>Once in 10 years</td>
<td>Once in 5 years</td>
<td>3 out of 10 years</td>
<td>4 out of 10 years</td>
<td>10 out of 10 years</td>
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<tr>
<td>10%</td>
<td></td>
<td>$0.78</td>
<td>$1.49</td>
<td>$2.12</td>
<td>$2.70</td>
<td>$5.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15%</td>
<td></td>
<td>$0.84</td>
<td>$1.61</td>
<td>$2.33</td>
<td>$2.95</td>
<td>$6.15</td>
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<tr>
<td>20%</td>
<td></td>
<td>$1.10</td>
<td>$2.07</td>
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<td>$7.87</td>
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<tr>
<td>30%</td>
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<td>$2.01</td>
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<td>$15.05</td>
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<tr>
<td>40%</td>
<td></td>
<td>$0.43</td>
<td>$2.15</td>
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</tr>
<tr>
<td>50%</td>
<td></td>
<td>$0.97</td>
<td>$4.73</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>60%</td>
<td></td>
<td>$2.57</td>
<td>$12.54</td>
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</tbody>
</table>

Water supply and conservation projects are economically feasible if they cost less than:
- $12.54 per 1,000 gallons and avoid a 60% water shortage once every 20 years.
- $15.05 per 1,000 gallons and avoid a 30% water shortage every year.

Using water value to assess economic feasibility of proposed reservoir in west Florida

- 4 reservoir configurations evaluated
- 0, 2.6, 5.5, 10 mgd of water supply
- Benefits included:
  1. Reduced stormwater and freshwater discharges to estuaries
  2. Reduced total phosphorus load to estuaries
  3. Water supply to utilities
- Annualized cost ranged from $2.3 million to $5.4 million
Water value is 46% to 54% of the total benefit provided

- **Deep Below Ground Reservoir - 5.5 mgd**
  - Value of Water Supply: $6,539,000
  - Water Supply to Utilities: $7,320,000
  - TP Reduction to Estuaries: $382,000
  - Reduced Discharge to Estuaries: $382,000

- **Deep Below and Above Ground Reservoir - 10 mgd**
  - Value of Water Supply: $11,890,000
  - Water Supply to Utilities: $9,610,000
  - TP Reduction to Estuaries: $563,000
  - Reduced Discharge to Estuaries: $563,000

Estimated Annual Benefits and Costs of Proposed Four Corners Reservoir, 2017 $

<table>
<thead>
<tr>
<th>Item</th>
<th>Alternative A</th>
<th>Alternative B</th>
<th>Alternative C</th>
<th>Alternative D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative Description:</td>
<td>Shallow Above-Ground Reservoir</td>
<td>Deep Above-Ground Reservoir</td>
<td>Deep Below Ground Reservoir</td>
<td>Deep Below- and Above Ground Reservoir</td>
</tr>
<tr>
<td>Net Storage Volume ac. ft.</td>
<td>1,120</td>
<td>5,510</td>
<td>6,816</td>
<td>11,979</td>
</tr>
<tr>
<td>Water Supply in mgd</td>
<td>0.0</td>
<td>2.6</td>
<td>5.5</td>
<td>10.0</td>
</tr>
<tr>
<td>Value of Annual Benefits, estimated:</td>
<td>$0</td>
<td>$3,091,000</td>
<td>$6,539,000</td>
<td>$11,890,000</td>
</tr>
<tr>
<td>Water Supply to Utilities</td>
<td>$90,000</td>
<td>$192,000</td>
<td>$382,000</td>
<td>$563,000</td>
</tr>
<tr>
<td>Reduced Water Flows to Estuaries</td>
<td>$3,360,000</td>
<td>$6,537,000</td>
<td>$7,320,000</td>
<td>$9,610,000</td>
</tr>
<tr>
<td>Total Value of Benefits</td>
<td>$3,450,000</td>
<td>$9,820,000</td>
<td>$14,241,000</td>
<td>$22,063,000</td>
</tr>
<tr>
<td>Total Annualized Capital, Admin, R&amp;R and O&amp;M Cost</td>
<td>$2,285,000</td>
<td>$4,333,000</td>
<td>$3,810,000</td>
<td>$5,430,000</td>
</tr>
<tr>
<td>Annual Net Benefits (B – C)</td>
<td>$1,165,000</td>
<td>$5,487,000</td>
<td>$10,431,000</td>
<td>$16,633,000</td>
</tr>
<tr>
<td>Project Economically Feasible?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Significant water value benefit increases economic feasibility of proposed Florida reservoir.
Using water value to assess economic feasibility of Florida’s Grove Land Reservoir and Stormwater Treatment Area

Water Flows out of STA
136 mgd (210 cfs)

Options for "using" the water
1. Discharge treated surface water to St. Johns River for water supply, environment
2. Send water to utilities and other large water users
3. Store in aquifer for later use
4. Send water with lower nutrient concentrations back to estuaries during dry season

Survey research used to estimate willingness-to-pay to avoid water shortages in Orlando, Florida

- Households surveyed were water customers of the Orlando Utilities Commission.
- Stated preference survey of 448 households conducted.
- Willingness-to-pay statistically evaluated using 3,813 observations.

<table>
<thead>
<tr>
<th>Avoided Water Use Reduction</th>
<th>Average Value Per Year Per Household</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>15% reduction</td>
<td>$9.05</td>
<td>-2.0 to 20.1</td>
</tr>
<tr>
<td>20% reduction</td>
<td><strong>$20.20</strong></td>
<td>4.8 to 35.6</td>
</tr>
</tbody>
</table>
$20.20 value of avoided water shortage to households translated to a water value per 1,000 gallons of $17.19

Net value of water after deducting water and sewer utility costs was $6 per 1,000 gallons.

Client impressed by high value but asked that value of water be = Minimum (Net value of potable water to customer, Cost of new water supply)

$2.50 per 1,000 gallons used instead in the valuation of benefits (instead of $6 per 1,000 gallons)

Value of benefits from proposed Grove Land Reservoir and Stormwater Treatment Area – Estimates in 2014 $
**Water’s value to potable customers economically justifies reservoir project under all revenue scenarios**

<table>
<thead>
<tr>
<th>Economic Feasibility Results Under Six Alternative Revenue Scenarios</th>
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<tbody>
<tr>
<td><strong>Financial Metric</strong></td>
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<tr>
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<tr>
<td>Net Present Value at 7.18% real discount rate</td>
</tr>
<tr>
<td>Internal Rate of Return, Real Annual</td>
</tr>
<tr>
<td>Benefit-to-Cost Ratio at 7.18% real discount rate</td>
</tr>
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<td>Payback Period in Years</td>
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</tr>
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<td>Payback Period in Years</td>
</tr>
</tbody>
</table>

3. Water value can be estimated using water utility and publicly available data.
Water use practices and customer characteristics determine water value. Water use determined by:

- **Water and Sewer Price**
- **Household & Business Income / Profit**
- **Irrigation requirements** (weather / plants / soil)
- **Household size / no. of employees**
- **Water using technologies**
- **Type and amount of production**

Water value determined from water demand equation

Single Family Household Annual Water Demand Equation (Price varies and all other factors are constant)

Value of Water = Consumer Surplus + Water (& Sewer) Bill
Two ways to estimate water demand equation and, thus, potable water value to customers

**Benefits-transfer**
- Results of other utility water valuation studies
- Use estimated price elasticity of water demand from other studies
- Add water demand and price to plot the customer demand equation
- Use equation to estimate water value and willingness-to-pay to avoid water shortages

**Statistical estimation**
- Parameters of water demand equation statistically estimated
- Using passively-generated customer data on water use, water price and other factors
- Using data collected from survey of water customers

Value can be inferred using price elasticity of water demand and water price and use data

- Elasticity measures extent to which customer will change amount of water purchased in response to a change in real water price
- Defined by % change in amount of water purchased in response to a 1% change in water price
- Price elasticity of -0.4 means a 10% increase in price causes in a 4% reduction in amount of water purchased
Price elasticity of water demand estimates from literature

- Research proves that water demand is inelastic: \(-1 < E_p(\text{water}) < 0\)
- In benefits-transfer, elasticity values chosen to represent utility's customers based on climate, weather and customer characteristics
- Price elasticity of demand estimates compiled by Hazen: 144 residential; 17 commercial; 42 industrial

<table>
<thead>
<tr>
<th>Price Elasticity of Water Demand Estimated in the Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Customer Sector</strong></td>
</tr>
<tr>
<td>Residential</td>
</tr>
<tr>
<td>Commercial/Government</td>
</tr>
</tbody>
</table>

(a) Average of 314 residential price elasticities of water demand from Dalhuisen et al. (2003)

Statistically estimate water demand equation to obtain water value – \(\mathbf{b1}\) is estimated parameter used to value water

\[
Q(i,t) = b0 + \mathbf{b1} \times P(i,t) + b2 \times F2(i,t) + \ldots + bk \times Fk(i,t) + e(i,t)
\]

Where:
- \(Q(i,t)\) is water use by the ith customer during time t or billing period t;
- \(b0\) is the constant of the estimated equation;
- \(P(i,t)\) is the water and sewer price;
- \(F2(i,t), \ldots, Fk(i,t)\) are other factors that influence water use;
- \(\mathbf{b1}, b2, \ldots bk\) are the coefficients estimated by the regression; and,
- \(e(i,t)\) is the estimation error.
4. Recommendations

Water organizations do not provide water value estimates or feature ways to estimate and use water values

- Current utility outreach focuses on:
  1. Water needed to produce a product
  2. Cost or price of water
  3. Economic impact to construction or service disruption
- These measures not helpful in assessing if a water supply project should be constructed.
- Need to illustrate to utilities:
  1. How the dollar value of potable water benefits can be used in decision-making
  2. How the dollar value can be estimated by the utility
- Need for utility outreach platform that is easy for non-economists to understand how to estimate and use water values.