Forecasting Water Demand in Seattle

Presented to the
DCDC and the ASUCEESE
Tempe, Arizona
May 11, 2012
by
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Seattle Public Utilities

Seattle
Seattle Regional Water System

- Serves 1.3 million people
- Retail and wholesale
- 2 main sources:
  - S. Fork Tolt River
  - Cedar River
Water demand peaks when rainfall’s at a minimum. Fortunately, there’s storage.

Water Use – Past & Future

- Past trends: What happened?
- What caused it?
- What’s going to happen?
- How do we model it?
- Research needs – what are we missing?
Water Demand & Forecasts: 1930-2011

National Water Use Comparison - MWRA
The Great Decoupling

- 1992 Drought and Curtailment
- Non-Revenue Water
- Pricing – Water and Sewer Rates
- Conservation Programs
- Plumbing Fixture Codes
Water and Sewer Rates

- **Base Service Charge:** $13.25/mo
- **Winter Volume Rate:** $4.04/ccb (All Levels of Consumption)
- **Sewer Volume Rate:** $10.68/ccb

Inclining Block Volume Rates for Single Family Summer Season
(2nd Block applies to Commercial)

- $4.34/ccb - $5.15/ccb

Real Growth in Average & Marginal Water & Sewer Rates

- **Residential**
  - Average
  - Marginal
  - 3rd Tier

- **Commercial & Sewer**
  - Average
  - Marginal
  - Sewer
Average Rates per CCF in Real 2011 $s

Conservation Program Savings by Category 2000-2010

About 15 mgd of programmatic savings since 1990.
Code Savings

  - Toilets: 3.5 to 5 gpf ⇒ 1.6 gpf
  - Showerheads: 3 to 5 gpm ⇒ 2.5 gpm
  - Faucet aerators: 3 to 5 gpm ⇒ 2.5 gpm

- Savings estimates based on replacement rates + new construction
  - Fixture lives of 30, 10 and 5 years assumed for toilets, showerheads, and aerators, respectively

- Estimated 20 year savings: 9 mgd

Impact of Conservation on Historical Water Demand

![Graph showing water demand over time with different conservation factors highlighted.](image-url)
Forecasting Demand

- **Main Purpose**
  - Supply Planning (Long Term)
  - Rate Design (Short Term)

- **Approach**: Variable Flow Factor Model
  - Takes advantage of econometric analysis done by others (and ourselves)
  - Assumptions can easily be made and varied (for sensitivity analysis)
  - Simple yet takes account of many explanatory variables
  - Modest data requirements

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**2011 Water Demand Forecast**

![Graph showing water demand forecast from 1995 to 2060](chart_image)

- **Current Firm Yield**
- **Actual Demand**
- **2011 Draft Forecast**

Axis labels:
- **Annual MGD**
- **Years: 1995 to 2060**
Factors Affecting Wholesale Demand

Block Contracts
- Northshore: 8.6 mgd
- Cascade Water Alliance

Model Overview
- Base Year Flow Factors by Sector
- Future Flow Factors affected by:
  - Projected growth in water and sewer rates
  - Projected growth in household income
  - Planned conservation program savings
  - Passive savings
- Forecasts of households and employment
- Other Adjustments
  - Non-Revenue Water
  - Other Sources of Supply
  - Blocks
Income Growth – Median vs. Average

Per Capita Income: 1920=1

Average Annual Rate of Growth: 2%

Income Growth – Median vs. Average

Index of U.S. Per Capita and Bottom 90% Income: 1920=1

Average Annual Rate of Growth: 2%
Income Growth – Median vs. Average

Implications for forecast of income growth
(Assuming per capita income growth rate of about 2% continues)

<table>
<thead>
<tr>
<th>Class Warfare Scenarios</th>
<th>Income Distribution</th>
<th>Annual Median Income Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wealthy-Take-All Continues</td>
<td>Gets worse</td>
<td>0%</td>
</tr>
<tr>
<td>Wealthy Take Most</td>
<td>Gets worse more slowly</td>
<td>0% - 2%</td>
</tr>
<tr>
<td>Rising Tide Lifts All Boats</td>
<td>Holds constant</td>
<td>2%</td>
</tr>
<tr>
<td>Wealthy Get Smaller Share of New Growth</td>
<td>Improves</td>
<td>&gt; 2%</td>
</tr>
</tbody>
</table>

• Model assumption: 0.9%

Forecast with High and Low Income Growth Scenarios
**Water & Sewer Rates**

- Water and sewer rates have increased by more than 2% annually, inflation-adjusted.
- Rate models project almost flat real rates after several years of large increases.

**Annual Growth Rates**

<table>
<thead>
<tr>
<th></th>
<th>Seattle Retail*</th>
<th>Wholesale Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-2015</td>
<td>6.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td>2015-2020</td>
<td>1.0%</td>
<td>0.9%</td>
</tr>
<tr>
<td>2020-2060</td>
<td>0.4%</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

**Forecasting Programmatic Conservation**

- Conservation Potential Assessment
- Alliance for Water Efficiency Conservation Tracking Tool
  - Diminishing returns
  - Code enhancement
- By policy
Programmatic Conservation Savings

Estimate based on policy: Seattle Regional Water System Operating Board, January 2006

- 15 mgd of combined price-induced and programmatic conservation savings between 2011 and 2030
- No programmatic conservation thereafter

Passive Savings

Code savings
- 1992 code for showerheads, toilets and aerators
- 2001 code for clothes washers
- 2002 code for aerators
- Anticipated 2012 (effective 2016)

Beyond Code – Market Transformation
- Energy Star/CEE standards for washing machines
- Toilets 1.6 gpf ⇒ 1.28 gpf
- Showerheads 2.5 gpm ⇒ 2.0 gpm
- Aerators 2.2 gpm ⇒ 2.0 gpm

Replacement, New Construction, PSE
Passive Savings Model

Example: Toilets

- Existing share by gpf:
  - 10%: 5 gpf
  - 40%: 3.5 gpf
  - 50%: 1.6 gpf
- Current gpf: 2.7 gpf
- Flushing/person/day: 4
- Persons/hhld: 2.5
- Flushing/hhld/day: 10
- Gallon/hhld/day: 27.0
- Ratio (gallon/gpf): 10
- Fixture Life: 30 yrs

Average Single Family Indoor Water Use
in gallons per day
Total 114.7 gpd/SF HH

- 22% showers
- 23% toilets
- 16% clothes washers
- 7% bathtubs
- 10% kitchen faucets
- 14% leaks

Seattle Public Utilities

Passive Savings Model

Example: Clothes Washers

- Current water factor: 8.5 gwp
- Average volume: 4 cf
- Current use per wash: 34.0 gwp
- Washes/machine/day: 0.55
- Gallon/hhld/day: 18.7
- Ratio (gallon/wf): 2.2
- Appliance Life: 12 yrs

Average Single Family Indoor Water Use
in gallons per day
Total 114.7 gpd/SF HH

- 22% showers
- 23% toilets
- 16% clothes washers
- 7% bathtubs
- 10% kitchen faucets
- 14% leaks

Seattle Public Utilities
## Passive Savings Assumptions

### Washing Machine Water Factors

<table>
<thead>
<tr>
<th>Year</th>
<th>Top</th>
<th>Horizntl Star</th>
<th>CE Star</th>
<th>Energy</th>
<th>ES</th>
<th>CEE</th>
<th>ME</th>
<th>Average</th>
<th>SF WF</th>
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<td>1996</td>
<td>11</td>
<td>11</td>
<td>9.5</td>
<td>6</td>
<td>90%</td>
<td>8%</td>
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<tr>
<td>1997</td>
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<td>11</td>
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<td>6</td>
<td>87%</td>
<td>10%</td>
<td>3%</td>
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<td>1998</td>
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<td>6</td>
<td>83%</td>
<td>11%</td>
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<td>1999</td>
<td>11</td>
<td>11</td>
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<td>6</td>
<td>80%</td>
<td>13%</td>
<td>7%</td>
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<tr>
<td>2000</td>
<td>11</td>
<td>11</td>
<td>9.5</td>
<td>6</td>
<td>77%</td>
<td>15%</td>
<td>9%</td>
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<td>9.5</td>
<td>7.5</td>
<td>6</td>
<td>73%</td>
<td>16%</td>
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<td>9.5</td>
<td>7.5</td>
<td>6</td>
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<td>18%</td>
<td>12%</td>
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<td>2003</td>
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<td>9.5</td>
<td>7.5</td>
<td>6</td>
<td>67%</td>
<td>20%</td>
<td>14%</td>
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<tr>
<td>2004</td>
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<td>9.5</td>
<td>7.5</td>
<td>6</td>
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<td>22%</td>
<td>15%</td>
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<td>2005</td>
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<td>9.5</td>
<td>7.5</td>
<td>6</td>
<td>60%</td>
<td>23%</td>
<td>17%</td>
<td>0%</td>
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<tr>
<td>2006</td>
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<td>9.5</td>
<td>7.5</td>
<td>6</td>
<td>57%</td>
<td>25%</td>
<td>18%</td>
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<td>100%</td>
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<tr>
<td>2007</td>
<td>9.5</td>
<td>9.5</td>
<td>7.5</td>
<td>6</td>
<td>53%</td>
<td>27%</td>
<td>20%</td>
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<tr>
<td>2008</td>
<td>9.5</td>
<td>9.5</td>
<td>7.5</td>
<td>4.5</td>
<td>50%</td>
<td>28%</td>
<td>22%</td>
<td>0%</td>
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<tr>
<td>2009</td>
<td>9.5</td>
<td>9.5</td>
<td>7.5</td>
<td>4.5</td>
<td>47%</td>
<td>30%</td>
<td>23%</td>
<td>0%</td>
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<tr>
<td>2010</td>
<td>9.5</td>
<td>9.5</td>
<td>6.4</td>
<td>4.5</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>0%</td>
<td>100%</td>
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</tbody>
</table>

### Forecast of Passive Savings

#### Shower-heads

<table>
<thead>
<tr>
<th>Year</th>
<th>Toilets</th>
<th>Aerators</th>
<th>Washers</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>2020</td>
<td>-0.1</td>
<td>2.7</td>
<td>0.2</td>
<td>1.9</td>
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<tr>
<td>2030</td>
<td>0.8</td>
<td>4.9</td>
<td>0.4</td>
<td>4.4</td>
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<td>2040</td>
<td>1.4</td>
<td>6.8</td>
<td>0.6</td>
<td>5.8</td>
</tr>
<tr>
<td>2050</td>
<td>1.8</td>
<td>8.0</td>
<td>0.7</td>
<td>6.6</td>
</tr>
<tr>
<td>2060</td>
<td>2.0</td>
<td>8.8</td>
<td>0.7</td>
<td>7.2</td>
</tr>
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</table>

#### Clothes Washers

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
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<tbody>
<tr>
<td>2020</td>
<td>4.7</td>
</tr>
<tr>
<td>2030</td>
<td>10.5</td>
</tr>
<tr>
<td>2040</td>
<td>14.5</td>
</tr>
<tr>
<td>2050</td>
<td>17.2</td>
</tr>
<tr>
<td>2060</td>
<td>18.7</td>
</tr>
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</table>

#### Single Family

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>2.3</td>
</tr>
<tr>
<td>2030</td>
<td>5.2</td>
</tr>
<tr>
<td>2040</td>
<td>7.1</td>
</tr>
<tr>
<td>2050</td>
<td>8.0</td>
</tr>
<tr>
<td>2060</td>
<td>8.5</td>
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</table>

#### Multi-family

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>2020</td>
<td>1.7</td>
</tr>
<tr>
<td>2030</td>
<td>4.0</td>
</tr>
<tr>
<td>2040</td>
<td>5.8</td>
</tr>
<tr>
<td>2050</td>
<td>7.0</td>
</tr>
<tr>
<td>2060</td>
<td>7.8</td>
</tr>
</tbody>
</table>

#### Non-Residential

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>0.6</td>
</tr>
<tr>
<td>2030</td>
<td>1.2</td>
</tr>
<tr>
<td>2040</td>
<td>1.7</td>
</tr>
<tr>
<td>2050</td>
<td>2.1</td>
</tr>
<tr>
<td>2060</td>
<td>2.4</td>
</tr>
</tbody>
</table>
Conservation Overlap Function (Free Riders)

Price/Programmatic/Passive

✓ Assumed that half the price effect overlaps with passive and programmatic savings
✓ Overall effect – reduces total gross conservation savings by 14%

Impact of Conservation on Forecast of Seattle’s S.F. Residential Water Demand
Modeling Demand Uncertainty

- Estimate range of uncertainty around model inputs
- Assign probability distributions
- Run Monte Carlo simulations
  ✓ 10,000 iterations
Model Validation/Backcasting

![Graph showing data over time]

Research Needs & Questions

- Household Income and Water Use
- End Use Studies – especially MF and CII
- Separating sources of conservation and accounting for overlap
- Modeling passive savings
- Future shock – what new technologies and trends can we foresee now?
- Technology tipping points
One Last Question

- Rate Structures Revenue Stability
  - Unstable rate structures adopted to provide strong price signals.
  - Is it time for utilities to reevaluate?