The Unexpected Consequences of Water Conservation on Water Reuse Facilities

Linda Sawyer
Water Conservation and Water Reuse

- Decreased Flows and Flow Projections
- Treatment Process Loading Capacity
- Alkalinity Limitations
- Effluent Quality
- Recycled Water Flows
Decreased Flows and Flow Projections
Drought Led to Water Conservation

- Water conservation measures include
  - Drought tolerant landscaping
  - Outdoor water restrictions
  - Low-flow toilets
  - Low-flow shower heads
  - Faucet aerators
  - Water conserving appliances
  - Greywater recycling
  - Not flushing as often
  - Shorter showers

![Gallons per Toilet Flush](chart.png)
Water Conservation Results in Lower Wastewater Flows

Summer flow is July through September
Water Conservation Results in Lower Wastewater Flows

Monthly Average Summer Influent Flows, mgd

- Plant C Flow
- Plant D Flow

Year


Summer flow is July through September
Water Conservation Results in Lower Wastewater Flows

Mandatory water rationing

Summer is average of July through September
Water Conservation Results in Lower Wastewater Flows

Summer Influent Flow as Percent of Permitted Flow

- Plant A: >50 mgd
- Plant B: >50 mgd
- Plant C: 20 - 50 mgd
- Plant D: 20 - 50 mgd
- Plant E: 10 - 20 mgd
- Plant F: 10 - 20 mgd


Year

Summer is average of July through September

2007-2009 Drought

2012-2016 Drought

Mandatory water rationing
Water Conservation Results in Lower Wastewater Flows

Letters indicate different plants. Flow range is permitted flow. Ratios based on summer flow (average of July through September).
Water Conservation Results in Lower Wastewater Flows

Letters indicate different plants. Flow range is permitted flow. Ratios based on summer flow (average of July through September).
Flow Projections and Decreased Flows

- Often developed with collection system planning
- Biggest concern is conveying peak flows
Flow Projections Conservatively High

![Graph showing projected flow in mgd from 2000 to 2030. The graph includes lines for 90 gpcd, 75 gpcd, 65 gpcd, 18 mgd, 15 mgd, and 13 mgd.]
Treatment Process Loading Capacity
Loadings Have Increased at Some Plants
Loadings Have Increased at Some Plants

Based on summer flow or loading (average of July through September)

Flow
BOD
TSS

2015 / 2011

A
C
D
E
G
H
Influent Concentrations Have Increased

Based on summer (average of July through September)

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
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<tr>
<td>E</td>
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<tr>
<td>G</td>
<td></td>
<td></td>
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<tr>
<td>H</td>
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</tbody>
</table>
Average Flow is Typically Used to Rate Capacity

Diagram showing a water treatment process with steps such as primary clarifiers, activated sludge, secondary clarifiers, filtration, chlorine contact, discharge, advanced treatment, and reuse. The process also includes stages for dewatering, digestion, and thickening.
What Really Limits Plant Capacity?

Peak Flow
Organics Loading and Peak Flow

Organics Loading
## Example of Plant Capacity Change

<table>
<thead>
<tr>
<th>Plant designed in the 1970s:</th>
<th>12 mgd at \textit{120 gal/capita-day}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20,000 lb BOD/day at \textit{0.2 lb BOD/capita-day}</td>
</tr>
<tr>
<td>Population:</td>
<td>100,000</td>
</tr>
</tbody>
</table>
Per Capita Flows Have Decreased
Treating design flow in 2015:
12 mgd at 60 gal/capita-day
20,000–40,000 lb BOD/day at 0.2 lb BOD/capita-day
Population: 100,000–200,000

Loading Capacity Exceeded at Design Flow
Flow Capacity Reduced at Design Loading

Treating design loading and population in 2015:

- 12 mgd
- 6 mgd at 120 60 gal/capita-day

Diagram showing BOD concentration in mg/L versus flow in mgd.
Flow and Capacity

- Loading is key to capacity
- Equivalent flow capacity now is probably less than it used to be
- Less flow does NOT mean spare capacity
Alkalinity Limitations
Alkalinity is needed for nitrification

<table>
<thead>
<tr>
<th>Process</th>
<th>Alkalinity consumed (g Alkalinity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrification</td>
<td>7.2</td>
</tr>
<tr>
<td>Denitrification</td>
<td></td>
</tr>
</tbody>
</table>

- **Nitrification consumes alkalinity (7.2 g Alkalinity (as CaCO$_3$) destroyed/g N)**
- **Denitrification recovers some alkalinity**

**Diagram:***
- **Ammonia Oxidizers**
- **Nitrite Oxidizers**
- **O$_2$**
- **Alkalinity**
- **Carbon**
- **Nitrogen Gas (N$_2$)**

**Equations:**
- 1 g Ammonia-N (NH$_3$/NH$_4^+$) → 1 g Nitrite-N (NO$_2^-$) → 1 g Nitrate-N (NO$_3^-$)
Case Study – El Estero Plant in Santa Barbara

- Process includes primary clarifiers and activated sludge
- Flow decreased 12%
- Converting to nitrification

El Estero Influent Ammonia Increased 35%
Alkalinity Concentration Only Increased 6%
Changes in Potable Water Source May Exacerbate the Problem

![Graph showing changes in alkalinity concentration over time.](image-url)
Before drought, alkalinity was sufficient.

Based on 2014 data, alkalinity supplementation was needed.

Source water changes can exacerbate the problem.

Monitor alkalinity and add chemical if needed.

### Alkalinity Supplementation Needed

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2014</th>
<th>Projected with desalination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average alkalinity, mg CaCO₃/L</td>
<td>385</td>
<td>402</td>
<td>309</td>
</tr>
<tr>
<td>Average Ammonia, mg N/L</td>
<td>39</td>
<td>52</td>
<td>52</td>
</tr>
</tbody>
</table>
Effluent Quality
Plant C Effluent Nitrate has Increased

![Graph showing effluent nitrate levels from 2004 to 2016. The x-axis represents years from 2004 to 2016, and the y-axis represents effluent NO3-N in mg/L. The graph highlights a significant increase in nitrate levels starting around 2012, during a period labeled as "Drought." The graph includes a trend line showing the 12-month average.]
Plant C Effluent Phosphorus has Increased

![Graph showing effluent TP mg/L from 2004 to 2015 with a shaded area from 2012-2015 labeled Drought. The graph includes data points and a trend line indicating an increase in effluent phosphorus levels over time.]
Process Models Predict Nutrient Concentration Increases

Note: BioWin model results for an MLE configuration. Influent TKN loading is 33,300 lb/d for all conditions.

<table>
<thead>
<tr>
<th>Hour</th>
<th>Influent NH3-N, mg/L</th>
<th>Effluent TN, mg/L</th>
<th>Effluent TN, lb/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>46.0</td>
<td>12.3</td>
<td>5,700</td>
</tr>
<tr>
<td>6</td>
<td>33.8</td>
<td>10.6</td>
<td>6,900</td>
</tr>
<tr>
<td>12</td>
<td>25.3</td>
<td>9.7</td>
<td>8,500</td>
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Planning for Effluent Concentration Increases

• Additional chemicals or improved processes may be needed

• Consider loading-based limits instead of concentration-based limits in permit negotiation
  • Attractive if strict discharge limit, but expect reduced discharge flow due to recycling.
Recycled Water
Less Water Available Due to Conservation

- Excess capacity (stranded assets)
- Insufficient water to meet demands
- Revenue impacts
Planning Conservatism

Highest flow is conservative

Lowest average flow may be conservative
Complete Reuse is Challenging

Seasonal water storage volume: 1,650 million gallons

- **Flow from Plant**
- **Industrial**
- **Discharge**
- **Total Recycled (Industrial + Irrigation)**
- **Irrigation**

Brown and Caldwell
Recycled Water – Challenges

- Less water available for recycling
- Peak reuse demand is often in a different season and year than peak influent flow
- IPR and DPR demands are year-round, but brine disposal is required
Planning for Water Conservation
Planning for Future Water Conservation

- Expect less flow that is more concentrated
- Understand the conservatism of flow projections
- Less flow may not mean spare treatment capacity
- Anticipate possible alkalinity limitations
- Expect increased effluent concentrations
- Plan for variations in recycled water supply and demand
Thank You