Demonstration-Scale Evaluation of Blending Desalinated Seawater into Long Beach’s Drinking Water Distribution System

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LBWD’s Resource Mix

2010

- Groundwater: 44%
- Imports: 32%
- Reclaimed: 9%
- Conservation: 15%

2015

- Groundwater: 33%
- Imports: 30%
- Reclaimed: 12%
- Conservation: 15%
- Desal: 10%
LBWD’s Desalination Program

- A $20 M, 10-year investment
- Leverage various partnerships for technical input and other support
- Federal / State / Local Funding

**Pretreatment**
- Under Ocean Floor Intake and Discharge

**NF² or RO**
- Membrane Configuration
- Different fouling control strategies

**Post treatment**
Possible Effects of Desalinated Water on Distribution System Corrosion and WQ

Desalinated Water

Low alkalinity and calcium levels → Increase corrosion and metal release

High chloride/sulfate ratio

High bromide levels

Decrease disinfectant stability
Existing Post Treatment Strategies

• Conditioning with chemicals-lime (Ca(OH)$_2$), calcite (CaCO$_3$), sodium bicarbonate (NaHCO$_3$), etc
• Blending with existing water sources

LBWD will use both approaches.
Does desalinated water still impact corrosion and disinfectant stability after chemical conditioning and blending?
Testing Approach

• **Three waters**
  – Distribution System Water (DSW)-control
  – Train 1-NF²: DSW blending water
  – Train 2-NF²: DSW blending water

• **Five pipe materials**
  – Excavated unlined cast iron (UCI)
  – New cement mortar-lined ductile iron (CML-DI)
  – New cement mortar-lined steel to simulate asbestos cement pipe (CML-AC)
  – New type L copper pipe
  – New copper pipe with leaded solder (50:50 lead: tin) melted inside (Copper-Solder)
Pipe Loop Setup

• Each material has three parallel loops
• 16 hour flow + 8 hour stagnation
• All pipes are enclosed with temperature control except for Copper-Solder pipes
## Testing Schedule and Post treatment Methods

<table>
<thead>
<tr>
<th>Phase</th>
<th>Blend ratio</th>
<th>Chemical Adjustment</th>
<th>LSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I (3 months)</td>
<td>DSW</td>
<td>DSW</td>
<td></td>
</tr>
<tr>
<td>Phase II (5 months)</td>
<td>NF2: DSW 50:50</td>
<td>add 40 mg/L alkalinity, adjust pH to 8</td>
<td>-0.42</td>
</tr>
<tr>
<td>Phase III (3 months)</td>
<td>NF2: DSW 50:50</td>
<td>add 120 mg/L alkalinity, adjust pH to 8, add phosphate to Train 2</td>
<td>-0.15</td>
</tr>
</tbody>
</table>
## Influent WQ

<table>
<thead>
<tr>
<th></th>
<th>WQ goal</th>
<th>DSW</th>
<th>Train 1</th>
<th>Train 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pH</strong></td>
<td>7-8.5</td>
<td>8-8.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total chlorine</strong></td>
<td>mg/L</td>
<td>1-4</td>
<td>2-2.5</td>
<td></td>
</tr>
<tr>
<td><strong>Total ammonia</strong></td>
<td>mg/L</td>
<td></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td><strong>TDS</strong></td>
<td>mg/L</td>
<td>&lt; 500</td>
<td>340</td>
<td>270</td>
</tr>
<tr>
<td><strong>Alkalinity, Phase II</strong></td>
<td>mg/L</td>
<td></td>
<td>123</td>
<td>80</td>
</tr>
<tr>
<td><strong>Alkalinity, Phase III</strong></td>
<td>mg/L</td>
<td>non-corrosive</td>
<td>123</td>
<td></td>
</tr>
<tr>
<td><strong>Calcium</strong></td>
<td>mg/L</td>
<td></td>
<td>34</td>
<td>17</td>
</tr>
<tr>
<td><strong>Sulfate</strong></td>
<td>mg/L</td>
<td></td>
<td>81</td>
<td>43</td>
</tr>
<tr>
<td><strong>Bromide</strong></td>
<td>ug/L</td>
<td></td>
<td>47</td>
<td>116</td>
</tr>
</tbody>
</table>
Corrosion Impacts
Unlined Cast Iron (UCI)

Figure: Iron release in UCI after 7 hour stagnation.
CML-DI and CML-AC

• Cement lining, corrosion can be evaluated by
  – pH
  – Alkalinity
  – Calcium
  – Aluminum

• CML-DI has a seal coating
Figure: pH change in CML-DI after 7 hour stagnation.
Blending water affects the following?

<table>
<thead>
<tr>
<th></th>
<th>CML-DI</th>
<th>CML-AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Calcium</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Aluminum</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Aluminum Change in CML-AC

![Graph showing aluminum change over time in CML-AC conditioning, 50:50 blending, and leaching phases.](image)

- **Conditioning**
- **50:50 blending**
- **50:50 blending**

**Change of Aluminum, ug/L**

- DSW
- Train 1
- Train 2

**Dates:**
- 2/6/09
- 3/28/09
- 5/17/09
- 7/6/09
- 8/25/09
- 10/14/09
- 12/3/09
- 1/22/10
- 3/13/10

**Legend:**
- **Leaching**
- **Absorbing**
• Blending water did not impact corrosion of CML-DI
• Blending water slightly increase aluminum leaching in CML-AC, but this increase is not significant
Figure: Copper release in copper pipe after 7 hour stagnation.
Figure: Total lead release after 20 hour (Phase I and II) and 7 hour (Phase III) stagnation in Copper-Solder.
Lead contamination can be a concern under extreme situation.
Conclusion-Corrosion

• After blending and chemical adjustment, NF² desalinated water
  – did not significantly increase corrosion of UCI, CML-DI, CML-AC and Copper
  – can increase lead release in the presence of extremely high level of leaded-solder and long stagnation time, further study under more realistic condition is needed
Conclusion-Corrosion

- With 50:50 blending, adding 40 mg/L alkalinity and adjusting pH is sufficient for corrosion control of most pipe materials, higher alkalinity did not bring additional protection.
Chloramine Stability
Figure: Total chlorine residual after 7 hour stagnation in UCI pipe.
Total Chlorine Residual in CML-DI

Figure: Total chlorine residual after 7 hour stagnation in CML-DI pipe.
Conclusion-Residual Stability

- After blending and chemical adjustment, NF\textsuperscript{2} desalinated water
  - did not reduce chloramine stability in UCI, copper and Copper-Solder pipe even with up to 1 mg/L bromide levels
  - can reduce chloramine stability in CML-DI and CML-AC pipes only when desalinated permeate WQ is severely degraded
Other WQ Issues

• compared to DSW, NF² blending water
  – did not increase bulk and biofilm HPC level
  – had similar or even less THM and HAA
Conclusion

Under normal operation, after blending and chemical adjustment, NF² desalinated water

– did not significantly increase corrosion of UCI, CML-DI, CML-AC and Copper
– may cause concern over lead contamination under extreme condition
– did not impact chloramine stability, HPC and DBPs levels
Acknowledgement

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✦ LBWD WQ Lab and treatment plant staff