Boiler Feed Recycled Water Conversion Project

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• Sustainability and Recycled Water at SJSU
• Boiler Pretreatment Process and Water Quality
• Estimated Phase 1 Savings
• Planned Phase 2

Agenda
Sustainability and Recycled Water at SJSU
Since 1998, SJSU has converted most non-potable uses to recycled water on the 134 acre main campus.
Phase 1 RW Conversion
The boiler feed was the largest remaining recycled water conversion opportunity

Conversion approach included:

- Maximize use of existing pretreatment equipment
  - Granular Activated Carbon (GAC)
  - Ion Exchange (IX)
  - Reverse Osmosis (RO)
- Collect treatment information to optimize replacement equipment selection for energy and other savings
Boiler Pretreatment Process and Water Quality
Existing Pretreatment System

GAC → IX → RO System → Boiler Make-Up Water Tank → Transfer Pump → Boiler System

25% Concentrate to Disposal
## Source Water Quality Differences

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Groundwater</th>
<th>Recycled Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>0.27 NTU</td>
<td>0.56-1.3 NTU</td>
</tr>
<tr>
<td>Total Organic Carbon</td>
<td>--</td>
<td>10 mg/L</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>537 mg/L</td>
<td>764-850 mg/L</td>
</tr>
<tr>
<td>Total Hardness (as CaCO3)</td>
<td>400 mg/L</td>
<td>270 mg/L</td>
</tr>
<tr>
<td>Ammonia (NH3)</td>
<td>0.04 mg/L</td>
<td>1.2 – 1.8 mg/L</td>
</tr>
<tr>
<td>Temperature</td>
<td>15 C</td>
<td>20- 28 C</td>
</tr>
</tbody>
</table>
System Performance After Conversion

GAC and Ion Exchange

Organic Carbon

Ion Exchange – 99% of calcium and Magnesium ions removed

Post GAC Non-Purgeable Organic Carbon

Graph showing the change in Non-Purgeable Organic Carbon mg/L from November 2016 to May 2017.
System Performance After Conversion

Reverse Osmosis

Lessons Learned
- Flush new recycled water pipeline well to avoid particulates and other contaminants from fouling membranes
Estimated Phase 1 Savings
Potable Water Savings

Year 2013-2017 Water Usage and Sewer Discharge

*FY16-17 potable water usage is 0.02 MG
<table>
<thead>
<tr>
<th>Est Annual Operating Costs</th>
<th>Existing RO System Before RW Conversion</th>
<th>Existing RO System After RW Conversion (incl membrane/GAC replacement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Water</td>
<td>$380,000</td>
<td>$190,000</td>
</tr>
<tr>
<td>Sewer Disposal</td>
<td>$60,000</td>
<td>$52,000</td>
</tr>
<tr>
<td>Salt Regeneration</td>
<td>$50,200</td>
<td>$28,000</td>
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<tr>
<td>Membrane Cleaning</td>
<td>$16,000</td>
<td>$8,000</td>
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<tr>
<td>Total Estimated Annual Cost</td>
<td>$506,200</td>
<td>$278,000</td>
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<tr>
<td>Estimated Annual Cost Savings</td>
<td></td>
<td>$228,20</td>
</tr>
</tbody>
</table>

* Other costs – 4 membranes plus spacers: $2,000 plus 12 spare membranes to use during cleaning $6,000 and $6,600 for replacement carbon in 2 vessels

**Note: no plant downtime during Phase 1 implementation, therefore no expensive power purchase required
Planned Phase 2
Design and Construction of More Efficient Treatment for Boiler Make-up Treatment
Closed Circuit Desalination vs Multi-stage RO

Closed Circuit Desalination
- up to 96% recovery
- tighter RO membrane
- batch mode that recycles concentrate to better use all RO elements in the system
- relative waste stream for 75 gpm permeate is 3-8 gpm
- requires less space

Multi-stage RO
- 90% Recovery
- Relative waste stream for 70 gpm permeate is 8.2 gpm

This recirculation loop and “batch” operation is a radical departure from typical continuous RO operation.
Other Estimated Savings from Phase 2

- 35% less energy than multi-stage RO
- Less concentrate for sanitary sewer discharge
- In-place membrane cleaning
- Also will reduce treatment influent from 75 gpm to 50 gpm to meet current boiler needs

<table>
<thead>
<tr>
<th>Est Annual Operating Costs</th>
<th>Existing RO System</th>
<th>CCD RO</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Recovery</td>
<td>75%</td>
<td>93%</td>
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<tr>
<td>Cost of Water</td>
<td>RW:$46,100</td>
<td>RW:$37,200</td>
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<tr>
<td>Sewer Disposal</td>
<td>$52,800</td>
<td>$11,900</td>
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<tr>
<td>Energy Usage ($0.16/kWh)</td>
<td>$3,700</td>
<td>$7,600</td>
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<tr>
<td>Total Annual Cost</td>
<td>$102,600</td>
<td>$56,700</td>
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<tr>
<td>Estimated Annual Cost Savings After Phase 2</td>
<td>$45,900</td>
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