Ironman Challenge –
Challenging Conventional Wisdom in Iron Removal

American Water Works Association Pennsylvania Section
Annual Conference 2016

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American Water
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Agenda

- Review of iron chemistry
- Standard practices for iron removal
- Pre-treatment with flocculation and sedimentation
- Sunset Road WTP Expansion project overview
- Verification of process design
  - Jar testing
  - Pilot testing
- Treatment and status of project
Review of Iron Chemistry
Iron Chemistry

\[
\begin{align*}
\text{Fe}^{2+} + \text{O}_2(g) & \iff \text{Fe}^{3+} + \text{HO}_2^* \\
\text{Fe}^{2+} + \text{HO}_2^* & \iff \text{Fe}^{3+} + \text{H}_2\text{O}_2 \\
\text{Fe}^{2+} + \text{H}_2\text{O}_2 & \iff \text{Fe}^{3+} + \text{HO}^* + \text{H}_2\text{O} \\
\text{Fe}^+ + \text{HO}^* & \iff \text{Fe}^{3+} + \text{H}_2\text{O}
\end{align*}
\]
Iron Chemistry

- Why remove?
- Removal principles
  - Increase in oxidation potential of water
  - Increase in pH of water
Standard Practices for Iron Treatment
Iron Removal Practices

Sequestration

0.3 mg/L < Fe < 0.6 mg/L
Iron Removal Practices

- Oxidation
  - Air
  - Chlorine
  - Permanganate
  - Chlorine Dioxide
  - Ozone

- Filtration
  - Sand/Anthracite
  - Manganese Dioxide Coated Sand
  - Manganese Dioxide Ore
  - Biofiltration
  - Ion Exchange

\[ 0.6 \text{ mg/L} < \text{Fe} < 5 \text{ mg/L} \]
Iron Removal Practices
Iron Removal Practices
Iron Removal Practices
Pre-Treatment with Flocculation and Sedimentation
Flocculation and Sedimentation

Loading Rate = 0.4 gpm/sf

Solids Contact Clarifier

Conventional Sedimentation

Plates or Tubes

Source: www.westechinc.com

Source: www.open.edu

Source: www.meurresearch.com
Sunset Road WTP Expansion Project Overview
Existing Sunset Road WTP

- Chemical Injection
- Clarifier
- Low Lift Pumps
- Clearwell
- Well 10
- BWHT
- Filters
- HS Pumps
- Clearwell
- Low Lift Pumps
- Chemical Injection
- Clarifier
- Clearwell
- BWHT
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- Chemical Injection
- Clarifier
- Clearwell
- BWHT
- Filters
- HS Pumps
Sunset Road WTP Expansion

Well 10 – 2.2 mgd

Well 17 – 1.7 mgd

Allocation
Monthly = 98.2 MG/month  Yearly = 280 MG/year
### Sunset Road WTP Water Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Well No. 10</th>
<th>Well No. 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalinity (mg/L)</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Hardness (mg/L as CaCO₃)</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Iron (mg/L)</td>
<td>8.5</td>
<td>9.0</td>
</tr>
<tr>
<td>Manganese (mg/L)</td>
<td>0.17</td>
<td>0.15</td>
</tr>
<tr>
<td>pH</td>
<td>6.5</td>
<td>6.7</td>
</tr>
</tbody>
</table>
Sunset Road WTP Expansion

- Reduce Iron Concentration on Filters
- Reduce Chemical Addition
- Minimize Capital Costs
- Recycle Backwash Waste
- SAFETY
Sunset Road WTP Design Concept

- Roof Modifications
- SCADA
- HVAC
- Chemical Storage
Verification of Process Design – Jar Testing
Process Design Verification

- Settling Time
- Coagulant
- Polymer
Jar Test 1 – American Water

Rapid Mix
15 or 30 sec

Flocculation Time
3, 5, or 8 min

Settling Time
6, 8 or 12 min

Chemicals
Caustic, Hypo and FeCl₃
Jar Test 2 – Nalco

Chemicals
Coagulant and Polymer

Operational Complexity

Building Addition

OPEX - Chemicals

OPEX - Maintenance

Seasonal Facility

ALL FeCl₃ Runs < 3 mg/L

7768 & FeCl₃ Run ~ 1 mg/L

7768 & 8158 Run < 1 mg/L

Is it worth it?
Verification of Process Design – Pilot Testing
Pilot Study – Clarifier

Well No. 10

Caustic, Hypo

Ferric, Polymer

Clarifier

Frac Tank
Pilot Study – Clarifier

Flocculation

Sedimentation
# Pilot Study – Clarifier Runs

<table>
<thead>
<tr>
<th>Run</th>
<th>FeCl₃</th>
<th>Polymer</th>
<th>Mixing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>-</td>
<td>-</td>
<td>1 stage</td>
</tr>
<tr>
<td>No. 2</td>
<td>8 mg/L</td>
<td>-</td>
<td>1 stage</td>
</tr>
<tr>
<td>No. 3</td>
<td>20 mg/L</td>
<td>-</td>
<td>1 stage</td>
</tr>
<tr>
<td>No. 4</td>
<td>-</td>
<td>-</td>
<td>1 stage</td>
</tr>
<tr>
<td>No. 5</td>
<td>-</td>
<td>Nalco 7768</td>
<td>1 stage</td>
</tr>
<tr>
<td>No. 6</td>
<td>20 mg/L</td>
<td>-</td>
<td>1 stage</td>
</tr>
<tr>
<td>No. 7</td>
<td>-</td>
<td>-</td>
<td>1 stage</td>
</tr>
<tr>
<td>No. 8</td>
<td>-</td>
<td>-</td>
<td>2 stage</td>
</tr>
</tbody>
</table>
Pilot Study – Clarifier Results

Run No. 1 — Run No. 2 — Run No. 3 — Run No. 4 — Run No. 5 — Run No. 6 — Run No. 7 — Run No. 8

Influent Iron 7.2 - 8.4 mg/L
Pilot Study – Clarifier Results

Run No. 1 — Run No. 2 — Run No. 3 — Run No. 4 — Run No. 5 — Run No. 6 — Run No. 7 — Run No. 8

Influent pH
Iron (mg/L)

Influent Iron 7.2 - 8.4 mg/L

No coagulant, no polymer
8 mg/L FeCl₃
20 mg/L FeCl₃
No coagulant, no polymer
Polymer, no coagulant
20 mg/L FeCl₃
No coagulant, no polymer
No coagulant, no polymer, 2 stage mixing

Influent pH

Run No.
1
2
3
4
5
6
7
8

Iron (mg/L)

0
1
2
3
4
5
6
7
8

Influent pH
Pilot Study – Clarifier Results

Run No. 1 — Run No. 2 — Run No. 3 — Run No. 4 — Run No. 5 — Run No. 6 — Run No. 7 — Run No. 8

<table>
<thead>
<tr>
<th>Run No.</th>
<th>Influent pH</th>
<th>Iron - Clarifier Effluent (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run No. 1</td>
<td>8.9</td>
<td>20 mg/L FeCl₃</td>
</tr>
<tr>
<td>Run No. 2</td>
<td>8.7</td>
<td>No coagulant, no polymer</td>
</tr>
<tr>
<td>Run No. 3</td>
<td>8.5</td>
<td>20 mg/L FeCl₃</td>
</tr>
<tr>
<td>Run No. 4</td>
<td>8.3</td>
<td>No coagulant, no polymer</td>
</tr>
<tr>
<td>Run No. 5</td>
<td>8.1</td>
<td>20 mg/L FeCl₃</td>
</tr>
<tr>
<td>Run No. 6</td>
<td>8.0</td>
<td>No coagulant, no polymer</td>
</tr>
<tr>
<td>Run No. 7</td>
<td>7.9</td>
<td>No coagulant, no polymer</td>
</tr>
<tr>
<td>Run No. 8</td>
<td>7.7</td>
<td>No coagulant, no polymer, 2 stage mixing</td>
</tr>
</tbody>
</table>

Influent Iron 7.2 - 8.4 mg/L
Pilot Study – Filters

Inches

<table>
<thead>
<tr>
<th>No. 1</th>
<th>No. 2</th>
<th>No. 3</th>
<th>No. 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>Anthracite</td>
<td>GreensandPlus</td>
<td></td>
</tr>
</tbody>
</table>
Pilot Study – Filters

Frac Tank -> Filter Columns -> Low Lift Pump Station
Pilot Study – Filter Results

![Graph showing filter results]

- **Run Time to Breakthrough (hours)** vs. **Filter Loading Rate (gpm/sf)**
- **Greensand Plus & Anthracite**
- **Inert Media (Sand or Sand & Anthracite)**

Goal (24 hours)
Filter No. 4 (Run No. 2 – 8 mg/L FeCl₃)

- Filter Headloss (PSI)
- Total Fe (mg/L)
- Turbidity (NTU)
- Headloss (PSI)

Graph showing:
- Filter Effluent Turbidity (NTU), Iron (mg/L)
- Filter Run Time (hours)
- Headloss (PSI)
- Total Fe (mg/L)
- Turbidity (NTU)

Key Points:
- 8 psi
- 0.3 mg/L

Graph data includes:
- Filter No. 4 (Run No. 2 – 8 mg/L FeCl₃)
- Filter Headloss (PSI)
- Total Fe (mg/L)
- Turbidity (NTU)
- Headloss (PSI)

Graph shows the relationship between filter run time and iron concentration, turbidity, and headloss over time.
### Filter No. 4 (Run No. 8 – No FeCl₃, 2 Stage Mixing)

<table>
<thead>
<tr>
<th>Filter Run Time (hours)</th>
<th>Filter Headloss (PSI)</th>
<th>Turbidity (NTU)</th>
<th>Total Fe (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.3 mg/L</td>
</tr>
<tr>
<td></td>
<td>8 psi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Filter Headloss (PSI)**
- **Turbidity (NTU)**
- **Total Fe (mg/L)**

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*Note: The graph shows the trend of headloss and turbidity over time for Filter No. 4 during Run No. 8 with no FeCl₃ additive and 2 stage mixing.*
Treatment and Project Status
Treatment and Project Status

- Increased hydraulic retention time
  - Two stage flocculation – 14 minutes/stage at peak flow
  - Inclined plate clarifiers – 96 minutes at peak flow
- Lowered loading rate
  - 0.4 gpm/sf (pilot test) at peak flow
  - <0.3 gpm/sf at average flow
- No coagulant, no polymer
  - Include provisions to recycle iron sludge in the future
Sunset Road WTP
TO BE CONTINUED...
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QUESTIONS?

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