Disinfection of Combined Sewer Overflows with Sodium Hypochlorite and Peracetic Acid

Jay Brady, P.E.
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Project Overview

• Fort Madison’s old east end is served by combined sewers
• 2006 Long Term Control Plan
• US EPA Consent Order
• 2009 CSO Disinfection Study
• 2010 Full Scale CSO Pilot Disinfection System Design and Construction
• 2011-2012 CSO Disinfection Pilot
CSO Disinfection Study

• CSO and Stormwater Disinfection Challenges
  – Highly variable flows – contact time, process control
  – High and variable TSS concentrations – barrier between disinfection agents and the bacteria
  – Debris
  – Physical constraints – space, hydraulic head
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• Three Alternatives Evaluated
  – UV Disinfection
  – Ozone
  – Chemical – Sodium Hypochlorite and Peracetic Acid

• Chemical Disinfection selected based on cost and best chance at success
CSO Disinfection Study

• Peracetic Acid
  – Equilibrium solution of acetic acid and hydrogen peroxide
  – Biocide
  – Fast acting
  – Good shelf life (6 mo)
  – Limited commercial availability; expensive
## Maximum Flow Rates (CFS)

<table>
<thead>
<tr>
<th>Year</th>
<th>4th St</th>
<th>5th St</th>
<th>6th St</th>
<th>7th St</th>
<th>8th St</th>
<th>9th St</th>
<th>10th St</th>
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<td>Avg</td>
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<td>10.5</td>
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<td>3.3</td>
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## Modeled Storm Events/Overflows

<table>
<thead>
<tr>
<th>Storm</th>
<th>Rain (in)</th>
<th>4&lt;sup&gt;th&lt;/sup&gt;</th>
<th>5&lt;sup&gt;th&lt;/sup&gt;</th>
<th>6&lt;sup&gt;th&lt;/sup&gt;</th>
<th>7&lt;sup&gt;th&lt;/sup&gt;</th>
<th>8&lt;sup&gt;th&lt;/sup&gt;</th>
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## Total Suspended Solids (mg/l)

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<tr>
<th>Location</th>
<th>Min</th>
<th>Avg</th>
<th>Max</th>
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<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; St</td>
<td>45</td>
<td>150</td>
<td>272</td>
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<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; St</td>
<td>75</td>
<td>335</td>
<td>823</td>
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<tr>
<td>7&lt;sup&gt;th&lt;/sup&gt; St</td>
<td>70</td>
<td>163</td>
<td>473</td>
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<tr>
<td>8&lt;sup&gt;th&lt;/sup&gt; St</td>
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<td>125</td>
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<tr>
<td>11&lt;sup&gt;th&lt;/sup&gt; St</td>
<td>264</td>
<td>619</td>
<td>1480</td>
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</table>
Total Suspended Solids (mg/l)

Correlation of Suspended Solids to Flow Rate

All CSO's

Stanley Consultants

WATERCON 2012
A Joint Conference and Expo
Bench Study

University of Iowa Civil and Environmental Engineering

- Dr. Gene Parkin, Jessica Beswick, and Matt Reusswig

- Examine NaOCl, PAA under different doses, contact times, and TSS concentrations - 50, 125, and 200 mg/l

- Synthetic CSO water – primary effluent dosed with solids to get desired TSS concentrations
Effect of Cl₂ dose (20, 30, 40 mg/L) at high TSS (TSS = 222 mg/L)

Courtesy: University of Iowa
Effect of TSS concentration (79, 139, 229 mg/L) at a Cl$_2$ dose of 20 mg/L

Courtesy: University of Iowa
Results for a Cl₂ dose (20 mg/L) at mid TSS concentration (153 mg/L)
Effect of PAA dose (10, 15, 20 mg/L) at high TSS (224 mg/L)
Bench Study Conclusions

- Both NaOCl and PAA can achieve target E. Coli within 5 minutes
- 10-20 mg/l PAA dose
- 20-30 mg/l Sodium Hypochlorite dose
- Dechlorination/Quenching Likely
- Longer contact time of 10 to 15 minutes may reduce dose
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Most Feasible Disinfection Technology

Chemical – Hypochlorite and Peracetic Acid

- Less affected by TSS and debris
- Cost effective
- Best potential for process control
CSO Disinfection Pilot

From Bench to Full Scale Pilot

- 15 minute contact time at maximum anticipated flow
- Broad chemical dose feed range
- Intermediate sampling locations
- Pilot both chemicals – dual chemical feed systems
Riverfront Park
Chemical Feed System Diagram

- Equipment Storage Shed Note 1
- Sodium Hypochlorite Feed
- Sodium Bisulfite Feed
- Dosing Manhole
- De-Chlorination Manhole
- Sampling Manhole
- River

Control Signal from Level Switch to Activate Dosing
- CSO Structure
- Floatable Removal Structure
- Baffles for Increased Solids Capture
- Retrofitted Screen
Site Plan
Chemical Building Layout
Sodium Hypochlorite System
PAA System
Construction Challenges

• Make work low bid
• Self performed underground work beyond their normal scope
• Wrap up/commissioning
• Underground chemical piping issues
• Early July 2010 completion deadline
• Finally, in April 2011, a functioning system
Pilot Results

- Very limited data from Fall 2010 indicates that Sodium Hypochlorite should be feasible
- Chemical Leaks Fall 2010 – Spring 2011
- Low Rain, Few CSOs July – December 2011
- Dearth of PAA data, Inadequate data to analyze/optimize
## CSO Water Quality

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>BOD mg/L</th>
<th>TSS mg/L</th>
<th>NH3N mg/L</th>
<th>Flow Volume, gal</th>
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<tbody>
<tr>
<td>Min</td>
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<td>3</td>
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<td>Median</td>
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<td>64</td>
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<td>36</td>
<td>529</td>
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<tr>
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<td>&lt;200</td>
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N = 31
CSO Water Quality

E-COLI

MPN/100 mL

0 5 10 15 20 25 30 35 40

0 500 1000 1500 2000 2500 3000 3500
Preliminary Conclusions

• Very Challenging Due to Variability
• Sodium Hypochlorite Results show promise
• Very Limited PAA Results are inconclusive
• Several Pilot System Challenges
  – Overall Control and Feedback
  – Chemical Feed Rates and Adequate Dispersion
  – Contact Pipe Sedimentation and Benthic Demand
    (Anaerobic Conditions during long periods between overflows)
Questions/Discussion