Plant Water Reduction
Phase One
Six Sigma Project

Project Champion: Dave Brown
Project Leader: Tom Moshage
Project Team: Ralph Moshage, Gary Moats
Key Contact: Elizabeth Luber ITSC
October 2015
Agenda

- Background
  - ISTC
  - Sipoc
- Process Flow Diagram
  - Data collection
  - Sustainability
- Annual Savings
ISTC

Illinois Sustainable Technology Center

- ISTC’s goal is to conserve 1 billion gallons of water in the state of Illinois

- Expected funding for 3 – 6 projects

- We requested half of the overall project cost

- Notification of funding June 2014

- Total funding equals $63,446
Project Charter: Plant Water Reduction

**Business Case:**
As of December 2014, our site was using approximately 1,360 gallons of water per minute daily which is equivalent to 1,958,400 gallons a day or 675 million gallons a year based on 345 days of running. We were being charged a rate of $0.798 per 100 cubic feet of water used that’s including the city’s 5% utility tax. 2014’s estimated water cost will be $720,763. We were tasked with developing a water reduction plan to reduce our water usage.
Project Charter: 
Plant Water Reduction

**Problem Statement:**
This year we began a new water contract with the city that increased our water usage rate to $1.145 per 100 cubic feet. If we continue to use water at our current rate, 2015's total water cost will be equivalent to $1,033,725. This is an increase of $312,962 at our current water usage.

**Goal/ Objective Statement:**
Our goal was to come up with a plan to reduce our current water usage. This project is phase one of the overall plan to accomplish this. Phase one consists of using spent non-contact cooling water from the Cairox® crystallizer hotwell to feed our water softeners in the boiler house instead of raw city water. The water softeners currently use on average 100 gallons of water per minute.
### Project Charter: Plant Water Reduction

**Cost of Poor Quality:**
The increased water costs equal $312,962. With this project's completion, we will save roughly 50 million gallons of water per year or approximately $76,000 per year.

<table>
<thead>
<tr>
<th><strong>Project Scope:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IN:</strong> Water system source quality and crystallizer integrity at hot well to water softeners that supply the RO System which in turn feeds the boiler and Cairox® seal water system</td>
</tr>
<tr>
<td><strong>OUT:</strong> Other water usage points throughout the site</td>
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</table>
## Project Charter: Plant Water Reduction

<table>
<thead>
<tr>
<th>Phase</th>
<th>Start Date</th>
<th>End Date</th>
<th>% Complete</th>
<th>Health</th>
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<tr>
<td>Define</td>
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<td></td>
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</tr>
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<td>Measure</td>
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<tr>
<td>Analyze</td>
<td></td>
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<td></td>
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<tr>
<td>Improve</td>
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<td></td>
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<tr>
<td>Control</td>
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<tr>
<td>Completion Date</td>
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### Project Status

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<th>Phase</th>
<th>On Track</th>
<th>Delayed</th>
<th>Stopped</th>
<th>Health</th>
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<tr>
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</tr>
<tr>
<td>Define</td>
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<tr>
<td>Measure</td>
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<tr>
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<tr>
<td>Completion Date</td>
<td>Green</td>
<td></td>
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<td>Green</td>
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</table>
# SIPOC

**Process/Project Name:** Plant Water Reductio
**Date:** 11/19/2014
**Prepared By:** Tom Moshage

## Suppliers

<table>
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<tr>
<th>Provider</th>
<th>Input Description</th>
<th>Input Requirements (optional)</th>
<th>Output Description</th>
<th>Output Requirements (optional)</th>
<th>Recipient of Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>City water storage tank</td>
<td>Raw city water</td>
<td>GPM</td>
<td>Raw city water</td>
<td>GPM</td>
<td>Water Softeners</td>
</tr>
<tr>
<td>City water storage tank</td>
<td>Raw city water</td>
<td>GPM</td>
<td>Recycled CW</td>
<td>GPM</td>
<td>Water Softeners</td>
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</table>

## Inputs

<table>
<thead>
<tr>
<th>Input Requirements (optional)</th>
<th>Input Requirements (optional)</th>
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<tbody>
<tr>
<td>GPM</td>
<td>GPM</td>
</tr>
</tbody>
</table>

## Process

See High Level Process Steps Next Slide

## Outputs

<table>
<thead>
<tr>
<th>Output Requirements (optional)</th>
<th>Output Requirements (optional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPM</td>
<td>GPM</td>
</tr>
</tbody>
</table>

## Customers

- Water Softeners
High Level Process Steps
Flow Chart

City Water Process Flow

1. Incoming raw city water to our water storage tank
2. Water is pumped to the site through process water pumps in the pump house
3. #1 Old Crystallizer Hotwell to feed #2 Crystallizer barometric feed pump
4. #2 Crystallizer Barometric Condenser to help produce the vacuum needed their

- Steam and inner condenser water from the Crystallizer Jets
- Pilot Plant Processes and Cairox processes
- The used non-contact cooling water enters the #2 Crystallizer Hotwell. Approx flow 650 GPM
- Water conductivity is checked and Hotwell level is good Yes or No
- Water is pumped from Hotwell to the Water Softeners through new

- Yes
  - Water Softeners
- No
  - Pump is shut down and valves switch to feed the softeners raw city water
  - Water is pumped from Hotwell to the Water Softeners through new

- South Lagoon
- End of process
Process Flow Diagram From RSView

2:41:53 PM OLD EVAP 1ST EFFECT BODY ALARMS NOT ENABLED 6HRS AFTER BOIL OUT

Aim: 1, Sup: 0
Process Flow Diagram From RSView Cont.
PI Tracking Trend Screen
Water Softener Usage
Two Sample T for Current and Future Water Costs

Two-sample T for 2014 cost vs 2015 cost. Cost is dollars /day

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014 cost</td>
<td>208</td>
<td>160.3</td>
<td>16.8</td>
<td>1.2</td>
</tr>
<tr>
<td>2015 cost</td>
<td>208</td>
<td>230.1</td>
<td>24.1</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Difference = μ(2014 cost) - μ(2015 cost)

Estimate for difference: -69.73 (per day)

95% CI for difference: (-73.73, -65.73)

T-Test of difference = 0 (vs not =):
T-Value = -34.28
P-Value = 0.000  DF = 369

43.5% increase in costs
Water Project Concerns

- Water contamination from the crystallizer de-mister
- Hotwell water level loss leading to vacuum loss in the crystallizer vaporizer
- Pump failure
- Initial and subsequent system start up contamination concerns
- Water quality, raw versus recycled
## Water Quality Raw Versus Recycled

<table>
<thead>
<tr>
<th>Test</th>
<th>Used Sample 1</th>
<th>Used Sample 2</th>
<th>Used Sample 3</th>
<th>New Sample 1</th>
<th>New Sample 2</th>
<th>New Sample 3</th>
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</thead>
<tbody>
<tr>
<td>Mn (ppm)</td>
<td>0.1967</td>
<td>nd</td>
<td>nd</td>
<td>0.2097</td>
<td>nd</td>
<td>nd</td>
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<tr>
<td>K (ppm)</td>
<td>4.691</td>
<td>5.646</td>
<td>5.339</td>
<td>4.951</td>
<td>5.396</td>
<td>5.339</td>
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<tr>
<td>COND (µS)</td>
<td>1130</td>
<td>1149</td>
<td>1142</td>
<td>1128</td>
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<td>1133</td>
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<tr>
<td>TDS (ppm)</td>
<td>774.6</td>
<td>796</td>
<td>786.7</td>
<td>792</td>
<td>808.9</td>
<td>797.4</td>
</tr>
<tr>
<td>pH</td>
<td>7.53</td>
<td>7.16</td>
<td>7.59</td>
<td>7.27</td>
<td>6.84</td>
<td>7.28</td>
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<table>
<thead>
<tr>
<th>Test</th>
<th>New Sample 1</th>
<th>Used Sample 2</th>
<th>New Sample 2</th>
<th>Used Sample 2</th>
<th>New Sample 3</th>
<th>Used Sample 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn (ppm)</td>
<td>0.2097</td>
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<td>nd</td>
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<td>7.28</td>
<td>7.59</td>
</tr>
</tbody>
</table>

nd: None Detected, below detection limit  

**Analyst**  
**Dylan Kemmerer**
The following SOPs have been modified to address the start up, shut down and by-pass of the system:

- CRX-016 Plant start up after full or partial power outage
- CRX-472 #2 Crystallizer hotwell pump shutdown.
- CRX-432 Cell/crystallizer complete shutdown and start-up
- CRX-103 Emergency drop of the crystallizer due to vaporizer drop leg being plugged
- LOTO Sheet for Full Outage CRX - 898
- A New Standard Operating Procedure CRX - 897
## Sustainability Cont.

<table>
<thead>
<tr>
<th>Site</th>
<th>PP</th>
<th>CRY Stuff</th>
<th>1300 WASH</th>
<th>600 NORTH</th>
<th>600 SOUTH</th>
<th>N OX % open</th>
<th>400 Feed Tank</th>
<th>Phosphate Cooling</th>
<th>Re-730</th>
<th>Re-750</th>
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<tr>
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<td></td>
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<td>20.0988218</td>
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### Water Cost Site Wide For The Previous 7 Days Ending 9/21/2015

**Total Pilot Plant usage for the last 7 days** 4,949,811 Gallons  
**Cost** $7,576.36

**Total Cairox usage for the last 7 days** 8,396,459 Gallons  
**Cost** $12,851.92

**Water used for the 1300 filter press** 202,596 Gallons  
Cost $310.10

**Water used for Crystallizer, cooling screw and Crystallizer inner condensor** 6,596,380 Gallons  
Cost $10,096.66

**Water used on both 600 filter presses** 44,031 Gallons  
Cost $67.39

**Water used for North Ox cooling** 1,407,484 Gallons  
Cost $2,755.27

**Water being used for water softeners and RO System** 0 Gallons  
Cost $-

**Water used for 400 feed tank cooling** 327,187 Gallons  
Cost $500.80

**Water used for Phosphate cooling** 476,280 Gallons  
Cost $729.01

**Water used for Re-730 cooling** 372,732 Gallons  
Cost $570.52

**Water used for Re-750 cooling** 555,927.27 Gallons  
Cost $850.92

**Misc water use, PP lab, tank filling etc.** 1,563,575 Gallons  
Cost $2,393.26

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---

**Store Data**
PI Screen Shot Of System Start Up

System Start Up
## 2 Sample T From Process Start Up

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Before</td>
<td>420</td>
<td>931.2</td>
<td>74.8</td>
<td>3.7</td>
</tr>
<tr>
<td>Use After</td>
<td>420</td>
<td>808.9</td>
<td>19.8</td>
<td>0.97</td>
</tr>
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</table>

Estimate for difference: **122.31**

95% CI for difference: (114.89, 129.73)

T-Test of difference = 0 (vs not =):

- T-Value = 32.39
- P-Value = 0.000
- DF = 477
# Project Costs

## Water Reduction Project Costs

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<th>Actual</th>
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<td>Initial Project Installation Costs:</td>
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<td>$132,870</td>
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<tr>
<td>Over Projected Costs</td>
<td></td>
<td>$5,977</td>
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Expected Cost Savings Overview

- 104 gallons per minute saved
- 51,865,920 gallons saved per year based on an operating period of 345 days
- 2015 water costs set at $1.145 per 100 cubic feet
- Based on data presented, this equates to $79,388 annually
- 0.8 year payback based on 50% funding from the ISTC funding
Final Cost Savings Overview

- 122 gallons per minute saved
- 60,609,600 gallons saved per year based on an operating period of 345 days
- 2015 water costs set at $1.145 per 100 cubic feet
- Based on data presented, this equates to $92,771 annually
- 0.8 year payback based on 50% funding from the ISTC
Cairox® Upcoming Projects
Phase 2

- Cairox® old crystallizer hotwell water management
- Project description
- Water storage tank and controls to eliminate current continuous hotwell overflow to sewer
- Recycle cooling water from Evap pump seal water cooling coils
- Recycle finished product cooling screw cooling water
- Project capital cost: $177K
- Annual savings: $99K / 130 GPM water
- Payback: 1.8 years
Projects Cont. Phase 3

- Recycle cooling water in the Pilot Plant under current evaluation
- Use recycled water from the sodium permanganate crystallizers and 400 feed tank.
- Temperature delta only 3-4 degrees F
- Used water to cool the N Oxidizer
- Roughly 114 GPM savings
Thank You For Your Time
Any Questions?