Policy and Planning to Address Impacts of Forest Fires to Source Water Quality

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City of Phoenix Background

- Six Surface Water Treatment Plants
  - Two water sources
  - 100 Billion Gallons per year

- 540 Square Miles of Service Area
  - 400,000 Accounts
  - 7,000 miles of distribution mains

System Conditions

- Periods of elevated TOC Levels
- Higher Temperature
- 77 Major Pressure Zones
  - Water Age (5+ days)
  - Chlorine Residual
Groundwater

Colorado River (CAP) 43%

Salt River

Reclaimed Wastewater

Verde River

Combined 49%

3%
Historical Total Organic Carbon in Source Waters (up to 2001)

Max. = 5.4 mg/L
Oct. '92-Sep. '93

Max. = 3.6 mg/L
Oct. '94-Sep. '95
Chapter 1 - The Plan (1989)

Water Quality Master Plan
EXECUTIVE SUMMARY

Water and Wastewater Department
City of Phoenix, Arizona

September 1989

MALCOLM PIRNIE
In association with John Carello Engineers
First Water Quality Master Planning Effort
Purpose of 1989 Water Quality Master Plan

- Identify water quality improvement options for City’s potable water delivery
  - Consider changing/uncertain regulatory environment
  - Provide healthful and best quality water to customers
  - Robust multiple barriers for multitude of contaminants

- Recommend long-term strategies for treatment process upgrades

- Identify key decision points
Highlights of 1989 Water Quality Master Planning Approach

- Seek advice of leading water industry experts to gage regulatory direction and best approach for compliance
- Conduct extensive bench and pilot-scale evaluation of potential treatment strategies
- Analyze treatment options for feasibility and cost
- Develop a road map with identified decision points
- Recommend short-term and long-term CIP strategies
Roadmap from 1989 Plan

Existing Operations

- pH Reduction to 7.3-7.5
- Discontinue Pre-Chlorination

A

Coagulation at pH 6.5 to 7.5

B

THM Control

- Cl₂/NH₂Cl

- O₃/ NH₂Cl

C

Cl₂/Cl₂

D

Enhance NOM Removal

- Cl₂/Cl₂

- Cl₂/NH₂Cl

E

- O₃/ Cl₂

- O₃/ NH₂Cl
1989 WQMP Recommendations

- Maintain chlorine usage
  - Primary and Secondary
- Reduce dissolved organics within existing design
  - Enhanced Coagulation
- Optimize distribution system to reduce water age
“At such time removal of TOC is required beyond capability of the plants, as designed, a choice will need to be made.”

Options to be evaluated in future

- Enhanced TOC removal through GAC
- Change from free chlorine to chloramines
Chapter 2 - The Plan Update (2006)
New Regulatory Drivers for Water Quality Planning

- SDWA
- THM Rule
- Stage 1 DBP Rule
- Stage 2 DBP Rule
Stage 2 DBP Rule

- Aimed at reducing customer exposures to harmful disinfection by products (Trihalomethanes and Haloacetic Acids)
  - DBPs have been regulated since 1979
  - New Rule does not allow averaging over the entire system
  - Compliance is required beginning 2nd Q 2012

- City of Phoenix challenges for compliance with this rule include:
  - Elevated water temperatures
  - Long water age
Purpose of 2006 Water Quality Master Plan Update

- Re-assess water quality goals and underlying philosophy of potable water treatment
  - Consider water quality parity
  - Consider improvements in treatment technology
  - Incorporate new information about disinfection, DBPs, and other contaminants

- Recommend treatment process upgrades needed for the known and emerging regulations
Highlights of 2006 Water Quality Master Planning Approach

- Stakeholder input from various City divisions to develop a consensus about potential strategies
- Examine chloramination
- Perform scenario planning to address future uncertainties
- Conduct extensive pilot-scale
  - GAC
  - Chloramination, and Ozonation
Historic TOC Values

Running Annual Average TOC (mg/L)

- **CAP Water**
- **SRP Water**

- **WQMPU analysis performed**
- **Max. = 3.5 mg/L March 2005**
- **Full Scale Testing Period**
- **Pilot Testing Period**

CAP water data compiled from Union Hills WTP and Pyramid Peak WTP (Glendale) raw water data
SRP water data compiled from 24th Street WTP and Cholla WTP (Glendale) raw water data
Results of Alternatives Evaluation

- **Existing Treatment Process**
  - **TTHMs↓**
  - **Enhanced Coagulation**
    - **TTHMs↓**
    - **GAC Filters**
      - **T&O ↓**
      - **Pathogens ↓**
      - **TTHMs↓**
      - **Pathogens ↓**
      - **Ozone (O₃-BAF)**
      - **UV**
      - **Ozone (O₃-Enhanced GAC)**
        - **Reactivate GAC More Frequently**
          - **T&O ↓**
          - **Pathogens ↓**
          - **TTHMs↓**
          - **UV**
        - **UV**
        - **Pathogens ↓**
      - **UV**
      - **Ozone (O₃-BAF)**
        - **Pathogens ↓**
        - **UV**
      - **Pathogens ↓**
      - **T&O ↓**
    - **T&O ↓**
    - **Pathogens ↓**
    - **TTHMs↓**
    - **Pathogens ↓**
    - **T&O ↓**
    - **TTHMs↓**
    - **Pathogens ↓**
    - **T&O ↓**
    - **TTHMs↓**
    - **Pathogens ↓**
      - **Post-filter GAC**
        - **Pathogens ↓**
        - **T&O ↓**
        - **TTHMs↓**
        - **Pathogens ↓**
}

**T&O**:
- Trace and Other

**TTHMs**:
- Trihalomethanes
Recommendations from 2006 Water Quality Master Plan

- Implement GAC Filter Adsorbers at all WTPs based on:
  - Additional cost of GAC is still within the comfort zone in light of the fact that the risks of exposure to contaminants is greatly minimized with GAC treatment
- Chlorine dioxide is recommended
  - Preoxidant to precipitate iron and manganese
  - Allows for the elimination of prechlorination
Chapter 3 - The Event

June 2002 Rodeo Chediski Fire
Rodeo-Chediski Fire
468,638 acres
June 2002
Changes in Source Water Quality

Running Annual Average TOC (mg/L)

- CAP Water
- SRP Water

WQMPU analysis performed

Pilot Testing Period

Full Scale Testing Period

CAP water data compiled from Union Hills WTP and Pyramid Peak WTP (Glendale) raw water data

SRP water data compiled from 24th Street WTP and Cholla WTP (Glendale) raw water data
Chapter 4 - Question the Plan
(Take a Trip)
Initiation of GAC Roadmap

- WQMP Updates
- GAC Roadmap

- SDWA Amendment
- THM Rule
- Elevated TOC

City of Phoenix
Primary Reasons for Concerns about the recommended approach

- Prolonged period of elevated TOC would require frequent replacement of GAC resulting in:
  - Operational hardship
  - Financial hardship
What Changed?

- Re-evaluation of Water Quality Philosophy
  - DBP Rule Compliance (Primary Focus) While Maintaining Flexibility to Implement Long-Term Water Quality Goals
  - Allow 90% TTHM MCL
  - Allow for WTP Specific TOC Targets
  - Allow for Seasonal TOC Targets
    - 1st and 4th Quarter - 56 ug/L TTHM
    - 2nd and 3rd Quarter – 88 ug/L TTHM
- Reduce life cycle costs of GAC Program
GAC Road Map Project Considered Alternatives (Lower Life cycle costs)
7-Yr Cycle GAC O&M Costs plus ClO2 + FeCl2 O&M Costs

- GAC O&M Costs
- ClO2 O&M Costs
- FeCl2 O&M Costs
- EC Chemical O&M
- Solids O&M

<table>
<thead>
<tr>
<th>Scenario</th>
<th>GAC O&amp;M Costs</th>
<th>ClO2 O&amp;M Costs</th>
<th>FeCl2 O&amp;M Costs</th>
<th>Solids O&amp;M</th>
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<td>Benchmark (1.4 mg/L TOC Target)</td>
<td>$233 M</td>
<td>$19 M</td>
<td>$157 M</td>
<td>$183 M</td>
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<td>Flow Adjusted (1.4 mg/L TOC Target)</td>
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<td>$157 M</td>
<td>$183 M</td>
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<td>Flow Adjusted &amp; Plant Specific TOC Targets + Optimized Enhanced Coagulation</td>
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<td>$16 M</td>
<td>$24 M</td>
<td>$58 M</td>
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<tr>
<td>Flow Adjusted &amp; Plant Specific TOC Targets, w/ 3ppm ClO2 &amp; FeCl2 + Optimized EC</td>
<td>$111 M</td>
<td>$16 M</td>
<td>$24 M</td>
<td>$58 M</td>
</tr>
</tbody>
</table>

City of Phoenix
GAC Road Map Results

- Continue with GAC Program
  - GAC Filter Adsorbers
    - VV WTP and DV WTP
  - Filter Contactors
    - 24th Street WTP
  - Biologically Active GAC Filters
    - UH WTP
- Chlorine Dioxide
  - Pre-Oxidant at 1 ppm max
- Optimize Enhanced Coagulation
Chapter 5 - The New Plan – High Rate Chlorine Dioxide
Revised Water Quality Strategy

- WQMP Updates
- GAC Roadmap
- WQ Strategy
Key Factors Considered

- **Operational Flexibility**
  - Multiple tools
  - Technologies can be switched “on/off”
  - Opportunities for operational cost savings

- **Maximize Future Options**
  - Adaptability to future regulatory changes

- **Life Cycle Cost**
  - Total costs of the compliance strategy
Chlorine Dioxide RSSCTs – SDS DBP Testing

TOC target increases when ClO₂ is applied:
• 1.60 mg/L for Baseline EC
• 2.40 mg/L for ClO₂ pre-treatment
Compliance Strategy

- **Initial Strategy**
  - Granular Activated Carbon (GAC) Filters
    - Removes THM precursors

- **Revised Strategy**
  - GAC Filters
    - Removes THM precursors
  - High Rate Chlorine Dioxide
    - Reduces formation of THMs
  - Distribution System Optimization
    - Reduces water age

Various combinations of these tools resulted in 11 alternative operating scenarios that are evaluated in detail.
Features of Selected Alternative

- Post-Filter Contactors at Val Vista
- Filter Adsorbers at Deer Valley
- 3 ppm Chlorine Dioxide at all WTPs
- Distribution system optimization
Cost Comparison

Original Program

- *Capital Cost = $243M*
- *O&M Cost = $31M/Yr to $46M/Yr*

Revised Strategy

- *Capital Cost = $238M*
- *O&M Cost = $25M/Yr to $34M/Yr*
Unintended Consequences - Customer Concerns

Startup

C1 ON

C1 OFF

- Rusty Water
- Milky/Dirty
- Bad Taste/Odor

City of Phoenix
Unintended Consequences- Customer Concerns

- Rusty Water
- Milky/Dirty
- Bad Taste/Odor

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Unintended Consequences - Customer Concerns

C3 OFF

C4 ON

Rusty Water
Milky/Dirty
Bad Taste/Odor

City of Phoenix

Non-Issue
Accounting for TOC and Temp, Salt River TTHM Formation Decreased by 16-35%
No Reduction in TTHM formation was Observed for Verde River Water

![Graph showing TTHM vs. TOC for Verde River ON and OFF conditions with linear trends for both conditions.](image-url)
Chapter 6 - The New Old Plan (Oct. 2010)

- Stop Design and Construction of 3 mg/l Chlorine Dioxide
- Implement GAC at all WTPs and 1 mg/l Chlorine Dioxide
  - Val Vista WTP GAC Contactors
  - Deer Valley WTP GAC Filter Adsorbers
  - Union Hills and 24th Street WTPs Biological GAC Filters
    - Previously designed filter adsorber plans modified

Distribution System Optimization
An Optimized Plan

- Distribution System Aeration Treatment
- Reduced Water Age
  - Piping and Reservoir Reconfiguration
- Optimization of Reservoirs on WTPs Sites
  - pH Control thru CT Reservoirs
- Chlorine Control thru CT Reservoirs
Steps for the Future

- Continue to optimize system
  - Addition of system Aeration treatment
  - System piping modifications
- Regional GAC Regeneration
- System GAC Treatment
- Water Quality Monitoring
The Moral of the Story – Our plan included a robust treatment system that allowed for flexibility. We believe that we can handle future Water Quality challenges.

Questions