The Lead and Copper Rule
Cedar Rapids’ Journey to Compliance

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Iowa’s Drinking Water: Could Flint Happen Here?

• In the early 1990s, Cedar Rapids’ was in violation of the new standard for lead in drinking water. The exceedance was:
  • Major, extensive & over a prolonged period of time
  • Both similarities & dissimilarities between events in Flint and Cedar Rapids

• This presentation will discuss:
  • Scope and nature of the Cedar Rapids’ lead corrosion phenomenon
  • Our response – Initial and long-term
  • How we ultimately achieved compliance
  • Lessons learned

• This presentation will also discuss:
  • Our “dirty laundry” – what we should have done better or differently
  • Our “points of pride” – what we did right
Lead and Copper Rule (LCR)

National Primary Drinking Water Regulation (NPDWR) Promulgated on June 7, 1991

• Addresses corrosion of lead and copper in drinking water primarily from lead service lines and household plumbing (brass fixtures)

• Maximum Contaminant Level Goals (MCLGs)
  • Lead - 0 ug/l (micrograms per liter)
  • Copper – 1.3 mg/l (milligrams per liter)

• Requires a treatment technique (optimized corrosion control) rather than a Maximum Contaminant Level (MCL)

• Tap Sample results are compared to an Action Level (AL) standard
  • Lead - 15 ug/l (or 0.015 mg/l)
  • Copper - 1.3 mg/l

• Action level for lead is a screen or indicator for optimal corrosion control. It is based on treatment feasibility; NOT on a health threshold
Regulatory Standard for Lead in Drinking Water

• Prior to June 1991
  • Maximum Contaminant Level (MCL) for Lead - 50 ug/l
  • Sampled at the point of entry into water distribution system
  • Lead rarely detected and compliance generally not an issue

• Subsequent to June 1991
  • Action Level for Lead – 0.015mg/l (or 15 ug/l)
    • Monitoring – At representative locations in distribution system deemed to be highest risk
    • Minimum # of samples based on population (CR minimum - 100 samples)
    • 90% of all sample results had to be less than the AL of 15 ug/l
  • Sampling Protocol: Conditions/locations most conducive for lead corrosion
    • Homes with lead service lines
    • Homes constructed between 1982-1986
    • First-draw samples after period of prolonged non-use (6 hours minimum)
Lead and Copper Rule
Regulatory Intent and Goals

• Universal Concerns re: Detrimental Health Effects of Lead
  • Young children
  • Pregnant women
  • All consumers

• Lead and Copper Rule
  • Provide a protective standard for water as it consumed or used
  • Complement other new standards for lead content (e.g. solder, brass fixtures)

• Potential Sources of Lead (corrosion or leaching)
  • Lead Service Lines
  • Lead Solder Joints
  • Brass Fixtures – faucets, water meters et al.
Exceedance of the Action Level
Actions Triggered

• If the 90\textsuperscript{th} percentile of a systems lead sampling results exceed the Action Level for lead, a system must:
  • Optimize corrosion control
    • Identify and install optimal corrosion control treatment
    • Comply with State-specified optimal water quality control parameters
  • Public Education
    • Mandatory language for pamphlets and brochures on lead
    • Media notice (radio, TV and newspaper)
    • Deliver informational materials to:
      • All customers
      • Organizations that serve sensitive subpopulations (e.g. schools, pediatricians)
  • Triggered Lead Service Line Replacement
    • Required if unable to achieve compliance (via corrosion-control treatment strategy)
    • Replace the portion of the lead service lines owned by the water utility
    • Offer to replace the customer’s portion of the service line at cost
    • Replace 7% of lead service lines each year
Cedar Rapids Water System

• Water Service Line Materials - Prior to about 1945 to 1947
  • Lead line – From Main to Stop Box (Utility owned and responsibility)
  • Galvanized Pipe – From stop box to house (Property owner’s responsibility)

• Monitoring Sites for LCR Compliance in 1992
  • Homes with lead service lines
    • Older homes in core or older, central area of Cedar Rapids
    • Higher percentage of lower-income families
  • Homes constructed between 1982-1986
    • New home construction concentrated in two new developments on fringes of CR
    • Predominantly middle to higher income families
Cedar Rapids Water System

• Corrosion Control Strategy – Prior to 1992
  • Finished water chemistry
    • Shallow alluvial wells, lime softening and chloramination
    • pH @ 9.3
    • Addition of Polyphosphates as a corrosion inhibitor
    • A slightly positive Langelier Index (i.e. water tends to deposit protective coatings)

• Immediately prior to first round of compliance monitoring
  • General Assumption: Protective biofilm/deposition layer was in place
  • Conducted preliminary monitoring
    • Limited number of samples (about 20)
    • Majority taken from homes with lead service lines
    • No indication of significant lead corrosion and/or possible compliance issues
CRWD – First Round of Compliance Monitoring
January – July 1992

• Regulatory Compliance Requirements
  • Minimum of 100 samples
  • Locations and conditions (first-draw, 6 hours of non-use) most conducive to lead corrosion
  • 90th percent value for lead test results must be < 0.015 mg/l

• Lead Monitoring Results
  • Samples – 105 locations
  • 90th percent value - 0.055 mg/l (Or 2.7 times higher than the A.L.)
  • # of samples exceeding A.L. – 59 (Or 56% of all samples)
  • Average Value – 0.027 mg/l
  • Median Value – 0.017 mg/l
  • Maximum Value – 0.174 mg/l

• Front Page of USA Today as a “Top Ten City for Lead Levels in Drinking Water”
CRWD’s Initial Response

• Hired a consulting engineer
• Continued to monitor representative sites
• Conducted bench tests to evaluate water chemistry adjustments
• Consulted with Iowa DNR
• Implemented new finished water chemistry in November 1992
  • Switched from polyphosphates to zinc orthophosphate (ZnPO4)
  • Added zinc orthophosphate at a higher than normal dose
  • Lowered finished water pH to 8.3 (from prior 9.3 target)
• Second round of compliance monitoring completed in Nov-Dec, 1992
• We shared test results with home owners
Lead Compliance Monitoring Results through Round # 2

<table>
<thead>
<tr>
<th></th>
<th>Round # 1 Jan-Jun, 1992</th>
<th>Round # 2 Nov – Dec, 1992</th>
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</thead>
<tbody>
<tr>
<td># of samples</td>
<td>105</td>
<td>101</td>
</tr>
<tr>
<td>90&lt;sup&gt;th&lt;/sup&gt; Percentile Value</td>
<td>0.055 mg/l</td>
<td>0.042 mg/l</td>
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<tr>
<td># exceeding the A.L.</td>
<td>59</td>
<td>50</td>
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<tr>
<td>Mean Value</td>
<td>0.027 mg/l</td>
<td>0.029 mg/l</td>
</tr>
<tr>
<td>Median Value</td>
<td>0.017 mg/l</td>
<td>0.015 mg/l</td>
</tr>
<tr>
<td>Maximum Value</td>
<td>0.174 mg/l</td>
<td>0.428 mg/l</td>
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# Lead Compliance Monitoring Results through Round # 3

<table>
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<tr>
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<th>Round # 1 Jan-Jun, 1992</th>
<th>Round # 2 Nov – Dec, 1992</th>
<th>Round # 3 December 1994</th>
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<tbody>
<tr>
<td># of samples</td>
<td>105</td>
<td>101</td>
<td>103</td>
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<tr>
<td>90&lt;sup&gt;th&lt;/sup&gt; Percentile Value</td>
<td>0.055 mg/l</td>
<td>0.042 mg/l</td>
<td>0.026 mg/l</td>
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<tr>
<td># exceeding the A.L.</td>
<td>59</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td>Mean Value</td>
<td>0.027 mg/l</td>
<td>0.029 mg/l</td>
<td>0.011 mg/l</td>
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<tr>
<td>Median Value</td>
<td>0.017 mg/l</td>
<td>0.015 mg/l</td>
<td>0.002 mg/l</td>
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<tr>
<td>Maximum Value</td>
<td>0.174 mg/l</td>
<td>0.428 mg/l</td>
<td>0.472 mg/l</td>
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# Lead Compliance Monitoring Results through Round # 4

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<tr>
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<th>Round # 1 Jan-Jun, 1992</th>
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<th>Round # 3 December 1994</th>
<th>Round # 4 December 1995</th>
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<td># of samples</td>
<td>105</td>
<td>101</td>
<td>103</td>
<td>100</td>
</tr>
<tr>
<td>90th Percentile Value</td>
<td>0.055 mg/l</td>
<td>0.042 mg/l</td>
<td>0.026 mg/l</td>
<td>0.014 mg/l</td>
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<tr>
<td># Exceeding the A.L.</td>
<td>59</td>
<td>50</td>
<td>15</td>
<td>10</td>
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<tr>
<td>Mean Value</td>
<td>0.027 mg/l</td>
<td>0.029 mg/l</td>
<td>0.011 mg/l</td>
<td>0.006 mg/l</td>
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<tr>
<td>Median Value</td>
<td>0.017 mg/l</td>
<td>0.015 mg/l</td>
<td>0.002 mg/l</td>
<td>0.003 mg/l</td>
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<tr>
<td>Maximum Value</td>
<td>0.174 mg/l</td>
<td>0.428 mg/l</td>
<td>0.472 mg/l</td>
<td>0.027 mg/l</td>
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### Exceedance Excursions
#### Rounds # 7, # 8 & # 9

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<tr>
<th></th>
<th>Round # 7 Nov- Dec, 1998</th>
<th>Round # 8 May - June, 1999</th>
<th>Round # 9 Nov- Dec 1999</th>
<th>Round # 10 Jan- July 2000</th>
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<td><strong># of samples</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>191</td>
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<tr>
<td><strong>90th Percentile Value</strong></td>
<td>0.018 mg/l</td>
<td>0.028 mg/l</td>
<td>0.015 mg/l</td>
<td>0.009 mg/l</td>
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<tr>
<td><strong># Exceeding the A.L.</strong></td>
<td>14</td>
<td>22</td>
<td>10</td>
<td>11</td>
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<tr>
<td><strong>Mean Value</strong></td>
<td>0.008 mg/l</td>
<td>0.012 mg/l</td>
<td>0.006 mg/l</td>
<td>0.004 mg/l</td>
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<tr>
<td><strong>Median Value</strong></td>
<td>0.002 mg/l</td>
<td>0.004 mg/l</td>
<td>0.003 mg/l</td>
<td>0.002 mg/l</td>
</tr>
<tr>
<td><strong>Maximum Value</strong></td>
<td>0.201 mg/l</td>
<td>0.133 mg/l</td>
<td>0.071 mg/l</td>
<td>0.090 mg/l</td>
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Lead Compliance Monitoring Summary 1992 through 2015

90th Percentile Value for Lead

Lead concentration mg/l

90th Percentile Value  
Action Level
Lead Compliance Monitoring Summary 1992 through 2015

Number of Samples above the 0.015 mg/l Action Level
CRWD’s Research and Response
Extensive and Prolonged Distribution System Monitoring

• Research and Monitoring at “High-Risk” Homes
  • Homes with lead service lines or constructed between 1982 - 1986
  • First-Draw lead & copper samples
  • Water chemistry profiles
  • Two or more locations in same home
  • Analysis of multiple, sequential one – liter samples
    • Lead service lines: Capture & analyze water in direct contact with lead service line
    • 1982-86 Homes: Lead corrosion at the faucet or elsewhere in home’s plumbing system?
  • Analysis of Samples – Unfiltered & filtered (Soluble or particulate matter?)

• Monitoring throughout Distribution System to ensure:
  • No degradation of general water quality parameters
  • No loss of disinfectant and/or bacterial growths
  • Appropriate dispersion of corrosion inhibitor – ZnPO4
CRWD’s Research and Response Extensive and Prolonged Loop Studies

• 8 - 10 Loops constructed to simulate home’s internal plumbing system
  • Approximately 25 feet of copper piping with and w/o solder joints
  • Faucets
  • Solenoid valves/timers for controlled “flow usage or flushing”

• Research focus or “variables” studied
  • Water chemistry
  • Corrosion inhibitors
    • Different Products: Polyphosphates, Zinc Orthophosphate, Phosphoric Acid, et al
    • Different Manufacturers or formulations of same “generic” product (especially ZnPO4)
    • Different concentrations of same product

• Research and Monitoring Activities
  • Water chemistry profiles
  • Monitoring of first-draw lead & copper samples
  • Analysis of sequential one – liter samples
  • Analysis of Samples – As collected (unfiltered) then filtered
CRWD’s Research and Response Distribution System

• Implemented Policy: Remove lead service lines at every opportunity
  • Street projects
  • Water line replacement projects
  • Water main and service line breaks

• Encouraged home owners: Replace your portion of service line (galvanized)
  • Major projects: CRWD solicited unit cost quotes for service line replacement work
  • For financially strapped customers:
    • CRWD underwrote the service line replacement costs incurred by the customer
    • Customer repaid the CRWD over five years via a surcharge on their utility bill
CRWD’s Research and Response
Extensive Public Relations & Information Efforts

• Our Commitments or Guiding Principles:
  • Protection of Public Health is Paramount
  • Be fully open and honest
  • Be as responsive as possible to public inquiries and concerns

• Mailings and Distribution of Informational Materials
  • EPA Mandated Information and Language
  • Additional Information about:
    • Scope and nature of the lead corrosion problem
    • Current activities
    • Strategic plan for identifying & implementing “treatment regimen for optimal corrosion control”

• Targeted Mailings and Outreaches
  • Schools, day care centers, et. al.
  • Pediatricians and other health care providers

• Coordinated and worked closely with:
  • Linn County Health Department
  • Local news media, especially the CR Gazette
  • Iowa Department of Natural Resources

• Regular Status Reports to City Council (televised)
Lessons Learned – Scientific & Research Findings

• Water chemistry and lead corrosion are complex
  • Multiple factors may affect or contribute to lead corrosion
  • There are no simple explanations or causes
  • There are no easy answers
  • There are trade-offs (e.g. Zinc creates a compliance challenge for WPC)

• Possible factors that might affect lead corrosion
  • Raw water source – surface water, shallow or deep wells
  • Type of water treatment (minimal treatment or lime softening or other method)
  • pH of the finished water
  • Stability of finished water (slightly depositing versus slightly corrosive)
  • Corrosion Inhibitor – type and feed rate
  • Disinfection method – chlorination or chloramination
Lessons Learned – Scientific & Research Findings

• Switch in water chemistry & corrosion inhibitor
  • Is a slow, long-term endeavor
  • May experience “spikes” during the transition

• Lead Service Lines were not a major source or contributor in CR
  • Demonstrated via analysis of samples in prolonged, direct contact with lead
  • High test results due to newly installed faucets and/or recent plumbing work

• Preponderance of high results were from homes constructed 1982-1986
• Brass fixtures and/or solder joints were likely the primary “culprits” in CR
• Occasional high results likely due to lead particles (i.e. not soluble lead)
Other Questions, Observations & Musings

- Some brass (manufacturers, lots etc.) might be more susceptible to corrosion
  - Monitoring of similar sites showed consistent & significantly different levels of lead
    - Monitoring of immediately adjacent homes - same contactor, age and brand of faucets
    - Monitoring of multiple faucets in same home to include side-by-side units in a master bathroom
  - Replaced a “problem” faucet – new unit in compliance within 30 days
  - Anecdotal evidence that some imported brass might have been more susceptible to lead corrosion
  - Quality of plumbing workmanship a possible factor (excessive, loose solder?)

- Apparent variation in efficacy of ZnPO4 from different manufacturers

- Zinc Orthophosphate has some aesthetic issues
  - Discoloration of plumbing fixtures
  - Discoloration of toilet tanks
Other Questions, Observations & Musings

• Was the treatment regimen change the “right, long-term” decision?
  • No compliance issues @ other Iowa cities with comparable water treatment regimens
  • Lament: Not able to research why the prior treatment regimen/inhibitor failed

• Explanation for efficacy of the new treatment regimen/corrosion inhibitor?
  • ZnPO4 provides a more effective protective layer than polyphosphates?
  • Readily available lead and lead particulate matter were leached/flushed over time?
  • Or some combination of the above factors?
  • Or other unknown factors?
Other Questions, Observations & Musings

• Cedar Rapids expended an enormous amount of money & time in researching/resolving its lead corrosion problem (Est. @ $1.0 Million plus)

• In a “perfect world”, a more beneficial use would be removal of lead-based paint from homes

• CRWD compiled a significant amount of monitoring data, observations and information regarding CRWD’s lead corrosion challenges

• Lament is that we did not have the time and resources to do so in a fully comprehensive, methodical manner that would facilitate research of the lead corrosion phenomenon (e.g. scientific publication)
Lessons Learned – “Crisis Management”

• Best Approach
  • Recognize that Protection of Public Health is the ultimate goal
  • Be open and honest
  • Admit when you don’t know
  • Citizen Concerns: Listen, acknowledge concerns and demonstrate empathy
  • Communicate, communicate, communicate!
  • Do the “Right Thing for the Right Reason”

• Allow appropriate individuals to make the appropriate decisions
  • Primary focus should be the problem(s) and solution(s)

• Recognize that others will call into question your individual or team’s
  • Professional competency
  • Honesty and integrity
Lessons Learned – A “Self-Critique”
What we did wrong or wish we could have done better

• We were too complacent! Prior to compliance monitoring, we should have:
  • Been more questioning – Is this the optimal finished water chemistry & corrosion inhibitor?
  • Done more sampling – Do we have a problem?

• We put ourselves in a position where we had to make decisions “on the fly”
  • What is the optimal water chemistry and corrosion inhibitor for CR?
  • Will the “quick and dirty” bench studies work on a system-wide scale?
  • Did we make the right or best decision for the long-term??

• “The Crisis was managing us – We were not managing the Crisis!”
A “Self-Critique” What We Did Right!

• After our wake up call, We
  • Acknowledged the situation
  • Made Protection of Public Health our primary focus
  • Marshalled all of our resources
  • Worked as a team and were relentless and determined in our efforts

• We deferred to Medical Professionals re: potential health issues
  • Linn County Health Director: “Three primary causes of elevated lead levels are lead-based paint, lead-based paint, and lead-based paint”

• CR City Leaders and Citizens
  • Deferred to us on technical matters  ***
  • Priority – Researching and resolving the problem  ***
  • Minimal finger-pointing, posturing and “CYA” activity  ***
  • Allowed us an opportunity to regain their TRUST  ***

*** There were some exceptions
The CRWD “Response Team”

- Citizens of Cedar Rapids
  - Mayor and Council, especially Mayor Serbousek & Councilman Lyle Hanson
  - Customers, especially those that served as sample sites

- Cedar Rapids Water & WPC Departments
  - Laboratory – Tom Noth, Roger Pfeiffer, Barb Wagner
  - CRWD Staff – especially customer service and plant maintenance crew
  - Cedar Rapids WPC Laboratory – completed all the metal analyses

- Local Agencies – Linn County Health, CR Gazette & local news media

- Iowa DNR – Dennis Alt, Roy Ney and Diane Moles
Ways to Reduce Potential Exposure to Lead in Drinking Water

• Always flush line before drawing water for consumption purposes (drinking, preparation of food or baby formula)
  • After prolonged periods of non-use: Flush until water is as cold as it is going to get
  • During periods of normal use: Flush long enough to purge the water in direct contact with the faucet

• **Never Use Hot Water** for consumption purposes (drinking, preparation of food or baby formula)
  • Hot water will leach lead much faster than cold water

• Questions about your drinking water
  • Consumer Confidence Report (Water Quality) – Posted on line
  • Contact your water utility