United States Environmental Protection Agency

Impact of Installing Novel Technologies on Existing Infrastructure

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"Green Infrastructure"

New Opportunity for Achievable Objectives

- Prevent the potential for contamination in the first place
- Dramatically reduce the extent of contamination
- Simplify central water treatment to provide better overall protection
  - Inorganic and organic contaminants
  - Limited corrosion
  - Maintaining disinfection residuals
  - Minimizing disinfection byproducts

What is "Green?"

Reduced use of non-renewable natural resources

Manufacture of plumbing materials

Municipal or supplemental DW treatment chemicals

Does not cause unhealthy levels of contamination under intended usage conditions throughout the distribution system

Metals

Organics

Microbial

Does not require supplemental treatment

Entry point

Point of use

Does not create environmental challenges with waste

Reduces metal loadings to WWTPs

Reduces nutrient loadings to WWTPs

Plumbing materials amenable to recycling/reuse

Unintended Consequences:

Can occur when water quality is not compatible with distribution system materials

Complex Situation

- A different approach to how water is handled will be required to achieve the net zero goal
- This will likely result in a change in water quality
- Budgets, logistics, water laws, existing contracts, construction delays, and implementation will dictate that it cannot be done overnight
- Therefore, a master plan is needed to assure safe water

Challenges of Water Conservation

Creates conditions of:

- Higher metal exposure potential
- Depletion of the disinfectant
- Temperature conditions favorable for nitrification and other biofilm growth

Problem is a function of:

- Background water chemistry
- Usage pattern
- Spatial distribution of contamination sources

Reasons to Avoid Supplemental Building Water Treatment

- Dangerous chemicals
- Requires chemical feed or other mechanical equipment operation
- Ongoing chemical/process cost
- Requires dosage and background chemistry monitoring to maintain proper conditions
- May require licensed operator and state or federal regulation as NTNCWS
- Contaminants can leach from within a building
- Even POU devices at each tap for consumption require monitoring and replacement

Developing a Corrosion Control Program

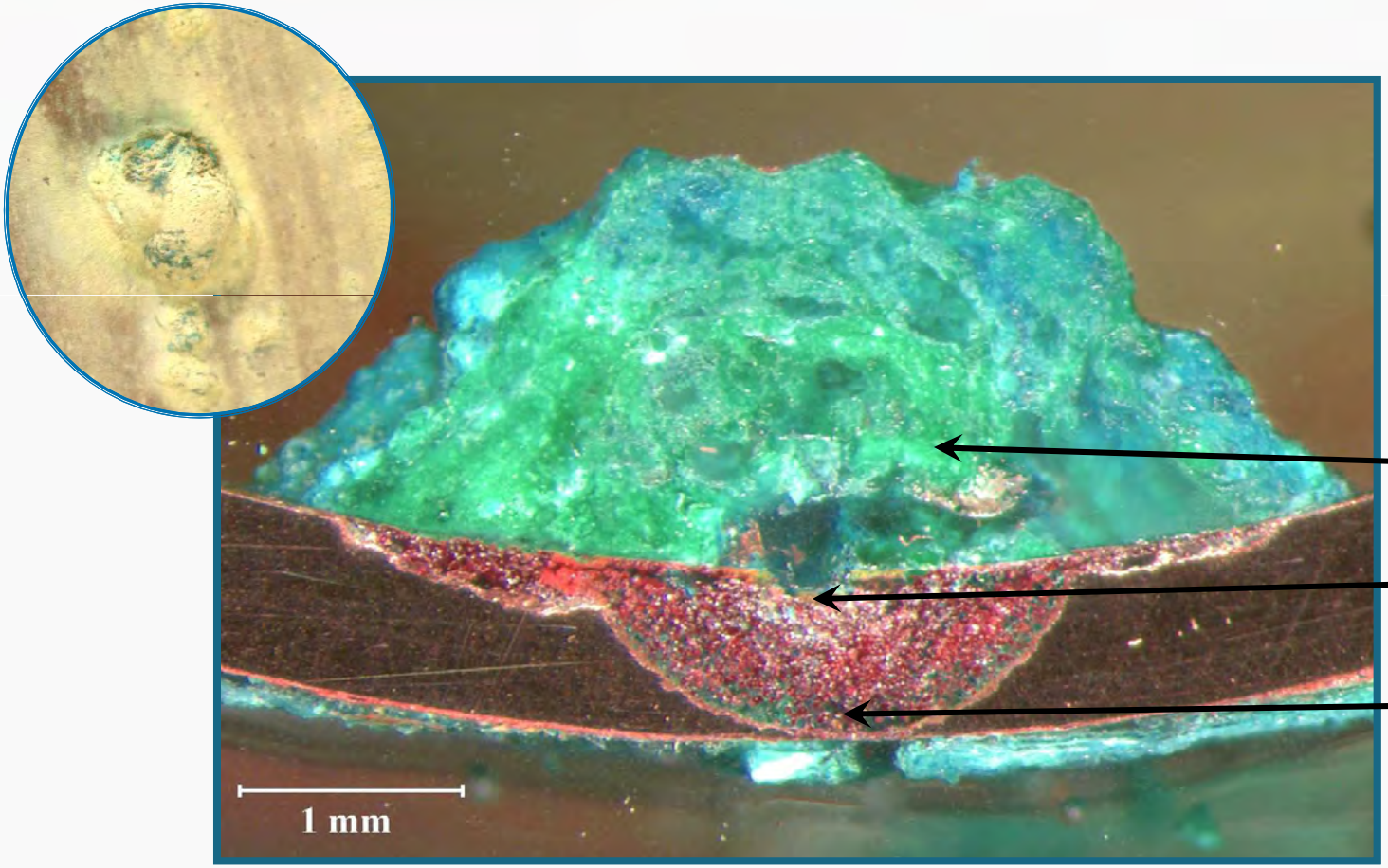
Separate the Impacts	Determine Health-Related Issues
Distribution System Materials • Old unlined iron • Asbestos-cement • Cement mortar lined • Bitumen-coated lined iron • Plastic • Cement & epoxy re-lining	**Metals Release** • Lead • Copper • Nickel (stainless steel) • Cadmium (galvanized coatings) • Chromium (stainless steels) • Manganese (post-deposition) • Heavy metals/radionuclides (post deposition)

Choose a Strategy to Achieve Both

Distribution System Corrosion

Types of Corrosion	
Uniform corrosion • Materials degradation • Metal release (Pb, Cu, etc.)	
Non-uniform corrosion • Pinhole leaks (copper) • Dezincification • Tuberculation (iron)	
Galvanic • Soldered joints • Brass devices • Coupling of different pipe materials	

Copper Pit Anatomy



Pit Cap

Perforated Membrane

Pit

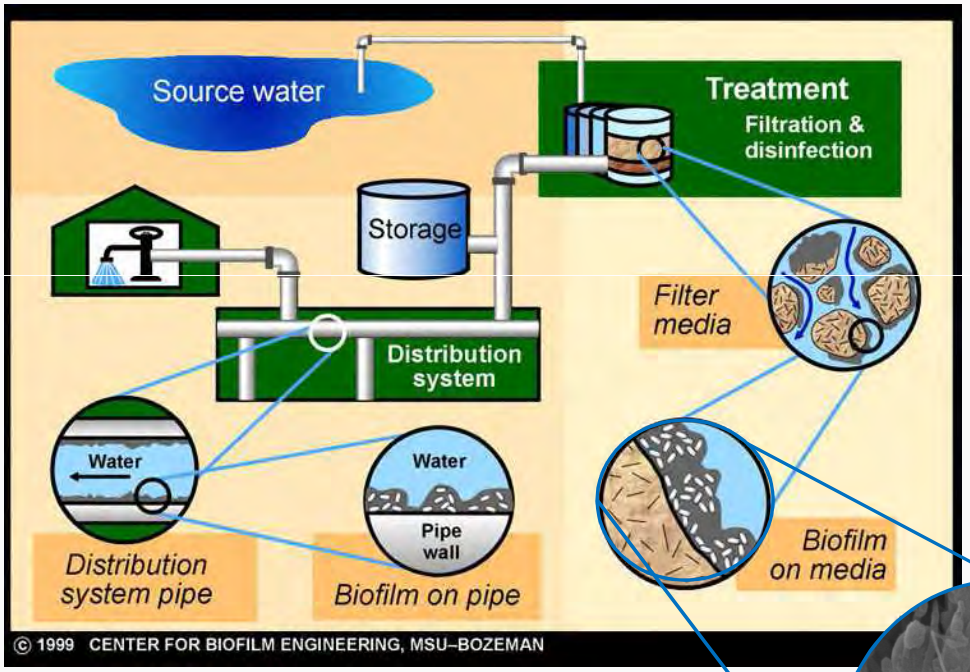
What are Contamination Sources?

- Pipes
- Faucets
- Flow control/shut-off valves
- Meters
- Pressure regulators
- Backflow preventers
- Storage tanks
- Pipe connectors

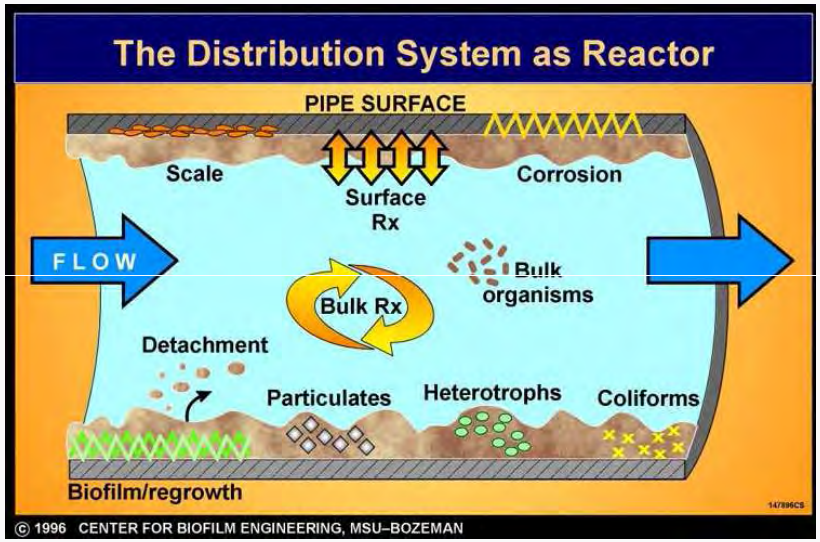
- Biofilms on all of the above

Biofilm Issues

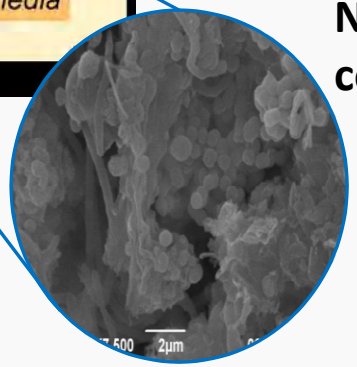
Complex situation



Schematic of a typical drinking water system



Nitrification in drinking water is commonly associated with biofilm

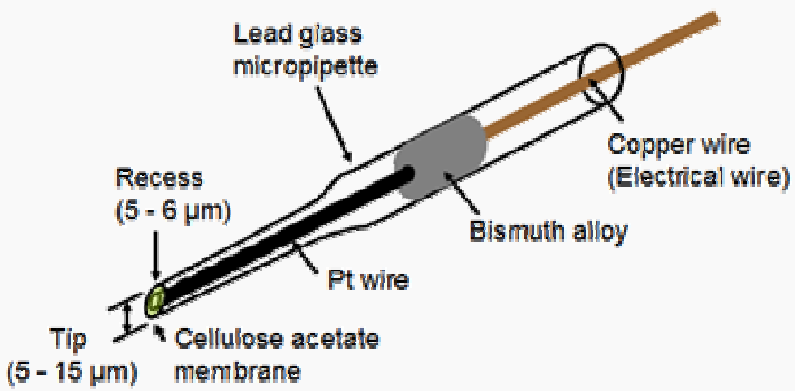


Biofilm Control: Distribution System

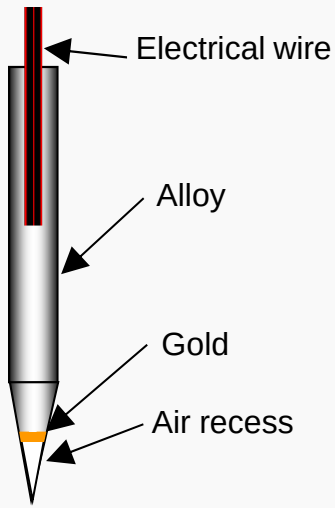
Investigations into Monochloramine Biofilm Penetration

Microelectrodes

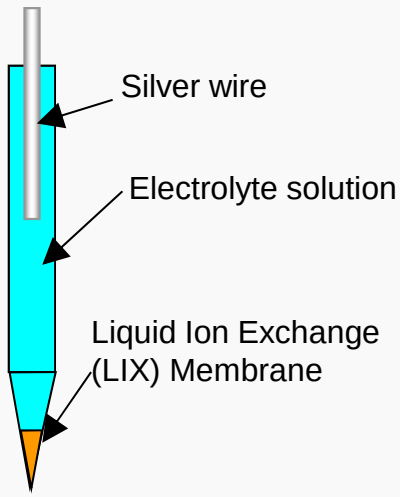
Total Chlorine



Dissolved Oxygen



pH, Ammonium, & Nitrate

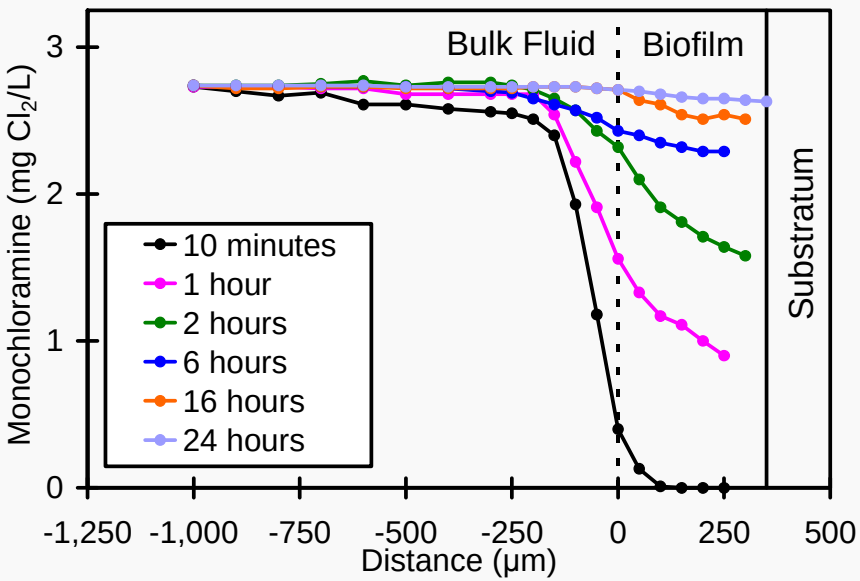


Biofilm Control: Distribution System

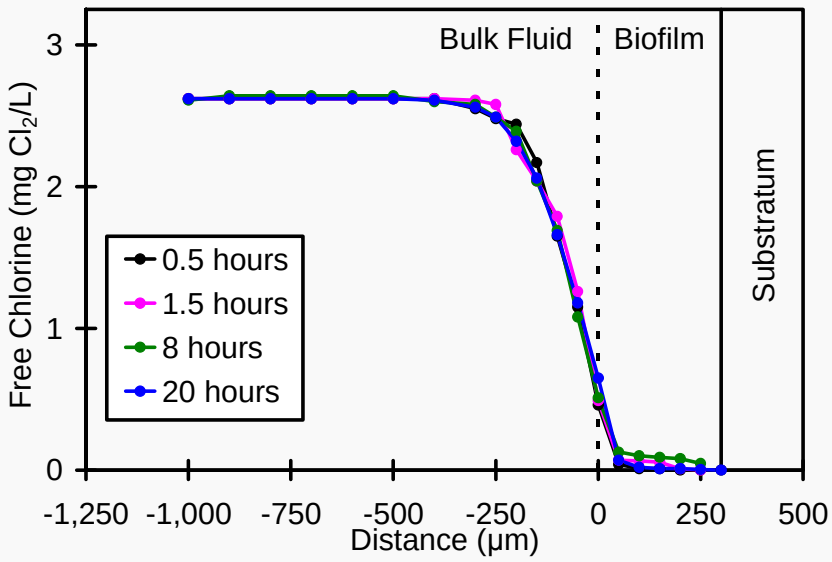
Monochloramine Biofilm Penetration

- Monochloramine → complete penetration
- Free chlorine
  - Stabilizes w/o complete penetration → diffusion limited
  - Shallow penetration depth → ~ 50 µM

Monochloramine Profiles

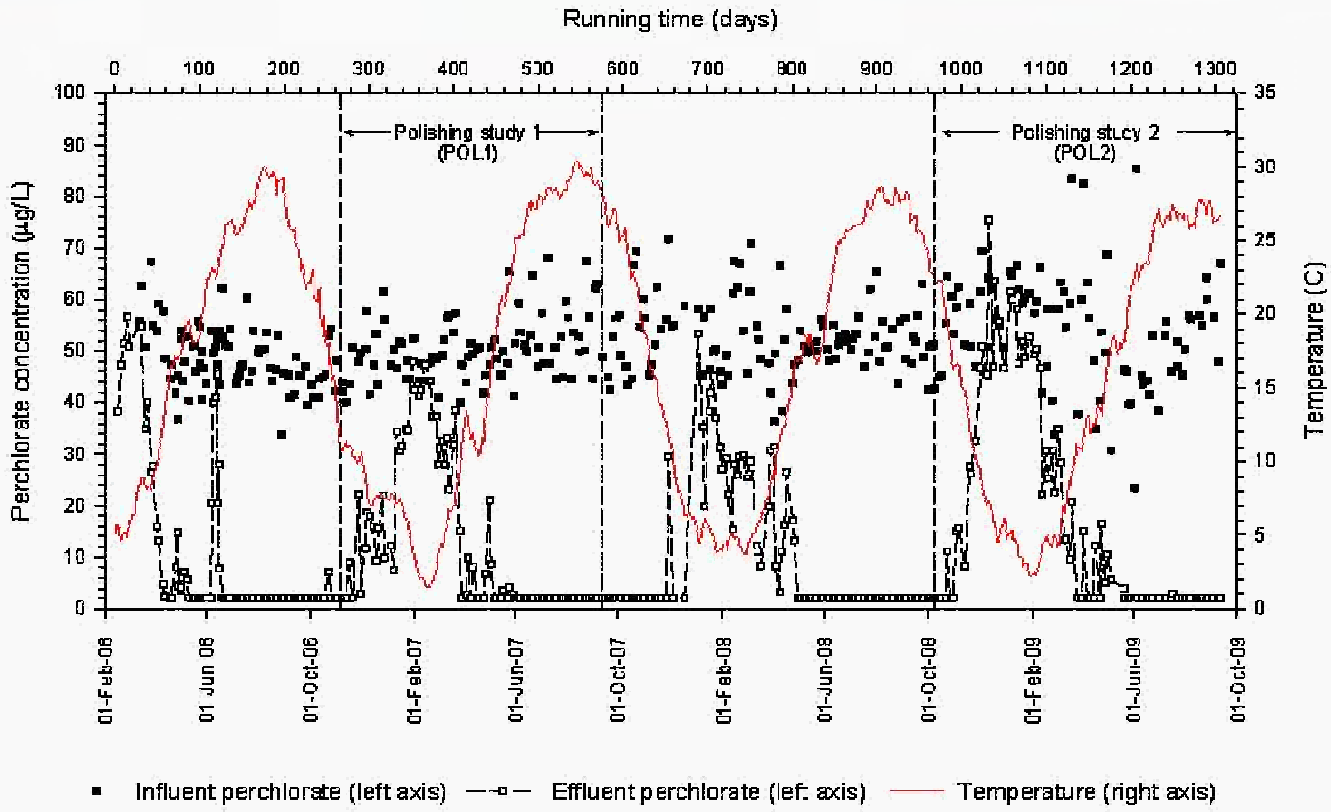


Free Chlorine Profiles



Anaerobic Biological Treatment

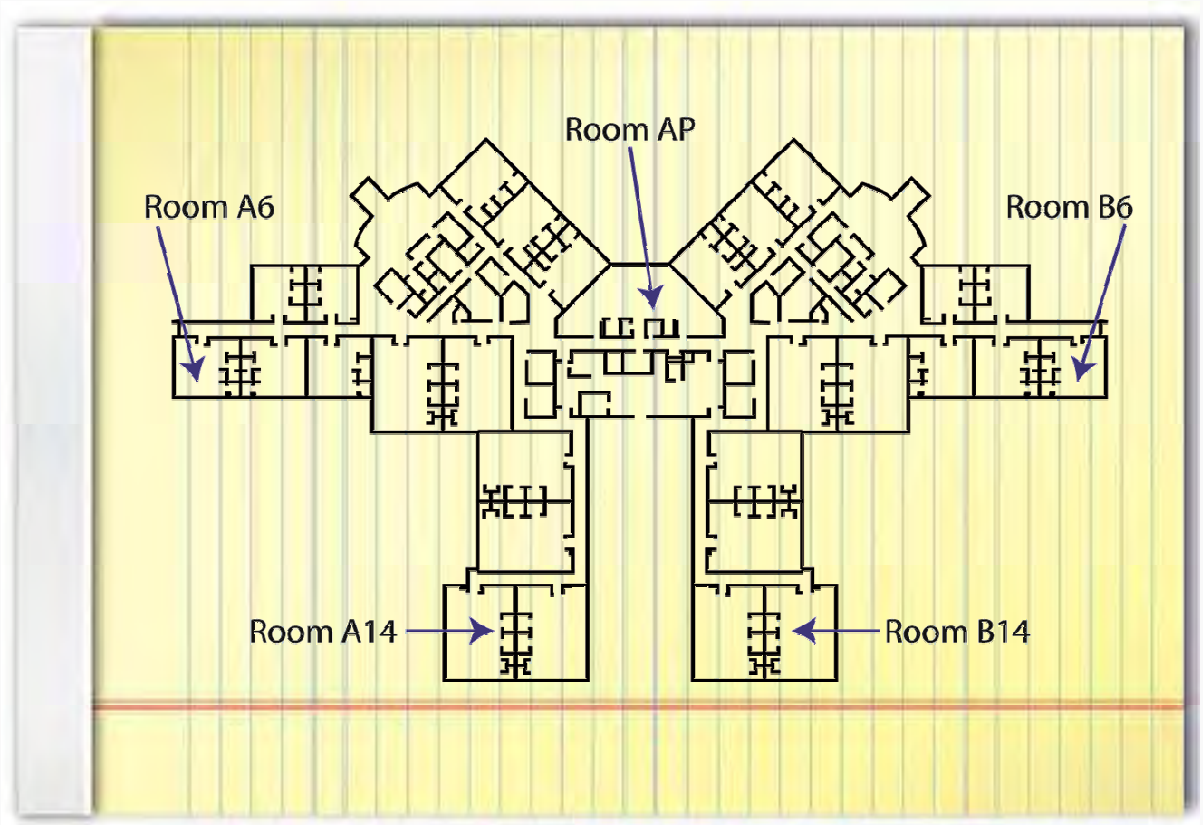
Summary for Perchlorate



Anaerobic biological treatment can be effective for numerous contaminants but requires expertise on treatment, polishing, and residuals handling

Distribution System Case Study

Wright-Patterson Air Force Base

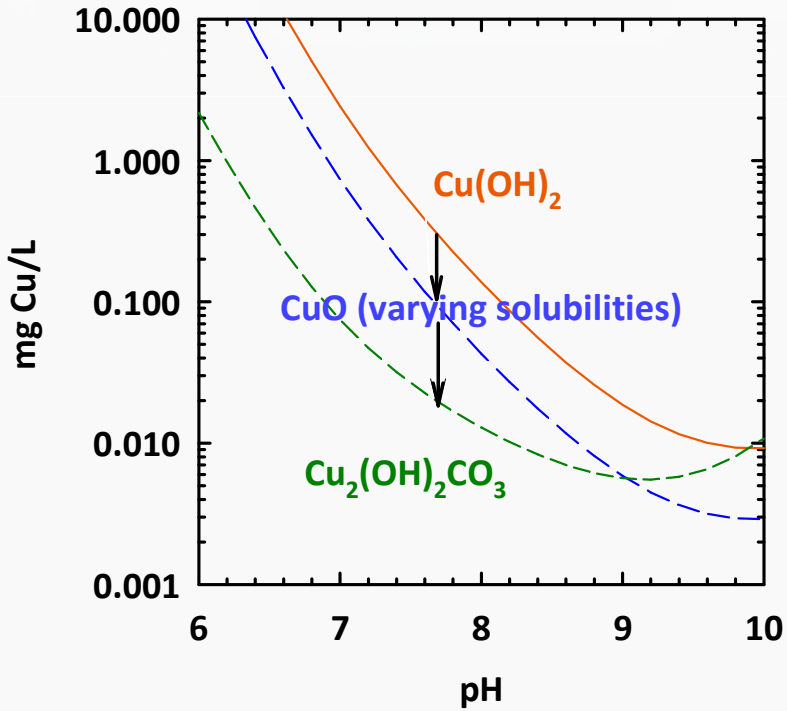


Copper Aging in High Alkalinity Water

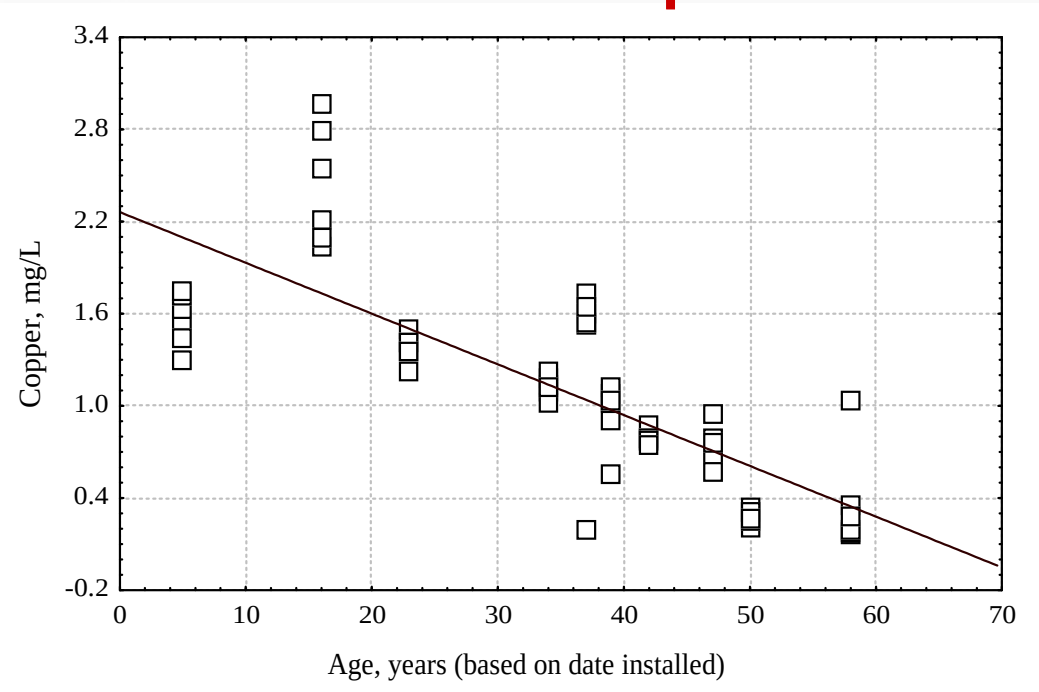
Copper Levels are Highest with New Plumbing

"Overnight Standing" samples

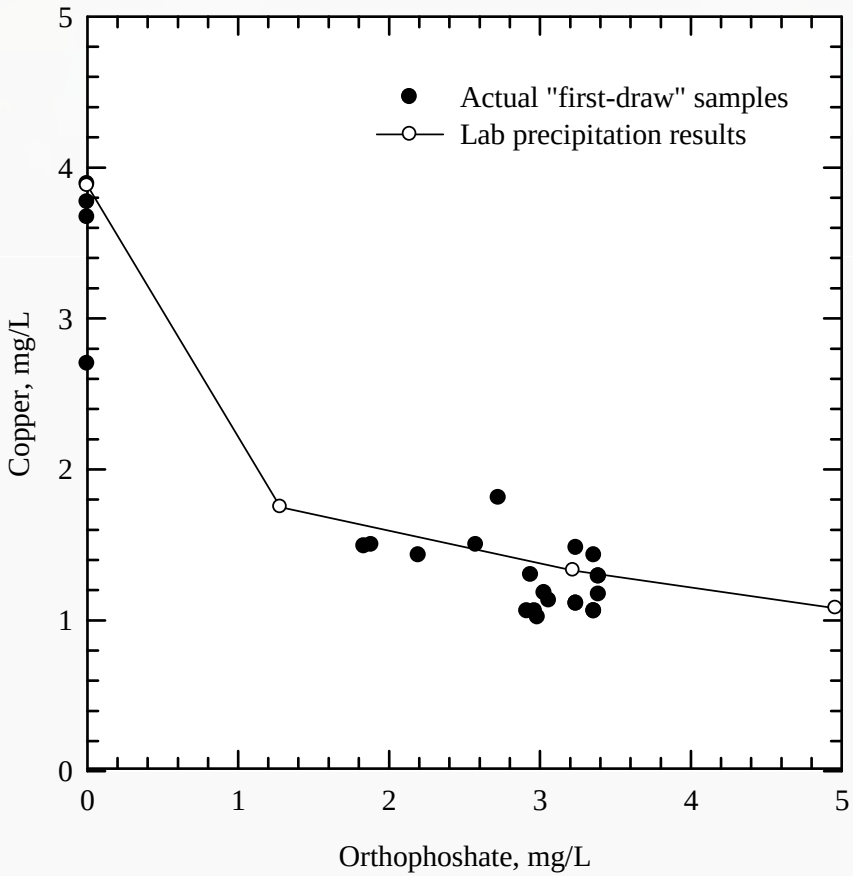
Theory…



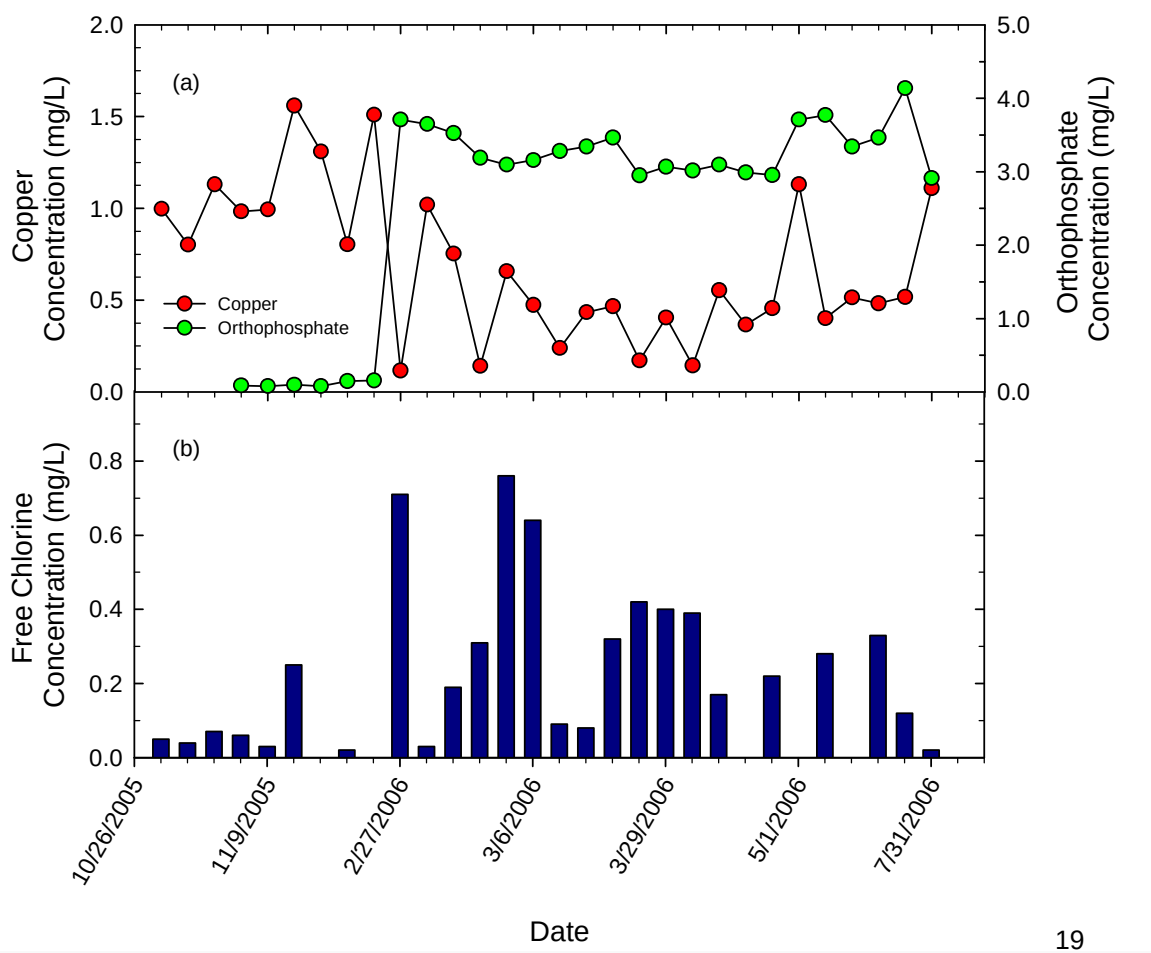
and "real world" practice!



Jar Tests in Predicting Copper Solubility

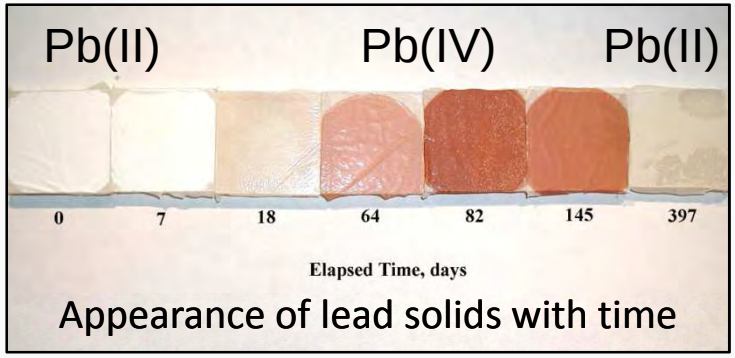


Impact of Orthophosphate on Copper and Chlorine Residual

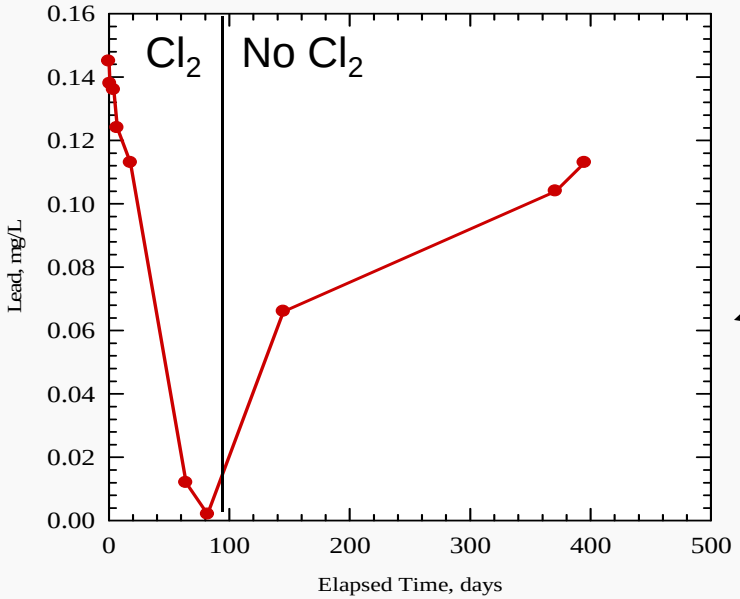


Corrosion Studies

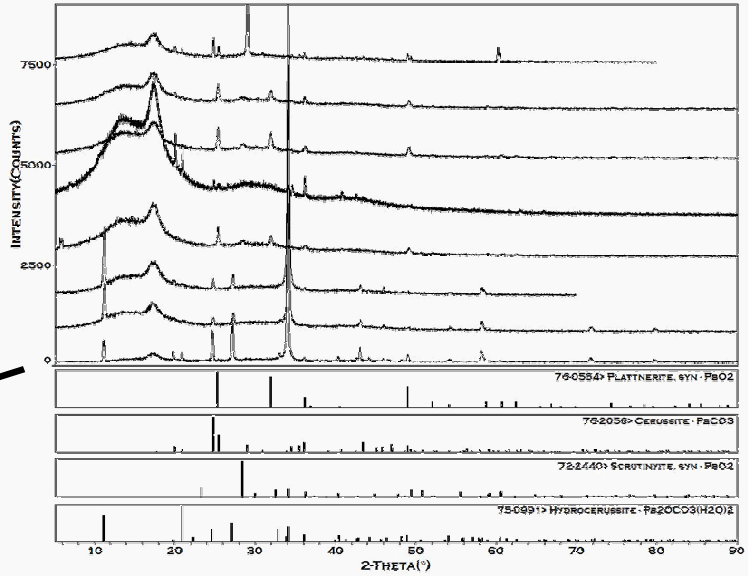
Lead Aging Study



Appearance of lead solids with time

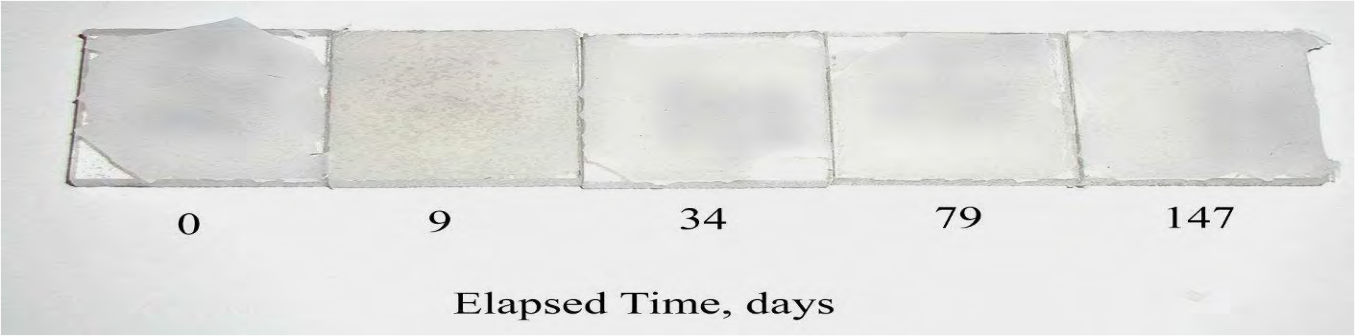


Mineralogy of lead solids with time with 3 mg/L starting Cl_2

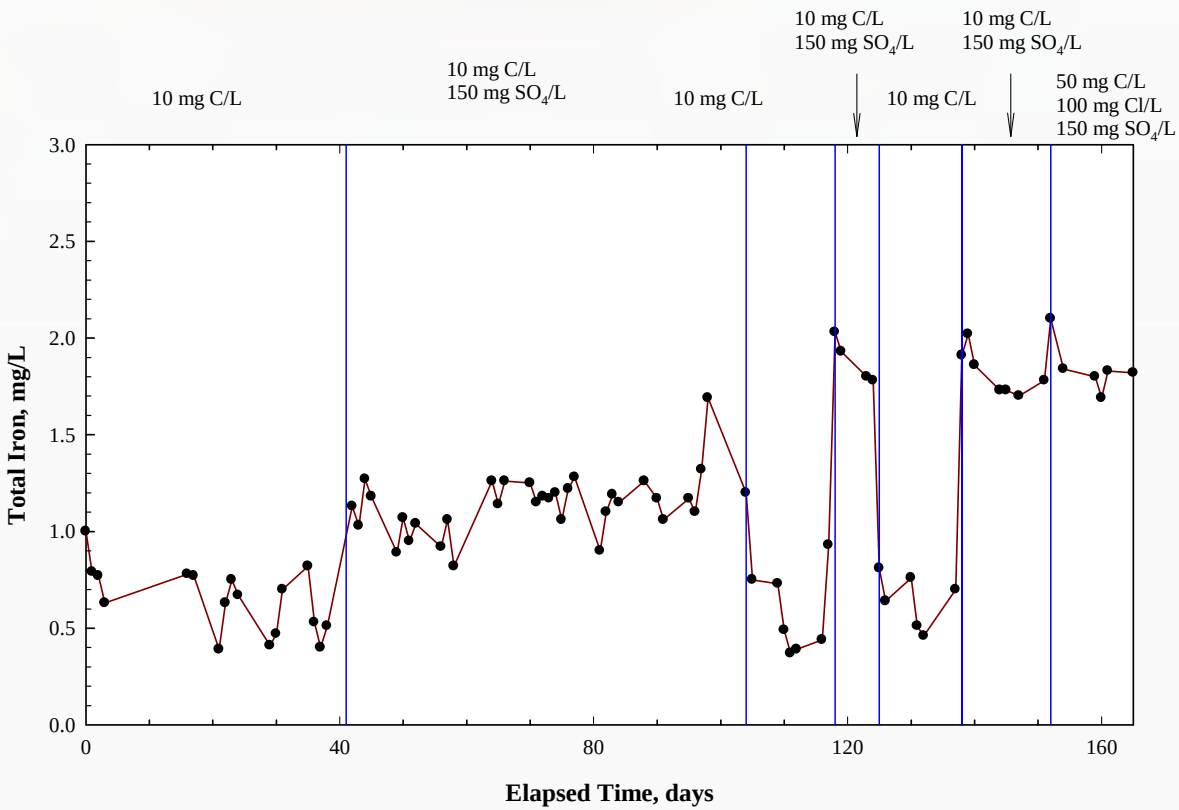


Orthophosphate Addition

- No oxidation state or phase change was observed over the aging period
- XRD identified pyromorphite (Pb(II)) as the only detectable phase
- Pyromorphite and other Pb(II)-phosphate compounds have relatively low lead solubility as compared to other Pb(II) phases (i.e.,cerussite)
- However, these Pb(II)-phosphates are stable only under a narrow pH range



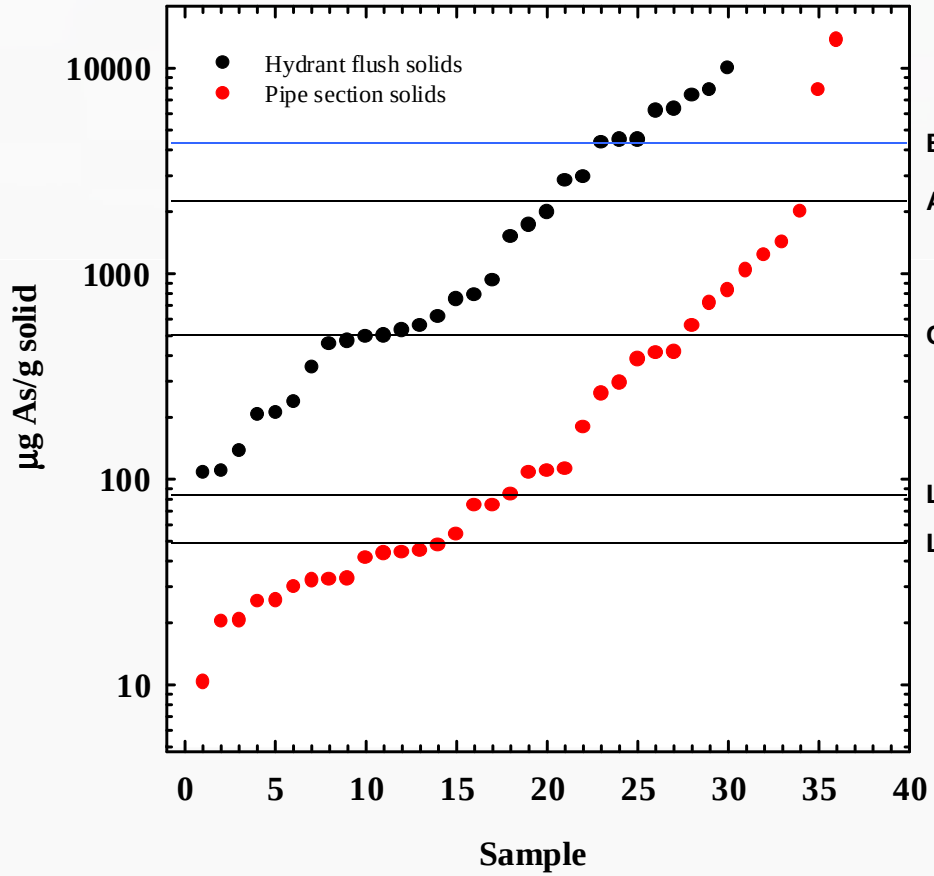
Iron Corrosion and Release



Iron Release

Conclusion: Sulfate and chloride can increase iron release, but they are not additive

Arsenic Accumulation in Distribution System Solids



Backwash solids (ave., 56 samples)

Adsorption media (ave., 28 samples)

California definition of hazardous waste

Land Disposal Limit, Dedicated Land Disposal sites

Land Application of "clean sludge"

Arsenic Demonstration Program

- Treatment systems have been installed and operated at 50 sites across the nation
- Focused on commercially-ready technologies or engineering approaches
- Developed performance, operation, and cost information for regulators and communities
- Characterization of the residuals and their disposal
- Impacts on the distribution system and water quality were studied

Summary and Conclusions

Impact on Novel Treatment on Existing Infrastructure

- ✓ Planning must include the entire system

  (source → treatment → distribution → buildings → fixtures)
- ✓ Novel treatment and approaches to achieve net zero will be integrated with existing infrastructure for some time
- ✓ Water quality changes and their impacts must be anticipated
- ✓ Testing throughout the water system is needed to avoid unintended health consequences
  - Inorganic and organic contamination
  - Corrosion
  - Disinfection / microbial growth
  - Disinfection byproducts

Questions?