Leaching of Heavy Metals Due to Changing Disinfectant (AwwaRF 3107)




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Presentation Overview

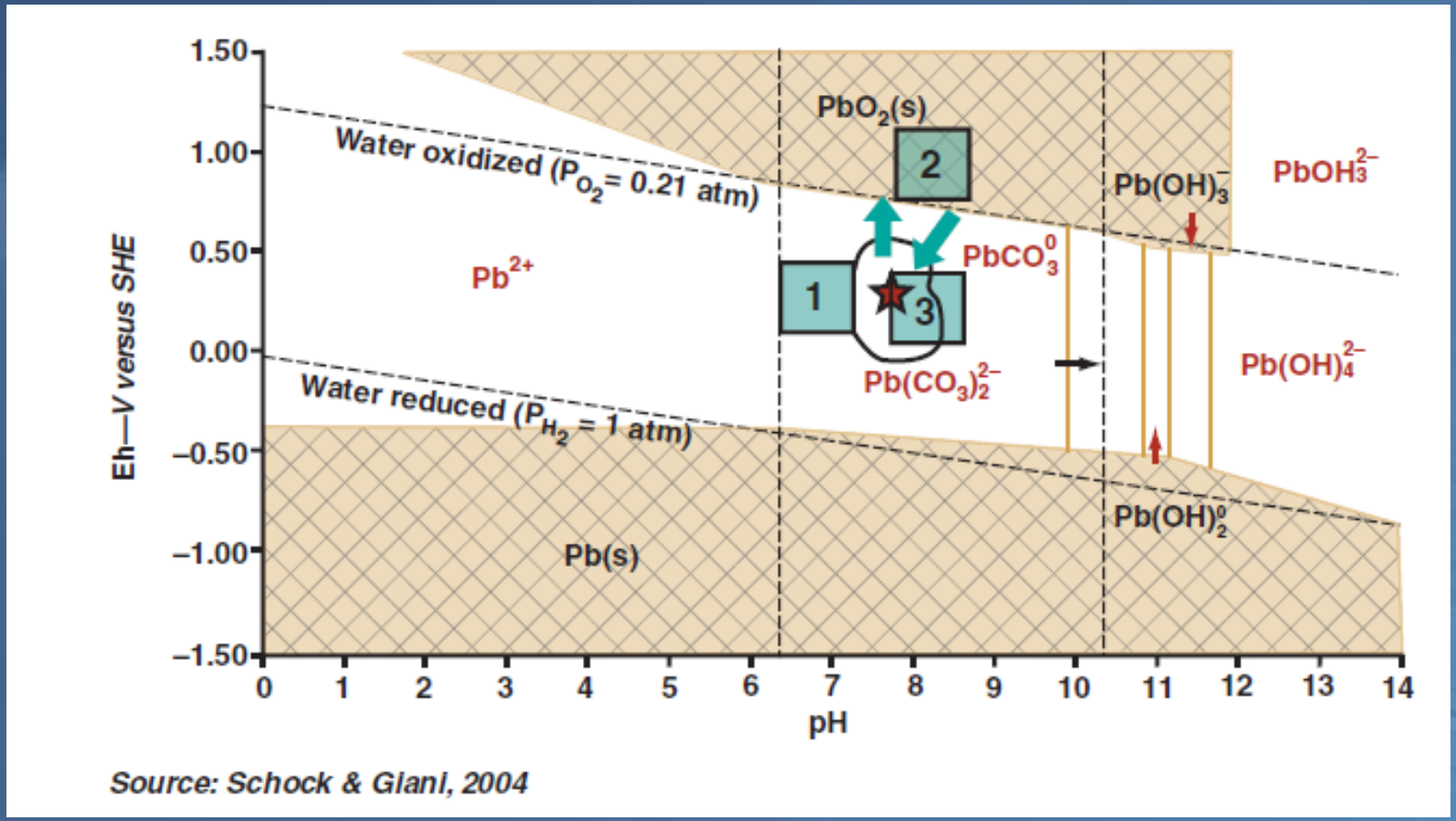
- Background
- Project/Presentation Objectives
- Experimental Methodology
- Results
- Conclusions
- Recommendations

Background

- The DCWASA experience
  - 2001 conversion to chloramines from free chlorine to reduce DBP formation
  - Elevated lead levels at customer taps observed between 2002 and 2004

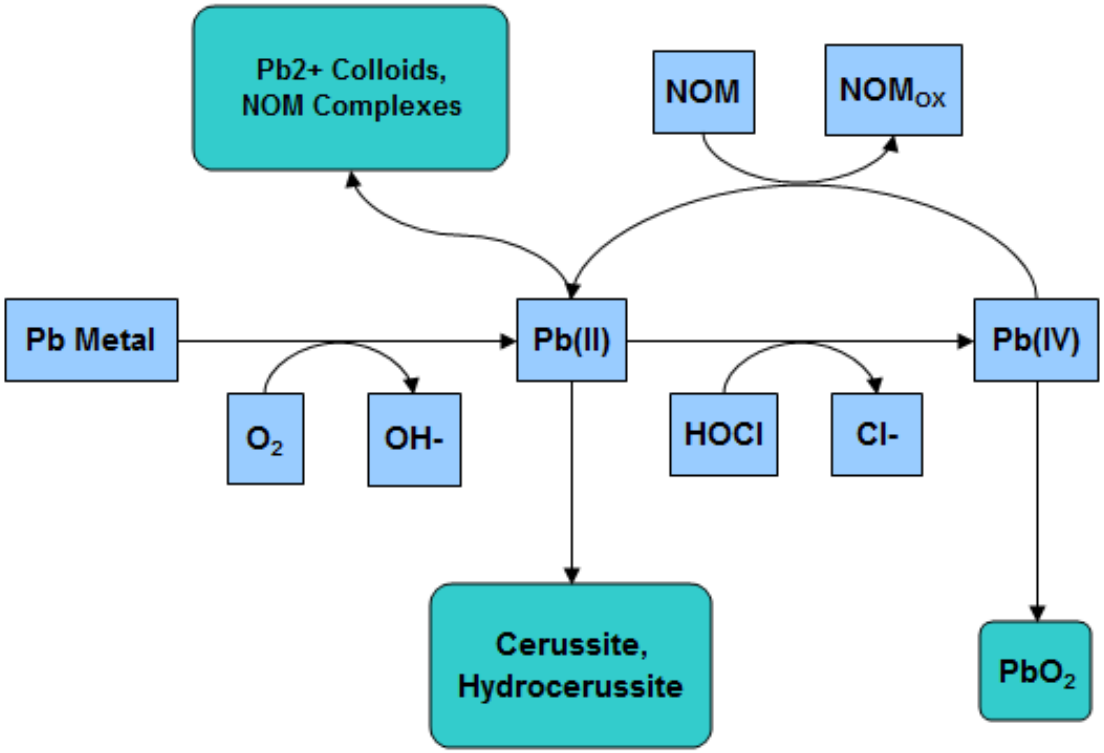
- Subsequent Investigations
  - Pb(IV) oxides observed in DCWASA service lines
    - Associated with high chlorine residuals and low operating pH (High ORP) conditions in mid-nineties
  - Suggested that Pb(IV) more critical to lead solubility than previously thought

Lead Re-dox Overview



Source: Schock & Gianl, 2004

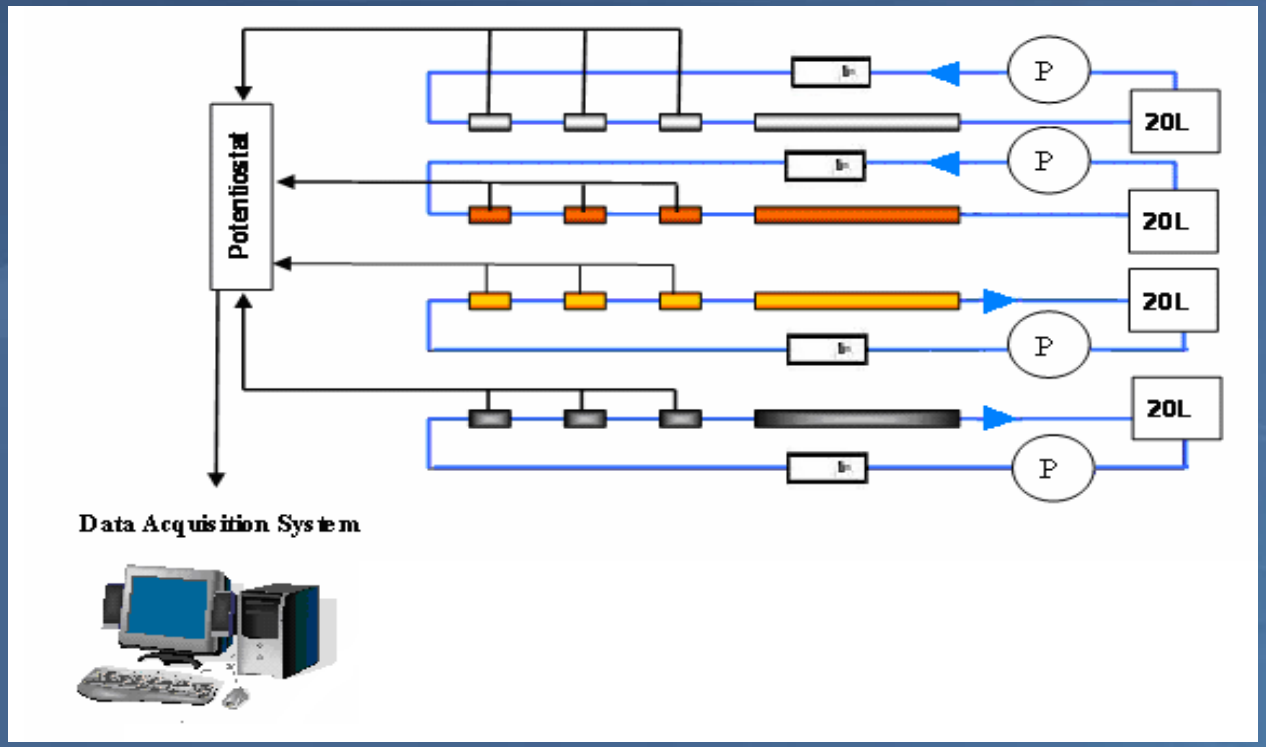
Lead Re-dox Overview



Objectives

- To examine corrosion process by measuring leaching rate and leaching levels from lead, brass, and copper distribution components in the presence of free chlorine and chloramines.
- To study effects of background water quality within the context of changing disinfectants.
- To provide practical guidance for utilities considering changing disinfectants

Pipe Loop Testing
HDR ARTC Facility



Lead – Fresh, unpassivated

Copper - New

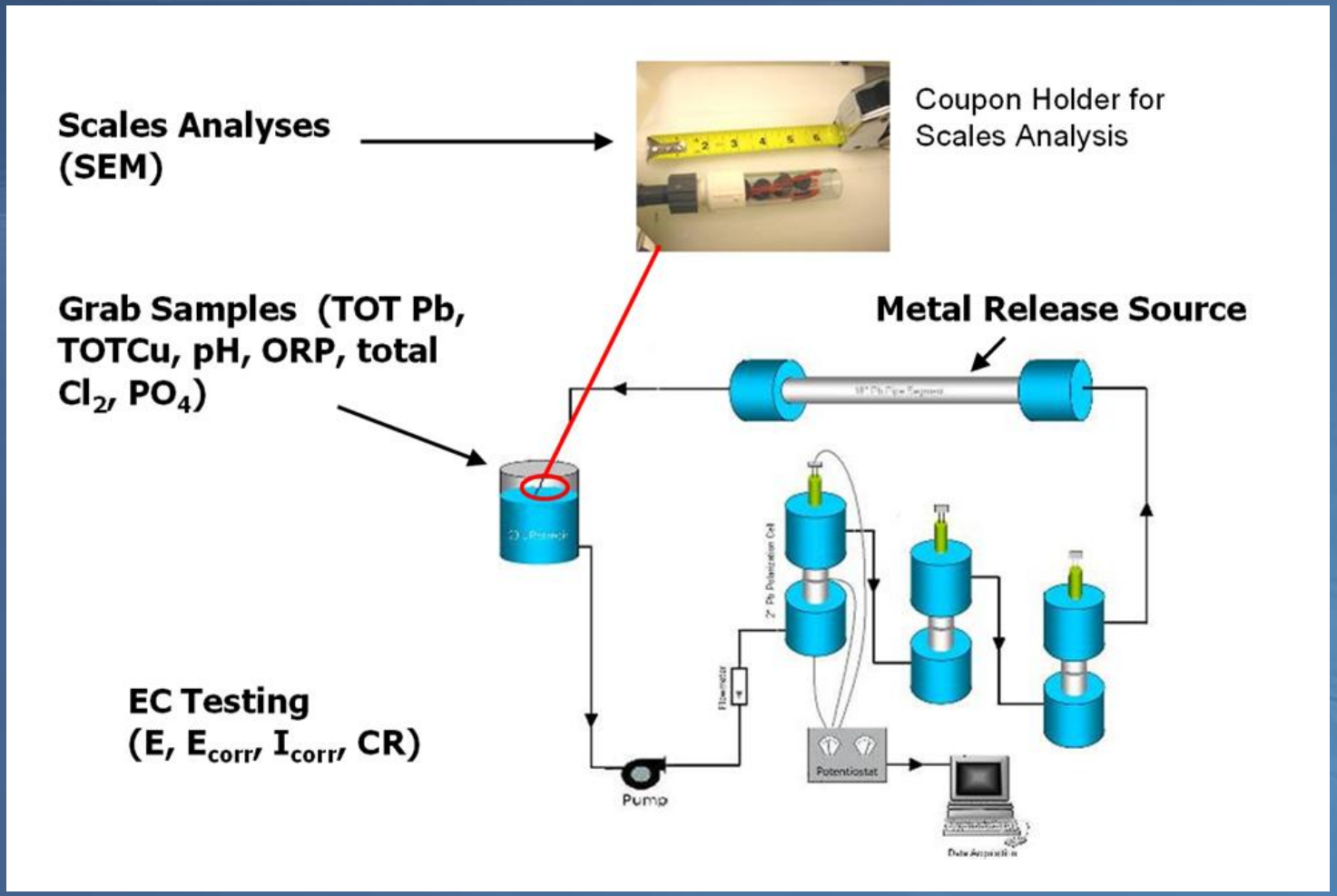
Bronze – New, UNS932, 8% leaded

Aged Lead – Passivated, ~50% PbO_2

Baseline Water Quality

Seattle Tap Water: pH 7.8-8.3, Alk=20 mg/L $CaCO_3$, T=23-25C, TOC=1 mg/L, Cl/SO_4=2-3, 0.8 mg/L Cl_2, no PO_4

Pipe Loop Apparatus



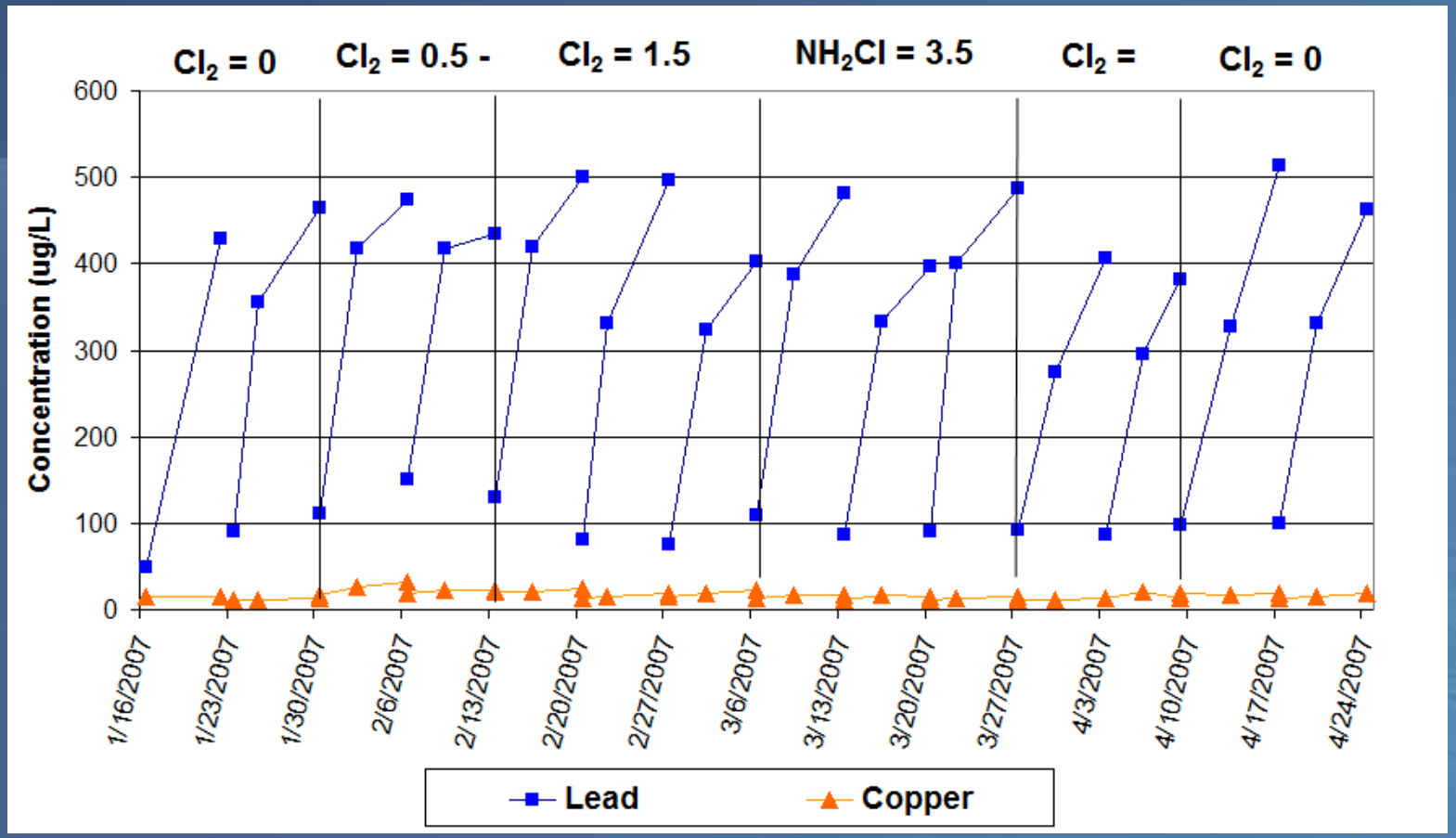
Pipe Loop Testing
Water Quality Sequences

Test No.	2007	Sequence of Water Quality Change						
1	1st Qtr	Dechld Tap	Dechld Tap	Cl_2	NH_2Cl	Cl_2	Dechld Tap	Dechld Tap
2	2nd Qtr	Dechld Tap	**alk↑**	Cl_2	NH_2Cl	Cl_2	**alk↓**	Dechld Tap
3	3rd Qtr	Dechld Tap	**pH ↓**	Cl_2	NH_2Cl	Cl_2	**pH ↑**	Dechld Tap
4	4th Qtr	Dechld Tap	**PO4↑**	Cl_2	NH_2Cl	Cl_2	**PO_4↓**	Dechld Tap

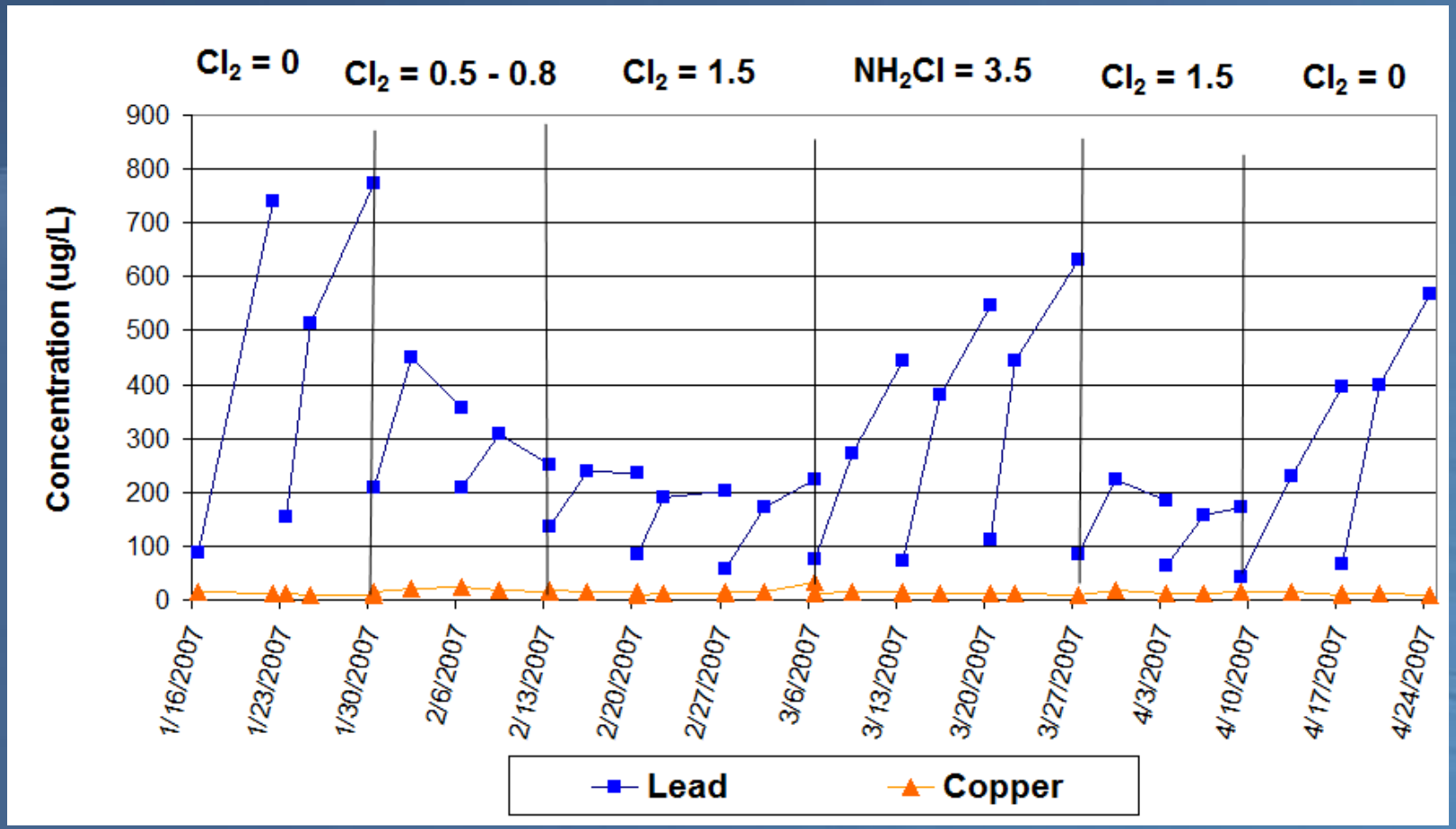
pH 7.8-8.3, Alk=20 mg/L $CaCO_3$, TOC ~ 2 mg/L, T=23-25C, TOC=1 mg/L, Cl/SO_4=2-3, 0.8 mg/L Cl_2, no PO_4


180
160
140
120
100
80
60
40
20

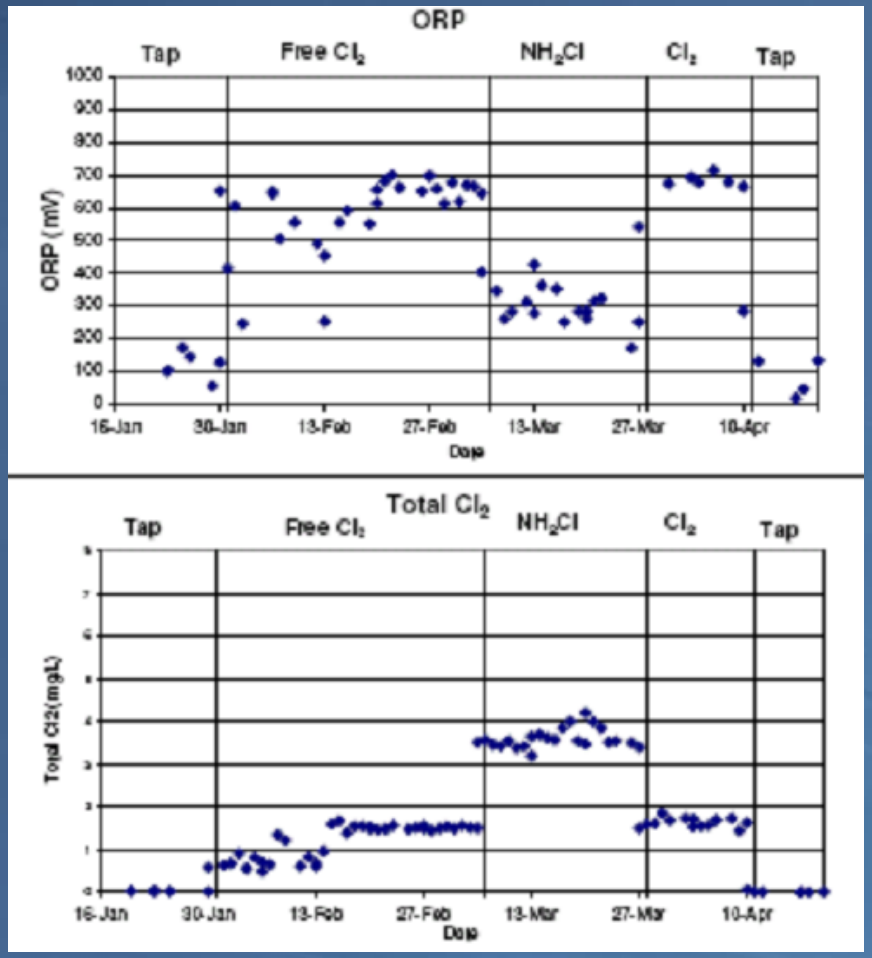
Results – Test 1, Unpassivated Lead



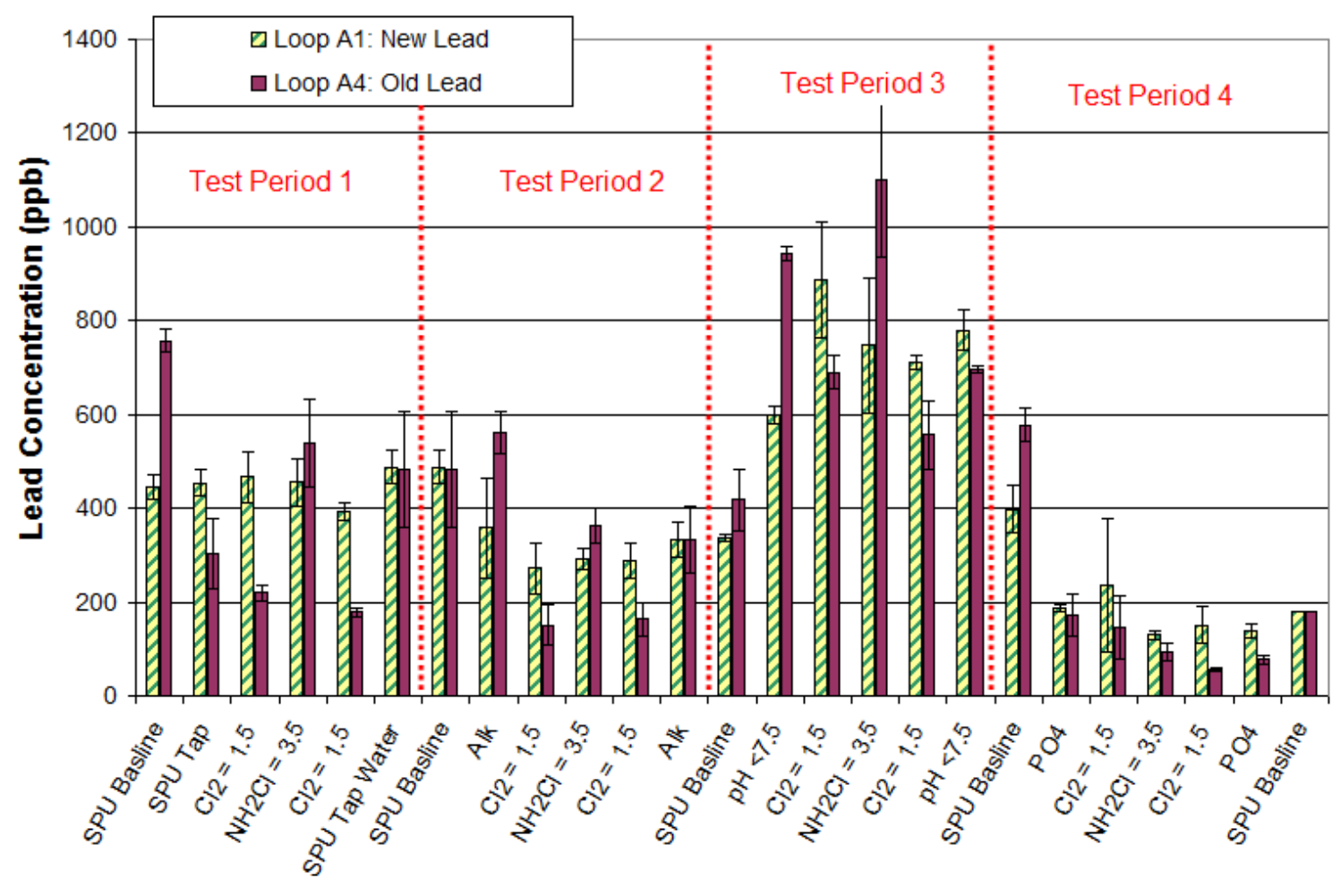
Results – Test 1, Aged Lead



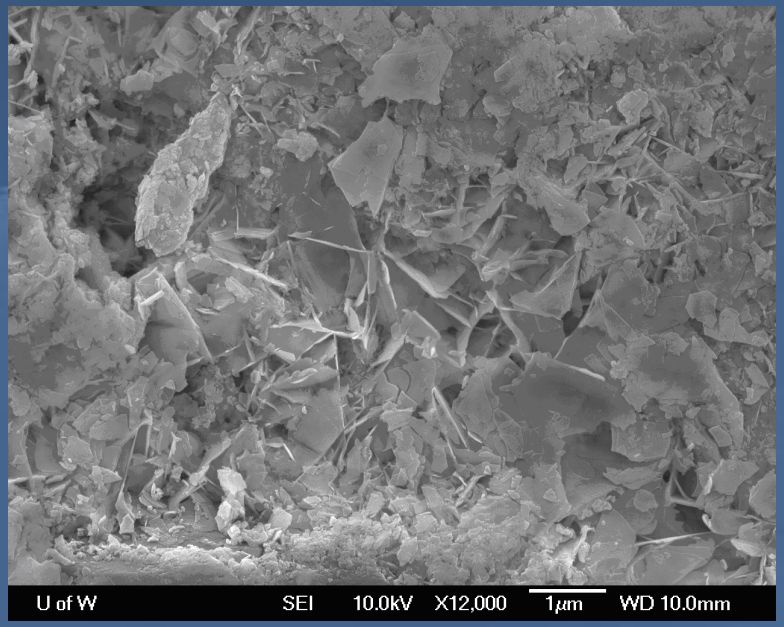
Results – Test 1, ORP Profile

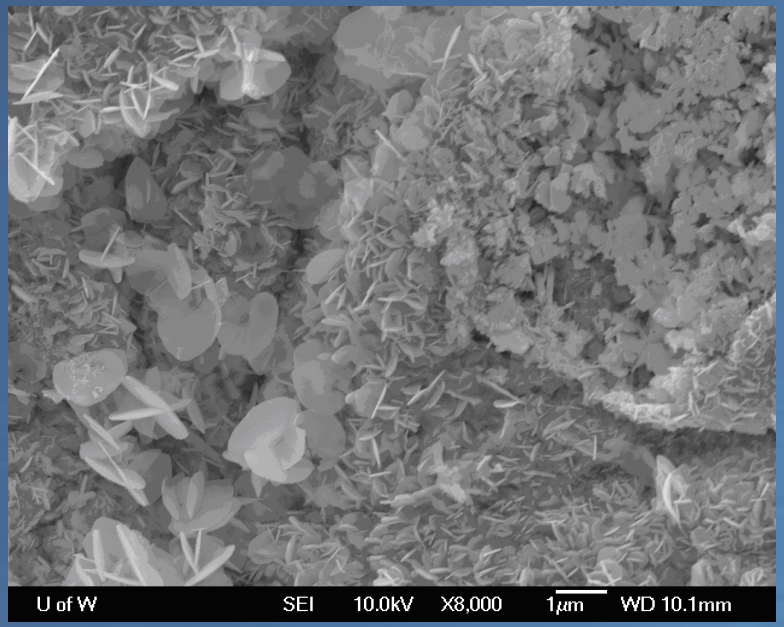


Results – Lead, Comparative Overview



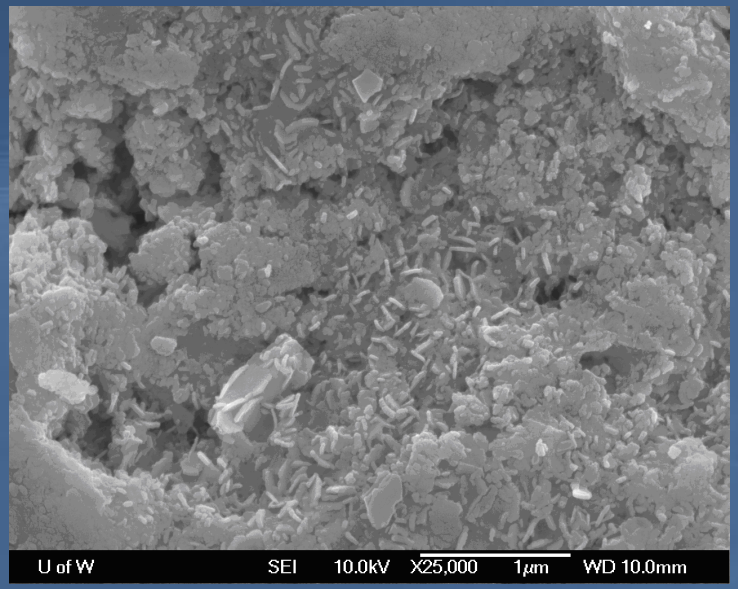
Results – New Lead Corrosion Scale Phases

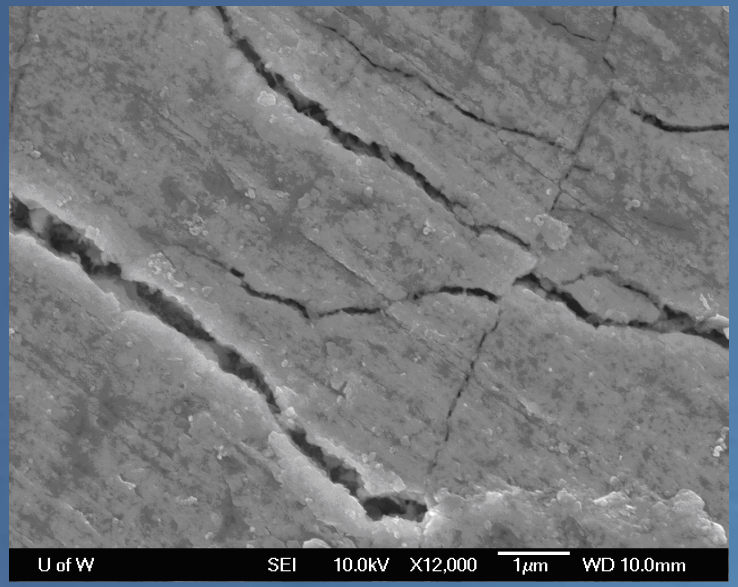




cerussite and hydrocerussite scales observed on unpassivated lead coupons after free-chlorine test periods

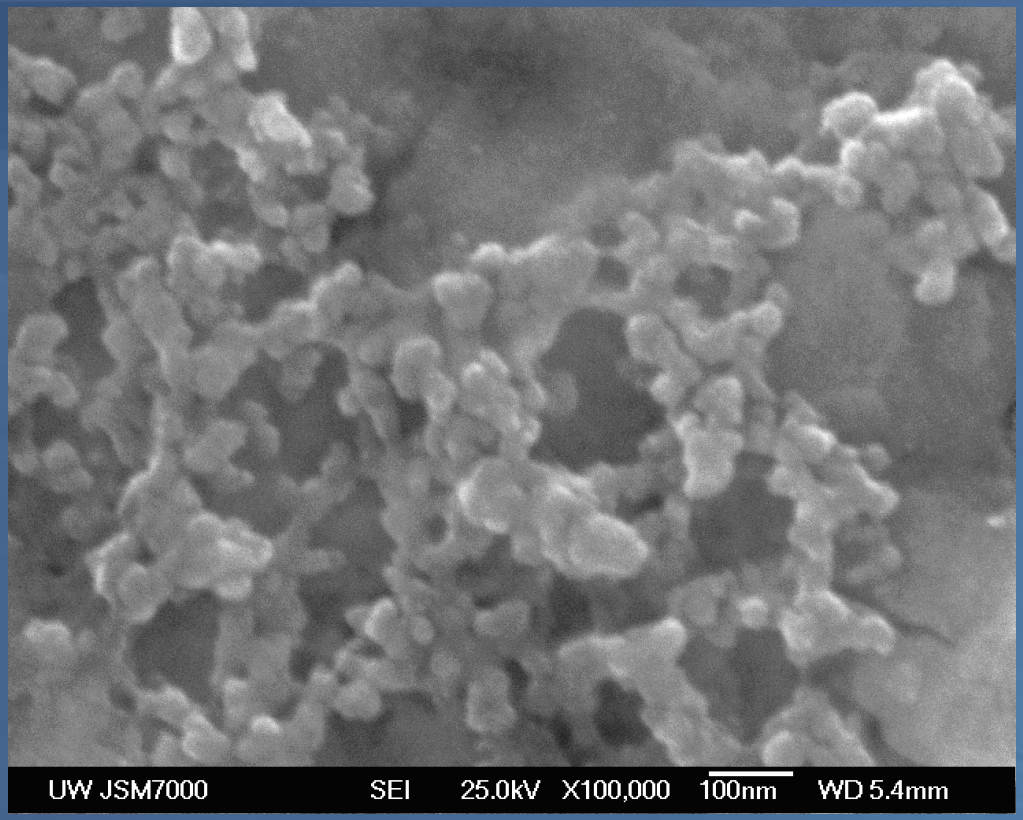
Results – New Lead Corrosion Scale Phases





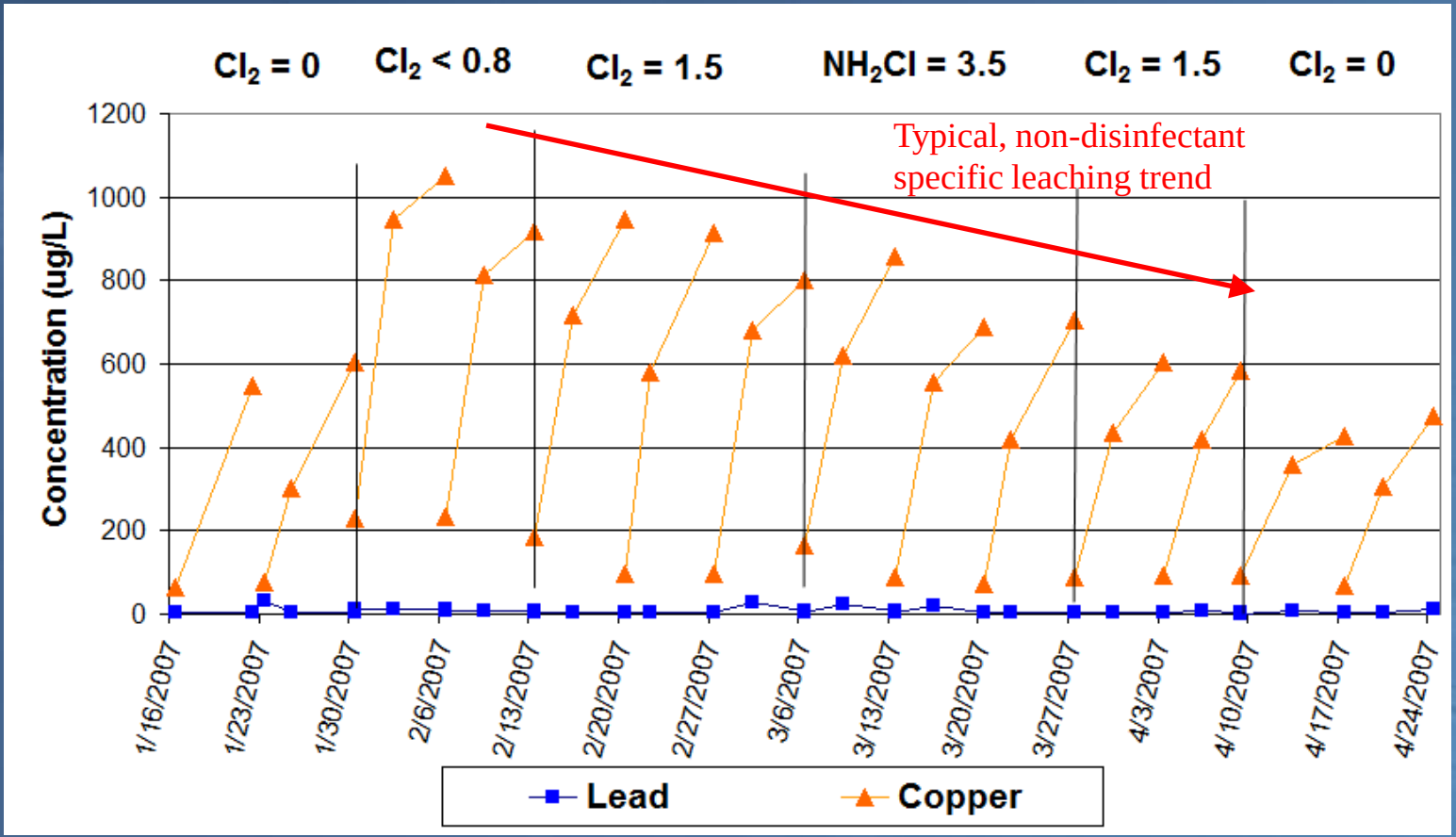
Amorphous material and film typical of coupons removed after chloramination

Results – New Lead Corrosion Scale Phases

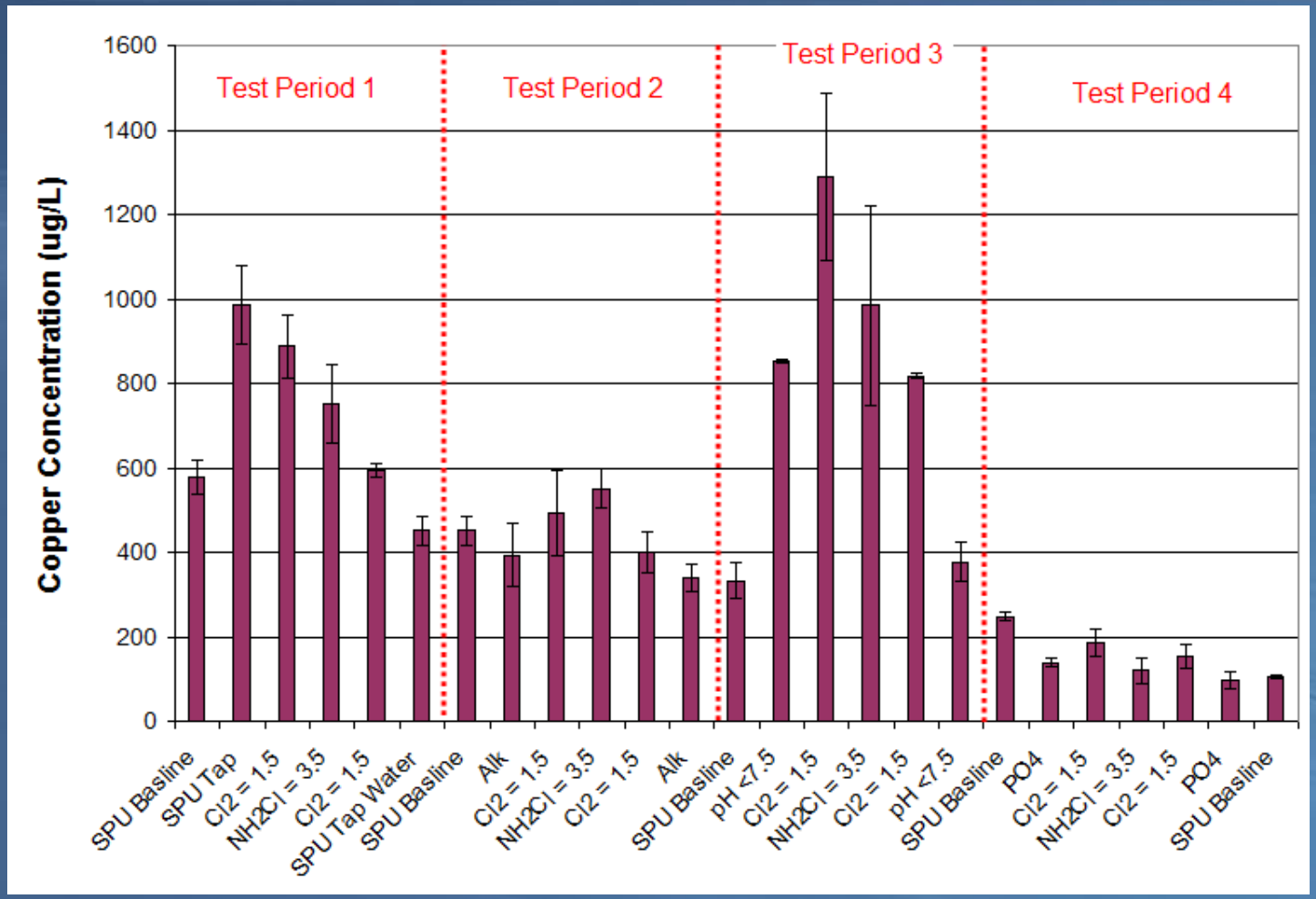


Dispersed PbO_2 observed after low pH/free chlorine test period

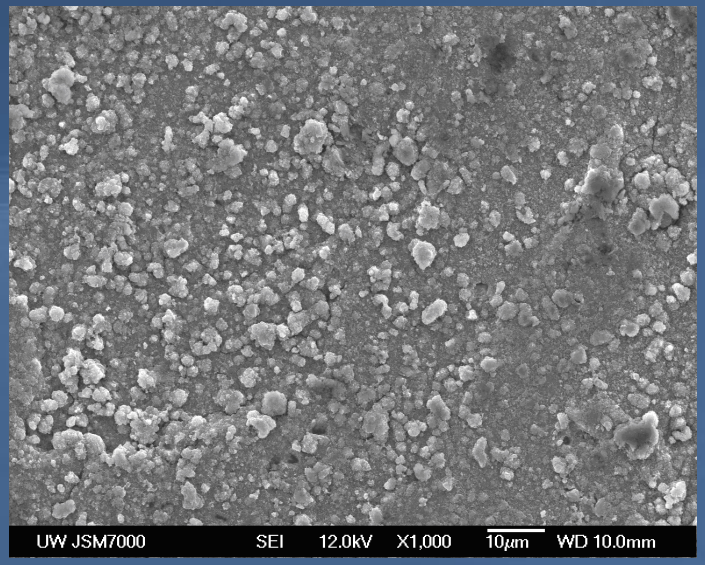
Results – Test 1, Copper



Results – Copper Overview

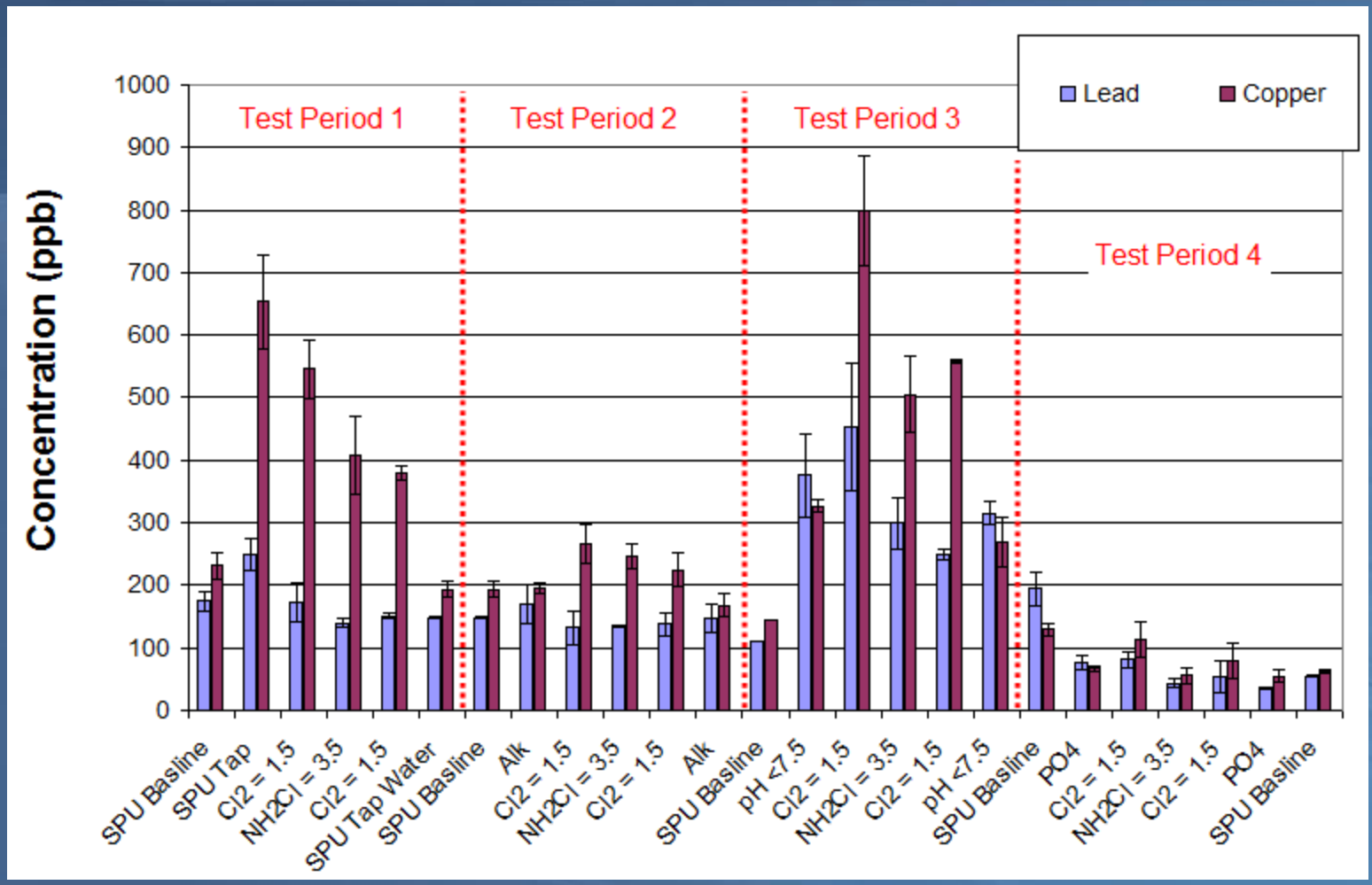


Results – Copper Scale Phases

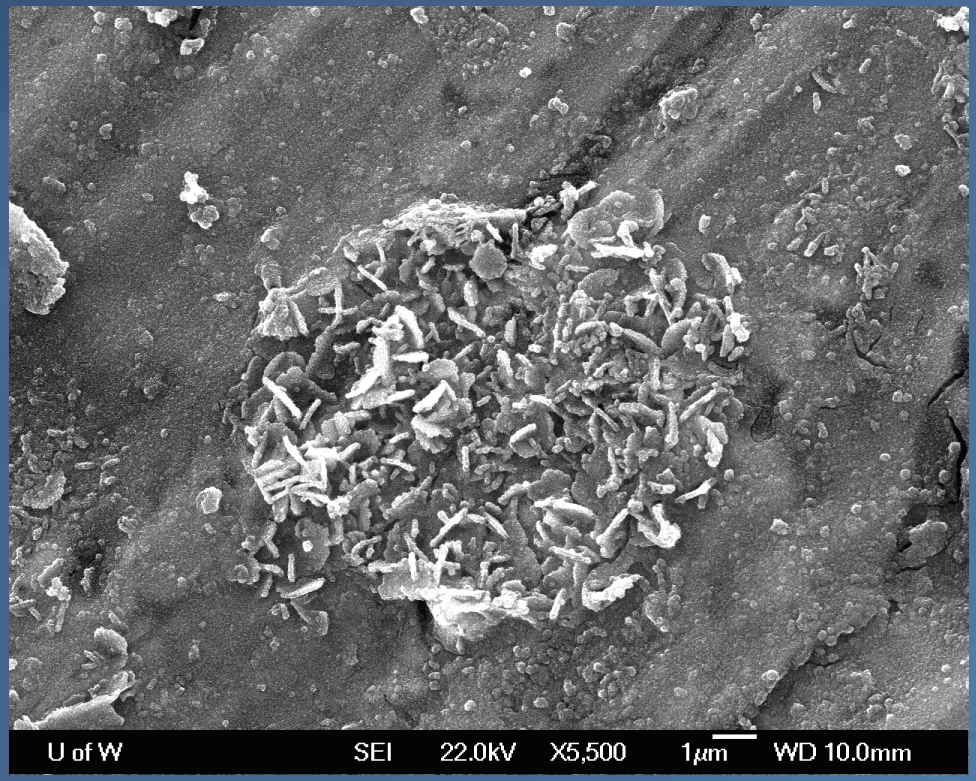


Typical cuprous oxide and films observed on copper coupons

Results – Bronze Overview



Results – Bronze Scale Phases



Typical discrete lead "islet" observed on bronze coupons

Conclusions

- **Switching from free chlorine to chloramines residual can potentially impact lead release in distribution system depending on existing conditions**
  - **Destabilizes existing Pb(IV) causing increased release**
  - **No notable effect where Pb(II) predominates**
- **High risk for increased lead release due to disinfectant change unlikely, unless:**
  - **Much lead and lead bearing components in system**
  - **History of very high ORP over extended periods**

Conclusions

- **No notable impact on copper release observed due to disinfectant change, but presence of disinfectant increases release**
- **Potential for Pb(IV)/Pb(II) release phenomenon associated with leaded bronze**
- **May degrade or cause films to appear on existing scales of any material, but no impact on metals release was observed**

Recommendations

Prior to implementing disinfectant change:

- Consider historical distribution system re-dox conditions
  - High free-chlorine residual (>2.5 ppm)
  - Low operating pH (< 7.2)
- Consider how much lead and LBM exist in distribution system
  - System age as possible indicator
- If historical data unavailable, examine scales on removed lead-bearing components

Questions

Thank You