Optimized Corrosion Control Treatment: Pilot-Scale Testing for Portland Water Bureau

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Just Add Water
2018 TACOMA PNWS-AWWA

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  - Danbi Won
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Why Was Pilot Testing Recommended?

- Confirm bench results
- Determine if more definitive CCT “leader” could be identified
- Use harvested materials with native scales

PWB Corrosion Control Treatment (CCT) Pilot Plant Trailer

PWB Lab Trailer

CCT Pilot Set-Up

- Four water quality scenarios
  - Current Bull Run (pH 8.2)
  - Moderate pH/Alk (8.6/40)
  - Hi pH/lower Alk (9.0/20)
  - Orthophosphate (0.75-1 mg/L P)
- 2 types of testing rigs

Four "material" rigs, each containing three materials harvested from DS

- Brass meters
- Galvanized pipe
- Joints of copper pipe with lead solder

2 PRS stations – 4 coupon chambers

- Lead
- Copper with lead solder
- Galvanized
- Brass

PWB CCT Pilot Trailer – Material Rigs

PWB CCT Pilot Trailer – Process Research Solutions (PRS) Stations

4-Chamber PRS Station

Caveats When Interpreting CCT Pilot Data

- No direct equivalency toward LCR compliance monitoring
  - **e.g., 20 µg/L pilot result ≠ 20 µg/L in distribution system**
- Cannot compare between rigs or materials– only within rig, for single material using different WQ endpoints
- Importance of Dissolved vs. Particulate
  - **Dissolved lead is result of uniform, galvanic, (and perhaps microbial) influenced corrosion**
  - **Particulate lead associated with release of scale due to hydraulic disturbance, change in water quality, etc.**

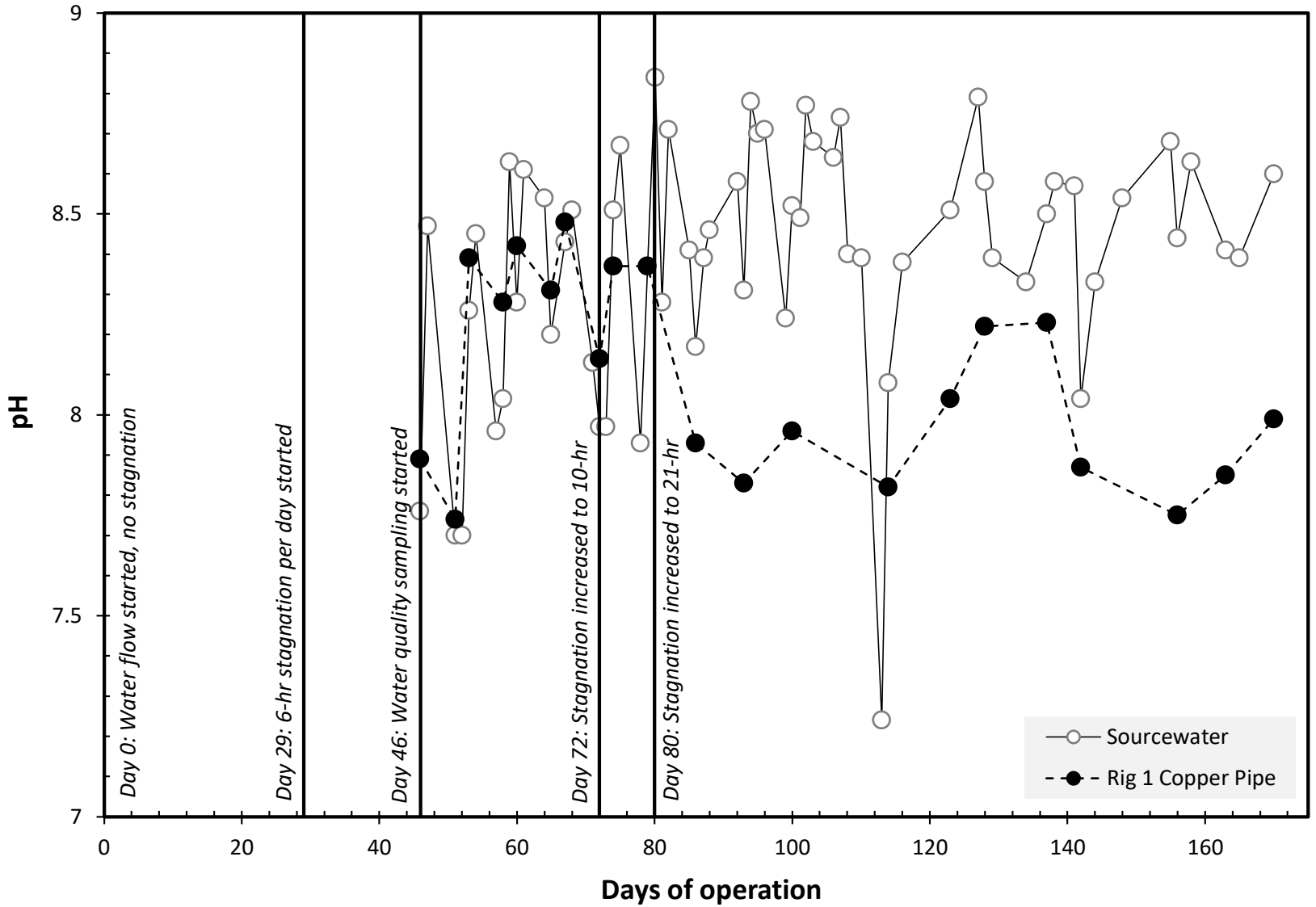
A Long Story Made Short….

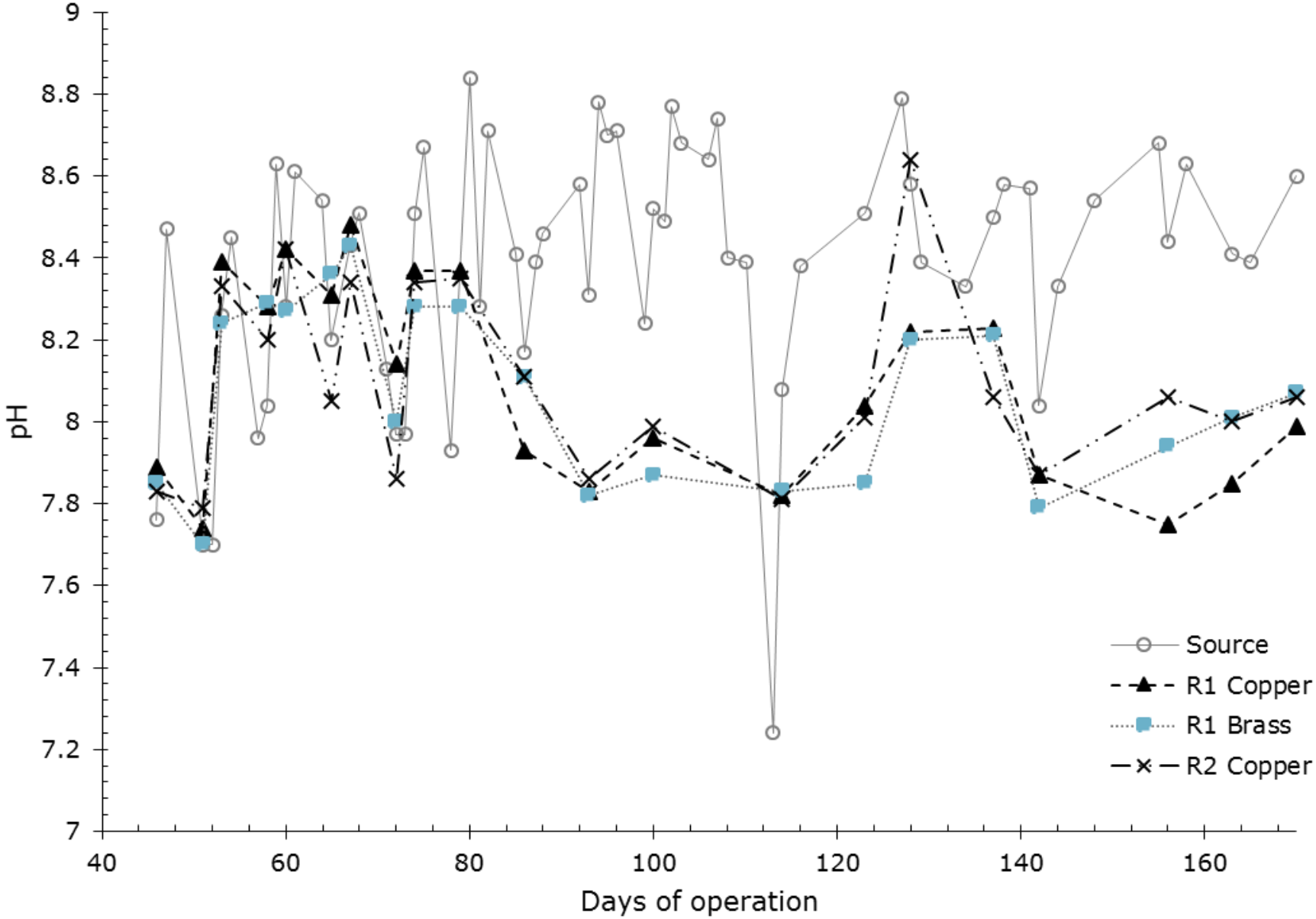
- Testing Condition
  - **Originally pH 8.0 leaving LHTF previous to project**
  - **Raised to pH 8.2 leaving LHTF at onset of project**
- pH Reaching Site was Greater than Expected and Increased Over Time
  - **Actual pH at pilot POE was much greater (~8.5) instead of 8.2**
  - **Chemical feed not practical (or necessary?)**
  - **Down-side (variable data, very low alkalinity/DIC, other….)**
  - **Increased stagnation period to ‘force’ lead release**

Filtration!

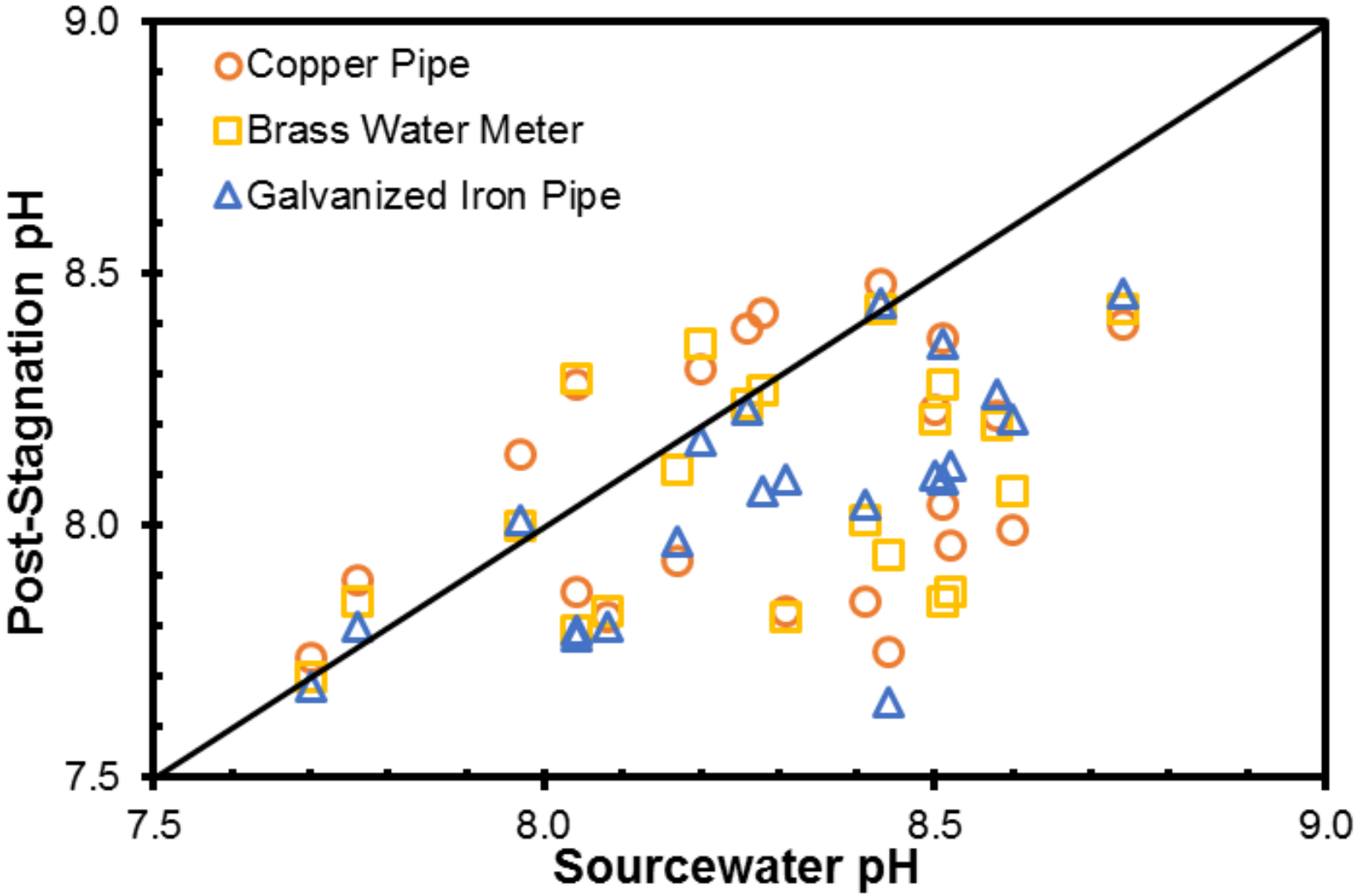
2 Summary of Findings

Source water vs. Rig 1 Cu/Pb Solder Stagnation pH




9
8.8
8.6
8.4
8.2
8
7.8
7.6
7.4
7.2
7
pH
40
60
80
100
120
140
160
Days of operation
Source
R1 Copper
R1 Brass
R2 Copper

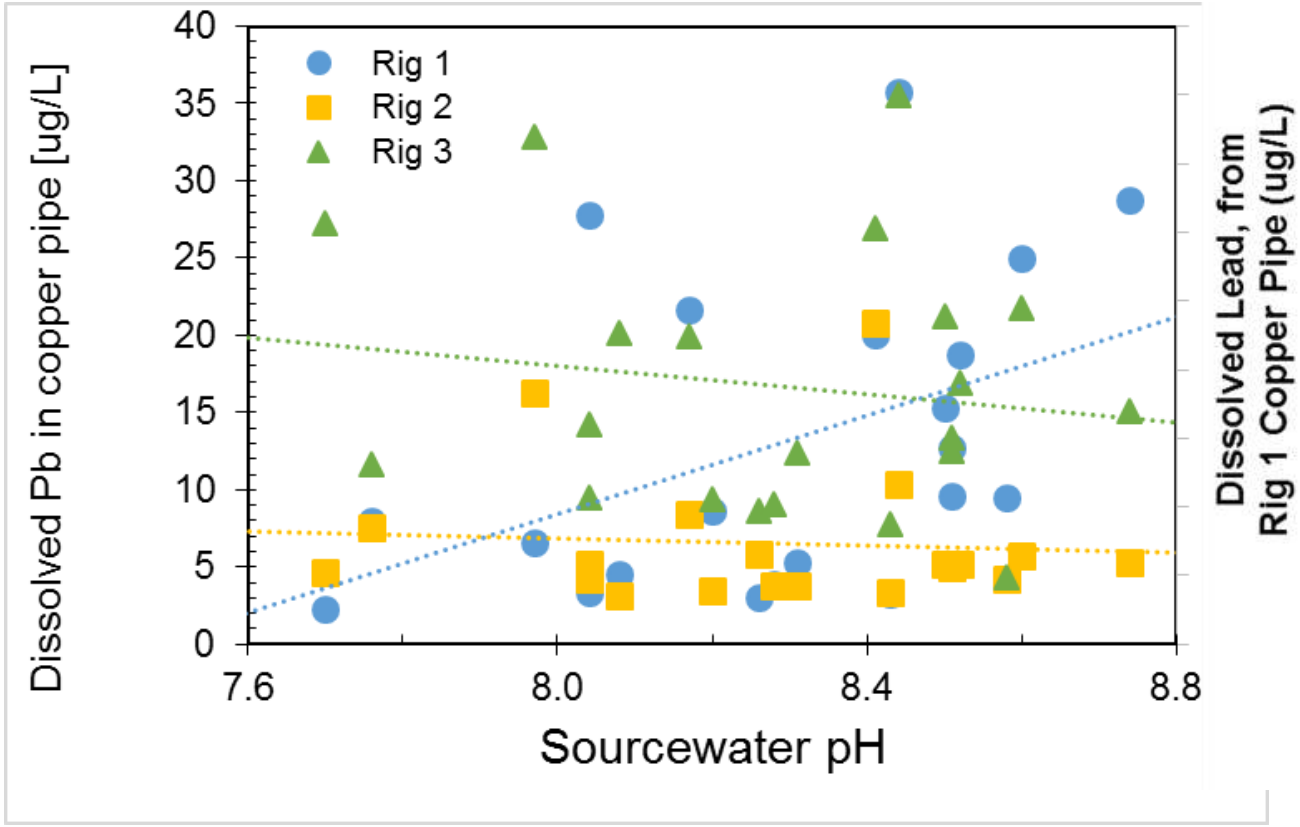
Impact of Stagnation on pH

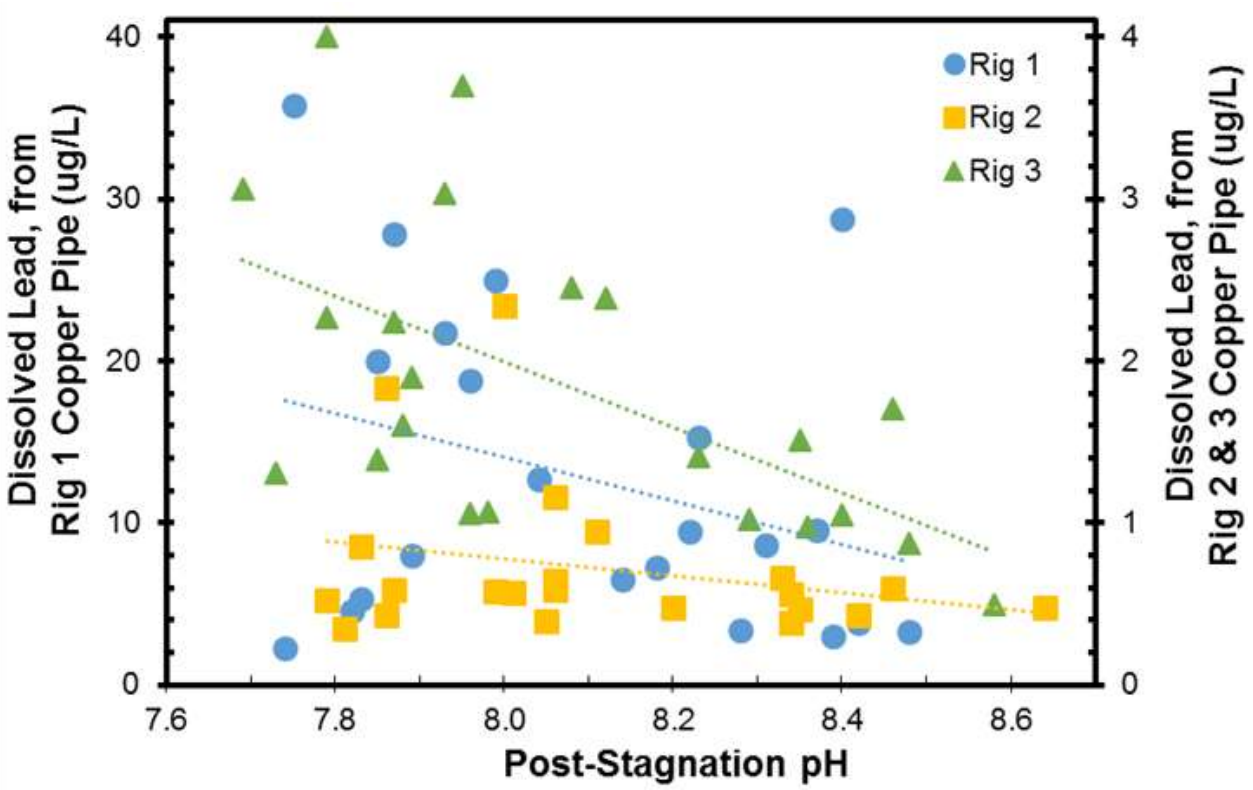


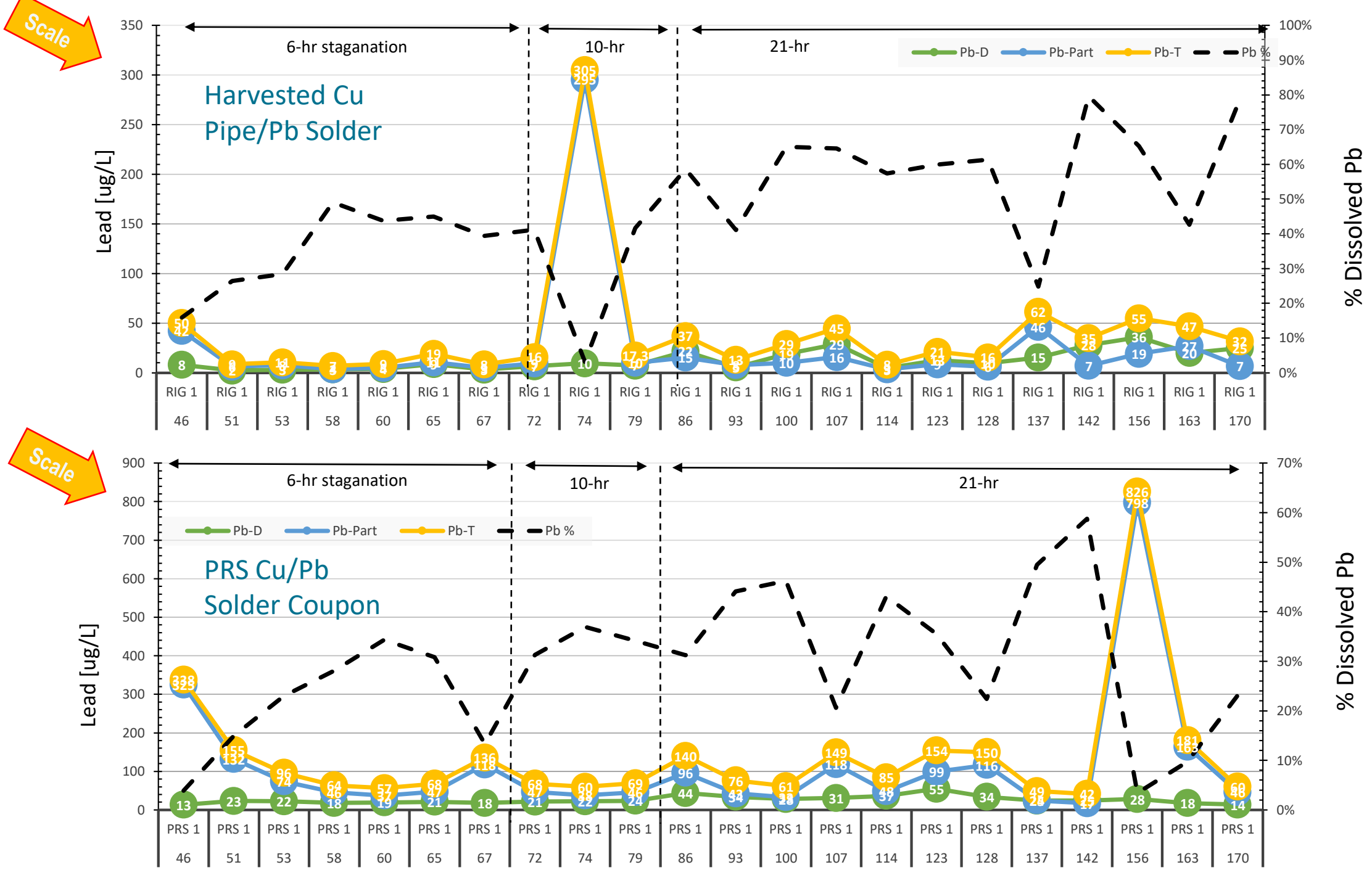
Bigger Picture Thoughts:

- Demonstrates limitations of WQP monitoring
- No way to pair/know residential tap pH conditions associated with LCR results
- Especially important in poorly-buffered waters

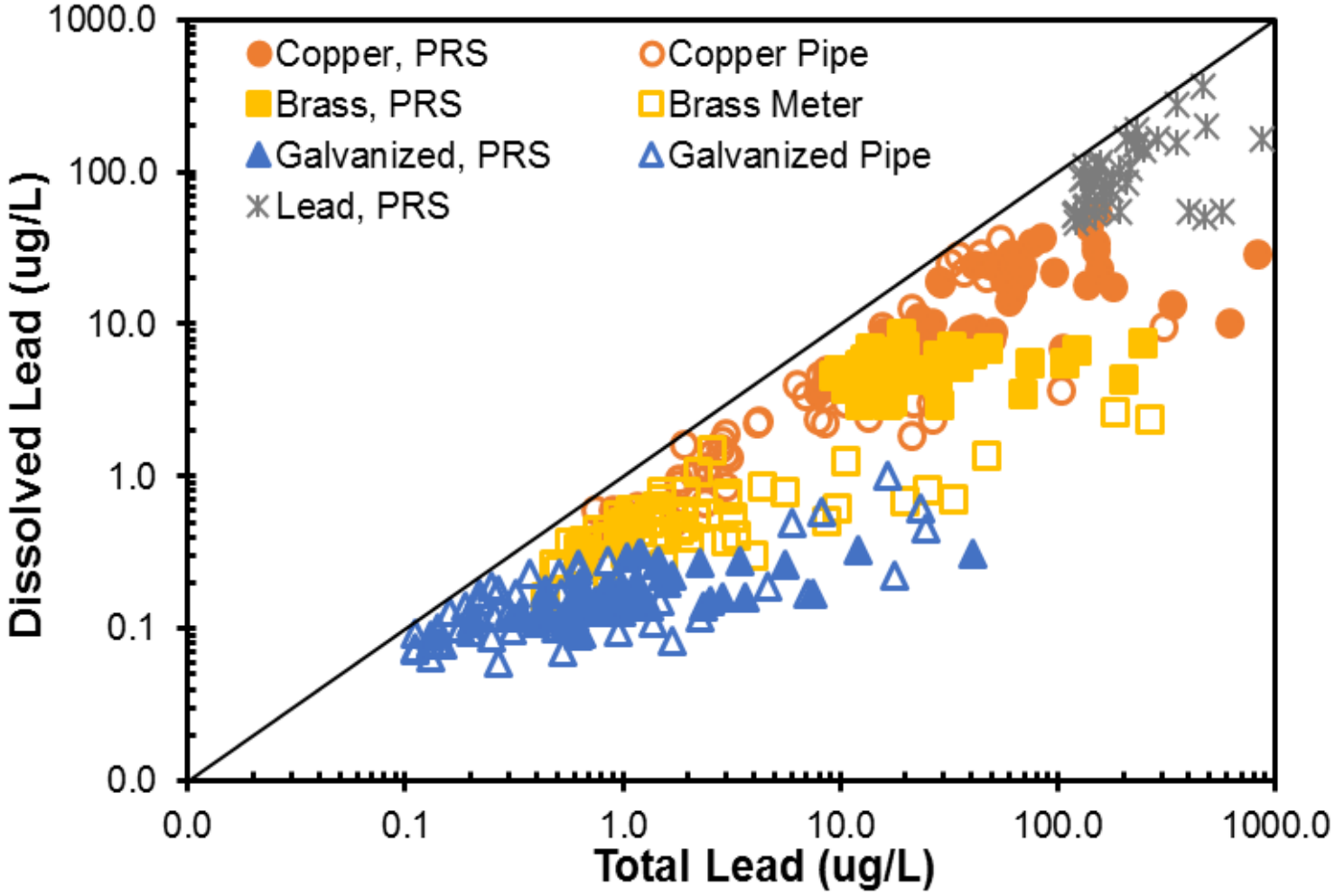
Impact of pH on Lead (harvested copper pipe with lead solder)



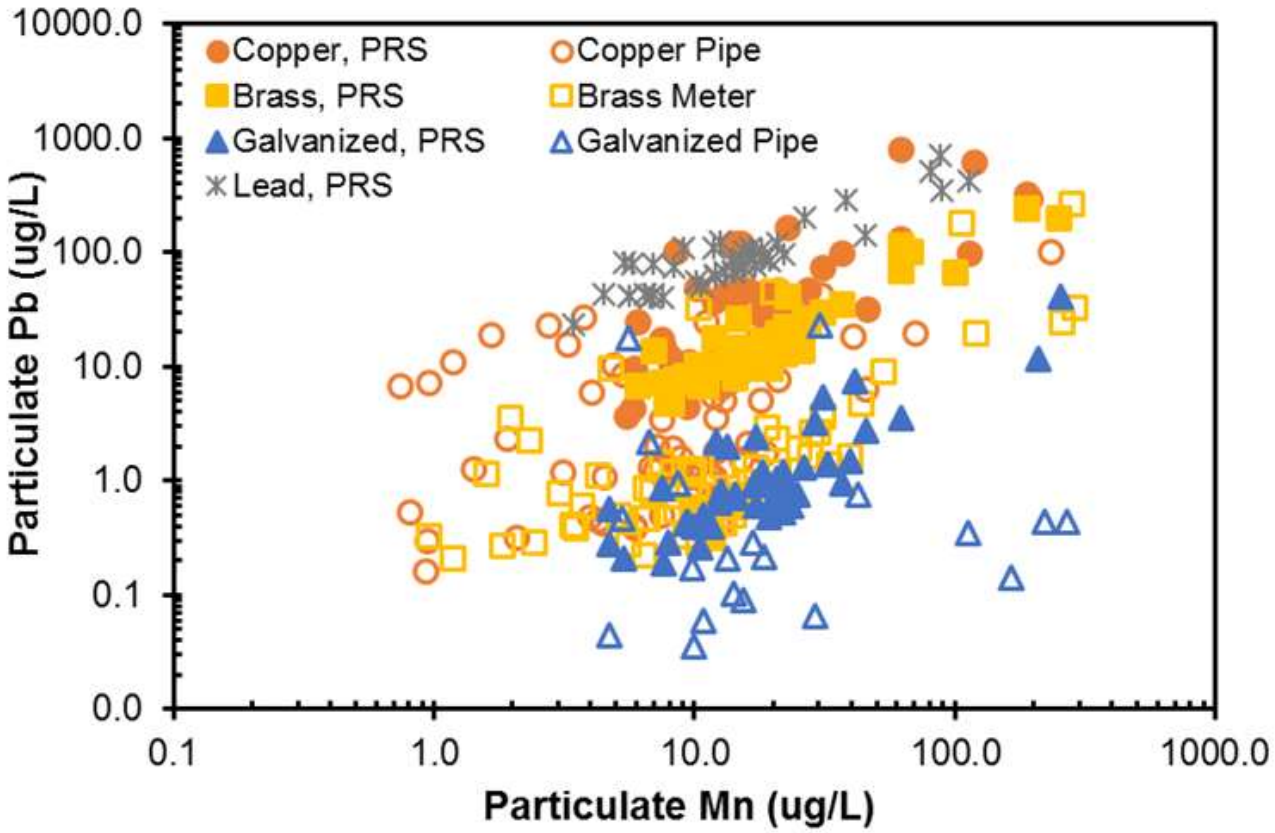


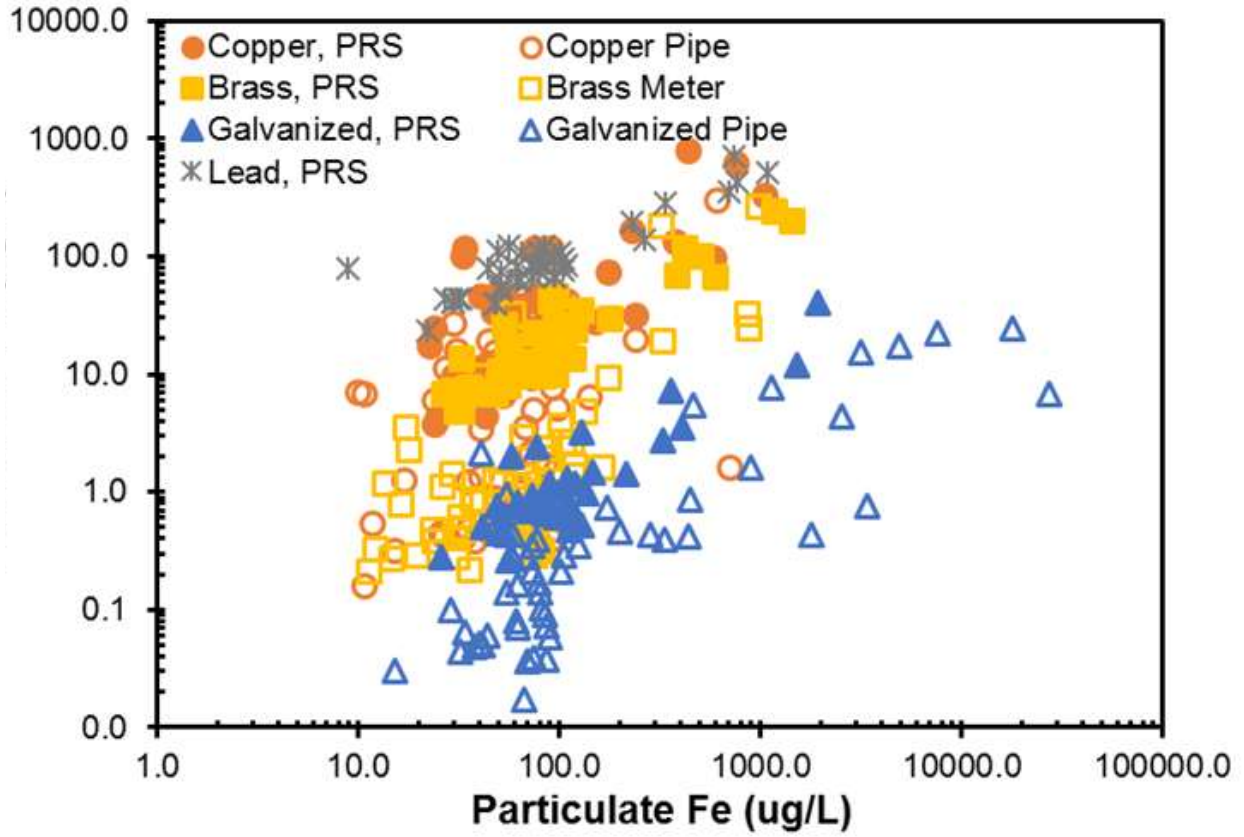

Scale
6-hr staganation
10-hr
21-hr
Pb-D
Pb-Part
Pb-T
Pb %
Harvested Cu
Pipe/Pb Solder
Lead [ug/L]
% Dissolved Pb
RIG 1
46
51
53
58
60
65
67
72
74
79
86
93
100
107
114
123
128
137
142
156
163
170
Scale
6-hr staganation
10-hr
21-hr
Pb-D
Pb-Part
Pb-T
Pb %
PRS Cu/Pb
Solder Coupon
Lead [ug/L]
% Dissolved Pb
PRS 1
46
51
53
58
60
65
67
72
74
79
86
93
100
107
114
123
128
137
142
156
163
170

Samples dominated by particulate lead



Particulate Metals: Lead vs. Manganese and Iron





Pb MRL = 0.05 ug/L

Mn MRL = 0.5 ug/L

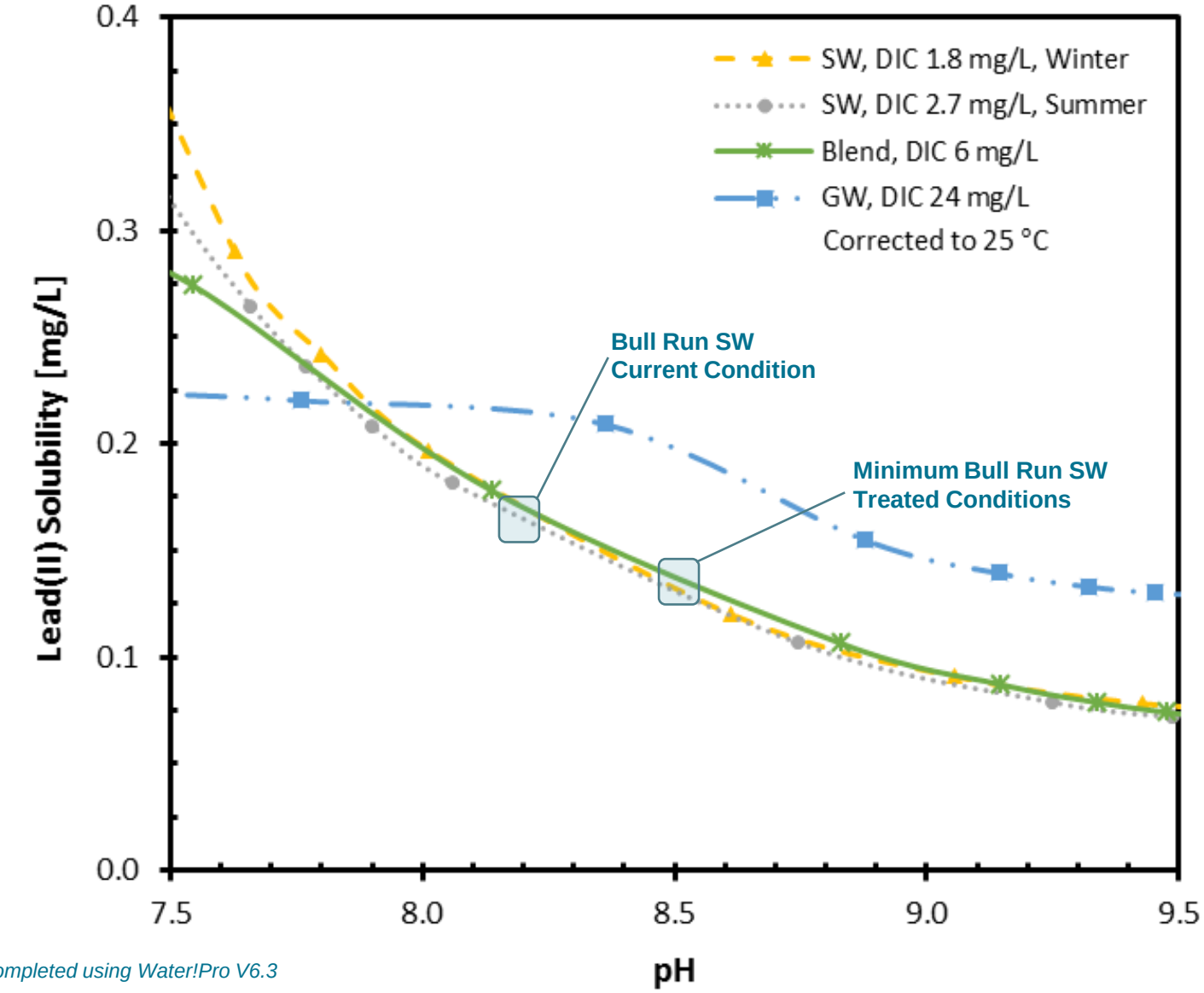
Findings

- Expected Variability Between Materials
- Site conditions allowed for “passive” testing of moderate pH conditions
  - Approximately pH 8.5-8.6
  - Very low DIC water (no Alkalinity addition)
- Lead release typically >50% particulate
- Particulate release correlated with other metals, indicating scale disturbance/release
- Dissolved lead controlled primarily by end of stagnation pH
- Results Support Bench-Scale Tests
  - Moderate pH control suppresses Pb release in all materials
  - pH reduction with increasing stagnation period
- Acclimated PRS stations provide useful tool to understand metals release

3 Recommendations

Interim Pre-Filtration CCT Recommendation (IPF-CCT)

- pH ≥ 8.5 throughout distribution system
- Alkalinity ≥ 25 mg/L $CaCO_3$
  - Increase buffering capacity
  - Increase DIC



Data from modeling completed using Water!Pro V6.3

4 Next Steps

Chemical Selection and Location

- Completing evaluation of pH/alkalinity adjustment options
- To be located at Lusted Hill
- Submit IPF-CCT Report to State
- Design and construct
- Online in 2022

Determine CCT for Filtered PWB Water

- Use of coagulants and potential impacts on galvanic corrosion
- Removal of Natural Organic Matter (NOM)
  - Impacts on metals solubility and biostability
- Changes in disinfection strategies and impacts on ORP, biostability, etc
- Disinfection Byproduct Formation

THANK YOU

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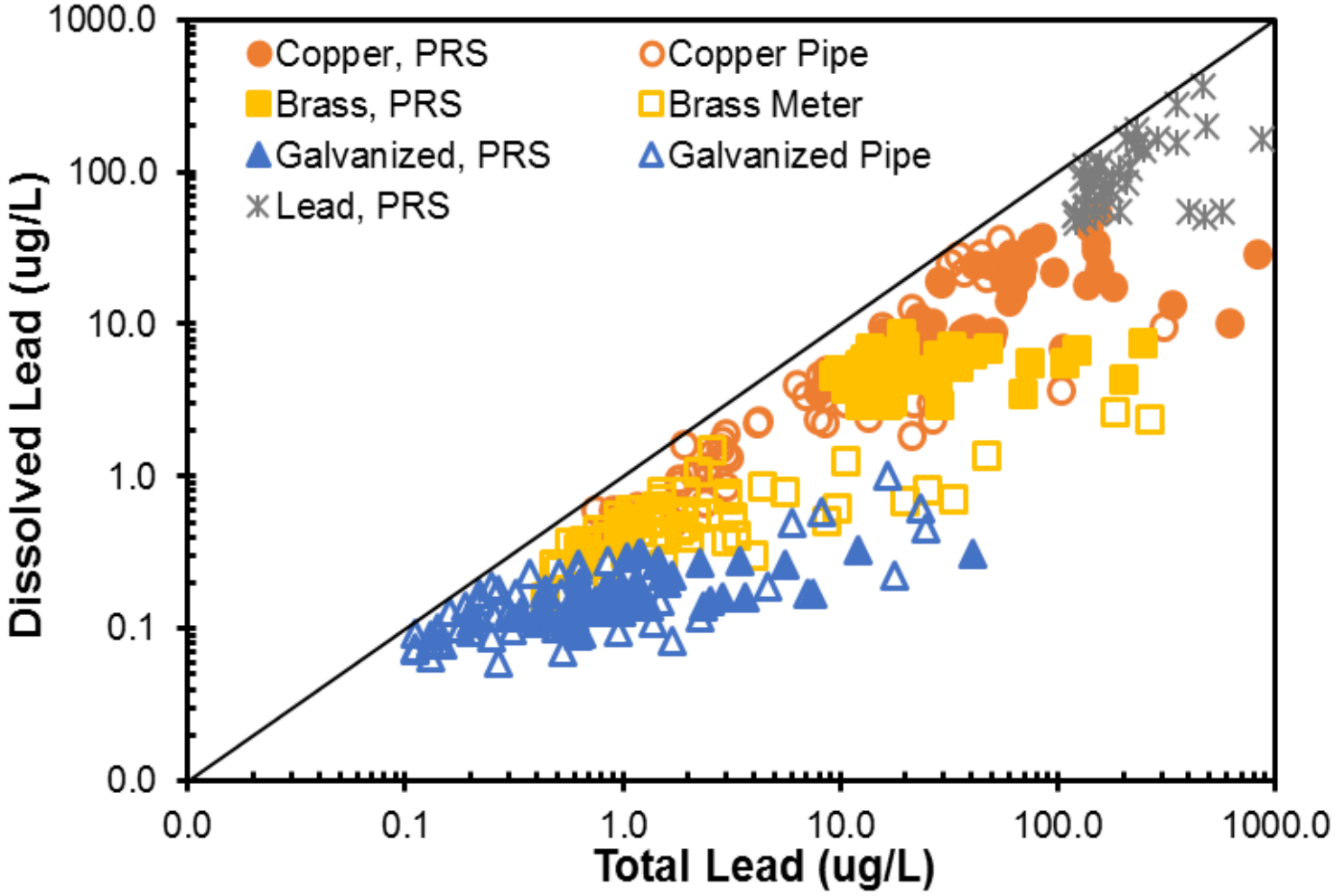
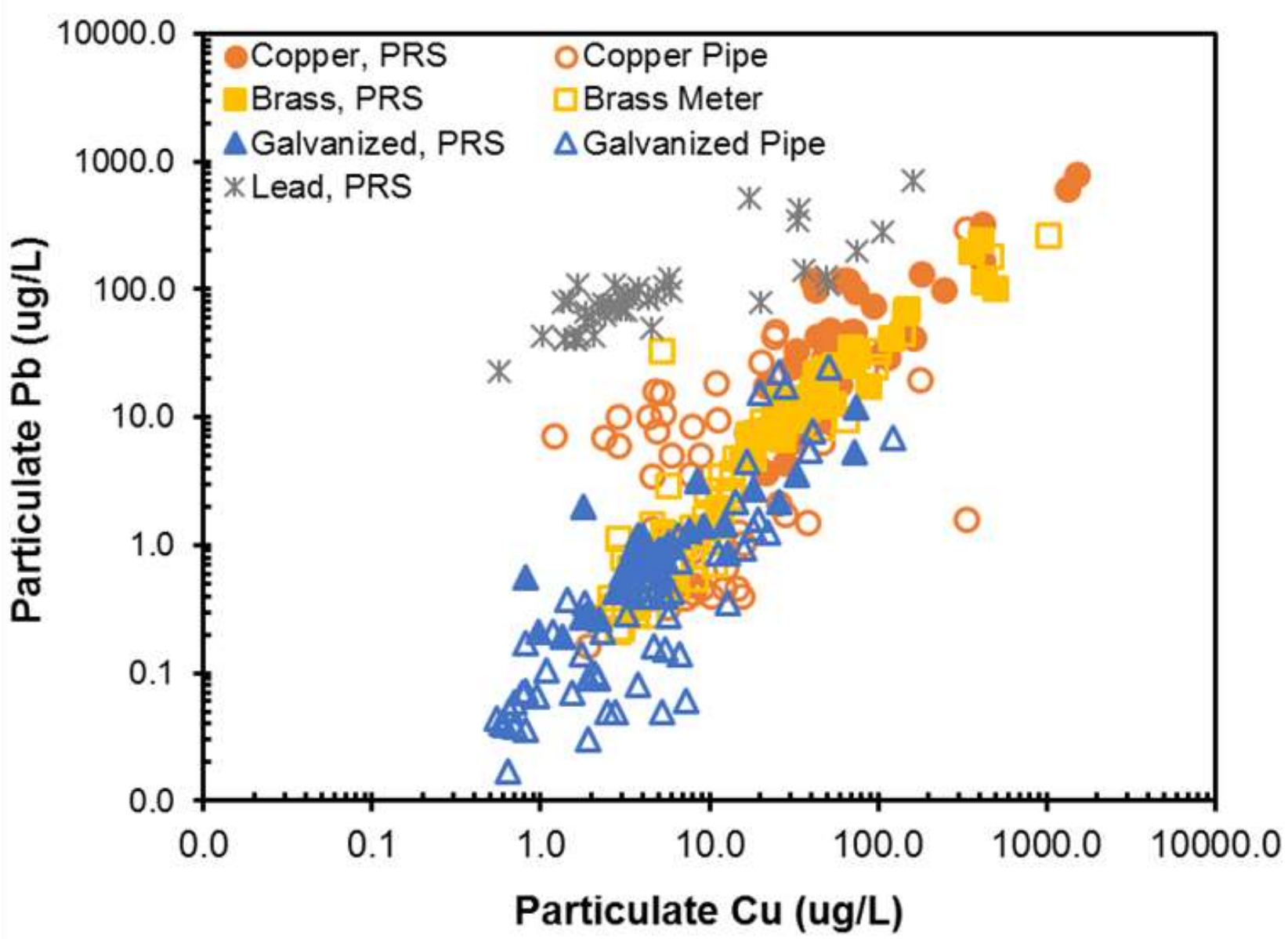
Samples dominated by particulate lead



Particulate Lead vs. Copper



Dissolved Lead vs. Manganese