

# CORROSION CONTROL – BEYOND pH AND ALKALINITY

AWWA PNWS Annual Conference

May 1, 2015

By

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# Background

- Town of Carbonado – 630 people in Pierce County, WA
- 200 gpm package filter plant built in 2007.
- Surface source – creek and springs
- Out of compliance for lead



# Lead and Copper Data

Parameter	May 2008	Sept. 2008	May 2009	Sept. 2009	May 2010
Number of Samples	5	20	21	20	20
90 % ile Pb (15 µg/L Action Level)	51	16	60	29	60
Compliance	No	No	No	No	No
90 % ile Cu (1.3 mg/L Action Level)	0.1	0.07	0.09	0.05	0.05
Compliance	Yes	Yes	Yes	Yes	Yes

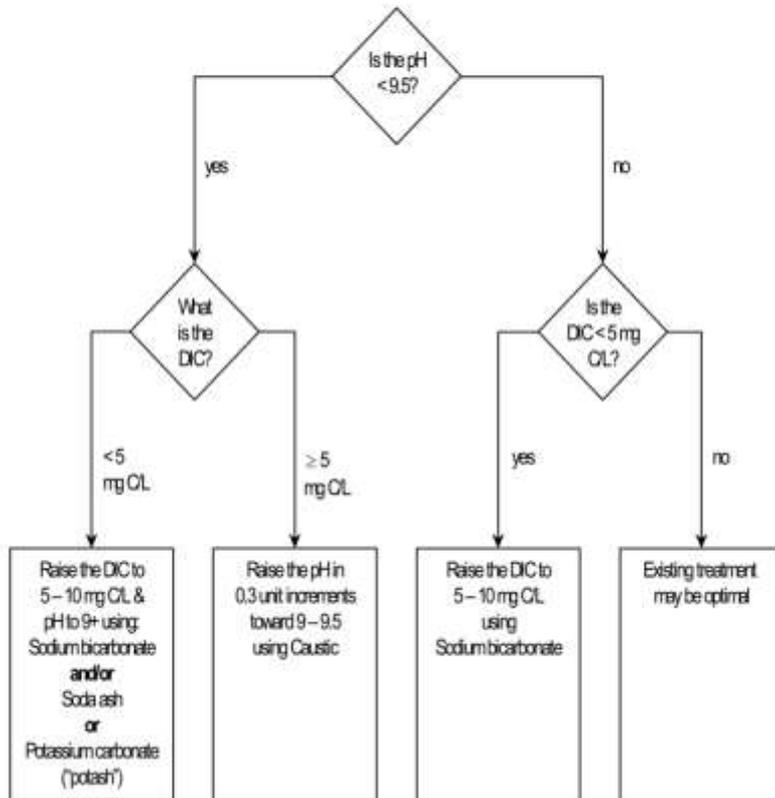
**Carbonado failed for lead but was okay for copper.**

# Finished Water Quality Data

Parameter	Value
pH	7.9-8.4
Alkalinity, mg/L as CaCO <sub>3</sub>	22

Relatively high pH.

Sheet 3B: Exceeded Lead Action Level Only



## USEPA 2003 Revised Guidance Manual for Selecting Lead and Copper Control Strategies

For pH 7.9-8.4 and DIC 7 mg C/L,  
add caustic to increase pH up to 9.0 to 9.5.

# Additional Background

What about Pb and Cu compliance before the new plant came online?

Parameter	1994 Data
Number of Samples	22
90 % ile Pb (15 µg/L MCL)	7
Compliance	Yes
90 % ile Cu (1.3 mg/L MCL)	2.6
Compliance	No

With old plant, copper was out of compliance but lead was fine.

# Finished Water Quality Data – Old Plant

Parameter	Value
pH	~7.0
Alkalinity, mg/L as CaCO <sub>3</sub>	12

Lower pH and alkalinity – typical of water quality that produces high copper.

# Further Background

The biggest difference between the new and old package plants is the old plant used powdered alum ( $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ ) while the new plant uses polyaluminum chloride (PAC) as a coagulant.

Parameter	Old Plant	New Plant
pH	~7.0	7.9-8.4
Alkalinity, mg/L as $\text{CaCO}_3$	12	22
Chloride, mg/L	~5	18
$\text{SO}_4^{-2}$ , mg/L	~38	1
Cl: $\text{SO}_4$ Mass Ratio (CSMR)	0.13	18



# Literature Search

- Examples of coagulant change and subsequent Pb level changes are in the literature<sup>(1)</sup>.
  - Greenville, NC
  - Stafford County, VA
  - Lab Experiments
- High CSMR correlates with higher lead levels when galvanically connected to copper<sup>(1)</sup>.

(1) Edwards, Marc, et. al. 2007, Chloride to sulfate mass ratio and lead leaching to water. Jour. AWWA, 99:7:96.

# New and Old Plant Comparison

Parameter	Old Plant Alum	New Plant PAC
pH	~7.0	7.9-8.4
Alkalinity, mg/L as CaCO <sub>3</sub>	12	22
Cl:SO <sub>4</sub> Mass Ratio (CSMR)	0.13	18
Compliance with Lead	Yes	No
Compliance with Copper	No	Yes

- The comparison suggests that coagulant use at Carbonado does affect lead and copper compliance.
  - Alum – high copper
  - PAC – high lead
- PAC – high Cl, Alum (Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>) – high sulfate

# Copper Compliance From Old Plant Data

- EPA Guidance Manual indicates that for low pH and low DIC, adjusting pH is best option.
- Optimal pH for copper control is 7.5-8.0.



# Proposed Pilot Study

- Investigate three water qualities.
  - PAC treated water – plant product (pH 7.9-8.4)
  - Alum treated water – lab product (pH 6.9-7.3)
  - Alum treated water – lab product (pH adjusted to 8.6-9.1 with soda ash)
- Alum jar testing indicated 80 mg/L was a good dose. Old plant records indicated 100 mg/L was normal dose.



# Proposed Pilot Study

- Coupon Test
- ½ copper coupler with 1 1/8" X 5/8" 50/50 Pb/Sn solder melted to inside surface.



# Proposed Pilot Study

- Each coupon placed in 100 ml water in bottle.
- Water in bottles was changed each week and replaced with same water quality.
- Each water quality tested in triplicate (9 bottles total).
- Bottles stored in refrigerator with  $\text{Cl}_2$  maintained between 0.5-0.7 mg/L.
- Pb and Cu sampled at the end of one week and five weeks.



# Pb Results

- After 1 Week

Water Quality	Average pH	Average Pb, $\mu\text{g/L}$ (3 samples)
PAC	7.8-8.3	14.7
Alum	6.9-7.3	4.09
Alum + Soda Ash	8.6-9.1	2.01

- Results are as expected – Pb lower in water treated with alum than with PAC.

# Pb Results

- After 5 Weeks

Water Quality	Average pH	Average Pb, $\mu\text{g/L}$ (3 samples)
PAC	7.8-8.3	2.72
Alum	6.9-7.3	2.83
Alum + Soda Ash	8.6-9.1	1.52

- Results not as clear– Pb lower in water treated with alum and soda ash but similar between alum and PAC.

# Cu Results

- After 1 Week

Water Quality	Average pH	Average Cu, mg/L (3 samples)
PAC	7.8-8.3	0.0656
Alum	6.9-7.3	0.0922
Alum + Soda Ash	8.6-9.1	0.0699

- Results as expected – water treated with alum produced higher Cu but effect alleviated with higher pH.

# Cu Results

- After 5 Weeks

Water Quality	Average pH	Average Cu, mg/L (3 samples)
PAC	7.8-8.3	0.0640
Alum	6.9-7.3	0.0780
Alum + Soda Ash	8.6-9.1	0.0835

- Results not as expected – water treated with alum and higher pH produced highest Cu. Copper levels still not that much higher than with PAC.

# General Pilot Water Quality Summary

- Comparison of chloride and sulfate pilot data.

Water Quality	Cl <sup>-</sup> , mg/L	SO <sub>4</sub> <sup>-2</sup> , mg/L	Cl:SO <sub>4</sub> Mass Ratio
PAC	13.6	1.29	10.5
Alum	11.5	10.8	1.06
Alum + Soda Ash	9.38	16.1	0.58

- The pilot study CSMR was 10–18 fold higher between PAC and alum.
- Historical comparison of treatment plant data indicated larger CSMR differences between PAC and alum operation.

# Pilot Study Summary and Recommendation

- Pilot study data, while not definitive, suggest that alum use will result in lower lead levels.
- Pilot study data, while not definitive, suggest that alum use with pH adjustment will result in copper levels that are not substantially higher than with PAC.
- Initial Recommendation – Switch coagulant to alum with soda ash addition for pH adjustment.



# Town Concerns

- Water treatment plant operator reluctant to switch to alum.
- Old plant used a dry feeder that was high maintenance, dusty, and problematic.
- Switching to alum was not desirable to the operator.
- EPA Guidance Manual indicated that raising pH to 9.0-9.5 was an option.
- DOH approved pH adjustment test at plant.



# pH Adjustment Test

- Treatment plant pH adjusted to a target of 9.0 with soda ash.
- Adjustment test operated for a few weeks to allow distribution system to come to steady state.
- Initial Pb/Cu test sampling results were encouraging.
  - 5 samples
  - 90 % ile Pb – 11.5  $\mu\text{g}/\text{L}$  with a high of 16  $\mu\text{g}/\text{L}$
  - Cu not detected in any sample
- DOH and Town decided to do compliance sampling in April 2012.



# Pb and Cu Sampling Data

	Pb, µg/L	Cu, mg/L
No. Samples	20	20
90% ile	31	<0.02
Average	9.5	<0.02
High	44	0.02

- Town failed for Pb but very little copper was detected.
- pH adjustment not the solution.

# Next Steps

- Lead water treatment plant operator retires.
- New water treatment plant operator amenable to switching to alum.
- Liquid alum product available so no changes to existing chemical feed system.
- Treatment plant switched from liquid PAC to liquid alum in June 2013.
- Soda ash was used to adjust pH to 8.0.



# Pb Sampling Data

	9/2013	5/2014
No. Samples	20	20
90 <sup>th</sup> ile, µg/L	13	2
Average, µg/L	7.4	2.3
High, µg/L	59	15

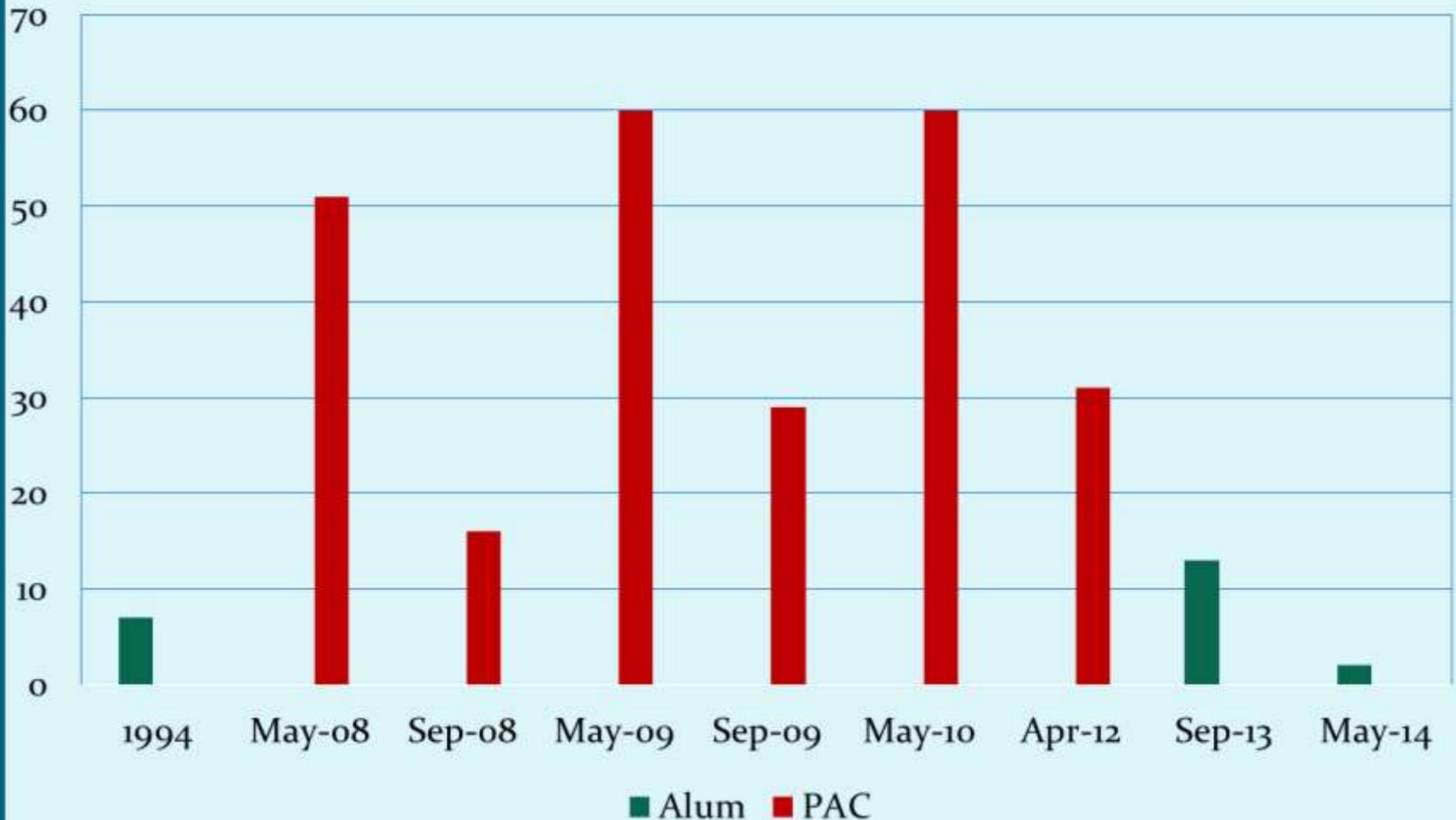
- Initial round of testing in September 2013, Town passed Pb. Two samples above 15 µg/L Action Level (59 and 15 µg/L).
- Second round of testing in May 2014 resulted in very low Pb levels and only one sample at the 15 µg/L Action Level.

# Cu Sampling Data

	9/2013	5/2014
No. Samples	20	20
90 <sup>th</sup> ile, mg/L	0.05	0.02
Average, mg/L	0.03	0.04
High, mg/L	0.05	0.06

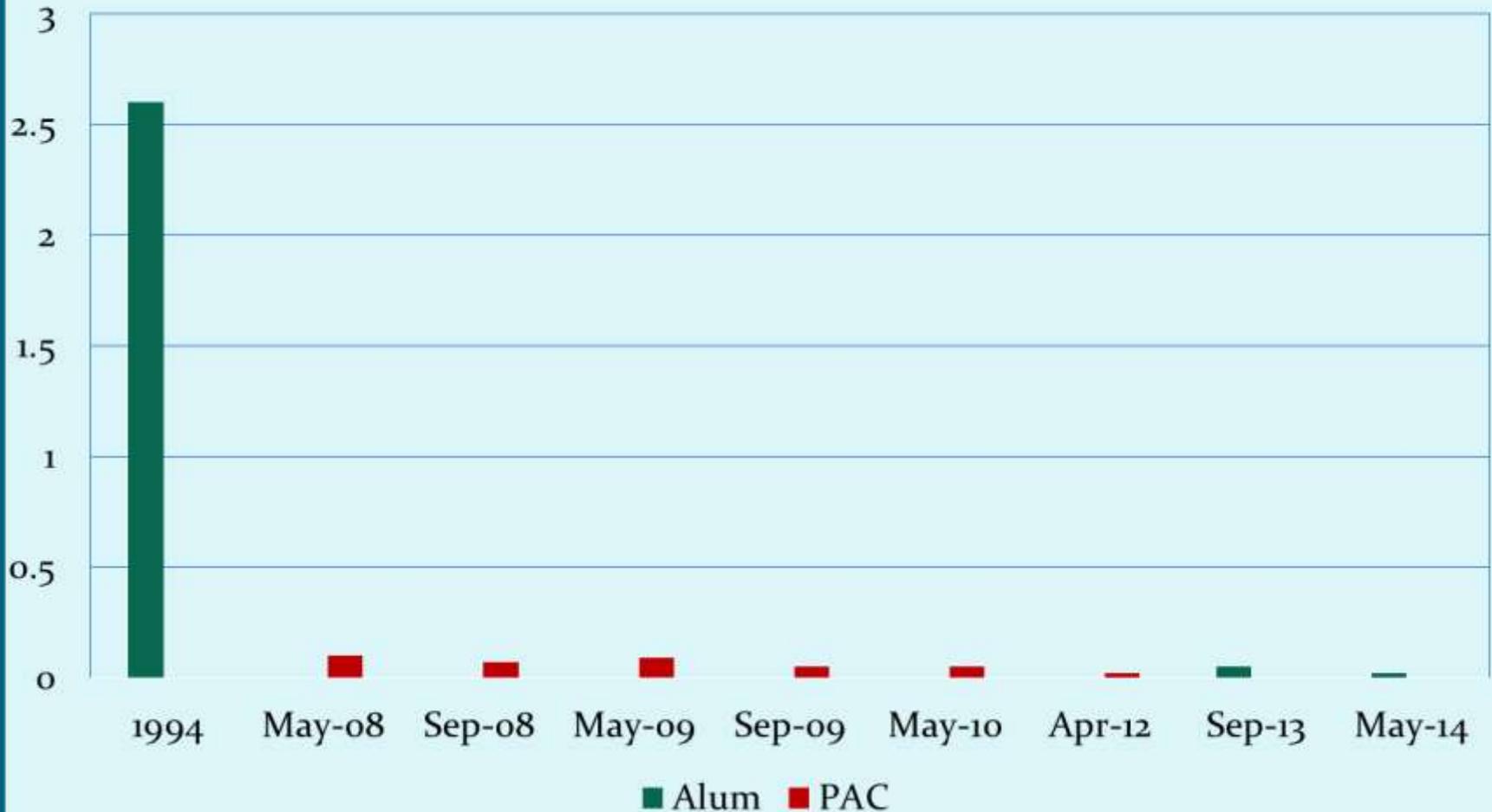
- Town also passed Cu with a slight increase in detectable Cu levels but well below 1.3 mg/L Action Level.

## Summary of 90%ile Pb Data ( $\mu\text{g/L}$ ) Comparing Coagulants



- Historical data show effect of alum use versus PAC on Pb levels.

## Summary of 90%ile Cu Data (mg/L) Comparing Coagulants



- Cu levels for alum with pH adjustment similar to PAC but much less than historical alum use.

# Conclusions

- The switch from PAC to alum allowed Town to be in compliance with lead Action Level of the Lead Copper Rule –CSMR key parameter.
- Using alum with pH adjustment resulted in only a slight increase in Cu levels over PAC use but much lower than Cu levels from the previous plant with alum.
- The liquid alum product easier to use than dry alum, a key element in the Town's decision to switch.



# Questions?

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