

WET Tests and the Perils of Polymer

Hugh G. Tozer, PE
Woodard & Curran Inc.

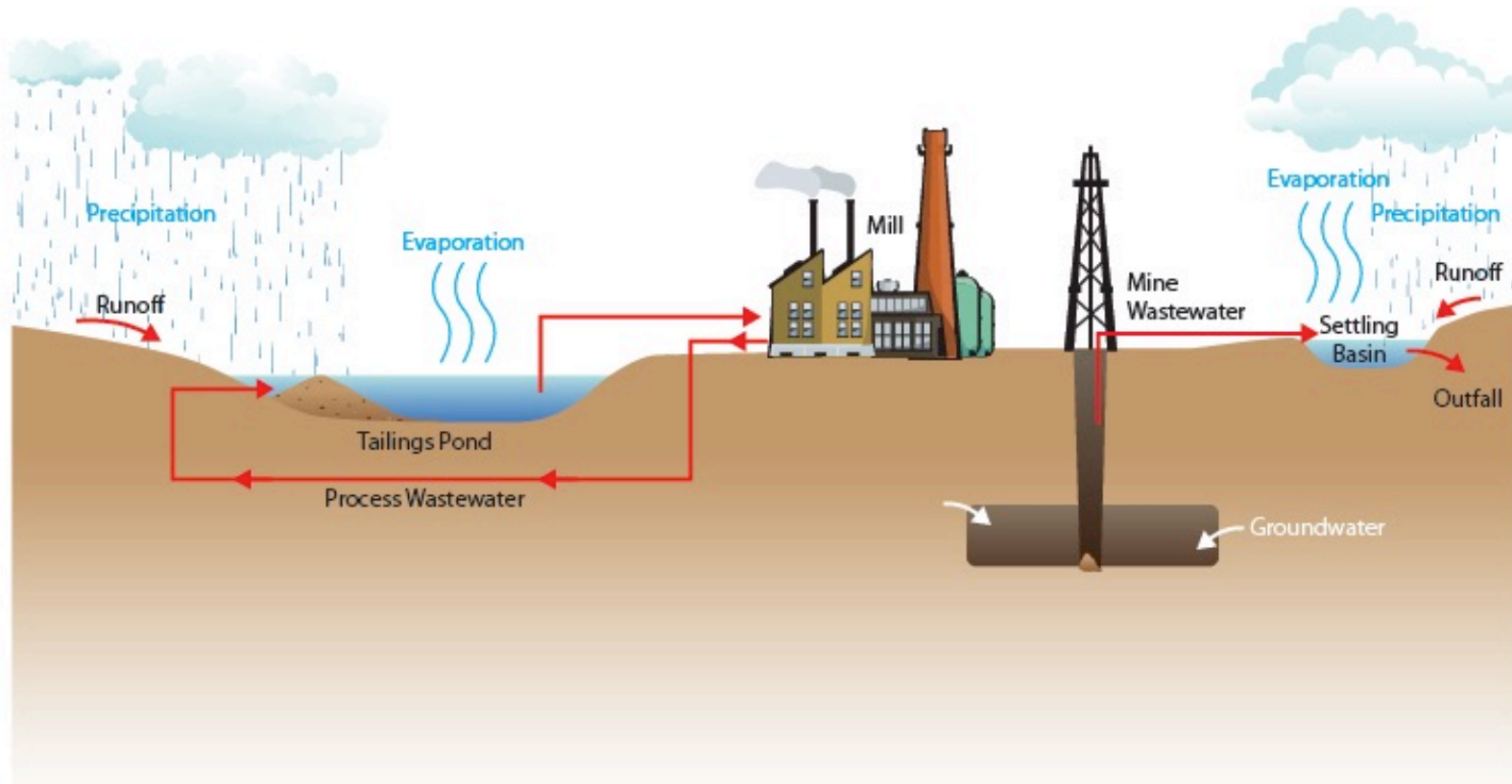


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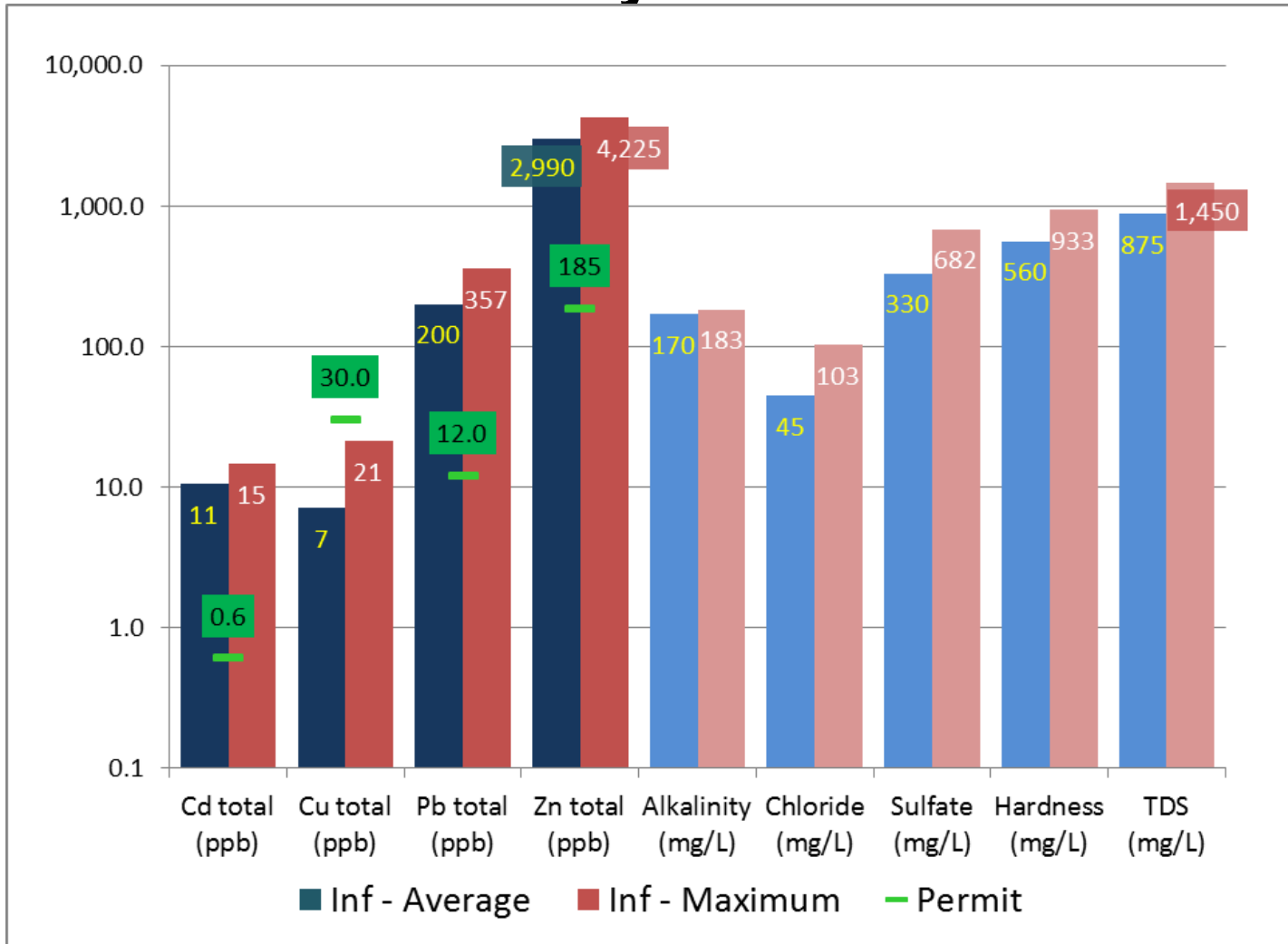
Overview

- Industrial Wastewater Treatment System
- Whole Effluent Toxicity Overview
- Evaluation of Toxicity
- Conclusions

Dewatering the underground metals mine generates up to 3000 gpm wastewater

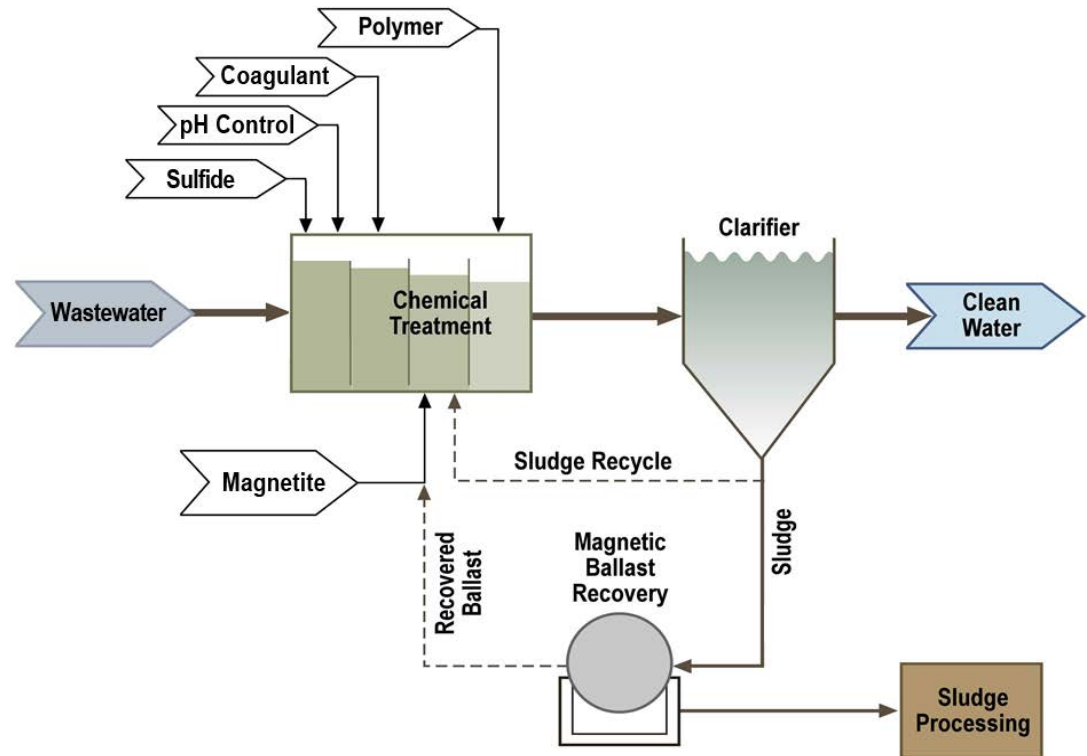


Mine's wastewater contains heavy metals and exhibits chronic toxicity

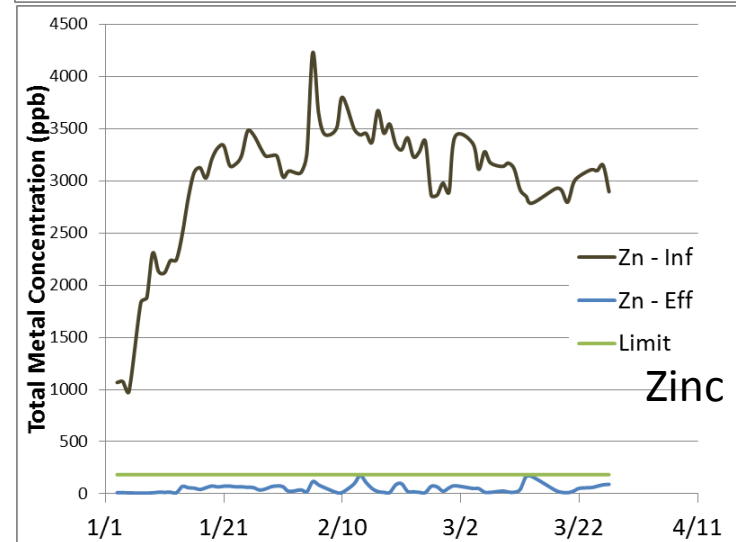
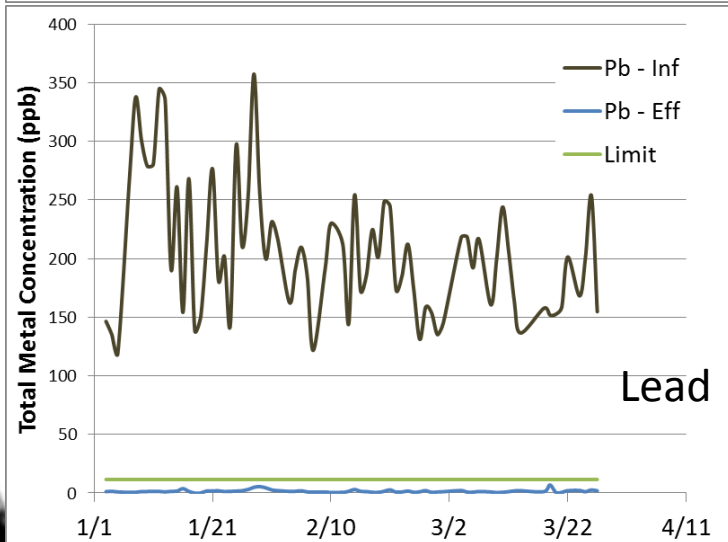
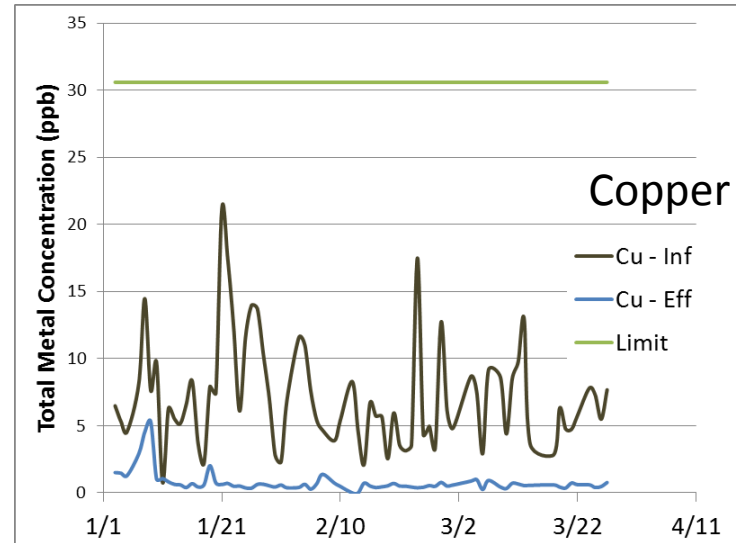
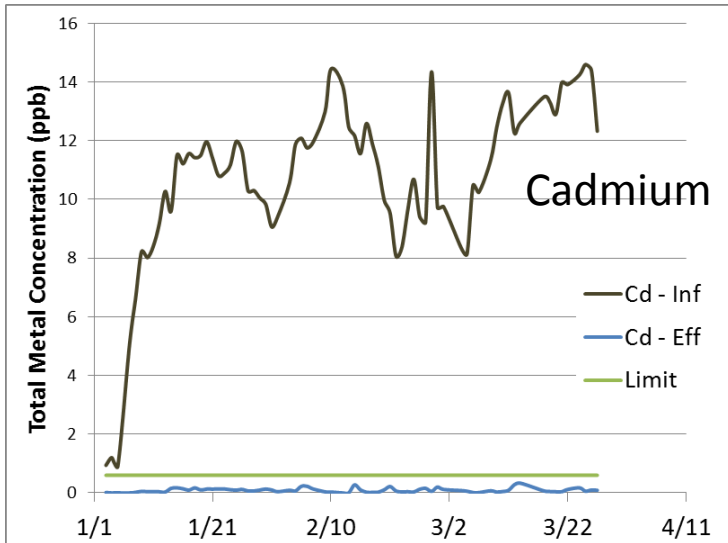


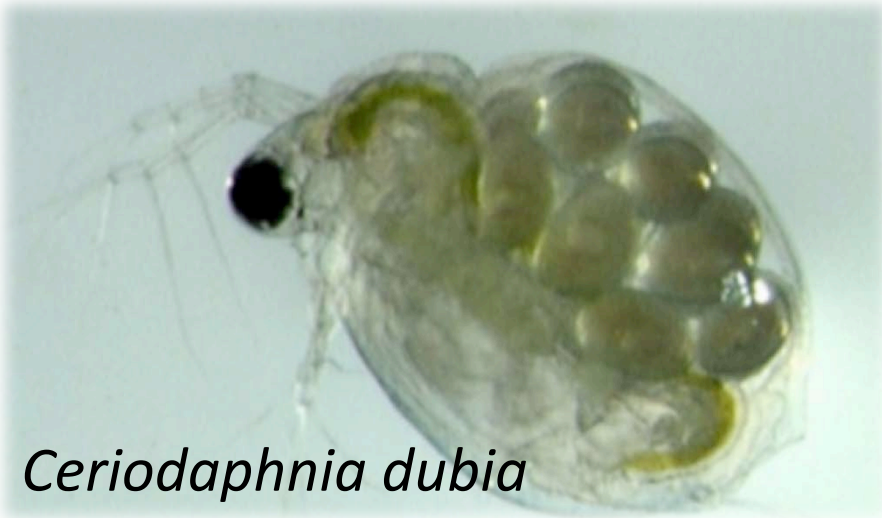
Field tests of 10 precipitants identified a treatment process to meet metal and toxicity limits

- Design flow = 2600 gpm
- Max flow = 3000 gpm
- Metals precipitated as sulfides and hydroxides
- Coagulation with iron salts
- Ballasted sedimentation
- Flocculation used emulsion anionic polymer
- Used dry polymer in pilot tests but emulsion polymer in full-scale system due to flow and convenience



Effluent met metal limits from startup





Ceriodaphnia dubia

Predict the effluent concentrations that interfere with normal growth, development and reproduction

Chronic Whole Effluent Toxicity



Pimephales promelas

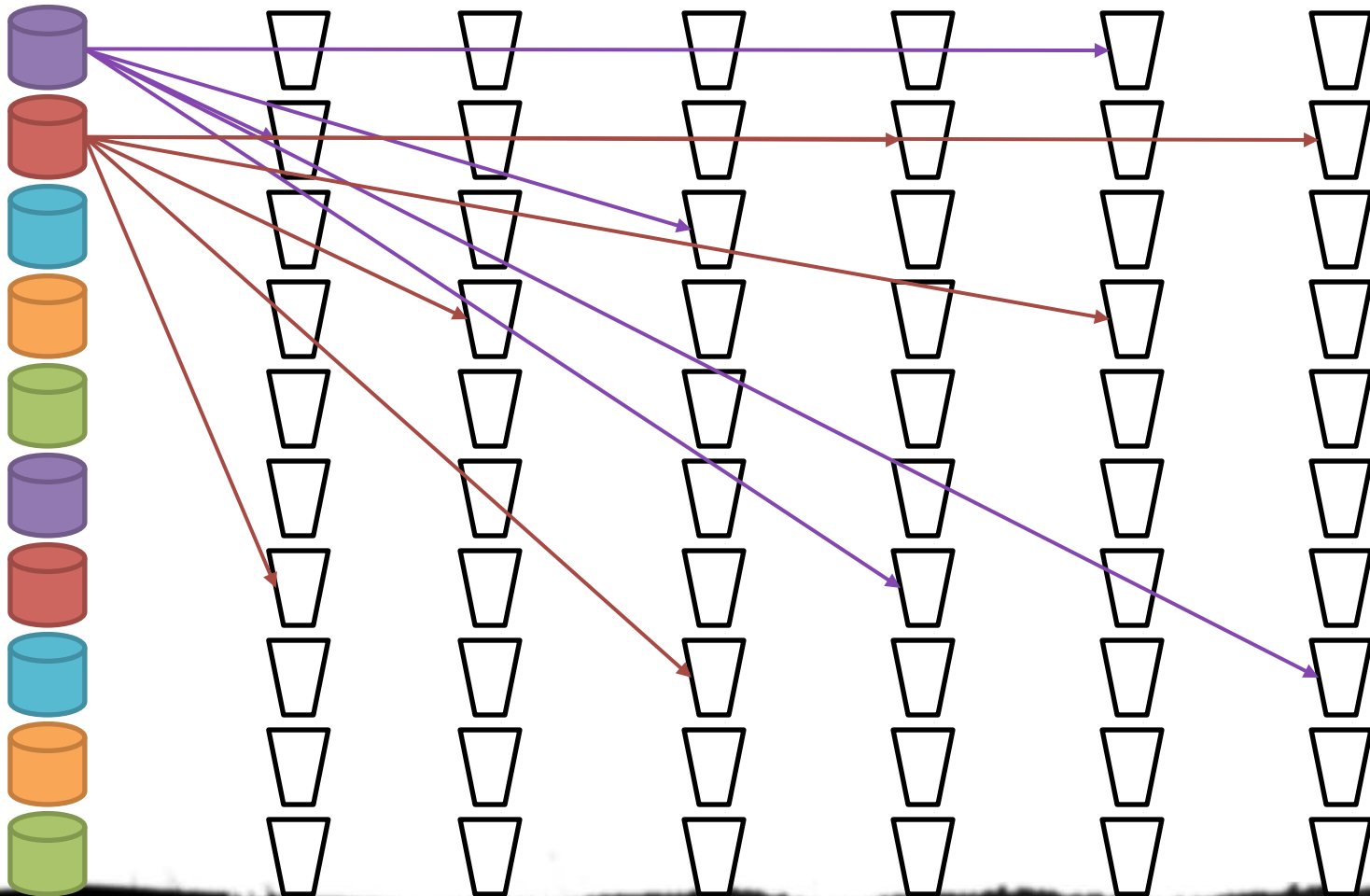
Lifecycle of *Ceriodaphnia dubia* (water fleas)

- Freshwater organism found in littoral zones throughout the world
- Females reproduce by cyclic parthenogenesis (asexually)
- They reproduce when they molt
- Typical clutch is 4 to 10 eggs in brood chamber
- Three broods in 7-day chronic WET test

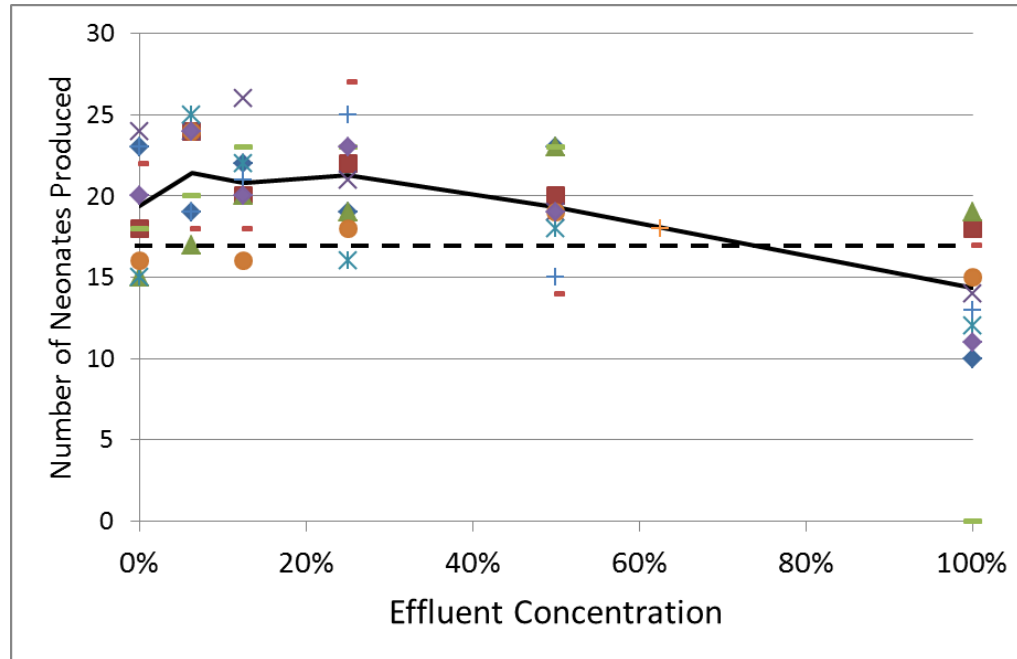


Technicians randomly distribute neonates to 10 cups at each dilution

Control	6.25%	12.5%	25%	50%	100%
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The number of neonates produced in 7-day period are statistically compared to control group



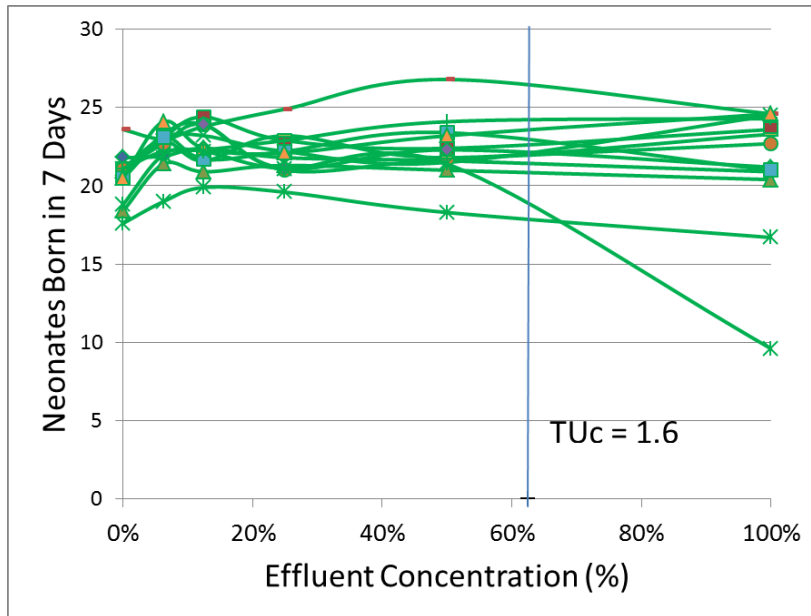
Inhibition concentration, such as IC25 = effluent concentration that causes a 25% reduction in growth or reproduction

IC25 is compared to in-stream waste concentration (IWC) of effluent

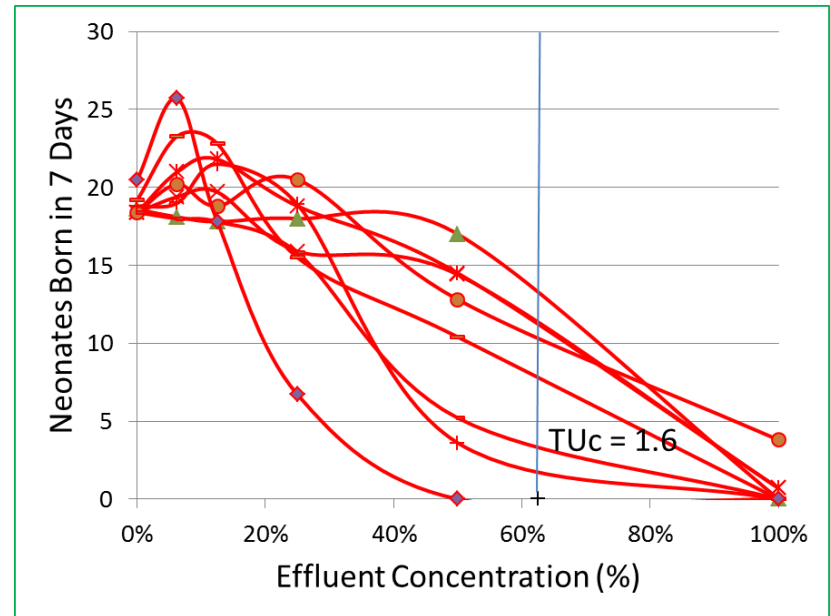
If $IC_{25} < IWC$, there is a potential to inhibit aquatic organisms

WET test results from treated mine water

PASSING TESTS



FAILING TESTS

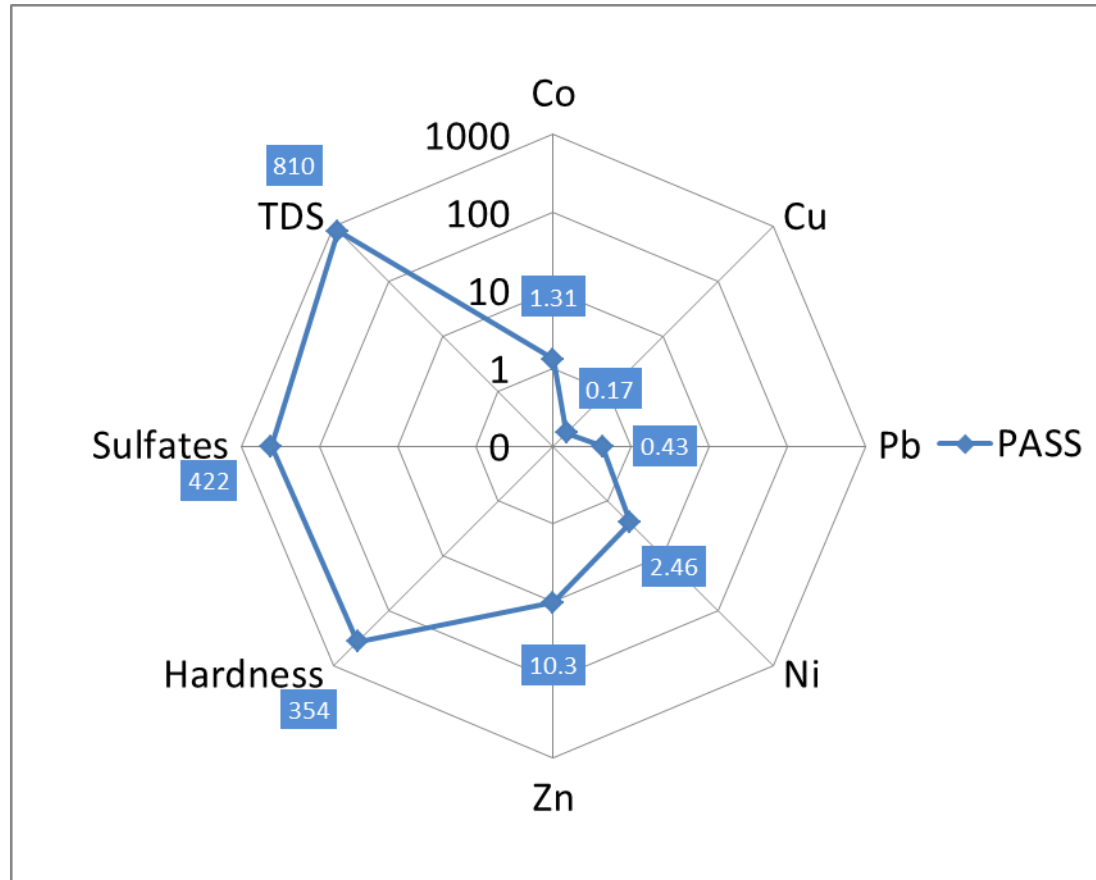


History of WET Tests at the Mine

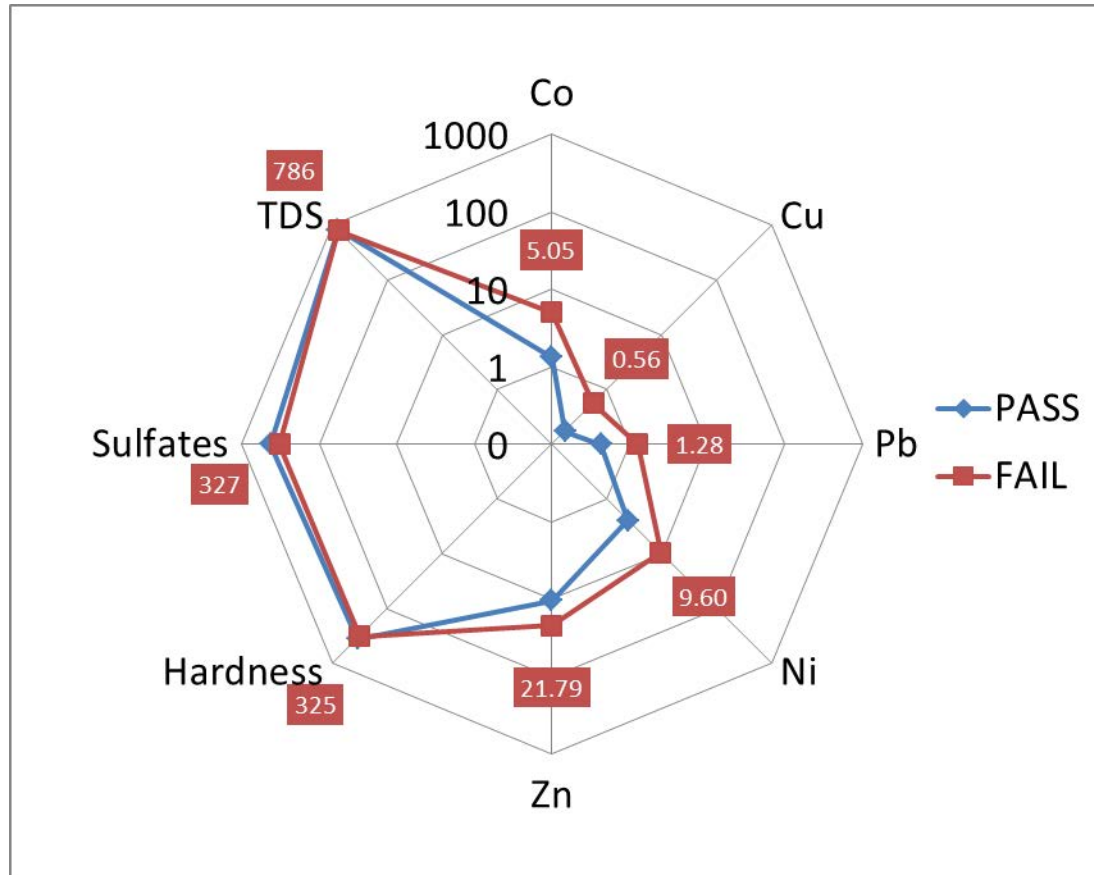
- Mine had typically failed its WET tests for *C. dubia*
- In pilot study, treated mine dewatering water passed WET tests
- 1st WET test after full-scale startup passed both *C. dubia* and minnows
- 2nd and 3rd WET tests failed *C. dubia*
- Operating at higher pH produced passing WET tests, but scale formation and costs were impractical



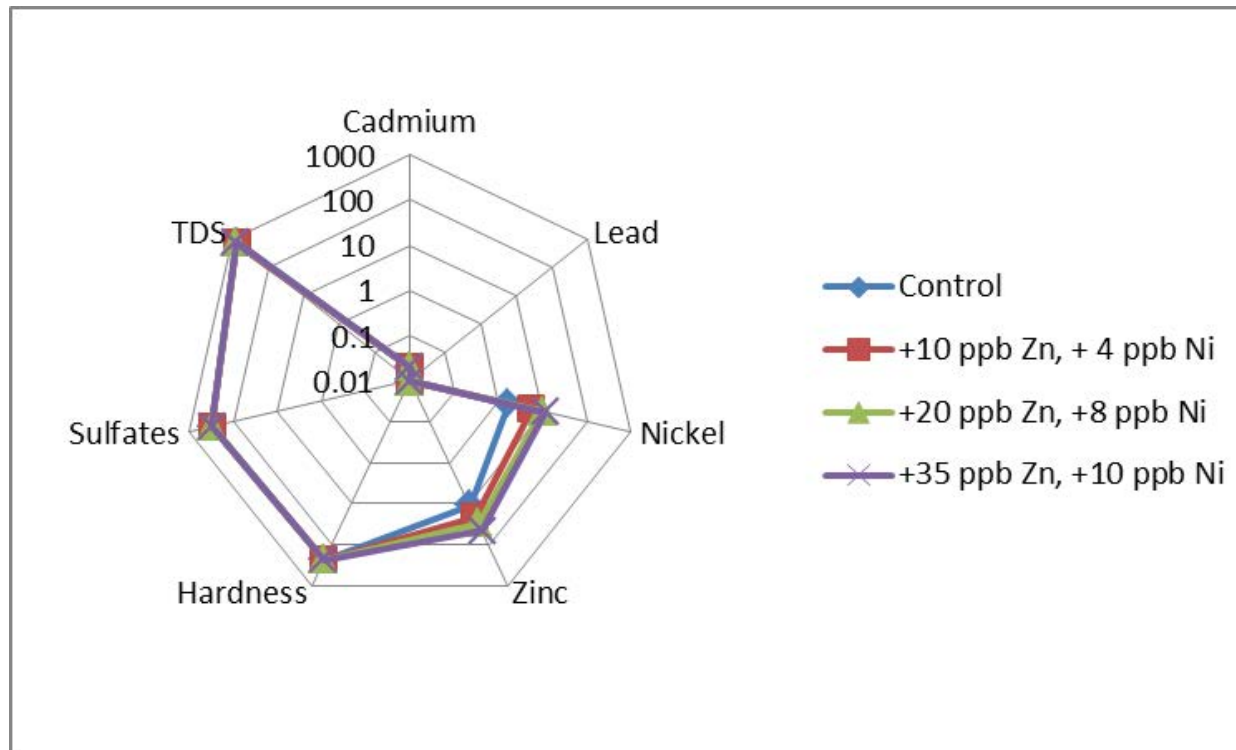
Average concentrations of heavy metals and ions in tests that passed and failed were similar



Metal concentrations in 100% effluent of failed tests were below those reported to be toxic in literature



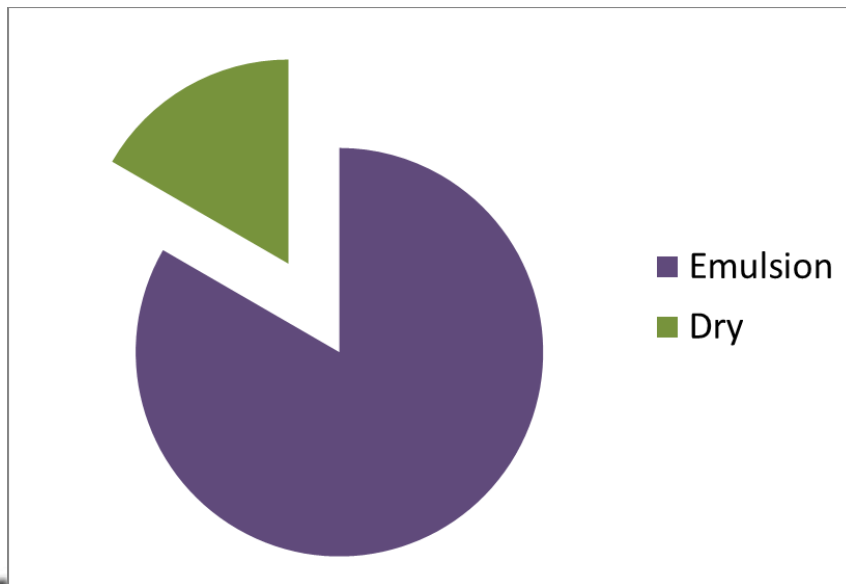
Spiked 100% effluent with Ni and Zn → No toxicity observed at higher concentrations



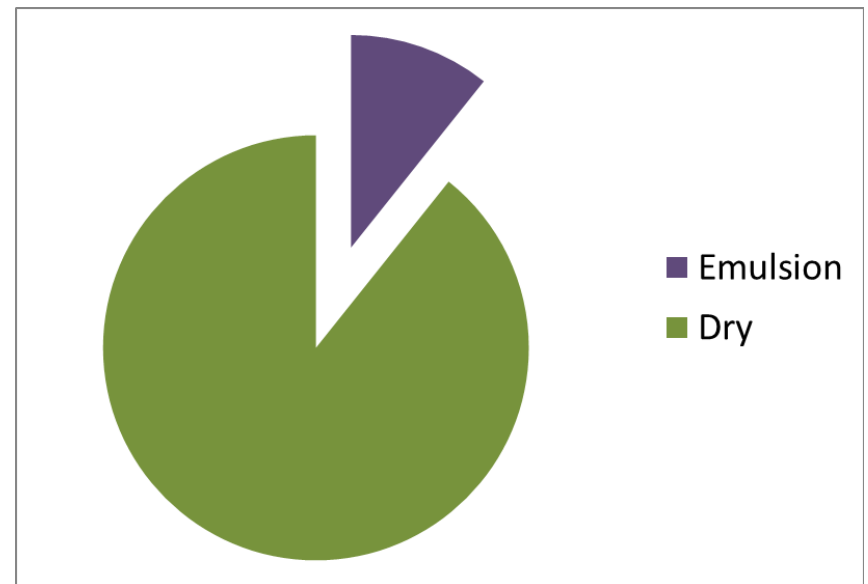
Correlations ≠ Causation

Emulsion polymer appeared to be associated with failed WET tests

FAILED WET TESTS



PASSING WET TESTS



25 of 28 passing WET tests used dry polymer

1 of 6 failing WET tests used dry polymer

Flocculant aid was a medium molecular weight, medium ANIONIC charge density emulsion



- Emulsion polymers are common in smaller systems
- Researchers (e.g., Stover) have reported toxicity with polymers
- Toxicity typically associated with cationic charged polymers
- Emulsions use mineral oil and surfactants

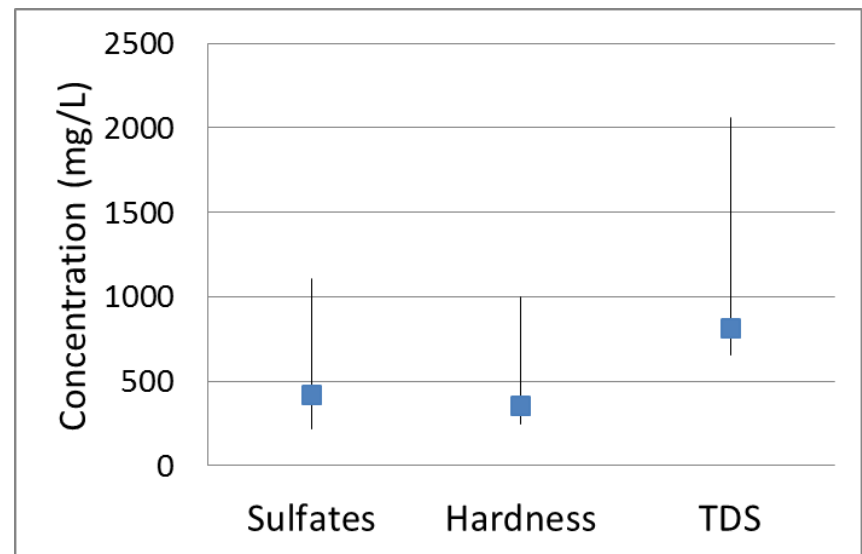
System changed to dry polymer feed system with similar molecular weight and charge density



- All WET tests have passed since changing to dry polymer, even at order of magnitude higher metal concentrations
- Dry polymer requires more attention by operators

Why did some tests using emulsion polymer pass?

- Effluent metal and ion concentrations were similar to other passing tests
- Passing tests operated at higher pH
- Large amounts of solids generated by softening water
- Excess polymer may have been tied up with solids



Conclusions

- Correlation \neq Causation – just because one can easily measure metals does not mean they are the source of toxicity
- Convenience of emulsion polymers may not warrant their use if plant is subject to chronic WET tests
- Emulsifying agents appeared to be source of toxicity and not the polymer