

# Solving mine drainage problems at the Soudan Mine

The final? answer

Paul Eger  
Global Minerals Engineering  
Peggy Jones, Doug Green  
American Peat Technology



Global Minerals Engineering

# Background

- ▣ Minnesota's oldest and deepest iron mine
  - Began in 1882
  - Ended 1962
- ▣ US Steel donated mine to state
  - DNR developed a state park 1965

**Becomes Paul's career project  
1994**



# The Problem

- ▣ Mine never had a discharge permit
  - Began in 1882
  - Ended 1962
- ▣ DNR applied for permit early 90's
- ▣ Neutral drainage
  - Elevated copper and cobalt
    - ▣ Total copper ~ 0.1- 1 mg/l
      - **standard 0.020 mg/l**
    - ▣ Total cobalt ~ .01-.04 mg/l
      - **standard 0.005 mg/l**



# A Little? Background....

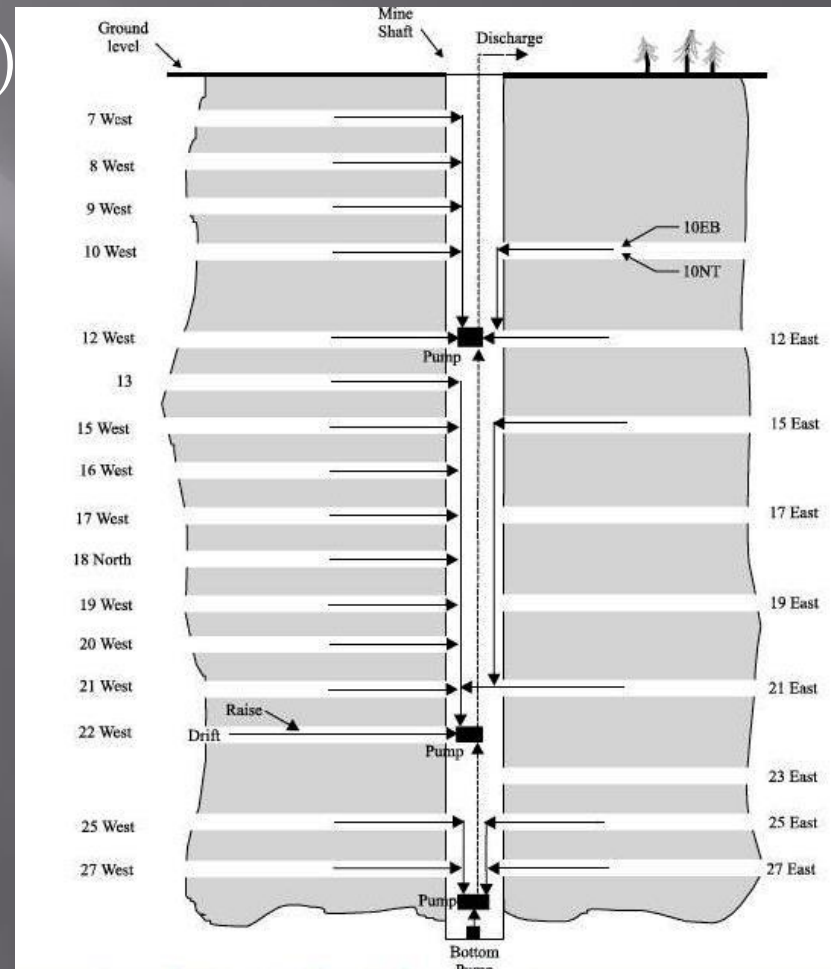
- Long and sordid story complete with numerous plot twists
  - (and endless ASMR papers)
- Cliffs Notes Summary:
  - Compliance 2009
  - Ion exchange treatment

Small unit in the mine

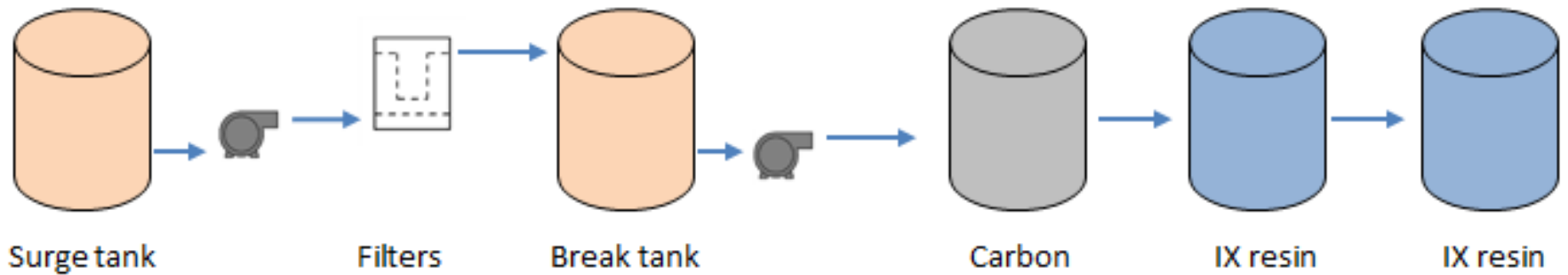
**Major source**

Large unit on surface

**Entire discharge**



# Current Treatment System

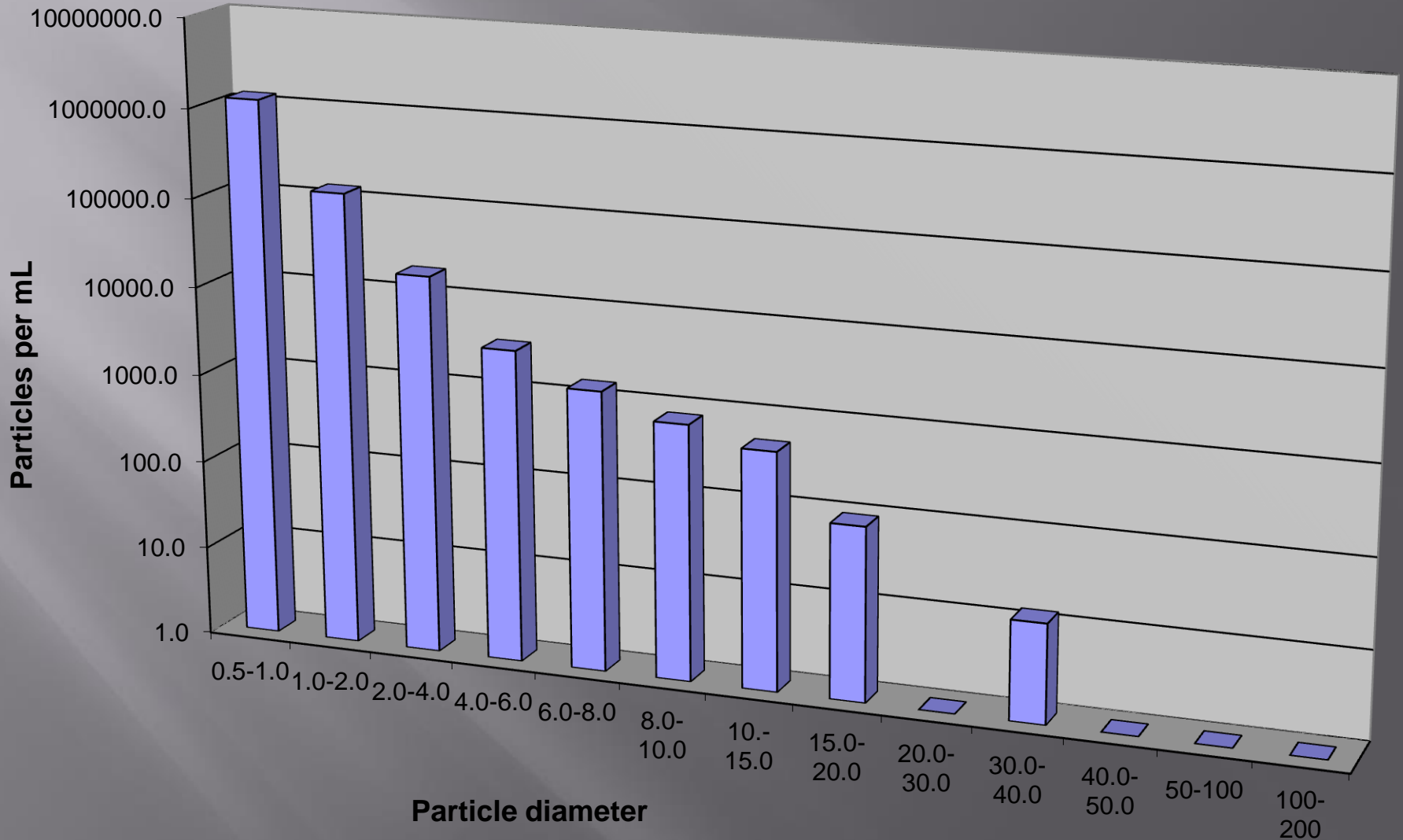


# So what's the problem?

- ▣ Unfiltered copper removal problematic
  - TSS ~ 5 mg/l
  - 75% of copper in discharge is in particulate form
  - Some suspended copper moves through system
  - Plugging of ion exchange tanks



# Particle Size Analysis, Input



## So what's the problem?

- Particles generally < 4 microns
- Only about 20% of the removal capacity utilized
  - 4-5 million gallons treated

**Is there a better approach?**



# Standard Options

- ▣ Physical filtration
- ▣ Coagulants, Flocculents and Clarifiers ( oh my)
  - Low solids
  - Chemical and O&M concerns
- ▣ Sand filters
  - Nominal removal: 10-20 micron
- ▣ Multimedia filters
  - Nominal removal: 5-10 micron



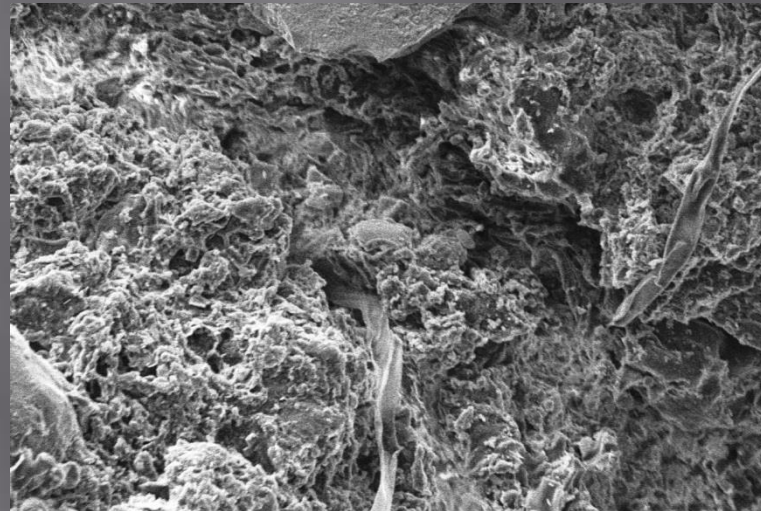
# A Better Approach?

## ▣ APTsorb™

- Patented peat based sorption media
- Hardened granule
- High hydraulic conductivity (~1 cm/sec)
  - ▣ Can be used in active or passive approach
- High metal affinity (1-15% max dry wgt)



APTsorb™ Granule



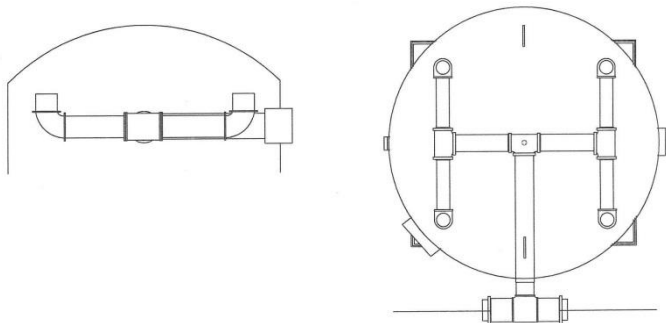
APTsorb™ Granule 1500x

# Approach

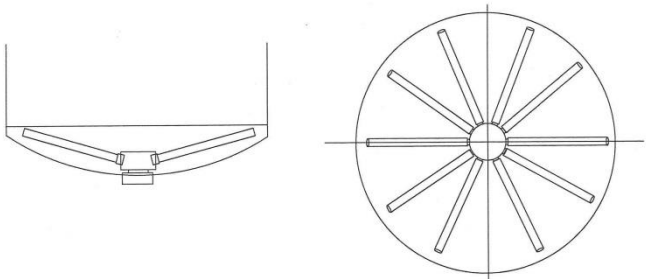
- ▣ Use tank with APTsorb as pretreatment
- ▣ Treatment tank
  - 1000 gallon
  - 500 gallons media
  - Design for periodic backwash
  - 30 – 100 gpm



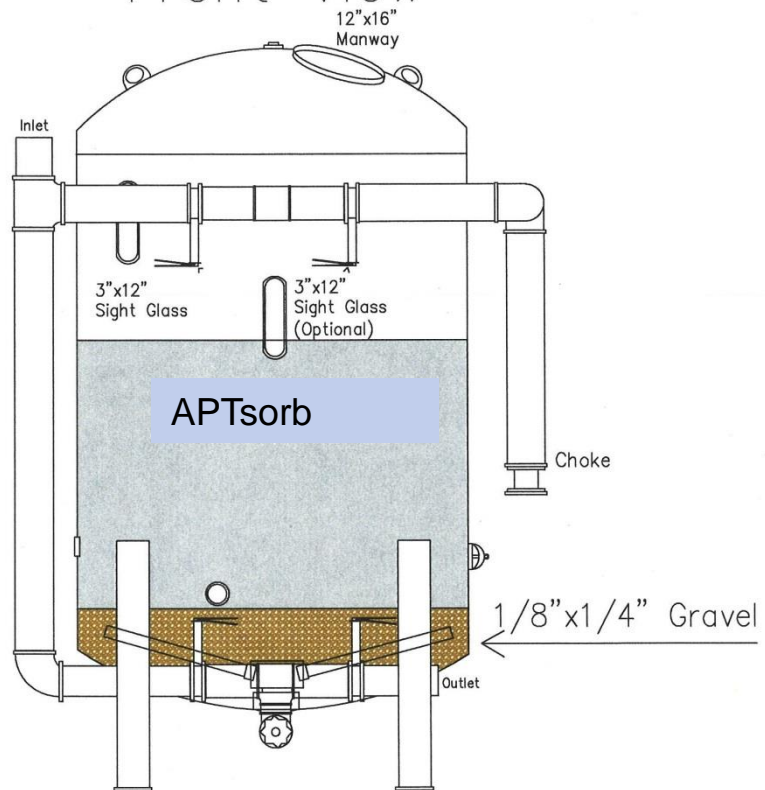
Top Manifold



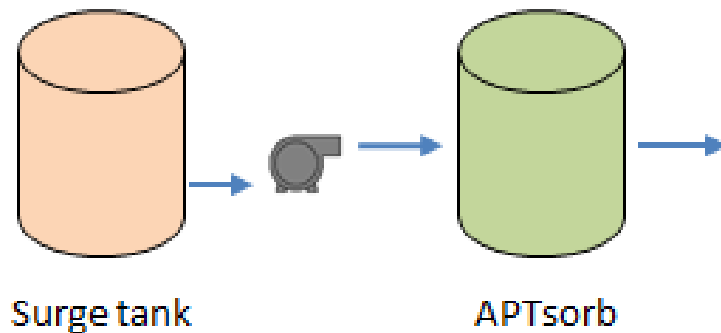
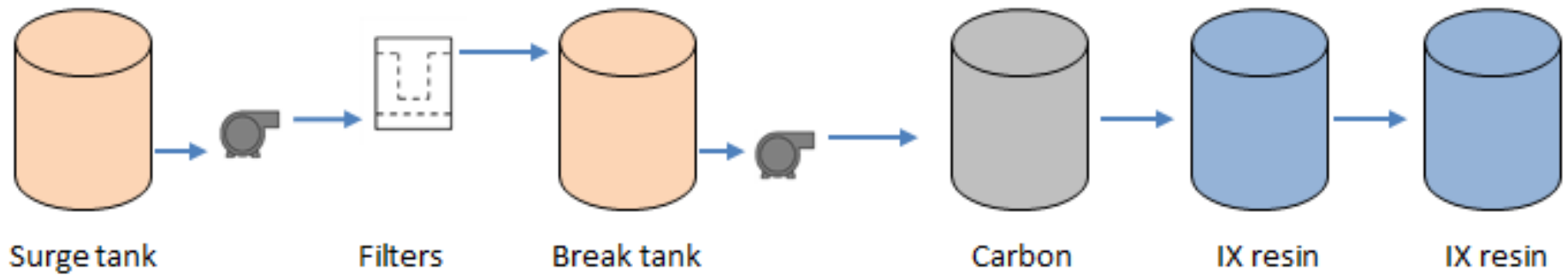
Bottom Manifold



Front View



# System Comparison



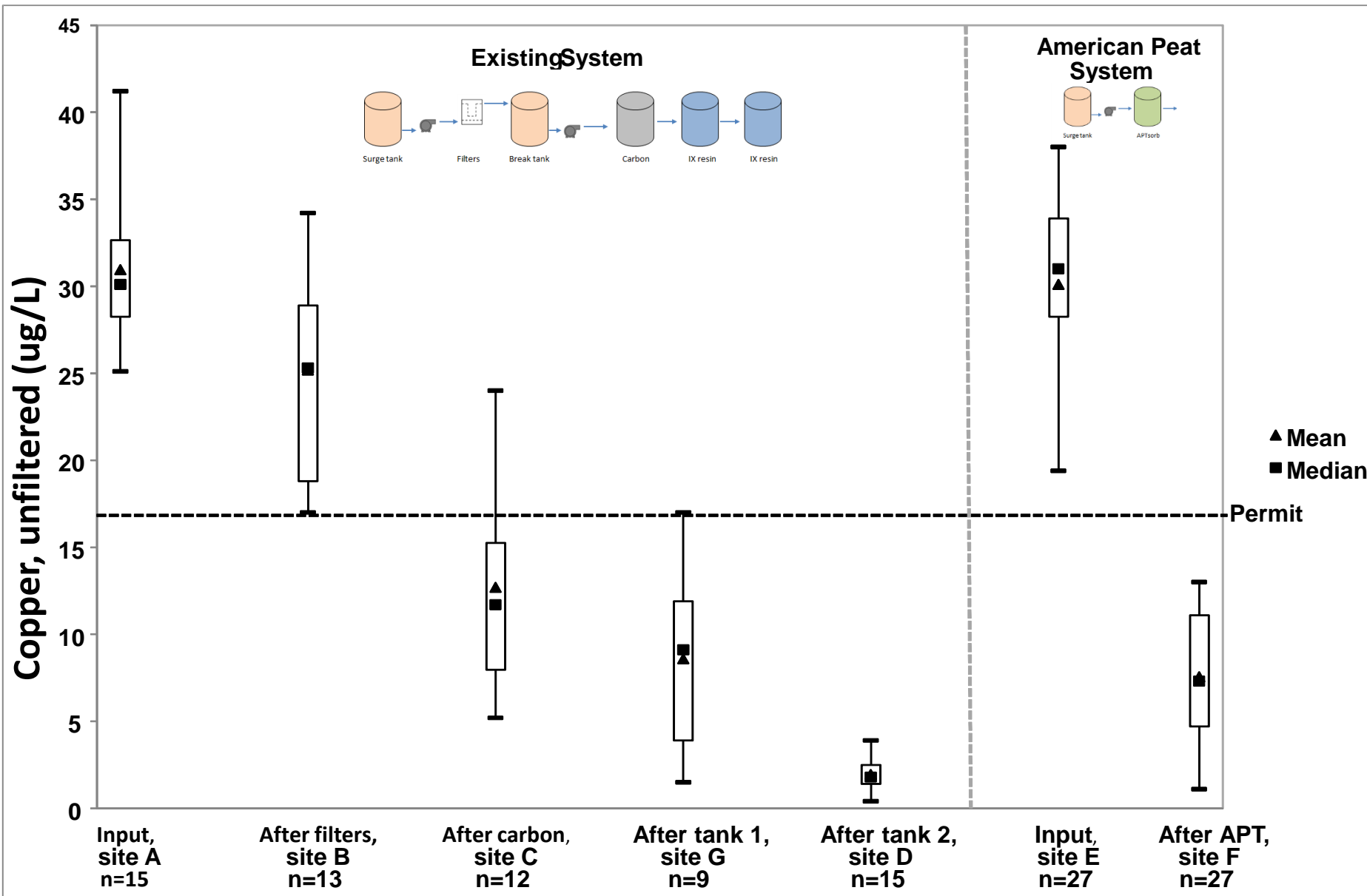
# RESULTS

# Talk like an engineer

Bed Volume = Volume of reactive media in treatment tank or system (gallons)    500 gallons

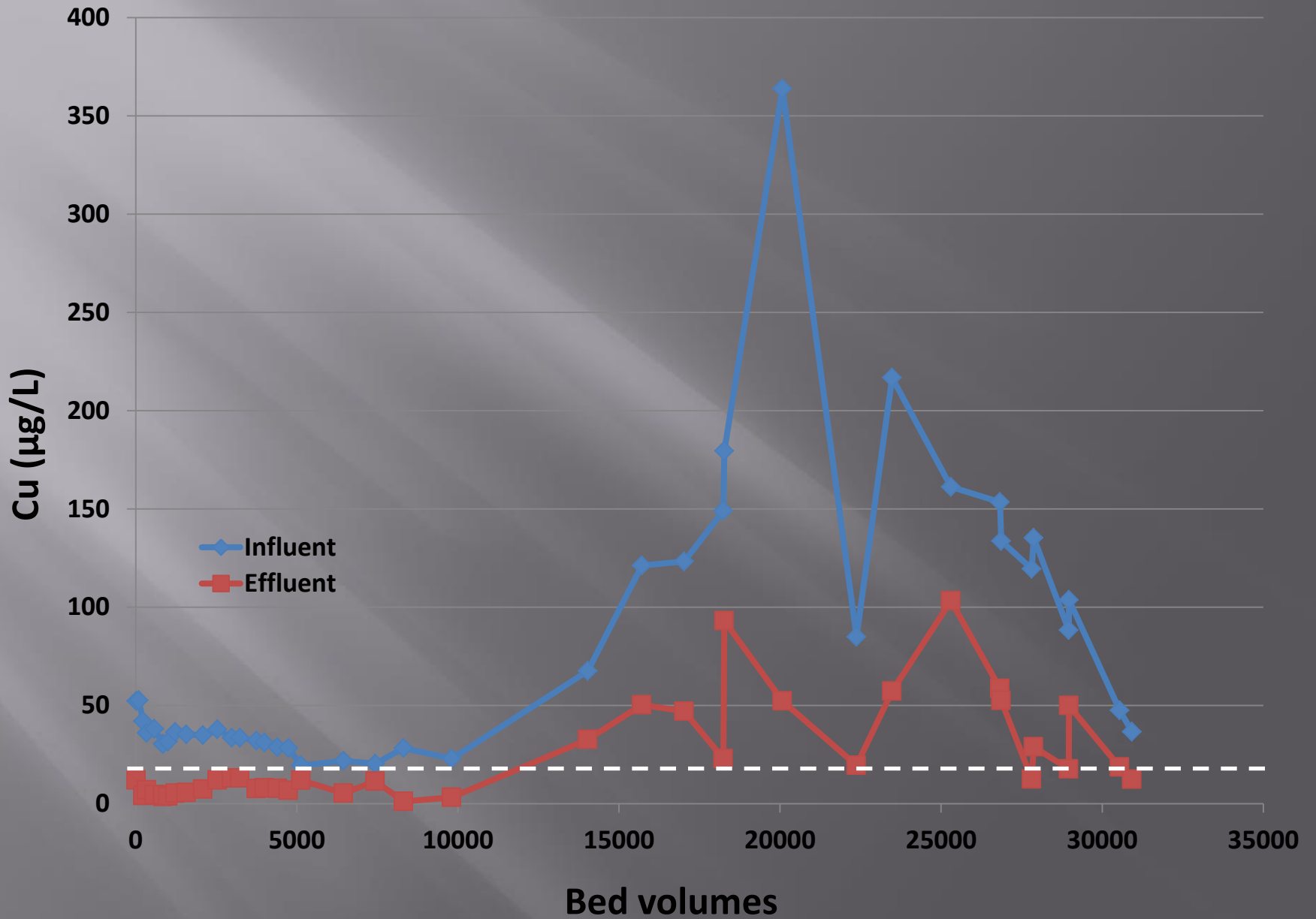
Empty bed contact time (min) =  $\frac{\text{Volume of reactive media(gallons)}}{\text{Flow rate (gallons/min)}}$   
5- 20 minutes



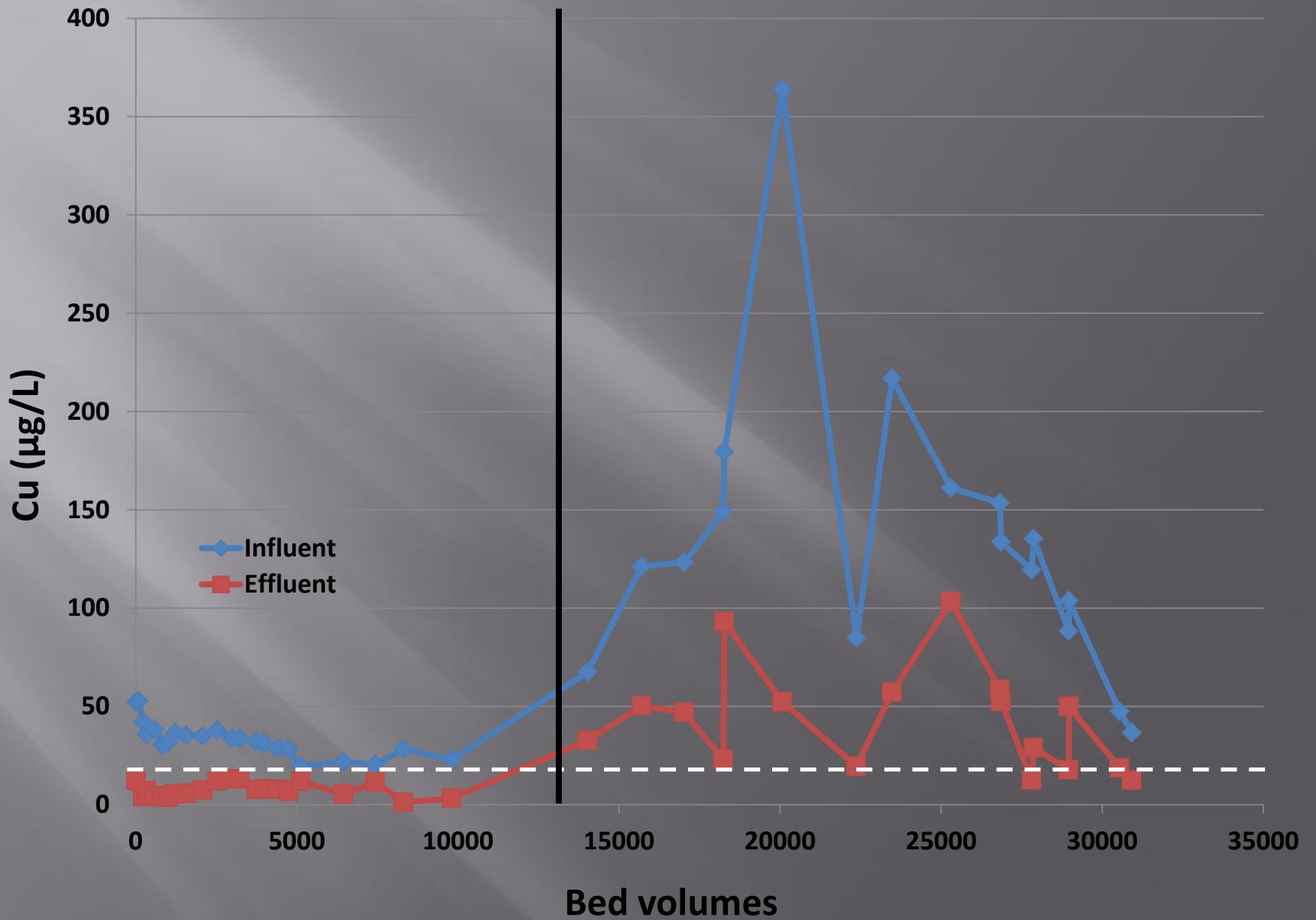




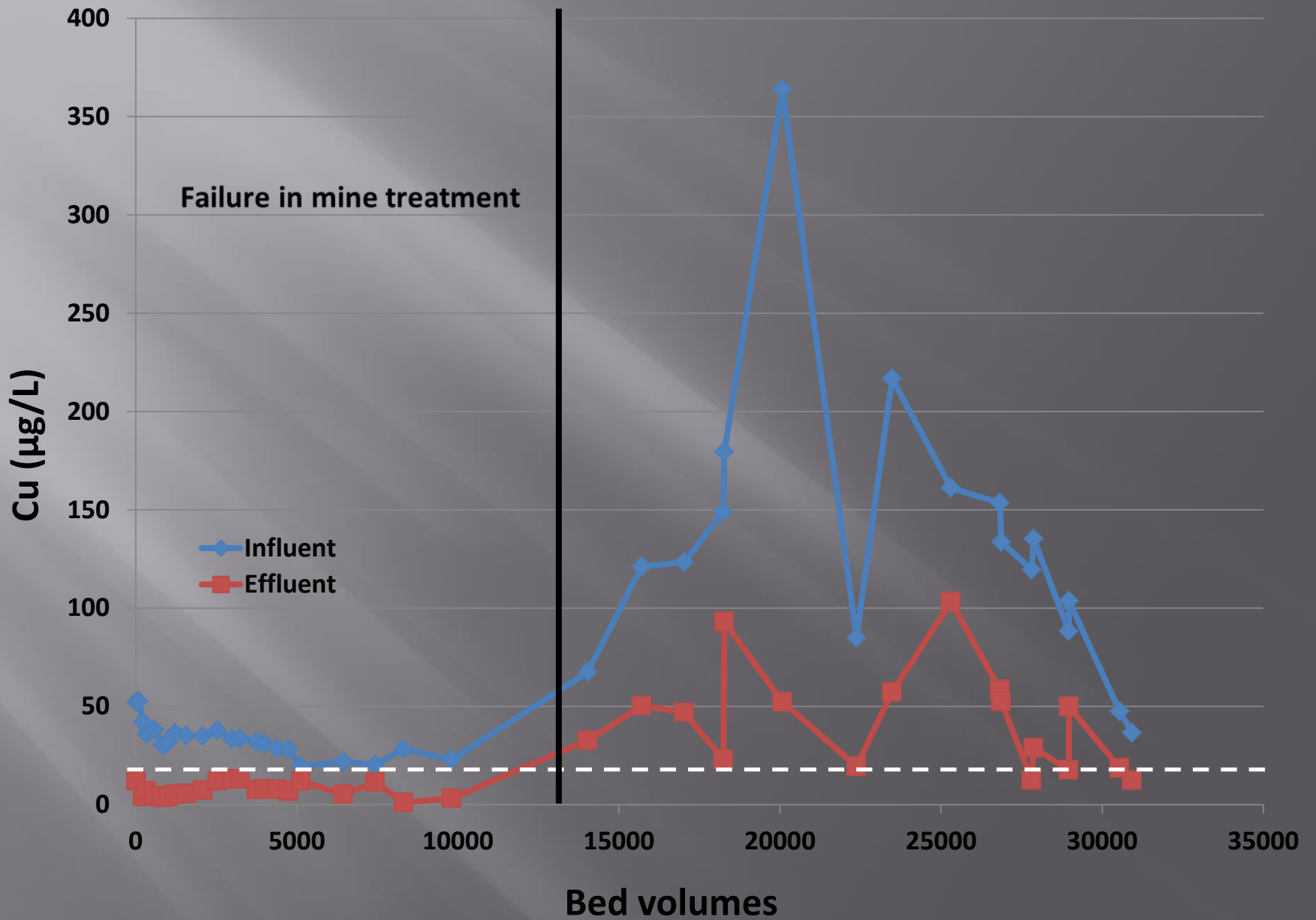
# Total copper



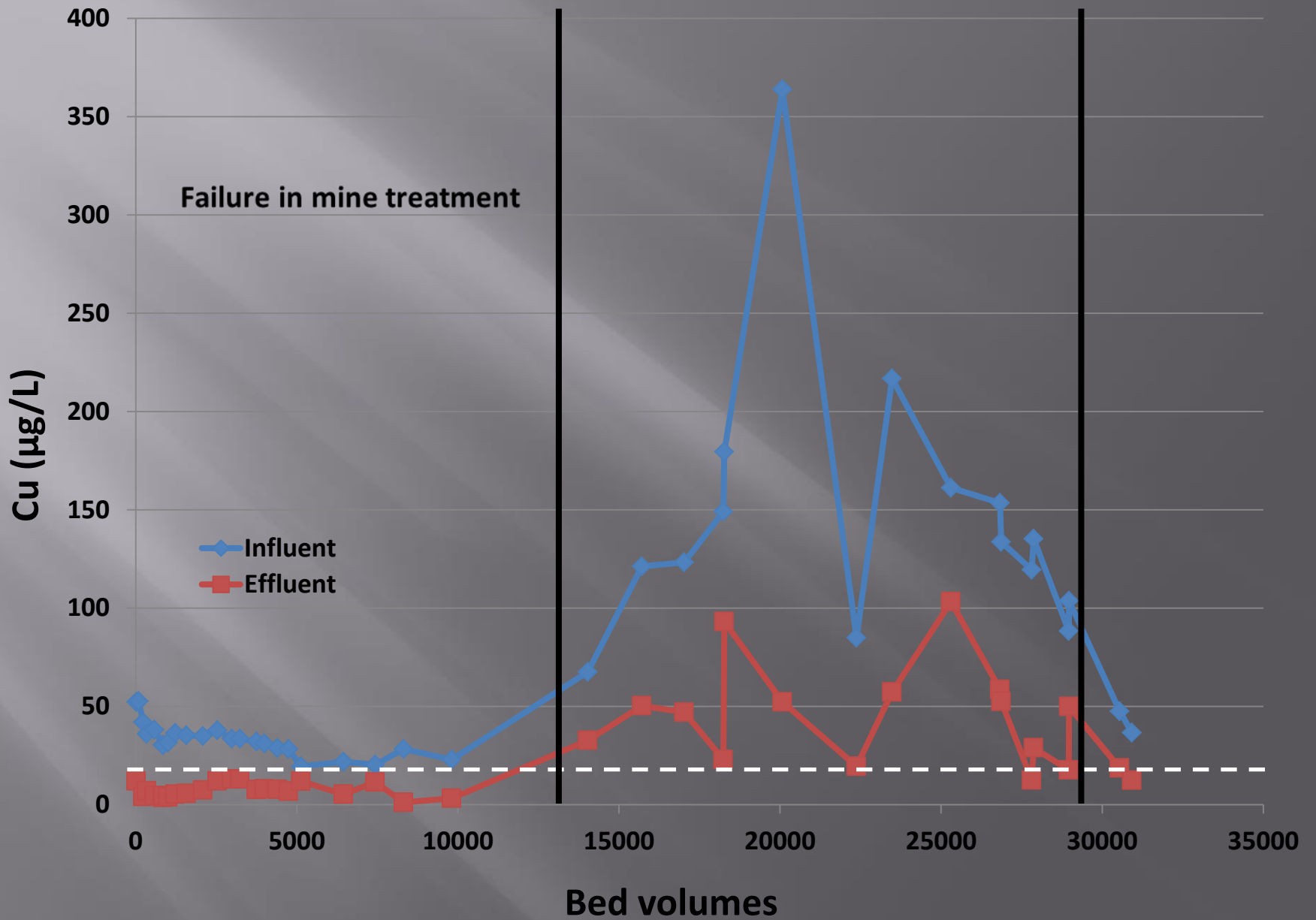
# Total copper



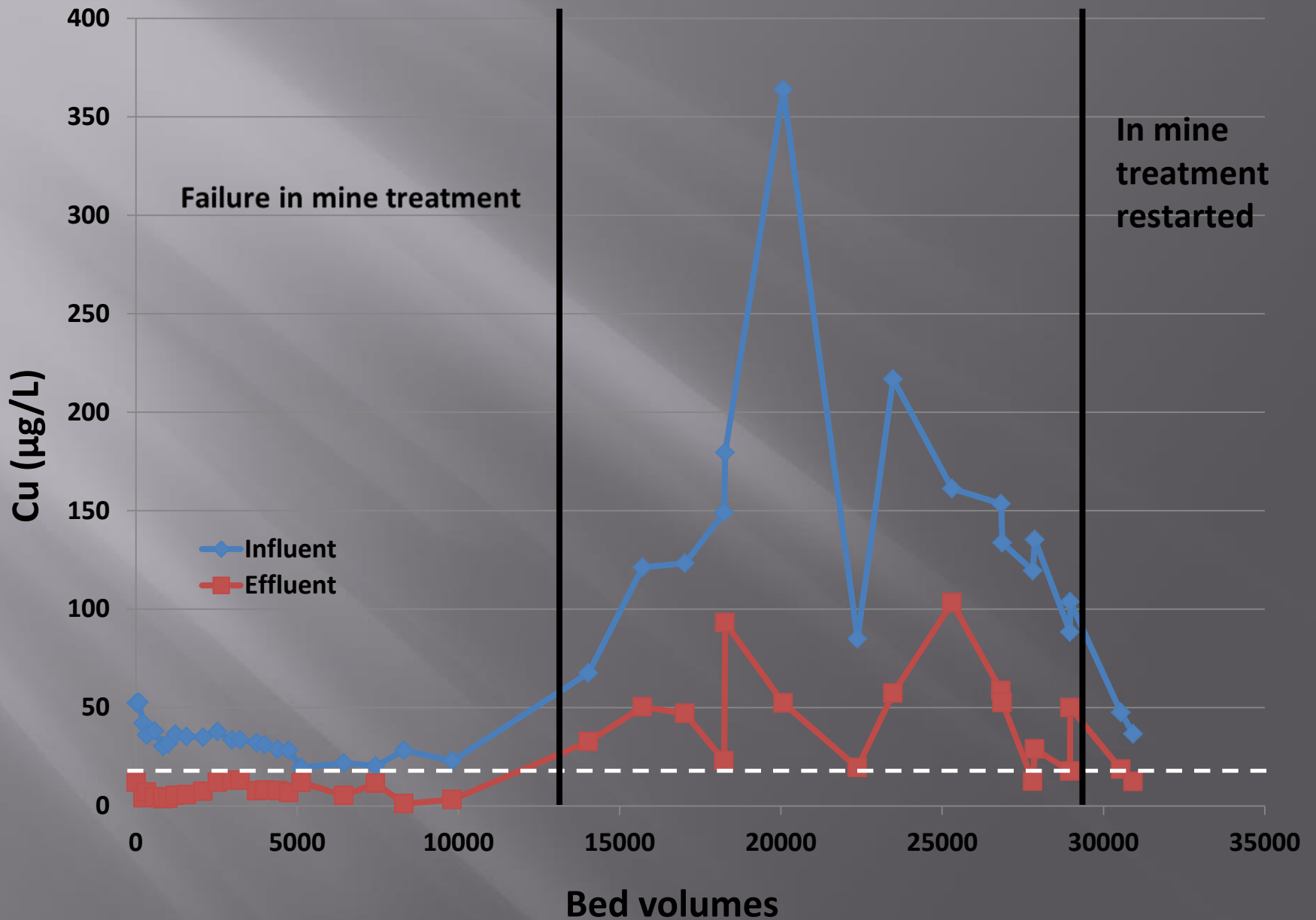
# Total copper



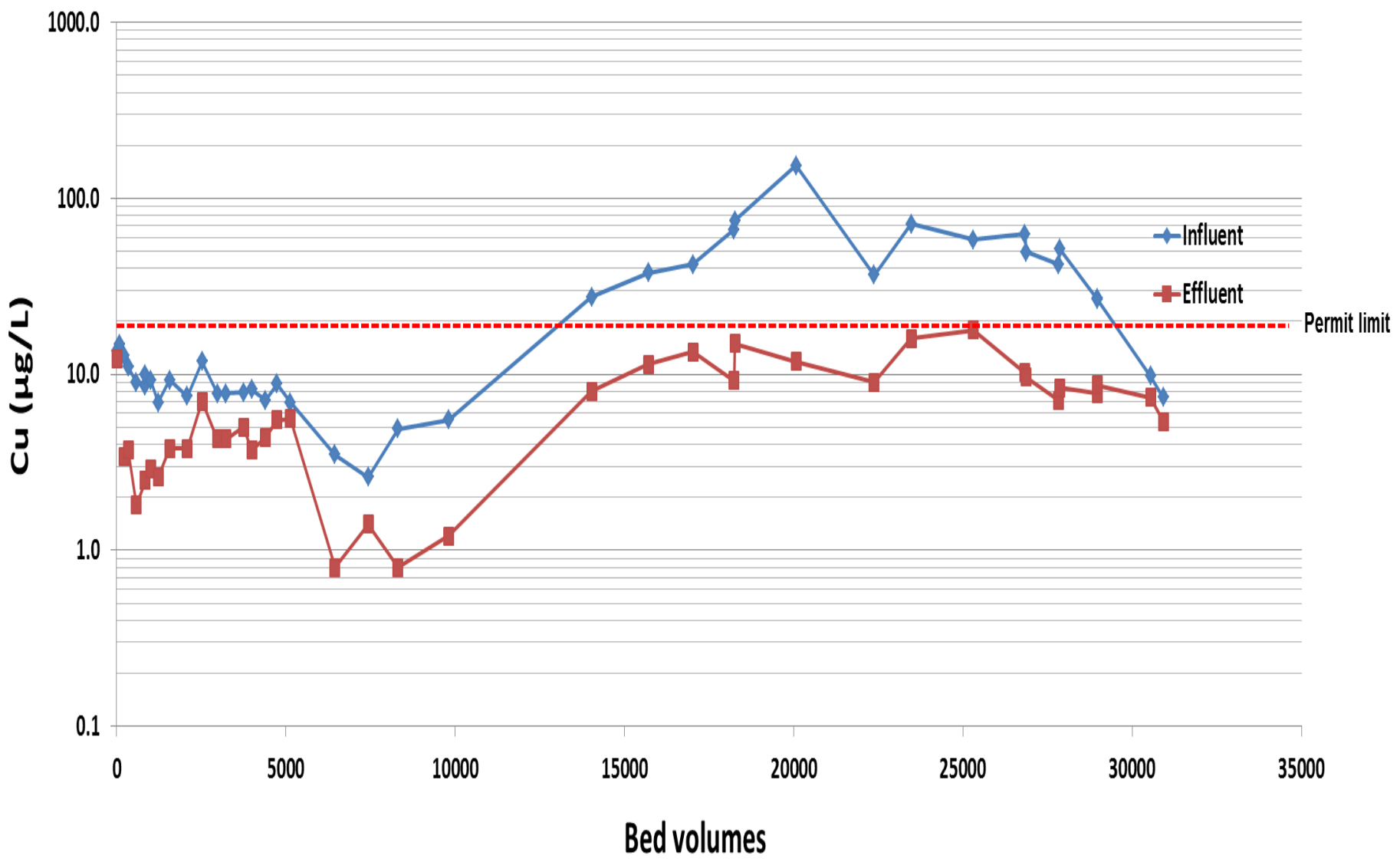
# Total copper



# Total copper



# Filtered copper



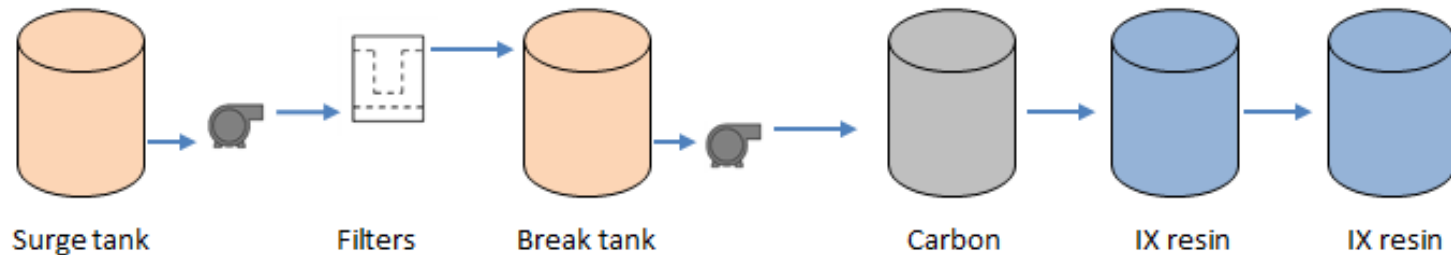
# Conclusions

- ▣ Effective removal of copper
  - Average 74% suspended
  - Average 60% dissolved
- ▣ 12 months operation:
  - ▣ 16 million gallons treated
  - ▣ 32, 000 bed volumes
  - ▣ Minimal maintenance
    - ▣ Backwash every 4-6 weeks
  - ▣ Treatment cost <\$0.00025/gallon
- ▣ Can simplify treatment system

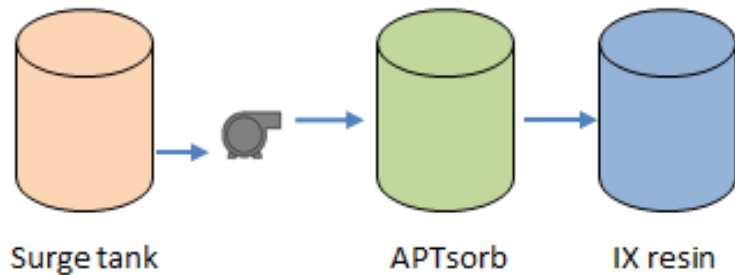


# System Comparison

## Existing System

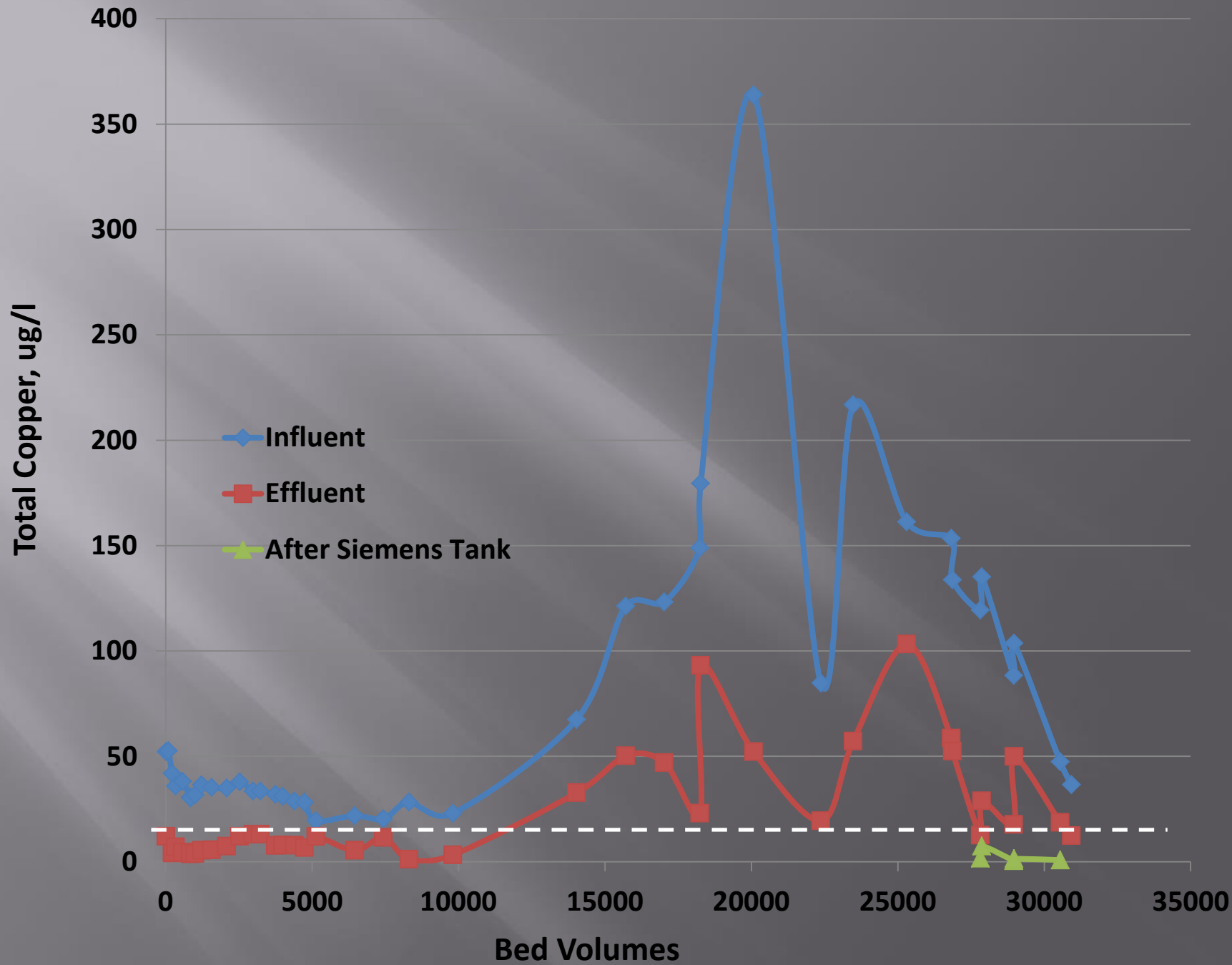


## APT System



APT<sub>sorb</sub> replaces filters, break tank, pump, carbon tank and first IX tank





# Cobalt

Bed Volumes	Cobalt influent	Cobalt, after APTsorb	Cobalt after Siemens
577	6.9	0.47	
1,003	9.1	1.4	
1,227	7.2	2.3	
1,566	7.2	5.8	
2,529	9.3	9.2	
3,751	11.4	10.7	
3,996	12.3	10.3	
27,817			0.47
27,871			0.1

All concentrations in ug/l; Permit limit 4 ug/l

# Estimated Annual Operating Costs

- ▣ Existing system: \$163,000<sup>a</sup>
- ▣ Proposed APTsorb system: \$ 70,000<sup>b</sup>



<sup>a</sup>4 exchanges per year

<sup>b</sup>2 exchanges per year

# Next Steps

- ▣ Proposal for implementation submitted
- ▣ Additional issues
  - Mercury
  - Typical discharge 40-60 ng/l
  - Standard 6.9 ng/l
  - 90% suspended
- ▣ Other applications
  - Treated coal mine drainage
  - Total aluminum exceeds limit
    - ▣ Most is suspended

# Looking for Answers?

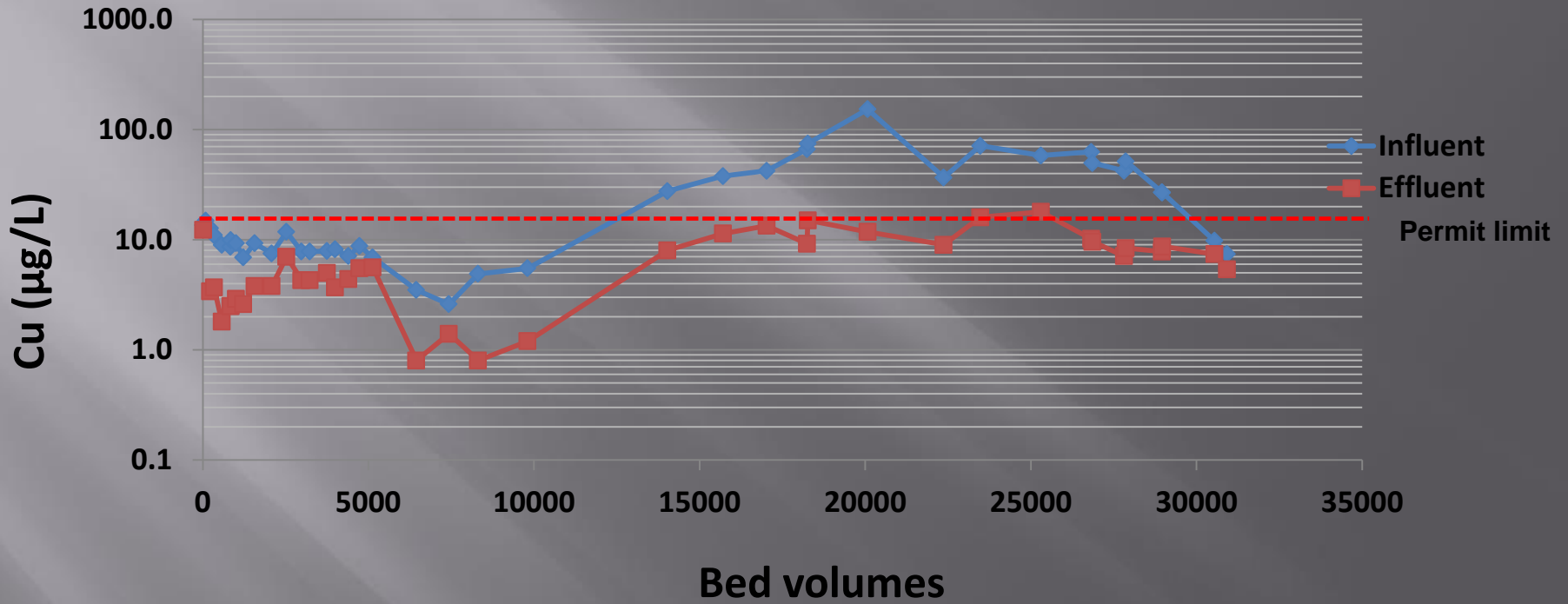


**Ask a question!**

“There are no rules here. We’re trying to accomplish something.”

Thomas Edison

### Filtered copper



# Cobalt Results

