Solving Mine Water Problems with Peat-based Sorption Media

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Overview

- 2 Pilot studies
  - Suspended and dissolved copper
  - Suspended and dissolved lead, zinc, cadmium
- Peat adsorption media
  - What is it
  - Properties
- Results
- Summary

SOUDAN UNDERGROUND MINE STATE PARK

Soudan, MN

Suspended and Dissolved Copper

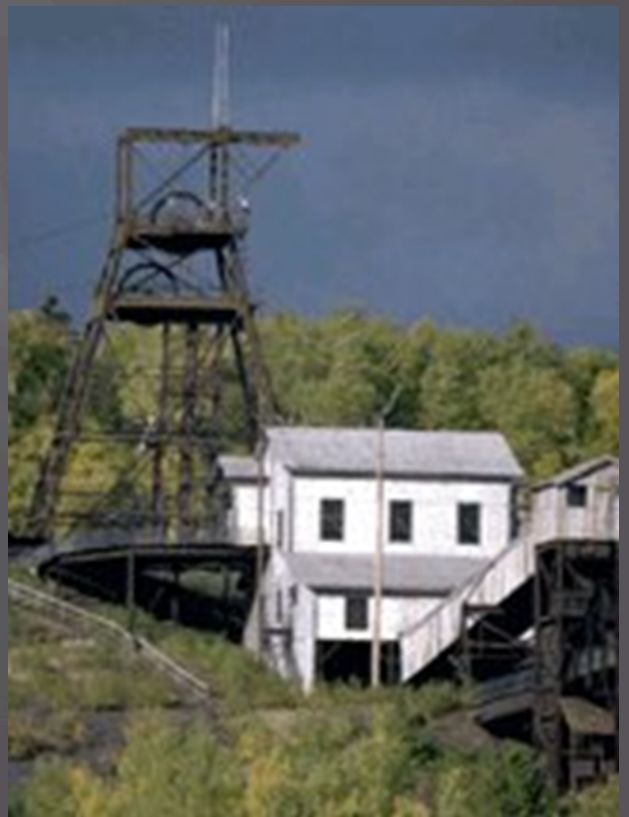
Background

- 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….

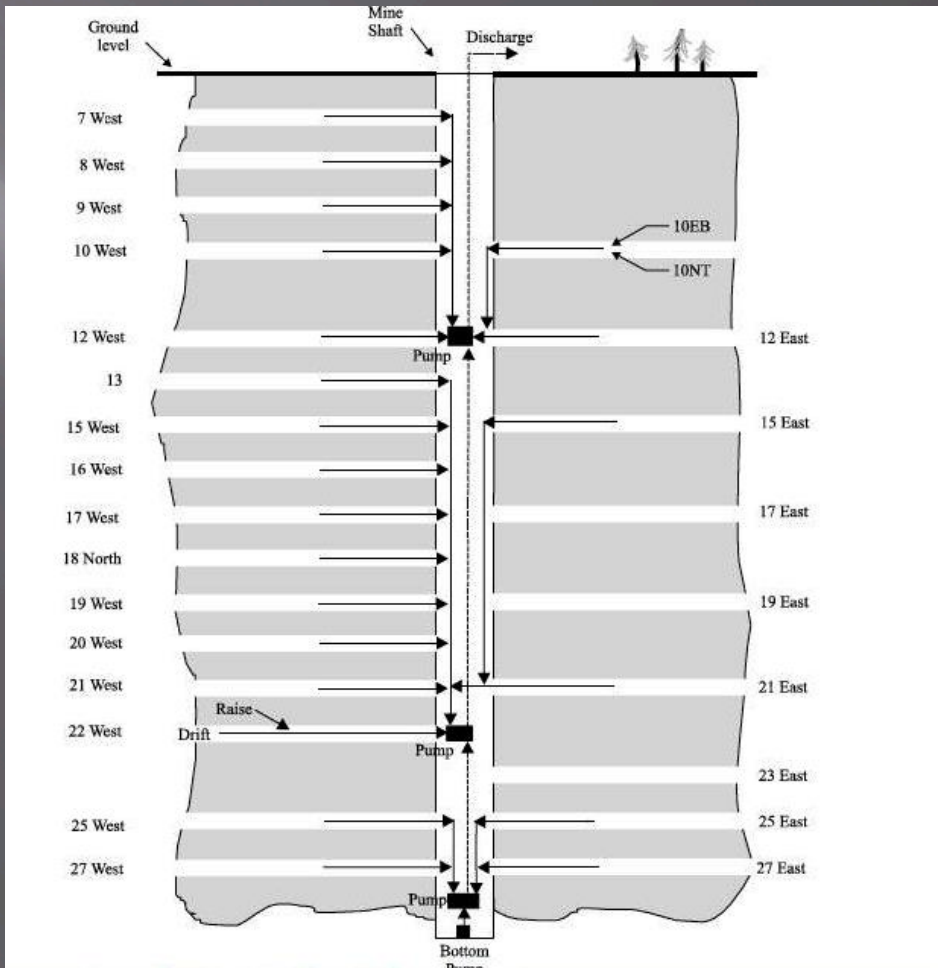
- Long and sordid story complete with numerous plot twists
- Cliffs Notes Summary:
  - Compliance 2009
  - Ion exchange treatment

Small unit in the mine

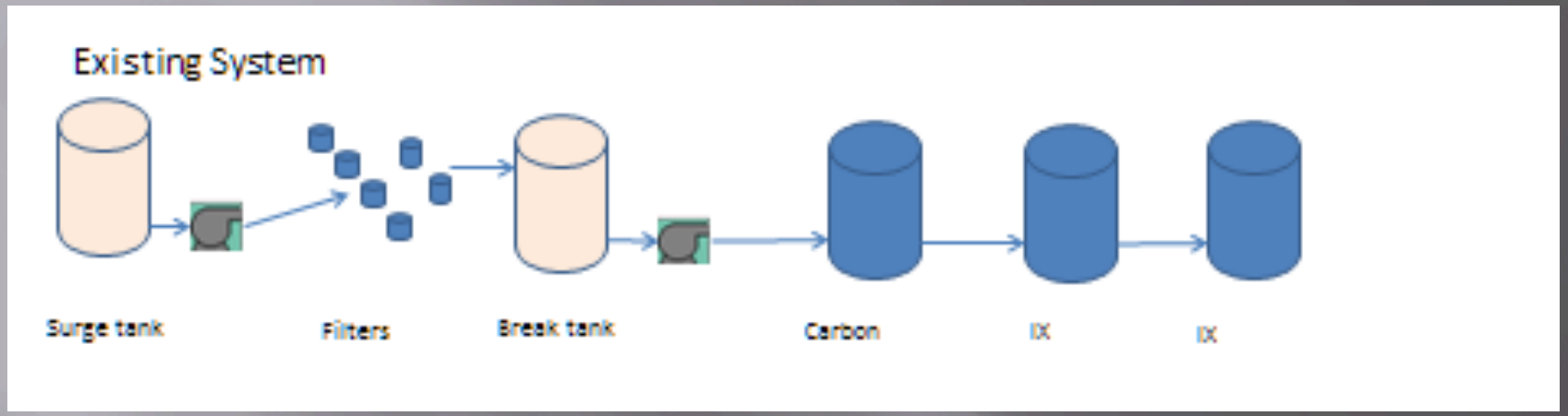
Major source

Large unit on surface

Entire discharge



Current Treatment System



So what's the problem?

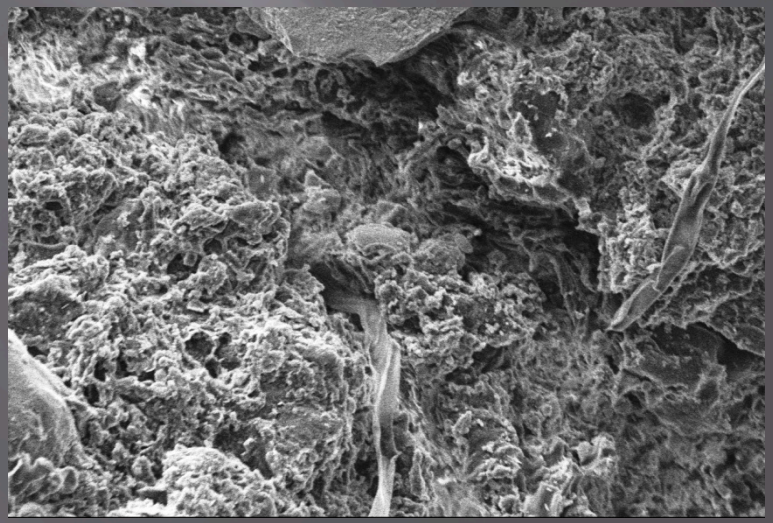
- Unfiltered copper removal problematic
  - Some suspended copper moves through system
  - Plugging of ion exchange tanks
    - Only about 20% of the removal capacity utilized

Is there a better approach?

A Better Approach?

- APTsorb ™
  - Patented peat based sorption media
  - Hardened granule
  - High hydraulic conductivity (~1 cm/sec)
  - High metal affinity (1-15% max dry wgt)

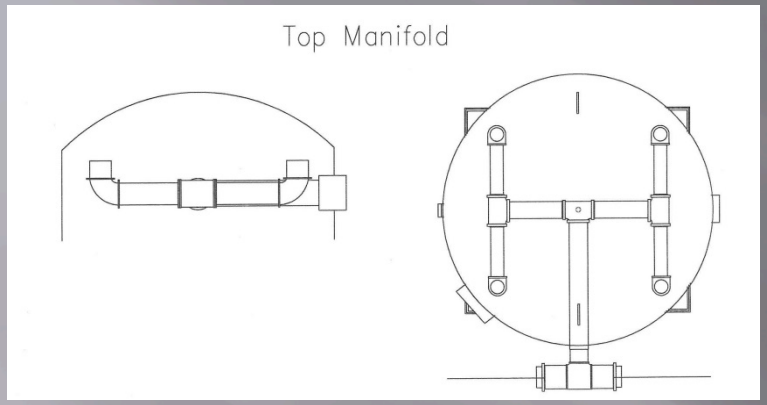
APTsorb ™ Granule

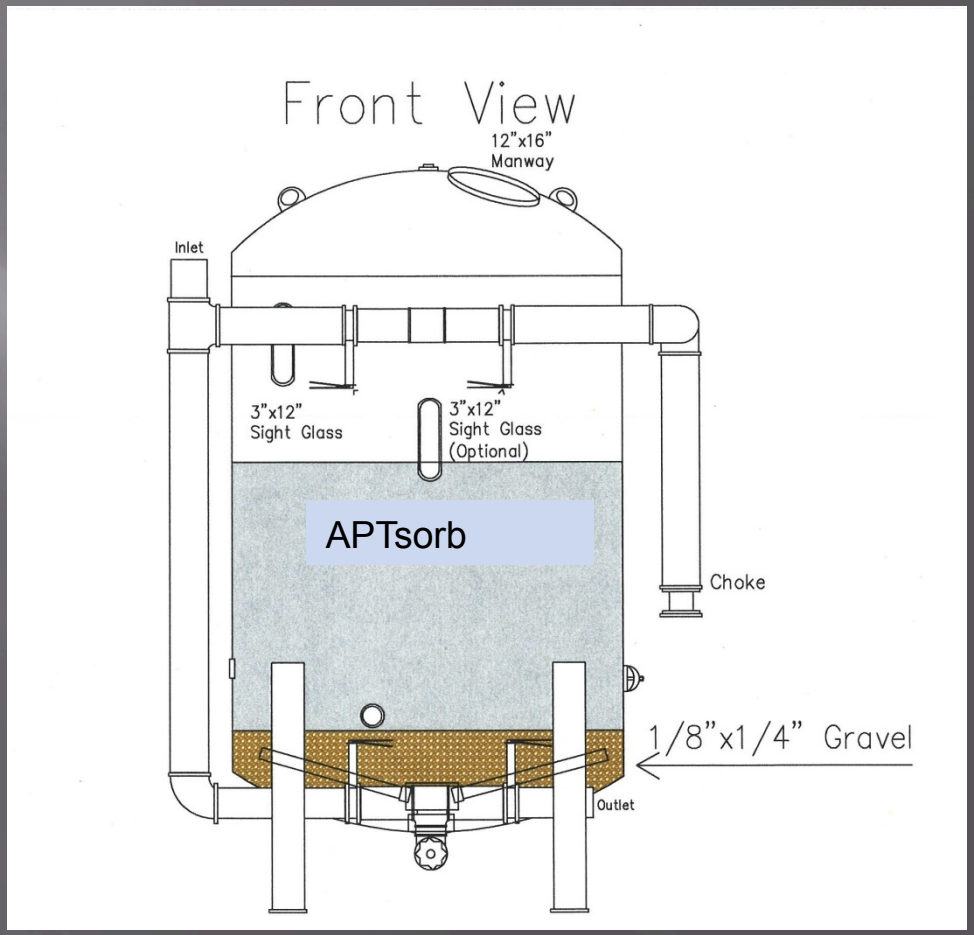


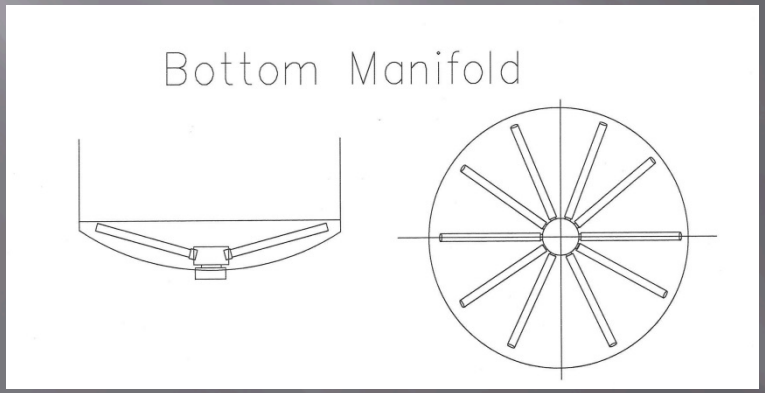
APTsorb ™ Granule 1500x

Approach

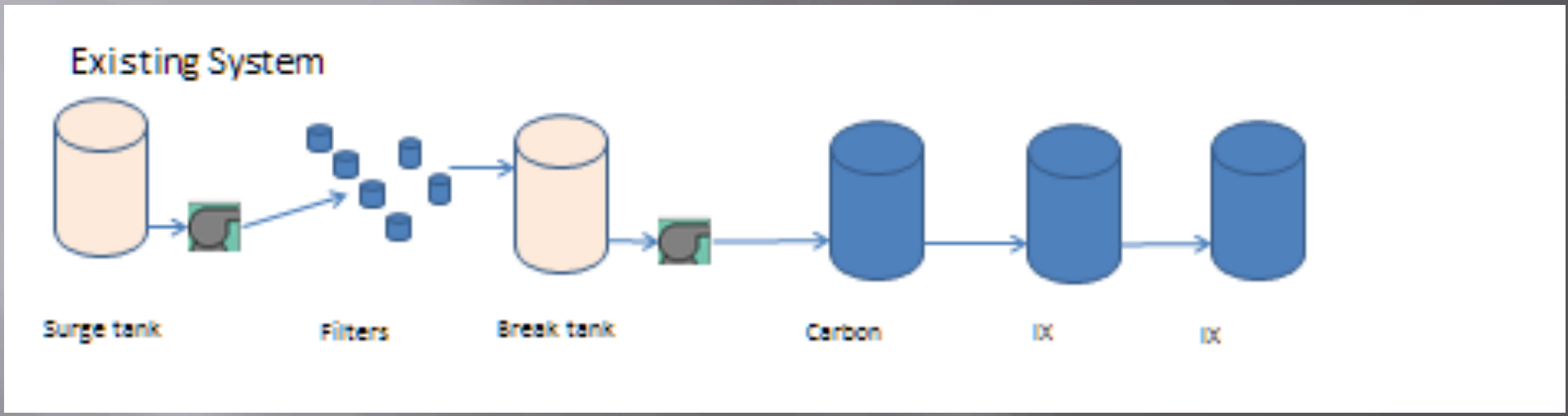
- Use tank with APTsorb as pretreatment
- Treatment tank
  - 1000 gallon
  - 500 gallons media
  - Design for periodic backwash

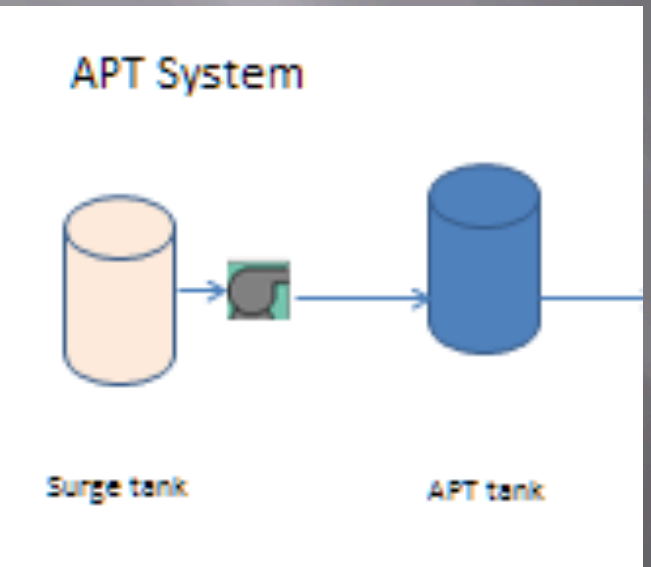

Top Manifold


Front View
12"x16"
Manway
Inlet
3"x12"
Sight Glass
3"x12"
Sight Glass
(Optional)
APTsorb
Choke
1/8"x1/4" Gravel
Outlet


Bottom Manifold

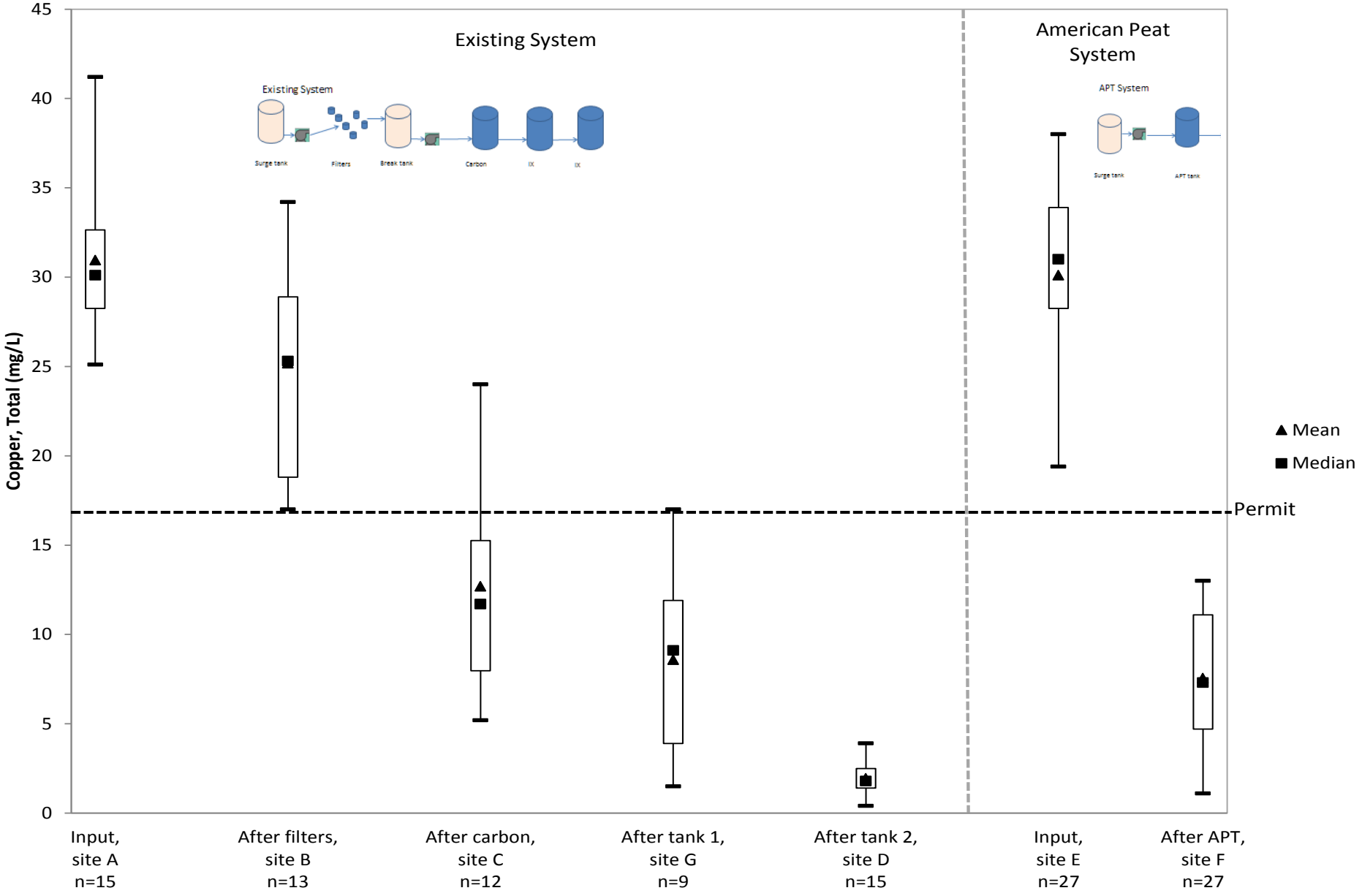
System Comparison

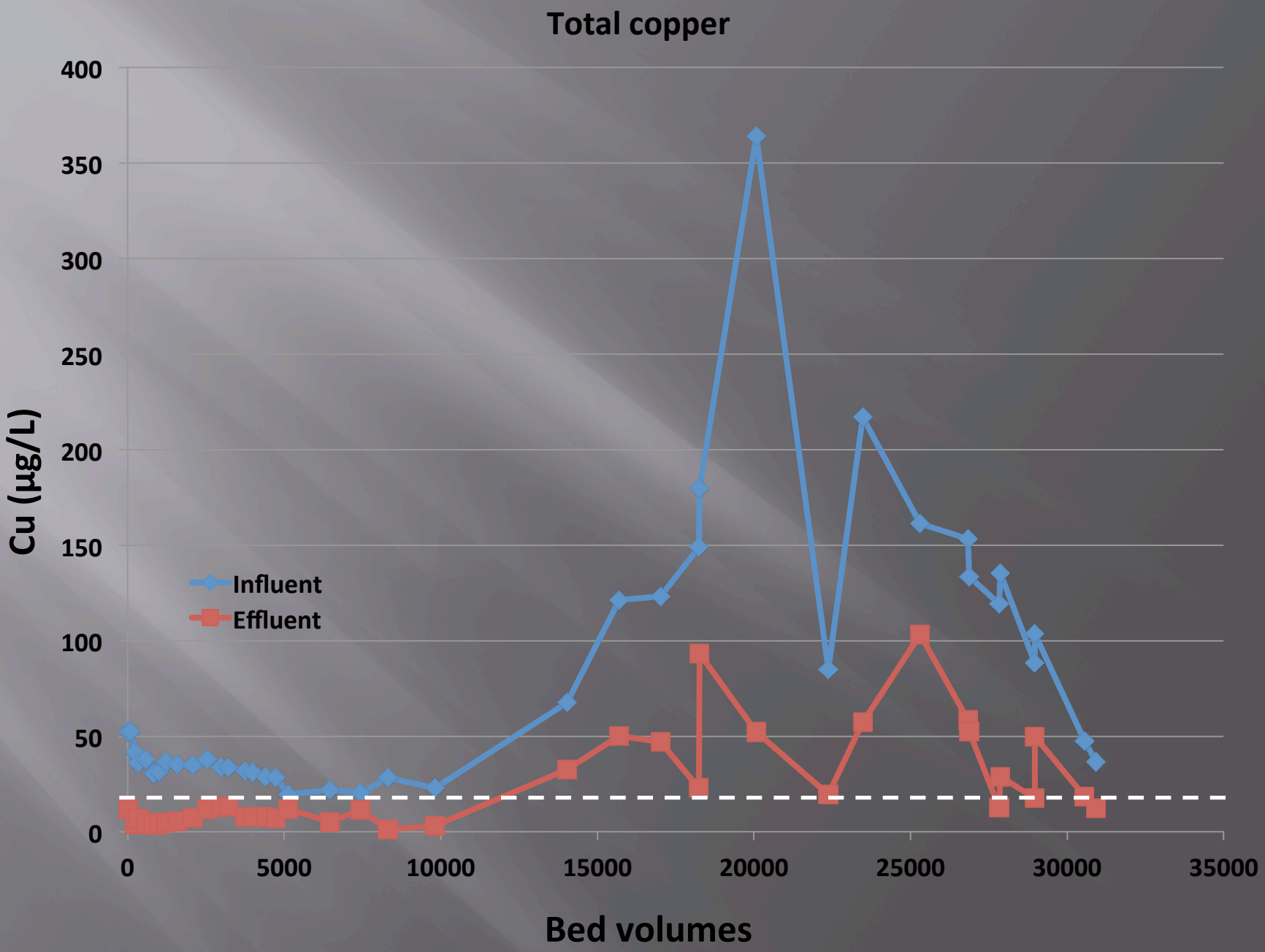


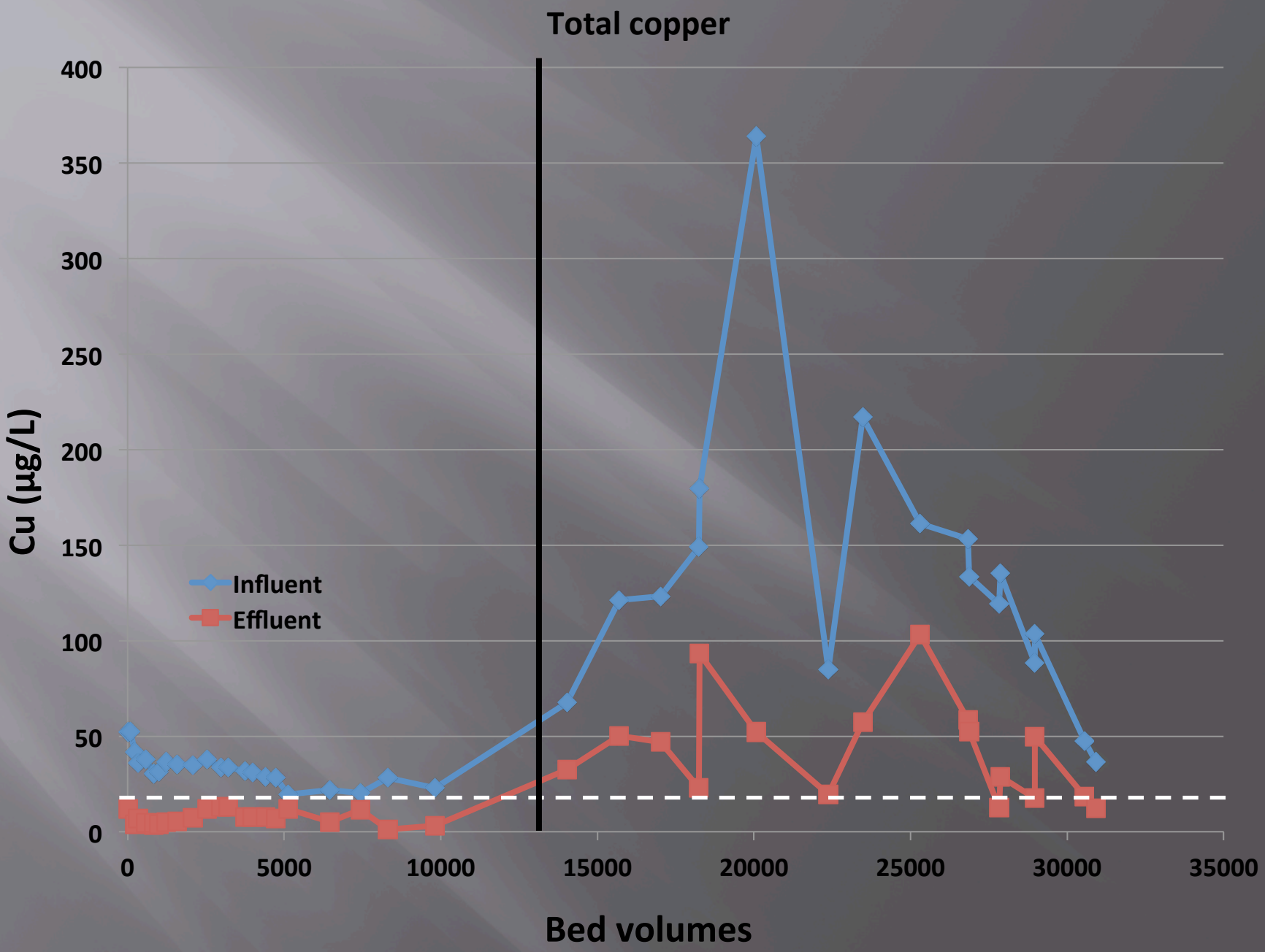


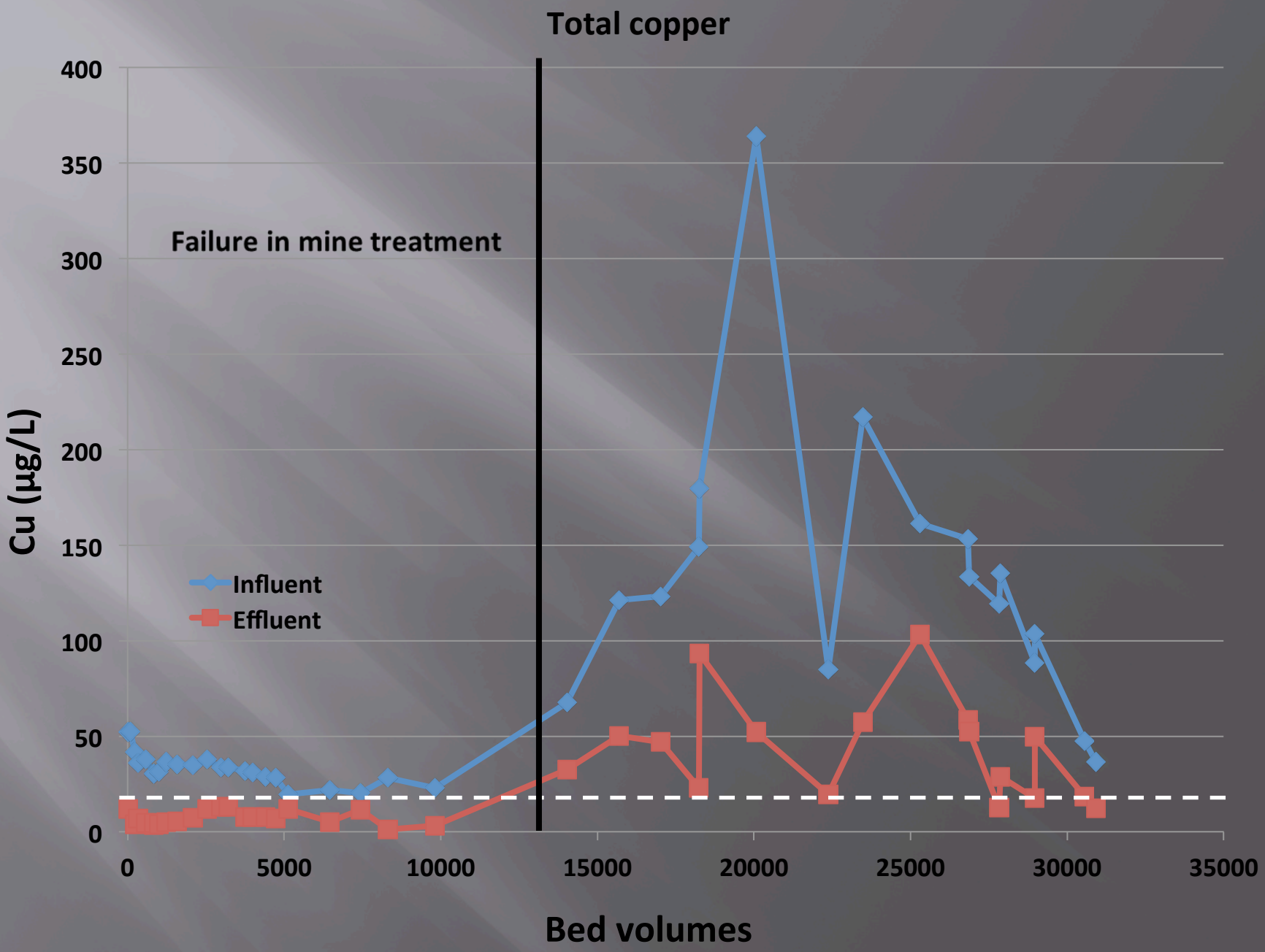
RESULTS

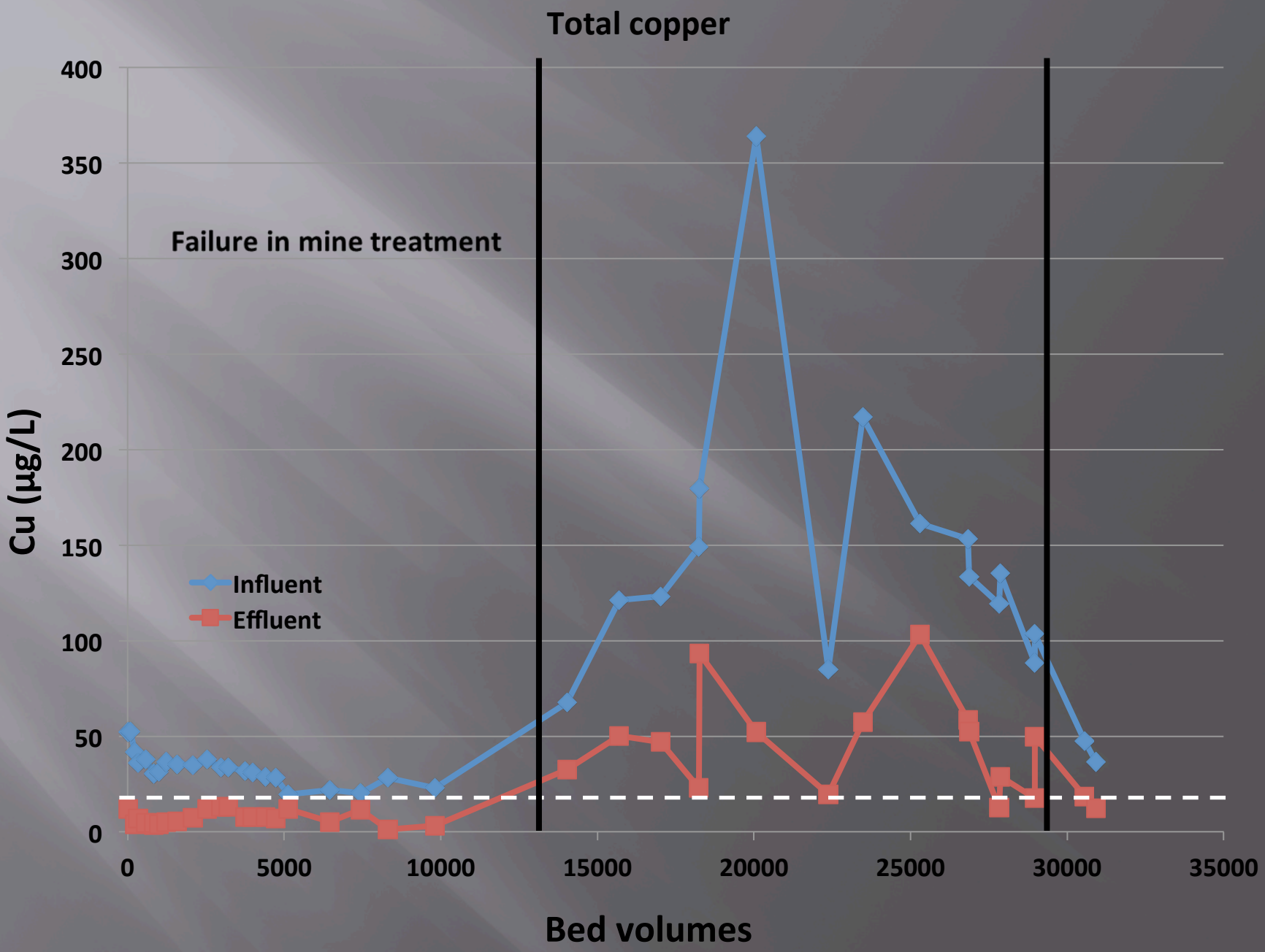
Box Plot: Copper, unfiltered

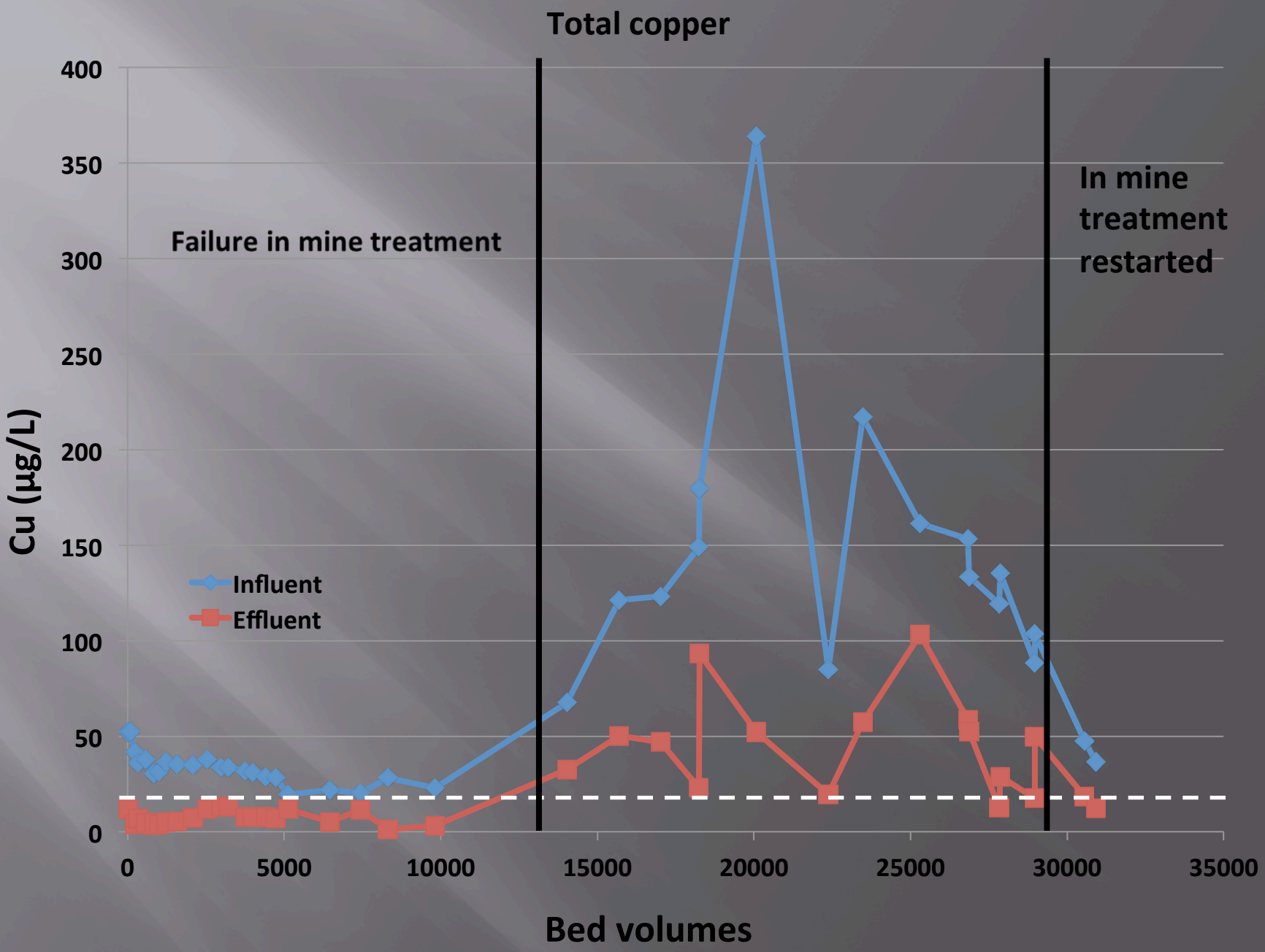



Total copper
400
350
300
250
200
150
100
50
0
Cu (µg/L)
Influent
Effluent
0
5000
10000
15000
20000
25000
30000
35000
Bed volumes


Total copper
Cu (µg/L)
400
350
300
250
200
150
100
50
0
Influent
Effluent
0
5000
10000
15000
20000
25000
30000
35000
Bed volumes


Total copper
Failure in mine treatment
Influent
Effluent
Cu (µg/L)
400
350
300
250
200
150
100
50
0
0
5000
10000
15000
20000
25000
30000
35000
Bed volumes

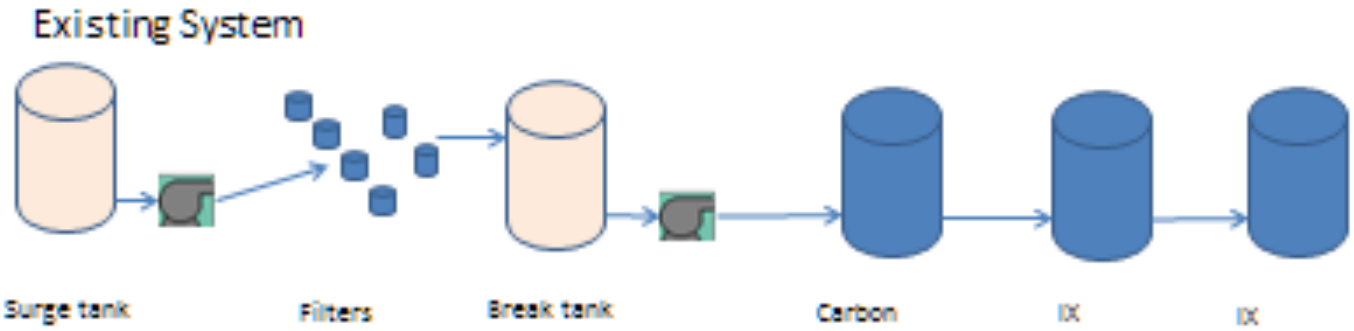

Total copper
Failure in mine treatment
Influent
Effluent
Cu (µg/L)
400
350
300
250
200
150
100
50
0
0
5000
10000
15000
20000
25000
30000
35000
Bed volumes

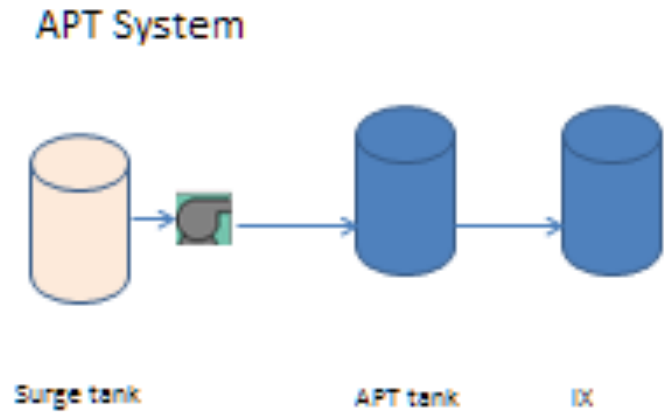

Total copper
Failure in mine treatment
In mine treatment restarted
Influent
Effluent
Cu (µg/L)
Bed volumes
400
350
300
250
200
150
100
50
0
0
5000
10000
15000
20000
25000
30000
35000

Conclusions

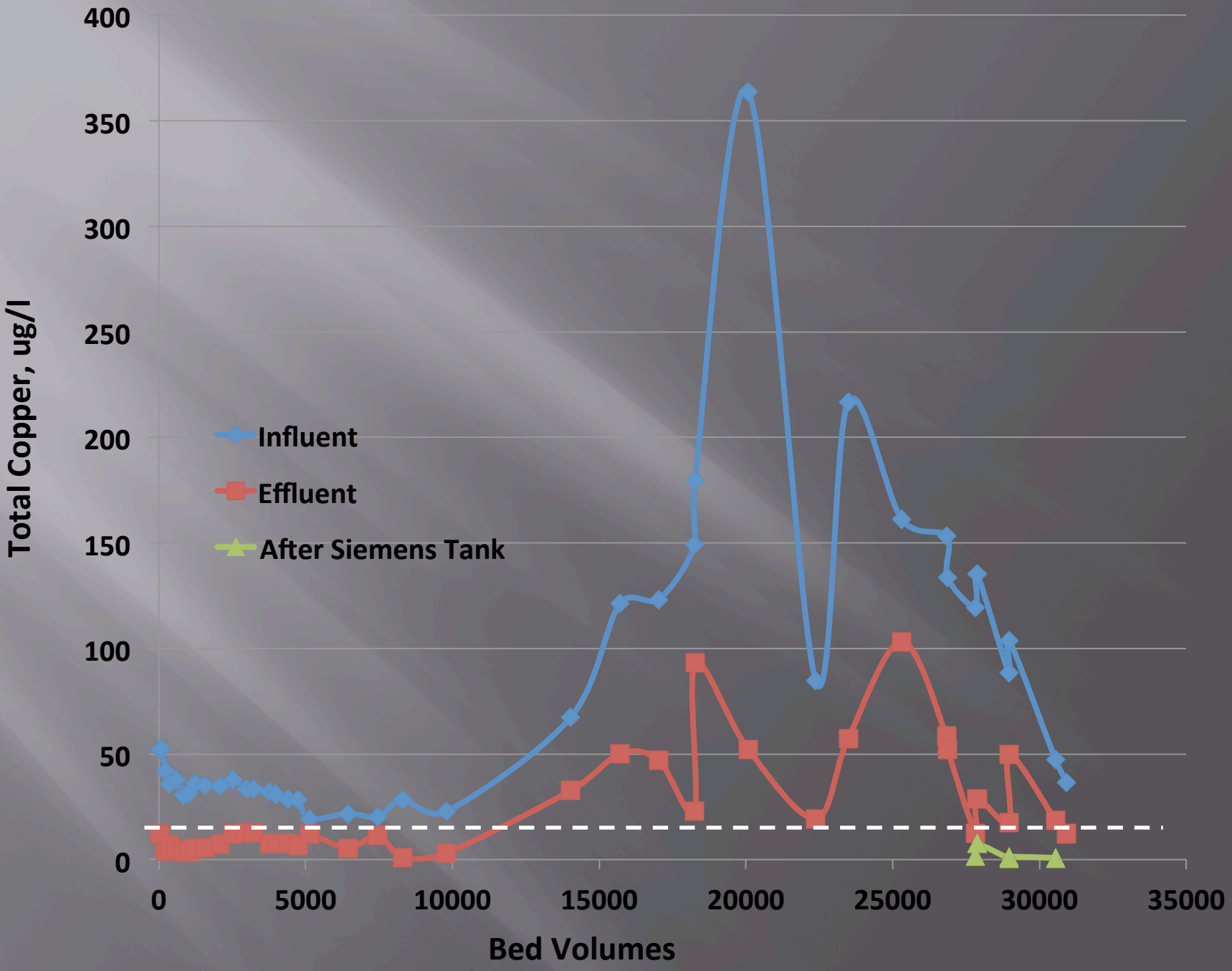
- Effective removal of copper
  - Average 74% suspended
  - Average 60% dissolved
- 12 months operation:
  - 16.5 million gallons treated
  - 32, 000 bed volumes
  - Treatment cost <$0.00025/gallon (25 cents/1000 gallons)
- Can simplify treatment system

System Comparison





APTsorb replaces filters, break tank, pump, carbon tank and first IX tank


Total Copper, ug/l
400
350
300
250
200
150
100
50
0
Influent
Effluent
After Siemens Tank
0
5000
10000
15000
20000
25000
30000
35000
Bed Volumes

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: $130,000
- APTsorb: $ 21,000

GETTING THE LEAD OUT

Base metal mine drainage testing

Suspended and dissolved Pb, Zn, Cd

Pb concentration; unfiltered (ug/l)						filtered
Site						
Bed Volumes	1	2	3	4	5	5
0 (Initial)	99	80	102	71	94.1	61.5
5					16.3	4.1
8	83	4.3	11	6.1		
10					17	6.0
20					17.4	3.1
30					17.8	3.4
35	30	4.2	24	3.2		
40					17.9	3.1
64	17	6.5	27	3.0		
99	8.5	3.1	15	2.7		
114	19	3.1	15	2.6		
145	8.7	3.7	20	3.6		
177	8.2	3.0	13	2.2		
205		1.9				
209	8.1			2.2		
236	6.2			2.7		
Permit limit	28	11.5	12.2	12.2	11.0	

Feasibility Test Effluent Results Pb, ug/l

Green < permit limit

The Challenge

- Treat direct mine discharge
- High and variable TSS
- Low limits
  - Pb 11 ug/l
  - Zn 137 ug/l
  - Cd 0.5 ug/l
- Treatment cost not to exceed $0.001/gallon ($1/1000 gallons)

Additional Testing

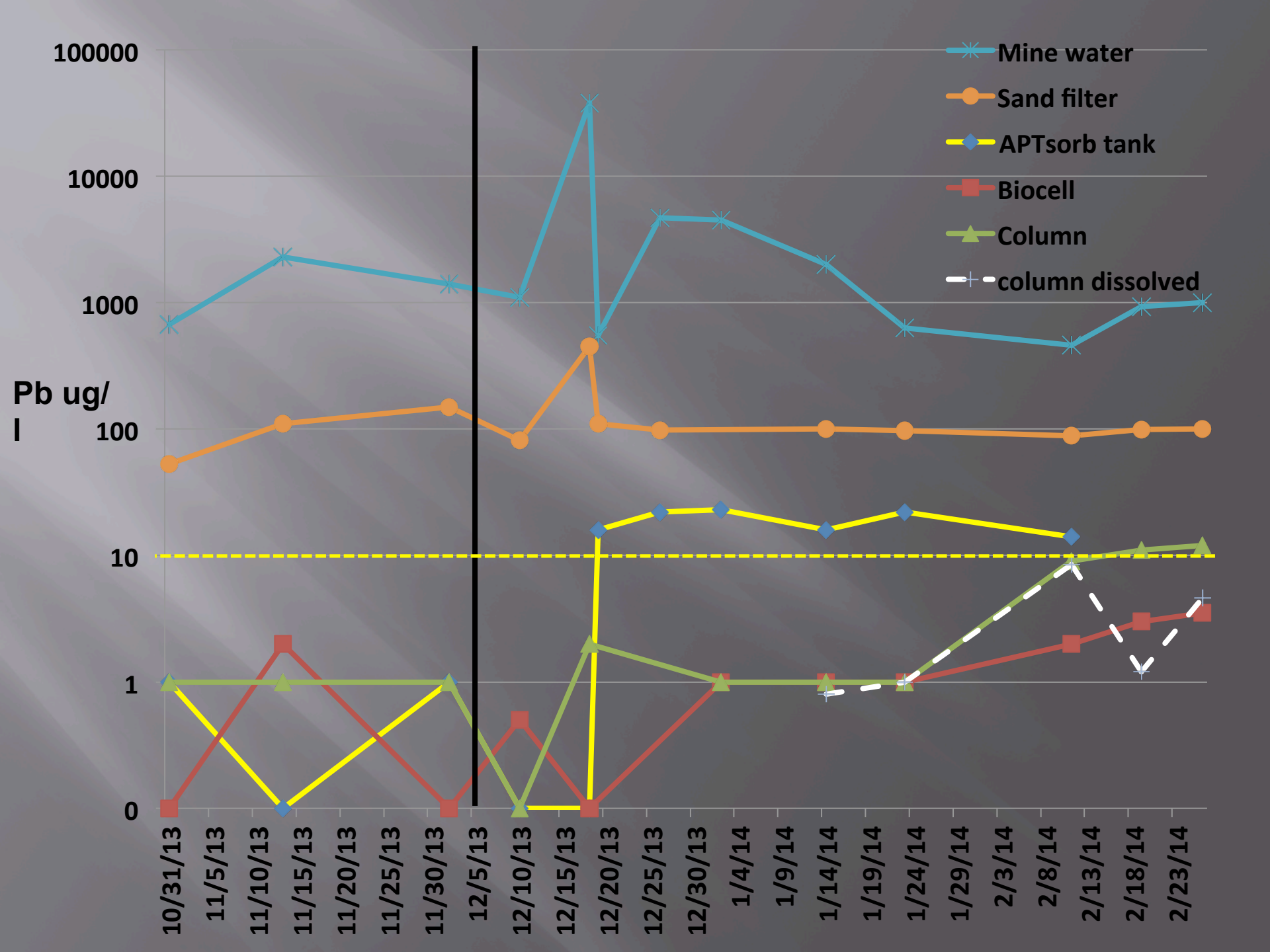
- On site columns
- Sand filter
- - 30 APTsorb

Pilot Test

“Semi”- Active

Passive - Biocells

Long term column


100000
10000
1000
Pb ug/l
100
10
1
0
Mine water
Sand filter
APTsorb tank
Biocell
Column
column dissolved
10/31/13
11/5/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
12/5/13
12/10/13
12/15/13
12/20/13
12/25/13
12/30/13
1/4/14
1/9/14
1/14/14
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1/24/14
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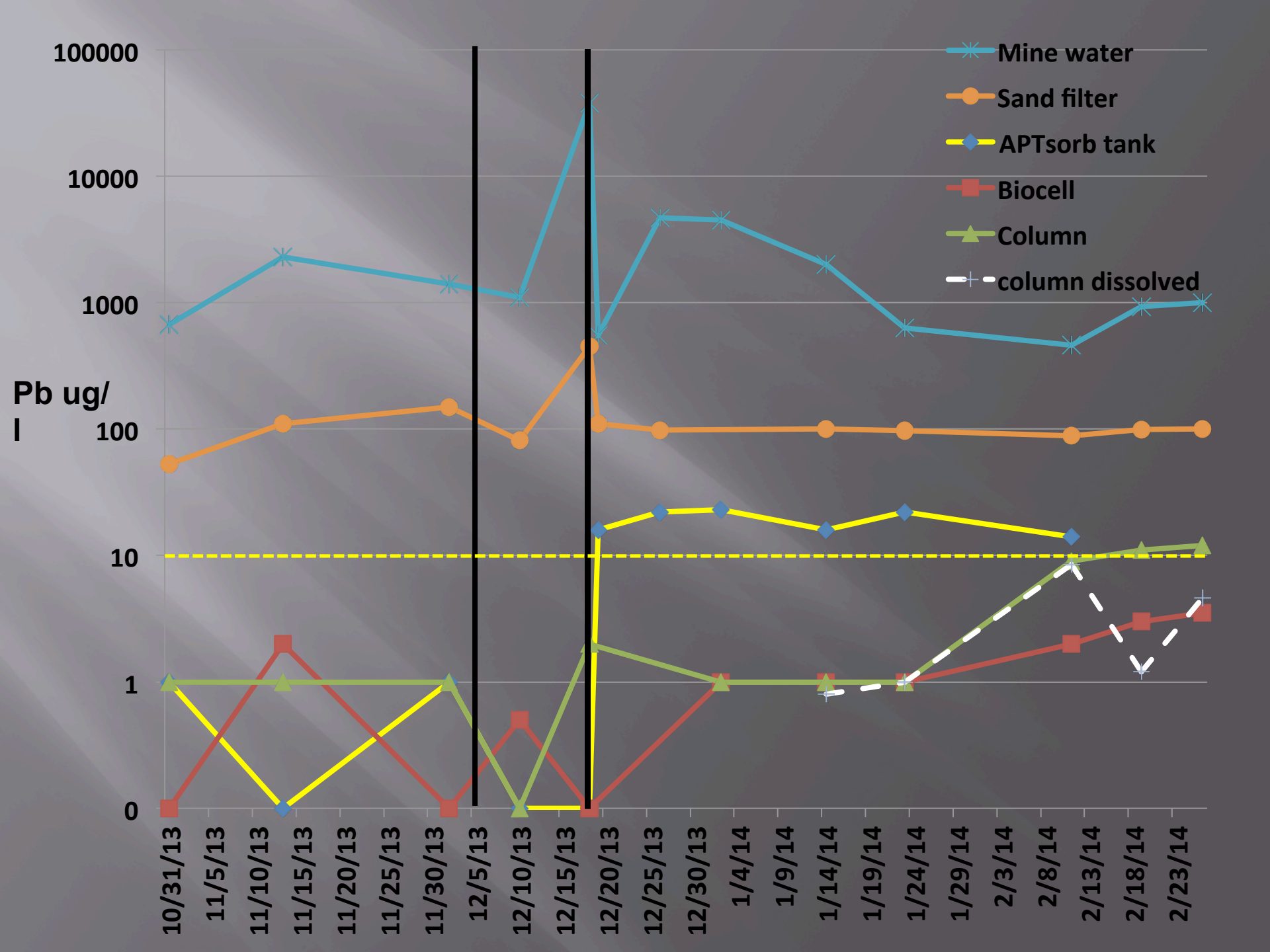
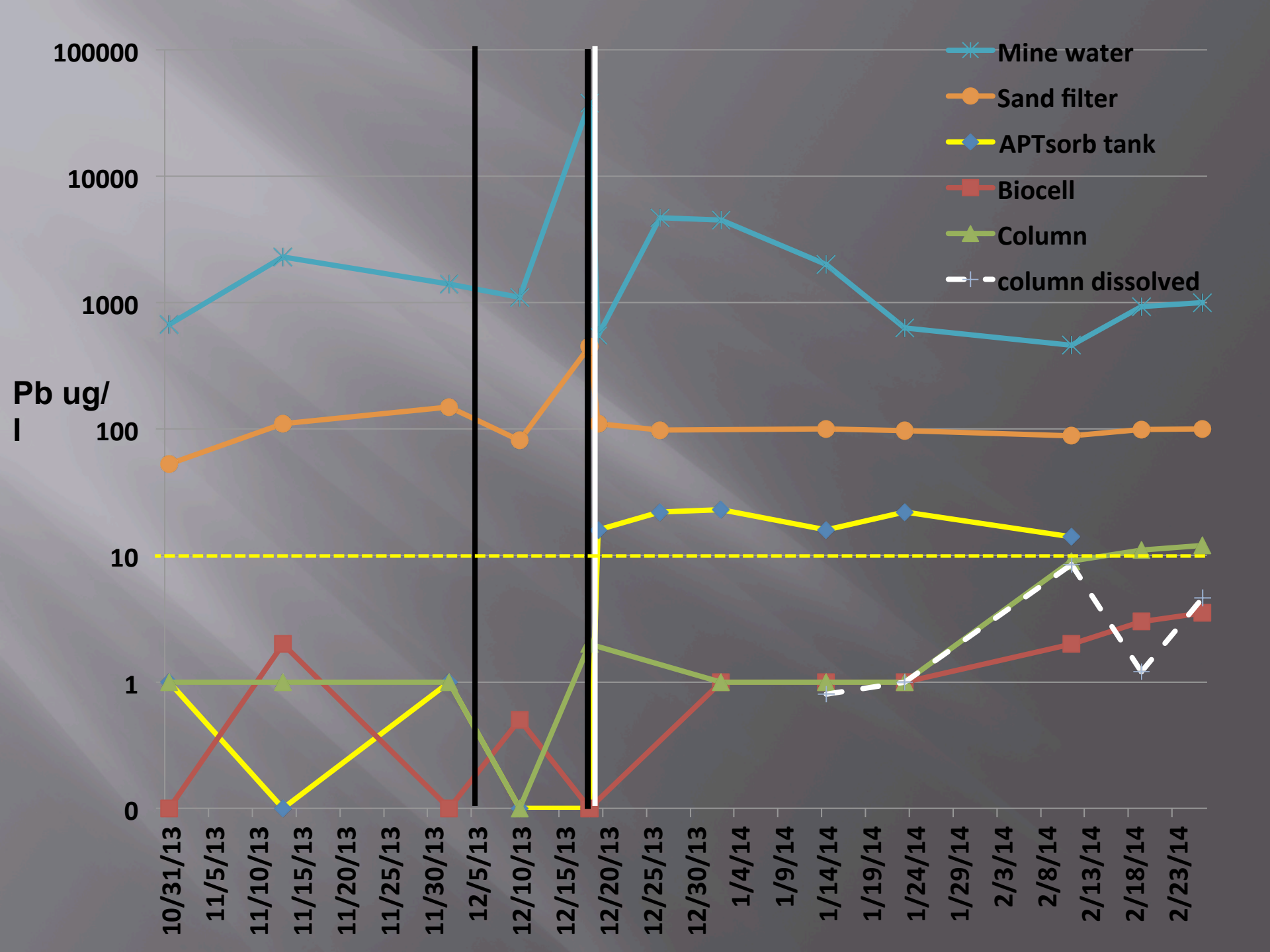
2/3/14
2/8/14
2/13/14
2/18/14
2/23/14


100000
10000
1000
Pb ug/l
100
10
1
0
Mine water
Sand filter
APTsorb tank
Biocell
Column
column dissolved
10/31/13
11/5/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
12/5/13
12/10/13
12/15/13
12/20/13
12/25/13
12/30/13
1/4/14
1/9/14
1/14/14
1/19/14
1/24/14
1/29/14
2/3/14
2/8/14
2/13/14
2/18/14
2/23/14


100000
10000
1000
Pb ug/l
100
10
1
0
Mine water
Sand filter
APTsorb tank
Biocell
Column
column dissolved
10/31/13
11/5/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
12/5/13
12/10/13
12/15/13
12/20/13
12/25/13
12/30/13
1/4/14
1/9/14
1/14/14
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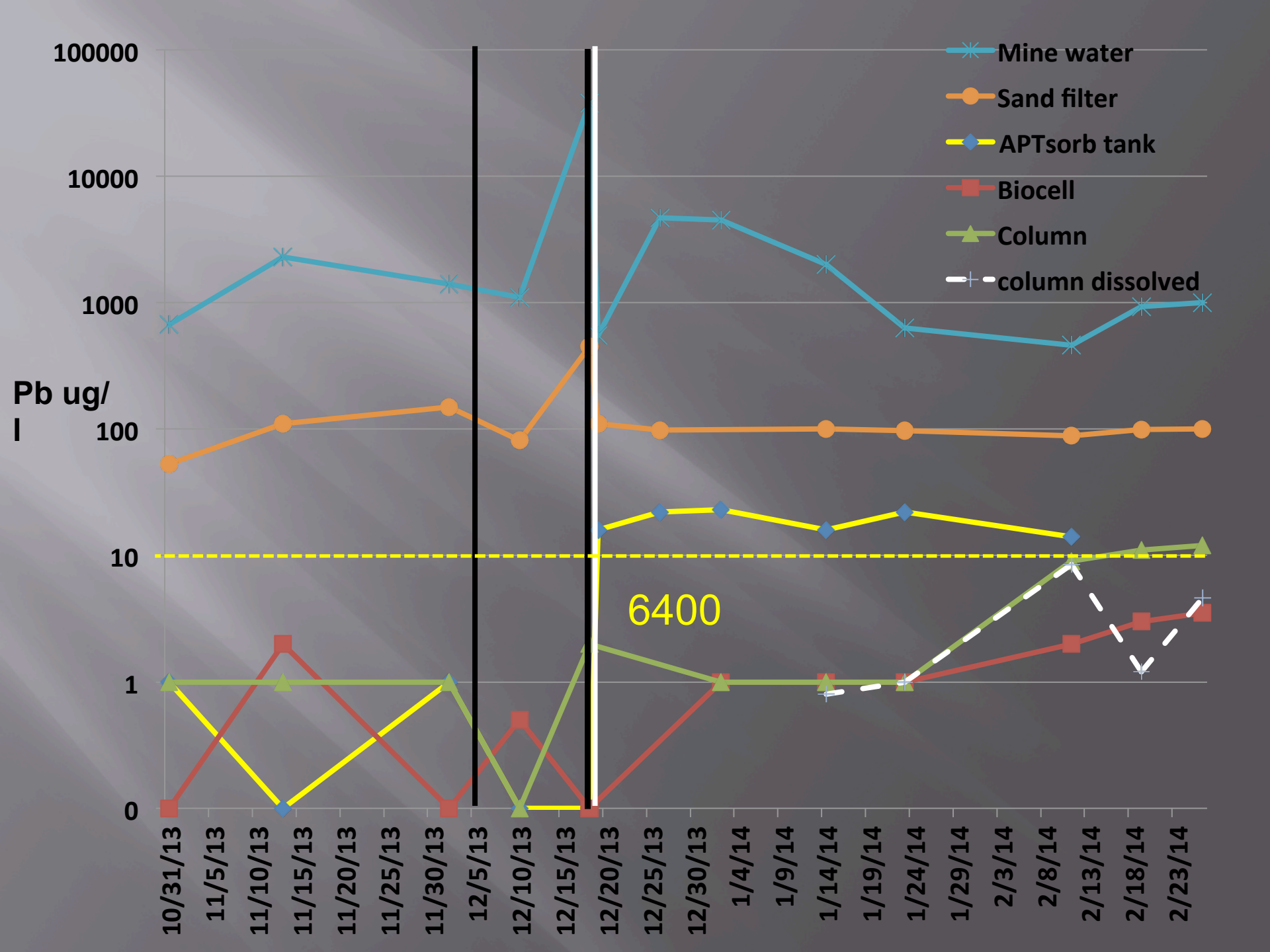
2/8/14
2/13/14
2/18/14
2/23/14


100000
10000
1000
100
10
1
0
Pb ug/l
Mine water
Sand filter
APTsorb tank
Biocell
Column
column dissolved
6400
10/31/13
11/5/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
12/5/13
12/10/13
12/15/13
12/20/13
12/25/13
12/30/13
1/4/14
1/9/14
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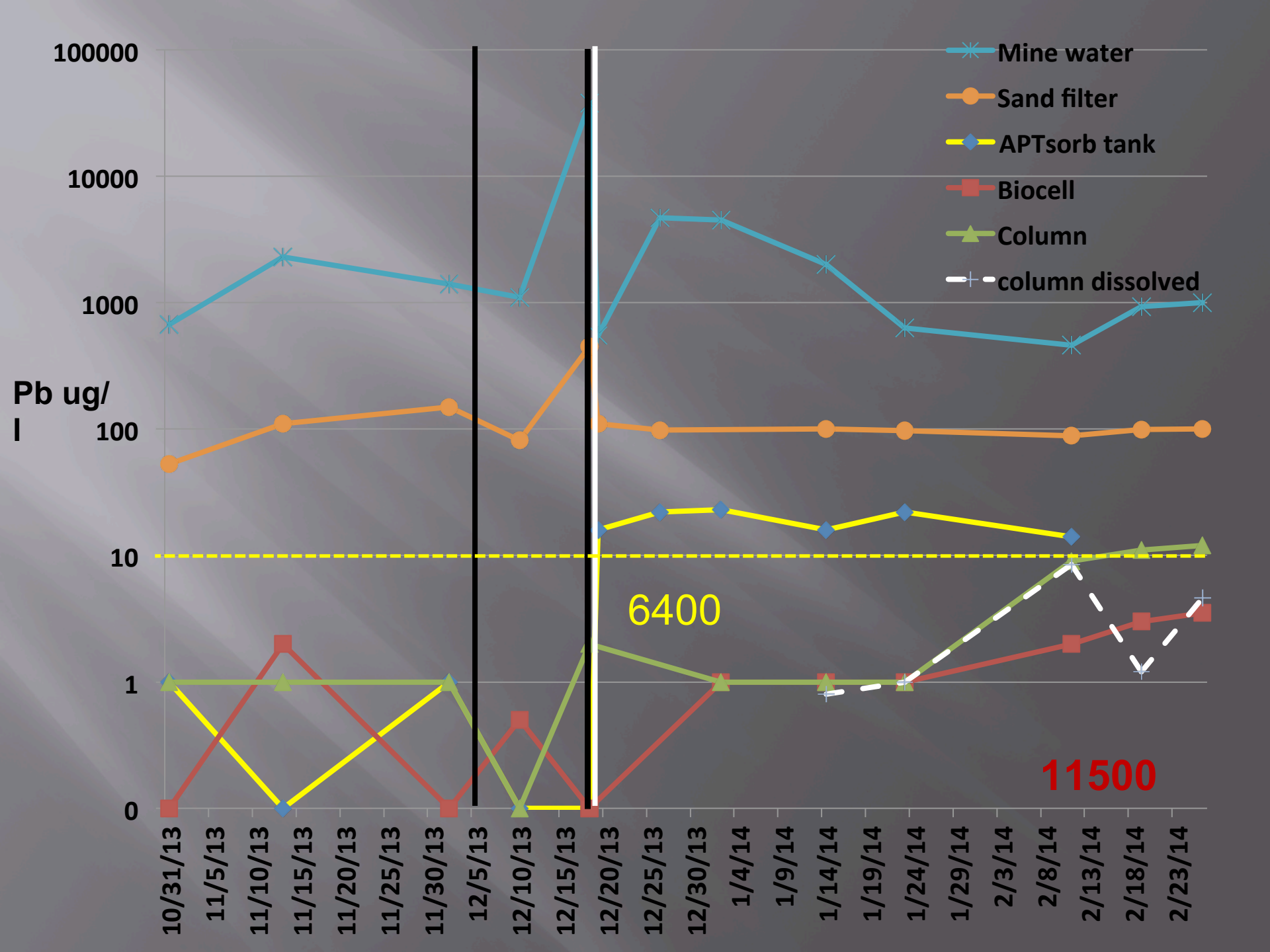
2/8/14
2/13/14
2/18/14
2/23/14


100000
10000
1000
100
10
1
0
Pb ug/l
Mine water
Sand filter
APTsorb tank
Biocell
Column
column dissolved
6400
11500
10/31/13
11/5/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
12/5/13
12/10/13
12/15/13
12/20/13
12/25/13
12/30/13
1/4/14
1/9/14
1/14/14
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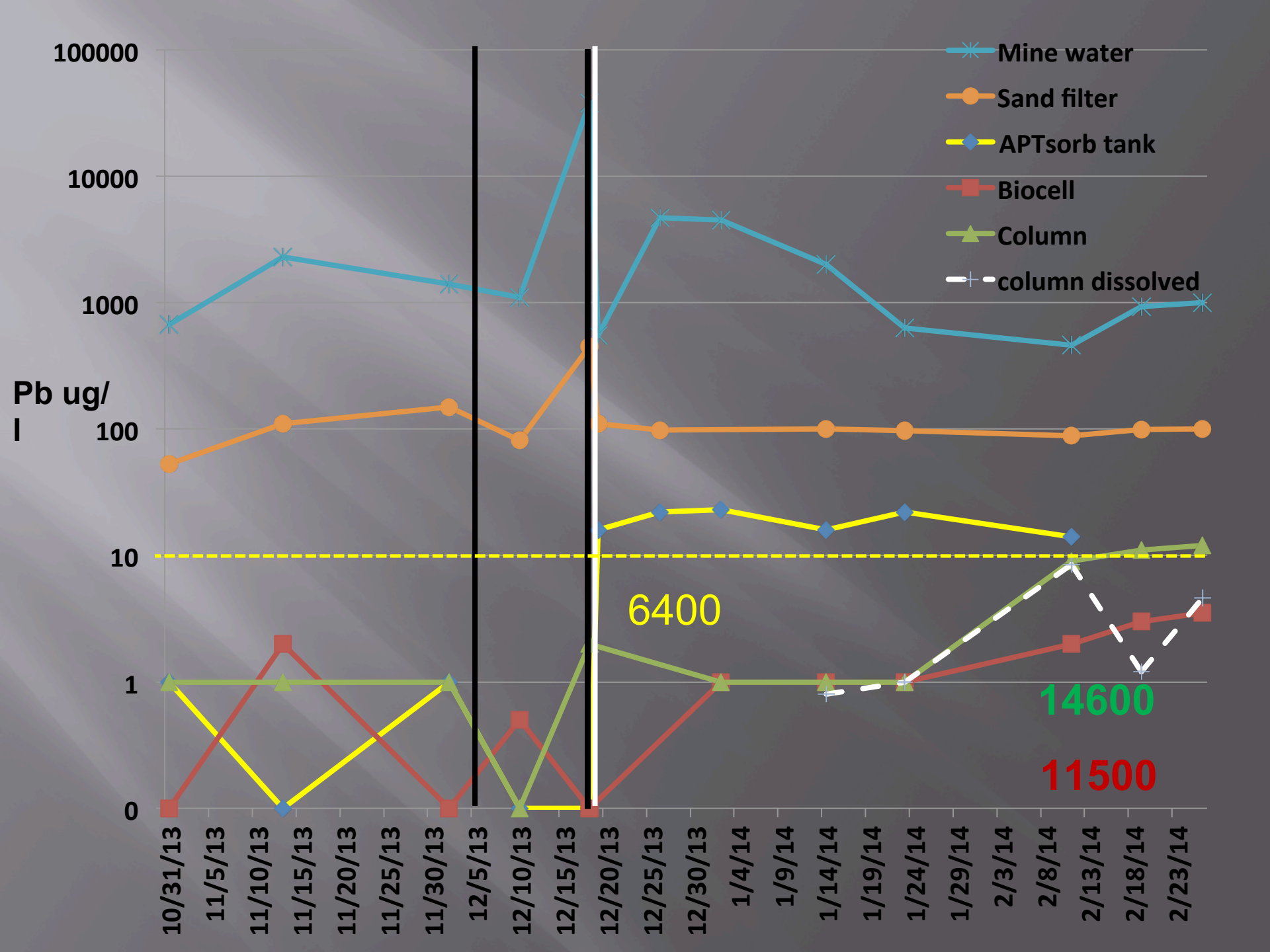
2/18/14
2/23/14


100000
10000
1000
100
10
1
0
Pb ug/l
Mine water
Sand filter
APTsorb tank
Biocell
Column
column dissolved
6400
14600
11500
10/31/13
11/5/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
12/5/13
12/10/13
12/15/13
12/20/13
12/25/13
12/30/13
1/4/14
1/9/14
1/14/14
1/19/14
1/24/14
1/29/14
2/3/14
2/8/14
2/13/14
2/18/14
2/23/14

Results to date

- Guaranteed treatment cost < $0.0005
  - Employ 2nd tank to reduce costs
  - Standard lead/lag design
- Passed all treatment requiremnts
  - Pb, Cd and Zn substantially below permit limit
  - No toxicity

Summary

- Peat based sorption media is a cost effective approach for mine drainage treatment
  - Cost<$0.0005/gallon (50 cents/1000 gallons)
- Can be used in either active or passive systems
- Low maintenance
- May provide opportunities for metal recovery

QUESTIONS?

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