Antimony Removal From Mine Water Using Adsorbent Media

Dustin Klempel, PE

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CDM Smith®

Drumlummon Mine

History

- Underground gold and silver mine dating to the 1870s
- Mine reaches a depth of 1,600 ft bgs
- Following closure in the early 1900's, the deeper workings flooded (daylight at the 400 level)

Current Operations

- In 2007 RX Exploration (owner/operator) began further exploration of the property.
- Dewatering the workings (300 gpm) to allow further exploration of the existing workings, and to support subsequent mining

Initial Water Treatment

- DEQ issued a temporary discharge permit. Based on the initial analyses of mine water, arsenic was the only constituent above discharge limits

Parameter	Historic Value	Discharge Limit
Arsenic	0.018 mg/L	0.003 mg/L

- CDM Smith installed arsenic treatment system underground, in the old hoist room. Treatment consisted of arsenic adsorption onto iron-based media (Bayoxide SORB 33®) prior to discharge
- Initial operation of the treatment system worked well

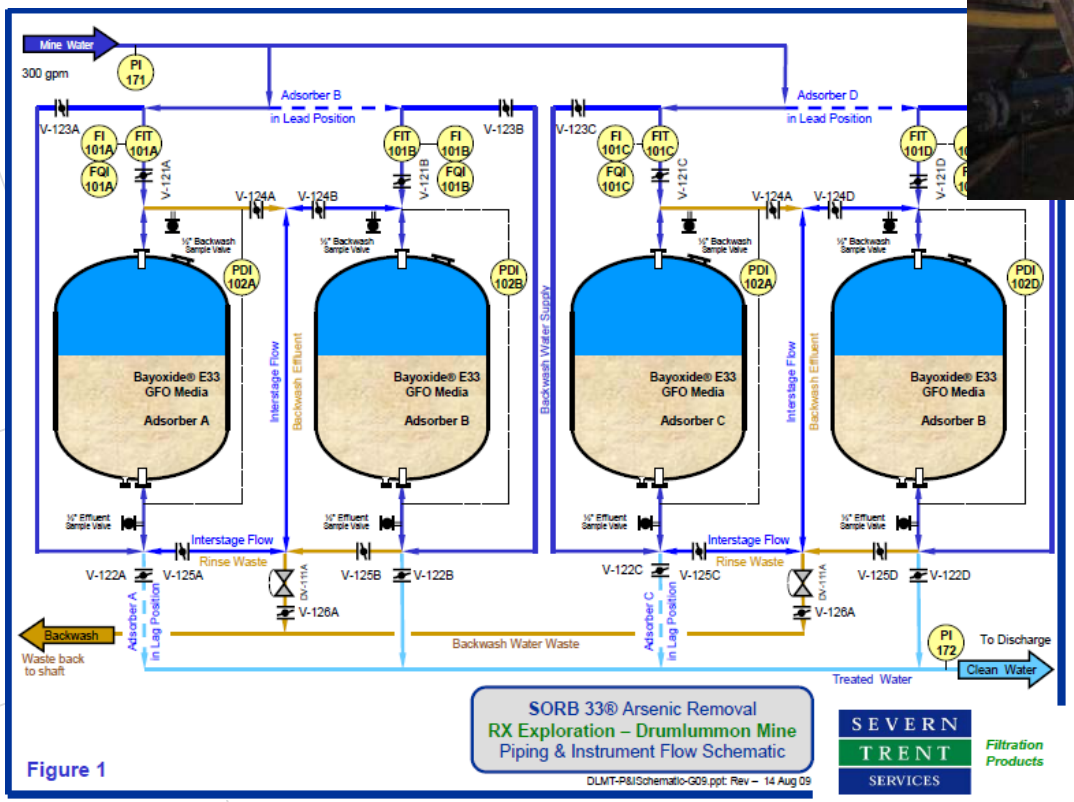

Mine Water
300 gpm
PI 171
Adsorber B in Lead Position
Adsorber D in Lead Position
V-123A
V-123B
V-123C
FI 101A
FIT 101A
FQI 101A
FI 101B
FIT 101B
FQI 101B
FI 101C
FIT 101C
FQI 101C
FIT 101D
V-121A
V-121B
V-121C
V-121D
V-124A
V-124B
V-124D
½" Backwash Sample Valve
PDI 102A
PDI 102B
PDI 102D
Bayoxide® E33 GFO Media
Adsorber A
Adsorber B
Adsorber C
Adsorber B
Interstage Flow
Backwash Effluent
Backwash Water Supply
½" Effluent Sample Valve
Rinse Waste
V-122A
V-125A
V-125B
V-122B
V-122C
V-125C
V-125D
V-122D
DV-111A
V-126A
Adsorber A in Lag Position
Adsorber C in Lag Position
Backwash
Waste back to shaft
Backwash Water Waste
PI 172
To Discharge
Clean Water
Treated Water
SORB 33® Arsenic Removal
RX Exploration – Drumlummon Mine
Piping & Instrument Flow Schematic
DLMT-P&ISchematic-G09.ppt: Rev – 14 Aug 09
SEVERN TRENT SERVICES
Filtration Products

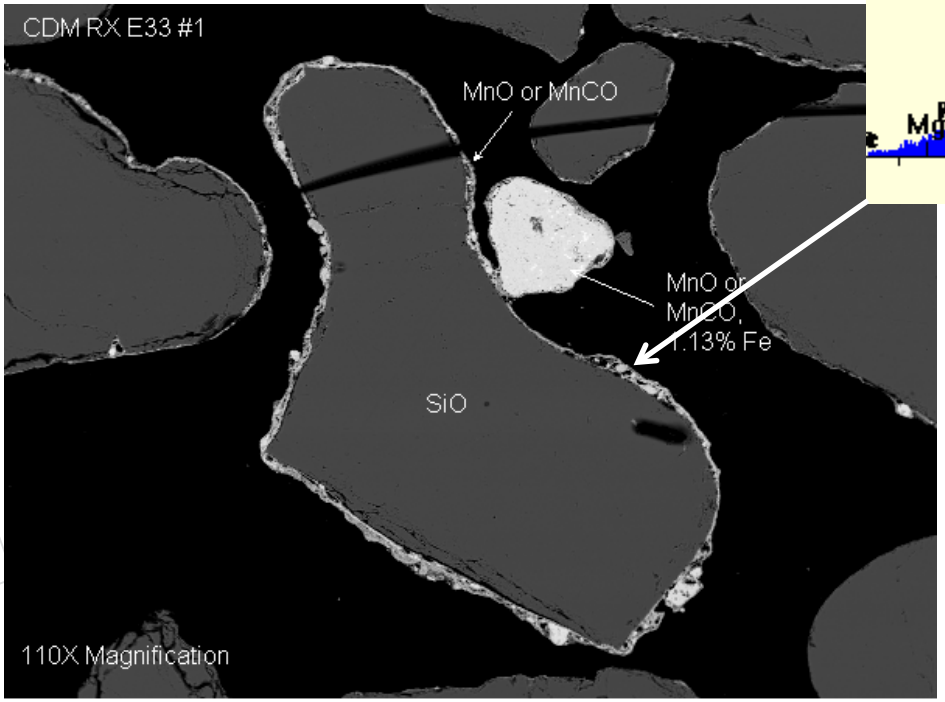
Figure 1

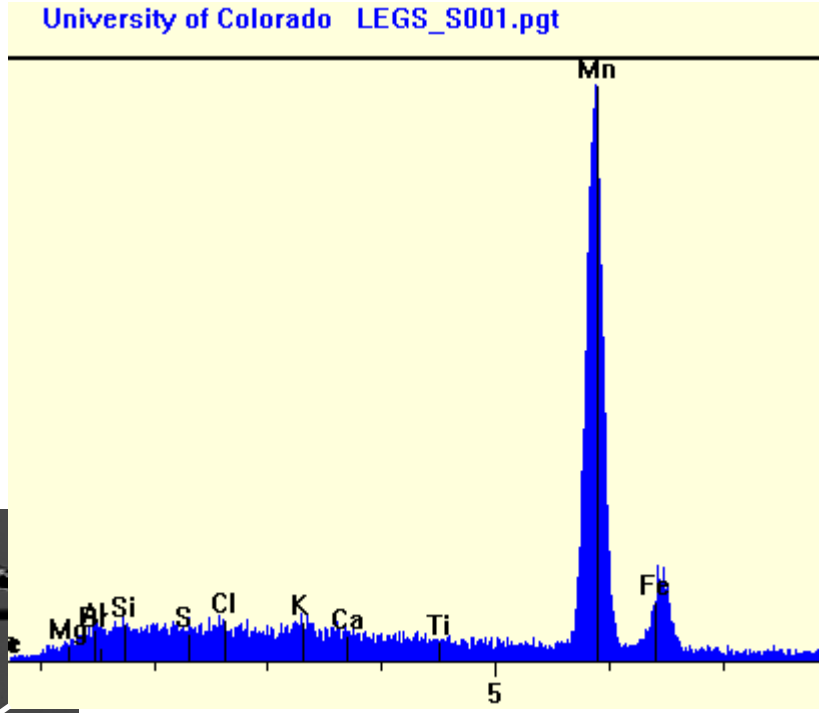
Water Treatment, Continued

- As treatment continued, adsorption media life was significantly shorter than predicted, requiring media change-out. Troubleshooting was performed.
- As dewatering continued and the water level in the mine receded, water quality changed significantly. Suspended solids, iron, manganese, arsenic, and pH increased. Antimony concentrations increased from non-detect to above the discharge limits

EMP Results

Manganese oxides coating the media





Manganese concentrations exiting the final adsorption vessels were much less than influent concentrations, indicating manganese precipitation within the media beds

Mine Water Quality

Parameter	Historic Values	Post Dewatering Values	Discharge Limit
pH	7.2-7.7	7.9-8.5	NA
Alkalinity	200- 300 mg/L	300 mg/L	NA
TDS	300 mg/L	300 mg/L	NA
Antimony	ND	20-40 mg/L	0.006 mg/L
Arsenic	0.018 mg/L	20-30 mg/L	0.003 mg/L
Iron	ND	0.5 mg/L	
Manganese	<1 mg/L	1-2 mg/L	NA

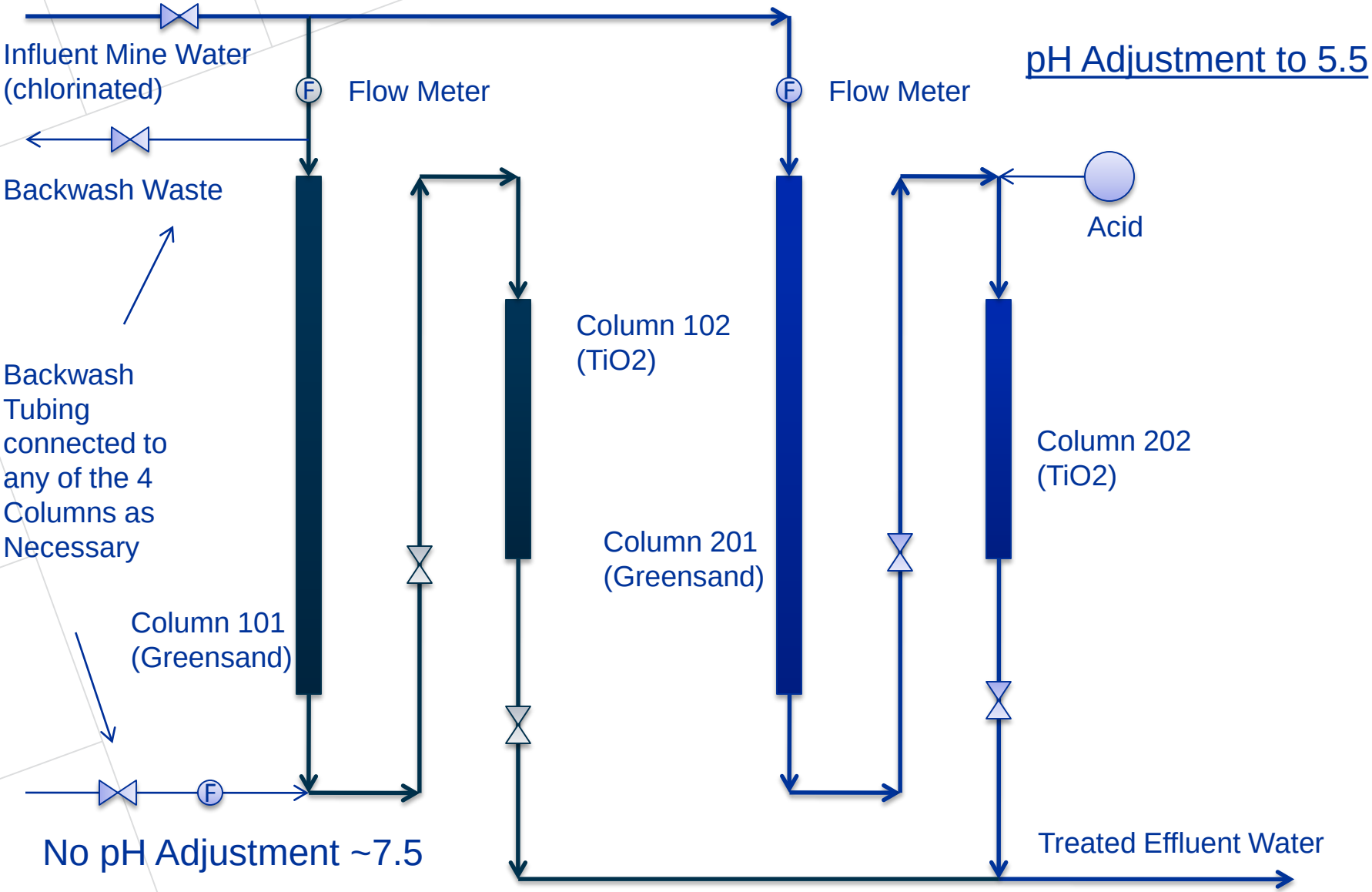
Conventional Antimony Treatment Options

- EPA BATs
  - Coagulation and Filtration
    - Iron or aluminum coagulant
    - Requires pH control (4.5 to 5.5)
    - Generates sludge
    - Competing oxidation states (oxidized arsenic, reduced antimony are optimum for adsorption)
  - RO
    - Generates continuous brine stream requiring disposal
- Approaches are effective for both antimony and arsenic removal, but neither was practical at the Mine

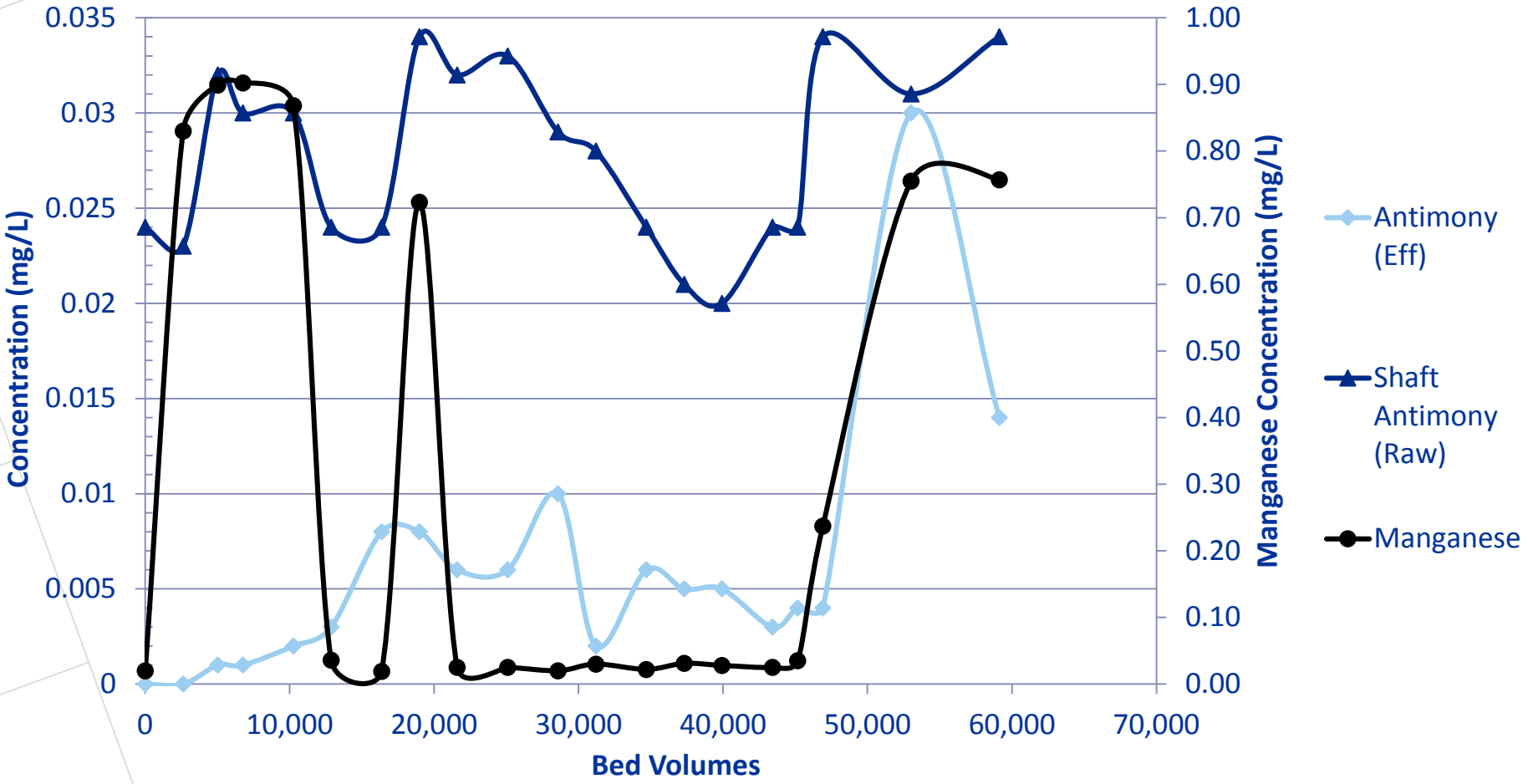
Antimony Removal

- Goal: identify an alternative means to achieve arsenic and antimony removal in a single process
- Arsenic removal chemistry well understood, but antimony removal mechanisms are not nearly as well known
- Titanium Dioxide media was identified as a possible adsorbent media that could achieve treatment objectives
- Iron and Manganese were identified as likely foulants and would require removal
- The approach would require testing

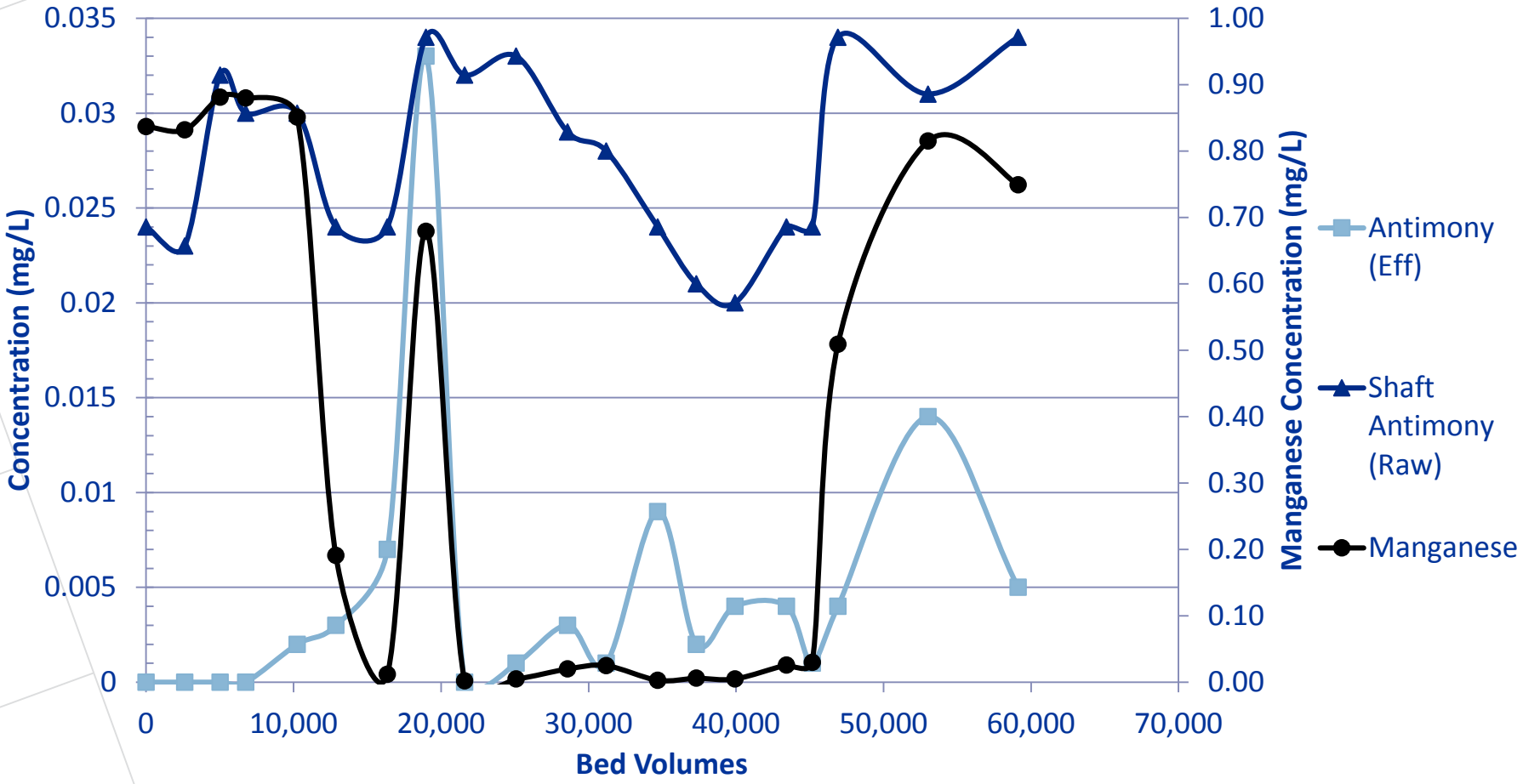
Column Test Design



Effect of Manganese and Influent Antimony at Existing pH



Effect of Manganese and Influent Antimony with pH Adjustment to 5.5 su



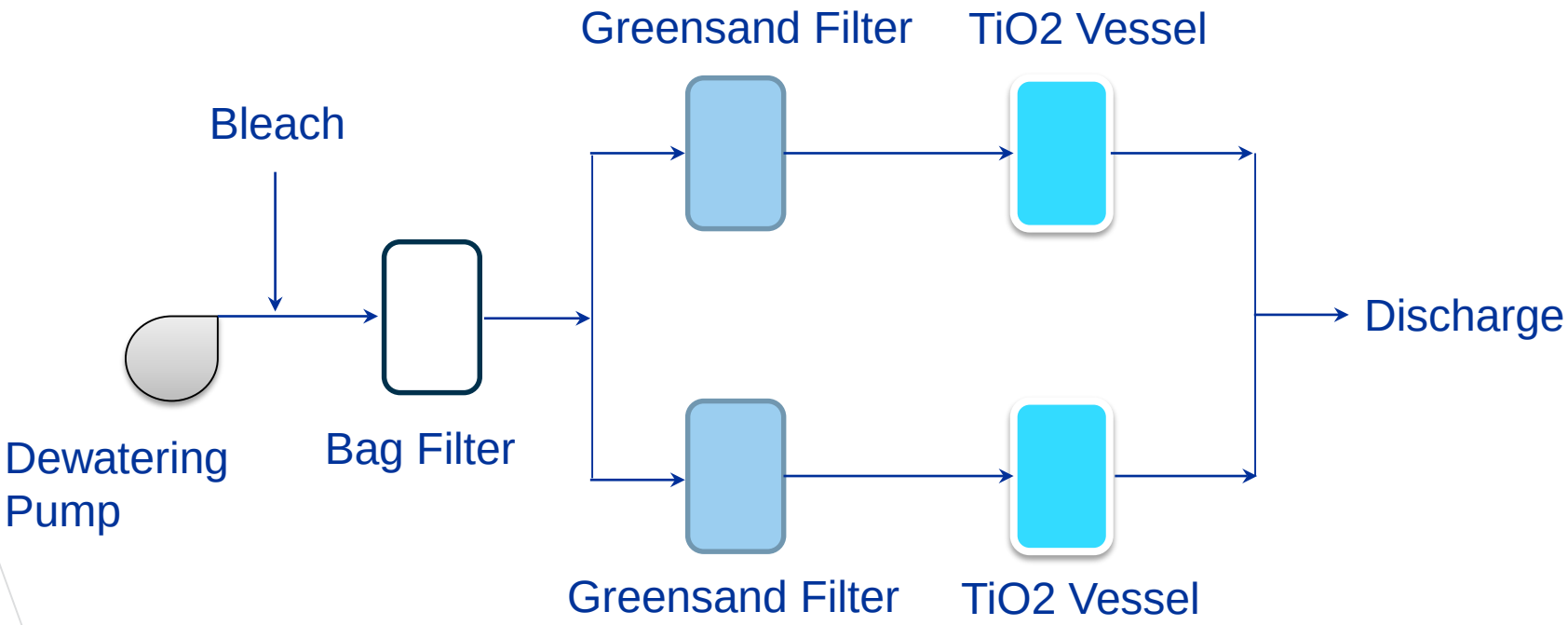
Column Testing Results

- Antimony removal was achieved under both test conditions
- Effluent arsenic concentrations were all were below detection
- Operating issues (poor chlorine and pH control) created some uncertainty in the test data
- Recommended optimum pH (~5.5 s.u.) was not necessary to obtain removal. Raw water and pH-adjusted water performed similarly for extended runtimes.
- Media is readily fouled from manganese

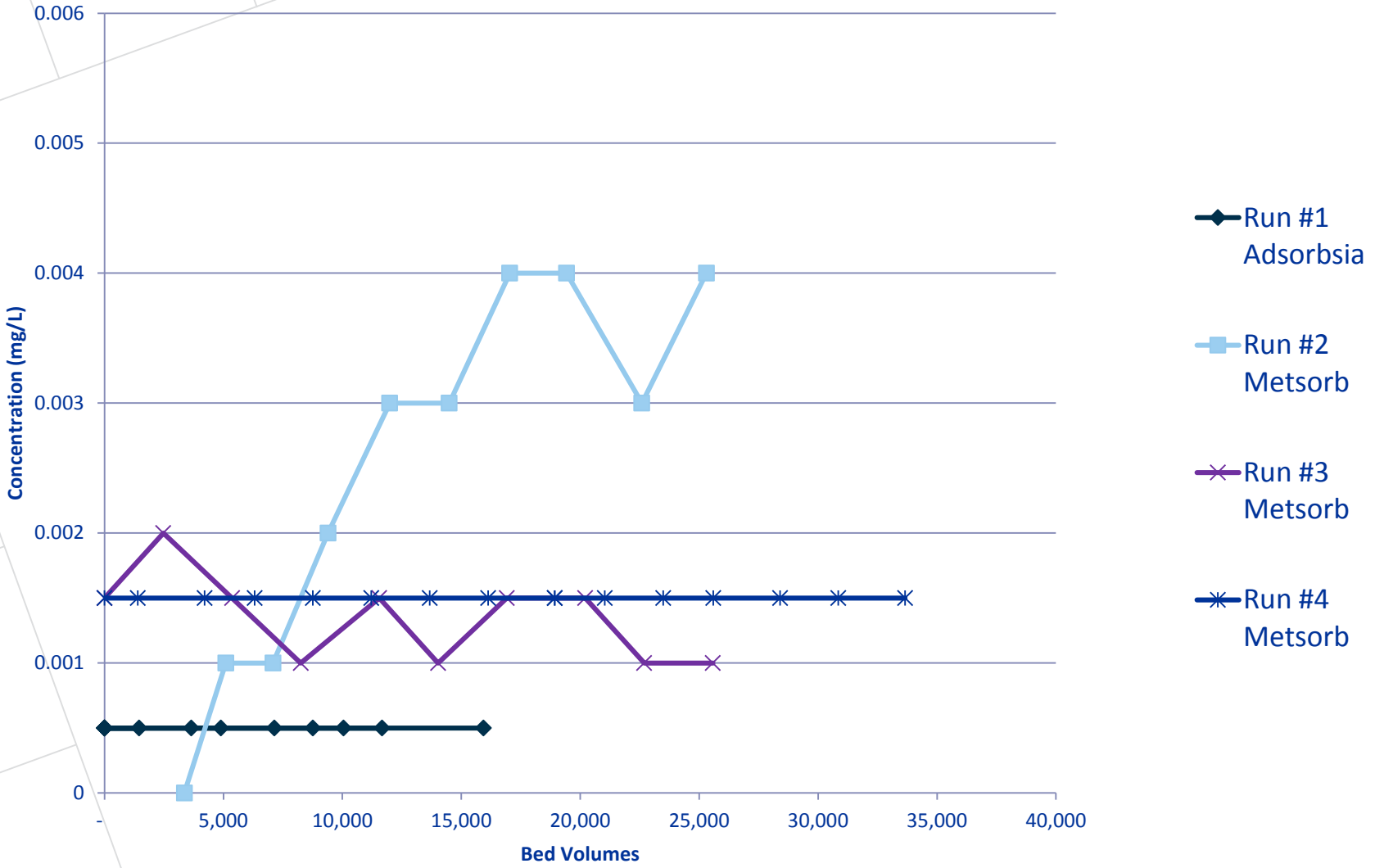
Treatment System Modifications

- Install modified greensand media (Omni-SORB^{TM}) to remove iron and manganese prior to the adsorption vessels.
- Addition of bleach upstream to disinfect the influent, maintain continuous regeneration the greensand media, and increase ORP (oxidize arsenic to As(V))
- Install TiO2 adsorption media (Adsorbsia/Metsorb) for removal of arsenic and antimony

Full Scale Treatment Process



Full Scale Performance



Operational Issues and Experience

- Titanium Dioxide Media – not dense and therefore backwashing is ineffective. Effective pretreatment is very important
- Breakdown of media in the presence of chlorine. Concentrations over 3 mg/L caused rapid breakdown of media. Concentrations ~1 mg/L allowed for extended operation of media. At Drumlummon, most media change-outs were due to media breakdown prior, not breakthrough
- Recommended optimum pH (~5.5 s.u.) was not necessary to obtain removal. pH adjustment may improve adsorption capacity for arsenic and antimony, but is not required. Not cost effective or worth hassle to include pH control equipment at Drumlummon Mine

Operational Issues and Experience

- Greensand media reduced Mn to 0.015 mg/L and Fe to 0.05 mg/L
- TiO2 media capacity is greater than 1 mg Sb/gram media, based on full scale operation
- Upstream removal of particulates, iron, and manganese is critical to the performance of the media. Pretreatment is more cost effective than frequent media replacement
- Vendors can't effectively model antimony removal
- Pros – simple, flexible, low capital cost
- Cons – operating costs highly dependent on WQ

Conclusions

- Titanium Dioxide media is an effective approach for removing both antimony and arsenic. With increasing regulatory presence, treatment using adsorption may be a cost effective approach in many applications
- Bench/Pilot Testing is highly recommended for any new application

Questions