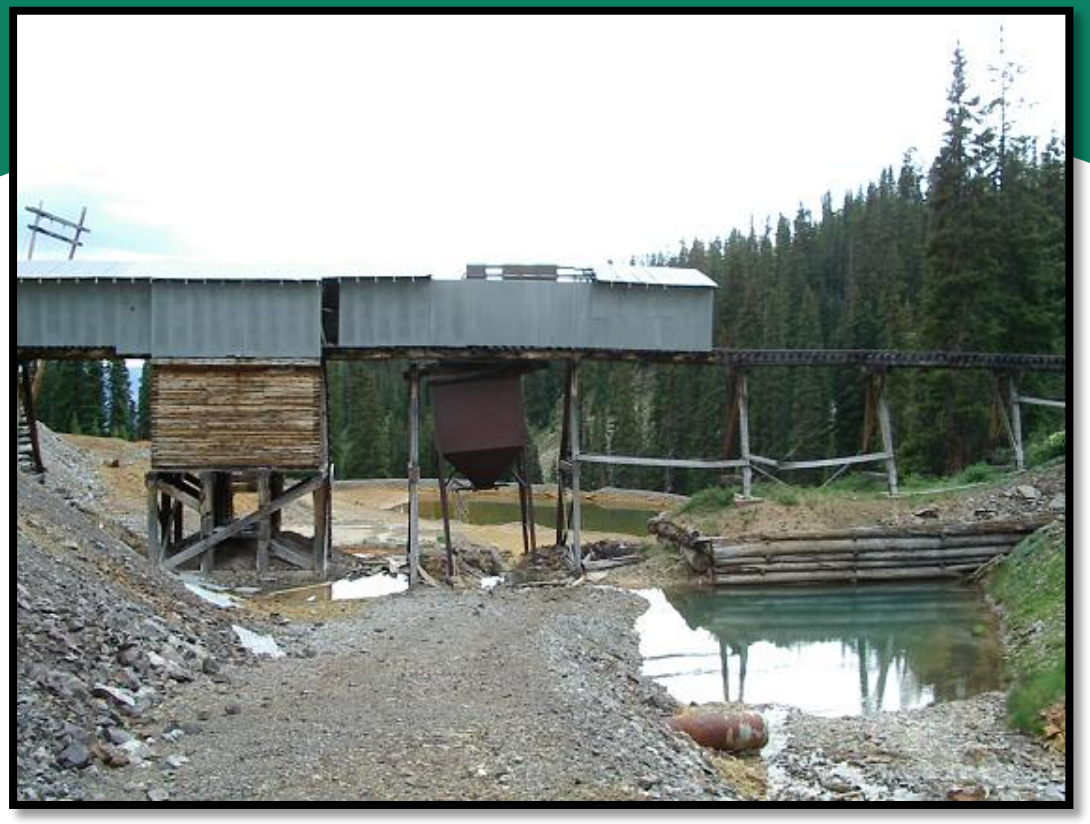


Decommissioned BCR Organic Media Characterization
Standard Mine Superfund Site, Crested Butte, CO

Neal Gallagher, Eric Blumenstein, Tom Rutkowski,
John DeAngelis (PWT)

Presented by: Neal Gallagher

Golder Associates

Overview

- Project Overview and Site Background
- Pilot BCR Operations Performance Summary
- Pilot BCR Decommissioning
  - Substrate metals removal data
  - TCLP & Paint Filter
  - Substrate longevity estimates
- Discussion and Conclusions

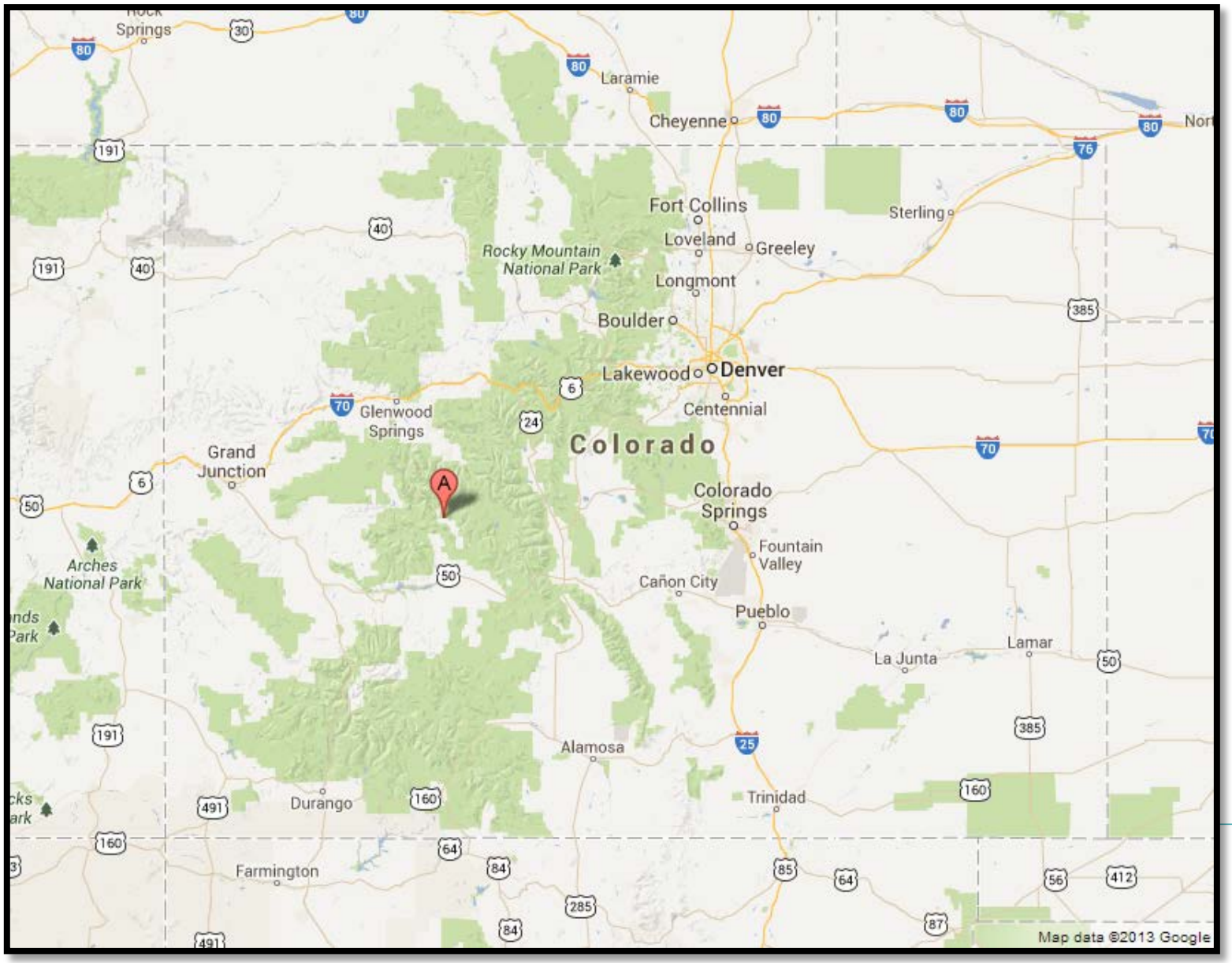
Golder Associates

Overview and Site Background

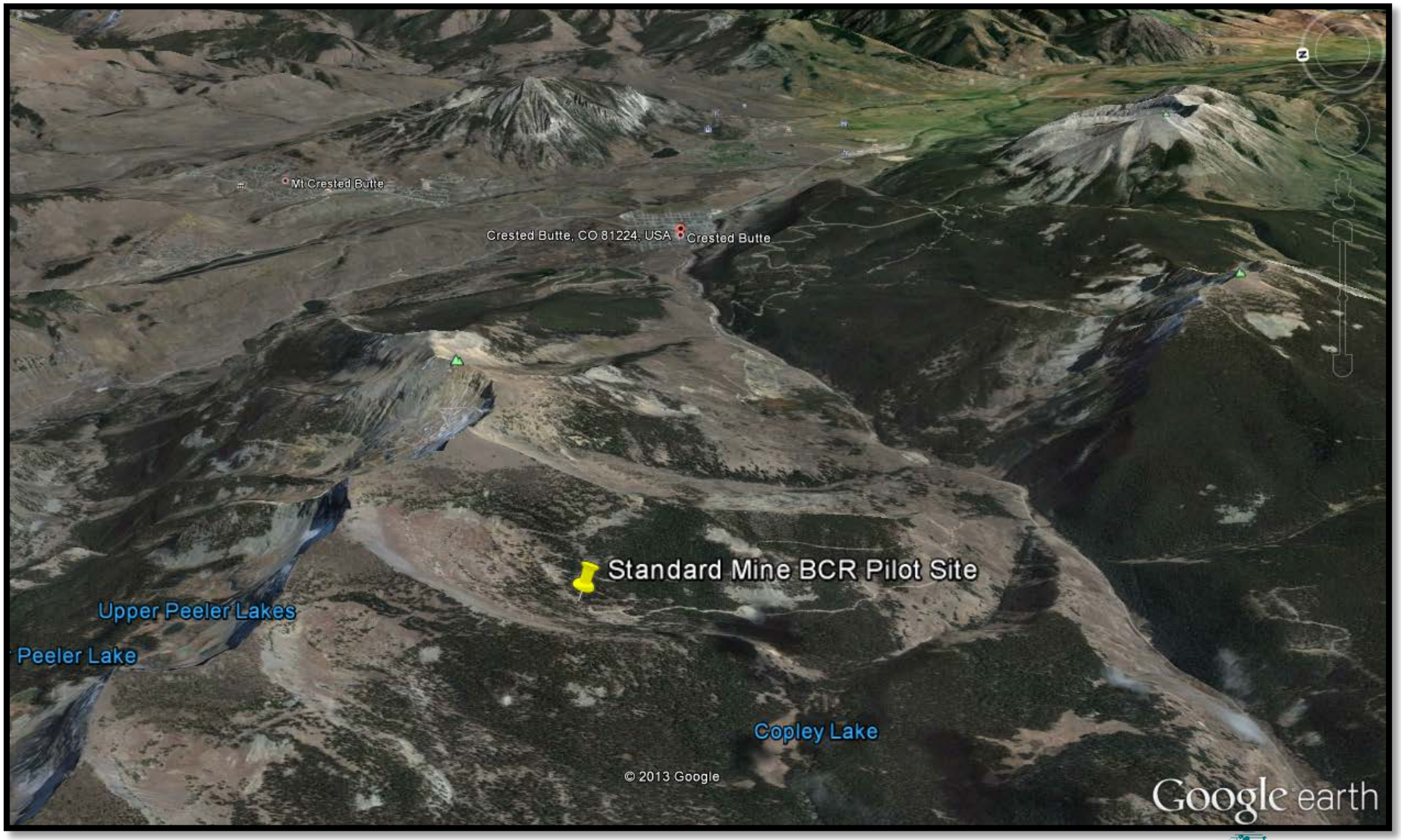
- Standard Mine Superfund Site
  - Approximately 3 miles west of Crested Butte, Colorado (8,900 ft)
  - Site elevation of 3,350 m (11,000 ft)
  - Annual snowfall 10.2 – 17.8 m (400 – 700 in)
- Inactive hard rock mine
  - Lead, zinc, silver, gold mined 1874 – 1966
- Adit level 1 discharges to Elk Creek
  - Influences Coal Creek, Crested Butte water supply
  - COC's: cadmium, copper, iron, lead, manganese, and zinc

Golder Associates

Overview and Site Background



Overview and Site Background



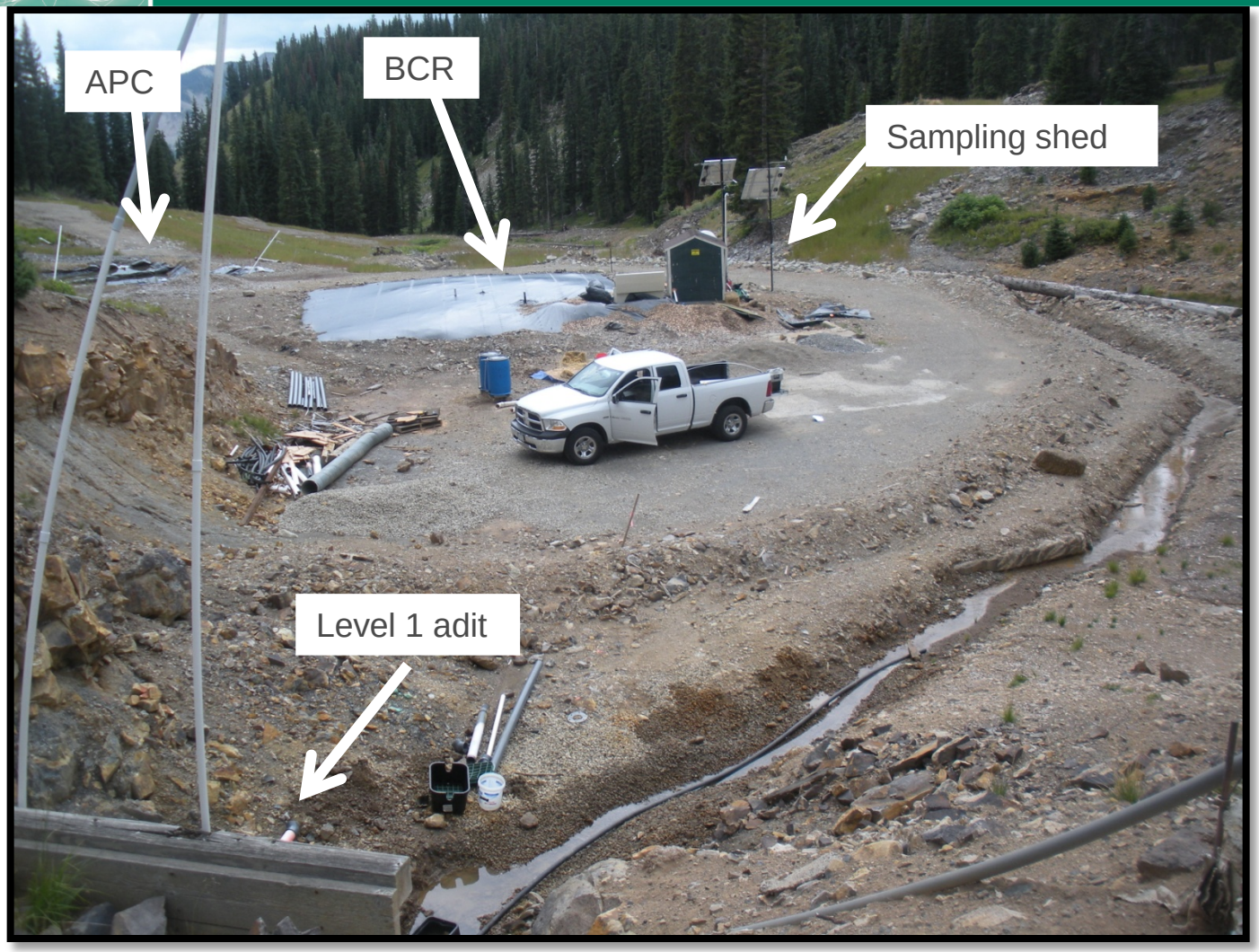
Overview and Site Background

Overview and Site Background

- Passive treatment pilot study (1 gpm):
  - Pilot Biochemical Reactor (BCR) constructed in 2007
  - Substrate composed of straw, woodchips, limestone
  - Operational for approximately 5 years
- Project Goals:
  - Test passive treatment performance at a high alpine, remote site
  - Design and construct pilot system to treat the COCs
  - Monitor the system year-round with remote monitoring equipment

Golder Associates

Overview and Site Background



Pilot Operations and Performance

- Water Chemistry:

		BCR		
		Influent	Effluent	Chronic Stream Standard
Temp	°C (°F)	3.4 (38)	3.2 (38)	--
pH	su	6.2	6.7	--
Cd	mg/L	0.13	0.00019	0.00031
Cu	mg/L	0.21	0.0014	0.0062
Fe	mg/L	9.1	0.56	1.0
Pb	mg/L	0.31	0.0013	0.0016
Mn	mg/L	10.9	9.3	1.43
Zn	mg/L	24.7	0.073	0.086
SO4	mg/L	281	119	--

Pilot Operations and Performance

Performance Summary

- 5 year operation
- Low detection limits allowed comparison to strict stream standards
- BCR performance:
  - Consistently meeting acute stream standards:
    - Cadmium, copper, iron, lead, zinc
  - Consistently meeting chronic stream standards:
    - Copper, lead, zinc
  - Demonstrated removal of dissolved metals below 5 µg/L
    - Cadmium, copper, and lead

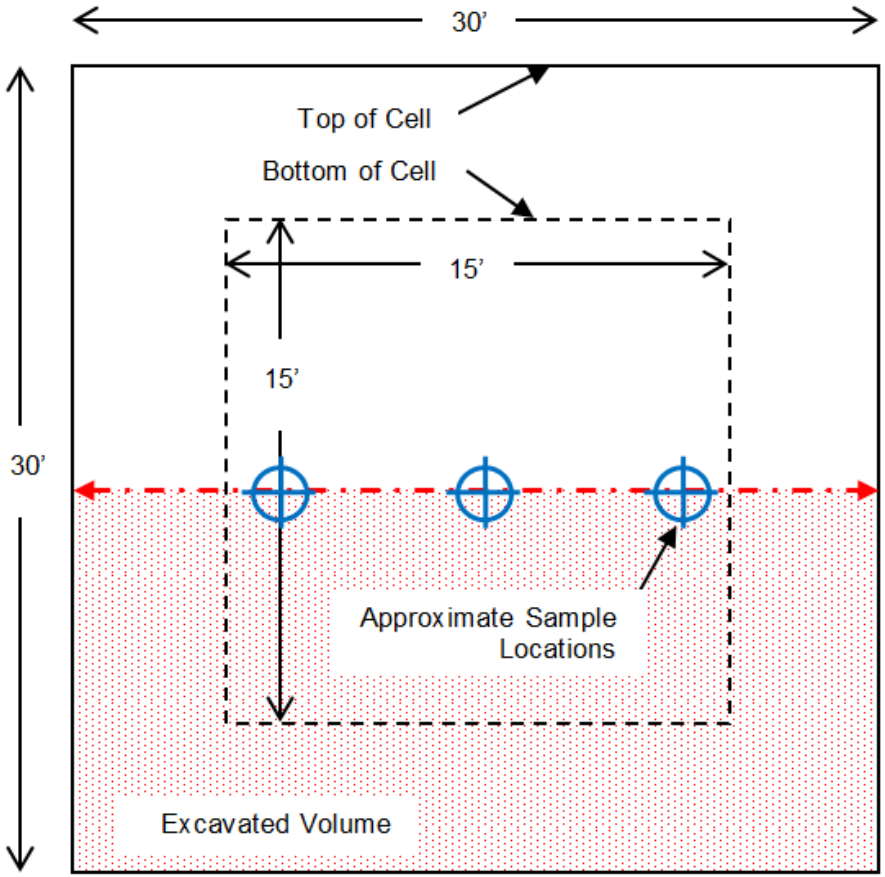
Pilot BCR Decommissioning

Pilot BCR Decommissioning

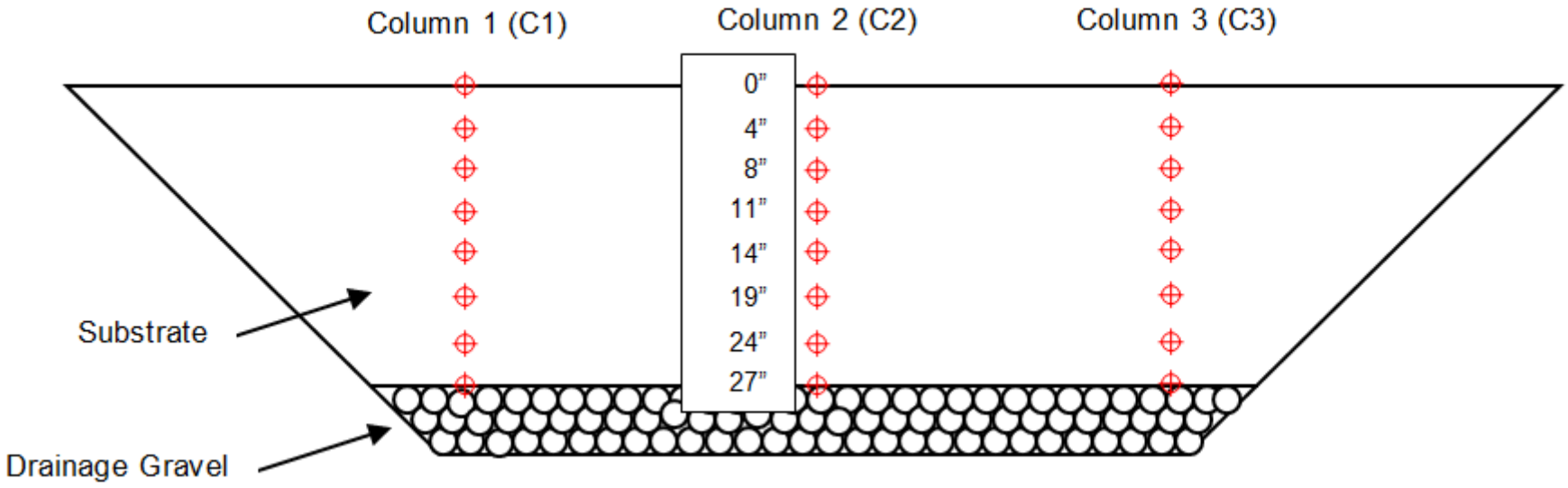
- Decommissioning Objectives:
  - Identify metal precipitation zones in substrate
  - Determine substrate disposal requirements (TCLP, Paint Filter)
  - Estimate substrate longevity for full scale design

Golder Associates

Pilot BCR Decommissioning



Pilot BCR Decommissioning



Pilot BCR Decommissioning

Expected Metals Precipitation Zones:

0”–1” below surface (BS)
Orange iron hydroxide layer – oxide zone (Thomas 2002)

1”–8” BS
Black sulfide zone – sulfate reduction unlikely here due to depressed pH.

8”–14” BS
Gray aluminum zone – aluminum hydroxysulfates (Thomas 2002)

14”–30” BS
Black sulfide zone

Reference: Thomas, R.C. 2002. Passive Treatment of Low pH, Ferric Iron-dominated Acid Rock Drainage. Doctoral Thesis. University of Georgia

Golder Associates

Pilot BCR Decommissioning

Metal Precipitation Results:

Columns 1-3 Average Total Metals Analysis, selected results:

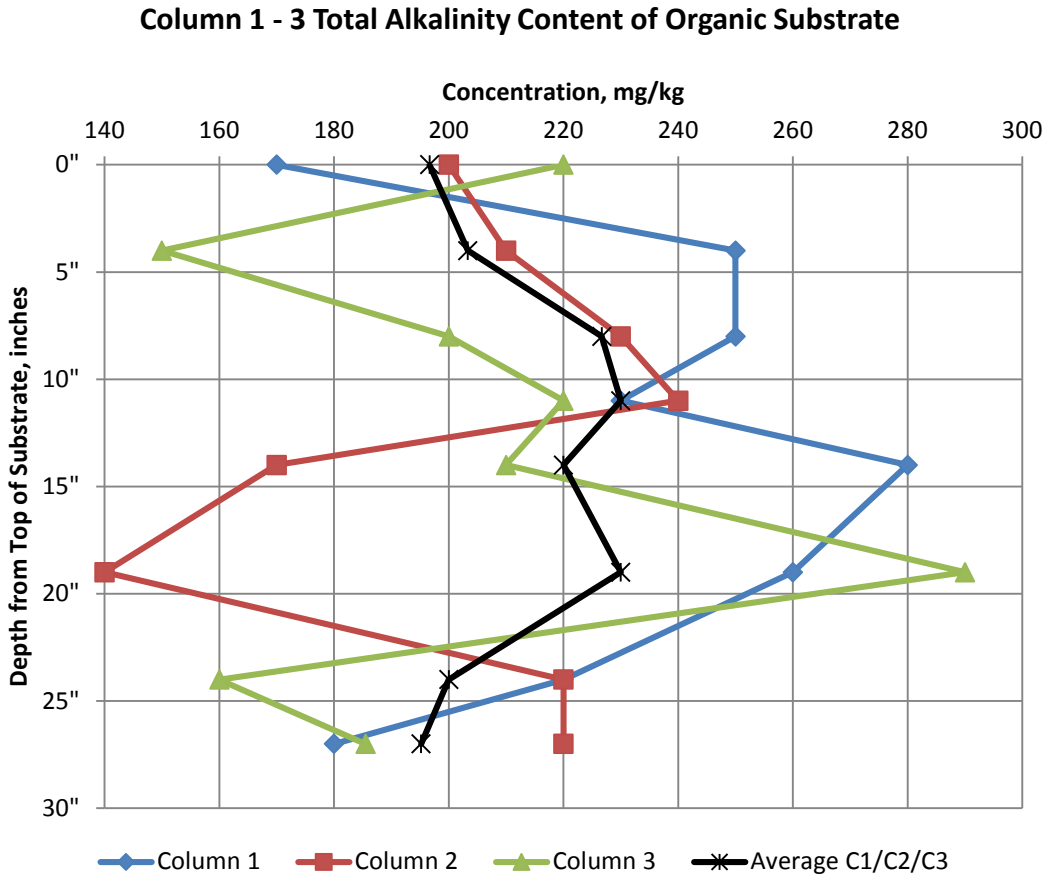
Average depth from top of substrate	Cadmium, total	Lead, total	Copper, total	Iron, total	Manganese, total	Zinc, total
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
0"	11.1	66.5	21.3	4,510	527	9,260
8"	2.2	46.4	11.1	5.323	547	5.133
19"	0.86	46.9	10.1	2,287	434	645
27"	0.77	44.3	9.6	1,603	418	288

- Initial (top) lift expected to contain metal hydroxides, and metal sulfides
- Decommissioning tests were not designed to determine metals removal processes

Golder Associates

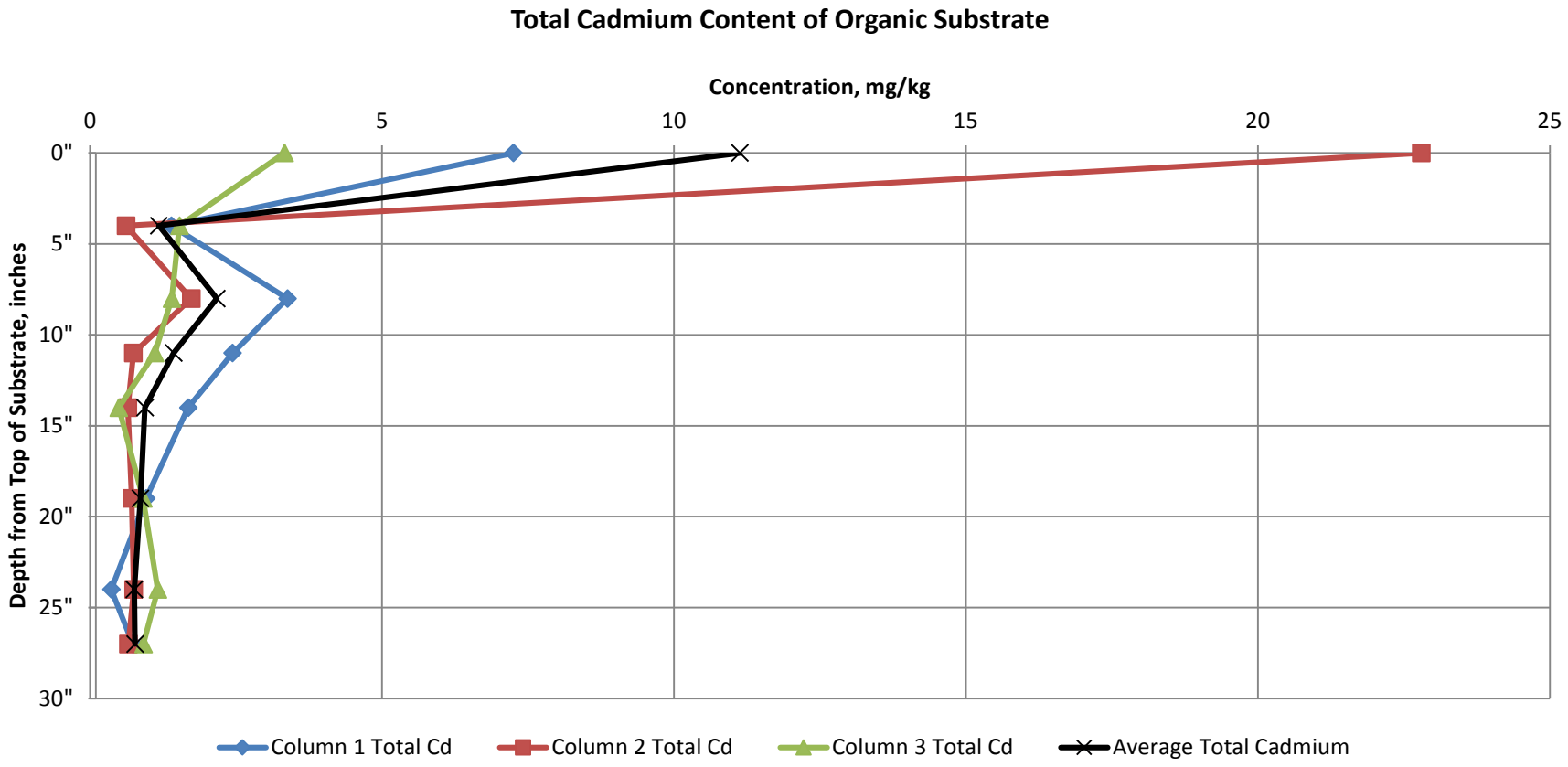
Pilot BCR Decommissioning

Metal Precipitation Results:



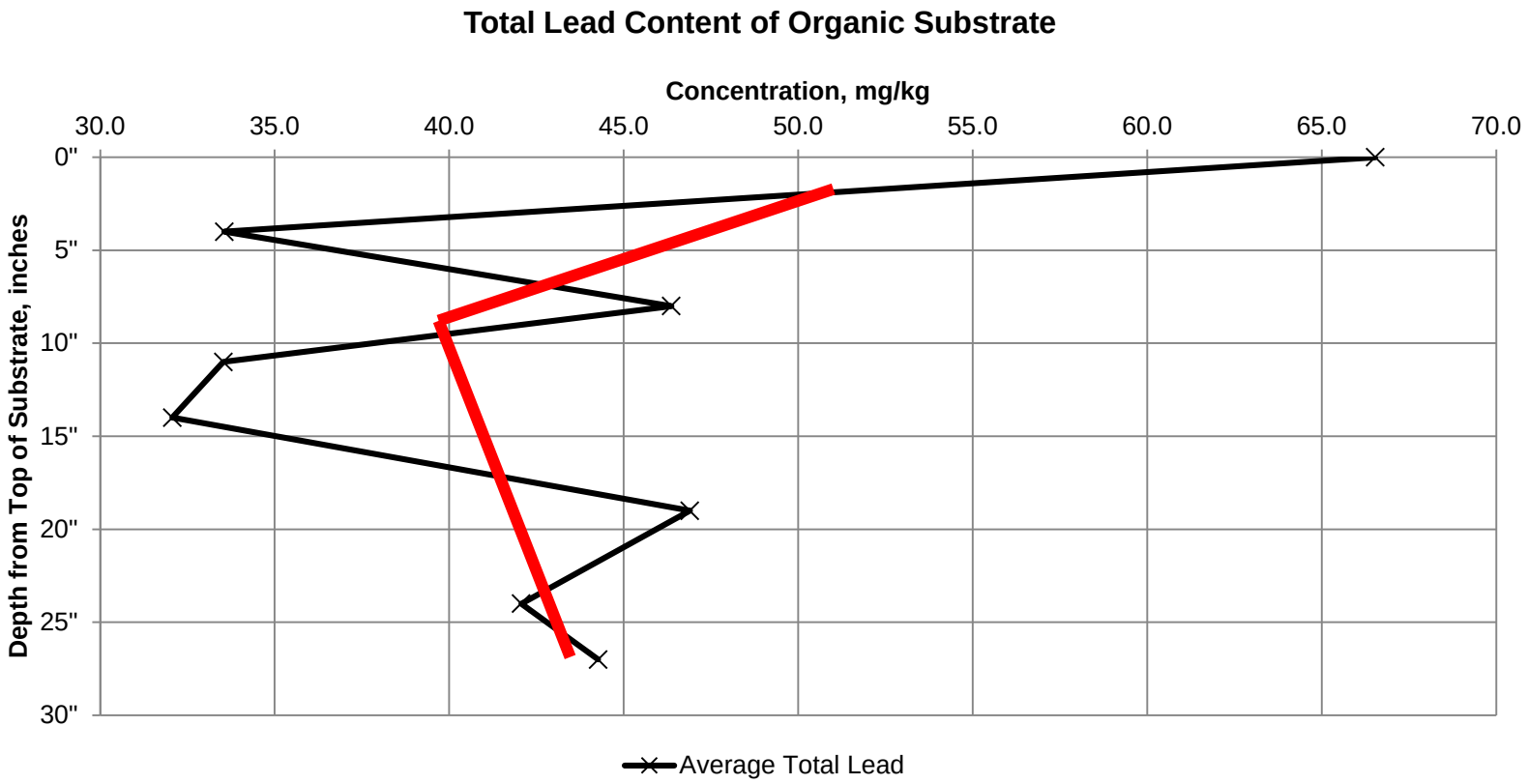
Pilot BCR Decommissioning

Metal Precipitation Results:



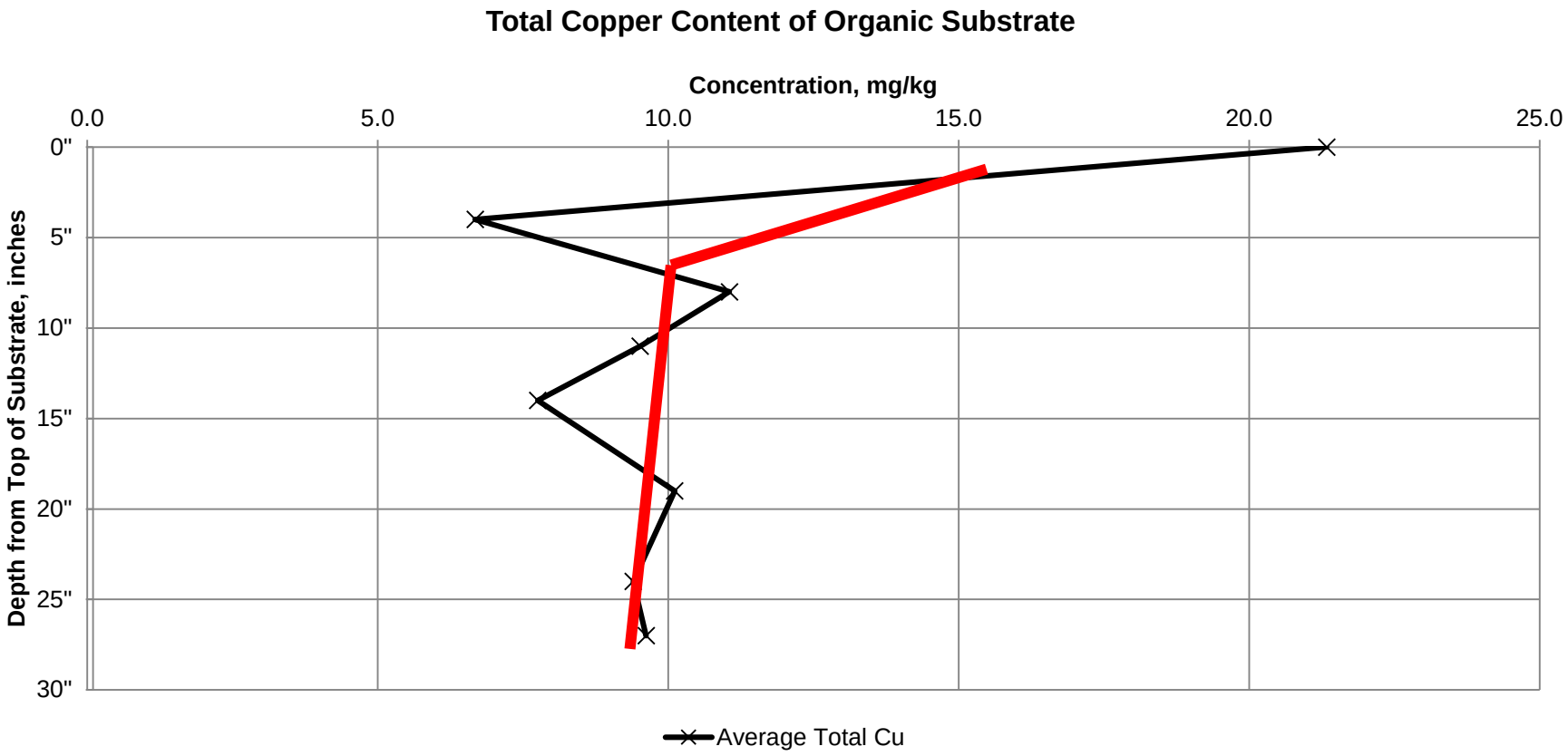
Pilot BCR Decommissioning

Metal Precipitation Results:



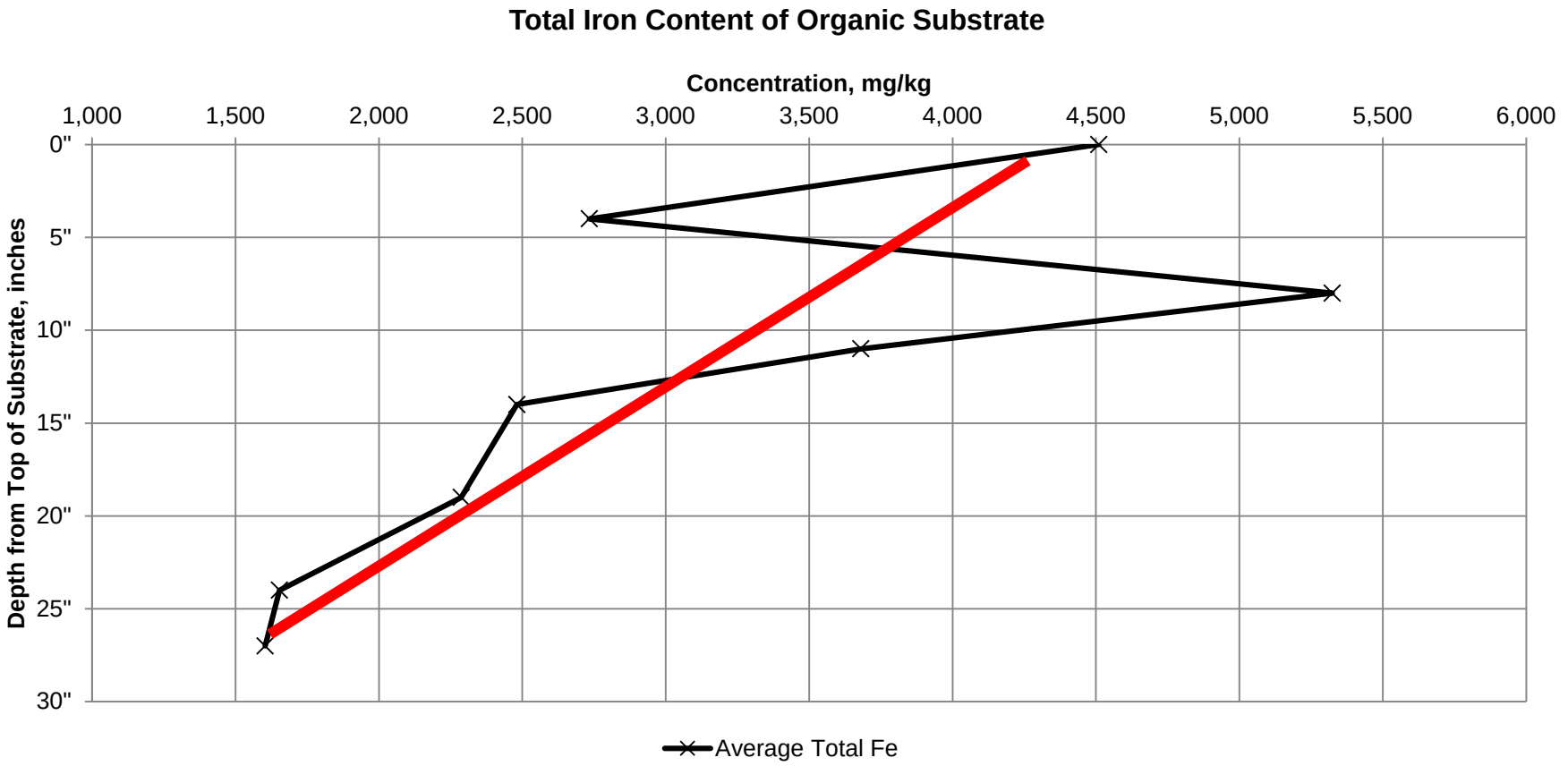
Pilot BCR Decommissioning

Metal Precipitation Results:



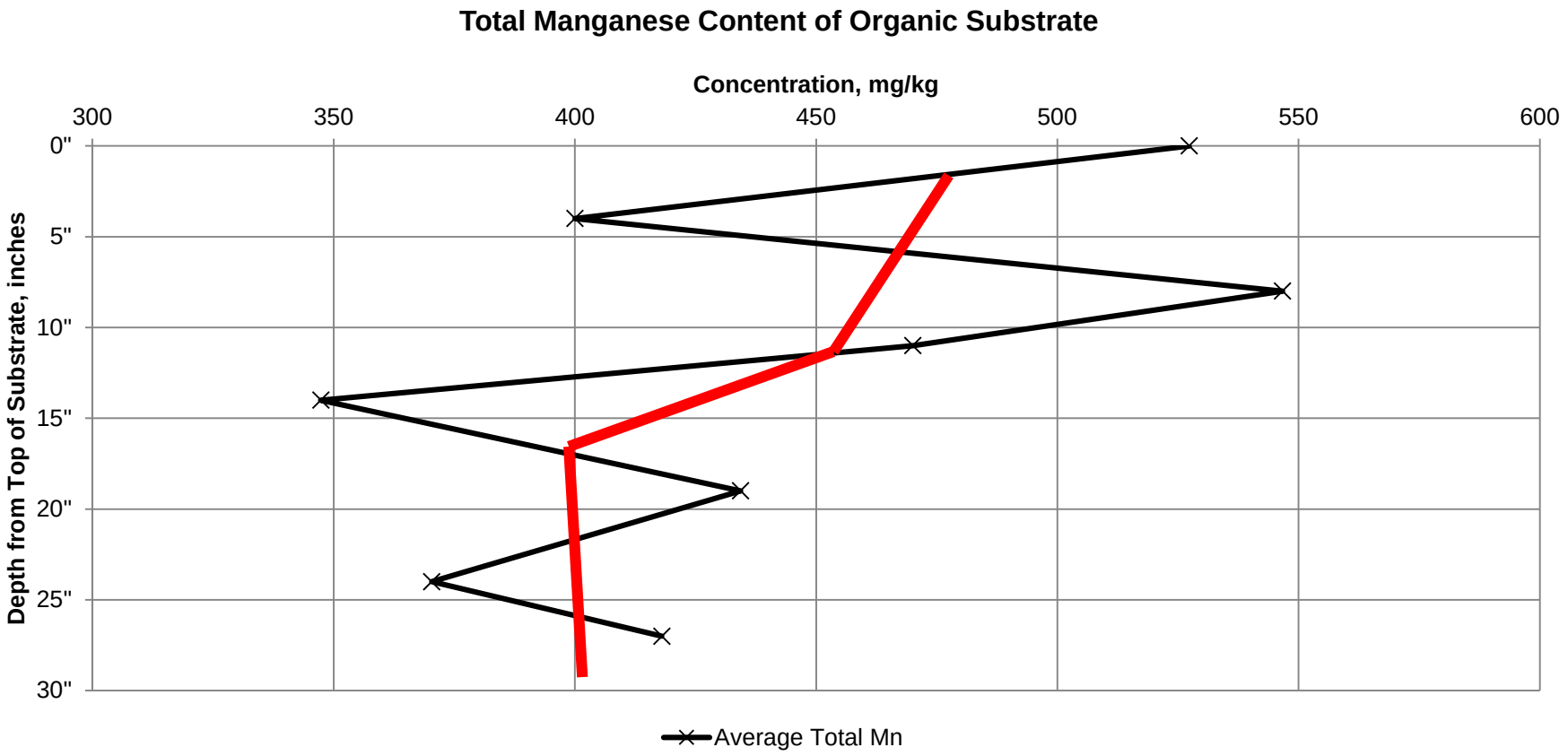
Pilot BCR Decommissioning

Metal Precipitation Results:



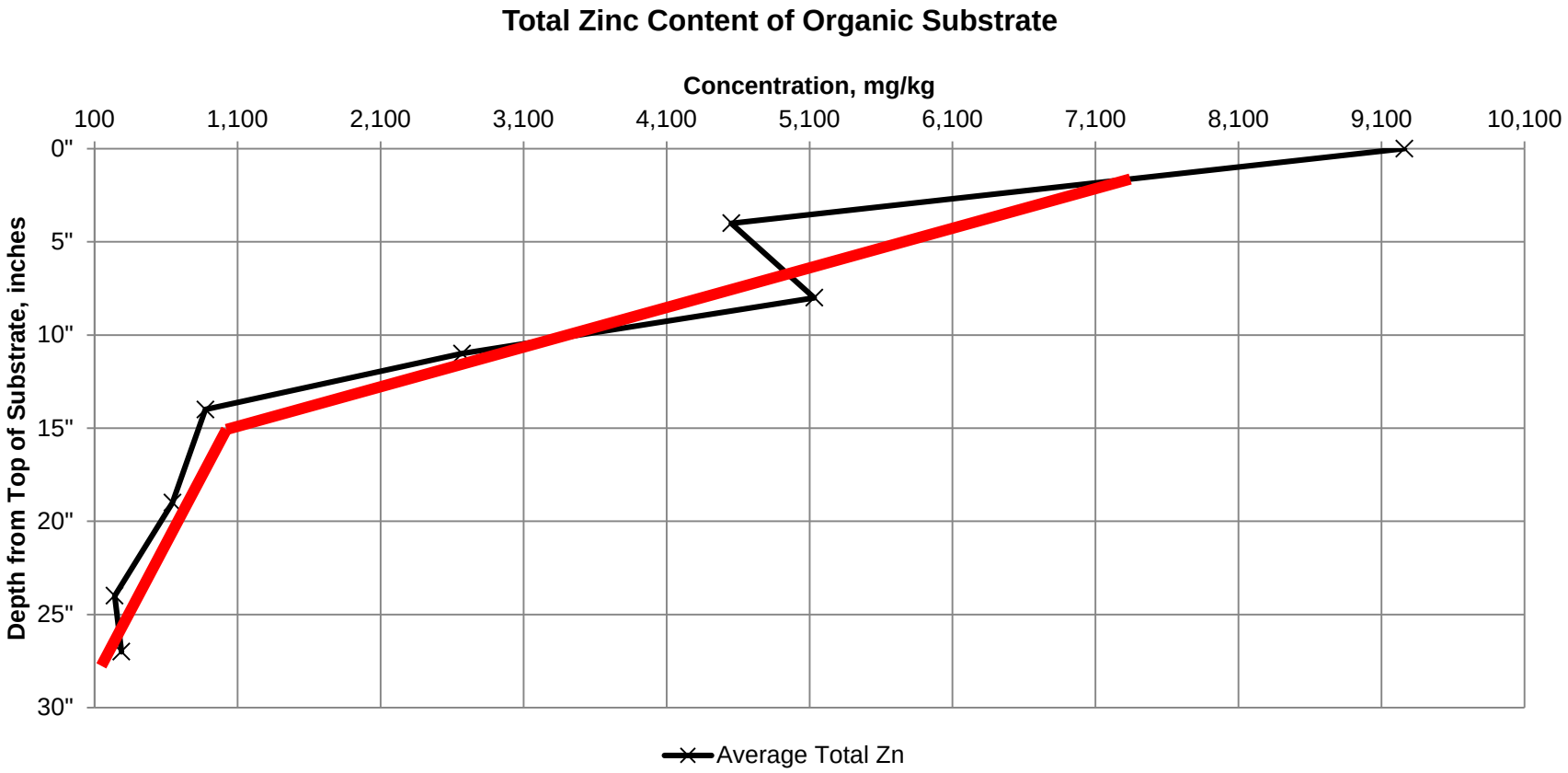
Pilot BCR Decommissioning

Metal Precipitation Results:



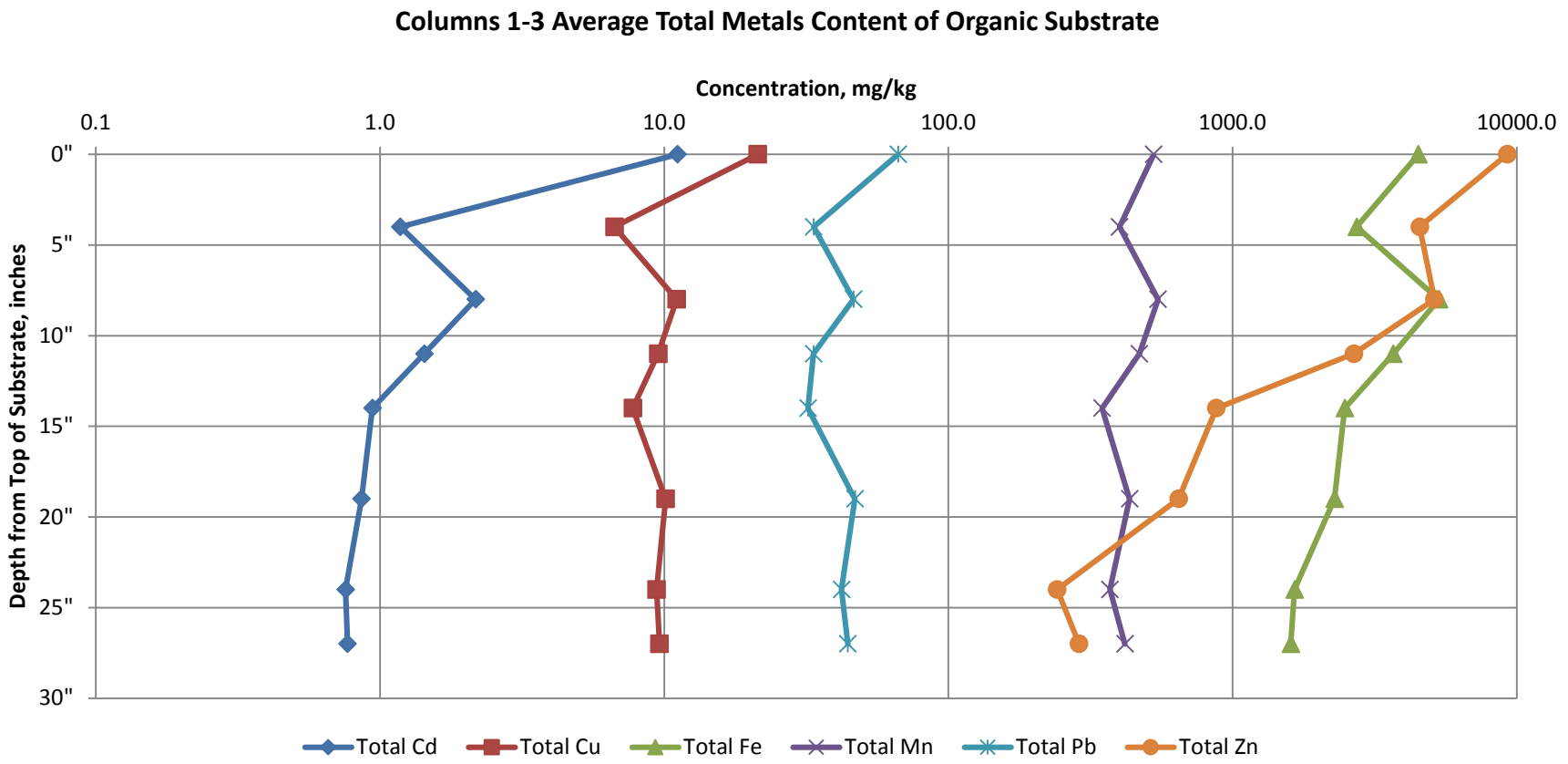
Pilot BCR Decommissioning

Metal Precipitation Results:



Pilot BCR Decommissioning

Metal Precipitation Results:



Pilot BCR Decommissioning

Columns 1-3 Average TCLP Results:

Sample ID	Average depth from top of substrate	Arsenic, total	Barium, total	Cadmium, total	Chromium, total	Lead, total	Mercury, total	Selenium, total	Silver, total
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
RCRA Standard[1]		5.0	100.0	1.0	5.0	5.0	0.2	1.0	5.0
C1 27"	0"	0.015	0.16	0.0019	0.0037	0.054	< 0.00003	0.028	0.0065
C1 23"	4"	0.017	0.13	< 0.002	0.0034	0.019	< 0.00003	0.026	0.0060
C1 19"	8"	0.019	0.13	< 0.002	0.0034	< 0.013	< 0.00003	0.021	0.0051
C1 16"	11"	< 0.22	0.20	< 0.002	< 0.003	0.010	< 0.00003	0.033	0.0072
C1 13"	14"	< 0.22	0.13	< 0.002	0.0047	0.057	< 0.00003	0.032	0.0056
C1 8"	19"	0.036	0.26	< 0.002	0.0045	0.037	< 0.00003	0.035	0.0064
C1 3"	24"	0.016	0.40	< 0.002	< 0.003	0.010	< 0.00003	0.040	0.0070
C1 0"	27"	0.016	0.13	< 0.002	0.0024	0.061	< 0.00003	0.017	0.0057

1: RCRA standards, e-CFR Title 40 Part 261.24 Toxicity characteristic.

- Paint Filter test results

Golder Associates

BCR Substrate Longevity

- Two Methods for determining substrate longevity:
  - Acidity buffering capacity (limestone longevity)
  - Remaining carbon longevity
- 3 Methods for determining limestone dissolution:
  - **Performance data - Ca in vs Ca out**
  - Field measurement of substrate (mass $CaCO_3$ / mass dry substrate)
  - Neutralization Potential as $CaCO_3$
- 2 Methods for carbon longevity:
  - **Sulfate reduction – 2 mol C per mol SO_4**
  - Field measurement of substrate TOC

Golder Associates

BCR Substrate Longevity

- Limestone dissolution (Calcium in vs Calcium out):
  - **8.5 – 14 years of remaining life**
- Carbon longevity (sulfide reduction):
  - **8.0 – 18 years of remaining life**
- Estimated BCR lifespan:
  - **5 years operation = 13 – 19 years of operation**

Golder Associates

Conclusions

- Substrate metals precipitation:
  - No defined reaction front observed
  - Increased precipitation observed at initial substrate-water interface
- TCLP & Paint filter:
  - Substrate is expected to be non-hazardous
- Substrate longevity:
  - 13 – 19 year design life, aligns with typical 10 – 20 year life estimate
- BCR performance:
  - Effluent Cd, Cu, Pb consistently below 5 µg/L
  - Met acute/chronic stream standards for majority of COCs

Golder Associates

Contact: ngallagher@golder.com

Golder Associates