

American Society of Reclamation Sciences 2025 – Butte Montana

On-Site Stabilization of Elemental Mercury

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June 2025

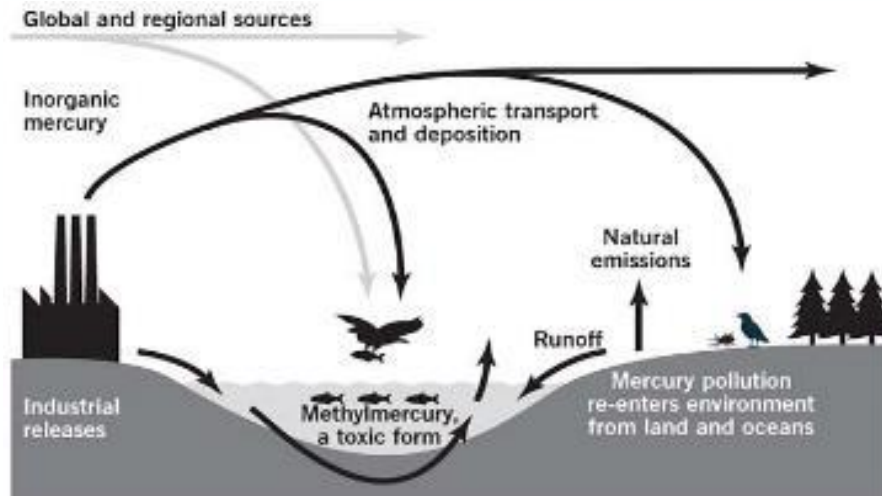


MercLokTM

A versatile *remediation technology* designed for the rapid stabilization of mercury found in a range of soils and industrial wastes.

Environmental Problem and MercLok™ Solution

TODAY'S PROBLEM



Mercury, Gold & Silver Mining



Industrial, Chemical & Munitions

ALBEMARLE'S SOLUTION



Target **sites** contaminated with **mercury**



Apply **MercLok™** to soil, sediments or mixed wastes



Use **In-situ** and **ex-situ remediation** techniques to contact, capture and immobilize mercury

Case Study 1 – Hg⁰ Stabilization in Cinders

Former Industrial Site – United States

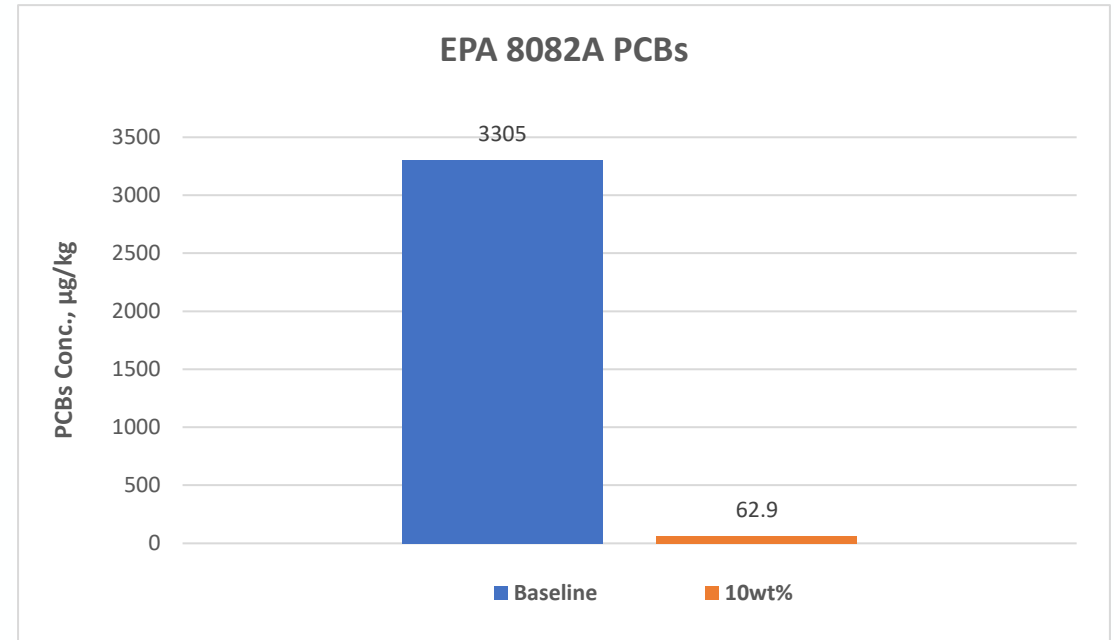
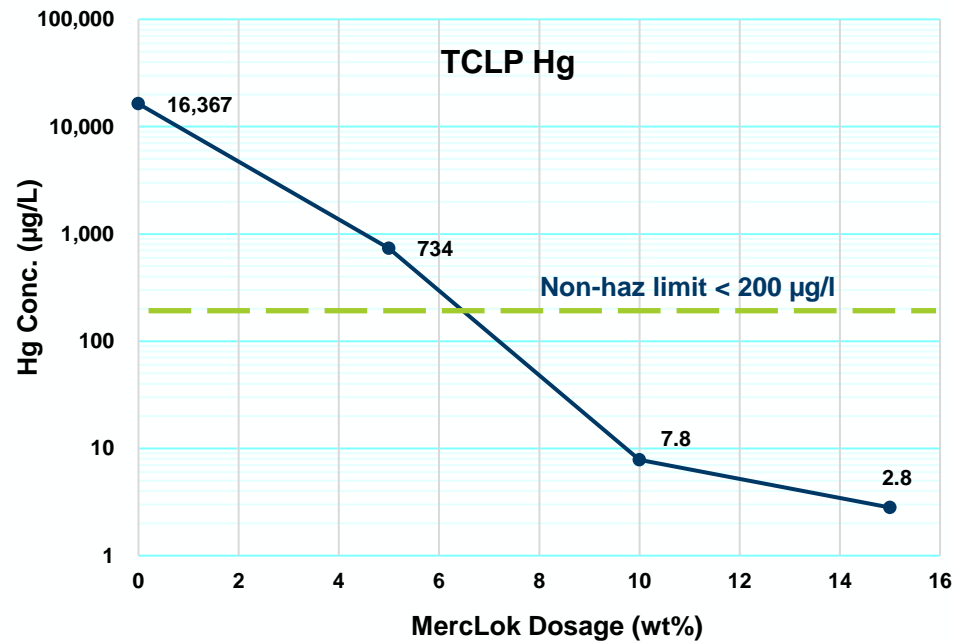
Brownfields Redevelopment

- Forge cinders were placed between a foundation slab and wood plank flooring for vibration dampening
- Spilled elemental mercury from the industrial process leaked through the floor and into the cinders
- Fugitive mercury also found its way into the soil and collected around the foundation footers



Case Study 1 – Treatability Study - Cinders

EPA 1311 TCLP		EPA 8082A
THg Analysis pH 4.5 (µg/L)	THg Analysis pH 2.88 (µg/L)	PCBs (µg/kg)
3,188.3	16,366.5	3,305.0



- Visible Hg restricts disposal in US – must be retorted
- Total PCBs > 1 ppm restricts retorting in US

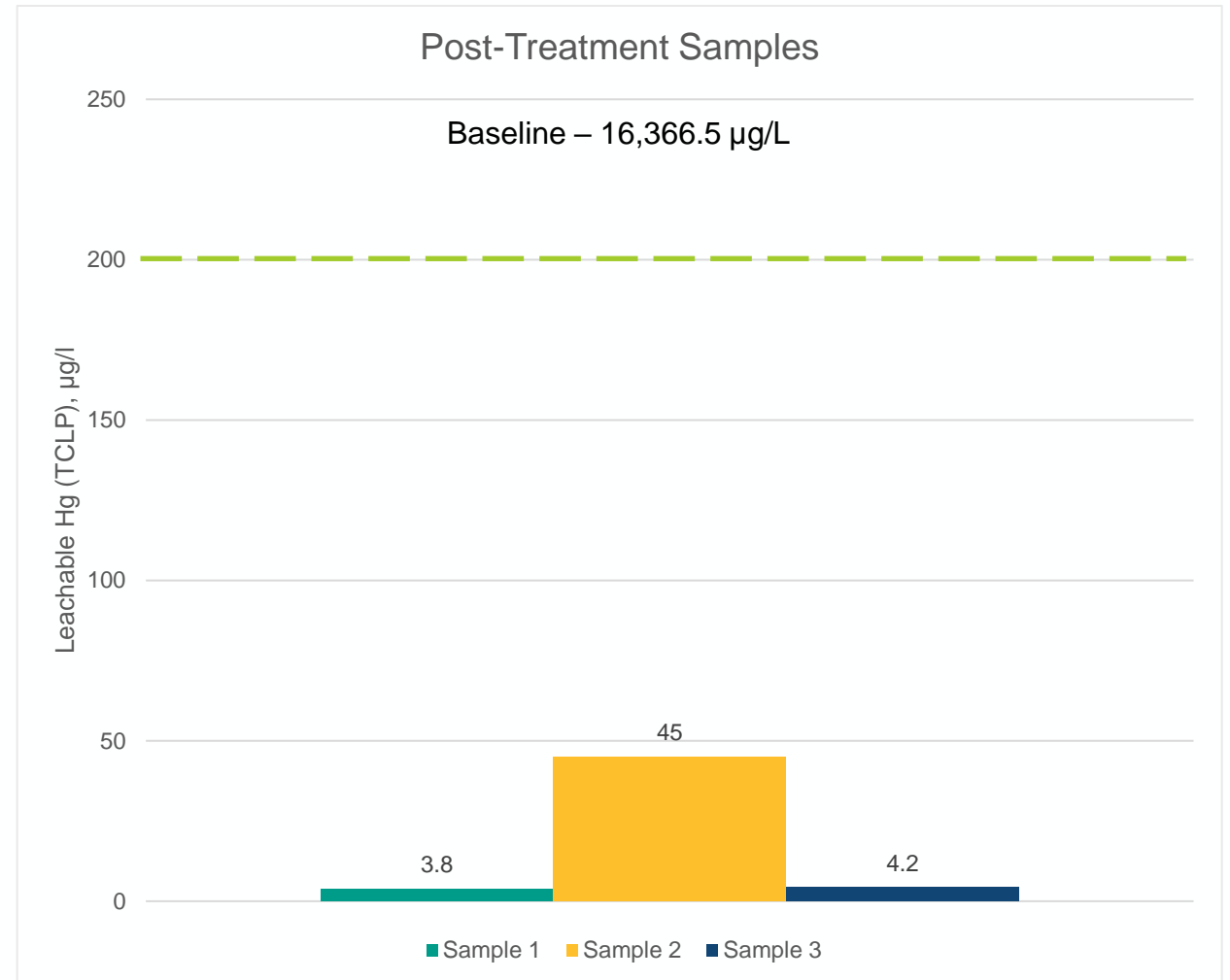
Case Study 1 – Treatment of Cinders



Total Cinders, lb.	MercLok™ Dosage	MercLok™ Added, lb.	Wt. of Water, lb.	Volume of Water, gal
4000	10%	400	640	77

Case Study 1 – Confirmation Sampling

- Due to visible and leachable Hg above TCLP limit and presence of PCBs, the cinders did not have a disposal destination
 - Hg was reduced to much less than 200 ppb (TCLP Limit)
 - Elemental Hg was not visible in post treatment material
 - PCB detection was reduced from 3 ppm (total) to ND (<0.23 ppm)
- Cinders were disposed of in a landfill as a high Hg, non-hazardous material



Case Study 1 – Hg⁰ Soil Stabilization

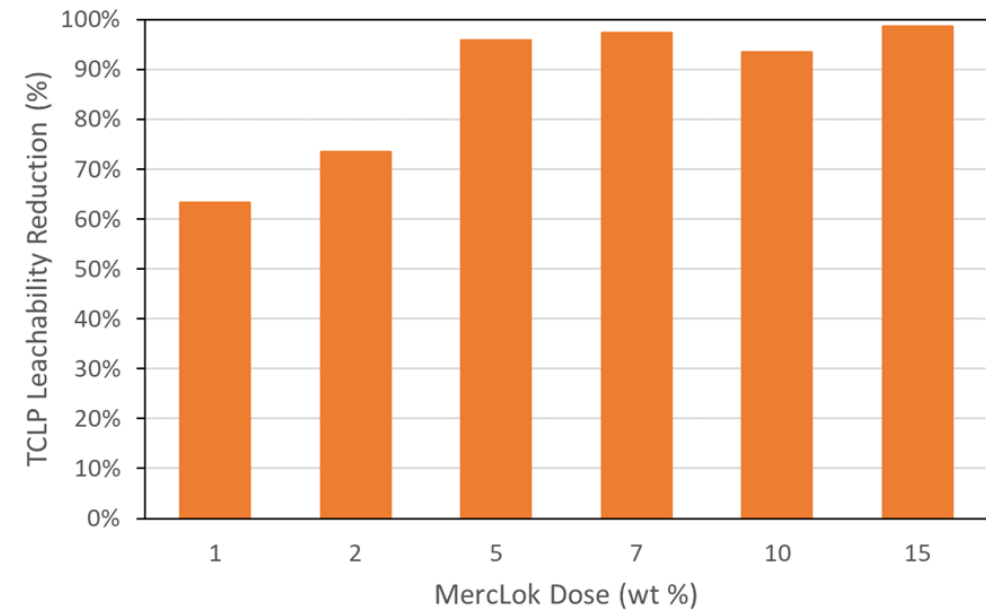
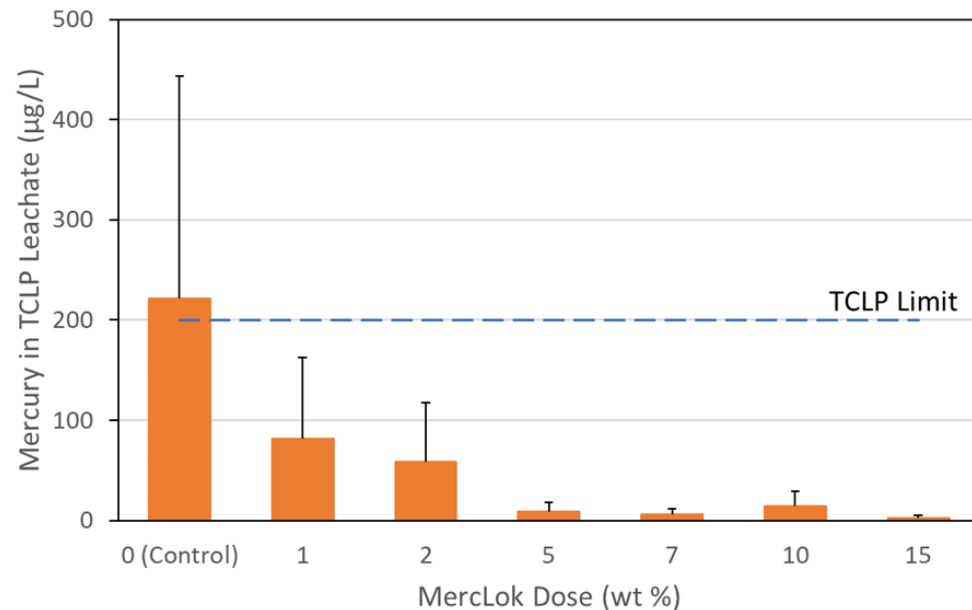
- Visible Hg located in soils beneath former building footprint and around foundation footers
- Total Hg 2,580 mg/kg
- Exceeded TCLP Limit of 200 µg/L



Case Study 1 – Hg⁰ Soil Stabilization

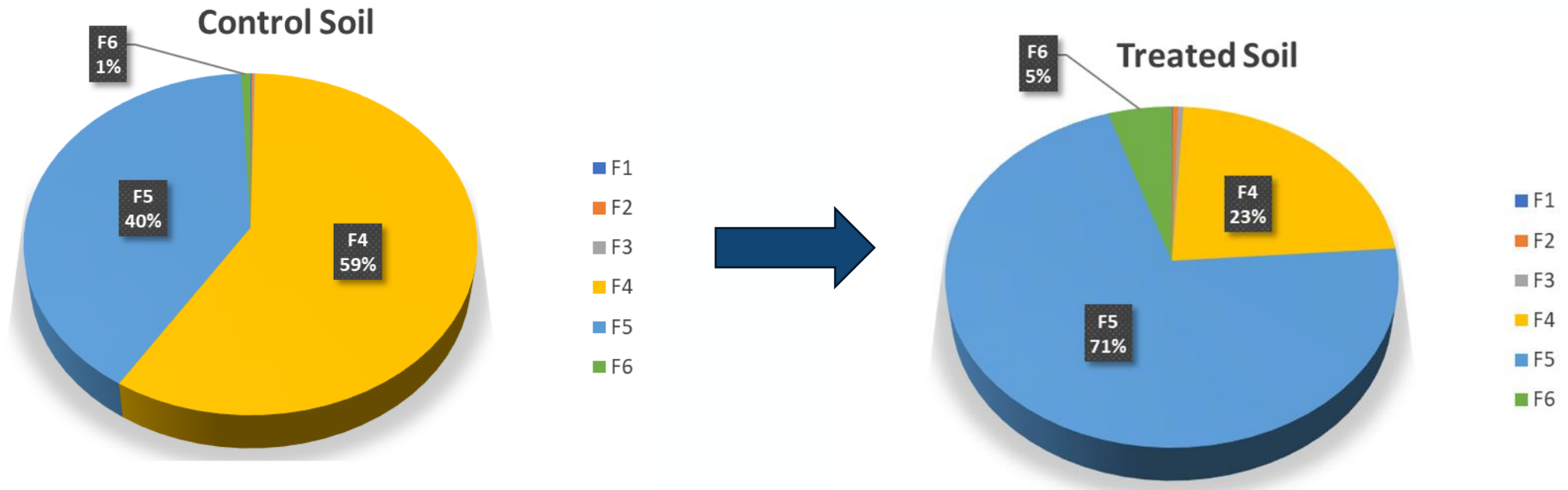
Leachable Hg Reduction – Method 1311 TCLP

- Effective leachate reduction at all dosages
- No visible Hg



Case Study 1 – Hg⁰ Soil Stabilization

Selective Sequential Extraction



- Shift from F4 (includes elemental) to F5
- Increase in F6 fraction
- Reduction in leachability - increase in **stability**

F1: Water soluble (HgCl₂, HgSO₄)
F2: Stomach acid soluble (HgO)
F3: Base leachable (organo-complexed)
F4: Oxidizable (strongly complexed and elemental)
F5: Aqua regia (cinnabar-like)
F6: HF (crystalline silicate-Hg matrix)

Case Study 2 –Hg⁰ Treatability Test

Treatability for soil from beneath former chlor-alkali cell house

- Visible Hg when excavated, dispersed during stockpiling
- Composite soils collected from 3 locations within 500 yd stockpile
- One aliquot of soil spiked with elemental Hg at added concentration of 1,000 mg/kg
- Following treatment, soils incubated in 2.5-gallon buckets at room temperature
- Evaluation of treated soil at 1 month incubation for vapor concentration and 2 months for leachability



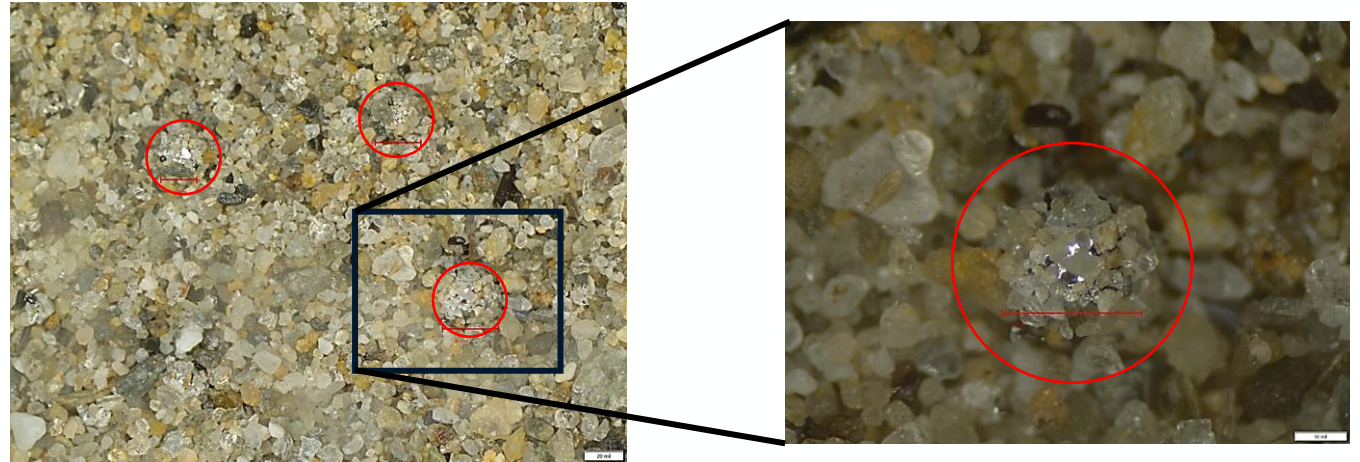
Sample ID	Sample Type	Dosage of P-640 (wt.%)	Vapor Concentration (ug/m ³)
TS-PA-01	Baseline	0	>500
TS-PA-02	Spiked	0	>500
TS-PA-03	Baseline	1	1.09
TS-PA-04	Baseline	2.5	0.54
TS-PA-05	Baseline	5	0.56
TS-PA-06	Spiked	1	6.78
TS-PA-07	Spiked	2.5	1.06
TS-PA-08	Spiked	5	0.74
TS-PA-09	Spiked	7.5	0.79



Case Study 2 – Leachability and Hg⁰

Treatability Study			
Sample - Treatment	Total Hg (mg/kg)	TCLP (µg/L)	SPLP (µg/L)
Baseline - Untreated	92.72	355.2	54.2
Baseline - 1% MercLok™	73.55	11.7	11.2
Baseline - 2.5% MercLok™	54.92	<1	<1
Baseline - 5% MercLok™	21.92	<1	<1
Spiked - Untreated	1179.71	2579.7	249.5
Spiked - 1% MercLok™	984.31	1254.8	2340.0
Spiked - 2.5% MercLok™	807.32	143.0	156.5
Spiked - 5% MercLok™	865.80	3.3	<1
Spiked - 7.5% MercLok™	133.02	1.0	<1

Spiked Control (Untreated)



Spiked - 1% MercLok



Spiked - 2.5% MercLok



Spiked - 5% MercLok

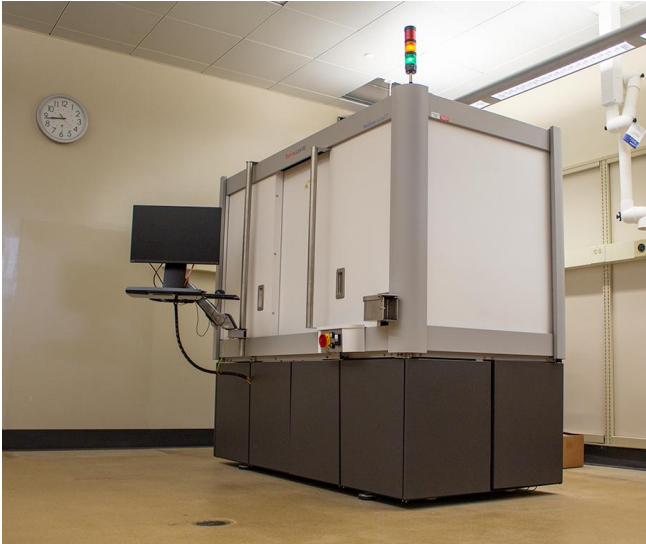


Spiked - 7.5% MercLok



Visualizing Hg⁰/MercLok™ Interactions

Micro CT - Proof of Concept



Thermo Fisher
Heliscan Mark II

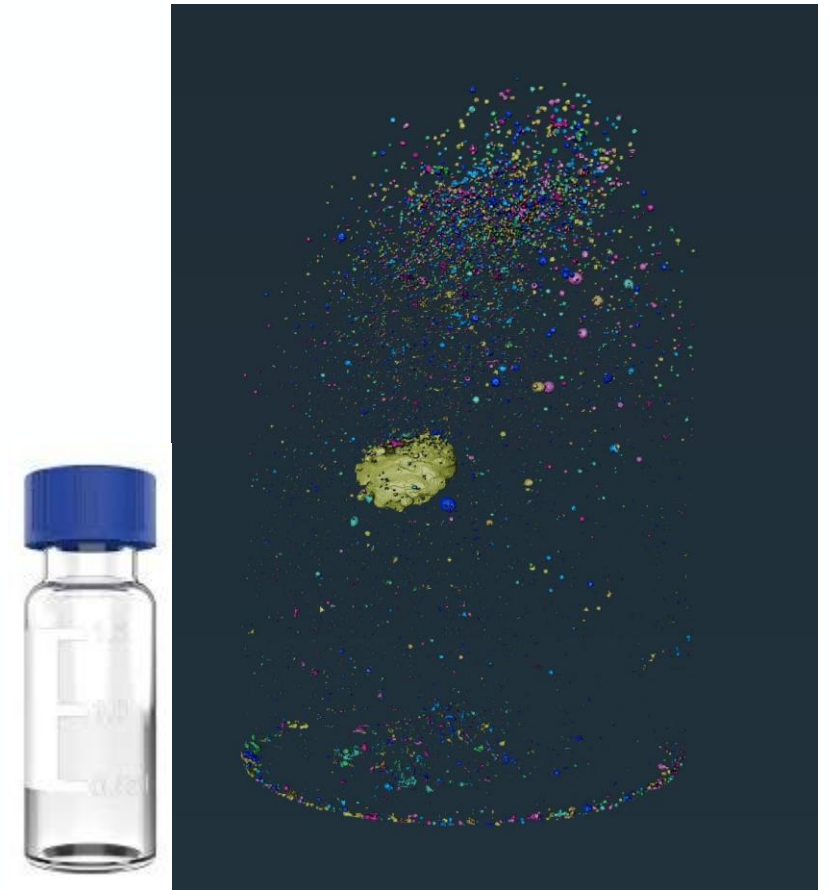
- 10-micron voxel size

2% Hg by weight stirred with sand as
suspending agent

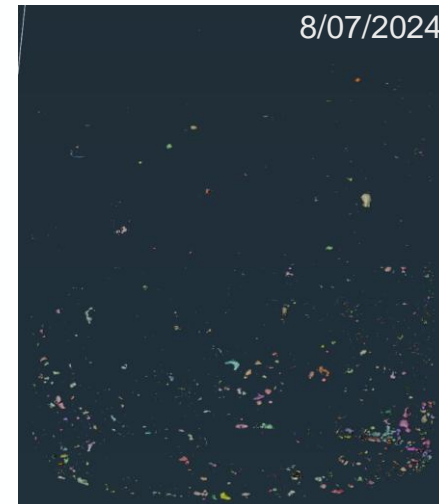
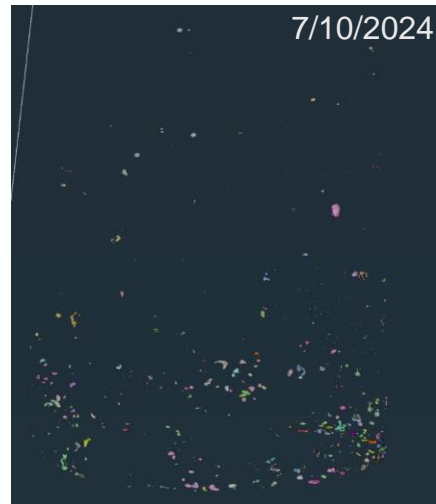
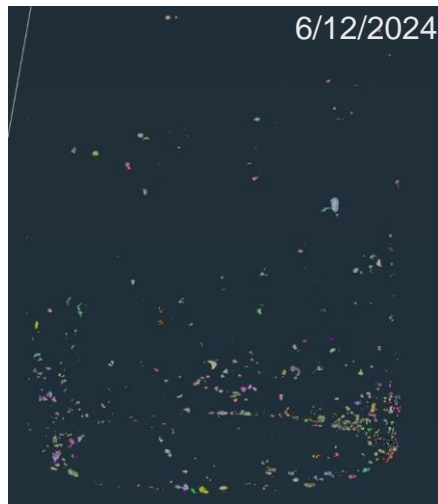
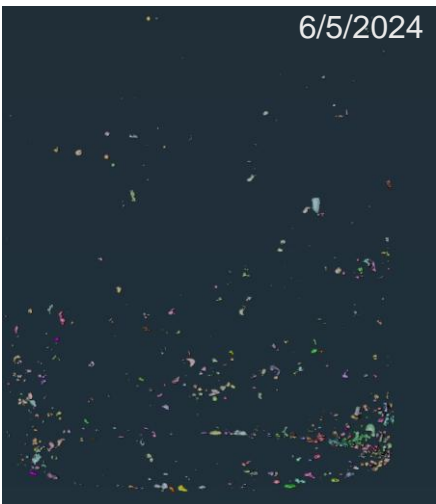
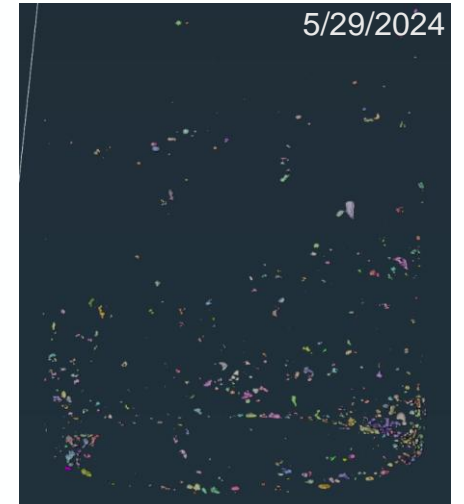
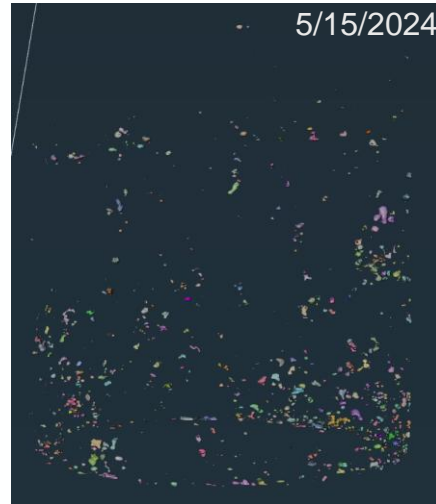
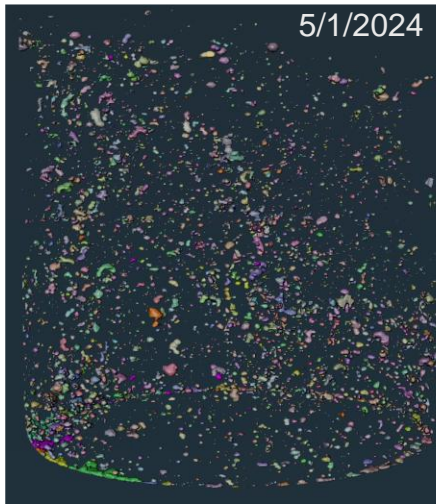
2-D X-Ray



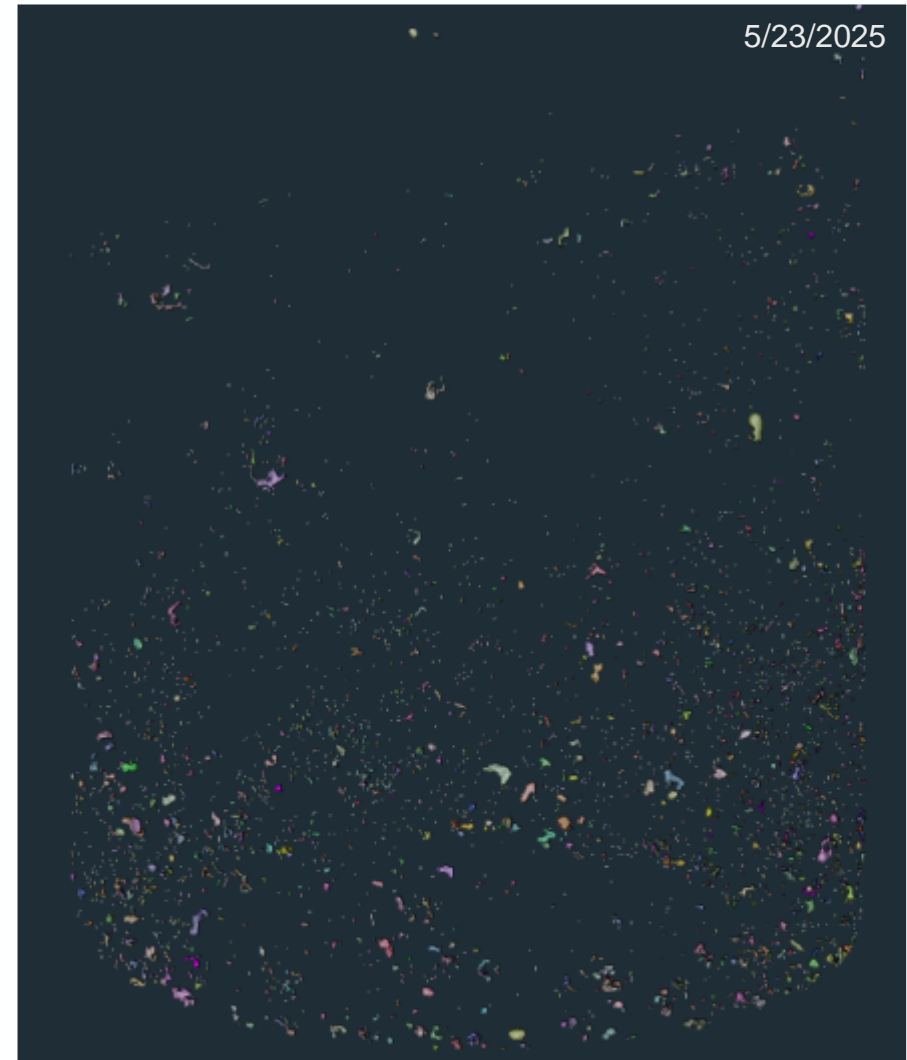
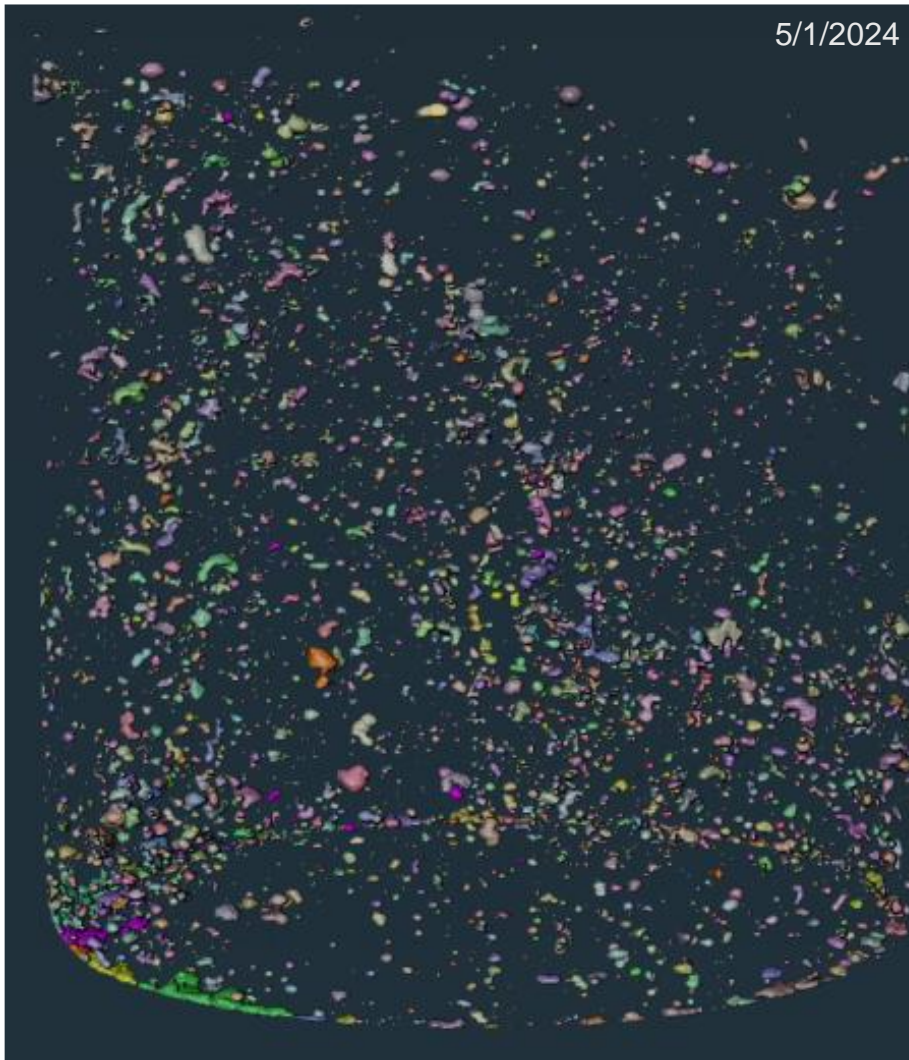
3-D X-Ray CT



Visualizing Elemental Hg/MercLok™ Interactions



Visualizing Elemental Hg/MercLok™ Interactions



Summary

Case Study 1:

- Reduction in the leachability of cinder materials containing highly leachable Hg species.
 - $>16,000\mu\text{g/L}$ to $< 45\mu\text{g/L}$
 - Concurrent reduction in PCBs
 - Elemental Hg no longer visible
- Shift in Hg species in soil from F4 (elemental) to F5 and F6 fractions.
 - Rendered more stable and elemental Hg was no longer visible via unaided visual inspection

Summary

Case Study 2

- Reduction in elemental Hg in vapor phase, leachability.
 - Elemental Hg bead size reduced from visible (>500 micron) to sub-visible (<100 micron), verified via enrichment/isolation of Hg⁰ followed by microscopic examination.

X-Ray/CT Visualization

- Interaction between Hg⁰/MercLok indicates a reduction both in the distribution (prevalence) and size of Hg microbeads in treated media within weeks of treatment.

Treatment reduces leachability, reduces the occurrence of Hg beads, and increases stability via direct interaction – Long-Term Sequestration.

Q&A

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California poppy growing on a
MercLok™ - amended calcine pile

