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Recovery of Critical Minerals from mining influenced water during legacy Superfund Site remediation: advancing innovative technologies through the EMRTAI

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EMRTAI

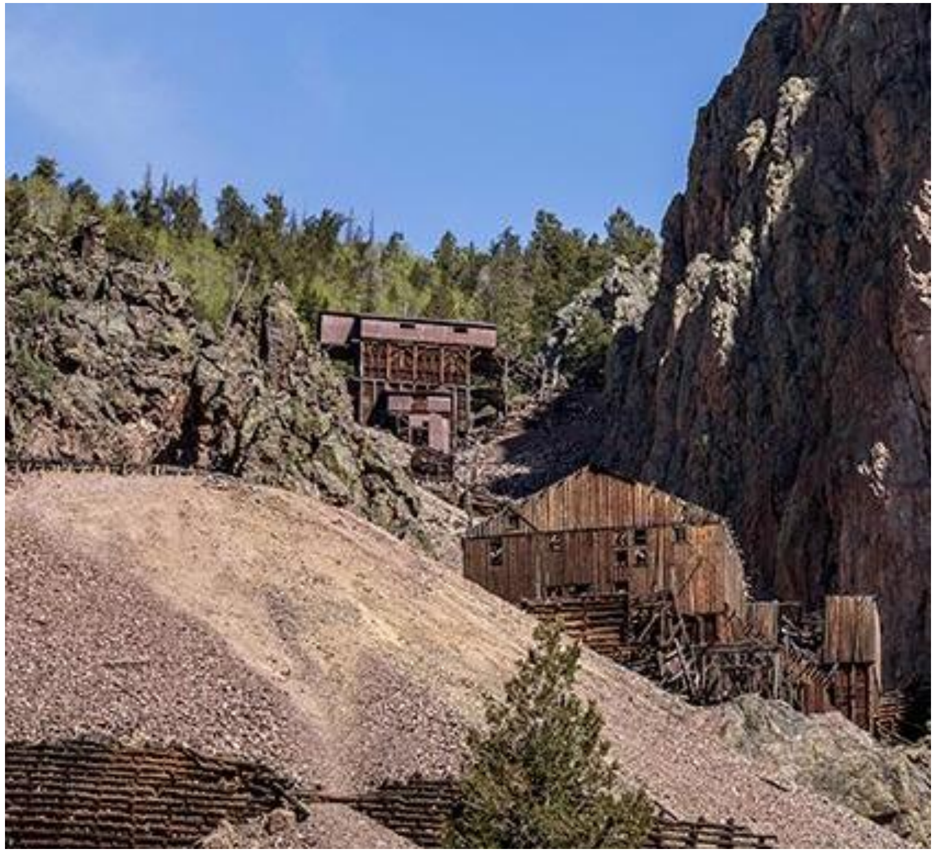
Environmental Monitoring and Remediation Technology Assessment Initiative

ASRS Annual Meeting, Laramie, Wyoming

Site Remediation and Critical Minerals Recovery

Mine waste as a liability and a resource

- 100+ mining and mineral processing (MMP) sites on EPA Superfund National Priority List (NPL) undergoing remediation
- MMP produces large amounts of waste materials
- MMP waste can serve as feedstock for metals recovery (unconventional source)
- Recovery of minerals can be incorporated into site remediation to support development of the U.S. supply chain and potentially offset remediation costs



In 2023, EPA established the EMRTAI to support testing and advancement of technologies to recover critical minerals from legacy MMP sites.

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Intro to EMRTAI – Program Goal and Objectives

Goal: To drive innovation and facilitate dialogue through technology assessments that produce data for informed decisions surrounding the identification and recovery of critical minerals from mine waste at legacy mining and mineral processing sites during site remediation.

Objectives:

(1) To conduct **technology assessments** that will produce credible performance data to accelerate technology implementation for the benefit of diverse stakeholders

(2) To advance the Initiative through **stakeholder engagement**

(3) To **collaborate** with mining and mineral processing site owners, federal, state, and local stakeholders, and communities where technology assessments may occur

(4) To create a **community** of technology developers and users focused on **CM resource recovery while reducing risk to human health and the environment**

Technology Assessments

Bridging "the valley of death" between technology development and implementation.

Focus: Remediation and resource recovery to support domestic CM supply chain.

- Credible, quality-assured performance data for technologies at different stages
  - Advance technologies to commercialization
  - Support implementation (where appropriate)

Calls for Applications (October 2024, Sept 2025, March 2026)

1. Technologies to recover critical minerals from mining-influenced water
2. Technologies to characterize critical minerals in solid mining and mineral processing waste
3. Technologies to recover critical minerals from solid mining and mineral processing waste

Technology Assessments

- Open to all technology developers/vendors that are ready for bench-scale or pilot-scale demonstrations
- Technologies must target critical minerals – USGS 2025, DOE 2023, Presidential Executive Orders

CFA Round	Company Name	Target Media	Technology Type/ Mechanism	Target Metals	Assessment Scale
1	Stalagmite	MIW	Ozone Driven Selective Recovery (ODSR)	Co, Mn, Ni, REEs	bench-scale
1	REETerra	MIW	biological ligand exchange (adsorption/desorption)	REEs	bench-scale
2	Draslovka	Spent ore/tailings	Enhanced, selective leaching	Cu, Ni, Au, Ag	bench-scale
2	Draslovka	Spent ore/tailings	Enhanced, selective leaching	Au, Ag	pilot-scale

Round 3 CFA closed on May 8, and we anticipate accepting 4-5 technology developers into the program, with 4-5 additional demonstrations focused on critical minerals recovery (Cu, Co, Ni, Sb, REEs, Zn, etc.)

Technology Assessment Framework

Technology Assessment Program

- Designed with data end users and technology developers as the focus

Benefits to Technology Developers and Vendors
• Access to real mine waste for technology testing • Access to independent third-party evaluation • Recognition resulting from assessment • Data to support technological advancement (e.g., de-risking) • Connection to potential users

Benefits to Stakeholders/Data Users
• Credibility of test data • Openness of testing process • Input on key assessment metrics • Increased confidence in technology selection • Data to support potential integration in remediation planning

Technology Assessment Framework

Technical Panels

Learn more about technical panels

Characterization

Quality Assurance Project Plan (QAPP) for Characterizing Concentrations of Critical Minerals in Solid Mine Waste using Handheld X-Ray Fluorescence

Recovery – Mining Influenced Water

Quality Assurance Project Plan (QAPP) for Critical Minerals Recovery Technologies for Mining Influenced Water (bench-scale and pilot-scale)

Recovery – Solid MMP Waste

Quality Assurance Project Plan (QAPP) for Critical Minerals Recovery Technologies for Solid Mining and Mineral Processing Waste (bench-scale and pilot-scale)

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Technology Assessment – Case Study: Stalagmite

Quality Assurance Project Plan (QAPP) for Critical Minerals Recovery Technologies for Mining Influenced Water (pilot-scale)

Metrics & Parameters for Evaluating Critical Minerals Recovery Technologies

- Performance Capabilities – CM Recovery
- Performance Capabilities – Treatment of COCs
- Operational Considerations

Support Tech Advancement

- Bench-scale demonstration
- TRL = 3-4
- Ongoing R&D focused on product purification
- Building field-deployable pilot-scale unit

Technology Assessment Testing Plan for the Stalagmite Recovery Technology

1. Selection of feedstock – provide options, discuss threshold concentrations, identify constraints, investigate other sites, etc.
2. Develop the Testing Plan within the framework of the categorical QAPP
3. Conduct the technology assessment
    - Collect bulk feedstock and ship to technology developer's facility
    - Phase 1: Optimization
    - Phase 2: Laboratory demonstration (3-4 days)
    - Collect samples and submit for laboratory analyses
4. Develop report and performance statement

Technology Assessment – Case Study: Stalagmite

1. **Selection of feedstock – Nelson Tunnel, Creed, CO**
    - Target critical minerals: Co, Mn, Ni, and REEs

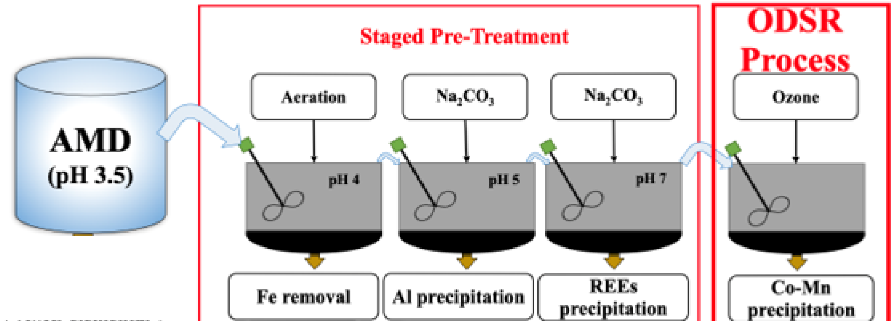
	Units	NT-1	NT-2	NT-3
Parameter				
pH	No unit	4.7	4.67	4.58
Total Dissolved Solids (TDS)	mg/L	1000	977	1000
Sulphate	mg/L	630	630	630
Element				
Aluminum (dissolved)	mg/L	0.407	0.406	0.409
Aluminum (total)	mg/L	0.433	0.443	0.436
Cobalt (dissolved)	mg/L	0.0243	0.0241	0.0241
Cobalt (total)	mg/L	0.0243	0.0246	0.0243
Iron (dissolved)	mg/L	0.045	0.042	0.045
Iron (total)	mg/L	2.09	2.02	2.08
Manganese (dissolved)	mg/L	15.6	15.2	15.3
Manganese (total)	mg/L	15.6	15.7	15.2
Nickel (dissolved)	mg/L	0.0097	0.0099	0.0101
Nickel (total)	mg/L	0.0101	0.0102	0.0101
REE Total	mg/L	0.31533	0.3175	0.31173

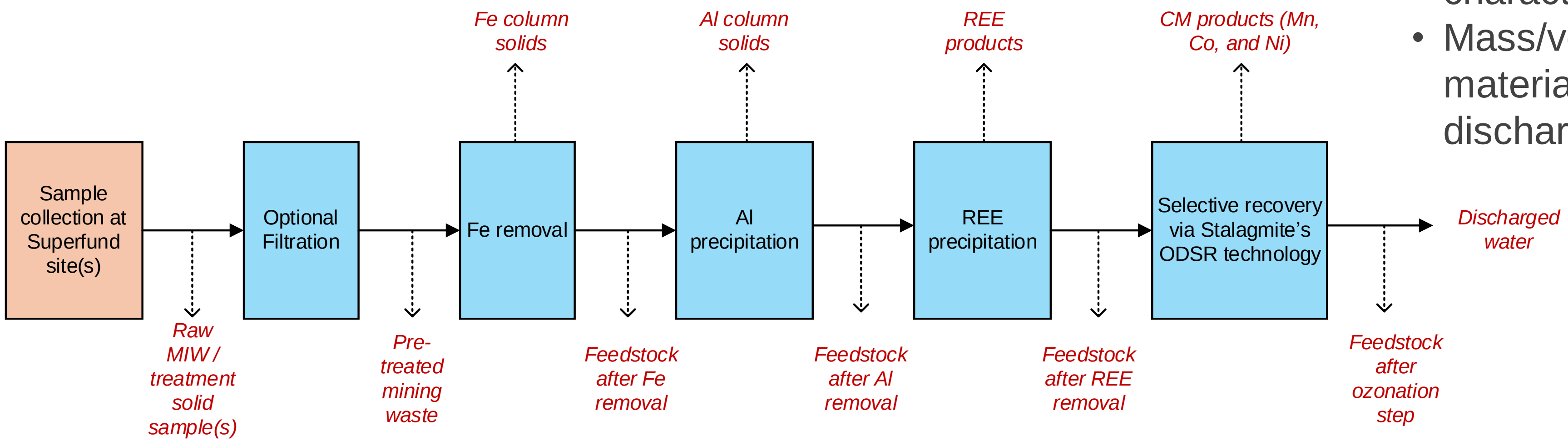
EMRTAI has characterized waste materials for five sites. Data are posted online. This is expected to grow to 10 by the end of 2026.

Check out our available data!

Technology Assessment – Case Study: Stalagmite

1. *Selection of feedstock – Nelson Tunnel, Creed, CO*
2. **Develop the Testing Plan within the framework of the categorical QAPP**





Sample collection/analyses to generate data for key performance metrics and operational considerations

- Purity and recovery/yield of targeted CMs
- Treatment of COC metals
- Residence time, amounts of applied chemicals, etc.
- Characterization of the feedstock
- Flow rate and concentration of constituents at various points in the technology
- Technology-specific characteristics/considerations
- Mass/volume and characterization of waste materials produced to address disposal or discharge considerations

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Technology Assessment – Case Study: Stalagmite

1. *Selection of feedstock – Nelson Tunnel, Creed, CO*
2. *Develop the Testing Plan within the framework of the categorical QAPP*
3. **Conduct the technology assessment**
   - **Collect bulk feedstock and ship to technology developer's facility**
   - **Phase 1: Optimization**
   - Phase 2: Laboratory demonstration (3-4 days)
   - Collect samples and submit for laboratory analyses

Technology developer's recovery target:

- 70% recovery of total REEs after REE precipitation step
- 70% removal of Co, Mn, and Ni after ODSR step

Technology Assessment – Case Study: Stalagmite

1. *Selection of feedstock – Nelson Tunnel, Creed, CO*
2. *Develop the Testing Plan within the framework of the categorical QAPP*
3. Conduct the technology assessment
   - Collect bulk feedstock and ship to technology developer's facility
   - Phase 1: Optimization
   - **Phase 2: Laboratory demonstration (2 days)**
   - **Collect samples and submit for laboratory analyses**

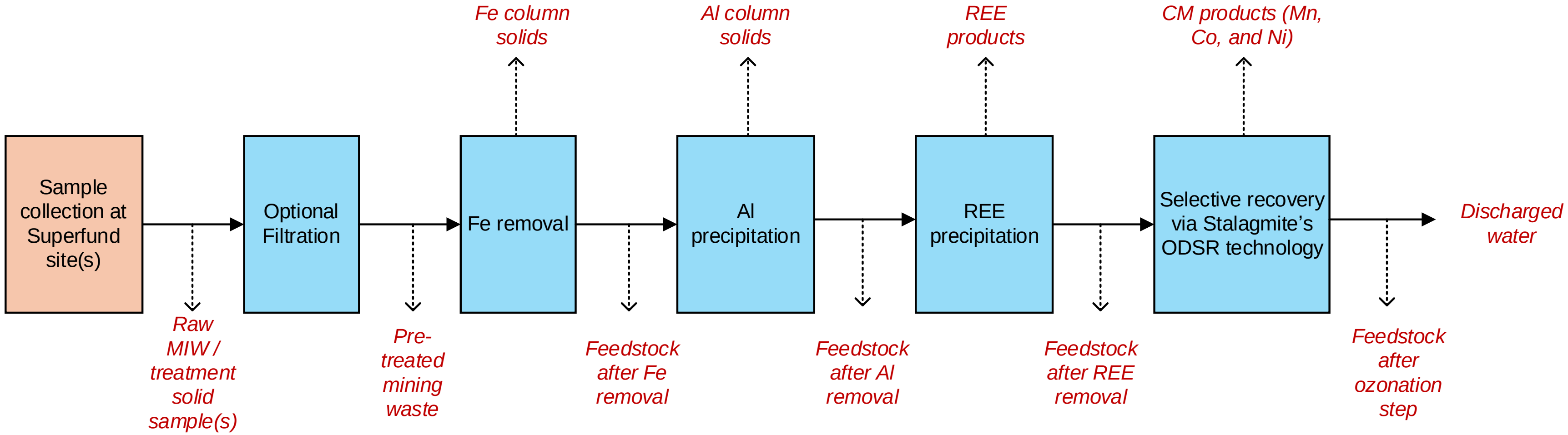

Table 6. Summary of Samples to be Collected during the TA

Sample Description	Day	Number of Samples	Minimum Amount per Sample	Constituents to be Characterized	Analytical Method(s)
Feedstock before pretreatment (raw MIW)	1	1	50 mL	All metals in feedstock	ICP-MS, pH, TDS, sulfate content
Feedstock after pretreatment (filtration if needed; sample taken every 30 minutes, during work hours)	1	4-5	50 mL	All metals in feedstock	ICP-MS
Feedstock after Fe removal (sample taken every 30 minutes, during work hours)	1	4-5	50 mL	All metals in feedstock	ICP-MS
Feedstock after Al removal (sample taken every 30 minutes, during work hours)	1	4-5	50 mL	All metals in feedstock	ICP-MS
Feedstock after REEs removal (sample taken every 30 minutes, during work hours)	1	4-5	50 mL	All metals in feedstock	ICP-MS
Feedstock after ozonation step (sample taken every 30 minutes, during work hours)	1	4-5	50 mL	All metals in feedstock	ICP-MS
Discharged water (samples taken every 30 minutes, during work hours)	1	4-5	50 mL	All metals in feedstock	ICP-MS
Influent to treatment system (sample taken every 30 minutes, during work hours)	2	4-5	50 mL	All metals in feedstock	ICP-MS
Feedstock after Fe removal (sample taken every 30 minutes, during work hours)	2	4-5	50 mL	All metals in feedstock	ICP-MS
Feedstock after Al removal (sample taken every 30 minutes, during work hours)	2	4-5	50 mL	All metals in feedstock	ICP-MS
Feedstock after REEs removal (sample taken every 30 minutes, during work hours)	2	4-5	50 mL	All metals in feedstock	ICP-MS
Feedstock after ozonation step (sample taken every 30 minutes, during work hours)	2	4-5	50 mL	All metals in feedstock	ICP-MS
Discharged water (samples taken every 30 minutes, during work hours)	2	4-5	50 mL	All metals in feedstock	ICP-MS
Total solids collected in the Fe removal column	2	1	All collected material	All metals in feedstock	Acid digestion followed by ICP-MS, TCLP
Total solids collected in the Al removal column	2	1	All collected material	All metals in feedstock	Acid digestion followed by ICP-MS, TCLP
Total solids collected in the REE removal column	2	1	5 g (if available), will collect all material	All metals in feedstock	Acid digestion followed by ICP-MS, TCLP
Total solids collected in the Mn, Co, Ni removal column	2	1	5 g (if available), will collect all material	All metals in feedstock	Acid digestion followed by ICP-MS, TCLP
Quality control samples	1, 2	Replicate samples (# = 10% of TA samples)	50 mL	All metals in feedstock	ICP-MS

Samples collected approximately 30 minutes over a 2-day run (1 batch per day)
Technical systems audit (TSA) performed to ensure alignment with Testing Plan.

Technology Assessment Framework

Technical Panel peer review of reports

Technology Assessment Report

- Comprehensive report

Performance Statement

- 2-4 page technology and results summary

Follow EMRTAI on LinkedIn for Updates
Join a Stakeholder Meeting for a presentation about each assessment

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What's ahead?

2026 2027

June | August | October | December | January | March | May | July-September

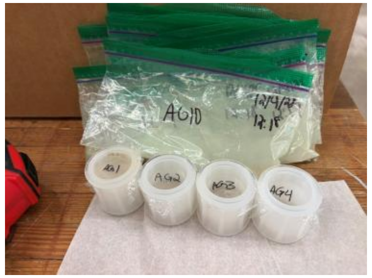
Waste sample collection

REETerra Report

Stalagmite Report

Draslovka Reports

Round 3 Technology Demonstrations Announced



Stakeholder Meeting

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Technology Assessments (10-12)

Report publication

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