EVOLVE CAPP

Evolve Central Appalachia

DE-FE0032055

Aaron Noble, Richard Bishop & the Evolve CAPP team

U.S. Department of Energy
National Energy Technology Laboratory
Resource Sustainability Project Review Meeting
April 3, 2024

ACKNOWLEDGEMENT

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DISCLAIMER

RESEARCH TEAM

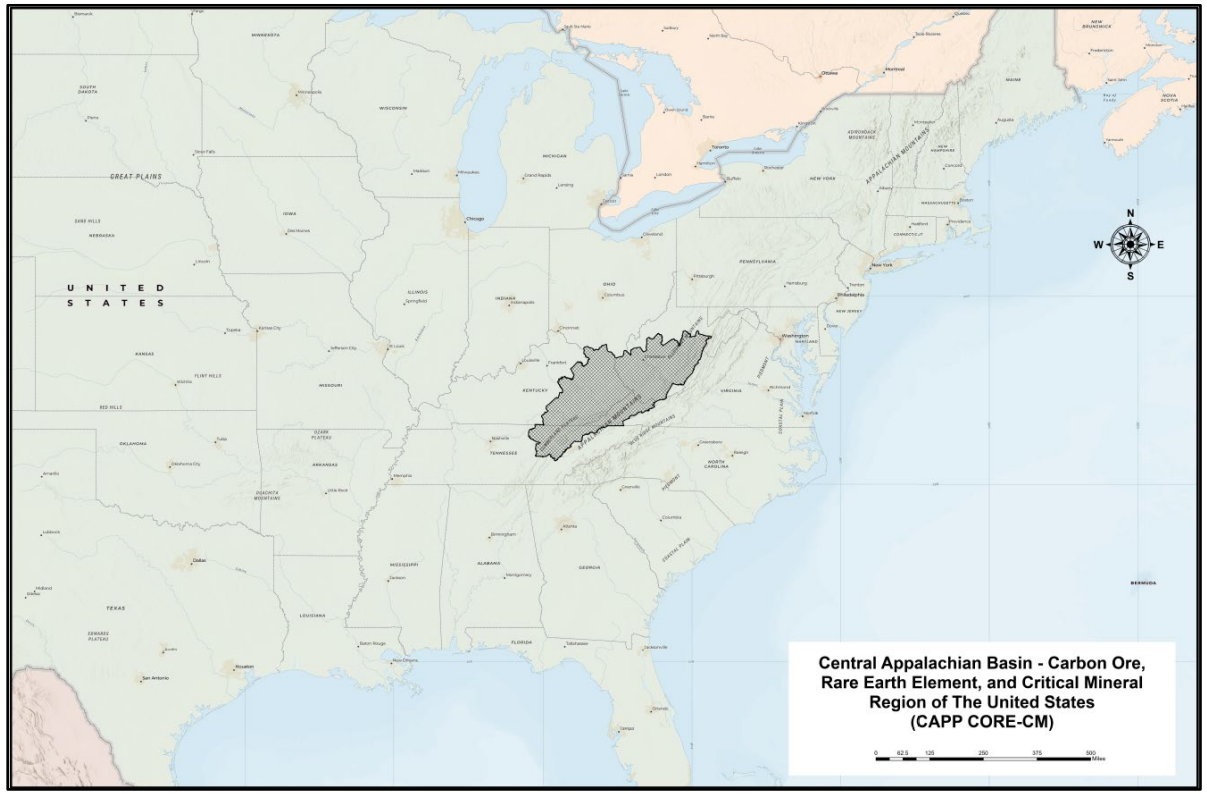
West Virginia University Mining Engineering	Virginia Tech VCCER & Mining Engineering	University of Kentucky Mining Engineering
Marshall Miller & Associates	Gray Energy Technologies	Oak Ridge National Laboratory
Advanced Resources Intl.	Chmura Economics	U. S. Geological Survey
Crescent Resource Innovation	Southern States Energy Board	Virginia Dept of Energy

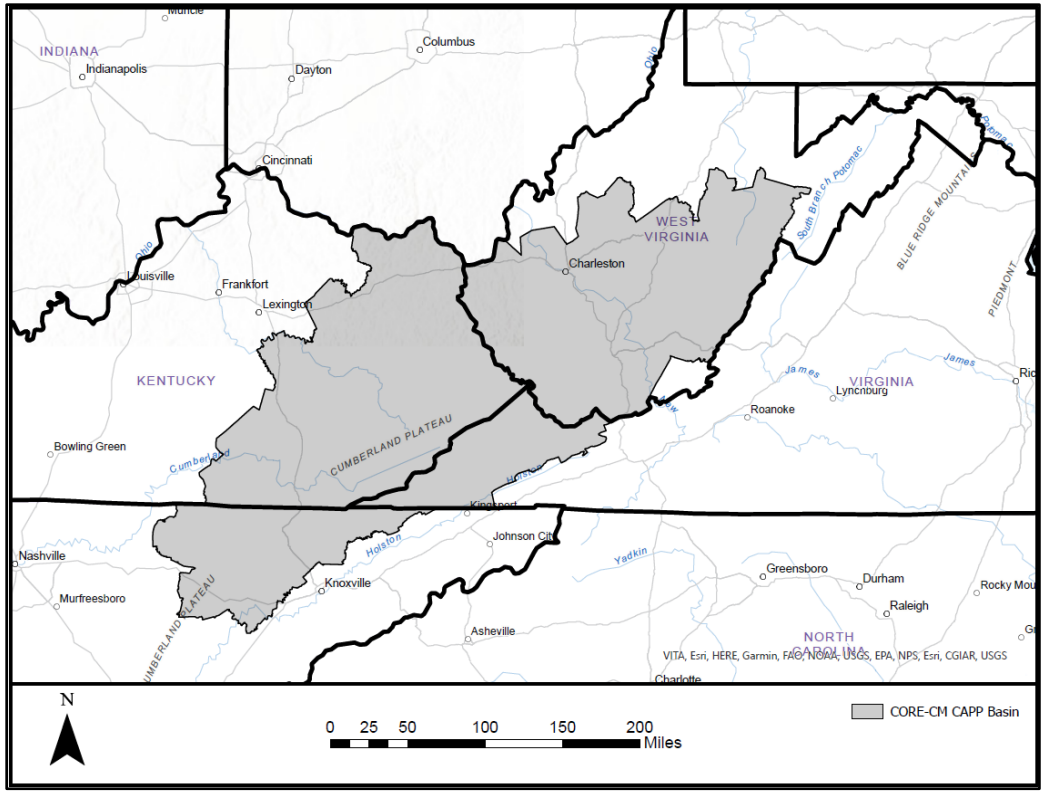
Mountain Empire Community College Coalition

- Mountain Empire Community College (MECC), VA
- Roane State Community College (RSCC), TN
- Southeast Kentucky Community & Tech. College (SKCTC)
- Southern West Virginia Comm. & Tech. College (SWVCTC)

PROJECT OVERVIEW

- *Investigating the Rare Earth & Critical Minerals potential of the Central Appalachian (CAPP) basin*
- *Project Dates: October 1, 2021 – March 31, 2024; Funding: $2,084,999 DOE + $623,868 cost share*





PROJECT SCOPE

The general Evolve CAPP project scope is to:

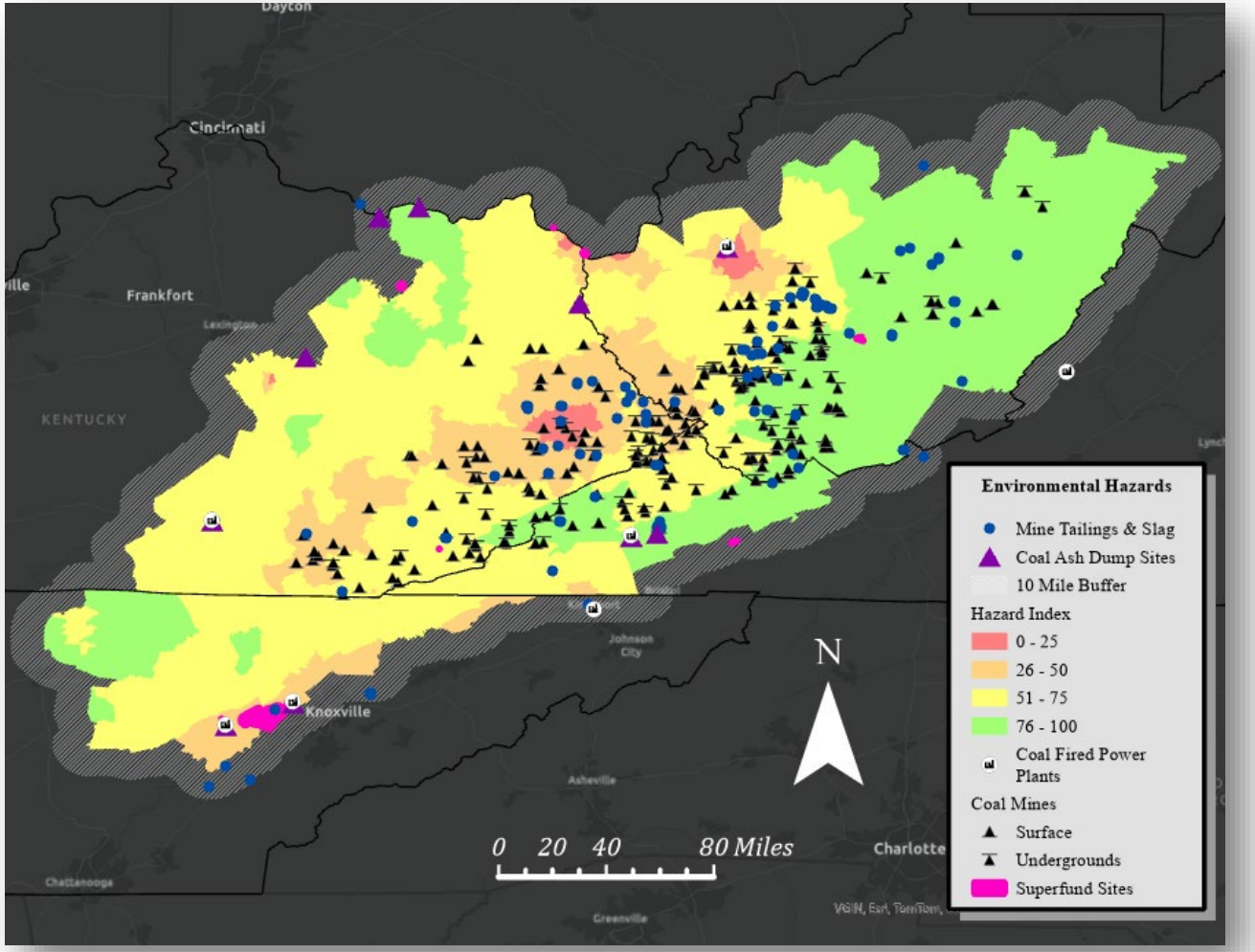
1) *Assess existing knowledge*
2) *Perform a gap analysis*
3) *Fill identified gaps with future projects*
4) *Provide educational & public outreach*


ENVIRONMENTAL
JUSTICE

ENVIRONMENTAL HAZARDS IN THE CAPP REGION

Methods of Analysis:
ArcGIS, EJScreen, CORD, CEJST, & other publicly available data

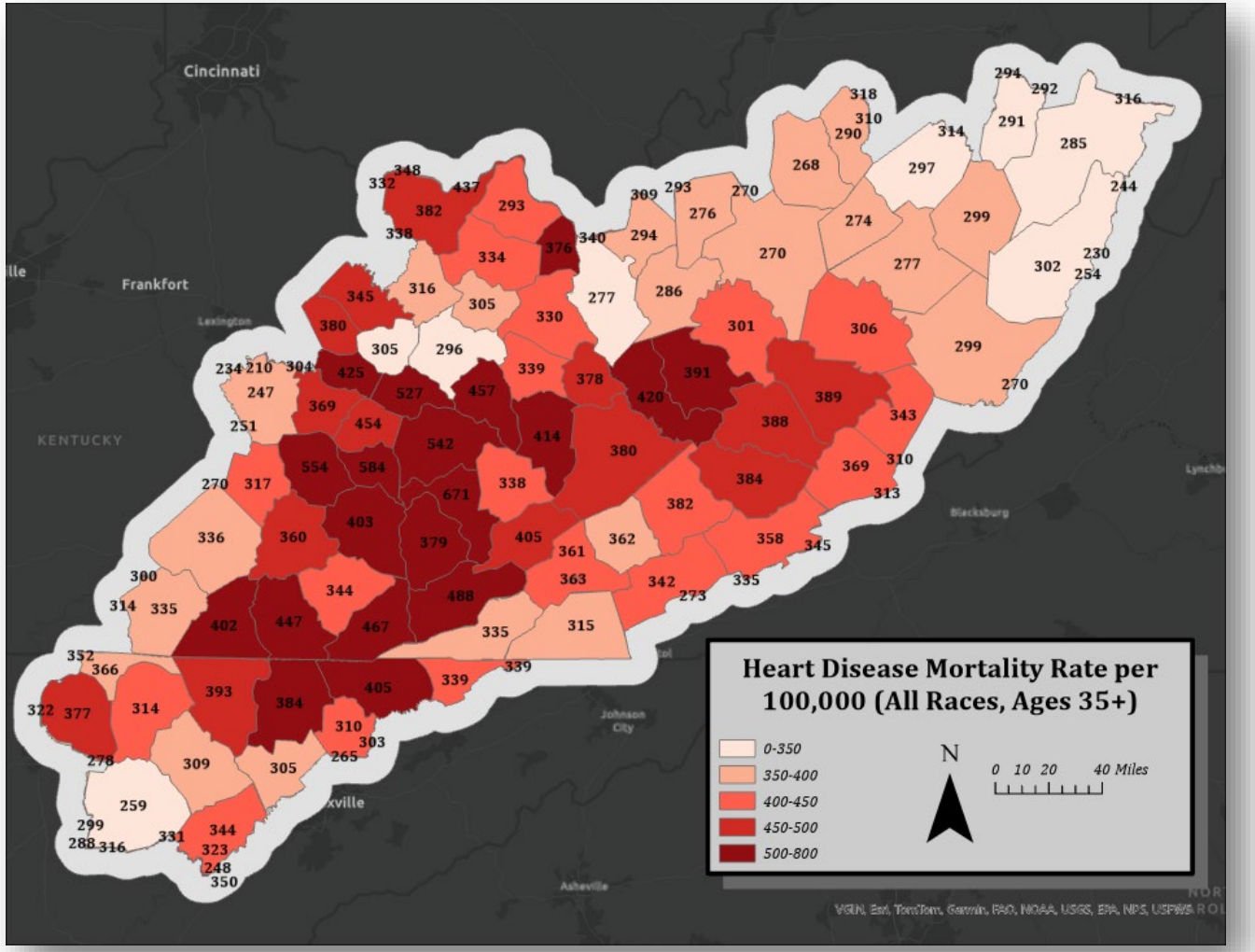
- 284 Active UG/OP Coal Mines
- 6 Coal-Fired Power Plants
- 13 Superfund Sites
- 80M CY of Coal Waste in SW VA
- >15% area in RED or ORANGE



Sources: EPA, USGS, EIA, VADOE

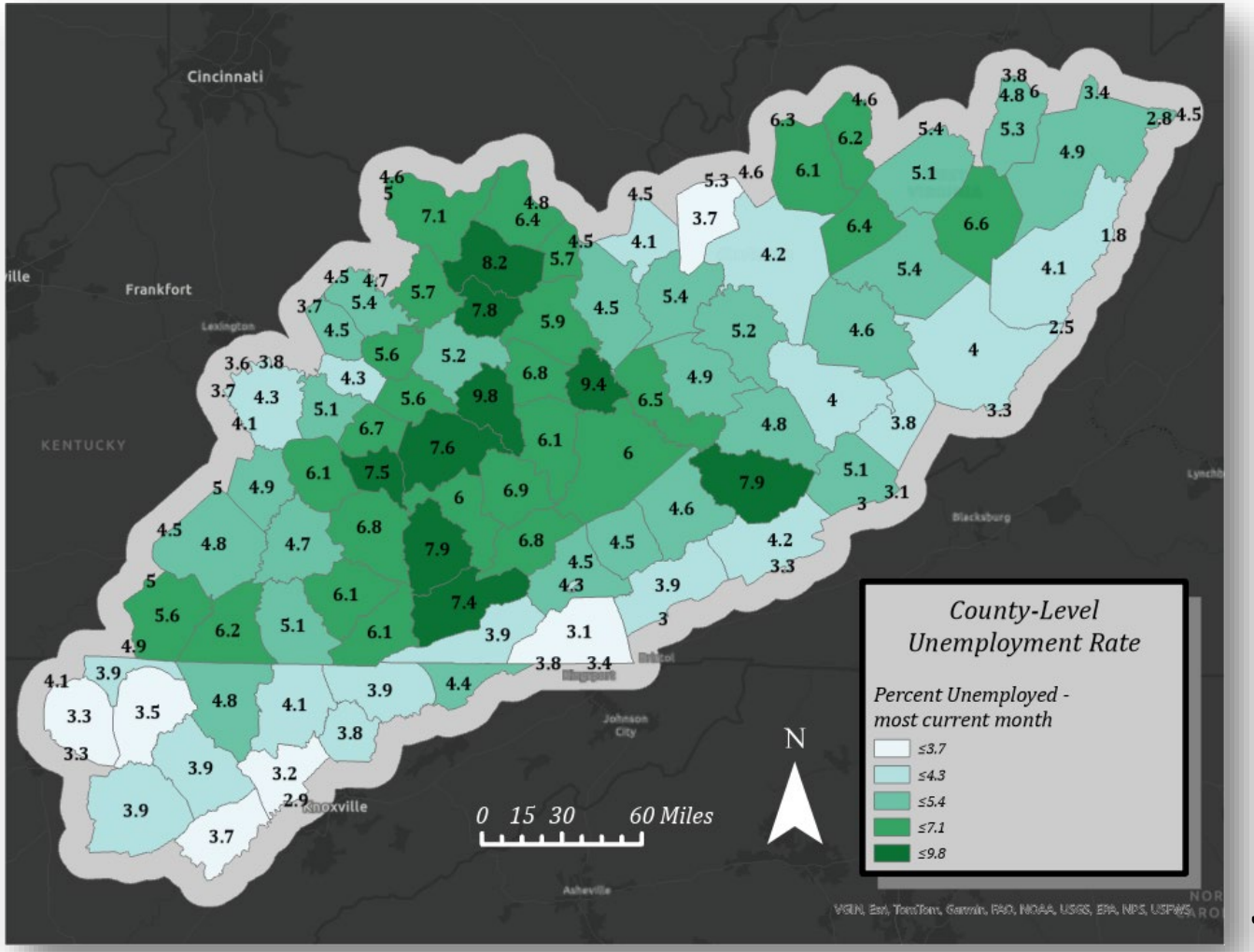
PUBLIC HEALTH CONCERNS IN THE CAPP REGION

- 429.3 Heart Disease MR (Age 35+)
- 32% Greater Mortality Rate
- Extreme High Lung Cancer Incidence
- Opioid Epidemic



Sources: EIA & NETL

ECONOMIC HARDSHIP IN THE CAPP REGION



- 5% Average Unemployment Rate
- Median Income $41,000 (44% less)
- Industrial Production Index?

Sources: BLS, Appalachian Regional Commission

EVOLVE CAPP PRIORITIES & PRINCIPLES

Evolve CAPP Priorities:

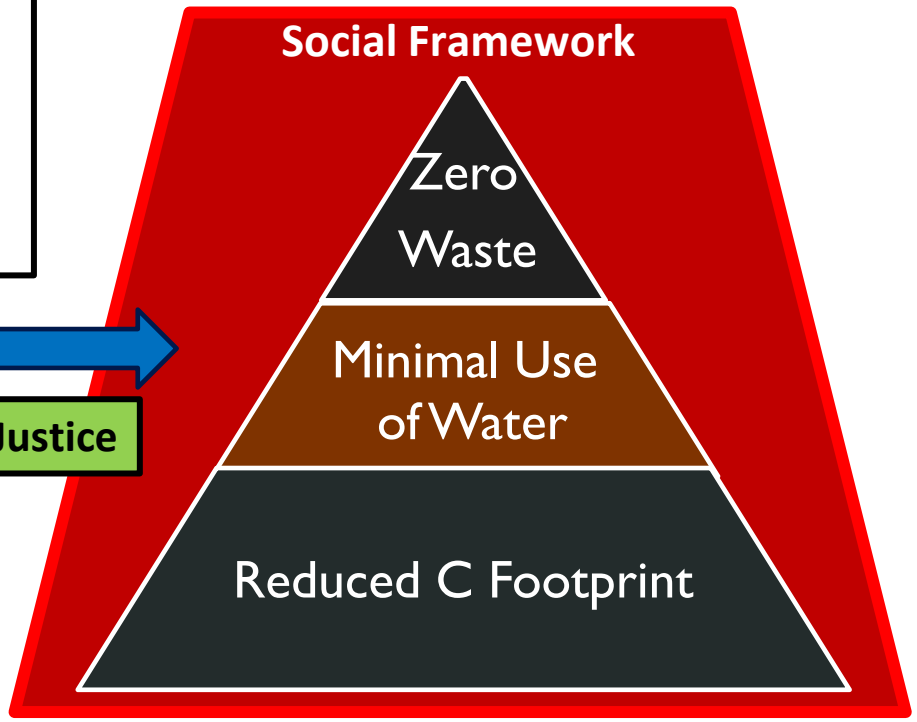
- ✓ Establish a CORE-CM Stakeholder **Community**
- ✓ Develop Vibrant CORE-CM Domestic Industries
- ✓ Supply Green & Digital Economy & Contribute to National Security
- ✓ Avoid Mineral Supply Risk, Potential Interruptions
- ✓ Create Downstream Value-Added Industries & Chains
- ✓ Stimulate Economic Growth in CAPP Region
- ✓ Foster New Job Creation & Upskilling of Local Workforce

Evolve CAPP Principles:

- Develop/Adopt Technologies, Processes & Best Practices that aim for "Zero Impacts" & can earn Social Acceptance
- **Sustainable/Responsible Sourcing**

Equity & Social Justice

Positive Environmental & Social Outcomes



ADDRESSING ISSUES, BARRIERS & INCENTIVES

Issues/Barriers (some are lost in the Technology conversation):

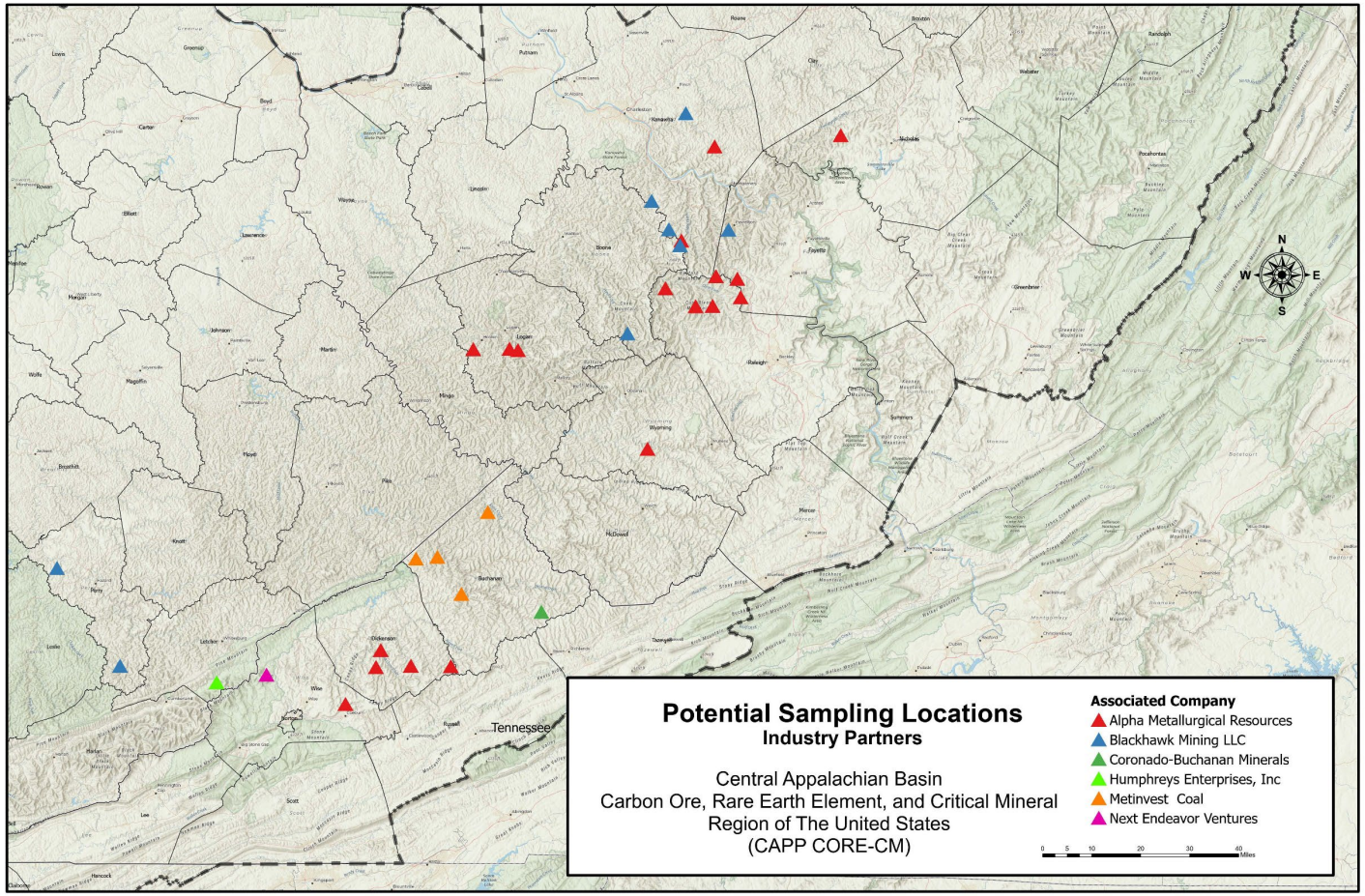
- ✓ Technology is not meeting Responsible Sourcing Standards!
- ✓ Asserting Minerals Titles to both Geologic & Waste Stream resources
- ✓ Waste Steams Regulations & Permitting - Authorities & Regulatory jurisdiction in Collection, Processing & Marketing
- ✓ Companies' reluctance to allow access to reclaimed waste sites for sampling & testing purposes. A significantly robust safety net & financial interest may have to be devised for those owners
- ✓ Is CORE-CM the Primary Production or a Byproduct? - What Happens if Mine/Plant closes?
- ✓ Local Community Expectations
- ✓ Production costs & margins
- ✓ Dependence on Global Pricing, “Dumping” & Arbitrage Issues

Incentives:

- ✓ Experience with Tax Credits, Low Interest Loans, Government-Supported FEED Studies
- ✓ New ideas needed (from Long-Term Government Contracts to Robust Community Benefits)

POTENTIAL SAMPLING LOCATIONS WITH INDUSTRY PARTNERS

- Targeting resource gaps
- Confirming historical sampling
- Leveraging industry partnerships

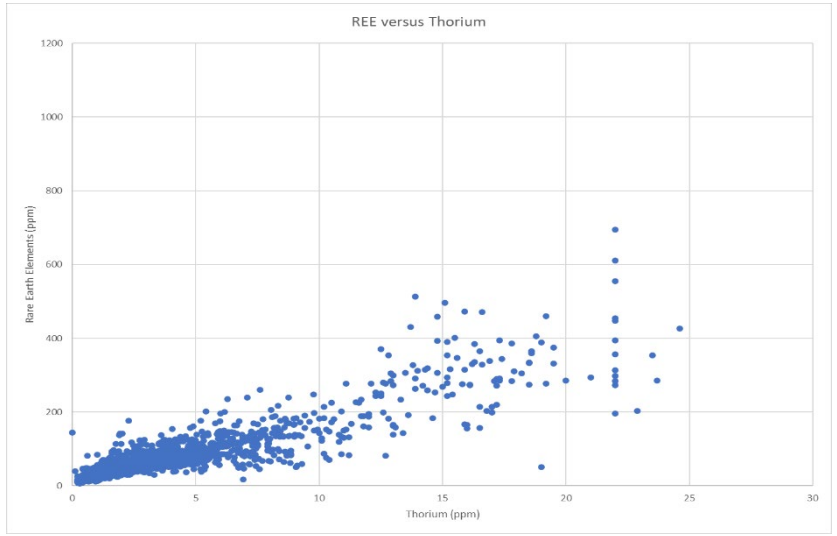


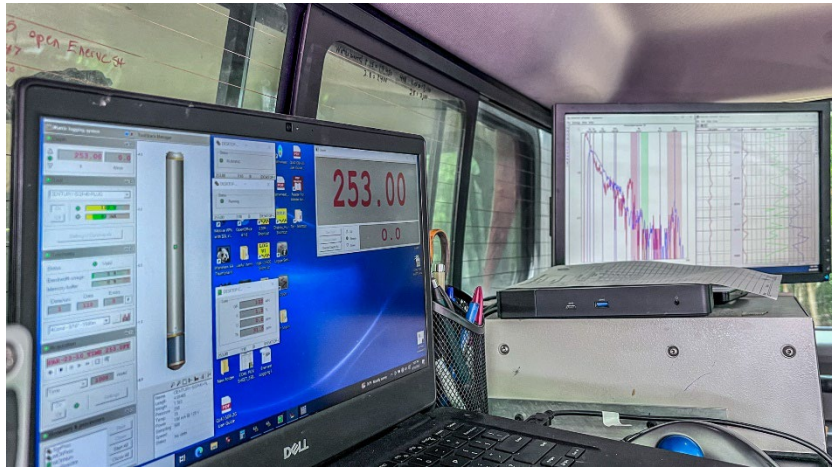
ASSESSMENT OF CORE-CM RESOURCES

- **Sampling:**
  - *CCR sampling commenced* ***September 2022 (25 samples)***
  - *Initial drill core samples* ***September 2022 (19 samples)***
  - *Produced water sampling commenced* ***December 2022 (30 samples)***
  - *Mine sampling commenced* ***July 2023 (30 samples)***
  - *Additional samples collected since* ***August 2023 (>760 samples)***


PRE-SCREENING TOOLS

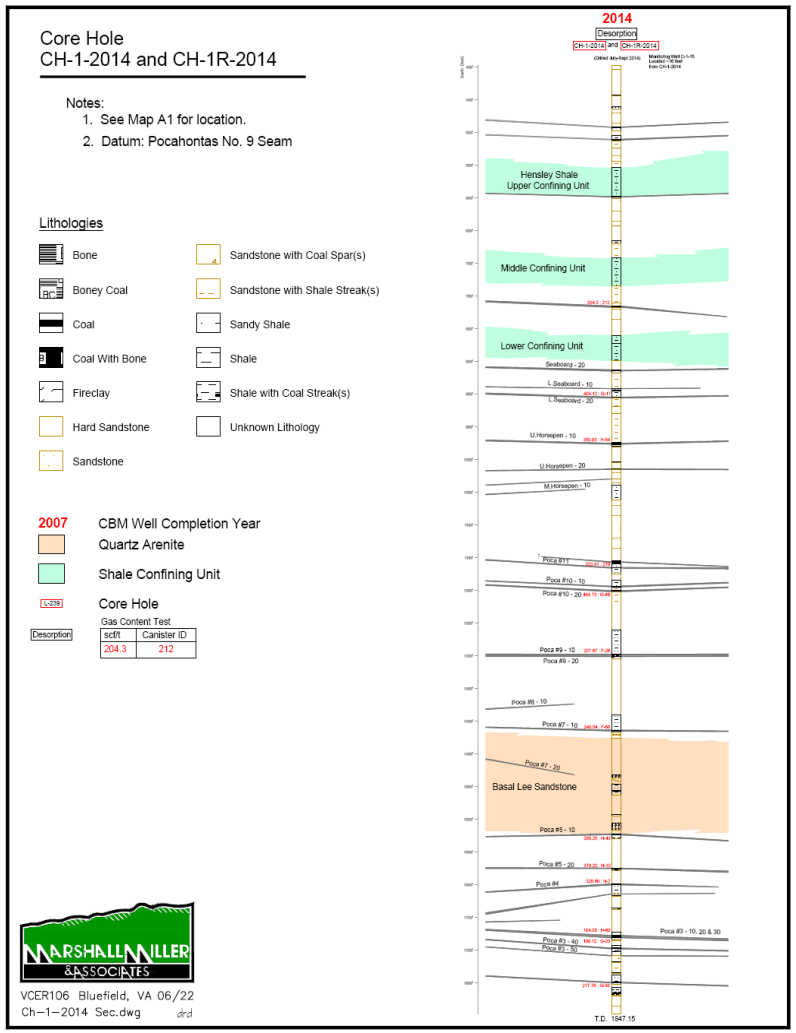
DOWNHOLE SPECTRAL GAMMA

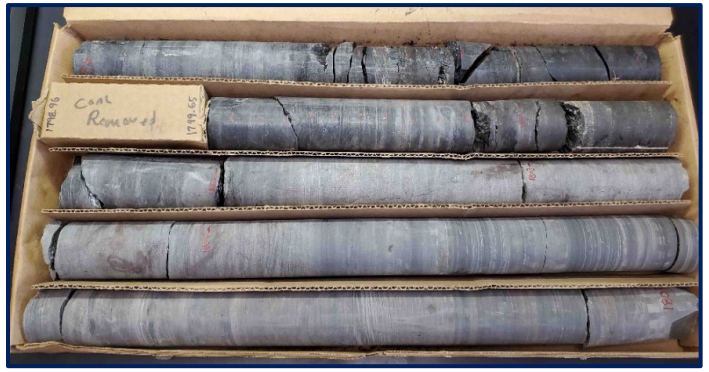




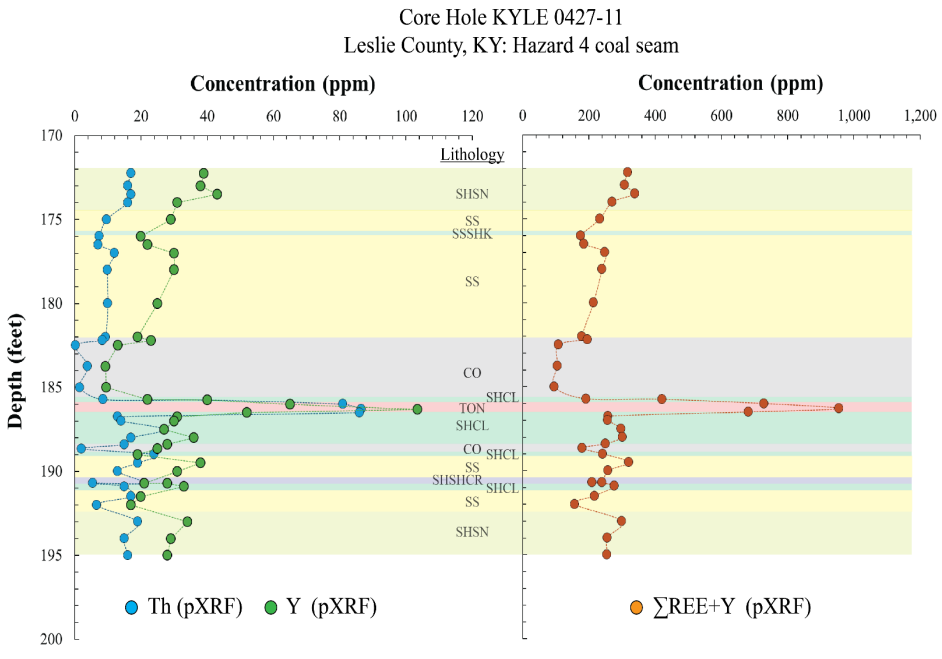
- REEs vs Thorium correlation, detectable w/ Spectral Gamma
- Gamma measured by converting gamma rays to electronic pulses that are measured & counted

P-XRF SCREENING





- Analyzing Core Holes for REE-CMs
- 764 XRF scan results collected
- Comparing to ICP-MS, Spectral Gamma & ~~LIBS~~



KYLE 0427-11, BOX 3: 185.72’ – 195.72’

SHCL (ash-mottled claystone):

pXRF: ∑REE+Y = **421 ppm**

TON (tonstein):

pXRF: Y = 104 ppm, Th = 87 ppm

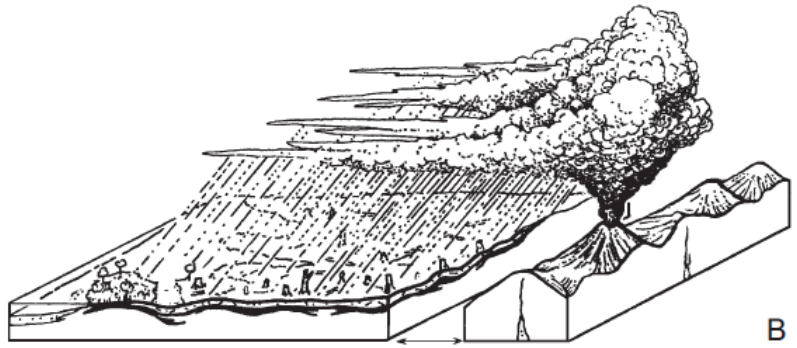
∑REE+Y = **955 ppm**

BUILDING A DEPOSITIONAL MODEL

- Basic model for flint clay deposition in sedimentary depositional environment

A. Peat accumulation in mire subject to clastic influx; will become lower bench of coal seam

B. Volcanic ash deposited; will become flint clay parting



C. Peat accumulates after the ash fall; will become upper bench of coal seam

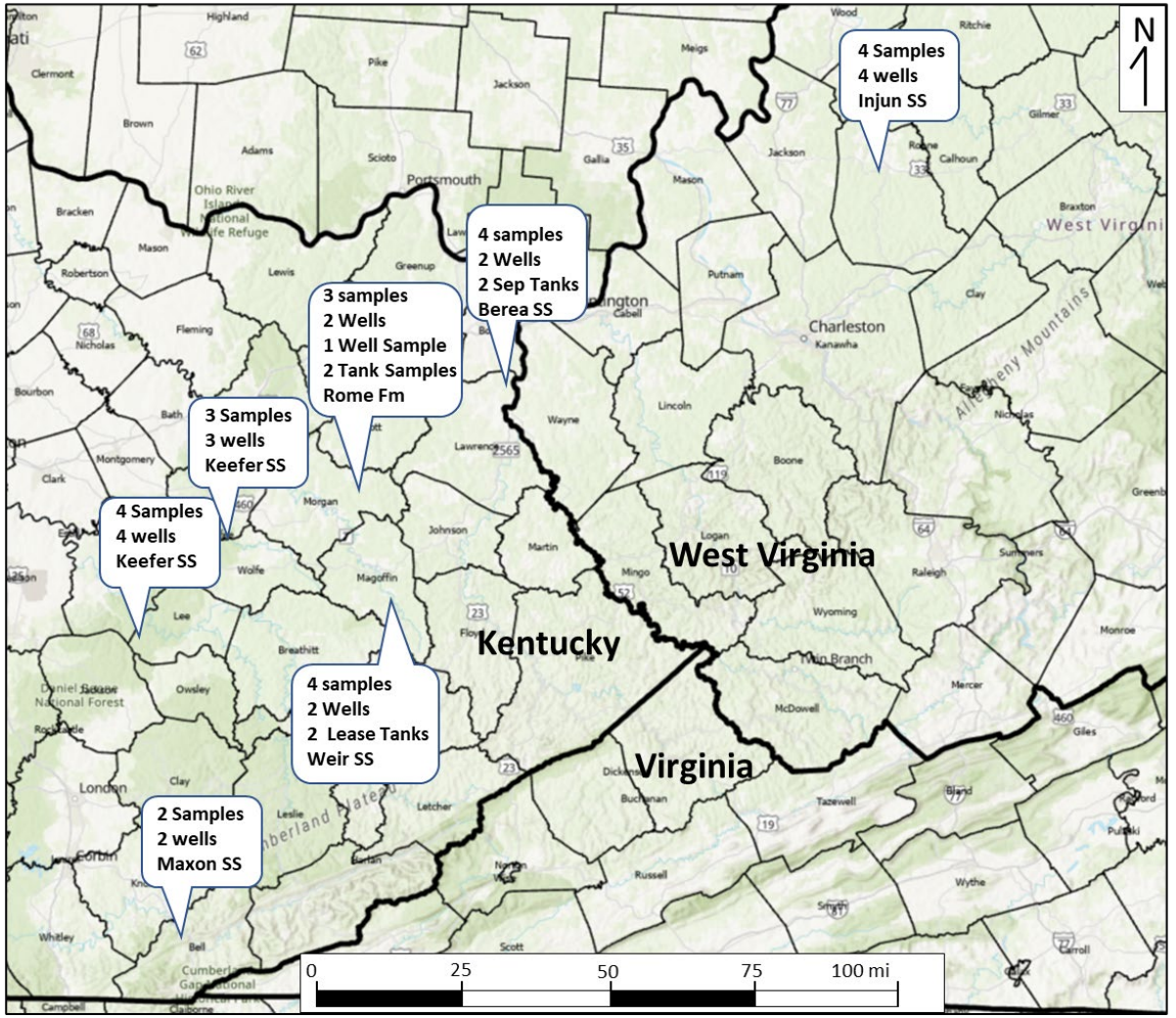
Eble, CF, Hower, JC, and Andrews, WM, 1999, Compositional Variations in the Fire Clay Coal Bed of Eastern Kentucky: Geochemistry, Petrography, Palynology, and Paleoecology, Report of Investigations 14, Series XI, Kentucky Geological Survey, University of Kentucky, Lexington, KY

PRODUCED WATER SAMPLING

Samples taken from 7 counties across the region:

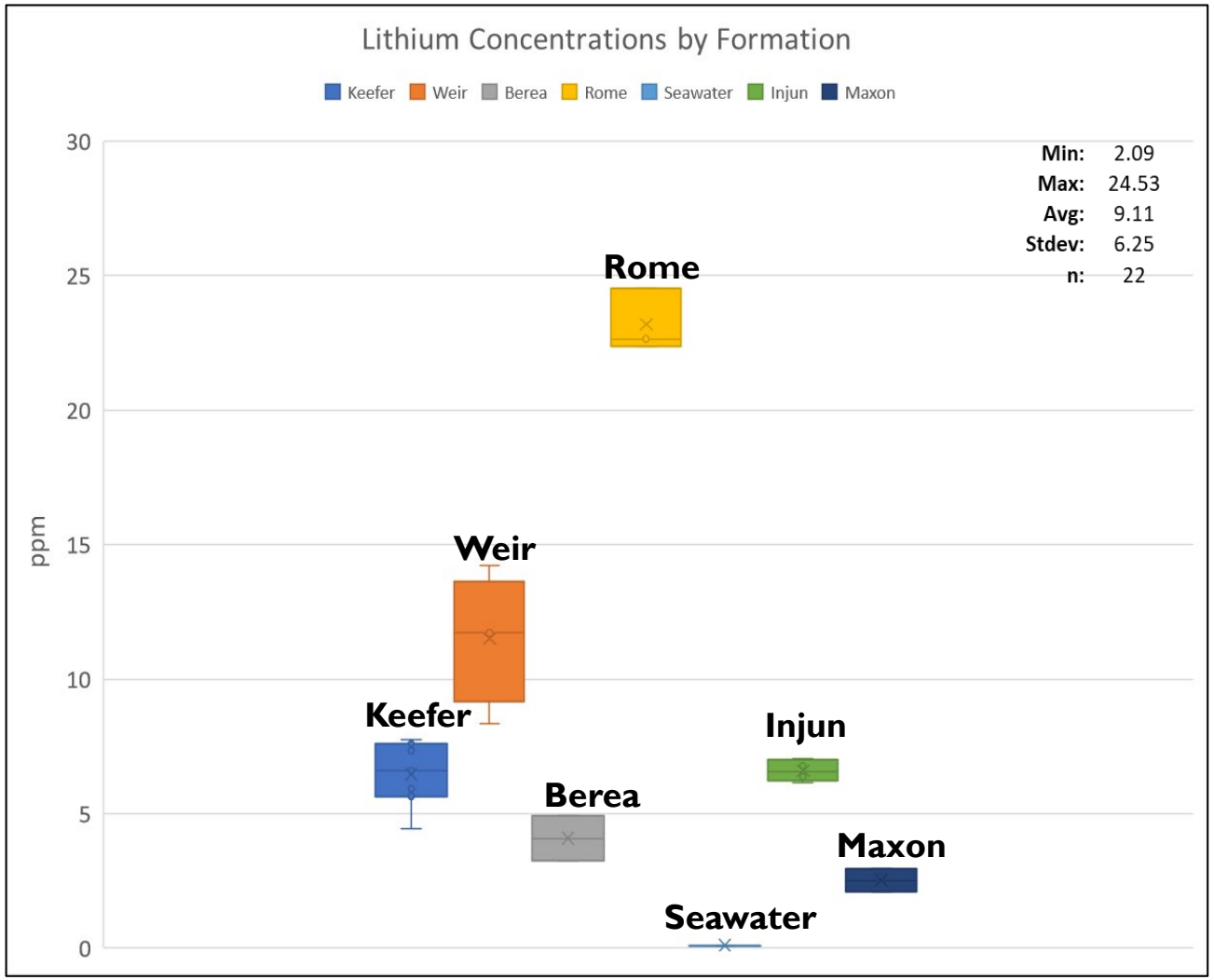
- Lee County, KY
- Wolfe County, KY
- Morgan County, KY
- Magoffin County, KY
- Lawrence County, KY
- Bell County, KY
- Roane County, WV

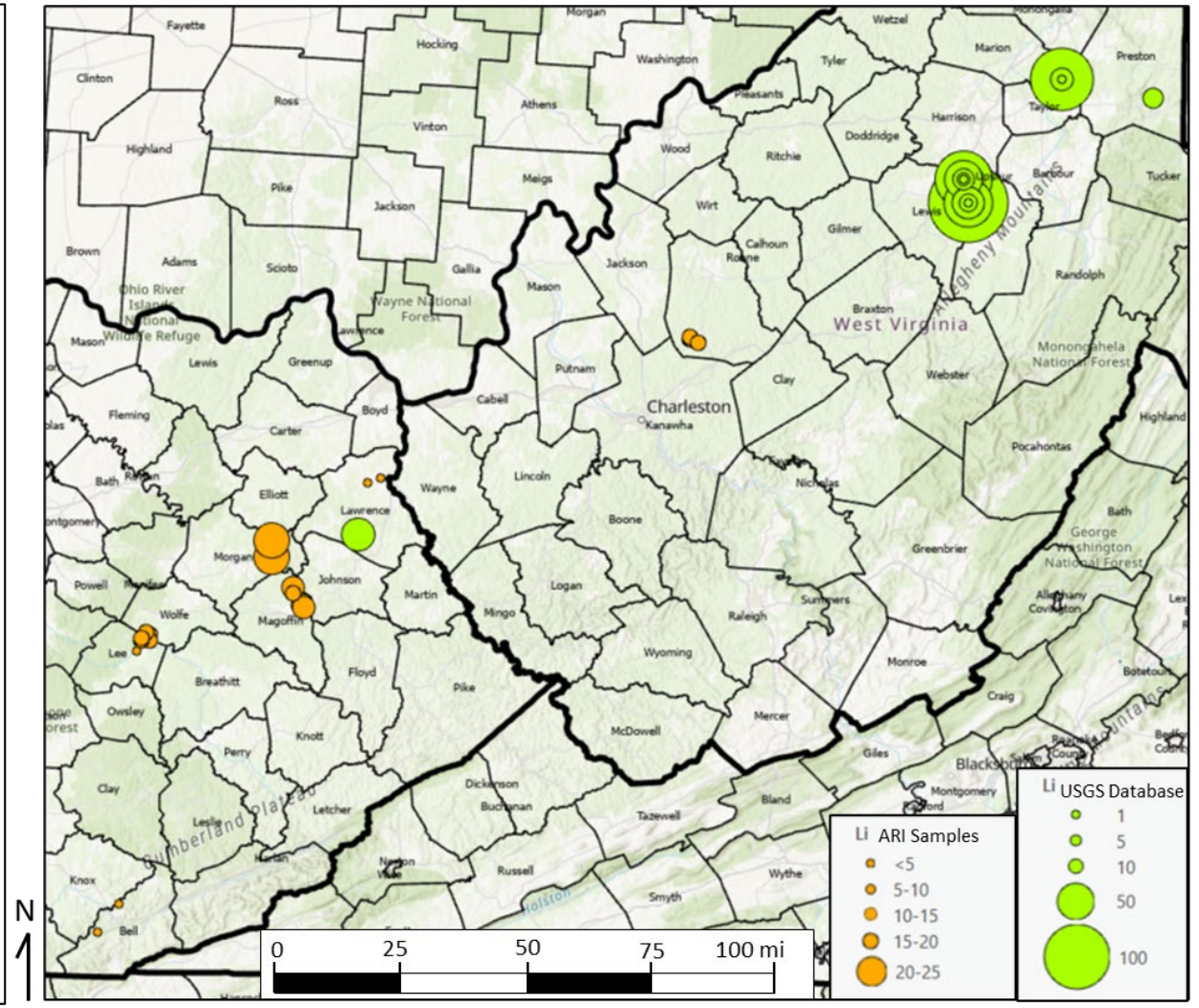
*24 samples were originally taken; however, two Berea samples were too oily to analyze & had to be omitted, bringing total sample count to 22



Advanced Resources International, Inc.

Produced water SAMPLING (Lithium)

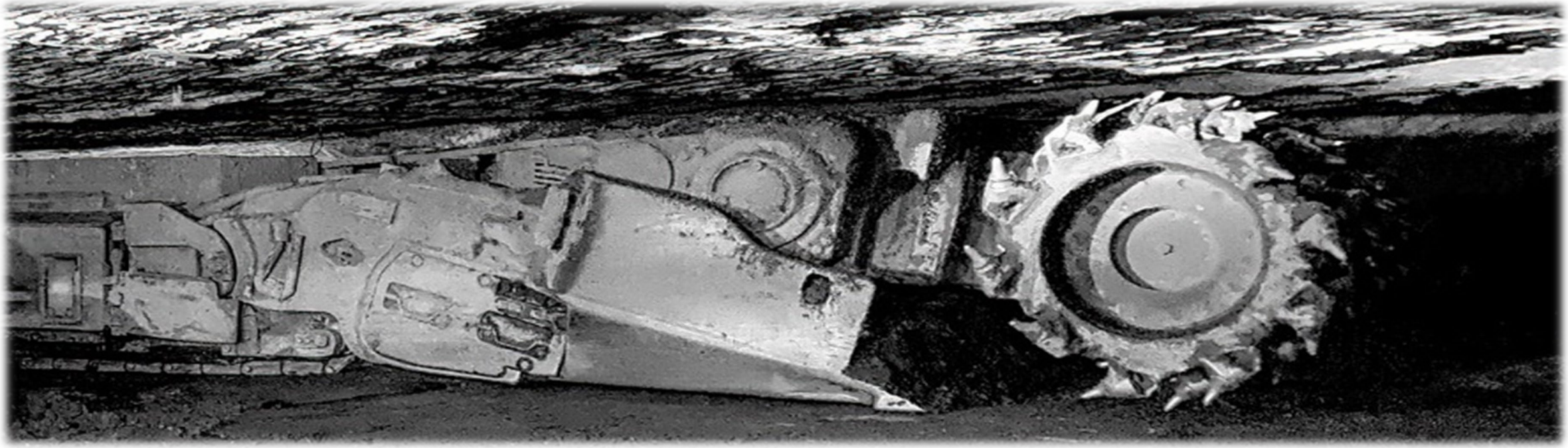




Advanced Resources International, Inc.

TECHNOLOGY ASSESSMENT, DEVELOPMENT & FIELD TESTING

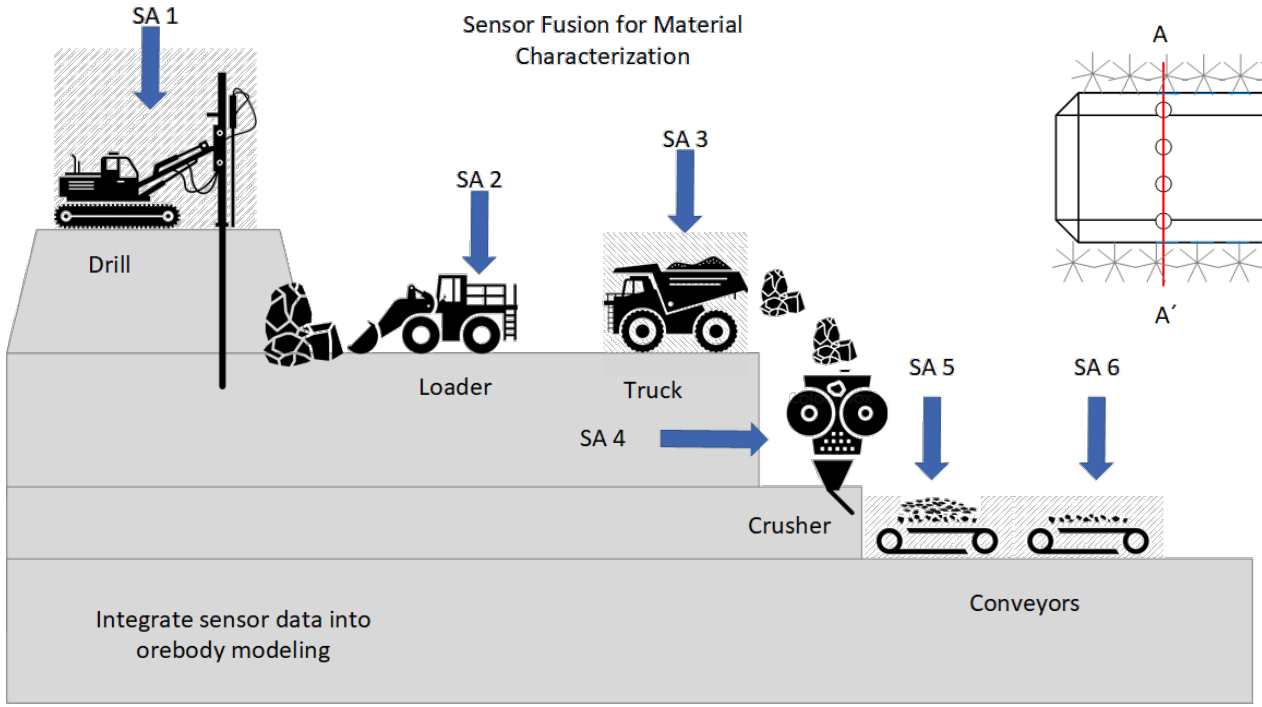
- Mining (primary, co-products, re-mining)
- Separation Processes
- Carbon Products
- Technology Assessment
- Field-Testing
- Gap Analysis

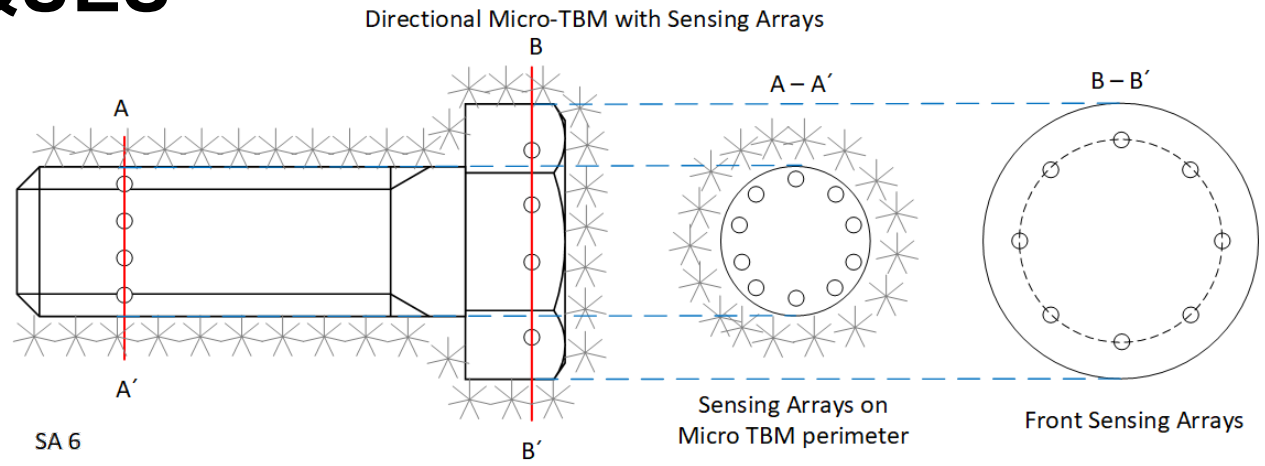


MINING TECHNOLOGY & OPERATIONS

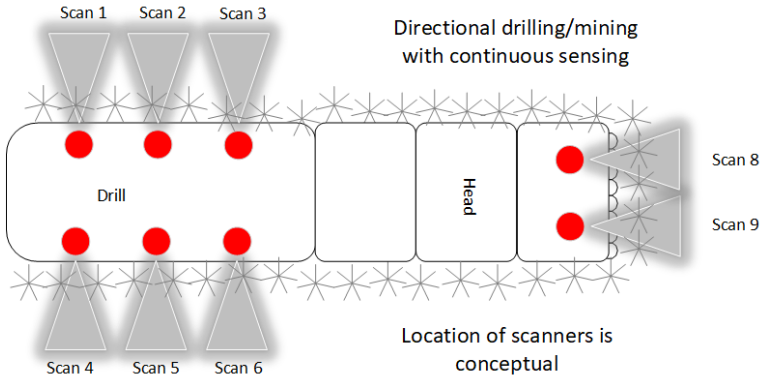
- **Material Handling**
  - Movement of ore from working face to processing operation
- **Surface Operations**
  - Out-of-Seam material placed in storage or replaced to get site back to approx. original contour
  - Material in storage may be available for re-mining operations to recover REE, but volume of material & mixing of material a challenge
  - Selective mining possible for out-of-seam material (flexibility in truck & shovel operations)
- **Underground Operations**
  - Selective material handling & selective mining are a challenge
  - Out-of-seam material is separated in processing plant & stored separately
  - Re-mining options available

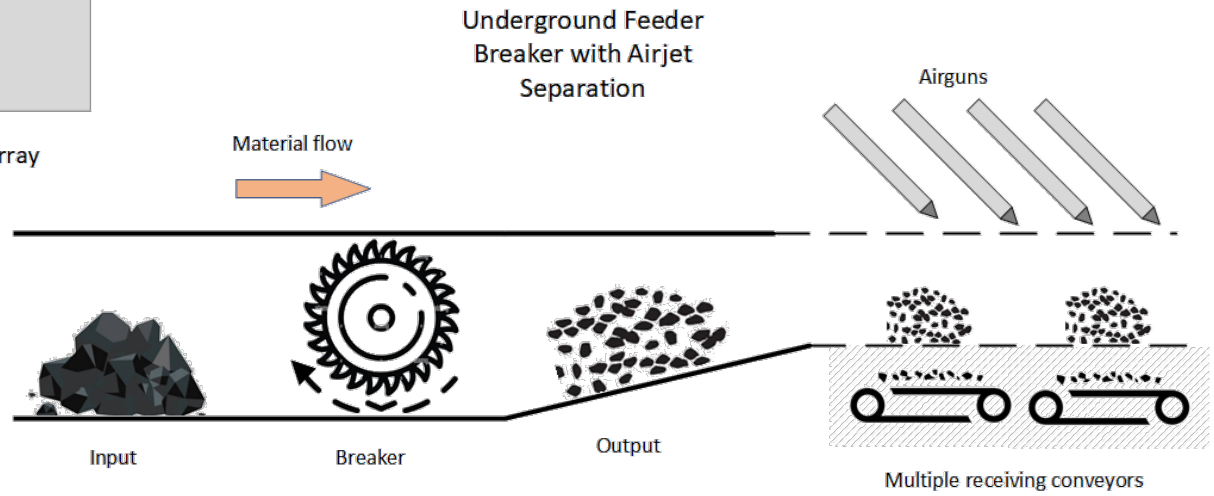
EXAMPLE MINING TECHNIQUES





SA = Sensor Array



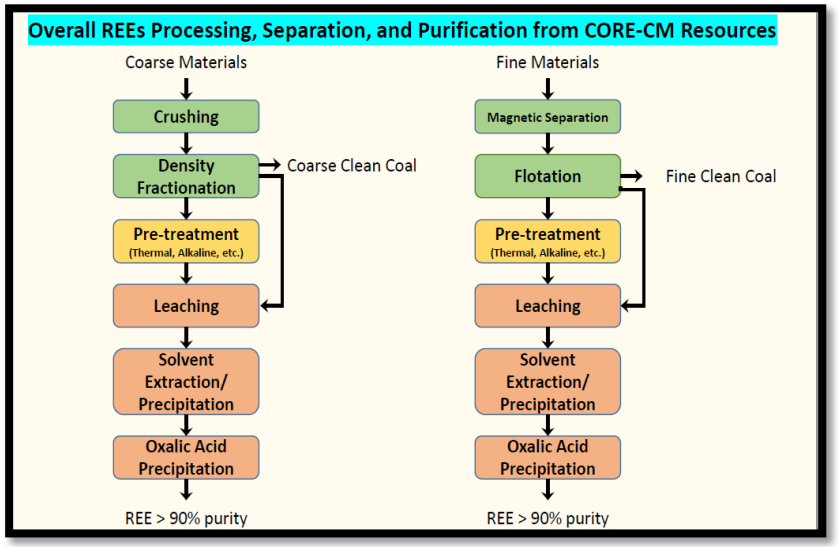


TECHNOLOGY ASSESSMENT – SELECTIVE SORTING

Free et al. (2020)

TECHNOLOGY ASSESSMENT – SEPARATION PROCESSES

- Existing separation technologies being assessed & evaluated for best results under the geologic & waste stream conditions encountered in CAPP basin



Zhang et al. (2020)

Sample	Coal Seam	Pre-Leach Treatment	Leach Conditions	Recovery			Reference
				TREE	LREE	HREE	
Coarse refuse (2.2 SG float, crushed to below 177 µm)	Pocahontas No. 3	None	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	14%	12%	23%	[21]
Coarse refuse (2.2 SG float, crushed to below 177 µm)	Pocahontas No. 3	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	81%	89%	27%	
Middlings (crushed to below 177 µm)	Pocahontas No. 3	None	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	28%	31%	19%	
Middlings (crushed to below 177 µm)	Pocahontas No. 3	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	76%	80%	57%	
Plant feed (2.2 SG sink, crushed to below 177 µm)	West Kentucky No. 13	None	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	24%	21%	36%	[54]
Plant feed (2.2 SG sink, crushed to below 177 µm)	West Kentucky No. 13	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	79%	87%	41%	
Plant feed (2.2 SG sink, crushed to below 177 µm)	Fire Clay	None	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	43%	43%	38%	
Plant feed (2.2 SG sink, crushed to below 177 µm)	Fire Clay	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	62%	68%	33%	
Plant feed (2.2 SG sink, crushed to below 177 µm)	Illinois No. 6	None	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	32%	31%	37%	
Plant feed (1.4 SG float, crushed to below 177 µm)	Illinois No. 6	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	65%	73%	41%	
Plant feed (1.4 SG float, crushed to below 177 µm)	West Kentucky No. 13	None	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	25%	30%	15%	[53]
Plant feed (1.4 SG float, crushed to below 177 µm)	West Kentucky No. 13	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	86%	88%	82%	
Plant feed (1.4 SG float, crushed to below 177 µm)	Fire Clay	None	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	41%	47%	20%	
Plant feed (1.4 SG float, crushed to below 177 µm)	Fire Clay	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (*w*/*v*) solid concentration, 5 h	84%	87%	75%	

OUTREACH INTEGRATED WITH PROJECT MANAGEMENT

Project Management & Planning

- EJ Considerations
- Economic Revitalization & Job Creation Outcomes
- EH&S Analysis

Stakeholder Outreach & Education

Initial Stakeholder Outreach & Education Plan

- Stakeholder Advisory Committee
- Workforce Readiness & Development
- Public Outreach, Education & Engagement

WORKFORCE READINESS & DEVELOPMENT

- Workforce Readiness Plan
- Workshops & Forums
  - ✓ Engage stakeholders/entrepreneurs, public, future workforce personnel
  - ✓ Identify & assess skillsets & employment opportunities
  - Offer programs, certifications & skills training to match needs of projects in basin

Workforce Readiness Plan

Step 1
Assess the Workforce

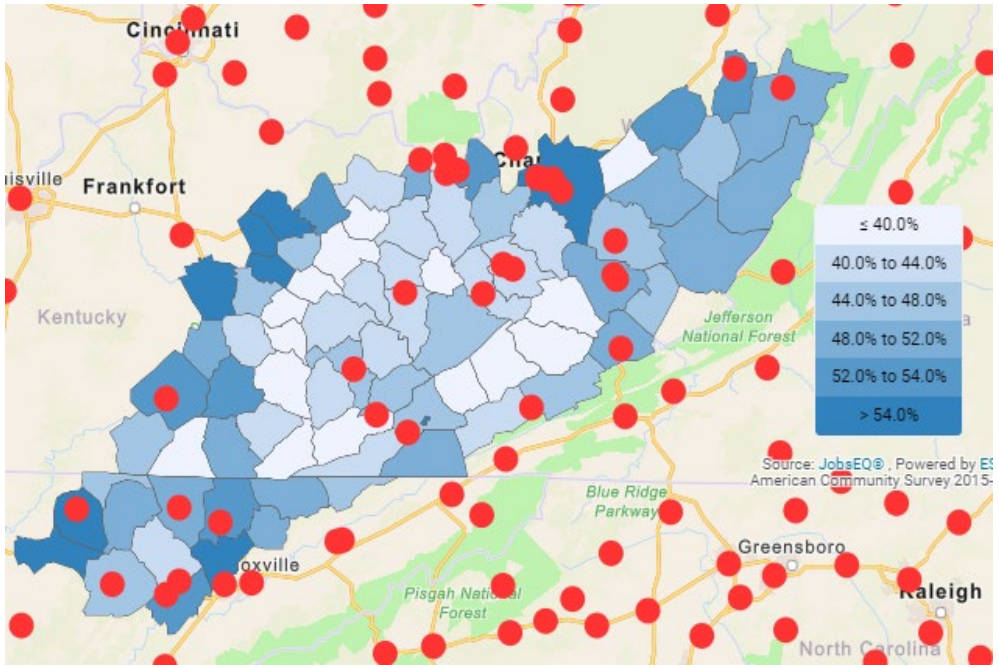
→

Step 2
Identify Supporting Organizations

→

Step 3
Develop the Workforce

Labor Force Participation Rate with locations of Public 2-year or Less Training Facilities



EDUCATION & TRAINING – CAPP REGION

School	Commercial Vehicle	Construction/ Heavy Equp.	Diesel Mech. & Technician	Drafting & Design Tech.	Electrical & Electronic Tech.	Electrical & Electronic Comm.	Electrician	Industrial Mechanics	Information Technologies	Machine Shop Tech.	Welding
Academy of Careers and Technology	x		x	x			x				x
Ashland Community and Technical College	x		x	x			x	x	x	x	
Ben Franklin Career Center		x	x								x
Berea College									x		
Big Sandy Community and Technical College	x		x	x	x		x	x	x	x	x
Bluefield State College						x			x		
BridgeValley Community & Technical College			x	x		x					x
Cabell County Career Technology Center							x			x	x
Carver Career Center							x				
Eastern Kentucky University									x		
Fayette Institute of Technology							x				
Fortis Institute-Cookeville	x										
Fred W Eberle Technical Center	x		x				x				x
Hazard Community and Technical College	x	x	x	x			x		x		x
Marshall University									x		
Mercer County Technical Education Center							x				x
Morehead State University									x		
Mountain Empire Community College						x			x		x
Mountwest Community and Technical College						x				x	x
New River Community and Technical College			x								x
Somerset Community College	x		x		x		x	x	x	x	
Southeast Kentucky Community			x	x	x		x	x		x	x
Southern WV Community and Technical College						x	x				x
Southwest Virginia Community College						x			x		x
TN College of Applied Technology-Crossville	x		x					x			x
TN College of Applied Technology-Harriman			x					x			x
TN College of Applied Technology-Jacksboro							x				x
TN College of Applied Technology-Livingston			x					x			x
TN College of Applied Technology-Oneida-Huntsville											x
University of the Cumberlands									x		
University of Pikeville									x		
West Virginia University Institute of Technology					x				x		

STAKEHOLDER OUTREACH & EDUCATION

- *Open Public Session + Stakeholder Mtg: Abingdon, VA,* ***March 2022***
- *Stakeholder Meeting: Lexington, KY,* ***December 2022***
- *Open Public Session + Stakeholder Mtg: Julian, WV,* ***August 2023***
- *Public Outreach, Education & Engagement:* ***37 presentations to date..***
  - ***MCPA, USEA, SSEB, SME, SME-CAS, SME-FL, SPE, etc.***

EVOLVE CAPP

Evolve Central Appalachia

Scan QR code for more info:

https://energy.vt.edu/research/evolve-capp.html

For more information, please contact:

Richard Bishop
ribishop@vt.edu

APPENDIX

PROJECT TIMELINE

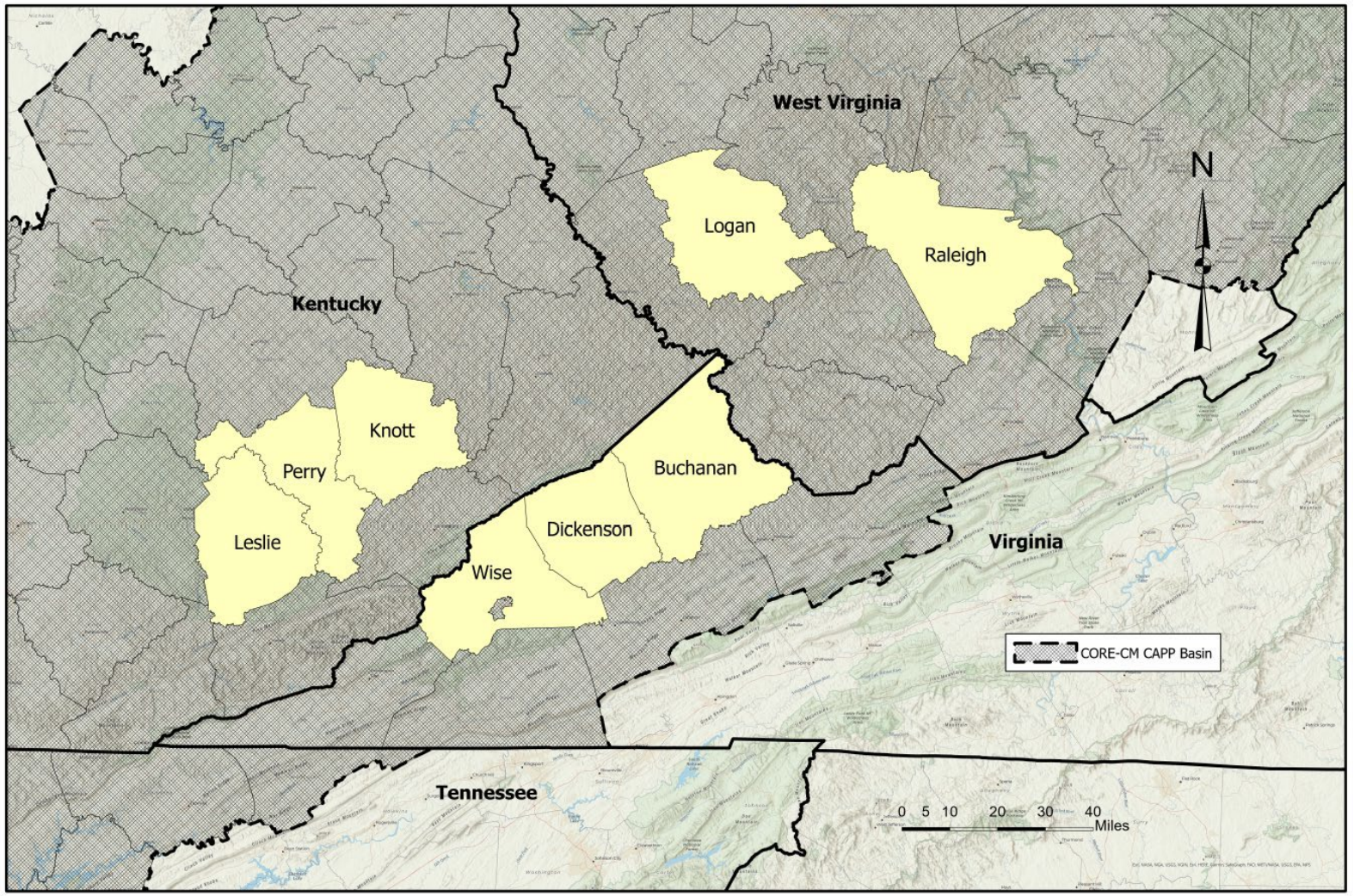
EVOLVE CAPP

Task Number	Task Name	2021			2022												2023												2024			
														Q5			Q6			Q7			Q8			Q9			Q10			
		10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1.0	**Project Management & Planning**	A	B											D												H						I
1.1	Summary of Environmental Justice Considerations																															
1.2	Summary of Economic Revitalization & Job Creation Outcomes																															
1.3	EHS Analysis for Products ... from CORE-CM Resources					C																										
2.0	**Basinal Assessment of CORE-CM Resources**									E																						
2.1	Preliminary Basinal Resource Assessment																															
2.2	Basinal Resource Gap Analysis																															
2.3	Characterization & Data Acquisition Plan																															
3.0	**Basinal Strategies for Reuse of Waste Streams**																															
3.1	Assessment of Mining Refuse & CCR Waste Streams																															
3.2	Assessment of Other Waste Streams																															
3.3	Waste Stream Gap Analysis																															
3.4	Waste Stream Utilization Roadmap																															
4.0	**Basinal Strategies for Infrastructure, Industries & Business**																															
4.1	Regional Infrastructure, Industry & Business Assessment																															
4.2	Strategies to Spur Economic Growth																															
4.3	Infrastructure Needs, Economic Challenges & Supply Chain Gaps																															
5.0	**Technology Assessment, Development & Field Testing**																															
5.1	Technology Assessment - Mining																															
5.2	Technology Assessment - Separation Processes																															
5.3	Technology Assessment - Carbon Products																															
5.4	Technology Assessment & Testing																															
5.5	Technology Gap Analysis & Field Testing																															
6.0	**Technology Innovation Centers (TIC)**																															
6.1	TIC Location																															
6.2	Commercial Acceleration																															
7.0	**Stakeholder Outreach & Education**																															
7.1	Initial Stakeholder Outreach & Education Plan									F																						
7.2	Stakeholders Advisory Committee					G																										
7.3	Workforce Readiness & Development																															
7.4	Public Outreach, Education & Engagement																															

Milestones:

- ✓ (A) Project Kick-off Meeting
- ✓ (B) Project Management Plan
- ✓ (C) EH&S Workshop
- ✓ (D) Interim Report #1
- ✓ (E) Preliminary Sampling Plan
- ✓ (F) Initial Outreach & Education Plan
- ✓ (G) Stakeholder Advisory Committee
- ✓ (H) Interim Report #2
- ❑ (I) Final Report

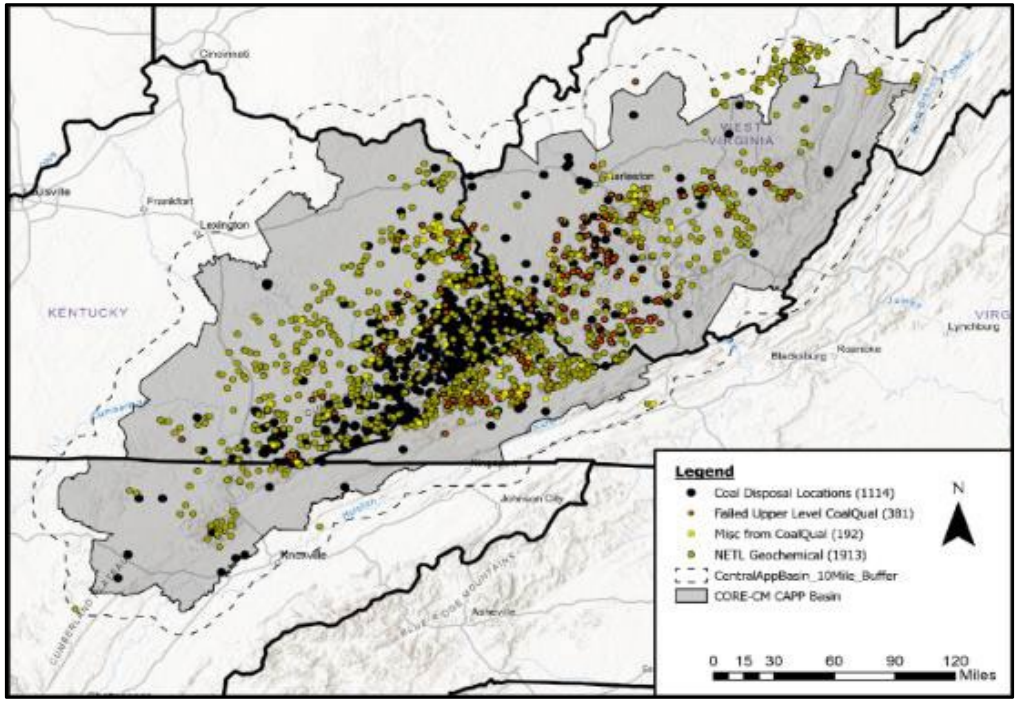
CAPP REGION COUNTIES WHERE SAMPLES WERE COLLECTED



BASINAL STRATEGIES FOR REUSE OF WASTE STREAMS

Assessment of Mine Refuse & CCR Waste Streams

- Identifying “permitted” sites through State & Federal Regulatory Agencies
- Identifying utility-known CCR landfills & impoundments based on EPA & State Solid Waste Database
- Contacting utilities & industry parties to identify CCR volumes, type of material stored & potential for REE-CMs
- Catalogue operational status in resource database



CAPP Basic Infrastructure & Waste Stream Locations

VA-C-1 Box #125: 1797’ – 1807’

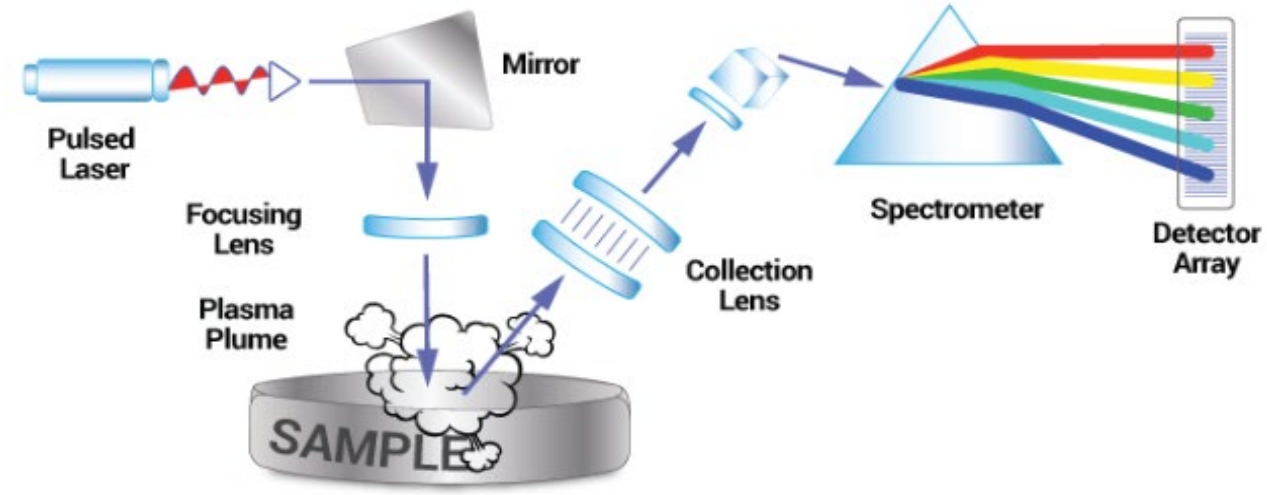
includes P2 coal (Buchanan County, VA)

pXRF: Y = **32 ppm**, Th = **15 ppm**

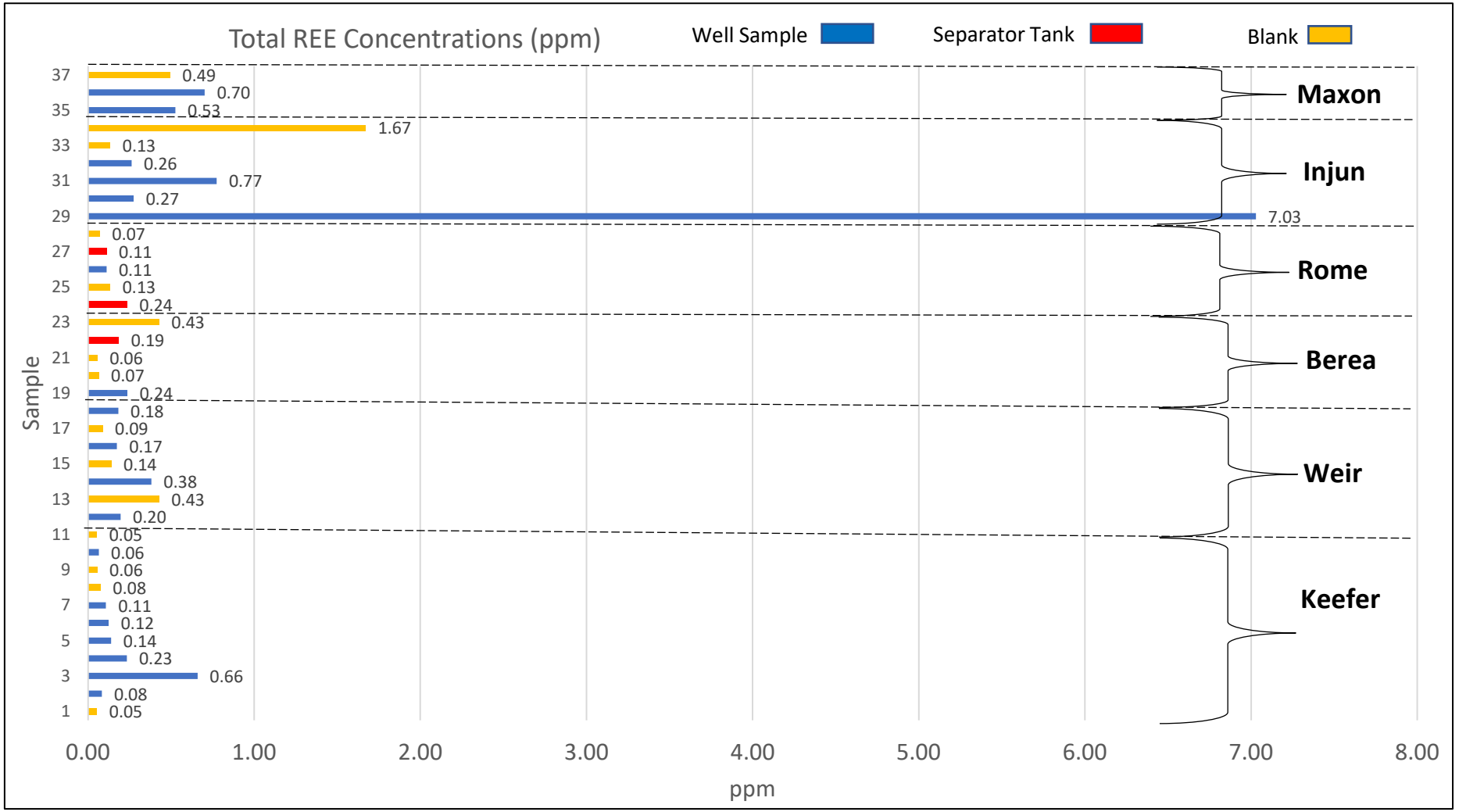
∑REE+Y	**269 ppm**
∑LREE	**215 ppm**
∑ HREE	**23 ppm**

LIBS SCREENING

- **L**aser **I**nduced **B**reakdown **S**pectroscopy
- Used >30 years as a lab technique capable of analyzing any element in periodic table, now available handheld
- Pulsed laser fired at sample creates a plasma
- Plasma cools, atoms combine with electrons & emit UV, Optical & IR light compared with known wavelengths



PRODUCED WATER SAMPLING (REE)



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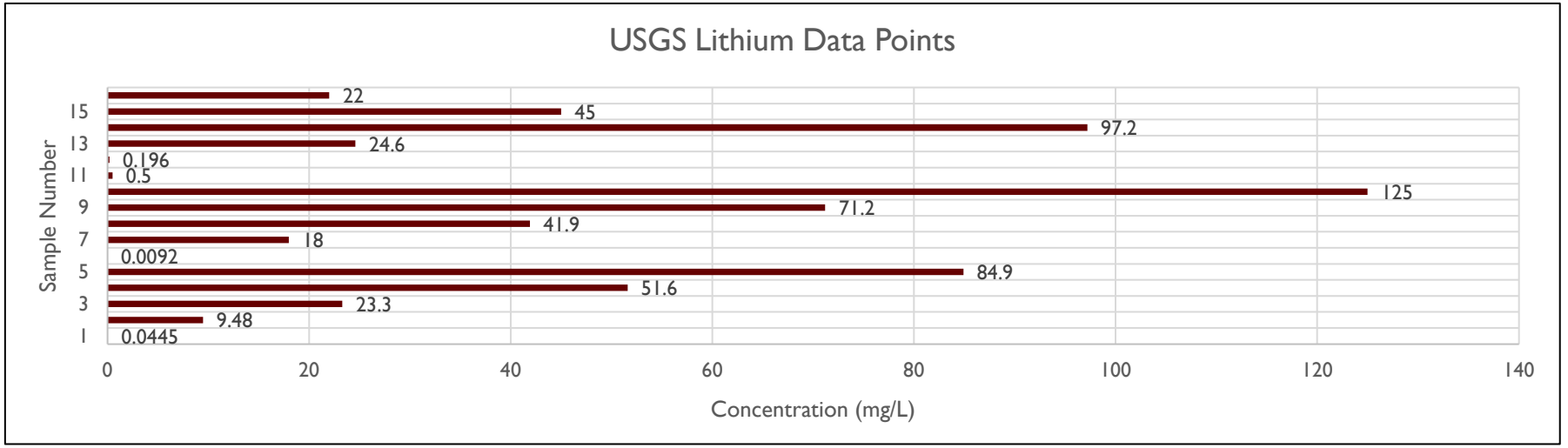
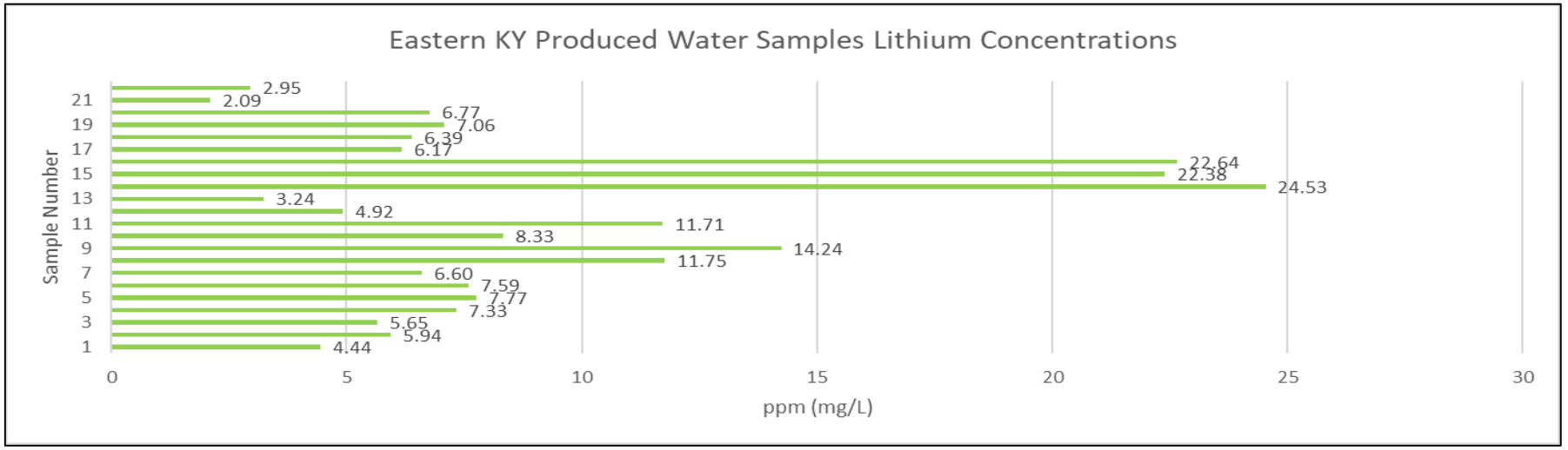
LITHIUM COMPARISON WITH USGS DATASET



n:	16
Min:	0.0092
Max:	125
Average:	38.43
Std Dev:	37.25



n:	22
Min:	2.09
Max:	24.53
Average:	9.11
St Dev:	6.25

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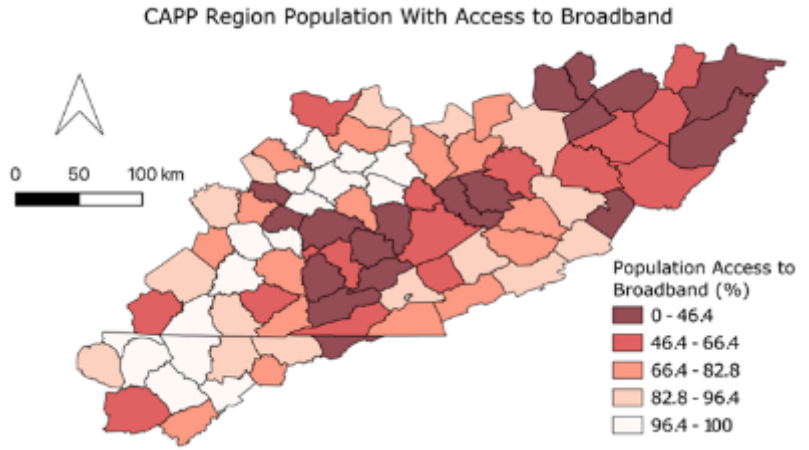
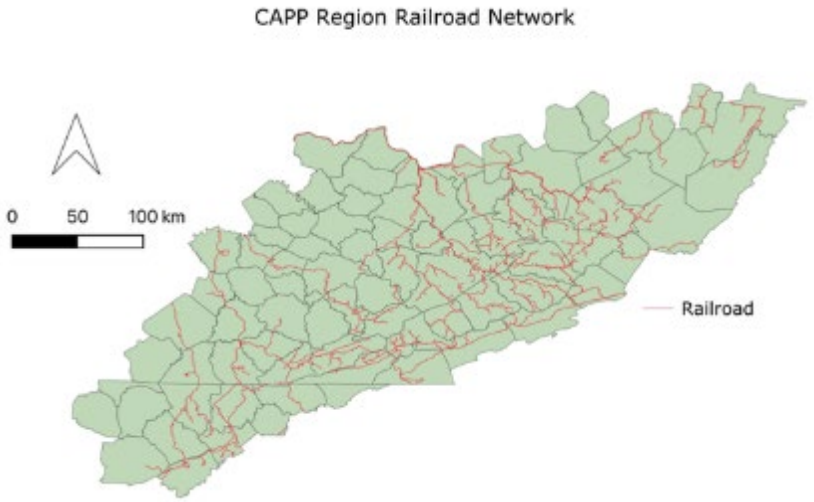
INITIAL INFRASTRUCTURE ASSESSMENT

Screening for various metrics, including:

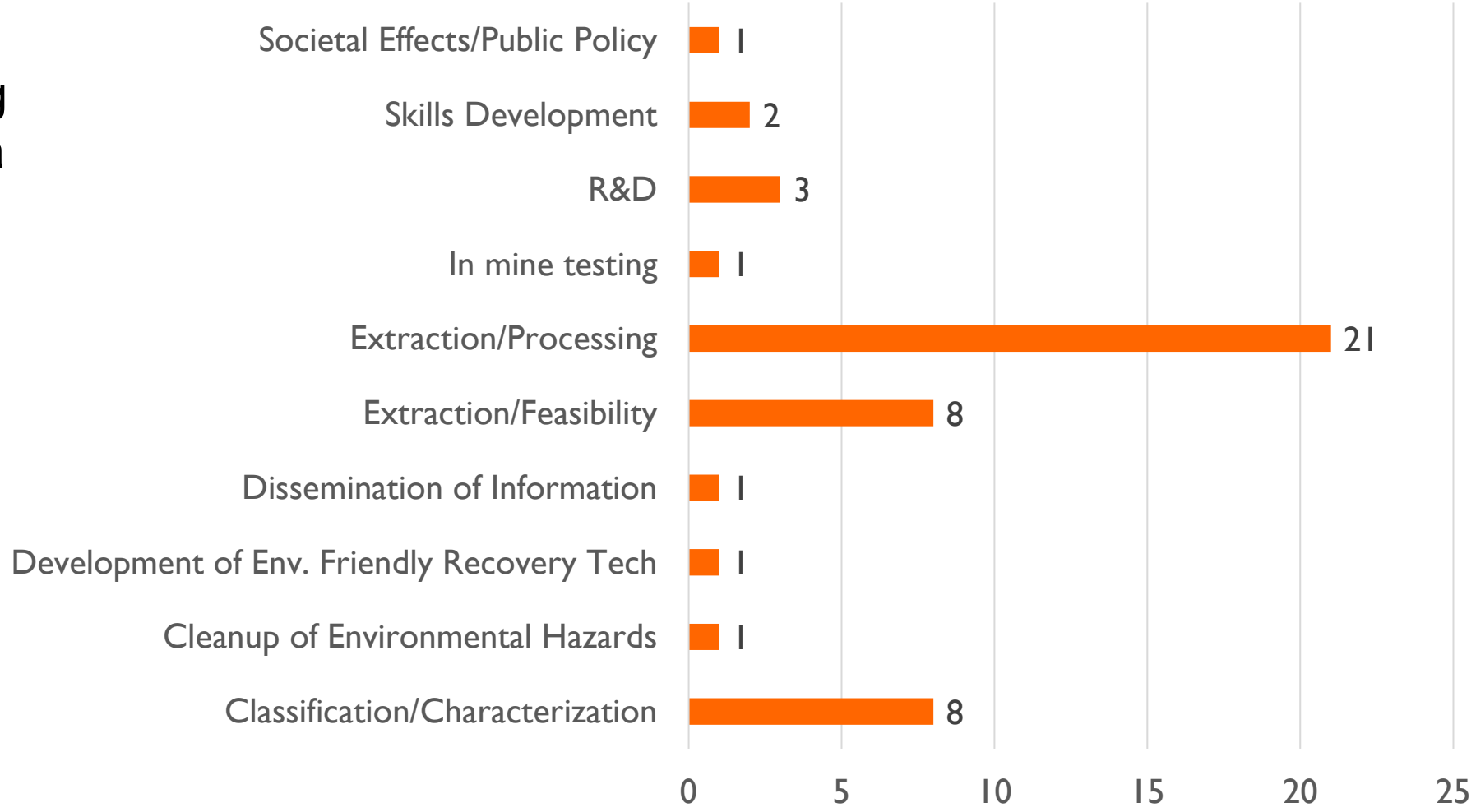
- Cheapest source of electricity
- Primary & secondary roads
- Power generation
- Railroad networks
- Commercially navigable waterways
- Fly ash pond locations
- Population with access to broadband
- Educational opportunities



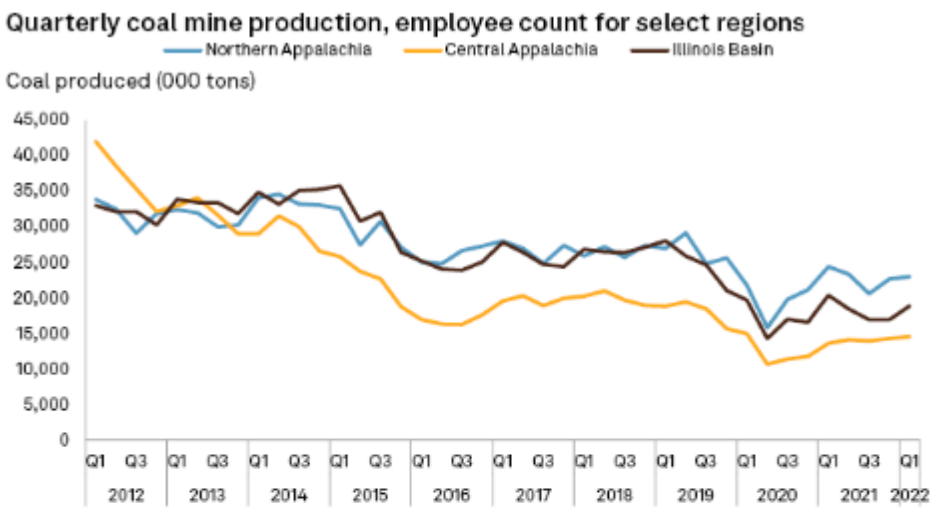


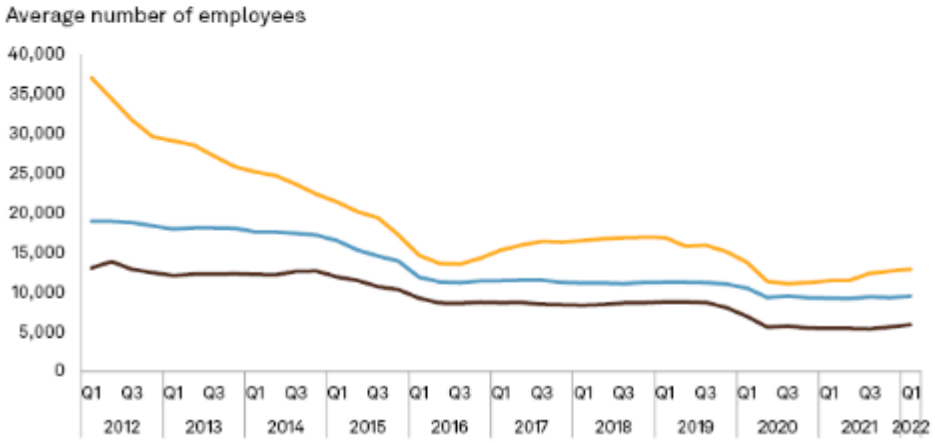
TECHNOLOGY INNOVATION CENTER - QUESTIONNAIRE

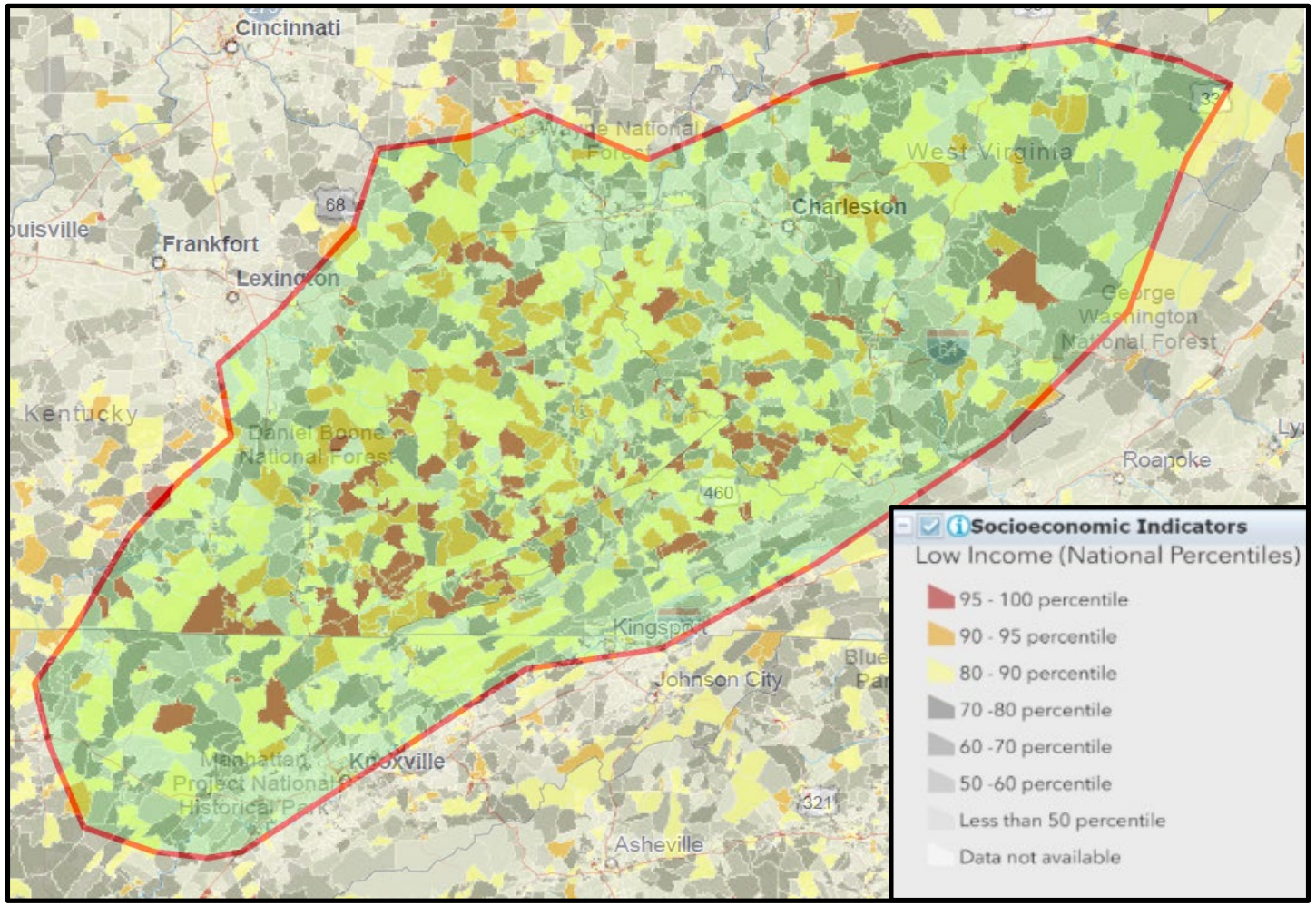
Surveyed various stakeholders regarding location & function of a Technology Innovation Center (TIC) for a new CORE-CM industry..



CAPP EMPLOYMENT TRENDS & SOCIOECONOMIC INDICATORS







Source: S&P Global Market Intelligence (May 2022)

IMPORTANT OPPORTUNITIES IN THE REE INDUSTRY

- Existing conditions in global market & region support establishment / growth of REE industries
- U.S. Government support is essential
- Targeted incentives:
  - Production tax credits
  - Research & development funding
  - Export restrictions or tariffs