Energy & Environmental Research Center (EERC)

Williston Basin CORE-CM Initiative

DE-FE0032060

John P. Kay
Energy & Environmental Research Center

U.S. Department of Energy
National Technology Laboratory
Resource Sustainability Project Review Meeting
October 25 – 27, 2022

Project Overview

- DOE – $1,500,000
- North Dakota Industrial Commission Lignite Research Program – $750,000
- North American Coal Corporation – $75,000
- BNI Energy – $75,000
- Minnkota Power Cooperative – $25,000
- Basin Electric Power Cooperative – $25,000
- Current Chemicals - $50,000 (in-kind)
- Total – $2,500,000

- Period of Performance: October 2021 – May 2023 (20 months)

CORE-CM WILLISTON BASIN

Program Support

EERC UND UNIVERSITY OF NORTH DAKOTA

Project Partners

U.S. Department of Energy
North Dakota Industrial Commission
Lignite Research Program

Lead Organization

EERC

Principal Investigator

John Kay

Project Advisors

EERC Leadership Team
D. Laudal, UND IES

Core Team

UND IES; Pacific Northwest National Laboratory; UND Nistler College; North Dakota State University; Montana Tech; Critical Materials Institute

Industry, Governmental, and Research Resources

Williston Basin CORE-CM Initiative Members

U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

BNI energy
AN ALLETE COMPANY

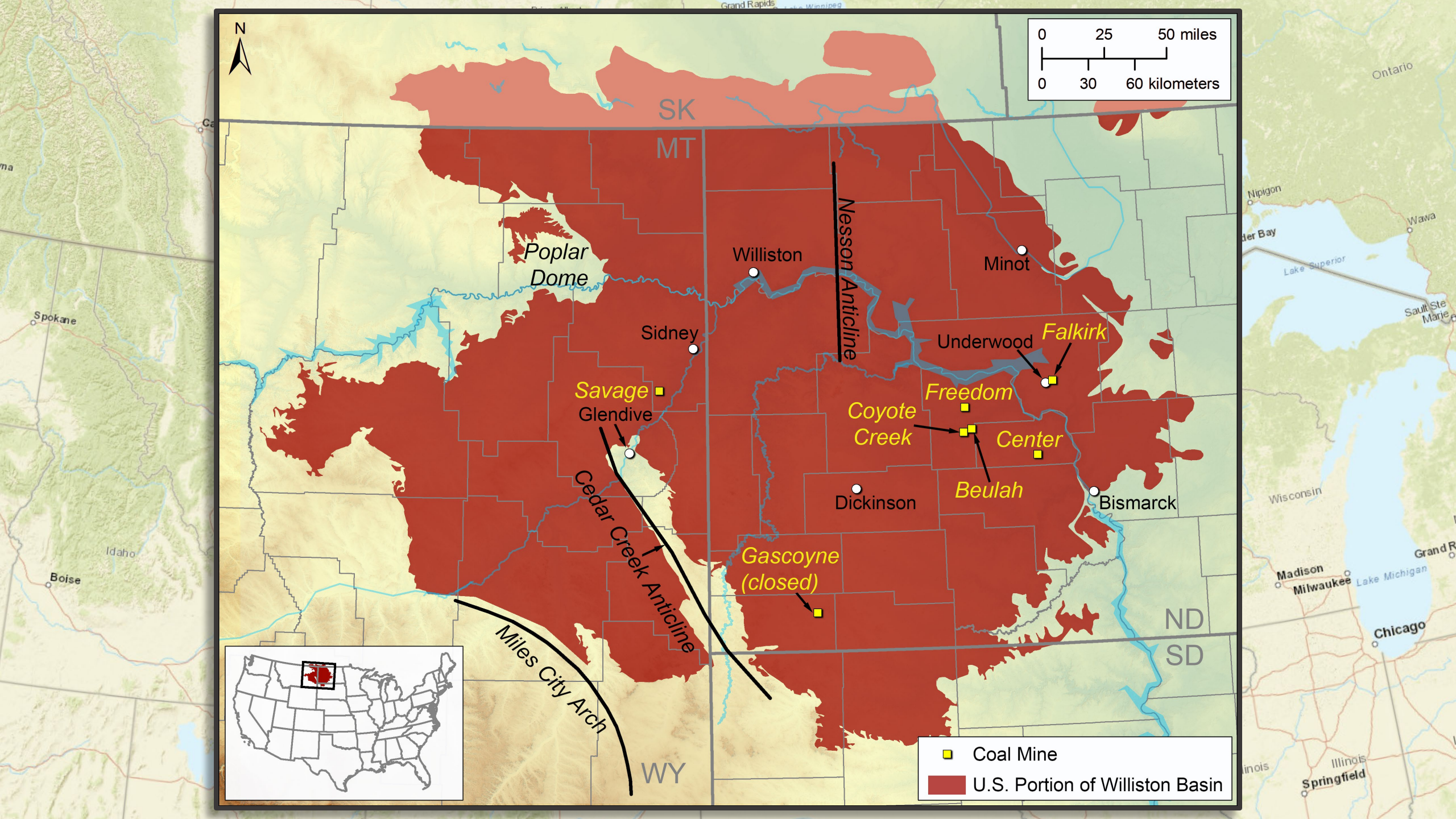
Current Chemicals

Minnkota Power COOPERATIVE
A Touchstone Energy® Cooperative

NORTH AMERICAN COAL CORPORATION

Objectives

Building partnerships; assessing resources, markets, and infrastructure; identifying data gaps; and establishing potential technology and business development pathways.


N
0 25 50 miles
0 30 60 kilometers
SK
MT
ND
SD
WY
Poplar Dome
Williston
Nesson Anticline
Minot
Sidney
Underwood
Falkirk
Savage
Glendive
Freedom
Coyote Creek
Center
Beulah
Dickinson
Bismarck
Gascoyne (closed)
Cedar Creek Anticline
Miles City Arch
Coal Mine
U.S. Portion of Williston Basin

IDENTIFY, CHARACTERIZE, AND ASSESS

Assessment of Resources

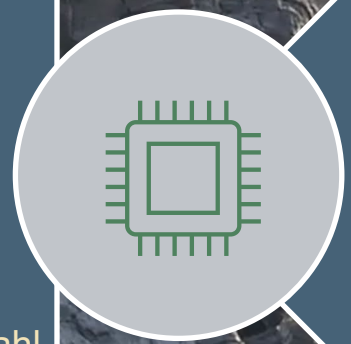
Task Lead: Todd Brasel

Strategies for Infrastructure, Industries, and Business

Task Lead: Jason Laumb

Strategies for Waste Stream Reuse

Task Lead: Bruce Folkedahl



Technology Innovation Centers

Task Lead: Bruce Folkedahl

Technology Assessment, Development, and Field Testing

Task Lead: Nolan Theaker

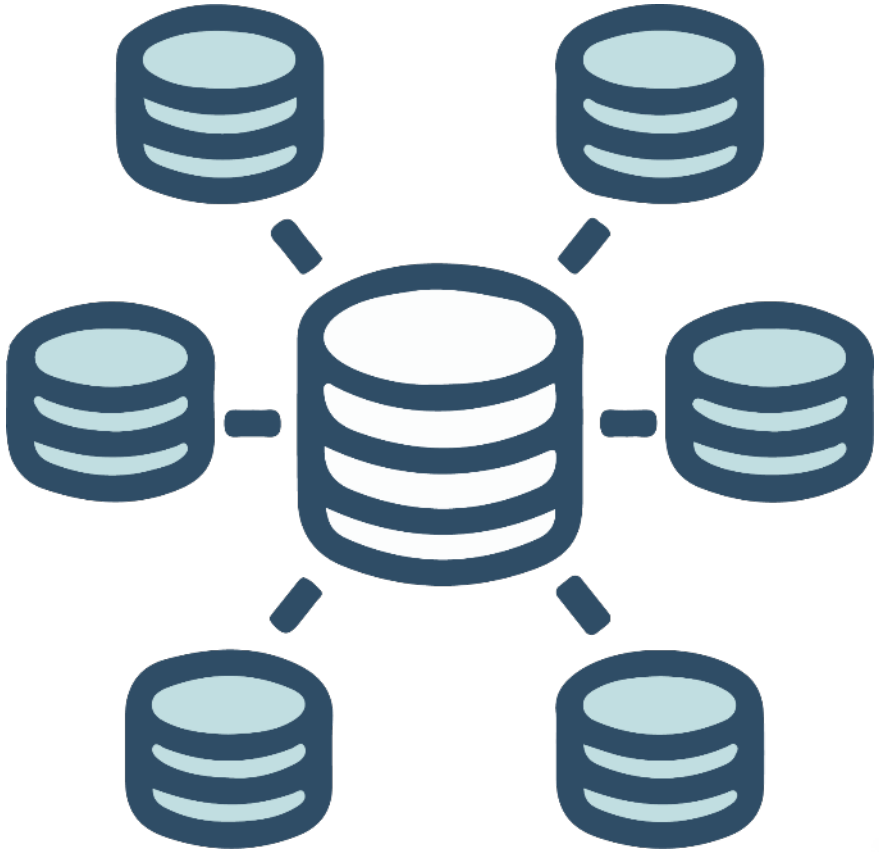
Stakeholder Education and Outreach

Task Lead: Charlene Crocker

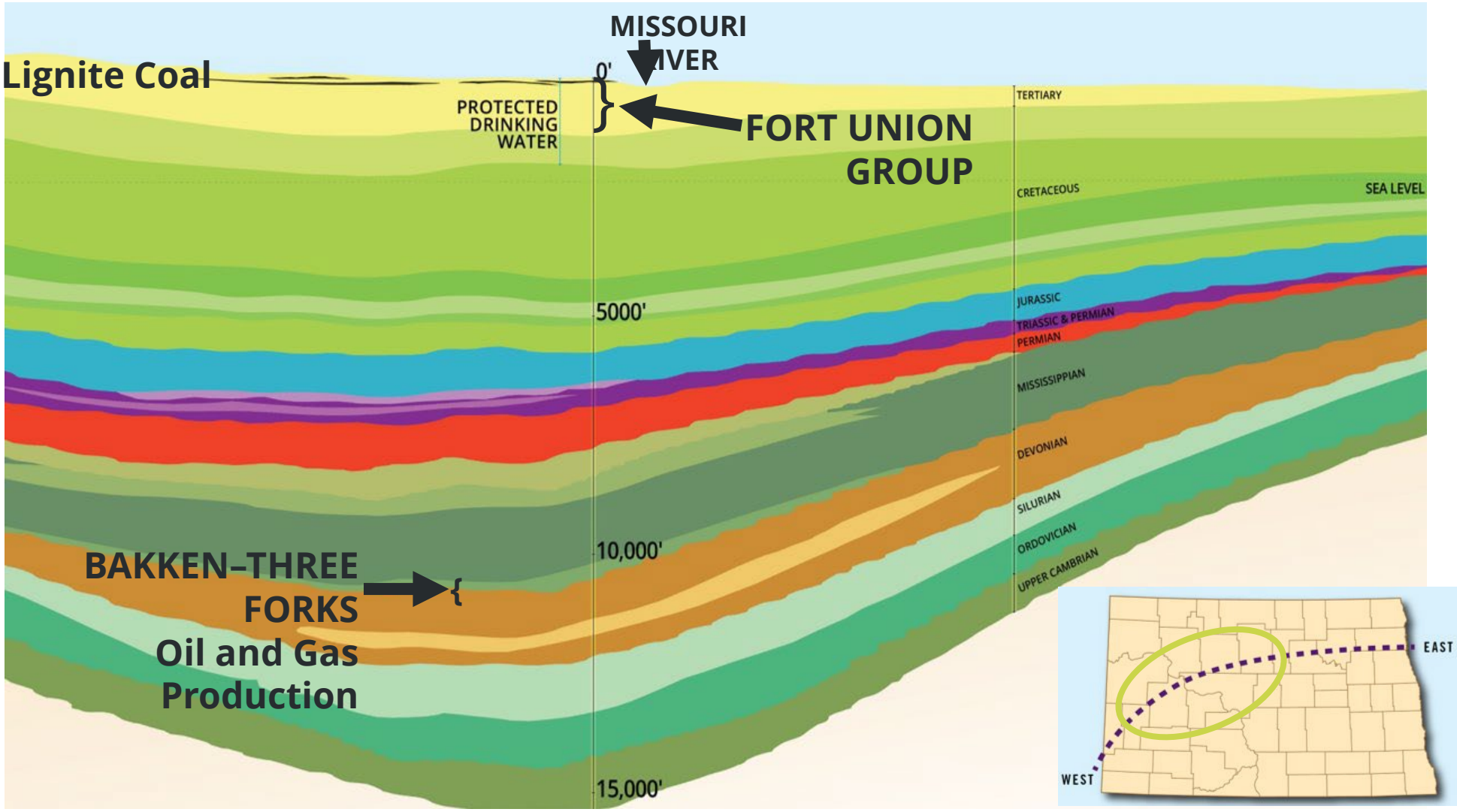
Lignite Coal and Waste Streams

Data Sources: Critical Mineral Concentrations in Williston Basin Coals

- North Dakota Geologic Survey (NDGS)
  - Bulk of the data and most recent data
- Energy & Environmental Research Center (EERC)
- UND Institute for Energy Studies (IES)
- COALQUAL Database (USGS)
  - Whole seam mixing
  - Older lab technology

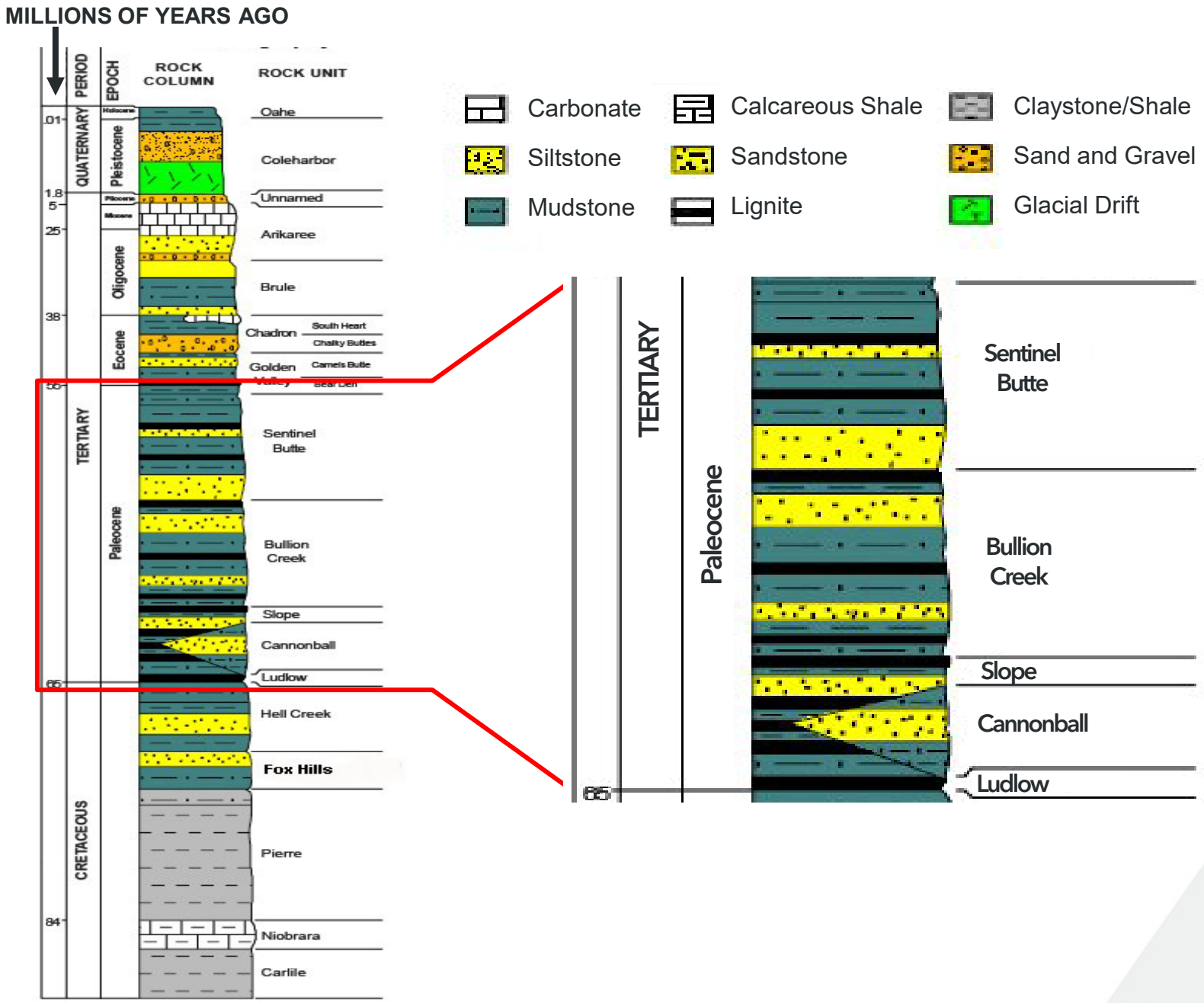


North Dakota Williston Basin Cross Section



North Dakota Stratigraphy

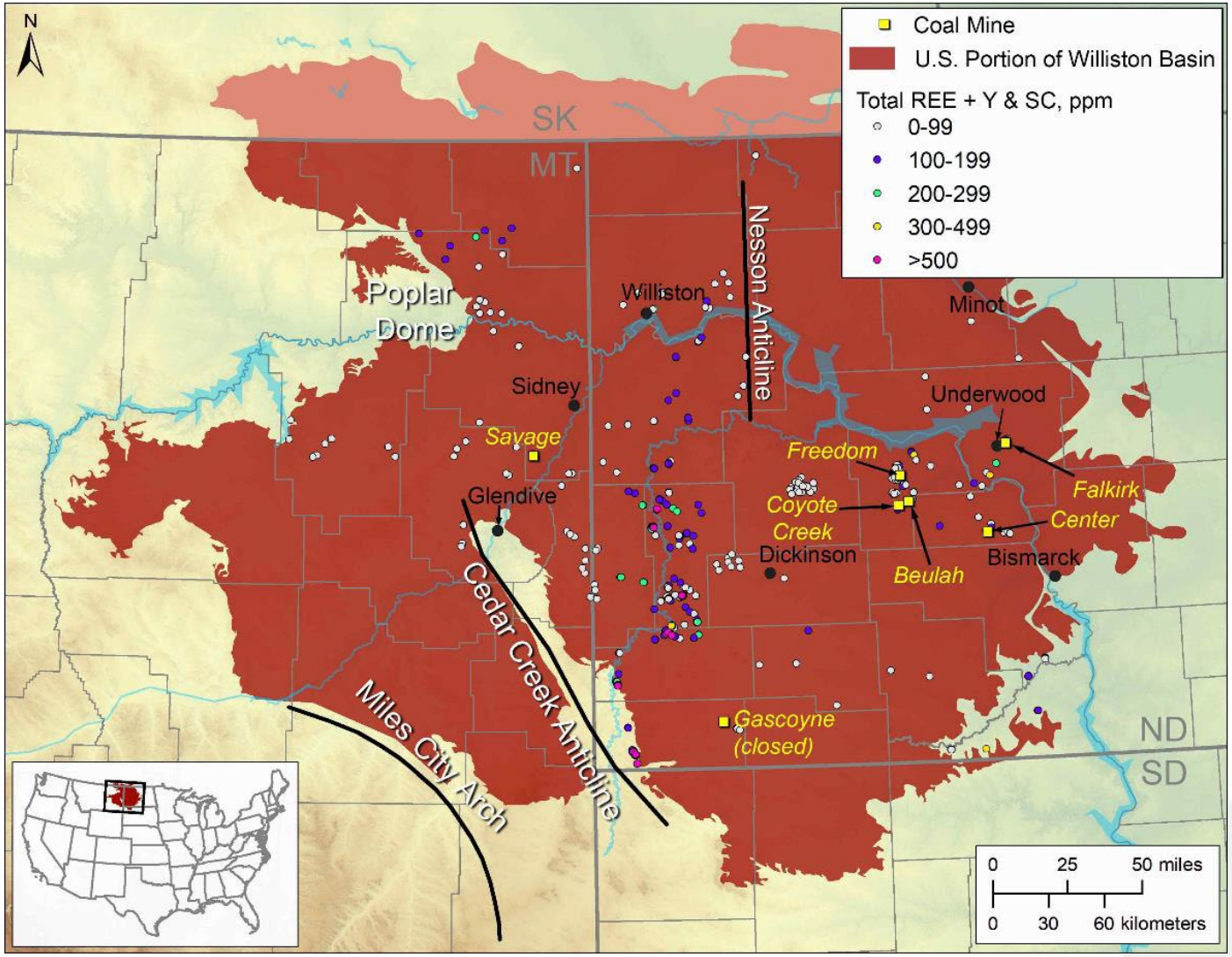
- Most coal samples were collected from the **Fort Union Group.**
- Coal depths from surface outcrops to hundreds of feet deep.



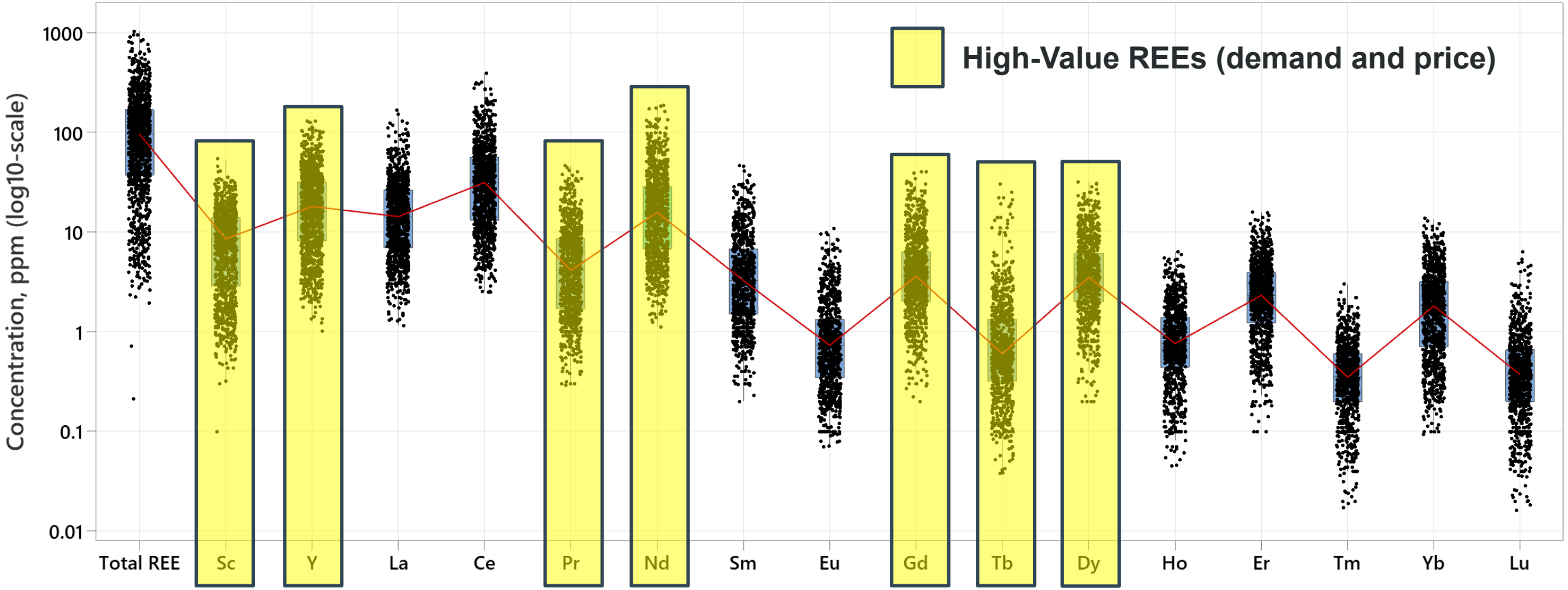
Rare-Earth Element Data Sample Locations

Sample locations are based on accessibility, not mining potential.

The H bed at sample site 68F, the site of the second highest rare-earth concentration in this study (638 ppm).



REE Concentrations Found in Williston Basin Lignite



Sc – Scandium
Y – Yttrium

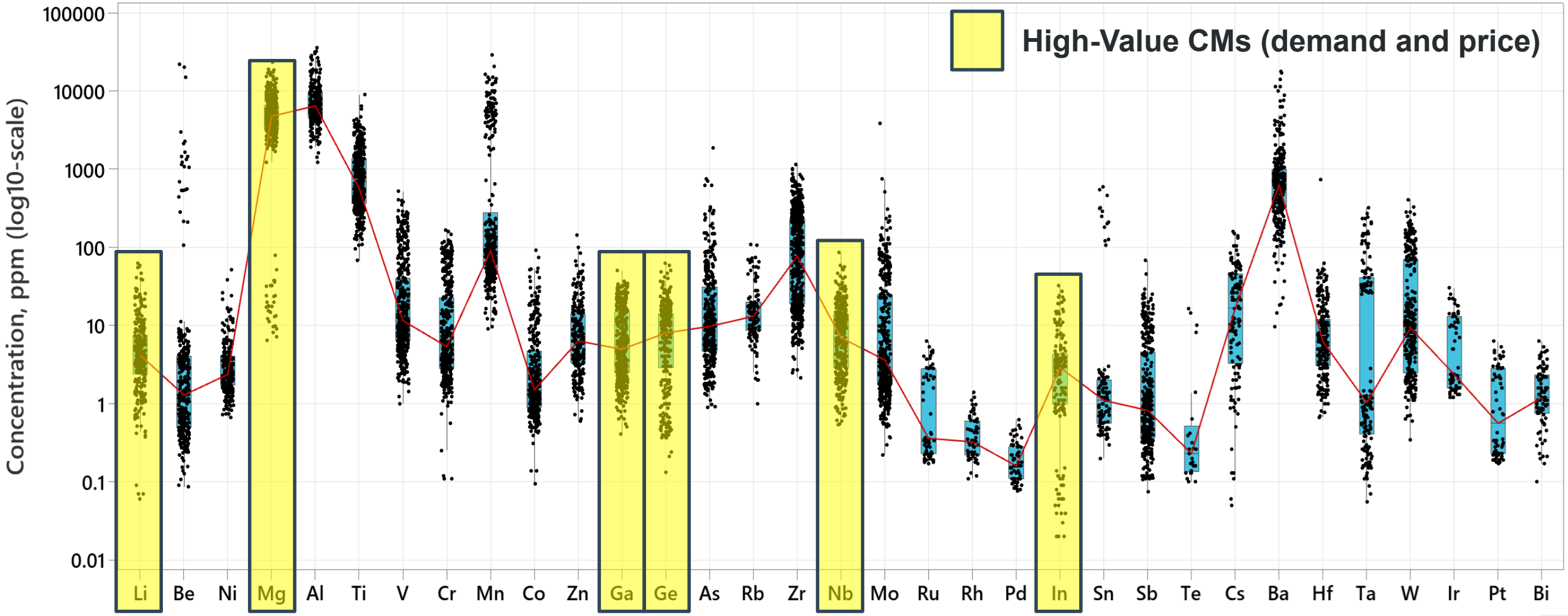
Pr – Praseodymium
Nd – Neodymium

Gd – Gadolinium
Tb – Terbium
Dy – Dysprosium

EERC UND University of North Dakota | U.S. Department of Energy | NETL National Energy Technology Laboratory | CORE-CM Williston Basin

Critical Challenges. Practical Solutions.

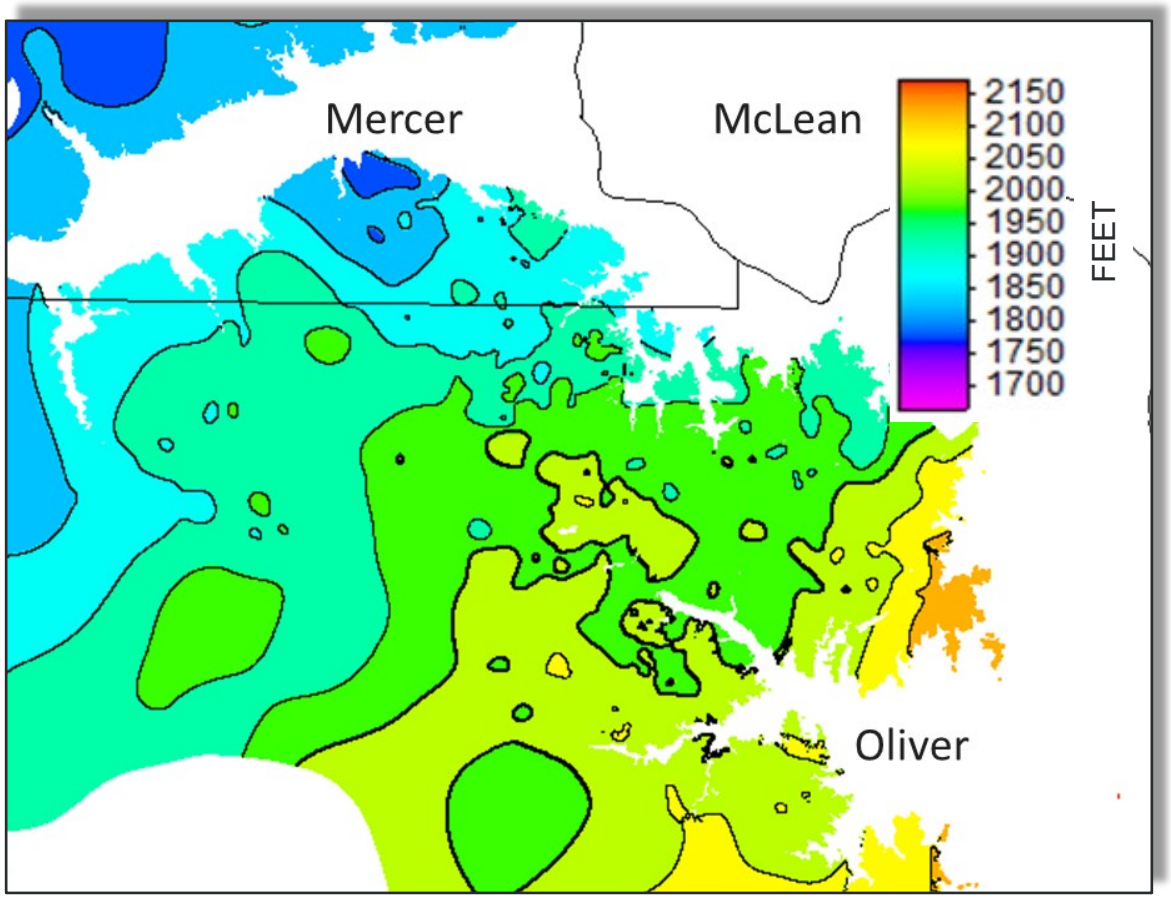
CM Concentrations Found in Williston Basin Lignite



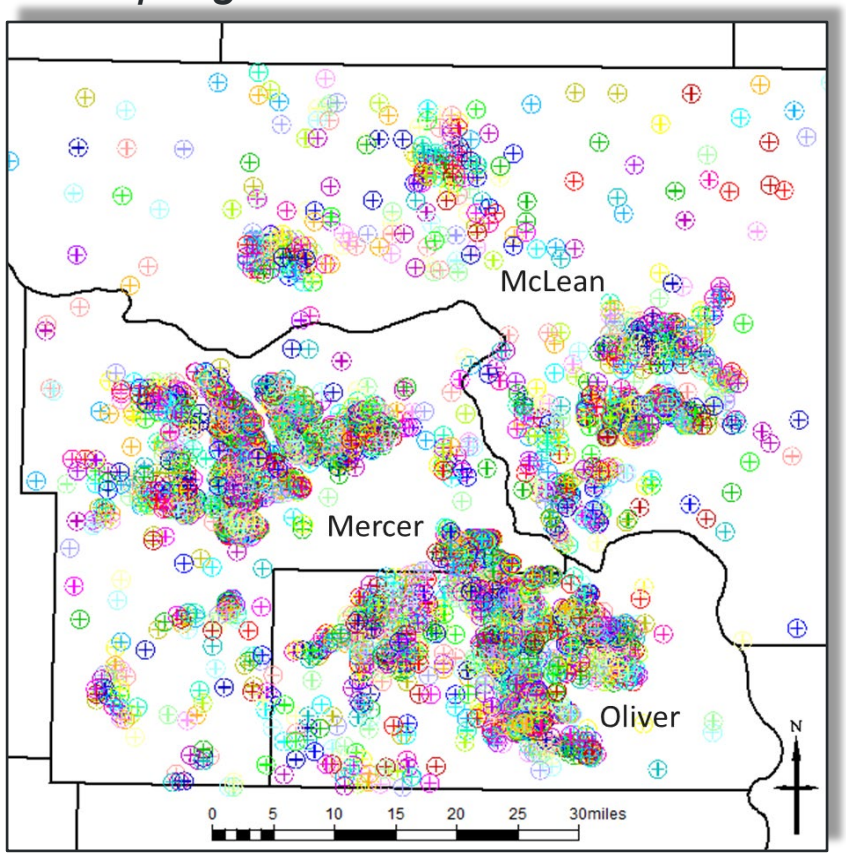
Li – Lithium
Mg – Magnesium
Ga – Gallium
Ge – Germanium
Nb – Niobium
In – Indium

Geologic Model

Elevation of the Tops of Coal Seams



Sampling Points

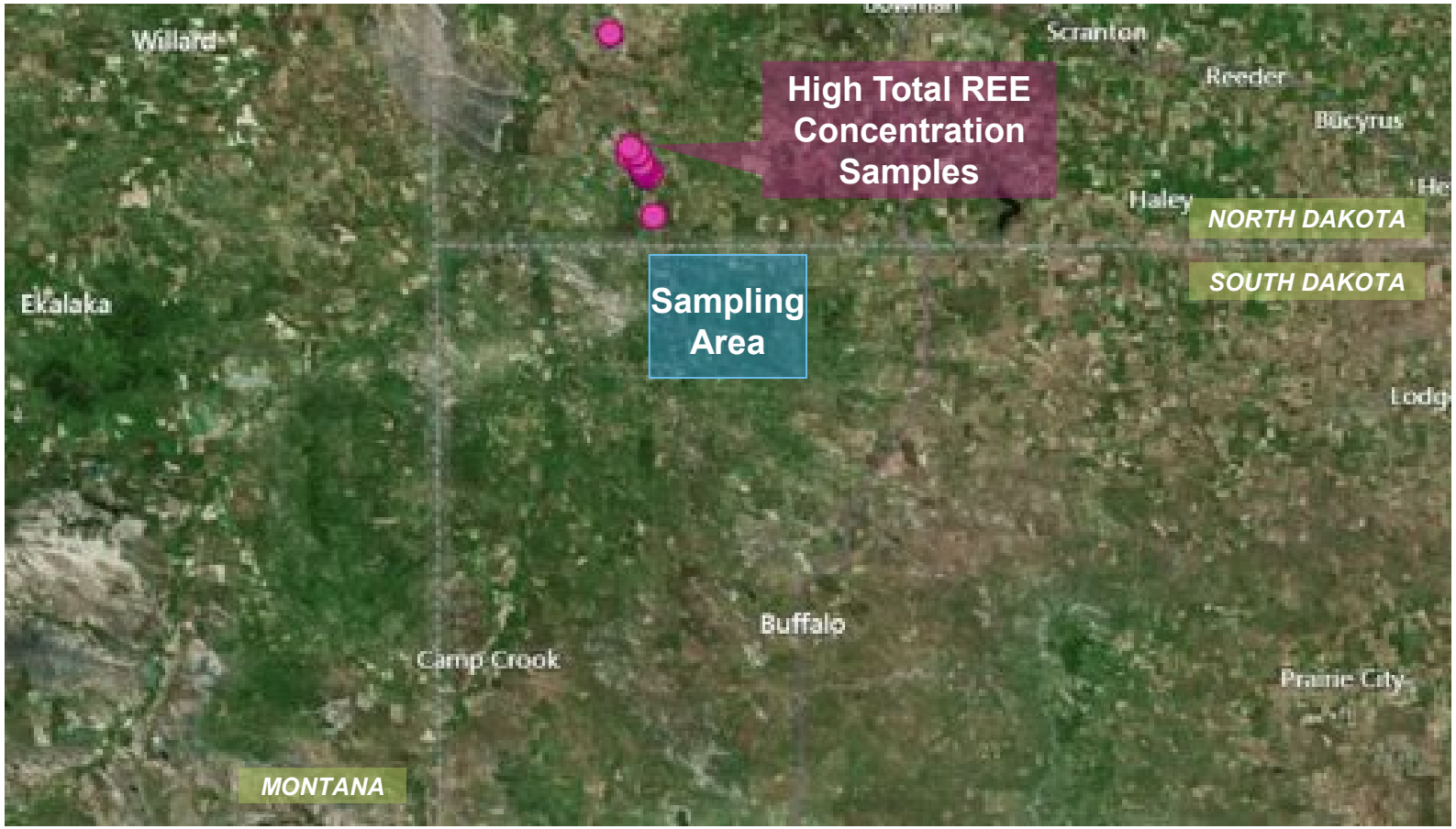


Maps tie REE concentrations spatially to individual coal seams.

Models will be improved as more subsurface information becomes available.

Coal Sampling in South Dakota

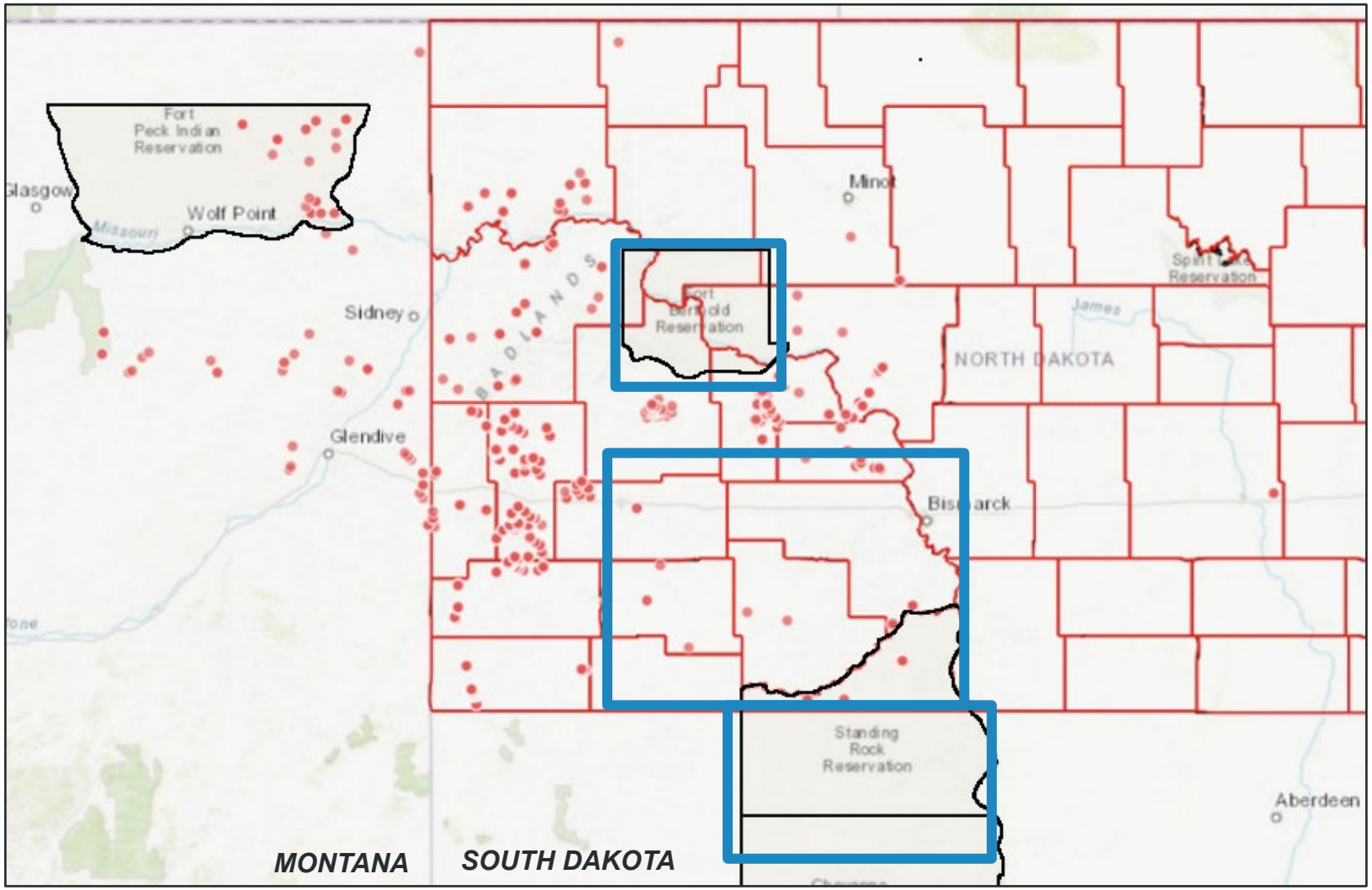
Sampling in South Dakota following high REE concentrations in North Dakota.



Future Potential Sampling Areas

= Potential Sampling

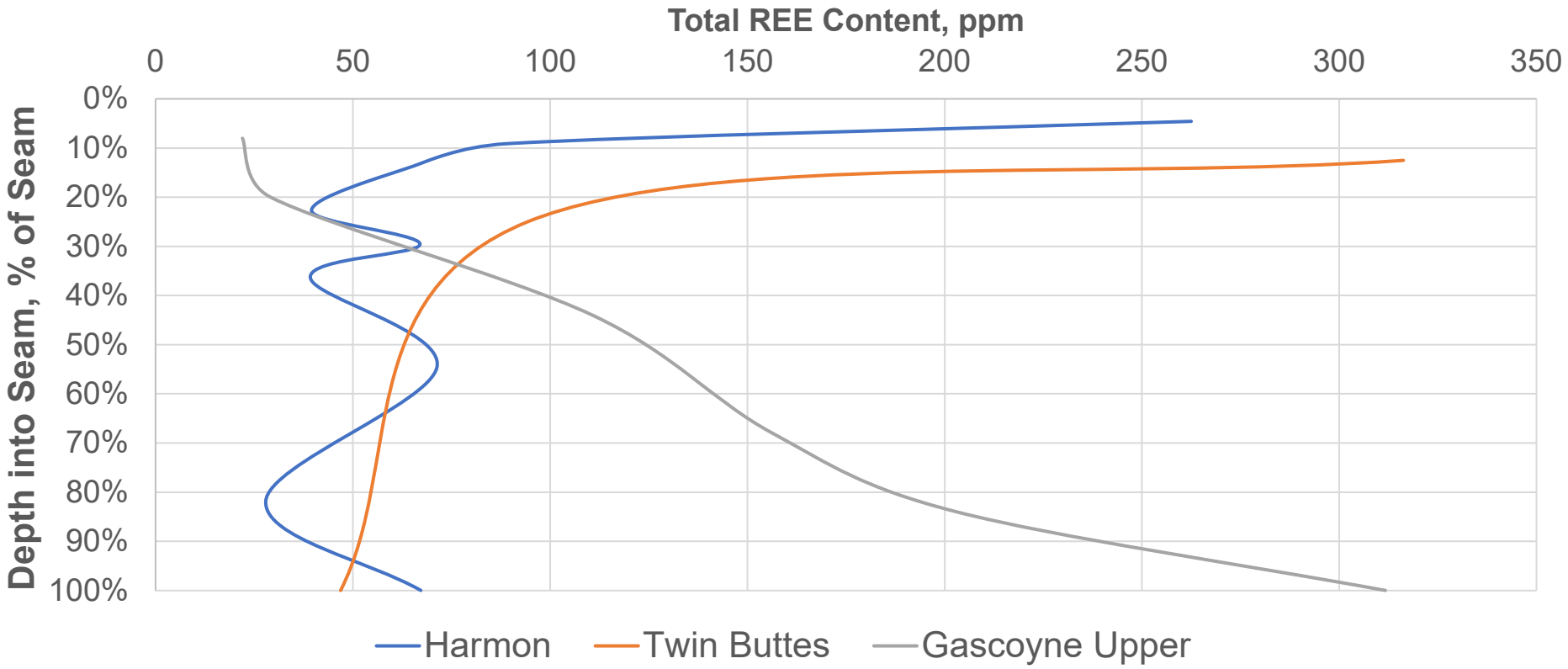
= Tribal Lands



What Are Some of the Resources Identified So Far?

Sources identified as feedstocks for REEs, CMs, and carbon products

- Lignite mining waste
  - Roof
  - Floor
  - Tonsteins
- Combustion by-products – ash



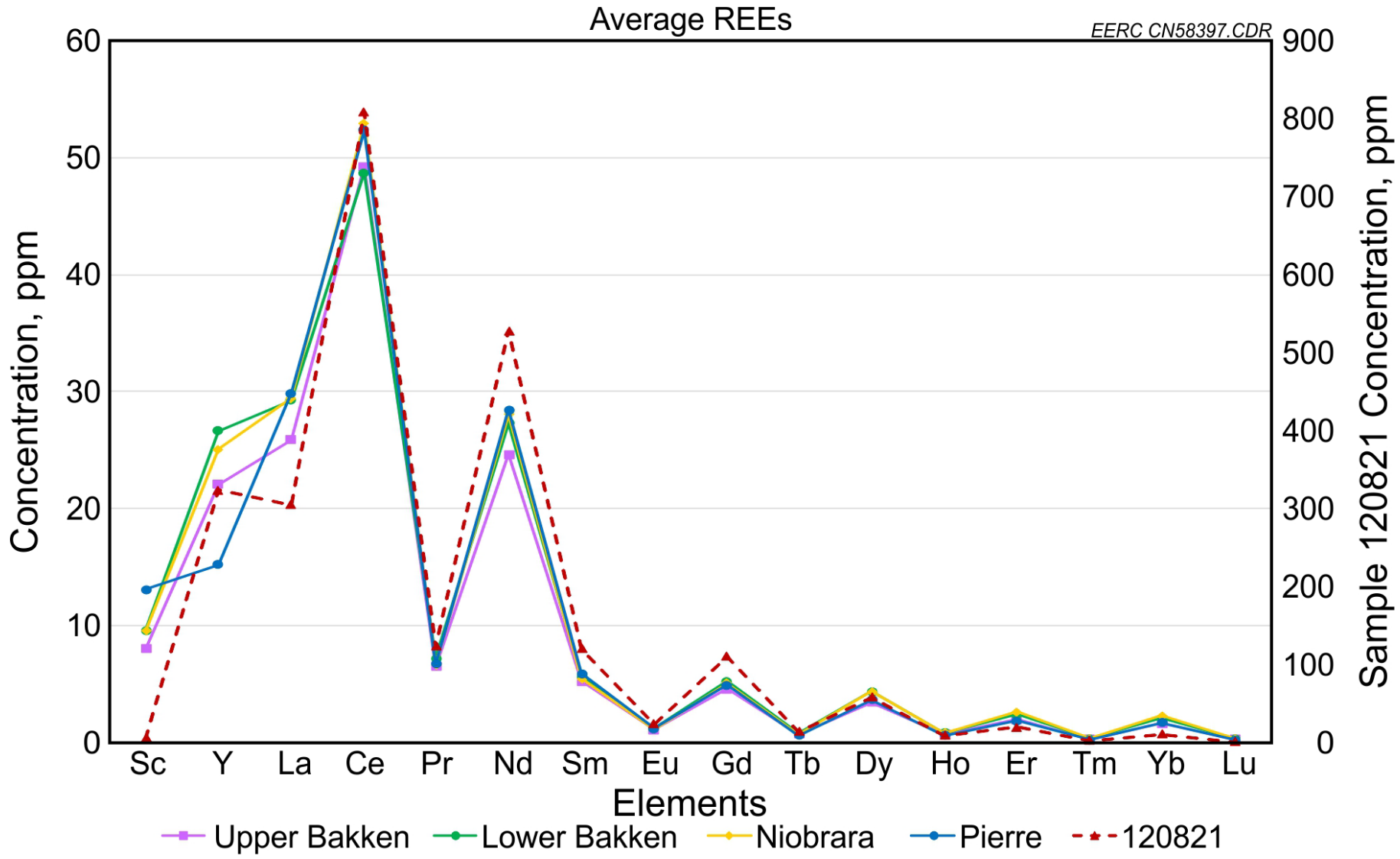
Other Resources – Shales

Of 43 Niobrara and Pierre samples, 9.3% had total REE levels greater than 300 ppm.

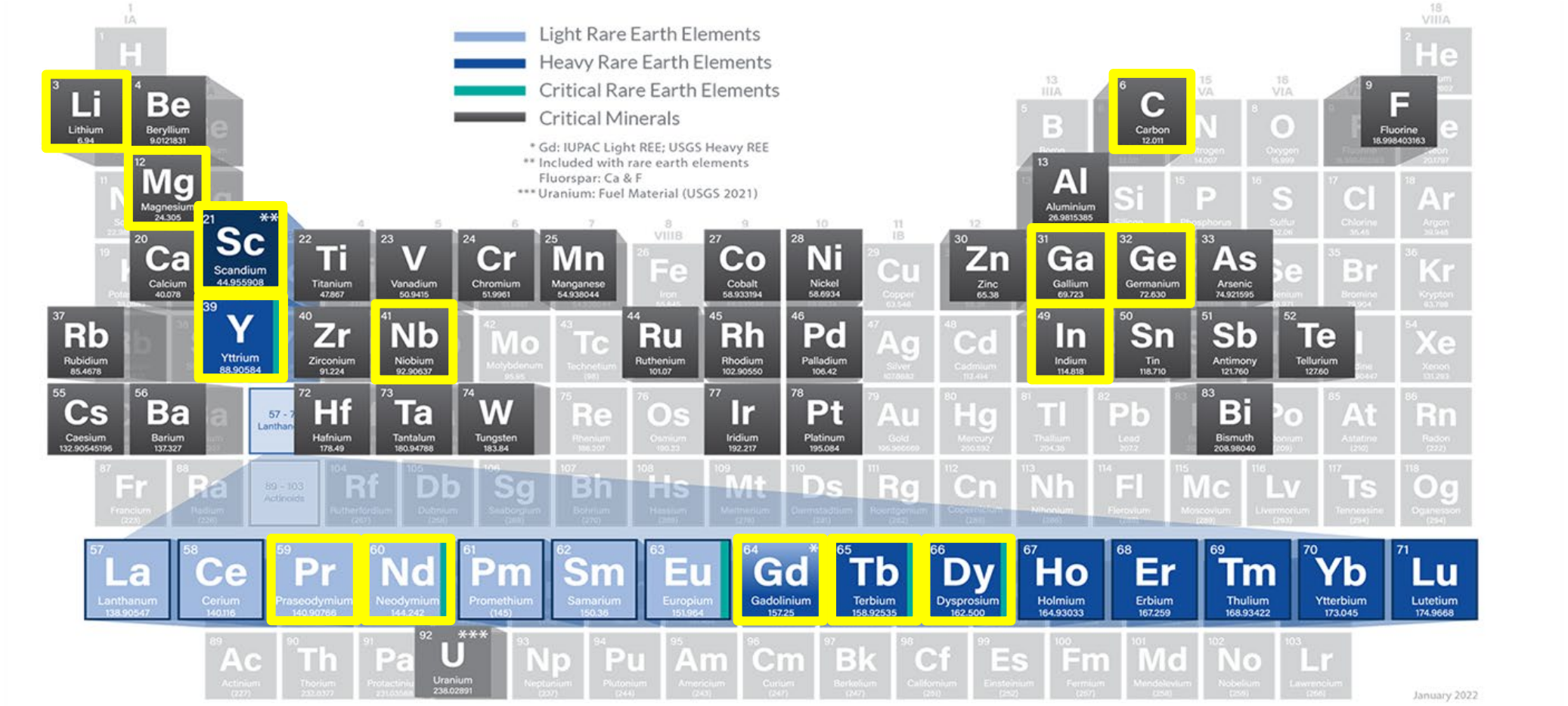
One location in the Bakken identified with REE levels over 2400 ppm.

Pierre shale with layers of bentonite.
Bentonite is weathered volcanic ash.

Average REE Levels in North Dakota Shales



Elements with Greatest Potential to Contribute to the Williston Basin Market



Technology Assessment

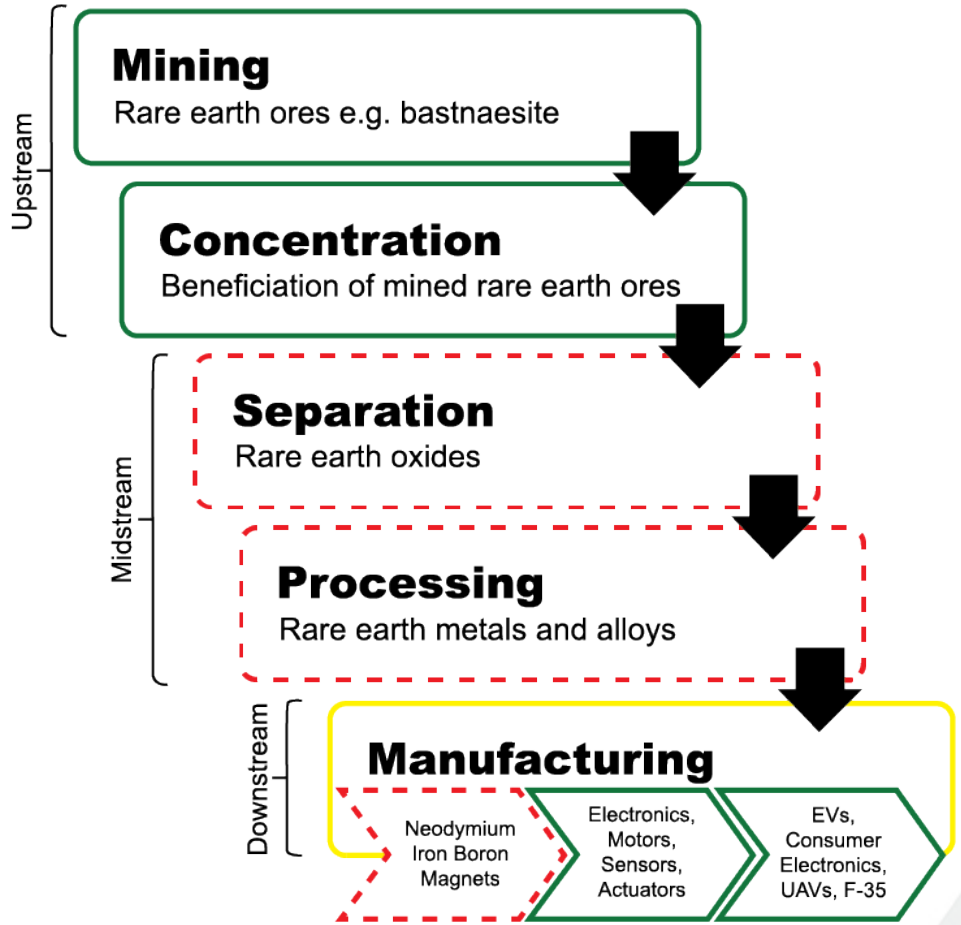
What Are We Trying To Achieve?

Identify technologies across supply chain to support REE/CM

- Which best utilize Williston Basin resources?
- Which can we use today?
- What impact might these have?
- Development of needed basinal products?
- Competitive advantage to use technology in the Williston Basin?

How do we fill these gaps?

- Technologies discussed from providers
- DOE- and DOD-funded projects



Assessment – Williston Basin Resources

- Coal and hard rock resources
  - Can these technologies use the W.B. low-rank coals?
    - What change is needed for them to?
  - What concentration/form of ore is needed?

Image Credit: Lignite Energy Council – Falkirk Mine

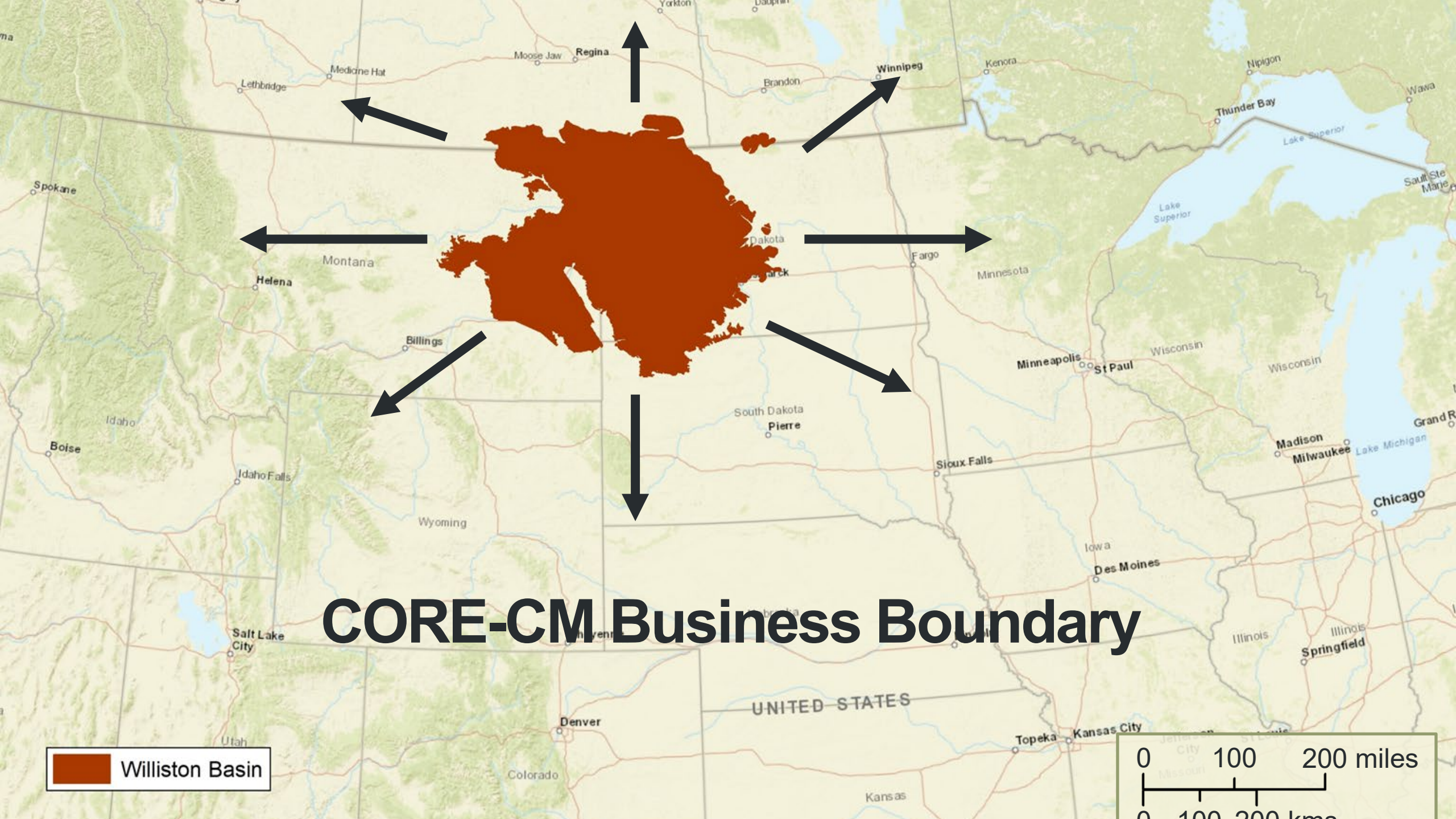
- Non-rock resources
  - Are there REEs/CMs within non-mineral resources within the region?
    - Can technologies account for the impurities/non-valuable effects of these?

Image Credit: USGS – Bakken Formation Oil Well Pad

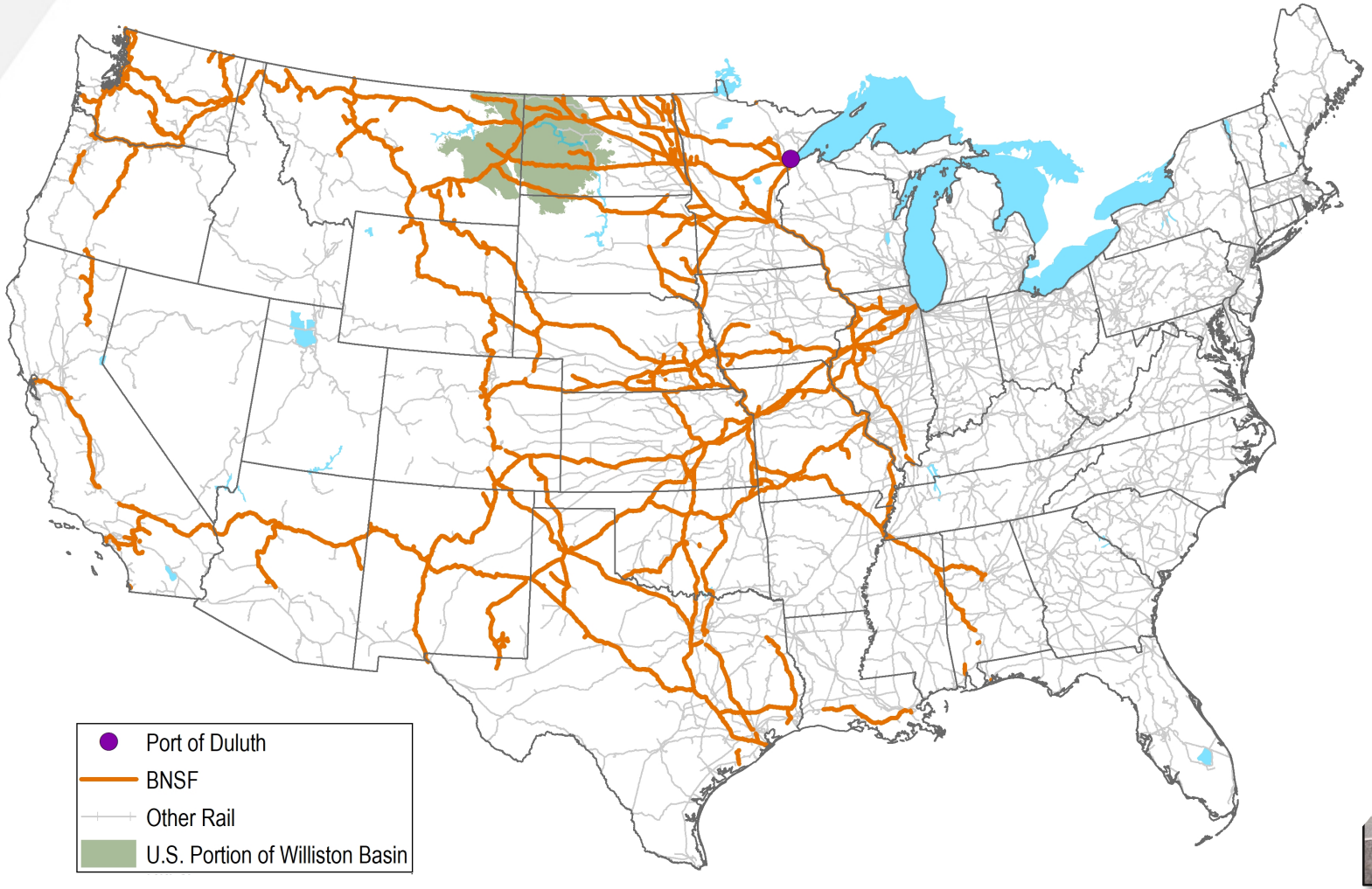
Assessment – Technology Readiness

- Identifying time-to-market for technologies
  - Scale of the technology tested
    - Beakers and grams?
    - Piloting and tons?
  - Risks with scale-up
    - Does the equipment to test it exist at commercial scales?
    - Are there permitting challenges associated with scale-up?
  - Does this work for the resources W.B. has?
    - Has it been tested on similar coals/ores?
    - Has it been tested with the W.B. resources directly?

Infrastructure, Industries, and Business


CORE-CM Business Boundary
Williston Basin
0 100 200 miles
0 100 200 kms
Regina
Moose Jaw
Medicine Hat
Lethbridge
Winnipeg
Brandon
Kenora
Nipigon
Thunder Bay
Wawa
Lake Superior
Sault Ste Marie
Spokane
Montana
Helena
Billings
Dakota
Fargo
Minnesota
Minneapolis
St Paul
Wisconsin
Madison
Milwaukee
Lake Michigan
Chicago
Grand R
South Dakota
Pierre
Sioux Falls
Idaho
Boise
Idaho Falls
Wyoming
Iowa
Des Moines
Illinois
Springfield
Salt Lake City
Utah
Denver
Colorado
Kansas
Topeka
Kansas City
UNITED STATES

Advantageous Transportation Infrastructure

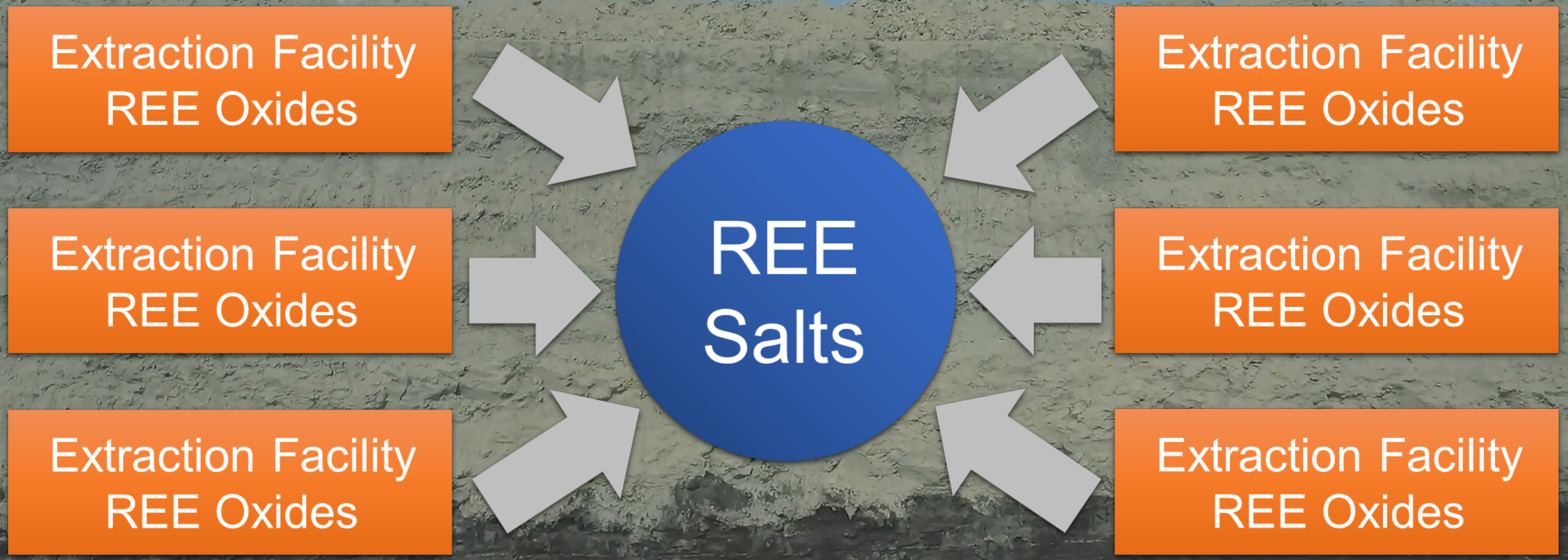


Rail

Truck

Port in Duluth

Extraction to Concentrate – Hub and Spoke



Barriers: Limited Market Penetration and Price Control

Market Assessment

- Key barrier – market penetration
  - Large purchase agreement
  - China controls the price!
- Use of CMs in our region?

Technology Innovation Centers

Technology Innovation Centers (TIC): Pushing the State of the Art

Working with Project Partners to Formulate Plans

- Basin-specific public–private partnerships
- Develop and validate CORE-CM technologies at laboratory scale

Photo by Cytonn Photography from Pexels

Creation of TIC Plans: Create the Innovation Pipeline

Identify Existing State/Regional Innovation Centers
Examples of Governance and Structure

Technology Innovation Centers and Business Incubators
- UND Center for Innovation
- NDSU Research Technology Park
- Grand Sky Business Park
- UND Tech Accelerator

Programmatic Centers (training and advice)
- Jamestown Regional Entrepreneur Center
- CTB (Center for Technology and Business) Bismarck

State Agencies
- Accelerate North Dakota
- State-Led Economic Development Regions

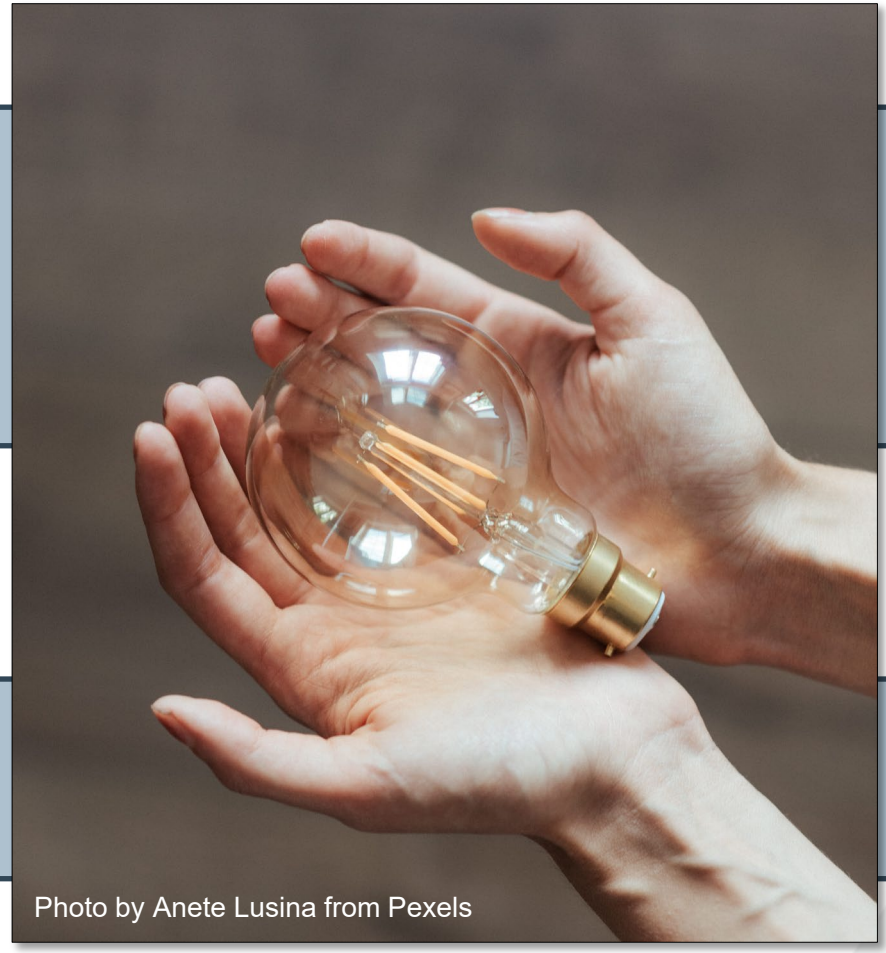


Photo by Anete Lusina from Pexels

Engagement and Outreach

Why Should I Care about Critical Minerals?

The Williston Basin CORE-CM Initiative

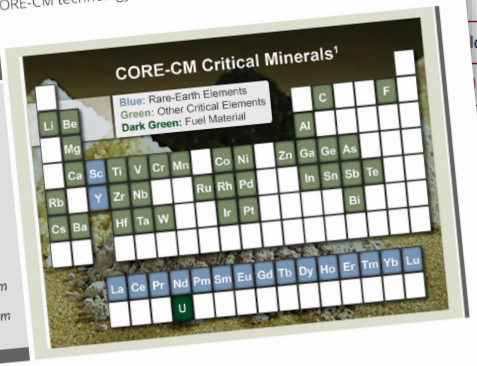
CORE-CM WILLISTON BASIN

The Williston Basin Carbon Ore, Rare Earth, and Critical Minerals (CORE-CM) Initiative is setting the stage for future expansion and transformation of coal use within the Williston Basin for the production of critical minerals (CMs), including rare-earth elements (REEs) and nonfuel carbon-based products. Phase I is focused on building partnerships; assessing resources, markets, and infrastructure; identifying data gaps; and establishing potential technology and business development pathways. Anticipated project outcomes include a database of known CM resources, e.g., coal deposits and waste streams; plans to address infrastructure and supply chain gaps; recommendations for CORE-CM technology development; and technology training and outreach plans.

What Makes a Mineral Critical?

With high demand and limited supply, these minerals and their elements are essential for everything from vehicles and mobile phones to food preservation and health care. Most elements are critical because no substitute exists. For example, chromium's unique properties are critical to the formation of stainless steel. REEs, in particular, enable portability, miniaturization, and technological advances; it takes nine different REEs to make an iPhone:

Y – yttrium
La – lanthanum
Ce – cerium
Pr – praseodymium
Nd – neodymium
Eu – europium
Gd – gadolinium
Tb – terbium
Dy – dysprosium



What Is the Benefit of the CORE-CM Project?

The overall goal is to secure a domestic supply of materials essential to health care, high technology, national security, and clean energy, which may catalyze economic growth and job creation. The United States currently imports most of the CMs and REEs needed for manufacturing, leaving the nation's economy vulnerable to supply chain disruption and raising concern about future demand for these metals. These imports include both raw materials and finished products. Developing a domestic supply chain would bring about sustainable opportunities for mining communities and extended usefulness for existing infrastructure.

Why Is Carbon Critical?

Carbon comes in many forms. Although coal is plentiful in the United States, another form of carbon, natural graphite, is not. Graphite is used in heat-resistant materials and is also essential for batteries, brake linings, lubricants, pencils, and steelmaking. Currently, the United States imports 100% of the graphite it needs.[2]

EERC

PROJECTS

Williston Basin CORE-CM

Setting the stage for future expansion in the Williston Basin

The goal of the Williston Basin CORE-CM project is to set the stage for future expansion and transformation of coal and coal-based resource utilization within the Williston Basin for the production of rare-earth elements (REEs), critical minerals (CMs), and nonfuel carbon-based products. The project will 1) assess the existing information available for

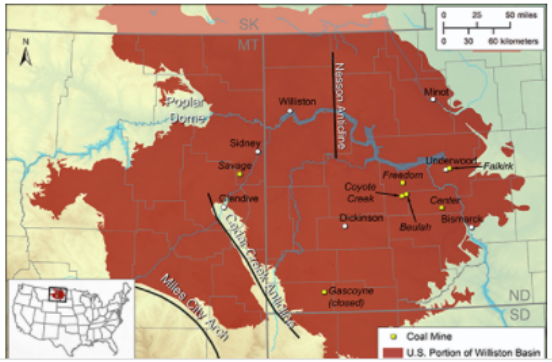
CORE-CM WILLISTON BASIN

elopment, innovation
gy development are
4) initiate stakeholder

Undeerc.org/wb-corecm

About the Williston Basin

The Williston Basin is a large sedimentary basin centered in western North Dakota with portions reaching into South Dakota, Montana, and Canada. It has a rich and extensive history of producing critical resources for the United States. Significant research has characterized REE and CM content in the lignite coals and combustion byproducts of the basin as well as exploration of technologies for extraction of these components. Additionally, recent research has also focused on the production of graphene, graphite, and carbon-based building materials from lignite coal.



Earth Elements and
ls?
E's National Energy
ory.
MENTS AND CRITICAL
NERALS

Healthcare
Transportation

rth Dakota's
Shales

This project, funded through the EERC's

Summary

- Large areas of the basin need to be explored and legacy data confirmed
  - Suitable concentrations of REEs are present in the Williston Basin
- Limited waste streams identified as viable
- Several technologies are in development for extraction of REEs from North Dakota lignite coal
- Graphite and graphene are being produced at the lab scale from lignite
- Market penetration must be addressed
- Advantageous transportation infrastructure is present
- Business boundary will extend well beyond the Williston Basin

End Products

- Characterization and data acquisition plans
  - Lignite resources
  - Related sources
- Technology assessment and field development plan
- Technology innovation center development plan
- Stakeholder identification, education, and outreach continued
- Summary of environmental justice considerations
- Summary of economic and workforce impacts
- Summary of environmental, health, and safety analysis

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THANK YOU

Critical Challenges. Practical Solutions.

DOE Acknowledgment

This material is based upon work supported by the U.S. Department of Energy National Energy Technology Laboratory under Award No. DE-FC26-05NT42592.

DISCLAIMER

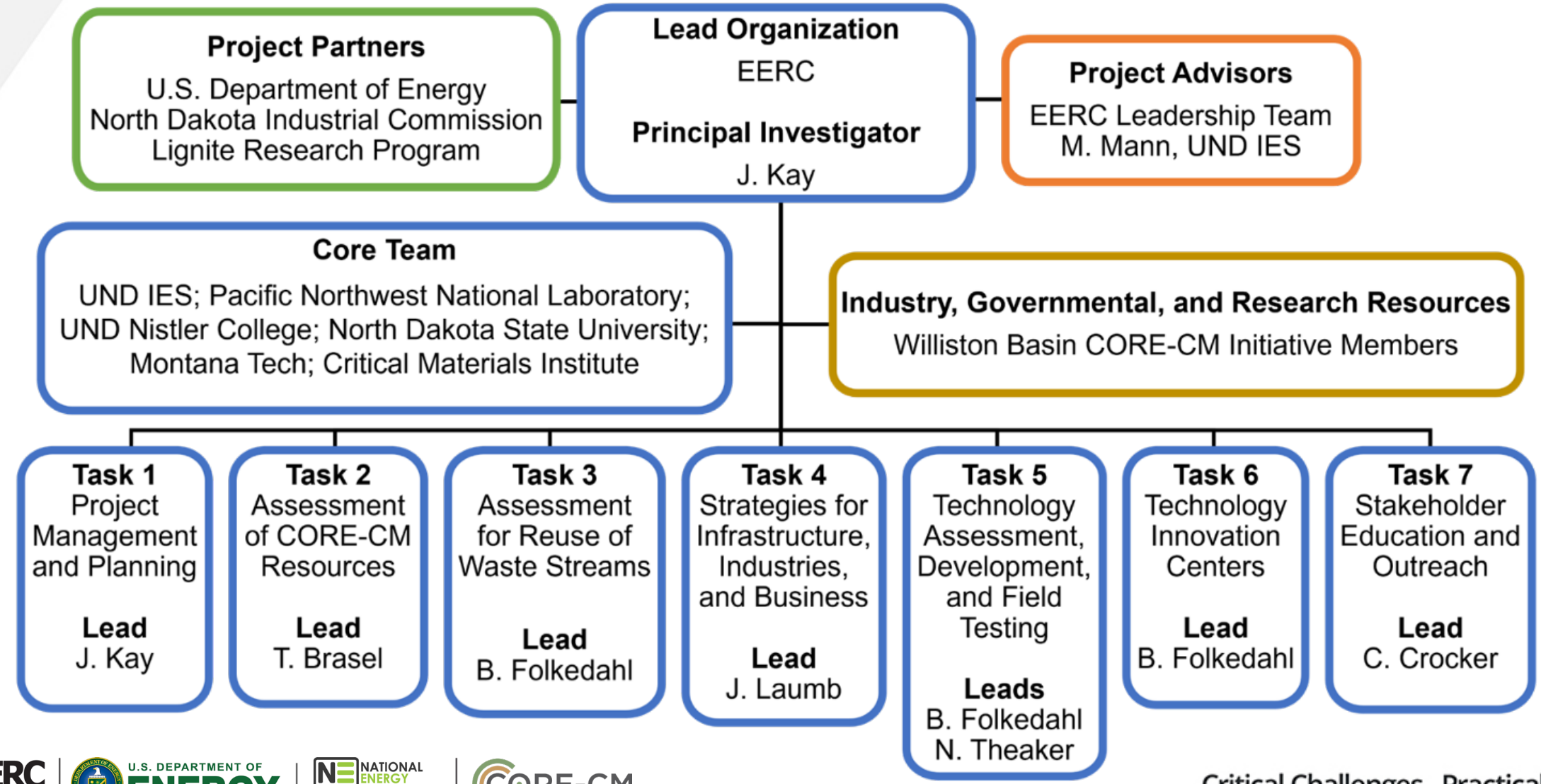
NDIC Acknowledgment

This material is based upon work supported by the North Dakota Industrial Commission under contract No. FY21-XCVI-236.

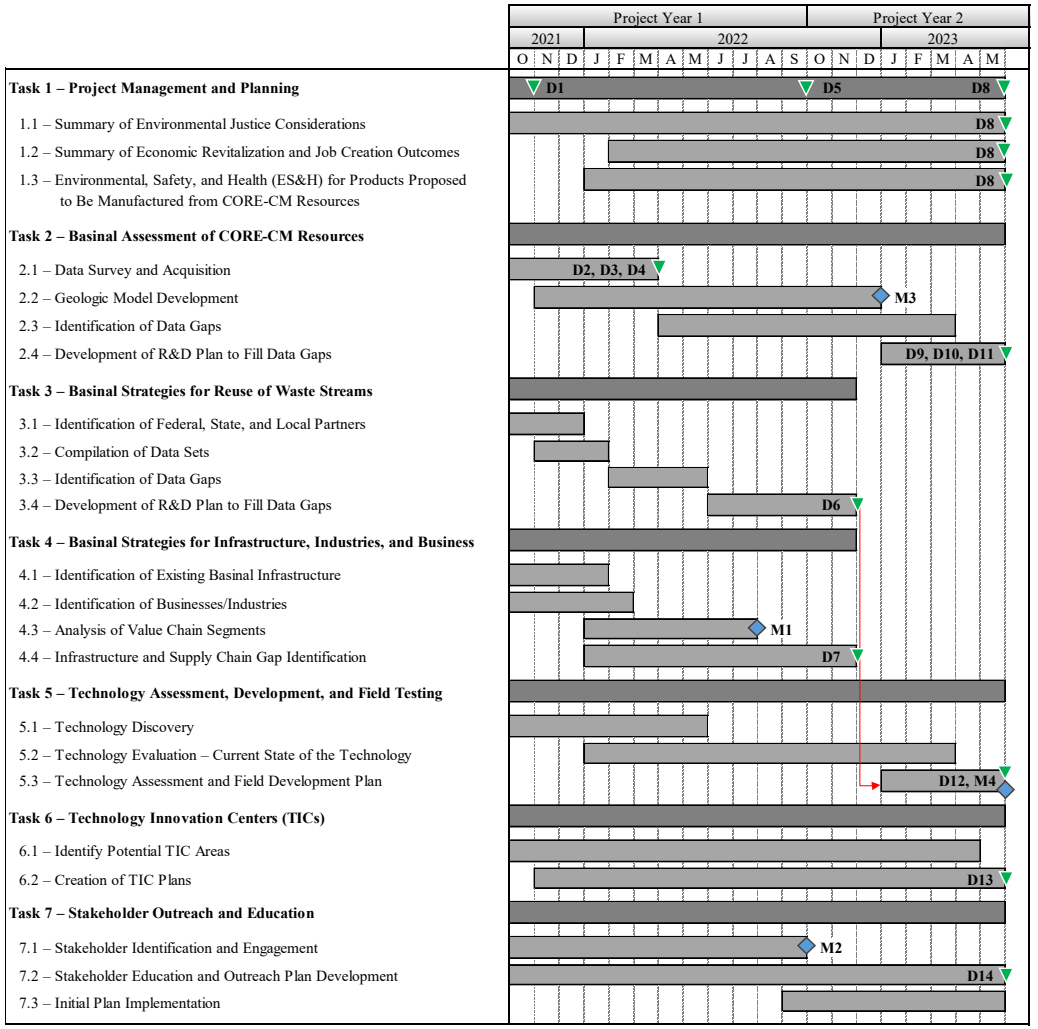
DISCLAIMER

Appendix

Organization Chart



Gantt Chart



Key for Deliverables (D)

D1 – Updated Project Management Plan
D2 – Site Access Assessment (If Samples Collected)
D3 – EDX FOA-2364 REE Researcher Database Template
D4 – Inputs for NETL REE-SED Sample Data Needs
D5 – Interim Report
D6 – Initial Waste Stream Reuse Plan
D7 – Results of the Basinal Strategies for Infrastructure, Industries, and Business Assessment
D8 – Final Report
D9 – Initial Basinal Resource Assessment
D10 – Characterization and Data Acquisition Plan
D11 – Resource Samples for Mineral Characterization and Analysis
D12 – Initial Technology Assessment and Field Development Plan
D13 – Initial Technology Innovation Center Plan
D14 – Initial Stakeholder Outreach and Education Plan

Key for Milestones (M)

M1 – Initial Analysis of Value Chain Segments Completed
M2 – Initial Stakeholder Engagement Meeting Held
M3 – Development of Geologic Model Structure
M4 – Technology Field Testing Options Determined

Summary Task
Activity Bar
Deliverable (D)
Milestone (M)
Critical Path

SK 10/26/2021