Attachment 2 – STATEMENT OF PROJECT OBJECTIVES
Bringing Alaska's CORE-CM Potential into Perspective

A. OBJECTIVE

Recipient will achieve the Objectives stated in Section I.C. of DE-FOA-0002364 Amendment 0003. The objective of this project is to establish a pathway whereby Alaska's Rare Earth Elements and Critical Minerals (REE-CM) can economically compete against imports, thereby reducing our nation's reliance on foreign suppliers of critical minerals.

B. SCOPE OF WORK

The Recipient will first assess REE-CM endowment by performing Basinal Assessments of Alaska's Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) basins, starting with the coal basin hosting the Usibelli Coal Mine and the extensive large-flake graphite deposit, Graphite Creek, and expanding from there. It is unlikely that a REE-CM mine can be economical on its own, the Recipient will also emphasize opportunities to create high value, non-fuel products from the carbon content in the basin associated with the REE-CM resource to increase its economic potential. This work will be expanded to other rich CORE-CM deposits according to the results of our Priority Matrix.

To assess the attractiveness of a particular CORE-CM basin for development, factors such as access to land infrastructure, waste processing, and specialized technology capable of limiting environmental disturbance will be critical to evaluate. Therefore, the Recipient will utilize the previously described Priority Matrix methodology for prioritizing CORE-CM basins.

C. TASKS TO BE PERFORMED

Task 1.0 - Project Management and Planning

The team shall manage and direct the project in accordance with a Project Management Plan to meet all technical, schedule and budget objectives and requirements. The team will coordinate activities in order to effectively accomplish the work. The team will ensure that project plans, results, and decisions are appropriately documented, and project reporting and briefing requirements are satisfied.

The team shall update the Project Management Plan 30 days after award and as necessary throughout the project to accurately reflect the current status of the project. Examples of when it may be appropriate to update the Project Management Plan include: (a) project management policy and procedural changes; (b) changes to the technical, cost, and/or schedule baseline for the project; (c) significant changes in scope, methods, or approaches; or (d) as otherwise required to ensure that the plan is the appropriate governing document for the work required to accomplish the project objectives.

Management of project risks will occur in accordance with the risk management methodology delineated in the Project Management Plan in order to identify, assess, monitor and mitigate technical uncertainties as well as schedule, budgetary and environmental risks associated with all aspects of the project. The results and status of the risk management process will be presented during project reviews and in quarterly progress reports with emphasis placed on the medium- and high-risk items.

The Recipient will participate in DOE-led Working Groups with other CORE-CM Recipients as required during the term of the project.

Subtask 1.1: Summary of Environmental Justice Considerations

The Recipient will submit a summary of environmental justice considerations of the proposed technology, process, or system. The following issues will be addressed:

- How the technology relies on limited resources such as coal, biomass, freshwater, land, and/or low-carbon energy. Indicate the relationship between the amount of resources used and the amount of product formed.
- If coal is used as a feedstock, where it will be mined and what are the associated near-term and legacy environmental impacts of the coal mining, including methane leakage.
- If coal wastes are being remediated, indicate the relationship between the amount of coal wastes used versus the amount of product formed.
- How the planned technology remediates legacy environmental impacts of the energy industry, including environmental impacts associated with the use of coal.
- The project's waste management strategy and the anticipated impacts of residual waste on local residents.
- How the project incorporates a plan to ensure community and stakeholder input and engagement from underserved communities, which include persons of color; members of religious minorities; lesbian, gay, bisexual, transgender, and queer (LGBTQ+) persons; persons with disabilities; persons who live in rural areas; and persons otherwise adversely affected by persistent poverty or inequality.

Subtask 1.2 – Summary of Economic Revitalization and Job Creation Outcomes

The Recipient will submit a summary of economic and workforce impacts associated with the proposed technology, process, or system. This includes discussion of:

- Whether application of the process will create new jobs, including clean energy jobs, at the prevailing wage.
- The extent to which those new jobs will be located in power plant and coal communities that are economically distressed and/or have been harmed by the adverse environmental impacts of the energy industry.
- The nature of the jobs, recruitment strategies for individuals who belong to groups that are historically underserved or underrepresented, anticipated recruitment of workers from the local community, and whether training will be required, or if the skills are associated with an existing labor force.
- How many new jobs will be created as a result of technology deployment (e.g., number of jobs per unit of product, # of jobs per unit of waste remediated, # of jobs per unit of emissions mitigated).

Subtask 1.3 - Environmental, Safety, and Health Analysis for Products Proposed to be Manufactured From CORE-CM Resources

As part of the Final Scientific/Technical Report, the Recipient will identify ES&H requirements for any products proposed to be manufactured from CORE-CM resources, based on anticipated effects on the environment, safety, and human health in the following situations:

- Processing (extraction/separation/recovery/waste stream management) of raw materials in an environmentally benign manner, leading to production of REE-CM-containing intermediate and/or end products, or other high-value products.
- Receiving, storage, handling, and use of raw materials to manufacture products
- Shipping to customer locations and handling of manufactured products at customer locations
- Field modification and installation (e.g., cutting, drilling, finishing, etc.) of manufactured products
- Long-term use of the manufactured product in residential, commercial, and industrial settings
- Demolition. removal, and recycling/disposal as applicable at the end of the manufactured product's life

Task 2.0 – Basinal Assessment of CORE-CM Resources

The Recipient will compile, catalogue, and analyze previous and ongoing studies that include data on carbon-ore resources and associated REE-CM concentrations. This statewide review will serve as the foundation for evaluating the most promising basins or stratigraphic intervals in Alaska. The Recipient will also identify and analyze existing samples and core material from various Alaska coal basins that are suitable for REE-CM analysis. A gap analysis of available data will help assess the spatial and temporal coverage of important coal-bearing basins and inform new data collection. Geological models will be created, or existing models updated, and basin maps created/updated to show locations of carbon-ore and REE-CM resources.

NOTE: Please refer to the NEPA term in the Award Terms and Conditions regarding "TBD" sites and activities.

Subtask 2.1: Characterization and Data Acquisition Plan

Based on the initial assessment and gap analysis, a Characterization and Data Acquisition Plan will be developed that justifies collection of new REE-CM data. This plan will consider which basins warrant the collection of new samples to fill data gaps or to further pursue promising preliminary results that are insufficiently characterized. The plan will also summarize the geologic field methods and techniques that will be employed to maximize the reach of the initial Basinal Resource Assessment.

Subtask 2.2: Priority Matrix

Due to Alaska's size and geologic complexity, it is impractical to conduct an in-depth assessment for each of the state's many coal-bearing sedimentary basins. A unique element in this proposed project is the creation of a Priority Matrix that justifies and ranks the basins and resources that the team will focus on improving/refining throughout the period of performance. This Priority Matrix will be informed by the geological, technical, and financial factors that impact the potential for the economic production of REE-CM's from Alaska carbon ores.
Other decision criteria will be identified and more thoroughly vetted, including stakeholder outreach to help determine best practices for attracting investors to a proposed basin or project.

Subtask 2.3: Implementation of the Characterization and Data Acquisition Plan

Following NETL approval of the Characterization and Data Acquisition Plan, the Recipient will carry out any required sampling, characterization, and data acquisition.

Task 3: Basinal Strategies for Reuse of Waste Streams

The objective of this task is to assess existing and future regional waste streams from carbon-ore mining operations that could be reused as inputs for production of REE-CM and/or high-value, nonfuel carbon- based products and other by-products as consumables, feedstock, and fuels. The initial focus of the waste stream assessment will be those associated with Usibelli coal production, bottom and fly ash from the CHP plants it supplies, and the planned flake graphite production (see Graphite One support letter).

An additional focus will be assessment of waste streams from hard-rock mining and from oil- and gas-produced water to recover REE-CM. The hard-rock mining sources will hopefully include Fort Knox, Pogo and Kensington gold mining operations. Oil- and gas-produced water waste streams will likely be located on the Alaska North Slope and the Cook Inlet. In addition, the Recipient will include refinery residual as a prospective source of REE-CM. The Recipient will work with these industries to explore synergies associated with utilization of their waste streams for CORE-CM production.

A thorough characterization will employ various data gathering analytical techniques including Inductively Coupled Plasma- Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma- Optical Emissions Spectrometry (ICP-OES). Preliminary waste stream reuse plans will be developed for extraction and recovery of REE and CM from fly ash, wet ash, and utilization of coal and other hard-rock operations-based acid mine drainage. Finally, the plans will further elucidate challenges and potential solutions necessary to realize the waste stream reuse opportunities.

Task 4: Basinal Strategies for Infrastructure, Industries and Businesses

Task 4's objective is to investigate extending economically viable infrastructure to CORE-CM prospective site(s), and, where not possible, establishing relatively self-sufficient mining and refining operations by investigating local energy sources, including the possibility of manufacturing liquid fuels and chemicals onsite.

Using the Basinal Assessment rankings, the team will work with the industry, businesses, and interested parties to build Development Scenarios for one or two basins of interest, and to identify challenges to developing the CORE-CM resources so that plans can be made to address them through technological innovation and research. The R&D plans arising from this task will be further used as planning documents for implementation of the Alaska-Focused Technology Innovation Center (AK-TIC), Task 6.

Task 5: Technology Assessment, Development and Field Testing

The Task 5 objective is to generate data that can guide a field development plan. This task is designed to provide potential CORE-CM basin developers with an understanding of technology and economics so that well-informed choices can be made with respect to environmentally sensitive development. Each of the subtasks is designed to assess either mining technology, separation and processing methods, or value-added products.

Subtask 5.1: Investigate innovative and sustainable mining for coal and other basinal minerals
Selective Mining: The Recipient will evaluate the potential for selective mining technology to improve the economics of REE-CM mining and recovery by lessening the initial volume of material from which REE- CM must be separated. The "precision selective mining technology" under consideration is a precise, large, mobile milling machine that follows along a deposit's GPS-defined bedding plane (preferably near planar, and ±20 degrees from horizontal). Removed layers can be up to 12-14 inches thick, with layer thickness precision approaching 0.5 inch. Mined material particle size distribution is predictable and repeatable and will not include large particles exceeding the thickness of a removed layer. Where bedding layers are distinctly different in mechanical properties, thick zones can be removed with drilling and blasting or gross direct mechanical means, exposing a planar deposit zone of interest, and that zone can then be mined with the precision selective mining technology.

Subtask 5.2: Investigate processes to separate and purify REE and CM

Characterization & Novel Pre-concentrating: Following sample characterization (Task 2), pre- concentration strategies will be investigated. Since REE minerals in coal tend to be concentrated in inorganic phases, such as clay minerals, *physical separations* of inorganics from coal feedstock can greatly enhance the concentrations of REEs. The Recipient will investigate novel pre-concentration methods, including gravimetric, density-based, magnetic separations; classification; and flotation processes that result in as much as 20X REE concentration enhancement and has been shown effective in UCM coal samples.
Pre-concentration can also be achieved through a sensitive rapid-detection method for luminescent lanthanides. Spectral discrimination occurs between the different lanthanide

elements present in leachates and indicate it should be possible to detect most lanthanides within complex matrices at concentrations as low as 200-300 ppb (Riman et al., in review). This method will be tested to sort gauge material from minerals containing high concentrations of REE.

Non-acidic bio-processing: Alaska and other coals characterized by our team typically have higher REE concentrations in the magnetic fraction (Akdogan et al., 2014), which indicates iron-containing phyllosilicate minerals sequestering REEs. This mineralogical property lends itself to a novel REE extraction method using non-acidic bio-processing. Members of our team have demonstrated that microbial bio-processing, performed at a circumneutral pH, is efficient at releasing REE ions from the phyllosilicate mineral matrix present in Alaska coal (patent pending). This process outperformed acid leaching in terms of total recovery for each of the REEs, and produces higher yields, eliminates process steps, and mitigates many acid leaching safety and environmental hazards. Preliminary techno-economic analysis (TEA) indicates this process is 40% cheaper than traditional methods. Further refinement of this extraction method will be investigated through a series of lab experiments.

Hybrid membrane separation: Solvent extraction (SX) and ion exchange (IX), multi-step separation trains can isolate individual REEs (Kronholm, et al., 2013). Significant drawbacks of SX for REE recovery from dilute solutions include up to 45 extraction stages and large volumes of organic solvent, which require downstream processing to concentrate REEs. Solvent contamination and low yields lead to deposit and process-viability concerns (Joshi et al., 2013). Conventional IX cannot be operated at high acidities and is limited in selectivity (Kumar et al, 2010).

Passive-engineered porosity graphene membrane physical separation is a more promising technology. It enables size-based separation of rare earth salts from those of alkali or other metals, and prior work demonstrated >99% selectivity towards separation of neodymium chloride from sodium chloride in three stages (Bhave et al., 2018). A hybrid approach, membrane solvent extraction (MSX), will be considered as it has many desirable advantages over SX (Kim et al., 2016). In addition, graphene membranes have very high permeance (41-58 L/m2/hr/bar) and therefore operations would be far less energy intensive versus SX or other hydrometallurgical methods. Graphene membranes may also efficiently separate heavy REEs from light REEs, and may replace SX altogether (Kim, et al., 2015).

<u>Subtask 5.3: Explore viability of creating intermediate and end-use products from carbon ores, REE and CM</u>

Sustainable Harvesting of Critical Materials: The Recipient will investigate hydrothermal processes of coal minerals to precipitate metal salts, non-metal salts and high-purity coal co-produced high-surface-area carbon with potential applications in carbon capture and utilization. Potentially, the low-cost carbon resulting from these processes could be used for making advanced composite materials, steel refractories, and as a soil amendment for CO2 sequestration. The salts can further be used by the chemical industry.

High value carbon based liquid products: The Recipient will investigate the potential for gasification and low- temperature pyrolysis (less than 900 º F) to produce hydrocarbon liquids from REE-CM available in Alaska coal ores, specifically including: technical and economic opportunities for producing phenols ($6 billion/year market, early production based on coal sources); polyolefins ($4 billion/year market; largest opportunity is liquid lubricant base stock substitutes); phenolic resins ($11 billion/year market, often found in coals); pyridines ($6 million/year market); asphalt additives (an import widely used in Alaska); and oil field chemicals used for enhanced oil recovery processes (imported polymers used in huge quantities in Alaska). Red Leaf has retort capability within their existing laboratory and demonstration facilities. Through pyrolysis, it is reasonable to expect REE-CM concentrations in pyrolysis tars and liquids as a byproduct of gasification. Early in the performance period, the Recipient will concentrate on an analysis of Usibelli Coal Mine (UCM) coal liquids previously produced by Red Leaf under another DOE-funded project, *Making Coal Relevant for Small Scale Applications: Modular Gasification for Syngas/Engine CHP Applications in Challenging Environments (DE-FE0031601).* The REE-CM concentrations found via low-temperature pyrolysis will be informative for both projects.

Task 6: Alaska-Focused Technology Innovation Center (AK-TIC)

Task 6 Objective is that AK-TIC will focus on developing and validating the tools and technologies needed to spur CORE-CM development in Alaska. The Recipient will utilize field-portable tools for initial resource evaluation, before an expensive ore-drilling program ensues in a later phase. The high cost of working in remote Alaska requires technologies that lower operational costs, and the AK-TIC will focus on identifying carbon-based, value-added, non-fuel products that can be manufactured in Alaska and exported worldwide. To accomplish this effort, the Recipient will develop three well-focused Thrust Areas: (1) carbon-based value-added products from both coal and graphite production and waste streams; (2) metals extracted from coal/carbon products; (3) coal fly and bottom ash, and carbon and metals products from alternate resources (*i.e.*, basaltic resources). Using these three Thrusts, the AK-TIC will effectively accelerate research, engage public-private partnerships, advance education and training, and integrate the Alaska's basin's natural resources, infrastructure, industrial needs, and waste stream reuse opportunities.

Priority	Description
1	Accelerate research that will enable Alaska Basin-specific commercial deployment of advanced processing and production of REE, CM and high-value, nonfuel, coal products.
2	Support engagement of Alaskan public-private partnerships and basinal industries to advance new and innovative technology development as well as potential for production of new products.
3	Advance opportunities for the education and training of the next generation of Alaskan technicians, skilled workers and STEM professionals.

Subtask 6.1- Establishment and Management

The Recipient has the experience and expertise to provide a centralized platform for developing key advancements while leveraging an extensive network of private, public, and national laboratory partnerships. Participants of an initial advisory public-private stakeholder panel will be recruited. They will work with the project team to draft the plans for the AK-TIC including the governance, responsibilities, and meeting schedules. Specific criteria to determine the success of the AK-TIC will also be developed. and possibly modeled after The National Coal Council (NCC), Carbon Advanced Material, Manufacturing and Production (CAMP) Centers with expansion to include REE-CM.

Subtask 6.2- Survey and select key emerging technologies

Alaska's unique environment drives innovation that also benefits other states. Emerging technologies to produce CORE-CM that reduce field costs and costs associated with electricity are greatly needed.

Plans will be developed on how the AK-TIC will identify and validate emerging technologies for use in Alaska. For example, designation of appropriate technology readiness levels, LCA projections, and TEA. The TEA model will be based on data obtained from limited testing and operation of the REE recovery systems, and with broader and more robust testing later in the performance period (Task 5). This task will help us determine (1) the detailed economics associated with the technology, (2) the areas where improvements are necessary to make it competitive with other existing technologies, and (3) a forecast for optimized production criteria for the REE recovery system. The main deliverables of the entire cost estimation will be the cost of production of REE oxides by considering the raw materials cost, amortized capital cost (Capex) including the system installation cost, operating cost (Opex) including energy cost and raw material cost, other fixed costs, and human capital costs. Production costs will be compared against the current market price of the REE oxides. The model developed will also have the capability of making economic forecasts by manipulating twenty-plus parameters including, for example: solvents, equipment materials, and membranes used for the process. The AK-TIC will broaden collaboration, testing, and ultimately integration of technologies for REE and CM extraction through purification and metal reduction ("metal making").

Task 7: Stakeholder Outreach and Education:

Subtask 7.1- Communication plans

. The project team will identify stakeholders to participate in preparing the Prioritization Matrix, and later for the Development Scenarios. Furthermore, networking with other TICs will leverage a broader level of expertise and resources to ensure success. Therefore, the Recipient will schedule quarterly virtual sessions starting in the second quarter of the project with other TICs. These meetings will define relationships, enhance development, and leverage distance learning opportunities (see Letters of Commitment).

<u>Subtask 7.2- Identify gaps in technologies and infrastructure</u>

The Recipient will leverage the networks of the Alaska Manufacturing Extension Partnership (MEP), Business Enterprise Institute (BEI), and Center for Innovation Commercialization, and Entrepreneurship (ICE) to expand and deepen our stakeholder's involvement. A comprehensive survey will be conducted to identify gaps in technology and infrastructure. Interviews with these stakeholders will be used to identify limitations, needed training, and roadblocks to producing CORE-CM in Alaska. These interviews will also be used as a starting point to build additional relationships with potential partners in the AK-TIC. This information will direct the AK-TIC on specific areas that need to be developed and validated.

D. DELIVERABLES

The periodic and final reports shall be submitted in accordance with the "Federal Assistance Reporting Checklist" and the instructions accompanying the checklist. In addition to the reports specified in the "Federal Assistance Reporting Checklist", the Recipient must provide the following to the NETL Project Manager (identified in Block 15 of the Assistance Agreement as the Program Manager).

Task / Subtask #	Deliverable Title	Due Date
1	Project Management Plan	Update due 30 days after award. Revisions to the PMP shall be submitted as requested by the NETL Project Manager.
1.1	Summary of Environmental Justice Considerations	To be included as an appendix to the Final Scientific/ Technical Report
1.2	Summary of Economic Revitalization and Job Creation Outcomes	To be included as an appendix to the Final Scientific/ Technical Report
1.3	Environmental, Safety, and Health Analysis	To be included as an appendix to the Final Scientific/ Technical Report
2	Overall CORE-CM Resource Sampling Plan providing sample locations, sampling methods for each location, and site-specific access agreements)	Due to NETL Project Manager before accessing the site.
2.1	Initial Basinal Resource Assessment	Due at the end of the Period of Performance.
2.2	Characterization and Data Acquisition Plan	Due at the end of the Period of Performance.

Task / Subtask #	Deliverable Title	Due Date
2.3	Priority Matrix/ Development Scenarios	Priority Matrix: Draft:6-months after award. Final: Due at the end of the Period of Performance
3	Initial Waste Stream Reuse Plan	Due at the end of the Period of Performance.
4	Results of the Basinal Strategies for Infrastructure, Industries and Business Assessment	Due at the end of the Period of Performance.
5	Initial Technology Assessment and Field Development Plan	Due at the end of the Period of Performance.
6	Initial Technology Innovation Center Plan	Due at the end of the Period of Performance.
7.1	Initial Stakeholder Outreach and Education Plan	Due at the end of the Period of Performance.
7.2	Identify gaps in technology and infrastructure	Due at the end of the Period of Performance.
1	Interim Report	Due to NETL Project Manager 12 months after award. This will include an outline of deliverable reports and preliminary findings to date.
2	Energy Data Exchange (EDX) FOA-2364 REE Researcher Database Template (per Appendix G of FOA 2364)	Due 60 days after data is produced. A (final) update is due at the end of the Period of Performance. State-specific, county-specific, and site-specific resource characterization and geographic location data (i.e., elemental concentrations; proximate/ultimate analyses; ash content; phase identification/concentrations; morphology information; etc.), and characterization information will be supplied to NETL and made publicly available through inclusion on NETL's EDX database platform.
2	Inputs for NETL REE-SED Sample Data Needs (per Appendices H and I of FOA 2364)	Due 60 days after data is produced. A (final) update is due at the end of the Period of Performance. This information will be supplied in the format specified in Appendix H for uploading into NETL's Geospatial EDX Database, for use in NETL RIC's Geologic Models.

Task / Subtask #	Deliverable Title	Due Date
2	Resource Samples for Mineral Characterization and Analysis	Due to NETL Technology Manager at the end of the Period of Performance. Recipients will provide NETL with a single split REE and CM sample for each type of material or core sample assessed that reflects the highest achieved REE or CM concentration identified during conduct of the project effort, and which reflects materials used by the award Recipient for their economic assessment. The quantity of sample material should be adequate for laboratory analysis of the sample. Material Safety Data Sheets (MSDS) are required to accompany material supplied to NETL.
Note: Geospatial Data Products should be compliant with requirements of the Federal Geospatial Data Act of 2018 and DOE's Geospatial Data Strategy https://www.energy.gov/cio/downloads/doe-geospatial-data-management-strategy-2021-2025		

E. BRIEFINGS/TECHNICAL PRESENTATIONS

The Recipient shall prepare detailed briefings for presentation to the FPM at the FPM's facility (or virtually at DOE's discretion), and to the Technology Manager(s) (TMs) located in Pittsburgh, PA, or Morgantown, WV (or virtually at DOE's discretion). The Recipient will make a presentation to the FPM and TMs at a kick-off meeting to be held within ninety (90) days of the award. Project progress will be formally presented at an annual NETL Annual Project Review Meeting. Annual briefings shall also be given by the Recipient to explain the plans, progress, and results of the technical effort and a final project briefing at the close of the project shall also be given.