CX Posting No.: DOE-ID-INL-21-022 R1

SECTION A. Project Title: Development of a real-time, conveyor mounted detection, classification, and sortation system for contaminants (MSW Characterization)

SECTION B. Project Description and Purpose:

Revision 1:

AMP Robotics (AMP), in partnership with Idaho National Laboratory (INL) and Michigan Technological University (Michigan Tech), propose development of a real-time, conveyor mounted detection, and classification system using artificial neural networks (ANNs) to identify contamination within the commodity streams that can be separated out of municipal solid waste (MSW) and residue from materials recycling facilities (MRF) in the form of “whole material contamination” (e.g., metal or glass in a residual paper stream) and “contact contamination” (e.g., remaining film/gunk in or on plastic containers). These material streams, otherwise destined for landfills, are viable feedstock for bioenergy conversion processes such as pyrolysis for waste-to-energy and waste-to-fuel applications.

However, understanding the effects of varying levels and types of contamination to this process yield is in its infancy are poorly understood. Amp Robotics will lead this project in designing and fabricating a conveyor-mounted, AMP Neuron vision system with Near infrared/shortwave infrared (NIR/SWIR 1000 nm to 1700nm wavelengths) cameras. This system will be shipped to INL and utilized to collect contamination data on waste materials. Amp will source pre-sorted waste materials and will send these to INL. They may include the following: polyethylene, polypropylene, polystyrene, flexible film packaging, polyethylene terephthalate (PET), PVC, polylactic acid (PLA), #7 plastic, multi-layer flexible packaging, empty containers of cleaning solution, drain cleaner, bleach, hydrogen peroxide, alkaline batteries, electronic circuit boards, aerosol cans, empty propane containers, paper containers, cardboard, paper, wood waste, yard waste, metal cans, aluminum foil, steel cans, and glass.

INL will analyze these materials using the NIR/SWIR cameras and will collect these data to send to Amp Robotics. The Amp system will be located at the Energy System Laboratory (ESL) in the INL’s Biomass Feedstock National User Facility (BFNUF) bay. Waste to be generated will be all materials deemed unsuitable for pyrolysis including PET, PVC, PLA, empty containers of cleaning solutions, drain cleaner, bleach, hydrogen peroxide, cardboard, paper, wood waste and yard waste, metal cans, aluminum foil, steel cans and glass. Plastic materials will be size reduced and sent to Michigan Tech for pyrolysis experiments. INL will receive the Amp system which will remain at INL at the end of the project.

The subtasks are described below:

Subtask 2.5: “Sensor identification, development and down selection”. Amp Robotics is responsible for this task which will assess different kinds of sensors that detect other wavelengths of light such as near infrared and shortwave infrared. The selected sensors will be installed on the unit that will be sent to INL.

Subtask 2.6 - Assemble and Install Budgeted Equipment (M1-M3) – Amp (Sponsor) will fabricate one (1) conveyor-mounted, AMP Neuron vision system with the sensor suite identified previously. This system will be delivered and installed at INL and used as the primary means of gathering sensor data to describe the contaminant material properties. A duplicate system will be installed at Amp. By duplicating the same sensor array at both AMP and INL, it will ensure a uniform artificial neural network (ANN) response from development and test through to verification.

Subtask 3.2: Sensor and Physical Characterization (MSW Batch #2) (M4-M5) Materials will be passed through the conveyor belt sensing system created, delivered, and installed to INL in Subtask 2.6. Should additional sensing spectrums (e.g., MIR, UV, XRF) be deemed necessary, the material will also be passed through the BFNUF sensing equipment. This process will be repeated to examine all sides of 3D materials and both sides of flat materials. If additional material attribute characterization is needed, representative pieces of each material type will also be examined with a Raman microscope and fluorescent confocal microscope. Samples will be collected from each material, milled to 2 mm particle size and characterized depending on material type. Organic materials will receive chemical compositional analyses while plastic materials will be analyzed for Proximate/Ultimate properties. Samples will also be sent to an external laboratory for elemental analyses if the XRF does not provide sufficient resolution of low molecular weight elements. The INL has current DoD funding to characterize aspects of the waste materials with NIR. XRF and Raman microscopy have been used to characterize biomass including corn stover and wood residues. They have not yet been explicitly used to characterize MSW, but it is straightforward to adapt these techniques for waste materials and the purpose of this program to better understand this process. XRF sensing and confocal microscopes are two of many laboratory sensing elements available to the project team through INL. Use of laboratory sensing in the first stages of the project allows the project team to formulate a fundamental material science understanding of the materials under investigation and informs what sensing paradigms should be considered for online system development. XRF technology has shown to be effective in identifying metal and glass, which are damaging to pyrolysis processes. This technology has successfully been deployed in real-time, online production systems.

Subtask 3.3: Ship MSW Batch #2 Samples for Pyrolysis Characterization (M5) – Samples of the MSW materials recorded in subtask 3.2 will be collected by INL, preprocessed to 1 cm nominal size and delivered to MTU for pyrolysis studies.

Subtask 3.7: Sensor and Physical Characterization (MSW Batch #3) (M5-M6) Repeat the process stated in Subtask 3.2 on Batch #3 material.

Subtask 3.8: Ship MSW Batch #3 Samples for Pyrolysis Characterization (M6) – Samples of the MSW materials recorded in subtask 3.7 will be collected by INL, preprocessed to 1 cm nominal size and delivered to MTU for pyrolysis studies.

Subtask 3.9: “Pyrolysis characterization” This task is MTU’s and will pyrolyze plastic materials that INL will send to them.

Subtask 3.10: “Sensor data annotation” and Amp Robotics is responsible. They will take the data INL collects using the Amp unit at INL and will characterize it.

Subtask 3.11: “Initial ANN training, refinement and performance assessment”. Amp Robotics is responsible for this and they will take all of the data collected by INL and MTU and feed it into their ANN (artificial neural network).

Subtask 3.13: Sensor and Physical Characterization (MSW Batch #4) (M12-M15) Repeat the process stated in Subtask 3.2 on Batch #4 low confidence MSW material. Select representative MSW samples, preprocess to 1 cm nominal size and ship to MTU.

Original ECP:

AMP Robotics (AMP) and Idaho National Laboratory (INL) propose to develop a multimodal sensor that can identify, in real time, the organic and plastic constituents of the municipal solid waste (MSW) stream diverted to landfills and characterize their Critical Material Attributes (CMAs), such as moisture content, caloric content, ash content, total volatile solids, etc., which are important to the success of downstream waste to energy processes such as gasification, incineration, pyrolysis, etc. This sensor would be applied to identify MSW objects on a conveyor belt prior to and after size reduction. The proposed sensor is a computing system that is an artificial neural network (ANN) designed to process information in a manner similar to the human brain and combines signals from optical, UV, VIS, NIR, MIR, structural (3D) and XRF sensors.

AMP seeks to show viability of applying this ANN technique to advanced sorting of feedstock for biofuel, bioproduction, and biopower markets. This goal will be achieved by leveraging AMP’s vision-based ANN infrastructure for recyclable materials and INL’s Biomass Feedstock National User Facility (BFNUF). The project has two primary objectives: (1) Demonstrate a multimodal ANN-based technique can identify MSW material categories at >90% classification accuracy and (2) Provide recommendations for a reduced sensor and spectrum range by at least 30% to enhance data processing speed while preserving >90% accuracy to guide sensor cost reduction. This work will be achieved through three budget periods described in the Technical Scope Summary below.

Technical Scope Summary

Budget Period 1 – Initial Verification (Benchmark Validation) - The initial verification is to confirm benchmark data and assumptions to establish the baseline against which future performance and cost improvements will be evaluated. The verification will also establish that the recipient has the capabilities and resources to perform the proposed project.

The first budget period focuses on establishing a benchmark for current state of the art, high-speed waste identification using the recipient’s commercial vision-based ANN (Neuron Vision System). This system has been developed for municipal recycling facilities (MRFs) with over 30 subcategories of materials (e.g., PET, HDPE, cartons, etc.).

The recipient will receive the first of a sequence of MSW plastic and organic materials to verify the ability to source test material and apply the vision-based ANN. The vision-based ANN benchmark assessment will guide which material categories warrant further investigation using multimodal sensing techniques for more accurate classification.

A Go/No-Go (GNG) decision is made after verification.

Budget Period 2 – System Design, Construction, and Verification - The second budget period includes efforts to establish baseline classification accuracy for a full-spectrum, multimodal ANN approach to plastic and organic MSW material identification. The development efforts within this period include establishing the sensor test equipment and processes at INL necessary to conduct multi spectrum analysis of MSW samples, developing ANN architectures to evaluate during training and test iterations, updating recipient’s data annotation tool (Toolkit) to support multimodal sensor input, and sourcing MSW test material identified in Budget Period 1 for initial data capture and training.

These efforts are applied by processing the test material through the laboratory equipment, annotating the resulting sensor data into training and test sets, training ANNs, and then quantifying performance on the test data sets. Throughout this process, materials with low ANN confidence will be identified. As low confidence materials are identified, additional material will be delivered to INL for further iterations of the process. This will culminate in establishing a baseline classification accuracy using full spectrum ANN analysis for organic and plastic material categories.

Go/No-Go Decision Point 2 - The expected end results of this phase of development include a multimodal ANN that delivers >20% classification improvement over the benchmark established in Budget Period 1 when applied to both organic and plastic MSW materials, and improvements to the Toolkit data annotation tool to support multimodal sensor input.

Budget Period 3 – Sensor and Performance Refinement - The final budget period will focus on identifying the reduced sensor spectrum necessary to preserve high classification accuracy while targeting a fieldable sensor configuration. This will be achieved through understanding and quantifying what constitutes a minimally viable set of sensor data to preserve at least 90% or greater classification accuracy as compared to the baseline established in Budget Period 2. The recipient will review and analyze the collected data to identify primary sensors and/or spectrum bands that contribute to the accuracy of the ANN. A statistical assessment (e.g., Pareto, sensitivity) will be performed to identify additional ANNs with varying mixtures of sensor and spectrum composition to refine and narrow the sensor requirements while maintaining ANN performance.

Tasks To Be Performed

Budget Period 1 – Benchmark Verification

Task 1.0: Initial Verification (M1-M3).

Subtask 1.1: MSW Receipt for Benchmark (M1) – INL will receive the first of a sequence of waste plastic and organic materials from MSW provider. These materials will be sorted into the material categories of interest and characterized (i.e. material count and mass) to provide ground truth to compare ANN classification against. The shipment will be one (1) 48”x40”x48” pallet container of approx. 200 sorted objects.

Subtask 1.2: Perform Benchmark with Vision-based ANN (M2-M3) - The material will be placed on conveyors to which a vision system is attached. The material will then be run under the vision system while a production vision ANN classifies the material in real-time. Each material category will be run in isolation to best assess classification accuracy as compared to the manually characterized ground truth. Moreover, this benchmark will also inform contamination differences of the target materials between MRF and MSW material streams.

Budget Period 2 – System Design, Construction, and Verification (M4-M17)

Task 2.0: System Design and Construction (M4-M9)

Subtask 2.1: Procure and Install Budgeted Equipment (M4-M6) - Fabricate two (2) vision systems with 3D sensing. One unit will be installed and commissioned at INL facility and the second will be installed and commissioned at the AMP facility. AMP conducted preliminary research into the field of 3D sensing during the summer of 2019 and concluded the Ensenso N35 and Intel RealSense are worth pursuing in this space.

Subtask 2.2: Configure Sensor Array and Calibration (M7-M9) - The project team will define and design methods to calibrate and align sensor data.

Subtask 2.3: Develop Artificial Neural Network (ANN) Architecture (M4-M9) - A literature search investigation into applicable ANN architectures and sensor fusion techniques relevant to multimodal sensor fusion will be performed to identify suitable architectures. Candidate architectures will be implemented and syntactically corrected with mock sensor data. A subset of architectures will be selected showing the most alignment and potential for multimodal sensor fusion for MSW material. These architectures will be implemented in the ANN framework and prepared for application in Subtask 3.5. It is understood that continued refinement of the ANNs will be performed in Subtask 3.5 where actual sensor data will be available to accurately tune and confirm sensor fusion techniques.

Subtask 2.4: Enhance Multimodal Data Annotation Tool (M4-M9) – AMP’s Toolkit has been developed and refined over several years to streamline the image annotation process extracting portions of the frame, associating metadata (e.g., type of material), and feeding ANN creation. This Toolkit will be modified to receive and display multimodal sensor data for annotation feeding the ANN creation pipeline.

It is envisioned that the modification to this tool to support multimodal sensor data will be a layered concept. The visual spectrum image will reside as the top layer which the annotator can view to understand the material edge. Each of the subsequent spectrums (near IR, mid IR, UV, etc.) which are pixel-based images will be calibrated and oriented to match the visual spectrum as additional layers. As the annotator draws the polygon on the visual image, the bounding box will permeate through the various aligned layers to create multimodal annotations from one “stack” of images. This same concept will be extended to annotate 3D image data (e.g., depth images) introducing the ability to rotate the image in three dimensions to correctly draw and capture the appropriate spatial bounding box.

Task 3.0: Characterization of MSW Fractions (M10-M17) - A shipment of MSW material will be received from Cascadia and separated into the material categories identified from GNG 1 and characterized (count and mass) to establish ground truth. The material samples will be further characterized through data collection via the sensor suite and physical processes to build separate ANN training and test data sets. Initial ANN training will be compared to characterized and separated ground truth and low confidence materials will be identified for further data collection, annotation and ANN training to strengthen the classification accuracy.

Subtask 3.1: MSW Receipt for Sensor Characterization (M10) – INL will receive additional MSW material from Cascadia. These materials will be stabilized through drying at room temperature and processed into the Biomass Feedstock Library with an identifying barcode that contains the type of material and manufacturer if possible.

Subtask 3.2: Sensor Characterization (M10 - M11) - Materials will then be placed on a conveyor belt and be passed under the Neuron for visual identification, 3-D detection followed by the NIR, MIR, UV and XRF sensors on the same conveyor. This process will be repeated to examine all sides of 3-D materials and both sides of flat materials. Representative pieces of each material type will also be examined with a Raman microscope and fluorescent confocal microscope if additional material attribute characterization is needed.

Subtask 3.3: Physical Characterization (M11 - M12) - Samples will be collected from each material type, milled to 2 mm particle size and characterized depending on material type. Organic materials will receive chemical compositional analyses while plastic materials will be analyzed for Proximate/Ultimate properties. Samples will also be sent to Huffman/Hazen labs for elemental analyses if the XRF does not provide sufficient resolution of low molecular weight elements.

Subtask 3.4: Sensor Data Annotation (M12-M13) - The sensor data collected in Subtask 3.2 and characterization data collected in Subtask 3.3 will be compiled into suitable digital formats for the modeling team. Sensor data will serve as features in supervised modeling approaches and likely consist of “n” channel 2-D pixel arrays and tabular spectral readings that will be preprocessed based on specifications provided by the modeling team. The physical characterization results will be annotated to match specific sensor data to be suitable for use as labels for supervised model development. This data will be staged for annotation through the modified Toolkit in preparation for ANN creation.

Subtask 3.5: Initial ANN Training and Performance Assessment (M13 - M15) - The annotated training sensor data will be used to create an initial multimodal ANN. The subset of architectures identified in Subtask 2.3 will be comparatively evaluated on the annotated test sensor data and ground truth waste characterization for performance assessment. It is expected that certain material categories will have low classification confidence at this stage of development. The low confidence material categories will be communicated to the MSW material provider to source additional material for delivery in Subtask 3.6.

Subtask 3.6: Targeted ANN Training on Low Confidence Material (M15-M17) – The requested low confidence material will be received from Cascadia. The process outlined in Subtask 3.1 through Subtask 3.5 will iterate to capture sensor data of this new material.

Budget Period 2 Go/No-Go Decision Point (M17):

At this stage of the project a single iteration of the ANN training process will have been completed. If the desired >20% performance metric improvement is not achieved, a determination of which material categories are under performing will be conducted with alternative pathways proposed (e.g., additional sensor modalities, further iterations of neural network trainings, alternative ANN backbone architectures, etc.) to either continue with the ANN techniques implemented for the performant material categories or alternative techniques to bring the lower confidence materials up to parity.

Budget Period 3 – Sensor and Performance Refinement (M18-M28)

Task 4.0: Identify Reduced Sensor Spectrum (M18-M23)

Subtask 4.1: Refine ANN from Reduced Sensor Spectrum (M18-M23) An investigation into sensor signatures or “fingerprint” for each material category will be performed to identify prominent spectrums (high signal) and superfluous spectrums (high noise) to identify an optimal reduced sensor spectrum. Three levels of ANNs will be targeted to investigate the effects of varying level of spectrum reduction:

1. Full spectrum (existing from Milestone 3.0)

2. Minor spectrum reduction

3. Aggressive spectrum reduction

Training and test data will be filtered to the reduced spectrums allowing for the minor and aggressive spectrum reduction ANNs to be created. Performance of the three ANNs will be compared and iterated upon to identify an optimal balance of classification accuracy with reduced spectrum input.

Task 5.0: Final Verification (M24-M28) - Performance data from unsorted, unseen material will be collected at INL to compare and validate performance of the generated ANNs. Final refinement to ANN tuning parameters and iterations of test material will be conducted to demonstrate stated classification accuracy of MSW material via a multimodal ANN across a range of conveyor belt speeds and to determine which spectrums contribute most heavily to ANN accuracy through statistical assessment (e.g., Pareto, sensitivity, etc. analysis).

Subtask 5.1: MSW Receipt for Final Test (M24) - INL will receive a final delivery of characterized MSW material from the MSW provider. The difference with this delivery is that the material will be unsorted in an effort to mimic real-world infeed of MSW material.

Subtask 5.2: Test ANN on Unsorted Material (M25-M27) - The unsorted test material will be run through INL's laboratory system. The three ANNs will be run live on the test data and performance will be determined as compared to ground truth characterization. If the complexity of the ANN and sensor interfaces cannot be operated in real-time to provide a live assessment, the sensor data will be recorded and fed through the ANNs for off-line performance assessment. A total of nine (9) runs of the test material will be conducted to quantify ANN precision accounting for material orientation and belt speed variability. Three (3) test runs will be conducted at each low (~100 fpm), medium (~200 fpm), and fast (~300 fpm) belt speeds.

Subtask 5.3: Prepare Final Report of ANN Performance on Unsorted Material (M28) - A comparison of the classification accuracy of the three ANNs across the tests performed in Subtask 5.2 will be quantified and compared to the material characterization ground-truth.

Task 6.0: - Techno-economic Analysis (TEA) and Life-cycle Analysis (LCA) (M7-M27) - The goals of this task include providing economic and environmental feasibility decision support to the overall project through integration of project results into techno-economic and life cycle analyses.

Subtask 6.1: Develop an Initial TEA Model (M7 – M12) - The project team will develop an initial model that describes the multimodal ANN performance integrated into high-speed devices for sorting MSW for several downstream waste-to-energy processes. The model will include assumptions and cost factors. These scenarios represent the downstream markets. Thermochemical conversions are diverse, and low moisture and high moisture content scenarios will be used. The mass balance, energy balance, and project performance results will be used to feed into further TEA refinement and LCA creation as further specifics of the propose technology approach are defined.

Subtask 6.2: Refine Initial TEA Model to Interim Model (M13 – M17) - The project team will refine the TEA model created in Subtask 6.1 incorporating preliminary ANN training results from the full spectrum sensor suite obtained in Subtask 3.3 and 3.5.

Subtask 6.3: Final Techno-economic Analysis and Modeling (M22 – M27) - A techno-economic analysis (TEA) for sorting a mixed MSW stream to recover value will be performed to assess the overall value of using the proposed technology. The experimental work can be scaled and integrated into industrial scale processes (up to 500 tons/day) to examine how the process would perform at commercial scales. The model will account for the equipment that contact the feedstock from the time. The costs and performance will be compared with the existing technical baselines (e.g., vision-based artificial neural networks in recycling, near-infrared sensors in recycling) established in Task 1 and contrasted to the costs of the refined sensor spectrum identified in Task 4. TEA will identify major cost drivers (e.g., sensors) and improvement opportunities (e.g., sensor deployment) for the proposed technology.

Subtask 6.4: Life-cycle Analysis (M18 – M27) - A life-cycle analysis (LCA) for sorting a mixed MSW stream to recover value will be performed applying the Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts (TRACI) developed by the U.S. Environmental Protection Agency. SimaPro 9 software in conjunction with the latest Ecoinvent 3.7, GREET, USLCI, and other databases will be referenced to quantify the environmental impact of the commercial operation of the proposed technology. The environmental potential will be compared with the existing baselines (e.g., purity, variability, and contamination of existing feedstock for selected conversion pathways).

Task 7.0: Project Management (M1 - M28) – Reports and other deliverables will be provided in accordance with Federal Assistance Reporting Checklist (FARC) following the instructions discussed and agreed upon. AMP Robotics and INL will be operating elements of this program at different facilities. INL is primarily responsible for collecting data via the sensor system of MSW components; AMP Robotics is going to undertake the modelling efforts to refine the computer vision algorithms. Each location's team will interact daily over the course of the project.

The test system will be setup and operated in the INL Research Center Room 104. AMP Robotics is providing a sensor platform that will be mounted to a small conveyor. Cascadia will provide the MSW. They have been instructed to supply only non-hazardous materials meeting project specifications. Another sensor system will be installed at the recycling facility as testing progresses.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

Note: If this project or activity produces or causes air emissions, and it is not stated in this ECP how those emissions caused by this project or activity are exempt, then an APAD is required for documentation. N/A

Discharging to Surface-, Storm-, or Ground Water

N/A

Disturbing Cultural or Biological Resources

N/A

Generating and Managing Waste

Generation of waste will include materials deemed unsuitable for pyrolysis such as: PET, PVC, PLA, empty containers of cleaning solutions, drain cleaner, bleach, hydrogen peroxide, cardboard, paper, wood waste and yard waste, metal cans, aluminum foil, steel cans and glass. Only non-hazardous material waste meeting project specifications will be supplied. The amount of waste generated will amount to 100 kg. Some PPE may be generated.

Releasing Contaminants

When chemicals are used, there is the potential the chemicals could be spilled to air, water, or soil.

Using, Reusing, and Conserving Natural Resources

All materials will be reused and recycled where economically practicable. All applicable waste will be diverted from disposal in the landfill where conditions allow. Being conscientious about the types of materials used could reduce the impact to our natural resources Project activities may release known greenhouse gases (GHGs) to the atmosphere and increase INL's energy use.

SECTION D. Determine Recommended Level of Environmental Review, Identify Reference(s), and State Justification: Identify the applicable categorical exclusion from 10 Code of Federal Regulation (CFR) 1021, Appendix B, give the appropriate justification, and the approval date.

For Categorical Exclusions (CXs), the proposed action must not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, or similar requirements of Department of Energy (DOE) or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment or facilities; (3) disturb hazardous substances, pollutants, contaminants, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources (see 10 CFR 1021). In addition, no extraordinary circumstances related to the proposal exist that would affect the significance of the action. In addition, the action is not "connected" to other action actions (40 CFR 1508.25(a)(1) and is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1608.27(b)(7)).

References:

10 CFR 1021 Appendix B to subpart D, Item B3.6, "Small-scale research and development, laboratory operations, and pilot projects" and B1.24 "Property Transfers"

Justification:

The proposed R&D activities are consistent with CX B3.6 "Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); small-scale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions, provided that construction or modification would be within or contiguous to a previously disturbed area (where active utilities and currently used roads are readily accessible). Not included in this category are demonstration actions, meaning actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment.", B1.24, "Transfer, lease, disposition, or acquisition of interests in personal property (including, but not limited to, equipment and materials) or real property (including, but not limited to, permanent structures and land), provided that under reasonably foreseeable uses (1) there would be no potential for release of substances at a level, or in a form, that could pose a threat to public health or the environment and (2) the covered actions would not have the potential to cause a significant change in impacts from before the transfer, lease, disposition, or acquisition of interests."

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act) ☐ Yes ☒ No

Approved by Jason L. Anderson, DOE-ID NEPA Compliance Officer on: 06/21/2022