California Energy Commission
January 24, 2024 Business Meeting
Backup Materials for Agenda Item No 08:
The Regents of the University of California, on behalf of the Berkeley Campus

The following backup materials for the above-referenced agenda item are available in this PDF packet as listed below:

1. Proposed Resolution
2. Grant Request Form
3. Scope of Work

RESOLUTION NO: 24-0124-08

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION: **The Regents of the University of California, on behalf of the Berkeley Campus**

RESOLVED, that the State Energy Resources Conservation and Development Commission (CEC) adopts the staff CEQA findings contained in the Agreement or Amendment Request Form (as applicable); and

RESOLVED, that the CEC approves agreement PIR-23-010 with The Regents of the University of California, on behalf of the Berkeley Campus, for a $3,000,000 grant to demonstrate the coupling of remote and embedded sensing technologies with an open-source seismic risk assessment tool. This demonstration project will take place in Alameda, Contra Costa, and Santa Clara counties, and will assess current conditions, predict future reliability of gas pipeline infrastructure, and inform appropriate prioritization of natural hazard and seismic risk mitigation measures; and

FURTHER BE IT RESOLVED, that the Executive Director or their designee shall execute the same on behalf of the CEC.

CERTIFICATION

The undersigned Secretariat to the CEC does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the CEC held on January 24, 2024.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

_____
Kristine Banaag
Secretariat

STATE OF CALIFORNIA
CALIFORNIA ENERGY COMMISSION

CEC-270 (Revised 9/2022)

GRANT REQUEST FORM (GRF)

A. New Agreement Number

IMPORTANT: New Agreement # to be completed by Contracts, Grants, and Loans Office.

New Agreement Number: PIR-23-010

B. Division Information

1. Division Name: ERDD
2. Agreement Manager: Pooya Khodaparast
3. MS-:51
4. Phone Number: N/A

C. Recipient's Information

1. Recipient's Legal Name: The Regents of the University of California on behalf of the Berkeley campus
2. Federal ID Number: 94-6002123

D. Title of Project

Title of project: Performance-based Monitoring and Risk Assessment Tool for Gas Pipelines under Natural Forces

E. Term and Amount

1. Start Date: 2/12/2024
2. End Date: 1/31/2027
3. Amount: $3,000,000.00

F. Business Meeting Information

1. Are the ARFVTP agreements $75K and under delegated to Executive Director? No
2. The Proposed Business Meeting Date: 1/24/2024 .
3. Consent or Discussion? Discussion
4. Business Meeting Presenter Name: Pooya Khodaparast
5. Time Needed for Business Meeting: 5 minutes.
6. The email subscription topic is: NaturalGas (NG Research Program).

Agenda Item Subject and Description:

The Regents of the University of California on behalf of the Berkeley Campus. Proposed resolution approving agreement PIR-23-010 with The Regents of the University of California on behalf of the Berkeley Campus for a $3,000,000 grant to demonstrate the coupling of remote and embedded sensing technologies with an open-source seismic risk assessment tool, and adopting staff's determination that this action is exempt from CEQA. This demonstration project will take place in Alameda, Contra Costa, and Santa Clara counties, and will assess current conditions, predict future reliability of gas pipeline infrastructure, and inform appropriate prioritization of natural hazard and seismic risk mitigation measures. (Gas R&D funding) Contact: Pooya Khodaparast

G. California Environmental Quality Act (CEQA) Compliance

1. **Is Agreement considered a "Project" under CEQA?**
   Yes

If yes, skip to question 2.

If no, complete the following (PRC 21065 and 14 CCR 15378) and explain why Agreement is not considered a "Project":

Agreement will not cause direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment because:

2. If Agreement is considered a "Project" under CEQA answer the following questions.

a) Agreement **IS** exempt?

Yes

Statutory Exemption?
No

If yes, list PRC and/or CCR section number(s) and separate each with a comma. If no, enter "None" and go to the next question.

PRC section number: None

CCR section number: None

Categorical Exemption?
Yes

If yes, list CCR section number(s) and separate each with a comma. If no, enter "None" and go to the next question.

CCR section number: Cal. Code Regs., tit. 14, § 15301 ; Cal. Code Regs., tit. 14, § 15306 ;

Common Sense Exemption? 14 CCR 15061 (b) (3)
No

If yes, explain reason why Agreement is exempt under the above section. If no, enter "Not applicable" and go to the next section.

This project will demonstrate the use of remote and embedded sensing technologies to monitor and gain insights into the performance of gas infrastructure assets in California and manage risk through a complete system approach that includes sensors, field data collection, data management and analysis, and risk assessment. Sensing technologies will be deployed at two field sites and large-scale experimental sites. Data collected will be coupled with an open-source integrated monitoring and seismic risk assessment tool in predictive modeling and data analytics (called OpenSRA II) for gas pipeline infrastructure portfolio managers to assess the current condition and predict the future reliability of gas pipeline infrastructure components and systems. The project will increase gas system safety and reliability by enabling more accurate identification of at-risk infrastructure.

California. Code Regs., tit 14, section 15301 provides that projects which consist of the operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, and which involve negligible or no expansion of existing or former use, are categorically exempt from the provisions of the California

Environmental Quality Act. This project will collect data using various sensing technologies to monitor and gain insights into the performance of gas pipeline infrastructure and manage risk. The sensing technologies are divided into two groups: remote and embedded sensing technologies. Tested remote sensing technologies will include (i) satellite-based interferometric synthetic aperture radar (InSAR) technology, (ii) light detection and ranging (LiDAR), (iii) optical cameras, and (iv) infrared and multispectral cameras. Tested embedded sensors will include (i) static distributed fiber optic strain sensors, (ii) dynamic distributed fiber optic acoustic sensors, (iii) distributed fiber optic temperature sensors, and (iv) Low Range Wide Area Network (LoRaWAN) with low-cost sensors for strain/tilt/temperature/soil moisture measurements. The sensing technologies will be coupled with OpenSRA II, a system seismic risk assessment methodology, and open-source software in predictive modeling and data analytics under uncertain scenarios. The project will be conducted at two field sites, the northern section of East Bay Hills-San Pablo along the Hayward Fault and a site in Gilroy on the Calaveras Fault, as well as at large-scale experimental sites. The sensing technologies that will be utilized at field and experimental sites will consist of minor modifications that will not result in expanding the capacity or use of the existing facilities.

This project is also exempt under California Code Regs., tit 14, section 15306 which provides that projects which consist of basic data collection, research, experimental management, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource are categorically exempt from the provisions of the California Environmental Quality Act. This project will collect data within the two field sites located in the East Bay Hills-San Pablo and Gilroy areas in real-time, for at least 12 months. Remote and embedded sensing approaches to data collection will facilitate monitoring of geohazard impacts under any natural hazard ground motion scenario (i.e., earthquake, landslide, subsidence, and liquefaction). The instruments will be accessed remotely to obtain the data recorded. With the data, a digital twin of these sites will be created that will be used to monitor continuously, map ground activity, and perform simulations to understand the impact of ongoing processes and future ground movement scenarios on the gas pipeline system. The data will be incorporated into a user-friendly, integrated monitoring and risk assessment tool (called OpenSRA II) for gas pipeline infrastructure portfolio managers. These activities will not result in a serious or major disturbance to an environmental resource.

For these reasons, the proposed work will not have any significant effect on the environment and falls under the exemptions in sections 15301 and 15306.

This project will not impact an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies; does not involve impacts on any particularly sensitive environment; does not involve any cumulative impacts of successive projects of the same type in the same place that might be considered significant; does not involve unusual circumstances that might have a significant effect on the

environment; will not result in damage to scenic resources within a highway officially designated as a state scenic highway; the project site is not included on any list compiled pursuant to Government Code section 65962.5; and the project will not cause a substantial adverse change in the significance of a historical resource. Therefore, none of the exceptions to categorical exemptions listed in CEQA Guidelines section 15300.2 apply to this project and this project will not have a significant effect on the environment.

b) Agreement **IS NOT** exempt.

IMPORTANT: consult with the legal office to determine next steps.

No

If yes, answer yes or no to all that applies. If no, list all as “no” and “None” as “yes”.

Additional Documents	Applies
Initial Study	No
Negative Declaration	No
Mitigated Negative Declaration	No
Environmental Impact Report	No
Statement of Overriding Considerations	No
None	Yes

H. Subcontractors

List all Subcontractors listed in the Budget (s) (major and minor). Insert additional rows if needed. If no subcontractors to report, enter “No subcontractors to report” and “0” to funds. **Delete** any unused rows from the table.

Subcontractor Legal Company Name	CEC Funds	Match Funds
Slate Geotechnical Consultants Inc.	$ 675,000	**$**0
Lawrence Berkeley National Laboratory	$ 450,000	**$**0

I. Vendors and Sellers for Equipment and Materials/Miscellaneous

List all Vendors and Sellers listed in Budget(s) for Equipment and Materials/Miscellaneous. Insert additional rows if needed. If no vendors or sellers to report, enter “No vendors or sellers to report” and “0” to funds. **Delete** any unused rows from the table.

Vendor/Seller Legal Company Name	CEC Funds	Match Funds
No vendors to report	**$**	**$**

J. Key Partners

List all key partner(s). Insert additional rows if needed. If no key partners to report, enter “No key partners to report.” **Delete** any unused rows from the table.

Key Partner Legal Company Name
No key partners to report

K. Budget Information

Include all budget information. Insert additional rows if needed. If no budget information to report, enter "N/A" for "Not Applicable" and "0" to Amount. **Delete** any unused rows from the table.

Funding Source	Funding Year of Appropriation	Budget List Number	Amount
NG Subaccount, PIERDD	21-22	501.001	$ 3,000,000

TOTAL Amount: $ 3,000,000

R&D Program Area: ESRB: ETSI

Explanation for "Other" selection Not applicable

Reimbursement Contract #: Not applicable

Federal Agreement #: Not applicable

L. Recipient's Contact Information

1. Recipient's Administrator/Officer

Name: Jeffrey Bui

Address: 1608 Fourth Street, Suite 220

City, State, Zip: Berkeley, CA 94720-1749

Phone: 510-643-2734

E-Mail: jeffreybui@berkeley.edu

3. Recipient's Project Manager

Name: Kenichi Soga

Address: 760 Davis Hall, University Of California, Berkeley

City, State, Zip: Berkeley, CA 94720-1710

Phone: 510-664-7534

E-Mail: soga@berkeley.edu

M. Selection Process Used

There are three types of selection process. List the one used for this GRF.

Selection Process	Additional Information
Competitive Solicitation #	GFO-22-503
First Come First Served Solicitation #	Not applicable
Other	Not applicable

N. Attached Items

1. List all items that should be attached to this GRF by entering “Yes” or “No”.

Item Number	Item Name	Attached
1	Exhibit A, Scope of Work/Schedule	Yes
2	Exhibit B, Budget Detail	Yes
3	CEC 105, Questionnaire for Identifying Conflicts	Yes
4	Recipient Resolution	No
5	Awardee CEQA Documentation	No

Approved By

Individuals who approve this form must enter their full name and approval date in the MS Word version.

Agreement Manager: Pooya Khodaparast

Approval Date: 12/15/2023

Branch Manager: Rey Gonzalez

Approval Date: 12/15/2023

Director: Rey Gonzalez for Jonah Steinbuck

Approval Date: 12/15/2023

Exhibit A
Scope of Work

I. TASK ACRONYM/TERM LISTS

A. Task List

Task #	CPR [1]	Task Name
1		General Project Tasks
2		Demonstration of Remote Sensing Application at East Bay Hills – San Pablo Site
3		Demonstration of Remote Sensing Application at Gilroy Field Site
4		Demonstration of Embedded Sensing Application at Gilroy Field Site
5	X	Demonstration of Embedded Sensing Application at Large-Scale Site Experiments
6		Development of *OpenSRA II*
7	X	User Workshop and Bi-Annual User Feedback
8		Evaluation of Project Benefits
9		Technology/Knowledge Transfer Activities

B. Acronym/Term List

Acronym/Term	Meaning
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CEC	California Energy Commission
CPR	Critical Project Review
CPT	Cone Penetration Test
DFOS	Direct Fiber Optic Sensor
GHG	Greenhouse Gas
GIS	Geographic Information System
GNSS	Global Navigation Satellite Systems
InSAR	Interferometric Synthetic Aperture Radar
LiDAR	Light Detection and Ranging
LoRAWAN	Low Range Wide Area Network
SfM	Structure from Motion
TAC	Technical Advisory Committee
WSN	Wireless Sensor Network

[1] Please see subtask 1.3 in Part III of the Scope of Work (General Project Tasks) for a description of Critical Project Review (CPR) Meetings.

II. PURPOSE OF AGREEMENT, PROBLEM/SOLUTION STATEMENT, AND GOALS AND OBJECTIVES

A. Purpose of Agreement

The purpose of this Agreement is to fund the evaluation of the capabilities and uses of sensing technologies and assess gas utilities' readiness for their uses. The goal is focused on using sensing technologies to assess the current condition and predict the future reliability of gas pipeline infrastructure components and systems using the integrated monitoring and risk assessment tool (called *OpenSRA II*) to be developed in this project. The previous version, OpenSRA I, was previously developed by the Recipient team with funding from the CEC under PIR-18-003 and this project will enhance the capabilities of the tool.

OpenSRA II will consider four levels of assessment depending on the nature of the data, and different analytical methods are utilized for each level. Level 1 analyses utilize data that are geospatially continuous at a uniform resolution over the entire state of California. These analyses have lower data resolution and are not informed by detailed site data, which leads to very high uncertainty of earthquake effects.

Level 2 analyses utilize data produced at regional scales collected at higher resolution than Level 1 data but are not necessarily geospatially continuous over the entire state of California. These analyses may be informed by subsurface data or estimated engineering properties. Level 2 analyses have high uncertainty, but less than that at Level 1.

Level 3 analyses utilize site-specific data such as Cone Penetration Test (CPT) data or 1:24,000 scale or larger geologic maps to evaluate geohazards or the response of gas infrastructure to ground shaking or ground deformation. Level 3 data enable assessment with medium uncertainty, which is less than possible with Level 2 data.

Level 4 analyses utilize high-quality geotechnical laboratory test data such as strength tests on "undisturbed" soil samples to enable the performance of advanced numerical analyses. They will have the least uncertainty in evaluating the response of gas infrastructure to ground shaking or ground deformation.

B. Problem/ Solution Statement

Problem

Gas pipelines are exposed to natural hazards and seismic risks that can result in failures that affect system reliability, safety, and integrity. In recent years, the Internet of Things has attracted new technologies related to sensors and communication. These technologies provide a new opportunity for assessing gas infrastructure risks of failure, but these technologies have not yet been widely implemented.

Solution

The Recipient and Subrecipient will demonstrate the usefulness of sensing and monitoring technologies and couple these technologies with an open-source seismic risk code (*OpenSRA II*) to provide a means for gas utilities to use the technology to assess risk to their systems. This will aid in the adoption of sensing and monitoring technologies and provide an increase in the safety and reliability of gas infrastructure by more accurately identifying locations of high risk of failure before these failures occur.

C. Goals and Objectives of the Agreement

Agreement Goals

The goals of this Agreement are to:

- Demonstrate the advantages of utilizing sensing and monitoring technologies;
- Provide gas utilities with a tool to analyze risk to their system that takes advantage of sensing and monitoring technology; and
- Enable better prioritization of natural hazard and seismic risk mitigation to reduce risk of gas infrastructure failures.

Ratepayer Benefits: This Agreement will result in the ratepayer benefits of greater reliability and increased safety. This will be accomplished by providing owners and regulators with a tool to estimate risk for gas infrastructure and identify those components that are most at risk from seismic events. When areas of high risk are identified, IOUs can prioritize cost-effective risk mitigation of existing infrastructure and better plan for future infrastructure to reduce the risk of failures. Remediation and risk-based construction can increase safety by reducing the risk in the highest risk areas. Reliability of infrastructure following seismic events will be improved by reducing the risk of failure.

Technological Advancement and Breakthroughs: This Agreement will lead to technological advancement and breakthroughs to overcome barriers to the achievement of the State of California's statutory energy goals by providing the *OpenSRA II* software that will use sensing and monitoring technology to provide quantification of the seismic risk of California's gas infrastructure. This Agreement will enable appropriate prioritization of seismic retrofits or other risk mitigation measures based on the quantitative results of the *OpenSRA II* analyses.

Agreement Objectives

The objectives of this Agreement are to:

- Perform monitoring using embedded sensors at two demonstration sites to demonstrate the effectiveness of the technologies;
- Analyze data from remote sensors at two demonstration sites to demonstrate the effectiveness of the technologies;
- Compare the effectiveness of monitoring and sensing technologies;
- Provide recommendations as to the most effective monitoring and sensing technologies; and

- Develop an open-source risk software (*OpenSRA II*) that utilizes sensing and monitoring technologies and is easy for utilities and/or regulators to use.

III. TASK 1 GENERAL PROJECT TASKS

PRODUCTS

Subtask 1.1 Products

The goal of this subtask is to establish the requirements for submitting project products (e.g., reports, summaries, plans, and presentation materials). Unless otherwise specified by the Commission Agreement Manager (CAM), the Recipient must deliver products as required below by the dates listed in the **Project Schedule (Part V).** All products submitted which will be viewed by the public, must comply with the accessibility requirements of Section 508 of the federal Rehabilitation Act of 1973, as amended (29 U.S.C. Sec. 794d), and regulations implementing that act as set forth in Part 1194 of Title 36 of the Federal Code of Regulations**.** All technical tasks should include product(s). Products that require a draft version are indicated by marking **"(draft and final)"** after the product name in the "Products" section of the task/subtask. If "(draft and final)" does not appear after the product name, only a final version of the product is required. With respect to due dates within this Scope of Work, **"days"** means working days.

The Recipient shall:

For products that require a draft version, including the Final Report Outline and Final Report

- Submit all draft products to the CAM for review and comment in accordance with the Project Schedule (Part V). The CAM will provide written comments to the Recipient on the draft product within 15 days of receipt, unless otherwise specified in the task/subtask for which the product is required.
- Consider incorporating all CAM comments into the final product. If the Recipient disagrees with any comment, provide a written response explaining why the comment was not incorporated into the final product.
- Submit the revised product and responses to comments within 10 days of notice by the CAM, unless the CAM specifies a longer time period, or approves a request for additional time.

For products that require a final version only

- Submit the product to the CAM for acceptance. The CAM may request minor revisions or explanations prior to acceptance.

For all products

- Submit all data and documents required as products in accordance with the following.

Instructions for Submitting Electronic Files and Developing Software:

- **Electronic File Format**
  - Submit all data and documents required as products under this Agreement in an electronic file format that is fully editable and compatible with the California Energy Commission's (CEC) software and Microsoft (MS)-operating computing platforms, or with any other format approved by the CAM. Deliver an electronic copy of the full text of any Agreement data and documents in a format specified by the CAM, such as memory stick.

  The following describes the accepted formats for electronic data and documents provided to the CEC as products under this Agreement, and establishes the software versions that will be required to review and approve all software products:
  - Data sets will be in MS Access or MS Excel file format (version 2007 or later), or any other format approved by the CAM.
  - Text documents will be in MS Word file format, version 2007 or later.
  - Project management documents will be in Microsoft Project file format, version 2007 or later.

- **Software Application Development**
  Use the following standard Application Architecture components in compatible versions for any software application development required by this Agreement (e.g., databases, models, modeling tools), unless the CAM approves other software applications such as open source programs:
  - Microsoft ASP.NET framework (version 3.5 and up). Recommend 4.0.
  - Microsoft Internet Information Services (IIS), (version 6 and up) Recommend 7.5.
  - Visual Studio.NET (version 2008 and up). Recommend 2010.
  - C# Programming Language with Presentation (UI), Business Object and Data Layers.
  - SQL (Structured Query Language).
  - Microsoft SQL Server 2008, Stored Procedures. Recommend 2008 R2.
  - Microsoft SQL Reporting Services. Recommend 2008 R2.
  - XML (external interfaces).

  Any exceptions to the Electronic File Format requirements above must be approved in writing by the CAM. The CAM will consult with the CEC's Information Technology Services Branch to determine whether the exceptions are allowable.

MEETINGS

Subtask 1.2 Kick-off Meeting

The goal of this subtask is to establish the lines of communication and procedures for implementing this Agreement.

Exhibit A
Scope of Work

The Recipient shall:

- Attend a "Kick-off" meeting with the CAM, the Commission Agreement Officer (CAO), and any other CEC staff relevant to the Agreement. The Recipient will bring its Project Manager and any other individuals designated by the CAM to this meeting. The administrative and technical aspects of the Agreement will be discussed at the meeting. Prior to the meeting, the CAM will provide an agenda to all potential meeting participants. The meeting may take place in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

  The administrative portion of the meeting will include discussion of the following:
  - Terms and conditions of the Agreement;
  - Invoicing and auditing procedures;
  - Administrative products (subtask 1.1);
  - CPR meetings (subtask 1.3);
  - Match fund documentation (subtask 1.7);
  - Permit documentation (subtask 1.8);
  - Subcontracts (subtask 1.9); and
  - Any other relevant topics.

  The technical portion of the meeting will include discussion of the following:
  - The CAM's expectations for accomplishing tasks described in the Scope of Work;
  - An updated Project Schedule;
  - Technical products (subtask 1.1);
  - Progress reports (subtask 1.5);
  - Final Report (subtask 1.6);
  - Technical Advisory Committee meetings (subtasks 1.10 and 1.11); and
  - Any other relevant topics.

- Provide *Kick-off Meeting Presentation* to include but not limited to:
  - Project overview (i.e. project description, goals and objectives, technical tasks, expected benefits, etc.)
  - Project schedule that identifies milestones
  - List of potential risk factors and hurdles, and mitigation strategy

- Provide an *Updated Project Schedule, Match Funds Status Letter,* and *Permit Status Letter*, as needed to reflect any changes in the documents.

The CAM shall:

- Designate the date and location of the meeting.
- Send the Recipient a *Kick-off Meeting Agenda*.

Recipient Products:

- Kick-off Meeting Presentation
- Updated Project Schedule *(if applicable)*
- Match Funds Status Letter (subtask 1.7) *(if applicable)*

- Permit Status Letter (subtask 1.8) *(if applicable)*

CAM Product:

- Kick-off Meeting Agenda

Subtask 1.3 Critical Project Review (CPR) Meetings

The goal of this subtask is to determine if the project should continue to receive CEC funding, and if so whether any modifications must be made to the tasks, products, schedule, or budget. CPR meetings provide the opportunity for frank discussions between the CEC and the Recipient. As determined by the CAM, discussions may include project status, challenges, successes, advisory group findings and recommendations, final report preparation, and progress on technical transfer and production readiness activities (if applicable). Participants will include the CAM and the Recipient and may include the CAO and any other individuals selected by the CAM to provide support to the CEC.

CPR meetings generally take place at key, predetermined points in the Agreement, as determined by the CAM and as shown in the Task List on page 1 of this Exhibit. However, the CAM may schedule additional CPR meetings as necessary. The budget will be reallocated to cover the additional costs borne by the Recipient, but the overall Agreement amount will not increase. CPR meetings generally take place at the CEC, but they may take place at another location, or may be conducted via electronic conferencing (e.g., WebEx) as determined by the CAM.

The Recipient shall:

- Prepare and submit a *CPR Report* for each CPR meeting that: (1) discusses the progress of the Agreement toward achieving its goals and objectives; and (2) includes recommendations and conclusions regarding continued work on the project.
- Attend the CPR meeting.
- Present the CPR Report and any other required information at each CPR meeting.

The CAM shall:

- Determine the location, date, and time of each CPR meeting with the Recipient's input.
- Send the Recipient a *CPR Agenda* with a list of expected CPR participants in advance of the CPR meeting. If applicable, the agenda will include a discussion of match funding and permits.
- Conduct and make a record of each CPR meeting. Provide the Recipient with a schedule for providing a Progress Determination on continuation of the project.
- Determine whether to continue the project, and if so whether modifications are needed to the tasks, schedule, products, or budget for the remainder of the Agreement. If the CAM concludes that satisfactory progress is not being made, this conclusion will be referred to the Deputy Director of the Energy Research and Development Division.

- Provide the Recipient with a *Progress Determination* on continuation of the project, in accordance with the schedule. The Progress Determination may include a requirement that the Recipient revise one or more products.

Recipient Products:
- CPR Report(s)

CAM Products:
- CPR Agenda
- Progress Determination

Subtask 1.4 Final Meeting
The goal of this subtask is to complete the closeout of this Agreement.

The Recipient shall:
- Meet with CEC staff to present project findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement. This meeting will be attended by the Recipient and CAM, at a minimum. The meeting may occur in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

  The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be divided into two separate meetings at the CAM's discretion.
  - The technical portion of the meeting will involve the presentation of findings, conclusions, and recommended next steps (if any) for the Agreement. The CAM will determine the appropriate meeting participants.
  - The administrative portion of the meeting will involve a discussion with the CAM and the CAO of the following Agreement closeout items:
    - Disposition of any procured equipment.
    - The CEC's request for specific "generated" data (not already provided in Agreement products).
    - Need to document the Recipient's disclosure of "subject inventions" developed under the Agreement.
    - "Surviving" Agreement provisions such as repayment provisions and confidential products.
    - Final invoicing and release of retention.
- Prepare a *Final Meeting Agreement Summary* that documents any agreement made between the Recipient and CEC staff during the meeting.
- Prepare a *Schedule for Completing Agreement Closeout Activities*.
- Provide copies of *All Final Products* on a USB memory stick, organized by the tasks in the Agreement.

Products:
- Final Meeting Agreement Summary *(if applicable)*
- Schedule for Completing Agreement Closeout Activities

- All Final Products

REPORTS AND INVOICES

Subtask 1.5 Progress Reports and Invoices

The goals of this subtask are to: (1) periodically verify that satisfactory and continued progress is made towards achieving the project objectives of this Agreement; and (2) ensure that invoices contain all required information and are submitted in the appropriate format.

The Recipient shall:

- Submit a monthly *Progress Report* to the CAM. Each progress report must:
  - Summarize progress made on all Agreement activities as specified in the scope of work for the preceding month, including accomplishments, problems, milestones, products, schedule, fiscal status, and an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. See the Progress Report Format Attachment for the recommended specifications.
- Submit a monthly or quarterly *Invoice* that follows the instructions in the "Payment of Funds" section of the terms and conditions, including a financial report on Match Funds and in-state expenditures.

Products:

- Progress Reports
- Invoices

Subtask 1.6 Final Report

The goal of this subtask is to prepare a comprehensive Final Report that describes the original purpose, approach, results, and conclusions of the work performed under this Agreement. When creating the Final Report Outline and the Final Report, the Recipient must use the CEC Style Manual provided by the CAM.

Subtask 1.6.1 Final Report Outline

The Recipient shall:

- Prepare a *Final Report Outline* in accordance with the *Energy Commission Style Manual* provided by the CAM.

Recipient Products:

- Final Report Outline (draft and final)

CAM Product:

- Energy Commission Style Manual
- Comments on Draft Final Report Outline
- Acceptance of Final Report Outline

Subtask 1.6.2 Final Report

The Recipient shall:

- Prepare a *Final Report* for this Agreement in accordance with the approved Final Report Outline, Energy Commission Style Manual, and Final Report Template provided by the CAM with the following considerations:
  - Ensure that the report includes the following items, in the following order:
    - Cover page (**required**)
    - Credits page on the reverse side of cover with legal disclaimer (**required**)
    - Acknowledgements page (optional)
    - Preface (**required**)
    - Abstract, keywords, and citation page (**required**)
    - Table of Contents (**required**, followed by List of Figures and List of Tables, if needed)
    - Executive summary (**required**)
    - Body of the report (**required**)
    - References (if applicable)
    - Glossary/Acronyms (If more than 10 acronyms or abbreviations are used, it is required.)
    - Bibliography (if applicable)
    - Appendices (if applicable) (Create a separate volume if very large.)
    - Attachments (if applicable)
- Submit a draft of the Executive Summary to the Technical Advisory Committee (TAC) for review and comment.
- Develop and submit a *Summary of TAC Comments on Draft Final Report* received on the Executive Summary. For each comment received, the recipient will identify in the summary the following:
  - Comments the recipient proposes to incorporate.
  - Comments the recipient does propose to incorporate and an explanation for why.
- Submit a draft of the report to the CAM for review and comment. The CAM will provide written comments to the Recipient on the draft product within 15 days of receipt.
- Incorporate all CAM comments into the Final Report. If the Recipient disagrees with any comment, provide a *Written Responses to Comments* explaining why the comments were not incorporated into the final product.
- Submit the revised Final Report electronically with any Written Responses to Comments within 10 days of receipt of CAM's Written Comments on the Draft Final Report, unless the CAM specifies a longer time period or approves a request for additional time.

Products:

- Summary of TAC Comments on Draft Final Report
- Draft Final Report
- Written Responses to Comments *(if applicable)*

- Final Report

CAM Product:

- Written Comments on the Draft Final Report

MATCH FUNDS, PERMITS, AND SUBCONTRACTS

Subtask 1.7 Match Funds

The goal of this subtask is to ensure that the Recipient obtains any match funds planned for this Agreement and applies them to the Agreement during the Agreement term.

While the costs to obtain and document match funds are not reimbursable under this Agreement, the Recipient may spend match funds for this task. The Recipient may only spend match funds during the Agreement term, either concurrently or prior to the use of CEC funds. Match funds must be identified in writing, and the Recipient must obtain any associated commitments before incurring any costs for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a *Match Funds Status Letter* that documents the match funds committed to this Agreement. If no match funds were part of the proposal that led to the CEC awarding this Agreement and none have been identified at the time this Agreement starts, then state this in the letter.

  If match funds were a part of the proposal that led to the CEC awarding this Agreement, then provide in the letter:
  - A list of the match funds that identifies:
    - The amount of cash match funds, their source(s) (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied.
    - The amount of each in-kind contribution, a description of the contribution type (e.g., property, services), the documented market or book value, the source (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Recipient must identify its owner and provide a contact name, address, telephone number, and the address where the property is located.
    - If different from the solicitation application, provide a letter of commitment from an authorized representative of each source of match funding that the funds or contributions have been secured.
- At the Kick-off meeting, discuss match funds and the impact on the project if they are significantly reduced or not obtained as committed. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide a *Supplemental Match Funds Notification Letter* to the CAM of receipt of additional match funds.

- Provide a *Match Funds Reduction Notification Letter* to the CAM if existing match funds are reduced during the course of the Agreement. Reduction of match funds may trigger a CPR meeting.

Products:

- Match Funds Status Letter
- Supplemental Match Funds Notification Letter *(if applicable)*
- Match Funds Reduction Notification Letter *(if applicable)*

Subtask 1.8 Permits

The goal of this subtask is to obtain all permits required for work completed under this Agreement in advance of the date they are needed to keep the Agreement schedule on track. Permit costs and the expenses associated with obtaining permits are not reimbursable under this Agreement, with the exception of costs incurred by University of California recipients. Permits must be identified and obtained before the Recipient may incur any costs related to the use of the permit(s) for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a *Permit Status Letter* that documents the permits required to conduct this Agreement. If no permits are required at the start of this Agreement, then state this in the letter. If permits will be required during the course of the Agreement, provide in the letter:
  - A list of the permits that identifies: (1) the type of permit; and (2) the name, address, and telephone number of the permitting jurisdictions or lead agencies.
  - The schedule the Recipient will follow in applying for and obtaining the permits.

  The list of permits and the schedule for obtaining them will be discussed at the Kick-off meeting (subtask 1.2), and a timetable for submitting the updated list, schedule, and copies of the permits will be developed. The impact on the project if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in progress reports and will be a topic at CPR meetings.
- If during the course of the Agreement additional permits become necessary, then provide the CAM with an *Updated List of Permits* (including the appropriate information on each permit) and an *Updated Schedule for Acquiring Permits*.
- Send the CAM a *Copy of Each Approved Permit*.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the CAM within 5 days. Either of these events may trigger a CPR meeting.

Products:

- Permit Status Letter
- Updated List of Permits *(if applicable)*
- Updated Schedule for Acquiring Permits *(if applicable)*

- Copy of Each Approved Permit *(if applicable)*

Subtask 1.9 Subcontracts
The goals of this subtask are to: (1) procure subcontracts required to carry out the tasks under this Agreement; and (2) ensure that the subcontracts are consistent with the terms and conditions of this Agreement.

The Recipient shall:

- Manage and coordinate subcontractor activities in accordance with the requirements of this Agreement.
- Incorporate this Agreement by reference into each subcontract.
- Include any required Energy Commission flow-down provisions in each subcontract, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subcontract terms.
- If required by the CAM, submit a draft of each *Subcontract* required to conduct the work under this Agreement.
- Submit a final copy of each executed subcontract.
- Notify and receive written approval from the CAM prior to adding any new subcontractors (see the discussion of subcontractor additions in the terms and conditions).

Products:

- Subcontracts *(draft if required by the CAM)*

TECHNICAL ADVISORY COMMITTEE

Subtask 1.10 Technical Advisory Committee (TAC)
The goal of this subtask is to create an advisory committee for this Agreement. The TAC should be composed of diverse professionals. The composition will vary depending on interest, availability, and need. TAC members will serve at the CAM's discretion. The purpose of the TAC is to:

- Provide guidance in project direction. The guidance may include scope and methodologies, timing, and coordination with other projects. The guidance may be based on:
  - Technical area expertise;
  - Knowledge of market applications; or
  - Linkages between the agreement work and other past, present, or future projects (both public and private sectors) that TAC members are aware of in a particular area.
- Review products and provide recommendations for needed product adjustments, refinements, or enhancements.
- Evaluate the tangible benefits of the project to the state of California, and provide recommendations as needed to enhance the benefits.
- Provide recommendations regarding information dissemination, market pathways, or commercialization strategies relevant to the project products.
- Help set the project team's goals and contribute to the development and evaluation of its statement of proposed objectives as the project evolves.

- Provide a credible and objective sounding board on the wide range of technical and financial barriers and opportunities.
- Help identify key areas where the project has a competitive advantage, value proposition, or strength upon which to build.
- Advocate, to the extent the TAC members feel is appropriate, on behalf of the project in its effort to build partnerships, governmental support and relationships with a national spectrum of influential leaders.
- Ask probing questions that insure a long-term perspective on decision-making and progress toward the project's strategic goals.

The TAC may be composed of qualified professionals spanning the following types of disciplines:

- Researchers knowledgeable about the project subject matter;
- Members of trades that will apply the results of the project (e.g., designers, engineers, architects, contractors, and trade representatives);
- Public interest market transformation implementers;
- Product developers relevant to the project;
- U.S. Department of Energy research managers, or experts from other federal or state agencies relevant to the project;
- Public interest environmental groups;
- Utility representatives;
- Air district staff; and
- Members of relevant technical society committees.

The Recipient shall:

- Prepare a *List of Potential TAC Members* that includes the names, companies, physical and electronic addresses, and phone numbers of potential members. The list will be discussed at the Kick-off meeting, and a schedule for recruiting members and holding the first TAC meeting will be developed.
- Recruit TAC members. Ensure that each individual understands member obligations and the TAC meeting schedule developed in subtask 1.11.
- Prepare a *List of TAC Members* once all TAC members have committed to serving on the TAC.
- Submit *Documentation of TAC Member Commitment* (such as Letters of Acceptance) from each TAC member.

Products:

- List of Potential TAC Members
- List of TAC Members
- Documentation of TAC Member Commitment

Subtask 1.11 TAC Meetings

The goal of this subtask is for the TAC to provide strategic guidance for the project by participating in regular meetings, which may be held via teleconference.

Exhibit A
Scope of Work

The Recipient shall:

- Discuss the TAC meeting schedule with the CAM at the Kick-off meeting. Determine the number and location of meetings (in-person and via teleconference) in consultation with the CAM.
- Prepare a *TAC Meeting Schedule* that will be presented to the TAC members during recruiting. Revise the schedule after the first TAC meeting to incorporate meeting comments.
- Prepare a *TAC Meeting Agenda* and *TAC Meeting Back-up Materials* for each TAC meeting.
- Organize and lead TAC meetings in accordance with the TAC Meeting Schedule. Changes to the schedule must be pre-approved in writing by the CAM.
- Prepare *TAC Meeting Summaries* that include any recommended resolutions of major TAC issues.

The TAC shall:

- Help set the project team's goals and contribute to the development and evaluation of its statement of proposed objectives as the project evolves.
- Provide a credible and objective sounding board on the wide range of technical and financial barriers and opportunities.
- Help identify key areas where the project has a competitive advantage, value proposition, or strength upon which to build.
- Advocate on behalf of the project in its effort to build partnerships, governmental support and relationships with a national spectrum of influential leaders.
- Ask probing questions that insure a long-term perspective on decision-making and progress toward the project's strategic goals.
- Review and provide comments to proposed project performance metrics.
- Review and provide comments to proposed project Draft Technology Transfer Plan.

Products:

- TAC Meeting Schedule (draft and final)
- TAC Meeting Agendas (draft and final)
- TAC Meeting Back-up Materials
- TAC Meeting Summaries

Subtask 1.12 Project Performance Metrics

The goal of this subtask is to finalize key performance targets for the project based on feedback from the TAC and report on final results in achieving those targets. The performance targets should be a combination of scientific, engineering, techno-economic, and/or programmatic metrics that provide the most significant indicator of the research or technology's potential success.

The Recipient shall:

- Complete and submit the project performance metrics section of the *Initial Project Benefits Questionnaire,* developed in the Evaluation of Project Benefits

task, to the CAM.

- Present the draft project performance metrics at the first TAC meeting to solicit input and comments from the TAC members.
- Develop and submit a *TAC Performance Metrics Summary* that summarizes comments received from the TAC members on the proposed project performance metrics. The *TAC Performance Metrics Summary* will identify:
  - TAC comments the Recipient proposes to incorporate into the *Initial Project Benefits Questionnaire*, developed in the Evaluation of Project Benefits task.
  - TAC comments the Recipient does not propose to incorporate with and explanation why.
- Develop and submit a *Project Performance Metrics Results* document describing the extent to which the Recipient met each of the performance metrics in the *Final Project Benefits Questionnaire,* developed in the Evaluation of Project Benefits task.
- Discuss the *Project Performance Metrics Results* at the Final Meeting.

Products:

- Initial Project Benefits Questionnaire (project performance metrics section)
- TAC Performance Metrics Summary
- Project Performance Metrics Results

IV. TECHNICAL TASKS

Subtask 1.1 (Products) describes the procedure for submitting products to the CAM. Products that require a draft version are indicated by marking **"(draft and final)"** after the product name in the "Products" section of the task/subtask. If "(draft and final)" does not appear after the product name, only a final version of the product is required.

TASK 2: DEMONSTRATION OF REMOTE SENSING APPLICATION AT EAST BAY HILLS-SAN PABLO SITE FOR *OPENSRA* LEVEL 2 AND 3 ASSESSMENTS

The goal of this task is to demonstrate the application of remote sensing capabilities within *OpenSRA* at the East Bay Hills-San Pablo site for level 2 and 3 assessments. These levels correlate to the scale at which the analysis is performed and quantity of data is available. Level 1 is a statewide analysis, Level 2 is a regional analysis, and Level 3 is a site-specific analysis. Finally, Level 4 is finite element modeling of the site.

The performance metrics of the remote sensing technologies used in this task include (i) accuracy/precision error, (ii) minimum ground displacement rate detected, (iii) coverage, (iv) sampling frequency, and (v) cost.

The performance metrics of the temperature sensing technologies used in this task include (i) accuracy/precision error, (ii) measurement distance, (iii) coverage, (iv) sampling frequency, and (v) cost.

The performance metrics of the gas sensing technologies used in this task include (i) suitable gas, (ii) accuracy/precision error, (iii) response time, (iv) coverage, (v) power consumption, and (v) cost.

The performance metrics of the wireless network sensor technologies used in this task include (i) distance/coverage, (ii) data rate, (iii) energy consumption, (iv) security features, and (v) cost.

The Recipient shall:

- Collect and analyze satellite data at the East Bay Hills – San Pablo site, or a similar site approved in writing by CAM.
  - Use both a compilation of all existing interferometric synthetic aperture radar (InSAR) results, spanning almost three decades, and newly collected InSAR time series from the TerraSAR-X, PAZ and Sentinel-1 spacecraft
  - Surface deformation measurements of spatiotemporal detail over the East Bay Hills area shall be collected.
- Develop a digital twin model of the site.
  - The digital twin model shall include a 3D model, along with the gas distribution system, and a 4D model using Light Detection and Ranging (LiDAR) and Structure from Motion (SfM) data.
  - A commercial GIS model such as ArcGIS will be used to create a digital twin platform.
  - A regional slope stability analysis shall be conducted for the entire site using a regional landsliding methodology to incorporate monitoring data and the identification of critical areas to be used for *OpenSRA* level 2 and 3 assessments.
- Prepare and submit a *Task 2 Field Test Plan* that may include:
  - Drawings,
  - Designs,
  - Instrumentation descriptions.
- Perform field monitoring at the site.
  - Unmanned aerial vehicles, terrestrial robots and wireless sensors shall be deployed to monitor critical areas.
  - Infrared and multispectral data shall be fused with LiDAR and optical data to:
    - Remotely characterize soil materials.
    - Assess and quantify moisture content.
    - Classify materials.
  - Terrestrial robots shall be equipped with sensors and high-resolution methane detection to assess potential gas leaks.
  - Data collected from field monitoring shall be used for the *OpenSRA* level 2 and 3 assessments.
- Perform Level 2 and 3 assessments at the site using *OpenSRA*
- Prepare and submit a *Demonstration of Remote Sensing Application at East Bay Hills – San Pablo Site Using OpenSRA Report* detailing the results of the demonstration.

- Report shall include but is not limited to background, site details, data, sensor evaluation, OpenSRA assessments and conclusions.

Products:

- Task 2 Field Test Plan
- Demonstration of Remote Sensing Application at East Bay Hills – San Pablo Site Using *OpenSRA* Report (draft and final)

TASK 3: DEMONSTRATION OF REMOTE SENSING APPLICATION AT GILROY FIELD SITE FOR *OPENSRA* LEVEL 3 AND 4 ASSESSMENTS

The goal of this task is to demonstrate the application of remote sensing capabilities within *OpenSRA* at the Gilroy site for level 3 and 4 assessments.

The performance metrics of the remote sensing technologies used in this task include (i) accuracy/precision error, (ii) minimum ground displacement rate detected, (iii) coverage, (iv) sampling frequency and (v) cost.

The performance metrics of the temperature sensing technologies used in this task include (i) accuracy/precision error, (ii) measurement distance, (iii) coverage, (iv) sampling frequency and (v) cost.

The performance metrics of the gas sensing technologies used in this task include (i) suitable gas, (ii) accuracy/precision error, (iii) response time, (iv) coverage, (v) power consumption and (v) cost.

The Recipient shall:

- Collect and analyze satellite data at the Gilroy site, or a similar site approved in writing by CAM.
  - The improvement of spatial sampling, accuracy, and temporal coverage of InSAR observations over the study site shall be assessed when a complete dataset of acquisitions by the Sentinel-1a, b, and c spacecraft is used.
  - Corner-cube reflectors and low-cost Global Navigation Satellite Systems (GNSS) receivers shall be installed to accurately tie the InSAR measurements to GNSS observations at daily resolution and mm-level precision.
- Develop a digital twin model of the site.
  - The digital twin model shall include a 3D model, along with the gas distribution system, and a 4D model using LiDAR and SfM data.
  - A commercial GIS model such as ArcGIS will be used to create a digital twin platform.
  - A regional slope stability analyses shall be conducted for the entire site using a regional landsliding methodology to incorporate monitoring data and the

identification of critical areas to be used for *OpenSRA* level 3 and 4 assessments.

- Prepare and submit a *Task 3 Field Test Plan* that may include:
  - Drawings,
  - Designs,
  - Instrumentation descriptions.
- Perform field monitoring at the site.
  - Unmanned aerial vehicles and terrestrial robots shall be deployed to monitor critical areas.
  - Infrared and multispectral data shall be fused with LiDAR and optical data to:
    - Remotely characterize soil materials.
    - Assess and quantify moisture content.
    - Classify materials.
  - Terrestrial robots shall be equipped with sensors and high-resolution methane detection to assess potential gas leaks.
- Data collected from field monitoring shall be used for the *OpenSRA* level 3 and 4 assessment.
- Perform Level 3 and 4 assessments at the site using *OpenSRA*.
- Prepare and submit a *Demonstration of Remote Sensing Application at Gilroy Site Using OpenSRA Report* detailing the results of the demonstration
  - Report shall include but is not limited to background, site details, data, sensor evaluation, OpenSRA assessments and conclusions.

Products:

- Task 3 Field Test Plan
- Demonstration of Remote Sensing Application at Gilroy Site Using *OpenSRA* Report (draft and final)

TASK 4: DEMONSTRATION OF EMBEDDED SENSING APPLICATION AT GILROY FIELD SITE FOR *OPENSRA* LEVEL 3 AND 4 ASSESSMENTS

The goal of this task is to demonstrate the application of embedded sensing capabilities within *OpenSRA* at the Gilroy site for level 3 and 4 assessments.

The performance metrics of the embedded distributed fiber optic sensing technologies used in this task include (i) accuracy/precision error, (ii) data interval, (iii) sampling frequency (iv) measurement distance and (v) cost.

The performance metrics of the wireless network sensor technologies used in this task include (i) distance/coverage, (ii) data rate, (iii) energy consumption (iv) security features and (v) cost.

The Recipient shall:

- Prepare and submit a *Task 4 Field Test Plan* that may include:
  - Drawings,
  - Designs,

  - Instrumentation descriptions
- Perform field monitoring at the Gilroy site, or a similar site approved in writing by CAM.
  - Deploy direct fiber optic sensor (DFOS) system directly on the pipeline and in a trench next to the pipeline to continuously conduct readings for at least 12 months, collecting temperature and strain data. Monthly readings shall also be collected.
  - Deploy LoRAWAN-based wireless sensor network (WSN) system and continuously conduct readings for at least 12 months. The WSN system shall incorporate selected low-cost sensors such as a soil moisture sensor, accelerometer, tilt meter, vibrating wire strain gauge, and gas sensor. 5G enabled intelligent and adaptive critical infrastructure sensing shall be investigated using 5G low-power data transmission standards to build massive networks of distributed sensing networks, linked to machine learning algorithms to assess and predict infrastructure conditions in real-time. Cyber security issues shall also be examined.
- Perform Level 3 and 4 assessments at the site using *OpenSRA*
  - Data collected from the field monitoring shall be used to constrain uncertainty on the stability of the slopes that affect the pipeline as part of *OpenSRA* level 3 and 4 assessments.
  - The cost effectiveness and greenhouse gas (GHG) reduction assessment of the embedded sensors systems shall be assessed.
- Prepare and submit a *Demonstration of Embedded Sensing Application at Gilroy Site Using OpenSRA Report* detailing the results of the demonstration.
  - Report shall include but is not limited to background, site details, data, sensor evaluation, OpenSRA assessments and conclusions.

Products:

- Task 4 Field Test Plan
- Demonstration of Embedded Sensing Application at Gilroy Site Using *OpenSRA* Report (draft and final)

TASK 5: DEMONSTRATION OF EMBEDDED SENSING APPLICATION AT LARGE-SCALE DEMONSTRATION SITE EXPERIMENTS FOR *OPENSRA* LEVEL 4 ASSESSMENT

The goals of this task are to:

- demonstrate that the system of embedded sensors within *OpenSRA* can provide early warning to pipeline failure, and
- link surface ground movement measured by remote sensing to the pipeline movement measured by embedded sensors.

The performance metrics of the embedded distributed fiber optic sensing technologies used in this task include (i) accuracy/precision error, (ii) data interval, (iii) sampling frequency (iv) measurement distance and (v) cost.

Exhibit A
Scope of Work

The performance metrics of the wireless network sensor technologies used in this task include (i) distance/coverage, (ii) data rate, (iii) energy consumption (iv) security features and (v) cost.

The Recipient shall:

- Prepare and submit a *Task 5 Field Test Plan* that may include:
  - Drawings,
  - Designs,
  - Instrumentation descriptions
- Perform field monitoring at the Blackhawk Geological Hazard Abatement District (BGHAD) site in Danville, Contra Costa County or the split basin tank device installed at UC Berkeley's Richmond Field Station site in Richmond, Contra Costa County, or a similar site approved in writing by CAM.
  - The field monitoring shall:
    - Demonstrate the system of embedded sensors with *OpenSRA* model to provide early warning to pipeline failure; and
    - Link surface ground movement measured by remote sensing to the pipeline movement measured by embedded sensors.
  - DFOS system shall be deployed in the test beds.
  - LoRAWAN-based WSN system shall be deployed in the test beds.
  - Perform pipeline failure experiments by controlled ground movements with embedded sensors.
  - Track the surface movements by selected remote sensing technologies that may include LiDAR and SfM acquisition.
  - Examine the performance of the DFOS and WSN systems for early warning system.
- Perform Level 4 assessments at the site using *OpenSRA*.
  - Data shall be collected and processed to examine the performance of *OpenSRA* level 4 assessment.
  - The cost effectiveness and GHG reduction assessment of the embedded sensors shall be assessed.
- Prepare and submit a *Demonstration of Embedded Sensing Application at Large Scale Demonstration Site Using OpenSRA Report* detailing the results of the demonstration
  - Report shall include but is not limited to Background, site details, data, sensor evaluation, OpenSRA assessments and conclusions.
- Prepare a *CPR Report #1* in accordance with subtask 1.3 (CPR Meetings).
- Participate in a CPR meeting.

Products:

- Task 5 Field Test Plan
- Demonstration of Embedded Sensing Application at Large Scale Demonstration Site Using *OpenSRA* Report (draft and final)
- CPR Report #1

TASK 6: DEVELOPMENT OF PERFORMANCE-BASED *OPENSRA* VERSION II

The goal of this task is to:

- Develop enhanced pipeline fragility models that consider distributed strain profiles.
- Update the OpenSRA Version II software.
- Test the performance of *OpenSRA* Version II using data from the two field demonstration cases and one large scale soil-pipeline interaction tests.

The performance metrics of the *OpenSRA* Version II include (i) incorporation of remote sensing data for *OpenSRA* assessments, (ii) incorporation of embedded sensing data for *OpenSRA* assessments, (iii) new pipeline fragility models that consider distributed strain and (iv) SimCenter R2D tool implementation.

The Recipient shall:

- Develop enhanced models to convert peak strain to distributed strain.
  - The enhanced models shall be developed to capture 3D pipeline orientations and ground movement orientations and shall enable full utilization of the measured distributed strain data from DFOS.
- Update *OpenSRA* to incorporate enhanced models.
  - The software will use observed data are used to derive the 'most probable model parameters', that are defined as a set of model parameters that represents the probabilistic mean of all possible sets of conditions for a given model when observed data becomes available.
- Implement *OpenSRA* in SimCenter R2D tool.
- Use the Bayesian calibration available in SimCenter Tools to integrate OpenSRA simulations with detailed fiber optic measurement data.
- Update the *OpenSRA* manual to include new models.
- Prepare and submit a *Performance-Based OpenSRA Version II Report* detailing the results of the demonstration.
  - Report shall include but is not limited to background, OpenSRA Version II details, case study validations, conclusions and future work.

Products:

- Performance-Based *OpenSRA* Version II Report (draft and final)

TASK 7: USER WORKSHOP AND BI-ANNUAL USER FEEDBACK

The main objectives of this task are to:

- Promote user adoption of *OpenSRA* II, and
- Support knowledge transfer of the project.

A User Workshop shall be held near the end of the project to share results and solicit feedback from a larger group of stakeholders in time to modify the software.

The Recipient shall:

- Convene a User Panel of California investor-owned utilities, California Public Utilities Commission and Division of Oil, Gas and Geothermal Resources staff.

The User Panel represents the Technical Advisory Committee function on this project.

- Hold bi-annual meetings with the User Panel to assess user needs and additional capabilities required
- Develop *User Workshop Materials* to educate the User Panel and additional users of *OpenSRA* II on its use and capabilities
- Hold a User Workshop to present the *User Workshop Materials*
- Prepare a *CPR Report #2* in accordance with subtask 1.3 (CPR Meetings).
- Participate in a CPR meeting.

Products:

- User Workshop Materials
- CPR Report #2

TASK 8: EVALUATION OF PROJECT BENEFITS

The goal of this task is to report the benefits resulting from this project.

The Recipient shall:

- Complete *the Initial Project Benefits Questionnaire*. The Initial Project Benefits Questionnaire shall be initially completed by the Recipient with 'Kick-off' selected for the 'Relevant data collection period' and submitted to the CAM for review and approval.
- Complete the *Annual Survey* by December 15th of each year. The Annual Survey includes but is not limited to the following information:
  - Technology commercialization progress
  - New media and publications
  - Company growth
  - Follow-on funding and awards received
- Complete the *Final Project Benefits Questionnaire*. The Final Project Benefits Questionnaire shall be completed by the Recipient with 'Final' selected for the 'Relevant data collection period' and submitted to the CAM for review and approval.
- Respond to CAM questions regarding the questionnaire drafts.
- Complete and update the project profile on the CEC's public online project and recipient directory on the Energize Innovation website (www.energizeinnovation.fund), and provide *Documentation of Project Profile on EnergizeInnovation.fund*, including the profile link.
- If the Prime Recipient is an Innovation Partner on the project, complete and update the organizational profile on the CEC's public online project and recipient directory on the Energize Innovation website (www.energizeinnovation.fund), and provide *Documentation of Organization Profile on EnergizeInnovation.fund*, including the profile link.

Products:

- Initial Project Benefits Questionnaire
- Annual Survey(s)

- Final Project Benefits Questionnaire
- Documentation of Project Profile on EnergizeInnovation.fund
- Documentation of Organization Profile on EnergizeInnovation.fund

TASK 9: TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES

The goal of this task is to ensure the technological learning that resulted from the demonstration(s) is captured and disseminated to the range of professions that will be responsible for future deployments of this technology or similar technologies.

The Recipient Shall:

- Develop and submit a *Project Case Study Plan* that outlines how the Recipient will document the planning, construction, commissioning, and operation of the technology or system being demonstrated. The *Project Case Study Plan* should include:
  - An outline of the objectives, goals, and activities of the case study.
  - The organization that will be conducting the case study and the plan for conducting it.
  - A list of professions and practitioners involved in the technology's deployment.
  - Specific activities the recipient will take to ensure the learning that results from the project is disseminated to those professions and practitioners.
  - Presentations/webinars/training events to disseminate the results of the case study.
- Present the *Draft Project Case Study Plan* to the TAC for review and comment.
- Develop and submit a *Summary of TAC Comments* that summarizes comments received from the TAC members on the *Draft Project Case Study Plan*. This document will identify:
  - TAC comments the recipient proposes to incorporate into the *Final Technology Transfer Plan*.
  - TAC comments the recipient does not propose to incorporate with and explanation why.
- Submit the *Final Project Case Study Plan* to the CAM for approval.
- Execute the *Final Project Case Study Plan* and develop and submit a *Project Case Study.*
- When directed by the CAM, develop presentation materials for an CEC-sponsored conference/workshop(s) on the project.
- Provide at least (6) six *High Quality Digital Photographs* (minimum resolution of 1300x500 pixels in landscape ratio) of pre and post technology installation at the project sites or related project photographs.

Products:

- Project Case Study Plan (draft and final)
- Summary of TAC Comments
- Project Case Study (draft and final)

- High Quality Digital Photographs

V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.