# RESEARCH PERFORMANCE PROGRESS REPORT

## 1. COVER PAGE DATA ELEMENTS: Mandatory

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| **Federal Agency and Organization Element to Which Report is Submitted** | **U.S. Department of Energy (DOE)**<br>**National Energy Technology Laboratory (NETL)** |
| **Federal Grant or Other Identifying Number Assigned by Agency** | DE-FE0029085 |
| **Project Title** | Long-Term Methane Emissions Rate Quantification and Alert System for Natural Gas Storage Wells and Fields |
| **PI Name, Title and Contact Information** | Ann P. Smith, Vice President<br>apsmith@gsi-net.com; 512.346.4474 |
| **Submission Date** | April 28, 2017 |
| **DUNS Number** | 181780776 |
| **Recipient Organization** | GSI Environmental Inc.<br>9600 Great Hills Trail, Suite 350E<br>Austin, Texas 78759 |
| **Project Period** | October 1, 2016 to May 31, 2019 |
| **Reporting Period End Date** | March 31, 2017 |
| **Report Term or Frequency** | Quarterly |
| **Signature of Submitting Official** | |

## 2. ACCOMPLISHMENTS: Mandatory

### a) What are the major goals of the project?

The primary goal of the project is to employ a novel combination of complementary measurement methods and technologies to detect and accurately quantify average annual methane emissions from underground natural gas storage facilities, including from above-ground equipment leaks plus seepage at the ground surface from underground leaks.

### b) What was accomplished under these goals?

All project goals for the second quarter (Q2) reporting period of January 2017 - March 2017 were met. A summary of the activities performed to achieve project goals during Q2 is included below.

**Stakeholder Meetings:** Technical Advisory Steering Committee (TASC) meetings were held on January 12th and 13th for industry members. A second set of TASC meetings that were open to all members were held on January 18th and 19th. A more specialized meeting was held for TASC members interested in additional technical details for high flow and optical imaging sampling methods. Lastly, a conference call was held with members from API to discuss project goals and proposed methodologies/technologies and exchange technology information with experts in the gas storage industry. Attendees for each meeting are listed below.

**Industry TASC Meeting:** Attendees included representatives from Anadarko, Apache, HARC, Spectra, Chevron, GE, Enbridge Gas, Shell, Dominion Questar, Energy Transfer Partners, and QEP Resources.

**Open TASC Meeting:** Attendees included representatives from USU (Utah State University), DOE NETL, BLM (Bureau of Land Management), New York State Department of Environmental Conservation, COGCC (Colorado Oil & Gas Conservation Commission), Maryland Department of the Environment, University of Cincinnati, EDF (Environmental Defense Fund), AGA (American Gas Association), INGAA (Interstate Natural Gas Association of America), API (American Petroleum Institute), EPA (United States Environmental Protection Agency), PHMSA (Pipeline Hazardous Material and Safety Administration), Utah Division of Air Quality.

**High Flow and Optical Imaging Technical Methods TASC Meeting:** Attendees included representatives from API (American Petroleum Institute), GHD Engineering, Shell Oil, Levon Group, UC (University of Cincinnati), HARC (Houston Advanced Research Center), USU (Utah State University), PHMSA (Pipeline Hazard Material Safety Association), USEPA (United States Environmental Protection Agency).

**API Technical Meeting:** Attendees included representatives from Chevron, ESS, GHD, XTO, Chesapeake, Spectra, Marathon, Encana, BP, Devon, ExxonMobil, Oxy, Anadarko, Shell, Pioneer, C/P, LOG, and API.

**Site Selection:** Proposed storage well components were identified for measurement. A diversity of wells representing depleted reservoir and salt cavern-type storage were selected for field evaluations.

**Initial Site Visits Performed:** GSI traveled to each selected salt cavern site for a day and to the entire depleted reservoir facility for another day to preview site conditions, meet the operations and facility managers, and finalize sampling protocols and schedules.

**Completion of Field Campaign 1:**

**March 6-10:** Evaluated emissions and counted surface infrastructure components at 9 salt cavern wells located at 2 facilities in the Gulf Coast region.

**March 20-31:** Conducted emissions screening and surface infrastructure component counts at 43 wells at a depleted petroleum reservoir in Clay Basin, Utah. Measured leak and loss rates, seeps and ambient emissions from 24 storage wells located at the facility.

The following was performed at each of the 9 salt cavern wells and 43 depleted reservoir wells described above:

**Emissions Screening:** Emissions from wellhead surface infrastructure were identified with an optical gas imaging camera (FLIR) and a portable combustible gas analyzer (LEL meter). Total counts of each time of evaluated wellhead component were obtained.

The following were performed at each of the 9 salt cavern wells and 24 depleted reservoir wells described above:

**High-Flow Sampling:** Directly measured methane emission rates from all components from which leaks were identifiable with the FLIR or LEL meter. As a baseline, additional components of each type from which leaks were not detected were also sampled.

**Flux Chamber Sampling:** Directly measured methane seepage at the ground surface at three locations in proximity to each wellhead.

**Open Path FTIR Sampling:** Performed a controlled release of sulfur hexafluoride (SF6; inert tracer) near each wellhead and measured ambient upwind (background) and downwind methane and SF6 concentrations using an open path Fourier transform infrared (OP-FTIR) spectrometer.

**c) What opportunities for training and professional development has the project provided?**

In February, two GSI personnel and one HARC employee attended a three-day training program to become certified in the use of the FLIR Systems infrared optical imaging camera utilized during the first field campaign.

**d) How have the results been disseminated to communities of interest?**

Field activities were shared real-time and immediately following completion of field programs with the DOE Project Manager. Preliminary results from field campaign 1 were discussed with the operators and project team members.

**e) What do you plan to do during the next reporting period to accomplish the goals?**

Results from the initial field program will be analyzed to develop preliminary emissions estimates and support development of a Year 1 data transmittal. High resolution methane leak monitoring will be initiated by way of remote monitoring of soil temperature and moisture conditions in relation to atmospheric conditions at one wellhead exhibiting an elevated ground-level flux of thermogenic methane.

## 3. PRODUCTS: Mandatory

**a) Publications, conference papers, and presentations**

**i. Journal publications.**

Not Applicable during this reporting period.

**ii. Books or other non-periodical, one-time publications.**

Not Applicable during this reporting period.

**iii. Other publications, conference papers and presentations.**

Not Applicable during this reporting period.

**b) Website(s) or other Internet site(s)**

Not Applicable during this reporting period.

**c) Technologies or techniques**

Not Applicable during this reporting period.

**d) Inventions, patent applications, and/or licenses**

Not Applicable during this reporting period.

**e) Other products**

Not Applicable during this reporting period.

## 4. PARTICIPANTS & OTHER COLLABORATING ORGNIZATIONS: Optional

**a) What individuals have worked on the project?**

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|---|---|
| **Name:** | Richard L. Bowers |
| **Project Role:** | Co-Principal Investigator |
| **Nearest Person Month Worked:** | 3 |
| **Contribution to the Project:** | Developed project deliverables and coordinated field activities with project partners. |
| **Funding Support** | None |
| **Collaborated with individual in foreign country:** | No |
| **Travelled to foreign country:** | No |

| | |
|---|---|
| **Name:** | Julie A. Spencer |
| **Project Role:** | Project Management and Technical Field Team Member |
| **Nearest Person Month Worked:** | 1 |
| **Contribution to the Project:** | Coordinated administrative project tasks and operated the FLIR Camera during field activities. |
| **Funding Support** | None |
| **Collaborated with individual in foreign country:** | No |
| **Travelled to foreign country:** | No |

**b) What other organizations have been involved as partners?**

| | |
|---|---|
| **Organization Name:** | Utah State University |
| **Location of Organization:** | Vernal, Utah |
| **Partner's contribution to the project:** | Subcontractor leading effort to collect gas emission samples during field trials. |
| **Financial Support:** | None |
| **In-kind Support:** | None |
| **Facilities** | Labs at Bingham Research Center, Utah State University, Vernal, UT |
| **Collaborative Research** | None |
| **Personnel Exchanges:** | None |
| **More detail on partner and contribution:** | None |

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|---|---|
| **Organization Name:** | Houston Advanced Research Center (HARC) |
| **Location of Organization:** | The Woodlands, Texas |
| **Partner's contribution to the project:** | Assisted with efforts to coordinate TASC participation. |
| **Financial Support:** | None |
| **In-kind Support:** | None |
| **Facilities** | HARC Labs in the Woodlands, TX |
| **Collaborative Research** | None |
| **Personnel Exchanges:** | None |
| **More detail on partner and contribution:** | None |

| | |
|---|---|
| **Organization Name:** | Colorado State University |
| **Location of Organization:** | Fort Collins, Colorado |
| **Partner's contribution to the project:** | Subcontractor assisting in effort to design underground sensor network for high resolution leak monitoring. |
| **Financial Support:** | None |
| **In-kind Support:** | None |
| **Facilities** | CSU Labs in Fort Collins, Colorado |
| **Collaborative Research** | None |
| **Personnel Exchanges:** | None |
| **More detail on partner and contribution:** | None |
| | |

**c) Have other collaborators or contacts been involved?**

Not Applicable during this reporting period.

## 5. IMPACT: Optional

**a) What is the impact on the development of the principal discipline(s) of the project?**

Not applicable during this reporting period.

**b) What is the impact on other disciplines?**

Not applicable during this reporting period.

**c) What is the impact on the development of human resources?**

Not applicable during this reporting period.

**d) What is the impact on physical, institutional, and information resources that form infrastructure?**

Not applicable during this reporting period.

**e) What is the impact on technology transfer?**

Technology transfer is being consistently performed throughout the project via TASC meetings, focused group meetings with team members and operators, conferences and workshops. These technology transfer activities improve labor skills of participating engineering and scientific companies and increase managerial education and project efficiency by getting real-time feedback on sampling protocols and data analysis.

**f) What is the impact on society beyond science and technology?**

Better understanding of air emissions sources reduces environmental impacts and minimizes loss to the industry.

**g) What dollar amount of the award's budget is being spent in foreign country(ies)?**

None.

## 6. CHANGES/PROBLEMS: Mandatory

**a) Changes in approach and reasons for change**

In order to assess different types of storage facilities, two salt cavern gas storage facilities, located in the Gulf Coast area, were added to our field program. The initial proposal was to perform a 4-week investigation of all 43 wells at the Clay Basin, Utah, depleted reservoir facility. We were able to complete field activities in Clay Basin in 2 weeks and complete another week of field activities in two additional facilities in the Gulf Coast area. We plan to repeat that process in the Year 2 field program. No additional costs were incurred on the project as a consequence of this change.

Access to the salt cavern facilities in the Gulf Coast region is contingent upon a Confidentiality Agreement between the operator and GSI. Due to a paucity of gas

storage facilities in the counties and states where these are located, our DOE NETL Project Manager and Contracts Manager have confirmed that i) the identity or specific location of the salt cavern sites need not be disclosed to DOE; ii) maintaining the confidentially of information by which the sites or their operator may be identified will not negatively impact results from the investigation and, in fact, will improve the understanding of emissions from multiple types of storage wells.

**b) Actual or anticipated problems or delays and actions or plans to resolve them**

Not applicable during this reporting period.

**c) Changes that have a significant impact on expenditures**

Not applicable during this reporting period.

**d) Significant changes in use or care of human subjects, vertebrate animals, and/or Biohazards**

Not Applicable to this Award.

**e) Change of primary performance site location from that originally proposed**

See response to 6(a) above.

## 7. SPECIAL REPORTING REQUIREMENTS: Mandatory

Not applicable during this reporting period.

## 8. BUDGETARY INFORMATION: Mandatory

A Cost Status Report is included as Attachment 1. In addition, graphs depicting the status of the budgeted versus cumulative costs of the overall project, technical transfer and cost share are included at Attachment 2.

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## Research Performance Progress Report

**Attachment 1: Cost Plan/Status**

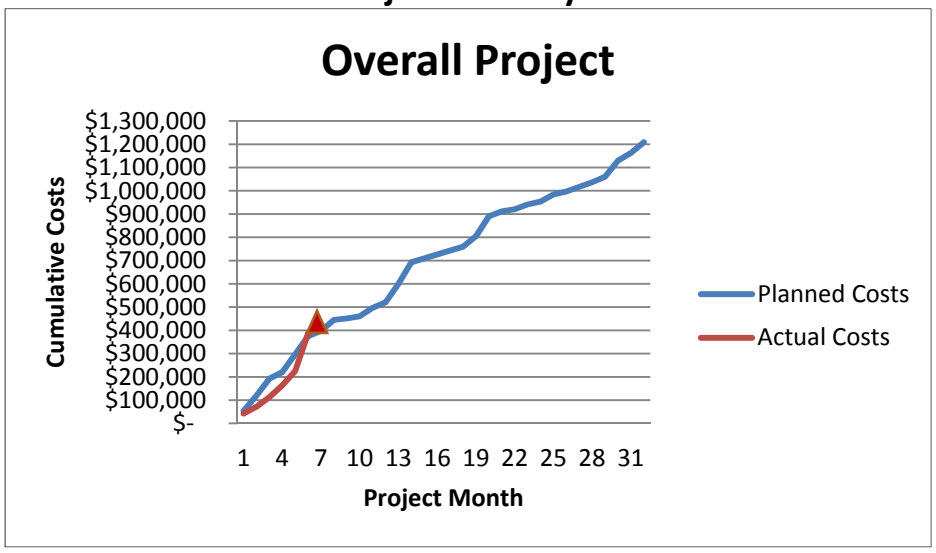
**DE-FE0029085: Long-Term Methane Emissions Rate Quantification and Alert System for Natural Gas Storage Wells and Fields**

| Baseline Reporting Quarter | Budget Period 1 | | | | | | | | Budget Period 2 | | | | | | | | Budget Period 3 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | | Q2 | | Q3 | | Q4 | | Q1 | | Q2 | | Q3 | | Q4 | | Q1 | | Q2 | | Q3 | |
| | 10/01/2016 - 12/31/2016 | | 01/01/2017 - 03/31/2017 | | 04/01/2017 - 06/30/2017 | | 07/01/2017 - 09/30/2017 | | 10/01/2017 - 12/31/2017 | | 01/01/2018 - 03/31/2018 | | 04/01/2018 - 06/30/2018 | | 07/01/2018 - 09/30/2018 | | 10/01/2018 - 12/31/2018 | | 01/01/2019 - 03/31/2019 | | 04/01/2019 - 06/30/2019 | |
| | Q1 | Cumulative Total | Q2 | Cumulative Total | Q3 | Cumulative Total | Q4 | Cumulative Total | Q1 | Cumulative Total | Q2 | Cumulative Total | Q3 | Cumulative Total | Q4 | Cumulative Total | Q1 | Cumulative Total | Q2 | Cumulative Total | Q3 | Cumulative Total |
| ***Baseline Cost Plan*** | | | | | | | | | | | | | | | | | | | | | | |
| Federal Share | $ 173,000.00 | $ 173,000.00 | $ 28,000.00 | $ 201,000.00 | $ 151,000.00 | $ 352,000.00 | $ 169,000.00 | $ 521,000.00 | $ 188,645.00 | $ 709,645.00 | $ 49,986.00 | $ 759,631.00 | $ 152,089.00 | $ 911,720.00 | $ 42,367.00 | $ 954,087.00 | $ 63,582.00 | $ 1,017,669.00 | $ 111,628.00 | $ 1,129,297.00 | $ 79,152.00 | $ 1,208,449.00 |
| Non-Federal Share | | $ - | $ 10,500.00 | $ 10,500.00 | $ 88,000.00 | $ 98,500.00 | $ 32,500.00 | $ 131,000.00 | $ - | $ 131,000.00 | $ - | $ 131,000.00 | $ 142,000.00 | $ 273,000.00 | | $ 273,000.00 | $ - | $ 273,000.00 | $ - | $ 273,000.00 | $ 32,000.00 | $ 305,000.00 |
| ***Total Planned*** | ***$ 173,000.00*** | ***$ 173,000.00*** | ***$ 38,500.00*** | ***$ 211,500.00*** | ***$ 239,000.00*** | ***$ 450,500.00*** | ***$ 201,500.00*** | ***$ 652,000.00*** | ***$ 188,645.00*** | ***$ 840,645.00*** | ***$ 49,986.00*** | ***$ 890,631.00*** | ***$ 294,089.00*** | ***$ 1,184,720.00*** | ***$ 42,367.00*** | ***$ 1,227,087.00*** | ***$ 63,582.00*** | ***$ 1,290,669.00*** | ***$ 111,628.00*** | ***$ 1,402,297.00*** | ***$ 111,152.00*** | ***$ 1,513,449.00*** |
| ***Actual Incurred Cost*** | | | | | | | | | | | | | | | | | | | | | | |
| Federal Share | $ 113,409.00 | $ 113,409.00 | $ 274,728.10 | $ 388,137.10 | | $ 388,137.10 | | $ 388,137.10 | | $ 388,137.10 | | $ 388,137.10 | | $ 388,137.10 | | $ 388,137.10 | | $ 388,137.10 | | $ 388,137.10 | | $ 388,137.10 |
| Non-Federal Share | | $ - | $ 131,400.00 | $ 131,400.00 | | $ 131,400.00 | | $ 131,400.00 | | $ 131,400.00 | | $ 131,400.00 | | $ 131,400.00 | | $ 131,400.00 | | $ 131,400.00 | | $ 131,400.00 | | $ 131,400.00 |
| ***Total Incurred Cost*** | ***$ 113,409.00*** | ***$ 113,409.00*** | ***$ 406,128.10*** | ***$ 519,537.10*** | ***$ -*** | ***$ 519,537.10*** | ***$ -*** | ***$ 519,537.10*** | ***$ -*** | ***$ 519,537.10*** | ***$ -*** | ***$ 519,537.10*** | ***$ -*** | ***$ 519,537.10*** | ***$ -*** | ***$ 519,537.10*** | ***$ -*** | ***$ 519,537.10*** | ***$ -*** | ***$ 519,537.10*** | ***$ -*** | ***$ 519,537.10*** |
| ***Variance*** | | | | | | | | | | | | | | | | | | | | | | |
| Federal Share | $ (59,591.00) | $ (59,591.00) | $ 246,728.10 | $ 187,137.10 | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| Non-Federal Share | $ - | $ - | $ 120,900.00 | $ 120,900.00 | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| ***Total Variance*** | ***$ (59,591.00)*** | ***$ (59,591.00)*** | ***$ 367,628.10*** | ***$ 308,037.10*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** | ***$ -*** |

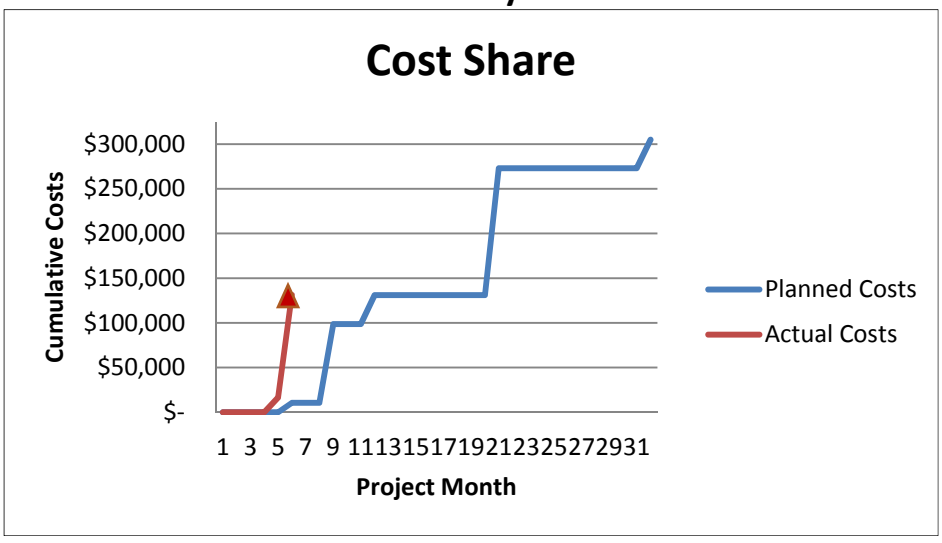
# RESEARCH PERFORMANCE PROGRESS REPORT

## Attachment 2: Summary Charts of Actual vs. Planned Expenditures
## DE-FE0029085: Costs through March 31, 2017

### Total Project Costs by Month




### Cost Share by Month



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# DE-FE0029085

## Summary Charts of Actual vs. Planned Expenditures
## Costs through March 31, 2017, cont.

### Technology Transfer by Month