DOE Oil & Gas Research Program

Advancing Technologies to Ensure Safe and Prudent Oil & Gas Development

Program Overview

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Program Elements

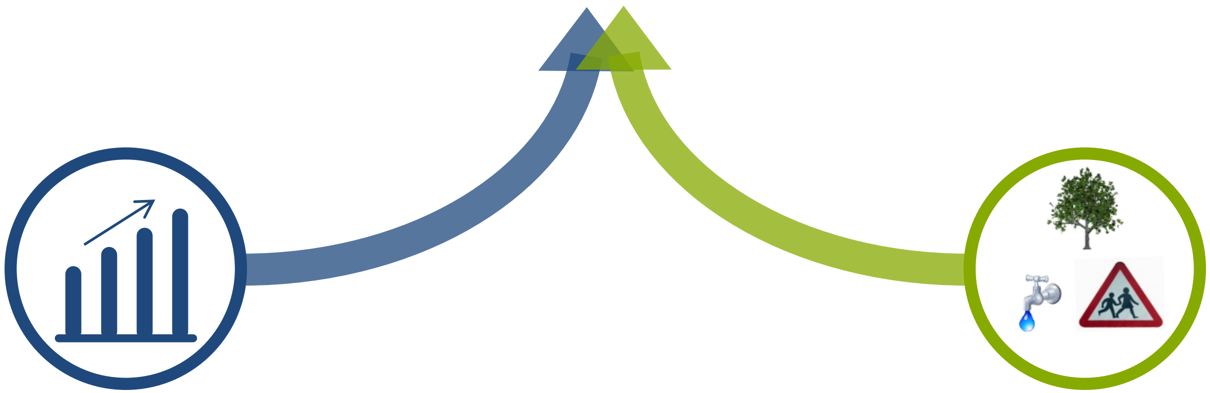
	**Unconventional Oil & Gas**	*Developing technologies to **maximize recovery and reduce environmental impact** from unconventional oil & gas development*
	**Methane Hydrates**	*Determine the potential for methane hydrates as a **energy resource**, the **environmental impacts** associated with production, and it's role in the global climate cycle.*
	**Methane Quantification**	*Assessing current methane emissions data and addressing data gaps (emission factors) in EPA's Greenhouse Gas Inventory*
	**Methane Mitigation**	*Developing technologies and practices to **mitigate CH4 emissions** from natural gas transmission, distribution, and storage facilities*
	**Offshore**	*Developing technologies that **minimize the environmental impacts and improve the safety** of deepwater and ultra-deepwater oil and natural gas production*

Mission

Prudent Development

Oil and natural gas resources development, operations, and delivery systems that achieve a broadly acceptable balance of several factors:

- *Energy security*
- *Economic growth*
- *Environmental stewardship and sustainability*
- *Human health and safety*



Maximize Public Benefits

The abundance of domestic oil and natural gas offers substantial supply for decades, helping reduce U.S. reliance on imported oil and promoting energy security.

Promote Sustainability

The scale and nature of the technologies used to develop unconventional oil and gas resources have prompted concerns over potential impacts.

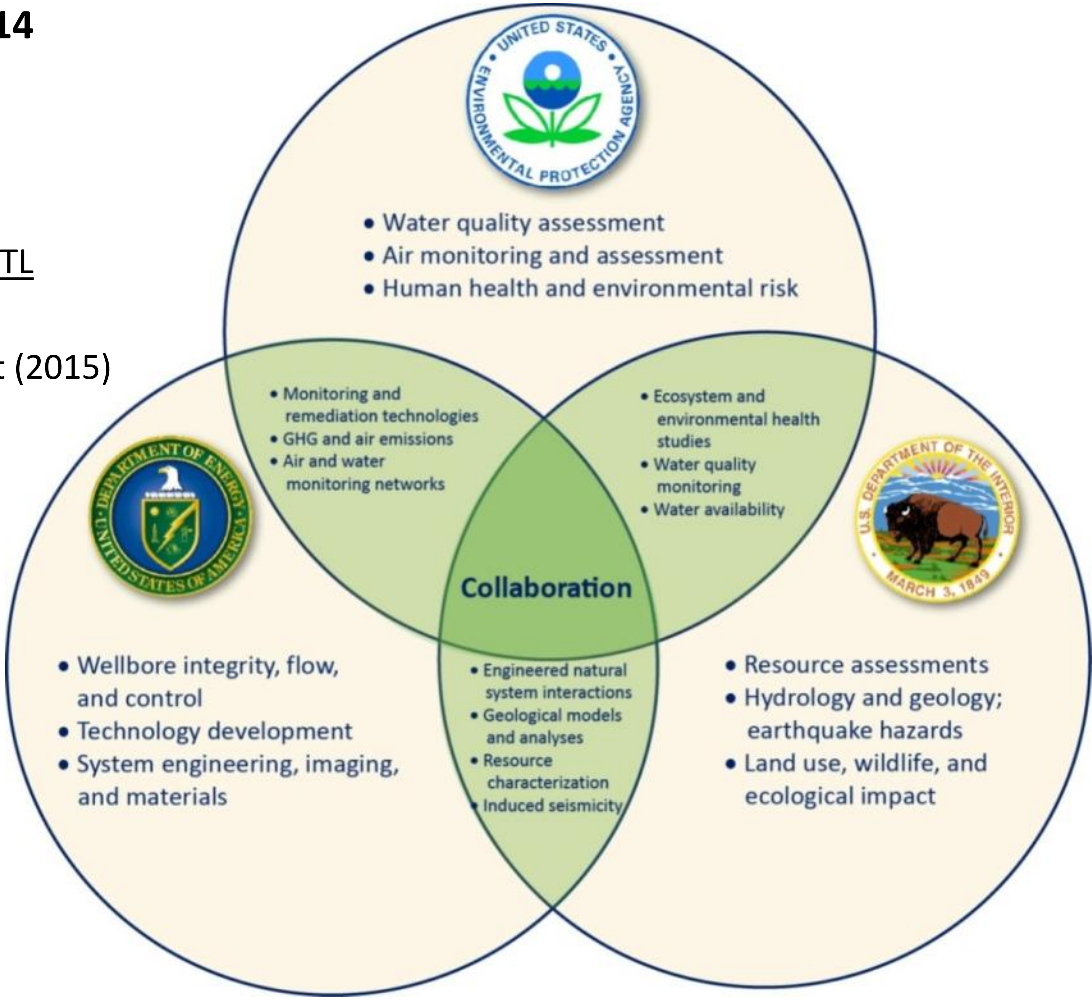
Unconventional

Unconventional Program Goals

Current Program Goals Established with 2014 Interagency Roadmap

Progress continually refined via

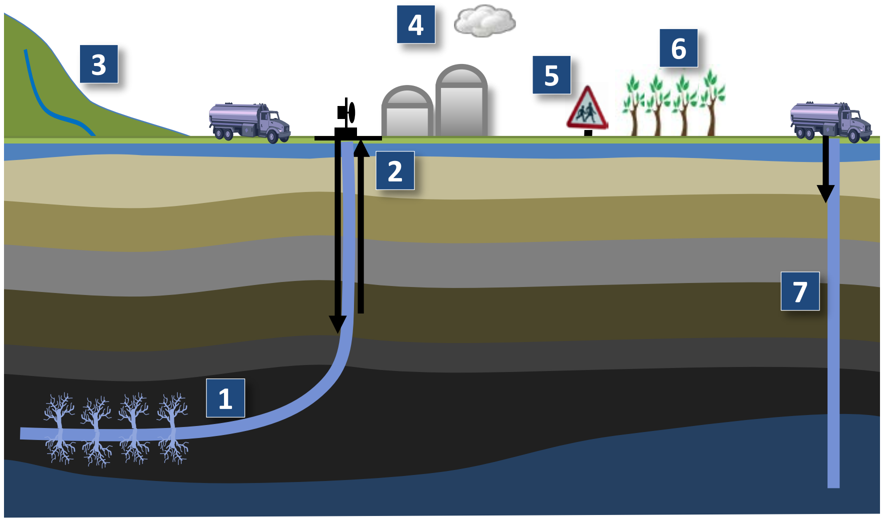
- Executive Steering Committee (G. Bromhal is NETL representative)
- DOE QTR and supporting Sci. & Tech Assessment (2015)



Unconventional Oil & Gas

Research Areas

Advancing technology to secure resources that cannot be produced economically through standard drilling and completion practices such as shale gas, shale oil, tight gas, and tight oil.



1. **Resource Optimization**
2. **Water Quality** – Protect Water Resources
3. **Water Availability** – Prevent Water Shortages
4. **Air Quality** And Greenhouse Gas Emissions
5. Safeguard **Human Health**
6. **Ecological Effects** – Protect Our Natural Resources
7. **Induced Seismicity** – Understand And Mitigate Seismicity Risks

- Access abundant, domestic resources as a vital component of energy portfolio
- Enhance energy, economic, and environmental security
- Create significant income, employment, and other economic benefits.

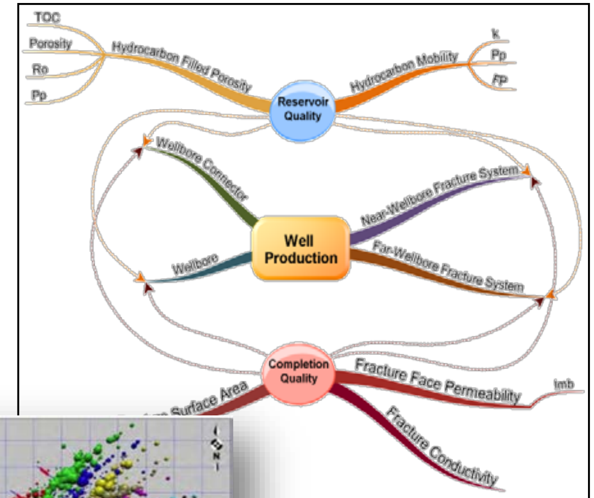
- Understand potential impacts on human health and the environment and how they can be mitigated
- Use natural gas as a bridge fuel during transition to even cleaner energy

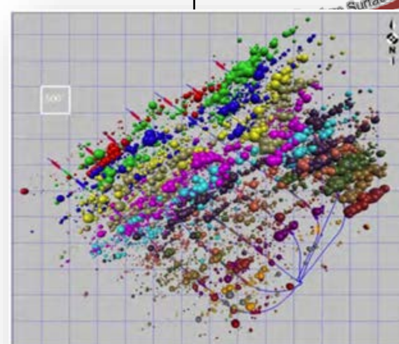
UOG Resource Optimization
"Mastering the Subsurface"

- **Resource Evaluation**
  - Resource is a dynamic function of technology
  - Need for information beyond currently-recoverable
  - Need to constrain the potential timing , scale, and nature of development

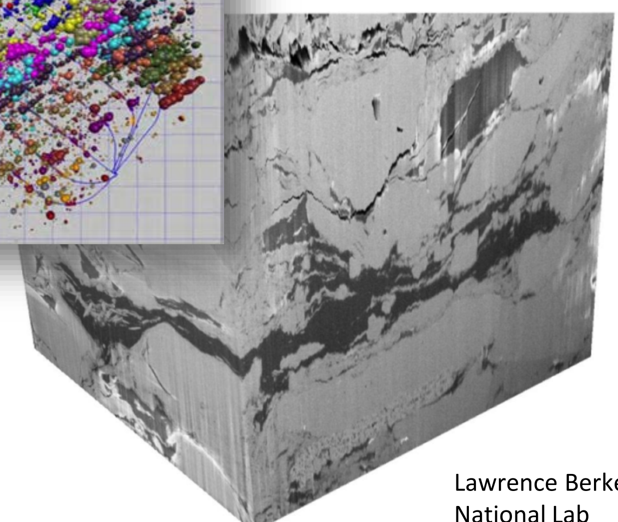
- **Fundamental Science**
  - No two UOG reservoirs are alike
  - Macro responses driven by micro phenomena
  - Fundamental principles do not apply

- **Research Needs**
  - Improved characterization "tools"
  - New SRV diagnostic "tools"
  - Control of Stimulation
  - New technology field demo's





Gas Technology Institute

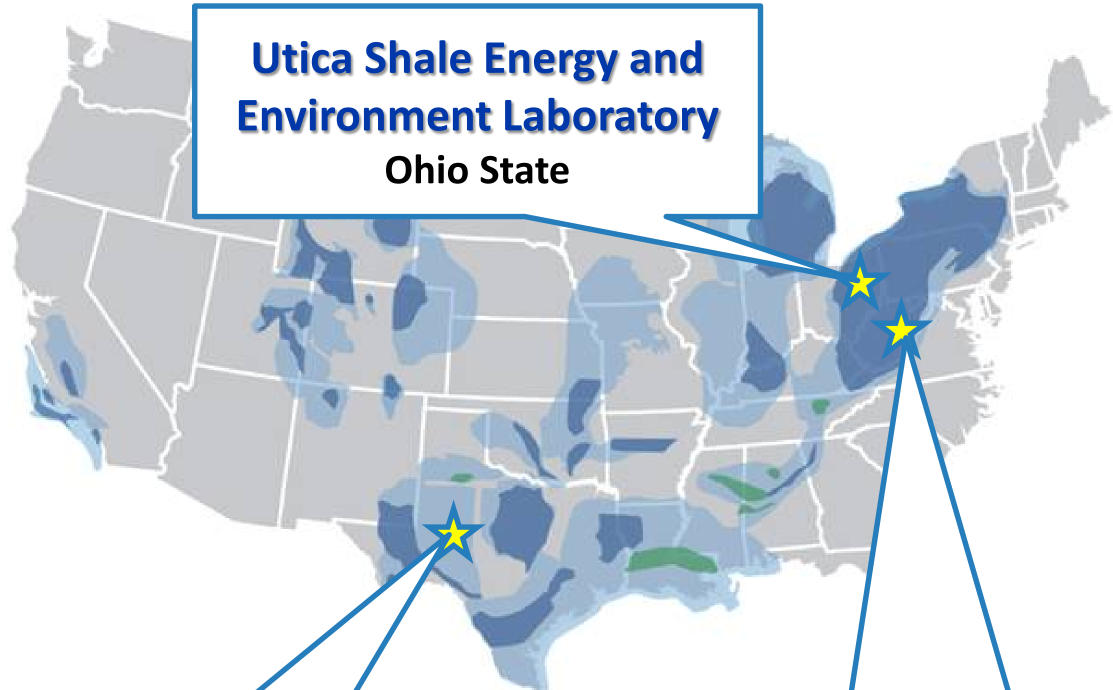


Lawrence Berkeley National Lab

SRV – Stimulated Rock Volume

Unconventional Field Laboratories

- Dedicated Science wells; extensive coring; instrumented production wells
- Baseline and real-time observation/monitoring
- NEW technology testing and demonstration
- Public and International training and outreach
- Broad collaborative opportunities



Methane Hydrates

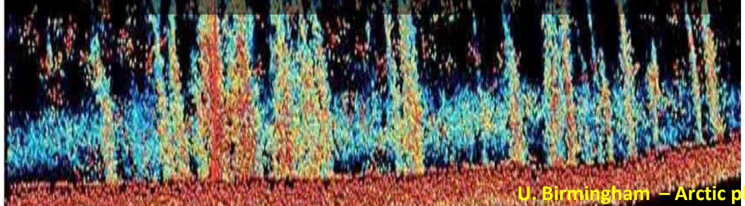
Methane Hydrates

Geohazards

1. Safe drilling/production through gas hydrate.

Global Environment

1. linkages to deep sea bio communities
2. destabilization of the sea-floor
3. Mediation of global carbon cycling
4. Feedback to climate change?



U. Birmingham – Arctic plumes

Energy Resource Potential

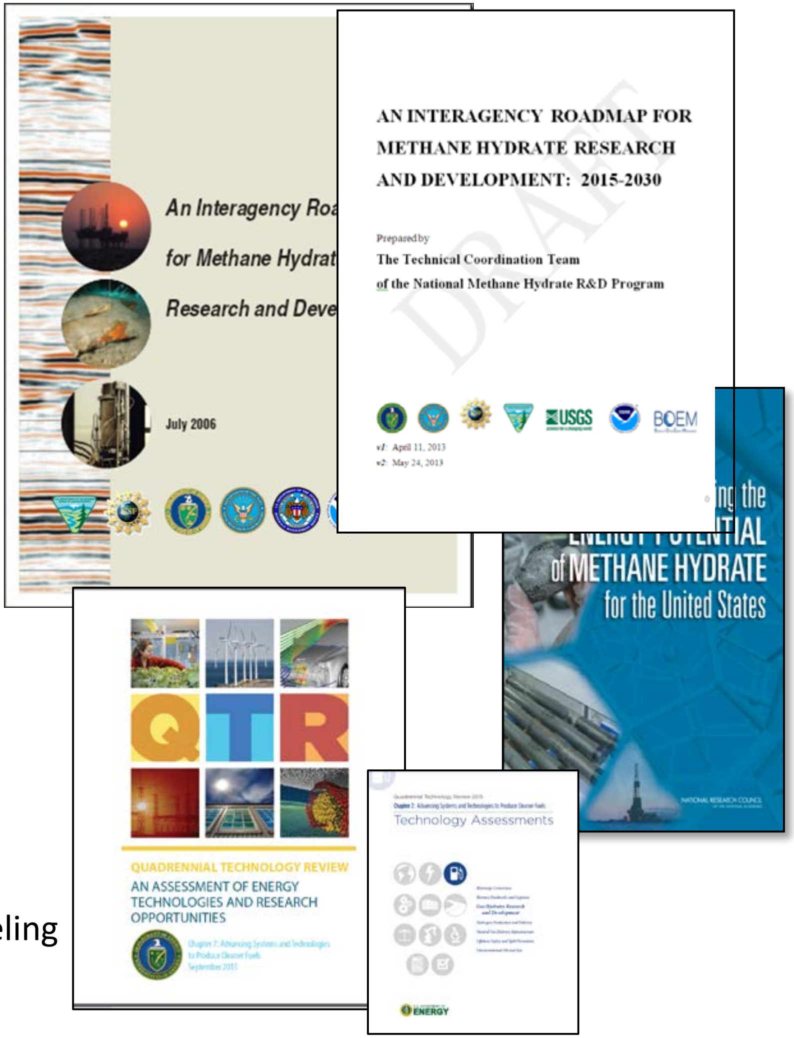
1. Feasible targets and potential volumes
2. Effective exploration
3. Safe and viable production
4. Environmental impacts mitigation

Methane Hydrate Program Goals

Current Program Goals Established with 2006 Interagency Roadmap

Goals continually refined via

- FAC (~ every 9 months)
- Interagency Technical Coordination Team (Bi-annual)
- National Academies Reviews (2005 & 2010)
- DOE QTR (2015)
- Secretary of Energy Advisory Board (2016)



NEAR-TERM GOALS (2020)

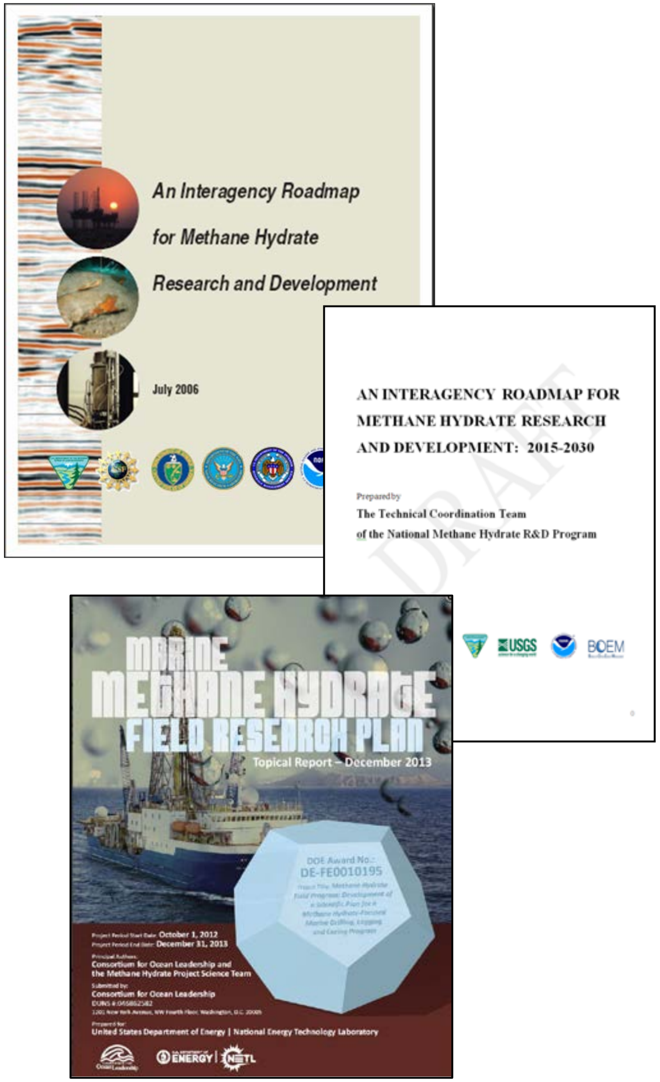
- Demonstrate long-term Technical Recoverability (Alaska)
- Confirm Gulf of Mexico Resource Assessment
- Continue International Collaborations

LONG-TERM GOALS (2025)

- Confirm scale of US resource base (+ Atlantic)
- Demonstrate Production Approach (Alaska + International)
- Consensus view on GH/Climate linkages via field programs + modeling

Methane Hydrate R&D Needs

- **Field Sampling Technology**
  - Tested, reliable coring and analytical tools
- **Exploration Technology**
  - Extension of prospecting approaches to more challenging settings
- **Resource Characterization**
  - Consensus on scale of US OCS resource
  - Marine petroleum systems evaluation incl. petrophysics
- **Production Technology**
  - Optimized production systems developed
  - Environmental impacts identified and mitigated
  - Reliable simulation capabilities demonstrated
  - Potential producibility of mud-hosted hydrates determined
- **Role in the Natural Environment**
  - Consensus on the nature and implications of GH geohazards



2016/2017 Hydrate Research Priorities

1. Characterize samples and update production models (with collaborating labs)—Samples from Alaska North Slope and GoM.
2. Complete numerical simulation modeling in collaboration with India and Korea in preparation for international field opportunities (collaboration with LBNL, USGS)
3. Increase numerical simulation modeling in preparation for Alaska production test (collaboration with Japan) → Design test parameters
4. (Gulf of Mexico) Complete a sea test of the DOE hydrate pressure coring system with UT-Austin
5. (Gulf of Mexico) Pursue opportunity for 2nd expedition through the Integrated Ocean Discovery Program
6. (Alaska) Conduct stratigraphic test drilling at a Prudhoe Bay site with Japan and industry partners. Confirm occurrence of suitable reservoirs for long-term testing.

2016 Funding Opportunity Announcement

- Two topic areas, fundamental science
- $4.5 Million DOE

Topic Area 1: Hydrate Production Science

Determine the petrophysical and thermodynamic nature of gas-hydrate bearing sediments (including reservoir and bounding units), and their response to induced changes in physical and/or chemical conditions. Critical for long-term production systems design and operation for <u>both marine and permafrost settings</u>.

Topic Area 2: Environmental/Climate Science:

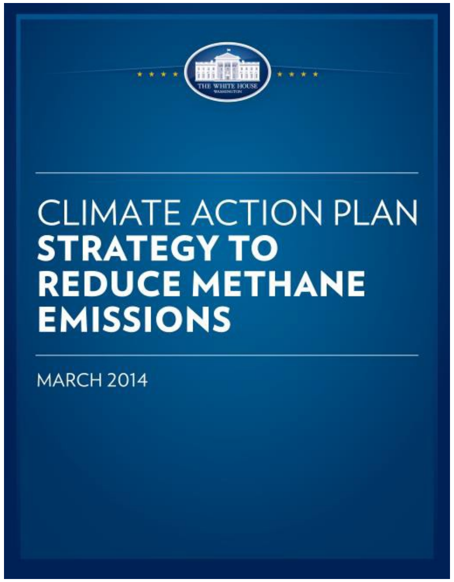
Determine gas hydrate's occurrence and role in the global natural environment. Specifically, determine the potential for significant response to <u>warming climates</u> (from climate-driven hydrate dissociation)

Natural Gas Infrastructure Program
Methane Quantification & Mitigation

Natural Gas Infrastructure

New Program



President's Climate Action Plan

"Curbing emissions of **methane** is critical to our overall effort to address global climate change. … To achieve additional progress, the Administration will":

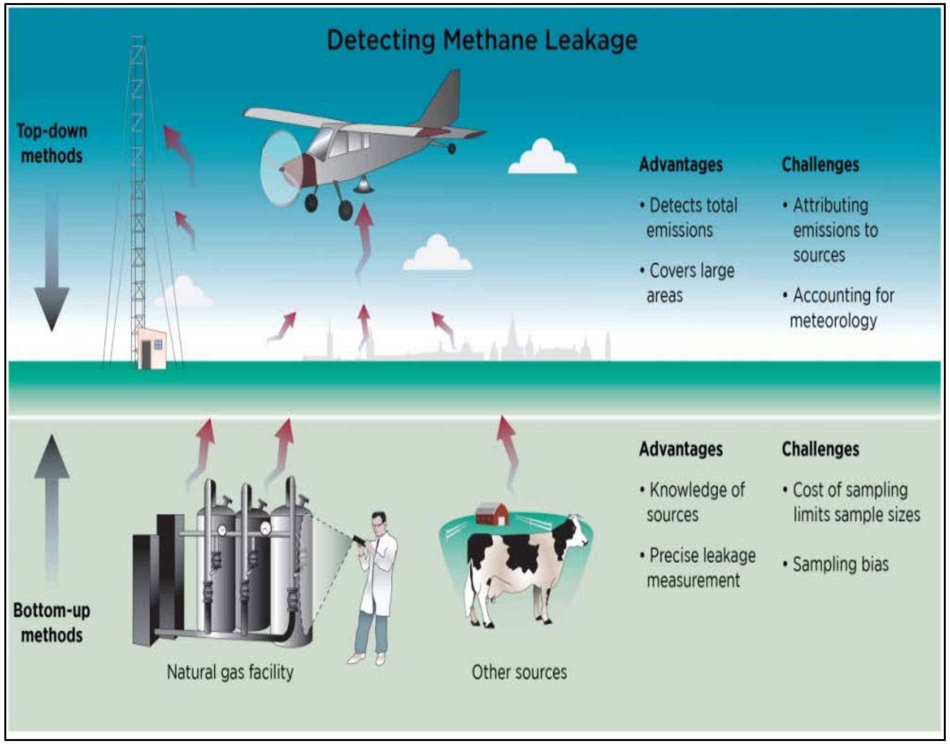
- Develop a comprehensive Interagency Methane Strategy **(completed March 2014)**
- Pursue a collaborative approach with state governments and the private sector and cover all methane emitting sectors

Interagency Methane Strategy – Three Pillars

Assessing current emissions data and addressing data gaps	Identifying Technologies and Best Practices for Reducing Emissions	Identifying Existing Authorities and Incentive-based Opportunities for Reducing Emissions

NG Infrastructure
Methane Emissions Quantification

- **Measurement**
  - Reconcile conflicting results from different approaches
  - Are leakage rates representative?
- **Attribution**
  - Accounting for other sources?
  - Accounting for dispersion?
  - Representative conditions?
  - Role of a few, large, emitters
- **Mitigation**
  - New standards in industry are reducing upstream emissions
  - New monitoring devices with focus on mid-stream are needed



MIT Energy Initiative, 2013

NG Infrastructure
Methane Mitigation

480,000+
Producing Gas Wells

275,000+
Separators

36,000+
Field Compressors

600+
Processing Plants

1,400+
Transmission
Compressor Stations

66,000,000+
Homes

300,000+
Miles Pipeline

www.eia.gov, **EPA: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012, April 15, 2014**

2016/2017 Key Research Priorities

1. Methane Quantification → **Initiate steps to inform EPA Greenhouse Gas Inventory**:
    - Initiate field measurements to improve component level emission data, activity data and non-inventoried natural gas emission sources from gathering systems and abandoned/legacy wells (Specifically, assessments to take place in the Sesquehannock State Forest and Oil Creek Park, Pennsylvania)
    - Initiate Modeling Activities: Time Series Modeling (emission factor), LCA (improve uncertainty of key methane contributions, Tracking/Evaluation of Methane Abatement Technology
    - Investigate emissions from distribution systems, and underground natural gas storage → inform EPA GHGI.
2. Mitigation:
    - Develop electrochemical point sensors for quantification of corrosion rates and environmental monitoring (e.g. pH), distributed optical sensor technologies for T, P, methane conc, passive sensors for multiparameter sensing.
    - Initiate the development of advanced liner and coatings.
    - Begin the development of advanced pipeline inspection & repair technologies (without evacuation of the methane gas)

Funding Opportunity Announcement
Natural Gas Infrastructure

- 6 Topic Areas
- $19 million

Quantification ($7 Million)

Topic Area 1: Gathering System Pipeline and Compressor Characterization

Topic Area 2: Distribution System Characterization

Topic Area 3: Underground Natural Gas Storage Emissions

Mitigation ($12 Million)

Topic Area 1: Pipeline Inspection & Repair

Topic Area 2: Smart Pipeline Sensors (Btu, gas quality, pressure, flow rate)

Topic Area 3: Advanced Technologies (pneumatic controllers, compressor seals, natural gas dehydrators, gathering lines & connections)

Offshore

Offshore R&D Needs
Safety & Environmental Sustainability

Operations Risk Reduction

- Geologic Uncertainty
- UDW Drilling and Completions Operations

Surface Facilities and Subsea Equipment Risk Reduction

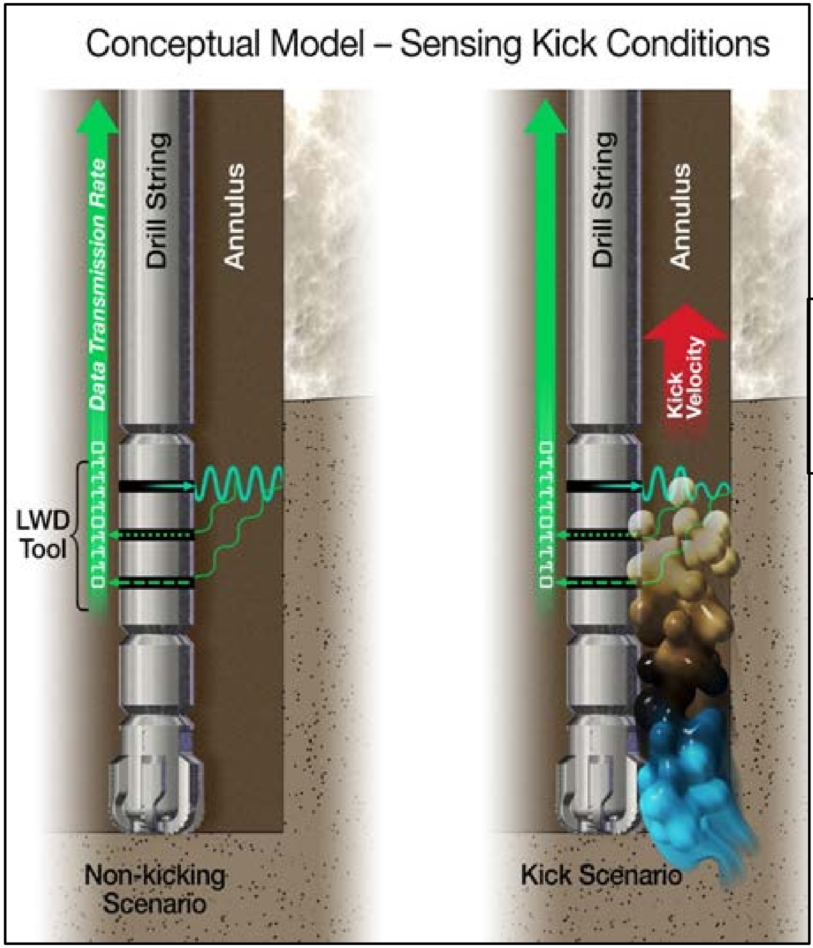
- Surface Systems and Umbilicals (Wellbore Stability)
- Subsea Systems Reliability / Automated Safety Systems

Technology Focus on Safety & Environmental Sustainability

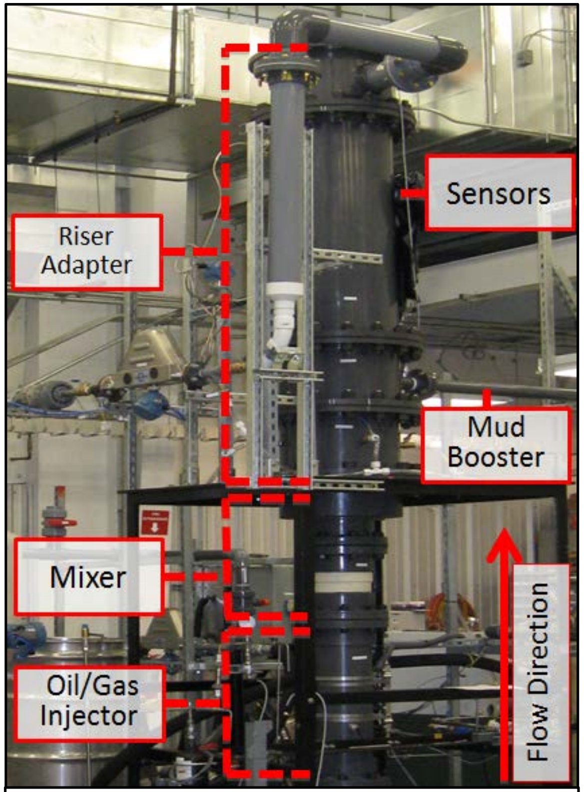
Reducing Geologic Uncertainty

Early Kick Detection

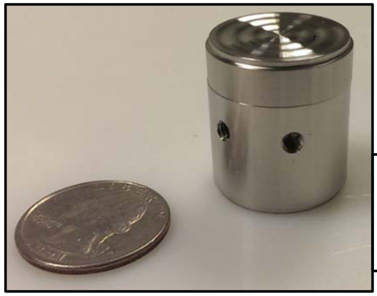
Geologic Uncertainty



Downhole Kick Detection: Based on LWD Signal Analytical Model



Detecting Small Mud Density Changes at Base of the Riser



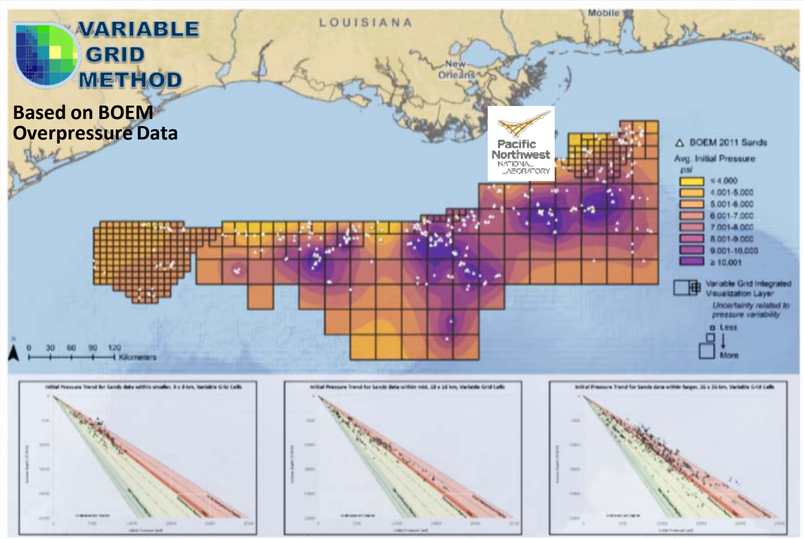
<u>Enabling Technology</u>: First HPHT DP Cell: Tested to 150 psi DP (2 X Full Scale) with Static Pressure Protection to 22,500 psi.

Reducing Geologic Uncertainty

Integrated Risk Assessment & EDX

When utilized for subsurface analysis and exploration, VGM helps analyze the ***relationship between uncertainty and data…***

Geologic Uncertainty

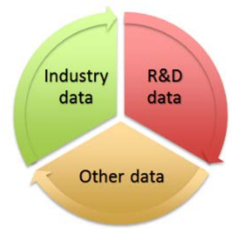


… to effectively guide research, management and policy decisions and drive advance computation analyses to reduce exploratory risk

Energy Data Exchange (EDX)

https://edx.netl.doe.gov

EDX
A Product of NETL

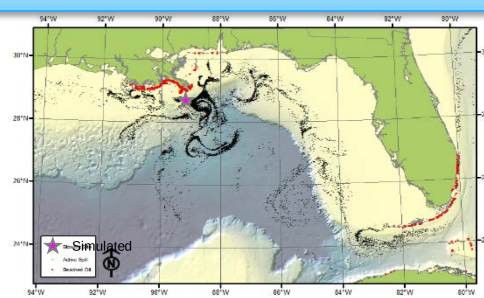


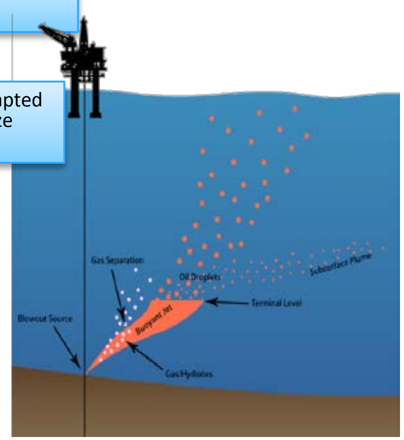
Use & Re-use -
Data often meet needs beyond original purpose

Data management is key to re-use

hadoop

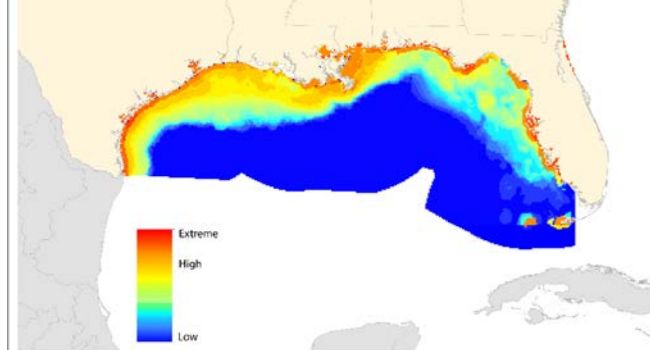
BLOSOM is a comprehensive modeling suite for offshore blowout events, adapted for jet/plume behavior, high pressures, gas and hydrate dynamics, droplet-size distributions, and subsurface plume formation





CSIL provides inputs for broad impacts modeling that can be used to identify spatial & temporal trends as well as help quantify potential impact severity associated with blowouts & leaks in the GOM to support oil spill prevention efforts

Cumulative Spatial Impact Layers (CSIL) Approach



FY2017 Offshore Research Priorities

1. Hydrocarbon Equation of State (EOS): Continue efforts that have placed NETL at the forefront of experimental and modeling studies of fluid density at extreme conditions.
2. Integrated Risk Assessment Model (IAM): Continue to develop the science based resources needed to improve understanding and performance of offshore oil and gas systems to reduce uncertainty for safe and responsible production of offshore resources.
3. Early Kick Detection: Continue to use field data from wells that have experienced a documented loss of well control to verify the kick detection methodology.
4. Metals: Continue to develop the scientific base for predicting and quantifying potential risks associated with exploration and production equipment in extreme offshore environments.
5. Lightweight cement (formerly foam cement): Continue to use NETL's state-of-the-art facilities, expertise in wellbore cements, and significant industry collaboration to improve the knowledge required to ensure safe operations in using lightweight cements in the deep offshore environment
6. Barrier interfaces: Continue to advance the science-base for understanding critical weak-links in the well integrity system and provide tools and data that industry and regulators can use to compare with their own in-house codes and technologies to ensure safe operations in the offshore environment

Partnerships Critical to Oil & Gas Mission
Thank You!

NETL

Los Alamos National Laboratory
Pacific Northwest NATIONAL LABORATORY
BSEE Bureau of Safety and Environmental Enforcement
Department of the Army, United States of America
Lawrence Livermore National Laboratory
United States Environmental Protection Agency
USGS science for a changing world
Berkeley Lab
Sandia National Laboratories
Argonne NATIONAL LABORATORY
Oak Ridge National Laboratory

Government

West Virginia University
University of California
Carnegie Mellon
University of Pittsburgh
Penn State
Princeton University
University of Pittsburgh
MIT
OSU Oregon State University
Virginia Tech
UK University of Kentucky

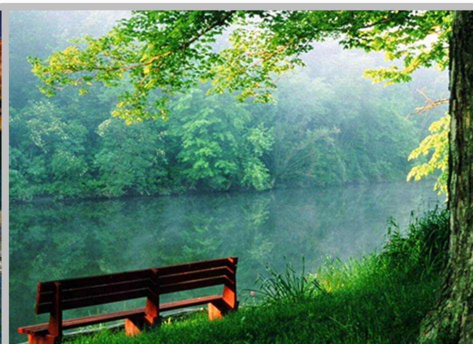
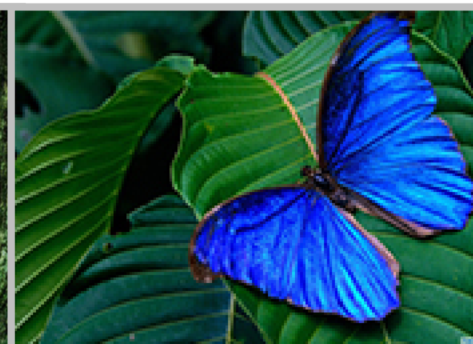
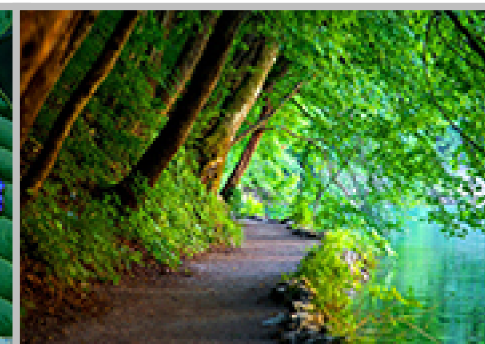
Academia (Supporting Inhouse R&D)

Industry (SEAM Phase I Example)

Anadarko
Marathon Oil Corporation
Statoil
Landmark A Halliburton Company
bhpbilliton resourcing the future
BR Petrobras
Total
WesternGeco
SIGMA³
RPSEA Research Partnership to Secure Energy for America
SEG
RSI
Repsol
CGG Passion for Geoscience
devon
nexen
PGS
Maersk Oil
Chevron Human Energy
Geotrace
emgs
ion GX Technology
ConocoPhillips
ExxonMobil Upstream Research
Eni
Hess

Social Responsibilities

Take Our Daughters and Sons to Work
Celebrate Earth Day! April 22
WV Regional Science Bowl
Society for Analytical Chemists of Pittsburgh
southwestern pa ScienceBowl
2015 NSB National Science Bowl a competition like no other . . .
Society for Spectroscopy of Pittsburgh 1946
Pittsburgh Regional Center for Science Teachers University of Pittsburgh
Mickey Leland Energy Fellowship

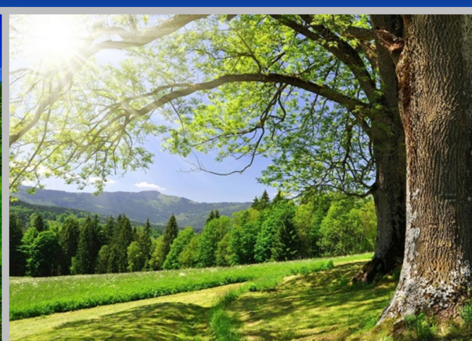





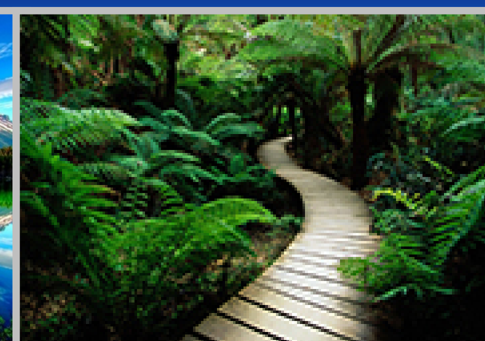
For More Information, Contact NETL

the ENERGY lab

Delivering Yesterday and Preparing for Tomorrow

www.netl.doe.gov



Marcellus Shale Experiment and Environment Laboratory (MSEEL)

Geochemistry (WVU; - OSU)

- **Rock – Kerogen; TOC; C/N/S; XRD; FIB/SM; cryo-laser ablation; Hg porosimetry**
- **Fluids/Gases – Continuous monitoring S/C/O/H isotopes, organics, DOC, NORM, noble gases**

Microbiology (OSU; WVU)

- **Biomass; microbial lipids, metagenomics**

Petrophysics/Geomechanics (WVU)

- **Steady-state permeability (*in situ* P/T); porosity; pore-size; adsorption → dynamic petrophysics f(P); vertical/lateral heterogeneity.**
- **Mechanical strength measurements (laboratory and well-log)**
- **FIB/SEM: pore and mineralogical structure**
- **Log to core calibration; comparison to industry standard methods;**
- **Real-time, actionable data for HF operations; comparative geometric (5H) and engineered (3H) completions**
- **natural fracture imaging; fibre-optics monitoring → Multi-scale (nano-scale to SRV) numerical simulation.**

Geophysics (WVU)

- **Borehole microseismic – SRV characterization in multi-well context**

Surface Water: Organics, inorganics, rads

Produced Water: Major cation/anion & trace elements, DOC, Sr/Li isotopes, S/C/O/H isotopes, organics, lipids, genomics, noble gas and radioactive elements

Air: C, H isotope composition of methane, ethane, CO2, noble gas isotopes, particulates & NOx

Complementary Research at the MSEEL

By NETL In-House

- *NETL:* multi-scale CT imaging/micro-scale structure; MSCL
- *NETL:* Sr/Li isotopes; major cation/anion/trace elements
- *NETL:* surface micro-science array; fracturing and relaxation
- *NETL:* SRA/TOC
- *NETL:* fracture modeling (FMI)

By Existing National Laboratory Contributors

- *LANL:* tri-axial core-flood w/tracers & AE → in situ fracture formation and permeability; X-ray tomography → apertures and conductivity.
- *LBNL:* thermodynamic; X-Ray CT → laboratory and numerical studies of fluids flow and mobility in shales t

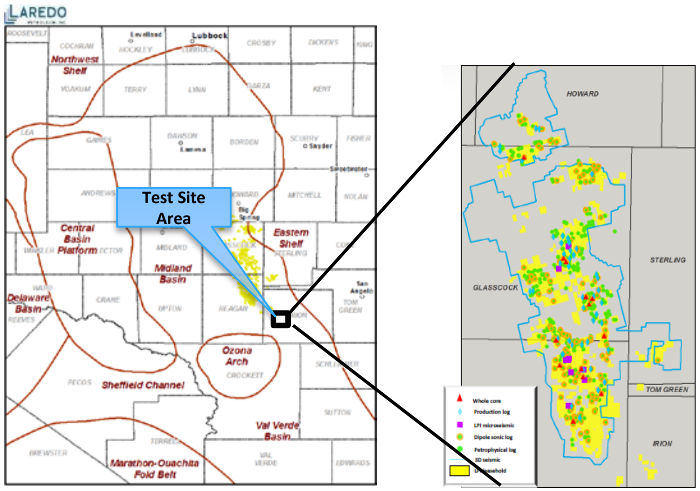
By Collaborating Federal Agencies

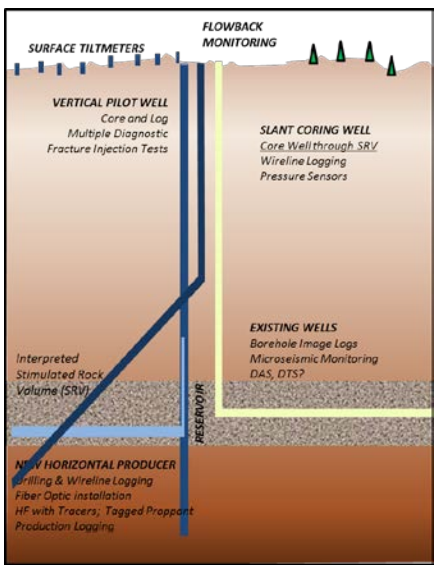
- *USGS:* contaminants in drill cuttings – wastewater evaluations

By Shale Gas Cooperative Agreement Contributors

- *UT-A:* tri-axial compressive strength; ultrasonic velocity; NMR during fracture; SEM and FIB
- *Ok. St:* petrophysical protocols: shale-fluid interaction
- UT-A: relative effect of pore pressure & confining stress on permeability
- SLAC: shale and fracturing fluid at the micro-nanoscale

Hydraulic Fracture Test Site (HTFS)





3 yrs: DOE Costs $7.61 m; Total Cost: $18 m
Liquid rich
Upper & Middle Wolfcamp Shale
Active site; Extensive existing data set brought by partner

Timing:
Oct-Dec 2015 – stimulate 11 wells;
Feb- Mar 2016 - drill & core slant well
May 2016- characterize core and install pressure sensors in slant well

Performer: GTI; Subs – U Texas at Austin & BEG
Field Site Host: Laredo Petroleum Inc.
JIP Participants: Devon, Encana, TOTAL, Discovery Natural Resources, Energen, Halliburton, & Core Labs

Objectives: Minimize environmental impacts, and determine optimum well spacing based on fracturing efficiency

Project: Hydraulic fracture of 11 new in-field wells, plus 2 previous horizontal producers were re-fractured

Hydraulic Fracture Test Site (HTFS)
Subsurface Science

Petrophysics/Geomechanics

- Characterization of Target Zone – logs & sidewall cores
- Slant well FMI log and core CT scans correlated
- Formation pressure to be monitored from slant well during production
- Diagnostic Fracture Injection Tests (DFIT) run in laterals to determine formation breakdown pressure
- Toe DFITs conducted in multiple wells
- Multiple stimulation designs used
- Slant well drilled through stimulated rock volume
- Core recovered from slant well at closest point of 2 wells being traversed
- Hydraulic and Natural Fracture Investigation – CT Scans, core characterization, fracture spatial organization
- Hydraulic Fracture Modeling – each fracture stage to be modeled
- Colored proppant used in area of slant well
- RA Tracers run in stimulations to track fracture growth & interference patterns

Geophysics

- Cross well conducted on 3 existing wells prior to and post stimulation
- Microseismic data collected during all 400+ stimulation stages

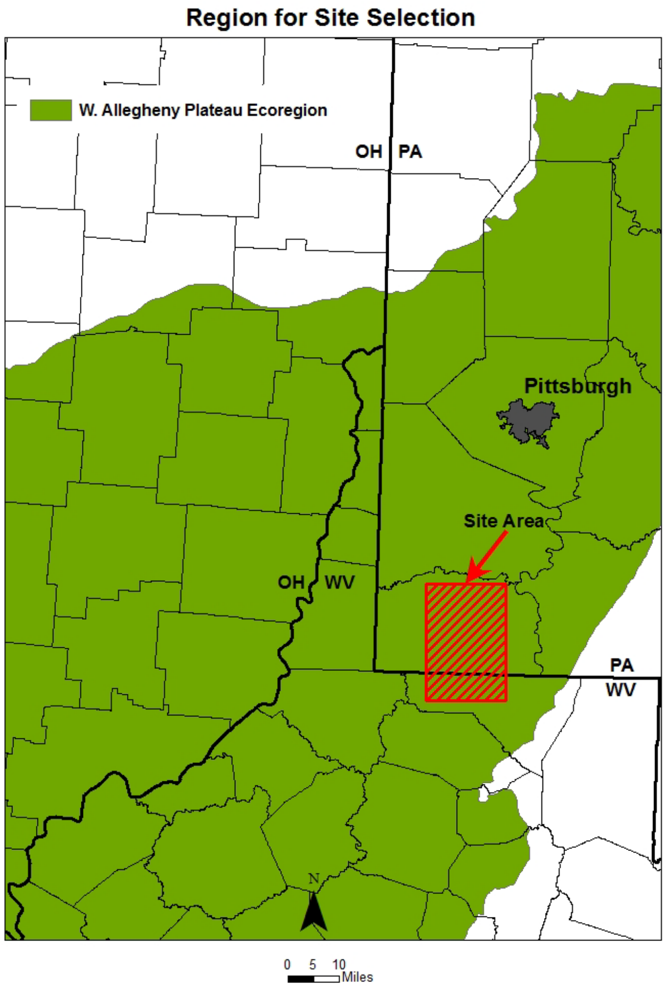
Microbiology

- Microbial Analysis – Characterize what microbial communities may be introduced via fracking and track how the communities in the deep sub-surface change over time

Environmental Science

- Baseline data provided by Laredo & U. Texas
- Groundwater analysis – 5 existing groundwater wells within 5,000 ft being monitored throughout life of project
- Air Monitoring – Conducted 1,000 ft upwind & 1,000 ft downwind of pad prior to, during and post stimulation

Utica Shale Energy and Environment Laboratory (USEEL)



5yrs: DOE Costs = $7.2 m

Site: Utica - TBD

- dry gas
- Deep Utica play (~14,000')
- Exploratory/pioneering science

Location: Deep Utica between Pittsburgh and Morgantown

Timing: Finalize site location July 2016; Baseline environmental to begin early summer 2016

Partners: OSU, w/ WVU, Ohio U., U Calgary, CSI, GSI, HARC, Miami U.)

Science Objectives: Specifics on subsurface scientific data acquisition TBD; and environmental long-term baseline monitoring pre/post drilling