# Conasauga Shale Research Consortium

Project Kick-Off WebEx Meeting

December 18, 2019

1:30-2:30pm ET

WVGES GEOLOGY UNDERLIES IT ALL

West Virginia University

seeblue.

Kentucky Geological Survey

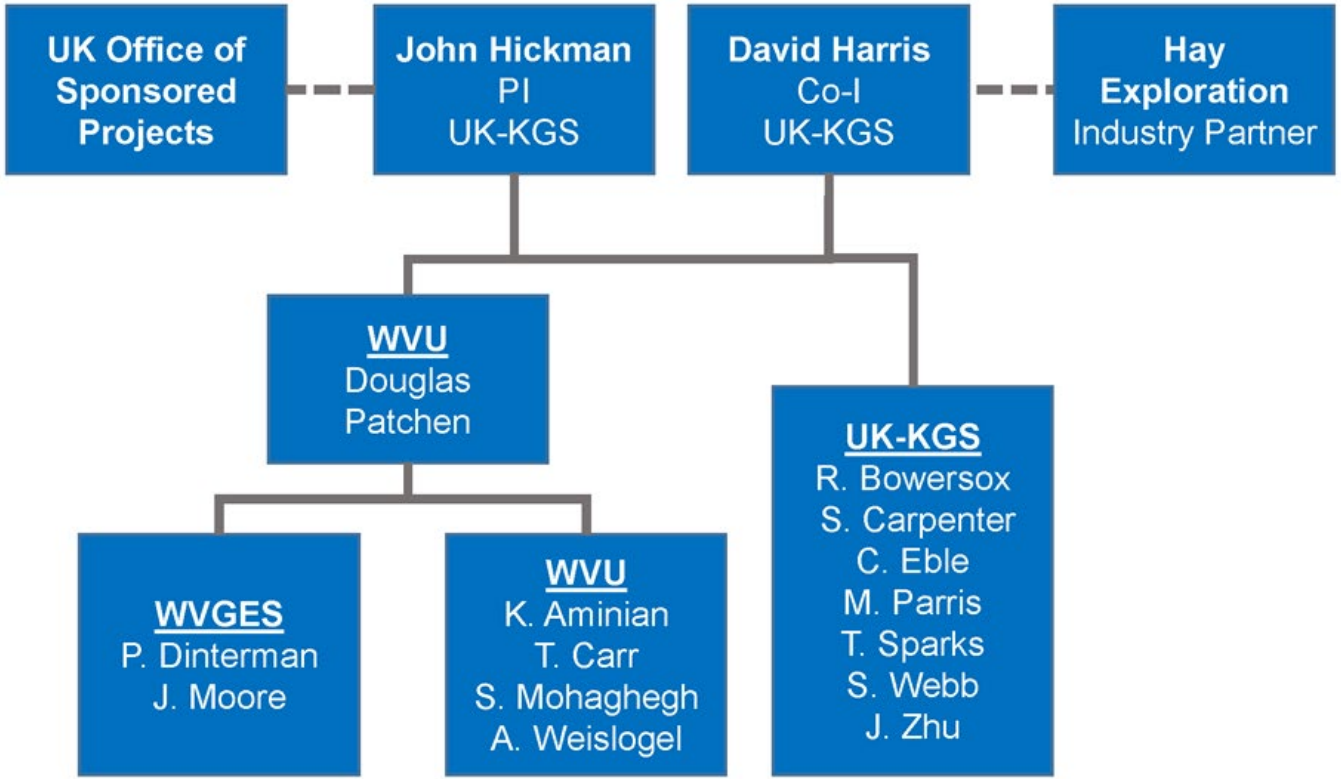
# Outline

- Project Objective
- Organizational structure
- Field Site and Donated Data
- Summary of Key Tasks
- Gantt Chart
- Major Milestones
- Discussion of first BP
- Machine Learning and Artificial Intelligence
- Key Project Risks and planned strategies for mitigation
- Project Budget

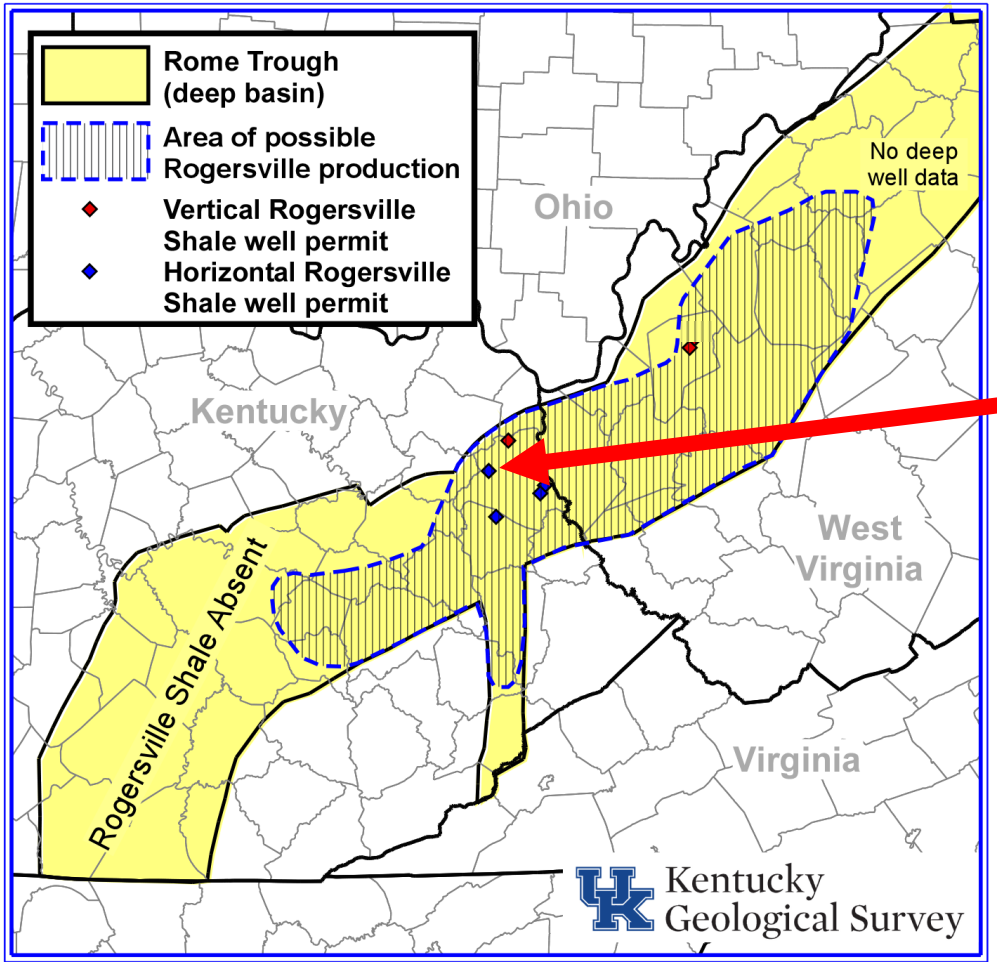
# Project Objective

The overall objective of the project is to establish a field laboratory and utilize a horizontal well of opportunity to conduct a scientific study designed to advance the understanding of the petrophysical and geomechanical properties of the Rogersville Shale. Understanding these properties will improve well placement and completion design, ultimately leading to commercial production and the acceleration of play development. The data generated and compiled in this project will then be integrated into a Rogersville Shale Development Strategy Plan that will enable oil and gas industry to accelerate the development of this emerging resource.

# CSRC Organizational Chart

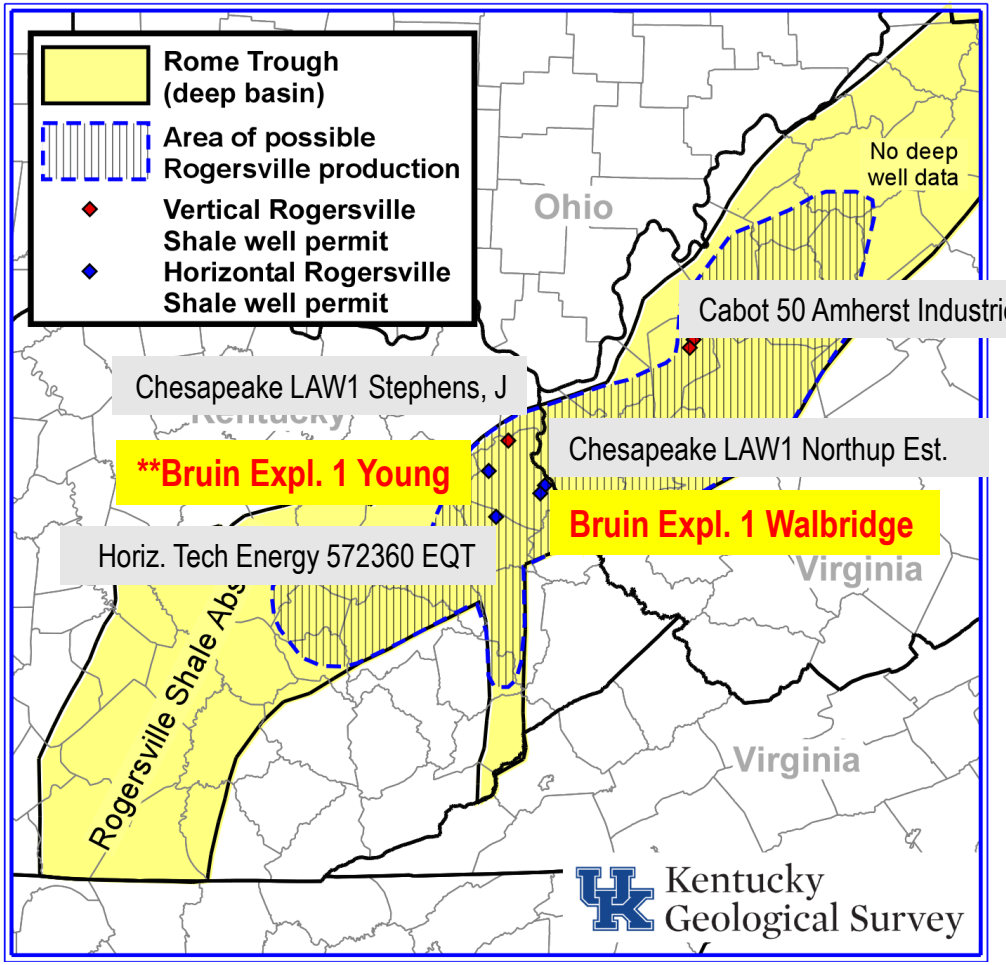


# Field Site and Donated Data




# Field Site

**Bruin Exploration #1 Silvia Young**

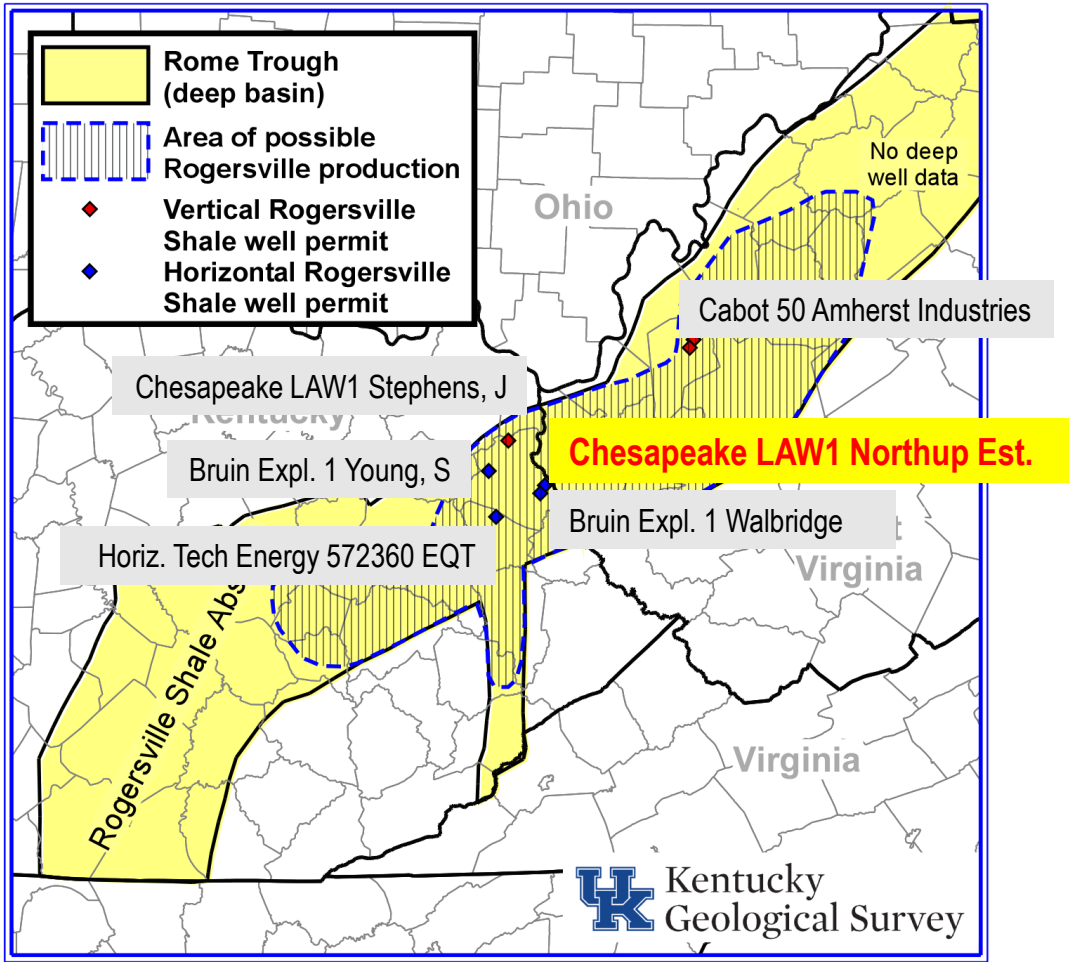



** Location of proposed
CSRC Research Well lateral

# Industry Data Donations to CSRC

**Cimarex Energy** is granting access to existing confidential data:

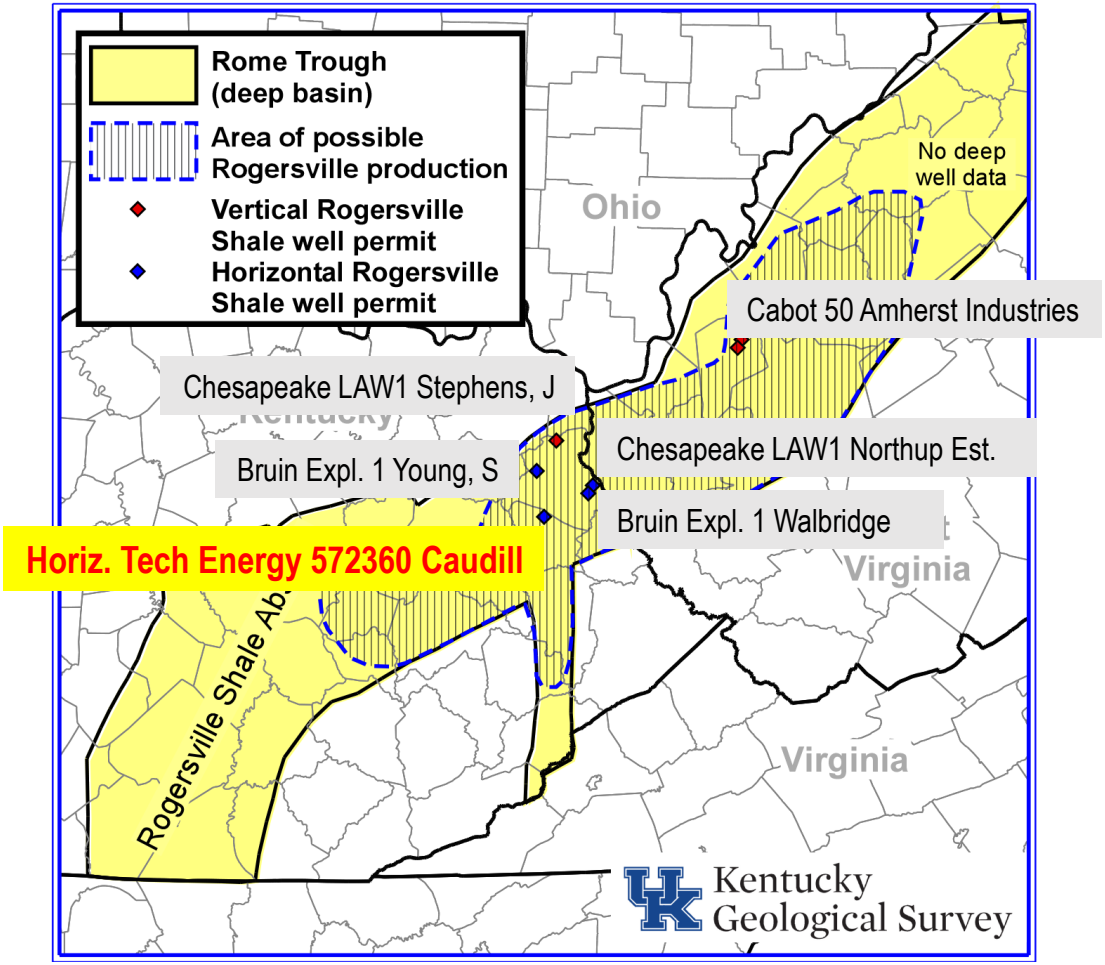
- Bruin Exploration No. 1 Sylvia Young well, Lawrence County, Ky. (project field laboratory site): proprietary data including digital log data, DFIT and completion data, mechanical rock properties data, sidewall core analyses, thin sections, XRD data, SEM images, organic carbon analyses, and oil/gas geochemistry.
- Bruin Exploration No. 1 Walbridge well, Lawrence County, Ky.: proprietary data including digital log data, DFIT and completion data, mechanical rock properties data, sidewall core analyses, thin sections, XRD data, SEM images, organic carbon analyses, and oil/gas geochemistry.
- Rogersville Shale related analytical data from older non-Cimarex-operated wells in Kentucky and West Virginia.


Rome Trough
(deep basin)
Area of possible
Rogersville production
Vertical Rogersville
Shale well permit
Horizontal Rogersville
Shale well permit
No deep
well data
Ohio
Cabot 50 Amherst Industries
Chesapeake LAW1 Stephens, J
Chesapeake LAW1 Northup Est.
Bruin Expl. 1 Young, S
Bruin Expl. 1 Walbridge
Horiz. Tech Energy 572360 EQT
Virginia
Rogersville Shale Abs
Virginia
Kentucky
Geological Survey

# Industry Data Donations to CSRC

**Chesapeake Energy** is granting access to data from Chesapeake #15-S-84-Law Northup, Lawrence County, Ky.:

- a. Wellbore Schematic
- b. Daily Well Reports
- c. Wireline Logs
  - Triple Combo, Spectral GR, OMRI, Acoustic Image, Sonic, Caliper
- d. Mud Logs
- e. Formation Tops
- f. Core Photos, Thin Section Photos
- g. Sidewall Core Photos
- h. Geochemistry Extracts
  - GC Plots, Biomarkers
- i. Completion Data
  - Perforated Intervals/Depths (Maryville, Rutledge, Rome)
  - DFIT Data
  - Frac Data
- j. Flowback Data
- k. Mud Gas Evaluation
  - Mass Spec GC
  - Gas Isotope Analysis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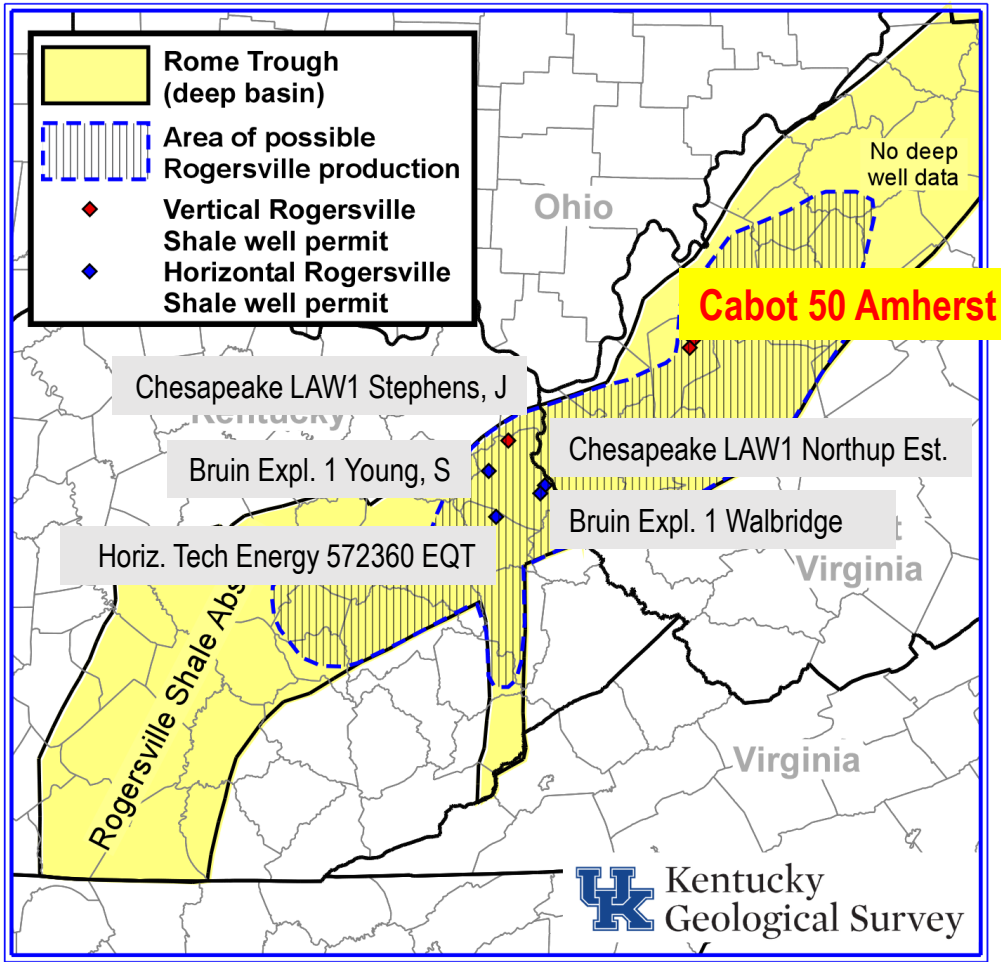
Bruin Expl. 1 Walbridge
Horiz. Tech Energy 572360 Caudill
Virginia
Rogersville Shale
Virginia
Kentucky
Geological Survey

# Industry Data Donations to CSRC

**EQT** is granting access to confidential data from Horizontal Technology Energy Co., LLC #592360 Winston Caudill well in Johnson County, KY:

1. Full diameter core analyses:
   - a. XRD
   - b. XRF (foot by foot)
   - c. Shale rock analysis (PHIT, Sw, Sg, So, Perm)
   - d. Rock Eval (TOC, S1, S2, HI, pyrograms)
   - e. Core spectral GR
   - f. PEF from core CT scan
   - g. Chlorite work for fluid sensitivity
2. Rotary sidewall core analyses:
   - a. XRD
   - b. Shale rock analysis (PHIT, Sw, Sg, So, Perm)
   - c. Rock Eval (TOC, S1, S2, HI, pyrograms)
   - d. Adsorption isotherms
3. Geophysical well logs:
   - a. Mass spec in vertical and both sidetracks
   - b. Triple combo with spectral GR (pilot well)
   - c. Multi-arm caliper (pilot well)
   - d. Dipole sonic (pilot well)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Geological Survey

# Industry Data Donations to CSRC

**Cabot Oil & Gas** is granting access to confidential data from Cabot #50 Amherst Industries, Putnam County, WV:

- a. Wellbore schematic
- b. Full Suite of wireline logs
- c. Mud logs
- d. Detailed production logs
- e. Vitrinite Reflectance thermal maturity data
- f. Total Organic Carbon data
- g. XRF of well cuttings
- h. XRD of well cuttings
- i. Organic geochemistry data of well cuttings

# Summary of Key Tasks

# Pre-drilling Operations (BP-1)

- Compile itemized inventory of currently available Conasauga Group samples and data
- Produce “postmortem” analysis of the 6 existing Rogersville Shale wells in the Rome Trough
- Begin ML analysis of previous UOG completion results
- Begin regional subsurface mapping of Conasauga Group stratigraphy using well, potential field, and reflection seismic data
- Begin monitoring natural background seismicity in the region of potential Rogersville Shale Play development

# Post-drilling, Pre-stimulation Operations (BP-2)

- Continue ML (T4.2), regional mapping (T5), and background seismicity (T6.5) tasks
- Collect well cuttings and formation fluids from new lateral for lab analysis
- Record and analyze full suite of geophysical logs in new well lateral
- Perform pre-stimulation hydrogeology site assessment at wellsite
- Perform lab analyses on new and legacy samples: TOC, XRD, XRF, $\%R_o$, Sm-Nd clay provenance, SEM and Raman spectroscopy, pyrolysis and source rock extract geochemistry, geomechanical testing of select core samples
- Model optimal completion plans and review with operator

# Post-stimulation Operations (BP-3, BP-4)

- Complete background seismicity analysis
- Monitor stimulation and initial production with local network of microseismic nodes
- Monitor stage-specific flow performance with downhole DAS
- Analyze and integrate the various lab results from BP-2
- Perform geochemical analysis of produced fluids and gasses
- Produce detailed 3D maps of reservoir facies and organic content
- Perform supporting infrastructure analysis of Play region
- Integrate all results into cohesive interpretive report
- Create Rogersville Development Strategy Plan for future exploration

# CSRC
# Project Timeline

# Gantt Chart, Tasks 1-6 (pre-drilling)

| Year | | 2019 | | 2020 | | | | 2021 | | | | 2022 | | | | 2023 . | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task | Title | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | |
| Conasauga Shale Research Consortium | | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| Budget Periods | | 1 | | 2 | | | | 3 | | | | | | 4 | | | |
| Task 1 | **Project Management and Planning** | | | | | | | | | | | | | | | | |
| Task 2 | **Workforce Readiness for Technology Deployment** | | | | | | | | | | | | | | | | |
| Task 3 | **Technology Transfer** | | | | | | | | | | | | | | | | |
| 3.1 | Project Website and Data Portal | | | | | | | | | | | | | | | | |
| 3.2 | Data and Sample Management | | | | | | | | | | | | | | | | |
| 3.3 | Present Results at Public Meetings | | | | | | | | | | | | | | | | |
| 3.4 | Compile Inventory of Rogersville Samples and data | | | | | | | | | | | | | | | | |
| Task 4 | **Engineering analysis of previous strategies** | | | | | | | | | | | | | | | | |
| 4.1 | Full “postmortem analysis” of past Rogersville well results | | | | | | | | | | | | | | | | |
| 4.2 | Machine learning analysis of previous completions | | | | | | | | | | | | | | | | |
| Task 5 | **Regional mapping of Conasauga Group units** | | | | | | | | | | | | | | | | |
| 5.1 | Seismic, potential fields, and well-tops interpretation | | | | | | | | | | | | | | | | |
| 5.2 | Detailed subsurface formation and fault mapping | | | | | | | | | | | | | | | | |
| Task 6 | **Drilling of Rogersville research lateral** | | | | | | | | | | | | | | | | |
| 6.1 | Collect well cuttings for analysis | | | | | | | | | | | | | | | | |
| 6.2 | Analysis of brines and gasses encountered while drilling | | | | | | | | | | | | | | | | |
| 6.3 | Record full suite of geophysical logs of new lateral | | | | | | | | | | | | | | | | |
| 6.4 | Site assessment analysis surrounding research lateral | | | | | | | | | | | | | | | | |
| 6.5 | Background seismicity characterization | | | | | | | | | | | | | | | | |

GO/NO-GO #1, Research Lateral Drilled

GO/NO GO #2, Research Lateral Stimulated

# Gantt Chart, Tasks 7-8 (post-drilling)

| Year | | 2019 | | 2020 | | | | 2021 | | | | 2022 | | | | 2023 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task | Title | Year 1 | | | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | |
| | Conasauga Shale Research Consortium | Q1 | Q2 | | Q3 | Q4 | Q1 | Q2 | | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| | Budget Periods | 1 | | | 2 | | | | | 3 | | | | | | 4 | | | |
| **Task 7** | **Reservoir and source rock characterization** | | | | | | | | | | | | | | | | | | |
| 7.1 | TOC analysis of available geological samples | | | | | | | | | | | | | | | | | | |
| 7.2 | X-ray Diffraction (XRD) lab analysis of sample mineralogy | | | | | | | | | | | | | | | | | | |
| 7.3 | X-ray Fluorescence (XRF) analysis | | | | | | | | | | | | | | | | | | |
| 7.4 | Portable XRF of available whole and rotary-sidewall cores | | | | | | | | | | | | | | | | | | |
| 7.5 | Bitumen reflectance microscopic analysis | | | | | | | | | | | | | | | | | | |
| 7.6 | Sm-Nd Isotopic composition for provenance analysis | | | | | | | | | | | | | | | | | | |
| 7.7 | Thin-section creation and optical microscopy analysis | | | | | | | | | | | | | | | | | | |
| 7.8 | SEM and Raman spectroscopy | | | | | | | | | | | | | | | | | | |
| 7.9 | Programed pyrolysis and source rock extract geochemistry | | | | | | | | | | | | | | | | | | |
| 7.10 | Detailed log analysis | | | | | | | | | | | | | | | | | | |
| 7.11 | Geomechanical testing of select reservoir cores | | | | | | | | | | | | | | | | | | |
| **Task 8** | **Well completion design and monitoring** | | | | | | | | | | | | | | | | | | |
| 8.1 | Model optimal completion plans and review with operator | | | | | | | | | | | | | | | | | | |
| 8.2 | Microseismic monitoring of well stimulation | | | | | | | | | | | | | | | | | | |

GO/NO-GO #1, Research Lateral Drilled

GO/NO-GO #2, Research Lateral Stimulate

# Gantt Chart, Tasks 9-13 (post-stimulation)

| Year | 2019 | 2020 | | | | 2021 | | | | 2022 | | | | 2023 . | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task | Title | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | |
| | Conasauga Shale Research Consortium | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| | Budget Periods | 1 | | 2 | | | | 3 | | | | | | 4 | | | |
| **Task 9** | **Detailed reservoir quality mapping** | | | | | | | | | | | | | | | | |
| 9.1 | 3D facies/lithology mapping | | | | | | | | | | | | | | | | |
| 9.2 | 3D Organic content mapping | | | | | | | | | | | | | | | | |
| 9.3 | Basin modeling for regional HC thermal maturation mapping | | | | | | | | | | | | | | | | |
| **Task 10** | **Geochemical analysis of produced fluids** | | | | | | | | | | | | | | | | |
| 10.1 | Oil chemistry and biomarker analysis | | | | | | | | | | | | | | | | |
| 10.2 | Molecular and isotopic chemistry of natural gases | | | | | | | | | | | | | | | | |
| 10.3 | Noble gas characterization | | | | | | | | | | | | | | | | |
| **Task 11** | **Post-completion petroleum engineering analysis** | | | | | | | | | | | | | | | | |
| 11.1 | Down-hole fiber optics production data acquisition | | | | | | | | | | | | | | | | |
| 11.2 | Full review of results from Young well lateral testing | | | | | | | | | | | | | | | | |
| **Task 12** | **Supporting infrastructure analysis** | | | | | | | | | | | | | | | | |
| 12.1 | Pipelines, proximity and available capacities | | | | | | | | | | | | | | | | |
| 12.2 | Road network density for access to potential drilling locations | | | | | | | | | | | | | | | | |
| **Task 13** | **Project completion and synthesis of results** | | | | | | | | | | | | | | | | |
| 13.1 | Development Strategy Plan | | | | | | | | | | | | | | | | |
| 13.2 | Final Project Report and public release of research findings | | | | | | | | | | | | | | | | |

GO/NO-GO #1, Research Lateral Drilled

GO/NO-GO #2, Research Lateral Stimulated

# Major Milestones

| Task/ Subtask | Milestone Title & Description | Planned Completion Date | Verification method |
|---|---|---|---|
| 3 | **Sample/data inventory complete** – Website and data portal operational, preexisting samples cataloged | Jul 15, 2020 | Website and data portal operational, preexisting samples cataloged |
| 4.1 | **"Postmortem analysis" complete** – Formal analysis of past Rogersville well results | May 15, 2020 | Report on formal analysis of past Rogersville well results completed. |
| 6 | **Authorization for Expenditure** | May 31, 2020 | AFE for drilling research lateral submitted to DOE |
| 5 | **Regional Mapping Complete** | Feb 15, 2021 | Task 5 complete, detailed subsurface maps of Conasauga units and related faults in the Rome Trough completed |
| 6.1, 6.2, 6.3 | **Lateral Drilled** – Well drilled, well samples collected, logged | Feb 15, 2021 | Lateral drilled as planned, logged and sampled successfully. |
| 7 | **Reservoir characterization** - Lab results completed and analyzed | Feb 15, 2022 | Lab results from geological samples completed and analyzed |
| 8 | **Microseismic monitoring array deployed** | Mar 1, 2021 | Seismic nodal array deployed around well location, prior to completion |
| 8 | **Lateral Completed** – Well completed and stimulated, initial flow testing begun | Feb 15, 2022 | Well completed and stimulated, initial flow testing begun. |
| 9 | **3D Reservoir maps complete** | Apr 15, 2023 | 3D reservoir mapping complete |
| 11 | **PE analysis complete** | Apr 15, 2023 | Down-hole fiber optic production data acquisition and results from Young well lateral testing complete |
| 12 | **Infrastructure Challenges** | Apr 15, 2023 | Draft summary of findings on infrastructure complete. |
| 13 | **Project Complete** | Nov 15, 2023 | Tasks 1 through 13 complete. Final Report submitted to DOE-NETL. |

# CSRC
# Budget Period 1

December 2019 through May 2020

# Discussion of BP-1 efforts

During BP-1, the CSRC will perform work on Tasks 1, 3, 4, 5, and 6.

- **Task 1 - Project management**
  - In addition to traditional project management duties (meet all technical, schedule and budget objectives), KGS will continue to work with Hay Exploration to secure drilling funds for the proposed research lateral.

- **Task 3 - Technology transfer**
  - T3.4 - Compile inventory of Rogersville samples and data
    - KGS and WVGES staff will compile an inventory of all available geological samples and publicly available geological data from the Rogersville Shale. These data will be posted on the RFL website and will be updated when and if new samples and data become available during the term of this project. Digital data will be made available for download from the RFL digital library.

# Discussion of BP-1 efforts

- **Task 4 - Engineering analysis of previous strategies**
  - T4.1 - Full “postmortem analysis” of past Rogersville well results
    - KGS will conduct a detailed analysis (using both public and proprietary data) of the drilling and testing results for preexisting wells drilled to test the UOG potential of the Rogersville Shale. The analysis will address both successful and unsuccessful techniques that were used in order to start building the Development Strategy Plan.
  - T4.2 - Machine learning analysis of previous completions
    - WVU will use *Shale Analytics* to assist in the design of completion practices for the Rogersville Shale. This data-driven technique includes artificial intelligence (AI), machine learning (ML), and data mining to increase the production efficiency of shale plays. WVU will utilize proprietary data sets that include production history, well log, completion, and well stimulation data (fluid and proppant type and amount, injection pressure and rate, and proppant concentration) to guide the model and determine well performance and to optimize the well stimulation process.

# Discussion of BP-1 efforts

- **Task 5 – Regional mapping of Conasauga units**
  - T5.1 - Seismic, potential fields, and well-tops interpretation
    - KGS and WVGES will conduct detailed subsurface mapping of the Rogersville Shale using well, seismic, and potential fields data. CSRC will use all available well data (geophysical well logs, lithologic strip logs, mud logs, etc.), approximately 1,200 miles of 2-D seismic reflection profiles (84 new miles of data will be purchased as part of this project), and regional potential fields datasets (Bouguer gravity, isostatic gravity, and aeromagnetic surveys) to produce detailed structure and isopach maps of the Rogersville.
  - T5.2 - Detailed subsurface formation and fault mapping
    - Using the information and data from Task 5.1, KGS and WVGES will produce detailed maps (both structure and thickness) of the Rogersville Shale. These maps will define the boundaries of the Rogersville Shale “geobody” in the subsurface, within which detailed 3D facies and lithology volumes will be interpreted in Task 9 (BP-3).

# Discussion of BP-1 efforts

- **Task 6 - Drilling of Rogersville research lateral**

  In advance of the drilling and completion operations, the CSRC will document the natural seismicity of the potential Rogersville Play region, in order to distinguish any induced seismic events

  - T6.5 - Background seismicity characterization
    - KGS will deploy and monitor eight seismic stations to improve the characterization of natural micro-earthquake activity in the Rogersville Shale play area. The seismic monitoring equipment will include state-of-the-art broadband seismometers and high-resolution data loggers (along with station power and telemetry components). New and archived network recordings will be processed with sophisticated detection algorithms including machine-learning, extended short-time-average to long-time-average (STA/LTA), and matched-filter detectors, to create a high-resolution earthquake catalog.

# AI and ML: *Shale Analytics*

- ***Shale Analytics*** is the collection of state-of-the-art **Artificial Intelligence** and **Machine Learning** techniques that attempts to increase the production efficiency of shale wells.

- ***Shale Analytics*** uses “hard data” (field measurements) from drilling, completion, stimulation, and production:
    - Well trajectory, lateral length, TVD, MD, well logs, completion design (stage length, number of clusters per stage, number of perforations per cluster), hydraulic fracturing implementation (fluid and proppant type and amount, injection pressure and rate, as well as proppant concentration), and operational constraints (well-head pressure and choke setting).

- Traditional approaches to modeling fluid flow in shale use “soft data”:
    - Frack length, frack width, frack height, frack conductivity, and in some cases Stimulated Reservoir Volume (SRV)

# AI and ML: Transfer Learning

- Machine Learning requires considerable amount of data for the open computer algorithms to learn.

- **Transfer Learning** is a Machine Learning related technology with the objective of taking advantage of the knowledge gained from a series of available data in order to solve a reasonably similar problem that does not include the required data.

- The CSRC will transfer the learned knowledge from a series of well-established shale plays into a Rogersville Shale model, in order to assist completion design and decision making in this new shale formation where enough data is not yet available.

# AI and ML: Predictive Analytics

- The CSRC will use the developed knowledge in order to make the right decisions for designing optimum completions in Conasauga shale.
    - Collection and Preparation of all the Data from Multiple Assets,
    - Building a Comprehensive Shale Analytics Data set (CSAD),
    - Building the Comprehensive Shale Analytics Model (CSAM), and
    - Using CSAM to Design Optimum Completion for Conasauga Shale.

# Key Project Risks and planned strategies for mitigation

| Perceived Risk | Risk Rating | | Mitigation/Response Strategy |
|---|---|---|---|
| | Probability | Impact | |
| **Financial Risks:** | | | |
| Driller (Hay Exploration) loses funding commitment for well from investors | LOW | HIGH | Identify alternate operator in Rogersville region |
| **Cost/Schedule Risks:** | | | |
| Well drilling or completion delayed | MED | LOW | Drilling scheduled early in project, modest delays should not significantly affect project outcome |
| Analytical lab results delayed | MED | LOW | Testing of sample material scheduled early in project, modest delays should not significantly affect project outcome |
| **Technical/Scope Risks:** | | | |
| Equipment outages at analytical labs | LOW | LOW | Identify alternate vendors |
| Wellbore condition prevents logging | LOW | MED | Will use logs from pilot hole and other nearby wells for facies and geomechanical analysis |
| Tool malfunction/stuck in hole | LOW | LOW | Tools insured, modest delays should not significantly affect project outcome |
| Ability to deploy fiber-optic production sensors 5 times over 12 months | MED | MED | Will attempt production analysis with lower resolution and/or different production logging techniques |
| **Management, Planning, and Oversight Risks:** | | | |
| Loss of research team members (relocation, change employment, death, etc.) | LOW | MED | UK, WVU, and WVGES are large organizations with multiple research geologists and engineers. Alternate researchers would be identified and put onto CSRC payroll. |
| **ES&H Risks:** | | | |
| Well blowout | LOW | HIGH | Safety equipment (BOP, pressure sensors/alarms, etc.) designed for well pad work will be in place. |
| Waste or chemical spill at drill site | LOW | HIGH | Standard industry safety protocols and wellsite design will be used to prevent possible spills. |
| **External Factor Risks:** | | | |
| Unable to gain landowners permissions to sample minimum number of domestic water wells | MED | LOW | Will analyze existing data to see spread of values, option of sampling more wells over larger search radius possible. |

# Budget Summary

| SUMMARY OF BUDGET CATEGORY COSTS PROPOSED<br>The values in this summary table are from entries made in subsequent tabs, only blank white cells require data entry | | | | | | | |
|---|---|---|---|---|---|---|---|
| Section A - Budget Summary | | | | | | | |
| | | Federal | Cost Share | | Total Costs | Cost Share % | Proposed Budget Period Dates |
| | Budget Period 1 | $464,218 | $114,916 | | $579,134 | 19.84% | 10/01/19 - 03/31/20 (6 months) |
| | Budget Period 2 | $1,440,946 | $1,112,606 | | $2,553,552 | 43.57% | 04/01/20 - 03/31/21 (12 months) |
| | Budget Period 3 | $3,062,820 | $155,035 | | $3,217,855 | 4.82% | 04/01/21 - 09/30/22 (18 months) |
| | Budget Period 4 | $908,912 | $141,516 | | $1,050,428 | 13.47% | 10/01/22 - 09/30/23 (12 months) |
| | Total | $5,876,897 | $1,524,073 | | $7,400,970 | 20.59% | |
| Section B - Budget Categories | | | | | | | |
| CATEGORY | Budget Period 1 | Budget Period 2 | Budget Period 3 | Budget Period 4 | Total Costs | % of Project | Comments (as needed) |
| a. Personnel | $77,613 | $223,676 | $203,756 | $224,223 | $729,269 | 9.85% | |
| b. Fringe Benefits | $24,140 | $69,737 | $61,956 | $66,539 | $222,372 | 3.00% | |
| c. Travel | $3,616 | $18,251 | $17,044 | $14,129 | $53,041 | 0.72% | |
| d. Equipment | $0 | $162,677 | $0 | $0 | $162,677 | 2.20% | |
| e. Supplies | $0 | $11,250 | $1,313 | $0 | $12,563 | 0.17% | |
| f. Contractual | | | | | | | |
| Sub-recipient | $146,845 | $543,979 | $928,361 | $583,945 | $2,203,130 | 29.77% | |
| Vendor | $0 | $1,199,430 | $1,196,208 | $0 | $2,395,638 | 32.37% | |
| FFRDC | $0 | $0 | $0 | $0 | $0 | 0.00% | |
| Total Contractual | $146,845 | $1,743,409 | $2,124,569 | $583,945 | $4,598,768 | 62.14% | |
| g. Construction | $0 | $0 | $0 | $0 | $0 | 0.00% | |
| h. Other Direct Costs | $194,700 | $31,183 | $16,124 | $0 | $242,007 | 3.27% | |
| Total Direct Costs | $446,914 | $2,260,183 | $2,424,762 | $888,836 | $6,020,696 | 81.35% | |
| i. Indirect Charges | $132,220 | $293,369 | $793,093 | $161,592 | $1,380,274 | 18.65% | |
| Total Costs | $579,134 | $2,553,552 | $3,217,855 | $1,050,428 | $7,400,970 | 100.00% | |

# Budget, Contractual

| SOPO Task # | Sub-Recipient Name/Organization | Purpose and Basis of Cost | Budget Period 1 | Budget Period 2 | Budget Period 3 | Budget Period 4 | Project Total |
|---|---|---|---|---|---|---|---|
| 2,4 | EXAMPLE!!! XYZ Corp. | Partner to develop optimal lens for Gen 2 product. Cost estimate based on personnel hours. | $48,000 | $32,000 | $16,000 | | $96,000 |
| | | | | | | | $0 |
| 4, 7, 8, 11 | West Virginia University | petroleum engineering and geological analysis | $146,845 | $543,979 | $928,361 | $583,945 | $2,203,130 |
| | | | | | | | $0 |
| | | | | | | | $0 |
| | | | | | | | $0 |
| | | | | | | | $0 |
| | | Sub-total | $146,845 | $543,979 | $928,361 | $583,945 | $2,203,130 |

| SOPO Task # | Vendor Name/Organization | Purpose and Basis of Cost | Budget Period 1 | Budget Period 2 | Budget Period 3 | Budget Period 4 | Project Total |
|---|---|---|---|---|---|---|---|
| 6 | EXAMPLE!!! ABC Corp. | Vendor for developing robotics to perform lens inspection. Estimate provided by vendor. | $32,900 | $86,500 | | | $119,400 |
| | | | | | | | $0 |
| 5 | Schlumberger | open-hole well logging | | $199,430 | | | $199,430 |
| 6 | Hay Exploration | drilling and well completion | | $1,000,000 | | | $1,000,000 |
| 9 | Schlumberger | well production monitoring fiber optic sensor, 5 days of monitoring per run (5 runs in BP3) | | | $1,196,208 | | $1,196,208 |
| | | | | | | | $0 |
| | | Sub-total | $0 | $1,199,430 | $1,196,208 | $0 | $2,395,638 |

| SOPO Task # | FFRDC Name/Organization | Purpose and Basis of Cost | Budget Period 1 | Budget Period 2 | Budget Period 3 | Budget Period 4 | Project Total |
|---|---|---|---|---|---|---|---|
| | | | | | | | $0 |
| | | | | | | | $0 |
| | | Sub-total | $0 | $0 | $0 | $0 | $0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Total Contractual | | $146,845 | $1,743,409 | $2,124,569 | $583,945 | $4,598,768 |

# Conasauga Shale Research Consortium

KGS:

John Hickman, David Harris, Rick Bowersox, Cortland Eble, Seth Carpenter, Marty Parris, Tom Sparks, Junfeng Zhu, Steve Webb, Jason Backus, Andrea Conner

WVGES:

Jessica Moore, Eric Lewis, Gary Daft, Sarah Brown, Phil Dinterman, Ron McDowell

WVU:

Doug Patchen, Tim Carr, Amy Weislogel, Kashy Aminian, Shahab Mohaghegh, (+3 future graduate students)

Industry Partner: Hay Exploration, Inc.

# Kentucky Geological Survey