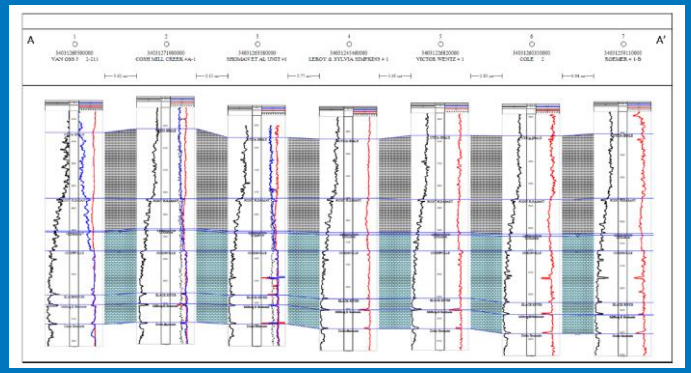
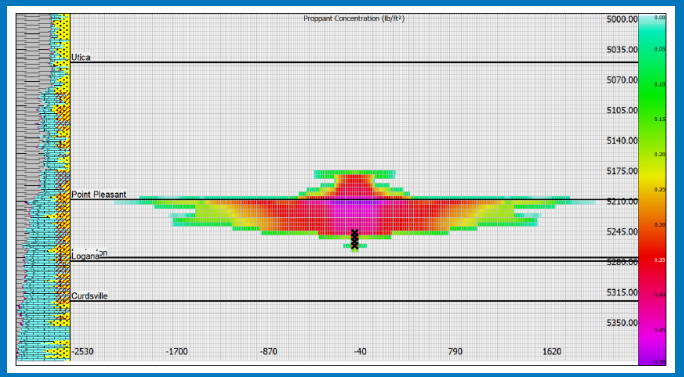
Using Natural Gas Liquids to Recover Unconventional Oil and Gas Resources





DE-FE-0031782

Mark Moody and Joel Sminchak
24 August 2020

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Management and Oil and Gas Research Project Review Meeting – Oil & Gas
August 23 - 27, 2021

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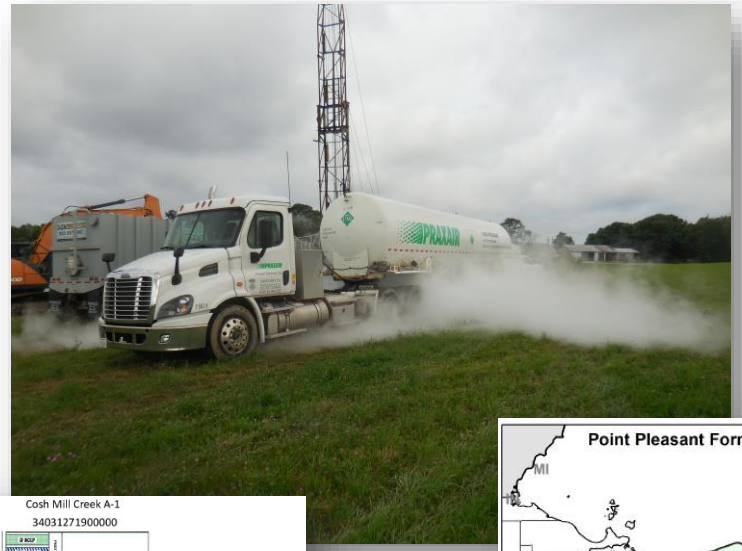
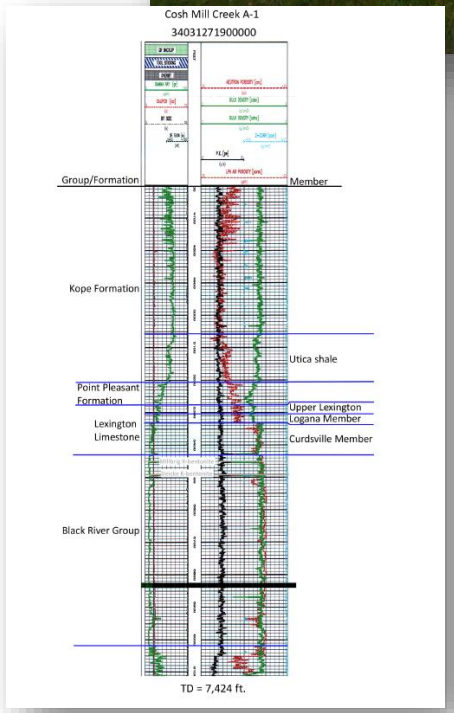
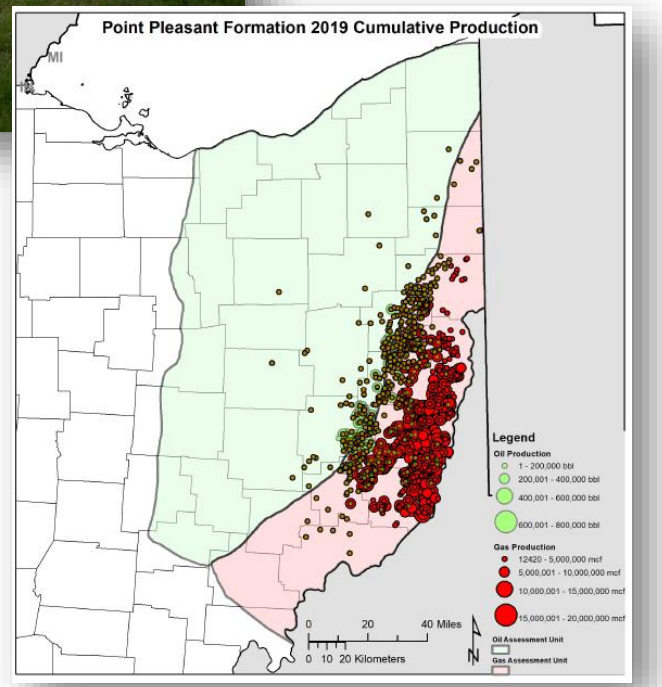
Presentation Outline

- Technical Status
- Accomplishments to Date
- Lessons Learned
- Project Summary
- Appendix
  - Benefit to Program
  - Project Overview
  - Organization Chart
  - Gantt Chart
  - Bibliography







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Introduction

- The project objective is to unlock oil from the “oil window” of the Utica/Point Pleasant (UPP) shale in Ohio using Y-Grade (unrefined) Natural Gas Liquids (NGL)
- A large portion of the Appalachian shale play is composed of tight, oil-rich reservoirs which have proven to be uneconomical using current completion technologies
- The oil molecules are too large to move through the low permeability rock, rendering the oil inaccessible
- Oil and Gas Exploration Companies are looking for the key to unlock this huge oil resource

NGLs might be a big part of the solution

Using NGL in the “Oil Window” of the UPP

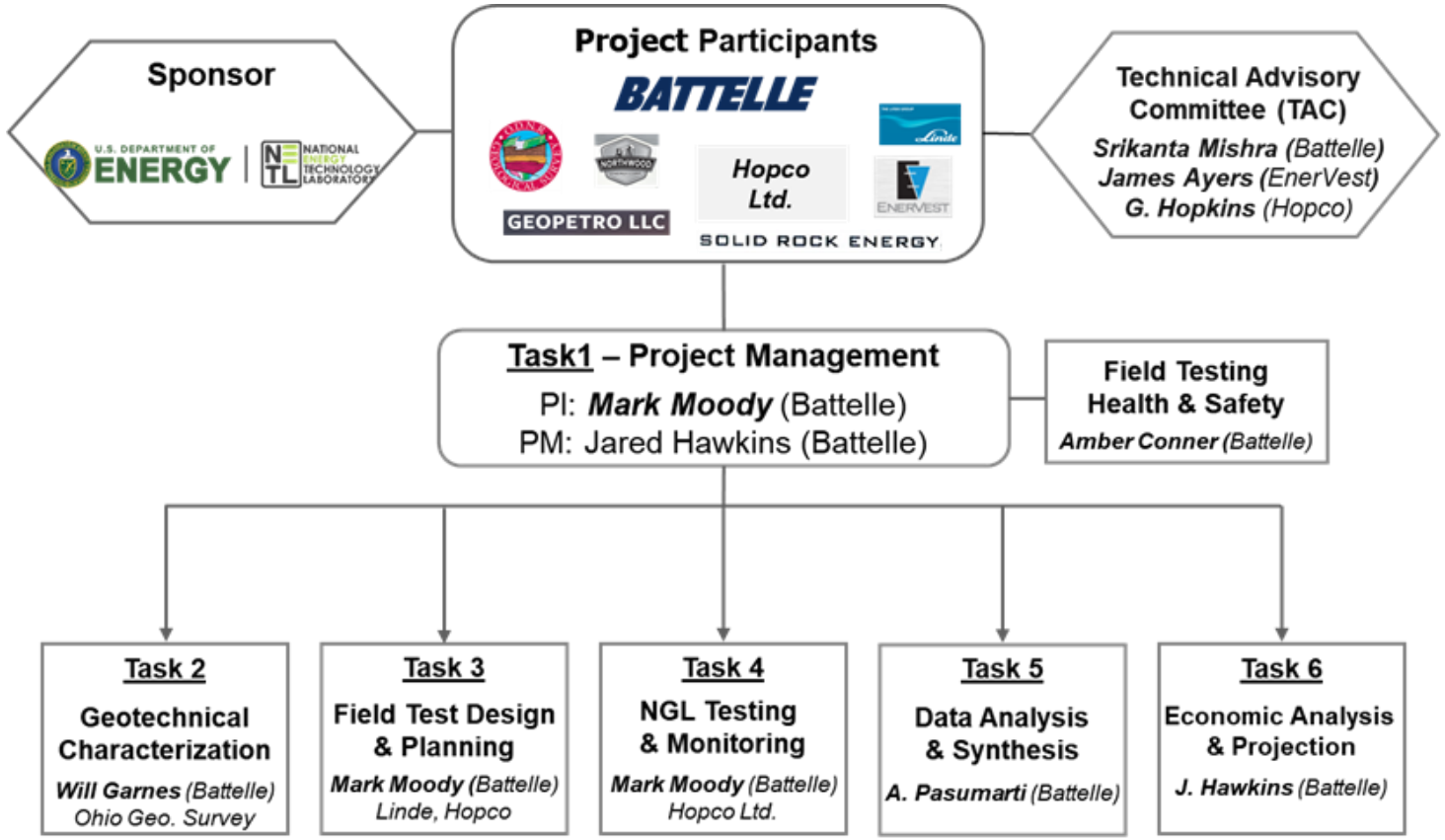
- Why use Y-Grade NGLs?
  - Liquid fuels production in the U.S. has increased by 5.5 million barrels per day between 2009 and 2016
  - Natural Gas Liquid (NGL) production from shale wells and tight oil formations has accounted for 29% of this growth
  - The Energy Information Administration (EIA) forecasts NGL production from Appalachian shale wells will increase 350% from 2013 to 2040
  - Battelle reservoir simulations indicate that NGLs recover greater volumes of oil than CO_2
  - The cost of using NGLs as a stimulation fluid can be partially recovered as the injected NGLs are produced back with the oil and gas
  - There is a surplus of locally produced NGLs
- ***NGLs are currently underutilized in the Appalachian Basin***

Project Schedule

- The period of performance of this project is 3 years, Oct. 2019 through Sept. 2022
  - The first year of the project will consist of research, lab work, modeling and computer simulations to determine the best treatment design
  - Treatment and monitoring will be performed during year two
  - Analysis and reporting will be performed during year three
- This is a proof-of-concept project
- Production results from the Y-Grade NGL treatment will be compared to production from the McCoy Unit #5 well and the COSH Mill Creek well to determine if Y-Grade NGLs are effective treatment fluid for the oil window of the UPP and other similar unconventional oil and gas reservoirs

Project Team

- Project Manager; Battelle Memorial Institute
- Operators; Hopco Ltd., Northwood Energy Corp., Geopetro LLC, Solid Rock Energy & EnerVest Operating Inc., Flat Rock Development Corp.
- Ohio Division of Geological Survey
- Linde Gas North America



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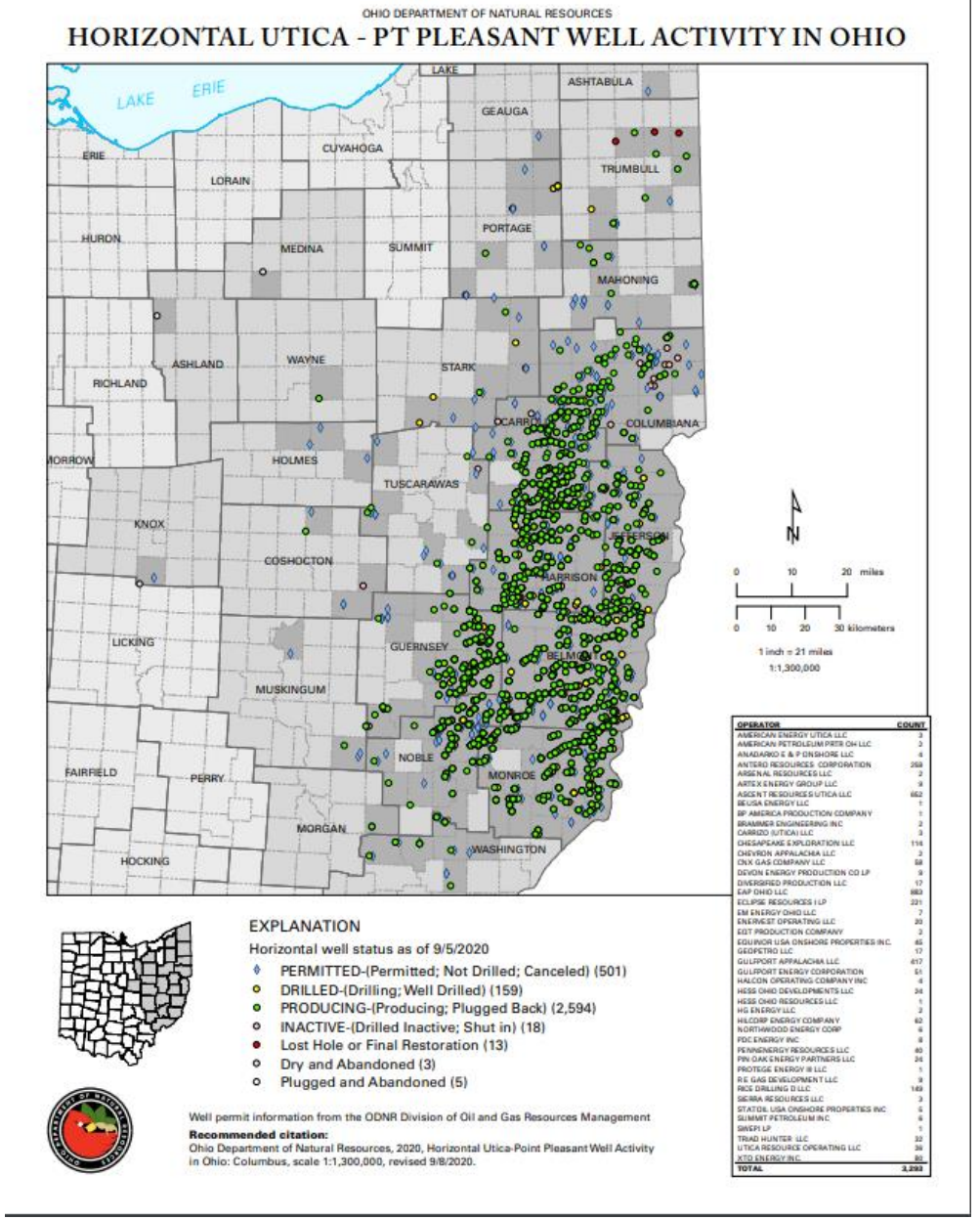
Utica/Point Pleasant Drilling Activity

As of September 5, 2020

Total of 3,293 wells:

501	Permitted; (Not Drilled; Cancelled)
159	Drilled; (Drilling; Well Drilled)
2,594	Producing; (Producing; Plugged Back)
18	Inactive; (Drilled Inactive; Shut In)
13	Lost Hole or Final Restoration
3	Dry and Abandoned
5	Plugged and Abandoned



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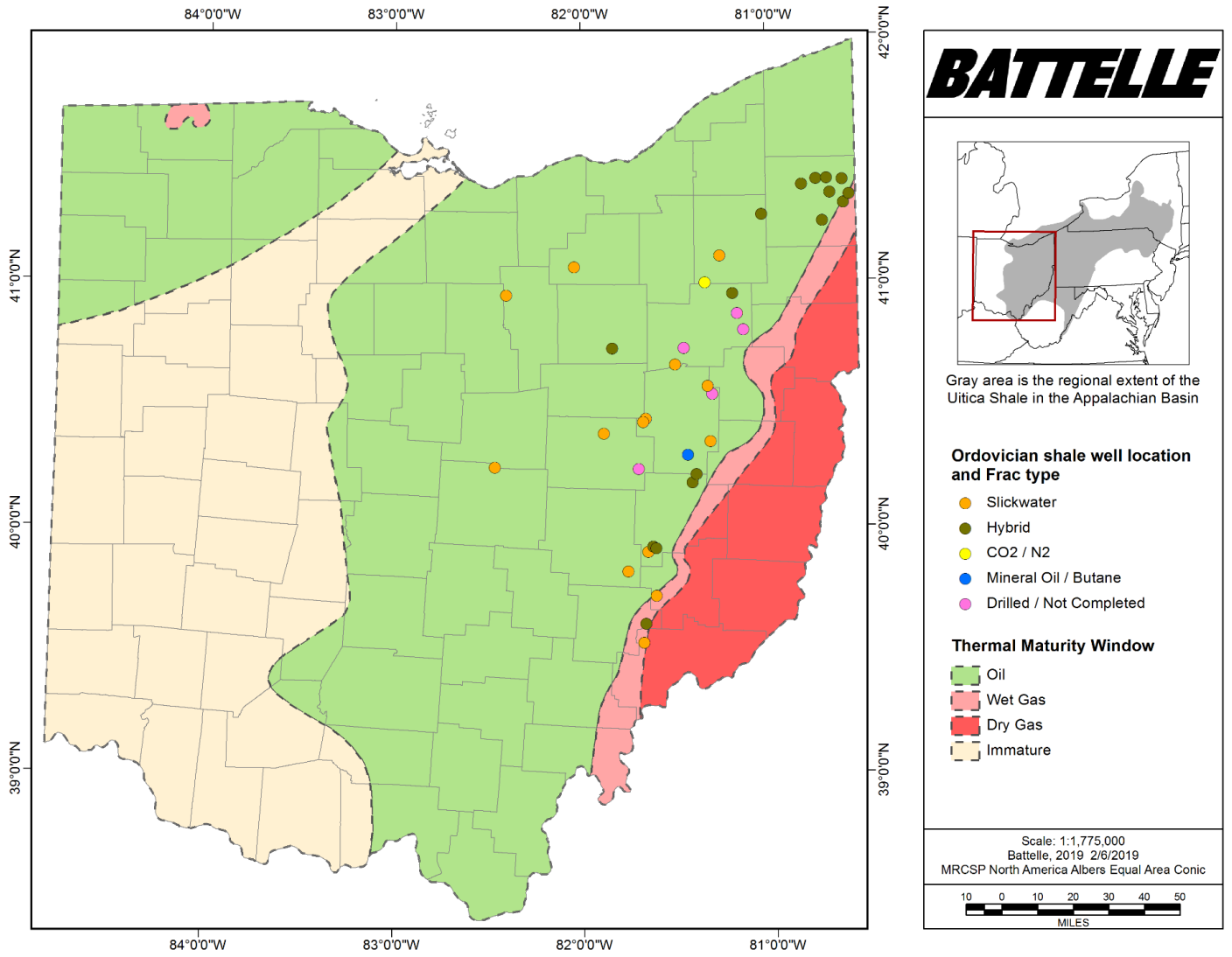
UPP “Oil Window” with Frac Type



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Gray area is the regional extent of the Utica Shale in the Appalachian Basin

Ordovician shale well location and Frac type

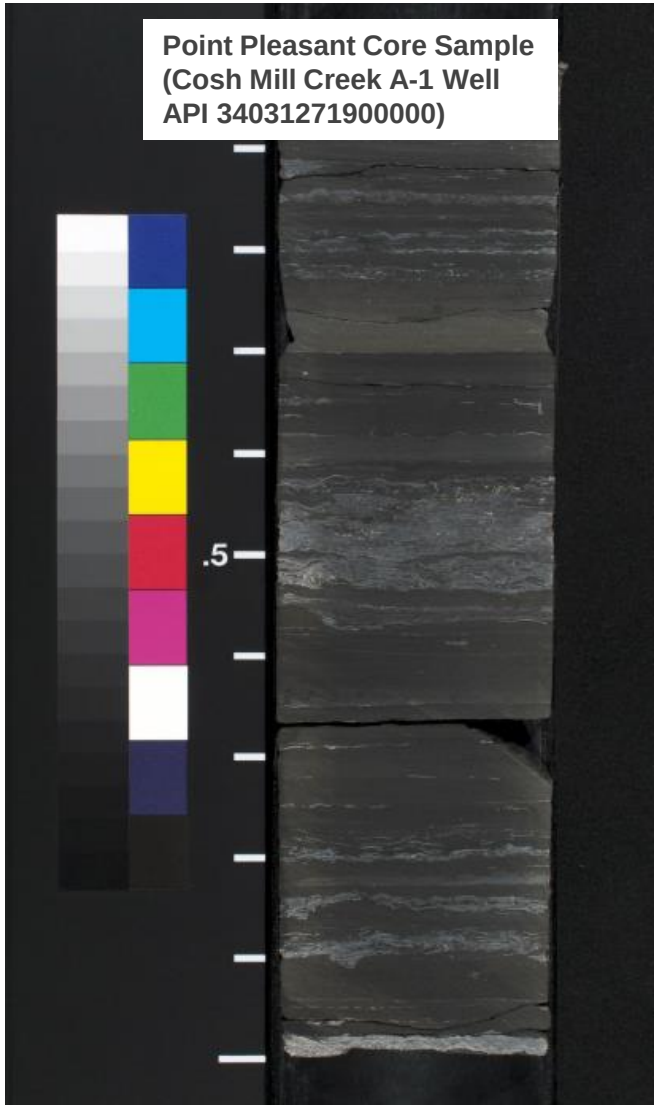
- Slickwater
- Hybrid
- CO2 / N2
- Mineral Oil / Butane
- Drilled / Not Completed

Thermal Maturity Window

- Oil
- Wet Gas
- Dry Gas
- Immature

Scale: 1:1,775,000
Battelle, 2019 2/6/2019
MRCSP North America Albers Equal Area Conic

10 0 10 20 30 40 50
MILES



ODNR Division of Oil and Gas Resources Management (2018)

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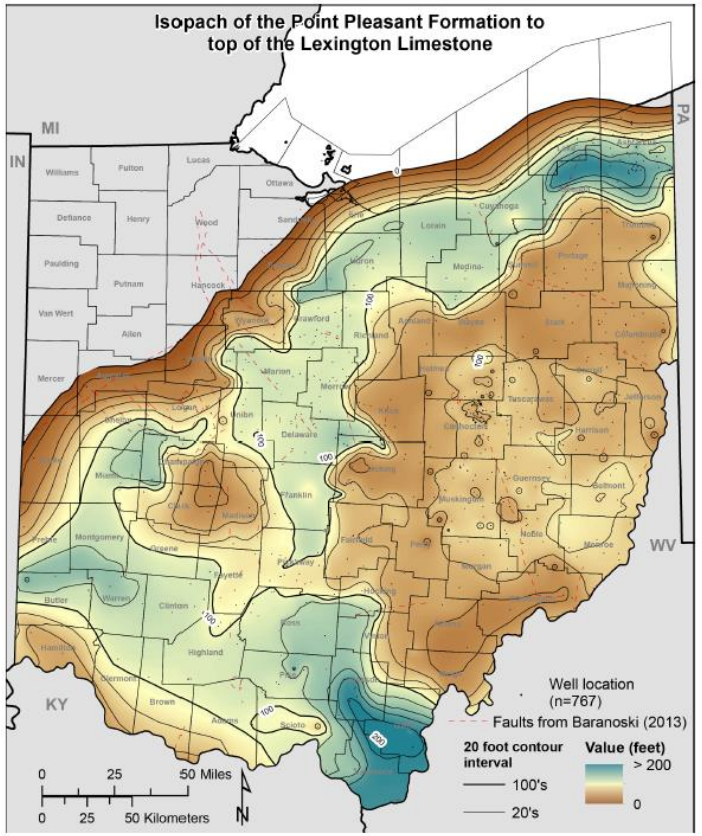
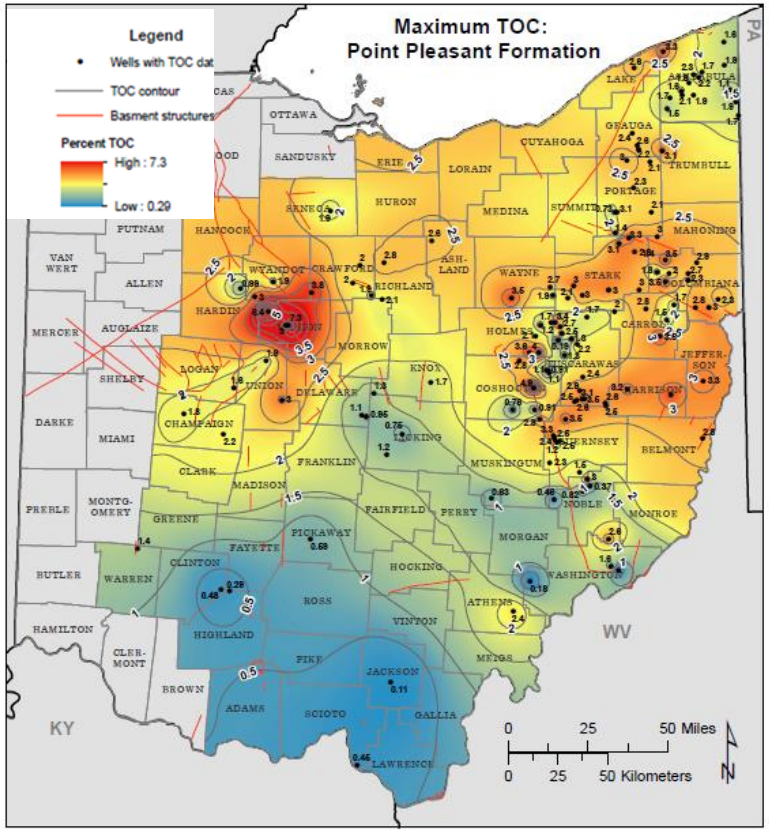
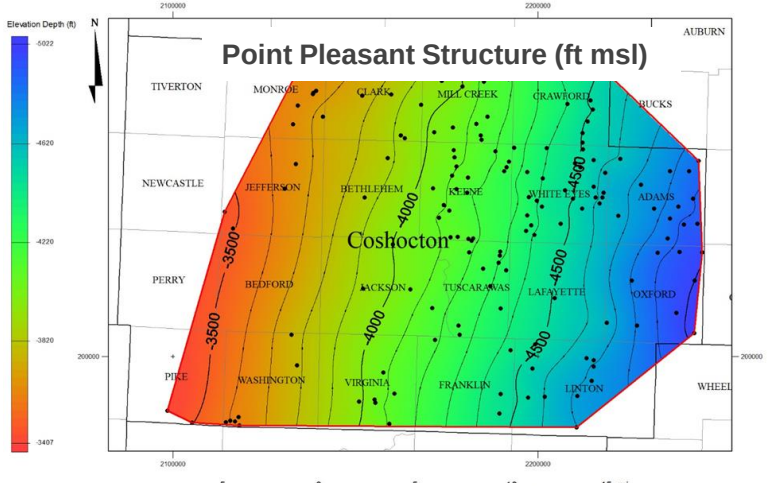
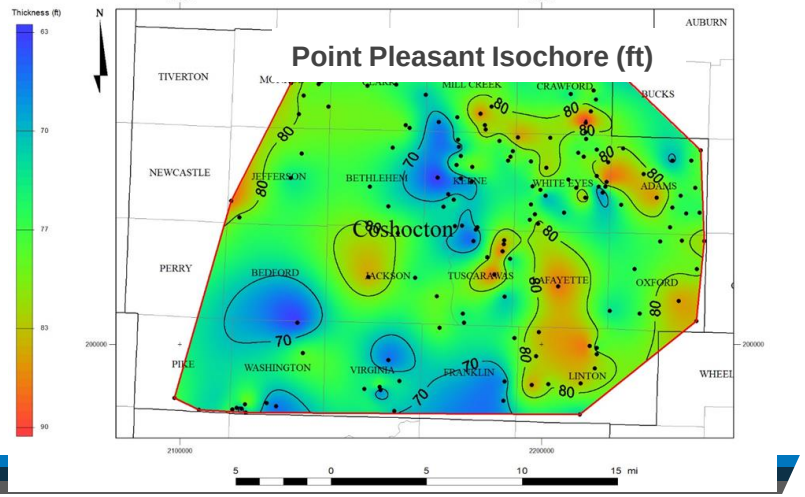
UPP Geological Characterization

- Ohio Div. of Geological Survey completed a regional characterization of the UPP and Battelle completed a local/site specific study on the field location.









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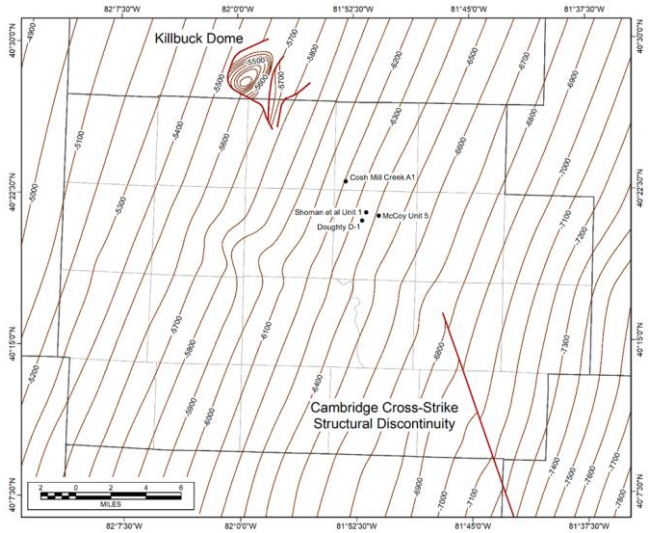
Proposed Field Test Sites

- Battelle plugged back two (2) Coshocton County Rose Run wells to the Utica/Point Pleasant formation in Fall 2020.
  - One well was perforated and treated in the UPP
  - The other well was used as for micro seismic monitoring well during stimulation.
- The test site wells are approximately 2-1/4 miles SE of the COSH Mill Creek #A-1 well drilled by Anadarko in 2012
  - The Cosh Mill Creek well was completed with 16 stages utilizing large volume slickwater frac jobs.
- The test site wells are approximately ¾ miles west of Northwood Energy's McCoy Unit #5, a Rose Run well which was plugged back and completed in the UPP in 2013 with a large volume slickwater frac job.



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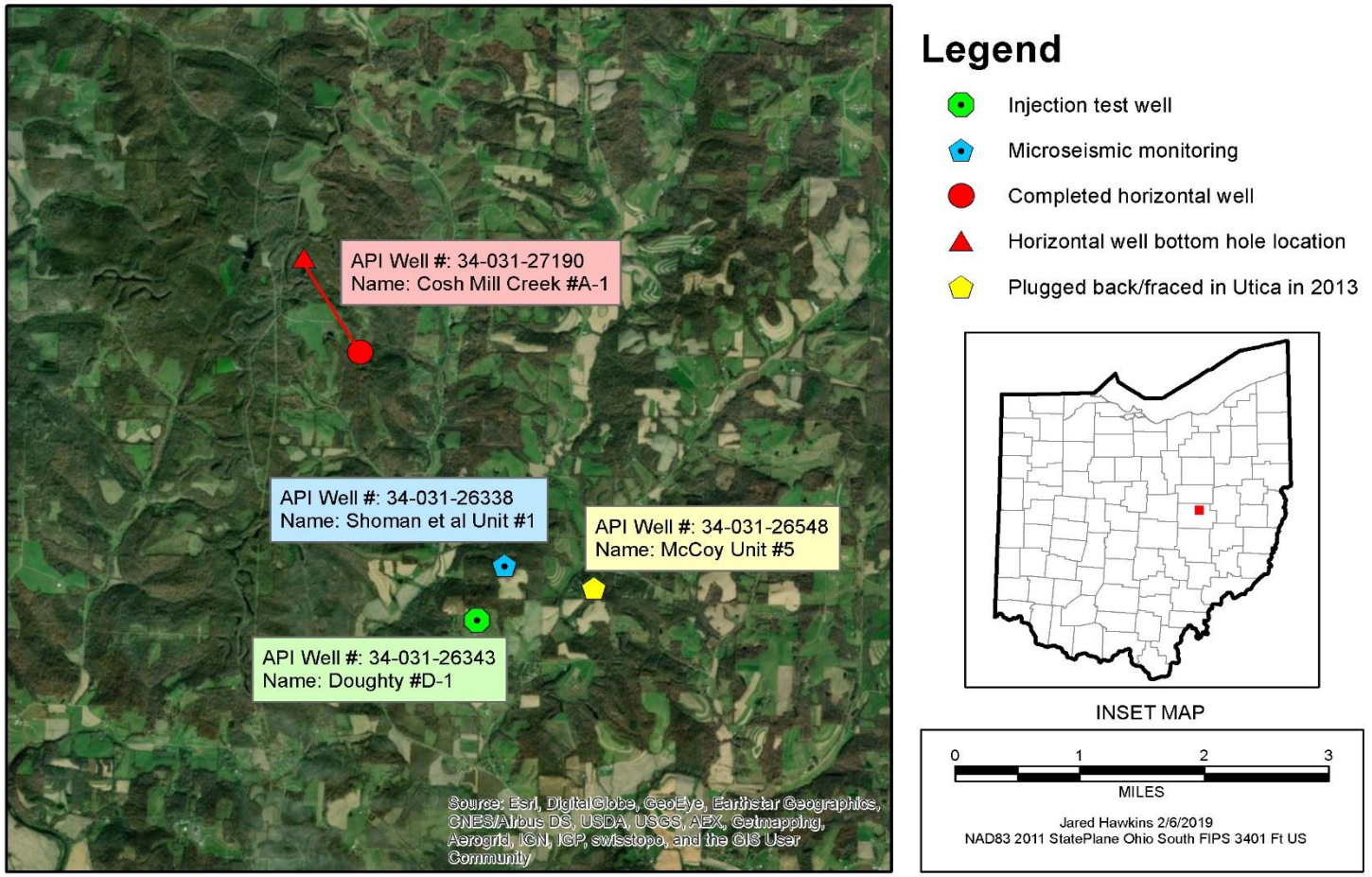
Project Map



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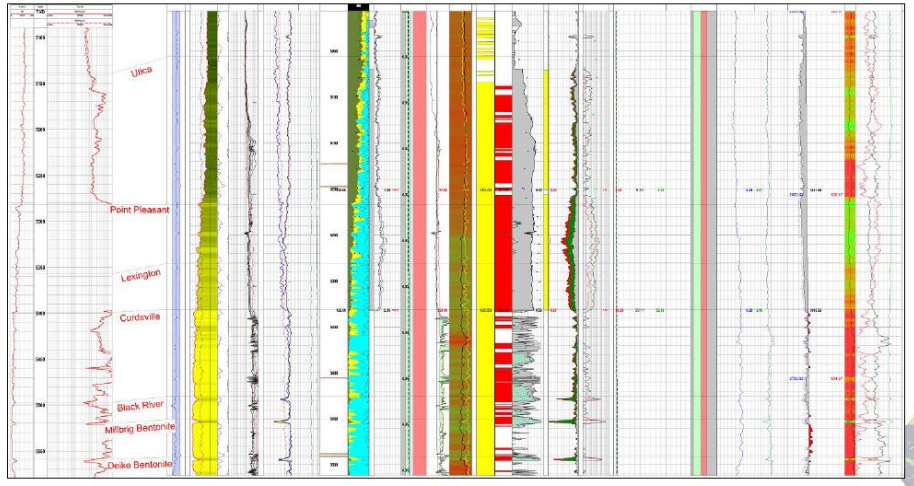
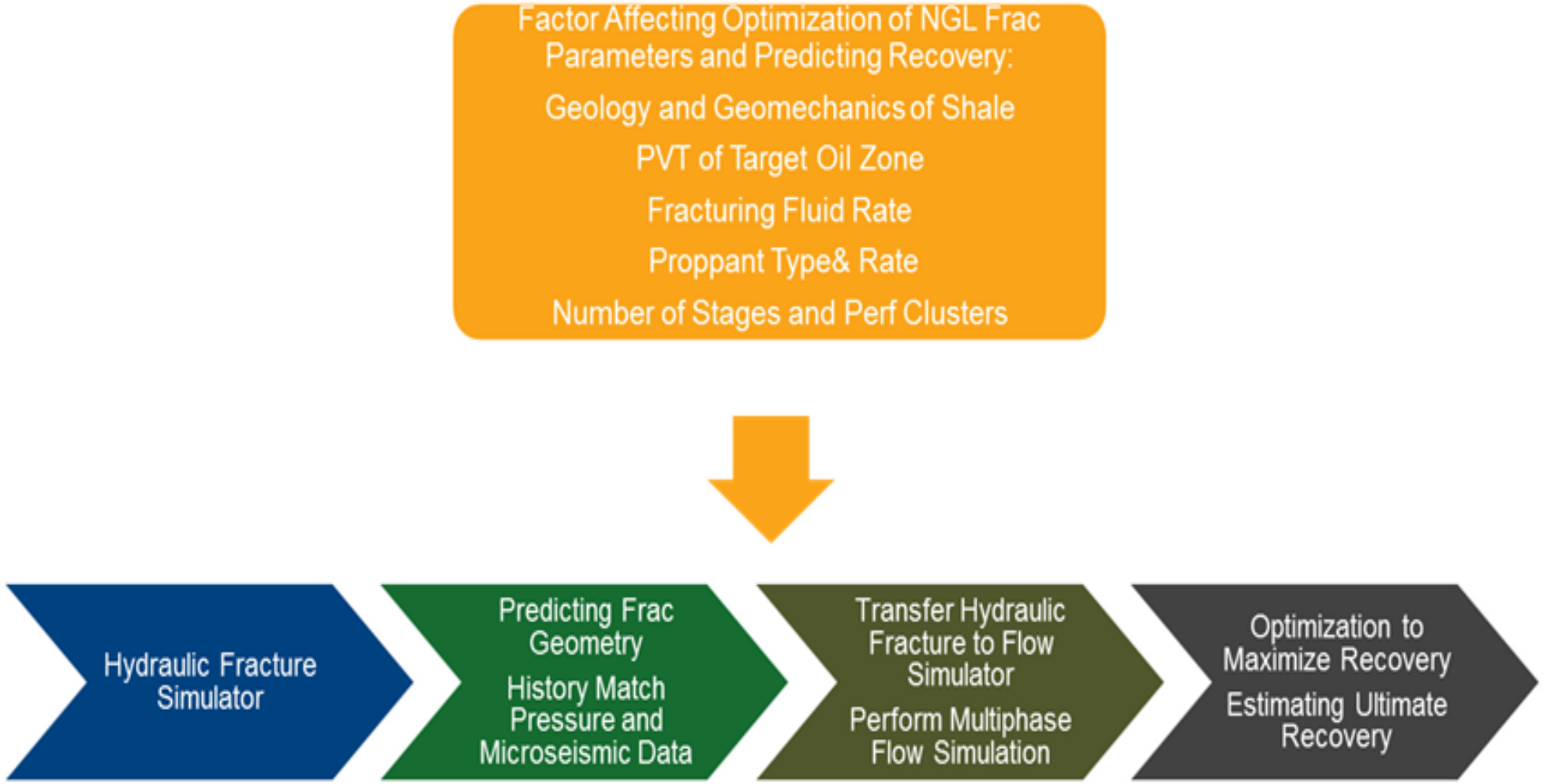
NGL Treatment Design

- In their natural state, Y-Grade NGLs have poor proppant transport capacity
- The project will research ways to increase the viscosity of the Y-Grade fluid by gelling or foaming
- As an alternative, a small-volume frac job consisting of a viscous, sand-laden fluid can be pumped ahead of the Y-Grade NGL
  - N2 foam or cross-link gelled water
  - The Y-Grade NGL can be pumped as a formation treatment following the frac job

Petrophysical Analysis of COSH Mill Creek A-1 and Doughty D-1 Well Logs



Treatment Design Workflow



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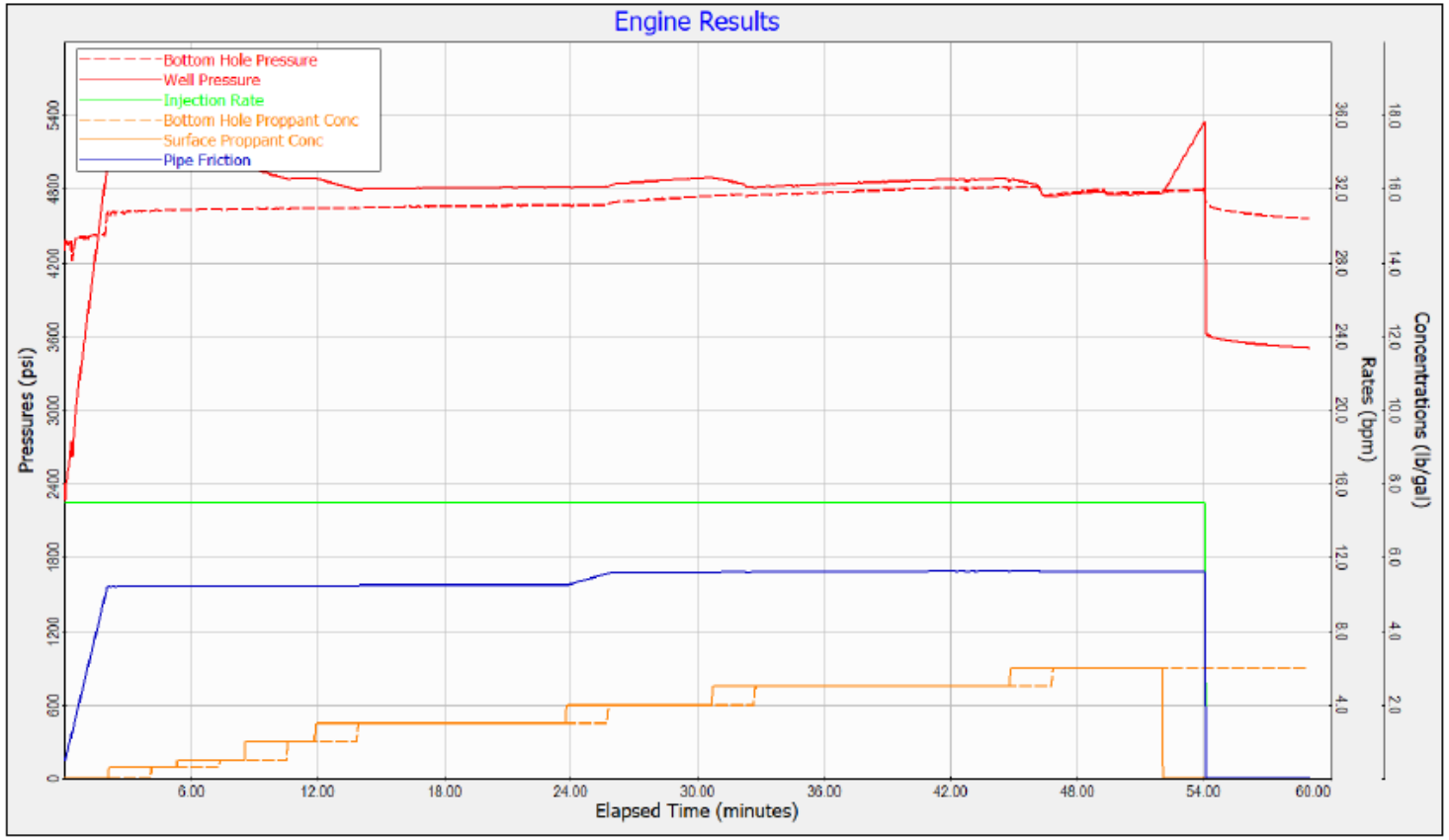
Fracture Modeling – Predicted Rates and Pressures

Predicted Surface and Bottom Hole Rates, Pressures and Proppant Concentrations



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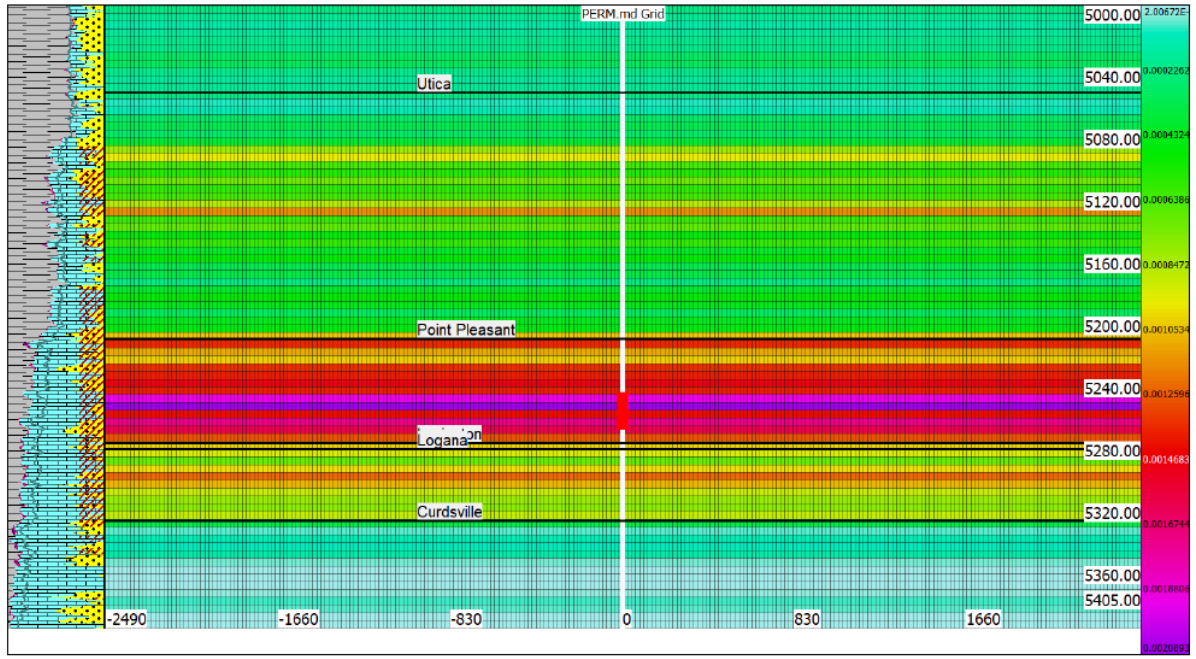
Fracture Modeling – Permeability

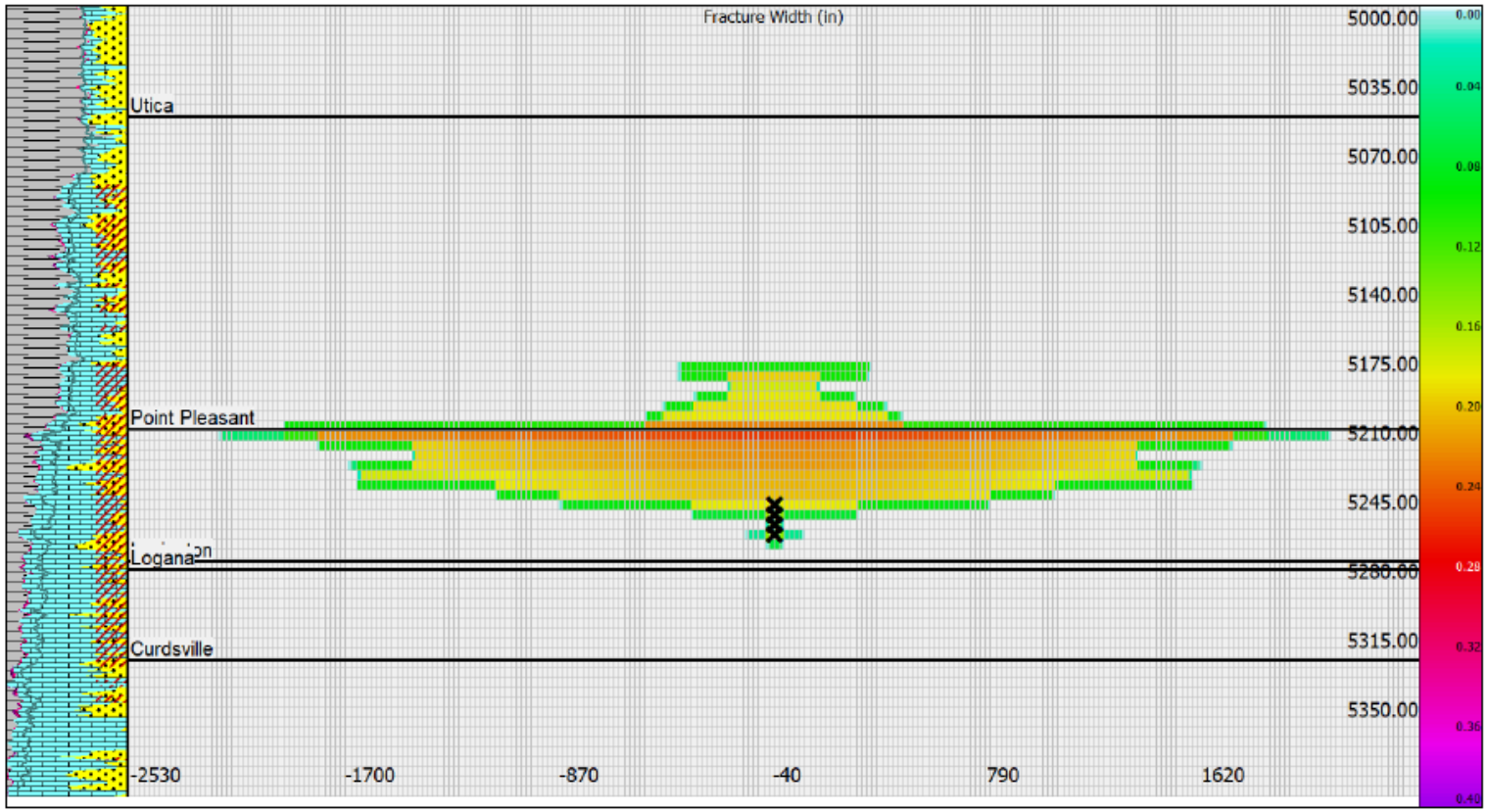
Simulated Permeability from log and core analysis.

Mill Creek A-1
Permeability



Fracture Modeling – Fracture Width

Model Based on:
1,000 Bbl 75 Quality N2 Foam Frac
100 Sacks 100 mesh and
400 sacks 40/70 mesh sand



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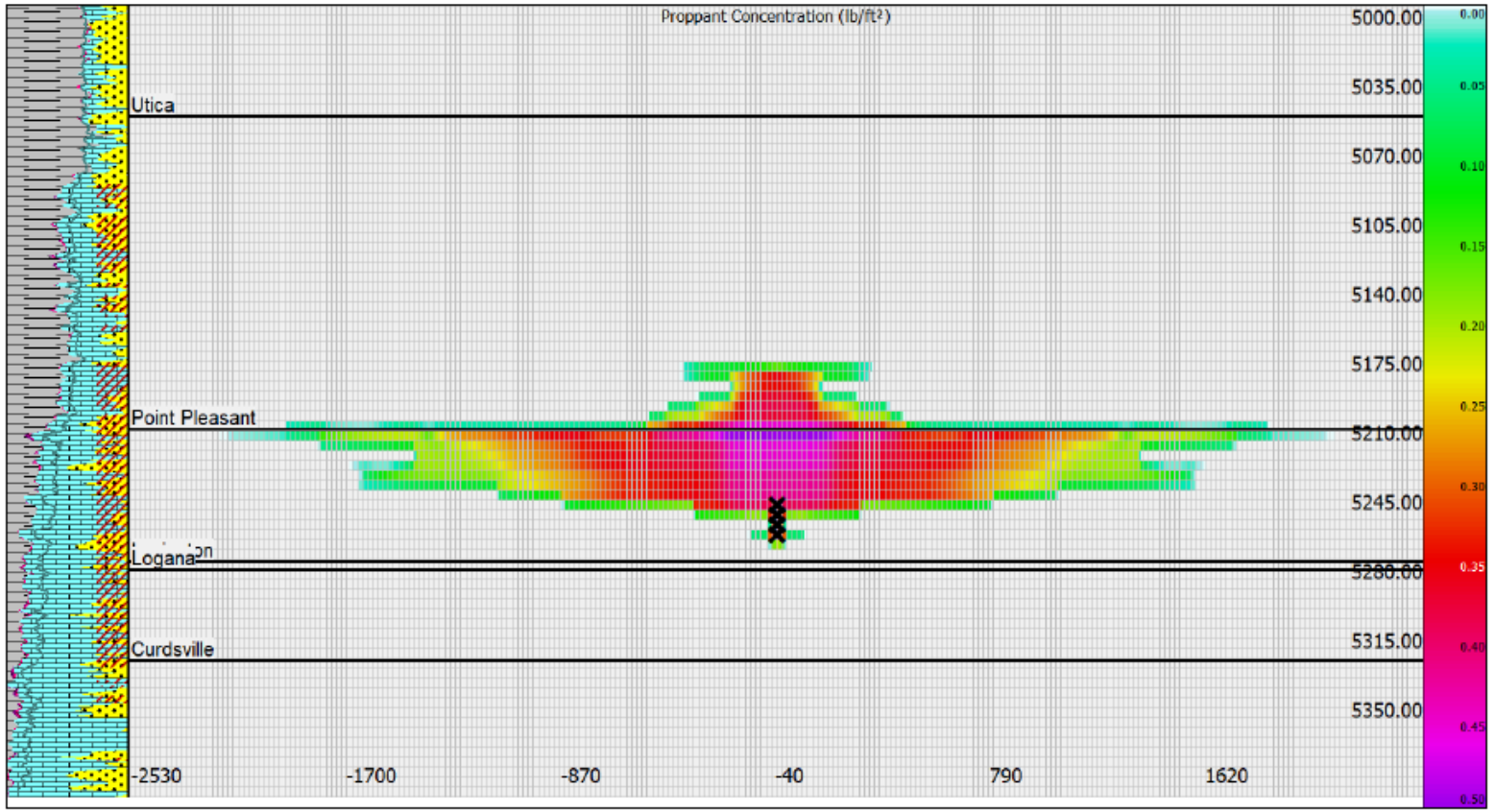
Fracture Modeling – Proppant Concentration

Proppant Concentration in pounds per square foot.



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Field Test Well Preparation - Shoman Etal Unit #1

Hopco Shoman Etal Unit #1
pad and well head

September 5, 2020

Field Test Well Preparation - Shoman Etal Unit #1

Hopco Shoman Etal Unit #1

Rigging up to plug back and cement the well across the Utica/Point Pleasant formation

September 11, 2020

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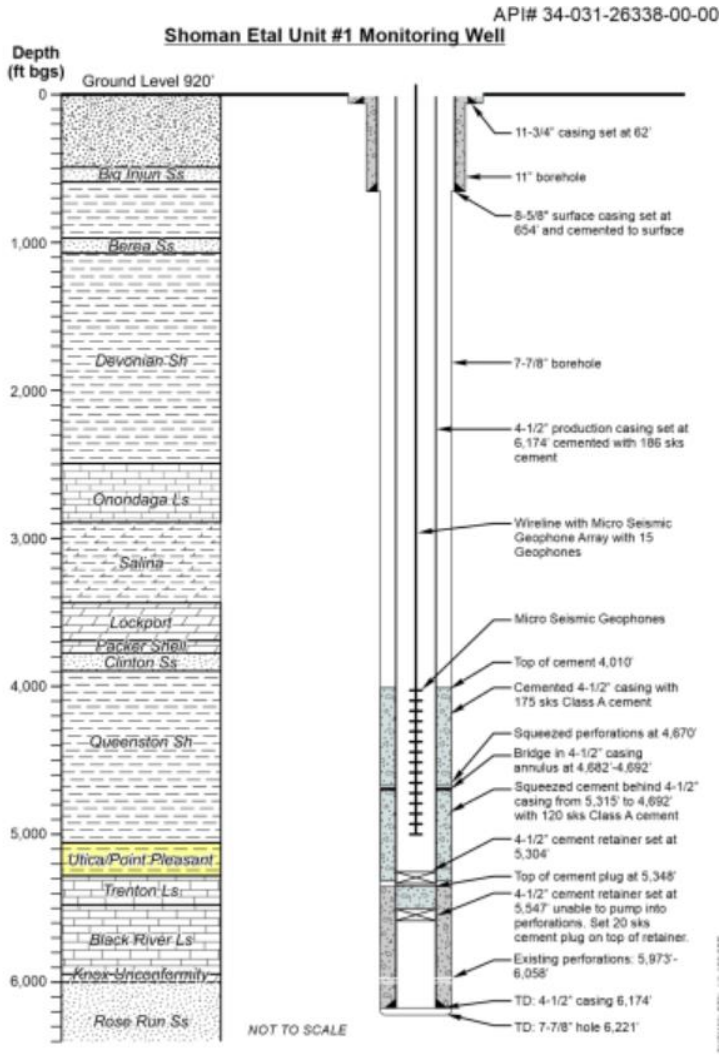
Field Test Well Preparation - Shoman Etal Unit #1

Hopco Shoman Etal Unit #1

Microseismic monitoring array installed August 16. A 1,462.5 ft. geophone array with 16 geophones installed to 5,250 ft.

Geophone array oriented with Geophysical vibrator truck from three different locations,

August 17, 2021: Reservoir Imaging monitored Doughty #D-1 foam frac with downhole geophone array. Seismic data will be sent to ESG Solutions for processing and fracture mapping.



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Field Test Well Preparation – Doughty #D-1

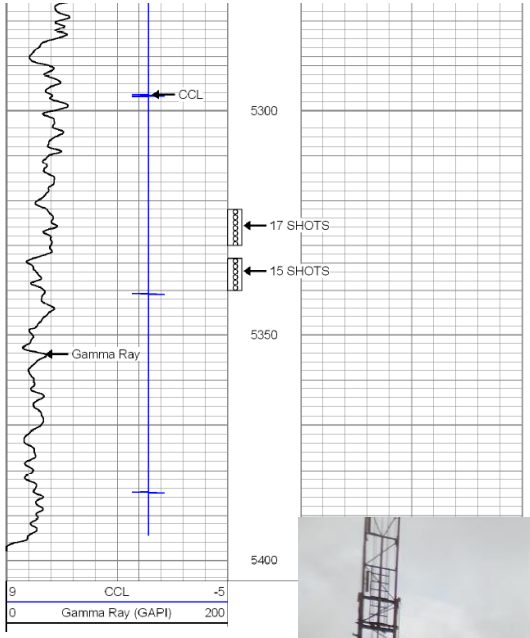
Doughty #D-1

Well plugged back from Rose Run Sandstone and cemented the well across the Utica/Point Pleasant formation September 2020.

Replace wellhead for treatment test July 2021

Perf well, N2 DFIT completed week of July 12, 2021

Complete 75 quality N2 foam frac August 17, 2021



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Project Status

Nitrogen DFIT Summary

Formation Break Down Pressure	5,130 psi
Average Treatment Rate	1.91 bpm
Average Treatment Pressure	4,731 psi
Load Volume	47,000 scf
Treatment Volume	133,000 scf
Total Volume	180,000 scf
ISIP	3,920 psi
5-Minute SIP	3,773 psi
10-minute SIP	3,688 psi
15-Minute SIP	3,630 psi

Monitoring pressure fall-off for 7 – 8 days with bottom home gauges.

Time	Pressure (pis)	Rate (scf/min)	scf/Bbl	Rate (BPM)	Comments
10:07	10,000	0	0	0.00	Pressure test
10:08	0	0	0	0.00	Replace remote pressure cable
10:29	0	0	0	0.00	Open tubing valve
10:31	1,000	1000	404	2.48	Commence pumping
10:38	2,400	2232	865	2.58	Load tubing
10:41	3,000	2800	1,036	2.70	Load tubing
10:43	3,400	2780	1,142	2.43	Load tubing
10:45	4,030	2780	1,297	2.14	Load tubing
10:46	4,270	2785	1,353	2.06	Load tubing
10:48	4,600	2780	1,427	1.95	Load tubing
10:49	4,850	2780	1,482	1.88	Pressure up to break formation, 47K scf N2
10:50	5,130	2780	1,541	1.80	Break down ~5,130 psi
10:51	4,950	2780	1,503	1.85	Establish pump rate
10:53	4,735	2780	1,457	1.91	
10:55	4,740	2780	1,458	1.91	
10:57	4,720	2780	1,454	1.91	
11:00	4,740	2780	1,458	1.91	128 F
11:02	4,720	2780	1,454	1.91	
11:04	4,720	2780	1,454	1.91	100 F
11:06	4,730	2780	1,456	1.91	115 F
11:08	4,730	2780	1,456	1.91	95 F
11:12	4,730	2780	1,456	1.91	115 F
11:14	4,730	2780	1,456	1.91	
11:16	4,740	2780	1,458	1.91	
11:20	4,750	2780	1,460	1.90	121 F
11:25	4,740	2780	1,458	1.91	
11:30	4,740	2780	1,458	1.91	102 F
11:35	4,700	2785	1,449	1.92	46 F
11:36	3,920	-	-	-	Shut down, ISIP
11:41	3,773	-	-	-	5-minute SIP
11:46	3,688	-	-	-	10-minute SIP
11:51	3,630	-	-	-	15-minute SIP, shut well in
11:55	-	-	-	-	Release pressure at pump truck
12:00	-	-	-	-	Knock off injection hose and plug valve
12:01	-	-	-	-	Well flowing up tubing annulus
12:02	-	-	-	-	Shut tubing annulus valve, install gauges.

Project Status

- Geotechnical Characterization of the Utica/Point Pleasant has been completed
- Field test wells were prepared
  - Both field test wells have been plugged back and cemented across the UPP formation for stimulation, treatment and micro seismic monitoring
- Procurement of contractors and vendors has been completed
- Stimulation and NGL Treatment is in progress
  - Nitrogen DFIT Completed on 7/22/2021
  - 1,000 Bbl 75 Quality N2 Foam Frac completed for 8/17/2021
  - Staging 1,000 Bbl NGL bulker tanks, fire protection, pump trucks, flowback protection
- ***1,000 Bbl Y-Grade NGL Injection Treatment scheduled for 8/25/2021***

Questions???

Mark Moody
moodym@battelle.org

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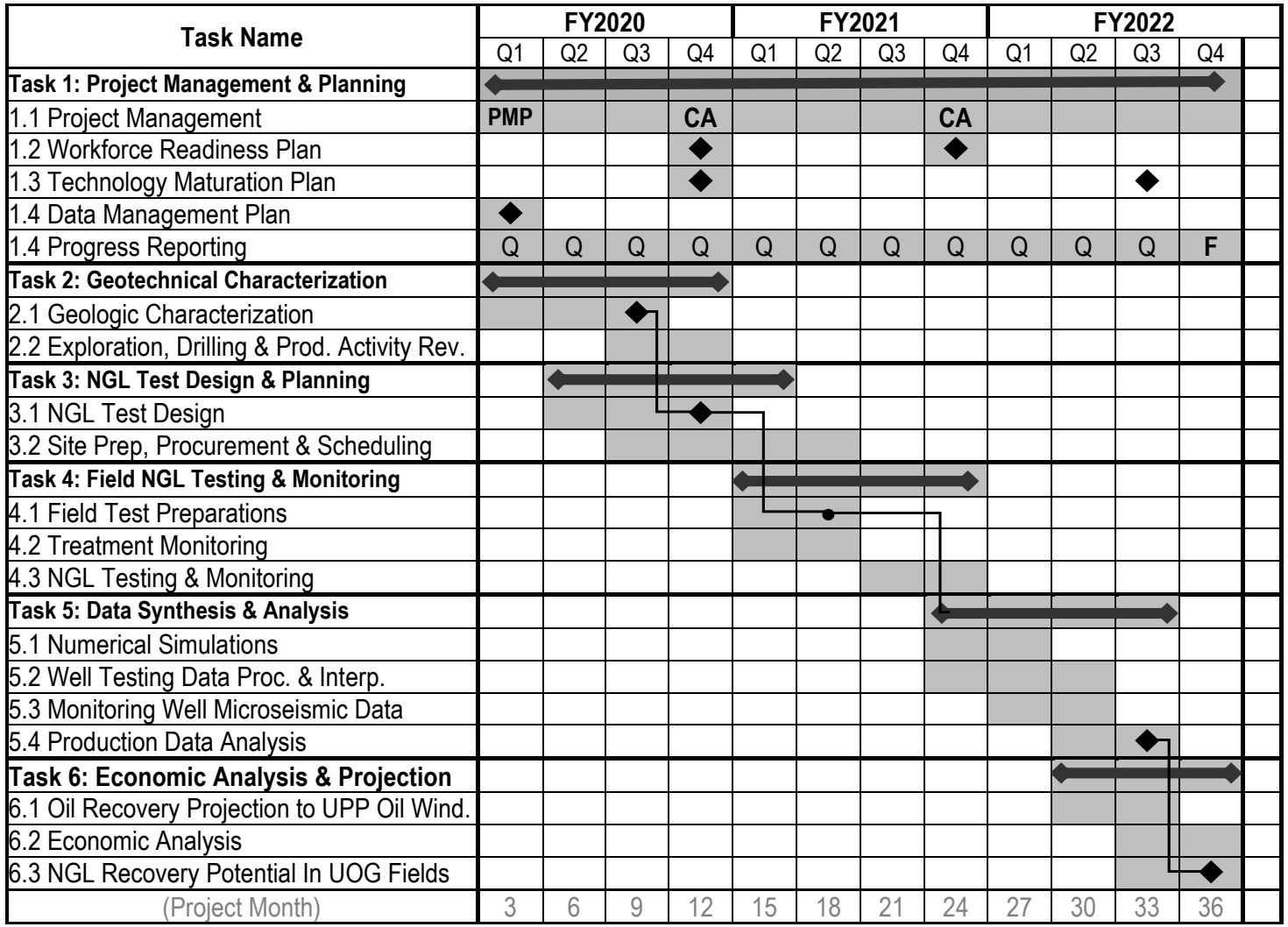
It can be done

800.201.2011 | solutions@battelle.org | www.battelle.org

Back Up Slides

Project Schedule



Project Milestones

- Field activity-based project with key milestones related to the NGL treatment testing.

Task/ Subtask	Milestone	Planned Completion Date	Verification method
1	Update PMP, Data Mgmt. Plan	9/30/2019	Submit updated PMP to DOE
1	Workforce Readiness, Tech. Mat. Plan	Sept 2020, 2021	Plans submitted w/ Cont. Appl.
2	Utica Characterization Task	6/30/2020	Submit Task Report
3	Site Access Agreement	3/30/2020	Access agreement in place
3	Testing Health & Safety Plan	8/30/2020	Health & Safety Plan
3	Complete Field-Testing Design & Plan	10/31/2020	Submit field testing plan to DOE
4	NGL Injection Field Testing	3/30/2021	Submit field test report to DOE
5	Complete NGL Injection Monitoring	9/30/2021	Submit field monitoring report to DOE
6	Complete data analysis and integration	3/30/2022	Task Summary Report
7	Complete Economic Analysis Task	8/15/2022	Task Summary Report
1	Submit field testing data to EDX	02/2022	EDX upload confirmation
1	Final Technical Report	9/30/2022	Submit Final Technical Report