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Energy & Environmental Research Center (EERC)

# BAKKEN PRODUCTION OPTIMIZATION PROGRAM (BPOP) UPDATE

Presented to the North Dakota Oil & Gas Research Council  
February 23, 2022

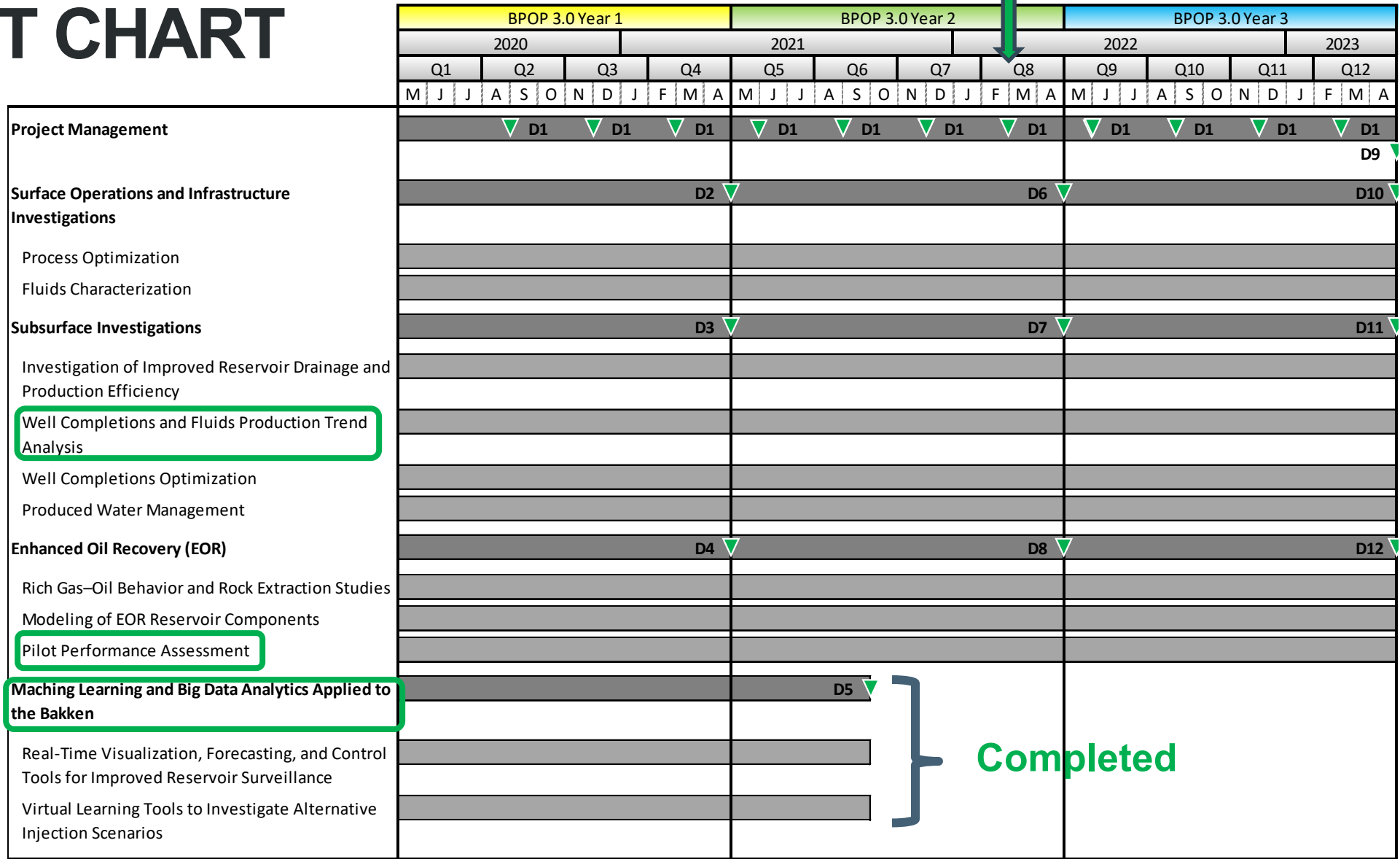
Jim Sorensen  
Director of Subsurface R&D

# Outline

- **Gantt chart – Activities & Timeline**
- **Update on Liberty Resources' Rich Gas EOR Pilot at East Nesson**
- **Machine Learning & Artificial Intelligence Highlights**
  - **Geologic Cluster Analysis Tool**
  - **3-Mile Lateral Study**
- **Financial Status**



# GANTT CHART



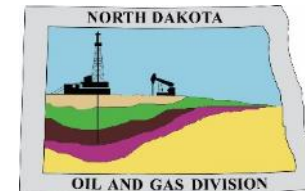
D1 – Quarterly Report

D2–D4, D5–D8, D10–D12 – Topical Report

D9 – Final Report

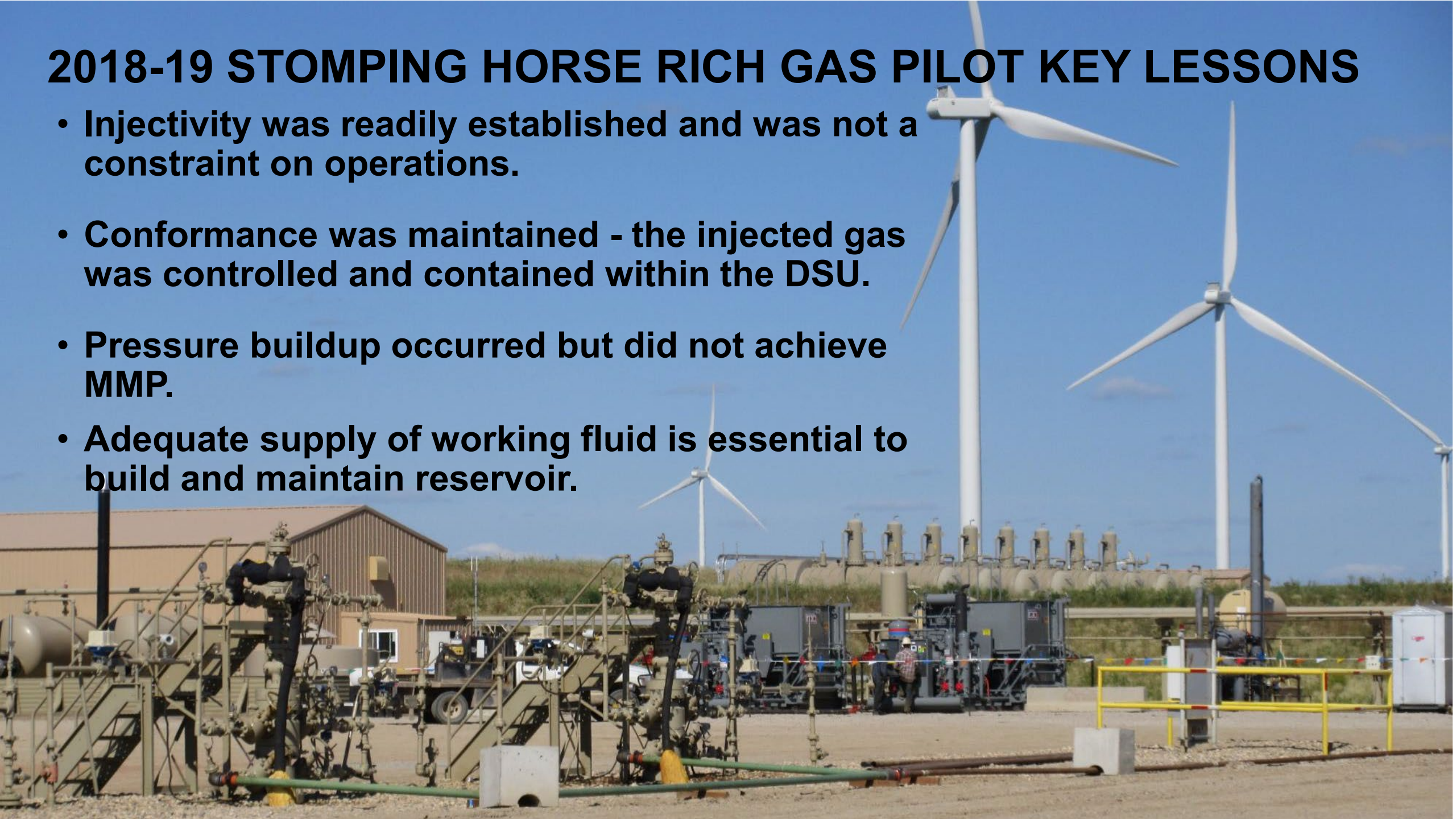
Completed

# BPOP PARTNERS



# 2018-19 STOMPING HORSE RICH GAS PILOT KEY LESSONS

- **Injectivity was readily established and was not a constraint on operations.**
- **Conformance was maintained - the injected gas was controlled and contained within the DSU.**
- **Pressure buildup occurred but did not achieve MMP.**
- **Adequate supply of working fluid is essential to build and maintain reservoir.**



# 2021-22 EAST NESSON PROJECT HYPOTHESIS AND GOALS

- **Hypotheses:**
  - ❑ Co-injection of gas and water can increase pressure beyond MMP and help improve conformance and containment in the Bakken.
  - ❑ Co-injection process can lower injection pressure needed and associated cost.
- **The main goal and objective:**
  - ❑ to demonstrate the economic viability of enhanced oil recovery from the Bakken Petroleum System by using produced rich gas in combination with water and surfactants.

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# EAST NESSON CO-INJECTION TECHNOLOGY IMPLEMENTED

- A novel Enhanced Oil Recovery (EOR) injection technology developed by EOR ETC.
- This technology is commonly referred to as co-injection but is formally called the Rapid-Switched, Stacked-Slug (RSSS) system.
- The RSSS system differs from conventional Water Alternating Gas (WAG) injection techniques by rapidly (in seconds and minutes) switching between liquid and gas injection to create a stacked slug flow regime in the injection path.
- A patent filing was submitted early 2021.





# EAST NESSON EOR PILOT IMPLEMENTATION

<b>Pilot Injection Start Date</b>	September 10, 2021
<b>Pilot Injection End Date</b>	October 11, 2021
<b>Number of cycle</b>	1
<b>Pilot Production Start Date</b>	October 12, 2021
<b>Rich gas injected volume</b>	46MMscf (avg. ~1.5 MMscfd)
<b>Water injected volume</b>	40Mbbbls (avg. ~1.3 Mbwpd)
<b>Surfactant injected</b>	~2400 gallons



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# EAST NESSON EOR PILOT OPERATIONAL PRESSURES



Initial Bottomhole Pressure	~1000 psi
Est. Minimum Miscibility Pressure (MMP)	~2430 psi
Max. Wellhead Pressure (measured)	~1300 psi
Max. Bottomhole Pressure (calculated)	~4450 psi

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# KEY OBSERVATIONS FROM EAST NESSON INJECTION CYCLE

- Injectivity was readily established.
- High pressure buildup occurred and was maintained with the co-injection, far beyond MMP.
- The lower wellhead injection pressure under 1300 psi was maintained by the co-injection.
- A minor gas breakthrough at one of the adjacent wells was observed but was able to be controlled and contained by increasing the water slug ratios to the well.



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# EAST NESSON PRODUCTION CYCLE IS ONGOING...



# ACKNOWLEDGEMENT: EAST NESSON PROJECT PARTNERS

- Liberty Resources Management
- EOR ETC
- CMG
- TAMU (Dr. David Schechter)



# AI & ML FOR EOR IN THE BAKKEN – 2021 HIGHLIGHTS

*Artificial Intelligence & Machine Learning for Unconventional EOR Strategies – Created algorithms informing reservoir performance predictions based on injection rate versus soak time, production time, and injection time.*

- *Created a tool to perform Real time visualization and forecasting intended to support real time decision making during production operations.*

**Modeling Conformance Treatments and EOR Strategies** – Explored advanced modeling and simulation techniques to determine mechanisms for improving conformance control in the Bakken, investigate alternative EOR strategies, and improve simulation run times.

- Embedded Discrete Fracture Modeling (EDFM) shown to improve simulation run times and demonstrated excellent results matching fluid injection and production data.
- **Modeling & simulation studies showed conformance can be gained through the use of water injection or surfactant injection and demonstrated improvements in oil recovery.**

# WEBINAR TOPIC – GEOLOGIC CLUSTER ANALYSIS TOOL

## Description

This dashboard provides an interactive tool to divide the Bakken petroleum system into several groups based on geological and geochemical, formation fluid chemistry, and oil and gas property variables selected by the user at the bottom of the page. The importance of the selected variables in defining a geologic cluster and differentiating it from other clusters are shown to the right of the map, in the "Variable Importance Plot." To display the variable importance plot for individual clusters, click on that cluster on the map.

## Steps to create the clustering map include:

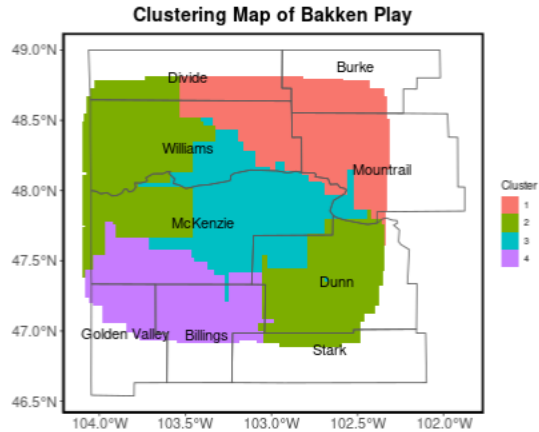
- Select the clustering algorithm.
- Select the number of clusters.
- Select variables from the geology & geochemical, oil & gas property, and water chemistry variables.
- Click the "Submit" button to run the selections.

## Clustering Algorithm:

K-means

## Cluster Number:

3 4 12



Click the map to obtain the variable importance plot for individual clusters.

The default number of clusters is 4 and the default clustering algorithm is "k-means". You can change these options using the tools on the left side of your screen.

Reset to default variable selection Deselect All Submit

## Geology & Geochemical Variables:

UB HI  LB HI  UB Tmax  LB Tmax  UB TOC  LB TOC  MB Temperature  LB Thickness  MB Thickness  UB Thickness  BK Thickness  TF Thickness  BK Depth  TF Depth  MB Pressure  Permeability  Porosity

## Oil & Gas Property Variables:

Sulfur (BK)  Parafn (BK)  Oil Gravity (BK)  Viscosity (BK)  C1 (BK)  C2 (BK)  C3 (BK)  C1/C2 (BK)  C1/C3 (BK)  Wetness (BK)  Sulfur (TF)  Parafn (TF)  Oil Gravity (TF)  Viscosity (TF)  C1 (TF)  C2 (TF)  C3 (TF)  C1/C2 (TF)  C1/C3 (TF)  Wetness (TF)

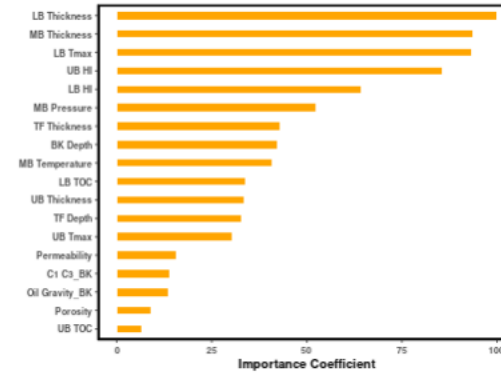
## Water Chemistry Variables:

Ca (BK)  Fe (BK)  Mg (BK)  Sulfate (BK)  NaCl (BK)  Ca (TF)  Fe (TF)  Mg (TF)  Sulfate (TF)  NaCl (TF)

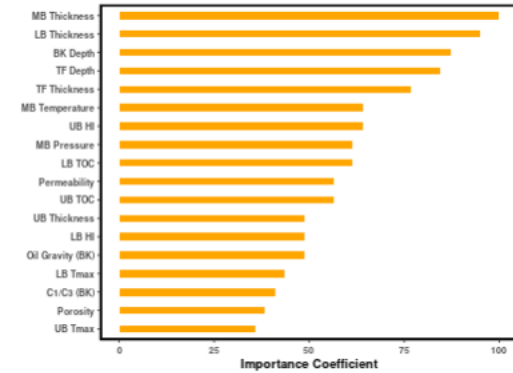
**Cluster Analysis Tool can be found on the Partners Only Web site!**

## Variable Importance Plot (all clusters, left; individual cluster, right)

### All Clusters

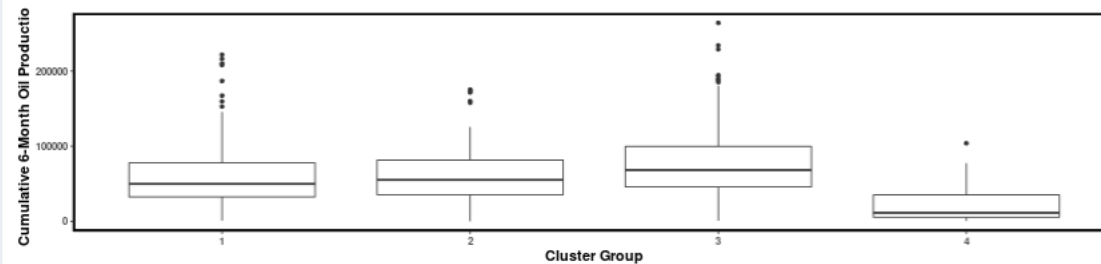


### Cluster 1

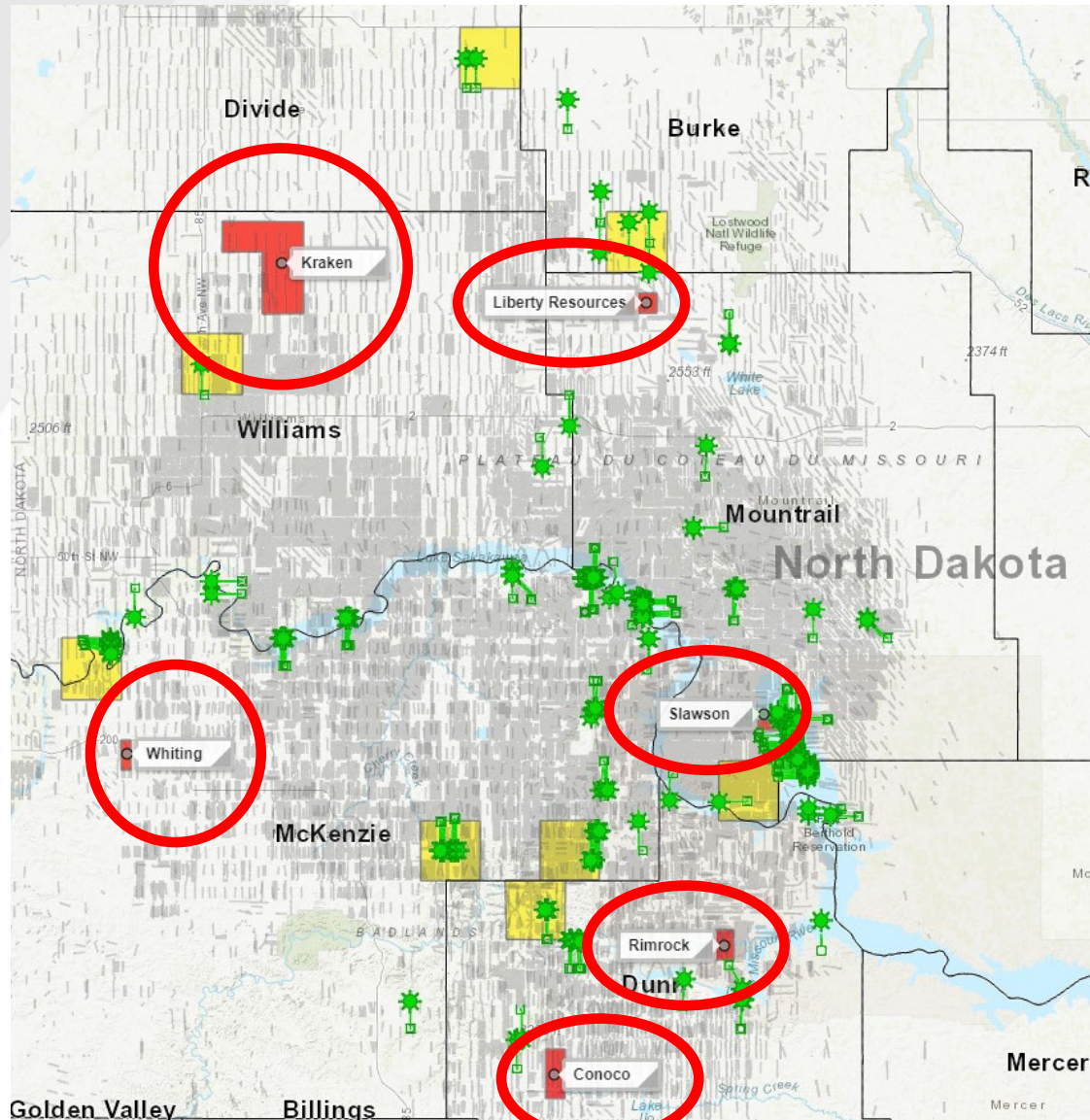


Select a variable to show its distribution among clusters

Cumulative 6-Month Oil Production



# WEBINAR TOPIC - STUDY OF 3-MILE LATERALS



Beginning to see development plans outside of geographic constraints that are designed to accommodate 3-mile horizontal wells.

Development characteristics:

26% - Average additional capital to drill and complete a 3-mile lateral.

20%-50% - Expected increase in EUR

Anticipated increased returns

Fewer facilities, improved costs

Less surface impact

Stand-ups producing better than laydowns



# FINANCIALS

Sponsors	Original Budget	Secured to Date
NDIC Share – Cash	\$6,000,000	\$6,000,000
Industry Share – Cash	\$500,000	\$800,000
DOE – Cash	\$1,500,000	\$1,500,000
Liberty – In-Kind	\$4,000,000	\$1,449,684
Oasis – In-Kind		\$2,109,144
EOR ETC – In-Kind		\$110,000
CMG – In-Kind		\$28,500
Balance – TBD		\$2,672
Total	\$12,000,000	\$12,000,000



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A wide-angle photograph of a university campus at sunset. The sun is low on the horizon, casting a warm glow over the scene. In the foreground, there are large trees with some yellowing leaves. In the background, there are several large, multi-story brick buildings and a parking lot filled with cars.

**THANK YOU**

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