



Energy & Environmental Research Center

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July 30, 2020


Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
600 East Boulevard Avenue, Department 405
State Capitol, 14th Floor
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: Quarterly Progress Report for the Period of May 1 – June 30, 2020, “Bakken
Production Optimization Program 3.0”; Contract No. G-051-98; EERC Fund 24568

Attached please find the Energy & Environmental Research Center (EERC) Quarterly
Progress Report for the subject project. If you have any questions, please contact me by phone at
(701) 777-5287 or by e-mail at jsorensen@undeerc.org.

Sincerely,

DocuSigned by:

0671D00C8437443...
James A Sorensen
Director for Subsurface R&D

JAS/bjr

Attachment

c/att: Brent Brannan, North Dakota Industrial Commission



BAKKEN PRODUCTION OPTIMIZATION PROGRAM

Quarterly Progress Report

(for the period May 1 – June 30, 2020)

Prepared for:

North Dakota Industrial Commission

Partners of the Bakken Production Optimization Program (BPOP) Consortium

ConocoPhillips
Equinor
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Liberty Resources LLC
Marathon Oil Company
Oasis Petroleum
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WPX Energy
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July 30, 2020

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TABLE OF CONTENTS

LIST OF TABLES i

EXECUTIVE SUMMARYII

INTRODUCTION 1

ACCOMPLISHMENTS DURING REPORTING PERIOD..... 1

 Process Optimization..... 2

 Fluids Characterization 2

 Well Completion Optimization 2

 Oil Fingerprinting..... 3

 Enhanced Oil Recovery..... 3

 Program Management and Development 3

PARTNERSHIP AND FINANCIAL INFORMATION 4

FUTURE ACTIVITIES 4

 Process Optimization..... 4

 Fluids Characterization 4

 Well Completion Optimization 5

 Oil Fingerprinting..... 5

 Enhanced Oil Recovery..... 5

 Program Management and Development 5

LIST OF TABLES

1 BPOP – Budget and Expenses to Date 4

BAKKEN PRODUCTION OPTIMIZATION PROGRAM

EXECUTIVE SUMMARY

The Bakken Production Optimization Program (BPOP) was established to facilitate Bakken petroleum system oil recovery while simultaneously reducing the environmental footprint of oil and gas development. This program is administered by the Energy & Environmental Research Center (EERC), with funding from the North Dakota Industrial Commission (NDIC) Oil and Gas Research Program (OGRP) and the North Dakota petroleum industry. Through BPOP, the EERC is working closely with a consortium of industry partners and the state to address emerging opportunities and challenges related to Bakken development. This progress report presents an overview of BPOP activities from May 1 through June 30, 2020.

“Bakken Production Optimization Program 3.0” under contract G-051-98 was initiated May 1, 2020, continuing BPOP through April 30, 2023. The BPOP 3.0 Program includes activities designed to 1) improve the efficiency and reduce the environmental footprint of surface facilities and infrastructure, 2) generate laboratory-, modeling-, and field-based data related to enhanced oil recovery (EOR), and 3) apply machine learning (ML) and artificial intelligence (AI) toward development of tools that can be used to streamline data analysis and operational decision making.

Technical activities conducted this quarter included the development of two webinars on potential flare mitigation technologies and the use of centralized facilities for produced fluids processing. The webinars will be presented in July. Reservoir modeling was also conducted to support the design of a future EOR pilot being planned by Liberty Resources. An experimental design plan was developed for laboratory work that will be conducted to support the design of a future EOR pilot being planned by Oasis. This quarter also included the completion of final reporting for the BPOP 2.0 contract, which was active through May 31, 2020. A no-cost time extension through June 30, 2020, was granted by NDIC to complete internal reviews of the project deliverables.

The following project deliverables were submitted to NDIC on June 30, 2020:

- Final report: BPOP Final Report November 2016 – May 2020
- Specific report on Enhanced Oil Recovery: Enhanced Oil Recovery in the Bakken – Key Observations and Lessons Learned from Laboratory Studies, Modeling, and Field Testing
- Report on Produced Fluid Characterization: Produced Fluid Characterization
- Report on Aromatic/Aliphatic Study: Turtles and Snakes: Using Molecular Shape to Understand Oil Migration and Production in the Bakken Petroleum System
- Report on Regulatory Review: Bakken Pilot Testing for the Purpose of Enhanced Oil Recovery: A North Dakota Regulatory Primer

Additional project deliverables were submitted previously. A value-add report on the data analytics task entitled “Advanced Analysis of Bakken Data to Optimize Future Production Strategies” and a summary of the final report entitled “Overview Summary of Advanced Analysis of Bakken Data to Optimize Future Production Strategies” were submitted to NDIC on June 30, 2020.

Value-add reports and technical briefs under several of the tasks were prepared, are under internal review, and will be provided to partners in July 2020. The project deliverables and value-add reports will be added to the BPOP website in July 2020.

The EERC holds an unwavering commitment to the health and well-being of its employees, partners and clients, and the global community. As such, precautionary measures have been implemented in response to COVID-19. Staff continue to carry out project-related activities remotely, and personnel supporting essential on-site laboratory and testing activities are proceeding under firm safety guidelines. Travel has been minimized, and protective measures are being undertaken for those who are required to travel. At this time, work conducted by EERC employees is anticipated to progress with minimal disruption. Challenges posed by economic variability will be met with open discussion between the EERC, the NDIC Project Manager, and BPOP partners to identify solutions. The EERC is monitoring developments across the nation and abroad to minimize risks, achieve project goals, and ensure the success of our partners and clients.

BAKKEN PRODUCTION OPTIMIZATION PROGRAM

INTRODUCTION

The Bakken Production Optimization Program (BPOP) was established to facilitate Bakken petroleum system (BPS) oil recovery while simultaneously reducing the environmental footprint of oil and gas development. This program is administered by the Energy & Environmental Research Center (EERC), with funding from the North Dakota Industrial Commission (NDIC) Oil and Gas Research Program (OGRP) and the North Dakota petroleum industry. Through BPOP, the EERC is working closely with a consortium of industry partners and the state to address emerging opportunities and challenges related to Bakken development.

The goals of BPOP are to:

- Provide the state and industry with science-based insight to maintain the economic and environmental sustainability of the Bakken play in North Dakota.
- Provide stakeholders with the knowledge needed to plan and implement innovative development strategies that will take the Bakken into the next decade and help achieve the Governor's goal of 2 million barrels per day of North Dakota oil production.

The anticipated ongoing outputs of BPOP are 1) increased well productivity and economic output of North Dakota's oil and gas resources; 2) decreased environmental impacts of wellsite operations; and 3) guidance to stakeholders regarding optimal, prudent development of North Dakota's Bakken petroleum resources.

ACCOMPLISHMENTS DURING REPORTING PERIOD

Several activities performed under BPOP 2.0 had continued interest from partners. Efforts continued this quarter to advance the research activities.

Two BPOP member companies (Liberty Resources and Oasis) continue to develop plans for future enhanced oil recovery (EOR) pilot tests, and EERC personnel conducted activities to support those planning efforts. Specific activities include the creation of a geologic model of the East Nesson area being considered by Liberty Resources for an EOR pilot and the development of an experimental design plan for laboratory-based testing of rocks and fluids to support design of an EOR pilot being considered by Oasis.

A journal article entitled "Comparison of CO₂ and Produced Gas Hydrocarbons to Dissolve and Mobilize Bakken Crude Oil at 10.3, 20.7, and 34.5 MPa and 110°C" was submitted to *Energy & Fuels* following peer review. The material is based upon work performed under BPOP and the matching effort under the U.S. Department of Energy (DOE).

Process Optimization

Processing produced fluids from the well to market, although simple when described in a basic flow diagram, is complicated by dynamic and variable production rates and fluids composition, extreme climate, complex business and financial models, and evolving regulations. By working with BPOP partners, the EERC can systematically analyze trends by assimilating data and information from multiple operators, assist in defining the challenges to improved process efficiency, and identify technological and operational solutions through process modeling and system design. Through BPOP, the EERC will continue to serve existing and new North Dakota Petroleum Council (NDPC) task force groups established to address challenges such as flaring, vapor pressure compliance, and emissions.

Over the past several months, the EERC has been conducting studies focused on the use of mobile data centers for flare gas mitigation, emissions from wellsite operations, and centralized facilities for crude oil conditioning. These topics were prioritized by project partners during a BPOP 2.0 partner meeting held on November 12, 2019, in Williston, North Dakota. Reports summarizing this work were completed and posted to the BPOP 2.0 Partner website.

During this reporting period, the EERC scheduled two web conferences to share findings from these recently completed investigations. A presentation summarizing the use of mobile data centers for flare gas mitigation is scheduled for July 7, 2020. A presentation summarizing the opportunities and challenges of large centralized facilities for processing produced fluids is scheduled for July 23, 2020.

Fluids Characterization

The optimization of crude oil production in North Dakota requires accurate understanding of the fluids being produced. Crude oil, associated gas, and produced water are complex mixtures, and their chemical and physical properties can vary geographically over the life of a well. Over the first 6 years of BPOP, a large amount of fluids data have been acquired, and a database of fluids information has been created. The EERC will continue to maintain and expand this valuable database and coordinate data gathering and sampling and analysis activities to support all the program tasks.

During this reporting period, activities consisted of coordinating the anticipated fluid sampling and analysis activities that will be needed to support the various project tasks. Planning of anticipated activities included the creation of maps from existing fluids data to evaluate Bakken production compared to estimated fracture networks, creation of water saturation maps to assess theoretical maximum production, and comparison of Bakken fluid chemistry data with additional data from adjacent formations.

Well Completion Optimization

Efforts continued to find optimal well completion parameters in the BPS. The goal was to improve the optimization calculations and to bring the analysis to the next level of sophistication. Available in-house geologic and reservoir data have been compiled for 400 wells basinwide.

Multiple kriging, or Gaussian process regression, methods were tested to extrapolate the geological data to 12,000 wells throughout the Williston Basin. Proof-of-concept calculations were performed to divide the BPS into four to ten subareas or clusters based on geological and geochemical characteristics, allowing for evaluation of optimal Bakken completion factors by cluster. Additional investigations and further discussions were held with NDIC representatives on improving the quality of publicly available data. Software solutions are being tested and selected for the visualization of trends and reporting purposes.

Oil Fingerprinting

To better understand drainage mechanisms and crude oil volumes in the different lithofacies of the BPS, oil fingerprinting methods were further improved. An EERC lab adopted several sample preparation methods, including 1) extraction of oil/bitumen from rock using sonication and Soxhlet extractors and 2) fractional separation using an open column. Pilot tests have been completed to understand the distributions of polycyclic aromatic compounds and saturate biomarkers in Bakken oil using gas chromatography–mass spectrometry (GC–MS).

Enhanced Oil Recovery

- Aggregated data including well logging, well tops, directional survey, core, fracture treatment, and monthly production data from publicly available sources such as NDIC were collected to build a 3D geologic model of the East Nesson area.
- A petrophysical analysis was conducted based on the available well log data for the wells nearby the East Nesson study area.
- A detailed, 3D geologic model of the East Nesson area was developed in Petrel.
- A simplified, layer-cake geologic model was also created based on the detailed 3D geologic model (using it as a reference) for fluid-flow simulation efficiency for the unconventional reservoir.
- The EERC held several discussions with producers and technology providers to discuss applicability and performance of hybrid surfactant systems for application to unconventional EOR scenarios.

Program Management and Development

Contract G-051-98 was initiated May 1, 2020, continuing BPOP through April 30, 2023.

Partnership fees for the current year were received from Hess Corporation. Liberty Resources will contribute to BPOP 3.0 with in-kind cost-share.

Final BPOP 2.0 project deliverables were uploaded to the BPOP website.

The EERC is operational and open for business. Personnel who are not essential for on-site operations have transitioned to working from home. Essential project, laboratory, and field-based activities are proceeding with the incorporation of Centers for Disease Control and Prevention (CDC), North Dakota State, and University of North Dakota guidelines associated with COVID-19, and mitigation measures have been implemented.

In collaboration with project partners, the EERC is continually assessing potential impacts to project activities resulting from COVID-19 and/or the U.S. economic situation.

In the event that any potential impacts to reporting, scope of work, schedule, or cost are identified, they will be discussed and addressed in cooperation with NDIC.

PARTNERSHIP AND FINANCIAL INFORMATION

The original budget as proposed to NDIC OGRP is \$12,000,000, as shown in Table 1. Expenses to date are also listed in Table 1.

Table 1. BPOP – Budget and Expenses to Date

Sponsors	Budget	Actual Expenses as of 6/30/20	Balance
NDIC Share – Cash	\$6,000,000	\$112,555	\$5,887,445
Industry Share – Cash	\$500,000	\$8,657	\$491,343
Liberty – In-Kind	\$4,000,000	-	-
DOE – Cash	\$1,500,000	\$16,496	\$1,483,504
Total	\$12,000,000	\$137,708	\$11,862,292

FUTURE ACTIVITIES

Process Optimization

Activities for future reporting periods will be influenced by the priorities initially developed during the November 2019 process optimization meeting and additional direction and input provided by program partners during the planned July 2020 web conferences. In addition to the topics of gas utilization and facility optimization, the EERC anticipates exploring issues related to the recent production reduction, well shut-ins, and strategies to improve production restart.

Fluids Characterization

Upcoming activities include developing partnerships with industry to understand their needs related to Bakken production issues and practices and to expand the geographical extent of the sampling and analysis effort. Data collection and sample acquisition are expected to continue, with results supporting the ongoing compositional evaluations of each fluid, supporting temporal evaluations, and enhancing the size and usefulness of the database to the various BPOP

research efforts. This task will also support new and developing field-based EOR and gas storage projects to be conducted by the EERC and specific BPOP partners.

Enhancement of the existing GC and GC–MS instrumentation and development of standard analytical methods to enable additional hydrocarbon analyses and sulfur compound characterization will continue. These methods will be used to analyze existing crude, water, gas, and available core samples collected from within the Bakken to determine oil source and reservoir connectivity and monitor subsurface migration during production activities.

Well Completion Optimization

During the next quarter, the data analytics team will focus on finalization of the geologic clustering method and testing of completion optimization calculations based on cluster location. Optimization calculations will be performed on both well and DSU (drill spacing unit) levels. Additional analyses will include an evaluation of operator-specific completion strategies with a focus on the most successful (productive) wells.

Oil Fingerprinting

To understand vertical and lateral variations in organic facies, dozens of source rock samples representing the Upper and Lower Bakken Shales and crude oil produced from the Middle Bakken will be characterized geochemically on a molecular level using GC–MS. New geochemical data will be integrated with available in-house information. Fingerprinting efforts will focus on identification of reliable indicators or hydrocarbon ratios for the oil/rock correlations in the BPS.

Enhanced Oil Recovery

The planned activities for the next quarter are detailed below:

- Build the fracture network using the embedded discrete fracture model approach (EDFM).
- Conduct a history-match to calibrate the simulation model to be used in prediction of EOR methods.

When the journal article entitled “Comparison of CO₂ and Produced Gas Hydrocarbons to Dissolve and Mobilize Bakken Crude Oil at 10.3, 20.7, and 34.5 MPa and 110°C” is published in *Energy & Fuels*, the link to the article will be added to the BPOP website.

Program Management and Development

The EERC will present in August to the Oil and Gas Research Council (OGRC) on a summary of BPOP 2.0 results and the anticipated direction of BPOP 3.0.

Additional research activity ideas for the current project year will be discussed with project partners.