



8/14/2025

North Dakota Industrial Commission
ATTN: Oil and Gas Research Program
State Capitol – Fourteenth Floor
600 East Boulevard Bismarck, North Dakota 58505

Subject: Transmittal Letter – Commitment to Complete Project

Dear Commissioners,

On behalf of Devon Energy, I hereby submit this application for the Surfactant-Based EOR Pilot Testing project. Devon Energy is committed to complete the project as described in the application, should the Commission approve and award the requested grant.

We appreciate your consideration and look forward to the opportunity to advance enhanced oil recovery technologies for the benefit of North Dakota.

Sincerely,

A handwritten signature in black ink, appearing to read "Brad Musgrove", written over a horizontal line.

Mr. Brad Musgrove
Asset Manager – Williston Basin – Rockies Business Unit

Devon Energy Corporation

333 W Sheridan Ave., Oklahoma City, OK, 73102-5015



**Proposal for a Surfactant-Based EOR Pilot Testing
Program, Bakken-Three Forks Fms.,
Williston Basin, North Dakota**

Submitted to:

North Dakota Industrial Commission

ATTN: Oil and Gas Research Program

State Capitol – Fourteenth Floor

600 East Boulevard Bismarck, North Dakota 58505

Applicant: Devon Energy Corporation, Oklahoma City, OK

Principal Investigator:

Mr. Brad Musgrove

Asset Manager, Williston Basin, Rockies Business Unit

Devon Energy Corporation

Brad.Musgrove@devon.com

O (405) 228-2484

Date: [07/24/2025]

Amount Requested: \$1.535MM

Total Project Cost: \$ 3.370MM

Duration: 24 months

TABLE OF CONTENTS

Project Abstract	3
Project Description	4
Strategic Objectives & Technical Approach Summary	7
Standards of Success	8
Project Management	10
Timeline and Budget	11
Project Team	12
Conclusions	13
About Devon Energy	13
APPENDIX	

PROJECT ABSTRACT

Devon Energy proposes a testing campaign followed by a field pilot to demonstrate the technical and economic viability of surfactant-based Enhanced Oil Recovery (EOR) in the Williston Basin, North Dakota. The project will study and select the appropriate surfactant and methodology, then proceed to inject a surfactant solution targeting the Middle Bakken and/or Three Forks formations on three wells. The objective is to increase oil recovery by mobilizing residual hydrocarbons, optimize operational parameters, and provide a scalable blueprint for broader EOR deployment in North Dakota. The pilot leverages Devon's infrastructure and technical expertise, with a strong focus on risk management, stakeholder engagement, and cost-sharing.

The initial laboratory work (Phase 1) will focus on understanding surfactant compatibility and survivability. Experiments and simulation will be conducted at the Tertiary Oil Recovery Program (TORP) labs of University of Kansas under the investigation of Dr. Reza Barati, Don W. Green Professor of Chemical and Petroleum Engineering, in cooperation with Premier Corex. Studies will focus on surfactant brine screening and product selection, emulsion and phase behavior tests, core parameters, K, Phi & Saturations and will culminate in a design to identify the best surfactant(s) performance in core plugs for piloting.

Phase 2 (pilot phase) will be executed at the Bull Moose/North John Elk DSU pad (or equivalent nearby pad based on ideal operability). These are multi-lateral developments targeting the Middle Bakken and Three Forks (four wells each). The test will focus on three horizontal injectors with volumes and surfactant concentrations to be determined.

PROJECT DESCRIPTION

Phase One: Laboratory Testing, Screening, and Pilot Design

Phase 1 of the Surfactant-based EOR project will focus on comprehensive laboratory evaluation and optimization of surfactant formulations for application in the Middle Bakken and Three Forks formations. The laboratory program, supported by technical partners at the University of Kansas and Premier Corex, includes:

- **Surfactant Screening and Survivability:** Multiple surfactant chemistries from leading providers (e.g., BASF, DOW, Locus Bio-Energy, Integrity Bio-Chem, Nissan Chemical) are screened for temperature and salinity stability under Bakken reservoir conditions. Survivability is tested at 250°F and 300°F for up to 7 days, with performance assessed via contact angle, surface tension, and interfacial tension (IFT) measurements.
- **Fluid Compatibility and Optimization:** Surfactant-brine mixtures are evaluated for stability, and oil-water IFT tests are conducted to shortlist optimal surfactants and concentrations. Emulsion testing determines the best salinity and concentration ranges for effective oil mobilization.
- **Core and Rock Analysis:** XRD/XRF analyses define rock compositions, while adsorption tests measure surfactant retention on representative lithofacies. Contact angle measurements assess wettability alteration potential.

- **Core Flood and HnP Simulation:** Air permeability and porosity are measured for core plugs. Core plugs are aged and saturated under reservoir conditions, then subjected to high-pressure, high-temperature (HPHT) huff-n-puff experiments to quantify incremental oil recovery from surfactant injection.
- **Data Analysis and Reporting:** All laboratory data are analyzed to inform pilot design, including selection of surfactant chemistry, injection concentrations, and operational parameters.

The deliverables from Phase 1 will include a ranked list of surfactant candidates, optimized injection recipes, and a detailed technical basis for field implementation. This phase ensures that only the most effective and compatible surfactant systems are advanced to the pilot phase, reducing risk and maximizing the likelihood of field success.

Phase Two: Pilot Implementation and Field Testing

The pilot phase will implement the optimized surfactant formulation in the field, targeting the Middle Bakken formation at the Bull Moose/North John Elk pad/lease or equivalent pad. The project will focus on a set of six producing wells operated by Devon with plans to bullhead inject surfactant solution based on lab work and operations. The pilot will emphasize robust surveillance, diagnostics, and analysis to evaluate performance and inform future scale-up.

General Pilot Design and Site Parameters

- **Number of Wells:** 6 producing wells (3 Devon injectors)

- **Formation:** Middle Bakken (MB)
- **Lateral Length:** Each well is a 2-mile horizontal
- **Water Volumes:** Large volumes will be injected to ensure sufficient surfactant delivery to the reservoir matrix
- **Injection Rate:** 20 barrels per minute (bpm) per well or a rate below frac gradient
- **Timing:** Early in the well life to maximize EOR response
- **Pre-Flush:** All wells will receive a pre-flush to condition the formation
- **Injection Method:** Bullhead injection that may test variable delivery methods to maximize lateral coverage
- **Surveillance and Diagnostics:** Comprehensive monitoring will be conducted, including production response, pressure data, and chemical tracers as needed

Mechanisms for Performance Enhancement

The pilot seeks to enhance oil recovery through several key surfactant mechanisms:

- **Interfacial Tension (IFT) Reduction:** Surfactants are selected for their ability to lower IFT between oil and water, decreasing capillary forces and mobilizing trapped hydrocarbons.

- **Wettability Alteration:** Certain surfactants can alter the wettability of reservoir rock from oil-wet to water-wet, improving oil displacement efficiency.
- **Prevention of Formation Damage:** Surfactant selection and concentration are optimized to prevent permeability reduction due to precipitation, adsorption, or phase trapping, and to minimize skin damage at fractures.
- **Compatibility and Stability:** Only surfactants with demonstrated temperature and salinity tolerance under Bakken conditions are advanced to field testing, ensuring robust performance and minimizing operational risks.

Project Execution

- **Bullhead Injection:** Surfactant solution will be injected into each well, with careful control of rates and volumes.
- **Surveillance and Diagnostics:** Real-time monitoring of injection and production, with data collection for subsequent analysis and optimization.
- **Modeling :** Field results will be integrated with laboratory and productivity data to calibrate analysis, validate assumptions, and inform broader deployment strategies.

STRATEGIC OBJECTIVES & TECHNICAL APPROACH SUMMARY

- Demonstrate surfactant injectivity and EOR feasibility in target wells
- Optimize injection parameters for maximum oil recovery
- Assess economic and operational scalability
- Integrate lab and field data for continuous improvement
- Engage stakeholders and manage project risks

STANDARDS OF SUCCESS

The success of this project will be measured by a combination of technical, economic, and societal criteria, with a focus on delivering tangible value to North Dakota and its stakeholders. The primary standards of success include:

1. Technical Performance:

Success will be demonstrated by achieving measurable increases in oil recovery from the targeted Middle Bakken and/or Three Forks formations through surfactant-based EOR. Key metrics will be evaluated based on a set of key performance metrics, focused on quantifying incremental oil production, enhancing production rates, and ultimately increasing the Estimated Ultimate Recovery (EUR) of the well. Beyond total volume, we will assess improvements in well productivity by monitoring for the ability to sustain production rates at a reduced pressure drawdown. Furthermore, treatment efficacy will be validated by confirming the successful injection of the target surfactant volume and by analyzing produced fluids to ensure effective containment and interaction of the surfactant within the reservoir. These outcomes will be rigorously quantified through established baseline production forecasts. The integration of laboratory and field data will be crucial to validate the effectiveness of the selected surfactant formulations and operational strategies.

2. Economic Viability:

The project will be considered successful if it demonstrates a positive economic case for surfactant EOR in North Dakota's unconventional reservoirs. This will be assessed through cost-benefit analysis, including capital and operating expenditures, incremental reserves,

and return on investment. The results will provide a scalable blueprint for commercial deployment, supporting the long-term competitiveness of North Dakota's oil and gas industry.

3. Value to North Dakota and Stakeholder Impact:

The project's results will be disseminated to North Dakota stakeholders, including operators, service companies, regulators, and academic institutions. The findings will inform best practices and regulatory frameworks, and will be shared through technical reports, presentations, and workshops. The potential for commercial application is high, and demonstration will encourage broader adoption of surfactant EOR, leading to increased resource recovery, preservation of existing jobs, and creation of new employment opportunities in operations, research, and service sectors.

4. Reporting and Accountability:

Devon Energy will provide regular progress updates and a comprehensive final report to the North Dakota Industrial Commission. These reports will detail technical results, economic analysis, lessons learned, and recommendations for future projects. The reporting process will ensure transparency, facilitate knowledge transfer, and support the mission of the NDIC to fund innovative, commercially viable projects that enhance the development and marketing of North Dakota's oil and natural gas resources.

Through these standards and methods of measurement, the project will satisfy the purposes established in the mission of the Program, delivering lasting benefits to North Dakota's economy, workforce, and energy future.

PROJECT MANAGEMENT

Devon Energy will manage and oversee this project through a structured project management framework designed to ensure timely execution, cost control, and achievement of all technical and economic objectives. The project will be led by a dedicated Principal Investigator and supported by a multidisciplinary team of reservoir engineers, geologists, facilities/operations managers, field specialists, and technical partners. Regular project meetings and milestone reviews will be held to monitor progress, address challenges, and adapt plans as necessary.

A detailed project schedule will be developed, with clear timelines for laboratory work, pilot design, field implementation, and data analysis. Key evaluation points will include: (1) completion of laboratory screening and selection of surfactant candidates, (2) finalization of pilot design and operational parameters, (3) initiation and completion of field injection, (4) interim production and surveillance data reviews, and (5) final project analysis and reporting. At each stage, progress will be measured against predefined deliverables and success criteria. Devon will utilize project management best practices, including risk assessment, change management, and stakeholder engagement, to ensure the project remains on track and aligned with its objectives. Regular updates will be provided to the North Dakota Industrial Commission and other stakeholders, ensuring transparency and accountability throughout the project lifecycle.

TIMELINE AND BUDGET

Phase One (Lab, Simulation, and Design): [Q2 2025-Q1 2026]

Phase Two (Pilot Implementation): [Q1-2026-Q2 2027]

- Interim Quarterly Reporting Quarterly, Commencing Q4 2025

Category	Estimated Cost (MM\$)
Laboratory & Simulation	\$0.153
Diagnostics & Data Collection	\$0.121
Regulatory, Land, Permitting	\$0.000
Facilities & Upgrades	\$0.000
Pilot Execution (OPEX)	\$2.770
Contingency	\$0.400
<u>ESTIMATED PROJECT TOTAL</u>	\$3.370
<u>REQUESTED MATCH</u>	\$1.535

A detailed project management plan and Gantt chart will be provided within 180 days of contract execution. Costs are subject to revision as Phase One results inform final design.

PROJECT TEAM

Devon Energy brings over 130 hours of multidisciplinary team experience in EOR, reservoir engineering, geoscience and project management. Key personnel include:

- Brad Musgrove, Principal Investigator, Asset Manager, Williston Basin, 33 yrs
- Brett Riley, Asset Supervisor, Williston Basin, 11.5yrs
- Amanda Baldwin, Sr Staff Reservoir Engineer – Reservoir Engineering & EOR, 15 yrs
- Marc Schutt, Reservoir Engineer –Williston Basin, 27 yrs
- Devin Dennie, Principal Geologist – Subsurface Modelling & Geoscience, 21 yrs
- Gentry Meyer, Staff Facilities/ Construction Engineer – Field implementation, 5 yrs
- Ryan Hornak, Sr Staff Facilities/ Construction Engineer, 10 yrs

Devon Energy will serve as the principal investigator and primary investigator and contractor to the NDIC. Other subcontractors, as needed, such as the EERC or private vendors will be managed via Devon Energy.

CONCLUSION

Devon Energy's technical expertise and commitment to innovation position us to deliver valuable results for North Dakota through this pilot. Successful evaluation of surfactant injection EOR will provide key data on performance and execution, scalability and economic upside for existing Bakken/Three Forks wells. We look forward to the opportunity to advance EOR technologies at the Bull Moose/North John Elk DSU or equivalent pad, furthering the goals of the NDIC OGRC and benefiting the state, its businesses, and landowners. Execution of this proposal is subject to finalization and execution pending relevant data, agreements and approvals as is required by Devon Energy management on all capital projects.

ABOUT DEVON ENERGY

Devon Energy Corporation is one of the largest independent oil and natural gas exploration and production companies in North America. Headquartered in Oklahoma City, Devon operates a diverse portfolio of assets across several prolific basins, including the Powder River Basin, Delaware Basin, and Williston Basin. The company is recognized for its technical expertise, operational excellence, and commitment to innovation in the oil and gas industry.

Devon currently operates and produces from more than 1,200 wells in the Williston Basin alone, with total oil production of nearly 100k barrels of oil per day across over 430,000 net

acres in North Dakota. The company has a strong track record of pioneering new technologies and approaches, such as the sealed wellbore pressure reservoir analysis technique, which is now widely used across the industry, and was among the first to implement three-mile laterals in the Rockies region. Devon has also led the way in deploying advanced field automation and remote monitoring systems, enhancing operational efficiency and environmental stewardship.

Devon's business philosophy emphasizes safety, environmental responsibility, and collaboration with local communities and stakeholders. The company is committed to delivering value through responsible resource development, continuous improvement, and the application of cutting-edge technologies to maximize recovery and minimize environmental impact.

Devon's leadership and technical teams bring decades of experience in enhanced oil recovery (EOR), reservoir engineering, and project management. The company's ongoing investments in research, field testing, and innovation underscore its dedication to advancing the science and practice of oil and gas production for the benefit of its partners, the states in which it operates, and the broader energy industry.