EERC
Energy & Environmental Research Center

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February 21, 2014

Mr. Brent Brannan
Director
North Dakota Oil & Gas Research Program
PO Box 7217
Bismarck, ND 58507

Dear Mr. Brannan:

Subject: EERC Proposal No. 2014-0118 Entitled "Expanding the Scope of the Bakken Production Optimization Program"

The Energy & Environmental Research Center (EERC) is pleased to submit the enclosed proposal. If you have any questions, please contact me by telephone at (701) 777-5157, by fax at (701) 777-5181, or by e-mail at jharju@undeerc.org.

Sincerely,

John A. Harju
Associate Director for Research

JAH/sah

Enclosures

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EXPANDING THE SCOPE OF THE BAKKEN PRODUCTION OPTIMIZATION PROGRAM

North Dakota Solutions to North Dakota Challenges

EERC Proposal 2014-0118

Submitted to:

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February 2014

UND University of North Dakota
Grand Forks

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North Dakota Solutions to North Dakota Challenges

SUMMARY

The Energy & Environmental Research Center (EERC), the North Dakota State University (NDSU) Range Science and Soil Science Programs, and the NDSU Extension Service jointly propose to expand the scope of the existing North Dakota Industrial Commission Oil & Gas Research Council (NDIC OGRC)-sponsored Bakken Production Optimization Program managed by the EERC. The purpose of this proposed expansion is to include efforts not previously defined within the Bakken Production Optimization Program scope of work and to address pressing waste management and landowner impact concerns that have arisen in North Dakota in recent months.

The proposed expansion is being defined as a collaborative effort between multiple industry-oriented university research groups, the state of North Dakota, and the North Dakota Petroleum Industry to apply North Dakota resources to provide North Dakota solutions to North Dakota challenges.

GOALS AND OBJECTIVES

The goals of the proposed expansion of the Bakken Production Optimization Program are:

- To develop a set of best management practices to minimize the generation and handling of wastes from oil and natural gas drilling, completion, production, and injection activities in North Dakota.

- To develop a set of best management practices to apply to soil remediation efforts following hydrocarbon and brine spills.

- To develop a set of best management practices to apply to land reclamation efforts following spill remediation or other industrial activities.

These efforts will include evaluations of the reporting, investigation, and compliance verification protocols currently in place and recommendations to industry for improvements to meet NDIC regulatory requirements. These efforts will also include planning and execution of site-specific pilot projects to validate the best management practices investigated and affirmed by the program.

VALUE PROPOSITION

The unprecedented, rapid growth of the oil industry in North Dakota has presented the state with innumerable benefits and a few attendant challenges. Because of the pace of oil and gas development, new challenges associated with waste management, spill remediation, and land

reclamation have arisen in the past year. While North Dakota producers and the North Dakota Department of Mineral Resources benefit from many decades of experience with these issues, all entities recognize the need for continuous improvement as they continue their mutual efforts to responsibly steward the vast resources within North Dakota. Various research-oriented agencies within North Dakota possess the tool sets required to contribute to continuous improvement with "in-house" knowledge. This program will employ those tool sets to help the state continue to responsibly develop its resources for economic gains, employment opportunities, and energy security.

The EERC believes that any expansion of the existing Bakken Production Optimization Program would benefit greatly from employment of expertise offered by NDSU Range Science and Soil Science Programs and the associated NDSU Extension Service to investigate cutting-edge methods of land reclamation and spill remediation. The EERC will also work with UND's School of Engineering and Mines to employ engineering interns who will receive education on real-world engineering and scientific issues while also contributing new perspectives to mitigate industrial challenges.

The EERC views this as an opportunity for North Dakota to invest further in the future of the state. The success of the Bakken Production Optimization Program to date justifies this as a sound investment with a high likelihood of significant return on investment. To date, the Bakken Production Optimization Program has provided valuable insight into the high-priority questions of gas flaring, naturally occurring radioactive materials disposal, and water use and reuse. The proposed program expansion described herein will further enhance the ability of industry and the State to address key issues related to waste management, site reclamation, and spill remediation in a timely, responsible, and cost-effective manner.

SCOPE OF WORK

The expanded scope of work would include items not delineated in the original program scope of work and would target efforts specifically helpful to mitigate land impacts from Bakken oil production activity. These activities fall into three broad categories: waste minimization and utilization, spill remediation, and land reclamation.

Waste Minimization and Utilization (Task 6)

The program will investigate improved waste management strategies, waste minimization techniques, and waste reutilization technologies to mitigate anticipated increases in waste production from wellsites as the number of wells on each site multiplies during and after infill drilling activities. Waste streams targeted for improved disposal and reuse include solid consumables waste from day-to-day operations and drill cuttings brought to the surface during the drilling process. While some of the cuttings are mixed with hydrocarbon-based or saltwater-based drilling fluids and would require additional treatment prior to beneficial reuse, the cuttings collected from the surface down to a depth of about 2000 feet are drilled with a freshwater-based mud system and may be quite viable for beneficial reuse applications without treatment.

One possible partner in these waste mitigation investigations is Nuverra Environmental Solutions, a contributing member of the existing Bakken Production Optimization Program.

Nuverra's technology development efforts are focused on the treatment of drill cuttings to recover and reuse hydrocarbons, to recover small amounts of fresh water, and to provide constructive uses of the resulting dry material. This environmentally friendly approach is a win-win for the state and for industry because it takes a material that would have previously been deemed a waste and turns it into a viable product with beneficial use.

With cooperation from producers participating in this program, the program team will work to plan and execute multiple site-specific pilot projects to demonstrate promising new waste minimizing/utilizing approaches. The capital costs associated with these pilot projects will likely require additional financial commitment on the part of the host producer(s), but planning and execution will fall under the auspices of this program. Further, the program team will coordinate closely, and as appropriate, with the North Dakota Department of Health (NDDH), the North Dakota Department of Mineral Resources Oil & Gas Division (DMR OGD), and the North Dakota Petroleum Council (NDPC) to ensure that results of the pilot projects directly address state concerns, maximize value to state taxpayers, and disseminate lessons widely to other producers.

Oil and gas producers will also partner with the EERC to provide valuable operational insights during investigations of potential waste minimization strategies. A significant amount of common waste related to wellsite consumables will be generated in the next several years as operators and producers complete infill drilling on multiwell pads. Although producers have decades of experience in responsible waste minimization strategies, the advent of high-density, multiwall pad operations will present new challenges and open doors for continuous improvement of these waste minimization strategies. Oil producers are interested in minimizing impact to local landfills by reducing waste volume, recycling materials where applicable, and minimizing excess trash during transport to continue excellent stewardship of the land.

Spill Remediation Investigations (Task 7)

Hydrocarbon (crude oil, diesel, and natural gas liquids) spills and saltwater spills in North Dakota have received much attention during the past year. As industry contemplates the potential reuse of saline water for hydraulic fracturing, there is increasing concern at the state level regarding large-volume saltwater storage and containment. Decades of experience have resulted in appropriate, aggressive, and effective spill remediation strategies employed by industry teamed with state regulators. Again, all entities recognize the need for continuous improvement of these spill remediation strategies. This program will investigate improved techniques of spill remediation (both hydrocarbon and brine spills) to return the affected land to productive use for agriculture, livestock grazing, and animal habitat and to continue stewardship of land largely untouched by industrial and commercial activity.

Techniques investigated will include bioremediation, chemical remediation, phytoremediation and physical remediation (excavation) techniques and their specific application to Williston Basin soils. This program will also evaluate best management practices for storage and spill containment of large volumes of saltwater in the event that saltwater recycling and reuse becomes more common.

Brine spills and hydrocarbon spills will require vastly different remediation approaches. For either spill type, new additives or advanced bioremediation-based approaches may be investigated within this program. A new slate of brine remediation accelerators is currently showing promise and may be tested in North Dakota to verify their function. Also of interest will be determination of whether excavation or in situ treatments will be more effective for each specific site assessed.

The salinization of soils from brine spills can inhibit or prevent plant growth and biological activity. To regain plant growth and biological activity, salts must first be effectively leached to achieve soil electrical conductivities that allow such growth. Leaching rates are dependent on the following:

- Soil properties
  - Particle-size distributions
  - Pore-size distributions
  - Pore volume
  - Aggregation
- Whether chemical additives are coapplied with the infiltrating water
- Whether the leachate is intercepted

Few chemical additives have been tested in similar and contrasting climatic regions. None of the additives tested seem to adequately alter water properties to improve interaction with mineral surfaces. Therefore, solute transport properties across a variety of soil types contaminated with brine will be evaluated in NDSU laboratories and in the field. The effectiveness of chemical additives coapplied via the infiltrating waters with and without the application of soil tension will be evaluated. This will provide insight into the amount of leached water needed to effectively reduce soil electrical conductivity in brine-impacted soils. Subsequent modeling of these processes will be completed to infer the time required to effectively reduce soil electrical conductivities that allow seed germination and plant growth.

Rangeland vegetation common to the Bakken oil and gas region in North Dakota is generally tolerant of soil conditions below certain electrical conductivity thresholds. Salt-tolerant plants are capable of surviving in environments with elevated electrical conductivity. Many of these plants uptake and store salts, effectively reducing soil salt concentrations over time. These plants can be harvested periodically, effectively lowering site salt concentrations. Over time, salt levels can be lowered to concentrations tolerated by native vegetation. However, it is unknown which vegetation varieties will germinate and persist in various contamination concentrations and in the extreme climatic and soil conditions present in the Bakken region. Therefore a variety of seed mixtures will be evaluated in a series of decreasing brine concentrations to both establish perennial vegetation stands and further lower soil electrical conductivity levels in both greenhouse and field environments.

In addition to site-specific prescriptions for return to soil productivity, the team will also compile a compendium of best practices based both on previous knowledge and knowledge gained through investigations summarized above. This best practices compendium will be made widely available to producers, state regulators, and private landowners. The compendium will

attempt to broadly categorize prescriptive remedial actions likely to work on a variety of various compromised soil situations, thus providing a framework upon which future remediation activities can be built.

With cooperation from producers participating in this program, the program team will work to plan and execute multiple site-specific pilot projects to demonstrate improved spill remediation approaches. These pilot projects will likely require additional financial commitment on the part of the host producer(s), but planning and execution will fall under the auspices of this program. The program team will coordinate closely, and as appropriate, with NDDH, DMR OGD, and NDPC to ensure that results of the pilot projects directly address state concerns, maximize value to state taxpayers, and disseminate lessons widely to other producers.

Effective execution of this scope of work will require full participation of producers and pipeline operators to facilitate access to the affected soils. Preliminary discussions with several current program partners and potential new consortium members indicate that industry will be eager to fully participate. Tesoro, which has been acting to restore affected soil after a spill reported in September 2013, has also expressed potential interest in participating in this effort.

Land Reclamation Investigations (Task 8)

Postindustrial Reclamation. Land reclamation after industrial activities such as oil production (both drilling and long-term production operations) is both a near-term and long-term issue facing the agriculturally dominated state of North Dakota, where every productive acre is a valuable component of the state economy. In the case of North Dakota oil production, the rapid appearance of thousands of wellpads and adjacent supporting functions using valuable North Dakota surface area has presented North Dakota with the unique challenge of returning every possible acre to other productive uses soon after temporary oil production supporting operations have ceased.

This program will investigate strategies to accelerate the return of land to productive use after drilling activities have ceased, after production ceases and wells are plugged and abandoned, and after access road and rights of way are remediated. In the short-term, drilling cessation typically means that adjacent water storage pits and drill cuttings pits are returned to other productive uses. Staging areas previously required to facilitate flow of dozens of trucks required to complete wells are also returned to other productive use. This program will investigate best management practices and methods to increase the pace at which these areas are returned to productive use.

With cooperation from producers participating in this program, the program team will work to plan and execute multiple site-specific pilot projects to demonstrate improved land reclamation approaches. These pilot projects will likely require additional financial commitment on the part of the host producer(s), but planning and execution will fall under the auspices of this program. The program team will coordinate closely, and as appropriate, with NDDH, DMR OGD, and NDPC to ensure that results of the pilot projects directly address state concerns and maximize value to state taxpayers.

Because pipeline rights-of-way (ROWs) are the predominant current reclamation effort, this will likely be the initial focal point of this vein of work. Results from these efforts will serve well to inform future wellsite reclamation efforts. Thus, it is anticipated that lessons learned from initial efforts on pipeline ROWs will be widely applicable to a variety of future oil and gas exploration and production reclamation efforts.

Postremediation Reclamation. Reclamation of brine-affected soils is needed to maintain and promote rangeland biodiversity and ecosystem productivity. Natural processes for reclaiming affected lands in cool, dry regions can take long periods of time (i.e., decades or longer). Bare, salinized soils from brine spills are prone to wind and water erosion, loss of biological activity, and elevated evaporation rates which can prevent salts from leaching beyond depths that allow seed germination and the propagation of plant roots. Therefore, land reclamation research and the development of educational publications and guidelines are needed to effectively optimize the time required for full reclamation of brine spill impacted lands. This study will consist of research and outreach components conducted with expertise provided by the NDSU Range Science and Soil Science Programs and the NDSU Extension Service. These expert entities will operate collaboratively with the EERC to develop and summarize land reclamation guidelines and educational materials.

The EERC–NDSU team will develop educational materials and conduct educational workshops related to science-based information on reclamation of affected lands within the Bakken region. The team will approach the outreach and research components in three areas:

- Area I – Public Education
  - Educational material will be developed to inform the public on relevant topics (e.g., "what is a brine spill?" and "reclaiming affected rangelands associated with oil and gas production").

- Area II – Contribution to Scientific Literature
  - Articles will be written and submitted to scientific journals to widely promote the advancements achieved as a result of this program.

- Area III – Guidelines for Industry and Regulators
  - Best management practices and other guidelines will be developed for industry and regulators. Educational workshops will be developed to deliver known options associated with reclamation of lands affected by oil and gas production activities. Research study outcomes will be incorporated into these workshops. A second clientele will include the NDSU county agent, as this office is the local arm of the university and has direct contact with our clientele out in the state.

WIDE-RANGING PARTICIPATION

The existing Bakken Production Optimization Program has achieved wide-ranging participation that can be leveraged to magnify the potential results of the proposed expansion of scope. Signed on as current members are producers that include the following:

- Continental Resources, Inc.
- Marathon Oil Corp.
- Whiting Petroleum Corp.
- Oasis Petroleum, Inc.
- Hess Corp.
- SM Energy Co.
- ConocoPhillips
- Petro-Hunt, LLC

and these oilfield service providers:

- Hitachi Data Systems
- Nuverra Environmental Solutions

Together, these participants provide operational insights required to effectively investigate improved methods and technologies to address the issues described in the scope of work.

COST

The estimated project cost is $554,500.

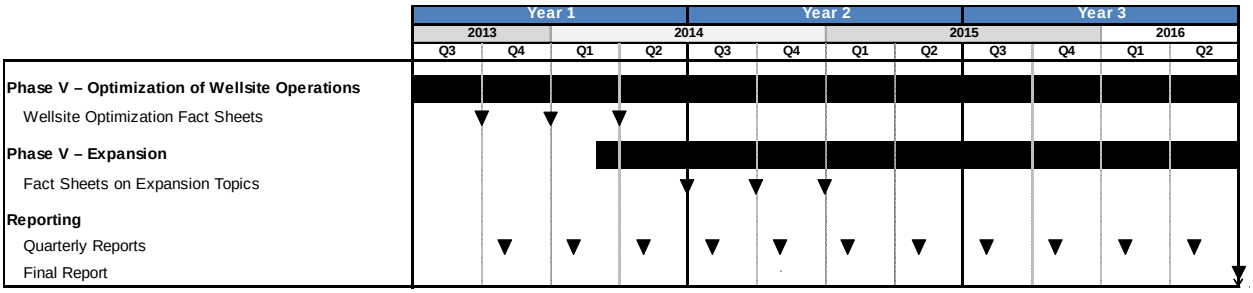
Table 1. Budget

Project-Associated Expense	NDIC Share, $
Total Labor	236,011
Travel	18,078
Supplies	22,350
Subcontract – NDSU	200,000
Facilities and Administrative Costs Applied to Subcontract	12,250
Other*	1,481
Operating Fees and Services	
Natural Materials Analytical Research Lab	32,405
Fuels & Materials Research Lab	4,464
Analytical Research Lab	9,733
Graphics Service	10,841
Research Information Service	6,887
Total Project Cost	**554,500**

* May include costs such as food, printing, communications, or other miscellaneous expenses.

SCHEDULE

The existing Bakken Production Optimization Program period of performance is June 1, 2013, through June 30, 2016. The expansion to the program is anticipated to take effect on March 17, 2014, and end on the program end date of June 30, 2016.



DELIVERABLES

1. Fact sheets highlighting the technical and economic challenges and opportunities associated with the topics of waste minimization and utilization, spill remediation, and land reclamation.

2. Quarterly reports to the NDIC OGRC highlighting results of ongoing research and outlining upcoming activities. Briefings on expansion topics will be included in the current program's quarterly report format.

3. Program staff will participate in programmatic briefings to appropriate legislative committees as directed by NDIC OGRC leadership.

4. A best management practices document on spill remediation

5. A best management practices document on land reclamation.

6. Topical reports summarizing the results of each completed task.

7. A final report to OGRC summarizing overall program achievements.

8. Partner-approved publications at technical conferences.