PROGRAM TO DETERMINE THE UNIQUENESS OF THREE FORKS BENCH RESERVES, DETERMINE OPTIMAL WELL DENSITY IN THE BAKKEN POOL, AND OPTIMIZE BAKKEN PRODUCTION (BAKKEN PRODUCTION OPTIMIZATION PROGRAM)

QUARTERLY PROGRESS REPORT
JANUARY – MARCH 2014

BACKGROUND

The goal of the Bakken Production Optimization Program (BPOP) being conducted by the Energy & Environmental Research Center (EERC) in close coordination with Continental Resources, Inc. (Continental) and several of the Williston Basin's other premier operating companies is to simultaneously improve Bakken system oil recovery while reducing its environmental footprint. The program is investigating new technologies and approaches to simultaneously increase the understanding of potential petroleum reserves in the Bakken–Three Forks system and decrease recovery costs in an environmentally sound manner.

The anticipated outcomes of the Bakken Production Optimization Program are to increase well productivity and economic output of North Dakota's oil and gas resources, decrease environmental impacts of wellsite operations, and reduce demand for infrastructure construction and maintenance. Specific results will include a) a greater understanding of Bakken–Three Forks reservoirs and subsequent significant increases to estimates of recoverable hydrocarbons; b) less truck traffic, resulting in decreased diesel emissions, road dust, and spills; c) reduced road maintenance costs, wastewater production, disposal costs, and freshwater use; d) reduced land use impacts; and e) increased revenue for the state, royalty owners, and operators from added product streams, captured earlier in the well life cycle.

The following quarterly report summarizes the program activities from January through March 2014.

ACCOMPLISHMENTS DURING REPORTING PERIOD

Phase I – Drilling Wells in the Hawkinson Unit Located in Sec. 22 and 27, 147N-96W

- Weatherford, the vendor completing the core analysis, provided a preliminary report on April 4, 2014. This report is presently under internal review at Continental Resources and is being tied into the petrophysical logs.

Phase II – Completion Operations of Eleven (11) New Wells

- Vertical seismic profile (VSP) analysis, defining zero-phase waveform, was implemented into the 3-D seismic processing flow. Final microseismic data processing quality control reports are being generated by Schlumberger. Progress continues on

interpretation. An agreement is in place, defining advanced processing goals, with delivery of raw field data to ESG Solutions expected in the near future.

Phase III – Reservoir Engineering

- Performed fracture modeling of the 4-22H, a TF2 well with and without pressure depletion effects of the original producers. Continental Resources is still waiting on core data from the Hawkinson pilot hole to calibrate the open hole logs.

- The last chemical tracer samples were collected in December 2013.

- The second round of pulse testing was designed, and testing should be initiated shortly. Continental Resources is currently waiting on well work to be completed on two wells.

- Began work on setting up the geological model for simulation. Geologic setup using average layer values from the pilot holes is nearly complete.

Phase IV – Expansion Applications via 3-D Seismic

- Final PSTM (Preliminary PreStack Migration), having a severe low-frequency static corrected with the best refraction static solution, was to be delivered April 6, 2014, for quality control purposes. The decision point of quality acceptance remains to be determined.

Phase V – Optimization of Wellsite Operations

On Friday, March 7, 2014, the EERC hosted BPOP member representatives for a daylong annual review meeting at the EERC. Progress and status of each phase of the program were discussed in detail, providing opportunity for membership to inquire on details and redirect efforts. This included extended discussion on Continental Resources' Hawkinson Project (Phases I–IV of this program). The agenda and a listing of meeting participants can be found in Appendix A. Presentation slides can be found on the partners-only Web site at www.undeerc.org/Bakken/Optimization/. If you need assistance with logging in, please contact Jay Almlie at (701) 777-5260.

Under the area of flaring mitigation (EERC Task 1 – Hydrocarbon Utilization), two distinct activities were initiated:

- North Dakota Petroleum Council (NDPC) Flaring Task Force/Database Development.

  – The EERC worked with companies that have technology and services capable of utilizing associated gas upstream of traditional gas-gathering and -processing infrastructure and gathered information describing their remote capture offerings. To date, 40 companies have provided company and technical information to the database.

- Companies with remote capture technology can submit information to the database by going to www.undeerc.org/Flaring_Solutions/.

- Companies looking for more information about remote capture technologies can view all of the information contained in the database by going to www.undeerc.org/Flaring_Solutions/Search.aspx.

– The EERC is reviewing technical data provided by vendors and is continuing to work with producers and vendors to identify opportunities for demonstration projects that have the potential to improve gas utilization and reduce the risk of implementing new technologies and strategies. Work continues to assess the relative impact individual technologies can have on gas use, thereby decreasing the fraction of flared gas in North Dakota.

– In addition to the development and maintenance of the Flaring Solutions database, the following activities were conducted to support the NDPC Flaring Task Force:

- Flaring statistics were reviewed and analyzed to identify those opportunities with the greatest potential to benefit from deployment of remote capture. Figures and charts were created to illustrate the nature of gas flaring in North Dakota based on rate of gas flared, quantity of flares, and geographical distribution across the Bakken.

- A PowerPoint presentation was prepared summarizing flaring statistics, outlining remote capture options, and describing the Flaring Solutions database effort. The EERC presented this information to the NDPC Flaring Task Force Working Group in Denver, Colorado, on January 14, 2014, and to the North Dakota Industrial Commission (NDIC) in Bismarck, North Dakota, on January 29, 2014.

- The EERC also participated in presenting this material to the North Dakota Legislative Management Energy Development and Transmission Committee in Bismarck, North Dakota, on February 11, 2014. PowerPoint slides presented to NDIC and the Legislative Committee are included in Appendix B and are available at www.ndoil.org/latest-news/news-release-industry-to-increase-natural-gas-capture-to-85-percent-within-two-years-and-90-percent-in-six-years/.

- The EERC's laboratory study that is evaluating the potential for utilizing rich Bakken gas for enhanced oil recovery (EOR) in the Bakken made the following progress:

– An apparatus for determining minimum miscibility pressure (MMP) using CO_2 and the EERC's new capillary rise technique was modified last quarter to allow MMP determinations using natural gas. Additional MMP determinations with pure methane and pure CO_2 were performed with three different Bakken crude oils (including a reconstituted "live" oil) at 110°C. The results show that the effect on MMP values using methane compared to CO_2 vary with the different Bakken crudes. The "live" crude oil MMP increased from 3180 psi with CO_2 to 5330 psi with

methane (a factor of 1.7). Two different Bakken crude oils collected at the wellhead showed quite different increases. One oil's MMP showed only a moderate increase in MMP from 4010 with CO_2 to 5316 with methane (a factor of 1.3), while the other oil's MMP nearly doubled from 3250 to 6380. Although all of the MMP values with methane are higher than CO_2, the pressures required to obtain MMP in the Bakken with methane are still attainable in the Bakken Formation.

– A new set of experiments to investigate hydrocarbon recovery rates using methane and mixed methane/ethane (85/15) were performed using 1-cm-diameter rods cut from Lower, Middle, and Upper Bakken Formations. Previous work with CO_2 showed >95% laboratory recovery of oil from the Middle Bakken rock in 24 hours, and surprisingly high recoveries (ca. 50%) even from the Lower and Upper Bakken shales with long exposure times (5 days). However, significantly lower yields were anticipated using methane as the extraction fluid since the MMP values of Bakken crude oils were significantly higher using methane than CO_2. The methane extractions were performed at 6000 psi (110°C) in the same manner as previous CO_2 extractions. Despite the expectation that methane would not be nearly as effective as CO_2 in recovering hydrocarbon, the recoveries of oil from the Upper, Middle, and Lower Bakken using methane and the methane/ethane mixture were nearly as fast and as efficient as those achieved using CO_2. These results suggest that EOR mechanisms in the Bakken are controlled by different factors (possibly thermal desorption) than the traditional "MMP-controlled" EOR processes in conventional reservoirs are.

Under the area of waste management (EERC Task 2), the following activities were conducted:

- Distribution of the EERC-produced naturally occurring radioactive material (NORM) fact sheets continued. The North Dakota Department of Health (NDDH) requested several hundred copies. The Montana Department of Environmental Quality also requested several copies.

- The EERC continued to support efforts of the NDPC's NORM waste task force, providing information on field-based radiation measurement technology and perspective on an ongoing Argonne National Laboratory (ANL) study commissioned by NDDH. The EERC was asked this quarter to provide a sampling and analysis plan to coordinate the sampling activities of NDPC members offering data to support the NDDH/ANL study.

- The EERC produced a draft copy of an educational booklet on oil and gas NORM waste and NORM science, intended for use in an educational campaign among industry personnel, regulatory personnel, and the general public. This booklet is now being reviewed by a small subset of NDPC and BPOP member representatives to ensure accuracy and appropriate messaging.

- EERC representatives attended the NORM and Natural Radiation Management North America Conference in Houston, Texas, March 25–26, 2014. Here, the team gathered information on NORM waste management and regulatory trends nationwide and networked with solution providers interested in the Bakken.

Under the area of water management (EERC Task 3), the following activities were conducted:

- A representative from the EERC participated in the Shale Innovation Conference in Grand Forks, North Dakota, on February 11, which included presentations on the recycling and reuse of produced water for hydraulic fracturing, crystallization of produced water, and improved water-handling practices.

No activities were conducted under the site logistics area (EERC Task 4) during this quarter.

In this quarter, the EERC initiated planning activities under Task 5 – Process Optimization and System Failure Analysis.

- The EERC completed a document describing analytical capabilities and in-house expertise to assist members with corrosion and scale diagnostics that could facilitate mitigation strategies. This document can be found in Appendix C.

EERC staff, along with Hitachi Data Systems representatives, met with Continental Resources staff to discuss “big data” management technologies and approaches.

During this quarter, the EERC proposed an expansion of BPOP to include tasks not previously delineated in the original scope of work. These tasks included Task 6—Waste Minimization and Reuse, Task 7 – Spill Remediation, and Task 8 – Land Reclamation. This expansion was approved and funded by NDIC. The research team also expanded to include experts in saline soil remediation and land reclamation from North Dakota State University’s Range Science and Soil Science programs.

The EERC requested a modification to the NDIC agreement to change the due date of the quarterly reports from the end of each calendar quarter, to the 15th of the month after the end of each calendar quarter. The modification was approved.

A proposal was submitted in response to a U.S. Department of Energy Funding Opportunity Announcement (DE-FOA-0001037 – Research for Safe and Permanent Geologic Storage of CO_2) in which BPOP agreed to participate through the provision of up to $145,000 of cash cofunding. The proposal goal of improved characterization and modeling of fracture networks and fluid flow in the Bakken, and its relevance to better understanding mechanisms that may enhance resource recovery, are consistent with the greater programmatic goals of the optimization program.

MEMBERSHIP AND FINANCIAL INFORMATION

This program is being sponsored by the NDIC Oil and Gas Research Council, Continental Resources, and a consortium of Bakken producers and service companies. Table 1 presents the current budget for this program, including the additional $554,500 approved by NDIC this quarter, bringing the NDIC contribution from $8,000,000 to $8,554,500. Continental's expected in-kind contribution over the project duration is $106M. During this reporting quarter, XTO Energy joined this program (invoiced and Year 1 payment received) bringing the anticipated contribution from other industry sponsors from $750,000 to $850,000 a year for a total of $2,550,000. To date, Whiting Petroleum Corporation, Marathon Oil Company, Nuverra Environmental Solutions, SM Energy Company, ConocoPhillips, Oasis Petroleum, and XTO Energy have provided payments for Year 1 totaling $625,000. Invoices have been requested by, and provided to, Petro-Hunt, Hess Corporation, and Hitachi Data Systems, totaling $225,000 of potential additional funding for Year 1. It is expected that equal payments will be provided by the industry partners in subsequent years. The EERC will also continue to seek broader industry participation.

Expenses to date by funding source are listed in Table 2.

Table 1. Bakken Production Optimization Program – Expected Budget

Sponsors	Y1	Y2	Y3	Total
NDIC Share – Cash*	$3,137,350	$3,137,350	$2,208,625	$8,554,500
Industry Share – Cash (Year 1 payment received)	$625,000	$625,000	$625,000	$1,875,000
Industry Share – Cash (Year 1 payment pending)	$225,000	$225,000	$225,000	$675,000
Continental Share – In-Kind	$40,989,233	$40,989,233	$24,051,534	$106,030,000
Total	**$44,976,583**	**$45,047,758**	**$27,110,159**	**$117,134,500**

*Includes $6.26M subcontract to Continental.

Table 2. Bakken Production Optimization Program – Expenses to Date

	Funding Source		
	NDIC	Industry	Total
EERC	$452,876	$188,321	$641,197
Continental – Subcontract*	$1,815,000		$1,815,000
Continental – In-Kind**		$94,353,371	$94,353,371
Total	**$2,267,876**	**$94,541,692**	**$96,809,568**

* Invoiced to the EERC.

** Reported to the EERC.

FUTURE ACTIVITIES

The planned activities for the next quarter include the following:

- Provide general BPOP presentations to the North Dakota Legislature's interim committee on Energy Development and Transmission (Minot) and the EmPower Commission (Bismarck) in early April.

- Prepare and deliver presentations at the Williston Basin Petroleum Conference to be held in Bismarck, North Dakota, May 20–22, 2014. The presentations will describe opportunities for remote capture, highlight possible impact to gas utilization, and report on the program's overall progress.

- Continue working with vendors to identify opportunities to deploy technology and/or services that match the needs of producers in their efforts to improve gas capture and utilization.

- Continue to consult with partners on NORM waste management strategies via the NDPC NORM task force. Provide input as the task force formulates a complementary approach to NDDH's ongoing NORM study.

- Manage NORM waste sample analysis activities in support of NDPC's data collection efforts.

- EERC staff will prepare a revised scope of work to assess key issues of interest to the BPOP members in the water management arena.

- Previous work with CO_2 in high-pressure view showed preferential mobilization of light hydrocarbons into an upper CO_2 phase. To investigate this effect with methane, oil hydrocarbons mobilized into the methane (upper phase) during crude oil (lower phase) exposure will be sampled at increasing and decreasing pressures and analyzed to determine hydrocarbon molecular weight distributions.

- A hypothesized thermal desorption mechanism for the unexpectedly high oil recoveries obtained from Bakken rocks using methane and methane/ethane will be investigated by extracting Middle Bakken rock sample at the same conditions, except using pure nitrogen.

- The EERC anticipates a kickoff of activities related to the recent expansion of the program. This expansion includes additional activity areas in Phase V – waste minimization, spill remediation, and land reclamation.

APPENDIX A

BAKKEN PRODUCTION OPTIMIZATION PROGRAM MEETING – MARCH 7, 2014

Bakken Production Optimization Program Meeting

EERC Energy & Environmental Research Center® Putting Research into Practice

AGENDA

Friday, March 7, 2014 — **EERC Discovery Hall**

Purpose:

Bakken Production Optimization Program (BPOP) Update

BPOP Members

TIME	ACTIVITY	DISCUSSION LEADER(S)
9:00 a.m.	Continental Breakfast	All
9:30 a.m.	Welcome and Introductions	John Harju
9:45 a.m.	Oil and Gas Research Council Member Priorities Discussion	
10:15 a.m.	Hydrocarbon Utilization – Flaring Task Force and Remote Capture	Chad Wocken
11:00 a.m.	Hawkinson Project Update (by Continental Resources)	Stan Wilson
12:00 Noon	Lunch (provided)	All
1:00 p.m.	Waste Management – NORM Task Force	Jay Almlie
1:45 p.m.	Optimization of Bakken Water Use and Reuse	Beth Kurz
2:00 p.m.	Tour of EERC Facilities	
3:00 p.m.	Associated Gas for Enhanced Oil Recovery	Steve Hawthorne, Jim Sorensen
3:30 p.m.	Expansion of BPOP to Include Reclamation and Remediation	Jay Almlie
4:00 p.m.	Adjourn	
4:30 p.m.	Social Hour at `I Bistro, CanadInn Hotel and Events Center	All
6:15 p.m.	Bus Departs CanadInn for Hockey Game*	All
6:30 p.m.	Buffet Dinner in Ralph Engelstad Arena (Suite No. 240)	
7:37 p.m.	University of North Dakota vs. Western Michigan	

*Bus will return everyone to the CanadInn following the game.

UND THE UNIVERSITY OF NORTH DAKOTA

BAKKEN PRODUCTION OPTIMIZATION PROGRAM MEETING
Energy & Environmental Research Center – Grand Forks, ND
March 7, 2014

Participant List
33 Participants

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APPENDIX B

NORTH DAKOTA INDUSTRIAL COMMISSION NDPC FLARING TASK FORCE – JANUARY 29, 2014

NORTH DAKOTA PETROLEUM COUNCIL

We keep North Dakota going strong

North Dakota Industrial Commission

NDPC Flaring Task Force

January 29, 2014

NDPC Flaring Task Force

- 500 member companies of NDPC
  - Responsible and efficient development of ND natural resources
- NDPC completely supports the State flaring goals
  - Reduce flare volumes
  - Reduce the number of wells flared, and
  - Reduce connect time period from first gas production to marketing gas sales

Unique, Very Focused

- Unique for Industry to work holistically
  - Not normal, companies are fierce competitors – upstream and midstream
- Started the task force last September
- Consists of 35 Industry experts in natural gas gathering, processing, and transport
- Met over 20 times since Sept. – very focused
- Tribal subcommittee has met 8 times since Nov

Key Factors for Flaring

- Shale Oil production profile – high surge of initial production followed by steep declines
- Unique Liquids-Rich Gas
- Time Needed to Build Infrastructure & Weather Constraints
- Size of the Bakken
- Technology Outpaced Production Expectations
- Easements and ROWs are Challenging

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Infrastructure and Investment

Current Infrastructure Statistics

New Infrastructure Since 2006

- 9,555 miles of gas gathering pipe
- 1.259 BCFD of gas processing
- Export capacity (downstream of plant)
  - Residue gas – 2.0+ BCFD
  - NGLs – 120-150,000 bbls/day

Industry Investment to Date

- Industry Investment in North Dakota
  - **Over $6 Billion**
- Preliminary numbers since January 2006
  - Gas gathering – wellhead to plant
  - Plant Processing – stand alone
  - Export capacity for residue gas and natural gas liquids (NGLs)

Future Investment

- Approved, publically announced (approx.)
- 2014-2015
- Over $1.7 Billion new infrastructure announced
- 1,000+ miles of gas gathering pipe
- 400 MMcfd gas processing
- 75,000 bbls NGL export
- 400 MMcfd gas export
- 400 miles of export pipe
- 375 miles of natural gas pipe

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Flaring Statistics

Entire State Flaring Statistics

- North Dakota Pipeline Authority data (Nov)
- Entire State
  - –Flaring 29%, 306 MMCFD of state gas production
    - Hess Tioga plant startup
  - –60% is from 216 well sites

Non-FBIR/FBIR Flaring Statistics

- Private and State Lands (excludes FBIR)
  - –238,228 MCFD
  - –Flaring 27% of non-FBIR production
- Ft. Berthold Indian Reservation lands
  - –57,832 MCFD
  - –Flaring 40% of FBIR production

Unique challenges on the FBIR

- ROWs are very slow to get – consent from landowner, Tribe
- More permit scrutiny - 3 federal agencies must approve (BLM, BIA, USFWS)
- Tribal policies conflict with getting pipelines to well locations
  - Developing a conditionally-assignable ROW form – 13 pages long
  - ½ mile setback for all pipelines and compressors from any occupied structure
- Topography and Lake Sakakawea make gas gathering systems challenging to operate

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Future Capture Targets

85% Capture in Two Years

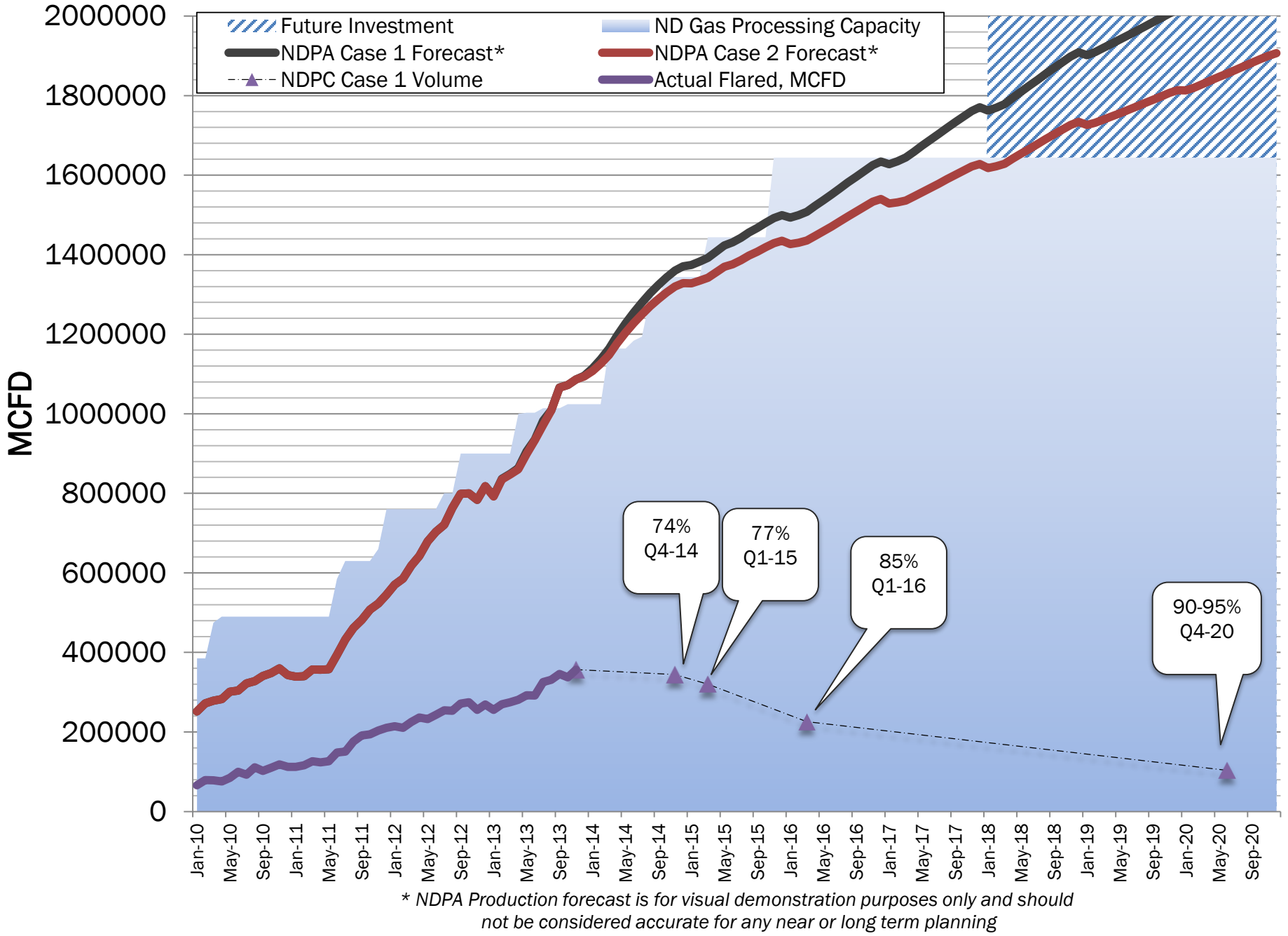
- **Capture 74% by 4th Qtr. 2014**
  - Recent processing expansion, BMPs
- **Capture 77% by 1st Qtr. 2015**
  - Continue capacity build out
  - Operational efficiencies
- **Capture 85% by 1st Qtr. 2016**
  - New recently announced processing plants
  - Value added North Dakota markets

90% Capture by 2020

.....with potential for 95% capture

- This plan allows for increased future oil production while reducing flaring

- Achieving this goal, requires full engagement by the industry, state, counties, NDIC, tribe, and landowners to implement this plan



** NDPA Production forecast is for visual demonstration purposes only and should not be considered accurate for any near or long term planning*

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Time Delays to Connect

Example Connect Times

- The typical process and time for connecting a well or multi-well pad to the gas plant is as follows:
  - Identify well(s), negotiate and execute gas processing agreement: **90 days** (try to negotiate the agreement before the well is spud and during drilling so facilities are ready to capture the first production after well stimulation)
  - Once agreement is executed, apply for county permit: **30 days**
  - Once permit is received, acquire right of way: **30-180 days**
  - Upon ROW acquisition, construct gathering lines and appurtenant facilities: **30 days**

Total time: up to **180 days, if no problem with ROW**.

Note: Typically, can connect a well in 90 days (weather permitting) if the contract is already in place.

Delays to Gas Connection

- **Single Biggest Challenge to connect gas**
  - Securing landowner permission for connection activities
    - **up to 180 days or longer**
- **Biggest obstacles and time delays**
  - Delays in zoning by counties and townships for midstream facilities
  - Short construction season/weather
  - Limited number of available construction crews
  - Review of permits for natural gas fueled equipment

New Focus on Flaring Reduction

- Management focus to reduce flaring
- Focused internal effort to reduce flaring
  - Better drilling, completions, and facilities coordination to reduce flaring
  - Communication with midstream
  - Evaluation of gas utilization before midstream
  - Increased emphasis on obtaining ROW

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Proposal to Meet Reduction Targets

NDPC Flaring Reduction Recommendations

- Gas Capture Plan
- Regulatory Consequences
- Midstream Planning and Tracking
- Gathering Line Oversight
- Rights of Way
- State Actions
- Remote Capture Technologies
- Monitoring and Reporting

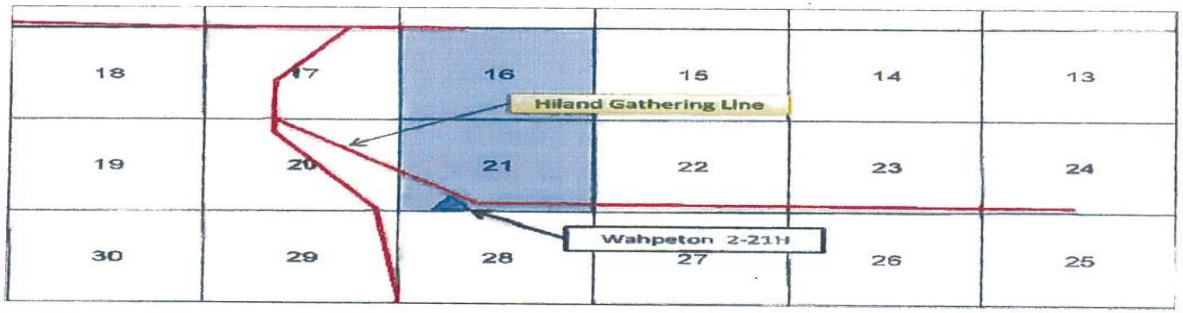
New Permit Requirement

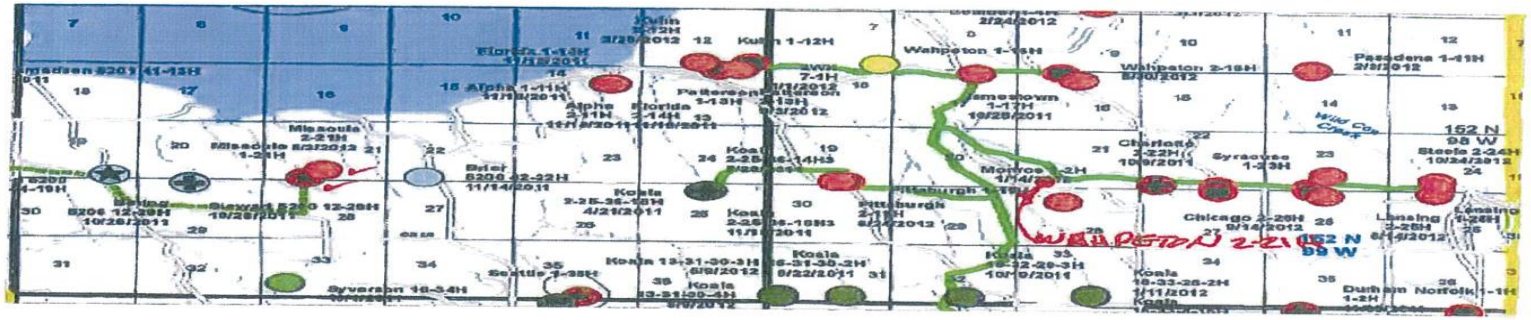
- **Gas Capture Plan (GCP)**
  - Forces gas capture planning prior to drilling
  - GCP may include at the discretion of NDIC:
    - Location map gathering system connection, processing plant(s) identified
    - Flowback strategy (rate, duration, plan for multi-well start up)
    - Current system capacity and utilization
    - Time period for connection

Sample Gas Capture Plan

Gas Pipeline Information

Increase Density
Sections 16 & 21 - 152N - 99W
McKenzie County, North Dakota





Gas Gatherer:	Hiland
Distance from Gas Gatherer to well:	0.25 miles
Anticipated date of 1st gas flow:	First Production
Gas to be processed at:	Watford City
Gathering pipeline capacity:	10,000 Mcfd
Current gathering pipeline throughput:	5,000 Mcfd

Continental Resources

Case #18496
Exhibit 12

INDUSTRIAL COMMISSION
STATE OF NORTH DAKOTA
DATE 10-25-12 CASE NO. 18946
Introduced By CRI
Exhibit 12
Identified By Wilson

Gas Capture Plan Milestones

- June 1, 2014: All new APDs must have a GCP
- For all existing flaring wells, the producer will submit a GCP
  - September 1, 2014: large volume wells (based on Nov NDPA data) 60% is from 216 wells >300 MCFD, 50% connected to sales
  - March 1, 2015: all other wells flaring longer than 90-days, excluding marginal wells

Regulatory Consequences

- **At the discretion of NDIC**, penalty for failure to comply
  - Failure to submit GCP
    - New wells – suspension or denial of permit
    - Existing wells – curtail production where no detriment to well or reservoir
  - Failure to comply with GCP
    - Curtail production
    - Not meeting flowback strategy
    - Mitigating circumstances may allow extension (i.e., economic evaluation, operator's overall capture rate, ROW, safety, weather, work crews, etc.)

Midstream Planning and Tracking

- Midstream companies meet with NDIC on a regular basis (i.e., annual, bi-annual) to status operations and updates
- Suggested reporting to include:
  - Percent gas captured by gathering system
  - Gathering forecast by gathering system
  - Status plant processing capacity and gathering capacity with future obligations and capture targets
  - Utilization and downtime/interruptions of service
    - Field compression downtime / Plant downtime/maintenance

Gathering Line Oversight

- North Dakota will be the first in the nation to regulate gathering systems, effective April 1, 2014 (House Bill 1333)
  - 18,000 miles of existing gathering line will be regulated
  - New electronic mapping requirements
  - $75 MM cleanup fund
  - Pipeline mediation

Pipeline Hotline

- NDIC develop and manage “hotline” for reporting surface owner issue related to pipelines
- Establish follow-up mechanism with company and surface owner to ensure quality control
- Provide landowner with easy notification system for problems and concerns

ROW Task Force

- ROW Task Force to address biggest time delay challenge
  - Discuss and review potential energy corridors, section line easements,legislation to improve ROW access to reduce flaring
  - Stakeholders to include:
    - NDIC, North Dakota Pipeline Authority
    - Attorney General due to legal issues
    - State Energy Impact Coordinator
    - Counties
    - Landowners groups
    - Industry members, both upstream and midstream

State Actions

- Incentivize rapid build out capacity for gas infrastructure
  - Property tax incentive, payment in lieu of taxes
  - Low interest loans (electrical transmission), etc.
  - Production tax credits for producers
- Incentivize intrastate value added markets
  - LNG, CNG, petrochemical, fertilizer plants, technology innovation
- Support dense phase, high pressure export pipeline
  - Major investment – approximately $3 billion
  - Long lead time – approximately 3 years construction time to mid-continent markets
  - NDPA is authorized by statute to take up to 10% of firm capacity

Incentivize Remote Capture Tech

- EERC evaluation process
- EERC pilot and scalability testing
- Increase funding for the Oil & Gas Research Council, focus on value added markets
  - Utilize Empower Commission Value Added Natural Gas Study

Flare Reporting and Monitoring

- Non-FBIR/FBIR flaring tracked separately
- Revise current NDIC gas production and sales report to include:
  - Non-routine flaring operations - safety, power outages, pressure control, pigging, etc.
  - Well testing and flowback operations
- NDPA report on target capture status to NDIC
  - 4rd Qtr. 2014
  - 2nd Qtr. 2015
  - 1st Qtr. 2016

90% Capture by 2020

- This plan allows for increased oil production while reducing flaring

- Possible target of 95% capture

Up To 95% Capture Possible

However,

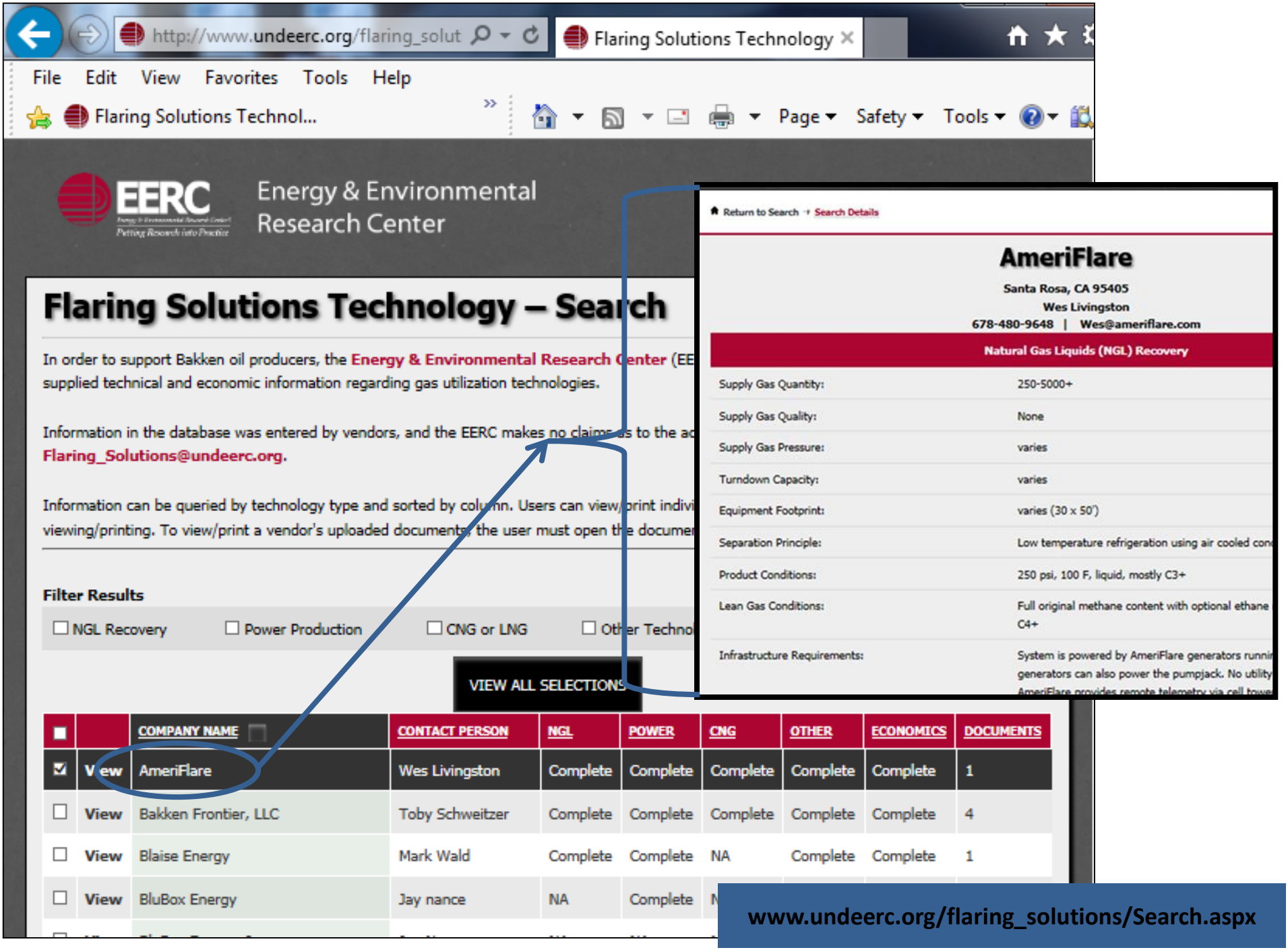
achieving these targets, requires full engagement by the state, counties, NDIC, tribe, landowners, and industry, to implement this plan

Solicited Technical Information Regarding Remote Capture Technologies

- Prepared and distributed a request for information (RFI) describing the nature of North Dakota flare gas and soliciting participation from vendors.
- RFI describes the quality, quantity and distribution of flared gas in North Dakota, providing vendors the information needed to tailor their offering to the unique conditions. Offers must:
  - Accommodate high concentrations of natural gas liquids.
  - Turn down capacity and mobility to accommodate production decline.
  - Be operable in extreme climates.
  - Account for large geographic area.

EERC Remote Capture Evaluation

- Created a database to assemble technical information about vendor technologies and services. Thirty companies have responded to the RFI to date.
- Review of technology information is ongoing:
  - Match technology with conditions.
  - Combine complementary technologies.
  - Adapt technologies, operations, and business models to accommodate conditions.
- Web-based database is available to view company and technical information. www.undeerc.org/flaring_solutions/Search.aspx

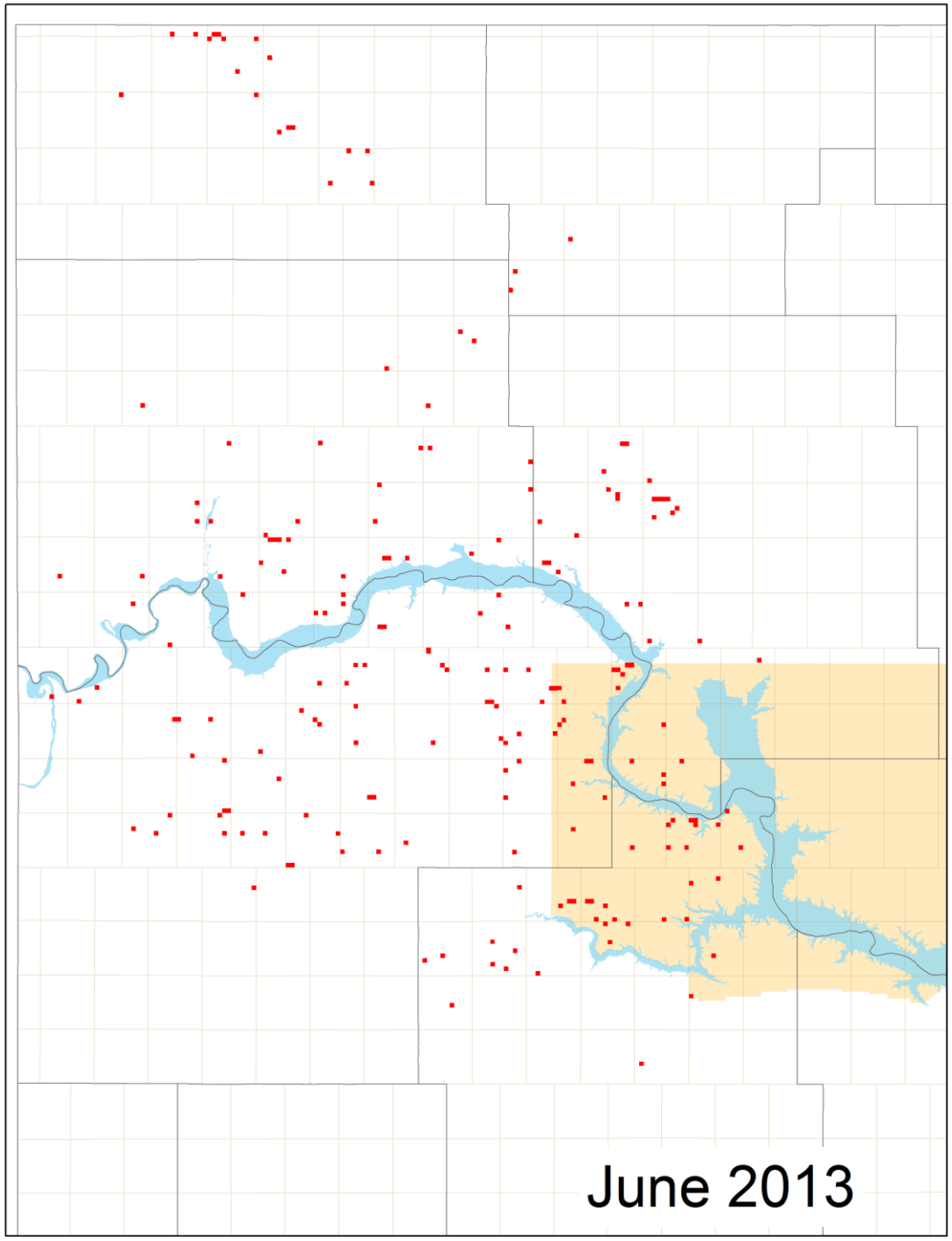

http://www.undeerc.org/flaring_solut
Flaring Solutions Technology
File Edit View Favorites Tools Help
Flaring Solutions Technol...
Page Safety Tools
EERC
Energy & Environmental Research Center
Flaring Solutions Technology – Search
In order to support Bakken oil producers, the Energy & Environmental Research Center (EE
supplied technical and economic information regarding gas utilization technologies.
Information in the database was entered by vendors, and the EERC makes no claims as to the ac
Flaring_Solutions@undeerc.org.
Information can be queried by technology type and sorted by column. Users can view/print indivi
viewing/printing. To view/print a vendor's uploaded documents, the user must open the documer
Filter Results
NGL Recovery
Power Production
CNG or LNG
Other Techno
VIEW ALL SELECTIONS
COMPANY NAME
CONTACT PERSON
NGL
POWER
CNG
OTHER
ECONOMICS
DOCUMENTS
View AmeriFlare Wes Livingston Complete Complete Complete Complete Complete 1
View Bakken Frontier, LLC Toby Schweitzer Complete Complete Complete Complete Complete 4
View Blaise Energy Mark Wald Complete Complete NA Complete Complete 1
View BluBox Energy Jay nance NA Complete
Return to Search Search Details
AmeriFlare
Santa Rosa, CA 95405
Wes Livingston
678-480-9648 | Wes@ameriflare.com
Natural Gas Liquids (NGL) Recovery
Supply Gas Quantity: 250-5000+
Supply Gas Quality: None
Supply Gas Pressure: varies
Turndown Capacity: varies
Equipment Footprint: varies (30 x 50')
Separation Principle: Low temperature refrigeration using air cooled con
Product Conditions: 250 psi, 100 F, liquid, mostly C3+
Lean Gas Conditions: Full original methane content with optional ethane C4+
Infrastructure Requirements: System is powered by AmeriFlare generators runnin generators can also power the pumpjack. No utility
www.undeerc.org/flaring_solutions/Search.aspx

Summary of Flared Gas Statistics

November nonconfidential locations

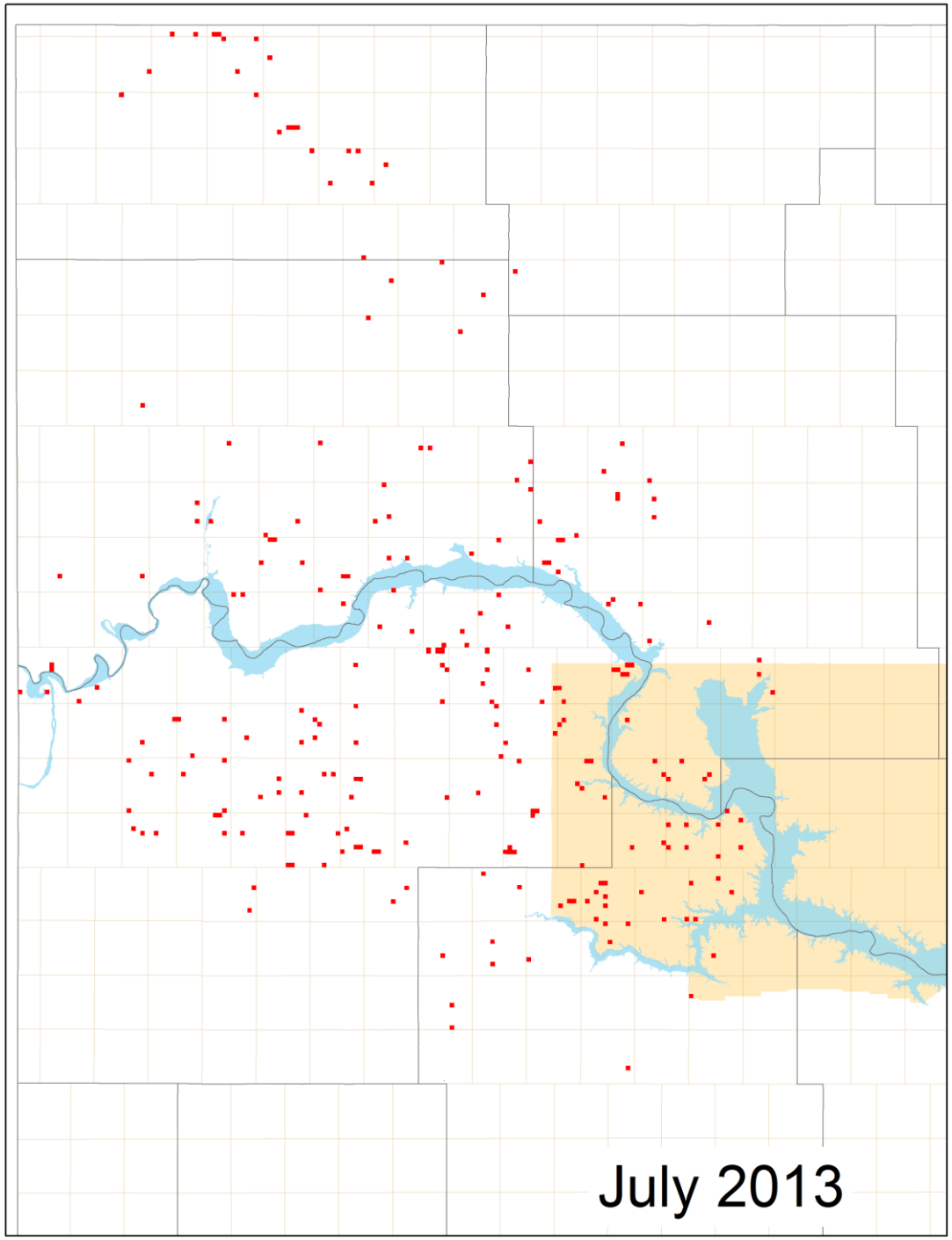
	<1 MCFD	1–299 MCFD	300–599 MCFD	600–1199 MCFD	1200+ MCFD
TOTAL LOCATIONS					
Locations	1925 (42%)	2501 (54%)	103 (2%)	69 (1%)	44 (1%)
Monthly Gas Flared, MCF	4504 (<1%)	3,135,152 (40%)	1,056,163 (14%)	1,448,272 (19%)	2,111,337 (27%)

216 Locations Flaring 60% of Total Flared Gas at Rates of >300 MCFD.



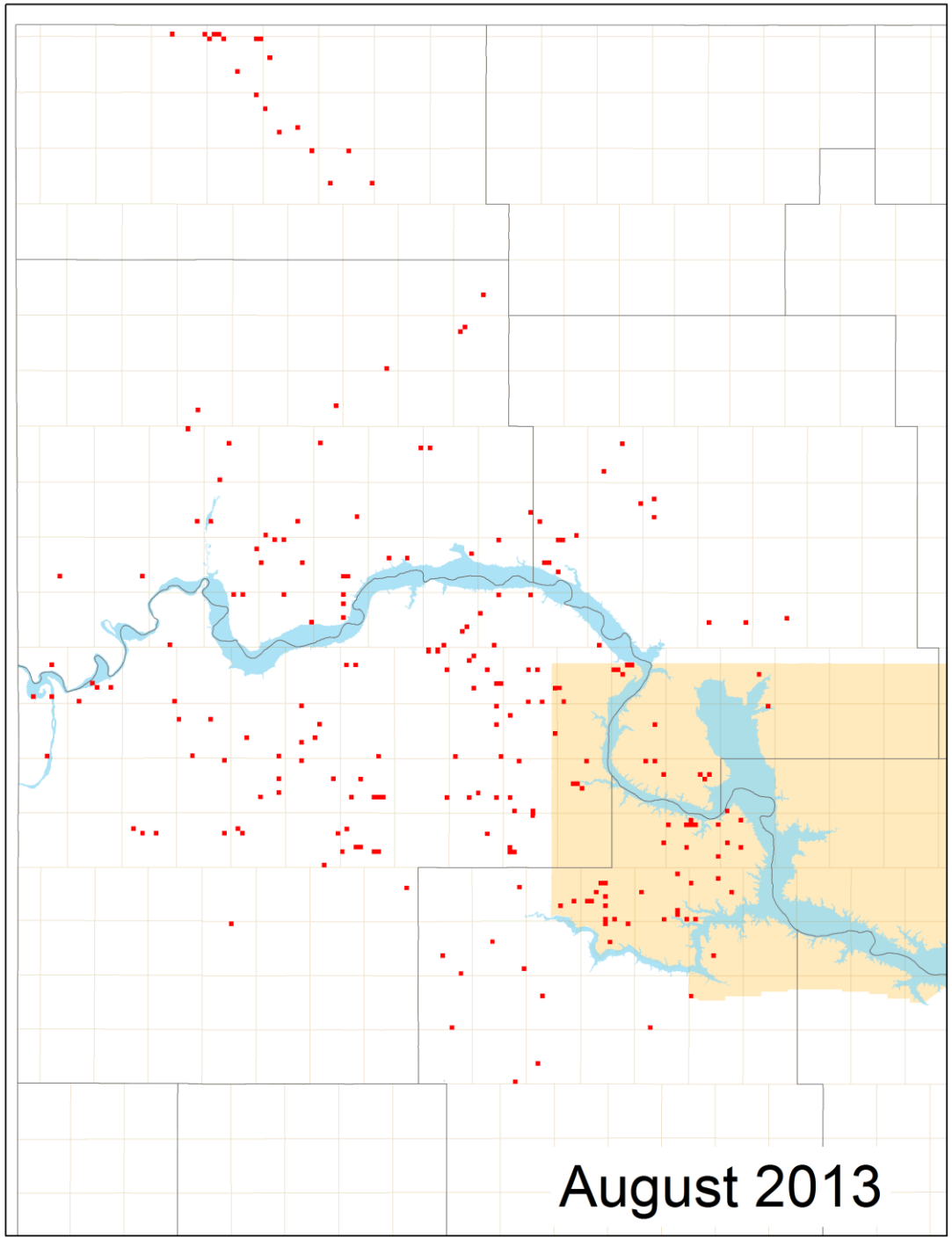
Geographic Distribution of Locations with Flaring Rates Greater than 300 MCFD

- June 222 Locations



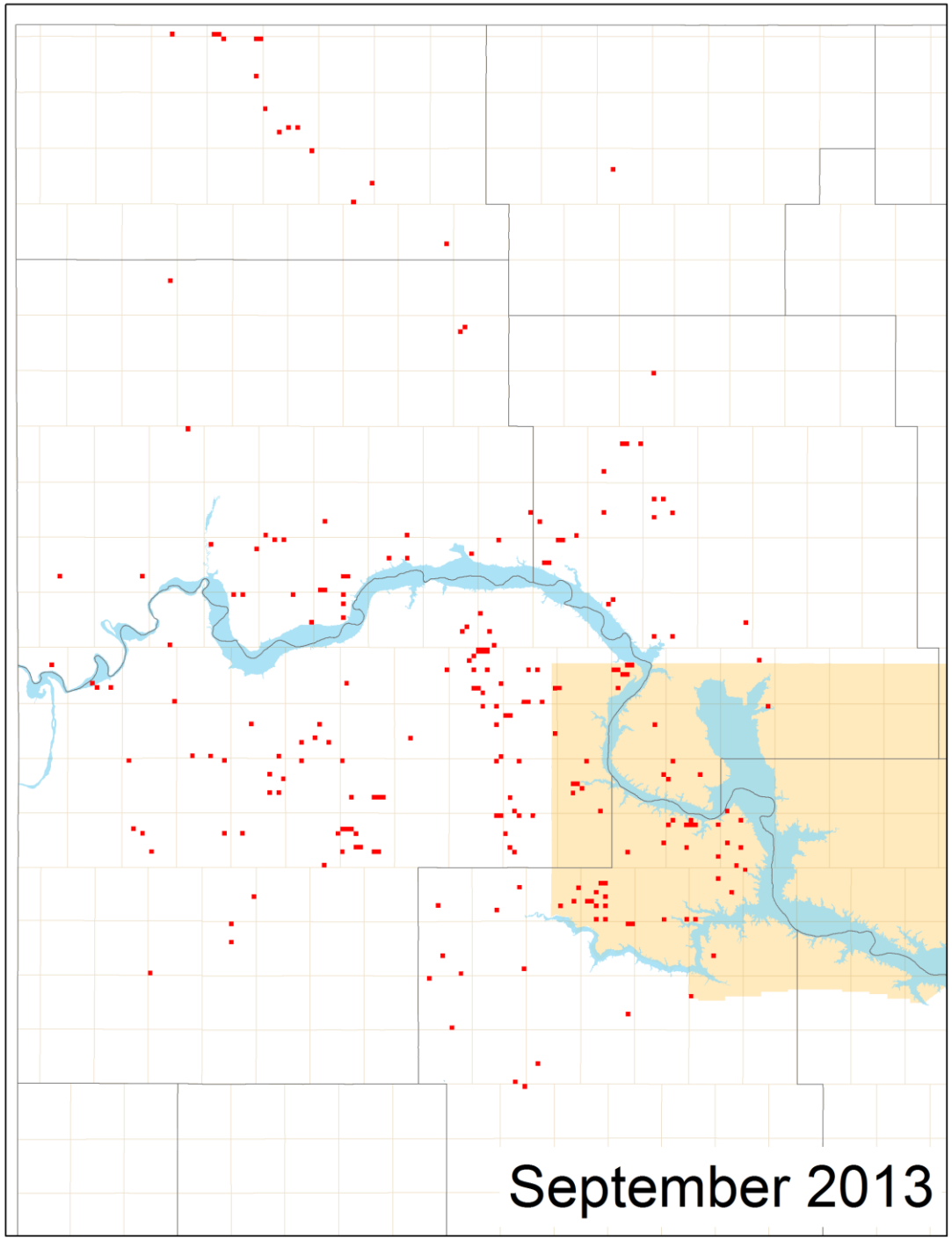
Geographic Distribution of Locations with Flaring Rates Greater than 300 MCFD

- June 222 Locations
- July 270 Locations



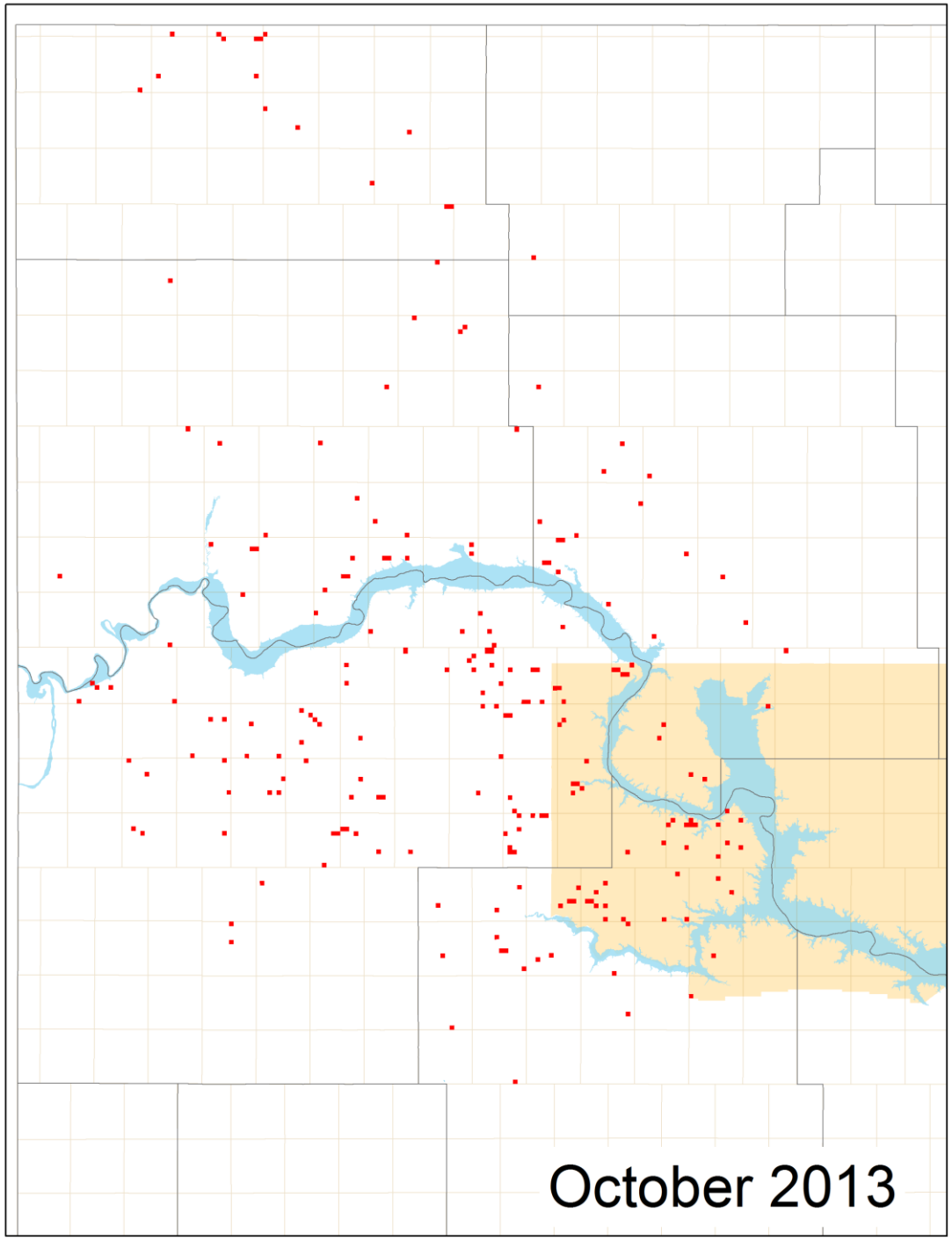
Geographic Distribution of Locations with Flaring Rates Greater than 300 MCFD

- June 222 Locations
- July 270 Locations
- August 242 Locations



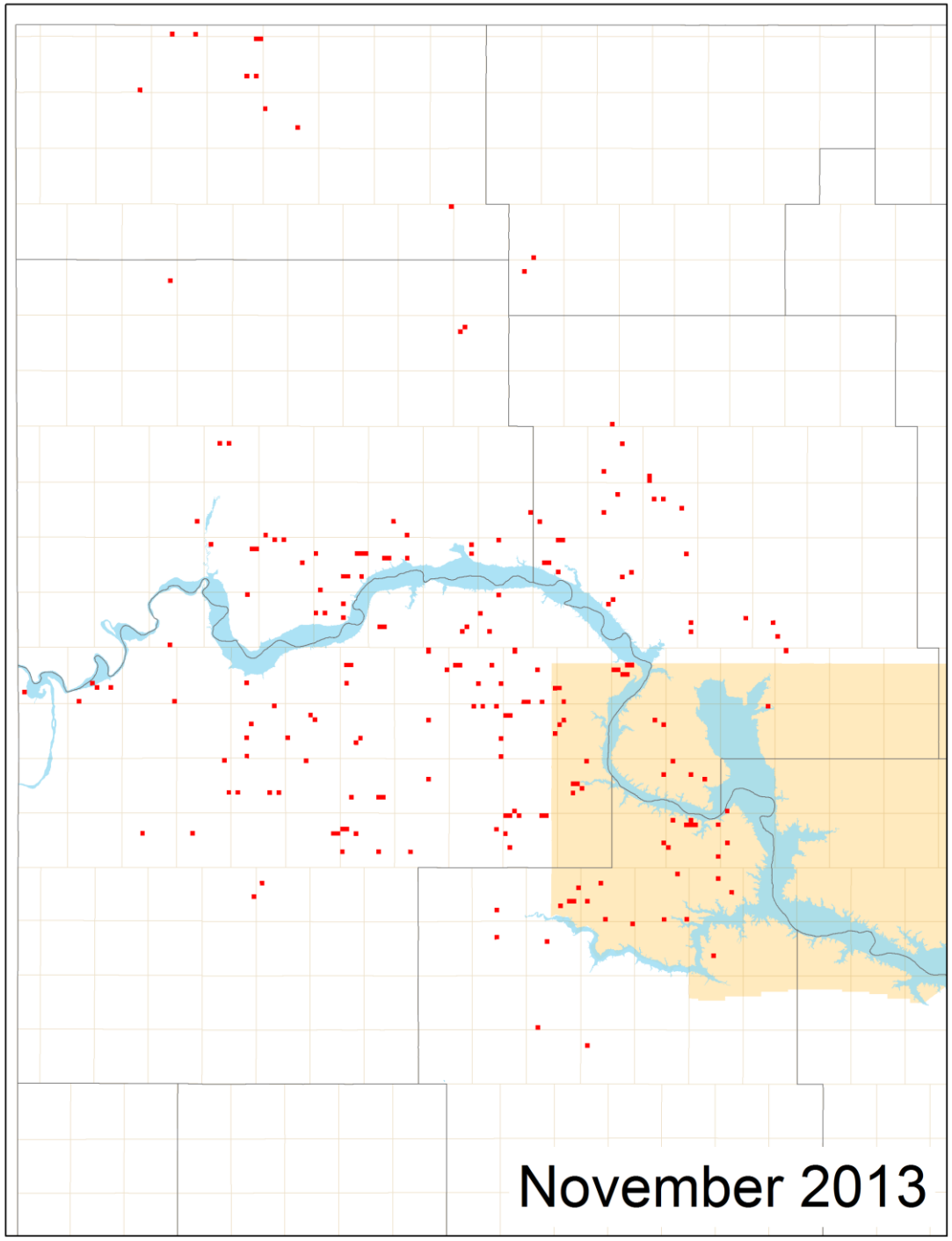
Geographic Distribution of Locations with Flaring Rates Greater than 300 MCFD

- June 222 Locations
- July 270 Locations
- August 242 Locations
- September 237 Locations



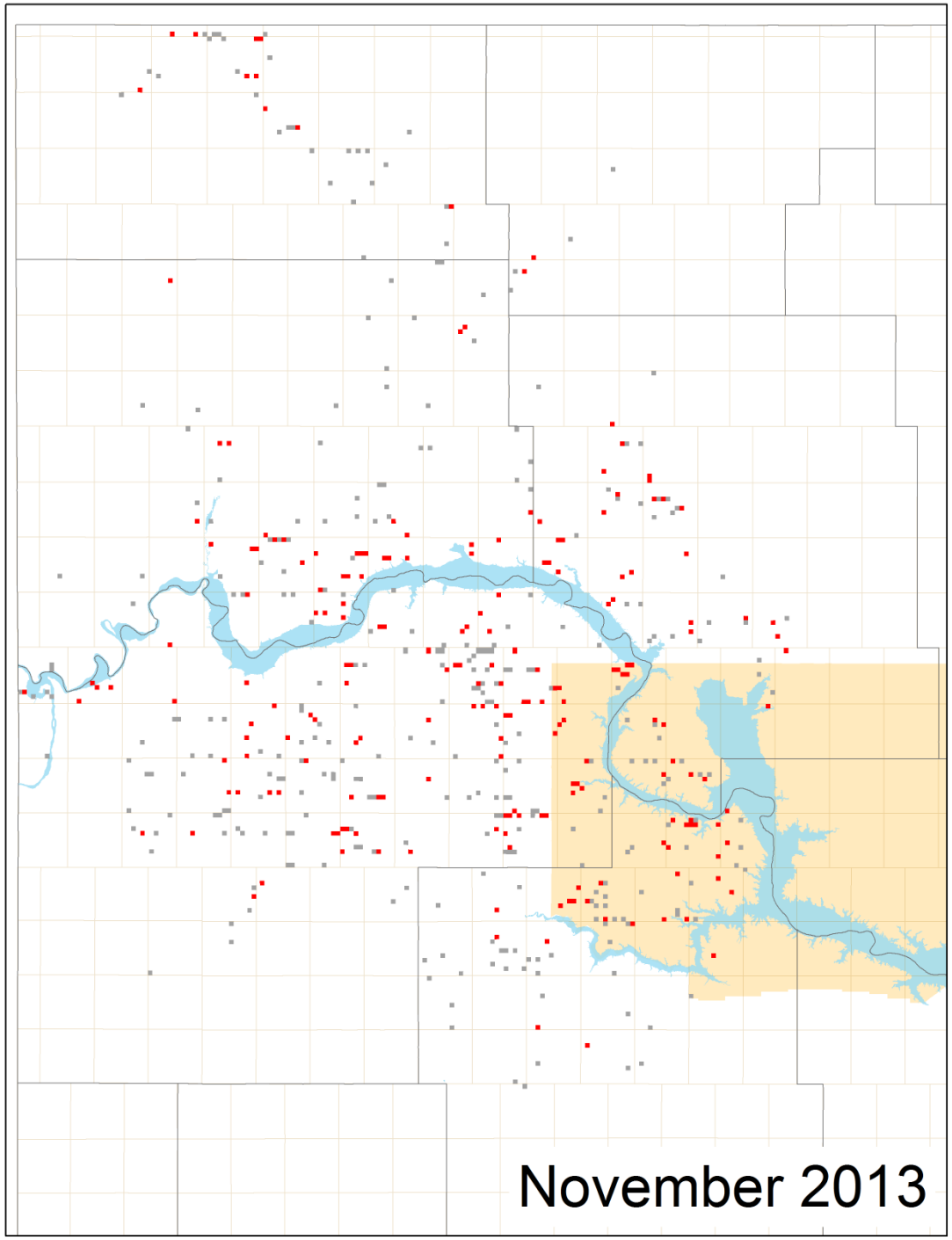
Geographic Distribution of Locations with Flaring Rates Greater than 300 MCFD

- June 222 Locations
- July 270 Locations
- August 242 Locations
- September 237 Locations
- October 227 Locations



Geographic Distribution of Locations with Flaring Rates Greater than 300 MCFD

- June 222 Locations
- July 270 Locations
- August 242 Locations
- September 237 Locations
- October 227 Locations
- November 216 Locations



Geographic Distribution of Locations with Flaring Rates Greater than 300 MCFD

- June 222 Locations
- July 270 Locations
- August 242 Locations
- September 237 Locations
- October 227 Locations
- November 216 Locations

Location Where Flare Rate Was >300 MCFD in Previous 5 Months

Flaring Statistics Summary Points

- Understanding the quantity, quality, and distribution of flares is critical to selecting effective remote capture technology.
- 60% of the total flared gas is coming from locations flaring at a rate of 300 MCFD or greater.
- 216 locations (4% of total locations) flare at a rate of 300 MCFD or greater.
- Historically 50% of flaring is occurring at locations with gas gathering and 50% at stranded locations.
  - Production has exceeded expectations, leading to constrained gathering systems and flaring from connected locations.

Technology	Possible Impact to Flared Volume	Pros	Cons
NGL Removal	7% reduction deployed at the 216 largest flaring locations	• Ease of deployment • Ease of operation • Extracts highest-value product from rich gas	• Best deployed during first 12 months of operation • Increases truck traffic, liquids storage
Power Diesel Replacement	0.5% reduction Power production at 100 one-well locations	• Fuel cost savings • Ease of deployment • Ease of operation	• Limited applicable sites
Power Local Load, Diesel Replacement	9% reduction Power production at 100 1-MW locations	• Reduces overall electrical load growth • Ease of deployment • Ease of operation	• Limited applicable sites
CNG/LNG	0.1% reduction 25,000-mile/day fleet	• Fuel cost savings	• Low demand for fuel • Infrastructure and vehicle conversion takes time
Truck Transport	31% reduction 100 1-MMCFD sites	• Significant flaring impact	• 900 trucks • 9 trucks/day/MMCFD
GTL	8% reduction 2500-bpd production	• Conversion of gas to a higher-value liquid product	• Immature at relevant scale • High capital cost • Complex operation • Requires large, consistent gas supply

Remote Capture Implemented

- ECO-AFS has installed bifuel systems on 30 drilling rigs to date. Gas use of up to 100 MCFD during active drilling.
- Statoil is demonstrating GE's technology to recover NGLs and compress/deliver lean gas to bifuel drilling rigs.
- Hess, EOG, and Halcon have worked with GTUIT for NGL recovery at flared locations.
- Whiting is working with BX Energy to haul rich gas from flaring location to gas plant.

Technology Summary Points

- Technologies exist that can be deployed to utilize flared gas, providing small incremental benefit to gas utilization.
- Gas flaring is a result of many factors. Each technology can address different challenges and improve gas capture under certain conditions.
- Distributed-scale technology alone cannot be economically deployed widely enough to achieve 90% gas capture.
- Remote capture can contribute to the target when coupled with increased gathering and improved gas capture planning.
- Demonstration of technologies in North Dakota can allow evaluation of technology in a relevant environment, ensure desired outcome, and assess ancillary impacts (truck traffic, safety risk).

NORTH DAKOTA PETROLEUM COUNCIL

We keep North Dakota going strong

Questions?

APPENDIX C

EERC ADVANCED CORROSION AND SCALE ANALYSIS CAPABILITIES FACT SHEET


EERC
Energy & Environmental Research Center®
Putting Research into Practice
Advanced Corrosion and Scale Analysis Capabilities
EERC . . . The International Center for Applied Energy Technology®

Advanced Corrosion and Scale Analysis Capabilities

Relevance to Oil and Gas Production

The use of carbon steel is ubiquitous throughout all facets of the upstream and downstream petroleum industry. As a result, various steel components are exposed to a myriad of environmental and anthropogenically induced conditions. Of specific concern is the use of steel in wellbore materials used for production and casing applications in potentially corrosive and scale-forming environments. Understanding the limitations of the steel used for new or existing wells in challenging environments is critical to ensuring the long-term success of any oil and gas operation.

An Integrated Analytical Approach

The Energy & Environmental Research Center (EERC) offers a unique approach to evaluating, analyzing, and addressing many of the issues encountered in the oil and gas arena. Our approach entails the integration of advanced analytical methods with the expertise provided by a diverse team of engineers and scientists to collectively solve even the most challenging of problems. The analytical techniques typically employed to address corrosion and scale issues include scanning electron microscopy (SEM) coupled with energy-dispersive spectroscopy (EDS), x-ray fluorescence (XRF) spectroscopy, and x-ray diffraction (XRD) analysis. SEM–EDS is used for micrometer-scale investigation of the chemistry and morphology of materials in an effort to identify observable surface features, such as corrosion type (localized pitting, etching, etc.) and the elemental and (inferred) mineralogical content of casing–scale interfaces viewed in cross section. In addition, XRD and XRF are used to determine the bulk mineralogy and bulk chemistry of materials, respectively. Each analytical technique provides unique yet complementary information that is used to evaluate specific corrosion mechanisms, scale deposition, and overall material performance.

Sample Analysis Data

Figure 1 shows a sample wellbore casing submitted to the EERC for analysis by an oil and gas producer. The casing, which was from a well located in a conventional oil play, exhibited localized areas of intense corrosion as well as scale deposition. Figure 2 shows pieces of the scale from the surface of one of the casing sections. The elemental and mineralogical content of the CS2 scale sample as determined by XRF and XRD is shown in Figure 3. Detailed SEM analyses of casing cross sections were completed and included backscatter electron micrographs to reveal the texture (Figure 4 upper) and mineral-phase maps and quantitative EDS analysis to display the elemental and mineralogical distribution throughout the corrosion–scale interface (Figure 4 lower). Similar analysis can be conducted proactively using corrosion coupons inserted into operational systems. See "corrosion coupon" inset.

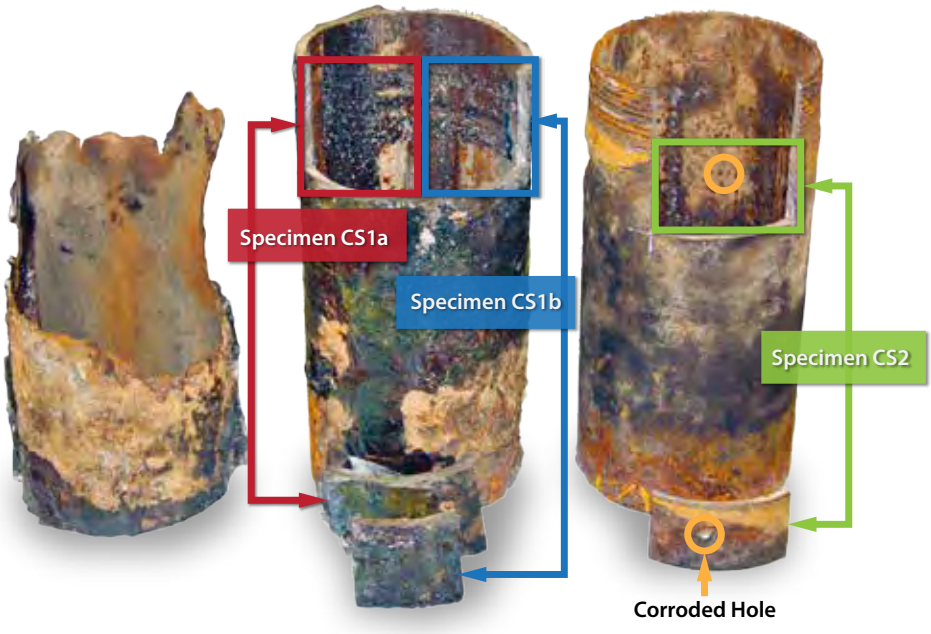
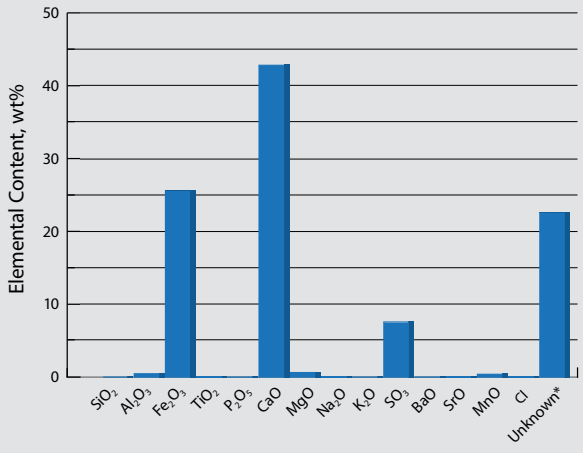


Figure 1. Corroded casing samples. The sections on the left and in the center were a single sample that was cut to obtain a representative sample for SEM analysis.

Figure 2. Scale deposits collected from the outside of the sample CS2 casing.

Sample XRF Data



Sample XRD Data

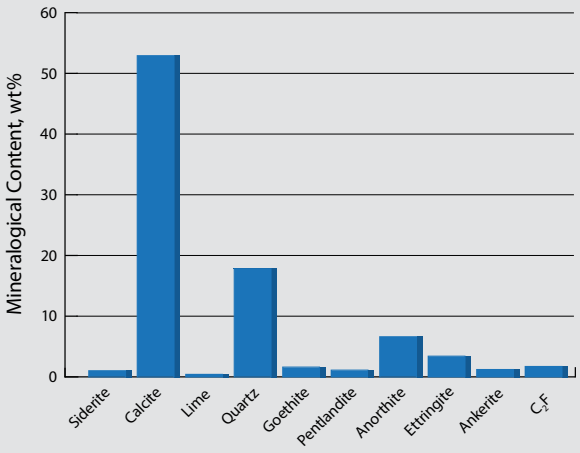
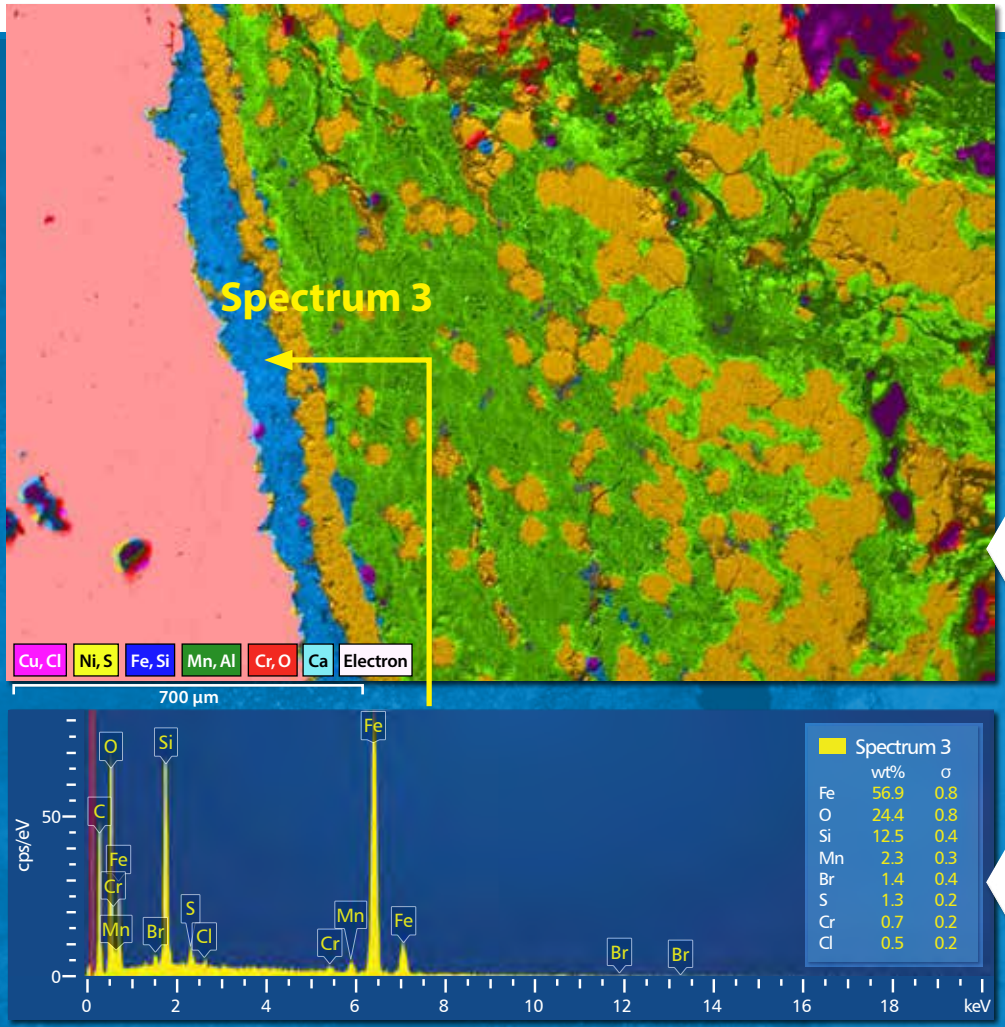


Figure 3. Elemental and mineralogical composition of casing scale as determined by XRF and XRD.
**The "unknowns" in this analysis are presumed to be carbonates, as supported by SEM and XRD analysis.*



Steel Casing
Iron Carbonate
Low-Sulfur Phase
High-Sulfur Phase
Epoxy

Mineral-Phase Map to Visualize Different Phases

EDS Spectrum and Quantitative Element Analysis

Figure 4. SEM mineral-phase map of the corrosion–scale interface from Casing CS1 and an EDS spectrum showing the elemental content of the low-sulfur mineral phase shown above.

Figure 5. Photo of corroded coupon.

Corrosion Coupon Analysis

Corrosion coupons can be an effective tool to evaluate metals performance in corrosive and scale-forming environments actively during operation versus postfailure. In addition to standard weight analysis of coupons pre- and postexposure to determine corrosion and scale formation rates, additional analytical techniques can be used to better assess causative mechanisms. For example, an optical profiler can be used to evaluate the corrosion patterns in very fine detail and to accurately determine the depth of pitting and/or thickness of scale buildup to within ±5 nanometers. Chemical and morphological analysis of the corrosion surface and/or any scale deposits can also be achieved using SEM–EDS. The images in Figures 5 and 6 depict the corrosion surface of a carbon steel coupon that was analyzed as part of a study to evaluate the corrosion potential of brackish groundwater. Figure 5 is a photo of a carbon steel coupon following 3 months of exposure to process conditions. Figures 6 shows images collected of the unexposed and exposed coupon utilizing an optical profiler.

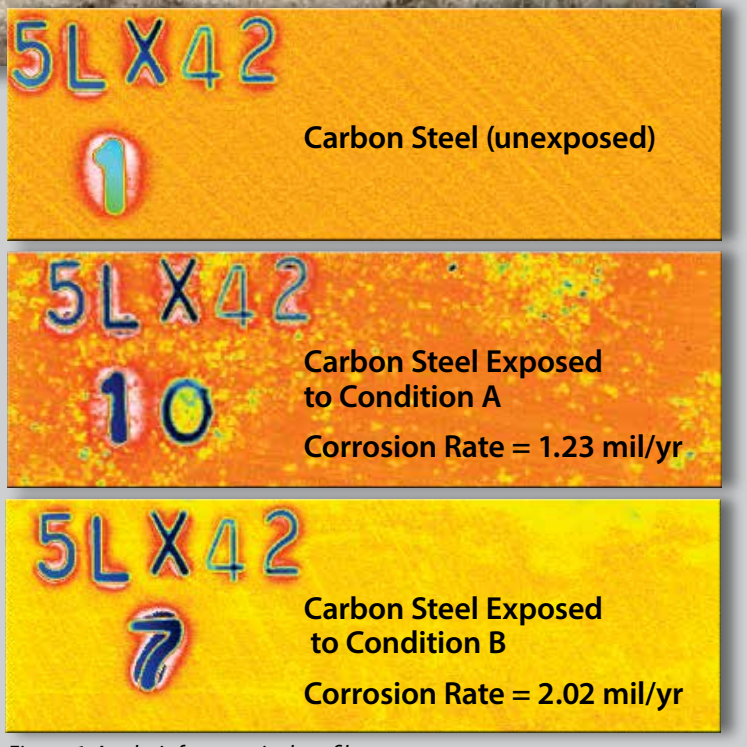


Figure 6. Analysis from optical profiler.

Data Interpretation

In the corroded-casing example, an integrated analytical approach was utilized to identify the chemical signatures of the multiple scale layers formed during emplacement of the well casing. In this case, the SEM analyses revealed localized scale deposits enriched in sulfur. These S-rich minerals were not detected by XRD analysis of bulk mineralogy, indicating an amorphous structure characteristic of microbially influenced corrosion. These analytical techniques, when combined, offer key pieces of data that would be missed if only one analytical technique were used. In addition, the analytical results from each of the aforementioned techniques were used in conjunction with data on the original steel alloy composition, formation water chemistry, and formation mineralogy to determine likely corrosion mechanisms. The EERC was able to identify two potential corrosion mechanisms for the client, leading to an improved corrosion and scale treatment strategy for the future.

In all corrosion and scale analyses conducted at the EERC, this integrated approach allows for an improved understanding of the scale types and corrosion mechanisms. This enables EERC scientific staff to work with clients to propose effective strategies and preventive solutions that best address their corrosion and scale issues.

Contact Us

If you are involved in the oil and gas industry and have corrosion and/or scaling issues with your pipes, rods, pumps, and other equipment, the EERC invites you to contact a member of our team to learn more about our capabilities and how we can help!

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