North Dakota Department of Mineral Resources

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Bismarck, ND 58505-0840
(701) 328-8020  (701) 328-8000

http://www.oilgas.nd.gov  http://www.state.nd.us/ndgs
Topics for Today

• Resource Plays
• Development History
• Impact mitigation
• CO2 potential
Topics for Today

- Resource Plays
- Development History
- Impact mitigation
- CO2 potential
Resource Plays

• 1) **Large area** of organic-rich source rock.
• 2) **Heat, pressure, and time to mature** source rock.
• 3) **Expulsion** of hydrocarbons into adjacent rocks.
• 4) **Trapping** of hydrocarbons in adjacent rocks that are porous, but low permeability.
• 5) **Technology** to extract hydrocarbons using horizontal drilling and natural or artificial fractures to get economic amounts of petroleum production.
1) Regional Extent
Tyler and Bakken
Topics for Today

• Resource Plays
• Development History
• Impact mitigation
• CO2 potential
203 Rigs
Topics for Today

- Resource Plays
- Development History
- Impact mitigation
- CO2 potential
Western North Dakota

• 1,100 to 2,700 wells/year = 2,000 expected
  – 100-225 rigs = 12,000 – 27,000 jobs = 12,000 – 27,000 jobs
  – Another 10,000 jobs operating wells and building infrastructure

  – 225 rigs can drill the 4,500 wells needed to secure leases in 2 years

  – 225 rigs can drill the 27,500 wells needed to develop spacing units in 16 years

  – 32,000 new wells = 30,000-35,000 long term jobs
New or Expanding Gas Plants
<table>
<thead>
<tr>
<th>NDAC</th>
<th>RULES</th>
<th>PROPOSED CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>43-02-03</td>
<td>GENERAL RULES</td>
<td></td>
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<tr>
<td>43-02-03-05</td>
<td>Enforcement of Laws and Rules</td>
<td>Move language to 43-02-03-28 (Safety Regulation)</td>
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<tr>
<td>43-02-03-15</td>
<td>Bonds</td>
<td>Increase $20,000 bond to $50,000</td>
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<tr>
<td>43-02-03-16</td>
<td>Permit to Drill</td>
<td>Commercial SWD bond increased from $20,000 bond to $50,000</td>
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<tr>
<td>43-02-03-16-3</td>
<td>Recovery of a Risk Penalty</td>
<td>Clarify that &quot;approximate&quot; well loc is to be included in the invitation to participate</td>
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<tr>
<td>43-02-03-18</td>
<td>Drilling Units</td>
<td>Requires the drilling or spacing unit be included in the invitation to participate</td>
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<tr>
<td>43-02-03-19</td>
<td>Site Construction</td>
<td>Requires flare pits to be at least 150 feet from wells and tanks</td>
</tr>
<tr>
<td>43-02-03-19.1</td>
<td>Fencing, Screening, and Netting of Pits</td>
<td>Requires all waste material from undesirable events to be immediately disposed</td>
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<tr>
<td>43-02-03-19.3</td>
<td>Earthen Pits and Open Receptacles</td>
<td>Requires remedial work for inadequate sur csg job to be approved by Director</td>
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<tr>
<td>43-02-03-19.4</td>
<td>Drilling Pits</td>
<td>Requires directional surveys to be in reference to true north</td>
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<tr>
<td>43-02-03-19.5</td>
<td>Reserve Pits</td>
<td>Requires automatic shut-down equip if well is threat to public health or safety</td>
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<tr>
<td>43-02-03-21</td>
<td>Casing, Tubing, and Cementing</td>
<td>Requires reclamation equipment from being installed &lt; 520' from occupied dwelling</td>
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<tr>
<td>43-02-03-25</td>
<td>Deviation Tests and Directional Surveys</td>
<td>Requires operators to respond to appropriate resources to contain &amp; clean up spills</td>
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<tr>
<td>43-02-03-27.1</td>
<td>Hydraulic Fracture Stimulation</td>
<td>Must use popoff valves, rupture disk, remote valve</td>
</tr>
<tr>
<td>43-02-03-28</td>
<td>Safety Regulation</td>
<td>Use frac string; no chem disclosure if $&gt; 350 psi on annulus after frac.</td>
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<tr>
<td>43-02-03-30.1</td>
<td>Leak and Spill Cleanup</td>
<td>Requires reclamation of treated water facilities</td>
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<tr>
<td>43-02-03-31</td>
<td>Well Log, Completion and Workover Reports</td>
<td>Requires oil recovered from saltwater handling facilities to be reported to Director</td>
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<tr>
<td>43-02-03-34.1</td>
<td>Reclamation of Surface</td>
<td>Requires reclamation of treated water facilities</td>
</tr>
<tr>
<td>43-02-03-39</td>
<td>Oil Spills, Prod Equip, Dikes, and Seals</td>
<td>Must remove &quot;unused&quot; equip rather than &quot;unusable&quot;</td>
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<tr>
<td>43-02-03-51</td>
<td>Treating Plant</td>
<td>Requires reclamation of treated water facilities</td>
</tr>
<tr>
<td>43-02-03-53</td>
<td>Saltwater Handling Facilities</td>
<td>Requires oil recovered from saltwater handling facilities to be reported to Director</td>
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<tr>
<td>43-02-03-54</td>
<td>Investigative Powers</td>
<td>Director can timely (instead of &quot;immediately&quot;) reply to a complaint</td>
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<tr>
<td>43-02-03-55</td>
<td>Abandonment of Wells-Suspension of Drilling</td>
<td>Allows Director to decline to investigate—can appeal to IC</td>
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<tr>
<td>43-02-03-88.1</td>
<td>Special Procedures Administrative Hearings</td>
<td>Allows applications for additional wells on a spacing unit without live testimony</td>
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<tr>
<td>43-02-03-90.2</td>
<td>Official Notice</td>
<td>Requires reclamation of treated water facilities</td>
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<tr>
<td>43-02-12</td>
<td>GEOPHYSICAL EXPLORATION REQUIREMENTS</td>
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<td>43-02-12-06</td>
<td>Notification of Work Performed</td>
<td>Director may require progress reports prior to completion of a project</td>
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<tr>
<td>Code</td>
<td>Section</td>
<td>Description</td>
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<tr>
<td>------------</td>
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<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>43-02-03-19.4</td>
<td>Drilling Pits</td>
<td>Creates new section addressing pits allowing cuttings, but no fluids</td>
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<tr>
<td></td>
<td></td>
<td>Must reclaim pit w/in 30 days after drilling well; Director may grant exceptions</td>
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<td></td>
<td></td>
<td>Allows small lined pit for trench water and rig wash, but reclaim before MORT</td>
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<td></td>
<td></td>
<td>Must dike pit to keep surface water from entering</td>
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<td>43-02-03-19.5</td>
<td>Reserve Pits</td>
<td>Creates new section allowing reserve pits only for wells &lt; 5000' deep or SWD</td>
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<td></td>
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<td>Must reclaim pit w/in one yr after completing well</td>
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<td></td>
<td></td>
<td>Must slope surface to promote surface drainage away from reclaimed area</td>
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<tr>
<td>43-02-03-27.1</td>
<td>Hydraulic Fracture Stimulation</td>
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<tr>
<td>--------------</td>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td>Creates new section addressing hydraulic fracture stimulation</td>
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<td></td>
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<tr>
<td>Must use popoff valves, rupture disk, remote valve</td>
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<tr>
<td>Use frack string: no chem disclosure if &gt; 350psi on annulus after frack</td>
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<tr>
<td>Frack down csg: run csg evaluation f/thickness of csg and cmt w/chem disclosure</td>
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</tbody>
</table>
WHY FRACK THE ROCK?

- Easy oil and gas are already developed
  - flow without fracing

- Unconventional Reserves
  - reservoirs are tight
    - look at sample
  - uneconomic to produce without fracing
  - must create a path for oil to flow
Performing hydraulic fracture stimulation south of Tioga
- all Bakken wells must be hydraulically fractured to produce
- 2-4 million gallons of water
- 3-5 million pounds of sand and ceramic
- cost $2-5 million
Thousands of fractures are created
- pumping water at 6,000-9,000 psi
- millions of pounds of sand and ceramic beads are pumped with the water to hold the fractures open.

Ball and Sleeve
- up to 40 stages
- ball opens the liner sleeve
Stage Fracturing
- up to 40 stages
Purposes of frac fluid

- crack the reservoir
- gel strength to carry sand

Frac fluid is produced back as flowback and produced water
Each hydraulic fracturing stage creates hundreds of fractures extending several hundred feet from wellbore.
Microseismic events are imaged via PSET, a migration based imaging algorithm.
“Excellent ‘frac saturation’....”

- 24-Stage Frac / IP: 2,558 BOE/D
- Excellent “frac saturation” evidenced by minimal gaps of unfraced rock along the wellbore with some stages impacting the same rock volume.
- Minimal gaps along NE trending natural fractures where the frac follows large regionally extensive fractures. These areas already have good naturally occurring fractures.
- Lateral frac wings that average 750’ on either side of the wellbore. This is consistent with our other fracs and planned spacing pattern for full field development.
States have been regulating the full life cycle of hydraulic fracturing for decades

- Geology of each sedimentary basin is different
- Water Appropriation Regulation
- Oil & Gas Regulation
- Health and Environmental Regulation
North Dakota has been regulating the full life cycle of hydraulic fracturing for decades

• Water Commission
  • water supply
• Industrial Commission
  • well construction
  • disposal of flow back water
• Health Department
  • spill cleanup
Water Commission Regulation

• Regulate water appropriations

• Guard against withdrawals exceeding recharge
Thirsty Horizontal Wells

- 2,000 - 3,000 wells / year
- 15 - 25 years duration
- 20 - 30 million gallons water / day
Glacial Drift Aquifers
FRAC WATER NEEDS

- Lake Sakakawea (Missouri River) is the best water resource
- one inch contains 10 billion gal water
- 5,000 wells @ 2 million gal/well
- 30 million gallons per day
Industrial Commission Regulation

- Well construction for Hydraulic fracturing
  - Two casing strings required
  - Both strings must be cemented
  - Pressure tests required
  - Frac is > 1.5 mile below potable water
• Drill with fresh water
• Total depth below lowest potable water
• Run in hole with surface casing
• 1st layer of surface water protection
• Cement casing back to surface of ground
• 2nd layer of surface water protection
• Drill vertically to kick-off point
• Run in hole with bent assembly
• Downhole mud motor
TYPICAL HORIZONTAL OIL WELL

- Drill 8-3/4” hole to pay
- Run in hole with 7” casing
- 3rd layer of protection
- Cement 7” casing
- 4th layer of protection

Potable Waters

9-5/8” in 13.5” Hole

7” Casing

Cement

Kick-off Point

Build Section
**TYPICAL HORIZONTAL OIL WELL**

- Potable Waters
- 7" Casing
- 9-5/8" in 13.5" Hole
- 7" Casing
- 2nd layer of protection
- Drill 6" horizontal hole in pay
- Kick-off Point
- Build Section
- Horizontal lateral

- Upper Bakken Shale
- Middle Bakken
- Lower Bakken Shale
Run in hole with:
- 4.5” liner
- 30-40 swell packers
- sliding sleeves
- 4.5” frack string
- 5th layer of protection
Three-Dimensional Geologic Model of the Parshall Area

Uranium/Coal
Shallow Gas
Frac Proppant
Geothermal
Base Freshwater

Salt-Water Disposal
Salts/Air Storage
CO₂ Sequestration

Oil & Gas

Potash

Deep Gas

NORTH DAKOTA GEOLOGICAL SURVEY
Figure 1 - TRIASSIC "A" SALT
CONTOUR INTERVAL - 50 FEET

Figure 2 - TRIASSIC "B" SALT
Figure 3 - PERMIAN "A" SALT

CONTOUR INTERVAL—50 FEET
Figure 4 - MISSISSIPPIAN "A" SALT
Figure 5 – MISSISSIPPIAN "B" SALT
Figure 6—MISSISSIPPIAN "C" SALT
Figure 7 - MISSISSIPPIAN "D" SALT
CONTOUR INTERVAL—10 FEET

Figure 8—MISSISSIPPIAN "E" SALT
CONTOUR INTERVAL - 10 FEET

Figure 9 - MISSISSIPPIAN "F" SALT
Industrial Commission Regulation

• Water flow back after frac
  • Storage in open pits prohibited
  • Disposal wells permitted through Underground Injection Program
• Disposal zone is 2,500 feet below potable waters with impermeable shale between
Three-Dimensional Geologic Model of the Parshall Area

300 disposal wells

450,000 barrels water/day

NORTH DAKOTA GEOLOGICAL SURVEY
Health Department Regulation

• Cleanup of discharge to environment
• Coordinate with local Emergency Managers
• Emergency Planning and Community Right-to-know Act (EPCRA)
• Congress passed for storing and handling of chemicals
• Requires material safety data sheet (MSDS) for each chemical on location
• **Compound**
  – **Purpose**
    • **Common application**

• Fresh **Water** – 80.5%
• Proppant – 19.0%
  – Allows the fractures to remain open so the oil and gas can escape
    • Drinking water filtration, **play ground sand**
• Acids - 0.12%
  – Help dissolve minerals and initiate fractures in rock (pre-fracture)
    • **Swimming pool cleaner**
• Petroleum distillates – 0.088%
  – Dissolve polymers and minimize friction
    • **Make-up remover**, laxatives, and candy
• Isopropanol – 0.081%
  – Increases the viscosity of the fracture fluid
    • **Glass cleaner**, antiperspirant, and hair color
• Potassium chloride – 0.06%
  – Creates a brine carrier fluid
    • Low-sodium **table salt substitute**
• Guar gum – 0.056%
  – Thickens the water to suspend the sand
    • **Thickener used in cosmetics**, baked goods, ice cream, toothpaste, sauces, and salad dressing
• Ethylene glycol – 0.043%
  – Prevents scale deposits in the pipe
    • Automotive **antifreeze**, household cleansers, deicing, and caulk
• Sodium or potassium carbonate – 0.011%
  – Improves the effectiveness of other components, such as cross-linkers
    • Washing soda, detergents, soap, water softeners, glass and ceramics
• Sodium Chloride – 0.01%
  – Delays break down of the gel polymer chains
    • Table Salt
• Polyacrylamide – 0.009%
  – Minimizes friction between fluid and pipe
    • Water treatment, soil conditioner
• Ammonium bisulfite – 0.008%
  – Removes oxygen from the water to protect the pipe from corrosion
    • Cosmetics, food and beverage processing, water treatment
• Borate salts – 0.007%
  – Maintain fluid viscosity as temperature increases
    • Used in laundry detergents, hand soaps and cosmetics
• Citric Acid – 0.004%
  – Prevents precipitation of metal oxides
    • Food additive; food and beverages; lemon juice
• N, n-Dimethyl formamide – 0.002%
  – Prevents the corrosion of the pipe
    • Used in pharmaceuticals, acrylic fibers and plastics
• Glutaraldehyde – 0.001%
  – Eliminates bacteria in the water
    • Disinfectant; Sterilizer for medical and dental equipment
Hydraulic Fracturing Stimulation is Safe

- IOGCC survey—no contamination
- EPA survey – no contamination
- GWPC study verifies State’s regs
- GWPC National Registry f/chemicals
  - FracFocus
### Find a Well

**Back To Search**

<table>
<thead>
<tr>
<th>API No.</th>
<th>Job Date</th>
<th>State</th>
<th>County</th>
<th>Operator</th>
<th>WellName</th>
<th>Well Type</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Datum</th>
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<tbody>
<tr>
<td>33-053-03180</td>
<td>1/26/2011</td>
<td>North Dakota</td>
<td>Mc Kenzie</td>
<td>XTO Energy/ExxonMobil</td>
<td>Mondak Federal 24X-12</td>
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## Hydraulic Fracturing Fluid Product Component Information Disclosure

**Fracture Date:** 3/22/2011  
**State:** North Dakota  
**County:** McKenzie  
**API Number:** 33-653-00113  
**Operator Name:** XTO Energy  
**Well Name and Number:** 101 Federal 21A-24  
**Longitude:** -104.668694  
**Latitude:** 47.641779  
**Length of Projection:** ND  
**Production Type:** Oil  
**True Vertical Depth (TVD):** 10,358  
**Total Water Volume (gal):** 2,301,910

### Hydraulic Fracturing Fluid Composition:

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Supplier</th>
<th>Purpose</th>
<th>Ingredients</th>
<th>Chemical Abstract Service Number (CAS #)</th>
<th>Maximum Ingredient Concentration in Additive (% by mass)**</th>
<th>Maximum Ingredient Concentration in HIF Fluid (% by mass)**</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Water</td>
<td>Vehicle</td>
<td>Water</td>
<td>Water</td>
<td>7732-18-5</td>
<td>100.00%</td>
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<tr>
<td>Sand</td>
<td>Superior Well Svcs</td>
<td>Proppant</td>
<td>Crystalline Silica</td>
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<td>LSG-1</td>
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<td>Delayed Cross-linker</td>
<td>Potassium Formate</td>
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<td>Clay Treat LT</td>
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<td>Choline Chloride</td>
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<td>PH-16L</td>
<td>Superior Well Svcs</td>
<td>Set Stabilizer (Buffer)</td>
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<td>Super GW-3</td>
<td>Superior Well Svcs</td>
<td>Non-Emulsifying Surfactant</td>
<td>Proprietary Component</td>
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<td>Gytro-T-475</td>
<td>Champion Technologies</td>
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<td>Bacron K-136W</td>
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<td>CB-2 MT</td>
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<td>Ammonium Resinate</td>
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</table>
SHALLOW GAS PROJECT

The Geological Survey recently completed phase I of a study of shallow natural gas in North Dakota. We investigated 9,400 ND State Water Commission monitoring well sites, tested 4,325 wells, and detected methane in 905 wells. Approximately 20% of the wells contained detectable gas.

During the second phase of the project, thirty groundwater samples, primarily from eastern North Dakota, will be analyzed for dissolved gas composition, isotopes, and general chemistry. This will enable us to determine the source of the gas and identify chemical groundwater signatures that might assist the oil and gas industry in natural gas exploration.

Monitoring wells that contained methane are indicated with red dots, black dots are wells that contained no detectable methane. The red dots are sized to reflect the concentration of methane -- the higher the concentration, the larger the dot.
| 43-02-03-28 | Safety Regulation | Incorporated language removed from 43-02-03-05 on well shut in f/public safety
Requires automatic shut-down equip if well is threat to public health or safety
Prohibits injection equipment from being installed < 500' from occupied dwelling |
<table>
<thead>
<tr>
<th>Date</th>
<th>Bonds</th>
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<tbody>
<tr>
<td>43-02-15</td>
<td>Increase $20,000 bond to $50,000</td>
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<tr>
<td></td>
<td>Commercial SWD bond increased from $20,000 bond to $50,000</td>
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<tr>
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<td>Eliminates $50,000 10-well blanket bond</td>
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Topics for Today

• Resource Plays
• Development History
• Impact mitigation
• CO2 potential
Bakken Development Plan

- Original dual-zone development plan
  - 8 wells per 1,280 acres - 4 MB, 4TF
  - 603,000 Boe EUR per well (avg. 24.5 stages/completion)
  - ECO-Pad® design: 
    2 wells south, 2 wells north

- Additional Three Forks potential

<table>
<thead>
<tr>
<th>County</th>
<th>Bakken OOIP per County</th>
<th>Bakken EUR per County</th>
<th>Three Forks OOIP per County</th>
<th>Three Forks EUR per County</th>
<th>Total OOIP per County</th>
<th>Total EUR per County</th>
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<td>Divide</td>
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<td>855,513,380</td>
<td>76,996,258</td>
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<td>1,872,555,554</td>
<td>169,113,151,504</td>
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