UIC CONFERENCE 2024 – NORTH DAKOTA CLASS II UPDATE

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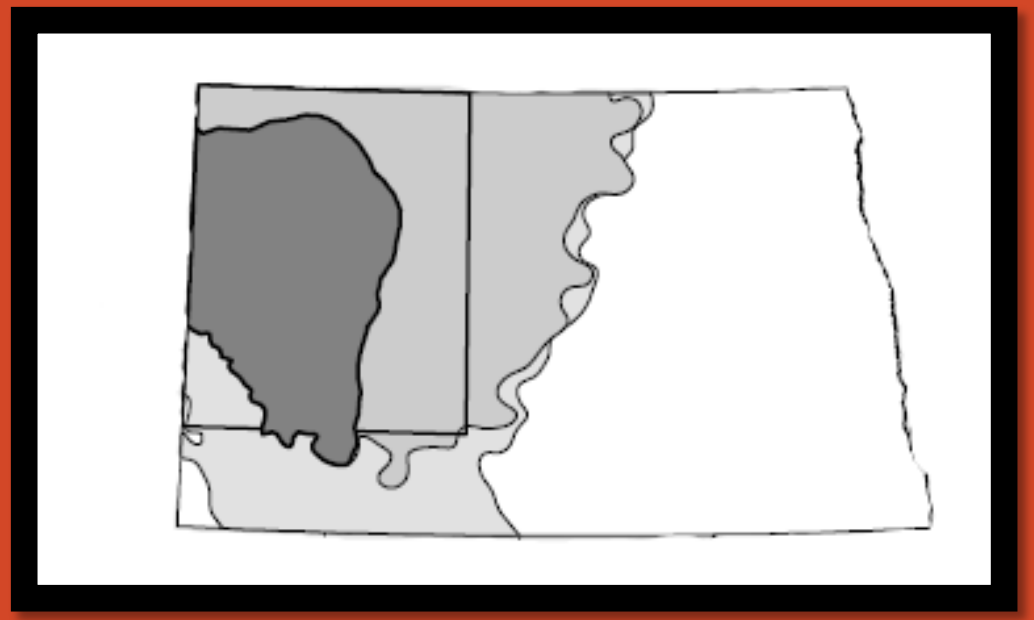
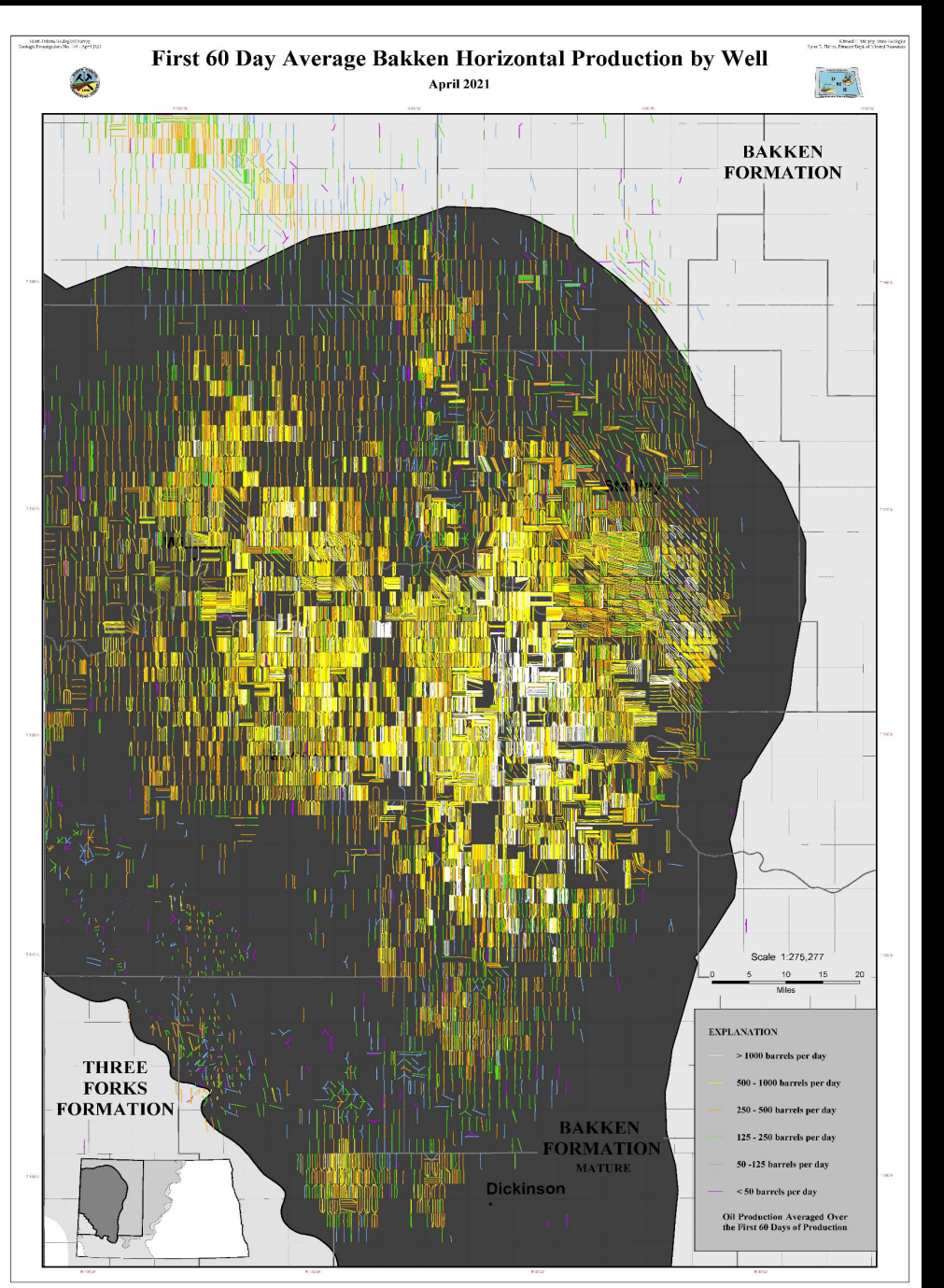
North Dakota Department of Mineral Resources, Oil & Gas Division

Bakken Extent in North Dakota



Bakken & Three Forks is 98% of current ND production



North Dakota Production
December 2023

Oil Production

1,273,071
barrels per day

98% Bakken & Three Forks
2% Legacy Pools

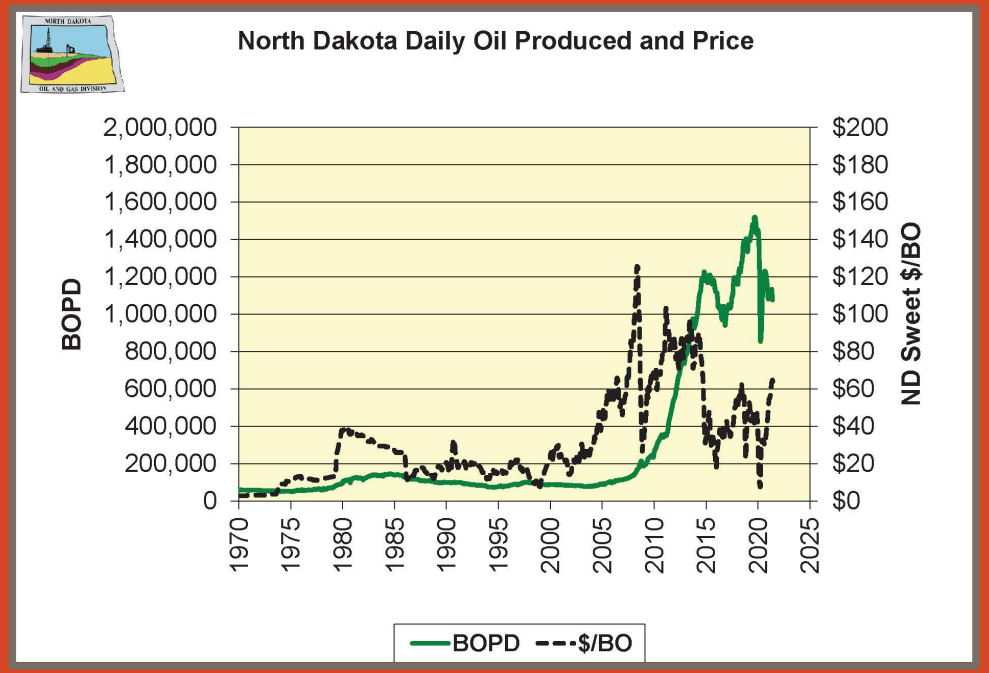
Natural Gas

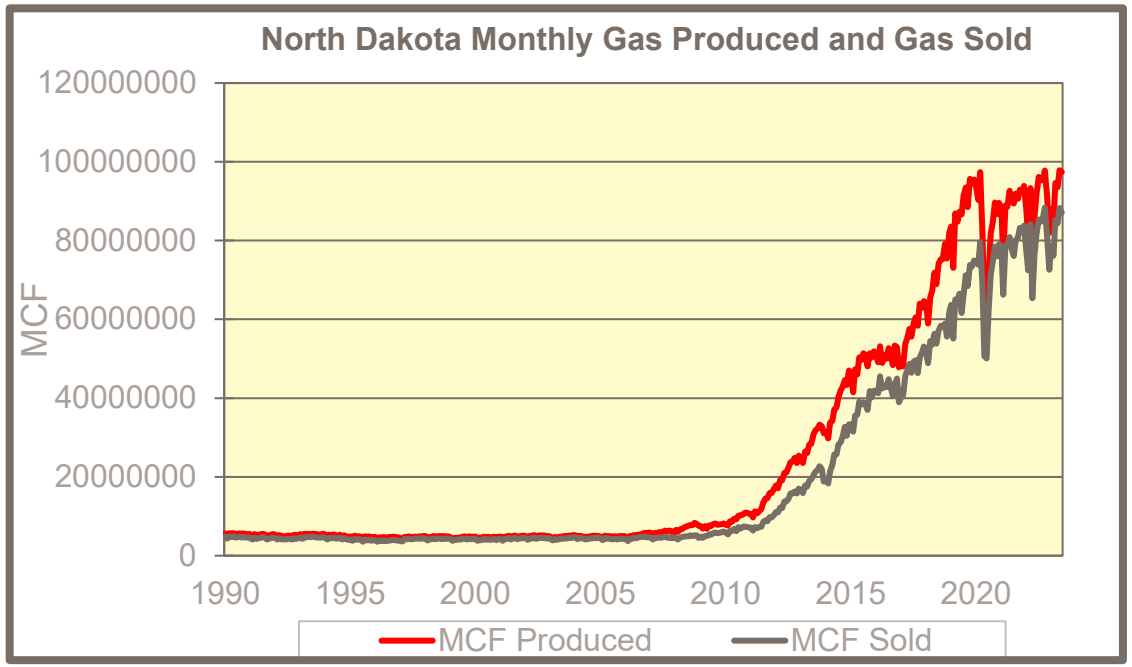
3,524,648
mcf per day

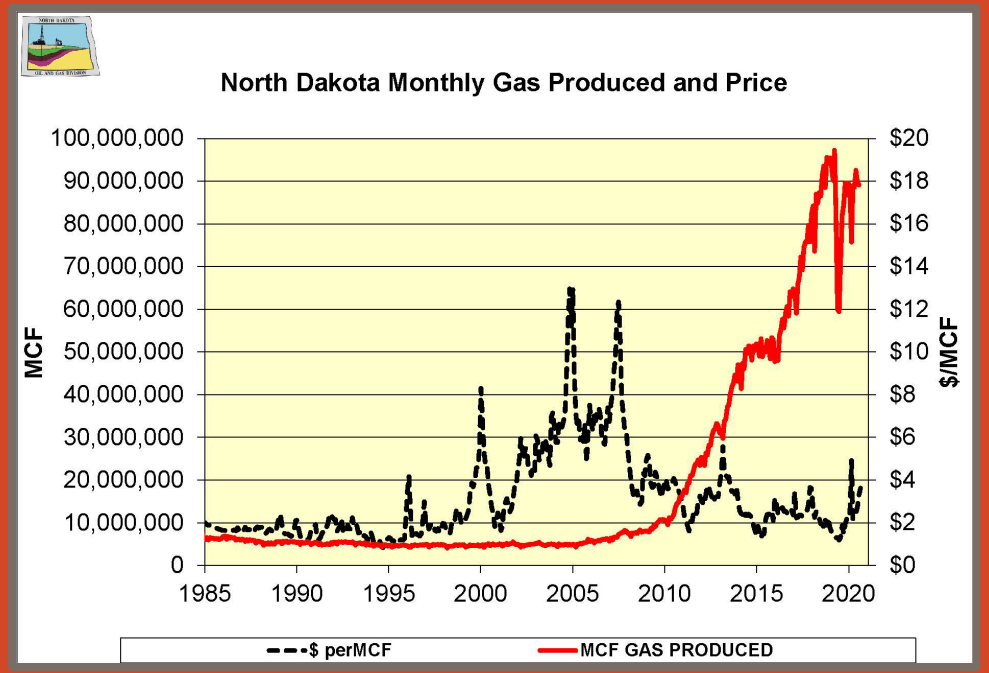
95%
natural gas captured

18,365
producing wells

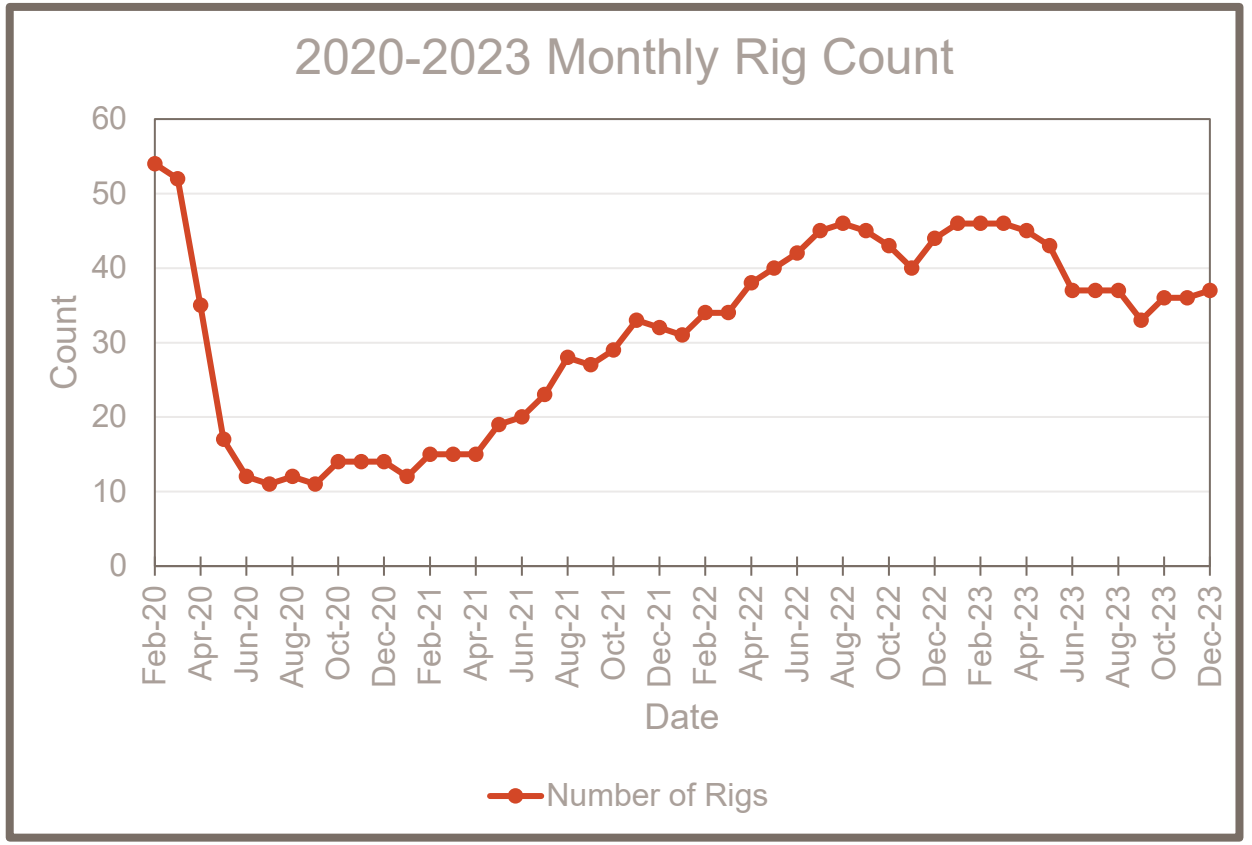
36
active drilling rigs







2020-2022 NORTH DAKOTA RIG COUNT

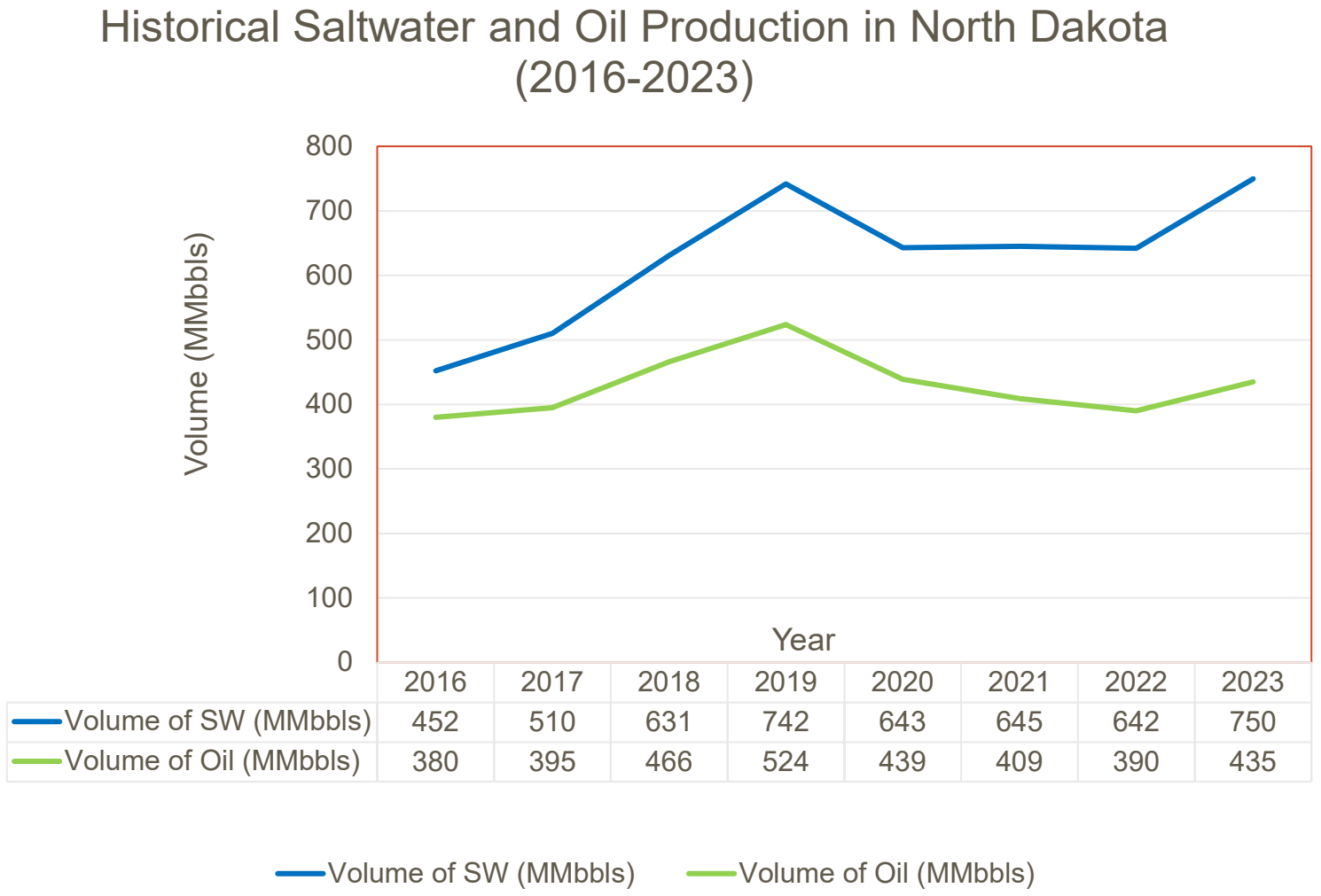


**All Time High was 218 rigs in May 2012

The Director's Cut
https://www.dmr.nd.gov/dmr/oilgas/directorscut

NORTH DAKOTA HISTORIC SW vs. OIL PRODUCTION

- Trending toward higher water production.
- Approaching 2 bbls of SW produced for every 1 bbl of oil.
- Bakken Produced Water
  - TSD = avg. 280,000 to 320,000 ppm
  - Specific Gravity = ~1.2
  - Equivalent Mudweight = ~10 ppg



NORTH DAKOTA CLASS II HISTORY

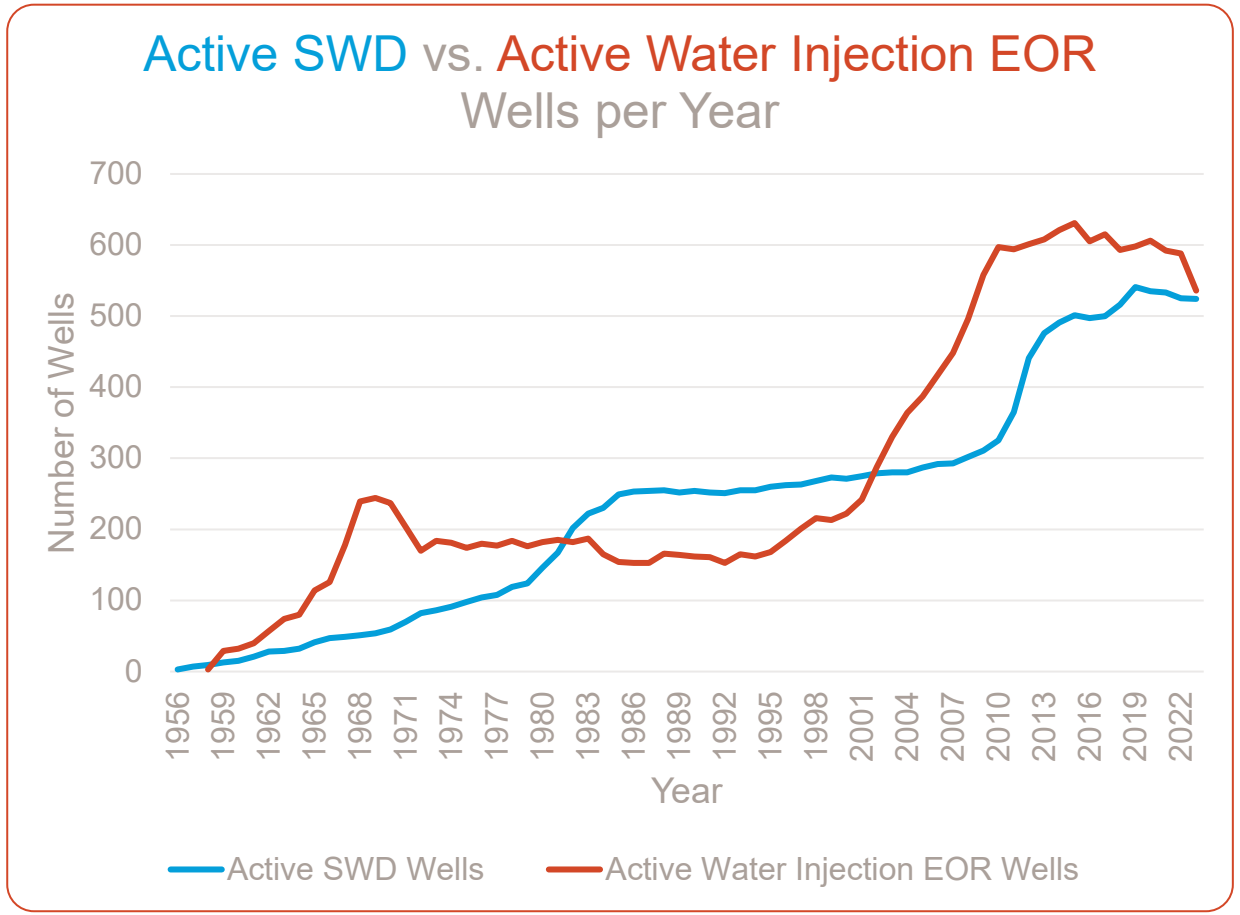
Class II Primacy

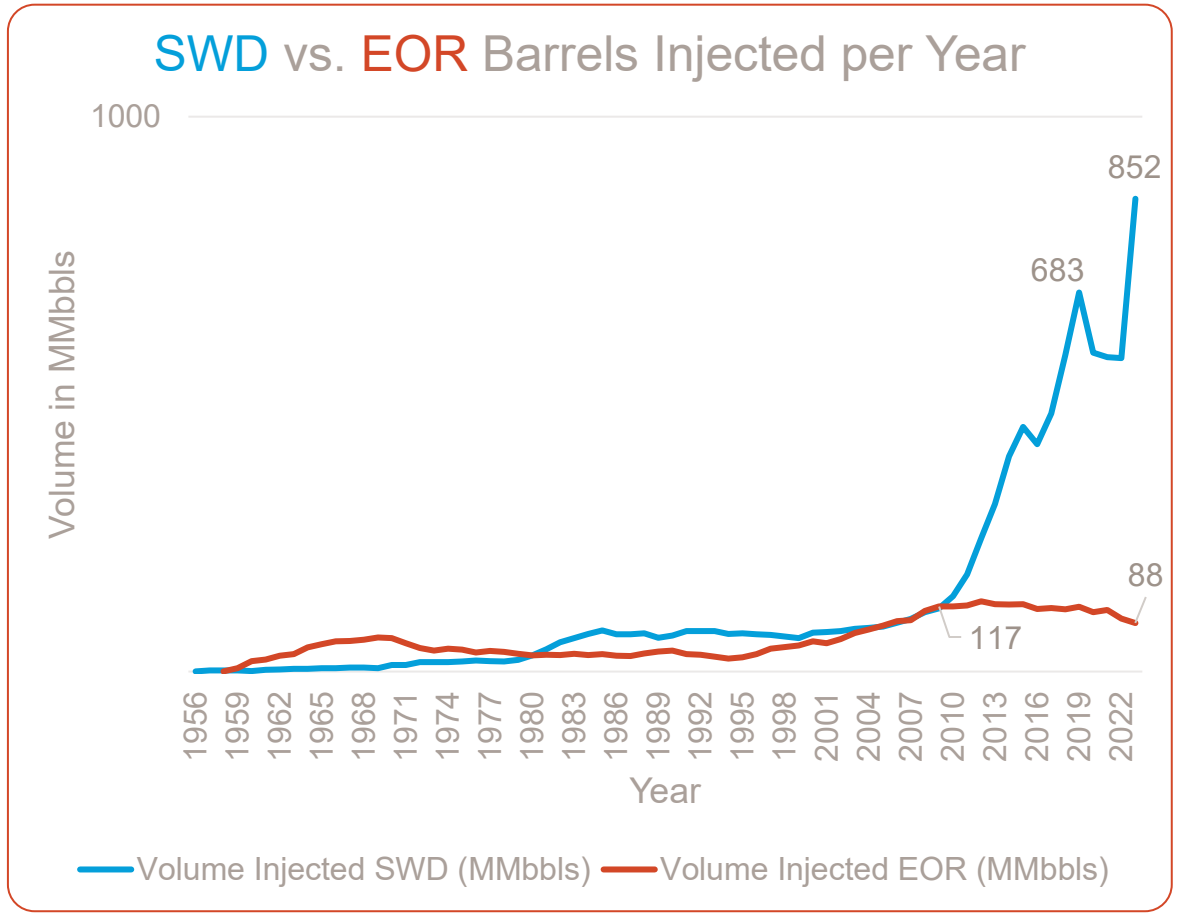
- August 23, 1983 – Approval of North Dakota's Class II Program was published in the Federal Register.
- The Class II program is classified as a 1425 program under the Safe Drinking Water Act.
- This approval does not cover Indian lands. Any Class II wells on the Fort Berthold Indian Reservation must receive a permit from EPA. Operators are also required to receive a permit from the Oil & Gas Division.

Dakota Aquifer Exemption

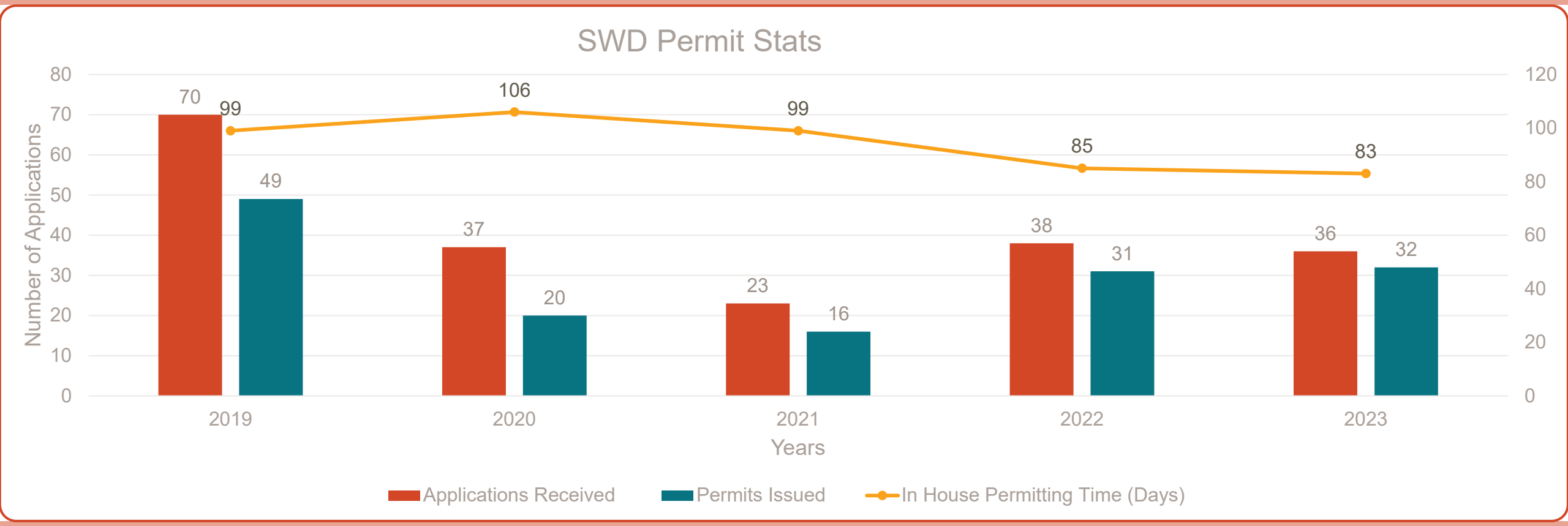
- Dakota-Lakota Aquifer was exempted for the use of Class II injection by EPA at the time Class II primacy approval.
- A study was conducted by the Oil and Gas Division which determined that the Inyan Kara Formation (targeted sands within the Dakota Group) fluids were on average greater than 10,000 ppm.
- The exemption allows for permitting of SWD wells without an operator having to sample the formation and potentially apply for an aquifer exemption from EPA if the TDS is less than 10,000 ppm.

NORTH DAKOTA HISTORICAL SALTWATER DISPOSAL vs. EOR INJECTION





NORTH DAKOTA SWD PERMITTING



NORTH DAKOTA SALTWATER DISPOSAL TRENDS

Vertical Wellbores vs. Deviated & Horizontal Wellbores	No SWD AOR is allowed to intersect with the AOR of another operator's SWD – pushing SWDs owned by different operators ½ mile apart.
Commercial SWD operators with large gathering systems	$100,000 Commercial SWD Well Bond $100,000 Gathering System Bond
Large operators splitting off SWDs and SW gathering systems into separate companies	These SWD & SW Gathering System companies are treated as Commercial
Commercial SWD operators owning SWDs under multiple LLCs	Challenge to keep track of related companies Require reporting of company officers & track previous rule violators
Drilling SWDs on OG well pads	More flexibility in application review priority to permit SWDs to be drilled while rig is drilling OG wells on pad

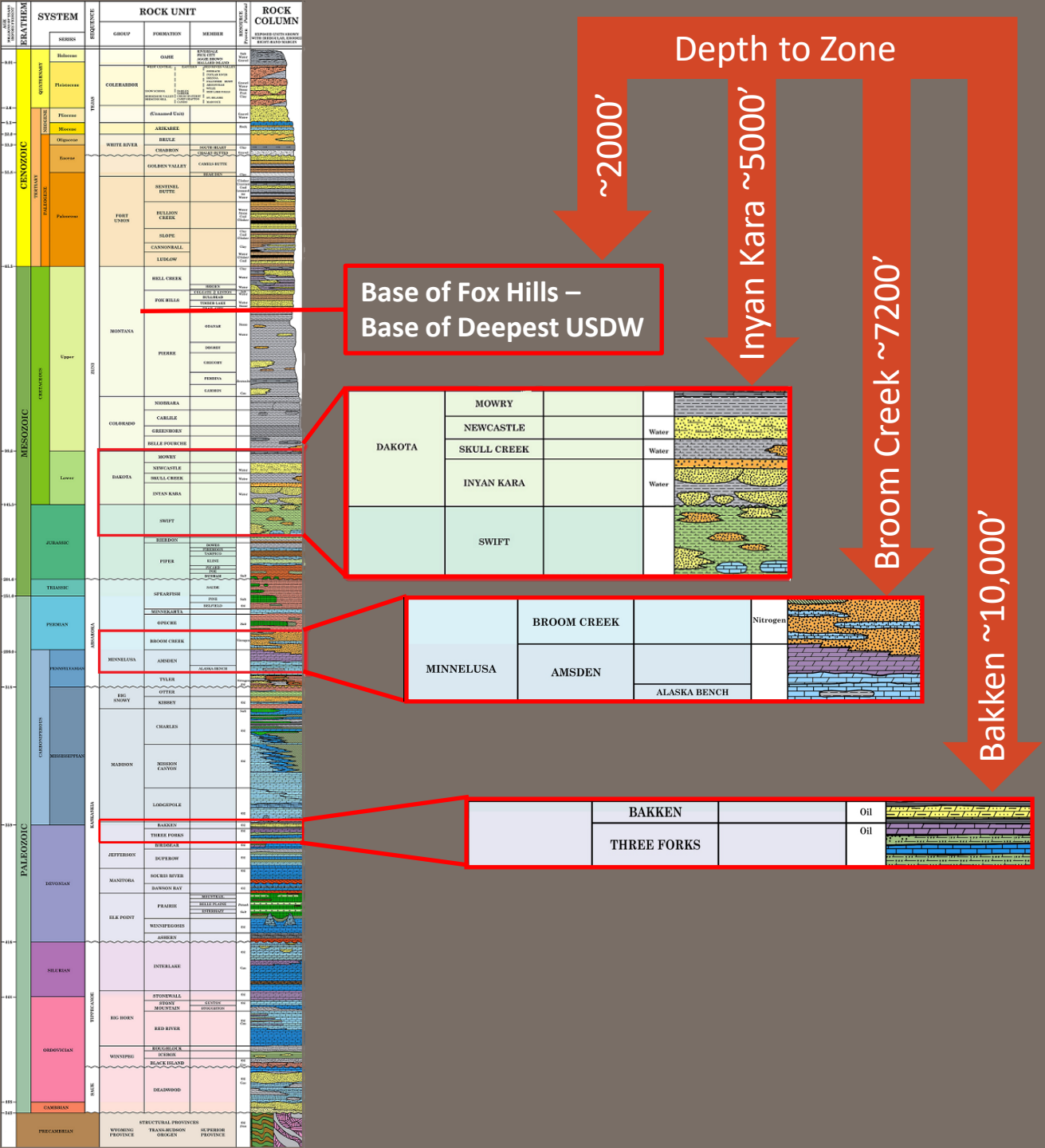
NORTH DAKOTA DISPOSAL FORMATIONS

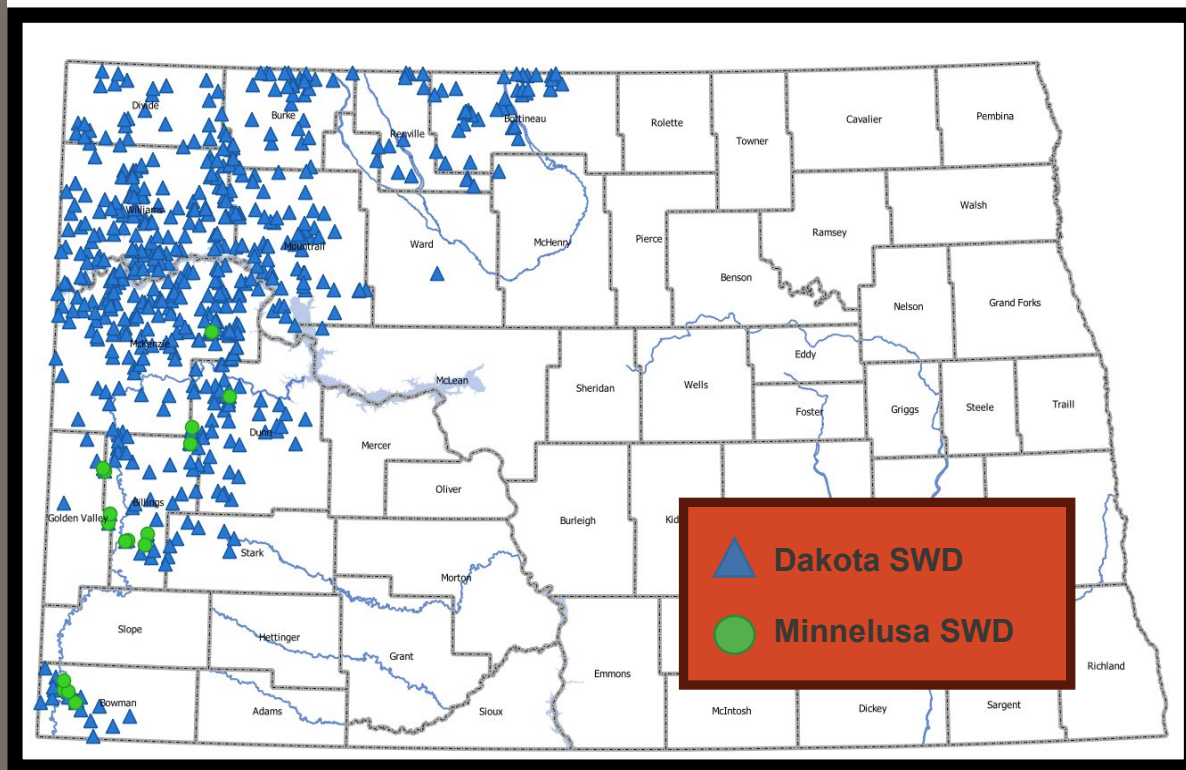
Primary Disposal Zone Target = Dakota Group

1. Inyan Kara Formation
2. Newcastle Formation

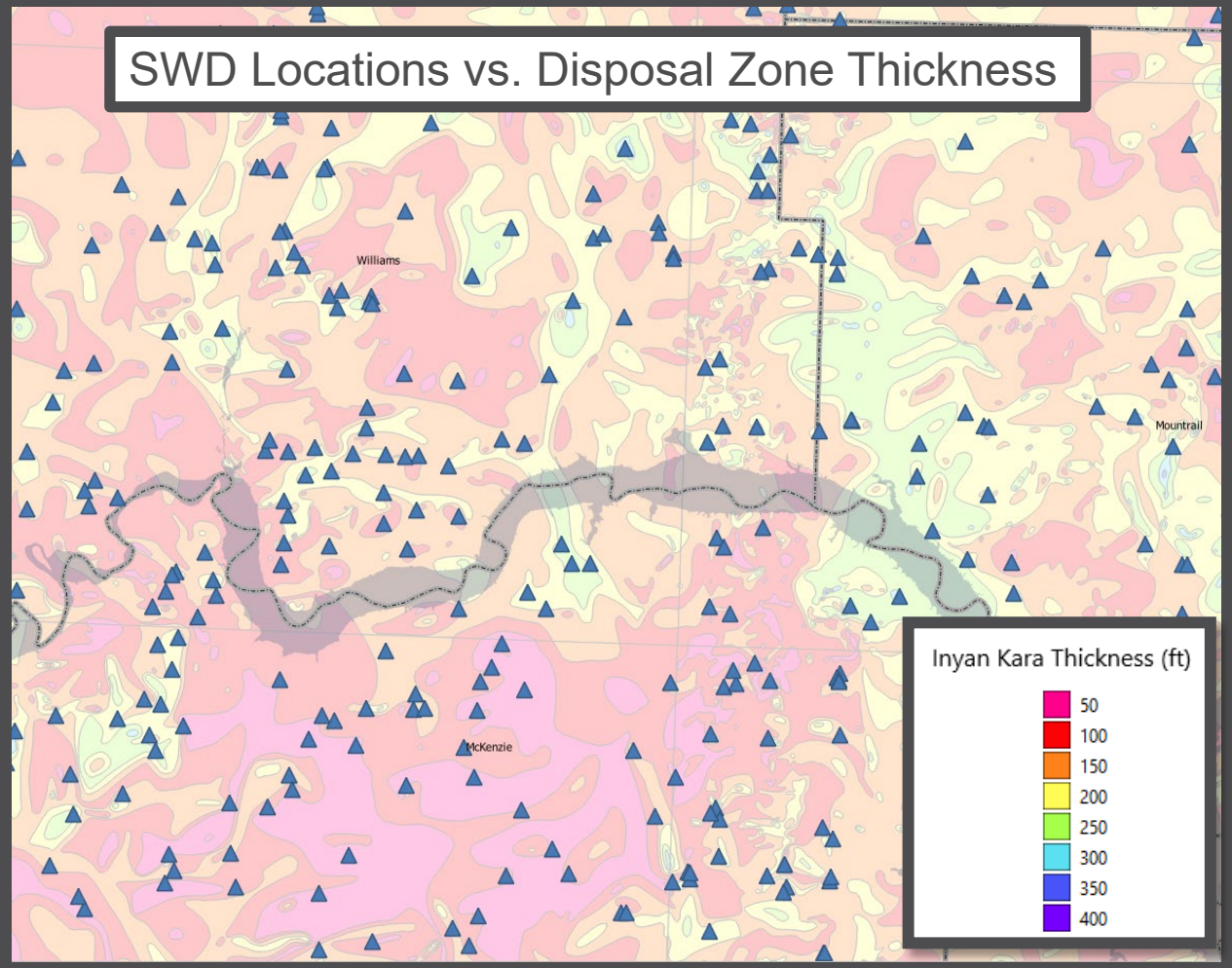
Secondary Disposal Zone Target = Minnelusa Group

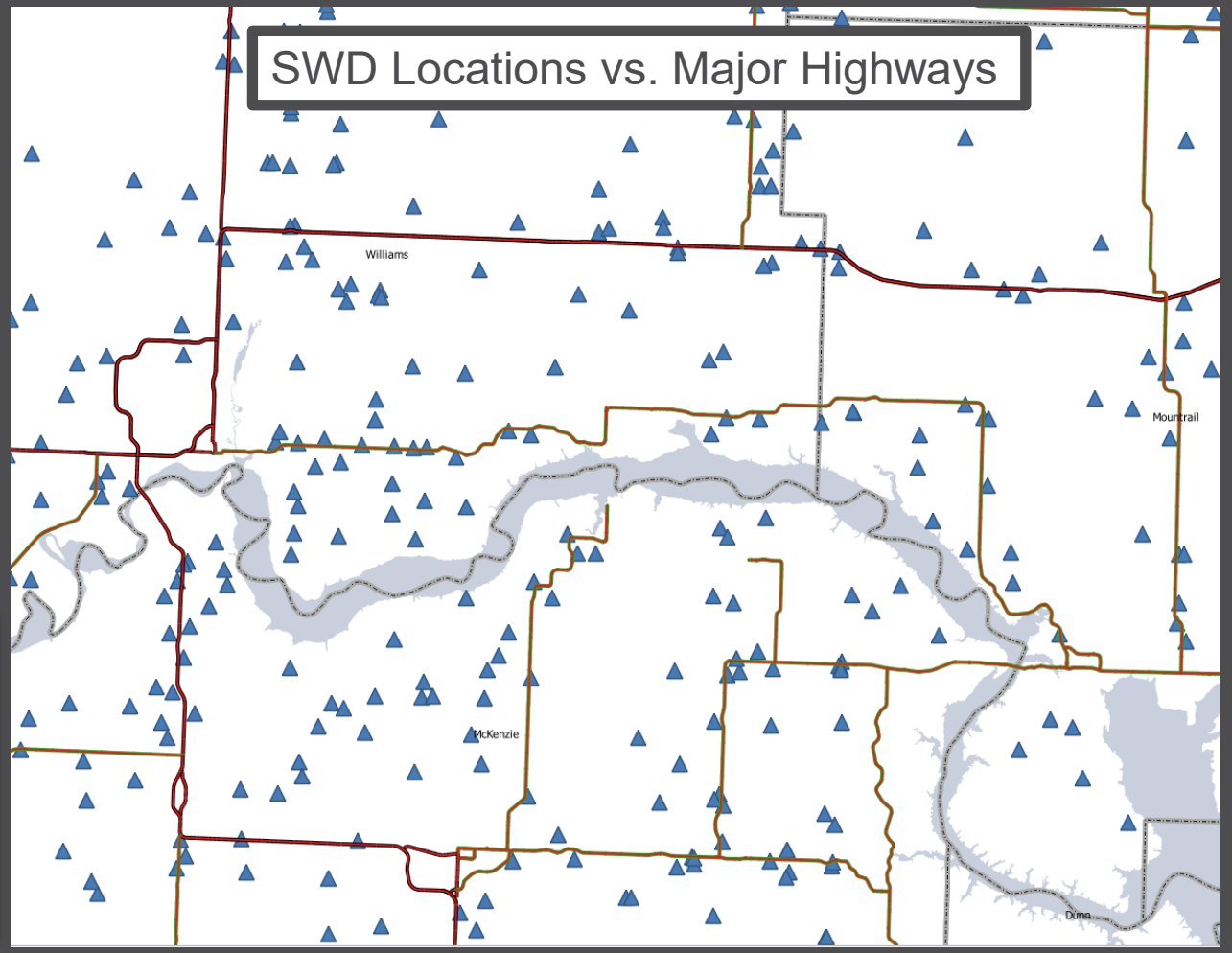
1. Broom Creek Formation





NORTH DAKOTA SWD LOCATIONS

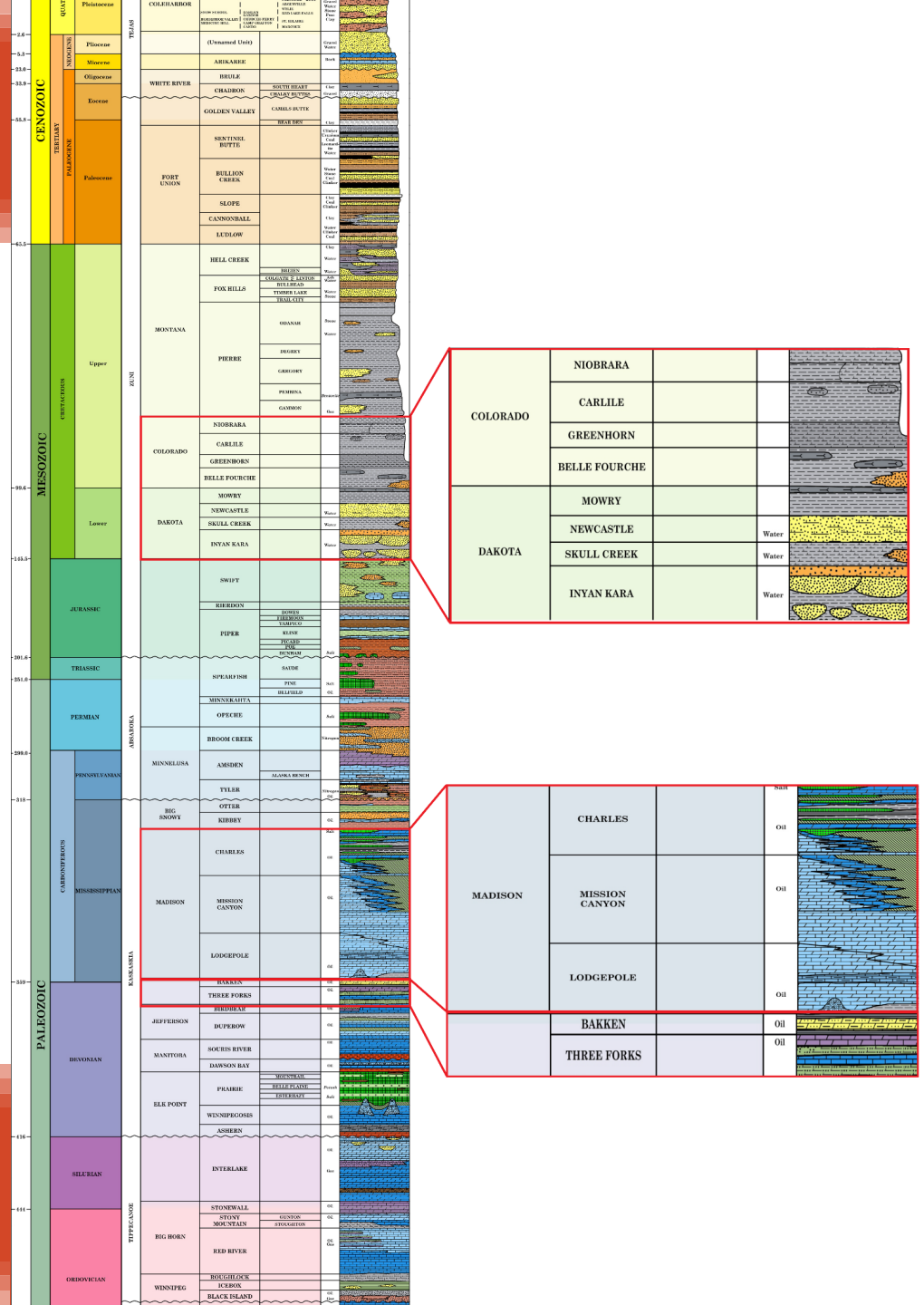




DAKOTA OVER PRESSURE

Overall Issues:

- High pressure in the Dakota
  - Mud weights required to hold back the Dakota have ranged from 11.7 ppg to 13.7 ppg
- Greenhorn (shale formation above Dakota Group) breaks down at a mud weight needed to drill through Dakota
- High mud weight used to hold back Dakota pressure breaks down the Mission Canyon (formation below Dakota Group but above Bakken Formation.



PROBLEMS

Increasing mud weight too early and breaking down the Greenhorn

Difficulty killing Dakota flow after Greenhorn has broken down.

- 8 wells plugged
- 18 surface holes plugged due to issues on the pad and the preset surface casing was not large enough to allow for an additional casing string.

Using brine while drilling the vertical portion of the wellbore damaging the shales above the Inyan Kara.

- Risk of getting BHA stuck in hole due to sluffing shales.
- Results in cementing the BHA in hole as part of plug back.
- Or BHA could be required to be fished out of hole depending on location to ensure proper isolation of formations during plug back.

SOLUTIONS

Blockade Squeezes

- Preemptive squeeze performed after drilling through Greenhorn and before entering Dakota
- Squeeze Greenhorn with asphalt grade fluid to strengthen formation enough to increase mud weight to get through Dakota and set Dakota String
- Like an LCM type squeeze, creates a barrier like a mud cake.

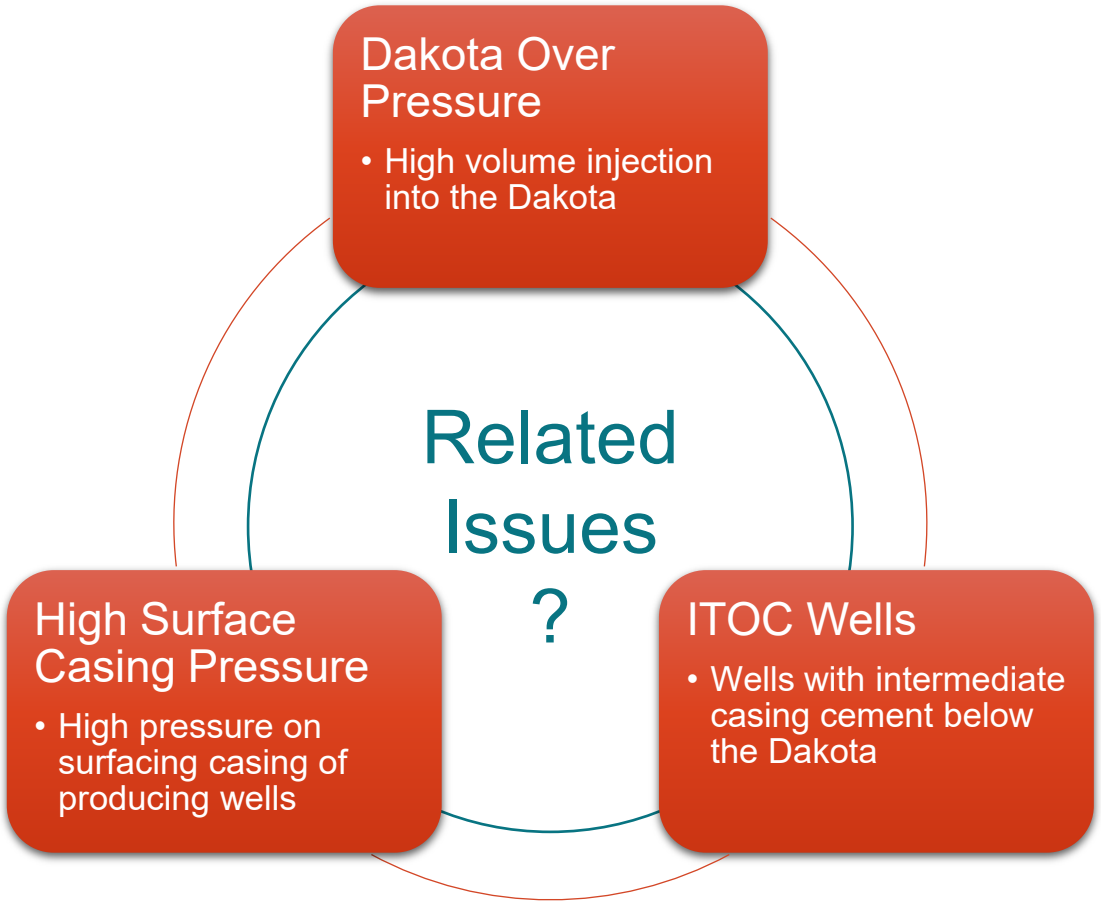
Cement plugs across the Greenhorn

- Balanced cement plug across Greenhorn, let cement set and come back and drill out
- Used to build strength across Greenhorn section
- Usually attempted after blockade squeeze failure

Pre-Drilling Planning

- Operators in areas of known pressure issues plan for additional strings during the permitting process
- Building maps and requesting data on nearby disposals

AGENCY TASK FORCES



- Formed Task Forces to look at major issues in the basin.
  1. Dakota/Greenhorn Task Force
  2. Surface Casing Pressure Task Force
- Each Task Force is made up of SMEs from the Bismarck Office and Field Offices.
- Goals:
  - Collect Data in collaboration with operators
  - Develop useful tools to help operators make informed drilling decisions
    - Providing data points
    - Creating maps
    - Writing guidance documents
- Currently working on data collection
  - Identified areas of interest
  - Working on operator assistance in detailed data collection for wells in these areas

ALTERNATE DISPOSAL ZONES

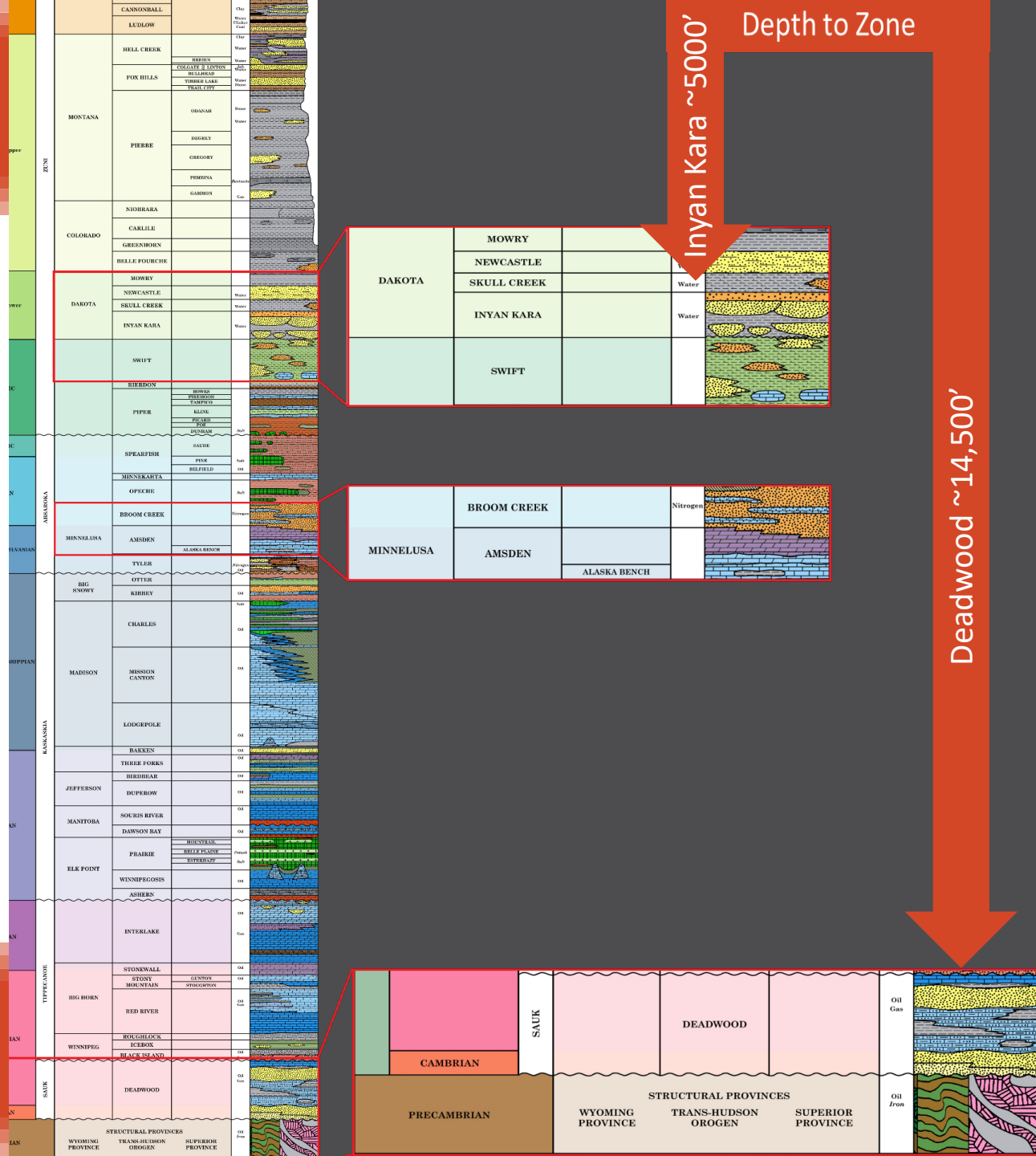
Deadwood

- Upper interbedded sandstones
- Located above the Precambrian basement rock
- At its deepest in the basin

  Top of Deadwood is ~14,500’

  Top of Bakken is at ~10,000’
- Not much information on the Deadwood in North Dakota
- Currently coring as part of Class VI projects.

Operators have discussed potential, but no projects have been pursued.



DISPOSAL INTO HISTORICALLY PRODUCTIVE ZONES

Operator must demonstrate that the correlative rights of all applicable owners can be protected.

Injection Formation Review

- [ ] Geologic Assessment
  - Structure map, isopach map, reservoir properties (porosity, permeability, oil or gas saturation, water saturation
- [ ] Presence of Hydrocarbons
  - All production records, production test, swab tests, drill stem tests, log analysis
- [ ] List of Wells and Logs used

Mineral Ownership Review

- [ ] Legal description of mineral & lessee ownership within ½ mile of the proposed completion interval
- [ ] Notification of all mineral interest owners, including overriding royalty interest owners & working interest owners of the proposed completion interval and injection formation
- [ ] Detailed analysis and explanation of how correlative rights of all owners will be protected

Commission is open to consider the potential of injection in historically productive zones and each is evaluated on a case-by-case basis.

ALTERNATIVE USE OF PRODUCED WATER?

High TDS limits SW treatment & recycle potential in the basin.

Produced Water Fracs

- Process of Rule Changes to allow for easier permitting of onsite storage of produced water in open top tanks

Lithium Extraction

- Interest in extracting lithium from produced water
- No current projects

FRACTURE SLURRY INJECTION (FSI)

1 Active SFI Well In ND

- KT Enterprises 34-22 SFI well located in Johnson Corner Field in McKenzie County
- Injection is into the Broom Creek and Amsden sands
- Active since April 13, 2021

Total Injection Volumes April 2021 - December 2023

Total Volume Injected = 3,338,973 bbls
Slurry Injected = 345,283 bbls
Solids Injected = 41,943 bbls

SFI Approval Process

- Prior to docketing any FSI project for hearing it is crucial to meet to with NDIC staff.
  - Initial geographical area review
  - Initial geological review
  - Go over all current requirements and concerns
- Application requirements are outlined in the most recent FSI order (Order No. 31434).
- Hearings involve detailed review of the geology and modeling presented for the proposed well(s).
  - A case to set the bond amount and a case for any associated treating plant are heard on the same day.
- Applications go through detailed review process.
- After the order is signed and the application has completed the review process the permit can be approved

BAKKEN EOR PILOT INJECTIVITY TESTS

Big Butte-Bakken Pilot – Hess

- Bakken Pool gas purchased from a sales point injected with water mixed with a surfactant blend to generate a foam in-situ

East Fork-Bakken – Continental

- Stimulation process utilizing cyclic injection of natural gas and flowback operations, may also inject treated freshwater and surfactant for voidage replacement to help achieve original reservoir pressure. Looking to achieve miscibility of the injected gas and reservoir oil to mobilize the oil

East Tioga-Bakken – Liberty

- Natural gas and surfactant-laiden fresh water, Rapid-Switched, Stacked-Slug - differs from WAG by rapidly (sec or mins) switching between liquid and gas injection to create a stacked slug flow

Clarks Creek-Bakken, Stanley-Bakken & Parshall-Bakken – EOG

- Temporary injection of gas during gas plant upsets or pipeline shut downs to avoid flaring and well shut-ins due to flaring and test EOR from cyclic injection and production.

McGregor-Bakken – Liberty

- Utilizing natural gas and natural gas liquids as an immiscible or miscible injectant in a fully developed Bakken Pool spacing unit. One of the takeaways of said pilot project was gas breakthrough in adjacent horizontal wells regardless of the target formation confirming communication between the middle member of the Bakken Formation and the first bench in the Three Forks Formation

Bear Creek-Bakken – XTO

- Utilizing dehydrated field gas to demonstrate the technical feasibility of increasing oil production and to optimize the gas injection, soak, and production cycles and strategies to improve gas injection and production performance

Questions?