Waste Water Disposal and Abandonment Philosophy

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Salt Water Disposal Overview

Multi-chem a Halliburton Service
Saltwater Disposal Wells

- Water plays a vital role in the oil field, whether used in the completions process or it occurs naturally in the formation being produced.
- Water must be disposed of in an environmentally sound and economically feasible way.
- Salt Water disposal systems or SWDs is one of the most economical ways to re-inject the produced water (brine) into a receiving formation.
- Operations can build their own facility or send it to a commercial SWD.
- Brine can be trucked, piped or sent by rail to the SWD, each of these includes its own set of challenges.
Operating Concerns
Maximize Oil Recovery and Water Injection Rates

Challenges
- Corrosion
- Emulsions
- Solids
- Scale
- Surface Equipment Operation

Solutions – Mechanical/Operational/Chemical
- Blanket Tanks / Chemical / Metallurgy
- Heat / Chemicals
- Filtration / Chemical
- Water conditioning / Predictive Models
- Proper design to handle the volume and quality of water
Monitoring and Economics

- Monitoring Programs
  - Well Defined Key Performance Indicators – Environmental Compliance
    - Corrosion – Coupons, Electrical Resistance, Water Analysis, etc.
    - Scale Modeling
    - Oil and grease
    - Operational Data and Proper Maintenance of Surface Equipment
      - Pressures
      - Temperatures
      - Injectivity – pressure constraints from oil and solids in the water

- Economics
  - Cost of Injection per Barrel
  - Oil recovery
  - Cost of Corrosion
    - Equipment Loss
    - Down time
Well Abandonment

Cementing
North Dakota Abandonment Philosophy

- Abandoned wells can act as a conduit in two ways.
  - Fluids from the well migrate up to other places
    - Enter freshwater aquifers
    - Transmitted to surface
    - Enter other reservoirs
  - Fluids from surface can migrate down into freshwater aquifers

- We use two methods in North Dakota to stop this from happening.
  - Squeeze Cementing
  - Plug Cementing
North Dakota Abandonment Philosophy

Squeeze Cementing

Plug Cementing

Existing Cement Sheath

Cement From Squeeze Job

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Plug and Abandon Process

**Squeeze Cementing**
- Retainer set high to meet regulatory plugging requirements
- Perform low pressure squeeze through retainer
- Run an injectivity test
- Utilize spacers and/or flushes
- Design slurry to meet formation and regulatory requirements

**Balanced Plug Cementing**
- Ensure the well is balanced and completely static
- Maximize hole cleaning and mud removal prior to cementing
- Utilize spacers and/or flushes
- Pull the pipe slowly
- Design slurry to meet formation and regulatory requirements
Typical Bakken / Three Forks Plug to Abandon

- Surface plug set a minimum of 50 ft. below surface and seals the annulus and casing.
- Base of surface casing squeeze.
- Dakota Group isolation utilizing a squeeze or balanced plug.
- Minnelusa isolation utilizing a squeeze or balanced plug.
- Bakken / Three Forks isolation utilizing a squeeze technique.