

Waste Water Disposal and Abandonment Philosophy

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Salt Water Disposal Overview

Multi-chem a Halliburton Service

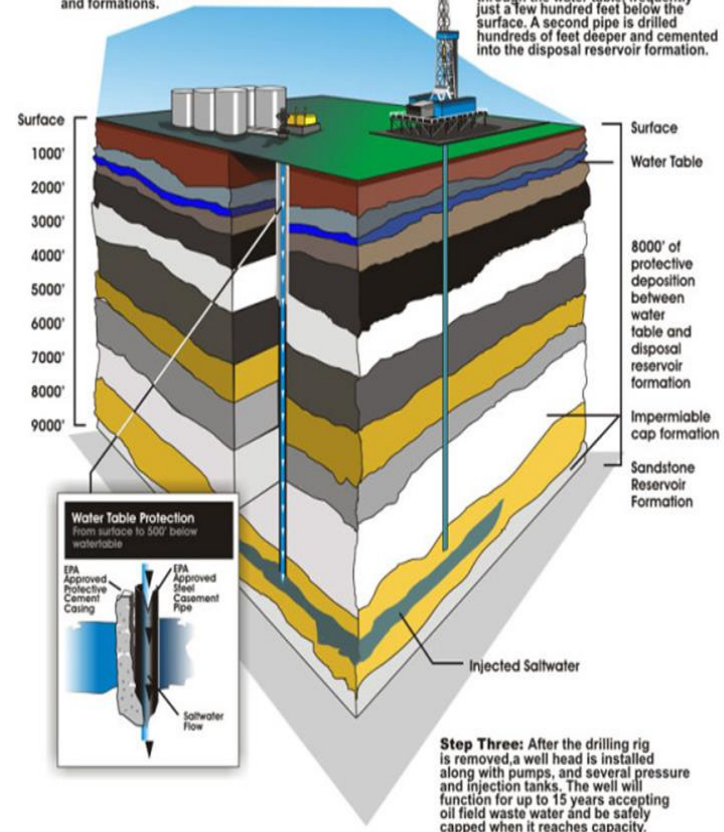
Saltwater Disposal Wells

- 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.

Saltwater Disposal Well

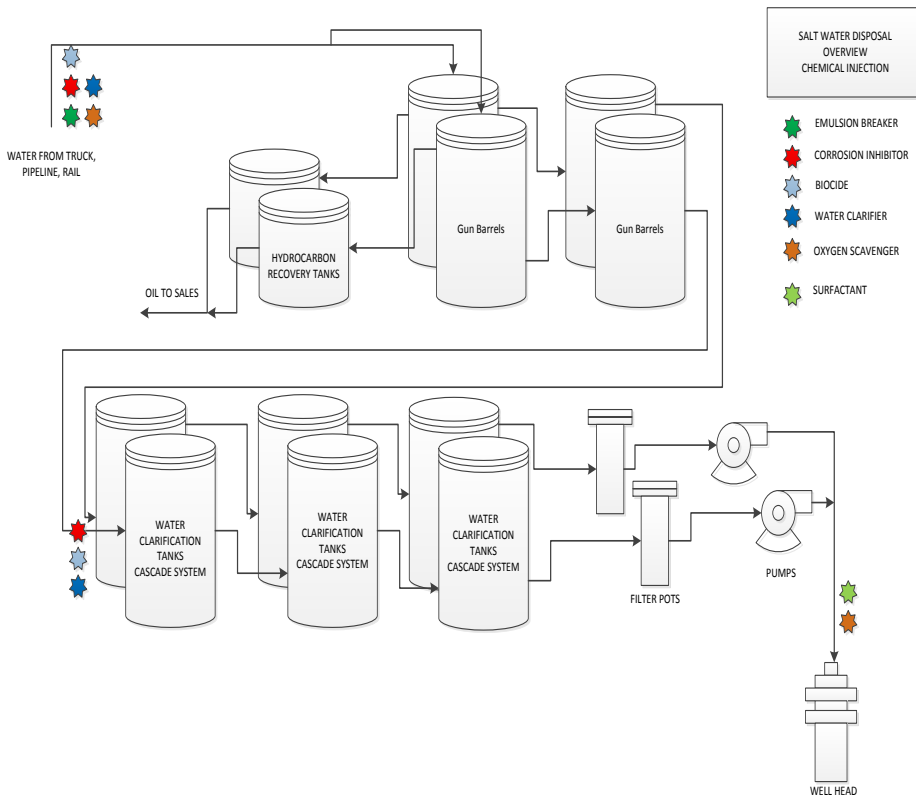
Step One: Site is prepared, drilling rig is setup and drilling begins. Over the next two weeks the well is drilled to a depth of over one mile depending on location and formations.

Step Two: Workers encase the drill pipe in a steel casing pipe as it passes through the water table, frequently just a few hundred feet below the surface. A second pipe is drilled hundreds of feet deeper and cemented into the disposal reservoir formation.



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

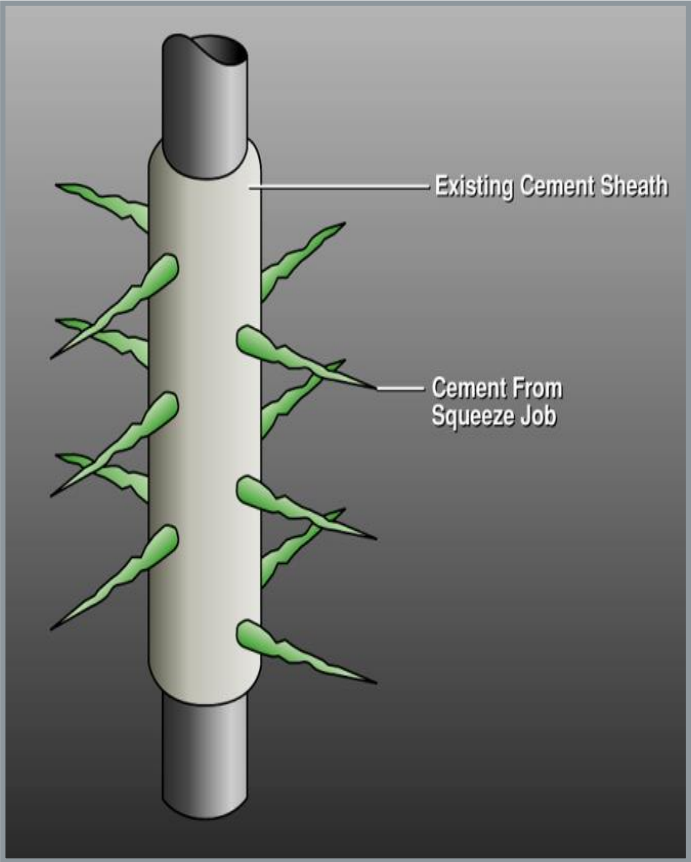
North Dakota Abandonment Philosophy

- 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

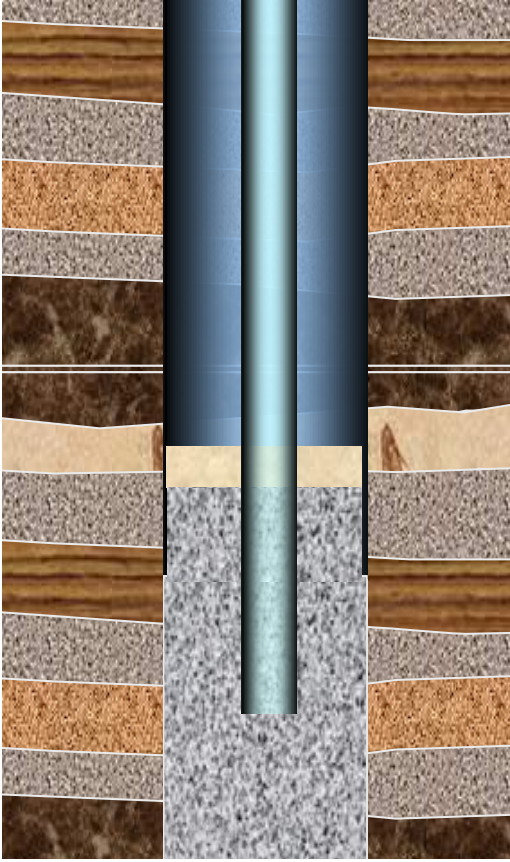
- We use two methods in North Dakota to stop this from happening.
 - Squeeze Cementing
 - Plug Cementing

North Dakota Abandonment Philosophy

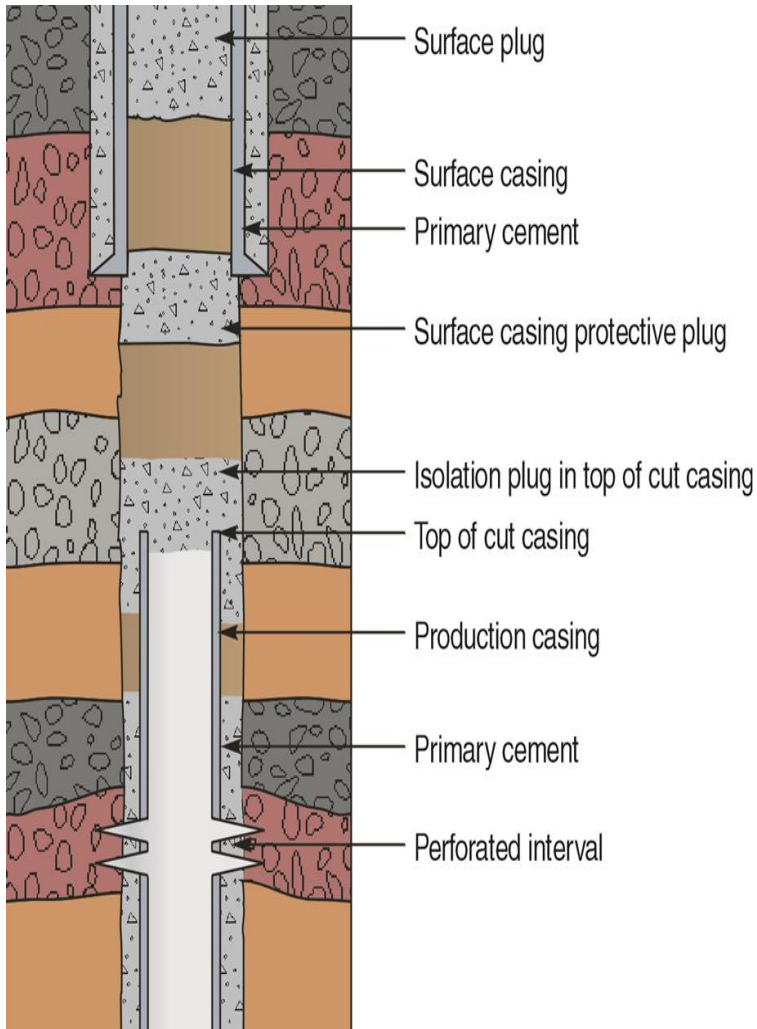
Squeeze Cementing



Plug Cementing



Plug and Abandon Process



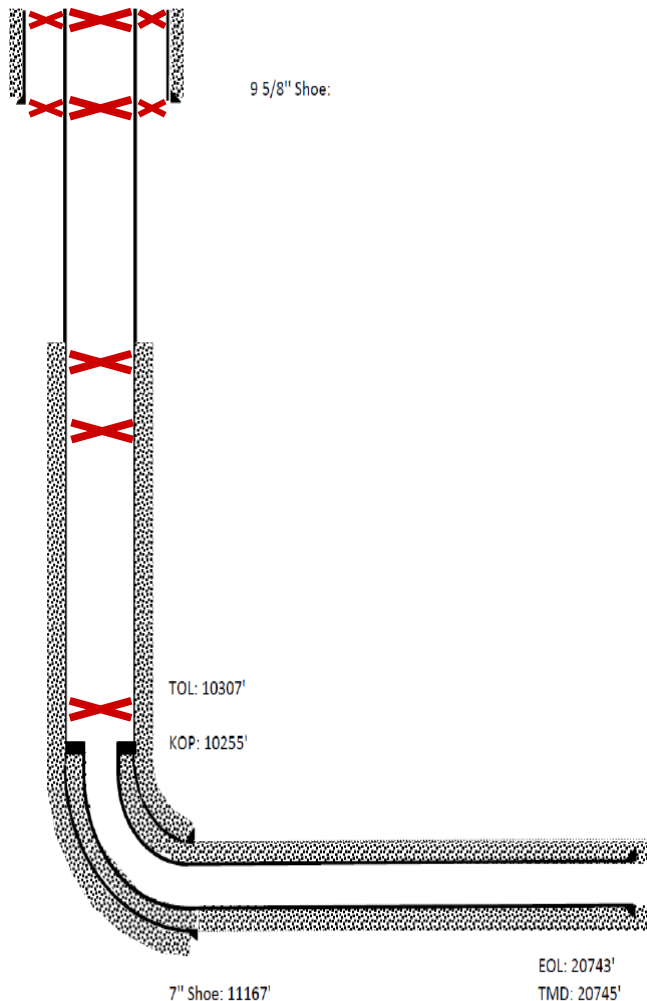
Squeeze Cementing

- 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.

THANK YOU

