

Water recycling in the oil field – how one service company does it



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A Select Energy Services Solution



Outline

- Different frac's use different chemistry
- Water quality needs – Chem 101
- Treatment techniques
 - Low-level
 - Mid-level
 - High-level
- Bonus challenges



Different formations need different frac strategy

- **Geology**

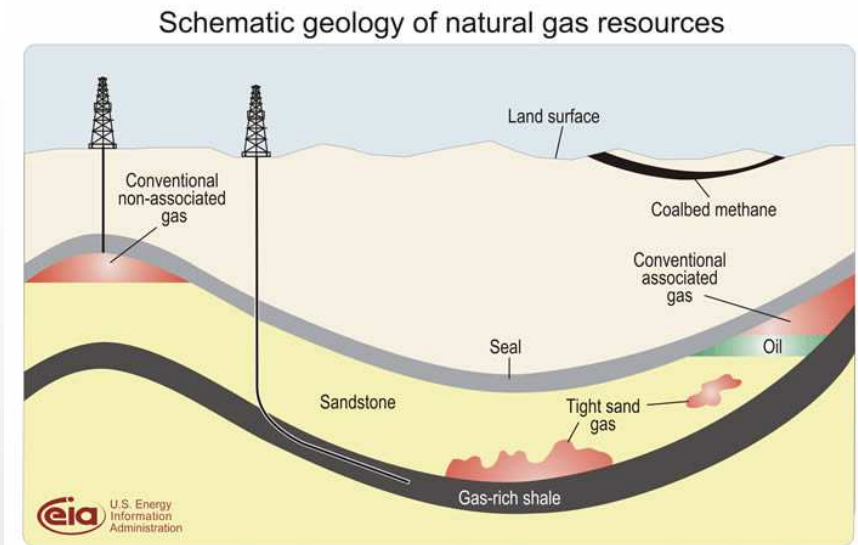
- Shale/tight sandstone/porosity
- Permeability
- Minerals
- Frac program:
 - Linear
 - Bilinear
 - Radial

- **Vertical Well**

- More often use simpler chemistry

- **Horizontal Well**

- More often use complex chemistry fracs



What are the different types of frac packages?

• Slick

- Forgiving chemistry (FR)
- Consumes more water/stage
- Minimal treatment



• Gel

- Variable complex chemistry
- Variable treatment needs
- More water efficient/stage

• Crosslink Gel

- Complex chemistry
- Highest water quality needs

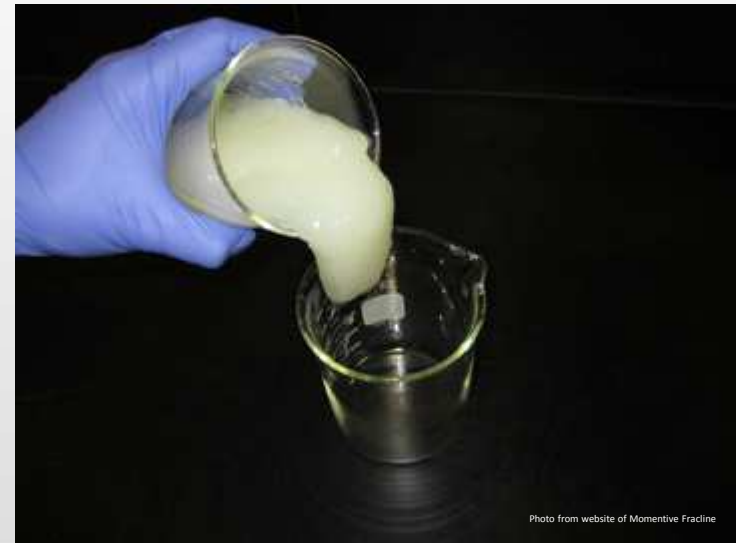


Photo from website of Momentive Fracline

What happens if I can't use fresh water
and have contaminants?
Frac contaminant chemistry 101

- Biological activity
 -
 -
 -
- Turbidity (TSS + oil)
 -
 -
 -
- Iron (Fe)
 -
 -
- Hardness & Sulfate
 -
 -
- Salts (including Boron)
 -
 -



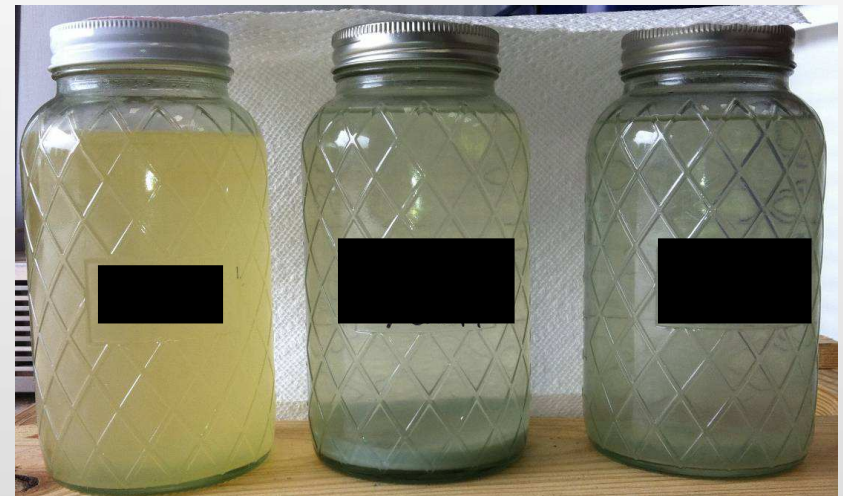
Frac contaminant chemistry 101

- Biological activity
 - Slime formation (loss of conductivity)
 - H₂S formation (safety and quality loss)
 - Corrosion (acid byproduct corrosion of piping and equipment)



Frac contaminant chemistry 101

- Biological activity
 - Slime formation
 - H₂S formation
 - Corrosion
- Turbidity (TSS + oil)
 - Consumes friction reducer (chemical bill goes up)
 - Solids can plug gaps between propanant (loss of conductivity)
 - Oil content is bug food during storage (water & well fouling)



Frac contaminant chemistry 101

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- Iron (Fe)
 - Can react and precipitates as a scale down hole (loss of conductivity)
 - Frac chemistry interference (particularly crosslinkers)



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- Hardness & Sulfate
 - Scaling (loss of conductivity)
 - Interference with frac chemistry (crosslinkers + hydration of FR)



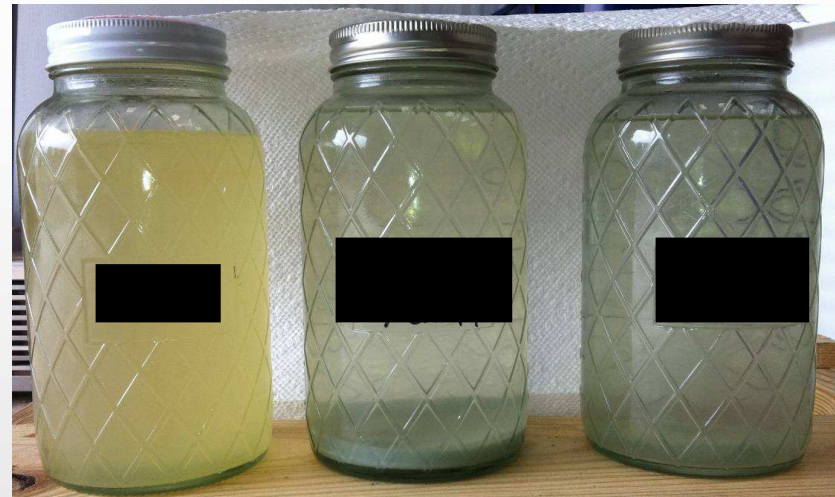
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- Salts
 - Affects frac chemistry (hydration & crosslinking)
 - Affects clay swelling (a good thing)



Recycle treatment levels

- **Low level: Basic**
 - Forgiving system and more is not needed
 - Willing to accept some risk
- **Mid level: Clean brine**
 - Target contaminant removal
 - Some risk mitigation
- **High level: Fresh water**
 - All TDS removed
 - Risk elimination
 - Simplified water logistics



Low level: Used for diluted and forgiving frac

- Bag filter
 - Pump through a pod with 50-100 micron sack filters
 - High rate and removes gravel, turtles, and twigs
 - Essentially no effect on anything else
- Bag filter + biocide
 - Same as above, plus sterilizes the water
- Field oxidation (ClO_2 , H_2O_2 , etc.)
 - Good sterilization
 - Harsh chemicals - require some care to avoid sending residual oxidizer downstream
 - Can create a solids byproduct issue



Mid level: Clean Brine - Good enough for most frac's with low risk

- EC + chemical treatment
 - Electrical current to aid coagulation
 - Chemical addition for further treatment
 - Settling tanks and polish filtration
 - Removes turbidity, Fe, bugs, and some hardness



Mid level: Clean Brine - Good enough for most frac's with low risk

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 - Electrical current to aid coagulation
 - Chemical addition for further treatment
 - Settling tanks and polish filtration
 - Removes turbidity, Fe, bugs, and some hardness
- Mobile clarification
 - Chemical addition for solubility adjustment and flocculation
 - Settling chambers with inclined plates for turbidity removal
 - Removes turbidity, Fe, bugs, some hardness
 - Filter press to minimize solids – dry cake solid waste



Mid level: Clean Brine – what if I want high rate treatment?

- Oxidation + solids management
 - ClO₂ oxidation, which is traditionally done for bio-kill.
 - Also a good mid-level recycle treatment – WHEN APPLIED CORRECTLY. Removes turbidity, iron, and sterilizes.
 - Integrated.
 - High rate treatment (40k bbl/day flowback. Same rate as frac with fresh water).
 - Differentiating ClO₂ approach
 - Professional. \$55MM development program.
 - 20 units.
 - Over 1000 inputs into the PLC for control.
 - Top safety integration.
 - Control every drop of water, not just a slip stream like most providers.



Water purification – High level: Good for all frac

- Oxidation plus membrane (OMNI)
 - Pretreat with: Ozone + chem-treat before membrane
 - Removes Fe, turbidity, bio, and some hardness
 - Oxidizes or removes membrane harming organics
 - Followed by membrane treatment
 - First banks of membrane removes all the hardness
 - Final bank of membranes remove TDS – giving pure water
 - Low TDS water: removed nearly all contaminants



Water purification – High level: Good for all frac – risk elimination

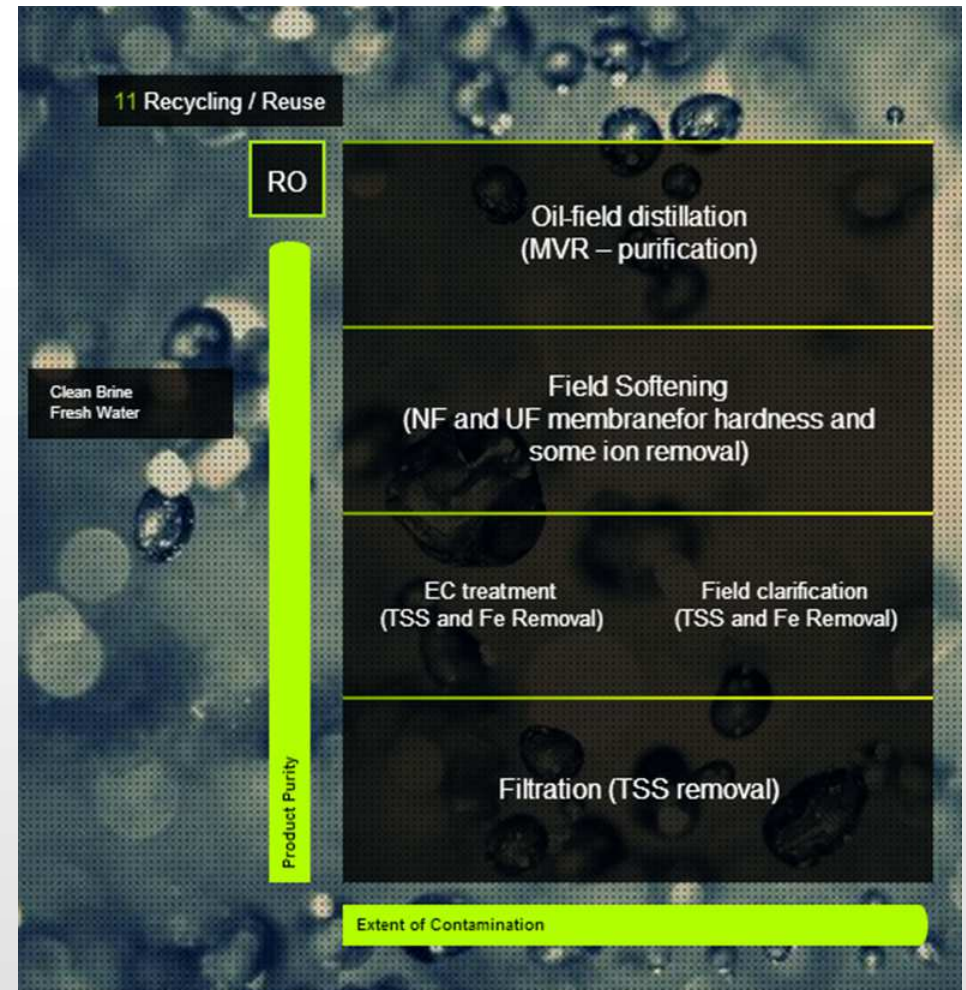
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 - Low TDS water: removed nearly all contaminants
- Thermal evaporation (NOMAD)
 - Pretreat with mobile clarification
 - Remove Fe, turbidity, bio, and some hardness
 - Dry cake solid waste
 - Distill with mechanical vapor recompression
 - High thermal efficiency (20X higher than simple boiling)
 - Distillate quality water - some states allow to transfer/store/handle like fresh water





Points to remember

- Economics rarely sell recycling – it's lack of availability that sells it
- There is no one-solution, because different frac calls for different quality water, that has different starting points.
- Select does not develop or own a water treatment technology – we partner with the developers and work with their operations to execute an overall project that includes the right treatment tech.





Purpose: Insufficient fresh water, so recycle high H₂S produced water for frac

Who: Apache

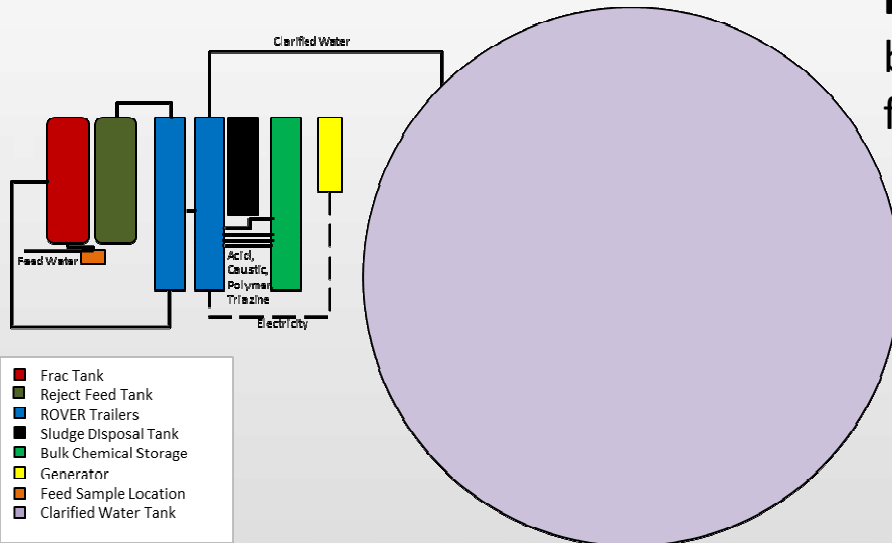
Job: Mob/Demob to central site and produce 250,000 BBL for use in a 4 well frac program

When: May - July 2013

Where: Notrees TX, Permian Region

What: Fountain Quail ROVER system + H₂S agent; Big Holdings containment; transfer

How: Neutralize H₂S; remove turbidity & Fe; kill bacteria; make clean high TDS reuse water for frac; inventory in tank; minimized solids waste



Result: Wells frac'd on schedule and on budget. Just starting another 40 well treatment campaign with same customer using the ROVER.

Additional oilfield water challenges to manage

- Sulfide laden water management
 - Oxidize (ClO₂, H₂O₂, Ozone)
 - Sequester (Agent)
- Stagnant water pit souring
 - Manage by aeration to oxygenate and prevent SRB from souring
- Pit volume uncertainties
 - 1-time Remote boat surveys with soundings for pit depth mapping
 - Real-time depth monitoring sensor with satellite coms.
- Zero liquid discharge
 - Complete elimination of all liquid streams – it's an option.
- Overall water program management
 - Service providers:
Source, transfer, containment, monitoring, treatment, disposal.





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