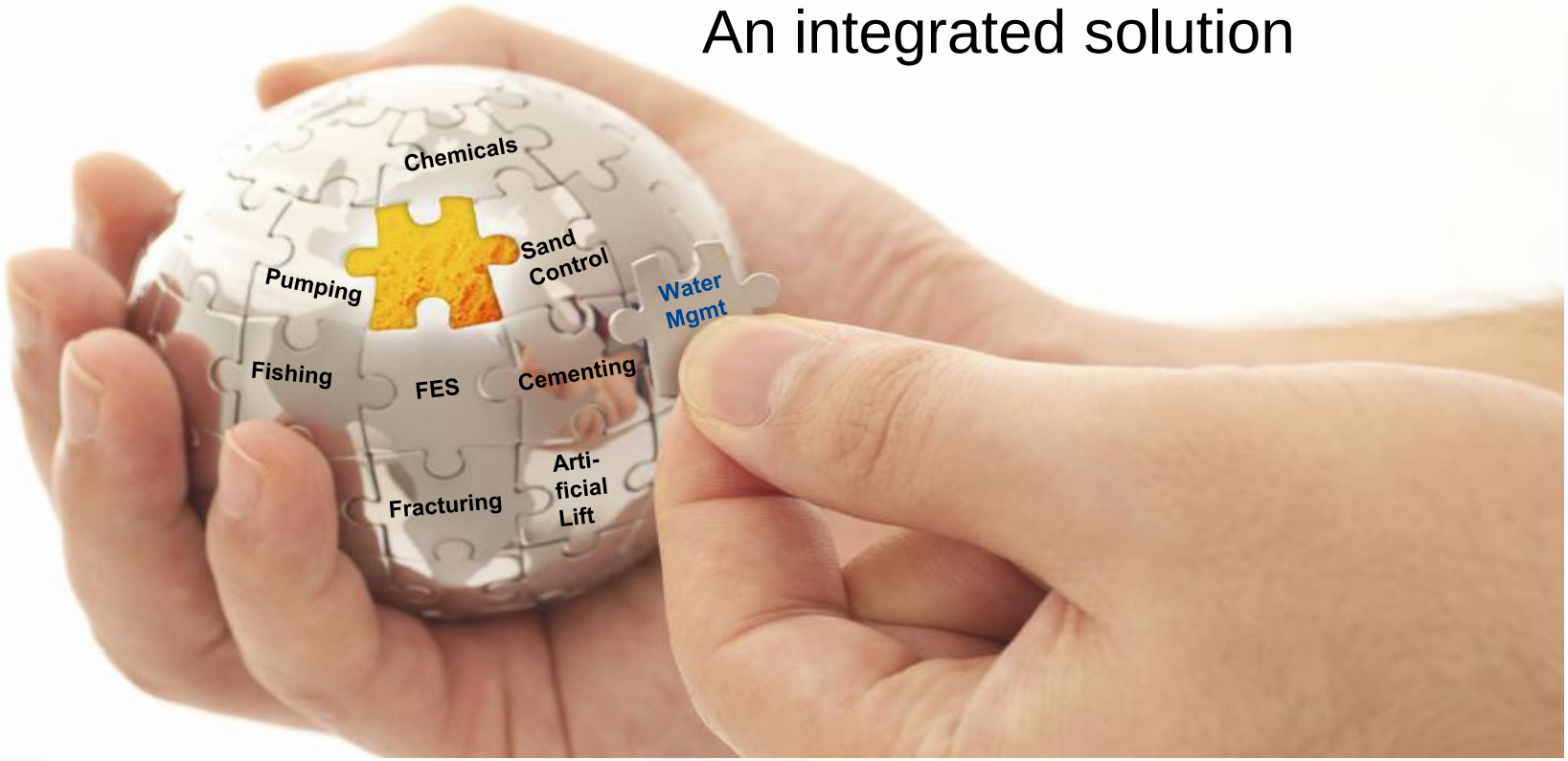
Sustainable fracturing

A case study in Baker Hughes Water Management

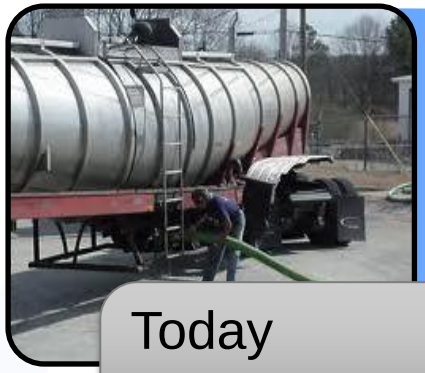


Why is water important?

- *In the last 100 years, water use has grown at more than twice the rate of population*
- *50% chance Hoover Dam goes dark by 2017*
- *Water that enters an underground aquifer remains takes 1,400 years to purge versus 16 days for rivers.*

1. *"Freshwater Crisis," National Geographic, 3/10*
2. *"When will Lake Mead go dry?", a Scripps Institution of Oceanography study, Dr. Tim Barnett and David Pierce, 11/07*
3. *"The Hidden Fresh Water Crises," World Watch, 2000*

Optimum water recycling is a complex problem



Today

- Haul & Dispose
- No Treatment

Mobile treatment
Stationary facility
Semi-permanent hybrid

Fluid compatibility
Proppant placement
Scale-potential
Microbiological growth
Formation damage

OTG piping
Permanent piping
Trucking

Disposal wait times/fees
Local regulations
Environmental footprint

- The best solution
  - Addresses people safety and the environment
  - Achieves quality and volume goals
  - Is price competitive with non-recycling options

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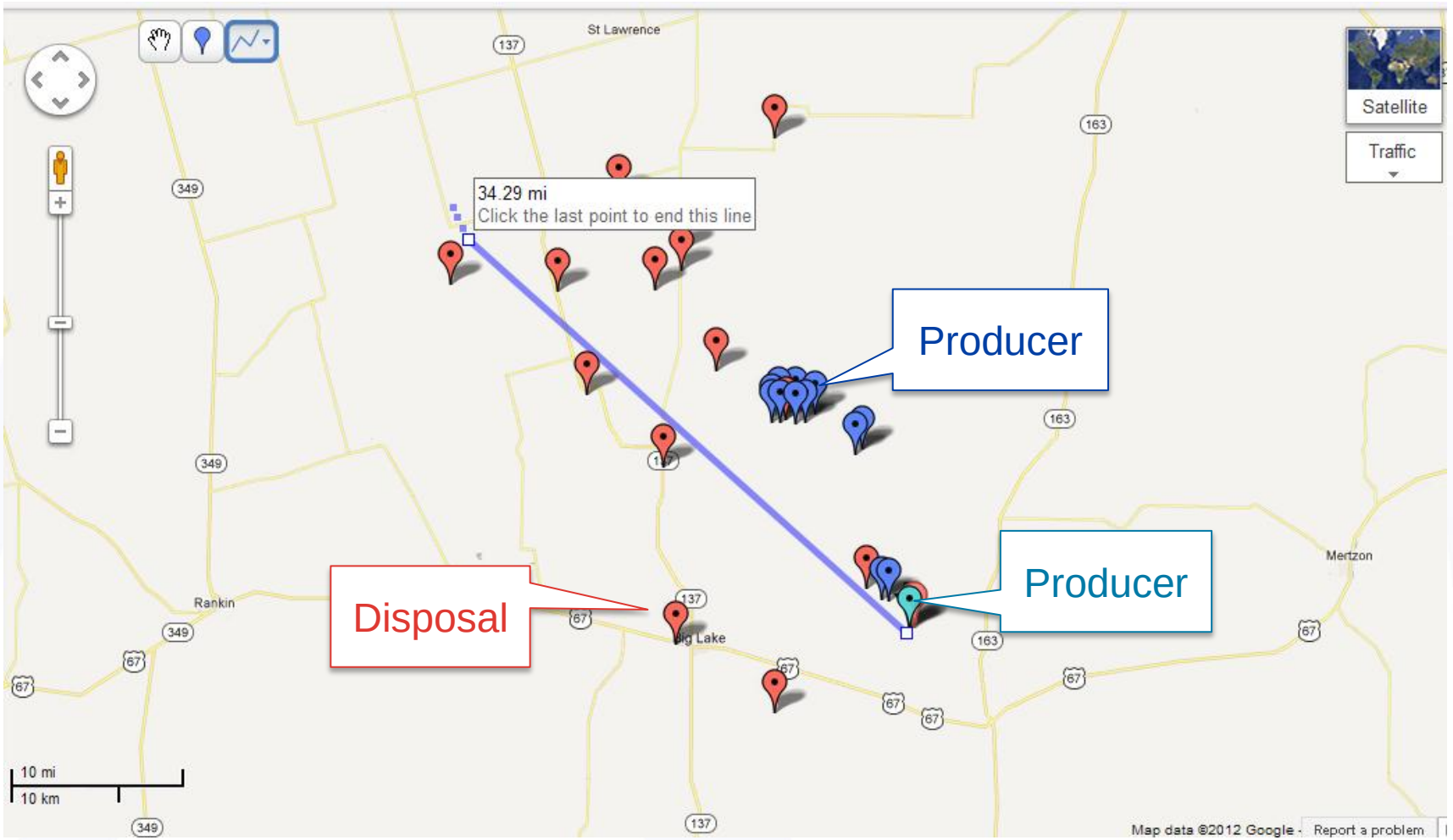
More produced water than needed for operations

Over 2 years

Fresh water required for fracturing	**4.8 MM BBLs**
Waste water generated	**7.1 MM BBLs**
Produced water generated	5.1MM BBLs
Flowback water generated	1.4MM BBLs
Reserve pit water generated	0.6MM BBLs
Total Water Costs	**$23 MM**
Fresh water	$2.1MM
Moving water	$6.9MM
Disposal fees	$14MM

But where is that water



Regulations are still emerging & complex

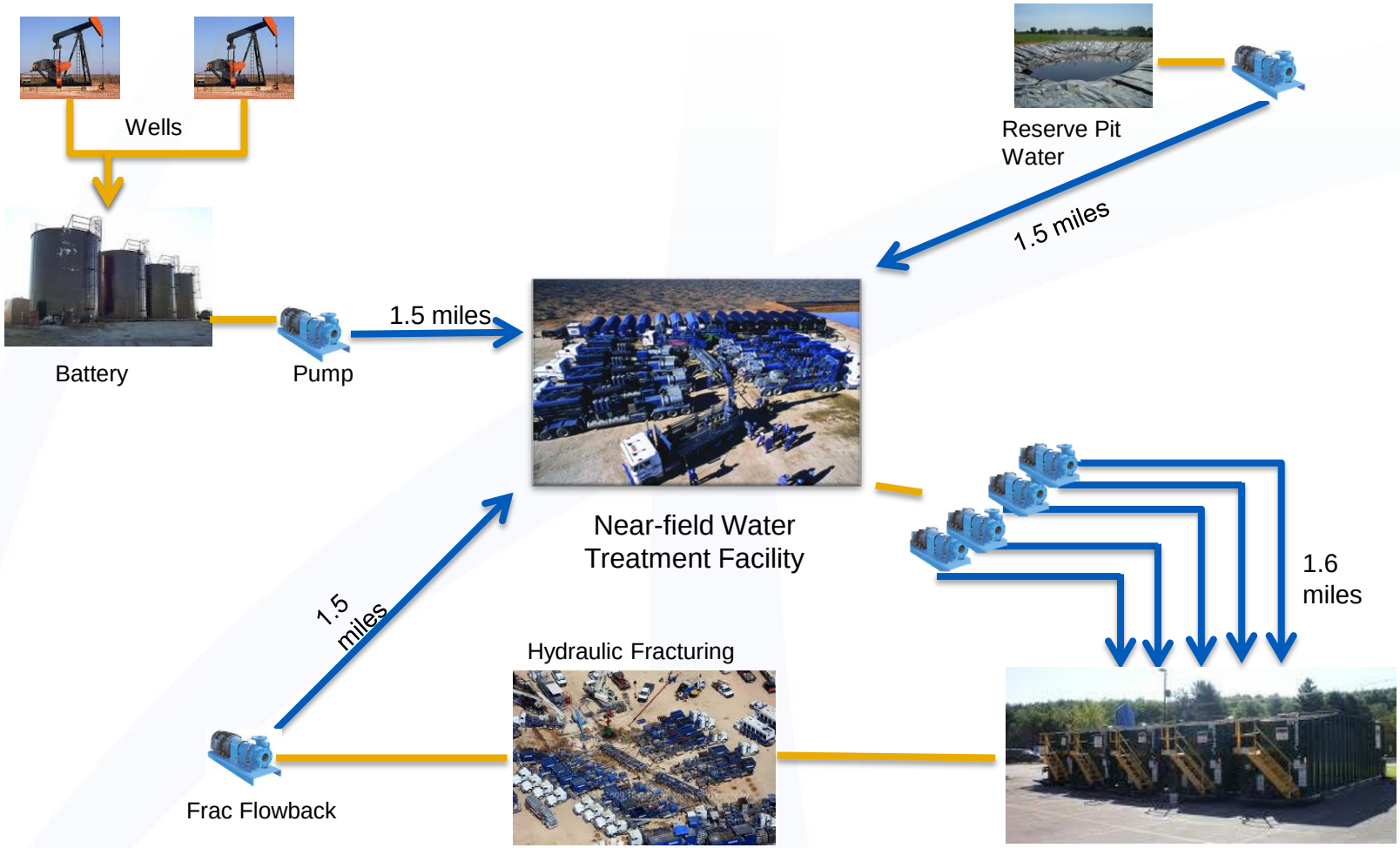
- Federal
  - U.S. Environmental Protection Agency (EPA) – RCRA C and D
  - Department of the Interior's Bureau of Land Management (BLM)
- Produced Water Management Information System

  http://www.netl.doe.gov/technologies/pwmis/regs/index.html
- State and Territorial Environment Agencies
  - Regulations vary widely…

Regulations Quiz… Texas Edition

Question	Answer
What Texas institution is responsible for air quality?	Texas Commission on Environmental Quality (TCEQ).
What Texas agency is responsible for regulation of oil and gas development?	Texas Railroad Commission (TRRC)
What TRRC regulation covers commercial water recycling?	*Title 16, Part* 1, Chapter 4, Subchapter B
What is the threshold level for chlorides in 'fresh' water?	3,000 mg/L
When operating a stationary treatment facility, can you accept waste from other operators?	Only when you are an operating company with an existing permit
Bonus question for John: What does FIFRA stand for?	Federal Insecticide, Fungicide and Rodenticide Act

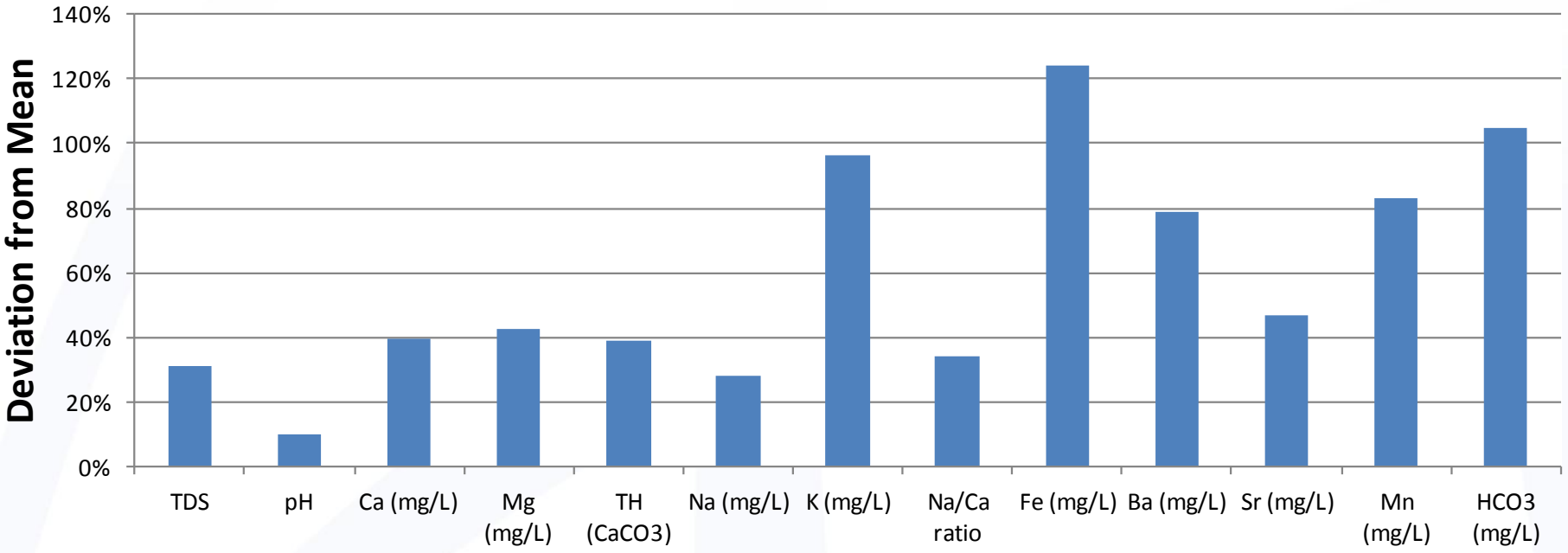
For this operator, near-field treatment made more sense



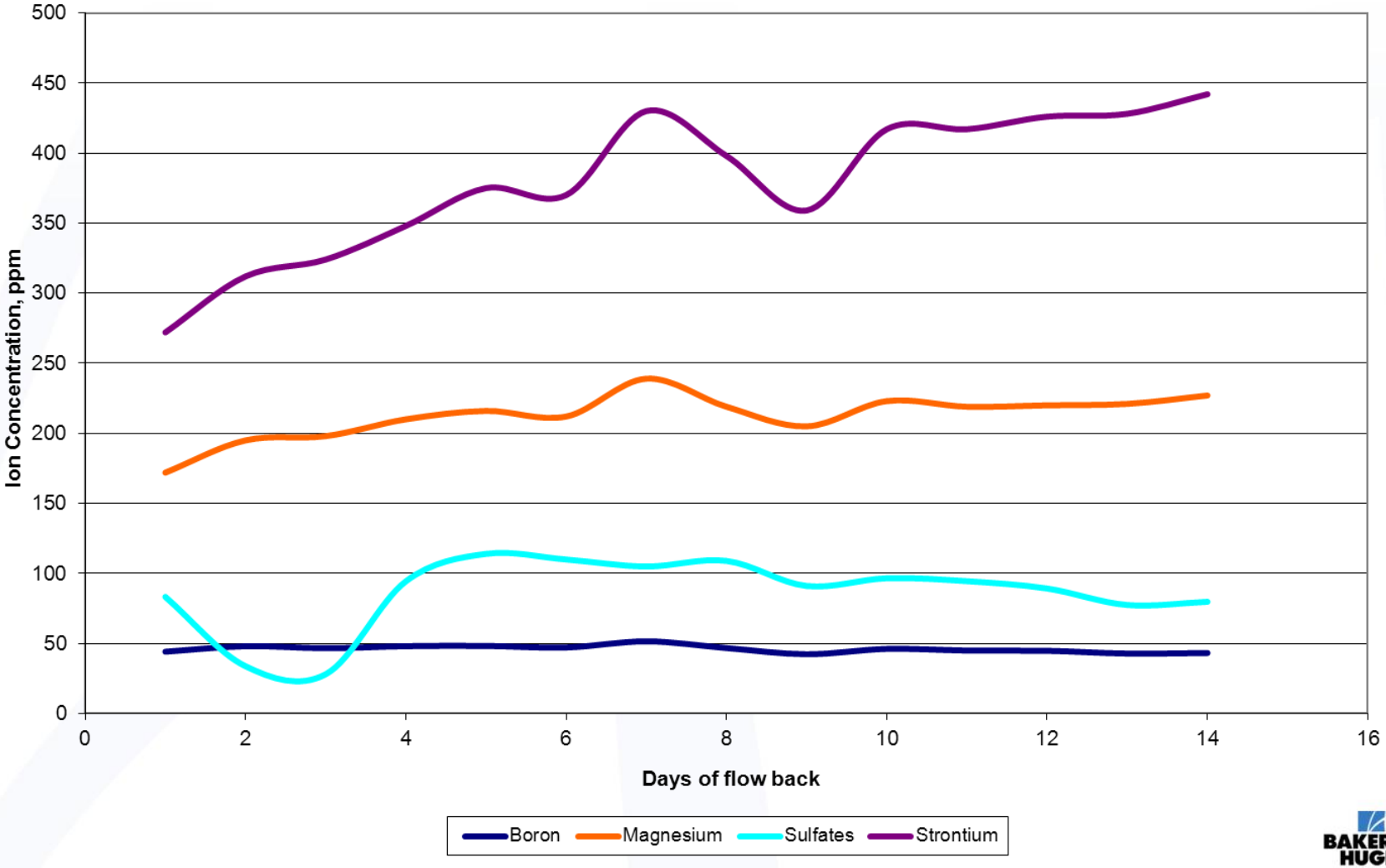
Treatment location options

	Central Facility	Near Field Location	Mobile Treatment
Pro	Economy of scale Standardization High volume	Modular Reduced footprint Scalable	Small footprint Quick response Lower OPEX
Con	CAPEX intensive Not easily moved Infrastructure	Infrastructure	Storage Temporary pipelines Lower volume

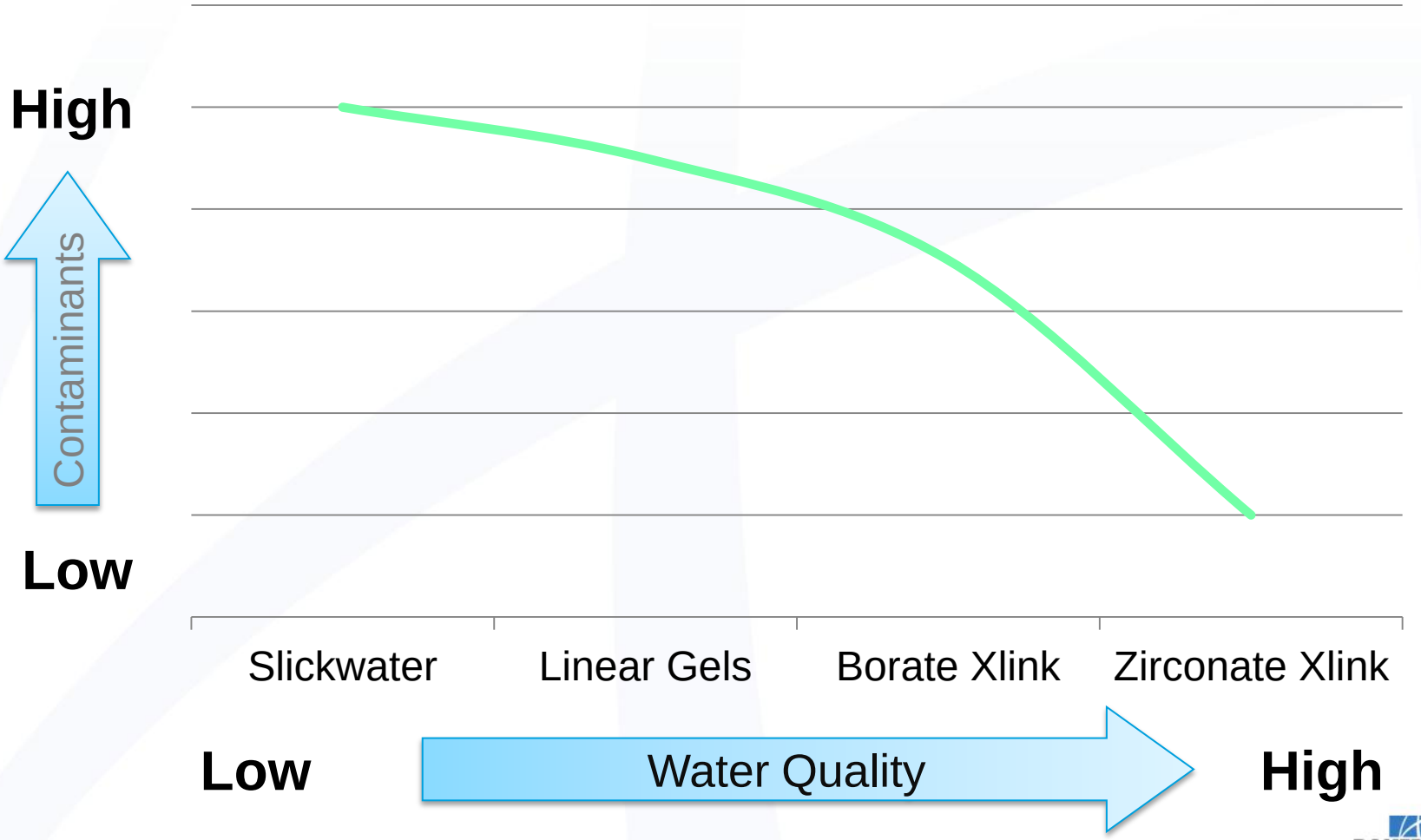
Water varies over different wells in the same field



And changes over time



Frac Fluid Compatibility



No one technology can do it all

Treating water ‘just enough’ for reuse

#	Treatment	Reusable?	Cost (Multiples of 1)	Waste (Multiples of 1)
1	Filtration	✓	1.0	1.0
2	Chemical Clarification 1	✗	0.5	1.0
3	Chemical Clarification 2	✓	1.3	2.0
4	Chemical Clarification 3	✗	0.3	0.6
5	ClO2	✗	0.5	0.6
6	ClO2 and filtration	✓	1.5	1.0
7	Electrocoagulation	✓	0.85	0.4

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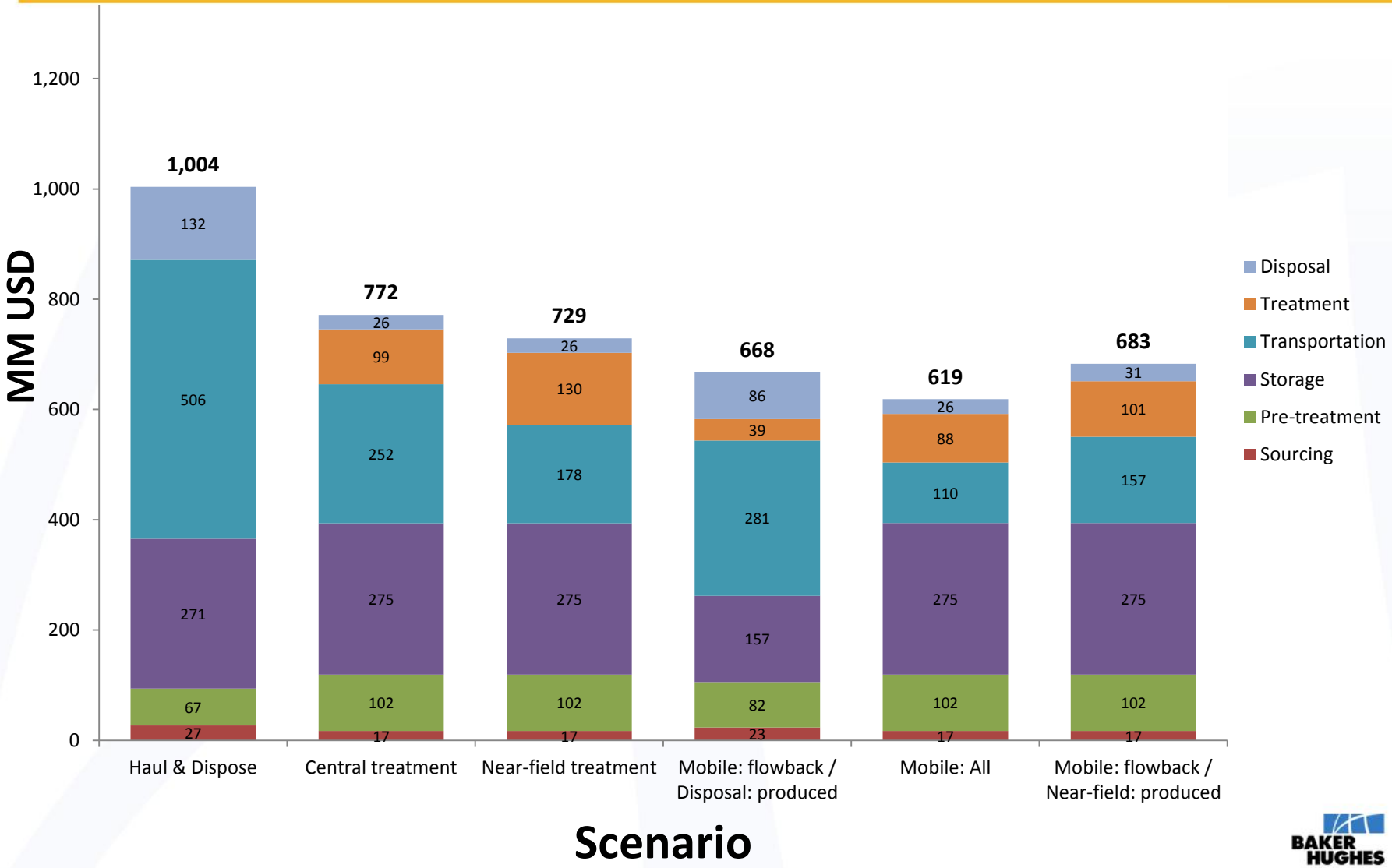
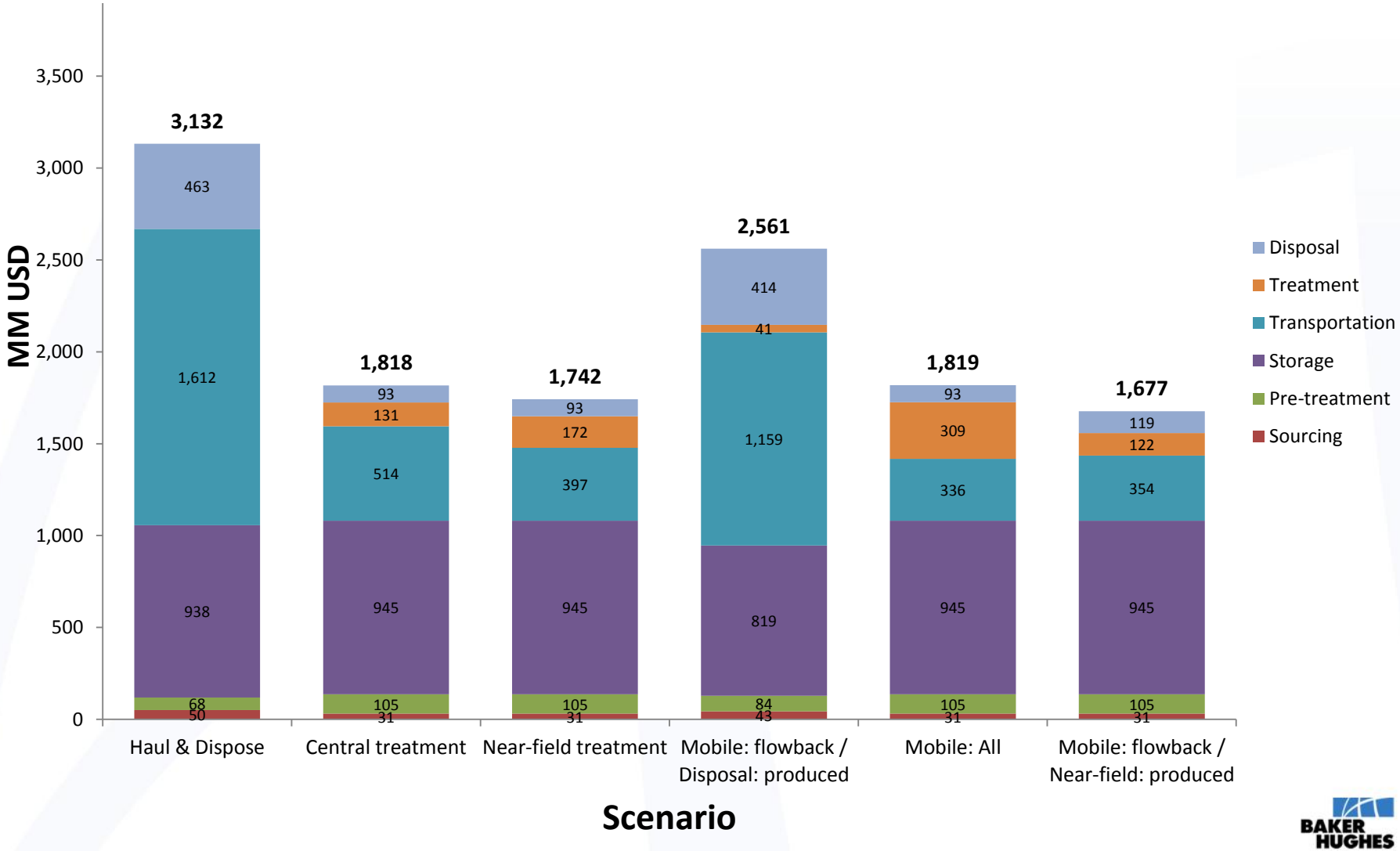
Mobile treatment best choice with 5 yr outlook

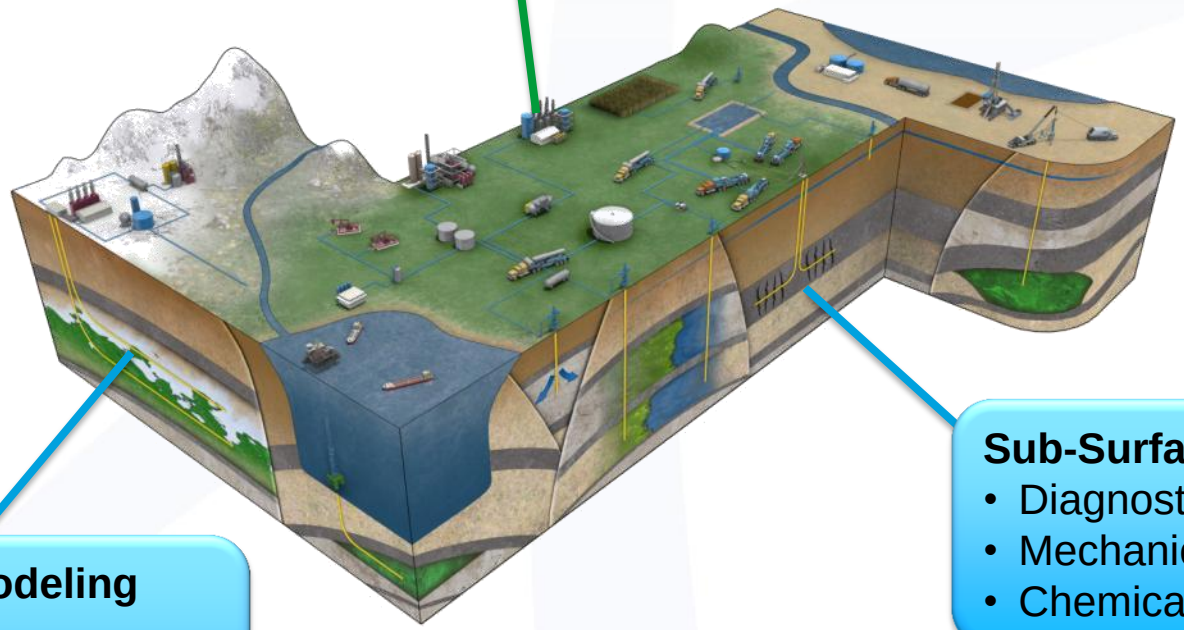


Hybrid solution best with 20 year outlook



What Baker Hughes offers

Flexible Surface Water Solutions
- Menu of technologies
- Stationary or mobile treatment
- **Reuse guarantee**



Reservoir Modeling
- Planning
- Avoidance
- Water shut-off

Sub-Surface Solutions
- Diagnostics
- Mechanical shutoff
- Chemical shutoff

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Focus on Production

We’ll take care of the Water

