



An Overview of New Water Treatment Technologies for Unconventional Oil & Gas

Tom Pankratz – Houston, Texas

Produced Water Dynamics

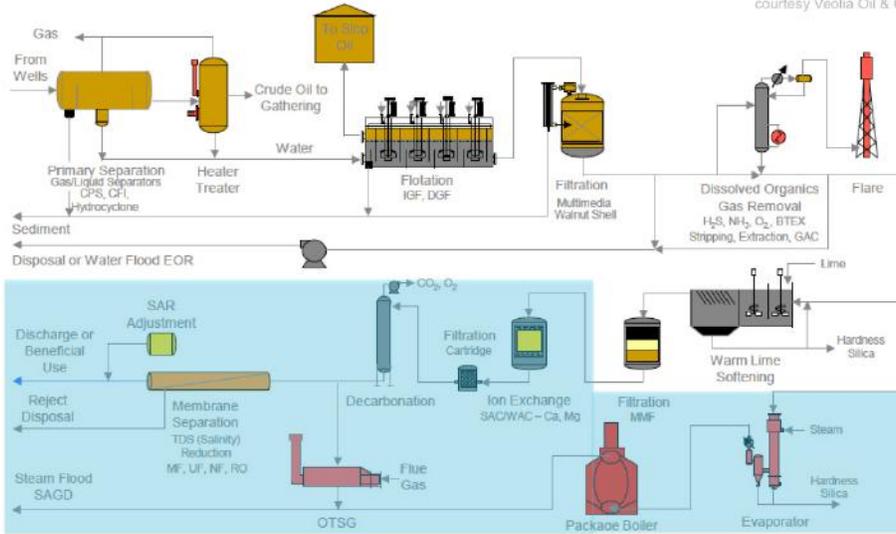


- New production techniques
- Higher volumes of PW generated
- Higher quality water often required
- Increasing energy costs
- Stricter environmental regulations
- Conventional disposal often not viable
- Water treatment companies don't know oilfield

Conventional PW Treatment

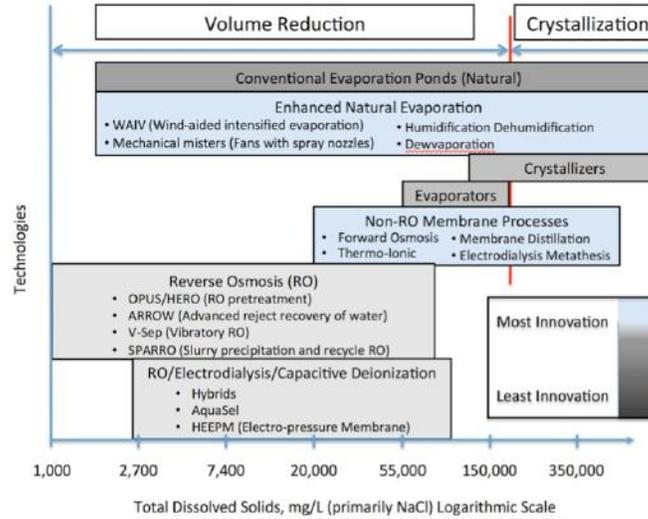


courtesy Veolia Oil & Gas



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Concentrate Technology Options



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Technology Comparisons



	Clarification, IGF, DGF	Clarification Filtration	Clarification UF Filtration	Clarification UF Filtration Ion Exchange, or NF	Clarification Evaporation	Clarification Evaporation Crystallizer
Oil, mg/L	10	5	5	<1	<01	<1
TSS, mg/L	50	10	5	5	<0.1	<0.1
Max Particle Size, µm	25	10	1	1	1	1
Soluble Divalent Ion Removal	<5%	<5%	<20%	+95%	+99%	+99%
Salt Removal, (NaCl)	0%	0%	0%	0%	+99%	+99%
Overall Recovery	98%	92%	90%	60%	60-90%	80-95%
Approximate Relative Cost	1.0	1.2	1.4	1.5-3.0	5	10

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Pacific Rubiales – 500,000 bbl/d RO

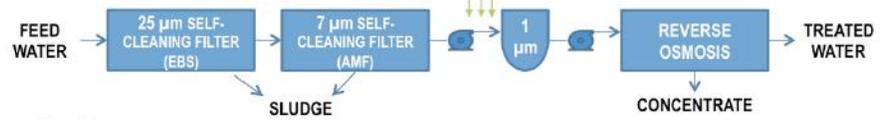


coagulant



RO AS SBS

2014/01/03



source: Nirasoft

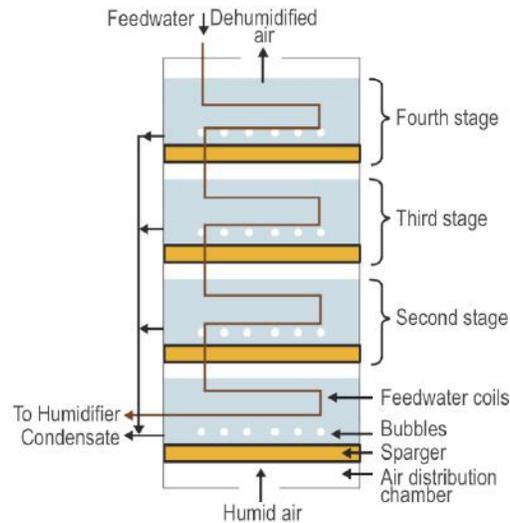
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Forward Osmosis – 4,000 bbl/d



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Humidify-Dehumidify (HDH)



source: Gradiant

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Multi-stage bubble column dehumidifier. This slide showed last time.

Produced water is fed in the top of the column and flows downward through coiled tubes the pre-heated feed is heated to 160°C and sprayed over a packed bed humidifier. The evaporating water humidifies the air. The concentrate is removed from the bottom of the humidifier and the hot humid air is sent to the bottom of the dehumidifier.

Humidify-Dehumidify (HDH)

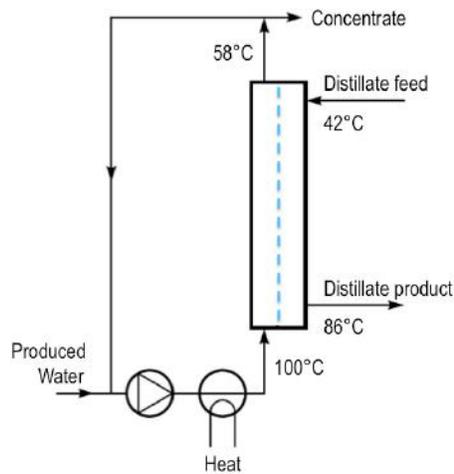


source: Gradiant

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MD is a thermally driven desalination process that employs a porous, hydrophobic membrane to separate heated feedwater from a cool distillate. The difference in feed and product water temperatures results in a difference in their vapor pressures, allowing pure water vapor to pass through the membrane before it condenses as distillate on the cooler side.

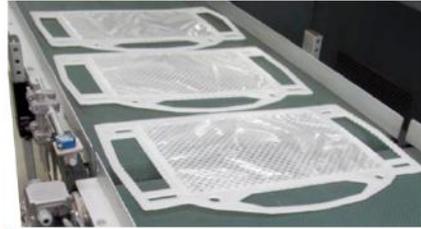
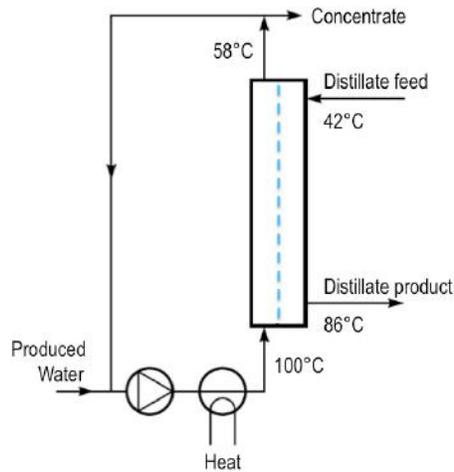
Membrane Distillation



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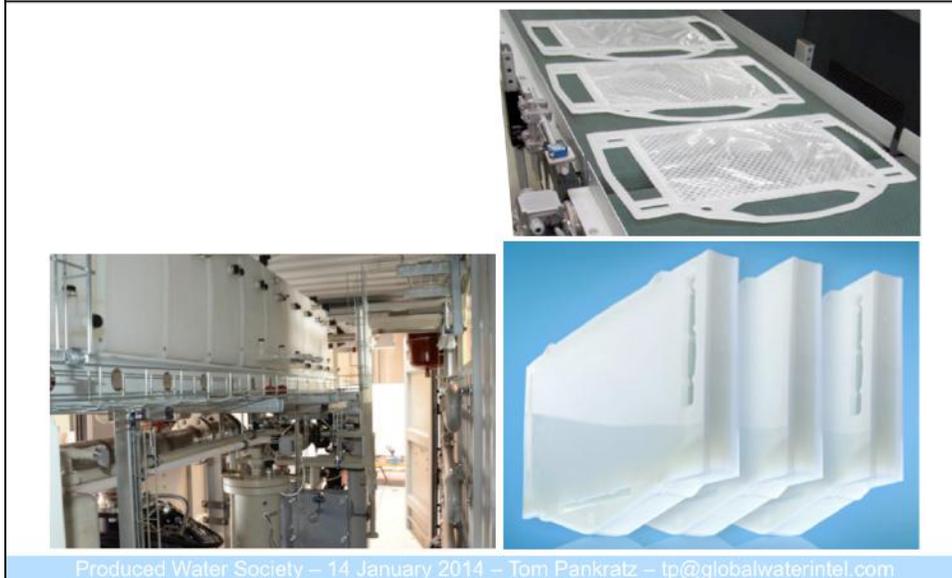


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Membrane Distillation

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In a West Texas pilot test, the ME MD unit concentrated 300 bbl/d of a high TDS shale gas produced water to 230,000 mg/L, with results very similar to those expected for brine concentrator evaporators. A commercial unit could concentrate almost 1000 bbl/d of brine, and memsys/GE expect to commercialize the process this year.

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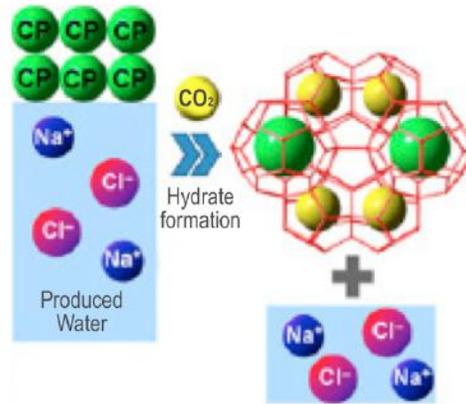
Gas Hydrates can Desalt Brine



Gas hydrate formation schematic with CO₂ and cyclopentane (CP) guest molecules

The Dept of Energy's National Energy Technology Laboratory is working on a new method of removing salt from brines with a gas hydrate-based process using water-immiscible hydrate formers.

Gas Hydrates can Desalt Brine

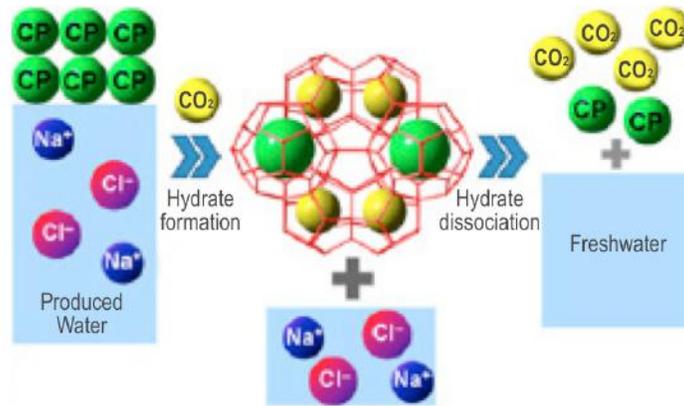


Gas hydrate formation schematic with CO₂ and cyclopentane (CP) guest molecules

Hydrates are solid compounds, often crystals, that form when water molecules combine with another substance. During the formation of gas hydrates, water and 'guest' gaseous molecules combine through a unique, non-covalent interaction while salts and other impurities are excluded from the crystalline hydrate structure and concentrated in the bulk solution.

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The hydrates can then be harvested from the brine, and when dissociated from the hydrate crystals, freshwater is recovered as a final desalination product.

So far, when starting with a 9% salt solution, they have been demonstrated a 90% salt removal at ambient temperatures and pressures to 450 psi.

Freeze Distillation



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CryoDesalination, a freeze desal process with a novel flotation method that does what previous freeze process couldn't: separating the ice from adhering brine. Norbert Buchsbaum, the inventor is a retired executive from Gulf Oil (now Chevron) and won the 2013 St Andrews Prize for the Environment, an initiative by Scotland's St Andrews University and ConocoPhillips.

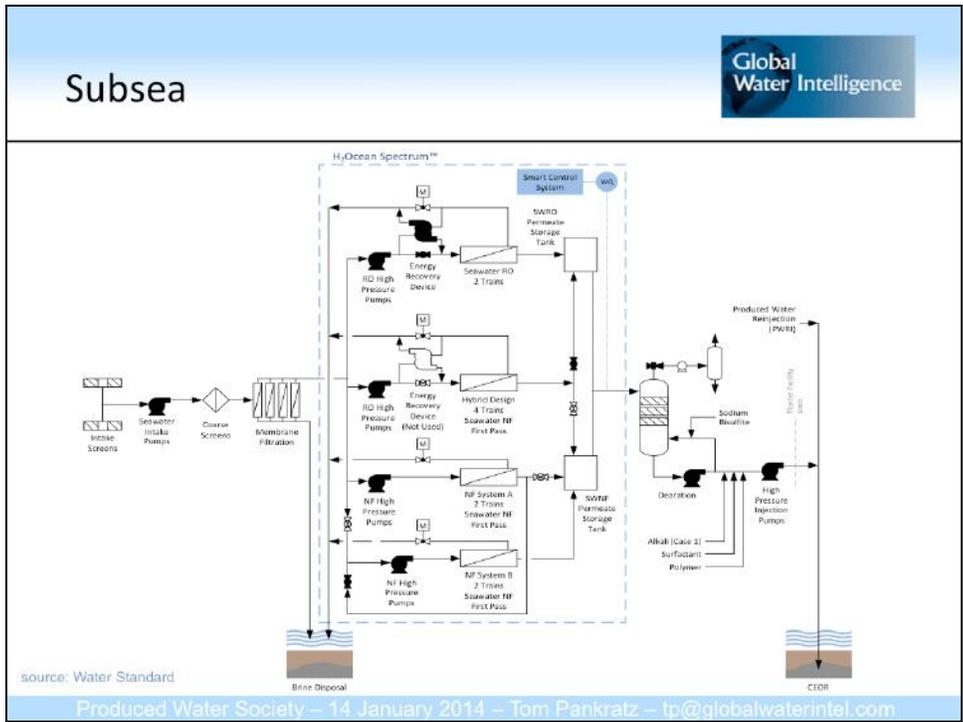
Freeze Distillation



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By selecting an oil that floats between the ice and brine, and including some additives—at present, they won't say which additives—in a separation column, he says that it is possible to effectively separate the ice from the brine and harvest it to produce fresh water. The company has built a 10-15 GPM (0.6-0.9 L/s) pilot unit and is now planning a pilot program.

By co-locating their system with LNG vaporization facilities because of the opportunity to use the latent heat consumed in evaporating the LNG.



Allows produced water to be integrated into EOR projects without salinity or hardness impacts, taking into changing produced water composition with time

Minimal CAPEX impact but substantial environmental risk mitigation,

Offshore UF/NF for Sulfate Removal



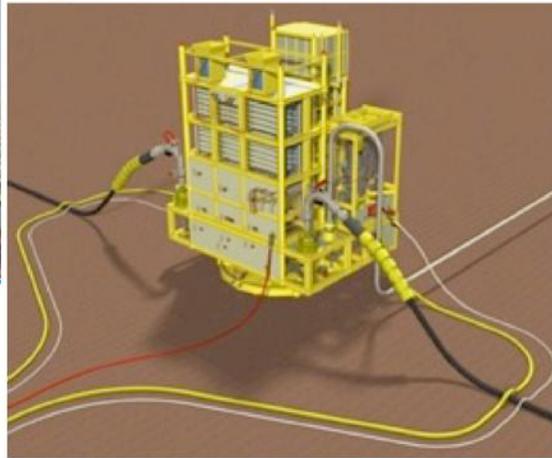
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As the complexities of offshore deepwater oil development increase, so has the use of specialized NF membrane systems to remove sulfate from the seawater used for waterfloods, pressure maintenance and reduce scaling. The benefits of seawater sulfate removal were first shown Marathon's Brae Alpha platform in the North Sea in 1988.

There are now over 60 offshore SRSs in operation, and as the water depth has increased, the use of SRS systems has become routine.

Subsea UF/NF for Sulfate Removal

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source: Veolia

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A joint research program between Total, Saipem, an Italian contractor, and Veolia's VWS Oil & Gas division is now developing a seawater SRS for installation on the seafloor.

Known as SPRINGS—for Subsea Processing and Injection Gear for Seawater—the modules will have treatment capacities of 20,000 to 40,000 bbl/d to operate in water depths of up to 10,000 ft. Modules are installed on a permanent foundation platform mounted on the seafloor. The individual process modules are dropped onto the platform and connected to each other through the platform.

An industrial trial is tentatively planned for 2015.

North American Upstream Map

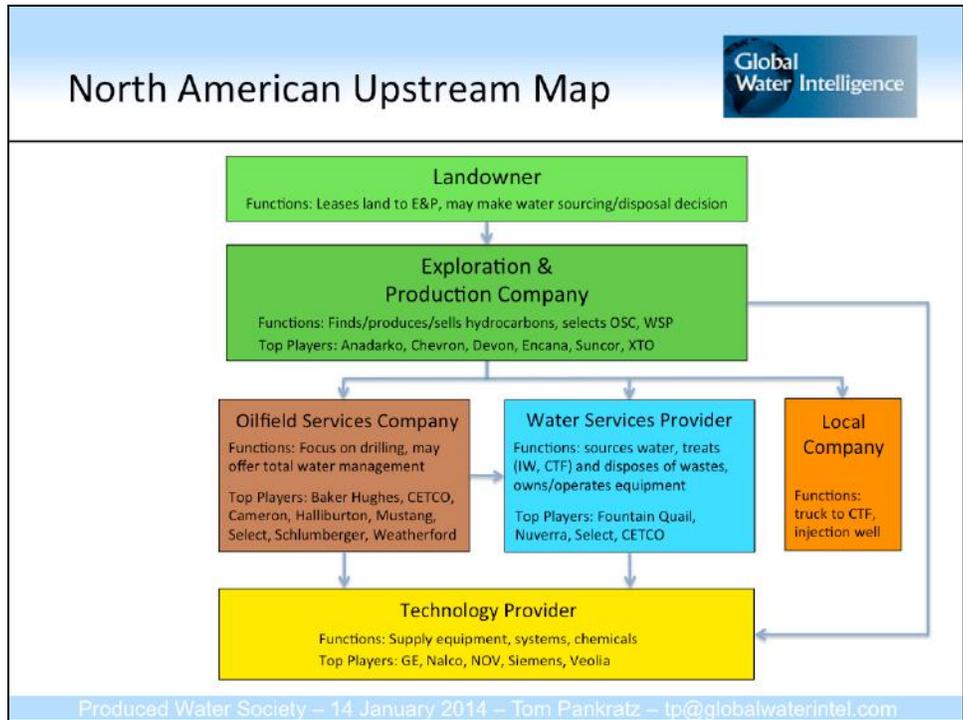


Exploration & Production Company

Functions: Finds/produces/sells hydrocarbons, selects OSC, WSP
Top Players: Anadarko, Chevron, Devon, Encana, Suncor, XTO

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E&P companies are the firms responsible for finding and producing O&G

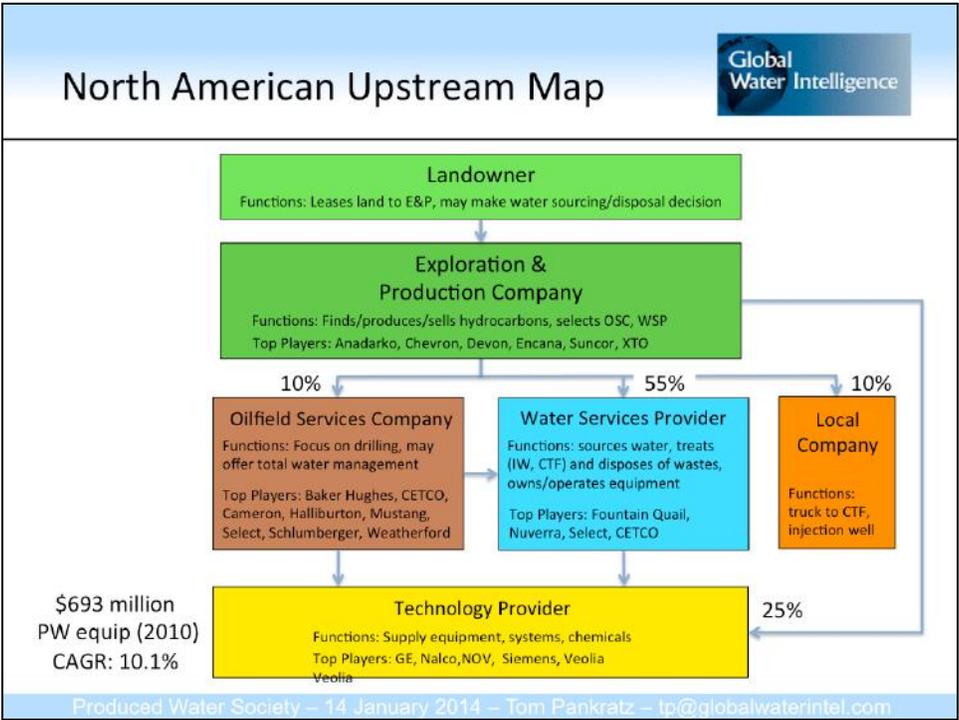


This map diagrams some of the relationships between the production companies and the technology providers.

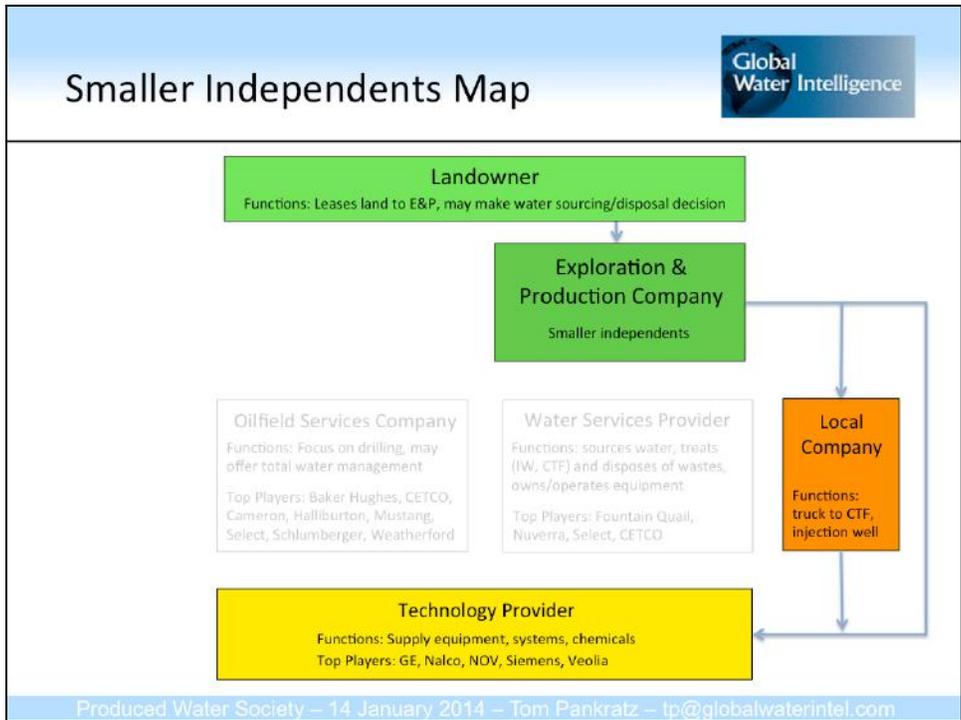
In most countries, mineral resources are owned by govt. In US, the landowner holds the rights and may lease them to an oil company.

In some rare occasion, the landowner may participate in water sourcing or disposal operations, but usually, an E&P company works with a service company—either one firm who handles all oilfield services—or a Water Service Provider.

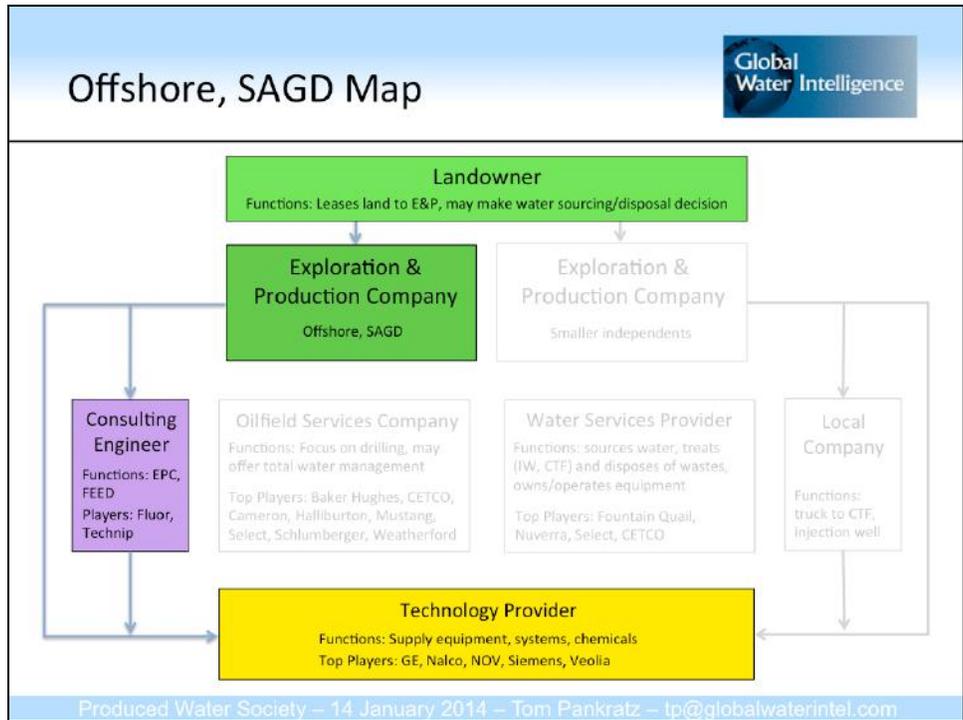
You can see that the Technology Provider may offer equipment or services to the service companies.



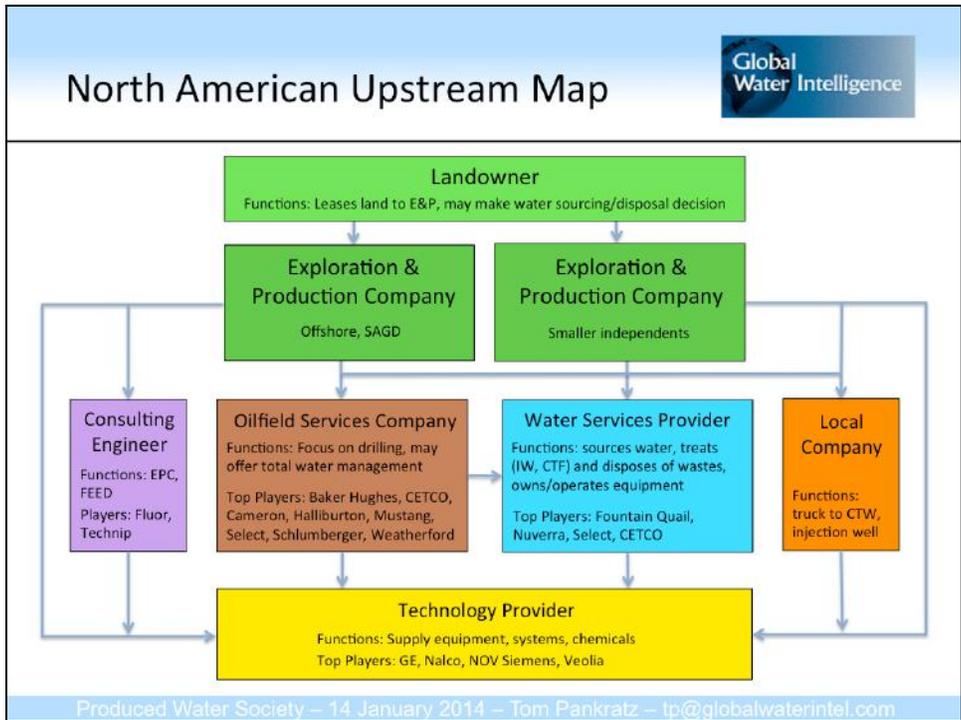
This slide show the breakdown for the estimated \$693 million spent on Produced Water treatment and disposal equipment in 2010, i



In many smaller fields some independents may deal directly with a local company for disposal, or they may own and operate their own central treatment facility, so it may be necessary to sell directly to E&P company.



The Offshore and SAGD markets are also somewhat unique. The technologies used in these applications are different and the geographies are remote. Because of the size and complexities of the projects, there is more interaction between the technology company and the production company, and a consulting engineer may be involved.



Here's what an overall supply chain market might look like.

Summary



- Membrane & thermal technologies will find increasing applications in the oil & gas industry
- No single Silver Bullet, many niche technologies