



Environmentally Friendly Drilling Workshop

University of Arkansas

Fayetteville, AR

November 16, 2010

ADAPTIVE SOLUTIONS FOR FAYETTEVILLE SHALE WATER MANAGEMENT

Brent Halldorson, *Aqua-Pure / Fountain Quail*



Fountain Quail
WATER MANAGEMENT

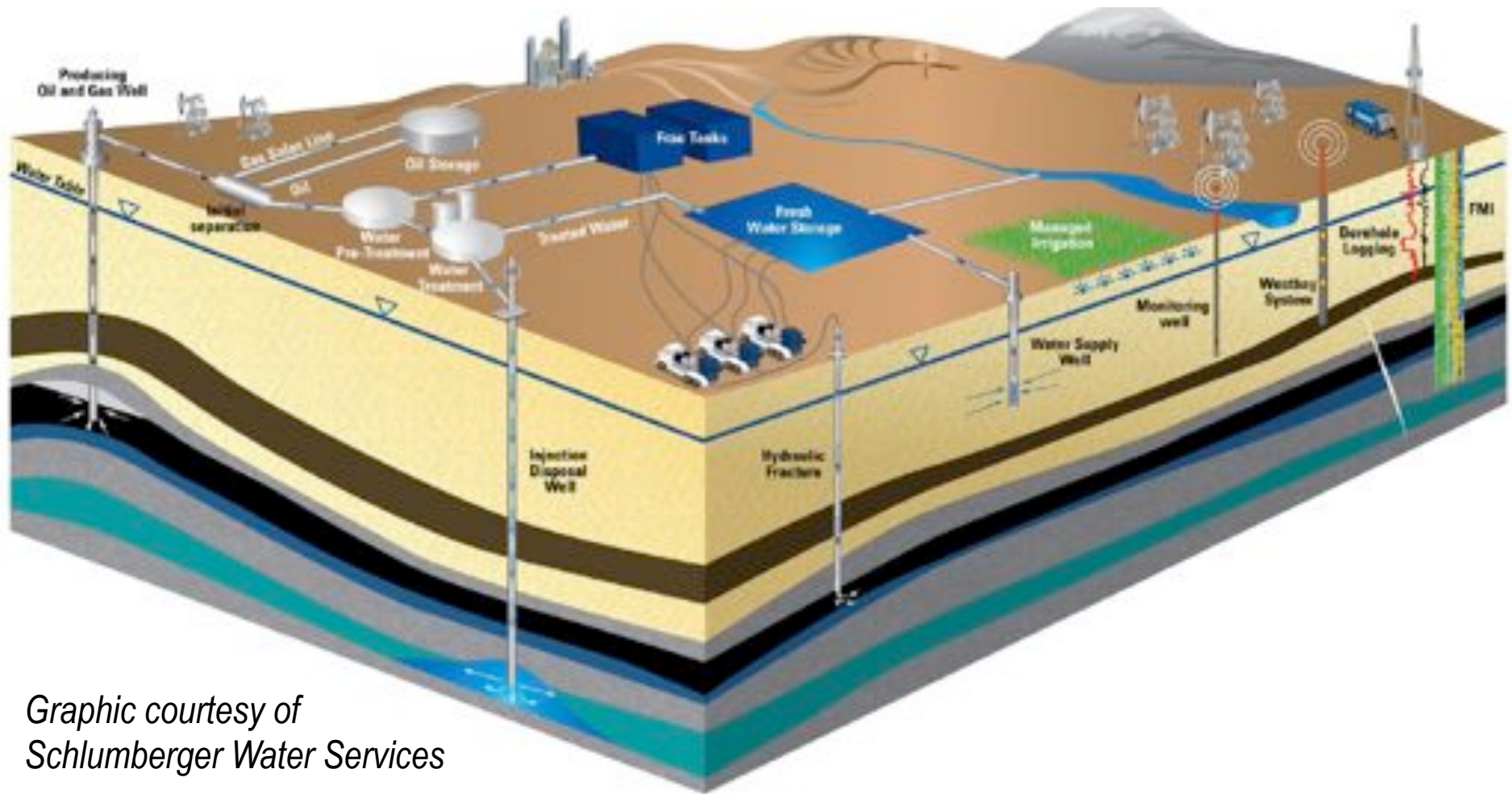
Outline

US Shale Gas Development

1. The Big Picture – Managing Water
2. Comparison Between Plays
 - a) Unique Features
 - b) Examples of Water Management Practices – Barnett, Marcellus
 - c) The Fayetteville Shale
3. Flexible & Adaptive Solutions



The Big Picture



*Graphic courtesy of
Schlumberger Water Services*



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*Adaptive Solutions for Fayetteville Shale Water Management
Brent Halldorson, Aqua-Pure / Fountain Quail*

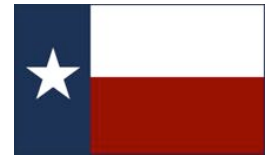
Key Water Issues

1. Disposal considerations.
 - *Availability & type of SWD formations.*
 - *Sustainability.*
2. Freshwater availability.
3. Recycling & Re-Use alternatives.
 - *Flowback / PW Composition.*
 - *Re-Use Specification.*
4. Transport & Logistics.
 - *Terrain, Climate.*
5. Regulatory & Community.



Barnett Shale

UNIQUE FEATURES



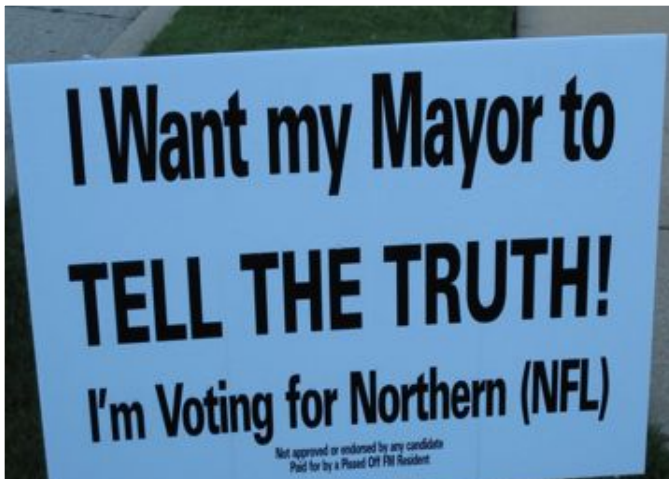
- Low cost SWD options (Ellenburger).
- Limited freshwater availability.
- Most developed shale play to date.
- Urban drilling.
- Relatively flat terrain.



Barnett Shale

URBAN DRILLING

Just Say
NO
to Urban
Gas Drilling



FORT WORTH
Star-Telegram

WWW.STAR-TELEGRAM.COM

Tempers flare as gas drilling rigs
rise near Alliance-area homes



**TOO CLOSE
FOR COMFORT**



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Barnett Shale

WATER MANAGEMENT

- Take advantage of low-cost disposal.
 - New SWDs are difficult to permit (Cleburne earthquakes).
- Freshwater has value:
 - Encourages recycling.
 - Water Management Districts forming.
 - With complete TDS removal the water can be fastlined.
- Terrain/Climate allows fastlining.



Barnett Shale

EXAMPLE



Over 500 million gallons of flowback & PW recycled with Devon Energy.

Freshwater is fastlined.

Move recycling plant to the drilling activity to reduce trucking.

Fountain Quail
NOMAD Recycling
Facility.

3 fracs, no trucks



Marcellus Shale

UNIQUE FEATURES



- Very limited disposal options.
 - Currently utilize SWDs in Ohio or metals-precip plants.
 - High cost (long truck trips).
- Largest geographic shale play.
- Near largest US market.
- N-I-M-B-Y.
- Difficult terrain.



Marcellus Shale

DIFFICULT TERRAIN



Marcellus Shale

WATER MANAGEMENT

- Re-use as much water as possible on-site.
 - Logistics dictate re-use of saltwater for fracs.
 - What level of treatment (if any) is needed?
- Recycling for discharge lower cost than SWDs.
 - Treat water for discharge to new regs (<500ppm TDS, <250ppm chlorides).



Marcellus Shale

EXAMPLE – On Site Treatment

	CLASS I	CLASS II	CLASS III	CLASS IV	CLASS V
	Clarification	Clarification Polishing Filter	Clarification UF Membrane	Clarification UF Membrane Ion Exchange	Clarification MVR Evaporation
TSS (mg/L)	50	10	5	5	< 5
Max Particle Size (um)	75	10	1	1	1
Divalent Ion Removal [Ca, Mg, Sr, Ba, SO ₄] (mg/L)	<20%	<20%	<20%	+90%	+99%
Salt Removal [NaCl] (mg/L)	0%	0%	0%	0%	+99%
Relative Cost	1.0	1.2	1.5	2.5	3.5



*Fountain Quail
Class II Mobile Pretreatment System*



Marcellus Shale

EXAMPLE – Centralized Treatment



Fayetteville Shale

UNIQUE FEATURES



- Relatively poor SWD formations (shallow sandstone).
- Limited need for freshwater – use “spudder” water or light flowback.
- Landfarm operations shutdown, produced water hauled long distances.



Fayetteville Shale

WATER MANAGEMENT



- Freshwater has limited value:
 - Treat for environmental discharge.
(if treatment costs < trucking + disposal)
- Flowback/PW is low TDS.
 - High recovery (>95%) with MVR.
- Different than Barnett and Marcellus.
 - Can fastline as in Barnett.
 - Light brine can be re-used on site.



Fayetteville Shale

WATER CHARACTERISTICS - ANALYSIS

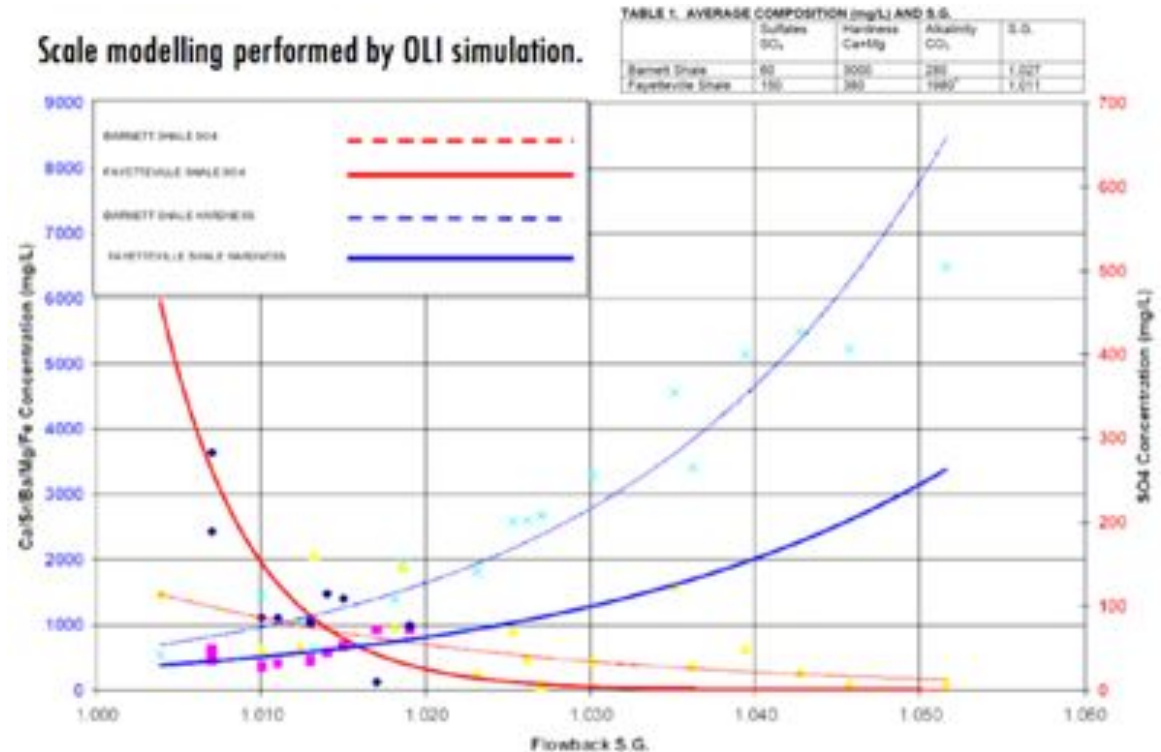
Table 1. Flowback Analysis Design Basis

		Fayetteville	Marcellus	Barnett
Na	(mg/L)	5362.6	24445.0	12453.0
Mg	(mg/L)	77.3	263.1	253.0
Ca	(mg/L)	256.3	2921.0	2242.0
Sr	(mg/L)	21.0	347.0	357.0
Ba	(mg/L)	0.8	679.0	42.0
Mn	(mg/L)	0.5	3.9	44.0
Fe	(mg/L)	27.6	25.5	33.0
SO4	(mg/L)	149.4	9.1	60.0
HCO3	(mg/L)	1281.4	261.4	289.0
Cl	(mg/L)	8042.3	43578.4	23797.5
TDS	(mg/L)	15,219	72,533	39,570
S.G.		1.010	1.050	1.030

Table 2. Critical Scale Component Ratios

	Fayetteville	Marcellus	Barnett
(Ca/HCO3)	0.3	17.0	11.8
(Ca/SO4)	4.1	772.3	89.5

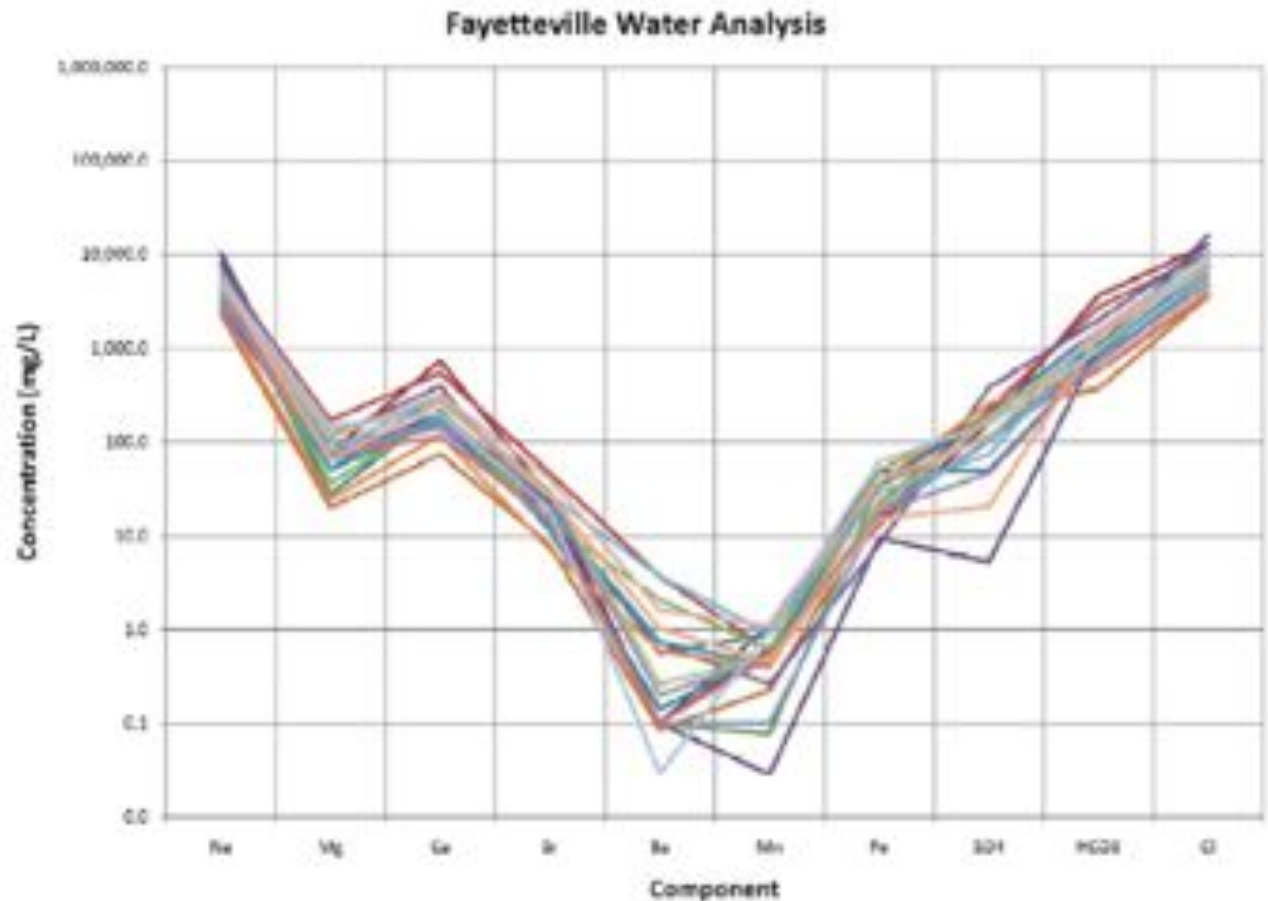
Scale modelling performed by OLI simulation.



Fayetteville Shale

WATER CHARACTERISTICS - TESTING

- ADEQ labs independently tested NOMAD distillate.
- Average TDS in distilled water: 15mg/L.
- Ammonia requires polishing for removal prior to discharge.



Fayetteville Shale

ARKANSAS SALTWATER RECYCLING, LLC

- Twin Groves, AR.
- Central location.
- ONLY recycling facility with NPDES discharge permit for treated Fayetteville waste.

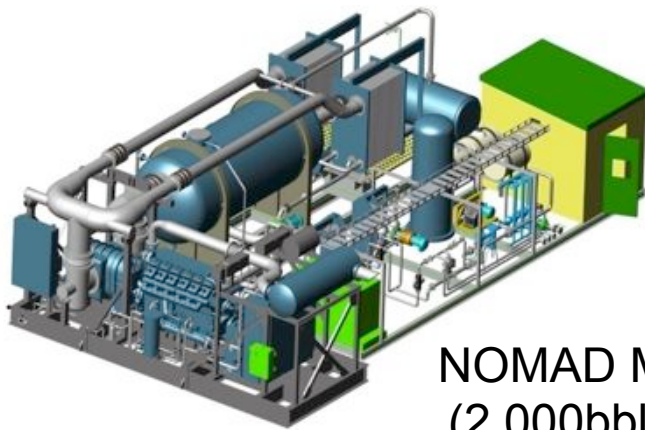


Producers can take freshwater back or it can be discharged (cleaner than river water).

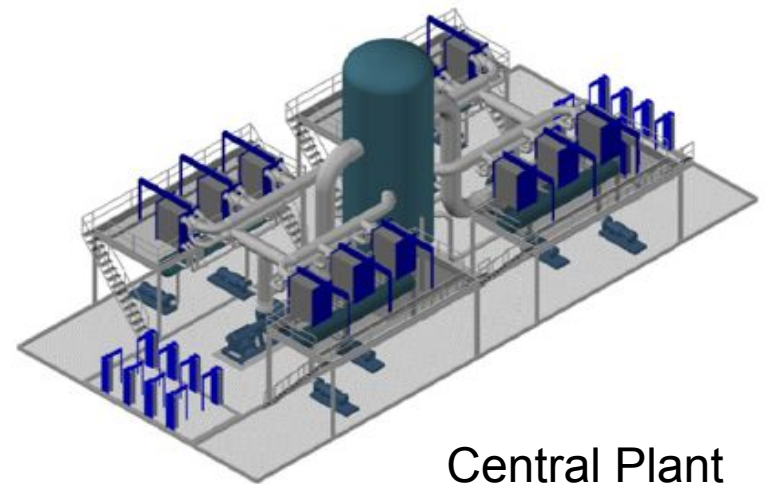
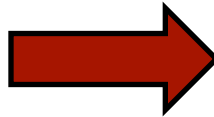


Flexibility Required

- Sustainability is key.
- Example: Start with NOMAD; graduate to base plant as need increases.



NOMAD Mobile Plant
(2,000bbl/d capacity)



Central Plant
(60,000bbl/d capacity)



What is Needed?

1. Common Sense Approach.

- ▶ Economics and regulation will determine how water is managed.
- ▶ Consider the big picture of overall water management.

2. Range of Solutions.

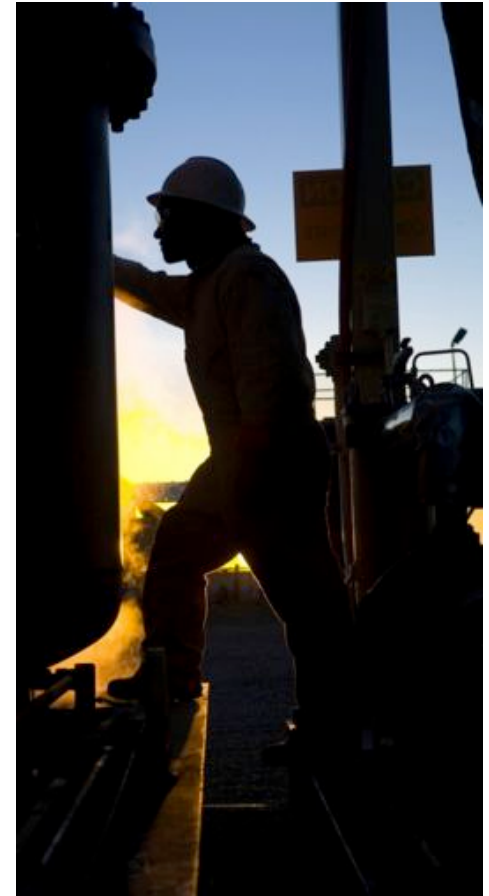
- ▶ Look for a proven track record. Talk to the customers.
- ▶ Nobody has “the magic cure”.
- ▶ Technology must be based on real science backed up with real results.

3. Flexibility.

- ▶ Solution must be adaptable to the changing needs of the industry.
- ▶ Example: Start with mobile NOMAD, build fixed plant as need increases.

4. Cooperation.

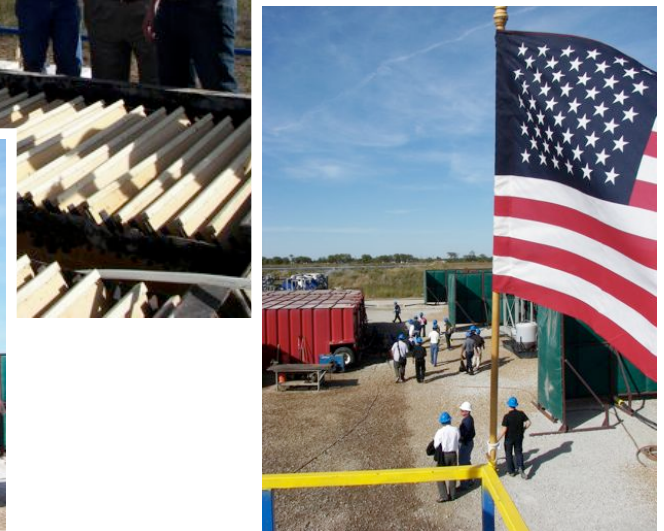
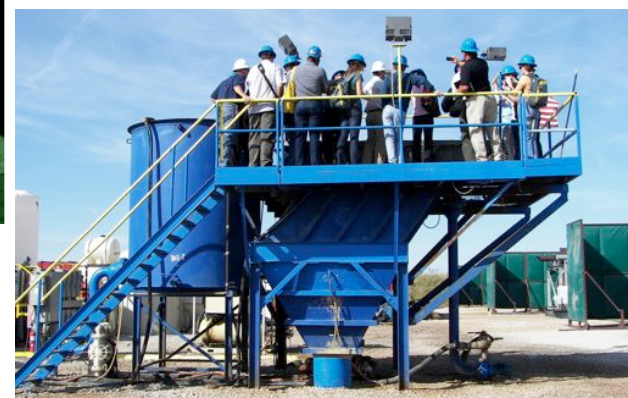
- ▶ Share results and experiences (good and bad). We can learn as much, or more, from what has not worked.



Share Experience

DALLAS SHALE GAS CONF – OCT 27, 2010

Over 75 attendees, *many competitors.*



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