ENGINEERING SOLUTIONS FOR SUSTAINABILITY:
MATERIALS AND RESOURCES 3

Toward a Circular Economy

February 18–19, 2017 | Denver, Colorado

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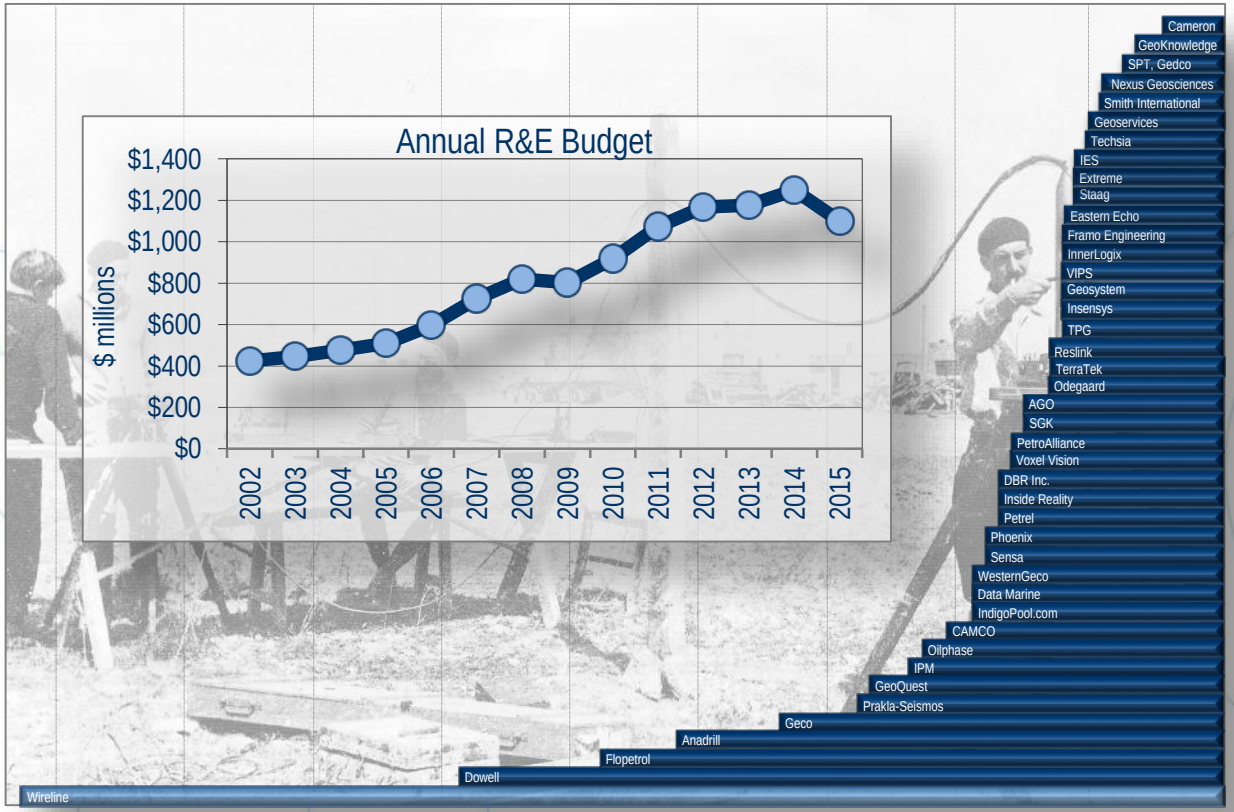
Session 4: Water

Incorporating Sustainability Practices to Reduce Water in Upstream Oil and Gas Development

Joe Lima, Director of Environmental Sustainability, Schlumberger

Schlumberger

Schlumberger at a Glance



Source: Schlumberger

The Resource Triangle

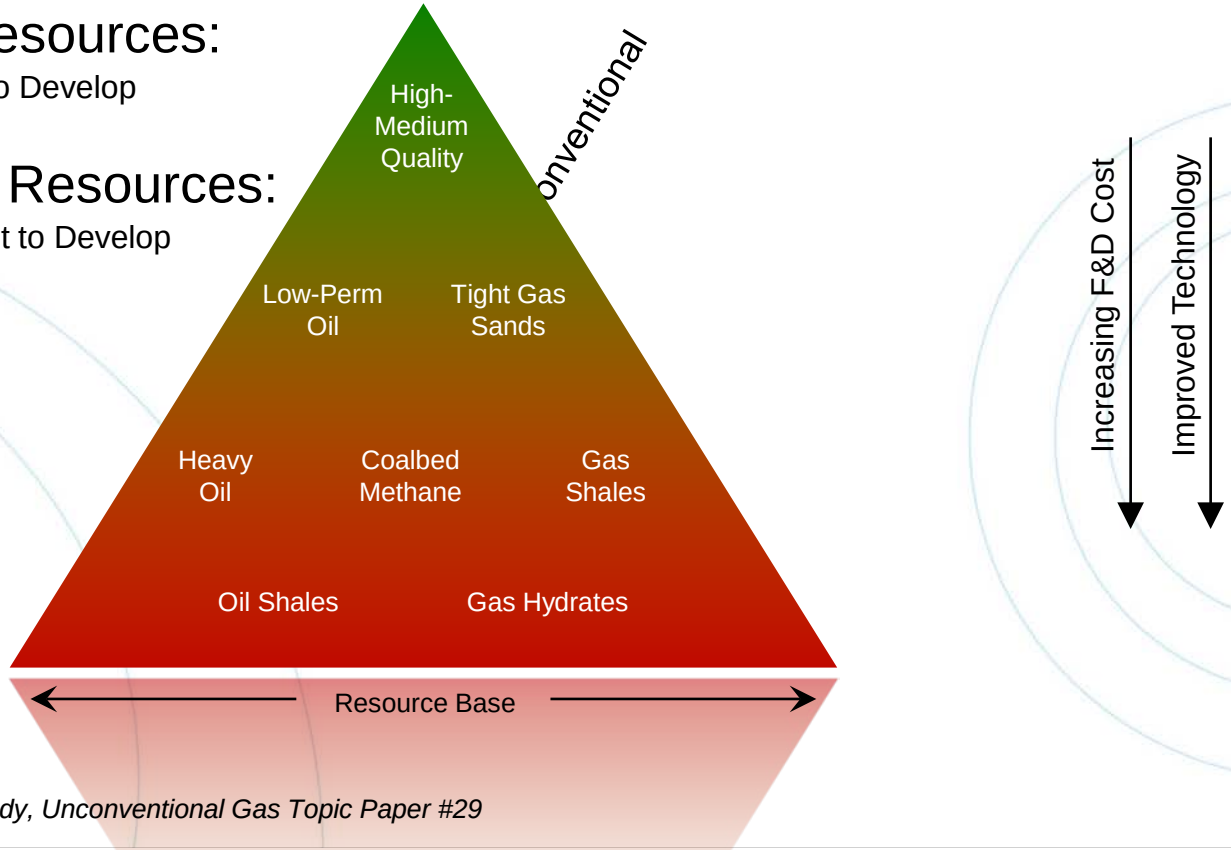
Conventional Resources:

Small Volumes… Easy to Develop

Unconventional Resources:

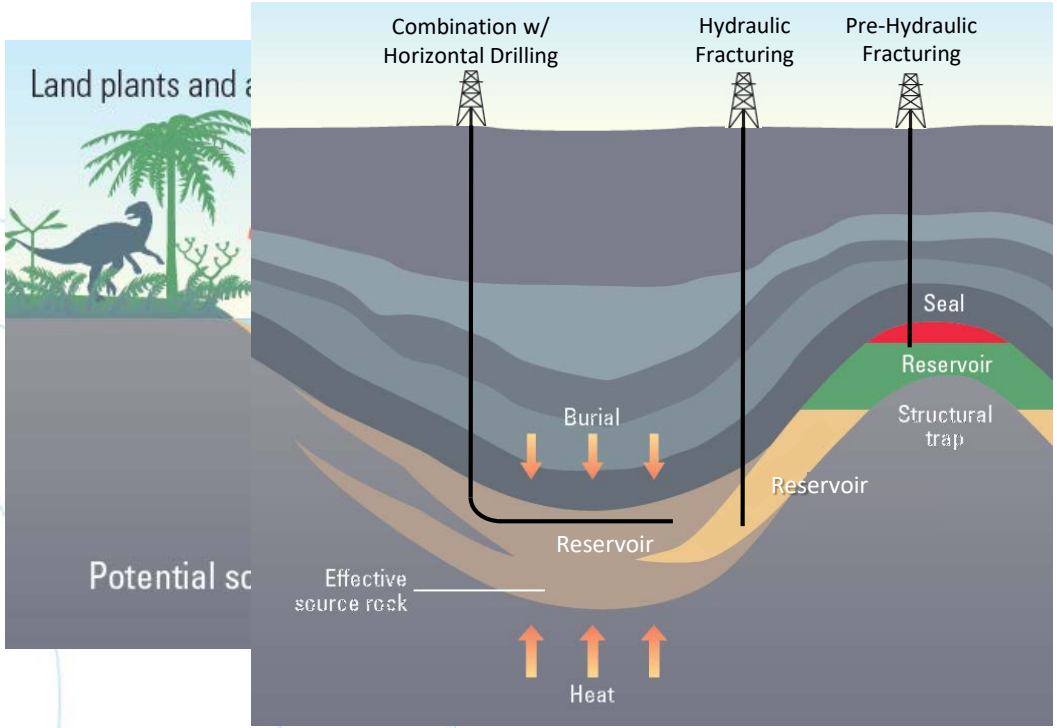
Large Volumes… Difficult to Develop

- Multiple Wells
- Hydraulic Fracturing

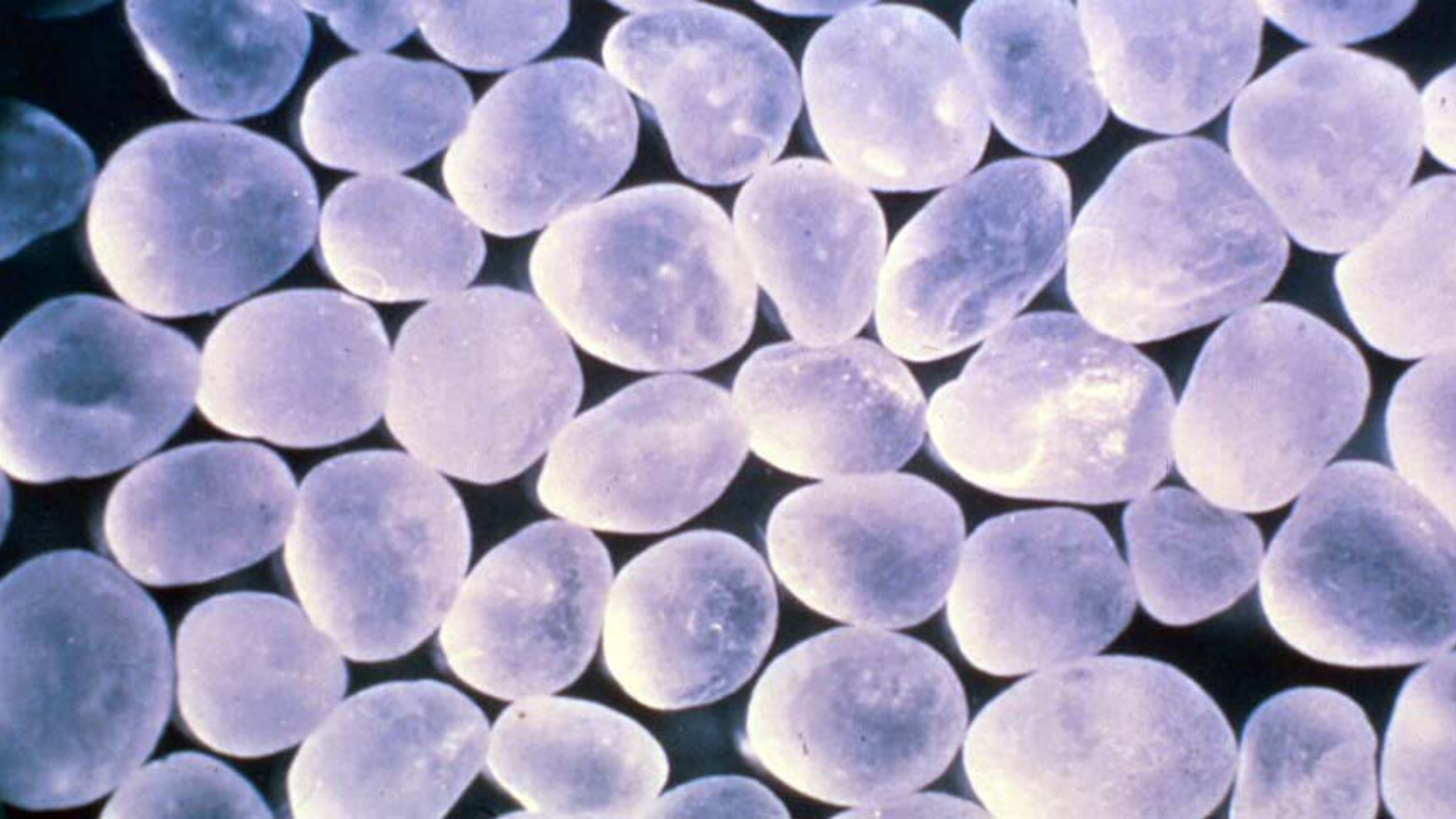


Source: 2007 NPC Global Oil & Gas Study, Unconventional Gas Topic Paper #29

Evolution of the Reservoir Rock



What is Hydraulic Fracturing



Why is Hydraulic Fracturing Effective

Vertical, Perforated Well

Vertical, Perforated Well with Single Hydraulic Fracture

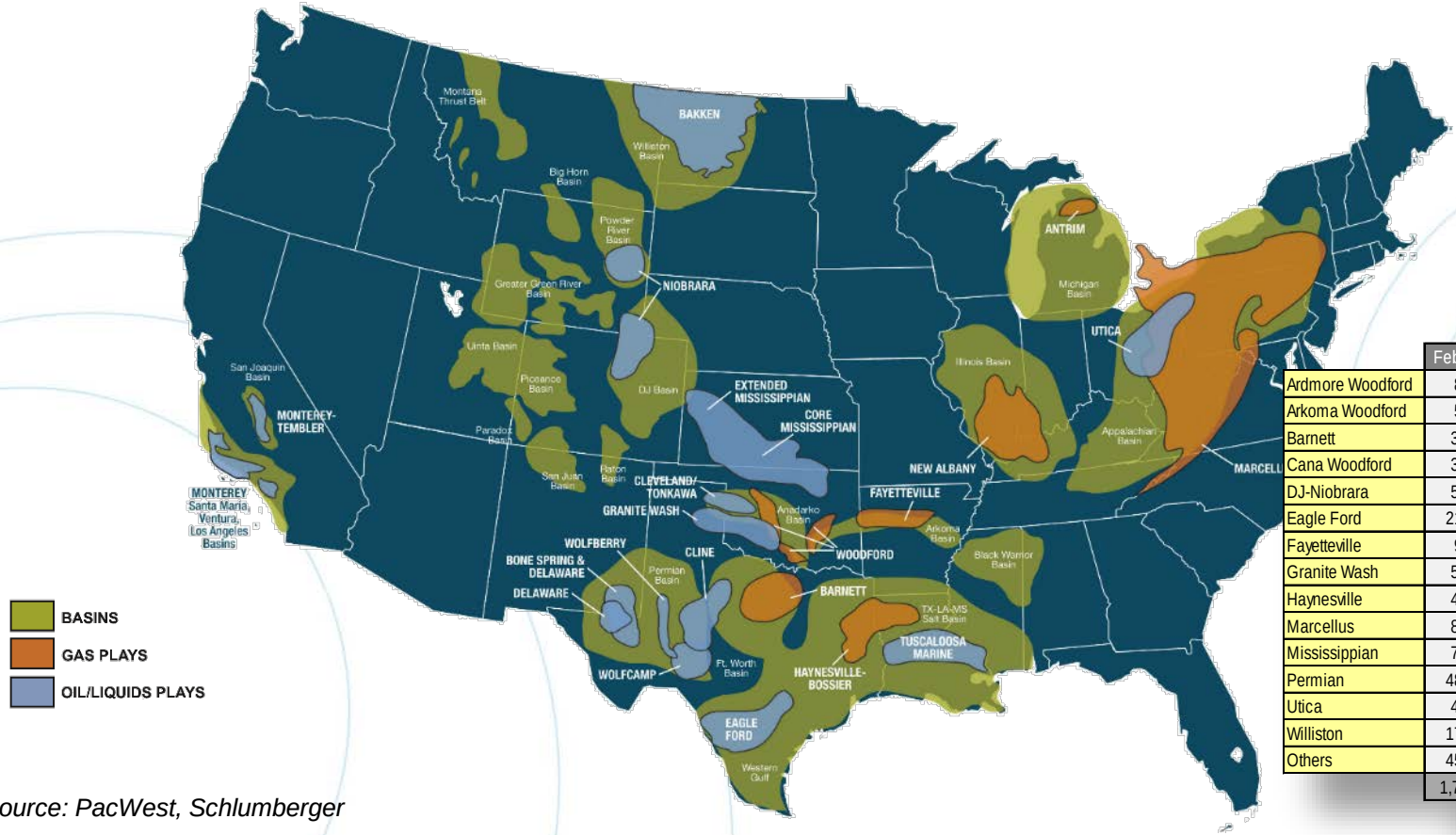
200 Ft High x 6” Wellbore

200 Ft High x (1) 200 Ft Frac

Horizontal, Perforated Well with 15 Hydraulic Fractures

200 Ft High x 6” Wellbore x (15) 200 Ft Fracs

The US (Lower 48) Unconventional Resources

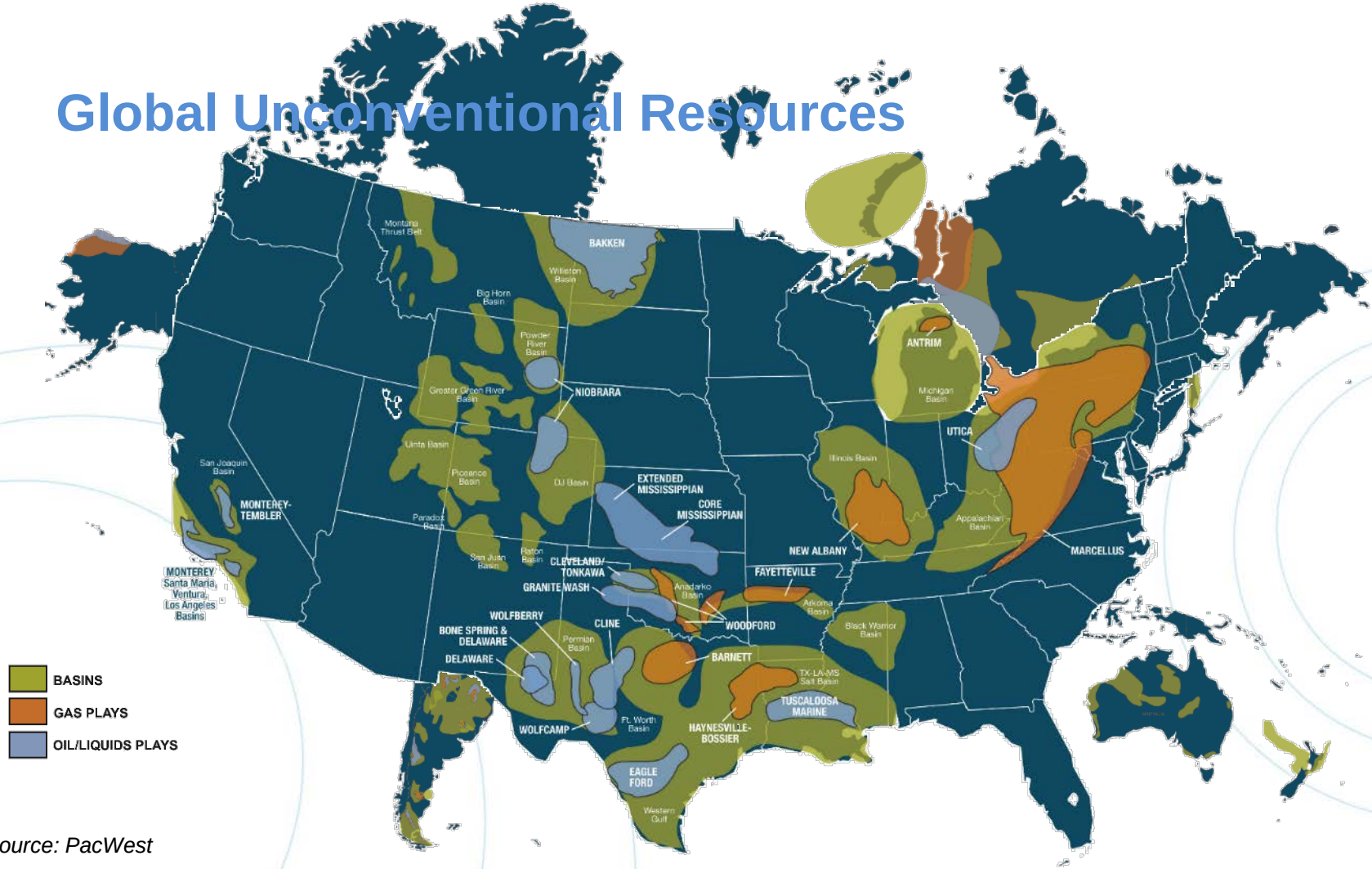


US Drilling Rig Count

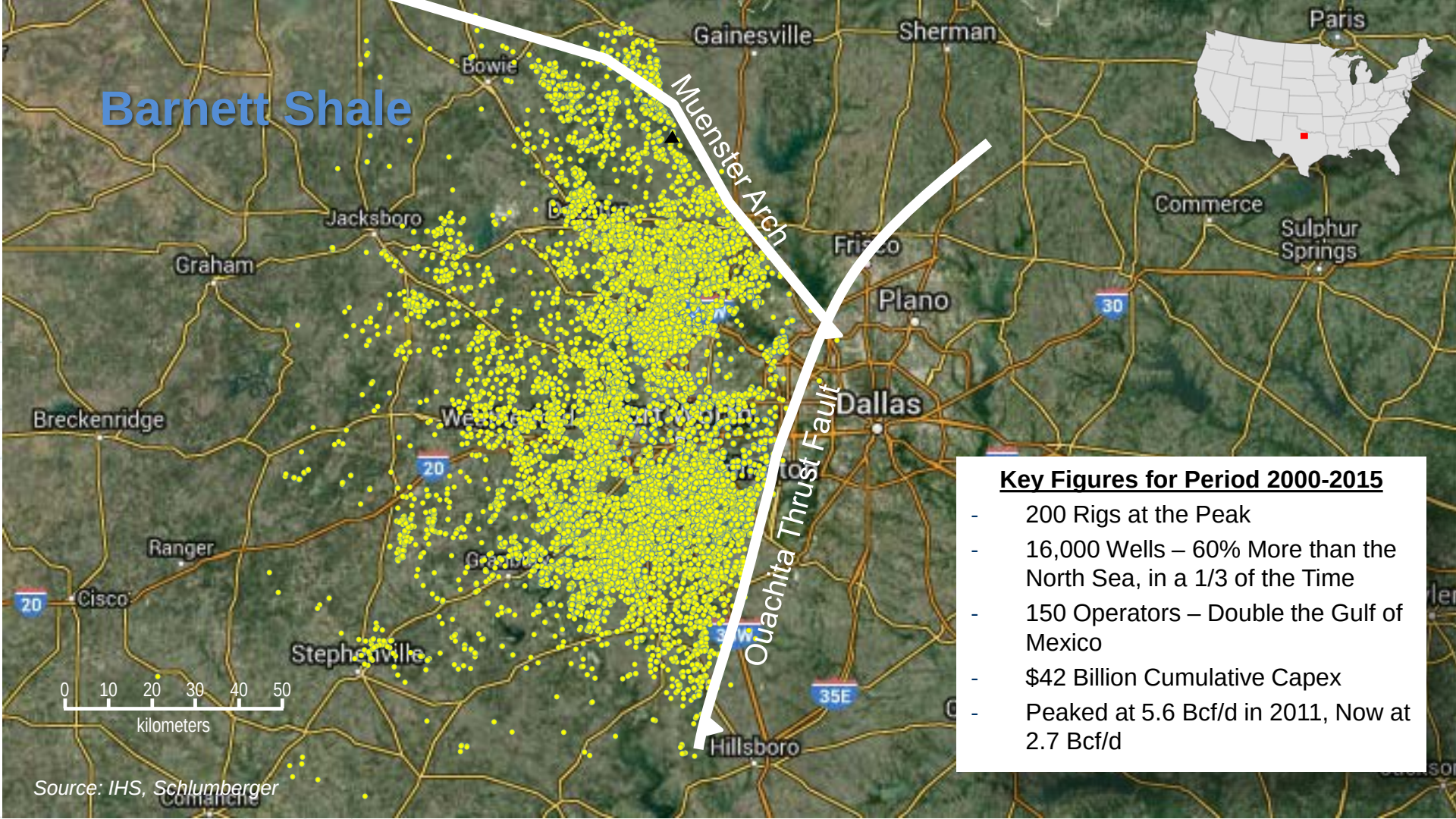
	Feb-14	Feb-15	Feb-16	Feb-17
Ardmore Woodford	8	6	2	2
Arkoma Woodford	5	6	5	5
Barnett	30	13	4	4
Cana Woodford	36	42	35	52
DJ-Niobrara	54	42	18	21
Eagle Ford	219	162	55	59
Fayetteville	9	9	0	1
Granite Wash	54	37	9	10
Haynesville	42	41	15	32
Marcellus	80	69	30	41
Mississippian	75	51	9	3
Permian	487	376	170	300
Utica	42	39	13	22
Williston	176	125	38	37
Others	452	331	131	154
	1,769	1,348	532	740

Source: PacWest, Schlumberger

Global Unconventional Resources



Source: PacWest

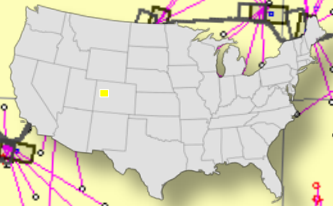


Key Figures for Period 2000-2015

- 200 Rigs at the Peak
- 16,000 Wells – 60% More than the North Sea, in a 1/3 of the Time
- 150 Operators – Double the Gulf of Mexico
- $42 Billion Cumulative Capex
- Peaked at 5.6 Bcf/d in 2011, Now at 2.7 Bcf/d

Source: IHS, Schlumberger

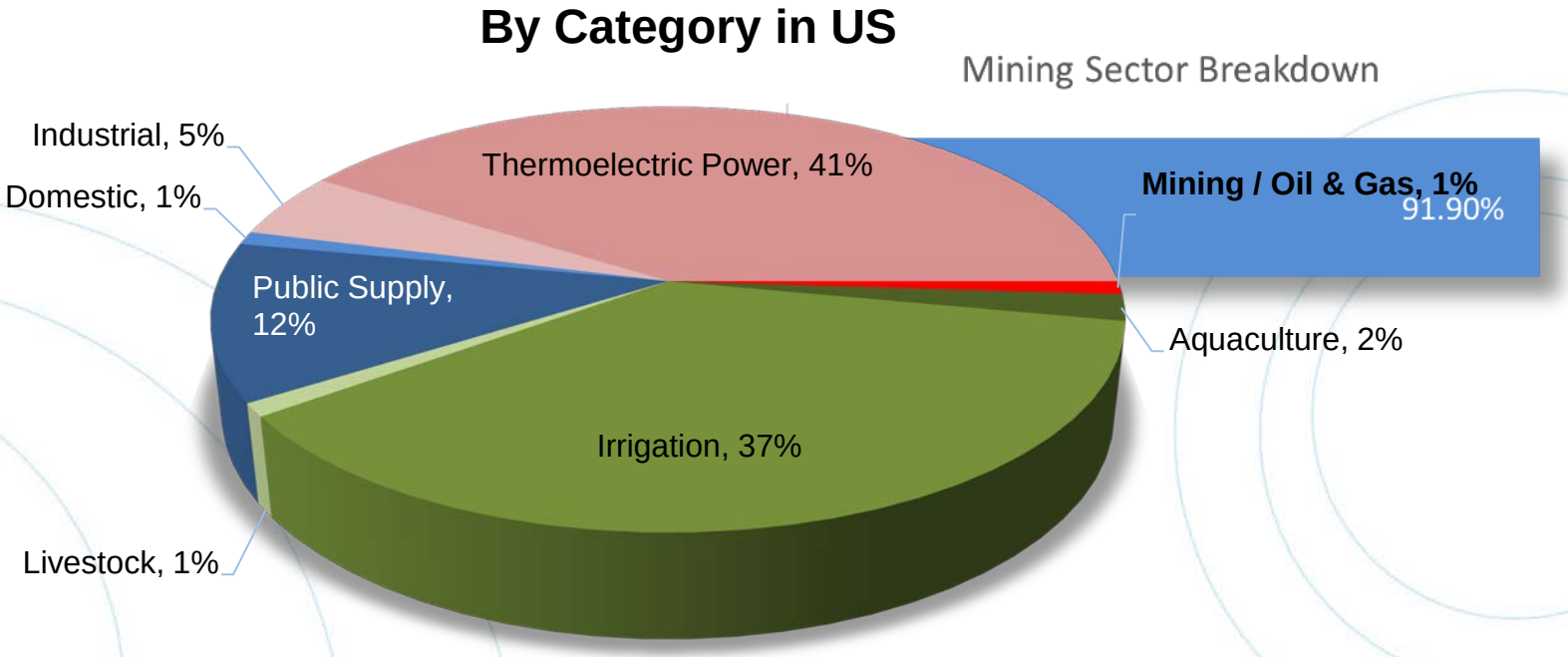
Surface Manage ing



0 0.5 1
km

Source: Encana USA

Water Use in Context



Source: FracFocus, IHS PacWest Water IQ, March 2016

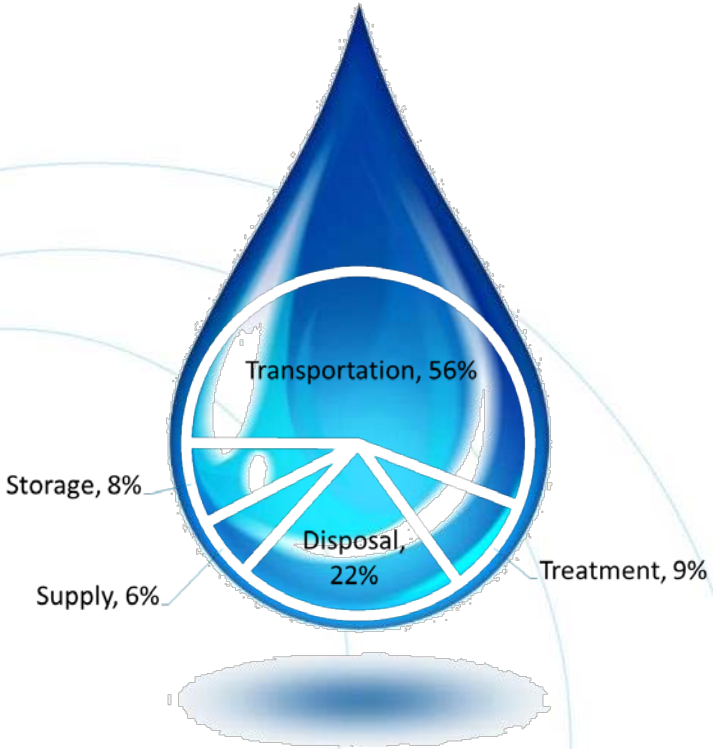
Water Requirements by Energy Source

Energy Resource	Range of Gallons of Water Used per MMBTU of Energy Produced
Marcellus Gas Well	1.30
Coal with No Slurry Transport	2 to 8
Coal with Slurry Transport	13 to 32
Nuclear (Uranium Ready to Use in a Power Plant)	8 to 14
Conventional Oil	8 to 20
Syncfuel – Coal Gasification	11 to 26
Oil Shale	22 to 56
Tar Sands	27 to 68
Syncfuel – Fischer Tropsch Synthesis (from Coal)	41 to 60
Enhanced Oil Recovery	21 to 2,500
Biofuels (Irrigated Corn Ethanol, Irrigated Soy Biodiesel)	> 2,500

Source: Chesapeake Energy Fact Sheet with Data from GWPC & DOE

An Image Problem

Water Use for Onshore Fracturing



Source: Bluefield Research

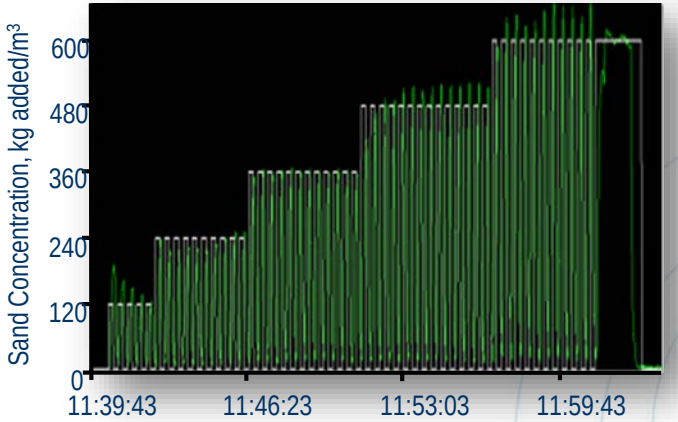
Direct Annual Use for Hydraulic Fracturing:

- Over 40 Billion Gallons in United States
- Average of 2.5 Million Gallons per Well
- Total Associated Costs over $10.7B

Best Practices Include:

- Recycling of Flowback
- Alternate Sources of Water

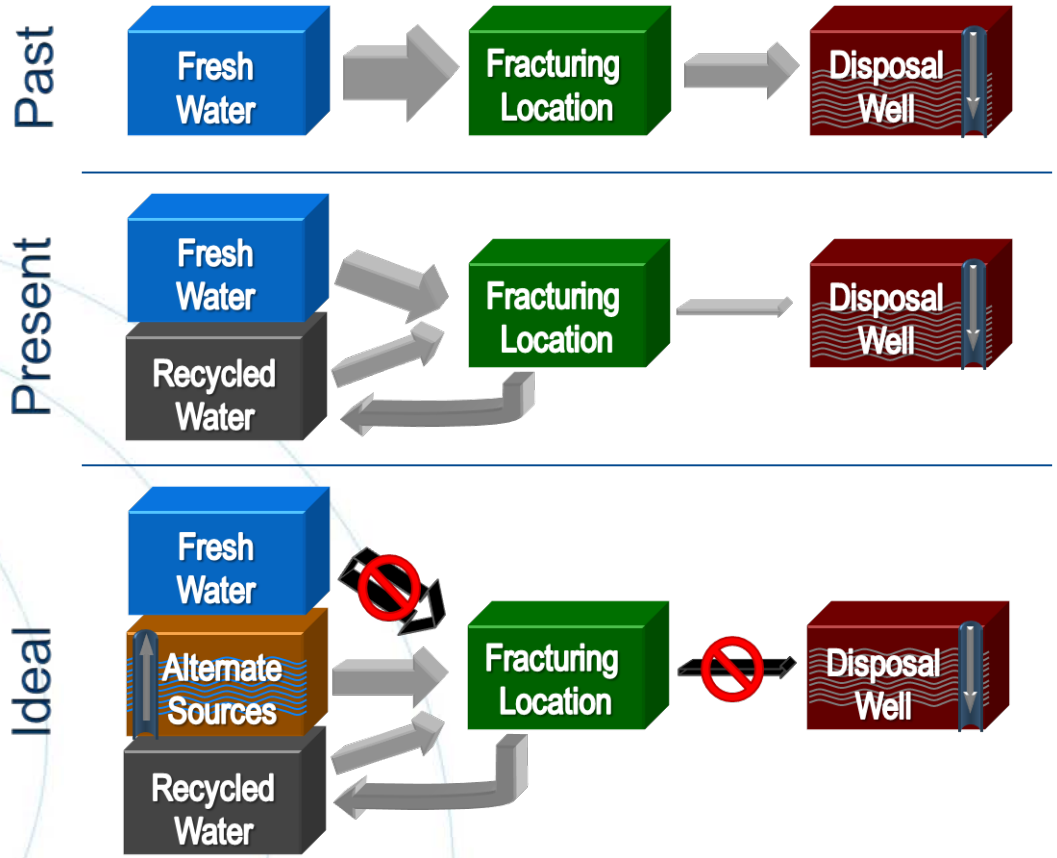
Reducing Hydraulic Fracturing Treatment Size



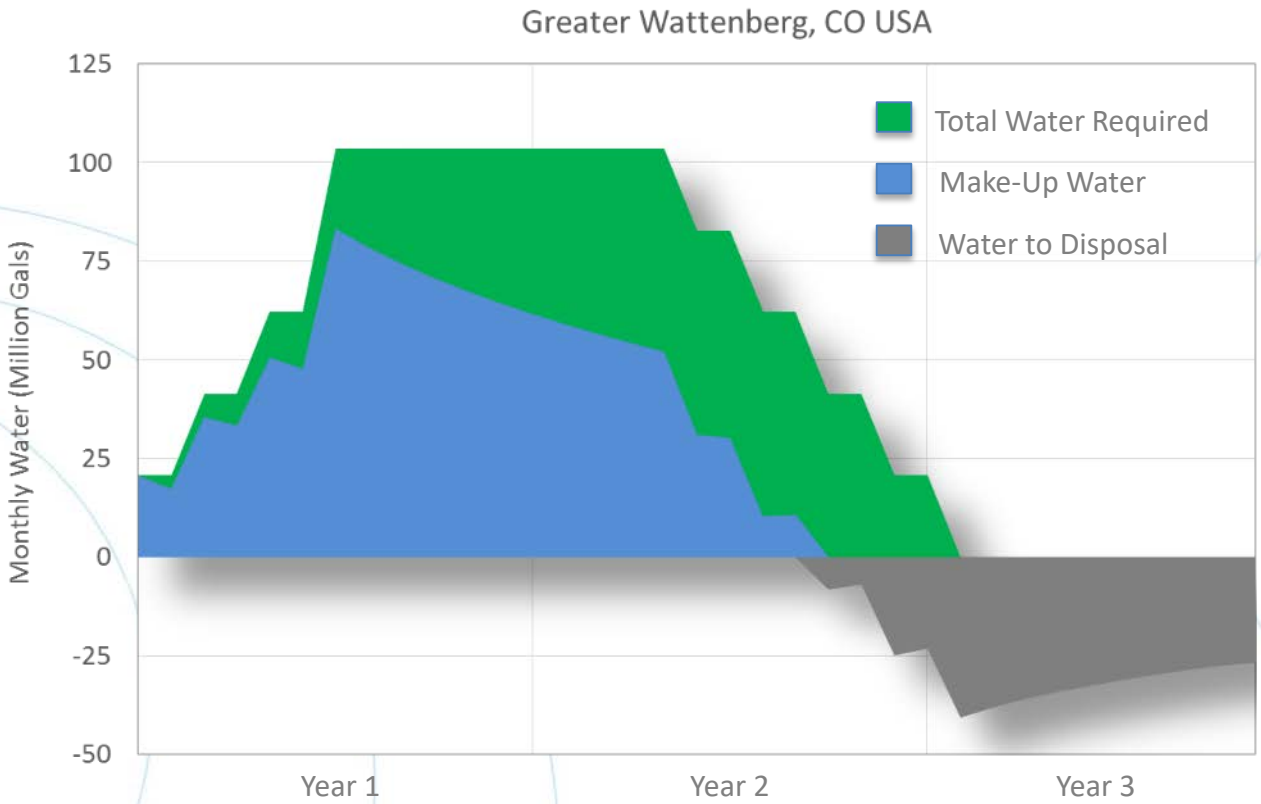
Current Run Rates:

- Water Consumption Reduction of 25%
- Proppant Consumption Reduction of 40%

Water Sourcing for Hydraulic Fracturing



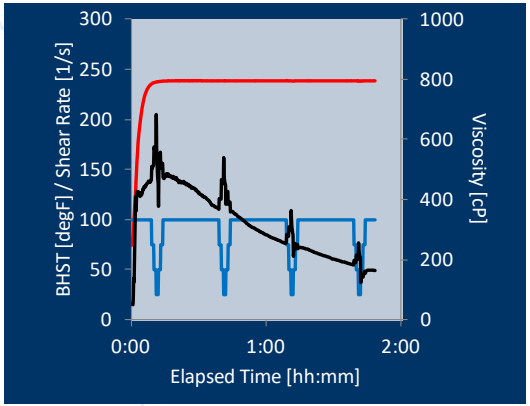
Upstream Development Water Requirements



Source: BCEI

Water Sourcing for Hydraulic Fracturing

Cation	Sample 1
Sodium	80,423
Calcium	18,938
Potassium	6,800
Magnesium	889
Iron	82.29
Boron	364
pH	5.68
SG	1.187
TDS	275,000



Reducing the Carbon Footprint of Hydraulic Fracturing

Proppant to Wellsite (55 Trucks)

Fresh Water to Wellsite (416 Trucks)

Recycled Water to Wellsite (104 Trucks)

Produced Water from Field to Disposal (416 Trucks)

Implementation of New Technologies

Proppant to Wellsite (33 Trucks)

Recycled Water to Wellsite (78 Trucks)

Produced Water from Field to Wellsite (312 Trucks)

- 57% Reduction in Truck Traffic
- 82% Reduction in Transportation Related CO_2 Emissions (19 Tons v 104 Tons)
- 28% Reduction in Treatment Related CO_2 Emissions (113 Tons v 156 Tons)
- Reduced Field Produced Water Disposal Volumes (1.5MM Gals per Well)