Examining The Investment In Large Scale Water Re-Use Programs In US Shale Plays To Determine Cost Saving Strategies, Intelligent Treatment Investment and Remaining Barriers to Investment

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Some of the materials in this presentation…

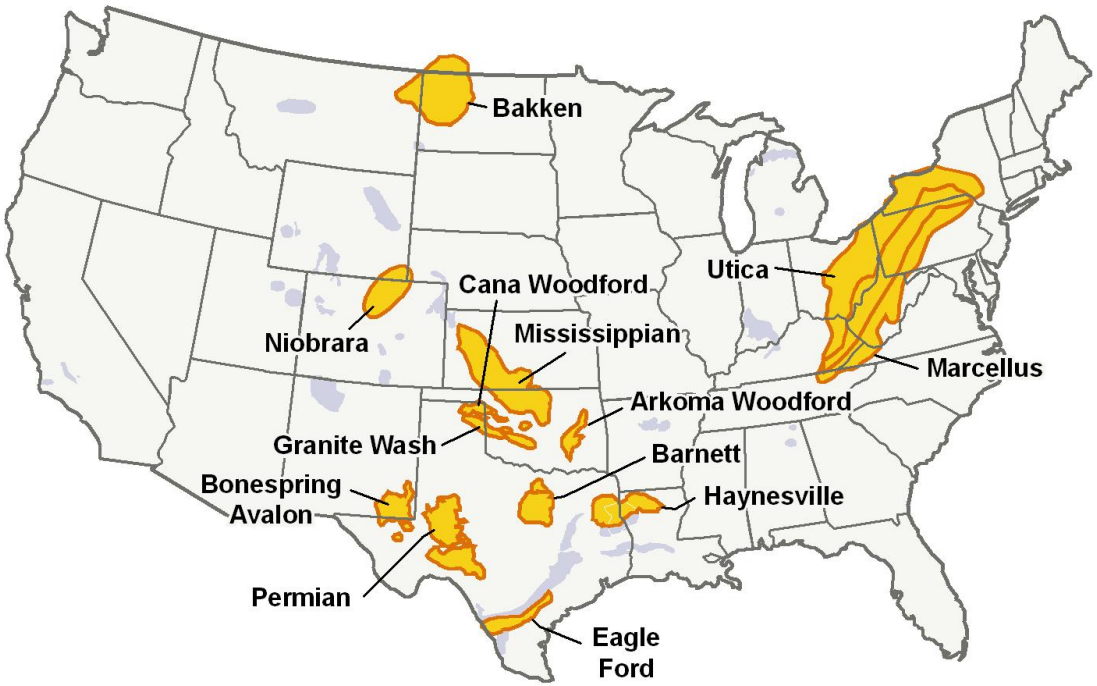
Come from two 2013 reports co-authored by CAP Resources and IHS on Unconventional Oil and Gas Water Management:

- Water Market Opportunities – directed at Oilfield Service Companies, Private Equity, and Venture Capitalists investing in the space

- Water Management Strategies – directed at Oil and Gas Operators (Exploration and Production companies)

The focus of these studies includes:

Play-by-play detailed level operational data and current actual practices in the onshore U.S. unconventional landscape



Focus of the Analysis

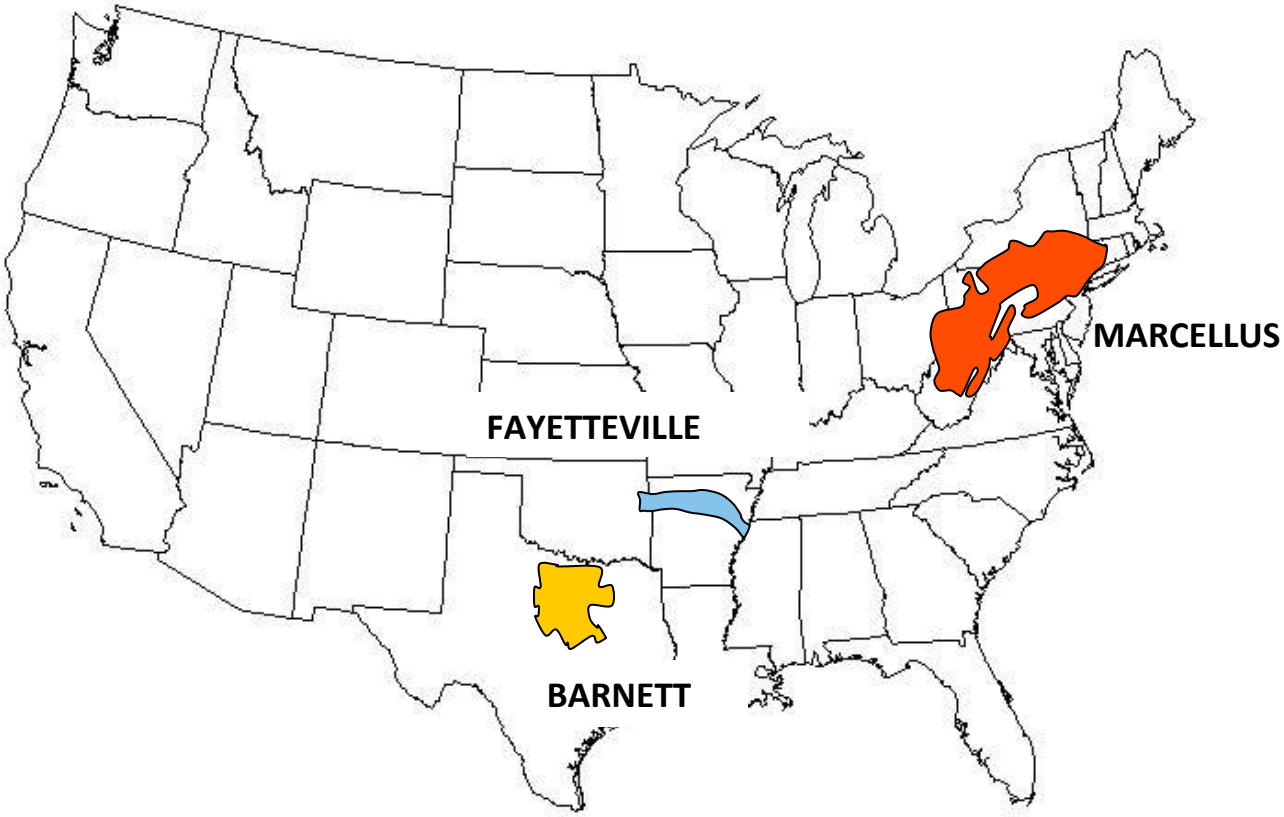
Arkoma Woodford
Bakken
Barnett
Cana Woodford
Eagle Ford
Fayetteville
Granite Wash
Haynesville
Marcellus
Mississippian
Niobrara
Permian Basin (Subset)*
Utica

Issues Outside California

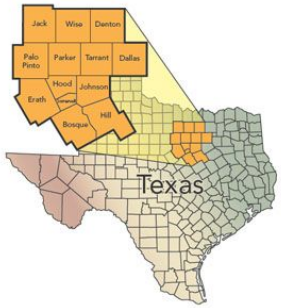
Industry Challenge: One Size does not "Fit All"

Every basin is (entirely) unique; mass volume efficiencies are thus difficult to gain.

Business models are instead customizing to basin / operator requirements (which is more expensive)

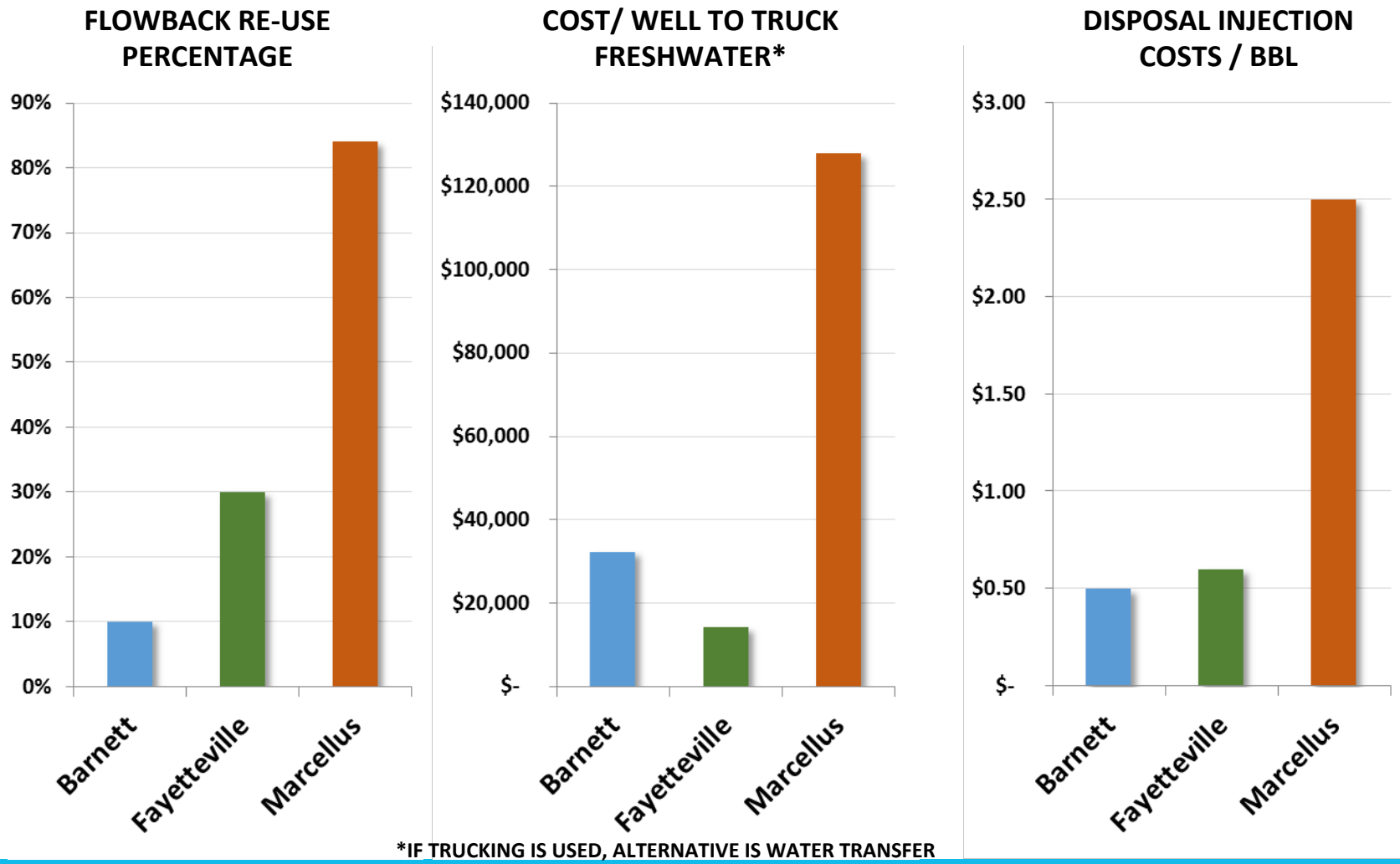


Basin Variability



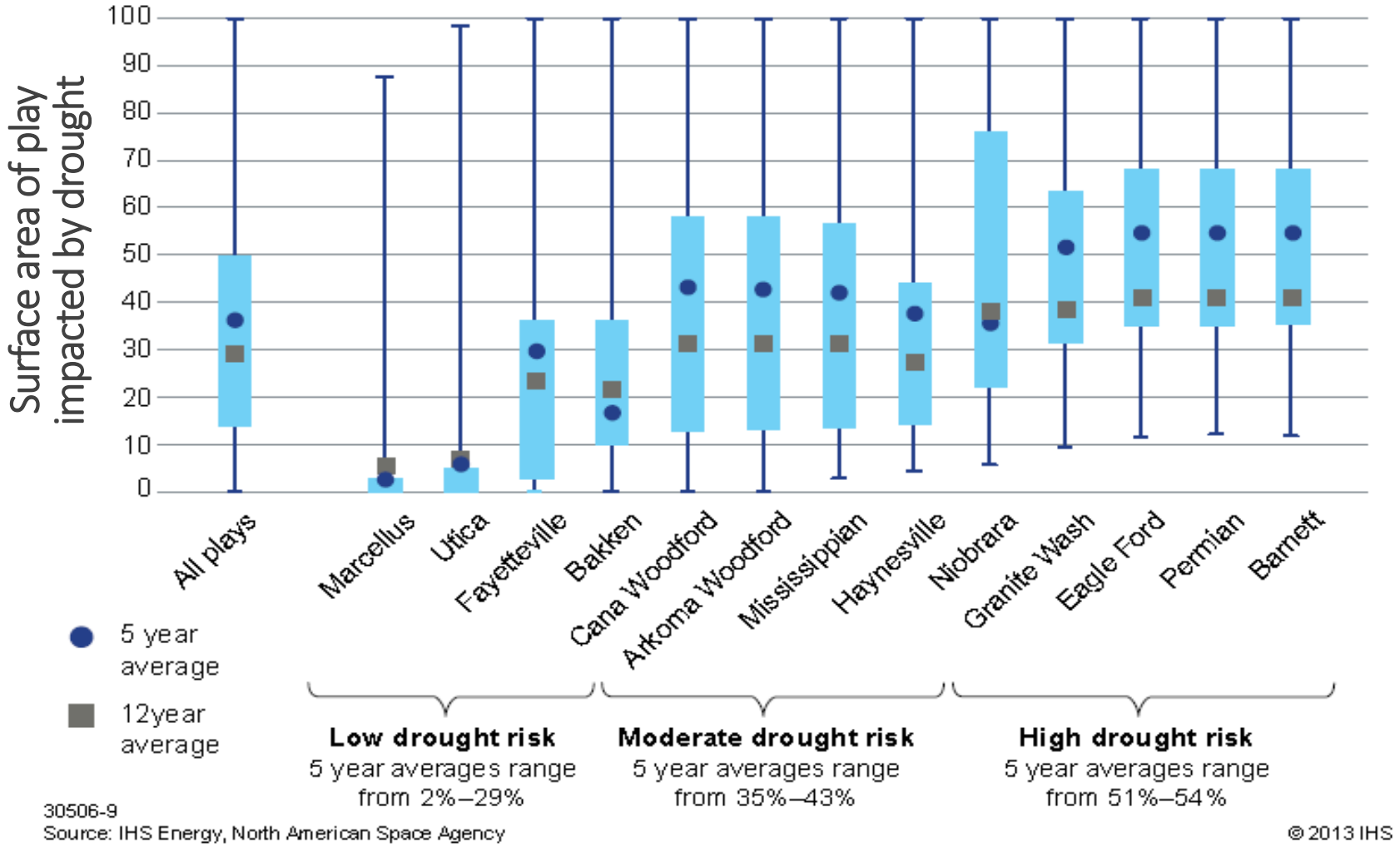
TDS / SALINITY LEVELS (ppm) IN PRODUCED WATER	**120,000**	**12,500**	**250,000**
TYPICAL BACTERIA COUNTS IN SOURCE WATER	**MEDIUM**	**HIGH**	**LOW**
DISPOSAL WELL COUNTS (STATE)	**50,000**	**450**	**<10**

Basin Variability and Cost Impact



*IF TRUCKING IS USED, ALTERNATIVE IS WATER TRANSFER

Drought impact is unpredictable, and growing



Conventional Fixed Water Treatment is “Easy”

Conventional fixed facilities (like municipal treatment plants, or SAGD operations) are optimized around steady state conditions:

- Consistent influent
- Large aggregation of influent sources evens out the “bumps”
- Large holding vessels can accommodate natural processes, long retention times

The rest of the U.S. is on a Water Roller Coaster

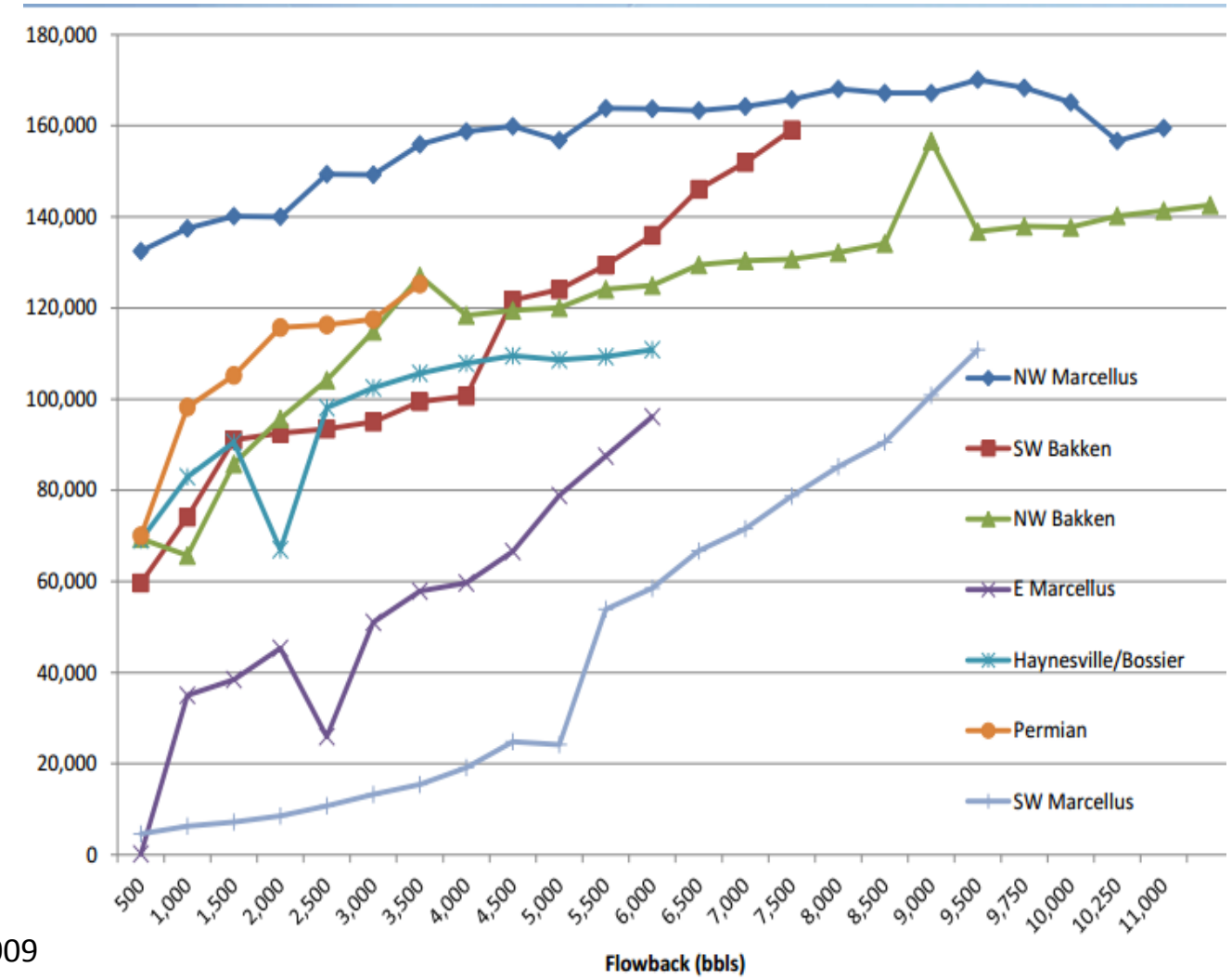
Shale Plays, and Light, Tight Oil, are far more challenging.

There is no "steady state" if drilling is going on:

- Production decline rates are dramatic (unlike SAGD).
- Water composition changes dramatically over the first year
  - Initially flows back additives, later this goes away…
  - Salt content escalates over the first year
- Disposal facilities have to treat "surges" of water, and each source can vary dramatically. (Drill water, completions fluids, flowback water, or produced water.)
- Fracturing substantially relies on mobile equipment with small footprints, the *concept of retention time doesn't work.*

Illustration: TDS Variance in Major Basins over Time

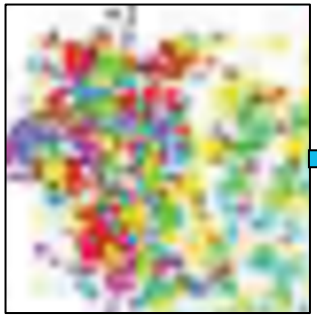
TDS Levels (Mg/L) Climb dramatically over the first year of production



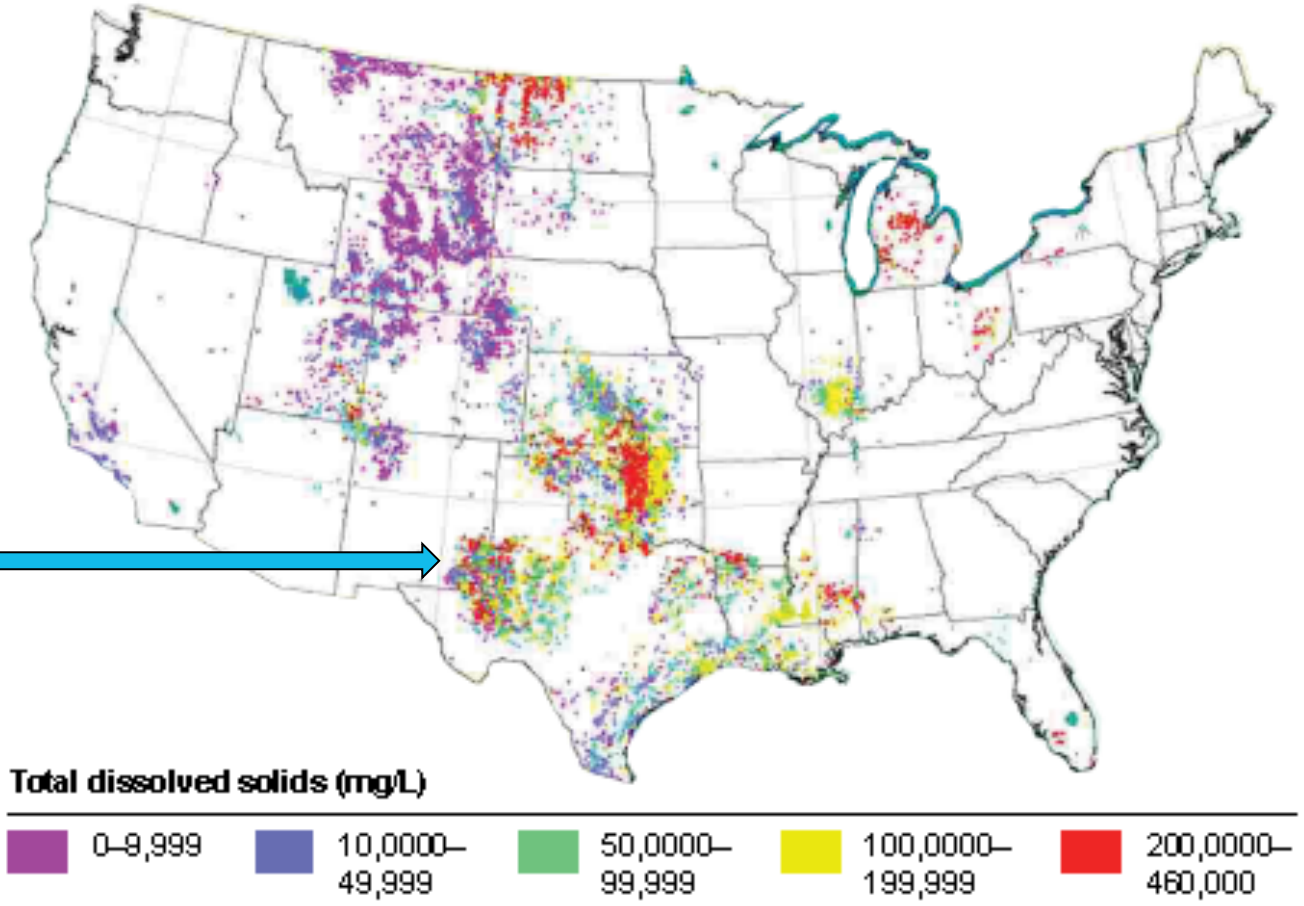
Ref: SPE 125740, Blauch, et.al. 2009

Illustration: Variance within in a given Region

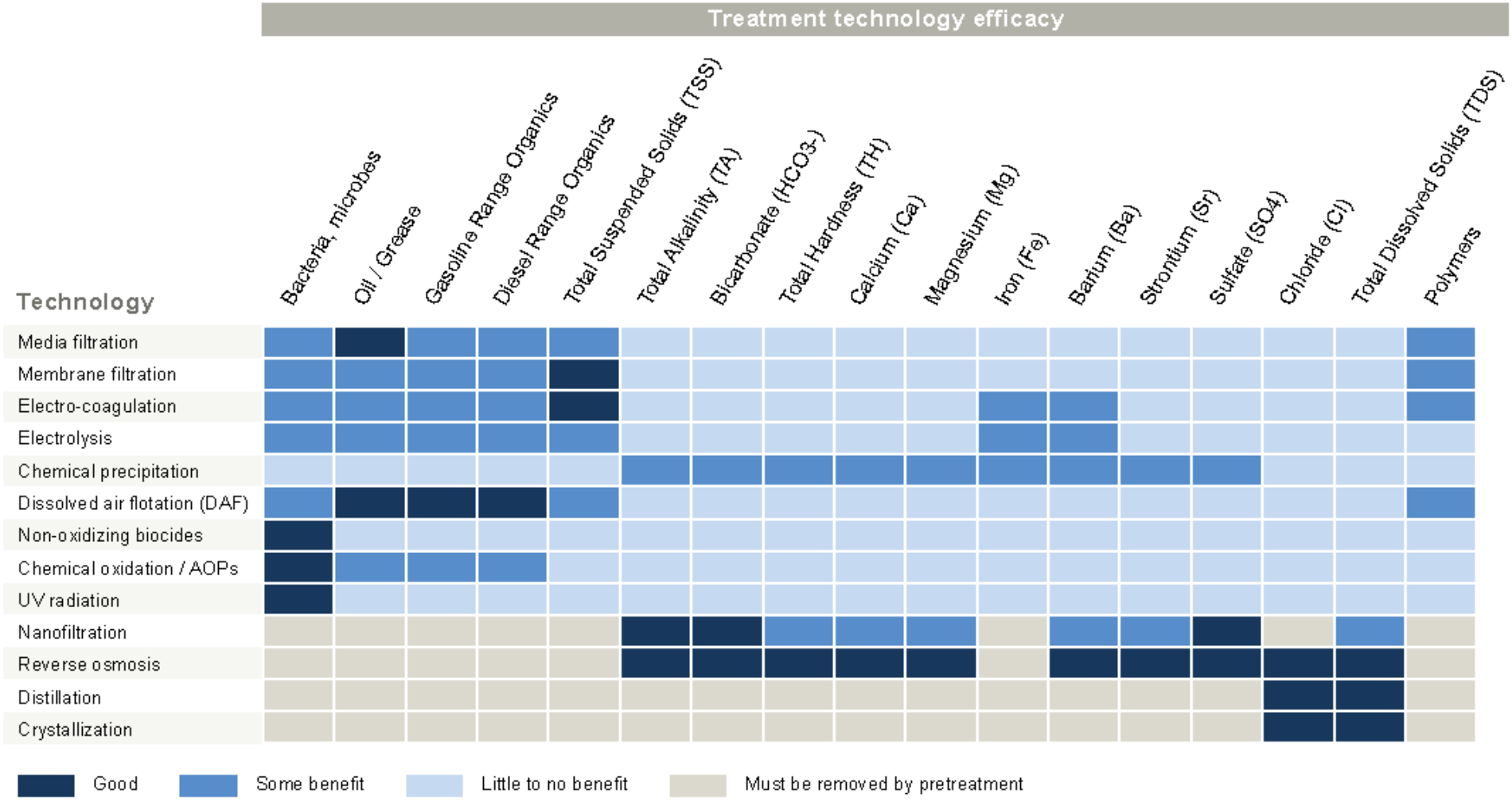
Within a region each Geologic Strata can have great variability



Chemistry of produced fluids across the United States



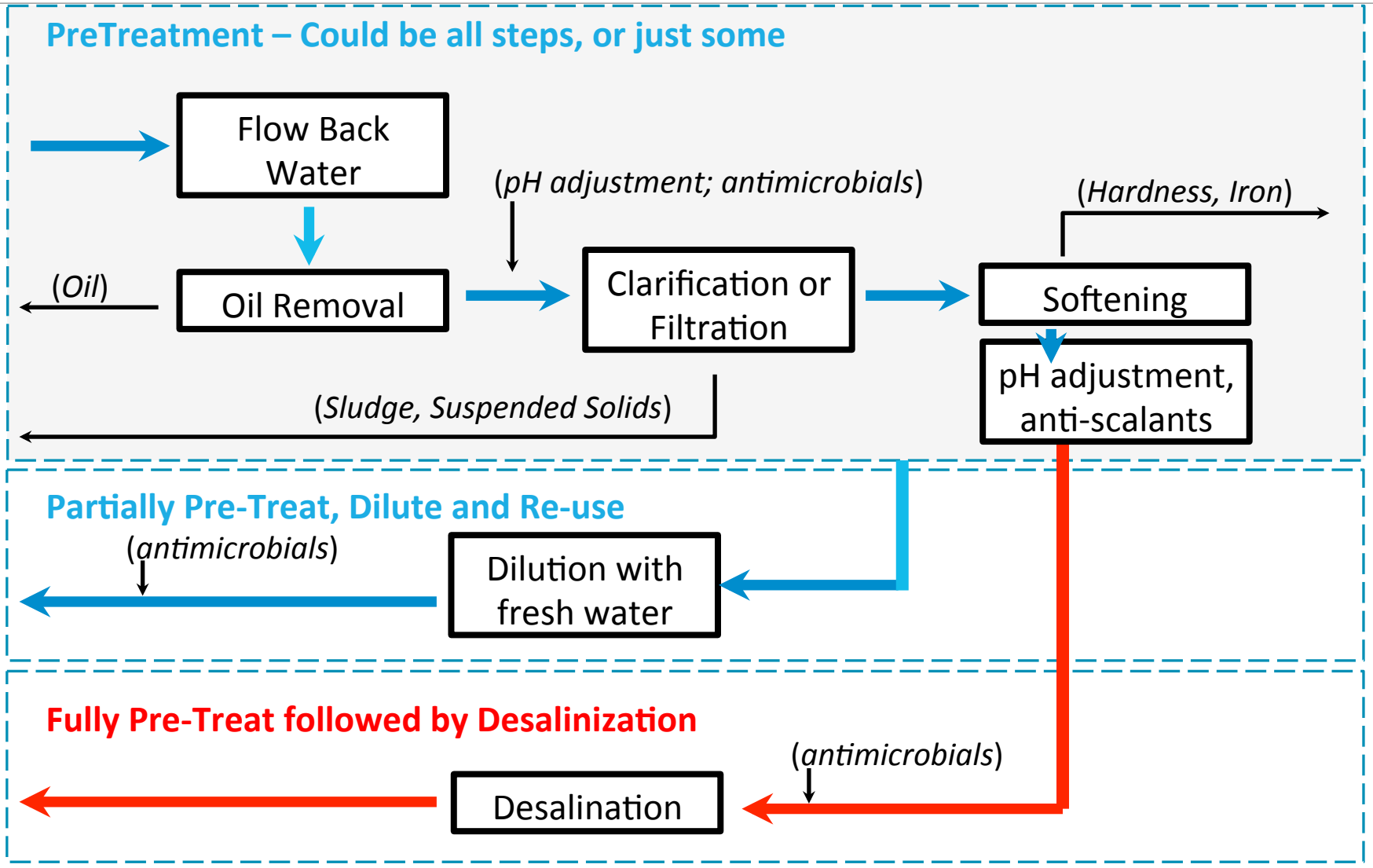
And no single technology can treat it all:



Source: IHS / CAP Resources "Water Market Opportunities 2013-2022"

Current Practices

Current Practices



Basic Treatment in Shale Plays

The market seems to be settling

We now understand plausible operating envelopes for existing technologies

Total Dissolved Solids (mostly salts) are a dominant determining factor in selecting technology (or chemicals).

Still a preference towards treating minimally / lowest cost:

- Eliminating bacteria which would foul a well
- Eliminating suspended solids via the simplest means possible (filters, most likely)
- Either diluting salt levels down to tolerable levels, or just "dealing with it" by paying more frac fluids which are TDS tolerant
- Prices on TDS tolerant fluids for slickwater fracs have come down as the technology matures, again making high TDS more tolerable in the minds of operators.

Opportunity Landscape: Treatment

Current Issues in Treatment driven largely by the oil plays:

"Gel frac" adoption for oil plays on the increase (as opposed to slickwater fracs, dominant in gas plays)

Good news is less water is "theoretically" used

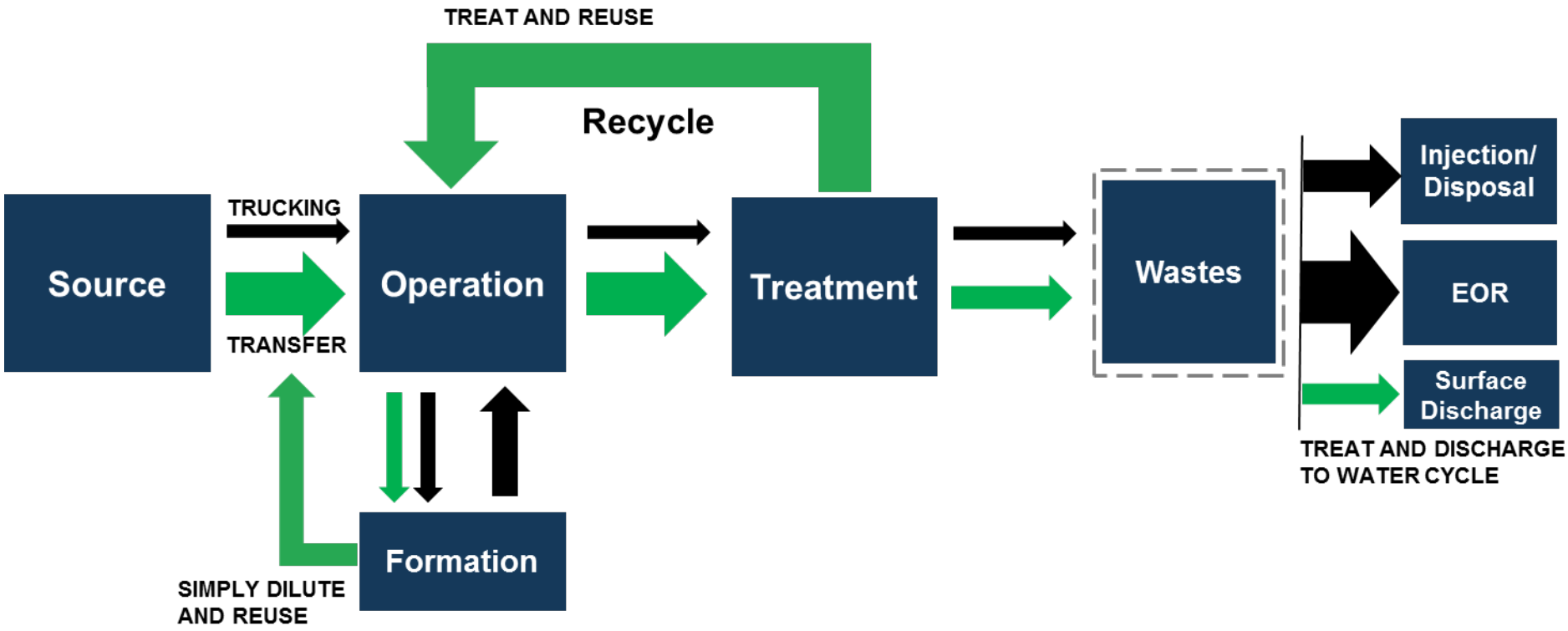
Bad news is…more issues with water re-use and Gel Fracs

- Gel Fracs are "finicky", and we are still on the learning curve
- If cross-linkers (such as Boron) are allowed to stay in produced streams, they can corrupt the "next" frac job by causing premature cross-linking
- Boron is among the most difficult of elements to cost effectively remove.
- As such, operators leaning towards fresh water instead of re-use.

Solving any of the above problems will be a significant market opportunity

Best Practices and Technologies

Best Practices in Water Management is a Continuum



Water Sourcing: Use and Re-use of Brackish Water

Brackish water is a newly recognized resource

- Significant resource
- Currently estimated at only 15% of U.S. supply

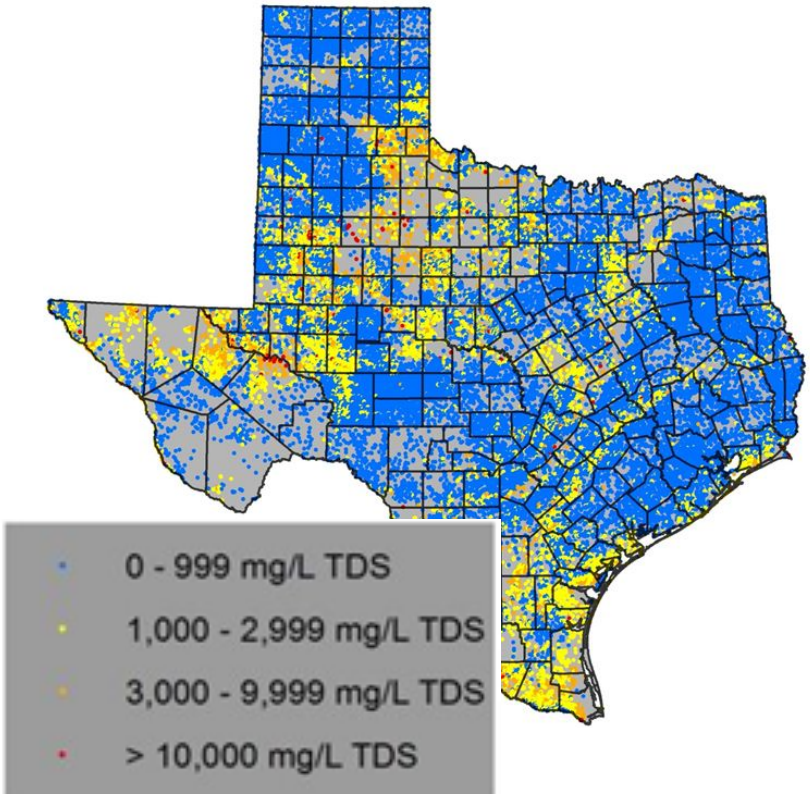
Operators want to re-use directly, *without* diluting

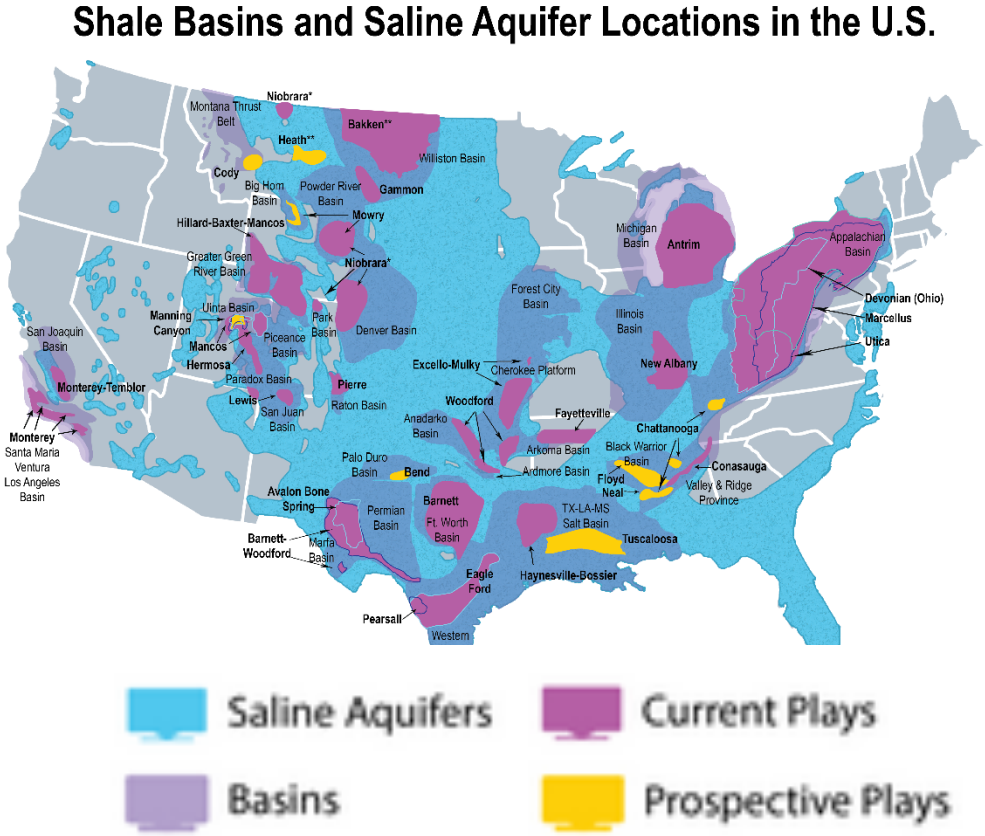
- Opportunity: Service companies to develop very high TDS tolerant fluids
- Opportunity: Service providers to treat flowback/produced water for direct re-use

Sharing

- New regulations in Texas may allow operators to transfer liabilities / share water
- May drive additional storage capacity

Saline Water: A Prolific Source





Source: Texas Water Development Board Groundwater Database

http://www.shaleplaywatermanagement.com/2013/11/exploring-water-treatment-reuse-and-alternative-sources-in-shale-production/

Water Hauling: Trucks are the “real” enemy

If Hauling is the only option for the operator, it can require:

700-1,000+ truckloads of fluid per well

A host of environmental and safety issues :

- Emissions
- Dust
- Wear and tear on roads (up to $250K)
- Traffic through small towns
- Safety

And often, huge costs for the operator

- Wait time (hours to load and unload)
- Costs: $200K - $700K / well*

*Example: 1000 trucks, 3 hours drive and wait time, $1.00/barrel/hour, 130 barrel truck capacity = $390,000

The simple answer? Water Transfer (Pipelining)

Reduces or eliminates hauling / trucking

Permanent or temporary pipelines

Initially borrowed from Agricultural;

>>> irrigation pipe called “fast-lining” (same as irrigation piping initially)

Still some challenges…

Initial challenges included:

- High CAPEX to build pipe inventory ($1 M+ per mile)
- For jointed pipe, likelihood to seep
- Liabilities for operator
  - High liabilities for brackish water, frac flowback or produced water
  - Therefore use is often limited to freshwater
  - In Marcellus, even freshwater spills are liability

Current issues include:

- **Lack of clear regulations – little guidance**
- Difficult to implement in hilly terrain
- Must be leakproof
- May not work in cold climates

Developers are Rapidly Responding

Developers of New Technologies are rapidly responding:

- Fit-for-purpose solutions
- Lay-flat pipe – no leak transmissions
- Leak proof joints
- Coiled / reeled storage and roll-out (less labor)
- Novel technologies to reduce pumping requirements

Storage Landscape

As a broad generalization, every ten wells would typically require

120 frac tanks

10 artificial containment ponds

1.2 inground pits

Opportunity Landscape: Storage

Downsides of conventional storage include:

Hauling - (how do you think they get frac tanks to the site?)

Small storage capacities of tanks that are transported (~500 Bbls)

Clean-up – when the party is over, who takes charge of cleaning up the environment on private lands?

Novel, above ground storage systems

Novel, above ground storage systems

- Usually consist of a transportable, re-usable modular framework
- Always lined (liners not reusable)
- Massive capacities – as many as 84 frac tanks!
- Virtually no environmental footprint left behind

Fixed Facilities Trends

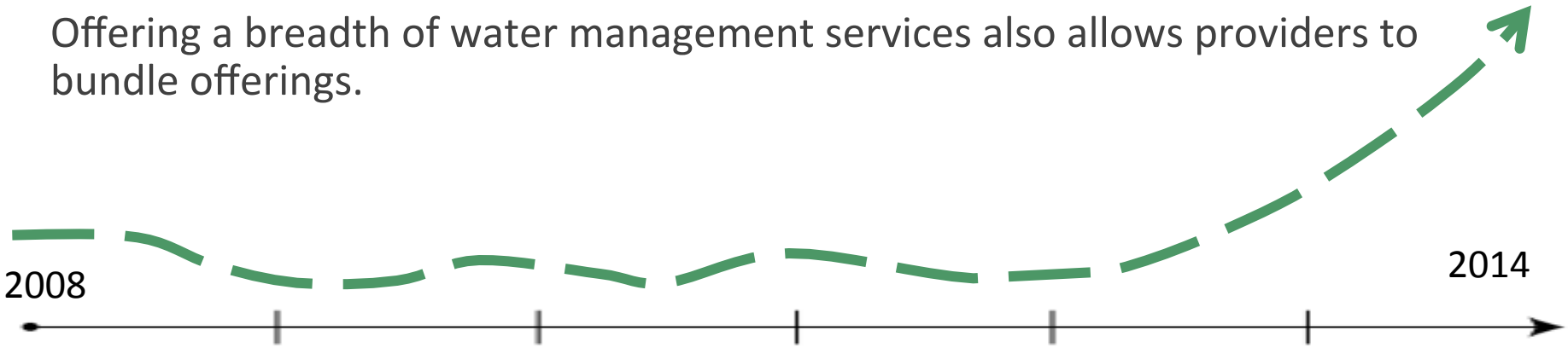
8 year History Fixed Facilities

Early entrants (2006-2007) struggled:

- Drilling was more distributed
- Influent water sources erratic (lack of steady business)
- Uncertain market requirements
- High cost to treat for discharge, few volume efficiencies
- Crash of 2008-2009-2010 didn't help!

More recently, we appear to have **turned the corner** – EVEN IN TEXAS !!!

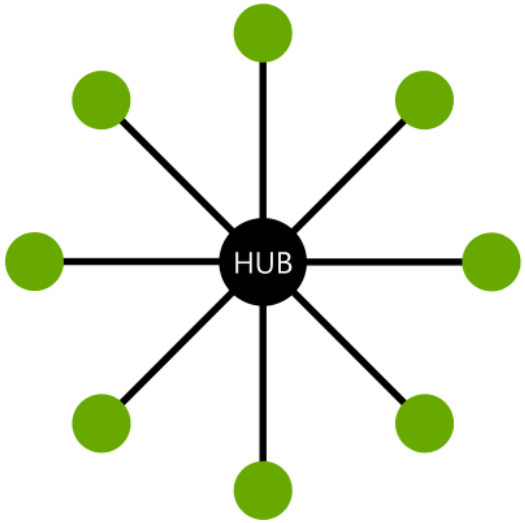
Offering a breadth of water management services also allows providers to bundle offerings.



Emerging Strategies in Fixed Facilities

Integrated Facilities – do more than Treat:

1) Hub and Spoke (pipeline) - reduce trucking, congestion
2) Large bays to reduce trucking wait time, improve operator economics (critical!!!)
3) Supplement with water supply (clear or brackish) to make use of return truck trips
4) Provide injection disposal capacity to reduce trucking for concentrate disposal
5) Handle multiple waste streams – liquids and solids

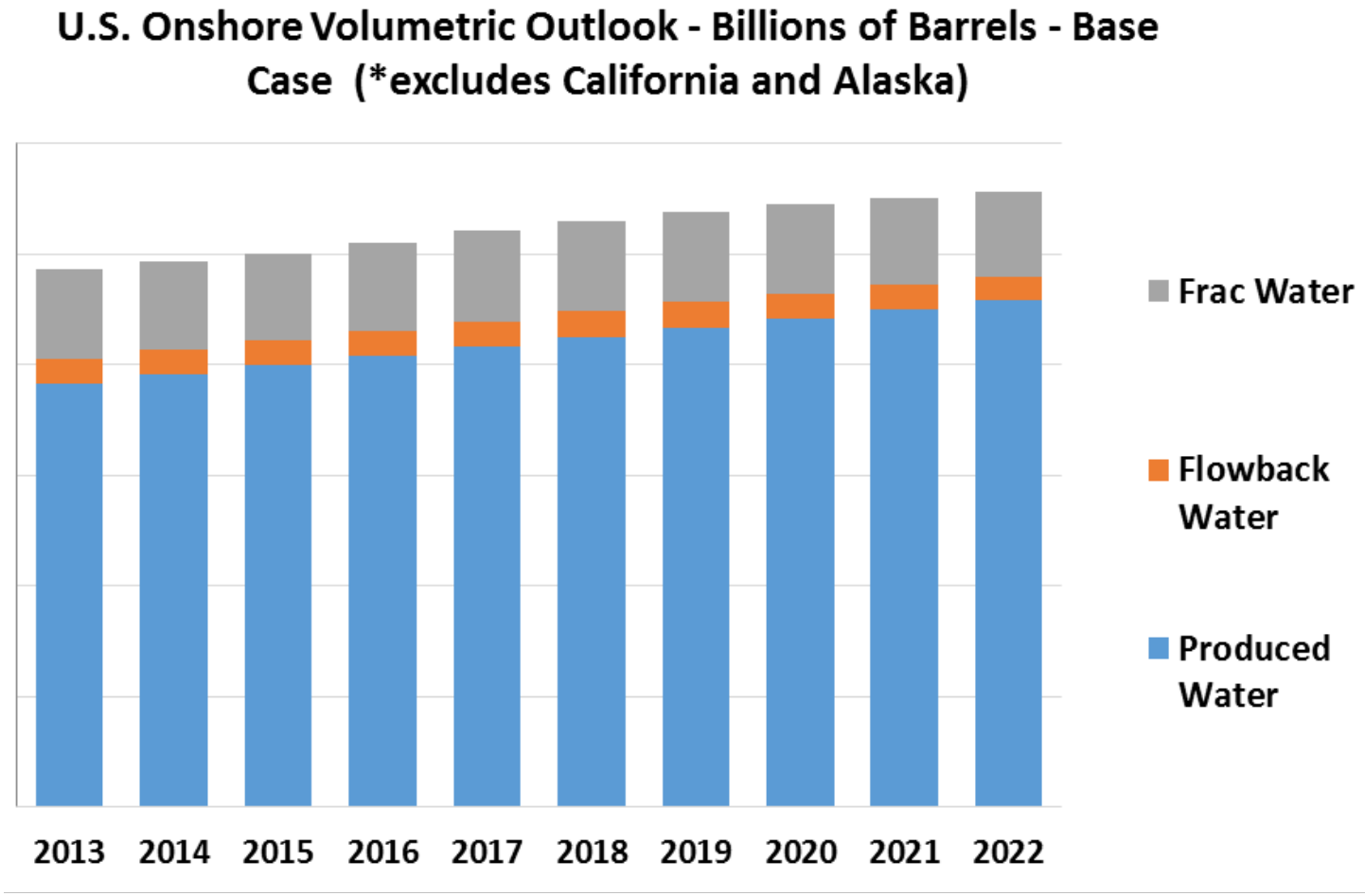


Emerging Strategies in Fixed Facilities

6) Best Available Technology for Oil Capture (offset operating costs)
7) Investigate subsurface solids injection (as opposed to landfill / landfarm)
8) Identify channels for clean brine concentrate sales
9) "Dial-in" Services
    - Advances in chemistry allow us to use a variety of water qualities to drill and stimulate.
    - It doesn't have to be fresh clear water.
    - New facilities allow customers to specify the quality of the returned product

Volumetrics

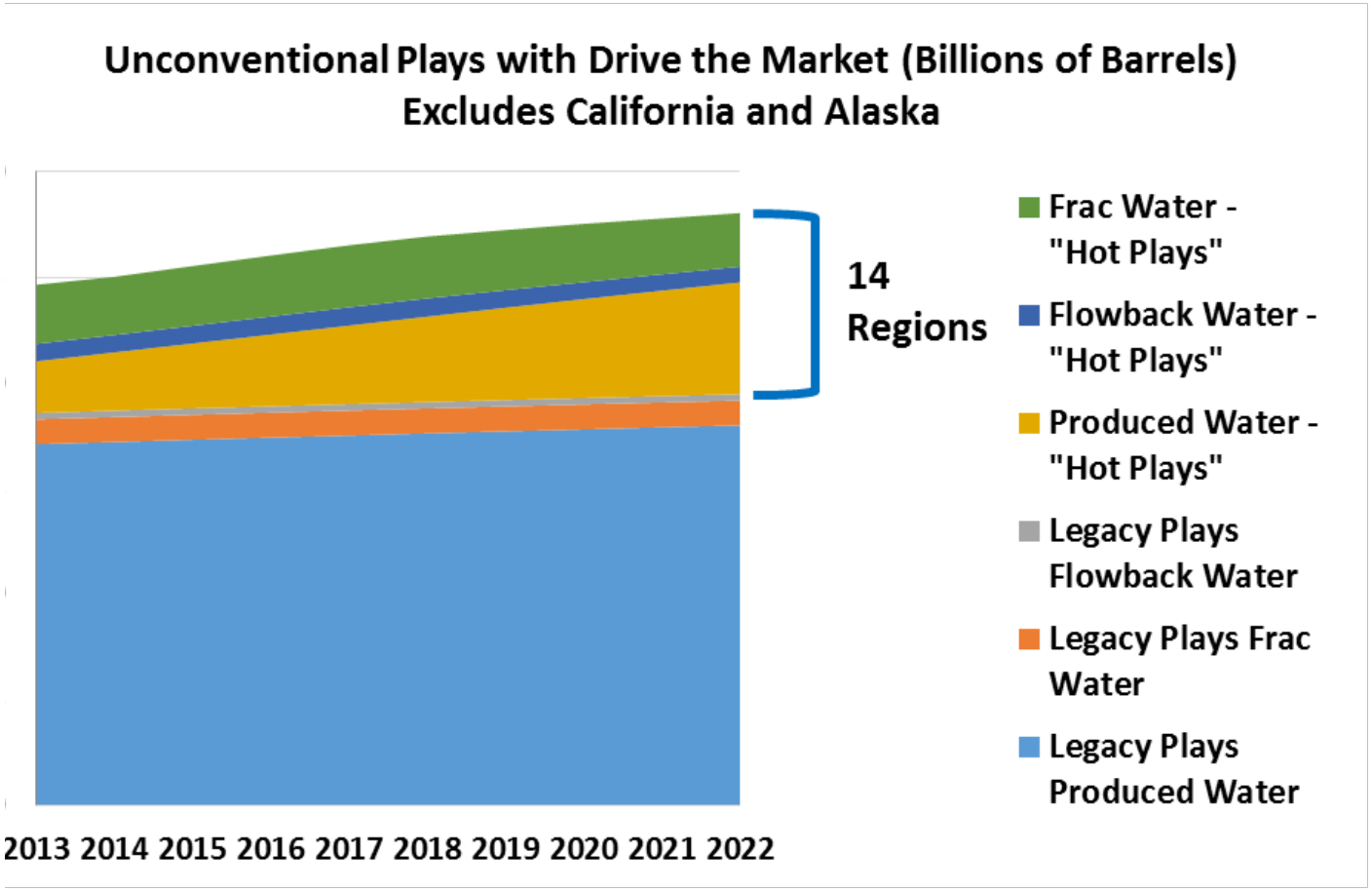
Water Management – Volumetric Outlook



Source: CAP Resources 2014

1/3 of Water Resource Management from New Plays

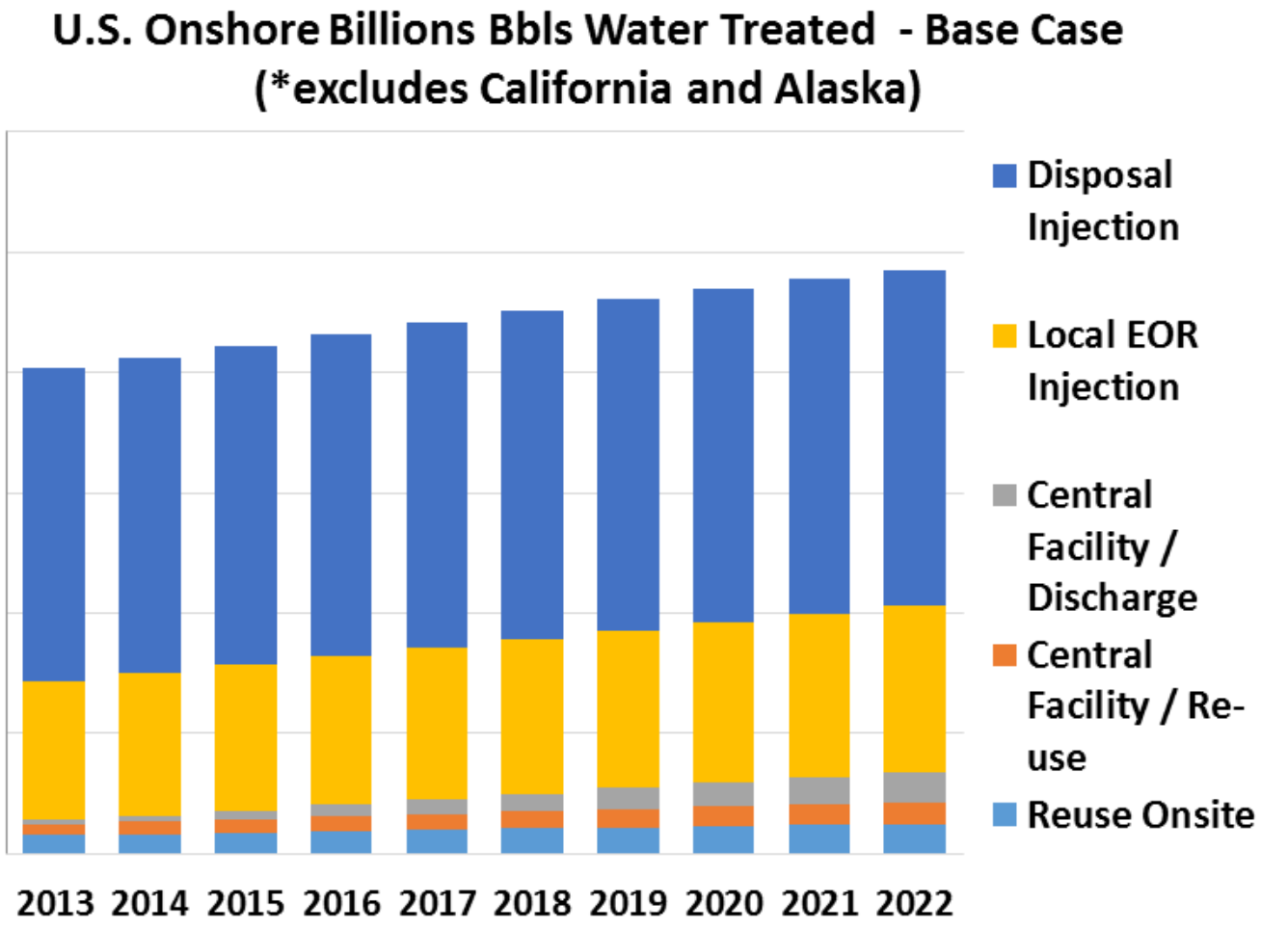
New Shale Plays are driving the growth; but existing production and ongoing drilling provide the baseline



Source: CAP Resources 2014

Base Case Water Treatment Outlooks

While volumes are high, current treatment levels can be minimal: basic settling, oil skimming, basic filtration



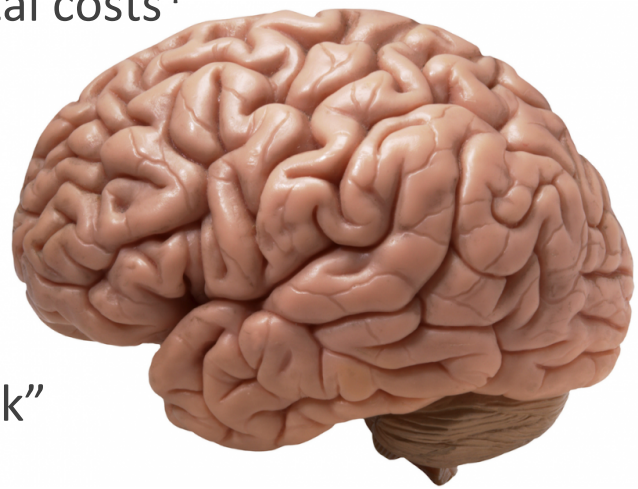
Source: CAP Resources 2014

Barriers to Adoption / Recycling

Behavioral & Other Barriers to Further Recycling Adoption

- Segregated Budget oversight – split across departments (drilling, production)
- Lack of big picture accounting encompassing total costs*

  *this has changed rapidly



- Classic reluctance to change
- Risk aversion mentality – “what if it doesn’t work”
- It turned out to be trickier than we thought, longer learning curve
- Chemistry tolerance to constituents keeps improving (maybe someone else will fix my problem!)

Barriers to Recycling

Concerns about Liabilities may be the single biggest barrier to "green" practices:

- Afraid to store produced water (leaks, spills>>>$$$)
- Afraid to transfer produced water with pipelines instead of trucks (leaks, spills)
- Cannot share produced water with operators that need it (transfer of liabilities)

Regulations are also lacking:

- No clear current regulations on water transfer (pipelay)

Recognition of use of Best Available Technology (BAT)

- Mobile treatment, transportable treatment, water re-use, water transfer, aboveground storage…

What you (and your legislators) can do

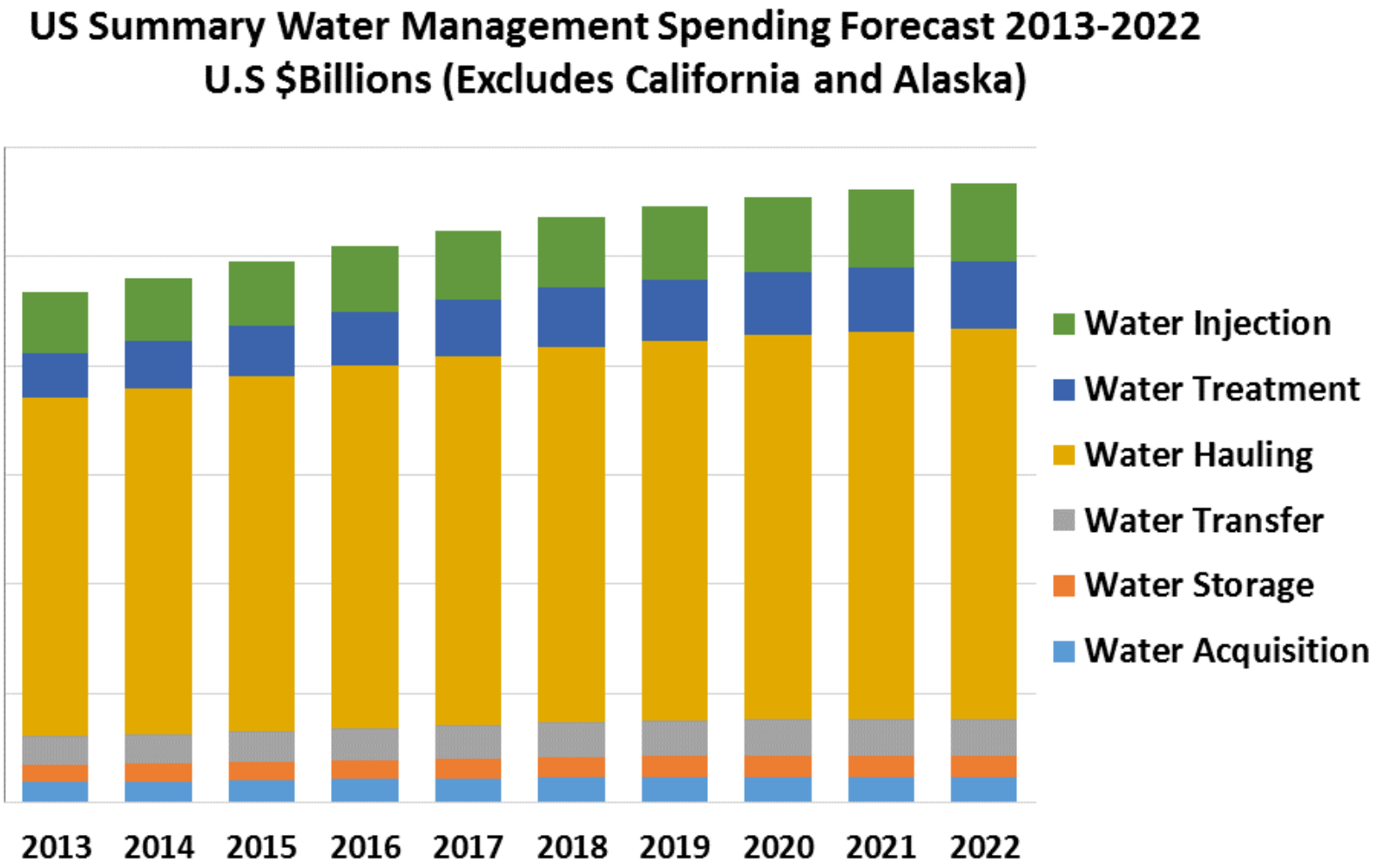
- Limit liabilities if Best Available Technology is used to reduce trucking

  >>>>> Encourage use of water transfer with pipelines with clear regulations

- Limit liabilities if Best Available Technology is used to achieve re-use
- Reduce regulatory burden / encourage use of mobile treatment and transportable treatment units
- Allow operators to transfer liabilities if they share used water
- Allow operators to co-mingle produced water for treatment without increasing liability

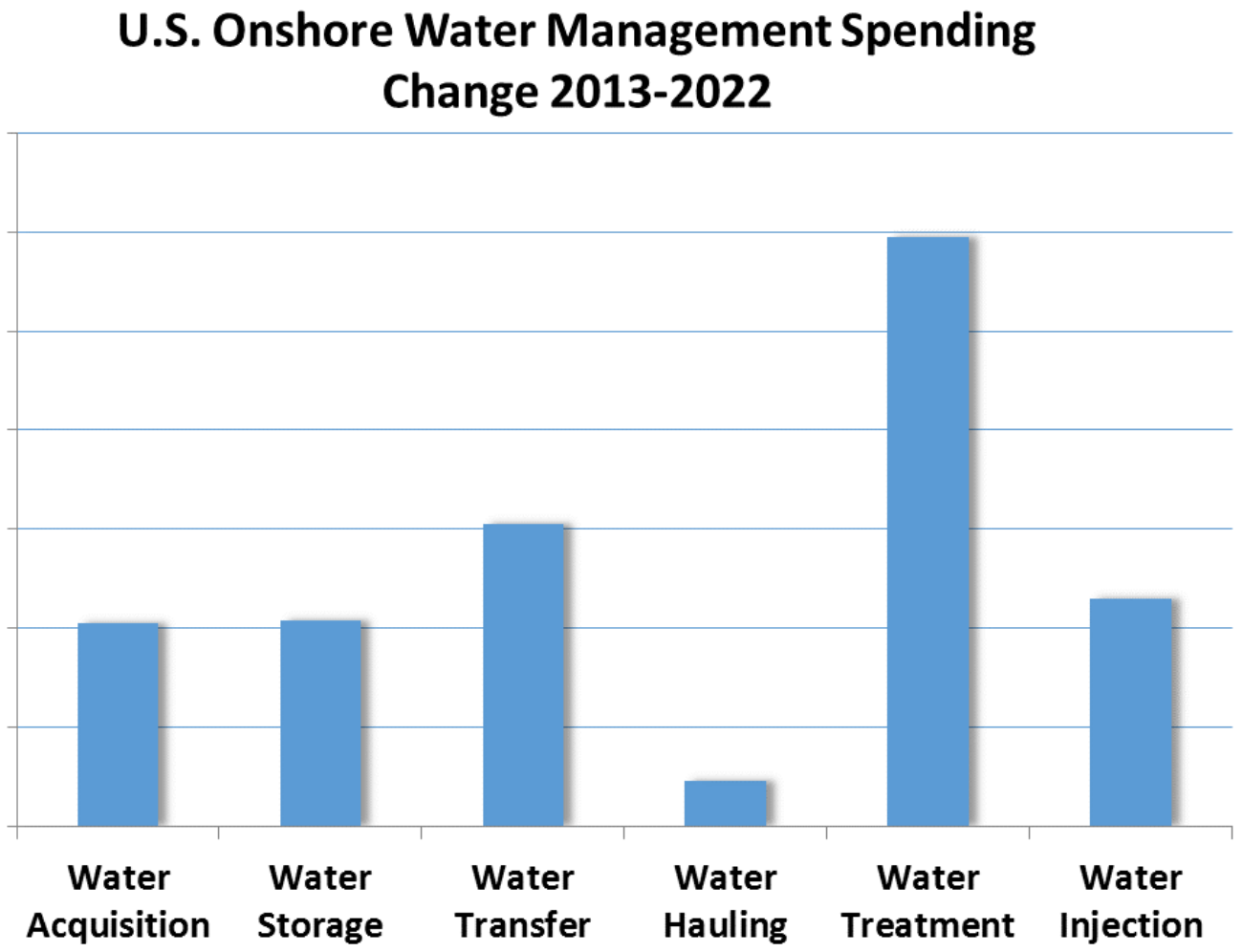
Market Spending on Water Management

Even with Cost Efficiencies, the Spend is Enormous

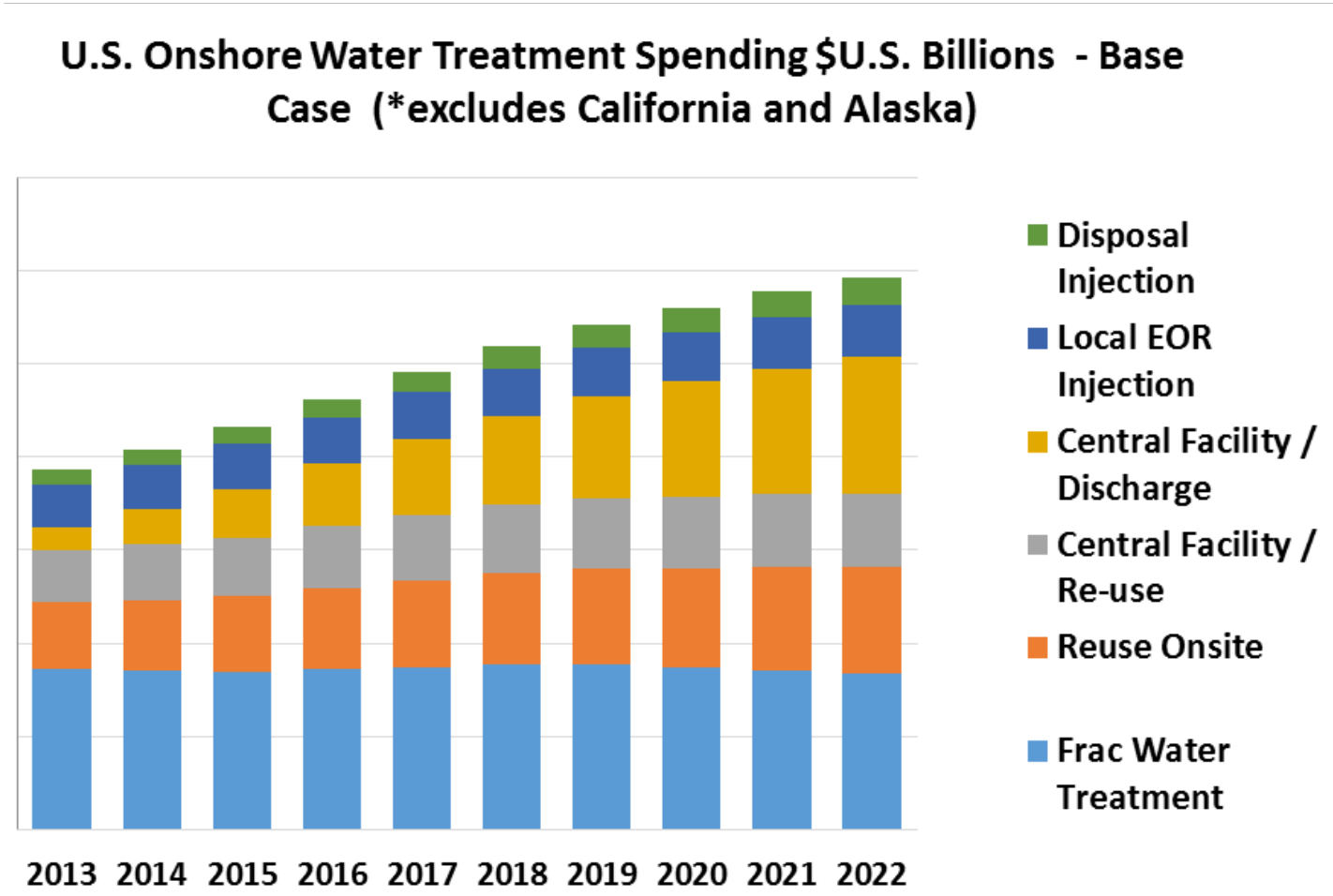


Source: CAP Resources 2014

And Unconventional Activity will drive the Opportunities



Water Treatment: A Growth Market



Source: CAP Resources 2014

Wildcards to watch out for…"what if…?"

Any *single* one of the following occurrences could dramatically change requirements and spending for water treatment:

Regulations

- Requirements to return water to the water cycle
- Tightening up of injection pressures/rates for disposal
- Restrictions on water quality that can be injected

Nature

- Ongoing Drought conditions will drive Water Conservation Districts to stricter measures

Cyclic Nature of Oil and Gas

- If prices crater, and operators slow completions, re-use for Frac'ing will diminish. This will drive treatment for discharge in some states, and will drive injection disposal demand in others.

Impairment of Reservoir Production

- It remains to be seen whether re-use without treatment will impair reservoir production….if it does…..

Impact of 10% mandated reduction of disposal injection

Hypothetical Scenario and Impact:

Due to seismic activity (earthquakes) caused by a very few careless disposal well owners exceeding capacity, this scenario assumes regulators restrict injection rates for disposal wells, resulting in lowered capacity.

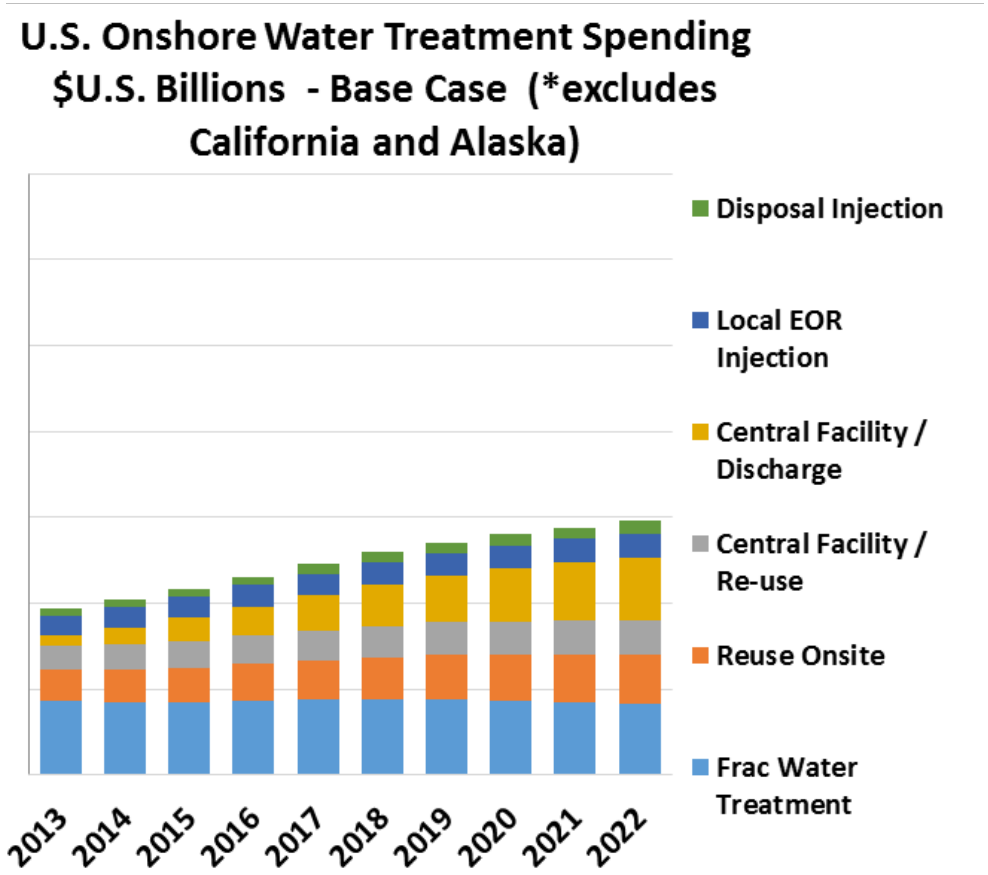
This scenario requires 10% of ALL produced water, flowback water and and drillwater be "re-allocated":

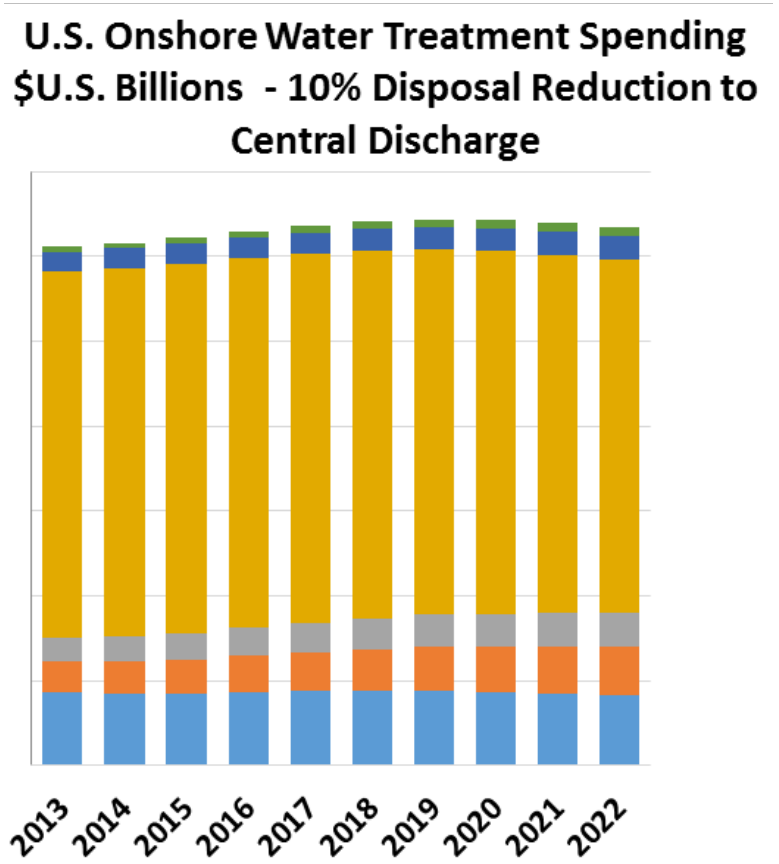
- Disposal Injection volumes reduced 10% (i.e. ~75% produced water to injection/ disposal now reduced to 65%)

- Assume corresponding volume (+10%) is instead treated to discharge standards in fixed facilities*

*in reality water would be treated, most likely, via many modalities; mobile treatment, central facility for reuse, etc.

Impact of 10% mandated reduction of disposal injection





*in reality the $500M increase to ~$9 B in water treatment spend would likely be spread across many modalities and for re-use, such as mobile treatment, central facility for reuse, etc.

In Closing....

"We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten. Don't let yourself be lulled into inaction."

From Bill Gates' book, "The Road Ahead," published in 1996.

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