Produced Water Society

February 14, 2018 - Sugarland, Texas

Midstream Challenge: Finding the Balance between Produced Water Disposal and Recycling

Amanda Brock, CCO Solaris Midstream

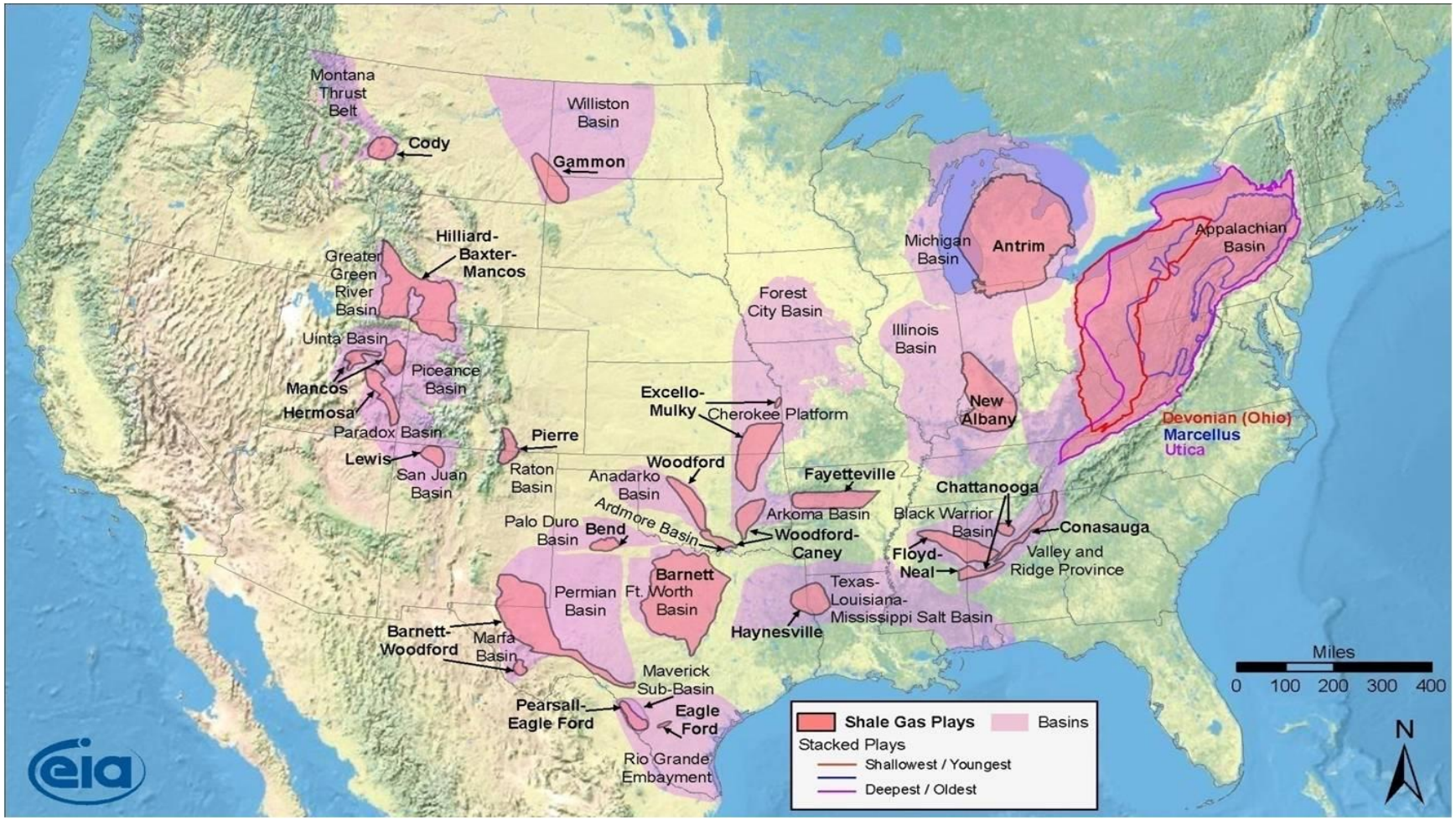
Understanding the Importance of Water

"Water is the most commonly used fluid in the oil and gas business, making its usage and management critical to the petroleum industry. More than ever, in fact, water is an integral part of the success of oil and gas operations. **Without adequate supplies of water, there is no multistage hydraulic fracturing, and without fracturing, there are no oil or gas resource plays**. And of course, without resource plays, the trend lines on domestic oil and natural gas supplies would look very different."

Newfield Exploration 2013

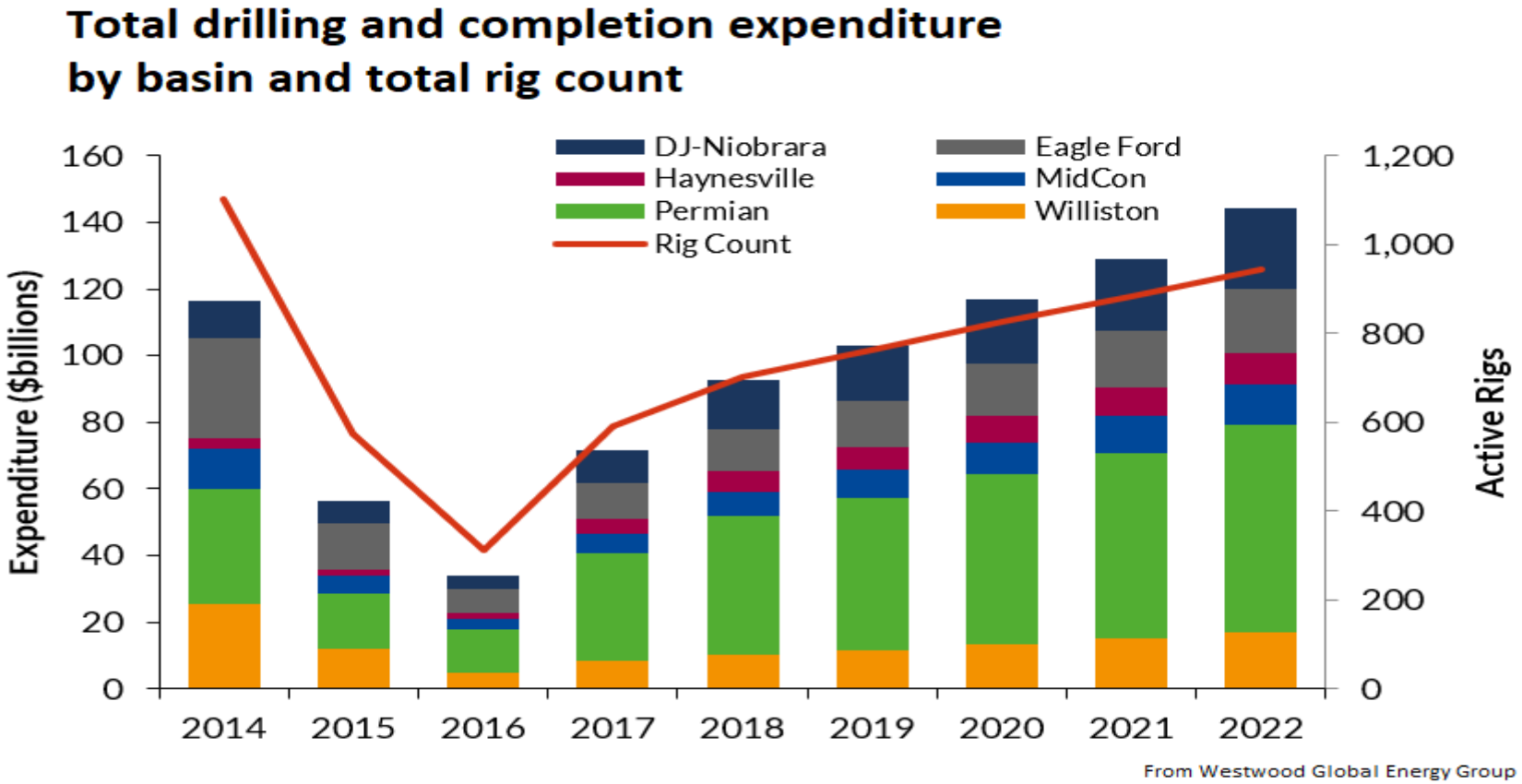
Market Dynamics and Geography

Explosive Growth of the Upstream Unconventional Sector; The Shale Revolution



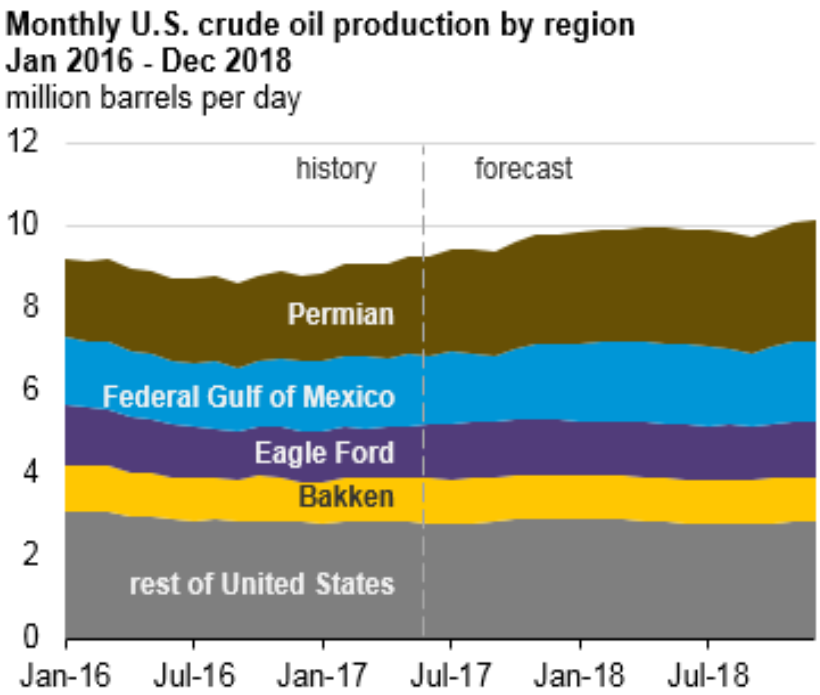
The Onshore Rig Count Tells the Story

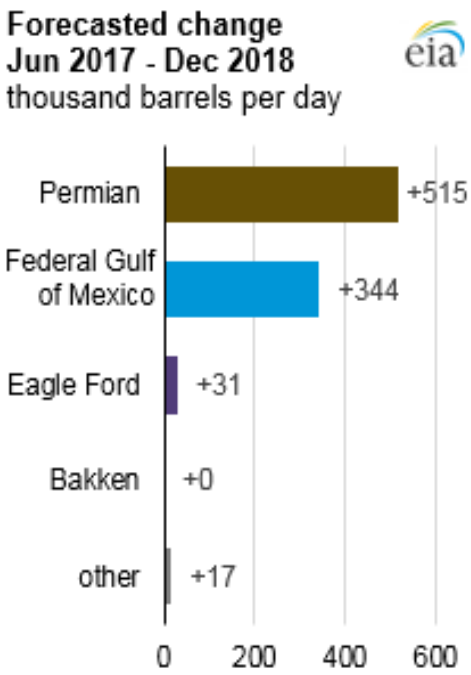
- As of February 9th, 2018 total US Rig Count was 975 active rigs, with the change from 2017 +234
- The Permian Basin now accounts for 46% of US active rigs at 437
- West Texas Intermediate closed February 13, 2018 at $59.29



US Crude Oil Production Forecast; Permian Leads

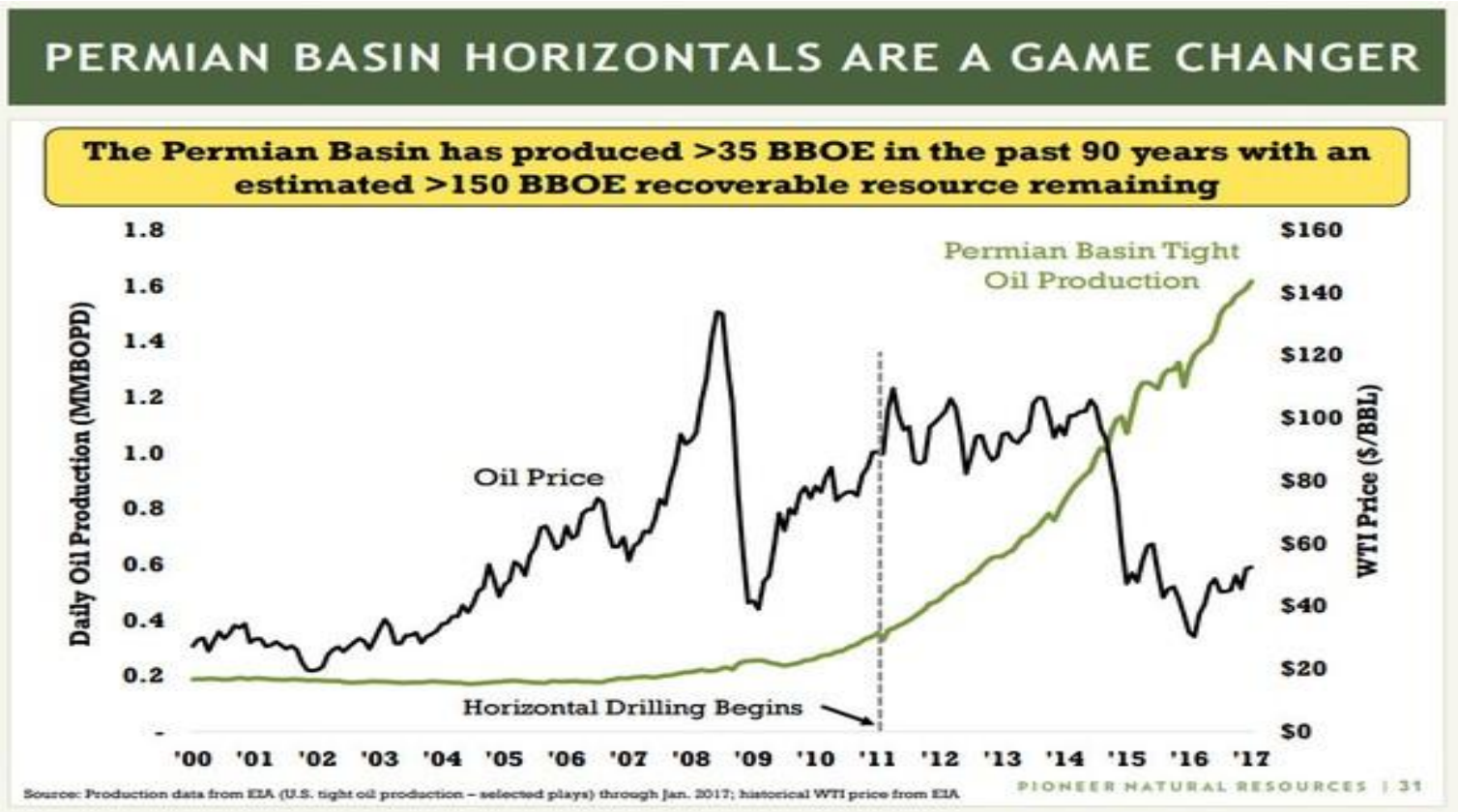
- Shale Production from the 7 major U.S. oil plays is expected to climb to 6.756M barrels a day with nationwide output exceeding 10M barrels
- The EIA projects that the Permian is expected to produce 2.9 million b/d of oil by the end of 2018, about 0.5 million b/d more than est. 2017 production level, nearly 30% of total U.S. crude oil production in 2018. 4 Million b/d by late 2020





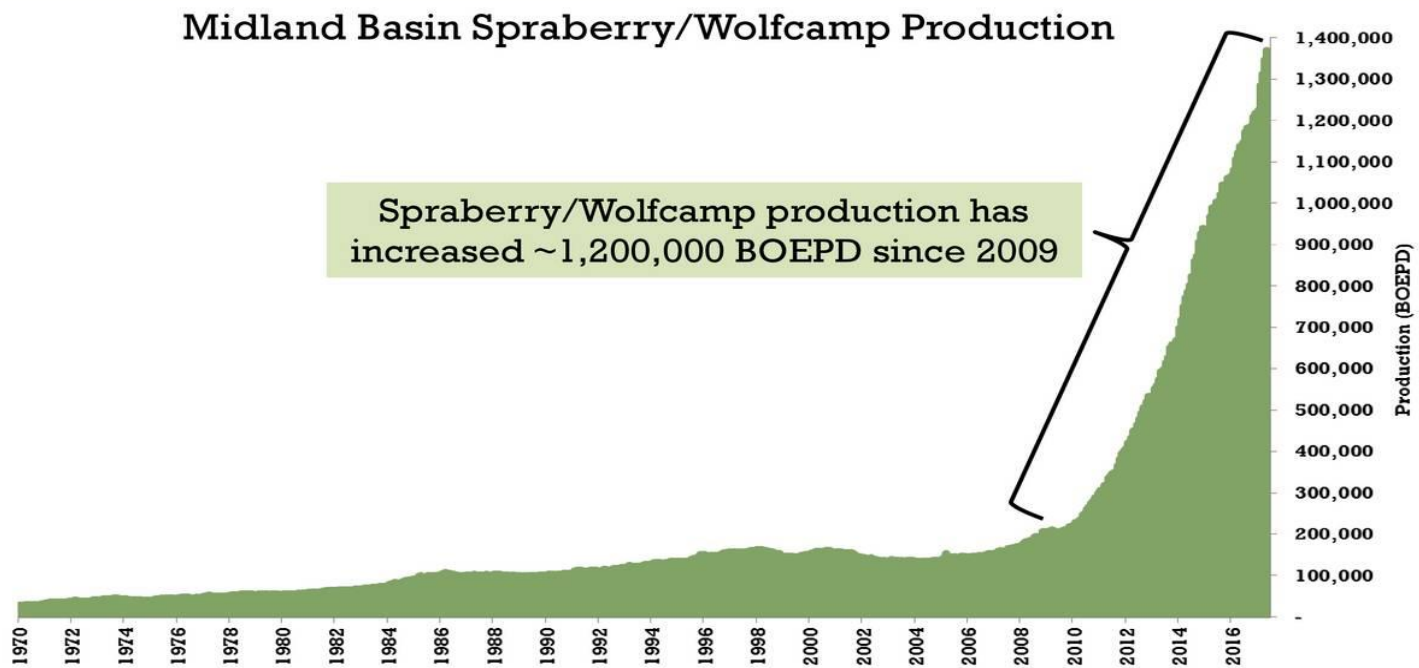
Horizontal Drilling has Driven Unprecedented Growth

- With leaseholds larger, producers are drilling longer horizontal wells or "laterals" now 7,500 to 10,000 feet and sometimes longer
- Intensifying well completions with more pressure, more water, more sand per linear foot of lateral and more frac stages



Midland Basin Horizontal Activity Growth

IMPACT OF HORIZONTAL TECHNOLOGY IN THE MIDLAND BASIN



- From 2009 to 2012, production growth primarily attributable to increased vertical activity
- Post 2012, production growth driven by horizontal activity

Source: IHS Energy monthly data through May 2017 for the Spraberry, Credo East, Garden City South and Lin Fields; 2-stream production data

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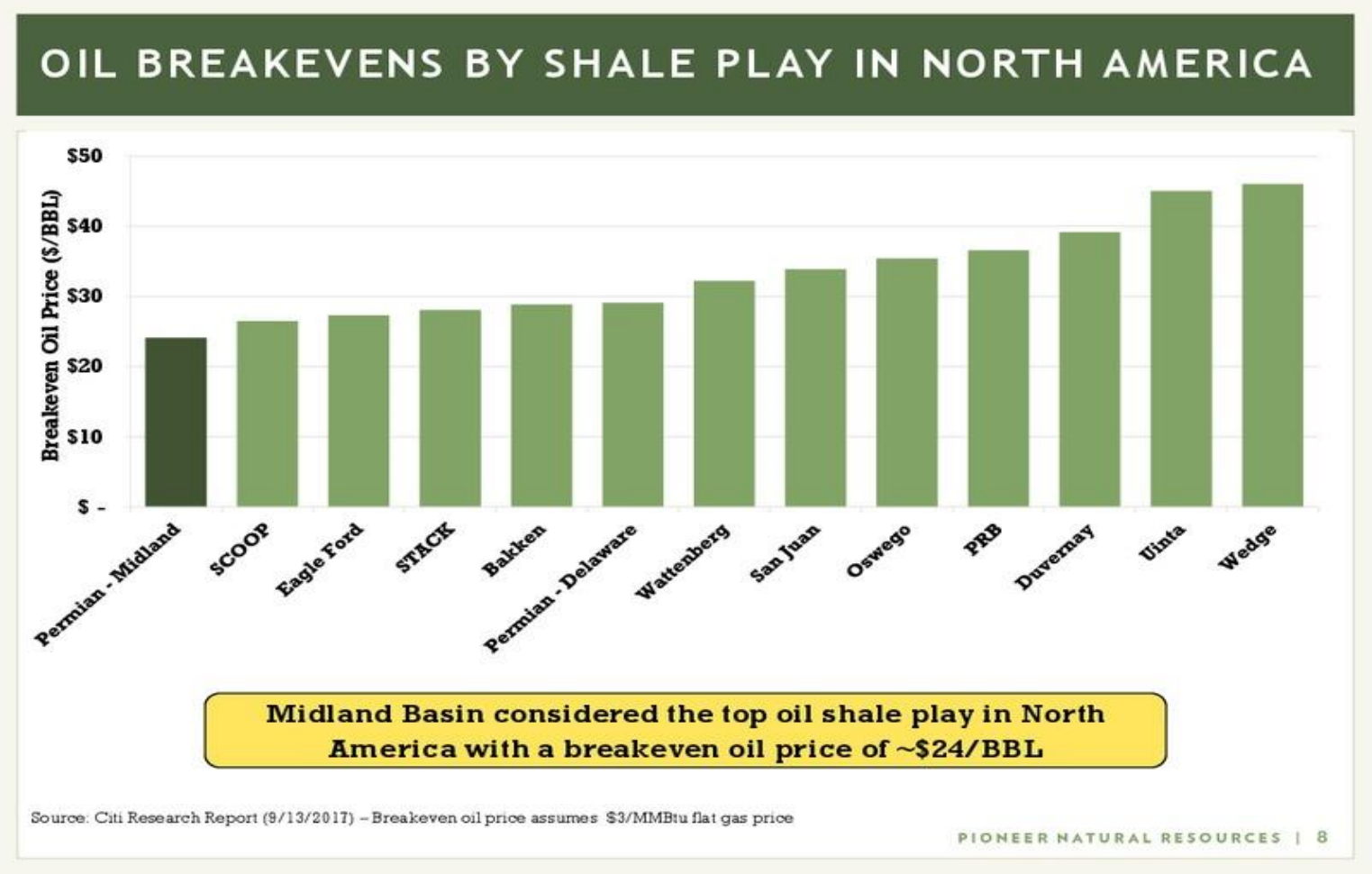
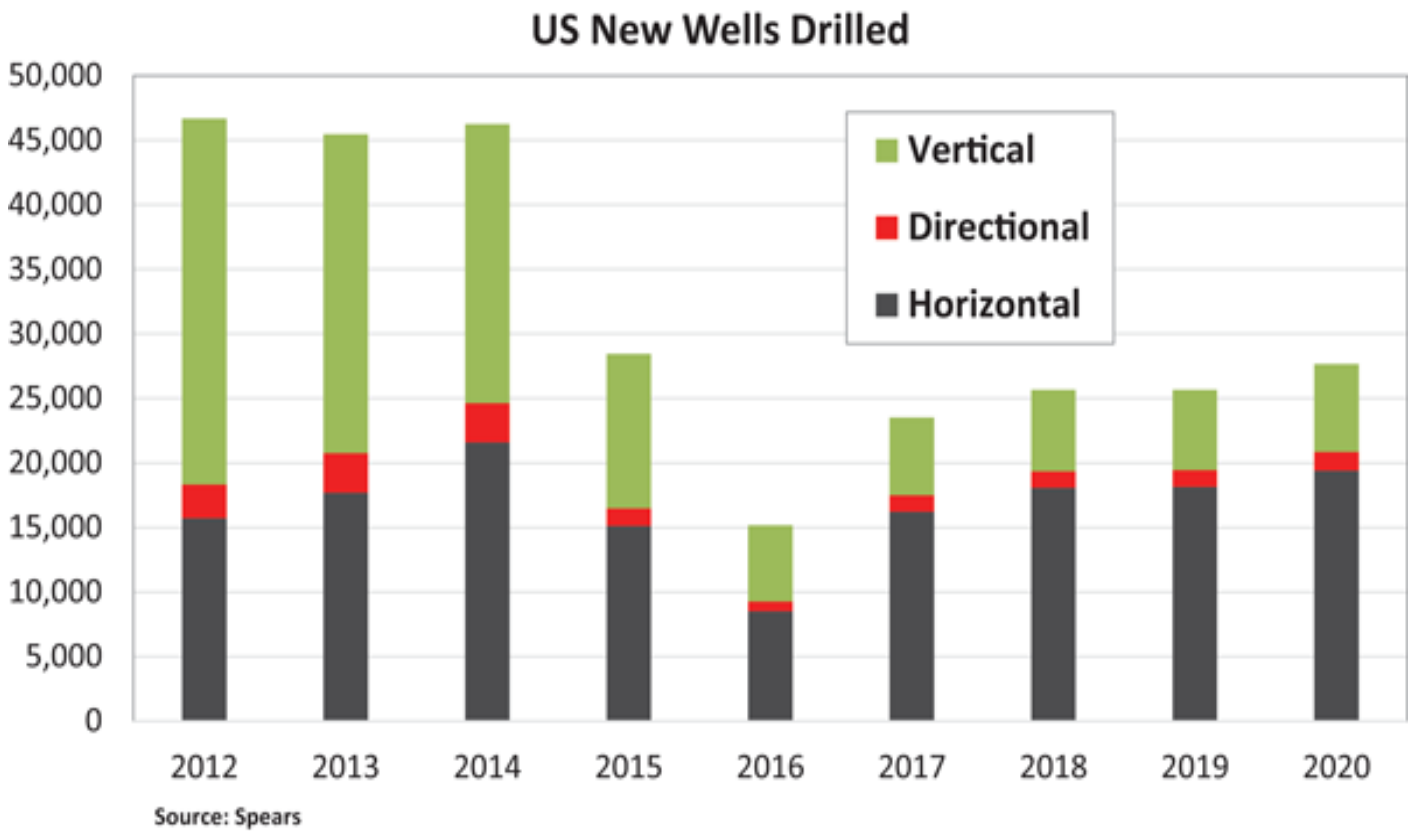
Breakeven Prices have Trended Down

Lower commodity prices have forced operational efficiencies, which together with technology improvements have dramatically reduced breakeven prices



With Strong Commodity Prices Growth will Continue

Assuming oil prices remain in the $50 to $55 range in 2018 and 2019, the number of wells drilled in the next two years in the US is likely to stay above 25,000.



Permian: Best Days are Still Ahead

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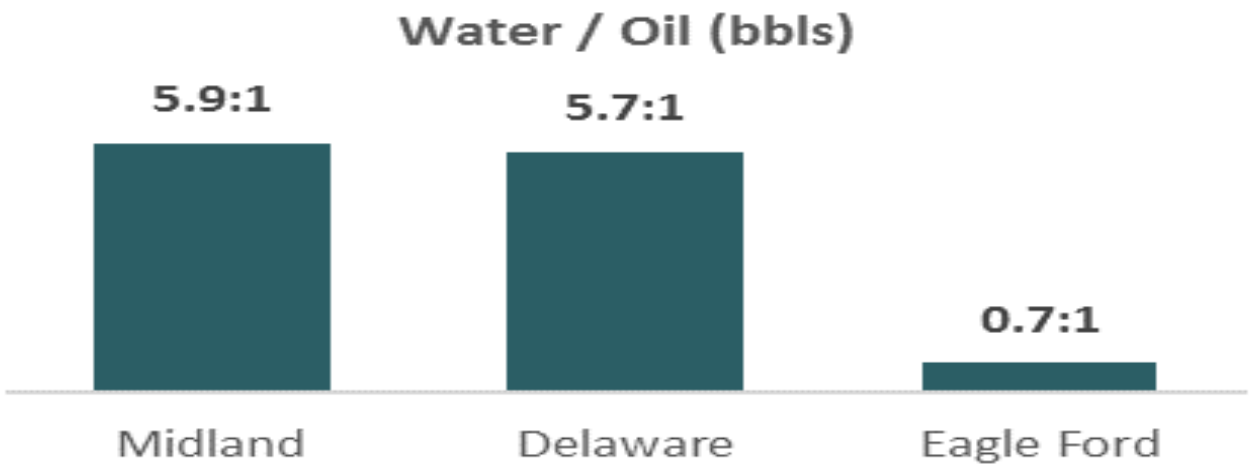
- **Exxon**
  - Oil giant Exxon Mobil Corp. plans to triple its daily production in the Permian in West Texas and New Mexico by 2025. Daily production is expected to increase to more than 600,000 oil equivalent barrels by 2025.
  - ExxonMobil expects the horizontal rig count in the Permian to increase 65 percent in the next several years.
  - ExxonMobil said it has **doubled its footage drilled per day on horizontal wells in the Permian since early 2014 and reduced its drilling costs per foot by about 70 percent as wells are drilled increasingly longer horizontally**. Exxon said its combined development and production costs in the Permian are less than $15 a barrel.
  - ExxonMobil said tight oil production from the Delaware and Midland basins will also increase five-fold by 2025.

- **Occidental Petroleum**
  - holds a vast Permian acreage position and is by far the basin's largest producer. Shale is a major growth driver for Occidental, with its production from tight oil resources expected to grow by a 20% to 30% compound annual rate through 2020
  - "**Recognize current limitations; Existing infrastructure capacity and water network**"

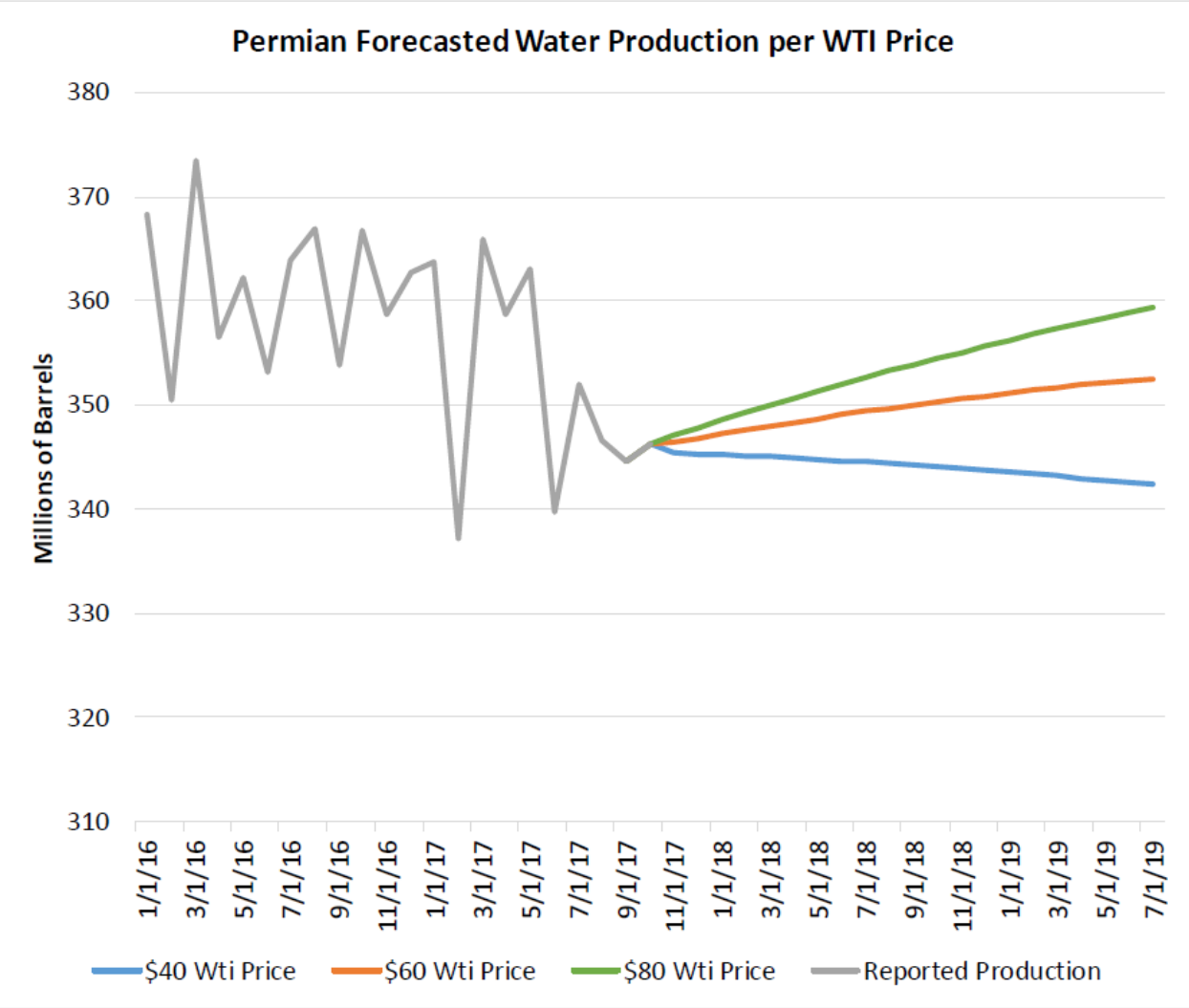
- **Chevron**
  - Has a long history in the Permian, having already produced 5 billion barrels of oil. As one of the basin's largest acreage holders, Chevron controls an estimated 9.3 billion barrels of oil equivalent resources. The company is ramping up horizontal drilling in the region, which could fuel 20% to 35% annual production growth through 2020 depending on oil prices, **boosting its Permian output to a range of 250,000-350,000 BOE/d.**
  - Meanwhile, there's plenty of growth beyond that, with Chevron believing it has the resources to eventually get its output up to 700,000 BOE/d within a decade.

Produced Water Volumes will Grow Rapidly

Permian Basin average oil to water ratio is 5.9:1 ~6X higher than Eagle Ford wells. As fields age, the water cuts increase.



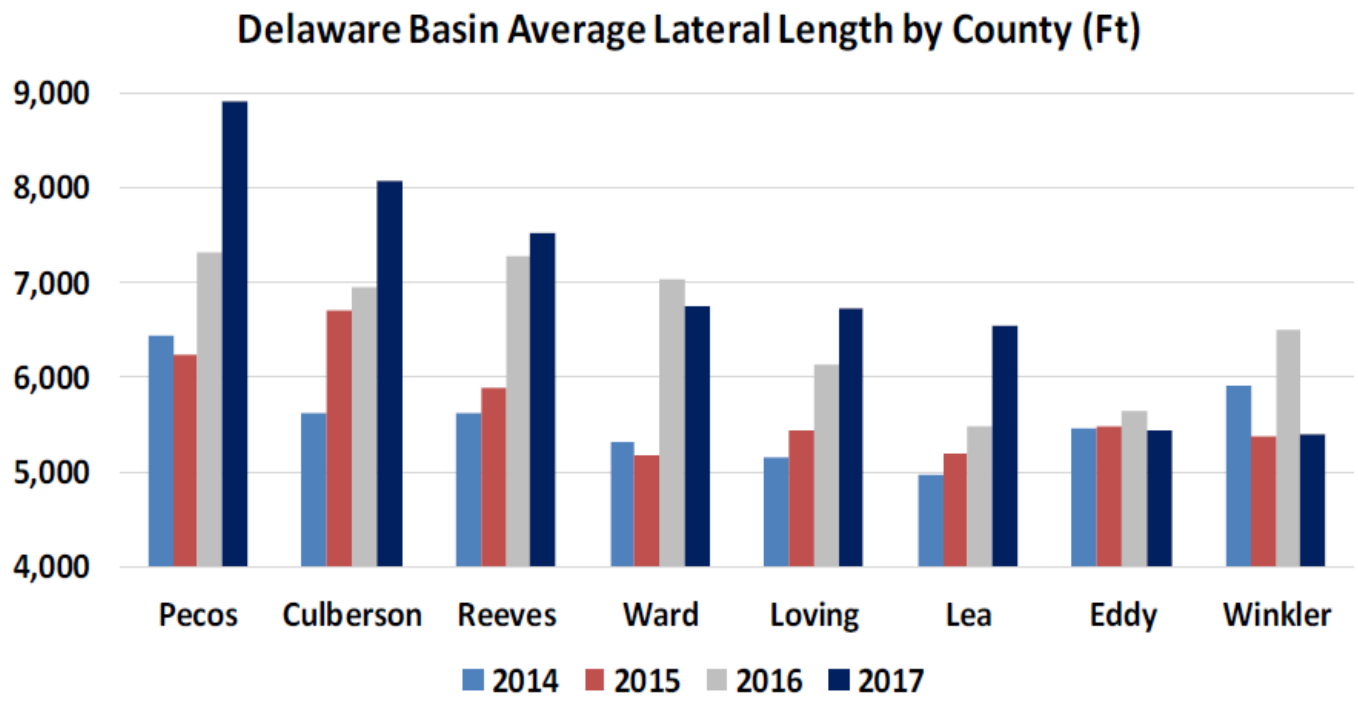
Produced Water at $350M barrels/month at $60



Water Production Forecast Scenarios (WTI Price)
Scenario 1: $40/bbl
Scenario 2: $60/bbl
Scenario 3: $80/bbl

Water Demand will Rise Rapidly: Delaware Example

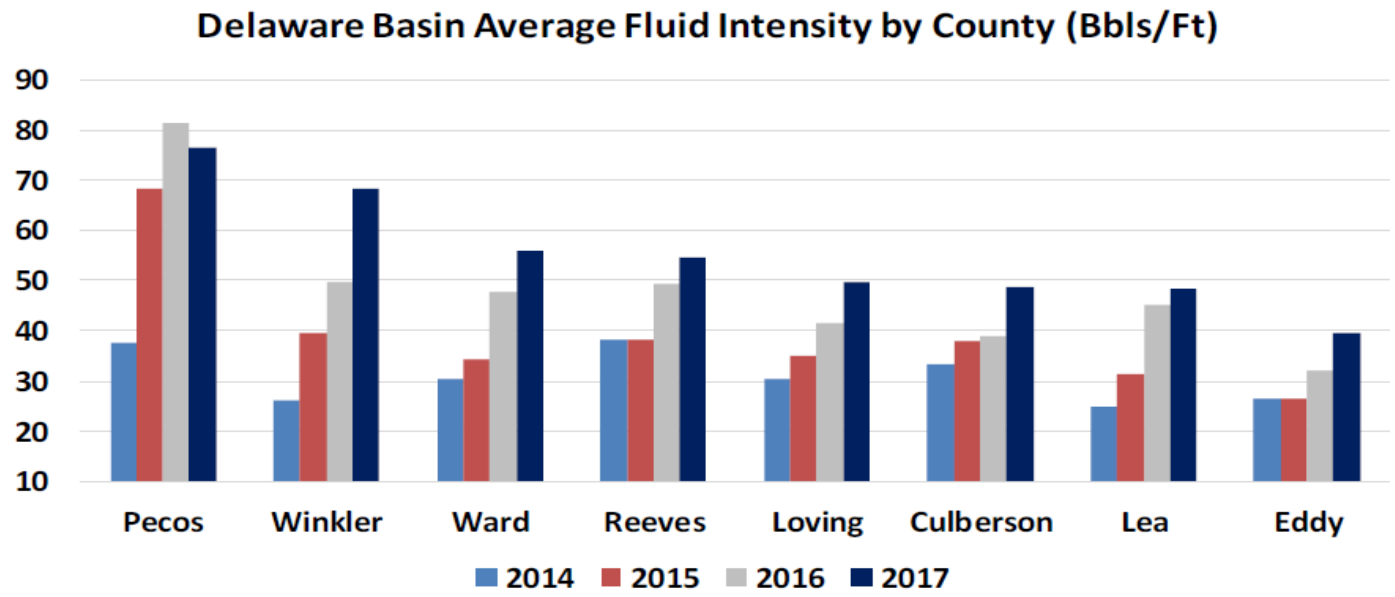
- Longer Laterals mean more water is used to complete a well
- In 2017 to date, average fluid intensity has been ~50 bbls/ft, which implies a ~10% increase vs. average fluid intensity in '16, a ~42% increase compared with '15 and a ~56% increase compared with '14.



Source: DrillingInfo, USCA

Fluid intensity by County in the Delaware

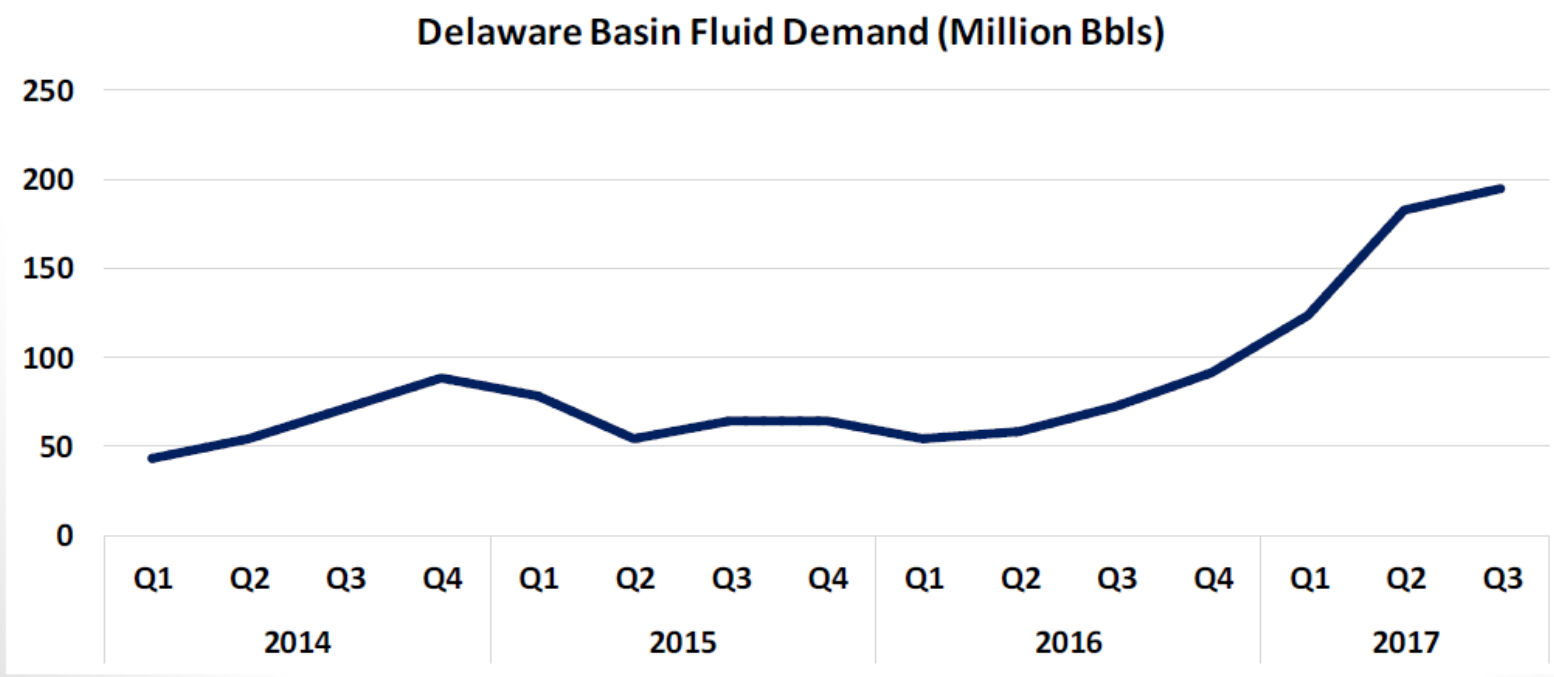
- Looking at 2017, most intense fluid concentrations have been in Pecos County, with average fluid loading of ~77 bbls/ft, followed by Winkler and Ward Counties at ~68 and ~56 bbls/ft, respectively.
- •Winkler, Culberson and Eddy Counties have seen the greatest rate of change, with 2017 average fluid intensity up ~38%, ~25% and ~24% compared with 2016, respectively.



Source: DrillingInfo, USCA

Delaware Fluid Demand will Continue to Rise

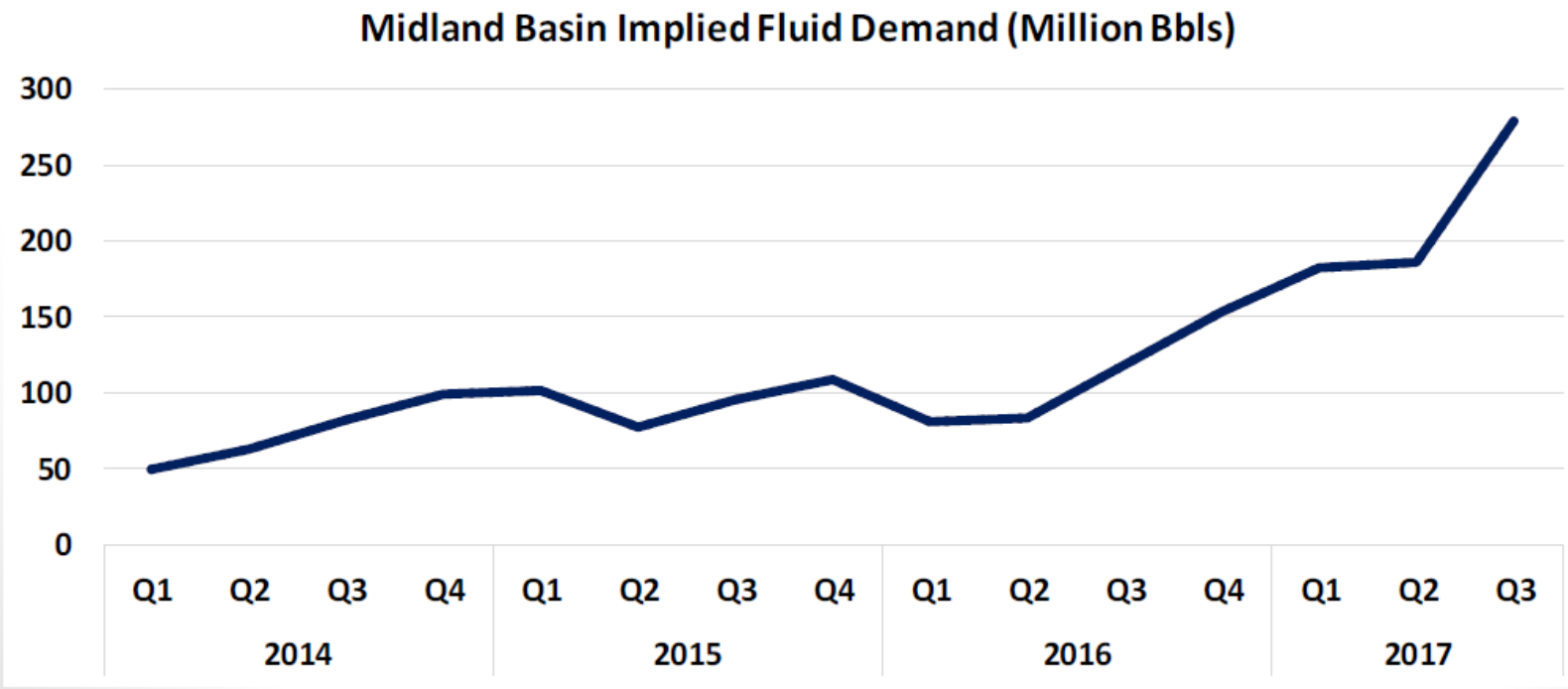
- Using quarterly data on rig count, cycle times, lateral length and fluid intensity, the chart below calculates implied frac fluid demand in the Delaware Basin by quarter.
- Looking at 2017 to date, average implied quarterly fluid demand has been ~167 million barrels, up ~145% y/y.
- ***Q3'17 implied quarterly fluid demand was just under 200 million barrels or nearly 3x the '14 quarterly average, highlighting the importance of water requirements in the basin on a go-forward basis.***



Source: DrillingInfo, Baker Hughes, USCA

Midland Basin Demand will Continue to Rise

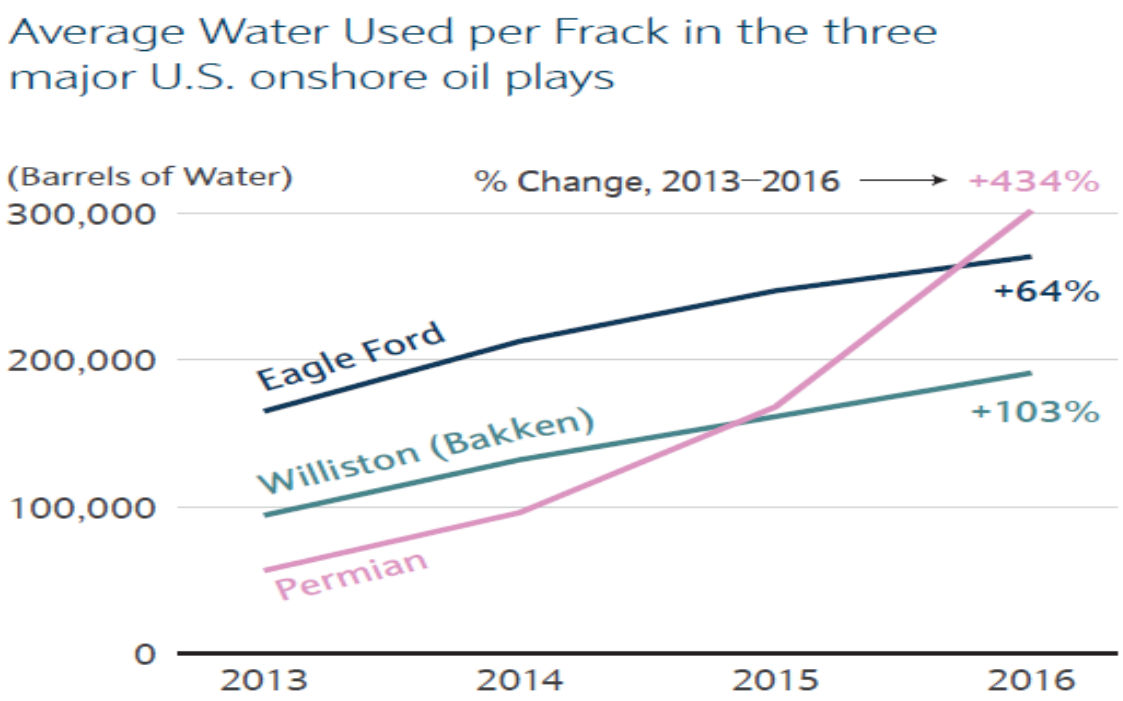
- Looking at 2017 to date, average implied quarterly fluid demand has been ~215 million barrels or up ~200% y/y.
- ***Q3'17 implied quarterly fluid demand was ~275 million barrels or almost 4x the '14 average. Midland fluid demand could exceed 300 million barrels per quarter in '18.***



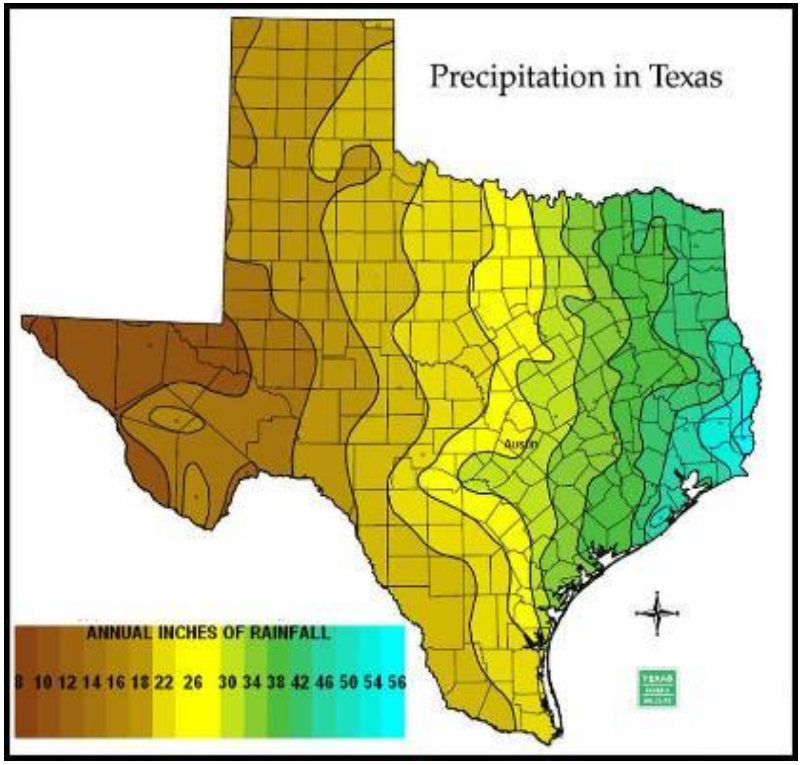
Source: DrillingInfo, Baker Hughes, USCA

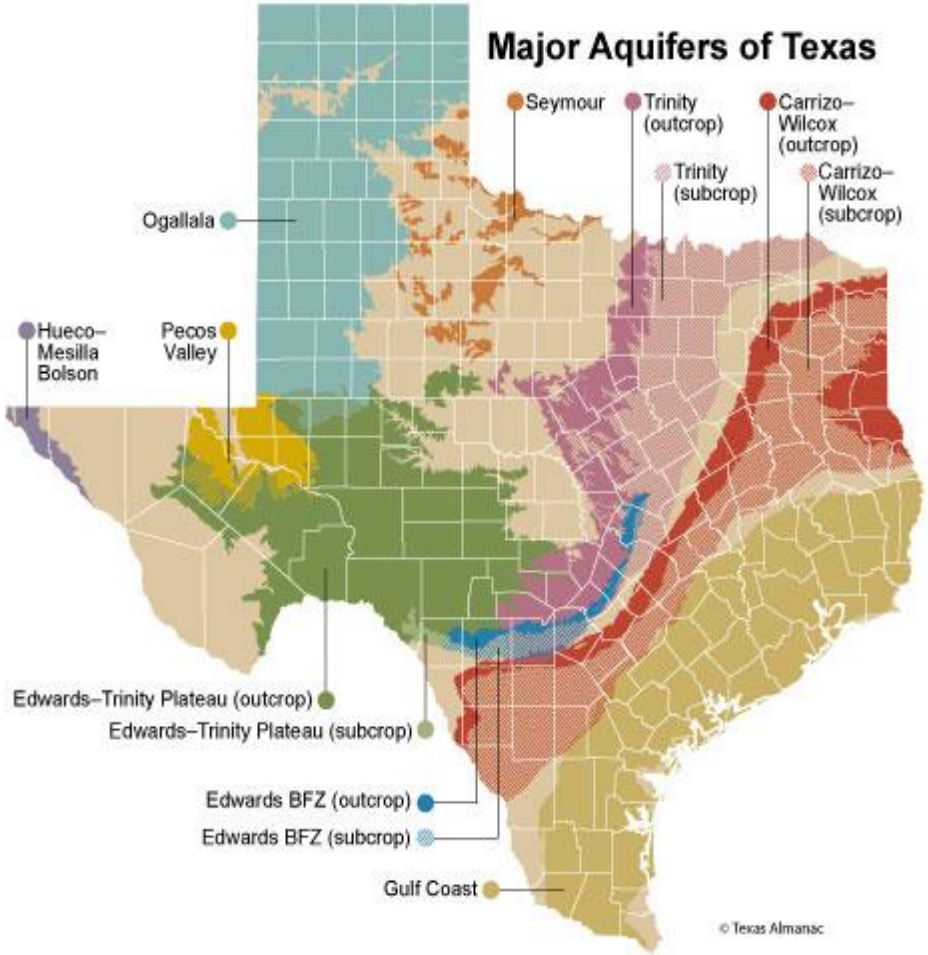
Water Use per Well Increases Accelerate

Permian Basin water demand exponentially increasing with longer lateral lengths, and a increase in water used per completion. Mega fracs can use over 1M/b per well with fracs with 2 miles laterals trending generally toward 500,000/b per frac . In 2016 the average Permian Basin frac job used 10,496,987 gallons or water or enough to fill almost 16 Olympic sized swimming pools; significant increase since 2016



The Permian has to Rely on Ground Water Withdrawals



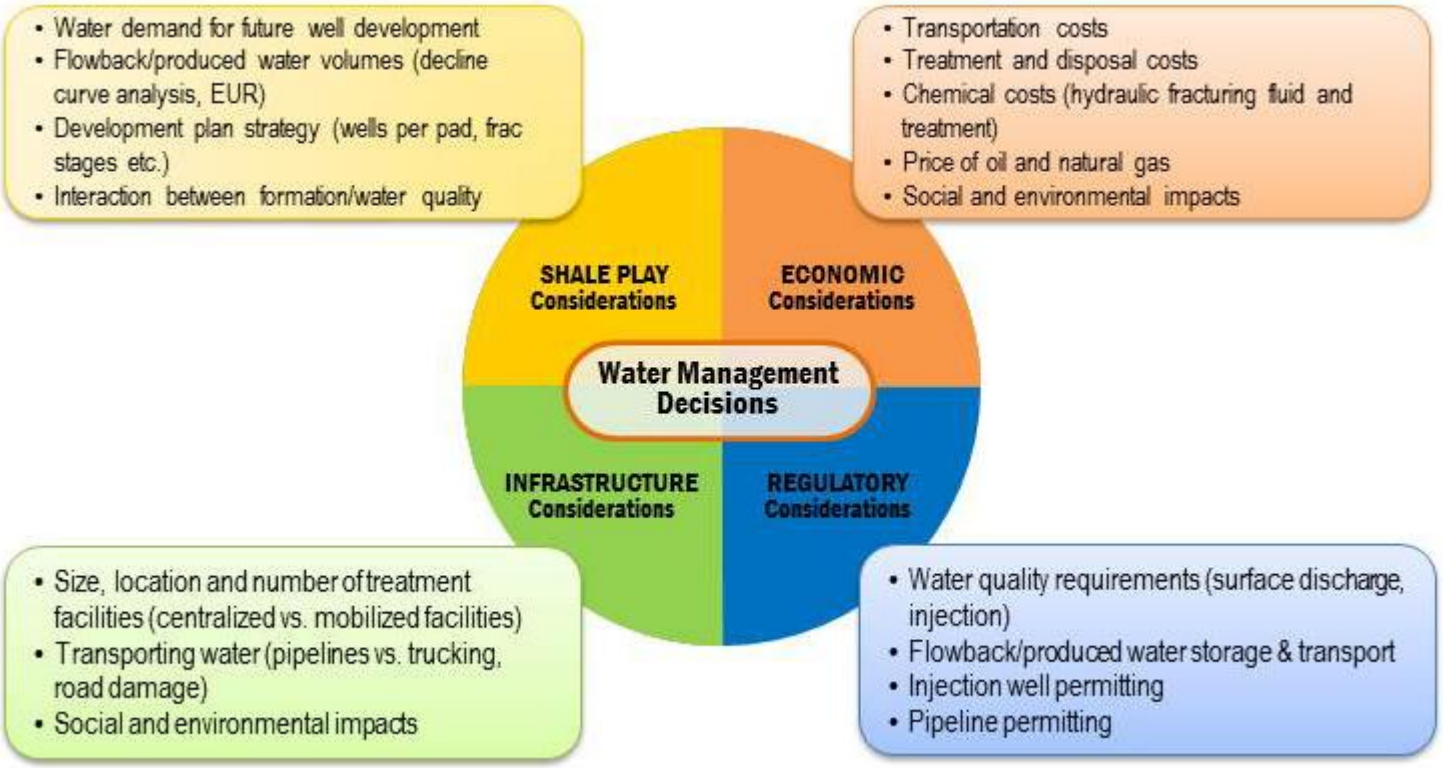


Demand for Water Management Growing

- Water use in the Permian has risen six-fold since the start of the shale oil boom, from more than 5 billion gallons (158M/B) in 2011 to almost 30 billion (952M/B) in 2016
- Energy research firm IHS Market predicted demand would double by the end of 2017, to 60 billion gallons, and more than triple by 2020, to almost 100 billion
- This is a stunning amount of water:
  - where will the water come from?
    - Fresh
    - Brackish
    - Reuse
  - how will produced water be disposed of cost effectively?
  - who will develop, fund and operate the infrastructure to support this growth?

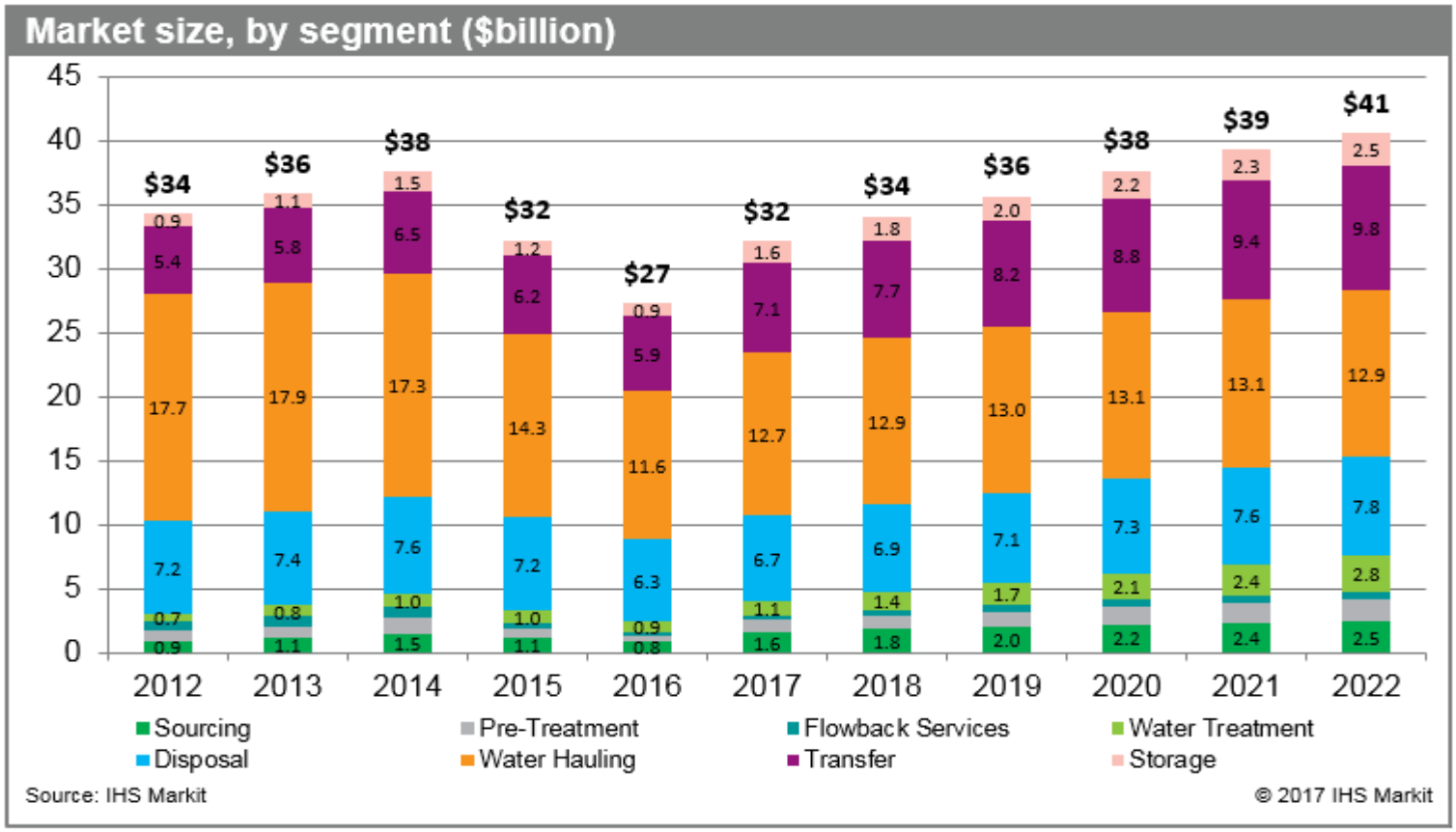
Producers are increasingly concerned and looking for sustainable solutions

Effective Water Management is now Critical



Costs will Drive key Decisions

- The Permian Basin (Delaware, Midland, and other Permian combined), with the largest volume of oilfield water produced among all US onshore regions, is expected to be the region with highest water spending, estimated at $10.9 billion in 2017.
- Water logistics (water hauling, transfer and storage) segment is going to be the main focus for E&Ps to reduce water-related costs. Truck hauling continues to represent the main share of the total logistics segment, however, this method of transporting water continues to decline in share steadily into 2022.



Trends in Water Management

Solaris has seen 3 consistent trends in water management in the Permian Basin

1. **Water is rapidly transforming into an infrastructure business, both for take-away & completions supply**

2. **The SWD Market is transitioning to focus on deeper injection intervals to avoid pressurization in shallower zones; costs increasing**

3. **Cost effective water reuse will be the key to balancing water demand and maintaining future growth and the competitiveness of the Permian Basin**

Oilfield Water Evolving to an Infrastructure Business

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	Water as an Oilfield Services Business	Water as Midstream Infrastructure
Assets	• Water hauling trucks • Saltwater disposal wells • Environmental cleaning facilities	• Fresh & produced water pipeline infrastructure • Saltwater disposal wells • Treatment & reuse facilities
General Contract Terms	• Primarily call out or ad-hoc • High degree of spot market rates	• Infrastructure build-out with dedicated operator acreage and/or volumes • Long-term contractual partnerships between operators and service/infrastructure providers
Operational Conditions	• Manual process subject to significant HS&E challenges, including spills, contamination and exposure • Subject to significant truck traffic and weather risk	• Automated process; data driven operations • Significant reduction in personnel needs • Improved HS&E levels and reduced trucking • Economies of scale for cost structure (CAPEX vs. OPEX)

- **Large-scale infrastructure investment required to create reliable & redundant systems that service multiple operators**
- **Transition from "mom and pop" SWDs & trucks to well-capitalized midstream participants**
- **Lower capital / higher operating cost → higher capital / lower operating cost**
- **Costs are basin and location specific**

Emergence of Midstream Water Infrastructure

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Significant equity infusion in last 3 years to fund private midstream water infrastructure players

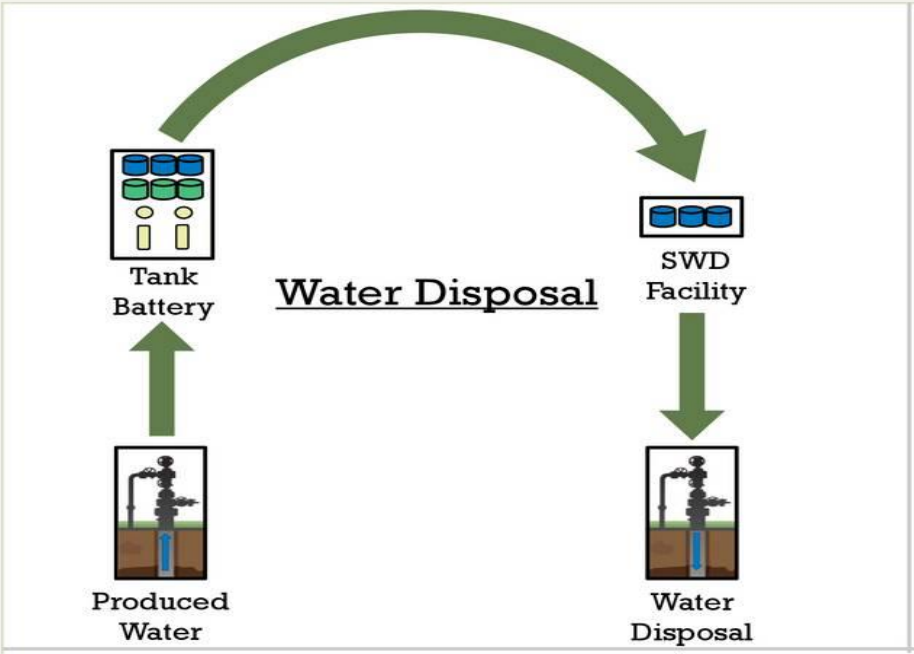
1. **Highly levered to shale development; water is present throughout the full cycle of oilfield development**

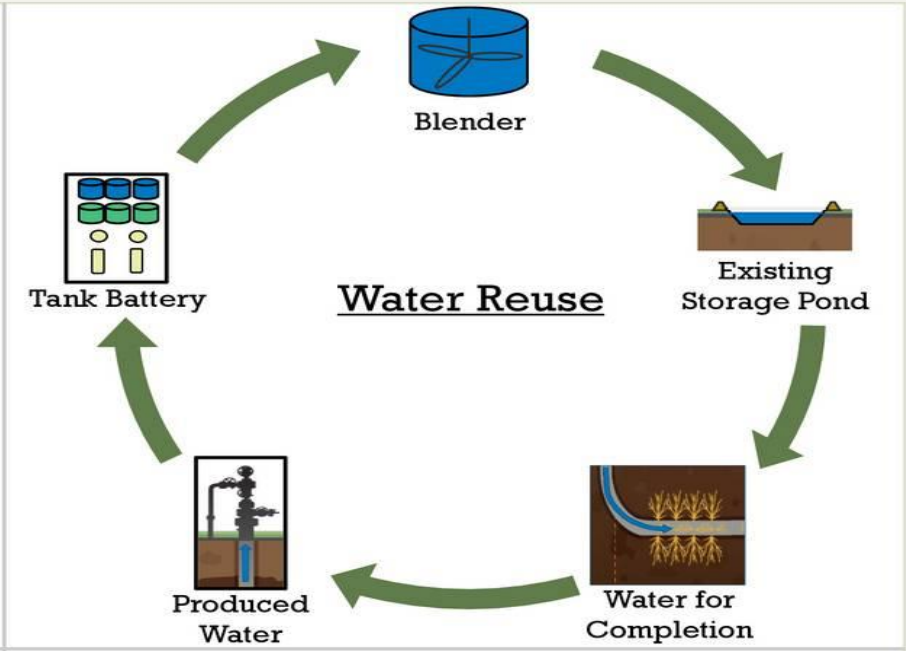
2. **Water Demand increasing with supply demand imbalances; growth in Frac water and reuse opportunities**

3. **Pipelines are key; low operating cost of pipeline infrastructure provides better margins and ability to secure long term contracts and acreage dedications**

Single Operator System: Pioneer Example

BENEFITS OF WATER REUSE VS. DISPOSAL





- Pioneer's water infrastructure provides a unique opportunity to reuse produced water
- Benefits of reusing produced water include:
  - Reduced disposal costs
  - Reduction of higher pressures in water disposal zone; could eventually allow a return to a 3-string casing design in certain areas
  - Low-cost frac water source
- Increasing water reuse in 2H 2017 in areas where water infrastructure is in place and drilling challenges have been the most prevalent

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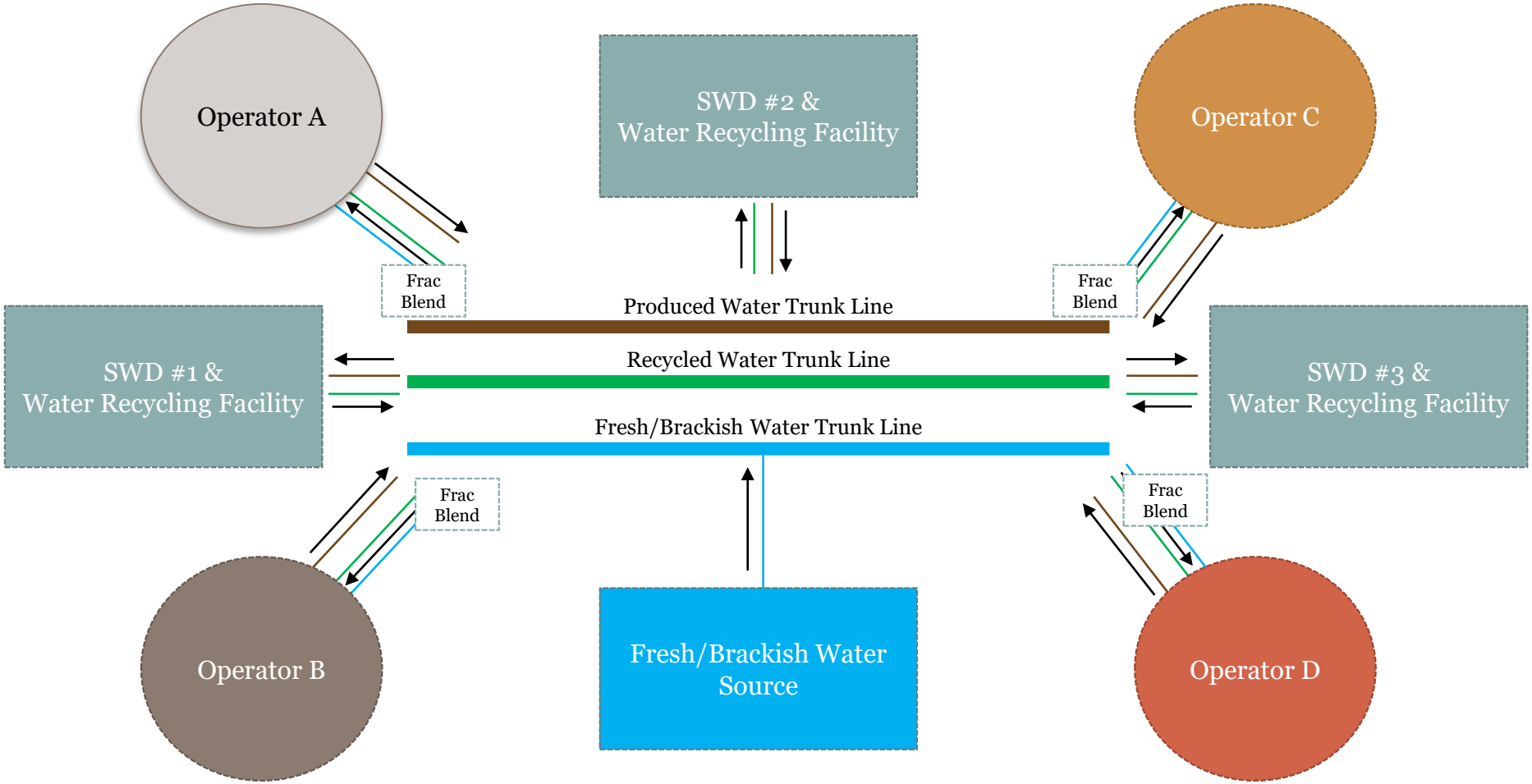
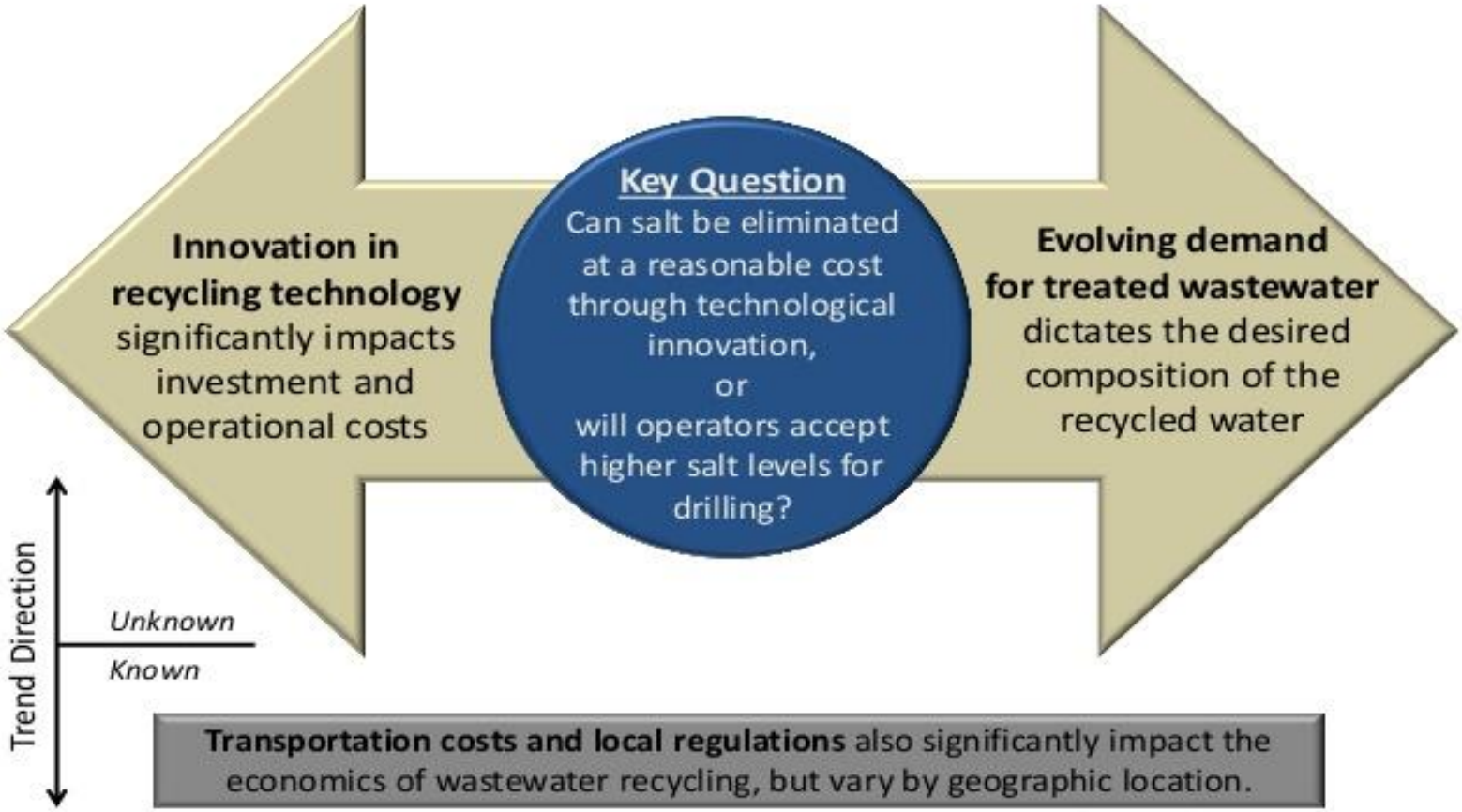
Effective Water Infrastructure Requires Integrated Water Systems



Feasibility of Reuse; Technology vs. Cost

Two major dynamics will determine economic feasibility of water recycling in the Permian Basin



Wilson Perumal & Company, Inc. 4

Water Reuse Mitigates Basin-Wide Water Challenges

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Operator Benefits from Water Recycling

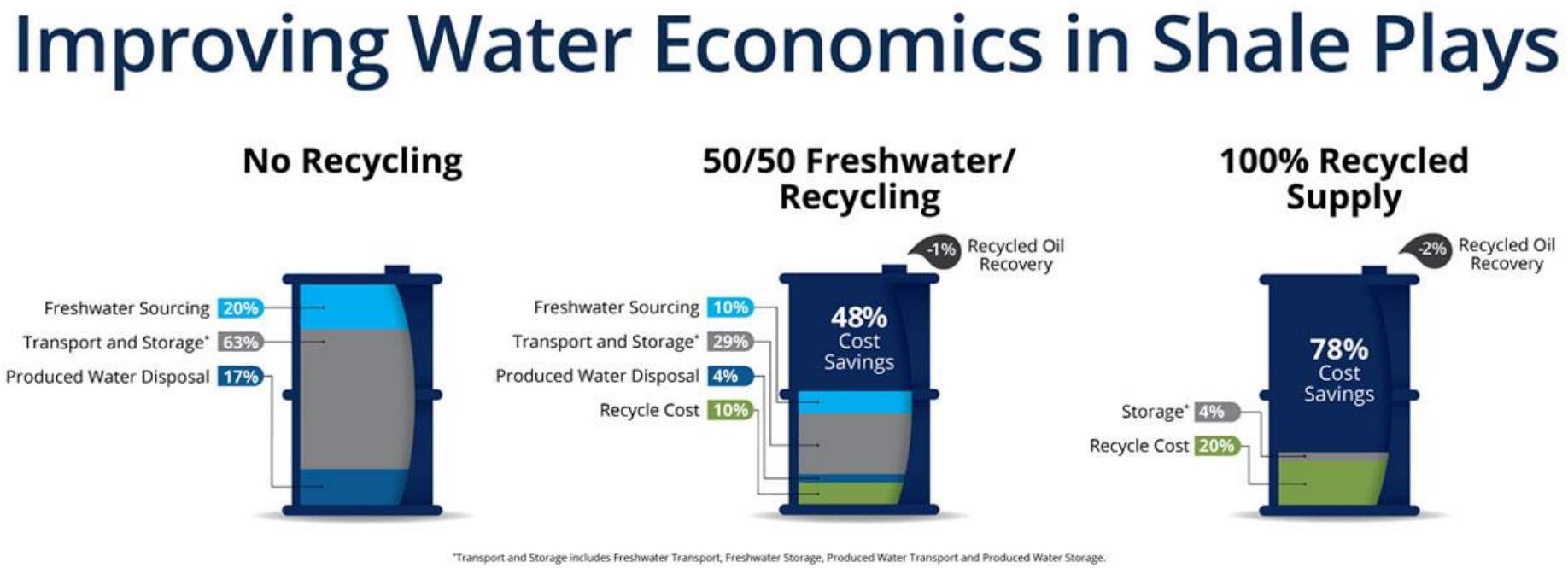
- **Operators now accept a wider range of water specification for completions; treating less. Increased treatment to meet higher water specifications for reuse, drive costs**
- Improved LOE/bbl versus fresh water sourcing
  - Fresh/brackish water sourcing: average $0.40-$1.50/bbl or more for water depending on the location (before transfer).
  - Water recycling represents a significant savings per barrel depending on treatment requirements.
- Reduces strain on local water resources
- Improves reliability and ability to meet frac schedule
- Reduces the number of SWDs required

Water Reuse only Works when Economics work

- Water recycling can be implemented in a "closed loop" system that integrates fresh water sourcing, produced water transfer, and produced water disposal
- Infrastructure providers will be able to offer "on-demand" water sourcing through trunk lines that run through major production corridors

Representative Costs Drivers in Reuse

The FountainQuail schematic below highlights the options which impact cost.



Disposal vs. Reuse Decision Factors

- MOST DECISIONS ARE COST DRIVEN
- **Recycling**
  - Recycle specification drives cost
  - Aggregation of volumes
  - Treatment costs
  - Managing demand; peak flows
  - Facility cost
    - Mobile vs. fixed
    - Treatment adjacent to SWD's
  - Storage: pits, ponds and tanks
  - Regulatory
    - Permit time lines; ponds in New Mexico
  - Corporate imperative
  - Reduce trucking
  - Who owns the produced water
  - Availability of disposal options
  - Environmental risks
  - Technology
    - New Salt-Tolerant Friction-Reducer System Enables 100% Reuse of Produced Water;01 December 2017 JPT

Disposal vs. Reuse Decision Factors

- **Fresh Water**
  - Availability
  - Fresh vs, Brackish
  - Cost
  - Landowner considerations; Surface Use Agreements
  - Right of Way costs
  - Aquifer drawdown
  - Transport and distances
  - Regulatory
    - Moving water across state lines, basins and Groundwater districts
  - Blending
  - Corporate sustainability goals
  - Environmental impact

Disposal vs. Reuse Decision Factors

- **Disposal options**
  - Location and injection pressures
  - Availability of Capacity vs. new
  - Pipeline vs. trucking
  - Pressurization
  - Seismic considerations
  - Cost of drilling to deeper injection intervals
  - Efficiency of a connected system and redundancies
  - Permitting
    - Time
    - Protests
    - Landowner royalties
  - Control vs. cost efficiency
  - Drilling risks

Shallow Disposal Zones Impacting Drilling

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- **Shallow injection zones are causing pressurization & drilling challenges**
  - Impact is most pronounced in Midland & Martin Counties with significant legacy production.
  - Operators in these areas are requiring an additional string of casing to combat pressure issues that arise from San Andres disposal
- **Operators are shifting towards deeper interval SWDs to combat drilling and completion issues**
  - San Andres and Delaware sands: ~5,000 ft.
  - Midland Basin - transitioning to Ellenburger interval SWDs: ~11,000-13,000 ft.
  - Delaware Basin - transitioning to Devonian interval SWDs: ~15,000-19,000 ft.
- **Deeper interval wells require significantly more capital and represent higher drilling & completion risk**
  - San Andres SWD: ~$1.0 million drilling & completion
  - Ellenburger SWDs: ~$3.5 million drilling & completion
  - Devonian SWD: ~$7.0 million drilling & completion
- **Additional capital required enhances need for well capitalized midstream partners**
  - Significantly more capital required.
  - Additional drilling & completion costs can be offset through higher utilization associated with a multi-operator infrastructure system.
  - Water recycling reduces the industry need for disposal wells.

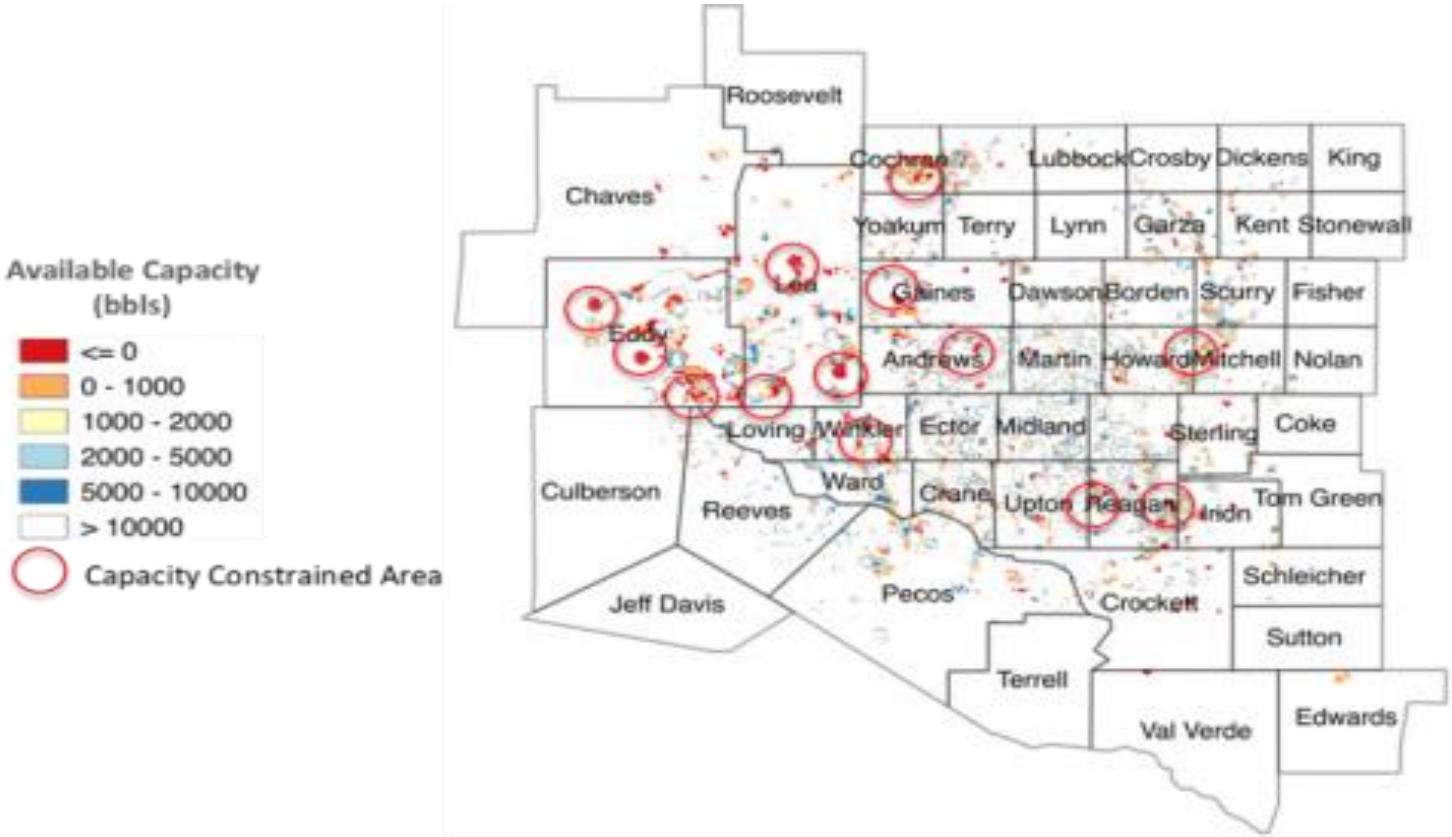
Supply Demand Balancing Act

- Wells et al. (2017)
  - predicted that renewed completion activity, continued drawdown of drilled-but--uncompleted wells, and high legacy well produced water volumes will drive demand for additional SWD capacity. However, given the recent slowdown in available SWD capacity, even a slight increase in produced water volumes may lead to increasing water costs until new disposal capacity becomes available.
  - **Estimated that water production in the Permian could increase by as much as 50 million bbl each month. If production increases by this amount, approximately 70 million bbl of produced water would need to be diverted from current disposal facilities to new facilities or be diverted for reuse**. A 15% volume increase in produced water would likely lead to multiple bottleneck areas in the Delaware and Midland Basins due to high disposal utilization, with Eddy, Lea, Hockley, Howard, Reagan, and Winkler counties being the most likely areas of acute bottlenecking.
  - Wells estimated that areas with overly pressured SWDs under this scenario would produce 35 million bbl of water per month in the Delaware, and 22 million bbl of water per month in the Midland.

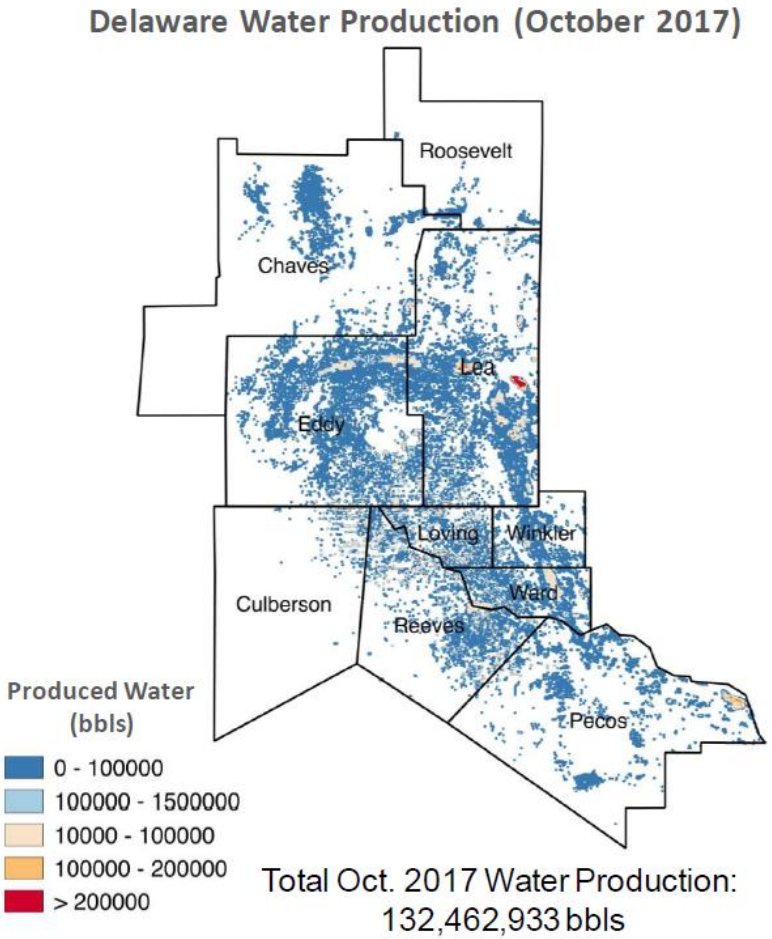
Potential SWD Bottlenecks; Capacity Constraints

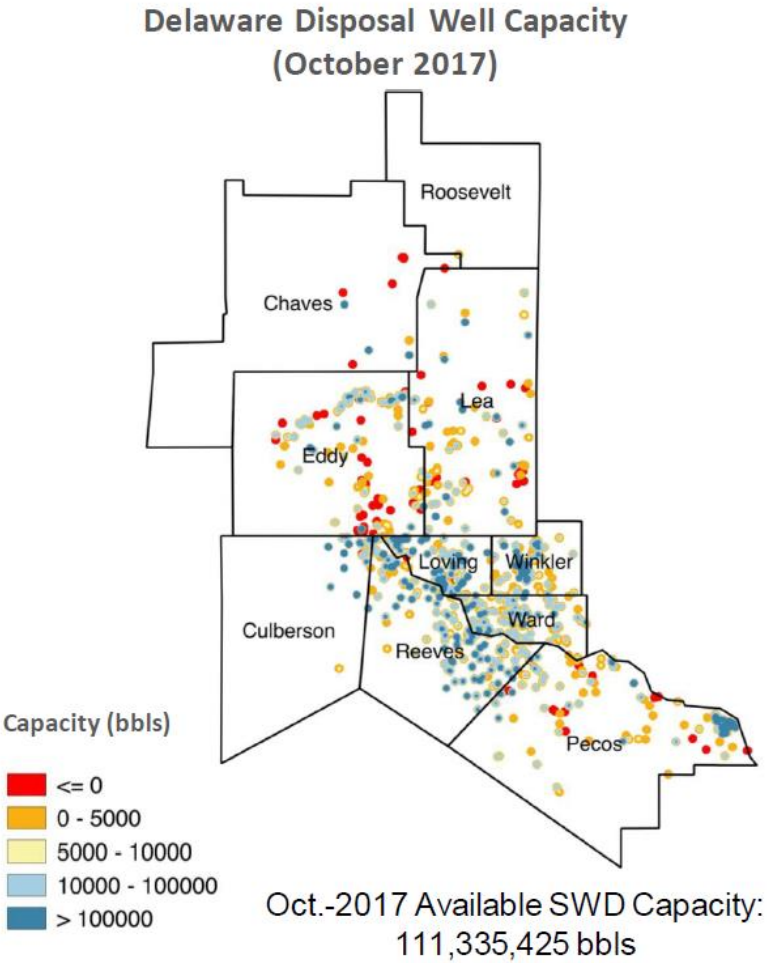
As producers push to move to deeper disposal intervals, constraints are already impacting excising shallow disposal wells exacerbating the challenge for infrastructure to keep up with growth.

Permian SWD Available Monthly Volume Capacity July 2017. Digital H2O

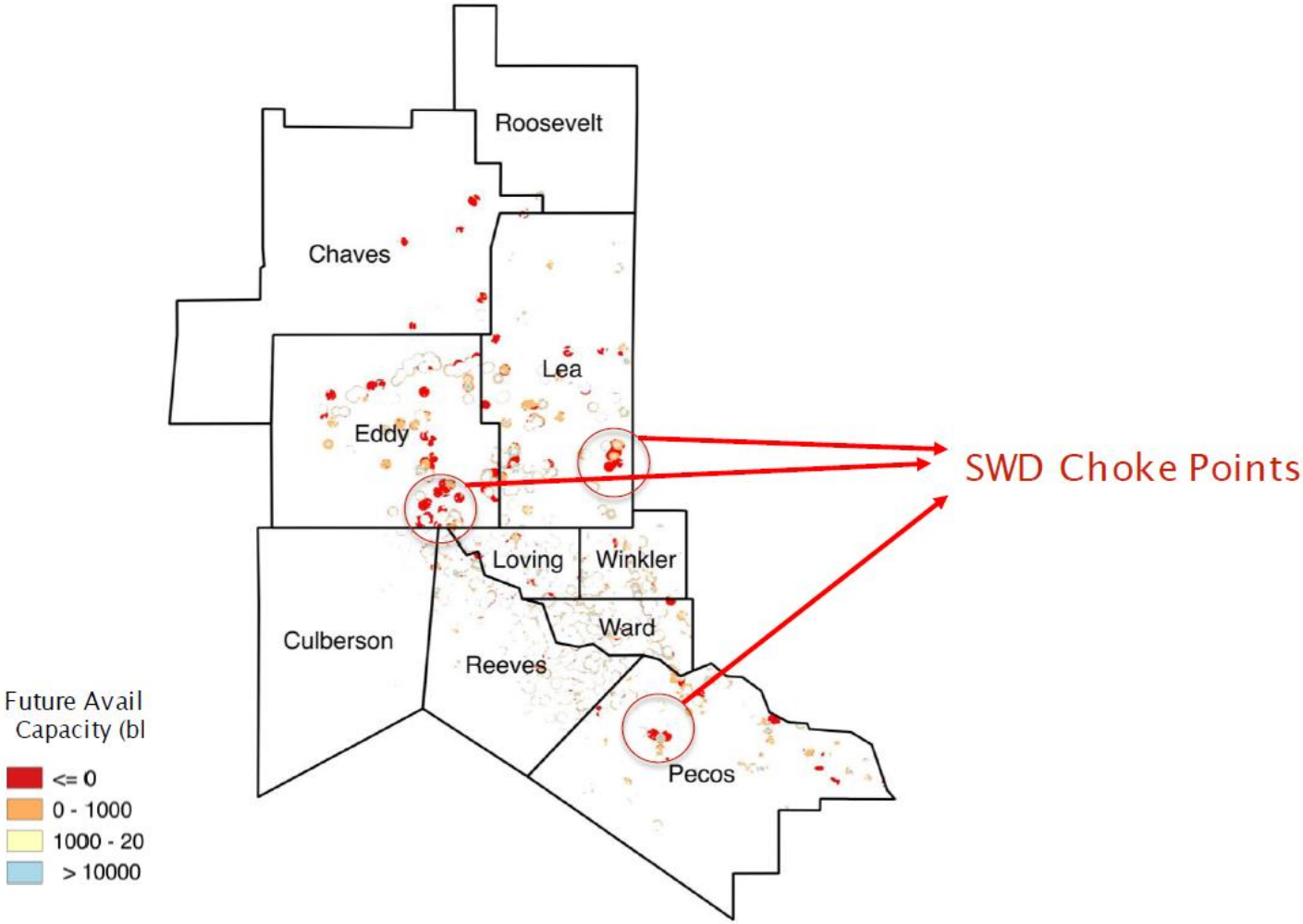


Delaware Disposal Constraints (2017)





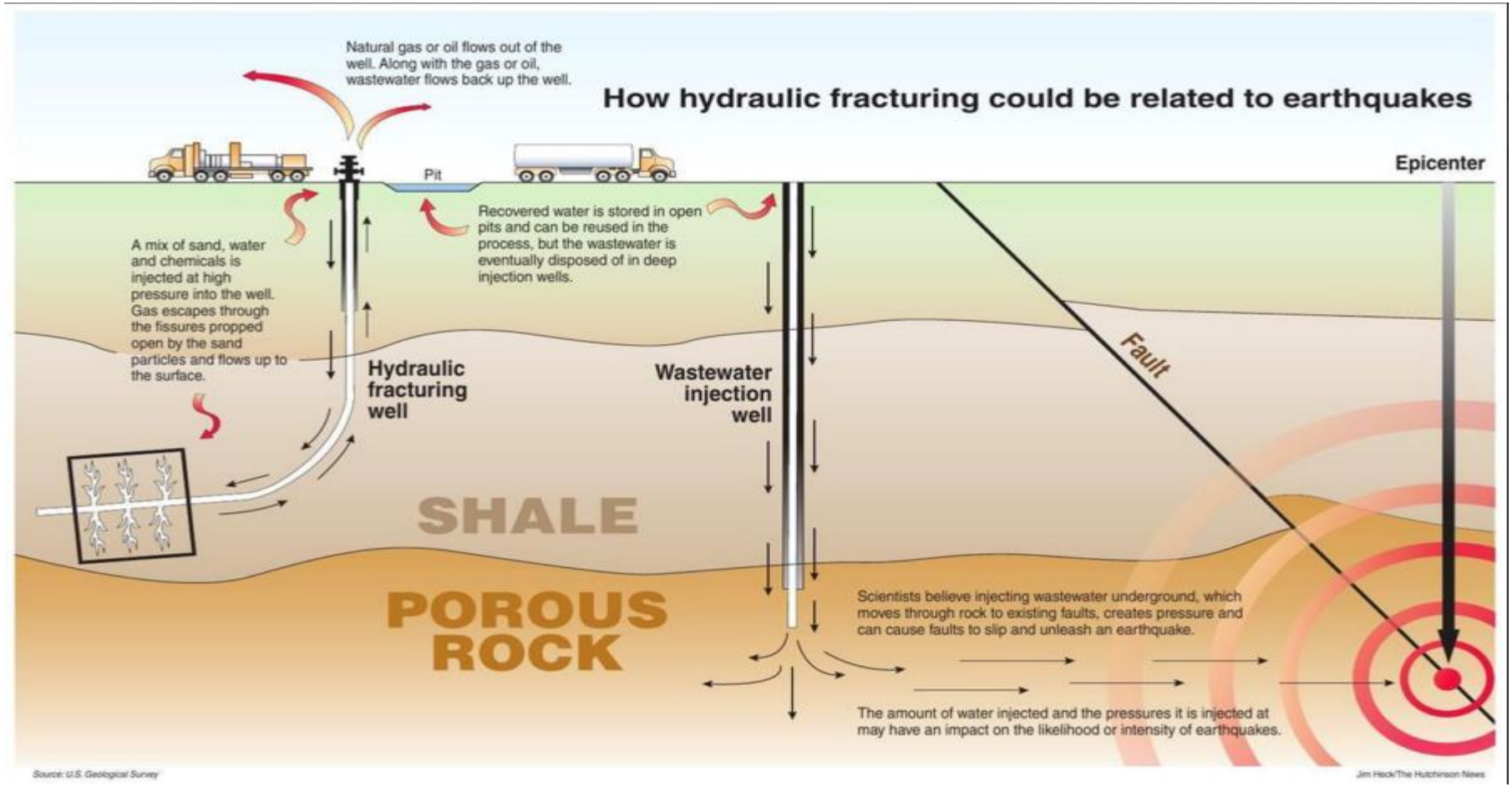
Disposal Challenges 2018; Drive Reuse Decisions?



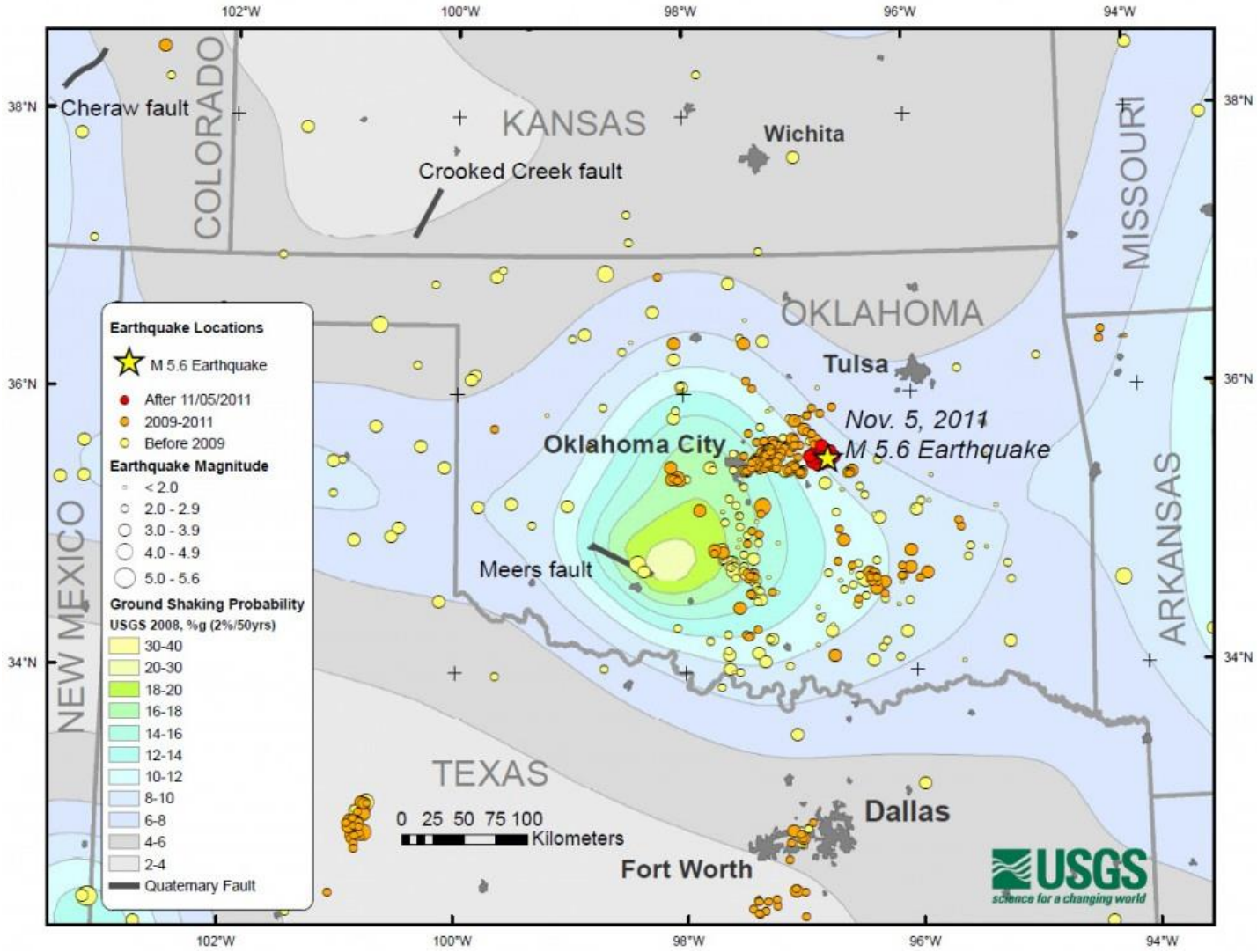
Source: Digital H2O Analysis, Texas RRC, NM OCD

Seismicity Considerations

Location specific but driving Regulations



Induced Seismic Activity



How Solaris is Creating Value

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Solaris Value Drivers

Fresh & Brackish Water Sourcing	• Supplement & blend recycled water with fresh & brackish water sources • Ability to meet entire frac schedules & provide complete outsourced water solutions
Water Re-Use & Storage	• Large-scale re-use from multiple operators facilitated by contractual arrangements, gathering network, & disposal capability • Ability to handle changing water quality from different sources & service 50% + produced water blend fracs • Integrating storage ponds to increase re-use options and limit disposal
Produced Water Disposal Capacity	• 10+ Solaris SWDs by the end of 1Q 2018 with 300,000+ bbl/d of capacity; tied into 3rd party wells for additional capacity • Solaris's disposal facilities serve as infrastructure for in-line treatment facilities • 30+ filed or approved SWD permits in Midland & Delaware Basins facilitate commercial speed of execution & flexibility
Produced Water Gathering Pipeline Network	• Over 200 miles of constructed & surveyed gathering lines servicing multiple operators in the Midland & Delaware Basins • Large diameter (12-20") buried lines gathering from multiple operators
Long-term Produced Water Gathering Contracts	• Acreage dedications and take-or-pays from leading operators serve as "backbone" of systems • Secures a valuable, "high multiple," revenue stream ("MLP-able") • Secures source water for gathering & re-use network • Provides underpinning for permanent infrastructure investment

Conclusion

SOLARIS MIDSTREAM

- **The Permian Basin began a rapid transformation from a declining conventional basin in 2012 to a Super Basin, defined as cumulative production of more than 5 Billion BOE**
- **One of the fundamental challenges in the Permian is how to manage and fund the infrastructure needed to support this growth**
- **Significant increase in water production and demand for source water is a key challenge, with bottlenecks in SWDs and infrastructure**
- **Reuse will become integral to managing the water mass balance and can be economic with changing frac designs**
- **The big question is when and where and how much reuse which is dependent on numerous considerations**
- **The market needs capitalized Midstream Infrastructure players to cost effectively develop, invest in and operate reliable and safe integrated systems**
- **In order to succeed, Water Midstream Infrastructure players are going to have to be well capitalized, understand and stay ahead of the trends and adopt an integrated model, balancing disposal and reuse, while delivering multi operator systems**