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Greater Oilfield Water Infrastructure Connectivity: The Case for a 'Hydrovascular' Network In the Permian Basin

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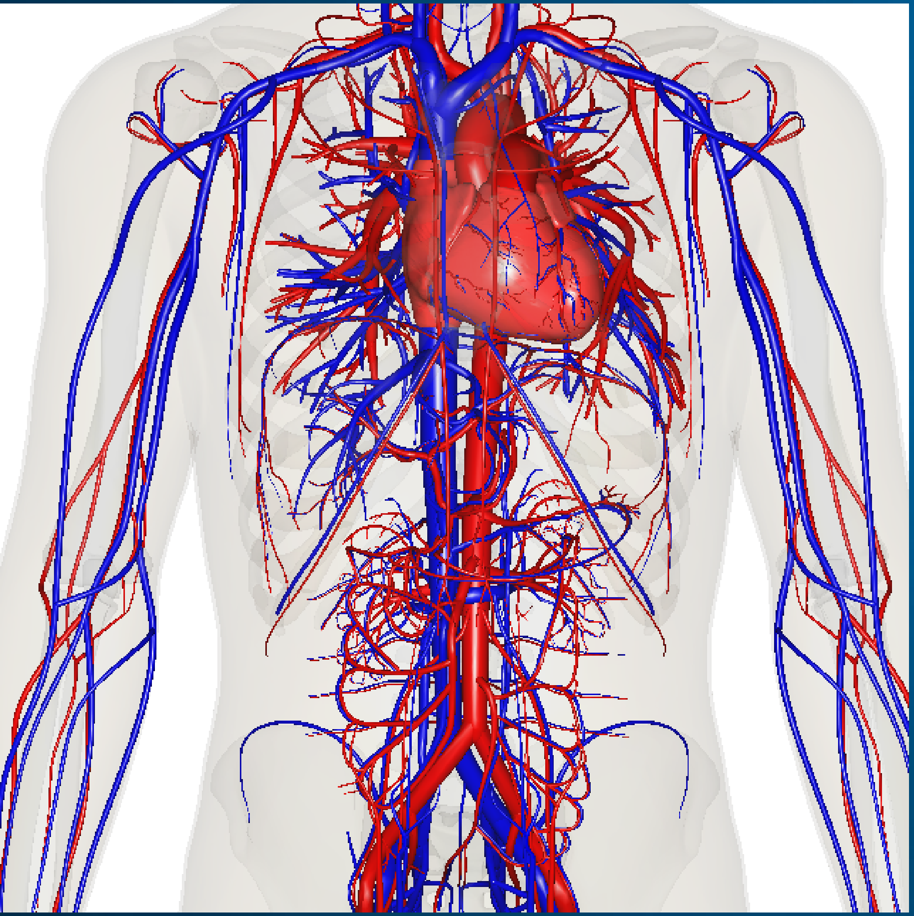
Mr. Collins holds a membership interest in Cactus Water Services, LLC. This relationship is covered by a Rice University conflict of interest management and monitoring plan.

What Is a Hydrovascular Grid?

- **Perfect the water midstream model**
- **Build interconnectivity**
- **Rationalize CAPEX and system utilization**
- **Achieve sustainable valuations**

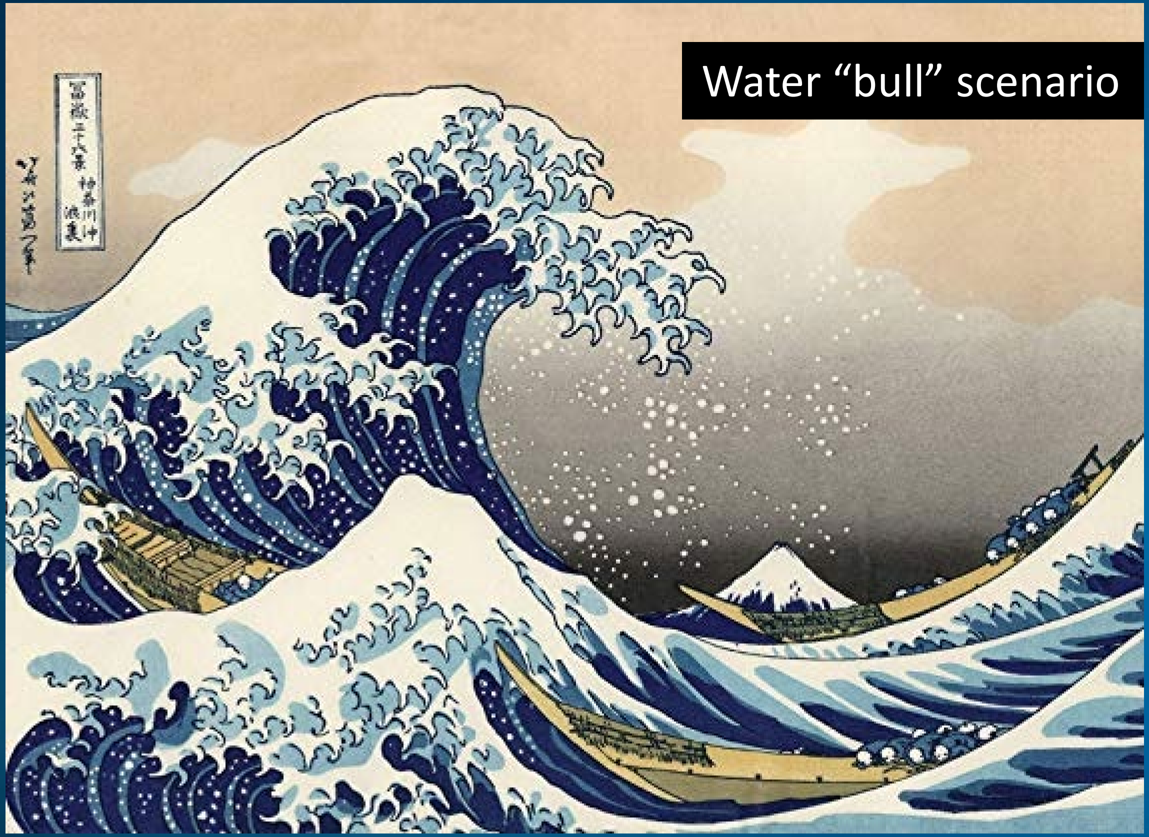


Source: Wikipedia

- ***"We would create a hydrovascular market, where we would have major arterials to convey water throughout the state. For us to develop this and to develop new water — whether it be desalination or reclaimed water or bring water from out of state — all of that needs to be looked at from a 50,000-foot view."*--Rep. Lyle Larson, R-San Antonio, May 2015**
- The idea of large-scale, highly connected water infrastructure to link regions of plenty to regions of scarcity in Texas dates to the 2015 legislative session. House Bill 3298 called for the Texas Water Development Board to study the potential for developing a water market and conveyance network that would eventually become a hydrovascular grid spanning multiple regions statewide. The bill did not become law and the issue has lain dormant for 4 years.
- More interconnected water systems can facilitate wheeling of oilfield water within the Basin, better utilization of disposal well and recycling capacity, and potentially, public-private partnerships that allow water to be moved outside the Basin to the mutual economic and hydrological benefit of multiple stakeholders.
- The oilfield water market in the Delaware and Midland Basins will gradually coalesce into several large "areas of market dominance" ("AOMDs") as water midstream firms and their E&P customers consolidate.
- The emergence of these broad AOMDs--akin to the watershed feeding a river system--opens the opportunity for optimized pipeline connectivity between the various oilfield watersheds that will, economics permitting, allow wheeling and movement of water in a manner that is largely impossible at present.

Why Talk About This Now?

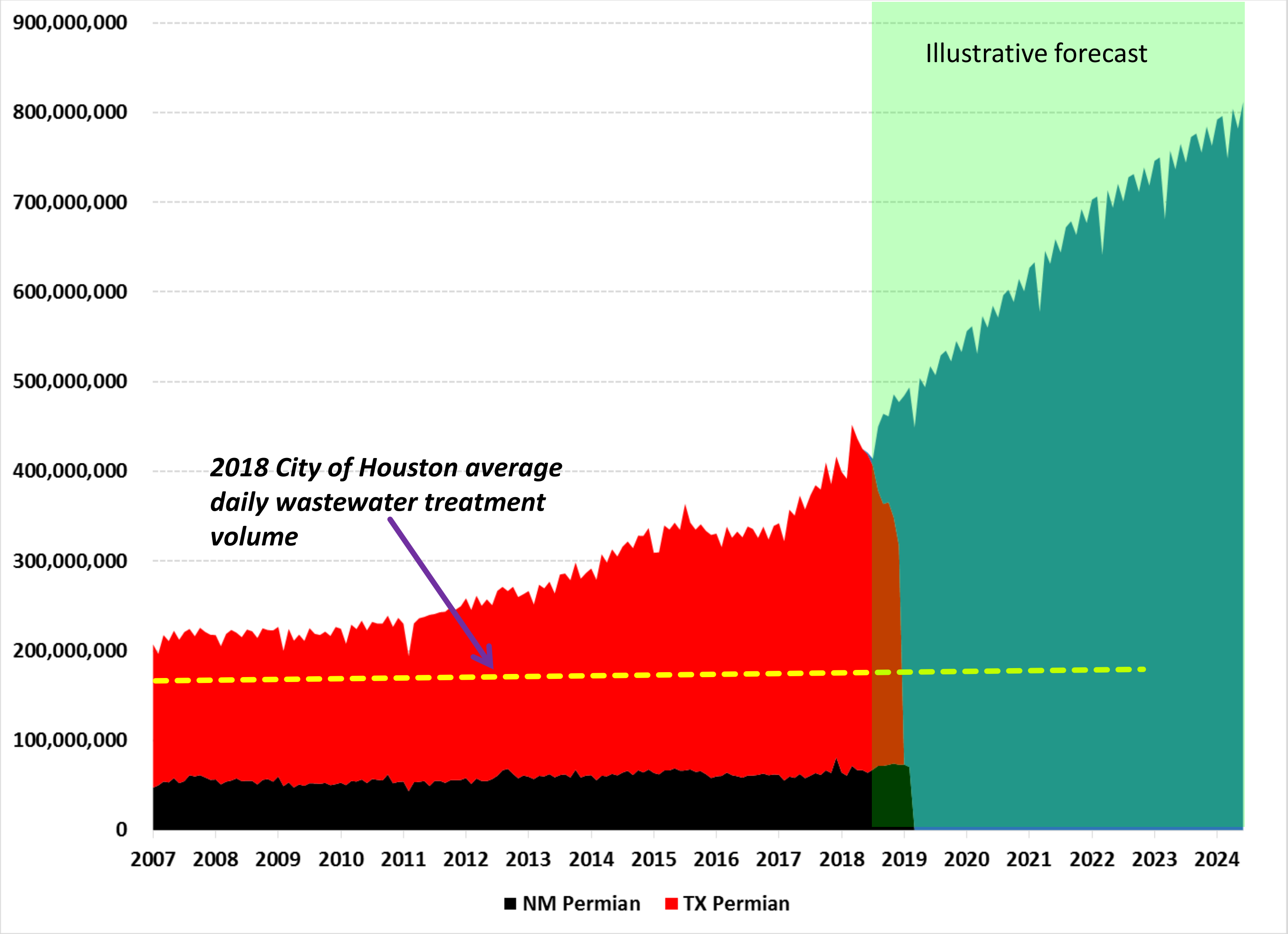
Scale will matter regardless…



A large-scale, more deeply interconnected Permian Basin water infrastructure opens up doors for optimal SWD use and true “out of Basin” value-added water solutions in a “water wave” scenario and can help optimize CAPEX and costs in a $40-to-45 WTI “water winter” scenario.

Permian Operators and Midstreams Must Now Collectively Handle More Water Than Major Texas Cities

Actual Permian Basin Water Injection Volumes, Barrels/Month



Source: NM OCD, TX RRC

- Basin-wide, E&Ps in the Permian used about 5 million bpd of frac water as of 4Q2018. This is equivalent to the average municipal water demand of San Antonio.
- On the produced water side—analogous to wastewater in cities—the Permian is huge. Average daily total water injection volumes are more than twice the volume of wastewater Houston (Texas's largest city and the United States' 4th-largest) treated on an average day in 2018. The unconventional water share alone is likely more than what Houston treats per day.
- If Permian oil output rises to 6.5 million bopd by June 2024 (i.e. 5 years from now) and we assume 4.0 bbl of water per bbl of oil produced Basin-wide, produced water volumes could basically double from where they are today.
- For this growth to happen, water midstream and other solutions must economically manage the resulting wall of water.

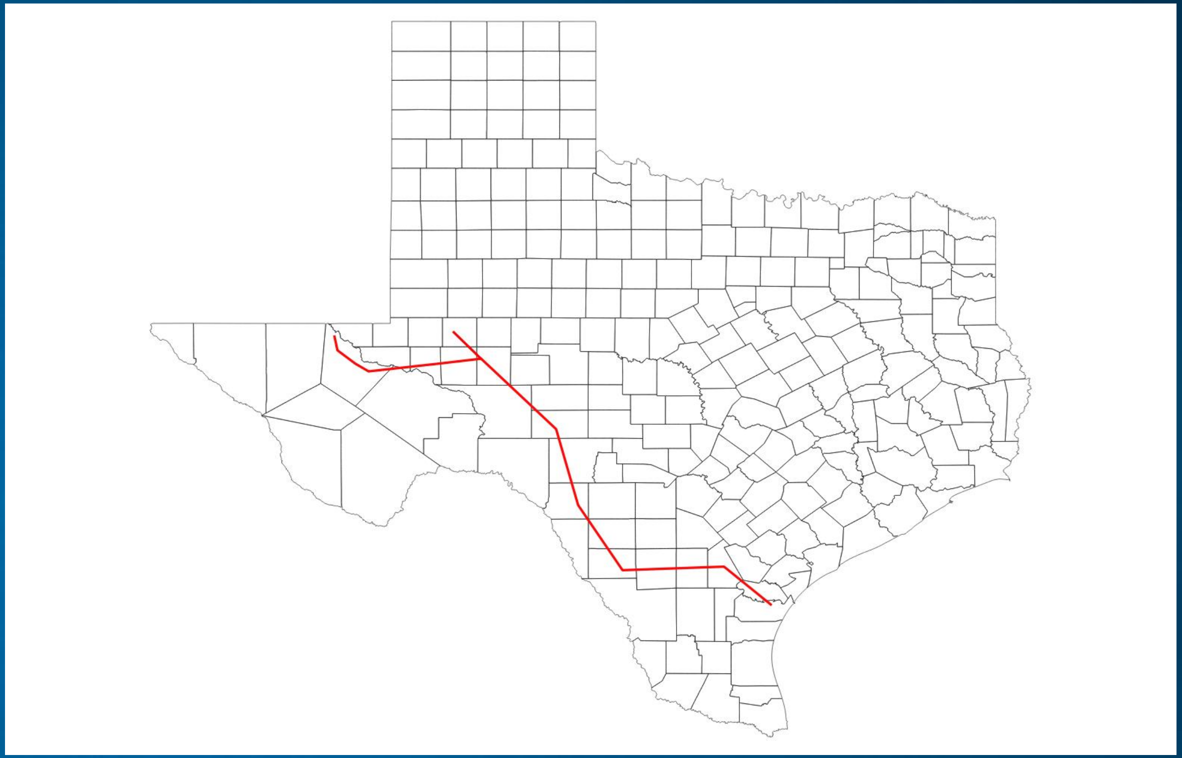
Accommodating Future PW Volumes Might Require Unorthodox Solutions

*****Note—updated from February 2019 presentation numbers to reflect higher capital cost*****

Example: ***What might the economics of piping produced water down to the Gulf Coast and discharging treated PW into the ocean or disposing of it in depleted offshore fields look like?***

Initial model based on Vista Ridge water pipeline to San Antonio.

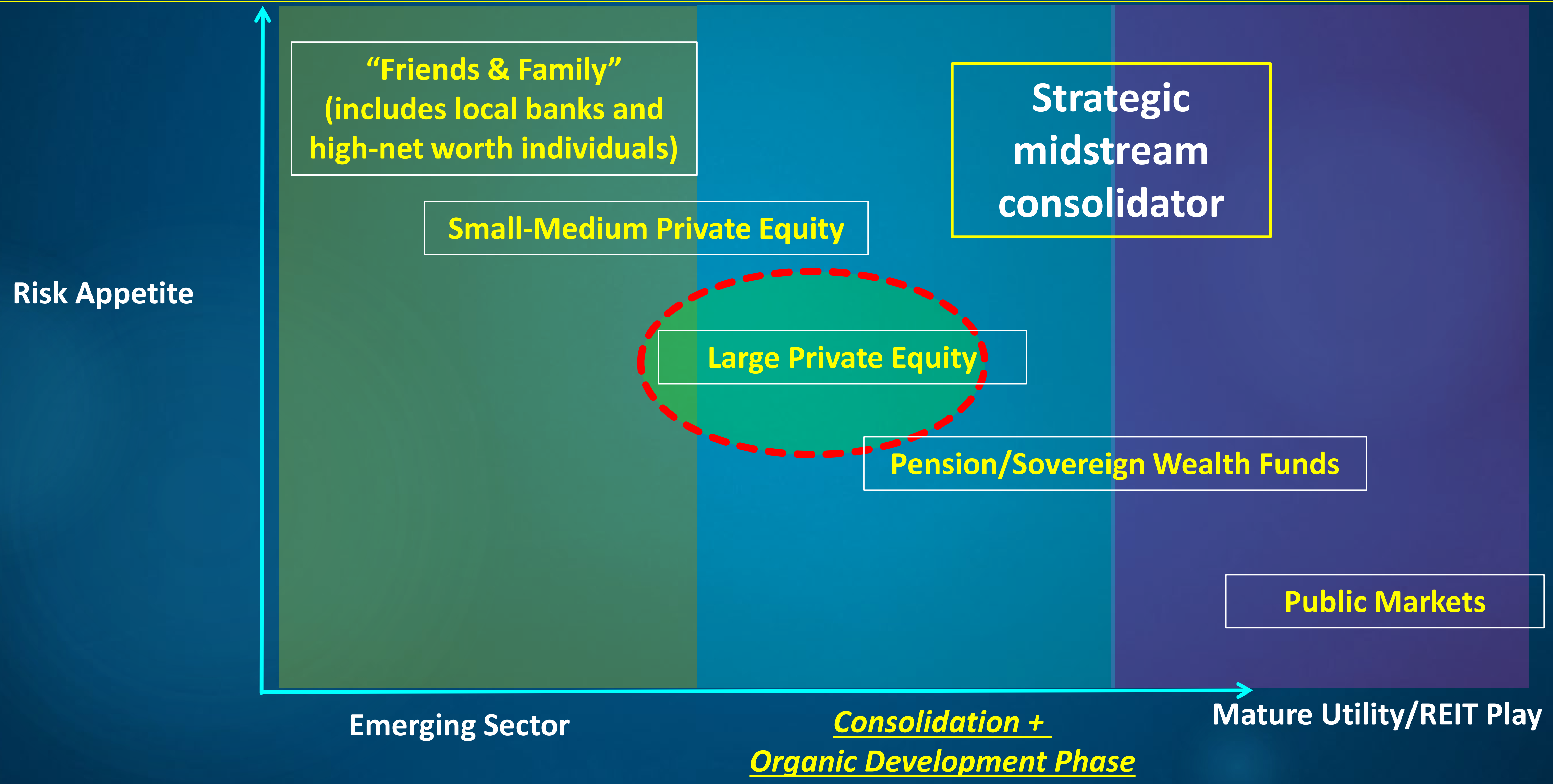
- 142 miles
- $930 million project cost
- 54-inch steel line
- Projected to move ~1 million bwpd.



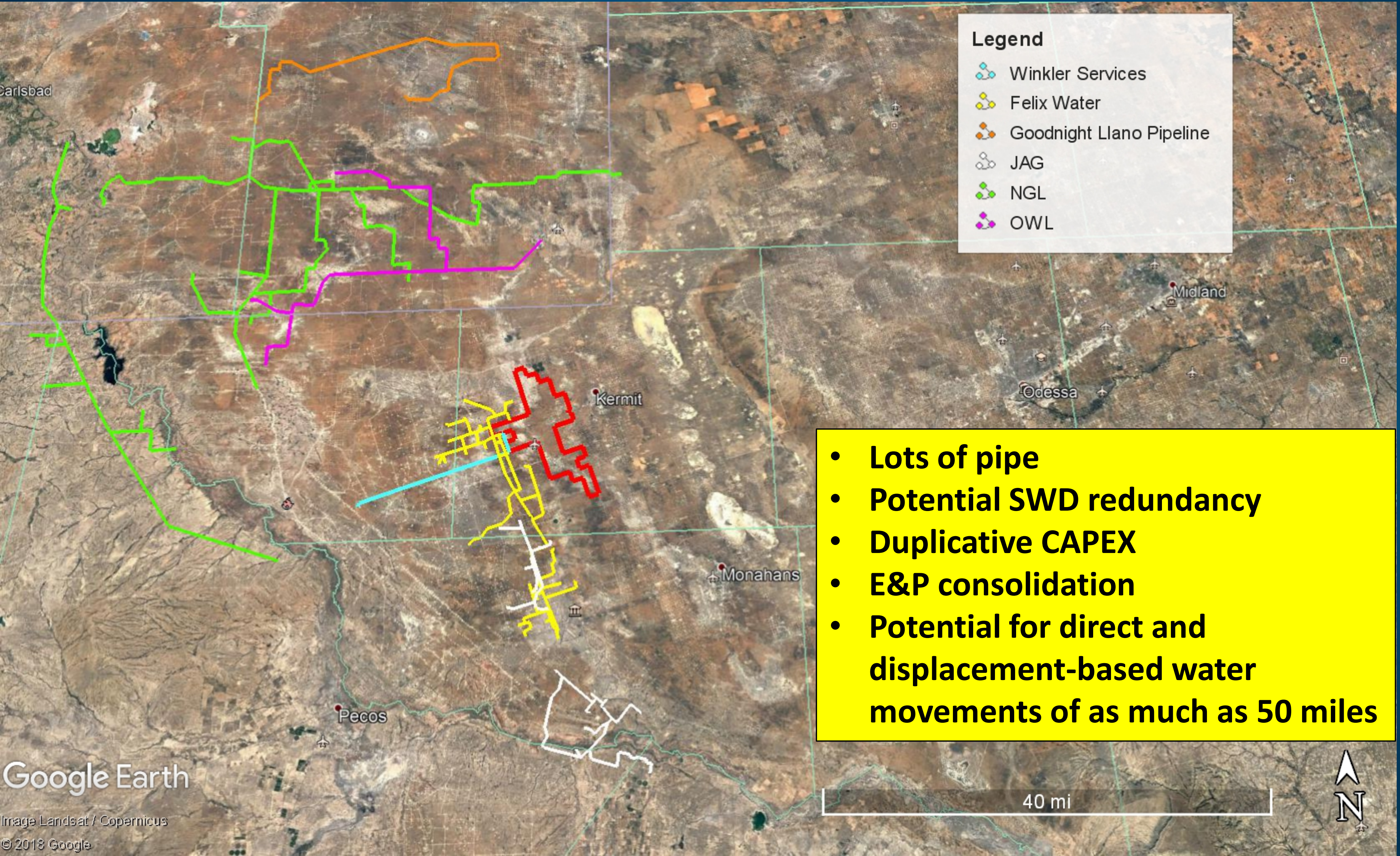
Using Vista Ridge's economics as a baseline, installing 5 X 54-Inch, 650-mile long water pipelines between Orla and Corpus Christi would cost about $16 billion and financed at a 15% interest rate over 20-years, would yield an estimated CAPEX cost of $1.38/bbl and OPEX cost of $0.23/bbl, for a delivered cost to the Gulf Coast of $1.61/bbl.

Water Midstream Risk Profile vs. Investor Types: Where Are We?

- "Returns on water midstream around the industry have been comparable to crude gathering—in the mid to high teens unlevered, depending on the contract structure. I am not aware of another manufacturing business in the U.S. with that potential in terms of quantity of capital and unlevered returns. Capital finds a way to get these things done. I don't see a market where public capital lets private equity have that kind of potential all to itself for the next 10 years."—Jason Downie, Co-Founder and Managing Partner, Tailwater Capital

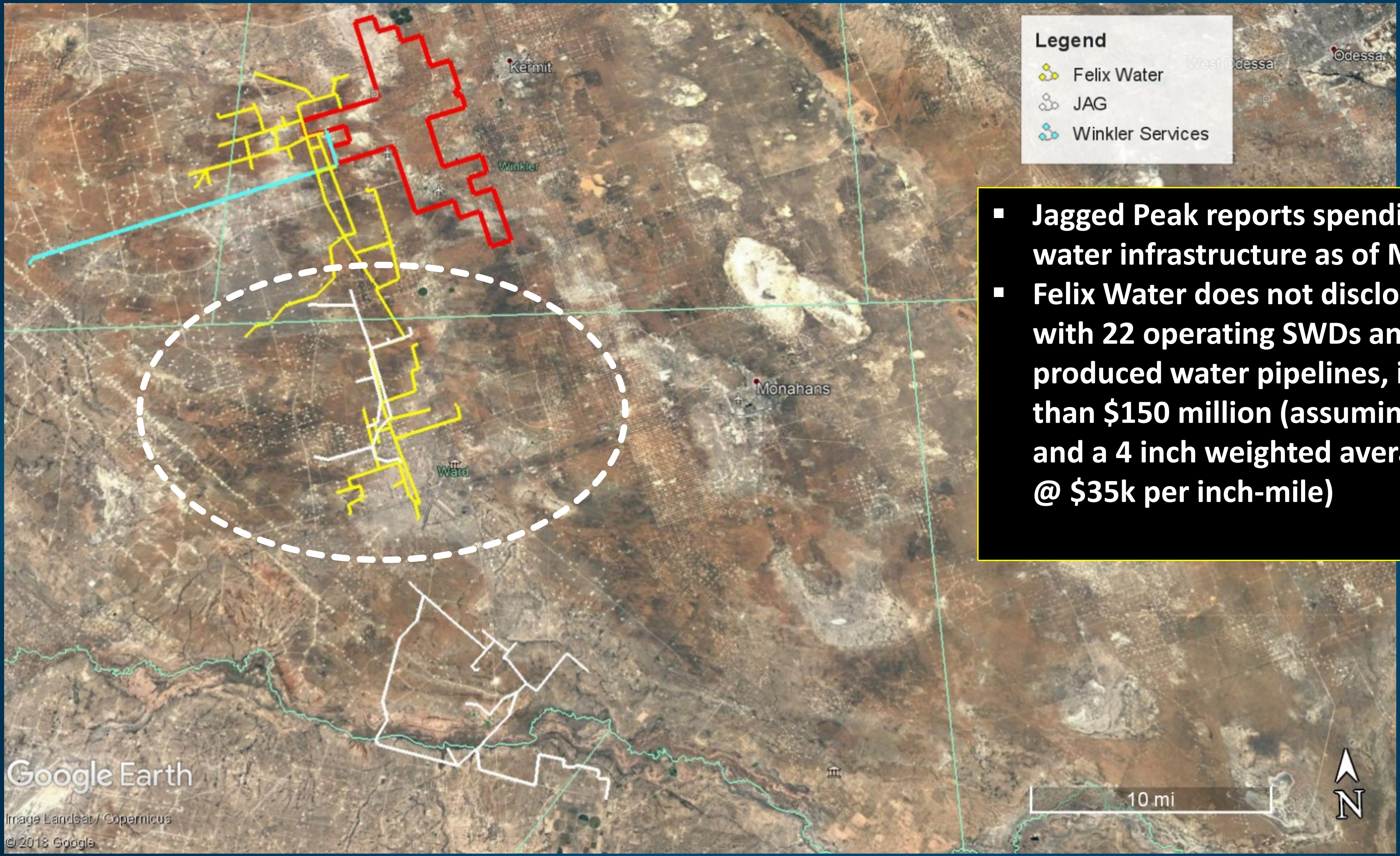


The Aggregation Case



- **Lots of pipe**
- **Potential SWD redundancy**
- **Duplicative CAPEX**
- **E&P consolidation**
- **Potential for direct and displacement-based water movements of as much as 50 miles**

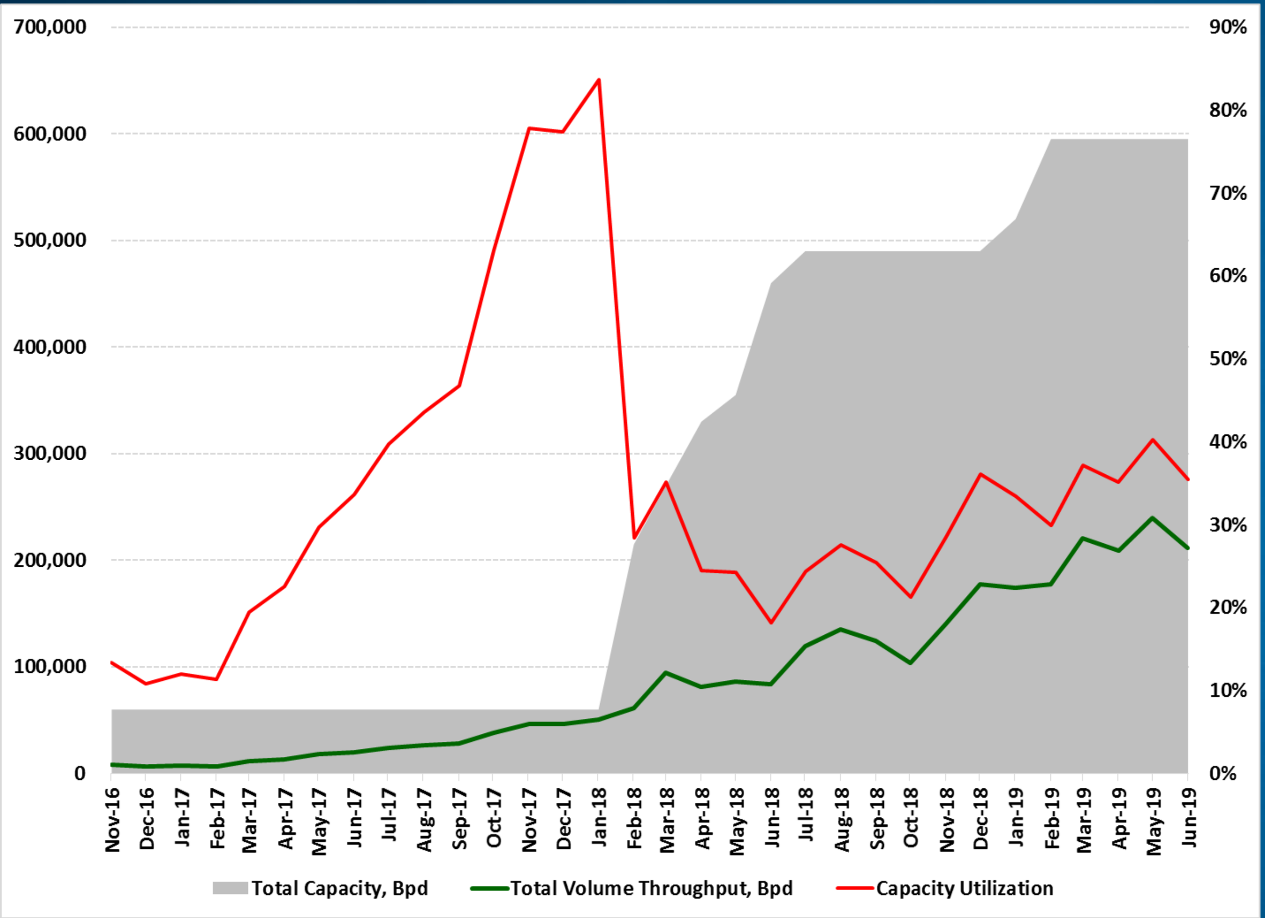
Case Example: Optimizing CAPEX



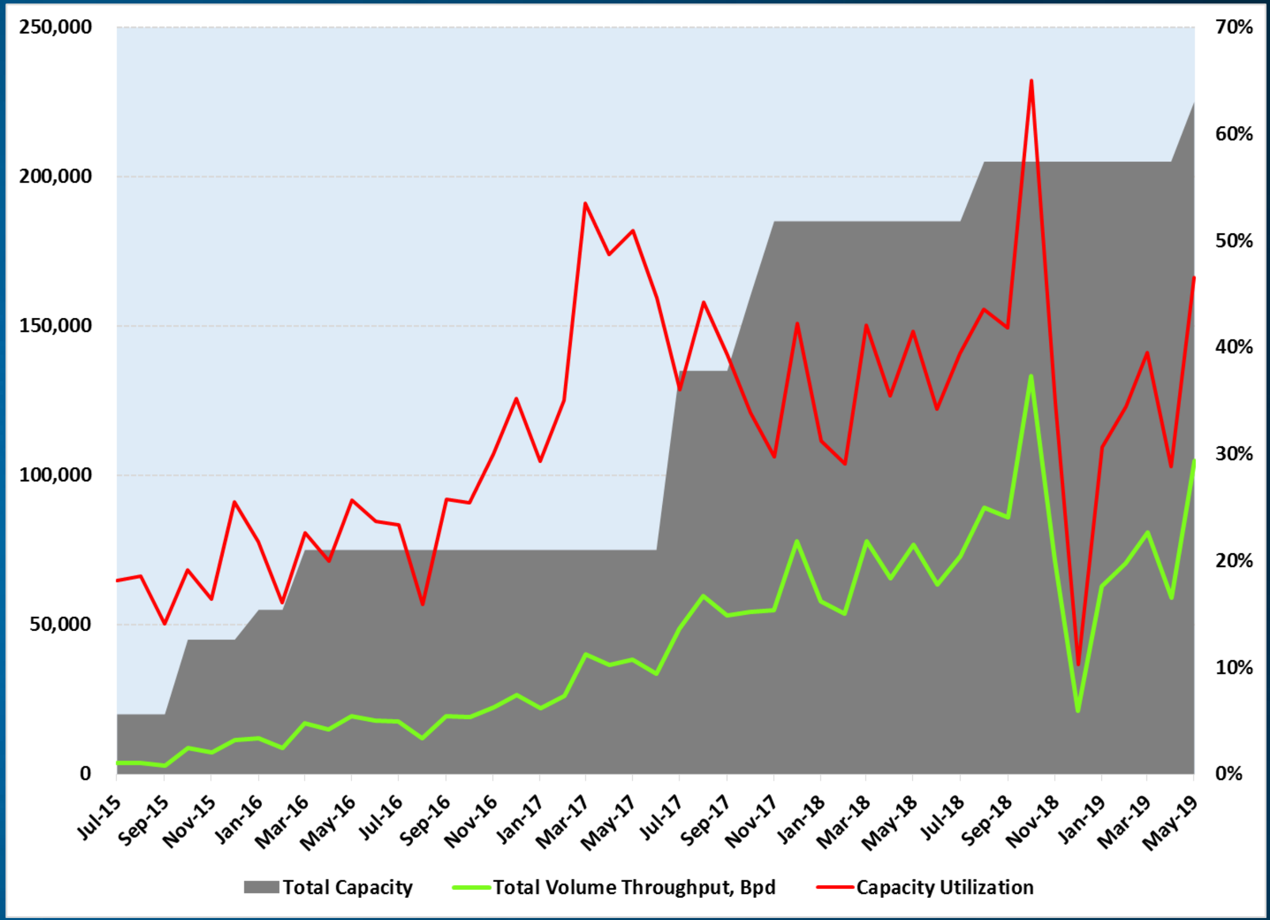
- Jagged Peak reports spending $68 million on water infrastructure as of May 2019.
- Felix Water does not disclose total CAPEX, but with 22 operating SWDs and 155 miles of produced water pipelines, it has likely spent more than $150 million (assuming $6 million per SWD and a 4 inch weighted average pipeline diameter @ $35k per inch-mile)

Case Example: Disposal Capacity vs. Utilization Rates

Felix Water, LLC



Jagged Peak Energy



Source: Texas RRC, Author’s Analysis

Each neighbor has a 4-car garage, but only two cars and probably won’t buy 4 vehicles anytime soon—argument for capacity sharing

Benefits of Scale

Food needs as analogous to CAPEX + OPEX

Human being
~17 calories/lb/day

Polar bear
~12 calories/lb/day

Blue whale
~10 calories/lb/day

Source: Australian Antarctic Division (blue whale), Get Drawings (human), World Wildlife Fund (polar bear)

Oilfield Water Wear & Tear: Effects of OPEX and Depreciation

Source: Reuters (February 2019)

	Original CAPEX	Depreciation Period, Yrs.	Annual Depreciation Cost
Hard Pipe	$103.0	25	$4.12
SWDs	$79.5	7	$11.36
Miscellaneous	$18.5	7	$2.64
Pits	$2.3	10	$0.23
Layflat	$1.1	7	$0.16
Total	$204.3	($ Millions)	$18.5

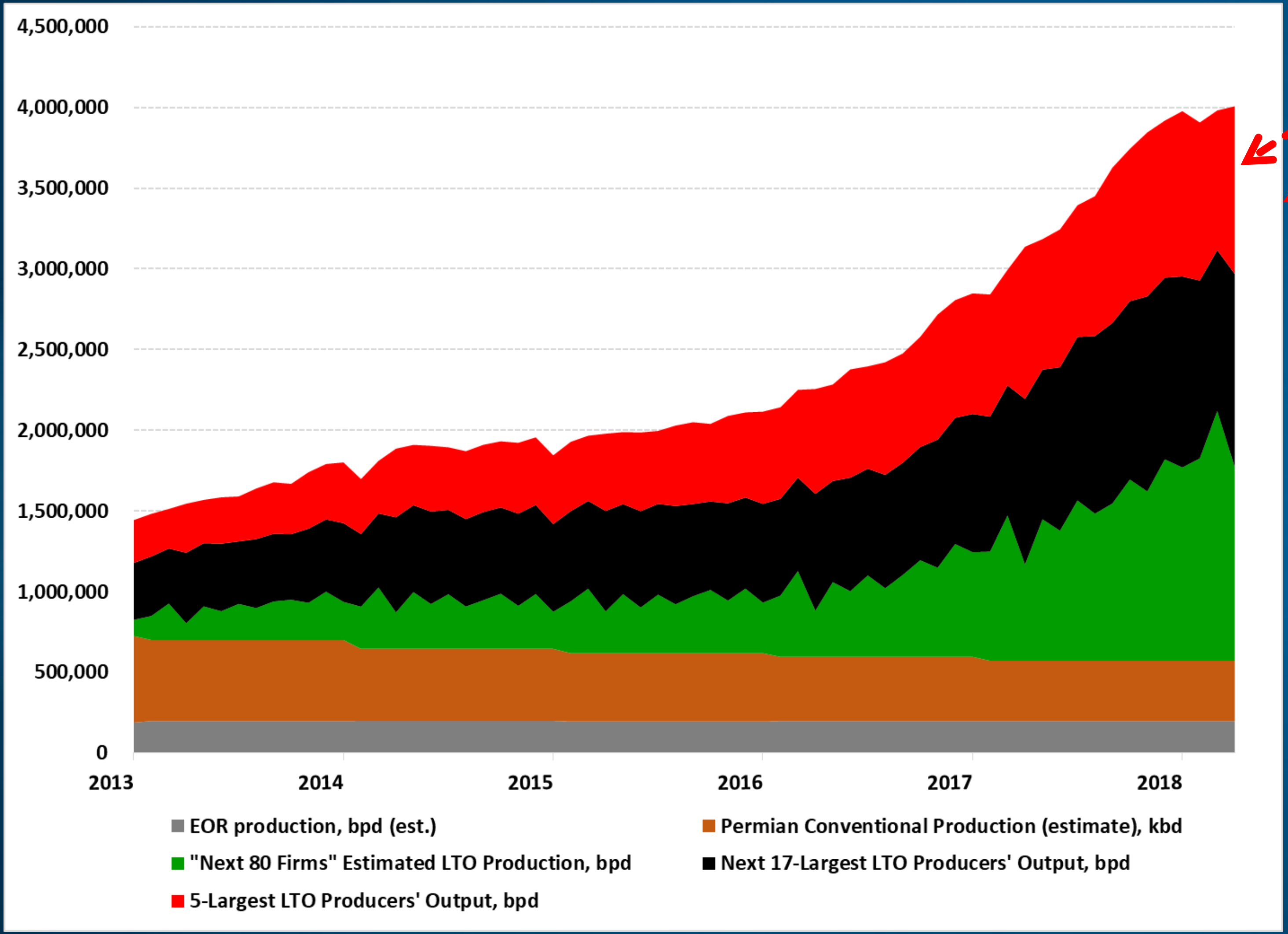
Consider contrast with municipal systems. City of Midland, TX reported owning about $484 million worth of water and sewer infrastructure in 2017. Depreciation for that fiscal year was just under $14 million.

Key Points

- **Even if an oilfield water company bills itself as a "utility" asset, depreciation timetables suggest significant distinctions that valuation professionals and investors should be aware of.**
- **Foremost among these is the reality that saltwater disposal wells make up a big portion of total system cost and will likely need to be replaced/worked over much more often than the pipes and pumps in a "traditional" water utility model.**

Hydrovascular Grid Case Strengthens When As Expectations for Permian E&P Returns Become More Realistic

Permian Liquids Production by Company Size



Source: Company Reports, Texas RRC, Author's Analysis

- More of these producers will consolidate the "next 80 firms"
- And most pointedly, the 5-7 largest players in the Basin will be the biggest forces for consolidation.
- What happens when investors begin to recognize that Permian unconventional may in fact be a "utility returns play?"
- Opens up a new range of potential capital sources, provided that the current bid-ask difference can be rationalized. In other words, once the "F-150 companies" stop asking for "Ferrari" prices, a whole new range of scale-oriented transactions potentially opens up for capital providers comfortable with long run returns on capital closer to 10-12%.

The Produced Water Aggregation Case Mirrors Evolving Well Spacing Trends

From Concho's 2Q2019 earnings deck (30 July 2019)

Dominator Project

› **Strong execution across the organization**
- Massive project online ahead of schedule
- Utilized 7 rigs and 5 frac spreads within 1-mile section
- ~15% improvement in feet drilled/day vs. 2018 area avg.

› **Tested dense development of the Upper Wolfcamp**
- Performance indicates project spaced too tight

Eider Project

› **Avalon delineation**
- Continue to evaluate multi-zone potential within Avalon

Recent Projects Inform Development Strategy

- Spacing is critical variable to maximizing performance & economics
- Tested upper limits of well spacing 2H18-1H19
- Integrated data & reverting to less dense configuration point forward

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A Fracking Experiment Fails to Pump as Predicted

Encana's cube project suggests output problems occur if oil wells are drilled too close together

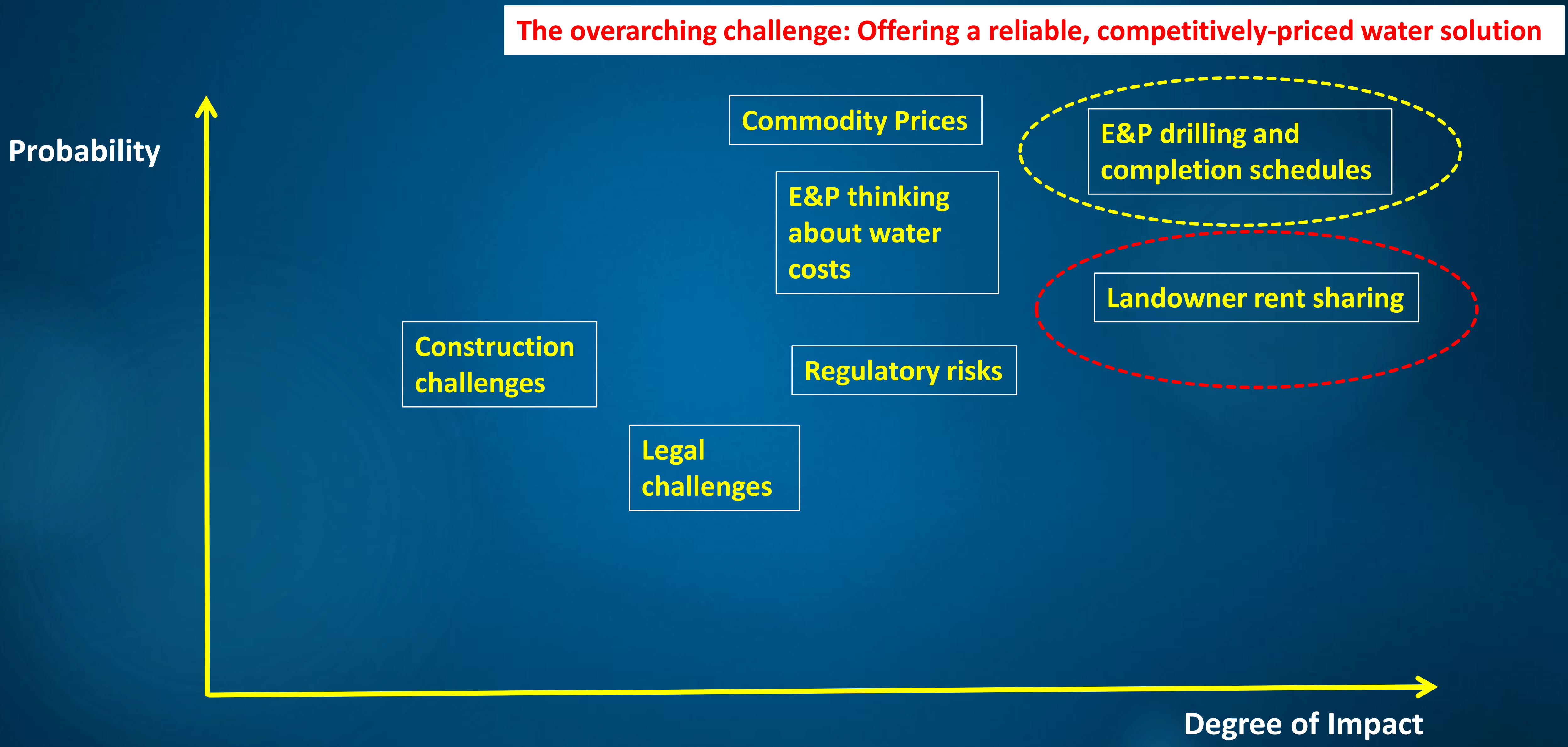
A 2017 aerial photo of Encana's RAB Davidson cube drilling development in West Texas. The site's 33 wells are each on track to pump 300,000 barrels of oil over 30 years. PHOTO: GOOGLE EARTH

By Bradley Olson

Updated July 4, 2019 5:01 pm ET

Lower density development means midstreams may need to cover larger physical footprints to achieve a given volume and returns profile

Key Challenges for a Hydrovascular Grid



Disposal Costs: Economic Perspectives of E&Ps and Water Midstreams

	Capital Recovery Fee, $/bbl	Desired Rate of Return			
		7%	12%	15%	20%
40% Util	Delaware Disposal Case	($0.37)	($0.49)	($0.57)	($0.72)
	Devonian Disposal Case	($0.46)	($0.61)	($0.71)	($0.89)
60% util	Delaware Disposal Case	($0.24)	($0.33)	($0.38)	($0.48)
	Devonian Disposal Case	($0.30)	($0.41)	($0.47)	($0.59)
80% Util	**Delaware Disposal Case**	**($0.18)**	**($0.25)**	**($0.29)**	**($0.36)**
	Devonian Disposal Case	**($0.23)**	**($0.30)**	**($0.35)**	**($0.45)**
100% Util	Delaware Disposal Case	($0.15)	($0.20)	($0.23)	($0.29)
	Devonian Disposal Case	($0.18)	($0.24)	($0.28)	($0.36)

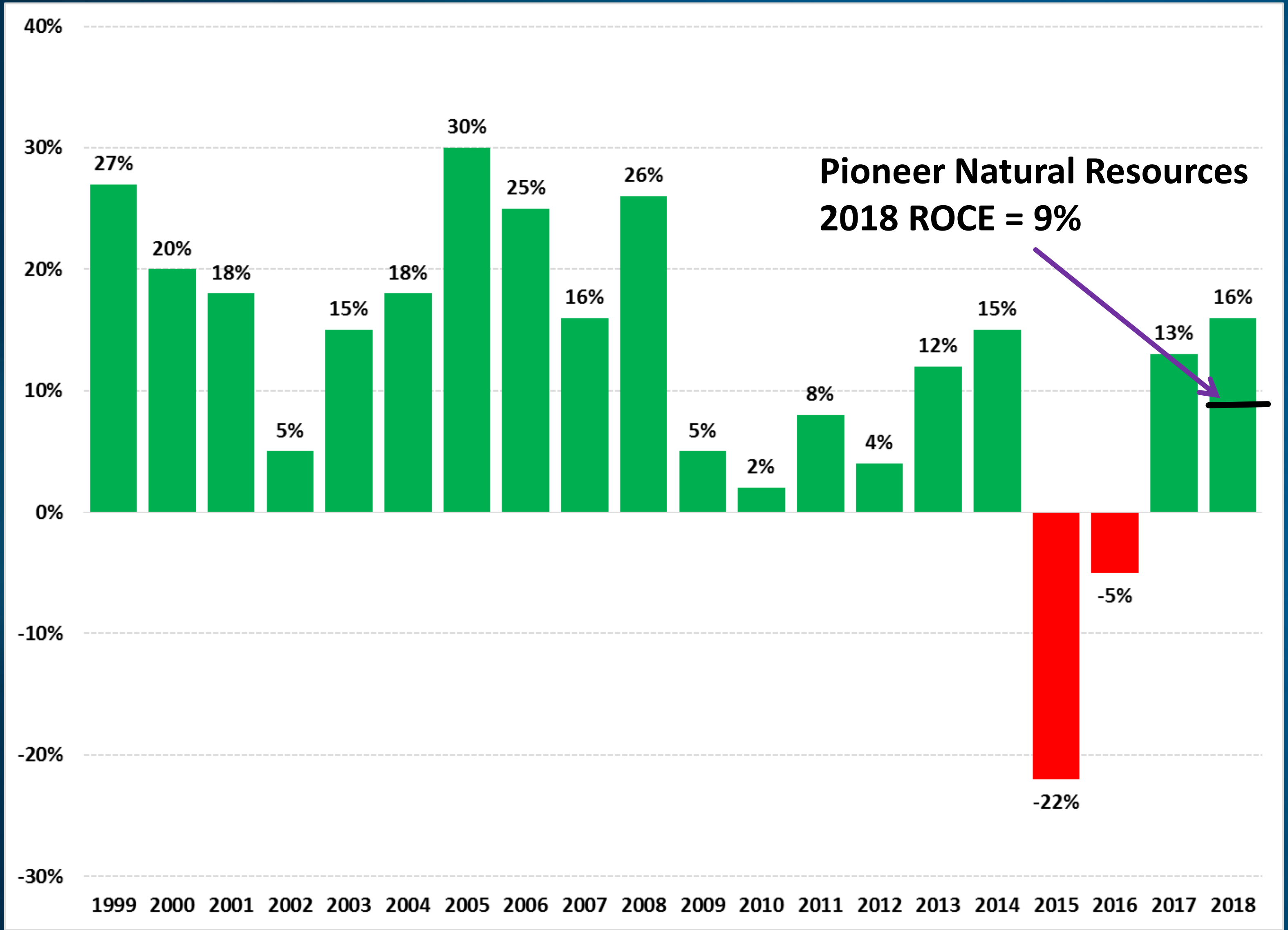
What is ultimately carried on the balance sheet?

Delaware Disposals				
	100% Capacity Utilization	80% Capacity Utilization	60% Capacity Utilization	40% Capacity Utilization
	$/bbl @ 200 kbd lifetime avg. volume	$/bbl @ 160 kbd lifetime avg. volume	$/bbl @ 120 kbd lifetime avg. volume	$/bbl @ 80 kbd lifetime avg. volume
Capital Recovery Fee @ 15% return	($0.23)	($0.29)	($0.38)	($0.57)
Variable Cost	($0.25)	($0.25)	($0.25)	($0.25)
Landowner Rent	($0.10)	($0.10)	($0.10)	($0.11)
WaterCo Staff Cost	($0.04)	($0.05)	($0.07)	($0.10)
Downtime Cost	($0.06)	($0.06)	($0.06)	($0.06)
Total Cost Per Barrel	($0.62)	($0.69)	($0.80)	($1.03)

- E&Ps commonly discuss internal disposal costs of between $0.20 and $0.40/barrel
- For instance, "*Average water acquisition and disposal costs of under $0.10 / Bw and $0.20 / Bw, respectively*"—Jagged Peak Energy, 23 March 2018
- The big questions arising from this are: (1) what is the assumed opportunity cost of capital and (2) are these "cost" figures cited by the companies truly "fully burdened" and reflective of operational and capital costs that structurally probably aren't much different from those of the third-party water midstreams?

Competition for Capital

EOG Resources Return on Capital Employed



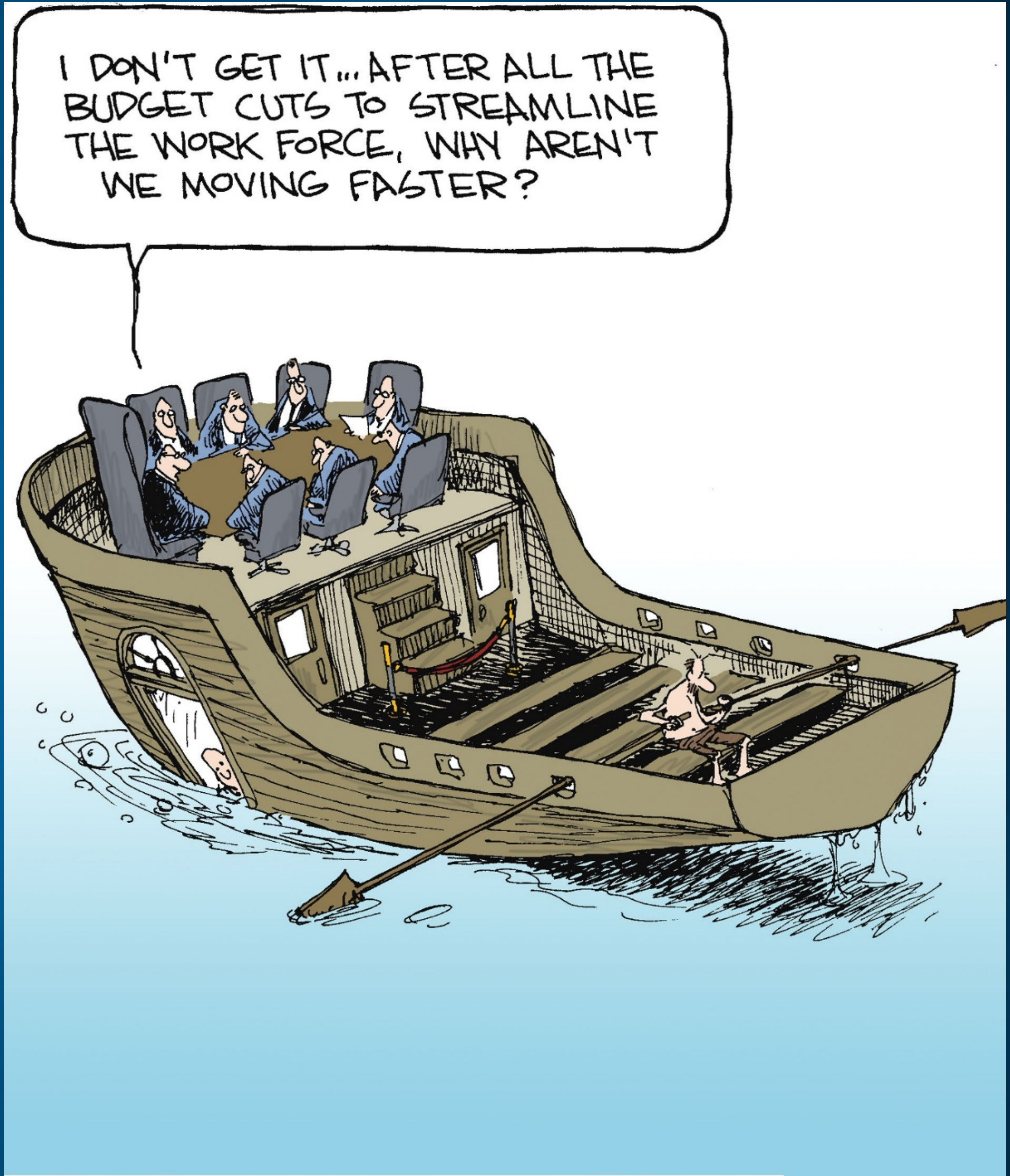
Source: Company Reports

- Return on capital employed is not a perfect proxy, but gives a directional sense as to how management may elect to deploy capital on projects, especially in a "live within cashflow" environment such as the one E&Ps now must operate in.
- Legacy investments in proprietary water infrastructure are tempting monetization targets at present in part because recent comparable transactions suggests a higher ROCE on dollars invested in SWDs and pipelines than for dollars sunk into oil & gas wellbores.
- But moving forward, investors are likely to cast a jaundiced eye on additional water system investments that could have gone to oil & gas development.
- The more public midstream names there are with meaningful water exposure, the stronger investor pressure will generally become on E&Ps to focus CAPEX on their core business and not plough money into midstream operations.

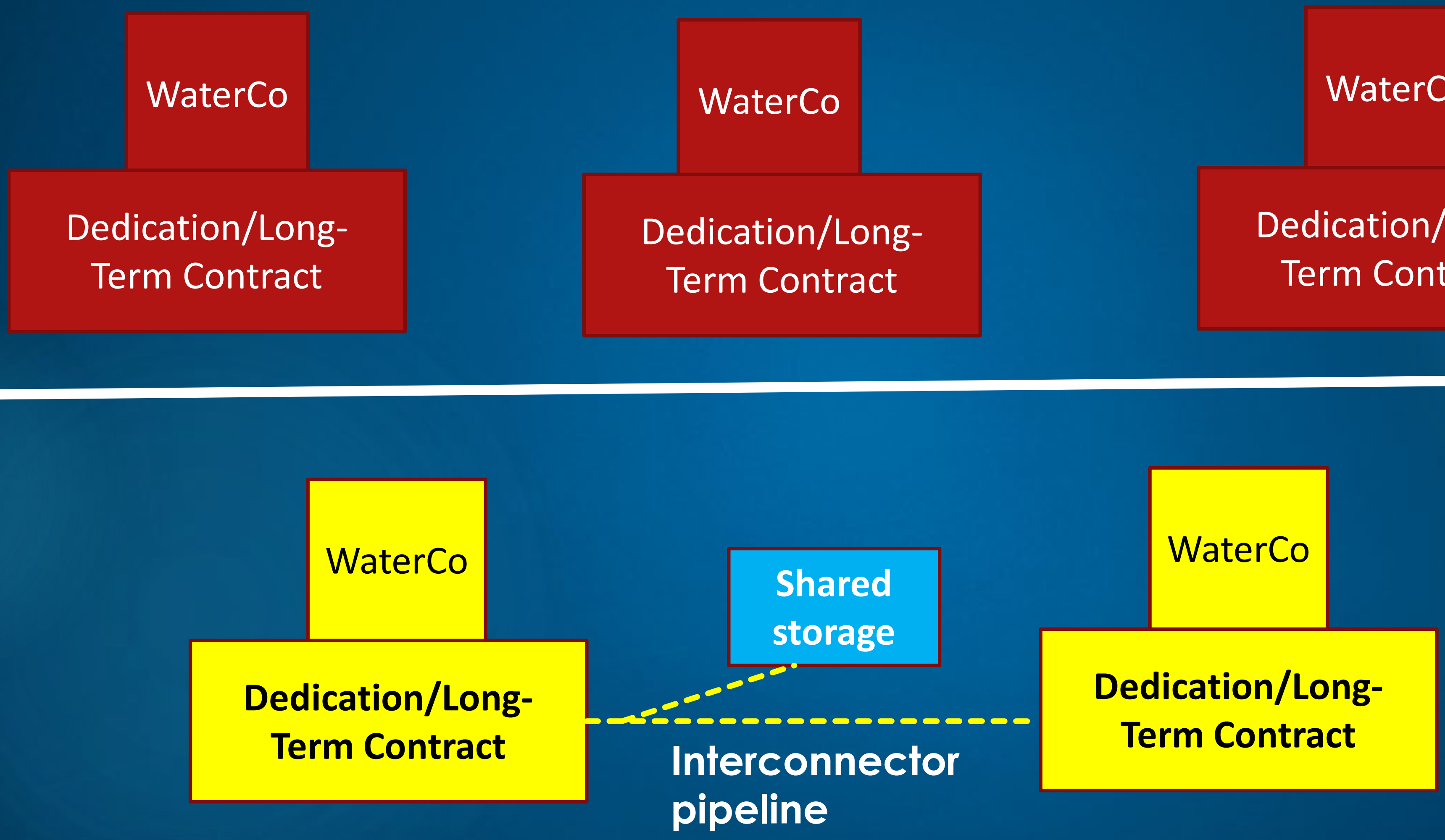
Disposal Costs: E&P Thinking vs. Water Midstream Thinking

- The big question for E&P managements facing water infrastructure decisions?
  - Do we think in "dollar" terms?
    - *What could we have drilled with that $100 million that we spent on a water system last year?*
    - *Can we plug a balance sheet hole by monetizing out midstream asset and buy a quarter or two of breathing room with Wall Street?*
  - Or do we think in "operational assurance" terms?
    - *Aren't we glad a third-party's operational failure didn't damage a well and set back our frac schedule for months!*

There is no simple answer and these will be case-by-case decisions. Furthermore, the public markets will likely have a limited appetite for water midstream assets sold at 9.0X EBITDA when the underlying oil & gas production assets that are providing the water only command a 6.0X EV/EBITDA value.

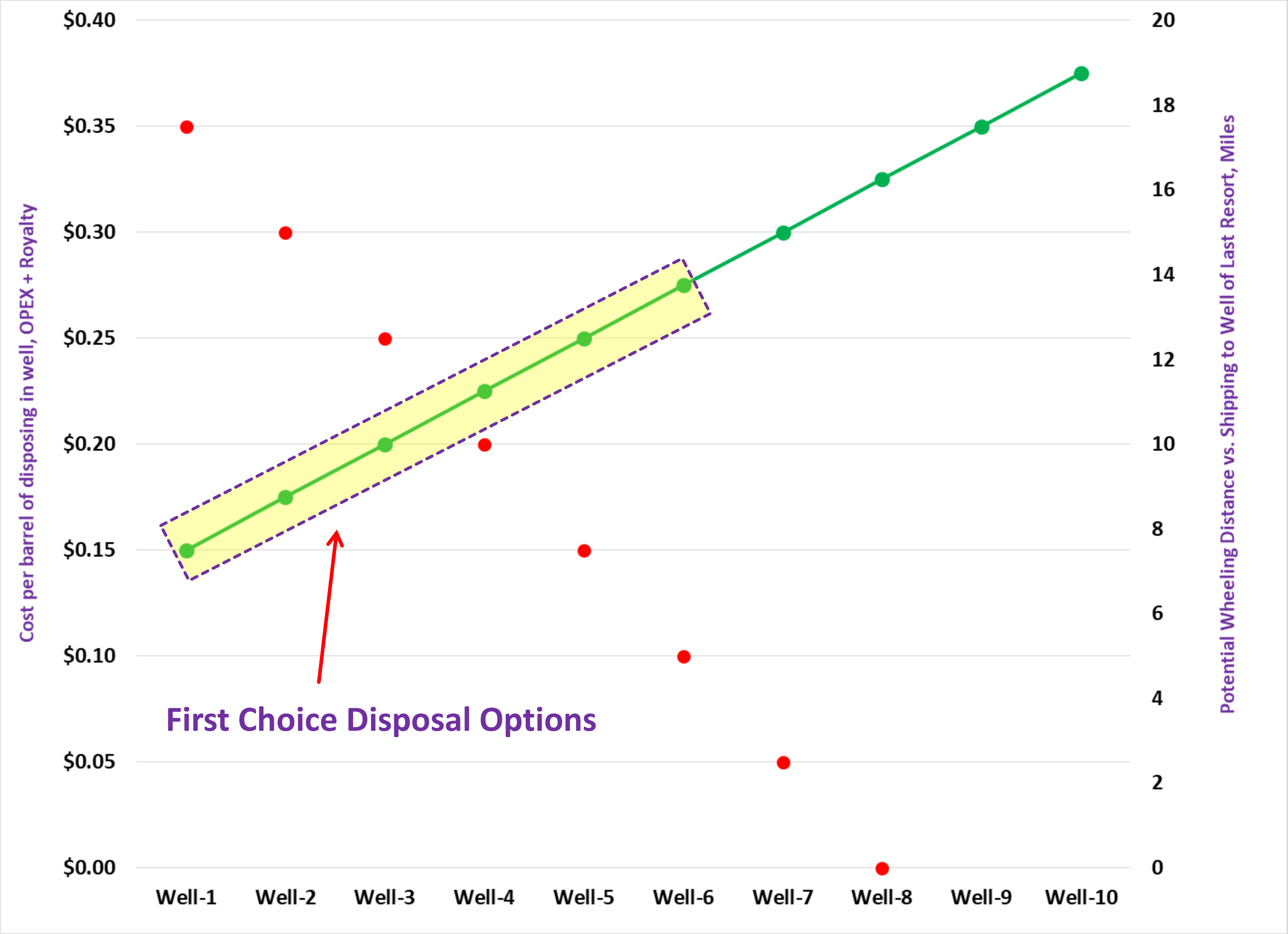


Financial Structures Will Evolve With Larger Scale and Increased Connectivity



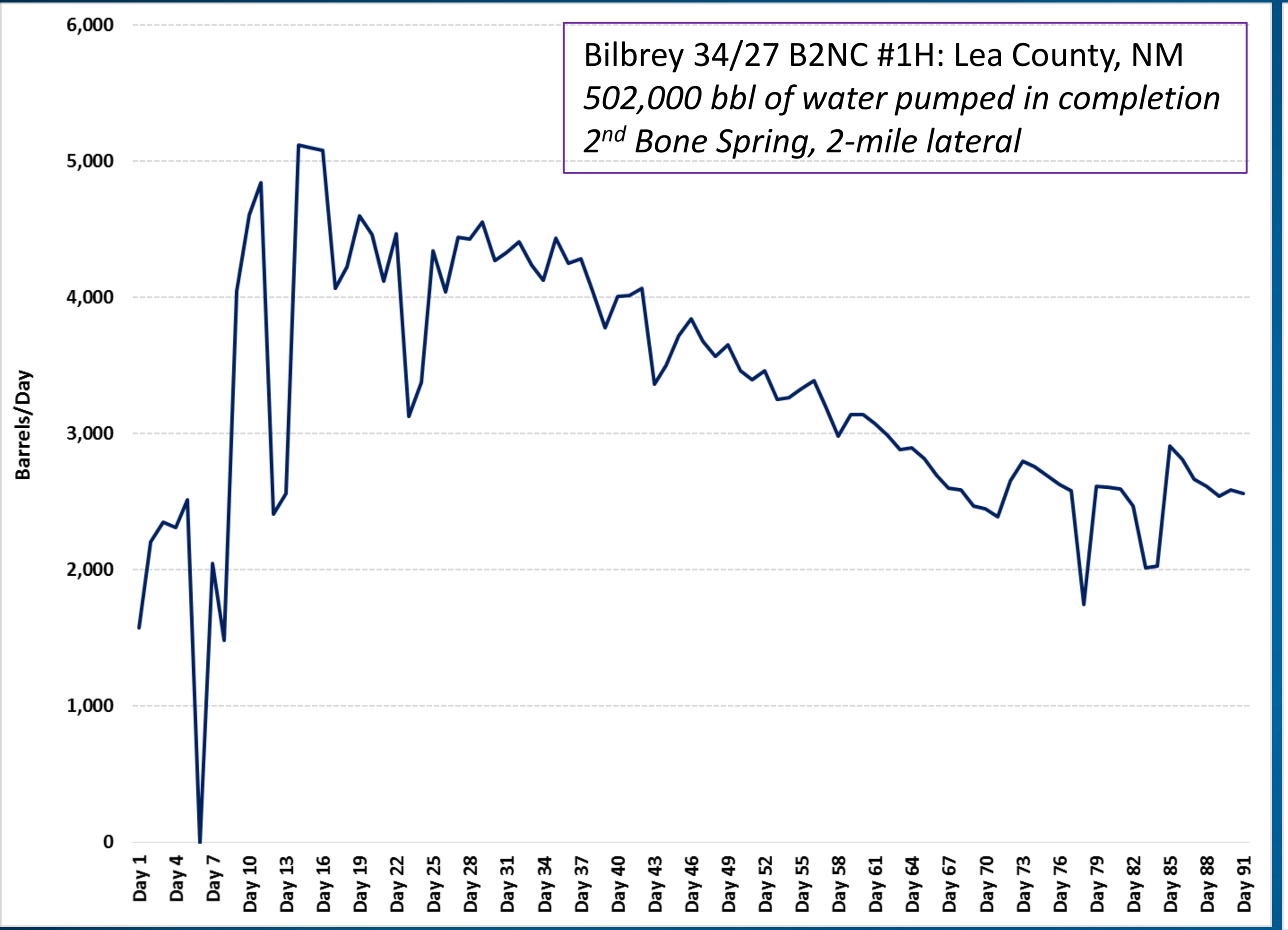
- Spot water deals
- Capacity reservations
- More dynamic pricing
- Water swaps
- Disposal cost optimization deals

Using Interconnectivity to Optimize Operating Costs

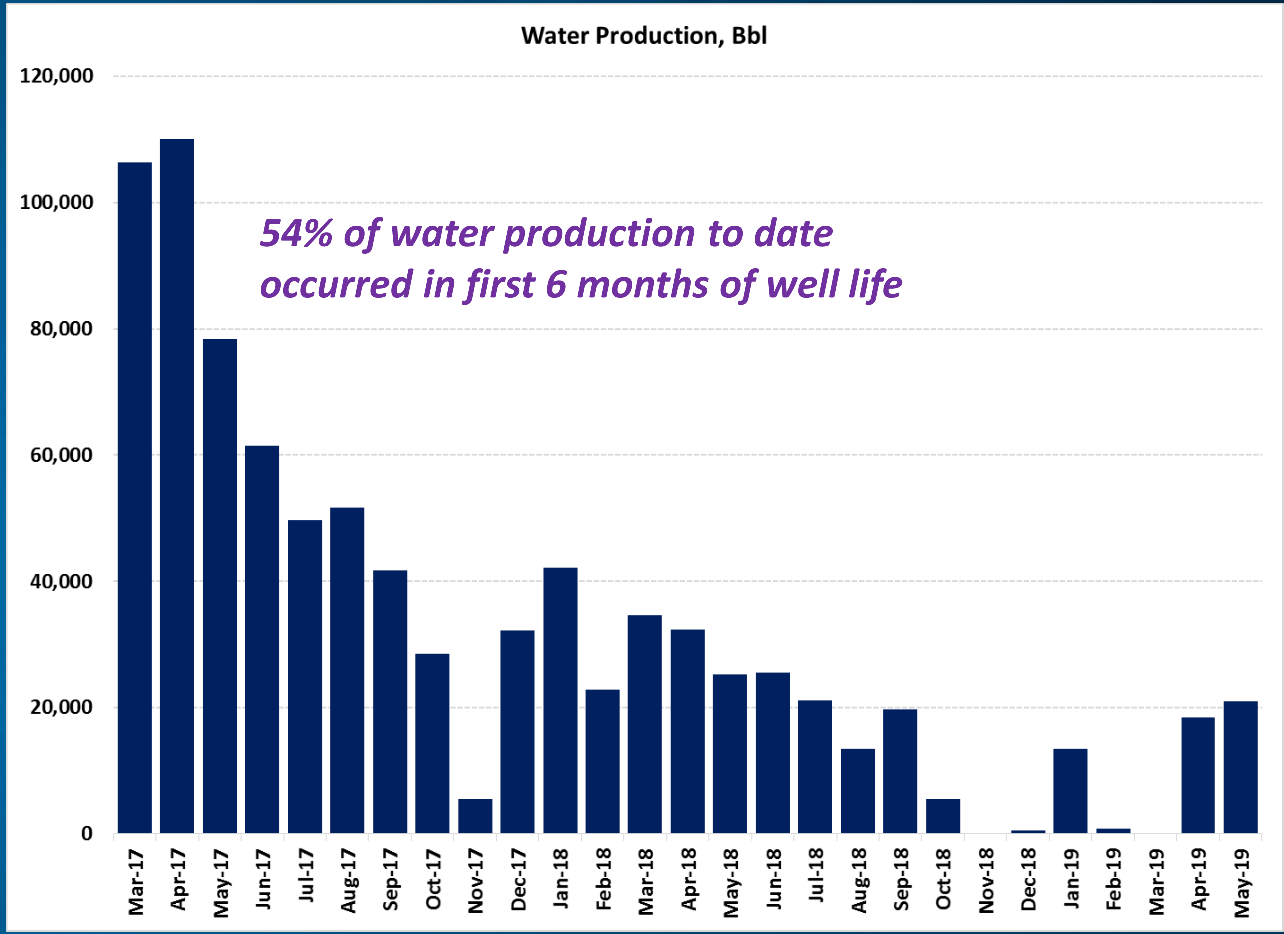


Hydrovascular Grid Can Optimize CAPEX In a World of Frontloaded Water Volumes

First 90 Days of Well Life



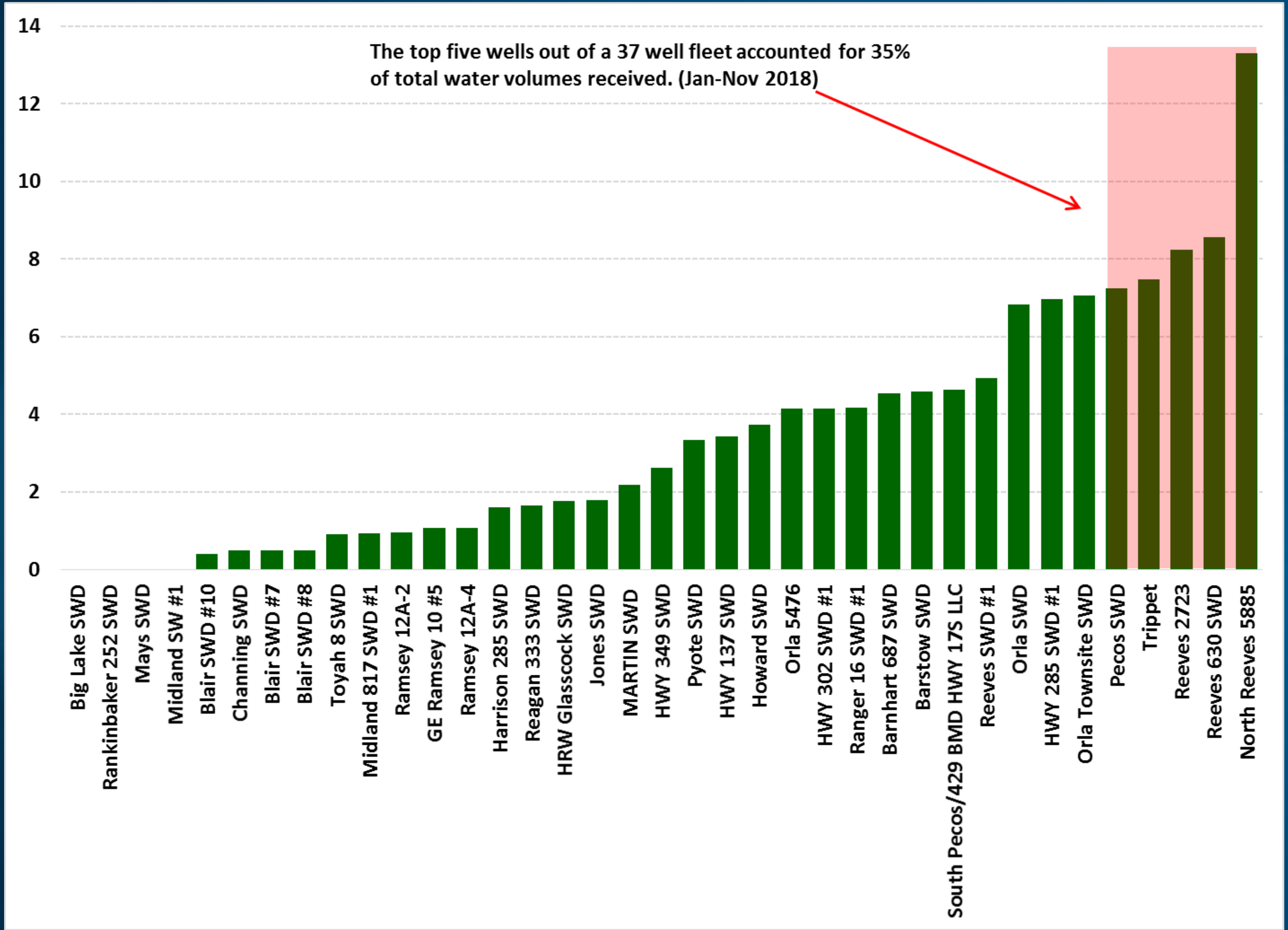
Well Life To Date



Source: Well Invoice Data, NM OCD

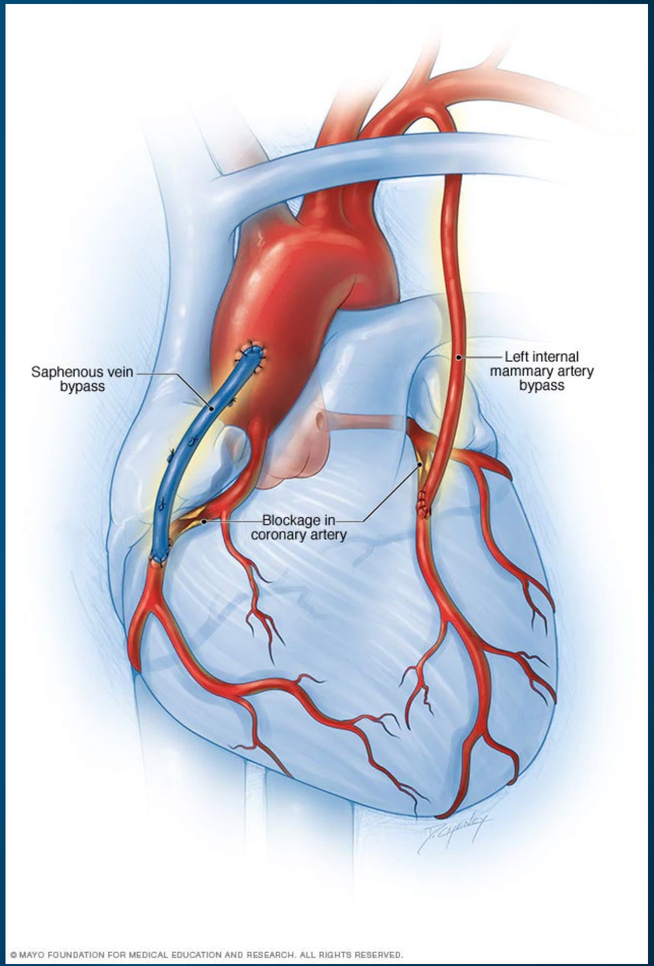
Better Connectivity Hedges Cashflow Risk & Reduces Customers' Flow Assurance Risk

NGL Permian Water Solutions 2018 YTD Volumes Received , By Well (Mmbbl)



Source: Texas RRC

Interconnectivity with other systems can help mitigate the risk of disruptions to key wells/pipelines.



Source: Mayo Clinic

Managing Volume and Price Risk: Timing Matters

Delaware Basin Wolfcamp Well Spud-to-Sales

	Drilling	Completion	Commencing Sales	Total Est. Spud-to-Sales Time
DUC Case	N/A	10-14 Days	5-6 Days	15-to-20 days
Base Case	20-25 Days	10-14 Days	5-6 Days	35-to-45 days
Pessimistic Case	30 Days	10-14 Days Frac + ~30 Days to Fill Frac Pit	7-10 Days	80-to-90 days

Source: Gabriel Collins and Kenneth B. Medlock, "*Assessing Shale Producers' Ability to Scale-up Activity*," Issue brief no. 01.17.17, Baker Institute for Public Policy, Houston, Texas, https://www.bakerinstitute.org/research/assessing-shale-producers-ability-scale-activity/

Temporal mismatches

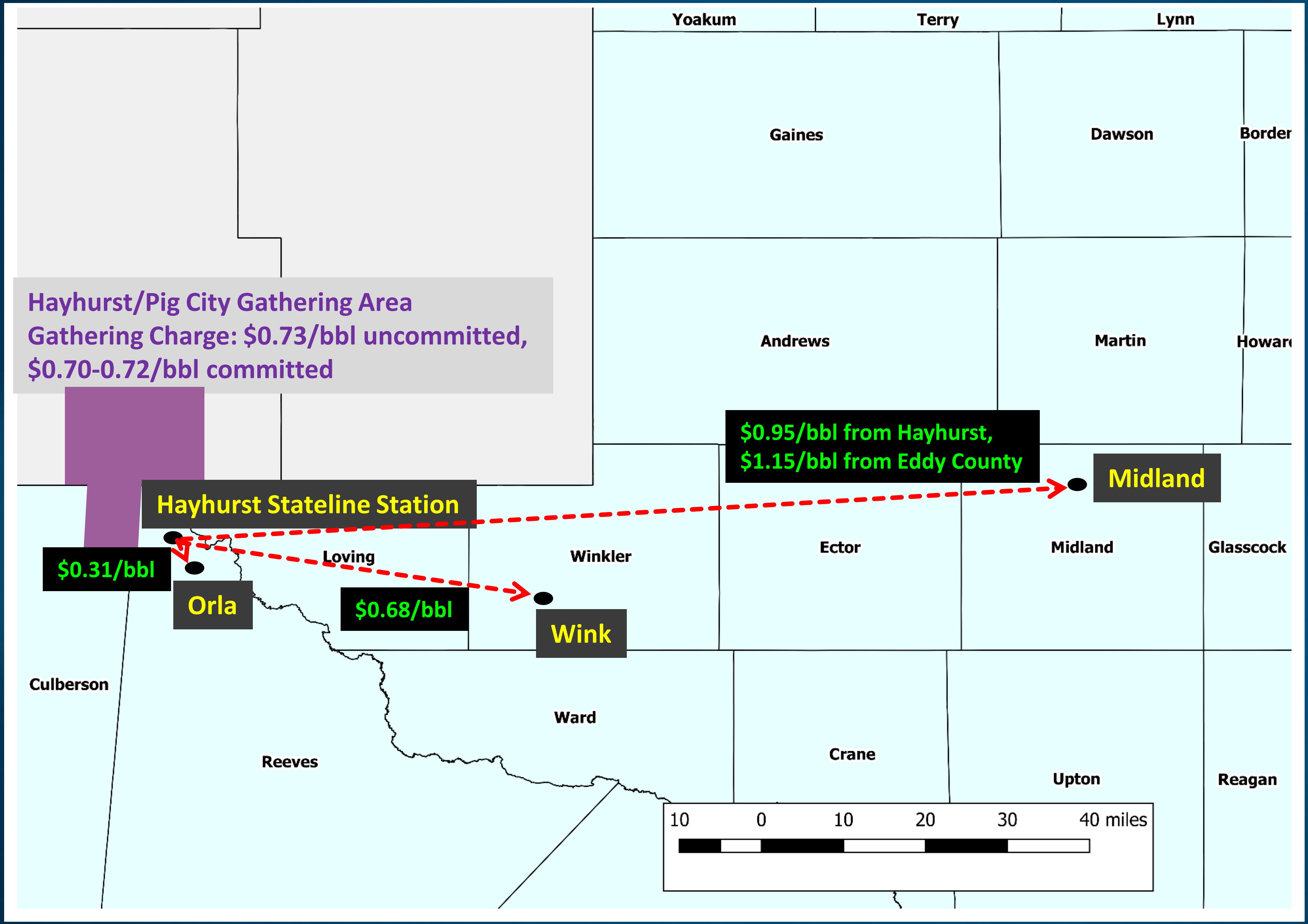
- **Can new SWDs be quickly brought online to serve pad-type drilling developments?**
- **Deeply interconnected pipelines networks help mitigate this risk on a localized basis by allowing specific pads access to a broader disposal and water-handling network.**

Delaware Basin SWD Permit-to-Injection

Land Purchase & Permitting	SWD Drilling	Procure and Install Surface Facilities	Commence Operations
2-to-12+ months	1-3 weeks	2-to-3 months	

Source: NGL Energy Partners, December 2018 Investor Presentation

Commodity Logistics Pricing at Basin-Wide Level (Case of Crude Oil)



Source: FERC, Google Earth, PAALP, Author's Analysis

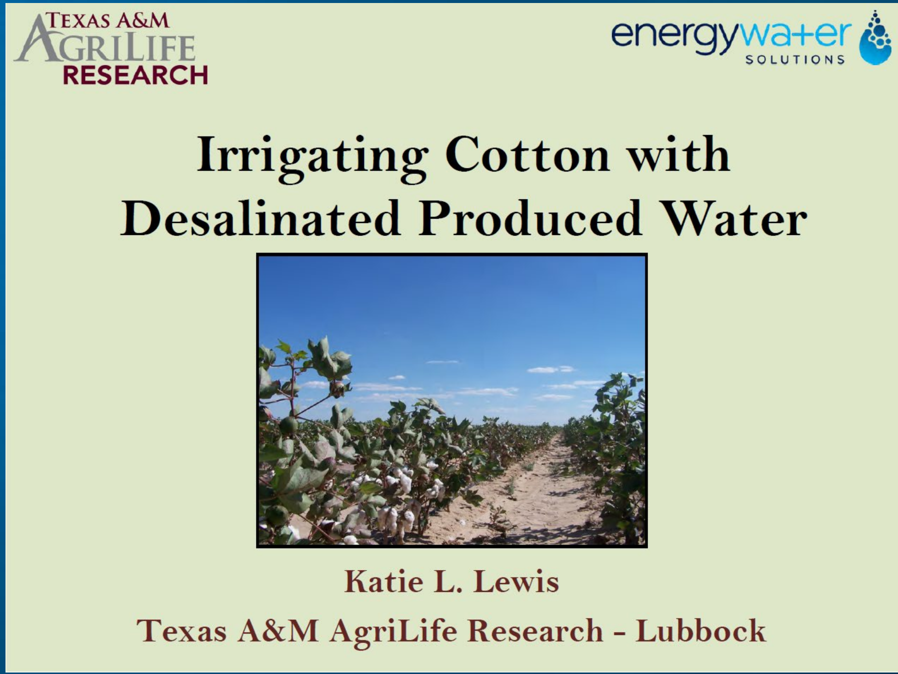
Produced Water Repurposing: Thinking Beyond the Oilfield

Large-scale midstream infrastructure has the potential to enable creative new uses of water that go beyond disposal and recycling alone. Here we are talking utility-scale systems with pipelines that could be 36" diameter or larger. These ideas also presuppose two other developments: (1) a higher degree of interconnection between oilfield water handling footprints, which at this point in time are highly fragmented and (2) lower-cost treatments that can provide "upgraded" produced water at scale.

It is also important to start thinking intensively now about re-purposing part of the produced water stream, so that the practices and technologies have a better chance of being in place when oilfield recycling demand begins to slow several years down the road as many parts of the Delaware and Midland Basins begin to mature.

A Few Potential Applications

- Non-food crops
- Pipeline to Gulf of Mexico
- Power plant cooling/industrial use
- Fuel algae



Source: https://vpr.colostate.edu/few/wp-content/uploads/sites/14/2016/07/Lewis-TAMU-AGL-NSF-FEW-workshop-12-2015.pdf

At What Price Would Treated Produced Water Become Practically Useful to Farmers?

For Biofuel Crops

Probably $0.10/bbl or less, assuming a 75% freshwater/25% treated PW irrigation blend

Alamo switchgrass grows well in TX climates and can be a feedstock for cellulosic ethanol production.

Source: USDA

For the Highest Value "Non-Food" Crops

Approximately $0.40/bbl, assuming a 75% freshwater/25% treated PW irrigation blend

Opium cultivation assuming that farmer sells morphine base instead of raw opium, such as that being harvested below by a farmer in southern Afghanistan.

Source: NPR

Disclaimer: The opium example is for illustrative purposes only.

Permian Oilfield Water Predictions

A. Within 12 months from today (start date August 2018)
  - A major Permian-focused water midstream firm goes public or has a similarly large liquidity event
  - At least 3 additional large private equity companies enter the space
  - At least 3 sizeable (80 kbd+ avg. actual volume handled) water midstream firms in the Permian will be acquired by a larger player
  - Treated co-mingled produced water will began to be re-sold at a commercial price

B. Within the next 12 months (by August 2020)
  - There will have been a billion-dollar oilfield water transaction in the Permian
  - At least five Permian-focused entities other than Pioneer Water Management will be transporting and injecting 500 kbd or more of produced water
  - There will be at least two restructurings of distressed water midstream assets

C. Within the next 24 months (i.e. by August 2021)
  - At least 4 million bpd of incremental produced water (relative to August 2018) must be handled

Source: Pinterest

Cutting-Edge Texas Groundwater and Oilfield Water Research

- Gabriel Collins, "*What Does it Take to Create a Billion Dollar Oilfield Water Midstream Company?*," PWS Permian Basin 2018 Symposium, 9 August 2018, Midland County Horseshoe Arena & Pavilion, https://texaswaterintelligence.files.wordpress.com/2018/08/collins_billion-dollar-oilfield-water-company_14-august-20181.pdf
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- Gabriel Collins and Hilmar Blumberg, "*Implementing three-dimensional groundwater management in a Texas groundwater conservation district,*" Texas Water Journal, Vol. 7, No.1, 2016 (69-81), https://journals.tdl.org/twj/index.php/twj/article/view/7037/pdf_17 (peer reviewed)
- Gabriel Collins, "*Blue Gold: Commoditize Groundwater and Use Correlative Management to Balance City, Farm, and Frac Water Use in Texas*," 55 Nat. Resources J. 441 (2015). (peer reviewed)

Supplementary Slides

Produced Water Becoming a Tradable Commodity in the Permian

The Northern Delaware Basin already has "Pipeline Grade" produced water commercially available.

Source: Cimarex, Hart Energy

What Volumes Could Justify a $2.5+ Billion WaterCo Valuation?

Sourcewater Sales, Kbd	Produced Water Handled, Kbd	Valuation at 8X EBITDA	Valuation at 9X EBITDA	Valuation at 10X EBITDA	Valuation at 11X EBITDA	Valuation at 12X EBITDA
33	100	$123	$139	$154	$170	$185
67	200	$335	$377	$418	$460	$502
100	300	$545	$614	$682	$750	$819
133	400	$756	$851	$945	$1,040	$1,136
167	500	$968	$1,089	$1,209	$1,330	$1,453
200	600	$1,178	$1,326	$1,473	$1,620	$1,770
233	700	$1,389	$1,563	$1,736	$1,910	$2,087
267	800	$1,600	$1,800	$2,000	$2,201	$2,404
300	900	$1,811	$2,037	$2,264	$2,490	$2,721
333	1,000	$1,999	$2,275	$2,527	$2,780	
367	1,100	$2,233	$2,512	$2,791		
400	1,200	$2,444	$2,749			
433	1,300	$2,655				
467	1,400	$2,866				

- Assume the following parameters:
  - 3:1 volumetric disposal/sourcewater sales ratio
  - $0.75/bbl gathering & disposal fee
  - $0.50/bbl sourcewater revenue
  - $0.20/bbl skim oil revenue
- $0.35/bbl OPEX + royalty on disposed water
- $0.25/bbl total recycling cost
- $0.03/bbl well water production cost
- $0.15/bbl sourcewater distribution cost
- $11 million annual staff cost
- D&A equal to 19% of operating income

10X and higher multiples most feasible after significant consolidation

At What Price Would Treated Produced Water Become Practically Useful to Farmers? Data Breakdown

Revenue		Quantity	Units	$/Unit	Total per Acre	Enterprise Total
Switchgrass		**5.668016**	**ton**	**$140.00**	**$793.52**	**$396,761.13**
Variable Costs						
Fertilizer						
	N-32 in water	20	lb	$0.39	$7.80	$3,900.00
	Urea, Solid (46% N)	45	lb	$0.20	$8.89	$4,443.75
Herbicide						
	2-4-D Amine 4	40	ounce	$0.14	$5.60	$2,800.00
Other Labor						
	Hand labor	0.14	hr	$15.00	$2.10	$1,050.00
Irrigation						
	ac-in	22				
	bbl/ac, freshwater	10,668	$	$0.018	$186.69	$93,342.73
	bbl/ac, treated PW	3,556	$	**$0.075**	$266.69	$133,346.76
	Irrigation Labor	0.03	hr	$15.00	$0.45	$225.00
Machinery Labor						
	Tractors	3	hr	$12.00	$36.00	$18,000.00
Diesel Fuel						
	Tractors	16	gal	$3.00	$48.00	$272.06
Repairs & Maintenance						
	Irrigation Equipment	1	acre	$12.02	$12.02	$6,010.00
	Tractors	1	acre	$20.06	$20.06	$10,030.00
	Implements	1	acre	$1.73	$1.73	$865.00
Interest on Credit Line				6.5%	$3.46	$1,730.00
Total Variable Costs, Ex-irrigation					$599.49	$299,743.25
Planned Returns Above Variable Costs						
Breakeven price to cover variable costs				$105.77	ton	
Fixed Costs						
Machinery Depreciation						
	Irrigation Equipment	1	acre	$48.64	$48.64	$24,320.00
	Tractors	1	acre	$24.68	$24.68	$12,340.00
	Implements	1	acre	$3.87	$3.87	$1,935.00
Equipment Investment						
	Irrigation Equipment	$364.78	Dollars	6.50%	$23.71	$11,855.35
	Tractors	$182.60	Dollars	6.50%	$11.87	$5,934.50
	Implements	$30.54	Dollars	6.50%	$1.99	$992.55
Allocated Establishment Cost		1	acre	$41.84	$41.84	$20,920.00
Trans-Pecos Irrigated Land		1	acre	$40.00	$40.00	$20,000.00
Total Fixed Costs					$196.59	$98,297.40
Total Specified Costs					$796.08	$398,040.65
Returns Above Specified Costs					-$2.56	-$1,279.51
Breakeven Price to Cover Total Costs				$140.45 ton		

Source: TAMU Ag Extension, M.A. Sanderson et.al., "Switchgrass cultivars and germplasm for biomass feedstock production in Texas," Bioresource Technology 67 (1999) 209-219

Opium poppy cultivation

Crop Acres 500

Revenue	**Quantity**	**Units**	**$/Unit**	**Total**	**Enterprise Total**
Morphine	5.80	Pound	$1,125.23	$6,526.32	$3,263,157.89
Production Costs	**$/Acre**	**$/bbl**	**Est. Irrigation Water**		**Enterprise Total**
Seed	$4.05		22.28	ac-inches	
Sowing	$23.76		14,404	bbl/ac	
Fertilizer	$207.92				
Weeding +	$99.34				
Water	$5,689.59	**$0.40**			
Labor	$200.00				
Farm Services	$187.47				
Local Taxes	$101.21				
Total Costs	$6,513.33				
Net Income	$12.98				

Source: Mahdavi-Damghani et.al., Water stress effects on growth, development and yield of opium poppy (Papaver somniferum L.), Agricultural Wa Management, Volume 97, Issue 10, 2010, Pages 1582-1590, ISSN 0378-3774, https://doi.org/10.1016/j.agwat.2010.05.011; Katharine Sanderson, "Opiates for the Masses," Nature 449, 268-269 (2007), doi:10.1038/449268a; Rainer Gonzalez Palau, "The Decision to Plant Poppies: Irrigation, Profits & Alternatives Crops in Afghanistan," Civil-Military Fusion Centre, August 2012, https://reliefweb.int/sites/reliefweb.int/files/resources/Full_Report_4263.pdf; Chris Murray, "An Overview Of The Tasmanian Poppy Industry," GRI July 2014, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2014/07/an-overview-of-the-tasmanian-poppy-industry