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## **Looking Forward: Importing Institutional Concepts from the Water World**

By

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I am honored for the opportunity to address the inaugural *Permian Basin Water in Energy Conference*. As a former professor and believer in the potential of universities to play an important role in innovation and institutional change (witness Silicon Valley and Stanford University), I foresee a bright future for this conference and UT Permian Basin to become catalysts for addressing the exciting water challenges facing the Permian Basin. Before sharing my perspectives from “water world”, I believe it helpful to start with a more general perspective:

Business practices and strategies suitable for one era of circumstances, when disrupted by fundamental change, must adapt or fail.

What are the fundamental changes at work in the Permian? How may business practices in the Permian adapt to meet the challenges?

### **The Challenges**

According to the international research firm IHS Markit, water use by the O&G industry in the Permian has already risen six-fold since the start of the shale oil boom, from more than 5 billion gallons in 2011 to almost 30 billion gallons in 2016.<sup>1</sup> IHS Markit projects O&G industry water demand will double to 60 billion gallons in 2018 and more than triple by 2020 to almost 100 billion gallons.<sup>2</sup>

The rapidly increasing O&G Industry demand for water reflects technological advancement in fracking, where the horizontal reach of drilling has increased considerably in recent

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<sup>1</sup> See “Fracking-related water issues draw attention in West Texas,” David Hunn, Houston Chronicle, August 4, 2017.

<sup>2</sup> *Ibid.* IHS Markit is an international research firm conducting studies on various industries, including an energy research group that issues reports for the Permian Basin.

years, which in turn requires additional water for fracing wells. For wells with a lateral length of 4,100 feet, the amount of water used in fracing a well is about 200,000 barrels.<sup>3</sup> For wells with a lateral length of 10,000 feet, the amount of water used in fracing a well is about 500,000 barrels.<sup>4</sup> These levels of estimated water use are above the 100,000+ barrels per well reported in a 2013 article in the Texas Tribune.<sup>5</sup> Rigs with new fracing technology are using from two-thirds more to four-fold more the amount of water.<sup>6</sup>

The adoption of latest technology has increased drilling productivity. Before 2014, new-well production per rig averaged about 100 barrels per day.<sup>7</sup> Since then, new-well production per rig doubled to 200 barrels per day by 2015 and stands at 600 barrels per day by 2017 (the peak for new-well production per rig is 700 barrels per day during mid-2016).<sup>8</sup> This substantially increased productivity has juiced the market value of oil from new oil production per rig (see Table 1). Before increased productivity, the market value of daily new production equaled \$10,500 per day at the peak oil price of \$105/barrel. With increased productivity, the market value of daily new production is \$18,000 per day at the trough price of \$30/barrel, \$36,000 per day at the current price of \$60/barrel and \$63,000 per day at the peak oil price of \$105/barrel. That is, technological advances have increased the market value of new production per rig above the levels with pre-2014 technology at even the peak oil price of \$105/barrel!

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<sup>3</sup> Calculated from data reported in “How Much Water Does Apache Potentially Need to Develop Alpine High?”, Gabriel Collins, Texas Water Intelligence, Water Note #5, 19 June 2017. <https://texaswaterintelligence.com/2017/06/19/how-much-water-does-apache-potentially-need-to-develop-alpine-high/> Drilling 51 wells per year with an average lateral length of 4,100 feet requires 27,000 barrels per day of water.

<sup>4</sup> *Ibid.* Drilling 153 wells per year with an average lateral length of 10,000 feet requires 200,000 barrels per day of water.

<sup>5</sup> “Use of Brackish Water Rising in Drilling Regions, but Challenges Persist”, Mose Buchele, *Texas Tribune*, March 28, 2013, “Fracking a well requires roughly 4 to 6 million gallons of water, . . .” <https://www.texastribune.org/2013/03/28/brackish-water-fracking-rising-amid-challenges/>.

<sup>6</sup> Low end estimate compares water use for a 4,100-foot lateral relative to the estimated per well use in the 2013 Texas Tribune article. High end estimate compares water use for a 10,000-foot lateral to the estimated per well use in the 2013 Texas Tribune article.

<sup>7</sup> See “Permian Region Drilling Productivity Report,” *Energy Information Administration*, August 2017 for data on rig counts and new-well oil production per rig.

<sup>8</sup> *Ibid.*

**Table 1**  
**Market Value of New Oil Production Per Rig**

Pricing Scenario	WTI Price \$/Barrel	Daily New Production/Rig	
		100 BBL	600 BBL
Trough	\$30	\$3,000	\$18,000
Current	\$60	\$6,000	\$36,000
Peak	\$105	\$10,500	\$63,000

Unsurprisingly, expanding water demands by the O&G industry of this magnitude will stress, if not overwhelm, available groundwater resources. The Panelist Discussion in Session One of this conference discussed groundwater resources in the Permian with well yields around 100 gallons per minute (“gpm”). For a well yield of 100 gpm, a total of 59 well/days are needed to meet the water demands of a 200,000 barrel frac job (see Table 2). In other words, if water deliveries are to occur over a 5 day period, for example, one needs twelve 100 gpm wells for the frac job.<sup>9</sup> With spacing requirements of 1,000 feet between wells and boundary lines, the footprint of this well field is about 470 acres.<sup>10</sup> For frac jobs with larger water demands of 500,000 barrels and 700,000 barrels, respectively, one needs 30 to 40 wells with yields of 100 gpm. The footprint of these well fields are, respectively, about 1,000 acres and 1,300 acres.<sup>11</sup>

**Table 2**  
**Well/Days To Meet Water Demands of Frac Job by Frac Water Demands**

Well Yield (gallons/minute)	200,000 Barrels	500,000 Barrels	700,000 Barrels
100	59	146	205

Two observations. Investment in such a well field requires a series of frac operations to sustain investment, not an occasional one. Finding more productive groundwater resources with higher well yields would be economically attractive.

<sup>9</sup> With a 59 well/day requirement, 5 days of operations requires 12 wells.

<sup>10</sup> Assume a well field layout of three lines of four wells. Each line of four wells would have a span of 5,000 feet (1,000 feet for each end to a boundary and a total of 3,000 feet for outsets between the four wells). The three lines need a span of 4,000 feet (1,000 feet for each end to a boundary and a total of 2,000 feet for outsets between the three lines). This 4,000 foot by 5,000 foot rectangle is 20,000 square feet, or 74% of a square mile. With 640 acres in a square mile, 74% of a square mile equals about 470 acres.

<sup>11</sup> Calculations based on the method in prior footnote.

In water world, before rising demands overtake available water supplies, it is time to start adapting.

### **Adaptation in the Permian**

The water challenges facing the Permian Basin remind me of comparable challenges facing the water industry. To meet emerging water demands, one needs to rethink and expand the “tool box” of water resource management. Unless water resource management adapts, water demands of the O&G industry will be unmet and the anticipated expansion in the Permian Basin unrealized. Fortunately, the increased economic productivity of fracking provides the economic wherewithal for change. It is time to rethink water resources and infrastructure in the Permian.

*Rethinking Water Resources.* Words have different meanings to different “tribes.” I note use of the language of “freshwater” and “produced water” at the conference. In “water world”, freshwater water means water with a TDS content less than 1,000 milligrams per liter (see Table 3). Water world uses the term “brackish” for waters with greater salinity with adjectives slightly saline, moderately saline, very saline and brine. When communicating with “water world”, use their lingo.

**Table 3**  
**Water Quality Groundwater Classification**

<i>Water Classification</i>	<i>TDS Range (mg/L)</i>
Fresh	<1,000
Slightly Saline	1,000 to 3,000
Moderately Saline	3,000 to 10,000
Very Saline	10,000 to 35,000
Brine	>35,000

I stress semantics for a fundamental reason: fracking operations can thrive on brackish groundwater, the use of “freshwater” is unnecessary. The use of brackish groundwater by the O&G industry has Austin’s political winds at your back. The use of freshwater does not. Session Three of the Conference (“Law and Regulation”) discussed legislative initiatives seeking to empower the use of brackish groundwater while harmonizing with the regulatory objectives of groundwater conservation districts. The O&G industry should embrace this effort. The reward is

reducing potential conflicts over maintaining the use of freshwater for historical water users (agricultural, municipal and other industrial) and future growth of local communities.

Recall the panel discussion of general managers of groundwater conservation districts. They expressed a willingness to work through issues involving the use of brackish groundwater and recycled produced water by the O&G industry. I counsel cultivating these fields.

In water world, we employ “all of the above strategy” for meeting water demands: development of new supplies, adoption of technological advances, water conservation and more. The conference sessions on recycling of produced water resonates with this water warrior. As an economist, I see the issue as the “optimal mix” of brackish groundwater and recycled produced water. How this mix unfolds over time and across locations in the Permian Basin will be driven many factors (initiative, science, technology, economics, logistics and collaboration). Mercifully, I was not allotted sufficient time to elaborate.

Another trend in “water world” is that pressing demands results in legislation and regulation. When the actual use of water is substantially below available developable resources, conflicts are minor. Expansion of water use by others pose minor risks. As stress on resources intensify and competing water demands collide, conflicts emerge. Parties run to lawyers and legislators.

Texas’s history of groundwater regulation is no exception. The Texas Legislature passed the Edwards Aquifer Authority Act to regulate groundwater pumping in the Edwards Aquifer. The catalyst? Increased groundwater pumping jeopardized springflows that are habitat for species protected under the Endangered Species Act. Then Secretary of the Interior Bruce Babbitt offered Texas a choice: adopt its own rules to address the problem or face federal intervention.

Session Three of the Conference (“Law and Regulation”) provided an excellent overview of the development of groundwater conservation districts in Texas. The take-away is that regulation emerges in response to problems. My perception is that the days of significant groundwater resources remaining outside the scope of local regulation are numbered. Lacking a crystal ball, I offer no predictions about timing and location. However, I take notice that Reeves County has a newly-formed groundwater conservation district.

At the risk of arrest and institutionalization, I share an experience that illustrates the benefit of well-crafted regulation. In 2008, I was putting together a regional pipeline project in the Edwards Aquifer near San Antonio based on the long-term lease of groundwater permits owned by farmers. I had an internationally-known investment bank as the project financier for infrastructure investment in excess of \$300 million. The well-crafted and predictable rules of the Edwards Aquifer Authority provided a more secure framework for project financing than if the project were located outside any local groundwater authority. With limits placed on groundwater pumping, my project did not face the risk of uncontrolled increases in future pumping by others jeopardizing the yield of the project's well field. The project also had legally recognized rights to pump a quantified amount of groundwater.

Postscript: My project failed due to the inability to secure necessary state legislation. The proper venue for further discussion would be an advanced seminar in politics.

*Rethinking Infrastructure.* Water is an “essential input” for the O&G industry. Expansion in the Permian must ultimately demonstrate that water supplies are available in sufficient volumes and at reasonable costs to support capital investment. Session Four of the Conference (“Evolving Midstream Business) discussed how the infrastructure tab will be substantial. Gone are the days of shoe-string CAPEX budgets on water matters with quick payouts. Future arrangements require development of business models that support robust CAPEX programs with long term horizons.

I see two major themes from water world already emerging in the Permian: (1) the rise of pipelines and (2) the need for integrated water management across functionalities of the O&G industry.

There are two advantages of pipelines over trucking. The first is cost. The cost of trucking is \$2 per barrel, the cost of pipelines is pennies per barrel.<sup>12</sup> The second is social considerations. Relying on trucking to transport greater and greater volumes of water will increase congestion and further erode roads. Moving to pipelines takes trucks off the road, reduce congestion and prolong road life. This would be an example of creating a favorable political profile in local communities.

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<sup>12</sup> “The Wall of Water”, Paul Wiseman, PB Oil & Gas, February 2018, p. 14 [www.mazdigital.com/webreader/54282?page=14](http://www.mazdigital.com/webreader/54282?page=14).

As with most things in life, there is the good, the bad and the ugly. In water world, pipeline projects are based on long-term, reliable water supplies and long-term, firm contractual commitments of water users. With these water supplies and contractual commitments, one can finance long-lived infrastructure projects at low costs. If a project involves a diversity of water sources and buyers, then a pipeline network links multiple water sources with multiple buyers. Well field and pipeline design and operations are exercises in logistics and systems analysis.

“Water world” is different from “energy world”. The location of a municipal water user does not move around (we can always find Austin’s city limits). The location of fracing operations moves around. What institutional design can provide the foundation for reasonable infrastructure investment while accommodating the O&G industry’s needs for “flexibility” in both location and volume of water needs?

As with any long-term planning exercise, let’s start at the destination. The long-term “take-or-pay” contracts of “water world” must evolve into a form of a “requirements contract” for “energy world”, a form of area (not necessarily acreage) dedications. Under a requirements contract, one party would agree to supply as much water as required by the counterparty in designated areas up to a defined annual maximum. With multiple delivery points on a pipeline network, there is potential for these contracts to span a broader geographic designation than served by one supply source. The pipeline owner would meet its supply obligation from the portfolio of water supplies owned or controlled by the pipeline company. An annual reservation fee per barrel of maximum annual designated volume of 10 cents or less could meet the demands of project financing.

The development of water pipeline systems is part of the future of the Permian Basin. On September 2, 2017, Layne Christensen announced completion of a more than 20-mile, high-capacity water pipeline near Pecos, TX.<sup>13</sup> The system has an initial capacity to produce and deliver 100,000 barrels per day of non-potable water. The system has sufficient capacity to support expansion from including additional water sources and delivery points.

With the rapid increase in water demands, there is room for many water pipeline projects in the Permian Basin. Longer term, it may be reasonable to anticipate an interconnected network

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<sup>13</sup> See “Layne Christensen Completes High-Capacity Water Pipeline in Delaware Basin,” September 1, 2017.

of water pipelines throughout the Permian Basin akin to networks of oil and natural gas pipelines. If this proves to be the case, the launching of a water pipeline today would be a candidate for a “roll-up” of water pipelines by a major industry player or, alternatively, the entry vehicle for launching a roll-up strategy of other water pipelines in the Permian Basin. If such regional water pipeline networks come to pass, there will be the opportunity to generate trading markets for the use of water pipeline capacity and water supplies in the Permian as was created for interstate natural gas pipelines in the 1980s.

An integrated regional pipeline network can also expand use of recycled produced water. The mixing of brackish groundwater with recycled produced water does not appear to have any operational obstacles. Therefore, local distribution lines of recycled produced water projects can intertie back into the regional water pipeline network. Integrated management of brackish groundwater and recycled produced water can deliver water to meet the demands of O&G customers of the network.

### **Embrace Change**

As the Nobel Prize winner in literature, Bob Dylan, once wrote, “for the times they are a changing.” The Permian Basin is entering the next chapter of greatness. The anticipated expansion in economic opportunity is substantial. The rewards for success are considerable. Why apply 20<sup>th</sup> century approaches to 21<sup>st</sup> century opportunities? It does not make sense to me. Does it make sense to you?