In September 2018, the U.S. Energy Information Agency reported that the U.S. had likely surpassed Russia and Saudi Arabia to become the world’s largest producer of crude oil. The growth in U.S. oil production is almost singularly attributable to technological advancement in extraction known as hydraulic fracturing (fracking). Fracking’s explosive growth has since spawned a $4 billion industry for a vital input – frac sand. Typical of new markets, producers initially offered high-margin, differentiated products, such as Northern White frac sand from deposits in the upper Midwest and dominated supply. However, the market matured with stunning speed, and these differentiated producers were undercut by sand upstarts offering a logistically advantaged, more commoditized product. These in-basin producers capitalized on the changing economics of oil production to provide superior value to their customers and captured roughly two-thirds of market share in a matter of years. Observers of the frac sand market have witnessed a full market cycle in roughly a decade, as differentiated products became commoditized, prices whipsawed, and entire supply chains were upended. The paradigm shift in sand sourcing has created a world of uncertainty that is expected to persist.
America’s largest shale oil basin, the Permian in West Texas, contains long-known mega reserves – approximately 66 billion barrels of oil and 297 trillion cubic feet of natural gas – but the bulk of these hydrocarbon reserves were considered too costly to extract. Starting in the late 2000s and accelerating around 2012, however, technological advancements lowered the cost of tapping these reserves, and now wells are drilled horizontally for several miles through the oil- and gas-rich shale. At various stages along the horizontal well, a mixture of water, chemicals and proppant is injected under immense pressure to blast fissures into the shale rock. Frac sand is the overwhelming proppant of choice and plays the critical role of propping open the fissures in the rock and allowing oil to flow freely once the pressure pumps are stopped.

The quality and characteristics of proppant used downhole are critical to optimizing the flow of hydrocarbons, and production companies have experimented with various proppant types and volumes. Frac sand is measured by its uniformity, grain size and crush strength. It must be a high-silica (about 99% quartz) sand. Beach sand, for instance, will not do, as it is too contaminated with less durable minerals and will not meet measures of crush strength. Uniformity is desirable, as it allows the sand to pack into the shale fractures like a jar of marbles, maximizing the void space between grains and inducing oil and gas flow, and a high crush strength (up to 9,000 pounds per square inch [psi] for the highest quality deposits) is vital to sustaining well performance under extreme pressure. High-purity quartz sand from the St. Peter Sandstone deposit in the Midwest dates to the Ordovician Period, 444 million years ago. Sand from this region is known as Northern White sand (NWS) and is considered a premium product with exceptional purity, crush strength, uniformity and a diversity of grades.

Volumes of frac sand used in the fracking process have increased drastically. Producers are not only drilling more wells, but those wells have longer lateral lengths and use more sand per foot of well length than ever before. The Permian Basin in West Texas currently consumes 37% of all U.S. proppant demand and is expected to increase consumption to 50% by 2022. In 2018, the average well there was 8,000 lateral feet, up from 6,000 feet in 2015, and used 2,250 pounds per foot of proppant, up from 1,200 pounds per foot in 2015. That increase, from 7.2 million pounds per well in 2016 to 18 million pounds per well in 2018, combined with a rebound in the number of wells drilled in 2017 and 2018, has translated to remarkable frac sand demand growth nationally. Depending on oil prices, frac sand demand in 2019 is forecast to range between 110 million and 130 million tons. This compares with 79 million tons in 2017 and represents a compound annual growth rate of just under 17% since 2011. A large inventory of drilled but uncompleted (DUC) wells accumulated in 2018 as falling oil prices and limited takeaway capacity in the Permian slowed well completion activity. As prices rebounded in first quarter 2019, the large DUC well count and high-volume sand usage created a sustained source of demand for frac sand that many expect to continue.

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1 U.S. Geological Survey estimates a total of 66.3 billion barrels of oil and 297 trillion cubic feet of natural gas in the Permian Basin alone, according to separate surveys in 2018 and 2016, respectively.
2 Black Mountain Sand and Morningstar.
3 Black Mountain Sand.
4 Rystad Energy, U.S. Silica and Morningstar.
5 Rystad Energy.
As late as 2015, over 75% of frac sand demand was met by high-purity Northern White deposits in Minnesota, Wisconsin, Iowa and Illinois. Midwestern producers possessed economies of scale with captive consumers in far-off U.S. shale basins. Frac sand’s historically steep cost curve was then driven by a scarcity of economically viable, high-quality deposits and the sizable investments industry leaders had made in processing plants and logistics infrastructure. Heavy investments in rail logistics created deep competitive moats in an industry where just 20 miles of trucking from mine to transload can add 10% to costs. Unit trains consisting of 110 to 120 railcars and capable of carrying over 13,000 tons of sand were common conduits for moving sand over 1,000 miles to the Permian and other U.S. shale basins. Even before reaching the wellsite, the sand needed to be unloaded into storage silos at the in-basin transload facility before being trucked to its ultimate destination. In the Wolfcamp shale formation within the Permian, the average wellsite alone required 300 truckloads of sand (or 6,000 tons).

Despite the complicated logistics of transporting frac sand to distant shale basins, NWS miners were able to extract margins of approximately $20 to $25 per ton of sand sold on delivered prices of $90 per ton to the Permian in 2017. Consumers, however, had to tolerate congested railways, overrun transloading facilities and sand truck gridlock. Despite still supplying some 75% of the demand for frac sand in 2015, an astonishing reversal is underway, and it is now expected that NWS will supply less than 30% of the midcycle frac sand demand in 2022.

**In-Basin Frac Sand**

The decline of NWS began during the 2015-2016 oil price collapse that forced exploration and production (E&P) companies to cut costs and lower breakeven prices on their wells. Oil and gas investors, which had previously evaluated E&Ps on their ability to grow production volumes, began to reward companies with the lowest oil production costs and highest margins. When WTI prices bottomed at $26 per barrel in January 2016, E&Ps looked to unbundle the products provided by oil field service companies and found frac sand representing as much as 25% of total well input costs and 50% of well completion costs. Hi-Crush Partners, a Houston-based public frac sand mining company, saw an opportunity and in mid-2016 purchased 1,200 acres outside Odessa Texas – the heart of the Permian Basin – with notions of developing a logistically advantaged source of frac sand. Before long, capital was pouring into the Permian to develop low-cost frac sand mines.

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6 Morningstar.
7 Goldman Sachs.
8 Morningstar and Black Mountain Sand.
With freight costs alone accounting for more than two-thirds of delivered NWS prices, in-basin mines immediately leveraged their logistics advantages to displace NWS tonnage. Locally supplied sand can save as much as $500,000 per well – or 6% to 10% of total costs. This new regional sand production flattened the cost curve dramatically, as essentially any regional deposit is economically advantaged to Northern White. In-basin sand has since erupted, with 23 sand mines in the Permian, seven in Eagle Ford, seven in Haynesville, five in the MidCon and more capacity expected. Some projections of total sand nameplate capacity forecast 250 million tons in 2019, dwarfing initial demand estimates of 110 million to 130 million tons for the year.

Logistically, in-basin sand need only be trucked around 50 miles from mine to wellhead at a cost of $10 to $20 per ton, whereas the intermodal transport of NWS can be triple that figure. Some E&Ps reported using upward of 90% in-basin sand in the second quarter of 2018, up from a mere 40% in the first quarter. Brian Shinn, CEO of frac sand producer U.S. Silica, stated on a February 2018 investor call that he “believe[s] that by the end of 2019, two-thirds of the total U.S. sand proppant demand will be supplied by in-basin sand with one-third supplied by Northern White sand.” Rick Shearer, CEO of Emerge Energy Services, another frac sand miner, echoed, “We view the industry shifting towards a micro targeted strategy where 50 miles within a basin makes an important difference for purchasing decisions.”

### Public Sand Miners’ Stock Performance

![Chart showing public sand miners' stock performance](image)

**Source:** U.S. Energy Information Administration. Past performance does not guarantee future results.

10 Black Mountain Sand.
11 Energent.
12 Bloomberg.
13 Another E&P, Encana Corp., recently announced it used 90% Permian local sand in the second quarter of 2018, up from 40% in the first quarter.

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**Frac Sand Sources**

### Northern White Sand (NWS)

Premium sand mined in the Midwest (Wisconsin, Illinois and Missouri) and available across all grades. These sources have exceptional uniformity and crush strength (about 9,000 psi) but significant logistics challenges in accessing Southern basins.

### Brown Sand

Lesser-quality sand located closer to or within producing shale basins. Brown Sand is available in predominately fine grades with lower crush strength (sub-5,000 psi to 9,000 psi in some sources).

- **Regional Sand Brown Sand:** Sand sourced closer to shale oil production than NWS but still out-of-basin. Regional sand was the first to begin displacing NWS but is now under threat of substitution from in-basin sand.

- **In-Basin Brown Sand:** Sand sourced within shale oil-producing basins and often within 50 miles of the well head. In-basin sand offers the lowest delivered cost and comparable quality to NWS in fine grades like 100 mesh.
Both sand prices – and share prices – have responded. Industry groups estimate in-basin Permian sand prices fell to $35 per ton in August 2018 and are expected to fall to $26 per ton by 2022, barely above the lowest prices recorded during the 2016 market trough and half the $55 per ton seen in 2015. New mines are opening in other basins, such as Eagle Ford, Haynesville, SCOOP and STACK and DJ Basins. The Permian is even expected to be a self-sufficient producer of 100 mesh sand popular in the region within a few years.

**Last Mile Logistics**

With the price of sand decreasing, E&Ps have focused on enhancing last mile logistics. Consider that a 10,000-foot horizontal well in the Permian using 2,250 pounds per foot of proppant would require over 465 24-ton truckloads. Permian sand truck traffic jams and dangerous roads are now well documented, and once on-site, further wait times, known as wellsite detention, can cost $3 per ton per hour and turn a profitable operation into an unprofitable one quickly. The *Commodity Markets Update* has written about the already tight trucking market across the country, and it may be most acute in the Permian. Federal regulations requiring electronic logging devices enacted in 2017 have increased compliance with the 14-hour workday limit, while Occupational Safety and Health Administration rules for silica dust exposure have exacerbated trucking price inflation and led to delays. Operators have adapted by using containerized sand or on-site silos that reduce truck turnaround times and dust exposure.

> The potential commoditization of frac sand contributed to our original investment in the last mile.”

Vertical Integration

Today, the market for frac sand is characterized by long-term contracts between producers and E&Ps, with roughly 20% of demand filled in the spot market. U.S. Silica, for example, signed a 15-year supply contract with Pioneer Natural Resources in 2018, while other E&Ps have started sourcing their own supply. PLG Consulting estimates that one-quarter to one-third of frac sand demand is now sourced directly by E&Ps. Frac sand miners have been keen to accept longer-term contracts with production companies, touting their stability, but in a downturn, they may face customers more restless to renegotiate than their old oilfield service counterparties. After all, it was oilfield service firms marking up frac sand and passing cost increases to E&Ps that started the direct sourcing trend. Should direct sourcing continue to proliferate, another oil downturn will test contract flexibility and the ability of frac sand mines to maintain profitable utilization.

Conclusion

Looking ahead, frac sand producers will need to confront an excess supply of sand and evolving innovations in last mile logistics. These dynamics make consolidation among producers likely as they seek economies of scale to provide the lowest all-in cost of supply. In addition, if oil prices were to return to their highs of 2014, E&Ps may return to their old focus on extracting as much oil as possible rather than keeping costs low, boosting demand for NWS once again. In the meantime, expect cost deflation to continue and the logistics headache within the Permian to subsist. Hallmark qualities of resiliency and innovation that have defined the U.S. energy renaissance are not going anywhere, but frac sand economics will remain just as volatile as the hydrocarbons they extract.

References to specific securities are for illustrative purposes only and are not intended to be, and should not be interpreted as, recommendations.