



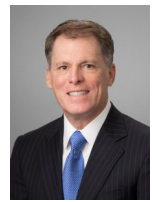
Weekly E&P Update

August 22, 2023

Vol. 33

Using Machine Learning to Improve Type Well Profile Accuracy

By Steve Hendrickson
President of Ralph E. Davis Associates



The current state-of-the-art in type well profile (TWP, aka "type curves") development for unconventional reservoirs involves identifying a set of analog wells in the area of interest (AOI), forecasting them using decline curve analysis, normalizing the forecasts for time and lateral length (and perhaps other parameters), and averaging the normalized data. Defining the analog set is critical and usually done by identifying wells in the same area and formation with similar completion and well spacing characteristics when using public data.

A problem with this approach is that the analog set may be small. This introduces uncertainty into the TWP estimate, which must be accounted for when assigning proved reserves: recall that proved reserves have a 90% exceedance confidence; that is, there is a 90% probability that they will be met or exceeded. Small analog sets have higher uncertainty than large ones, and their estimated ultimate recovery (EUR) distribution is sometimes wider. As a result, the proved value of a portfolio of future locations may need to be discounted significantly from the expected value to meet proved reserves requirements.

Machine learning (ML) techniques allow for a more extensive data set to be used, reducing the uncertainty of the TWP estimate and providing a narrower P10/P90 ratio. For example, using the Random Forest algorithm, I constructed an ML model using over 6,000 Marcellus wells with lateral lengths of at least 9,000 feet. This approach was much more accurate than traditional linear regression. The inputs to the model were lateral length, well spacing, proppant intensity, year of first production and latitude/longitude. The model was trained on 80% of the data and achieved an r-squared value of 0.95; the r-squared on the test data was 0.64

I applied the model to an example problem of predicting the proved EUR/ft of a ten-well program of 10,000-foot laterals drilled in Susquehanna County at four wells per section and completed with 2,000 of proppant per ft. There were only eight analog wells in the county (even allowing for a small range around the selection parameters), yet the ML approach allowed me to use information from all 6,000+ wells. Because of the more extensive data set and reduced P10/P90 ratio, a larger aggregation factor could be used: in this case, the proved reserves estimate was 22% greater than the analog approach.

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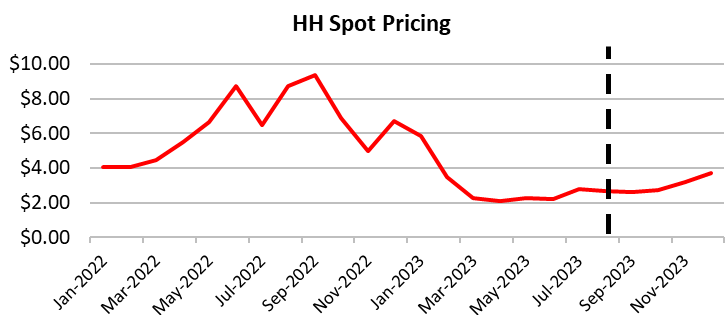
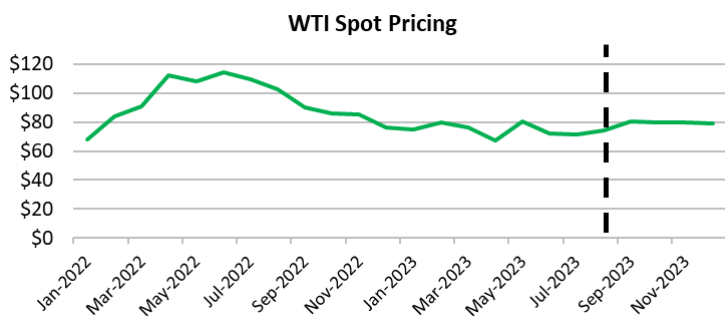
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Parameter	Analog Approach	ML Approach
Samples	8	6,233
EUR/ft, mcf	2,290	2,420
P10/P90 ratio	2.91	1.97
Planned program	10	10
Proved aggregation factor	0.77	0.89
Proved EUR/ft	1,763	2,153

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NYMEX FUTURE PRICING



MONDAY'S MARKET CLOSE

NYMEX WTI CRUDE OIL FUTURES as of August 21, 2023 Close (\$/bbl)

Period	Current	WoW Change	Last Week	1 Yr Ago
2023	\$80.00	(\$1.68)	\$81.67	\$85.13
2024	\$77.02	(\$0.80)	\$77.82	\$78.04
2025	\$72.94	(\$0.06)	\$73.00	\$72.56
2026	\$69.45	\$0.30	\$69.15	\$68.41
2027	\$66.36	\$0.45	\$65.91	\$65.31

NYMEX HH NATURAL GAS FUTURES as of August 21, 2023 Close (\$/MMBtu)

Period	Current	WoW Change	Last Week	1 Yr Ago
2023	\$3.07	(\$0.16)	\$3.23	\$6.39
2024	\$3.57	(\$0.05)	\$3.62	\$5.07
2025	\$4.01	(\$0.10)	\$4.01	\$4.76
2026	\$4.05	\$0.03	\$4.02	\$4.64
2027	\$3.98	\$0.06	\$3.92	\$4.59

INDUSTRY METRICS—QUICK SNAPSHOT

	Current	Last Week	WoW Change	%Change
Crude Oil Near-Month Price (\$/bbl)	\$81.43	\$83.09	(\$1.66)	(2%)
Natural Gas Near-Month Price (\$/MMBtu)	\$2.56	\$2.78	(\$0.22)	(8%)
Weekly Upstream-Deal Transaction Value (\$MM)	\$700.00	\$6.70	\$693.30	10,348%
Weekly Number of Upstream-Deal Transactions	2	3	(1)	(33%)
Current Total US Rig Count	642	654	(12)	(2%)
US Field Crude Oil Production (MMbbl/day)	12.7	12.6	0.1	0.8%
US Field Dry Natural Gas Production (Bcf/day)	108.0	108.1	(0.1)	(0.1%)
Commercial Crude Oil Stocks-Excluding SPR (MMbbl)	440	446	(6)	(1%)
Natural Gas Stocks-Working Gas Underground Storage (Bcf)	3,065	3,030	35	1%
Total Drilled But Uncompleted Wells (DUC-Last Month)	4,787	4,804	(17)	(0.4%)

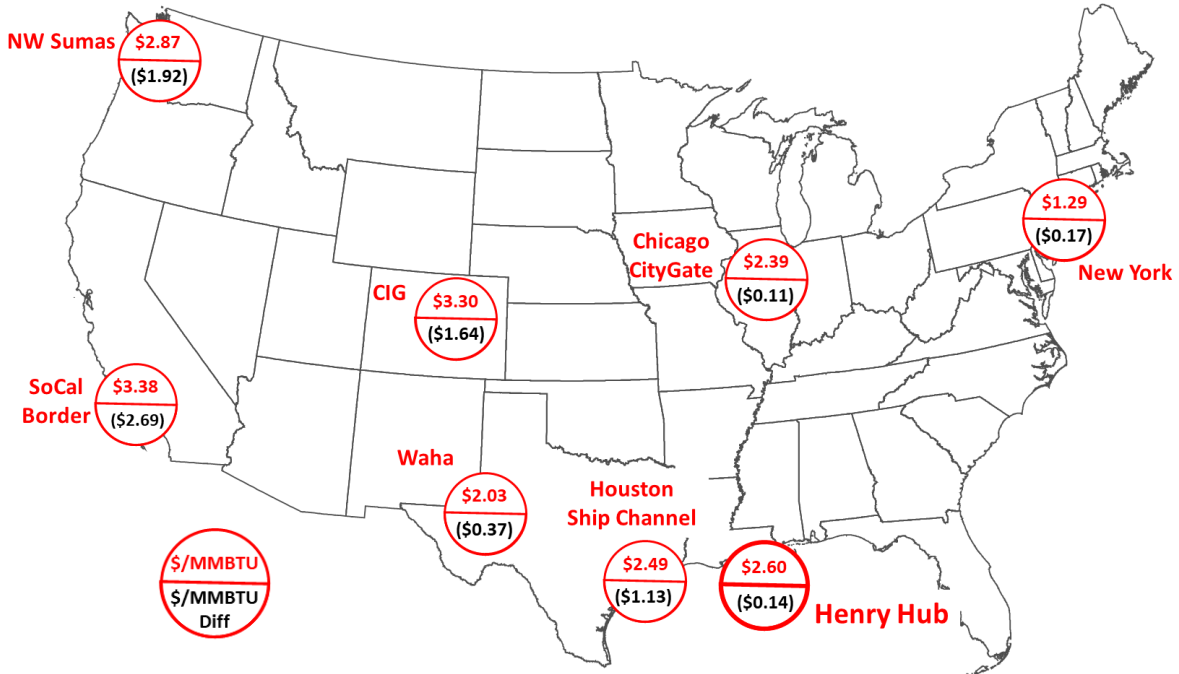
*Source—Energy Information Administration, United States (EIA)

*Source—Baker Hughes North America Rotary Rig Count & PLS M&A Database

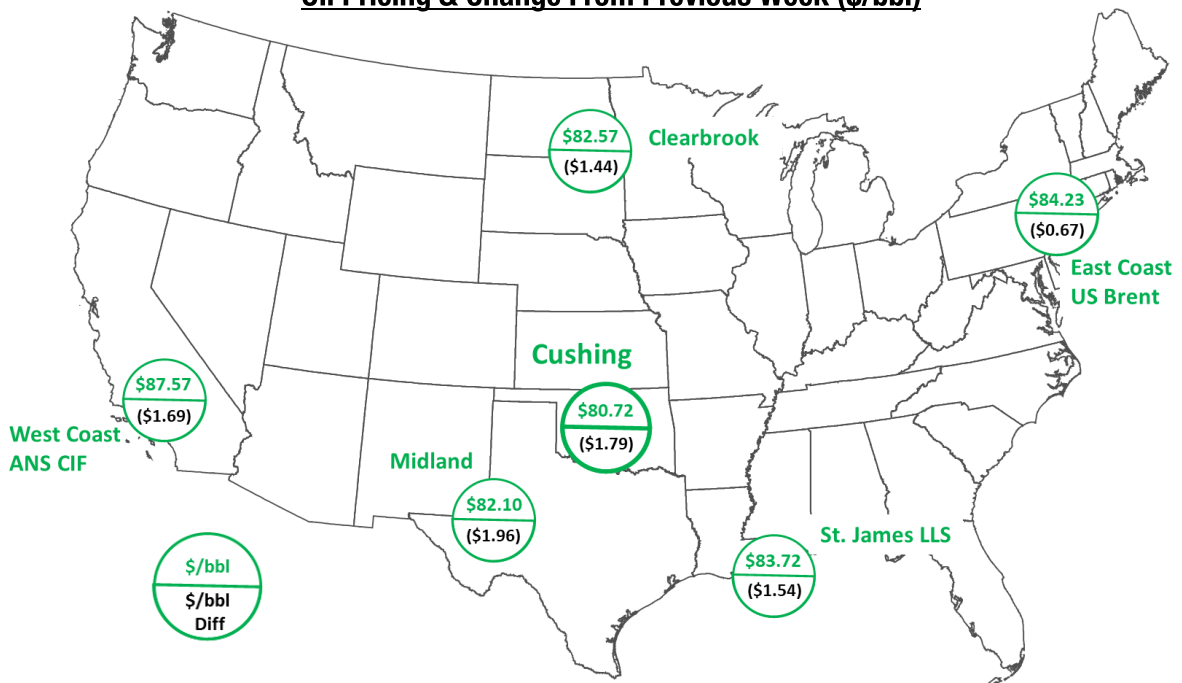


US COMMODITY PRICES CONTINUED

Natural Gas Pricing & Change From Previous Week (\$/MMBTu)



Oil Pricing & Change From Previous Week (\$/bbl)



*Source—Bloomberg LP



SELECTED INDUSTRY HEADLINES

Crude Battles Interest Rates, Demand Uncertainty

Crude oil fell into negative territory as it battled possible U.S. interest rate increases and uncertainty around future Chinese demand recently.

This Is When USA Oil Output Will Average Over 13MM Barrels Per Day

U.S. crude oil production will average more than 13 million barrels per day in the second quarter of next year and keep rising, according to the U.S. Energy Information Administration's (EIA) latest short term energy outlook (STEO), which was released recently.

Will China's Appetite For Saudi Oil Return?

China's crude oil imports from Saudi Arabia are unlikely to materially increase in the near term despite tanker-tracking evidence that arrivals rose in the first half of August, analysts say.

Oil Rises As Dollar Eases, China Seeks To Soothe Economic Woes (LOGIN CREDENTIALS REQUIRED)

Oil prices rose on Thursday after falling for three straight sessions, as the dollar weakened and China's central bank sought to bolster the property market and wider economy.

Texas Devotes \$4.3 Billion To Improve Transportation Infrastructure In Permian Basin

The Permian Strategic Partnership (PSP) applauds the Texas Department of Transportation's (TxDOT) approval of the Unified Transportation Program (UTP), which serves as TxDOT's infrastructure plan for the next decade.

Federal Court Rejects Rail Board's Approval For Crude Oil Trains Through Utah, Colorado

A plan to build an 85-mile stretch of new rail line in central Utah was derailed -- at least temporarily -- by federal judges' ruling recently. The court's decision means trains carrying crude oil will not be rolling through the I-70 corridor in Colorado.

USA Hurricane Center Tracking 5 Atlantic Disturbances

The U.S. National Hurricane Center (NHC) is tracking five disturbances in the Atlantic. One unnamed disturbance is in the Gulf of Mexico and has an 80 percent chance of cyclone formation in 48 hours, the NHC site outlined.

A Progressive's Case for Getting Rid of 'ESG'

It's fine to incorporate environmental, social and governance considerations into decision-making. But not if we're ignoring other important factors.

ESG's Long History: 1700s to Today

From Methodist John Wesley to the Vietnam War. The roots of ESG investing go back centuries.

North Sea Oil And Gas In Jeopardy As Financing Falters

The UK's oil and gas sector faces the growing prospect of a cash crunch, with the Treasury's latest attempts to lure lenders back to the North Sea recently likely to fall on deaf ears.

Ecuadorians Vote to Stop Oil Drilling in the Amazon Rainforest

This Sunday, Ecuadorians voted to end oil drilling in the Yasuni rainforest, one of the most biodiverse regions of the world.



SELECTED RECENT TRANSACTIONS

Chesapeake Energy Corporation Announces Sale Of Final Eagle Ford Package For \$700 Million

Chesapeake Energy Corporation recently announced that it has executed an agreement to sell its remaining Eagle Ford assets to SilverBow Resources, Inc. for \$700 million, bringing the total proceeds from its Eagle Ford exit to more than \$3.5 billion.

Empire Petroleum Announces Acquisition Of Additional Interests In New Mexico Units

Empire Petroleum recently announced that it closed on the acquisition of COERT Holdings 1 LLC's interests in Empire's three New Mexico assets, Eunice Monument South Unit A, Eunice Monument South Unit B, and Arrowhead Grayburg Unit, all of which are located in Lea County. The purchase price for the Transaction was approximately \$6.7 million.

ExxonMobil Announces Acquisition Of Denbury

Exxon Mobil Corporation (NYSE: XOM) today announced it has entered into a definitive agreement to acquire Denbury Inc., an experienced developer of carbon capture, utilization and storage (CCS) solutions and enhanced oil recovery. The acquisition is an all-stock transaction valued at \$4.9 billion, or \$89.45 per share based on ExxonMobil's closing price recently.

Sandridge Energy, Inc. Announces The Closing Of An Acquisition Which Increases Its Interest In Wells It Operates In The Northwest Stack

SandRidge Energy, Inc. today announced the closing of an acquisition which increases its interest in twenty-six producing wells operated by the Company within the Northwest Stack play for approximately \$11.25 million.

Ring Energy Announces Accretive All Cash Asset Acquisition Strategically Expanding Core Operating Area

Ring Energy, Inc. today announced it has entered into an agreement to acquire the Central Basin Platform assets of Founders Oil & Gas IV, LLC for \$75 million in cash. Founders' CBP operations are located in the Permian Basin in Ector County, Texas and are focused on the development of approximately 3,600 net acres that are similar to Ring's CBP assets acquired in 2022 from Stronghold Energy Operating II, LLC and its affiliate.

Zenith Energy Expands Its US Presence With Stateside Energy LLC Deal

Zenith Energy Ltd. the international energy production company with assets in Africa and Europe, has announced that it has entered into an agreement with Stateside Energy LLC, an Oklahoma-based oil and gas operator, to acquire and operate a portfolio of oil production and development licences in Oklahoma, as well as certain other states in the USA.

Civitas Resources to Enter Permian Basin through Transformative Transactions

Civitas has also agreed to purchase Hibernia's Midland Basin assets for \$2.25 billion in cash, subject to customary purchase price adjustments.

SM Energy Company Announces Certain Second Quarter 2023 Activity And Acquired 6,300 Net Acres In The Midland Basin

The Company's Midland Basin assets are located in the Permian Basin in West Texas is comprised of approximately 80,000 net acres.

Riverbend Energy Group Announces Acquisition to Mark the Rebuilding of Its Non-Operated Energy Strategy

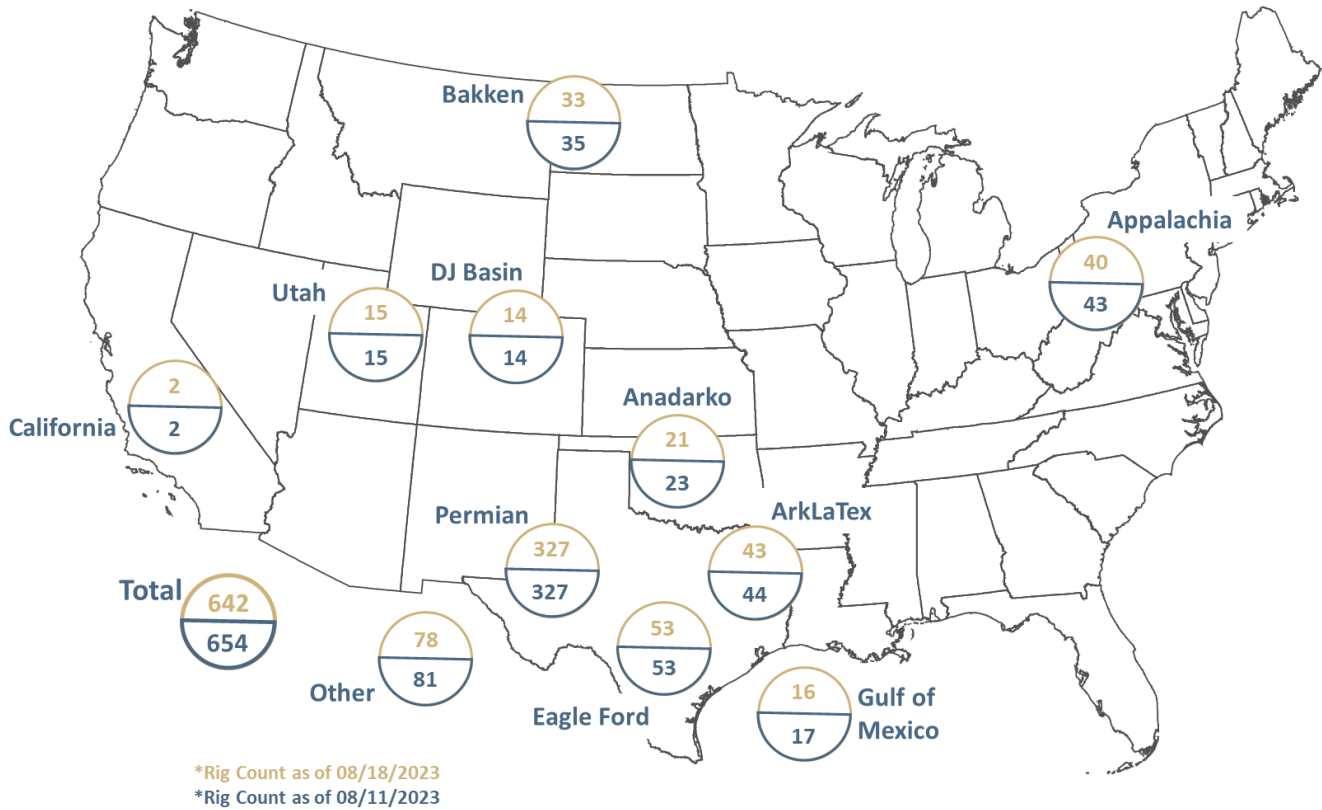
Riverbend Energy Group, via certain of its affiliates, announced today the acquisition of a sizeable non-operated working interest position in the core of the Williston Basin.

Earthstone Energy Announces \$1.0 Billion Delaware Basin Acquisition

Earthstone Energy, Inc. recently announced that it has entered into an agreement to acquire Novo Oil & Gas Holdings, LLC, a privately-held Delaware Basin focused E&P company backed by EnCap Investments L.P., for \$1.5 billion.



RIG ACTIVITY BY US REGION

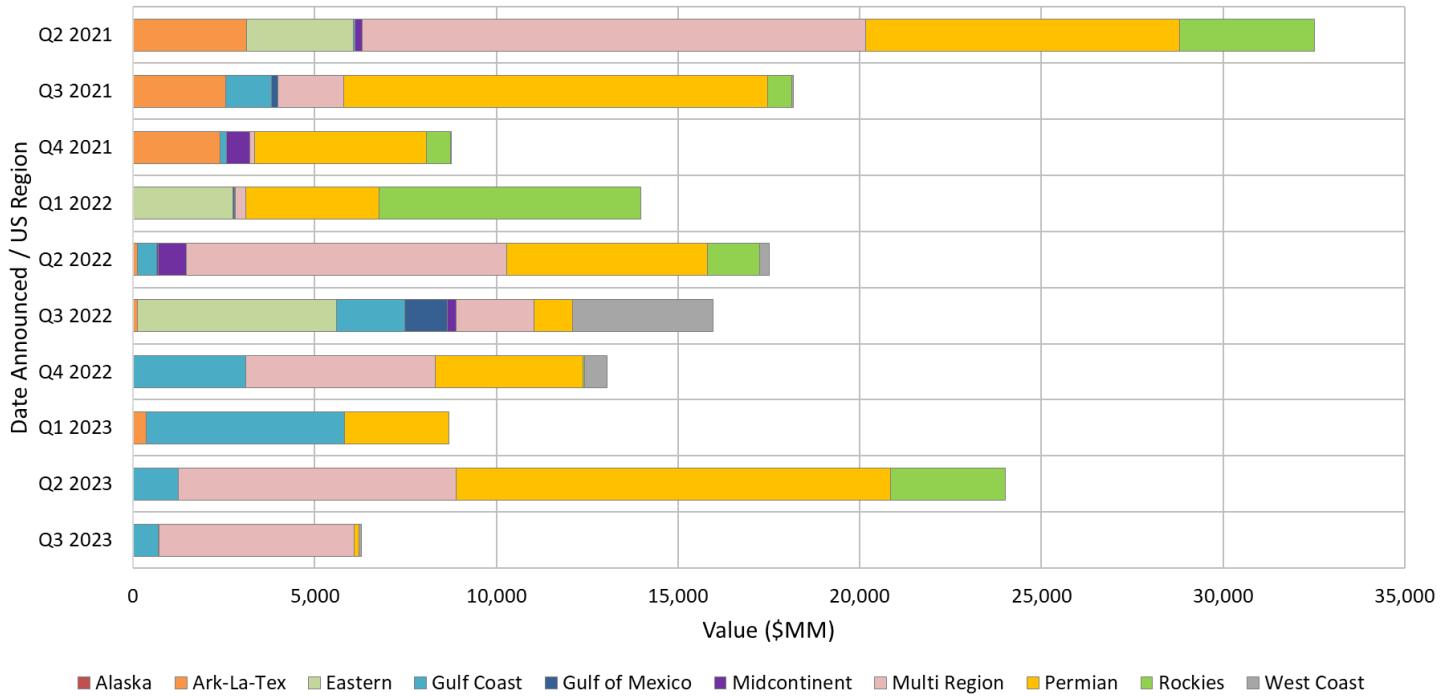


	Week Ending 08/18/2023		Week Ending 08/11/2023		Week Ending 08/19/2022
U.S. Rig Breakouts	Count	+/-	Count	+/-	Count
Oil	520	(5)	525	(81)	601
Gas	117	(6)	123	(42)	159
Not Specified	5	(1)	6	3	2
Directional	52	(1)	53	13	39
Horizontal	572	(7)	579	(122)	694
Vertical	18	(4)	22	(11)	29
Land (Inc Others)	621	(11)	632	(120)	741
Inland Waters	4	0	4	1	3
Offshore	17	(1)	18	(1)	18
US Total	642	(12)	654	(120)	762

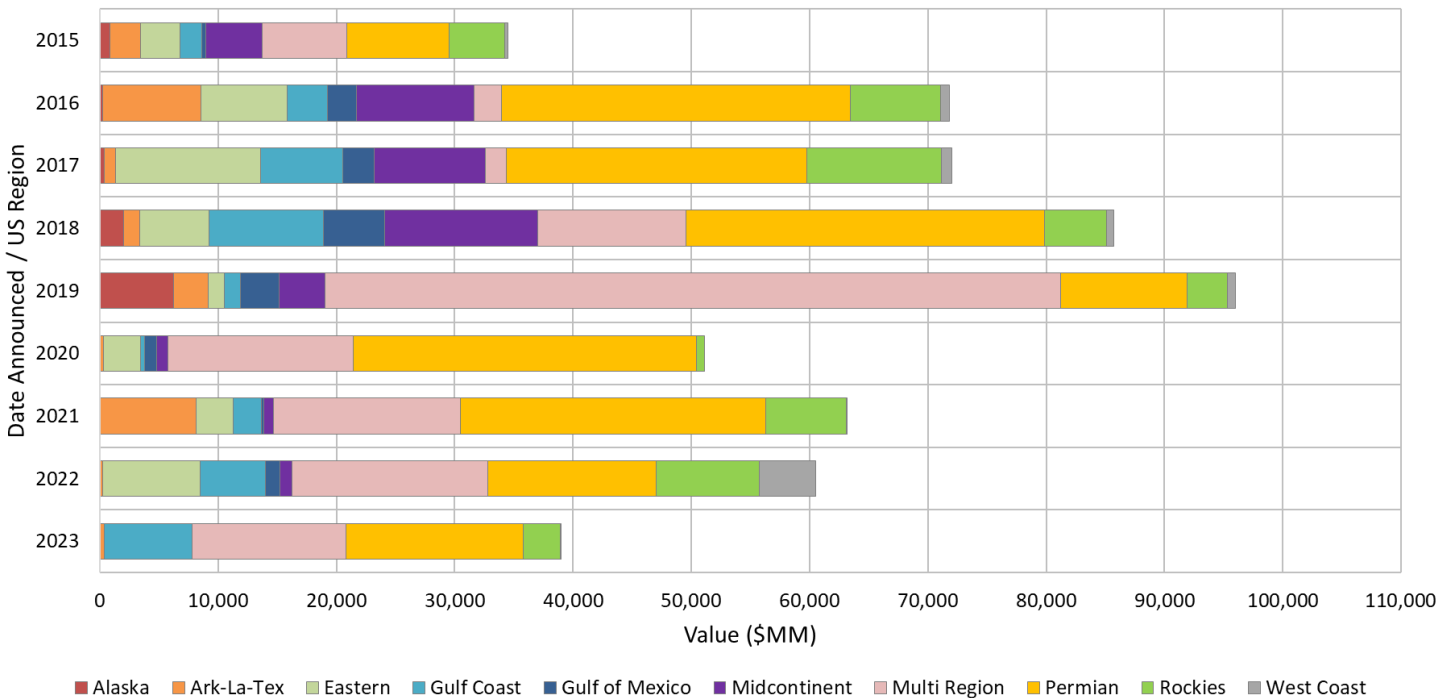
*Source—Baker Hughes Weekly Rig Counts



DEAL VALUE BY US REGION (BY QUARTER)



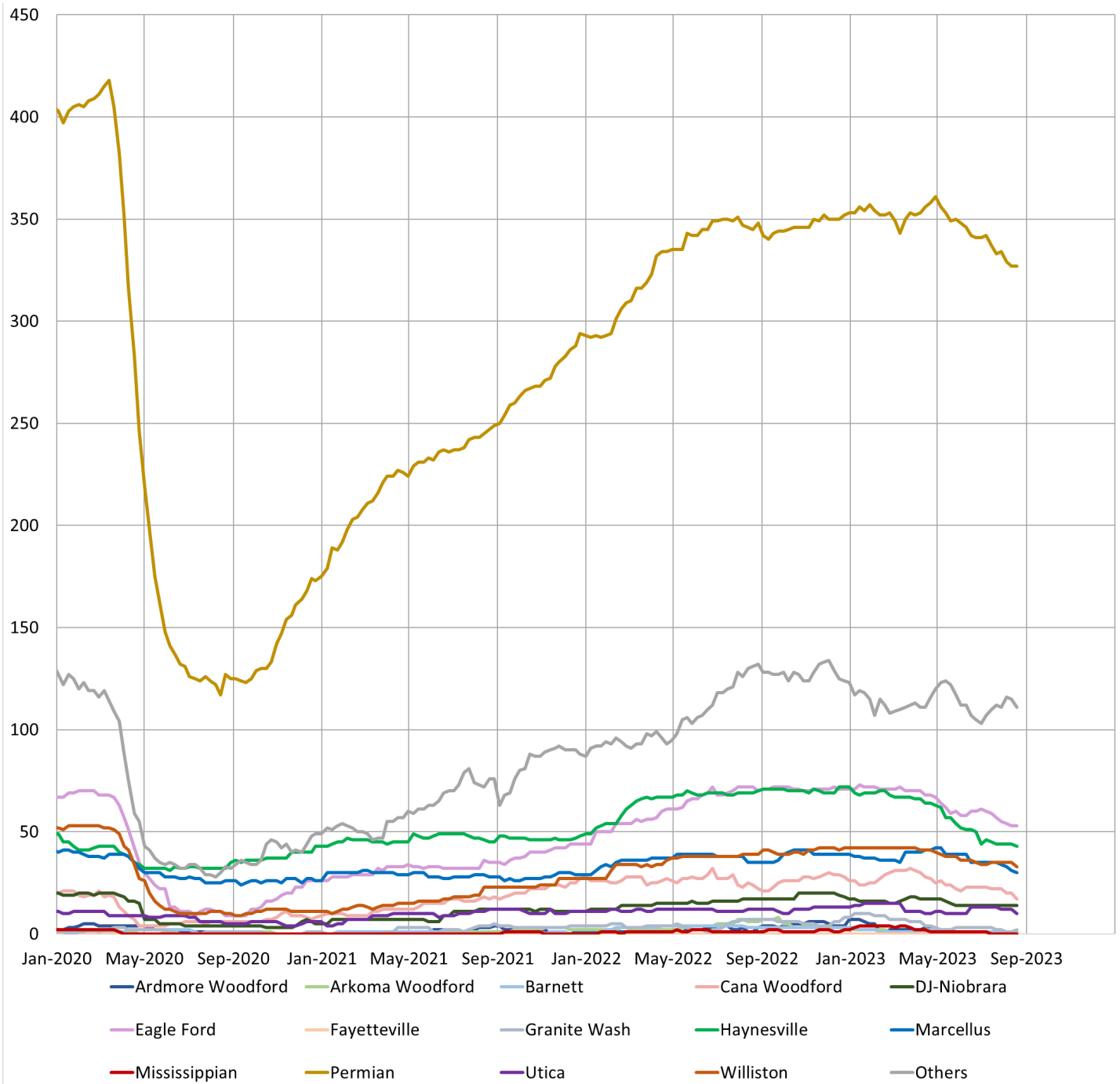
DEAL VALUE BY US REGION (BY YEAR)



*Source—PLS M&A Database (Charts exclude terminated deals)



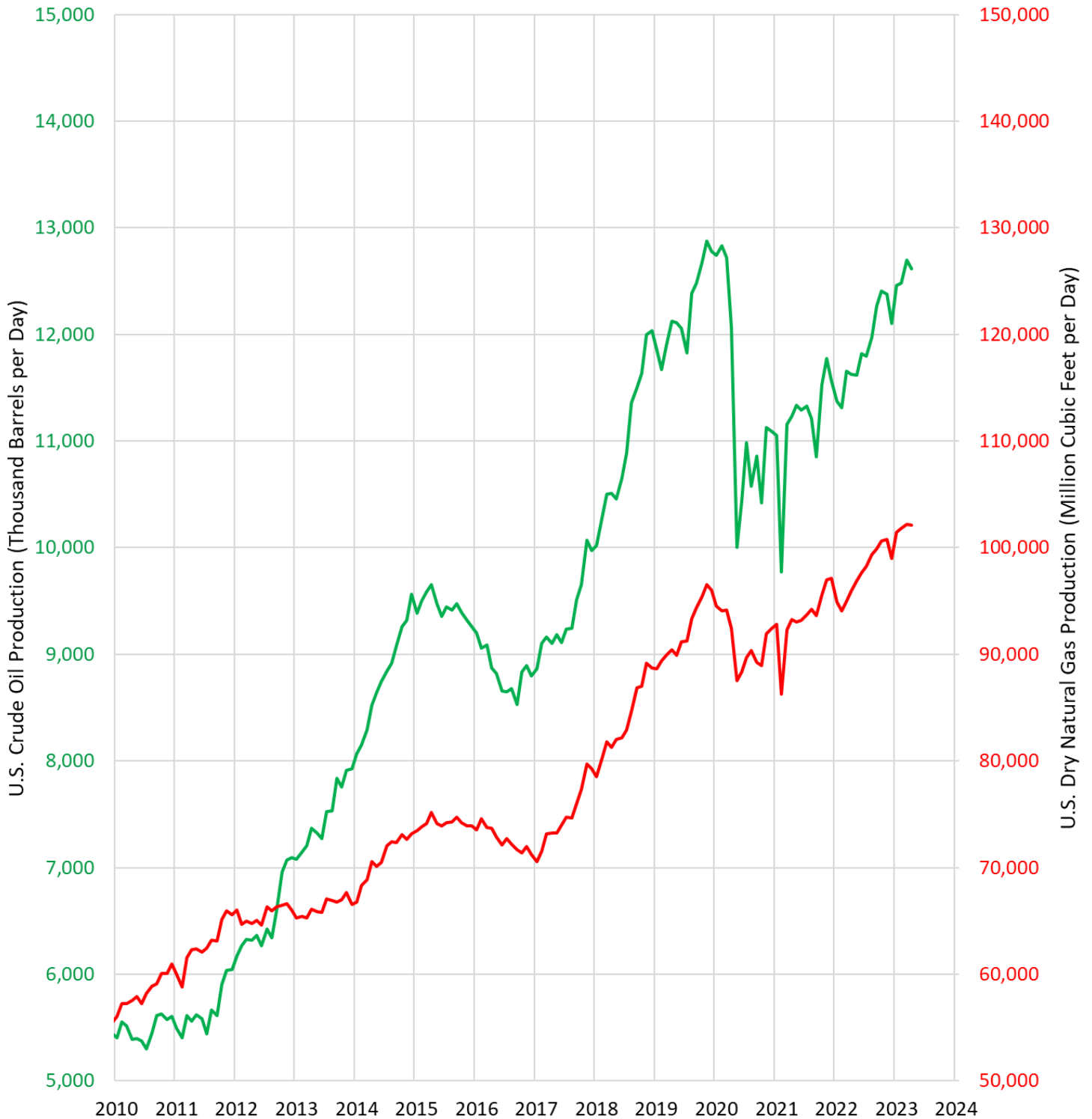
RIG ACTIVITY BY US REGION



*Source—Baker Hughes Weekly Rig Counts



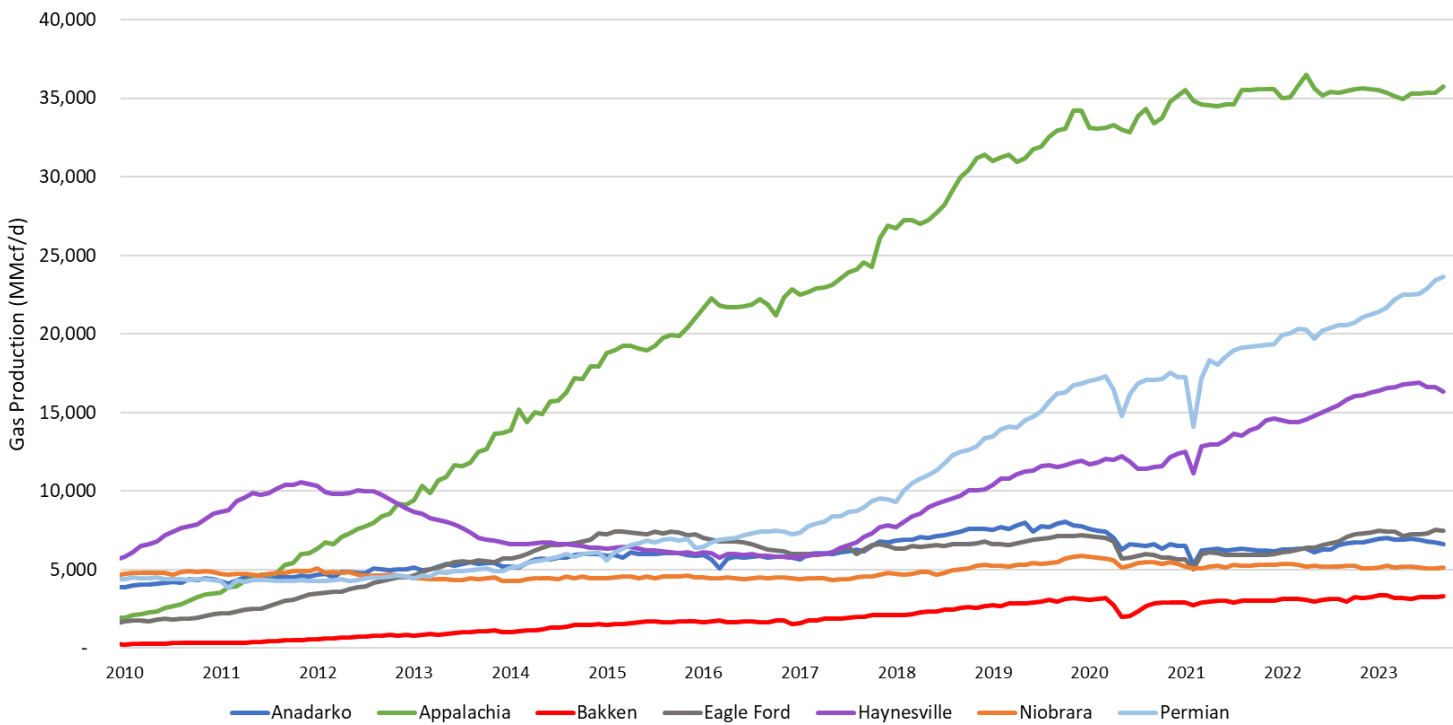
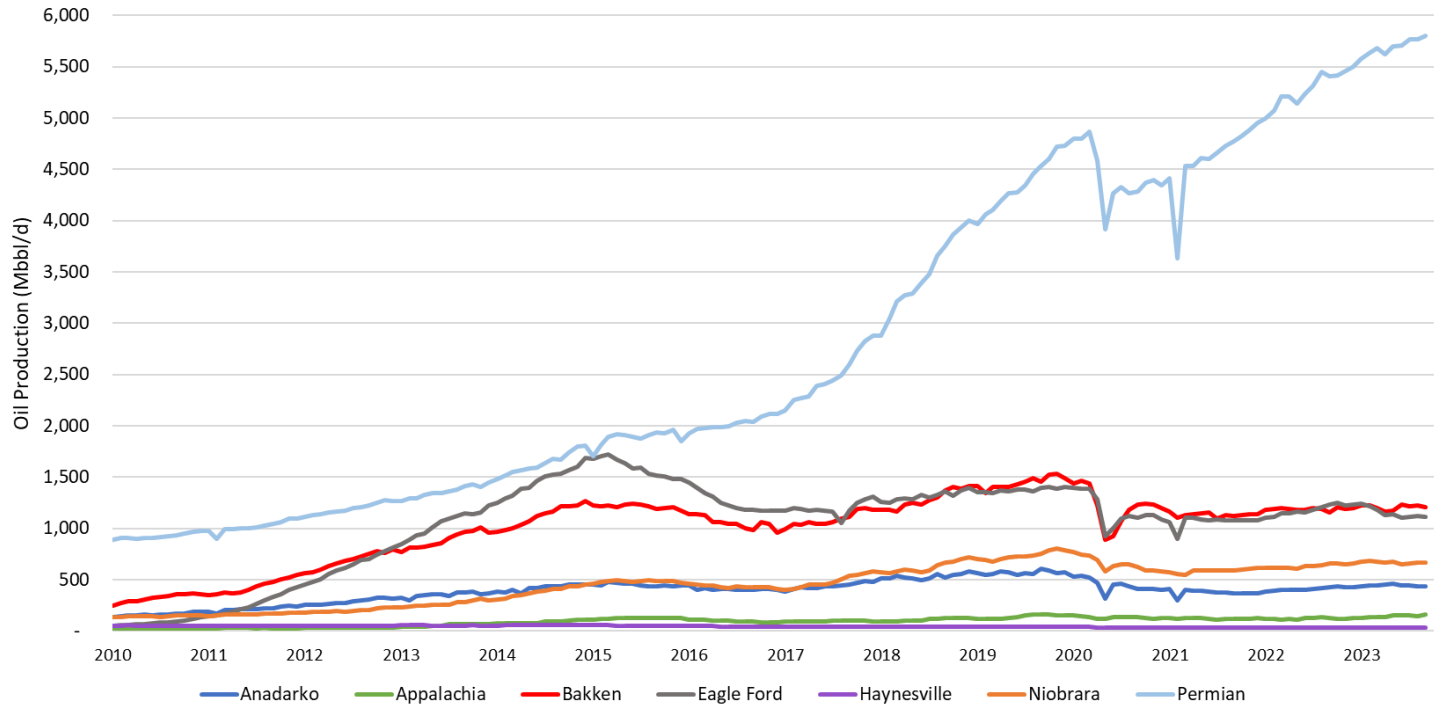
US DAILY CRUDE (MMbbl) & DRY NATURAL GAS PRODUCTION (MMcf)



*Source—Energy Information Administration, United States (EIA)



HISTORICAL PRODUCTION OF SELECTED US SHALE REGIONS



*Source—Energy Information Administration, United States (EIA)



UPCOMING EVENTS

August 2023

<u>TXCPA Energy Conference</u>	August 25	Houston, TX
<u>Society of Petroleum Engineers (SPE) - Saint Arnold's Season Kick-Off Social</u>	August 30	Houston, TX

September 2023

<u>Enertia User Conference</u>	September 21-22	Fort Lauderdale, FL
<u>HPF 29th Annual Golf Tournament</u>	September 25	Cypress, TX
<u>World Oilman's Overnight Poker Tournament (WOOP)</u>	September 28-29	Lake Charles, LA

October 2023

<u>Hart Energy—Energy Capital Conference</u>	October 2	Dallas, TX
<u>Hart Energy—A&D Strategies and Opportunities Conference</u>	October 3	Dallas, TX
<u>2023 National Conference of Bankruptcy Judges (NCBJ)</u>	October 11-14	Austin, TX
<u>Tulsa Octoberfest</u>	October 19-22	Tulsa, OK

*Denotes an Opportune Sponsored Event



ABOUT RALPH E. DAVIS ASSOCIATES

Ralph E. Davis Associates LLC (RED) is an industry-leading petroleum engineering and geosciences firm committed to satisfying the individual needs of clients. We accomplish this by holding ourselves to the highest standards of integrity and professionalism to deliver honest, direct and actionable insights to help clients achieve their strategic objectives. We distinguish ourselves by combining reservoir engineering, geoscience evaluation techniques and advanced data analytics with economic analyses to provide our clients with individual, customized solutions.

Banks, bondholders, private equity firms, financial institutions and law firms around the world trust in RED's diverse services and unrivaled upstream oil and gas expertise to deliver comprehensive solutions that help clients make informed decisions. We add value to every engagement by employing a team approach, leveraging Opportune LLP's experienced bench of experts in transactional due diligence, tax advisory, investment banking, restructuring and valuation.

We offer technical and economic analyses to deliver our clients a complete, independent, accurate and detailed assessment of the value of their assets. We apply a robust set of technical capabilities to assist our clients. Our capabilities include:

- Reservoir engineering and geosciences
- Economic forecasting and reporting
- Data analytics and geospatial analysis

KEY CONTACTS



Steve Hendrickson is the President of Ralph E. Davis Associates, an Opportune LLP company. Steve has over 35 years of professional leadership experience in the energy industry with a proven track record of adding value through acquisitions, development and operations. Steve is a licensed professional engineer in the state of Texas, and holds an M.S. in Finance from the University of Houston and a B.S. in Chemical Engineering from The University of Texas at Austin. He recently served as a board member of the Society of Petroleum Evaluation Engineers (SPEE) and is a registered FINRA representative.



John Beaird is Vice President of Ralph E. Davis Associates, an Opportune LLP company. John has 39 years of oil and gas management, reservoir engineering, and petroleum economics evaluation experience. Recent relevant experience includes the Permian, Western Gulf, Tx-La-Miss Salt, Mid-Continent, Denver-Julesburg, Wind River, Williston Basin, and Appalachian Basins. John is a registered Petroleum Engineer in the State of Texas and holds a B.S. in Petroleum Engineering from Louisiana Tech University. He is also an active member of the Society of Petroleum Evaluation Engineers (SPEE).



Yvonne Trujillo is a Senior Petroleum Engineer at Ralph E. Davis Associates, an Opportune LLP company. Yvonne has over 25 years experience in the oil and gas industry with extensive expertise in reserves engineering, SEC and PRMS/SPE reporting and economics and asset evaluation in conventional and unconventional reservoirs in the U.S. Lower 48. Yvonne earned a B.S. in Mechanical Engineering at Simon Bolivar University in Caracas, Venezuela and an M.S. in Petroleum Engineering at the University of Houston.



David Edwards is a Petroleum Engineer at Ralph E. Davis Associates, an Opportune LLP company. David has over three years of reserves engineering experience in conventional and unconventional reservoirs. Before RED, David was a Petroleum Engineer at a lower middle market A&D advisory firm where he handled the technical processes for marketed assets. He began his career with an operator in Dallas, where he contributed to its engineering, operations, and A&D teams. David holds an M.B.A. from The University of Texas Permian Basin and a B.S. in Petroleum Engineering from The University of Oklahoma.

