



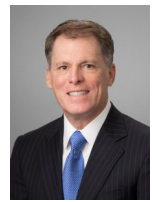
Weekly E&P Update

September 19, 2023

Vol. 37

The End of Type Curve Areas? (Part 2)

By Steve Hendrickson
President of Ralph E. Davis Associates



Last week, I discussed how machine learning (ML) algorithms could allow us to develop models that generate estimates of well performance over large areas and eliminate the use of "type curve areas" (TCA). Recall that TCA's are somewhat arbitrary regions defined by an evaluator with the goal of defining a set of analog wells that have similar geologic and reservoir characteristics. The ML models can also incorporate other parameters that influence well performance, such as lateral length, proppant intensity, depth, and parent/child relationships. Other parameters like reservoir porosity and completion details (cluster spacing, for instance) could also be included if non-public data is available.

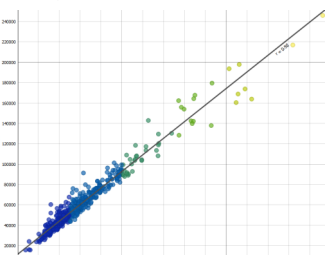
To illustrate the technique, I processed approximately 800 horizontal wells in the Middle Bakken in Dunn County, North Dakota in our in-house type well profile platform. In addition to forecasting the wells to determine their EUR/foot of lateral, it assigns classifications for parent/child relationship and how they were bounded and automatically determines their nominal well spacing.

We passed the forecasting results through two machine learning algorithms: Random Forest and Adaboost. Each was quickly tuned to determine the parameters that minimized the error on the training sets while avoiding overfitting. I noted that each model had some weaknesses when comparing the model data to the test data, so I stacked the results to create the final model. The machine learning aspects were performed in Orange ML, an open-source platform, and took about 30 minutes.

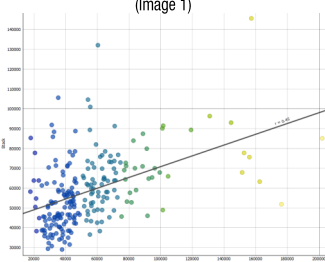
The input parameters included the year drilled, lateral length, TVD, midpoint latitude/longitude of the well path, proppant intensity, fluid intensity, and the parent/child categories. The graph below shows the predicted versus actual EUR in barrels per 1000' of lateral for the training data (Image 1).

And here is the same presentation for the test data (Image 2).

Note that there is a wide spread between the predicted and actual values. Just eyeballing the data suggests that the P10/P90 ratio is close to 2, but this is less than we typically see. For example, if we had used a single type curve for this area, the P10/P90 ratio would have been about 3.25, indicating more significant uncertainty in the estimate. The ML approach allows for more granular predictions of per foot recovery without splitting the region into smaller TCA's, which would take longer and have lower reliability.



CLICK TO ENLARGE
(Image 1)



CLICK TO ENLARGE
(Image 2)

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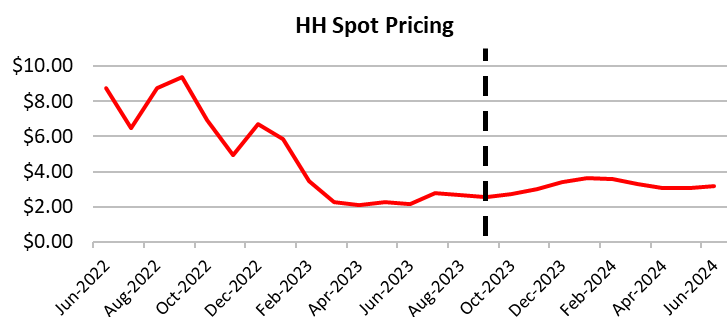
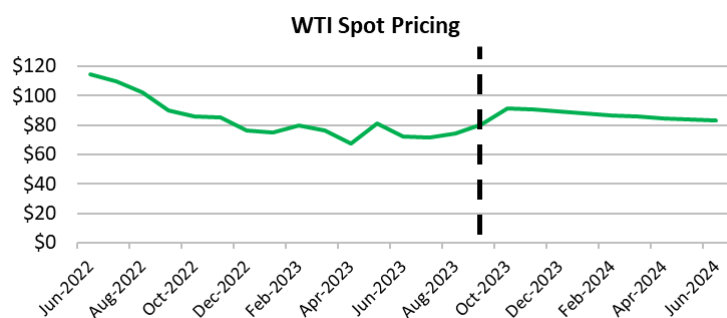
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NYMEX FUTURE PRICING



MONDAY'S MARKET CLOSE

NYMEX WTI CRUDE OIL FUTURES as of September 18, 2023 Close (\$/bbl)

Period	Current	WoW Change	Last Week	1 Yr Ago
2023	\$90.44	\$3.81	\$86.63	\$78.79
2024	\$83.10	\$1.66	\$81.44	\$72.36
2025	\$76.18	\$0.75	\$75.43	\$68.14
2026	\$71.43	\$0.37	\$71.06	\$64.95
2027	\$67.78	\$0.19	\$67.59	\$62.33

NYMEX HH NATURAL GAS FUTURES as of September 18, 2023 Close (\$/MMBtu)

Period	Current	WoW Change	Last Week	1 Yr Ago
2023	\$3.04	\$0.06	\$2.98	\$6.08
2024	\$3.42	\$0.01	\$3.41	\$5.16
2025	\$3.94	\$0.02	\$3.92	\$4.92
2026	\$3.98	\$0.06	\$3.92	\$4.82
2027	\$3.93	\$0.08	\$3.85	\$4.82

INDUSTRY METRICS—QUICK SNAPSHOT

	Current	Last Week	WoW Change	%Change
Crude Oil Near-Month Price (\$/bbl)	\$90.67	\$87.40	\$3.27	4%
Natural Gas Near-Month Price (\$/MMBtu)	\$2.70	\$2.61	\$0.09	4%
Weekly Upstream-Deal Transaction Value (\$MM)	\$1,165.00	\$1,564.70	(\$399.70)	(26%)
Weekly Number of Upstream-Deal Transactions	3	4	(1)	(25%)
Current Total US Rig Count	641	632	9	1.4%
US Field Crude Oil Production (MMbbl/day)	12.9	12.8	0.1	0.8
US Field Dry Natural Gas Production (Bcf/day)	107.3	107.9	(0.6)	(0.6%)
Commercial Crude Oil Stocks-Excluding SPR (MMbbl)	421	417	4	0.9%
Natural Gas Stocks-Working Gas Underground Storage (Bcf)	3,205	3,148	57	2%
Total Drilled But Uncompleted Wells (DUC-Last Month)	4,787	4,787	0	-

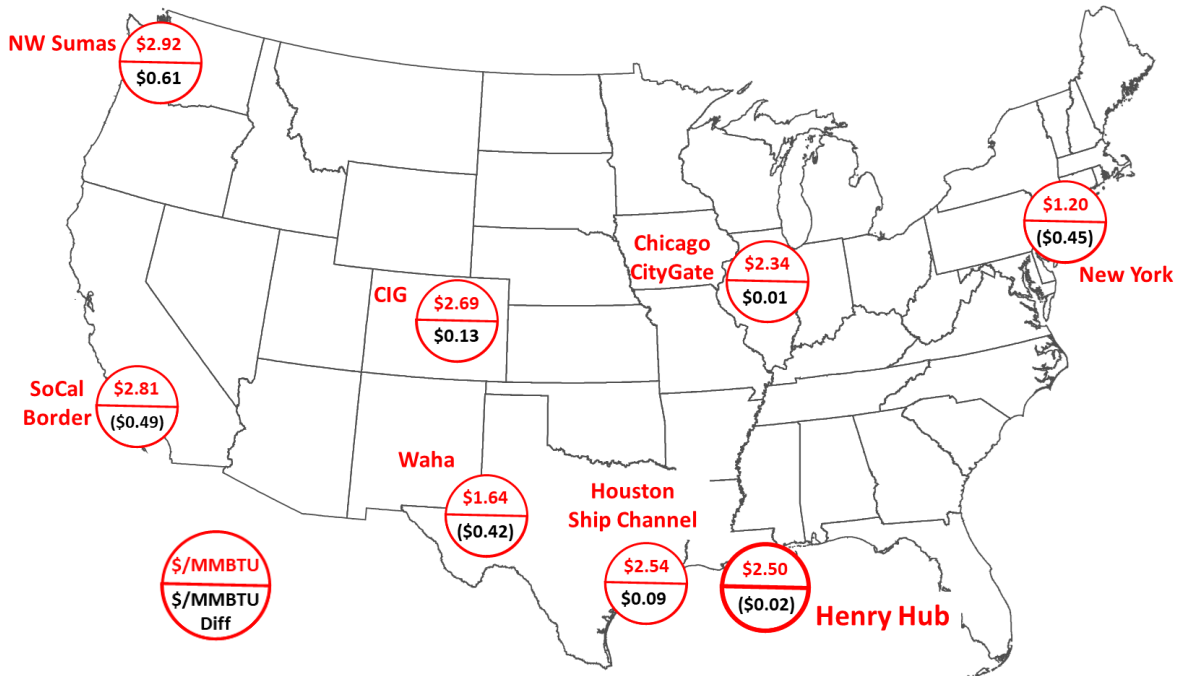
*Source—Energy Information Administration, United States (EIA)

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

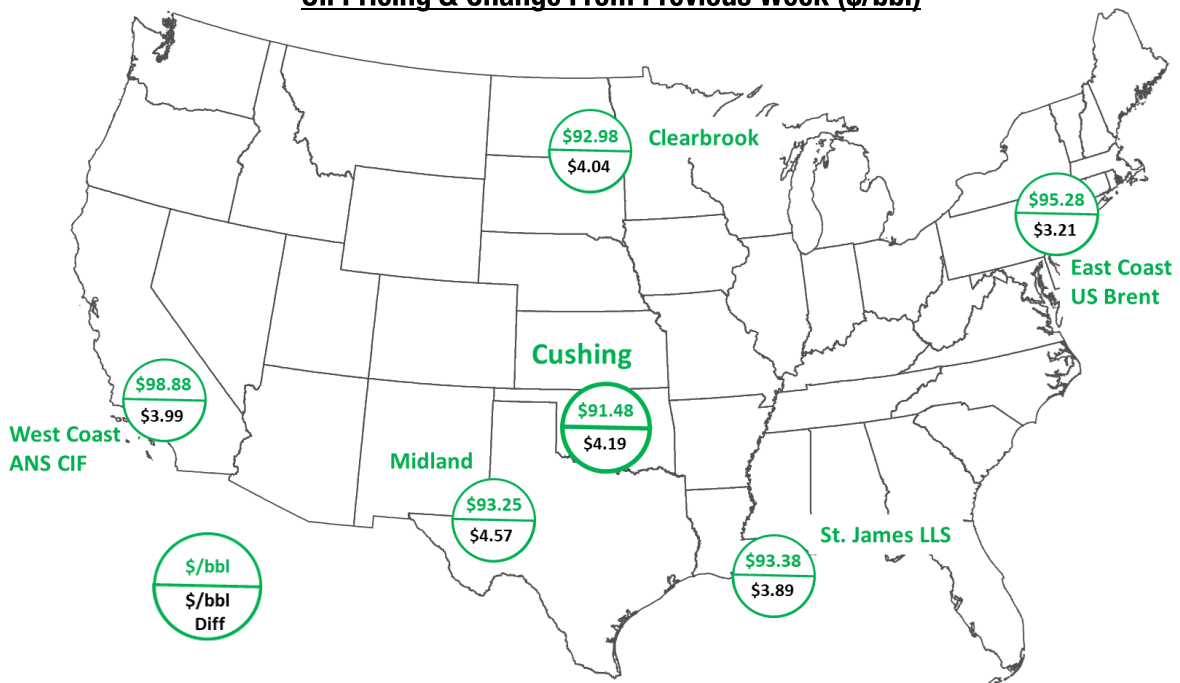


US COMMODITY PRICES CONTINUED

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



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



*Source—Bloomberg LP



SELECTED INDUSTRY HEADLINES

Oil Industry Not Spending Enough To Balance Supply & Demand

After years of warnings of failure to invest in enough new exploration, the industry has begun spending more. Yet, it would still be less than is necessary to secure enough supply to respond to demand.

Oil Extends Rally as Physical Market Flashes Signs of Tightness

The gains in recent sessions have been accompanied by a jump in key timespreads that suggest the market is undersupplied, while bullish call options are also getting more expensive.

US Oil Output From Top Shale Areas To Fall For 3rd Straight Month In October, EIA Says

U.S. oil output from top shale-producing regions is on track to fall for a third month in a row in October to the lowest level since May 2023, the U.S. Energy Information Administration (EIA) said in its monthly drilling productivity report recently.

North America Breaks Rig Loss Streak

North America has broken a string of consecutive weekly rig losses, according to Baker Hughes' latest rotary rig count, which was released recently.

Energy Stocks Climb As Oil Prices Shoot To New 2023 High—And Banks Say There's More Room To Grow

Crude oil prices set another 2023 high recently, surging upwards alongside energy stocks, which are gaining increasingly loud backing among market strategists.

Oil Prices Rise As Tight Supply Outlook Offsets Demand Woes

Oil prices rose on Monday after flirting with \$95 a barrel earlier in the session, as expectations of a supply deficit stemming from extended output cuts by Saudi Arabia and Russia as well as weak shale production outweighed concerns about demand.

Saudi Energy Minister Says OPEC Targeting Stable Oil Prices (LOGIN CREDENTIALS REQUIRED)

Saudi Arabia Energy Minister Prince Abdulaziz bin Salman said OPEC is working to keep oil markets stable and improve global energy security, without targeting any specific price level for crude.

Pipelines Are Limiting U.S. Natural Gas Production

In its latest biennial assessment delivered last week, the Potential Gas Committee (PGC) reported that U.S. natural gas supply has hit a record 3,978 trillion cubic feet.

US Gas Prices Are Unusually High. Here's Why You Shouldn't Worry

Falling leaves typically coincide with falling gas prices as the summer driving season comes to a close and demand at the pump wanes.

U.S. Renewables Capacity To Soar With The Inflation Reduction Act

The Inflation Reduction Act (IRA) is spurring a land rush for development sites and giving impetus to clean energy equipment manufacturing in the United States.

Chevron Assumes Lead Role in Largest US Hydrogen Storage Project

The Advanced Clean Energy Storage project in Utah involves two 4.5-million-bbl salt caverns that will store up to 100 metric tons of hydrogen per day.

Orphaned Wells: The Forgotten Problem

Methane emissions can be patched when the oil and gas industry knows where they originate, but sealing some orphan wells can be a cross between a scavenger hunt and a detective story.



SELECTED RECENT TRANSACTIONS

Vital Energy acquires Permian Basin Assets from Henry, Maple and Tall City

Vital Energy has signed agreements valued at about \$1.17 billion to expand its acreage in the Permian Basin, where dealmaking is gathering pace as drillers tap the largest U.S. oil patch to quickly replenish their depleting reserves.

Magnolia Oil & Gas Announces Bolt-On Asset Acquisition in Giddings

Magnolia Oil & Gas Corporation announced recently that the Company has entered into a definitive purchase agreement to acquire certain oil and gas producing properties including leasehold and mineral interests in Giddings for \$300 million, subject to customary purchase price adjustments.

Viper Energy Partners LP, A Subsidiary Of Diamondback Energy, Inc., Announces Acquisition

Viper Energy Partners LP, recently announced it has entered into a definitive purchase and sale agreement to acquire certain mineral and royalty interests from affiliates of Warwick Capital Partners and GRP Energy Capital in exchange for approximately 9.02 million Viper common units and \$750 million of cash, subject to customary adjustments.

Phoenix Capital Group Purchases Assets in North Dakota

Phoenix Capital Group, a leading oil and gas mineral rights acquisition company, has announced the purchase of roughly 2,530 net acres of land in Mountrail County, North Dakota valued at roughly \$9 million.

Crescent Energy to Acquire Additional Interests in its Operated Western Eagle Ford Position

Crescent Energy Company recently announced that it has entered into a definitive purchase agreement to acquire incremental working interest in its operated Western Eagle Ford assets for total consideration of \$250 million in cash, subject to customary purchase price adjustments.

Dorchester Minerals, L.P. Completes Acquisition of Mineral and Royalty Interests

Dorchester Minerals, L.P. announced that it has completed an acquisition of mineral and royalty interests totaling approximately 3,355 gross acres and 568 net royalty acres located in three counties in Texas.

Permian Resources To Buy Earthstone In \$4.5 bln Deal

Permian Resources said it would buy Earthstone Energy in an all-stock transaction valued at about \$4.5 billion, including debt, boosting the shale producer's presence in the Delaware Basin.

Crescent Point Announces Sale Of Its North Dakota Assets

Crescent Point Energy Corp. is pleased to announce that it has entered into an agreement with a private operator to sell its North Dakota assets for US\$500 million.

PHX Minerals Announces Accretive Acquisitions in Haynesville and SCOOP

PHX Minerals Inc. announced that it has agreed to acquire approximately 988 net royalty acres targeting the Haynesville play in Louisiana and Texas and the SCOOP play in Oklahoma from five separate sellers for aggregate consideration of \$13.6 million in cash subject to certain closing conditions and adjustments.

Empire Petroleum Announces Acquisition Of Additional Interests In New Mexico Units

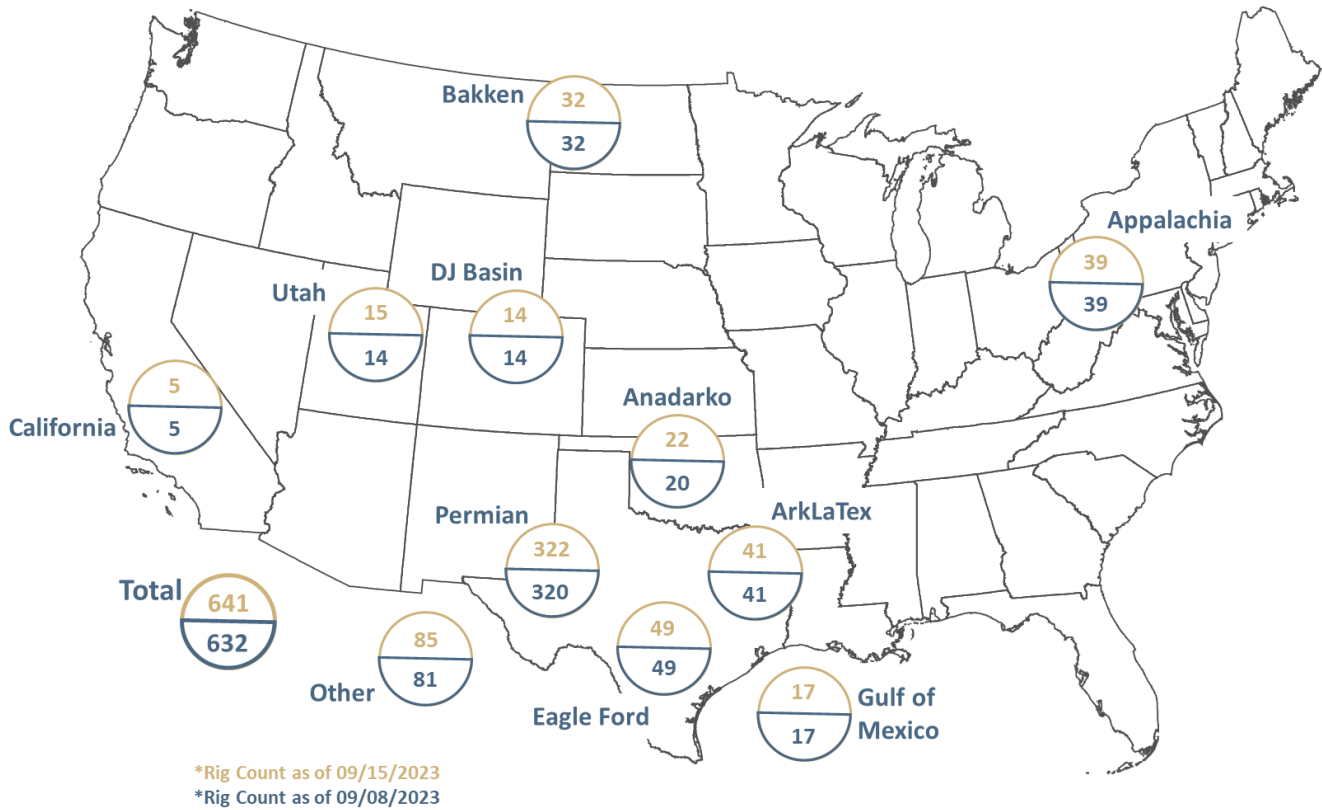
Empire Petroleum announced that it closed on the acquisition of COERT Holdings 1 LLC's interests in Empire's three New Mexico assets, Eunice Monument South Unit A, Eunice Monument South Unit B, and Arrowhead Grayburg Unit, all of which are located in Lea County. The purchase price for the Transaction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

ExxonMobil Announces Acquisition Of Denbury

Exxon Mobil Corporation 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



RIG ACTIVITY BY US REGION

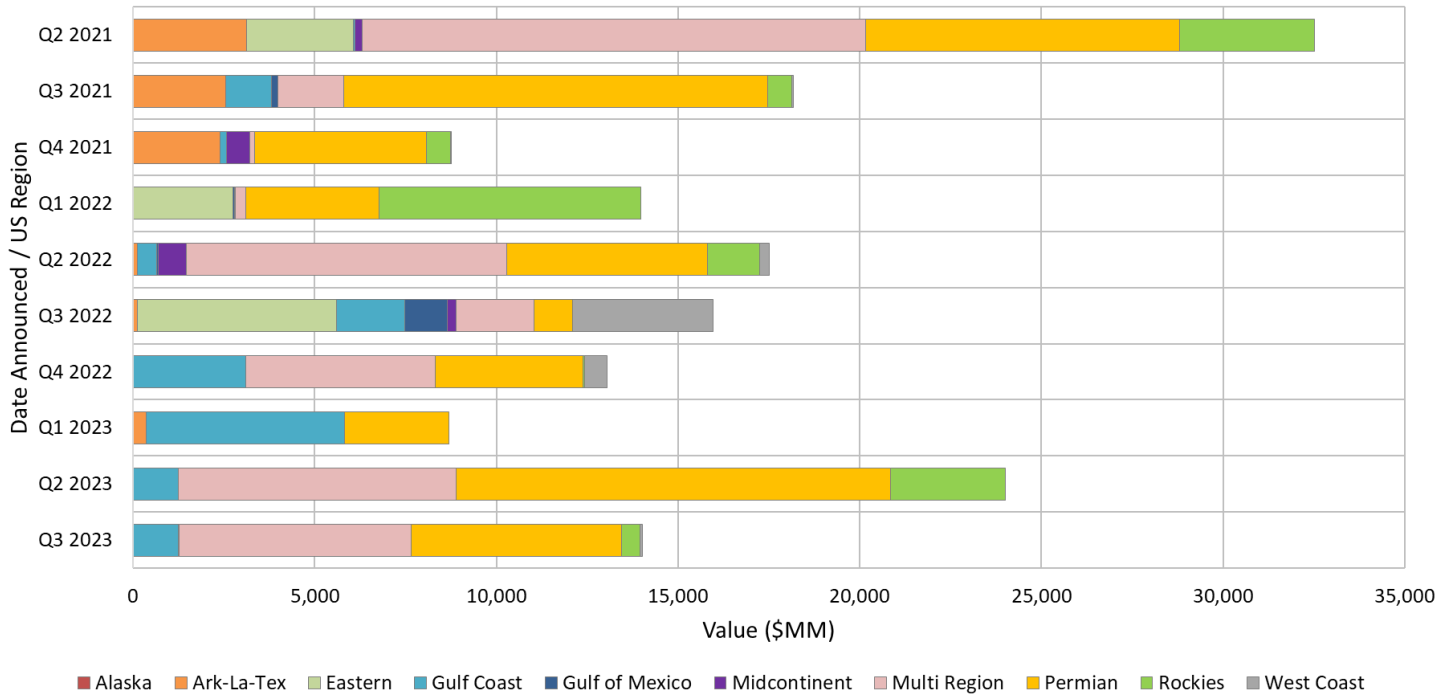


	Week Ending 09/15/2023			Week Ending 09/08/2023		Week Ending 09/16/2022
U.S. Rig Breakouts	Count	+/-	Count	+/-	Count	
Oil	515	2	513	(84)	599	
Gas	121	8	113	(41)	162	
Not Specified	5	(1)	6	3	2	
Directional	57	1	56	12	45	
Horizontal	567	5	562	(128)	695	
Vertical	17	3	14	(6)	23	
Land (Inc Others)	619	9	610	(125)	744	
Inland Waters	3	0	3	(1)	4	
Offshore	19	0	19	4	15	
US Total	641	9	632	(122)	763	

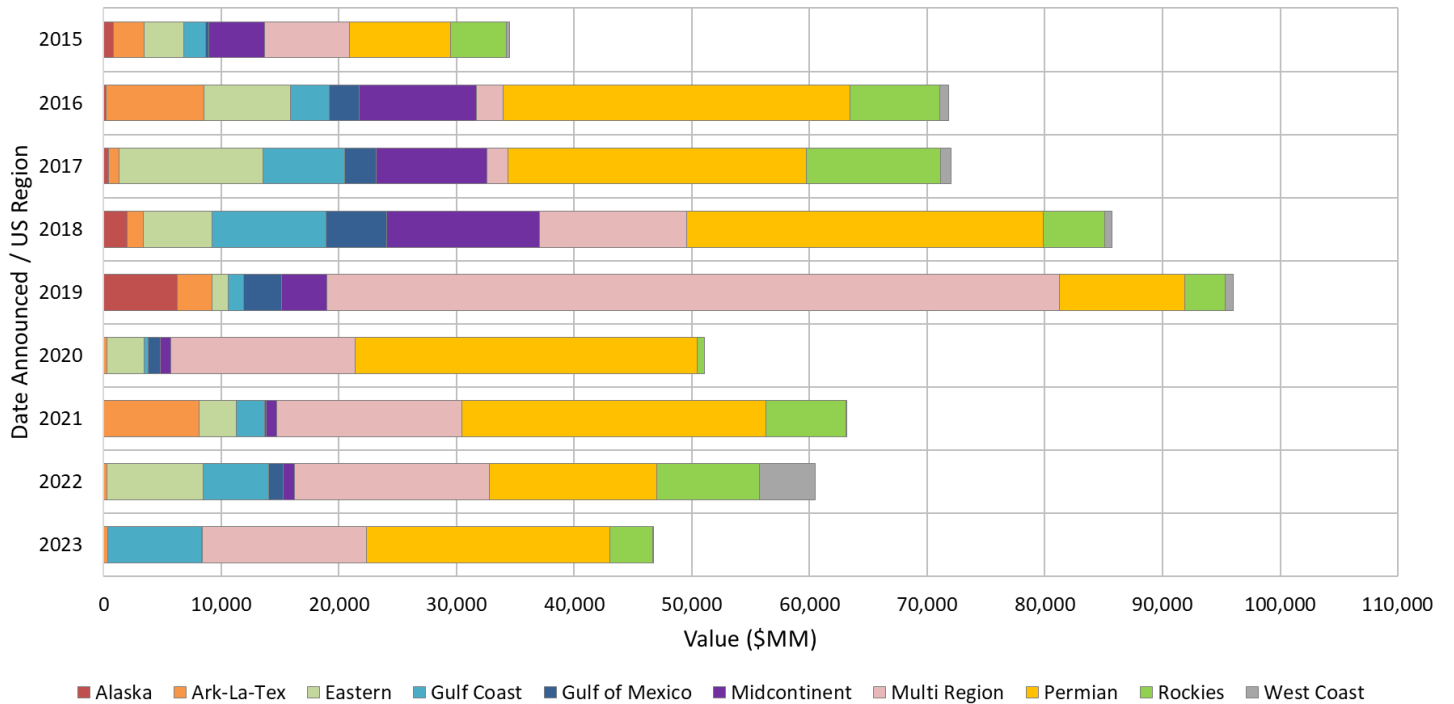
*Source—Baker Hughes Weekly Rig Counts



DEAL VALUE BY US REGION (BY QUARTER)



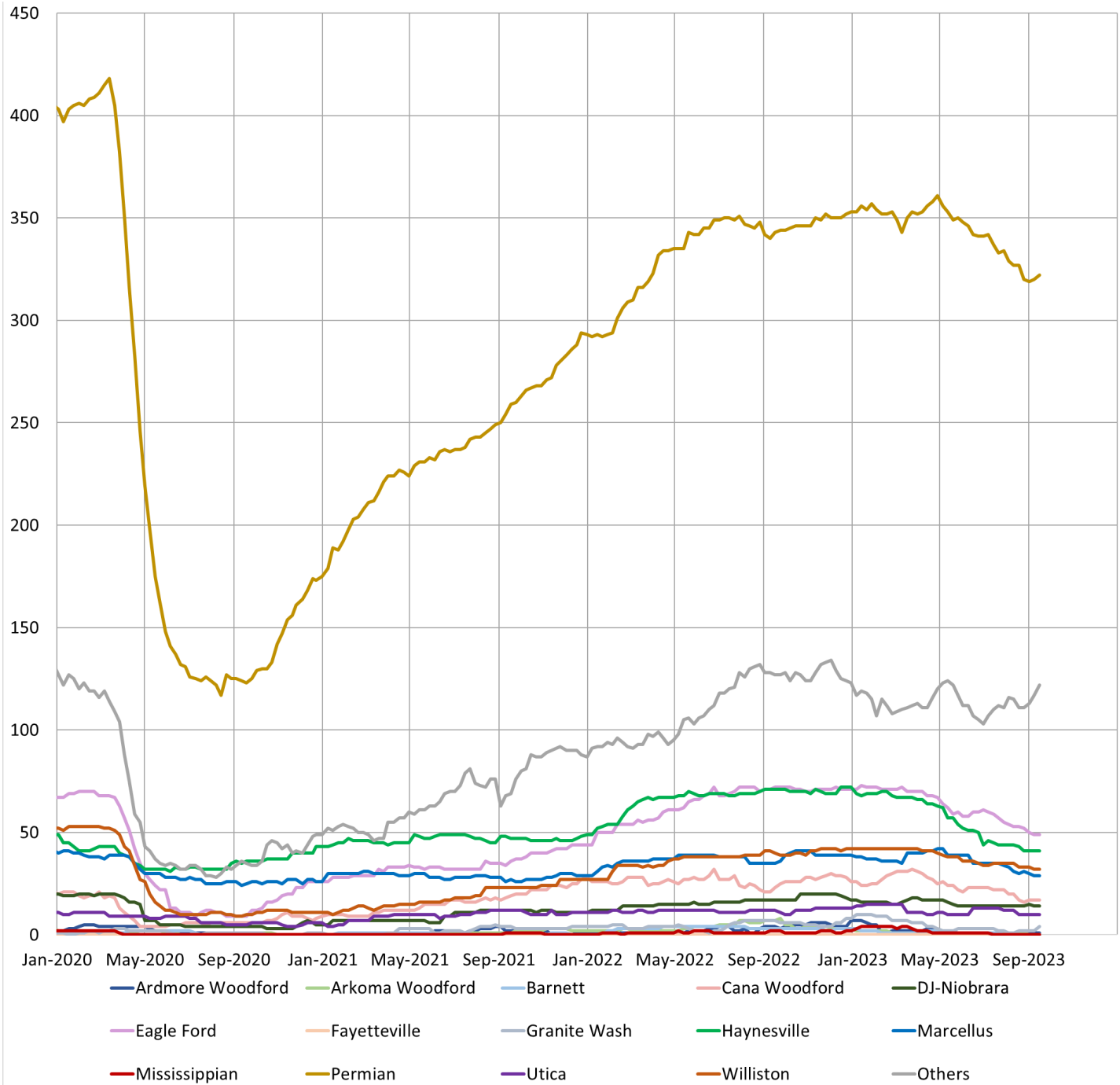
DEAL VALUE BY US REGION (BY YEAR)



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



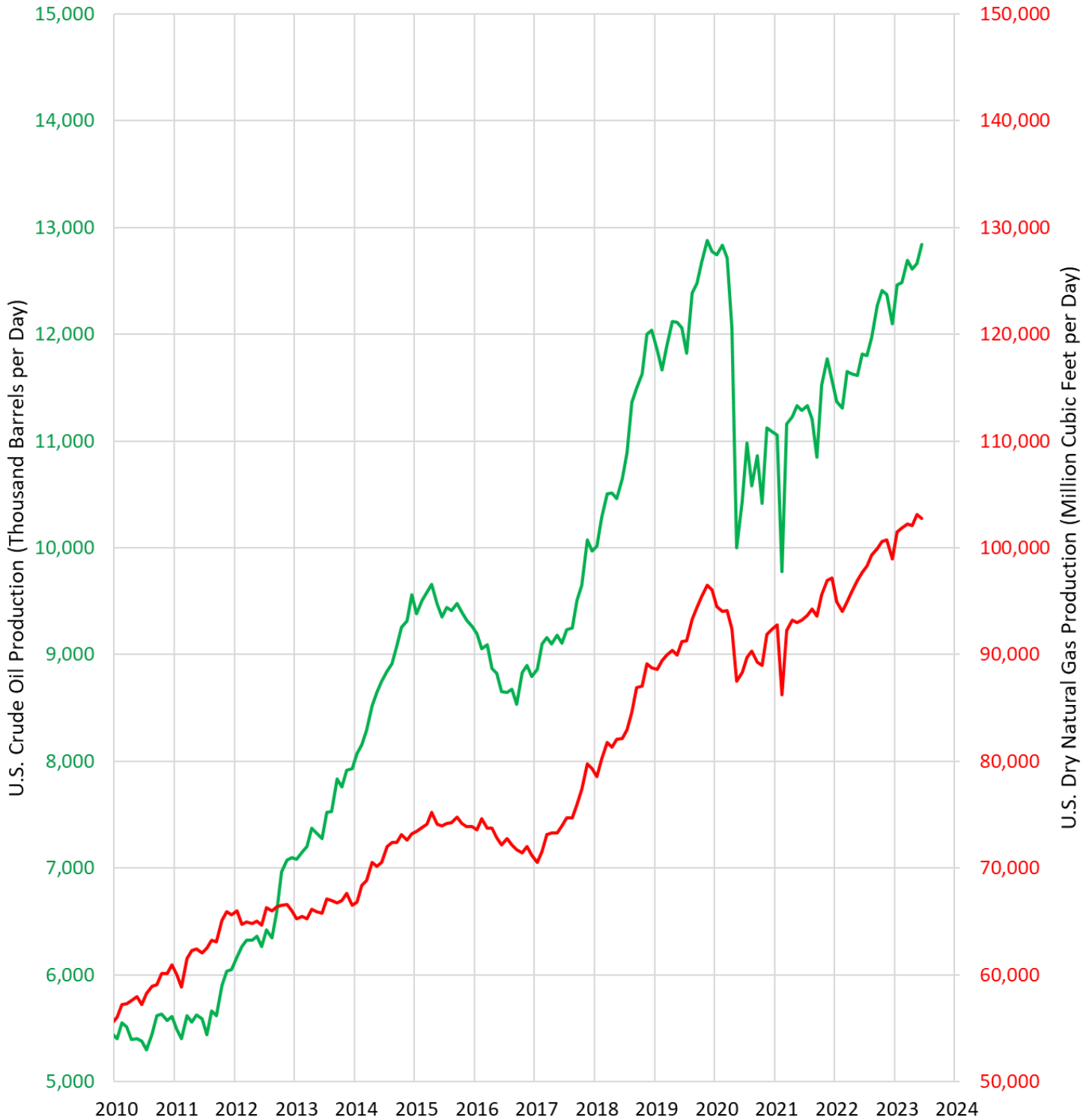
RIG ACTIVITY BY US REGION



*Source—Baker Hughes Weekly Rig Counts



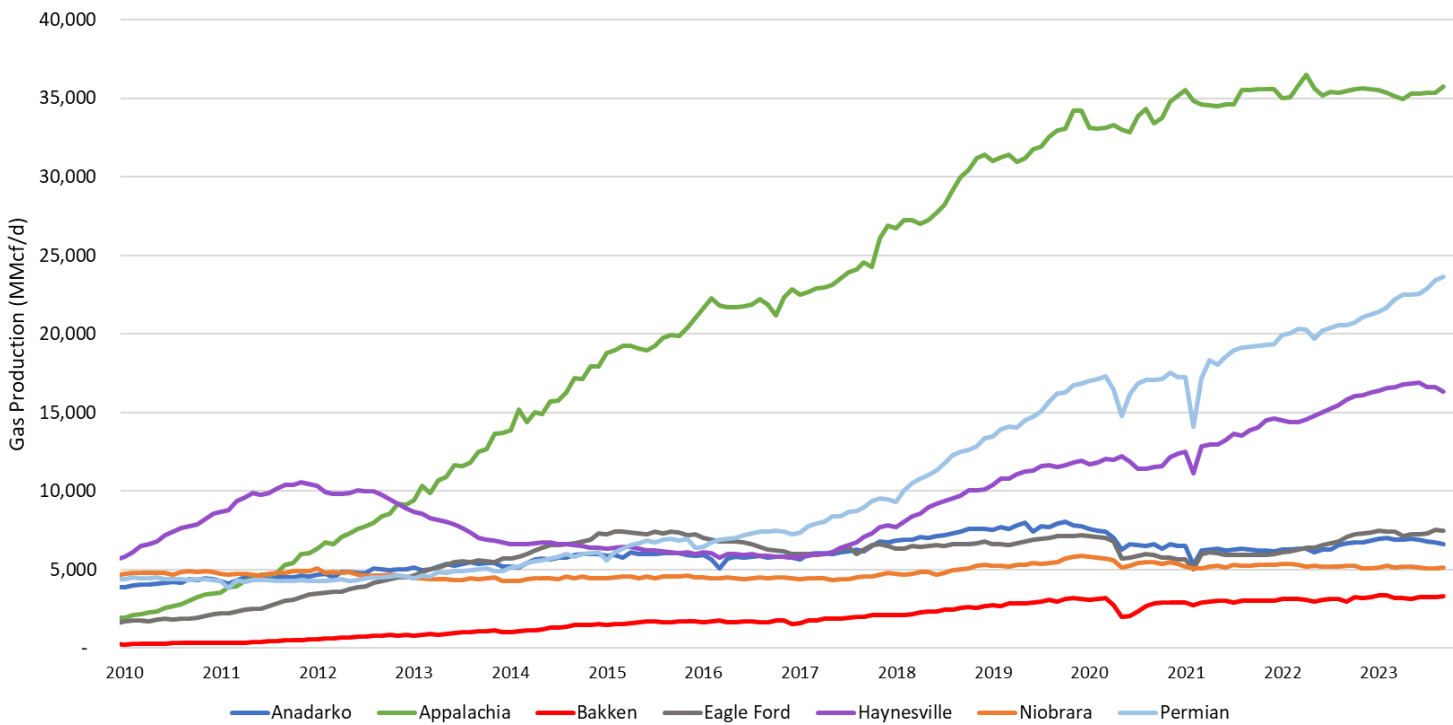
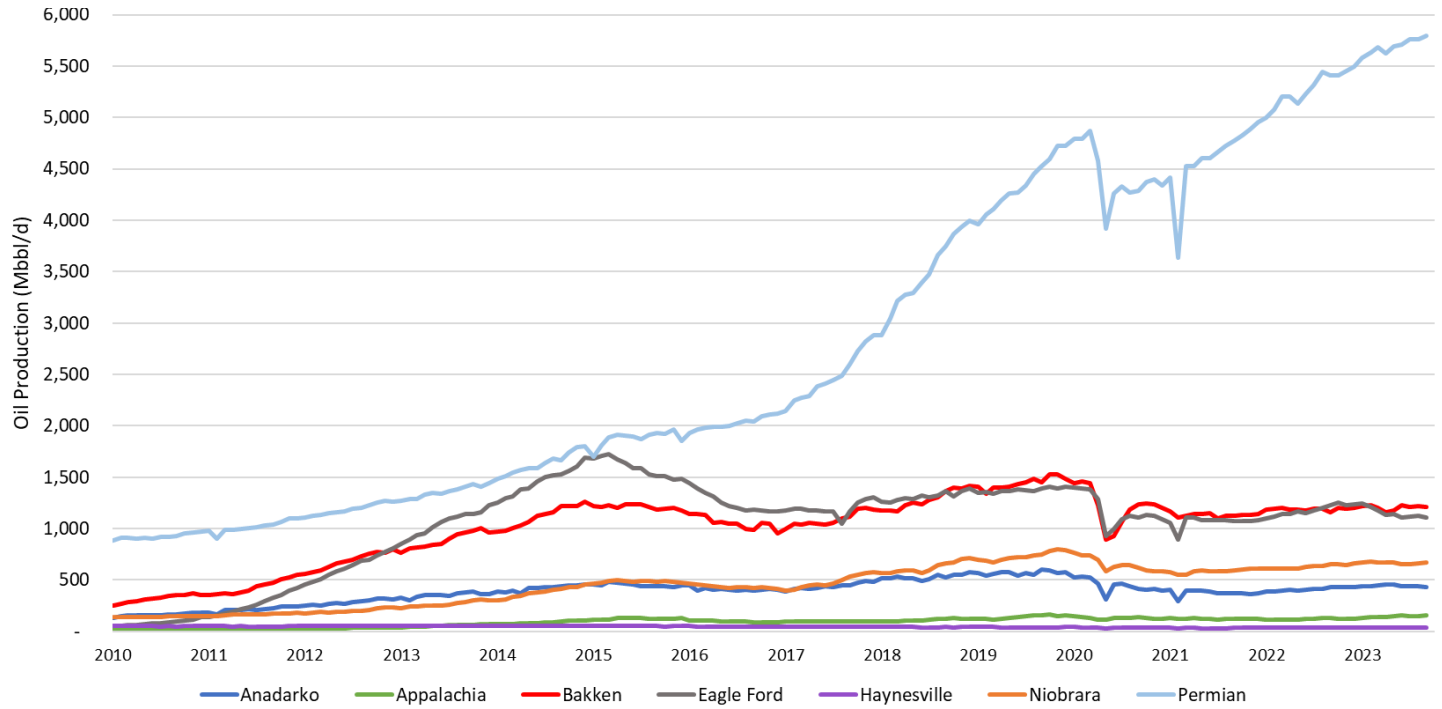
US DAILY CRUDE (MMbbl) & DRY NATURAL GAS PRODUCTION (MMcf)



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



HISTORICAL PRODUCTION OF SELECTED US SHALE REGIONS



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



UPCOMING EVENTS

September 2023

SEARCH 3rd Annual Cornhole Tournament	September 20	Houston, TX
SPE Business Development – Permian Panel	September 20	Houston, TX
HEFG Wine and Whiskey Event	September 21	Houston, TX
Enertia User Conference	September 21-22	Fort Lauderdale, FL
HPF 29th Annual Golf Tournament	September 25	Cypress, TX
World Oilman's Overnight Poker Tournament (WOOP)	September 28-29	Lake Charles, LA

October 2023

Hart Energy—Energy Capital Conference	October 2	Dallas, TX
Hart Energy—A&D Strategies and Opportunities Conference	October 3	Dallas, TX
2023 National Conference of Bankruptcy Judges (NCBJ)	October 11-14	Austin, TX
Tulsa Oktoberfest	October 19-22	Tulsa, OK
Small Steps Golf Classic	October 30	Houston, TX
Digital Wildcatters—FUZE	October 30-31	Houston, TX

November 2023

IPAA Annual Meeting	November 6-8	San Antonio, TX
AICPA Oil & Gas Conference	November 8-10	Las Vegas, NV
Accounting and Financial Reporting Conference	November 16	Tulsa, OK
OSU Oil and Gas Accounting Conference	November 17	Tulsa, OK
Boys & Girls Club 8th Annual Sporting Clays Tournament	November 17	Houston, TX

*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.

