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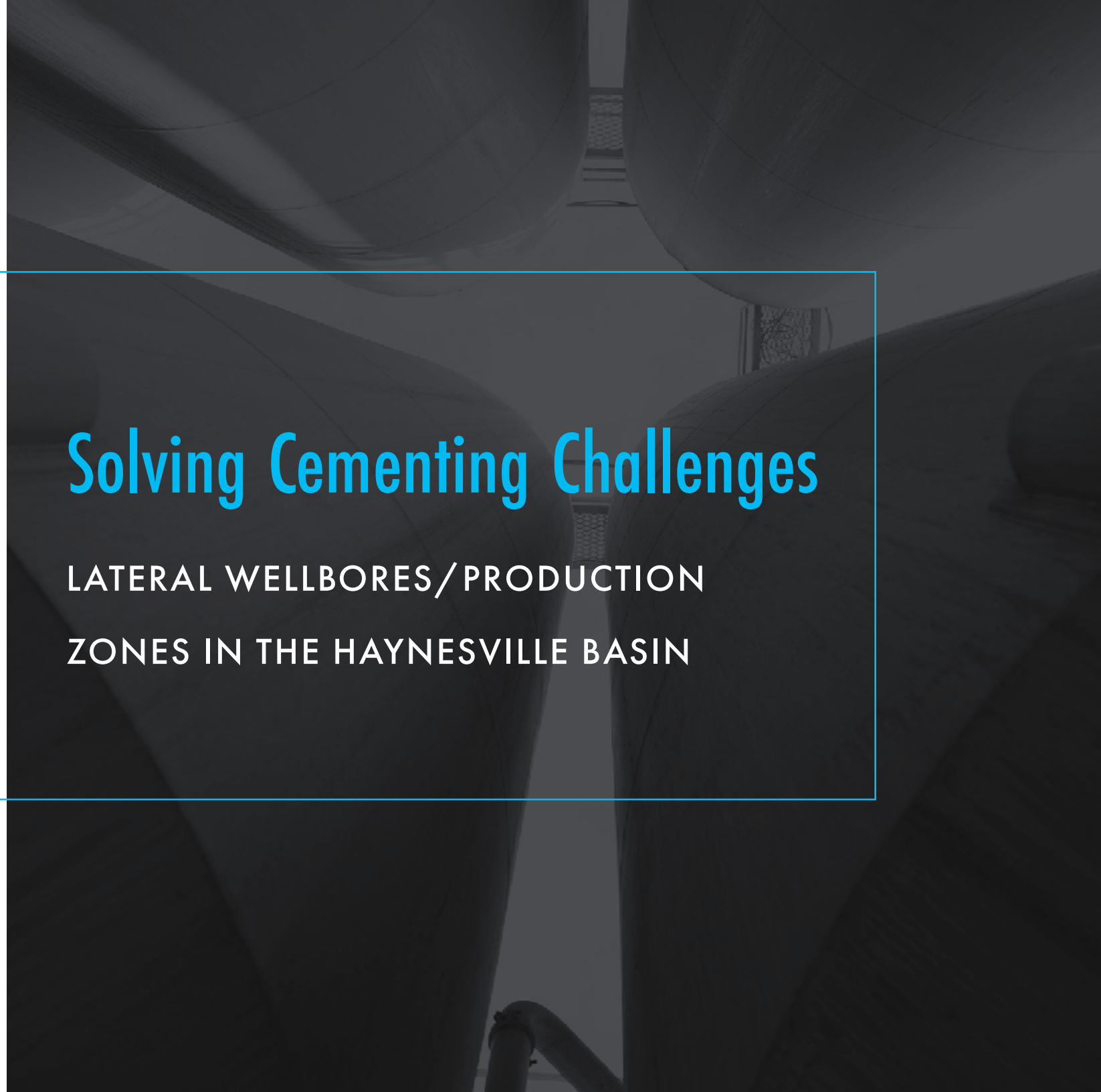
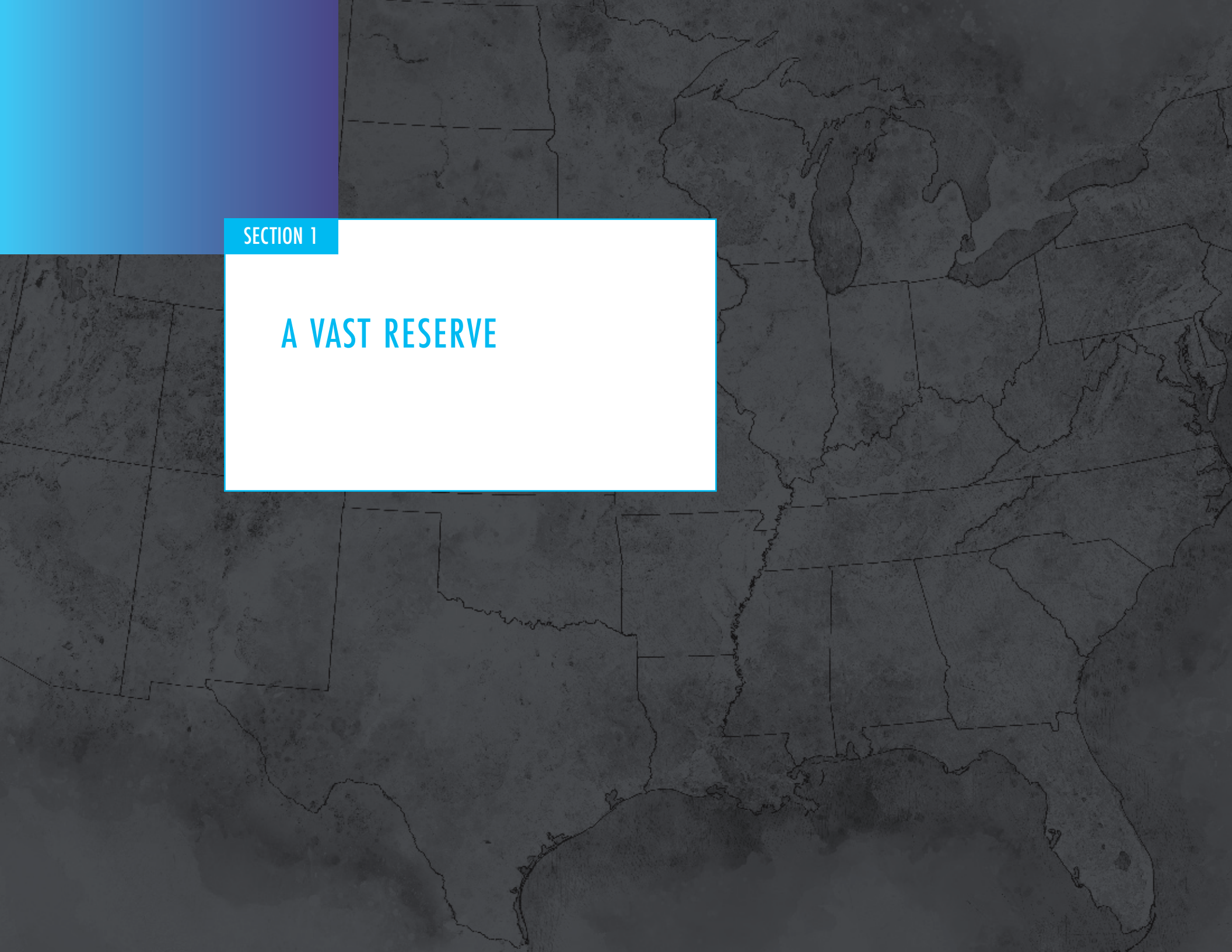


Solving Cementing Challenges

LATERAL WELLBORES/PRODUCTION ZONES IN THE HAYNESVILLE BASIN

CONTENT



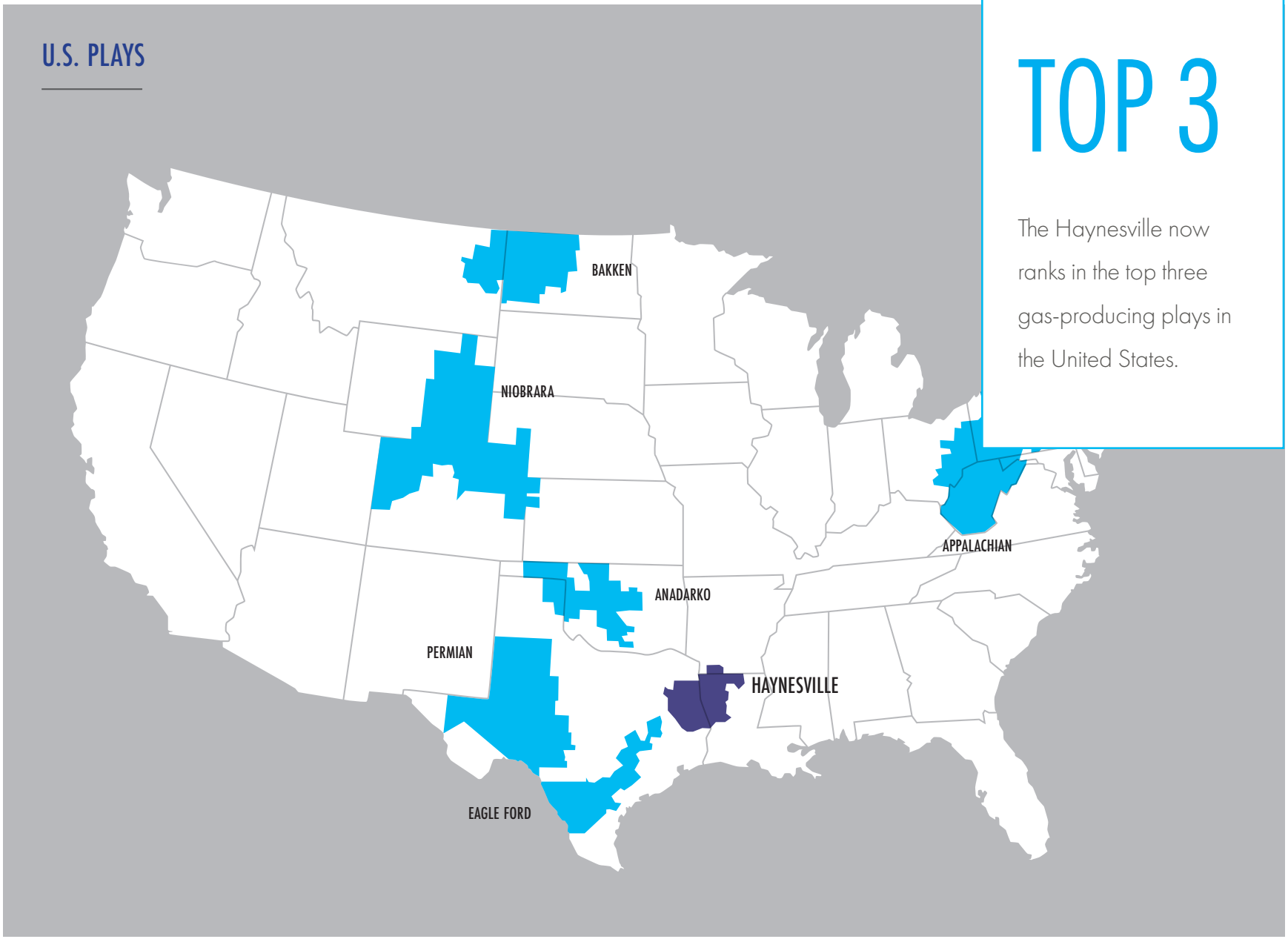
SECTION 1

A VAST RESERVE

THE HAYNESVILLE SHALE

The Haynesville Shale sprawls beneath Louisiana, East Texas, and Arkansas. Once considered part of the Bossier Shale, it is now recognized as a separate formation. In 2008, new production drew significant investment to the vast recoverable reserves of natural gas. The Haynesville now ranks in the top three gas-producing plays in the United States, and operators working in the area have overcome location-specific challenges by implementing new technologies that have made shale production more efficient.

U.S. PLAYS



TOP 3

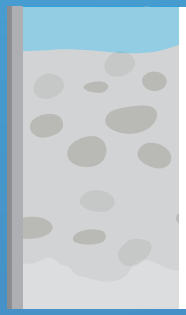
The Haynesville now ranks in the top three gas-producing plays in the United States.

SECTION 2

CHALLENGES FOR CEMENTING OPERATIONS IN THE HAYNESVILLE

THE PERFECT STORM

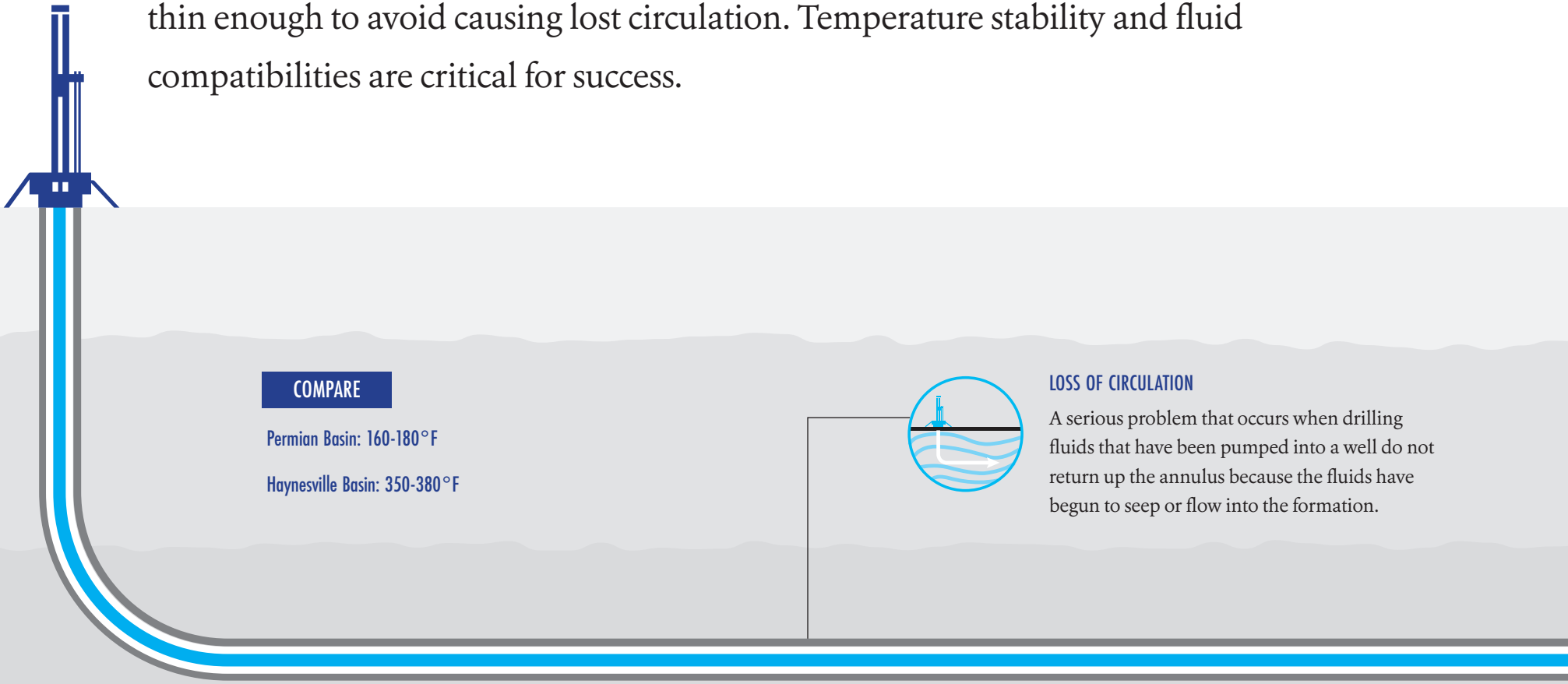
Operators in unconventional basins in the United States are keenly aware of the pressure to maximize economic efficiency in wells with laterals that just keep getting longer. Economic success depends largely on optimizing zonal isolation by creating a cement sheath that protects the casing and prevents fluid migration. In the Haynesville Shale, this objective is complicated by high temperatures downhole, high pressure, and tight annular clearances.



Cementing is critical, not just for the vertical portion of the well but also for production work in the extended laterals, where specialized design criteria are necessary.

CHALLENGE 1: HIGH TEMPERATURES DOWNHOLE

In the Haynesville, well temperatures downhole can exceed 350°F. The cementing slurry for these wells must be stable enough to withstand high temperatures, yet thin enough to avoid causing lost circulation. Temperature stability and fluid compatibilities are critical for success.



COMPARE

Permian Basin: 160-180°F

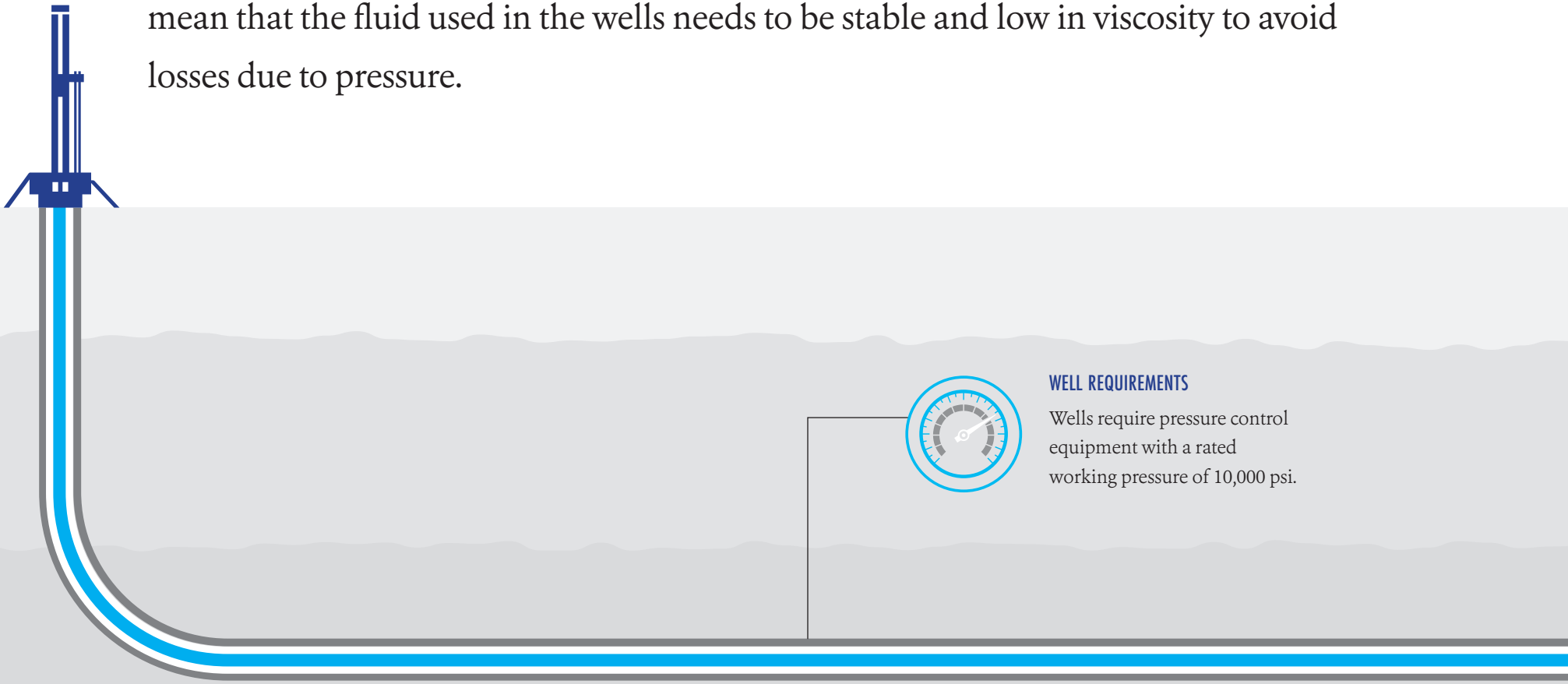
Haynesville Basin: 350-380°F

LOSS OF CIRCULATION

A serious problem that occurs when drilling fluids that have been pumped into a well do not return up the annulus because the fluids have begun to seep or flow into the formation.

CHALLENGE 2: HIGH PRESSURE

Wells in this basin require pressure control equipment with a rated working pressure of 10,000 psi. The combined well conditions of long laterals and high temperatures mean that the fluid used in the wells needs to be stable and low in viscosity to avoid losses due to pressure.

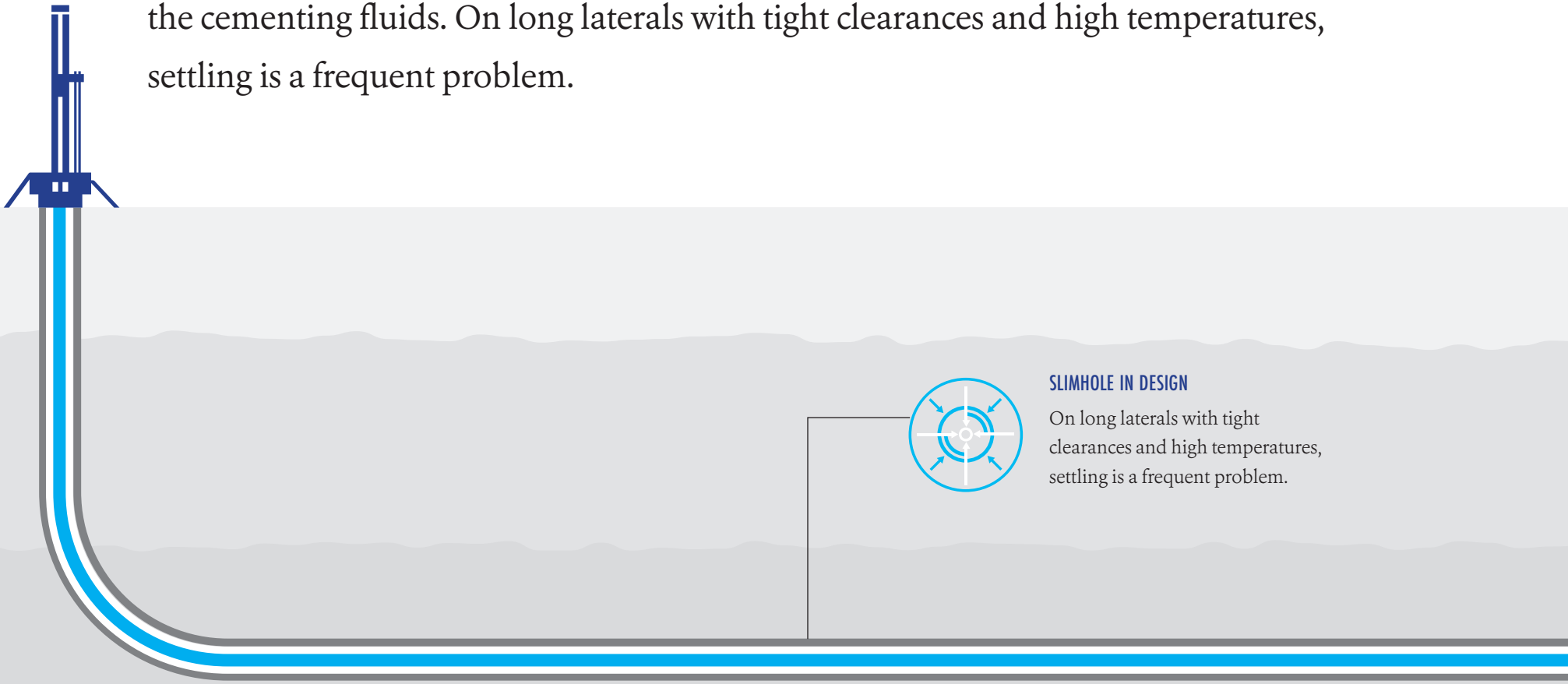


WELL REQUIREMENTS

Wells require pressure control equipment with a rated working pressure of 10,000 psi.

CHALLENGE 3: TIGHT SPACES (TIGHT ANNULAR CLEARANCE)

Haynesville wells are slimhole in design, often with 5-inch casing in a 6.75-inch hole. This complicates the circulation of fluids and the pressure associated with the cementing fluids. On long laterals with tight clearances and high temperatures, settling is a frequent problem.



SECTION 3

IMPORTANT SUCCESS FACTORS

CEMENT TYPE: LATEX OR NON-LATEX?

In a Haynesville slimhole production casing, it is critical that a cement slurry remain stable while maintaining low pumping pressures and low equivalent circulation densities (ECDs). Control of ECDs is important to ensure that the cement circulates properly and at a rate that removes solids and whole drilling fluid. A high quality, non-latex cement slurry with these properties will cost significantly less than a latex version. However, a traditional latex cement slurry may be more appropriate if gas migration is a concern.

Additives with excellent suspension and friction-minimizing properties can be incorporated into traditional latex slurries to improve density control.

SPACER FLUID: WHAT IS THE IDEAL?

Spacer fluids help the displacing process and optimize zone isolation in horizontal wells. Haynesville spacer fluid should also allow for casing rotation throughout the entire production, which will help overcome torque limitations, dramatically improving the quality of the cement job.

Spacer fluids must be compatible with the drilling fluid and the cement slurry and, in the Haynesville, must remain stable at temperatures of up to 380°F.

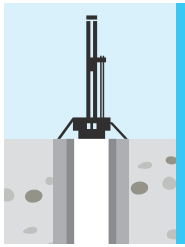
SPACER FLUID SHOULD ALSO INCLUDE THE FOLLOWING FEATURES:

+ Flexible design rheology with density
+ Sealing properties
+ Wettability of pipe for bonding
+ Reduced fluid loss in cement
+ Loss control
+ Excellent mud removal

Reactive spacers may also be helpful in preventing lost circulation in the Permian. Reactive spacers with the addition of lost circulation materials (LCMs) can help to heal seepage.

HIGH PRESSURE PUMPING: HOW HIGH?

Because the Haynesville formation is such a high pressure environment, pump trucks used on cementing jobs need to be extremely powerful.



To be successful in most Haynesville wellbores, a **minimum of 7,000 psi** at surface will be required.

SECTION 4

CASE STUDIES

EXTENDED LATERAL SLIMHOLE CASE STUDY

EXTENDED LATERAL SLIMHOLE CASE STUDY

For an operator working a 16,600-foot (over three-mile) lateral section of a well, Nine Energy Service provided a specialized solution that combined the use of conventional non-latex cement, the MS Spacer, and the Patriot Pump Truck.

Wellbore Geometry: 6.75" OH x 5" Casing

Length of Lateral: 16,600 feet

Temperature: 350°F

Mud weight: 15.6 ppg

1 NON-LATEX CEMENT

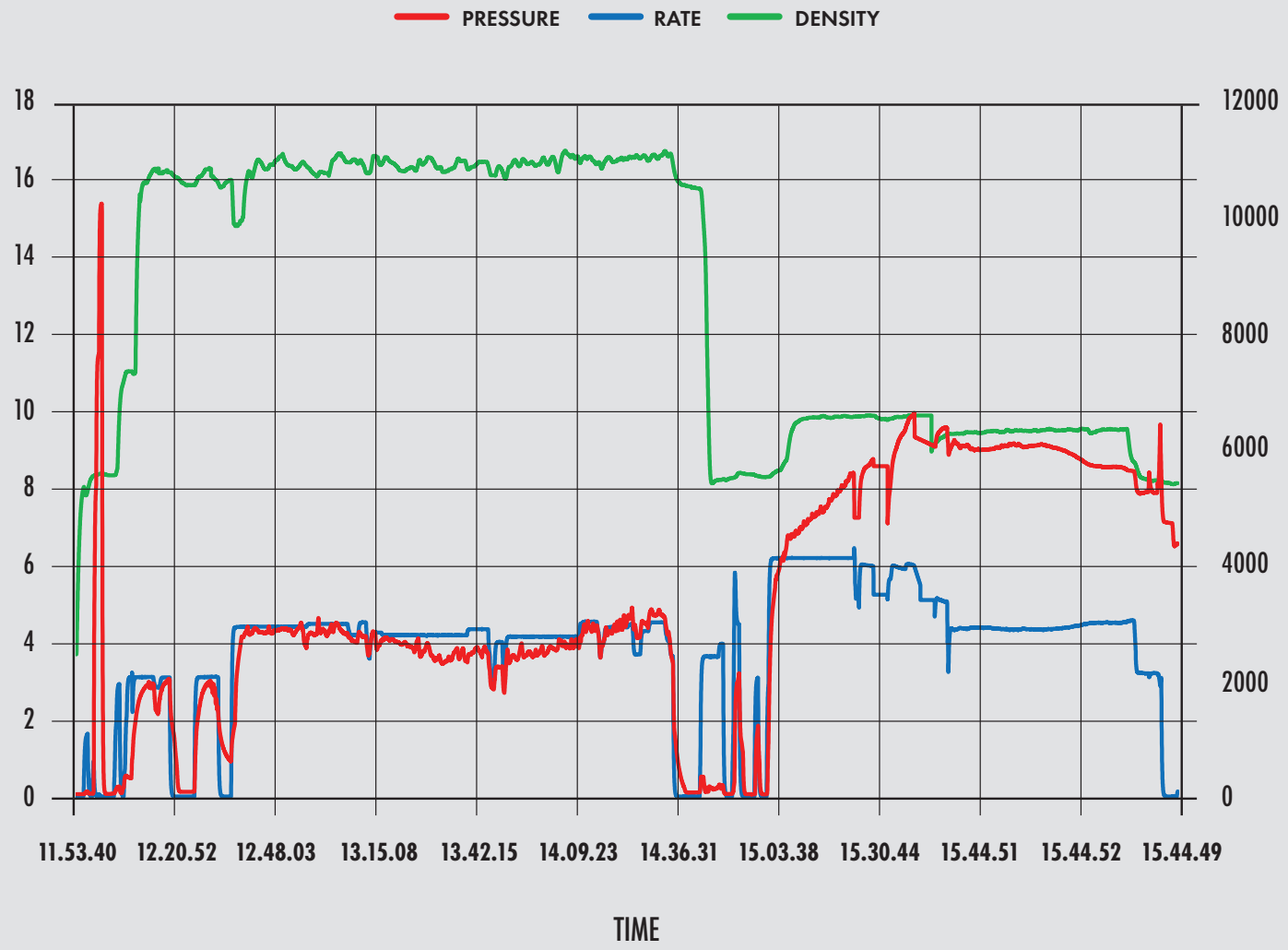
+

2 MS SPACER

+

3 PATRIOT PUMP TRUCK

HAYNESVILLE 3 MILE 6.75" OH LATERAL



THE RESULTS

1. Exceptional density control achieved through slurry design, equipment, and experienced operators.
2. Lower than average pressures. Typical pressures on long laterals can exceed 8,000 psi at 3 bpm.
3. Unmatched pumping power during displacement ensured good mud removal and cement coverage.

CASING ROTATION CASE STUDY

CASING ROTATION CASE STUDY

The solutions employed in the previous case study prompted additional study because the operator noticed the initial job using the MS Spacer was the first time that casing rotation was maintained throughout the entire treatment. Previous jobs had torqued out, which means the pipe movement could not be maintained once the spacer entered the annulus. This indicates incompatibility and settling.

In horizontal wells with slimhole design, the rotation of pipe is especially significant for displacement efficiency.

CASING ROTATION CASE STUDY

The operator studied 18 wells with bottom hole circulating temperatures of 280°F to 370°F where the MS Spacer was used. Only two wells could not maintain casing rotation, and these exceptions had malfunctions unrelated to the fluids being pumped. For each of these wells, the pre-job pressure signatures also matched the actual job pressures.

Nine considers this case study of the MS Spacer's effect on casing rotation to have a 100% success rate.

IN SUMMARY

Nine creates customized solutions for unique challenges. The extreme drilling circumstances of the Haynesville Shale present unique production cementing challenges, especially for lateral wells. Specialized design criteria, technology and expertise are essential to operate in the area.

REFERENCES

Multifunctional Cement Spacer Fluid Improves Cement Seal Integrity, Minimizes Formation Damage, and Controls Lost Circulation, Fred Sabins, John Ward, Larry Watters, Russel Roberts AADE 2022

MS Spacer Case Study, Nine Energy Service Nine Energy Service 2023

ABOUT NINE ENERGY SERVICE

Nine Energy Service is an oilfield services company that offers completion and production solutions throughout North America. The Company brings years of experience with a deep commitment to serving clients with smarter, customized solutions and world-class resources that drive efficiencies. Strategically located throughout the U.S. and Canada, Nine continues to differentiate itself through superior service quality, wellsite execution and cutting-edge technology. Nine is headquartered in Houston, Texas with operating facilities in the Permian, Eagle Ford, SCOOP/STACK, Niobrara, Barnett, Bakken, Marcellus, Utica and throughout Canada. For more information, visit nineenergyservice.com.