Permian Basin Field Observations, Lessons Learned, and Optimization Solutions in a Downturn

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Abstract

The author, Andrew N. Hunter, has spent the previous 5 years working as an office-based drilling engineer managing the planning and execution for 2 to 3 horizontal rig teams in various fields including the Haynesville, Eagle Ford, Barnett, and Wolfcamp plays. Since January 2015, the author has been working as a drilling supervisor on a horizontal rig in the Permian Basin. The author's goal with this presentation is to answer the following questions: 1) what are the most noteworthy observations during the last 8 months on the rig 2) what are the key performance drivers for executing each hole section 3) what are ideal rig specs for drilling 10,000' laterals in the Wolfcamp play 4) How can an operator maintain best-in-class drilling performance and optimization efforts in a low-oil-price environment?

Outline

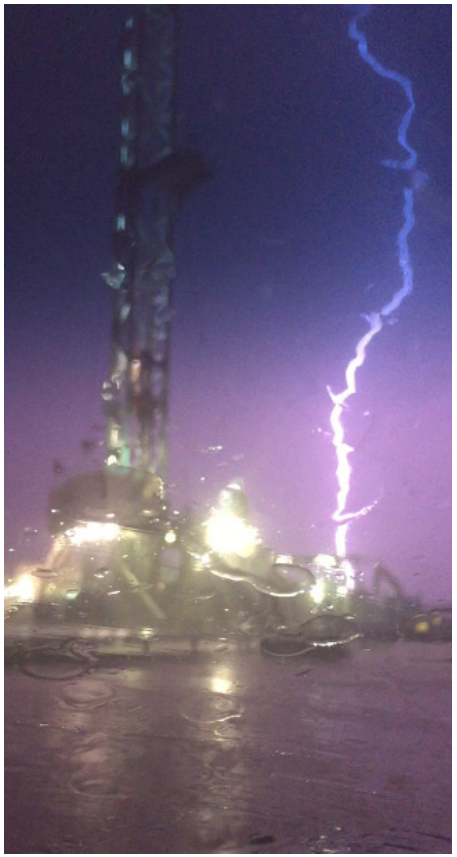
1. **Field Observations**

2. **Lessons Learned: Drilling Parameters and Abnormal Hole Conditions**

2. **Rig Design for Multi-well Pads with 10,000’ Laterals in the Permian Basin**

3. **Maintaining Best-in-Class Engineering Performance in a Downturn**

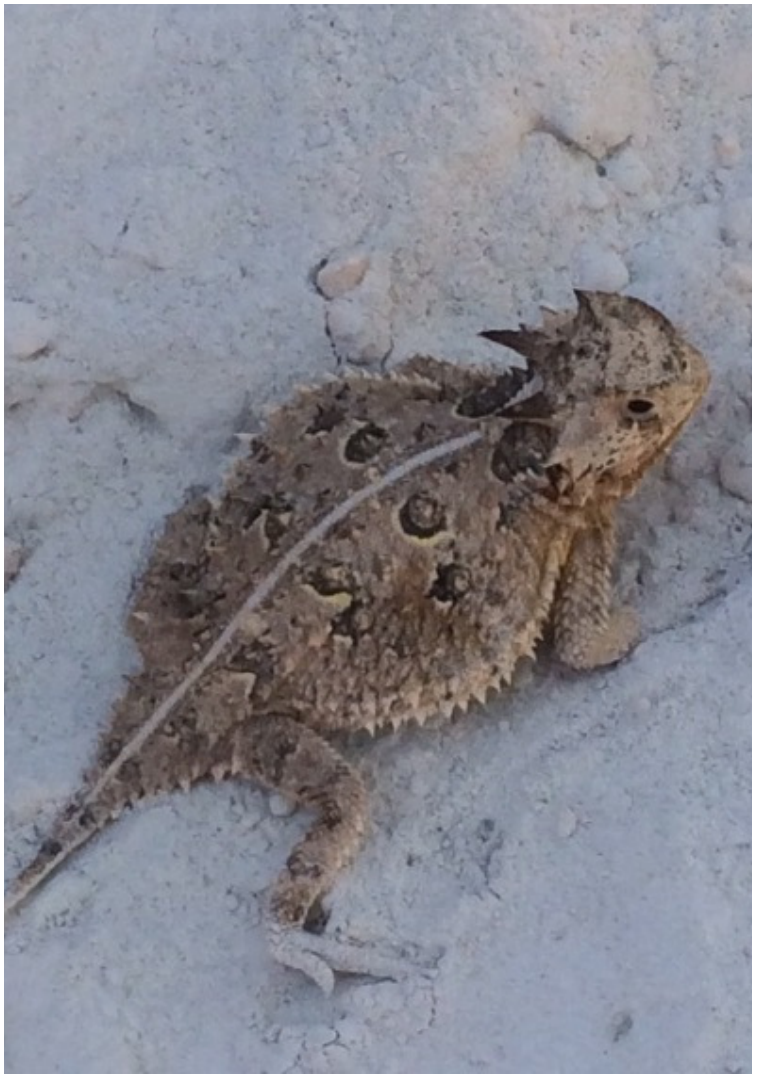
2014-15’ Record Drought to Record Rainfall

- **Midland, TX average annual precipitation = 14.6”**
- **2013 = 8.5”, 2014 = 7.6” or 55% below average over 2 year period**
- **2015 YTD precipitation thru June = 11”, or 44% above average YTD thru same month.**

May 13, 2015 Northeast Reagan County

Midland Basin Wildlife



“You can’t coach today’s game by yesterday’s rules.”

Jeff Banister
Manager of the Texas Rangers Baseball Team, 8/24/15

Field Observations

Old-school foreman mentality towards reporting and sharing of information must be addressed

- "the more I tell the office, the more explaining I have to do"
- "sometimes the less they know, the better"
- "I don't want to share all my secrets or my competitive edge"

Build trust and emphasize the importance of reporting critical information to accelerate learning and to prepare for future offset drilling

- Engineers and managers should be able to read the drilling report and know all important information about hole conditions, hazards, equipment problems, etc., without even picking up the phone
- Better reports actually equates to fewer phone calls and questions from engineer
- Information about hole conditions will be critical to planning and executing future offset wells
- Document best practices to lead the way for other rigs
- Our foremen "bought-in" very quickly after time was taken to explain reasoning and after leading by example
- Reports and knowledge sharing have improved dramatically

Field Observations, cont.

Pre-tour safety meetings held at picnic table outside toolpusher house provides less-than-ideal conditions for planning and team discussion

- Hard to hear with background noise from nearby rig generators
- Sunglasses prevent eye contact and confirmation of crew engagement
- Existing picnic table was also the designated smoking area (potential distraction)
- Extreme weather conditions tend to shorten meetings and attention spans
- Not best environment for team discussions, planning, and risk assessment
- With a $3000/hr operation and a hazard-rich environment, planning is essential

Rented 10’ x 30’ meeting trailer at $40/day with 2 folding tables and chairs to create a climate-controlled board-room-type environment

- Allows distribution and discussion of written daily work plans and hazards
- Allows full engagement with crews and 3rd parties
- Toolpusher stated “our meetings are 10 times better now”
- $40/day is less than 1 minute of spread rate
- Better pre-tour planning provides a huge return on investment and a safer workplace

Lessons Learned – Drilling Parameters

Optimized drilling parameters are paramount

Each rig's auto-driller settings must be calibrated for each interval thru trial and error

Adjust settings to achieve smooth ROP curve to avoid dumping weight on the bit aka "see-sawing"

<u>12.25" section:</u>

- **55 rpms to prolong bit shoulder life (without giving up ROP)**
- **Maintain constant motor differential pressure (400-800 psi) to keep bit engaged to reduce impact damage (ignore WOB)**
- **Goal: Average 2000 ft/day from drill out to TD**

<u>8.5" Curve/Lateral section:</u>

- **75-90 rpms for hole cleaning**
- **500-700 psi diff**
- **Goal: Average 1800 ft/day from Kick-off-Point to TD**

Lessons Learned – Abnormal Hole Conditions

Production hole wellbore collapse

- Drilled target in transition zone
- Wellbore collapsed on bit trip with 9.6 ppg after drilling half the lateral with no problems
- Several offset wells with deeper targets drilled successfully with 9.6 ppg.
- Took 6 days, 10.4 ppg, and asphalt product to open wellbore and recondition.
- Wells targeted in transition zone may require more MW than the deeper target

Rotating head packed off with plug parts after drilling 9-5/8" shoe

- Install rotating head rubber after circulating out plug parts (if possible)
- Always check BOPs and surface equipment when troubleshooting abnormal losses

Working tight hole and stuck pipe is truly an art form - the only way to learn is from first hand experience

- Plan to have at least one experienced hand on each hitch if training new hands
- We have encountered some form of tight hole on 50% of wells drilled

Recommended Rig Specs for 10k Wolfcamp Lateral on MWPs

X-Y walking capability with at least 100' of reach to drill a 4-well multi-well pad (MWP) on 25' spacing

7500 psi standpipe with 6" liners (ex. 5650 psi working pressure at 85% on Gardner Denver 2000 PXL)

Over-designed air condition system for VFD house to handle extreme temps and heavy power load

(10) 8" DC w/ NC56 connections (in addition to 6" DC and 5" HWDP)

Range 3 drill pipe with monkey board height designed accordingly (R3 stands are 3-4' shorter than R2)

Minimum of (3) top-tier shale shakers (new or recently rebuilt)

3 steel tank mud system: 2 for active system, 1 for pre-mixing ops to allow displacement to WBM in 12-1/4" section

Trip tank with min of 75 bbl capacity and centrifugal pump system to allow circulation across BOPs

Drillpipe oscillating system (ex. Slider) for improved sliding ROP once greater than 5000' VS

Gas separator incorporated into substructure to enable efficient walking operations

Dual-fuel capable generators to allow use of natural gas including gas detection system installed in generator house

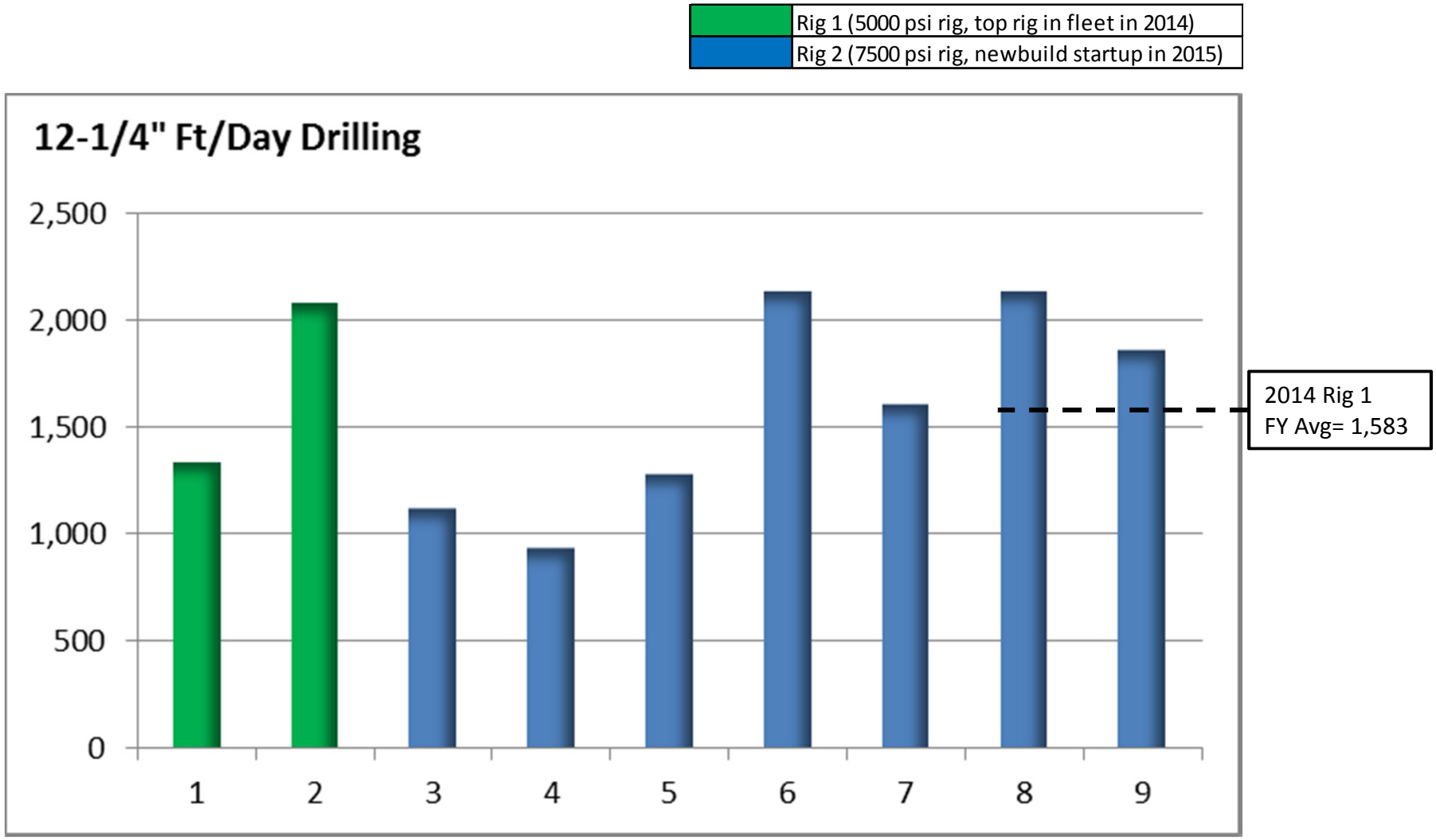
Flowline configuration to allow direct path for 10" PVC overboard line to reserve pit (drop flowline into top of possum belly)*

Multi-bowl wellhead system to allow 9-5/8" to be landed without breaking BOPs*

BOP quick-connect system for more efficient NU/ND of BOPs on a multi-well pad*

*Not rig contractor equipment but noteworthy

5000 psi vs. 7500 psi Rig Performance 2015 YTD*



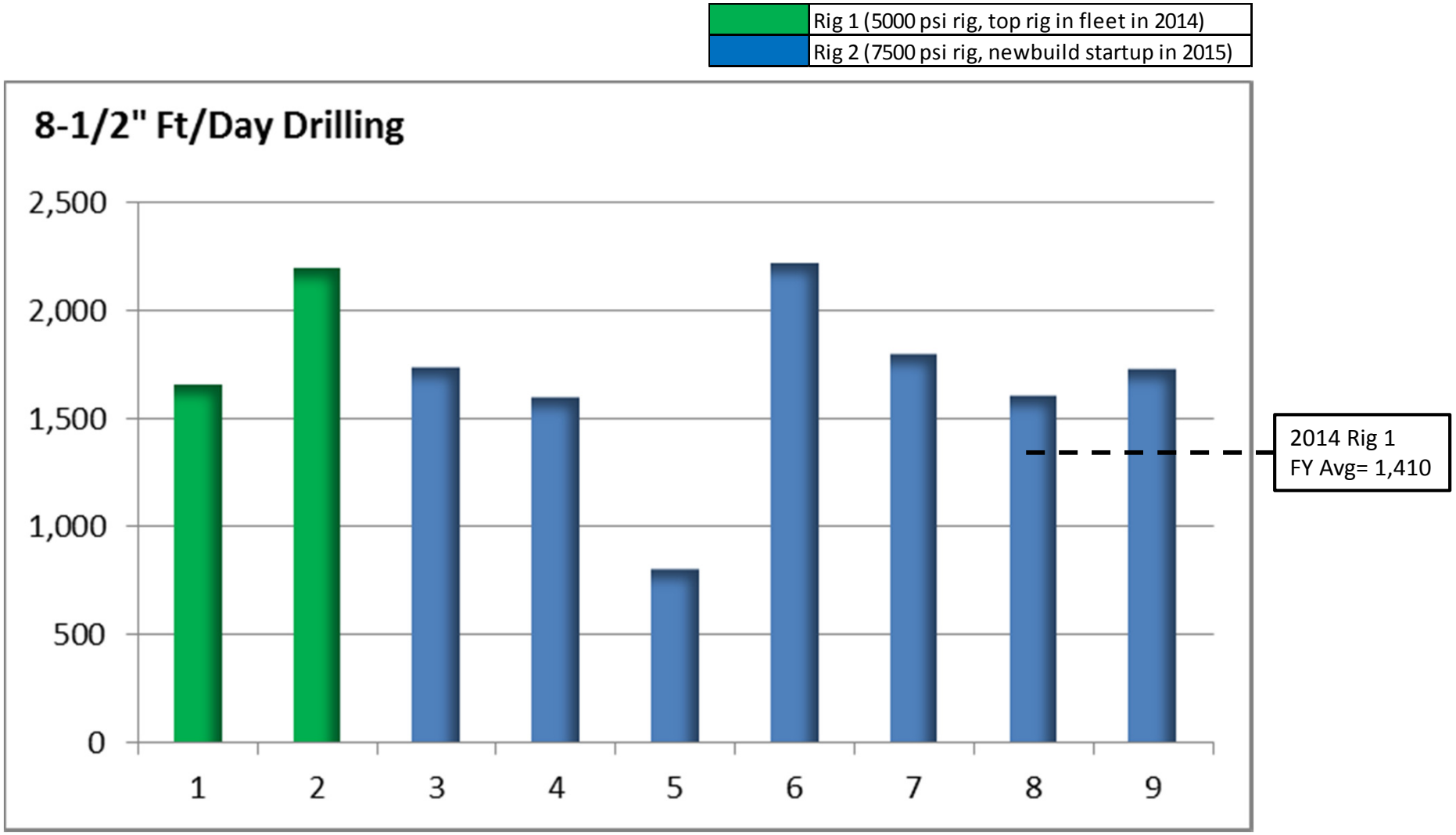
20% YOY improvement to date on Rig 2 vs Rig 1 2014 FY Average (Laredo's top performing 5000 psi rig in 2014)

***All wells drilled were Upper and Middle Wolfcamp targets**

***Author began field assignment on Rig 1 and moved to startup new-build Rig 2 along with all key vendors from Rig 1**

Best practices by each hole section in backup slides

5000 psi vs. 7500 psi Rig Performance 2015 YTD*



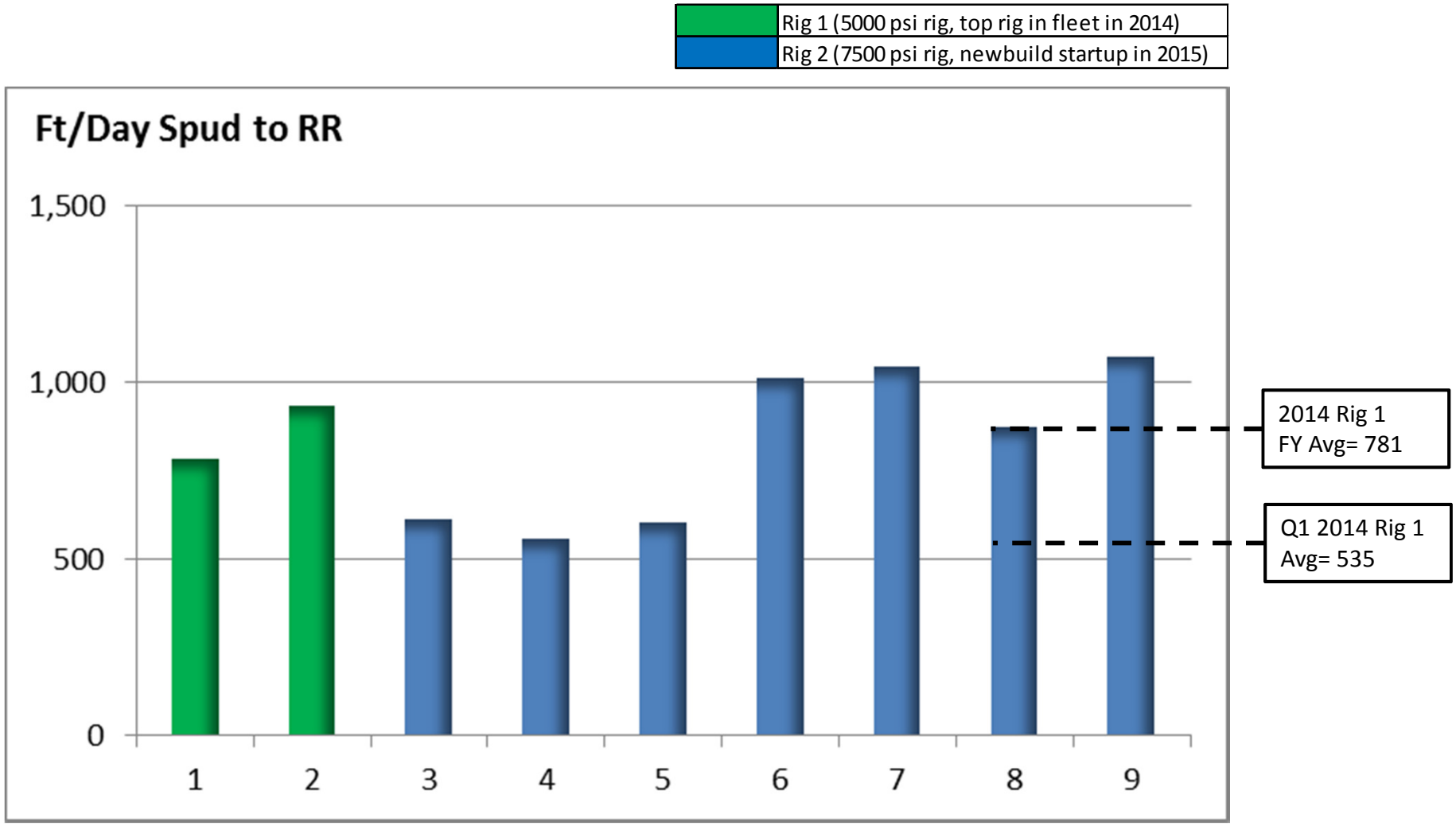
17% YOY improvement to date on Rig 2 vs Rig 1 2014 FY Average (Laredo's top performing 5000 psi rig in 2014)

***All wells drilled were Upper and Middle Wolfcamp targets**

***Author began field assignment on Rig 1 and moved to startup new-build Rig 2 along with all key vendors from Rig 1**

Best practices by each hole section in backup slides. Note: well #5 was the wellbore collapse mentioned on lessons learned

5000 psi vs. 7500 psi Rig Performance 2015 YTD



6% YOY improvement to date on Rig 2 vs Rig 1 2014 FY Average (Laredo's top performing 5000 psi rig in 2014)

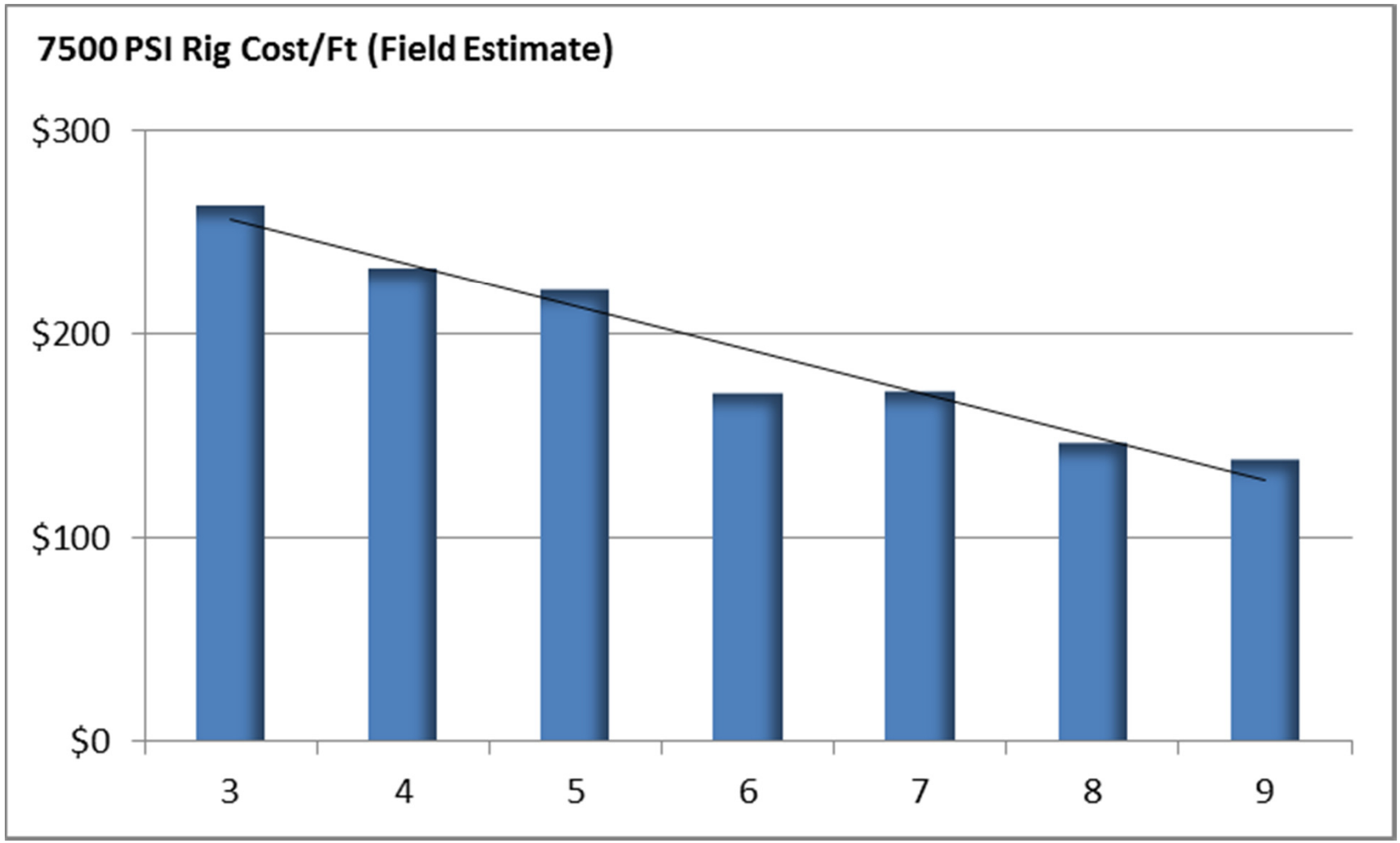
Room for improvement on newbuild 7500 psi rig with flat times

– reflected in 17-20% improvement of drilling efficiency vs. only 6% overall well efficiency from Spud to RR

4 most recent wells show 87% improvement vs. Q1 2014 average

Right Rig Design -> Detailed Data Analysis -> Optimized Strategy -> Team Execution

End Result: Best-in-Class Performance



Maintaining Drilling Performance in a Downturn

Our goal is to deliver wells with best-in-class drilling performance

It is even more critical to maintain good capital efficiency in a $40- $50 oil market

When the rig count goes down, the tendency is to cut staff drastically in response

When Drilling Engineers are assigned to too many rigs, they do not have enough time for detailed analysis of data and best practices to accomplish best-in-class performance

Critical to maintain dedicated resources that are focused on optimization, best practices, and performance

The cost benefit to the focus on data analysis far outweighs the cost of an engineer

Potential options to maintain a focus on performance include:

1. **Reallocate engineers to Performance Engineer position**
2. **Put "surplus" engineers to work as Drilling Foremen (when the interest is mutual)**
3. **Consider rotational schedule for office Drilling Engineers to improve efficiency**

"Often we become satisfied with an established procedure and only the press of circumstances will bring about improvement in that procedure… **We need to be less self-satisfied with existing programs or techniques and be more venturesome in various other areas in which we operate."**

J.H. Marsee
(Phillips Petroleum, Odessa, Texas, **1952**)

Quoted in Leonard Franklin's **1952** SPE Paper "Drilling & Completion Practices, Spraberry Trend"

Takeaways

Address "old-school" foreman mentality towards reporting

Assess the quality and environment of pre-tour meetings

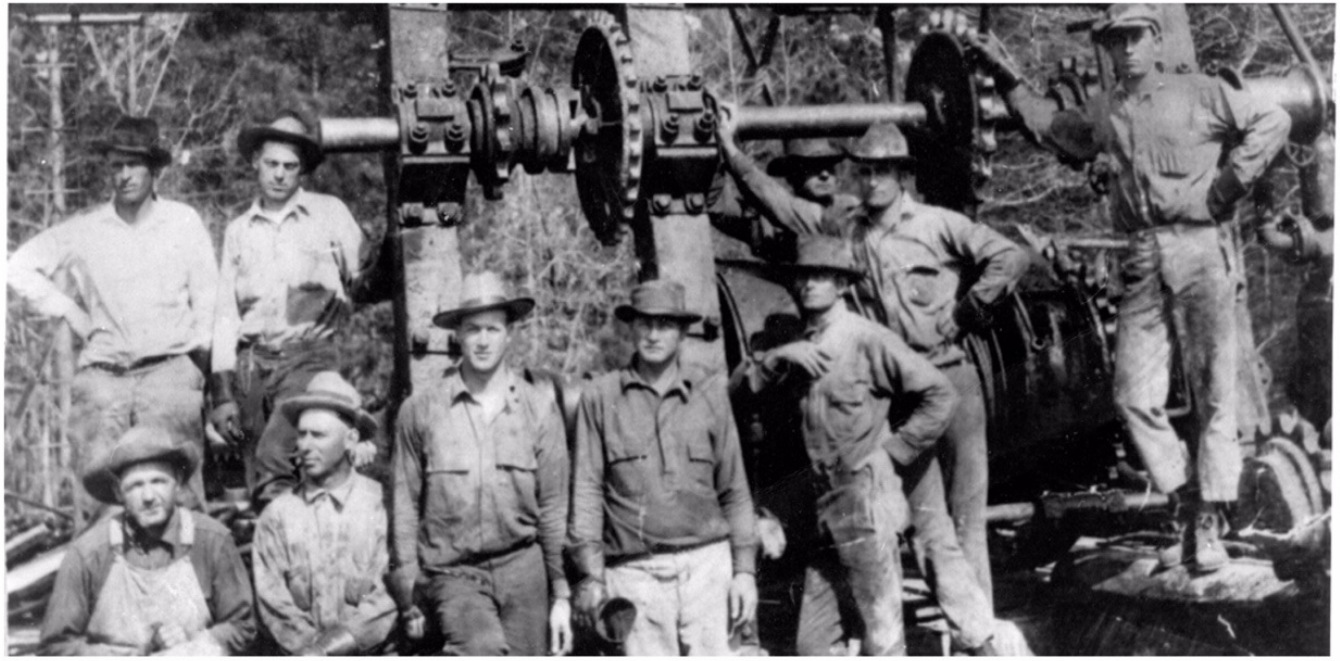
Focus on continuous improvement, data-driven decisions, best practices, and collaboration between rig teams

Critical to maintain dedicated resources to ensure a focus on optimization and performance in a downturn

Cost benefit to the focus on data analysis far outweighs the cost of a drilling engineer

Surround yourself with good people who have passion and perseverance for long term goals[1]

[1] Credit to recent essay by Jeff Banister, Manager of Texas Rangers about the importance of "Grit and Gratitude" (see backup)

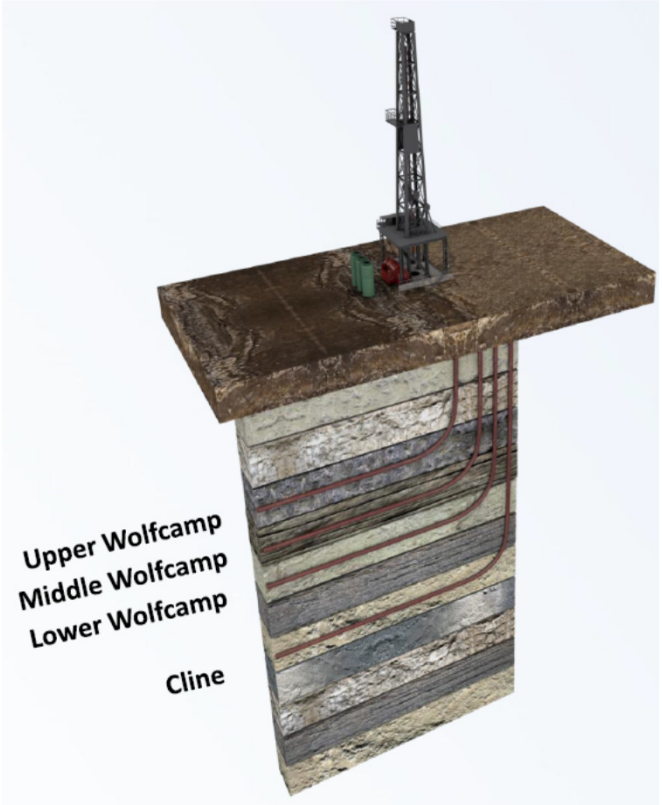


Author's great-grandfather, also a driller, pictured 3rd from left on bottom in 1920

Author with rig crew on Ensign 151 in April 2015

Backup Slides

Project Background



Midland Basin

SE Glasscock and NE Reagan Counties

3 String Well Design: 13-3/8" x 9-5/8" x 5-1/2"

4 key performance metrics for normalizing drilling efficiency

- Spud to RR Ft/Day = Total Measured Depth divided by Total Days from Spud to RR
- Cost/Ft = Total Drilling Cost divided by Total Measured Depth
- 12-1/4" Intermediate Section Ft/Day = Interval Footage divided by Total Days from Drill Out to TD
- 8-1/2" Curve/Lateral Ft/Day = Interval Footage divided by Total Days from KOP to TD

'Spud to RR' data is days from spud of 12-1/4" section to rig release

- Due to turnkey pre-set of surface casing by spudder rig for efficiency
- To compare to rig data that includes surface, add 2 days
- To compare to other well data that includes rig moves, add 5 days

12-1/4” Intermediate Drilling Best Practices

1. Reduce impact damage by keeping PDC bit engaged on bottom by maintaining constant differential pressure of 400-700 psi. Auto-driller settings are paramount and must be calibrated for each rig.

2. 716 PDC bit with 11-3/4” stabilizers above and below 7/8 lobe, 0.3 rpg, 1.83° motor

3. Run (3) Stds of 8” NC56 DC and (3) Stds of 5” HWDP (No 6” DC)
   - In accordance with API RP 7G which recommends BSR ≤ 2.75
   - NC56 connection has 12 times the box fatigue life vs. 6-5/8” Reg (See SPE 87197, Ellis, Reynolds, Lee)

4. Do not back off of differential pressure at top of San Andres or other harder formations. This will encourage vibration and whirl and will actually lead to impact damage to PDC cutters.
   - In accordance with Fred Dupriest Exxon Mobile Presentation

5. Where possible, minimize sliding if anti-collision requirements are met

6. Displace brine to gel WBM system with visc = 40-45 sec/qt at ± 4000’ and dump and dilute to not exceed 9.1 ppg (frac gradient is 9.4 ppg). Pump 20 bbl sweeps every stand until 5500’ and then every other stand. Add polymers on the fly to target min visc of 35 sec/qt when drilling and 45-60 visc at TD.

7. Use of Oil Based Mud (OBM) in Intermediate section may lead to faster drilling time and easier hole conditions but the total fluid management cost is $400,000 more per well more on average vs. WBM

9-5/8” Casing & Cementing Best Practices

1. Place DV Tool and External Casing Packer 200’ above top of Clear Fork formation

2. Circulate BU with cement unit, then swap to rig pumps and circulate for 4 hours between stages to allow Stage 1 cement to set up in case the packer doesn’t fully isolate weak zones below

3. Plan minimum cement slurry density and height to meet RRC requirements to reduce the chances of lost returns
   - Stage 1: 500’ of 13.2 ppg H-plus tail, 11.9 ppg 50/50 H-Poz (10% excess)
   - Stage 2: 300’ of 13.5 ppg C (100% excess), 11.9 ppg 50/50 C-Poz (250% excess)
   - Understand cost/bbl of lead cement and compare to spread rate cost to run temp log. Break even point is circulating and dumping roughly 200 bbls of cement to surface (don’t be afraid to pump high excess on stage 2 lead)

4. Do not over-displace any portion of shoe tract. Not much downside to having to drill out a little extra cement (different for production casing)

5. For this geographical area, in this data set, we have been 100% successful in achieving required shoe integrity for all target zones when placing the 9-5/8” shoe 60’ above KOP with the curve planned on 8s

6. If insufficient cement top is achieved, and temp log is inconclusive, run Ultrasonic Inspection Log to determine top of cement. The lightweight lead cement often doesn’t show up on a traditional bond log but is visible on the USIT log.

7. Install rotating head rubber after drilling out 9-5/8” shoe tract and circulating out plug debris.

8-1/2” Curve/Lateral Best Practices

1. Where possible, utilize short bit-to-bend (4.2’ to 4.5’) 1.83° motors and 516 PDC bits that are efficient in both the curve and lateral which allows for one-run BHA strategy

2. Utilize 7/8 Lobe, 0.3 rev/gal slow speed motors in all zones. This allows you to run optimal topdrive rpms for hole cleaning (70-90) while reducing revs at the bit to prolong bit life (shoulder wear) in harder formations.

3. Utilize K&M drilling parameters (70- 90 RPMs) in the lateral for optimal hole cleaning and ROP

4. Target 450 – 650 differential pressure when rotating in the lateral

5. Weight up to max expected mud weight by 30° in the curve to avoid instability

6. Plan curves on 8° /100 to avoid cost of ± $180,000 2-trip scenario for insufficient BRs

7. Always know your lowest landing limit and your DL needed to land at the limit prior to tripping for a higher bend motor

8. Perform Formation Integrity Test after drilling out 9-5/8” shoe to confirm integrity of primary cement job and to confirm ability to achieve the mud weight required to drill the planned landing point

9. Prior to spending > $30,000 to pull rods and run a gyro survey in offset vertical wells, determine NPV of existing well, and utilize a risk-based calculation to determine chance of collision and risked cost of collision.

5-1/2” Casing & Cementing Best Practices

1. At TD, circulate at 100 rpms for 1 hour per 1000’ of lateral racking back 1 stand after each bottoms up. Spotting beads and planned wiper trips have been proven unnecessary. Rack back 10 stands and start laying down pipe if first 10 pull slick. Adjust as needed for observed hole conditions.

2. Mix cement at maximum practical rates and displace at a minimum of 5-7 bpm to achieve adequate displacement efficiency in lateral interval where casing is laying on low side of hole and mud on low side has the potential to be bypassed.

3. If concerned with lost returns, model hydraulics of cement job, adjust design accordingly, and consider slowing down displacement rate once the cement reaches 30 degrees in the curve (and begins to lift)

4. Utilize a low cost cement scavenger to recover OBM left on the annulus of the production casing.

The True Meaning of Leadership

Author's Note: Jeff Banister was hired before the 2015 season after the Rangers had the worst record in the American League in 2014. As of 9/1/15 the team is currently 6 games over 0.500 and 1 game up in the playoff wild card standings

By Jeff Banister, Texas Rangers Manager, essay published on 8/24/15 (paraphrased) http://espn.go.com/blog/buster-olney/insider/post?id=11034

Grit is perseverance and passion for long-term goals. Grit is taught through a growth mindset, and for teams that have it, it can qualify as a huge advantage. We see this in the daily celebration of progress.

With the Rangers, our core group of players loves to celebrate the small victories we see each day. Teams with true grit understand that the game is filled with challenges and failure and a long grind of 162-plus games. You know a team has it when each player, 1 through 25, exhibits this quality and each individual goes to another level of fight. Different players will step up on different nights, and the sole focus is on execution and there are no excuses or explanations

Our best example of grit this season has been through the leadership and resiliency of our team captain (Adrien Beltre). He shows up every day with an unwavering commitment to getting the job done, no matter what. He has a complete commitment to the mission, and doesn't let distractions, the odds or the opponent affect his level of commitment.

I don't have all the answers, but I do know that today's players are more talented than ever, and they have high expectations of their leader. Coaching the 21st century athlete, you can't coach today's game by yesterday's rules. The millennial athlete needs for their leader to be a serving leader who focuses primarily on the growth and well-being of the people and the communities in which they belong. I believe a requisite of service leadership is gratitude.

In our organization, we try to cultivate this daily. Individuals need to experience a sense of appreciation for their contributions and be acknowledged for their efforts to the team. When doing so, it enhances the sense of well-being and goodwill among individuals and groups and creates meaningful relationships among team members.

We believe in the adage that, "you are either growing or getting old." A pursuit is a difficult and long-term mission. The mission you are on must mean something to you, and you have to be committed to not stopping until you figure out a way to get it done. Grit and gratitude are catalysts of successful people, organizations and communities. They are essential winning ingredients to put you into position to achieve your goals, or in our case, win championships.

A few final thoughts on leadership principles we try to live by in the Rangers organization:

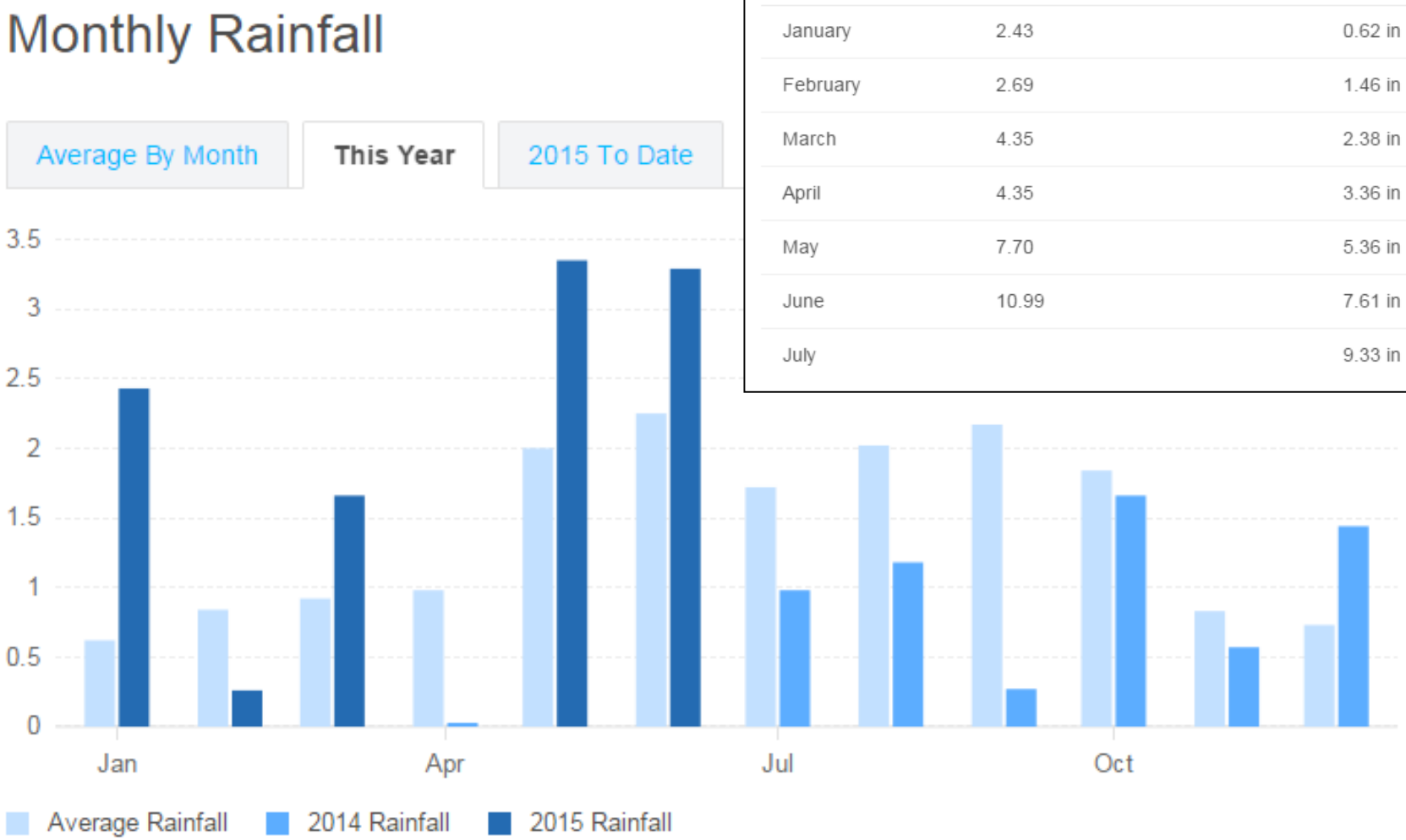
1. Leadership today is about authenticity, not authority.
2. You can lead only as far as you grow, and you will grow only as far as you let yourself.
3. Understand your "why." For me, it's to help and develop our team as we strive to be the standard-bearer for a championship organization.

I wish you all the best in your own leadership journey.

Midland Rainfall Data

http://rainfall.weatherdb.com/l/251/Midland-Texas

http://www.srh.noaa.gov/maf/?n=cli_maf_pcpn_annual



Month	2015 Year To Date	Average Year to Date
January	2.43	0.62 in
February	2.69	1.46 in
March	4.35	2.38 in
April	4.35	3.36 in
May	7.70	5.36 in
June	10.99	7.61 in
July		9.33 in