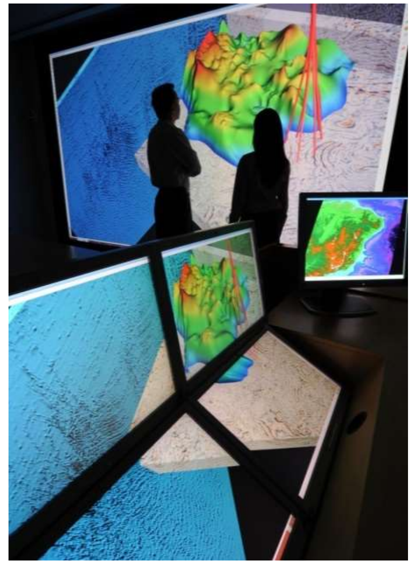



Laredo Sugg 171-A Pad GTI HFTS Project

Microseismic Fracture Mapping

Neil Stegent, Cody Candler, Magdy Hassan, and Mohamed Sawan

HALLIBURTON

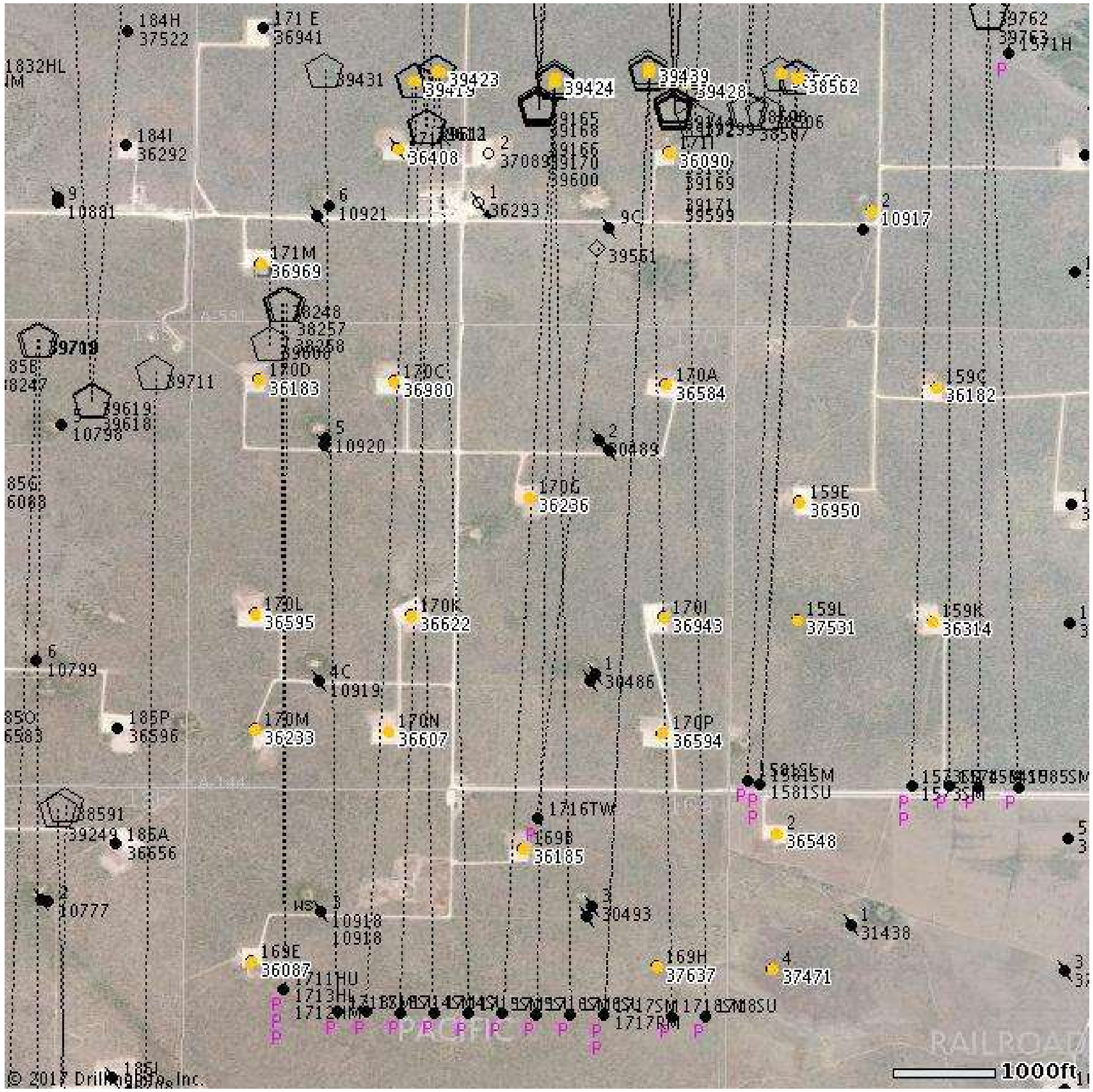
Objectives and Setup

- Overall fracture generation:
    - Overall fracture network coverage (entire pad).
    - Effective reservoir stimulation coverage resulting from chevron drilled pattern
    - Investigate interaction with large-scale pre-stressed natural features in the area, if any.
    - Fracture geometry (height, length, cluster coverage width, and azimuth)
    - Relative degree of fracture complexity
    - Maximum potential upward fracture growth from downhole microdeformation.
- Determine the relationships between fracture height, half-length and time (i.e., injected volume).
- Investigate stimulation interaction with offset vertical wells.
    - Impact of the refrac of the 158H wells on resulting fracture development of the 8SU
- Investigate the impact of zipper frac completion
    - sequence and timing of adjacent stages
    - impact of completing Upper Wolfcamp wells prior to Middle Wolfcamp
- Examine the impact of completion strategy (number of perf clusters per stage and cluster spacing)
- Examine MSM data relative to the Slant Well (6TW) core intervals (6SU and 6SM)

Project Setup

Map View – Project wells

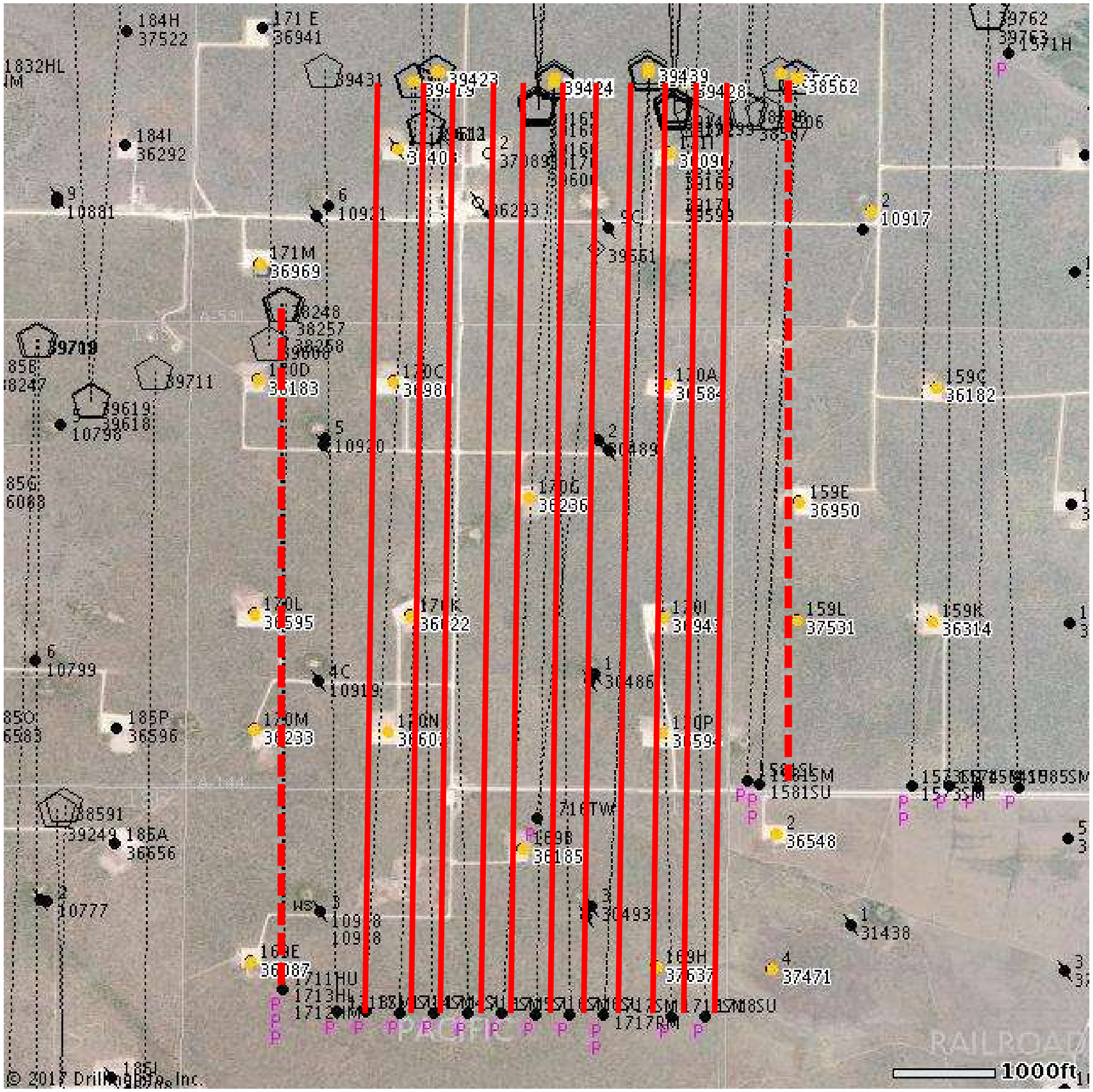
previous production/depletion in this area



HALLIBURTON

Map View – Project wells

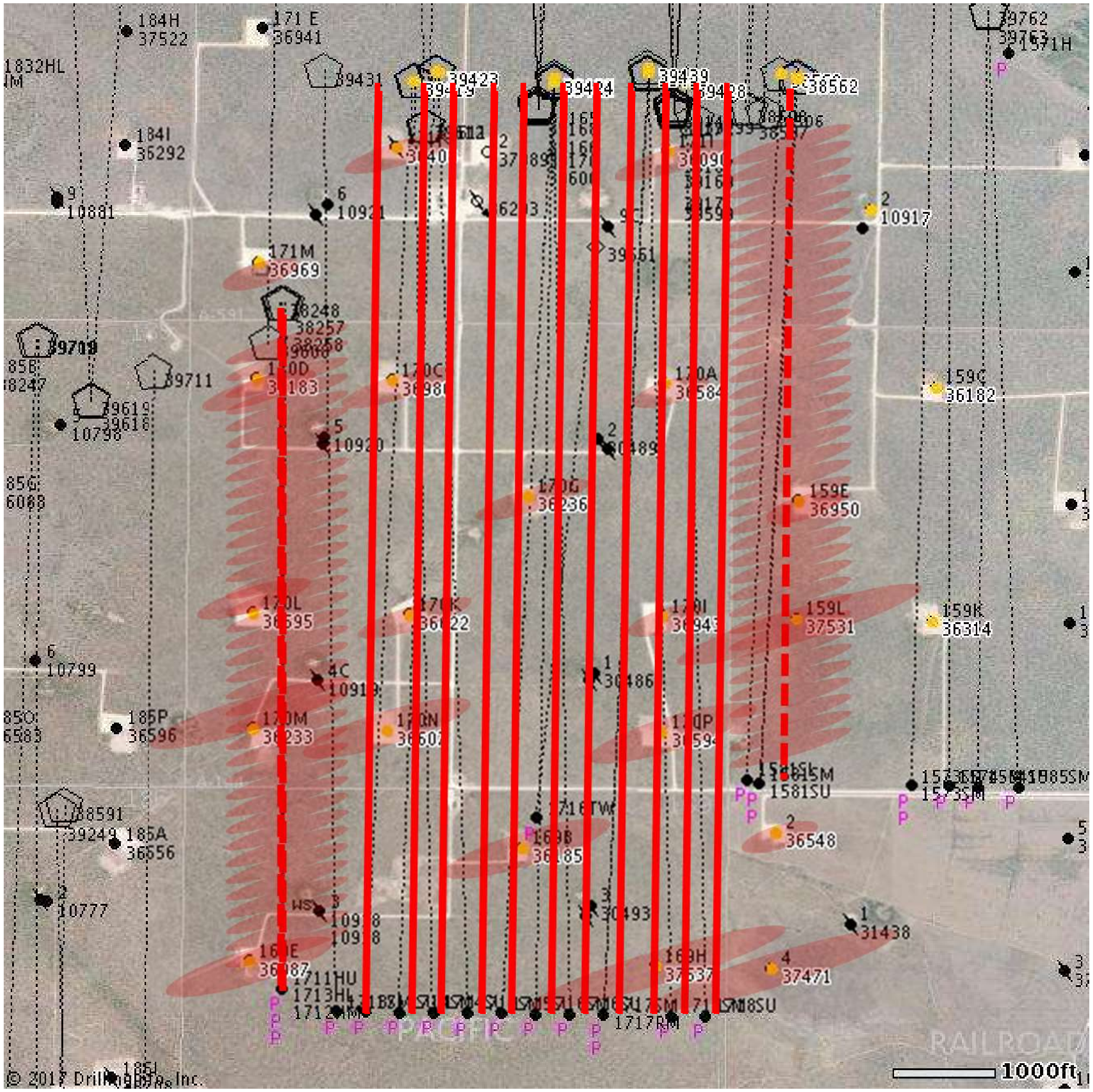
previous production/depletion in this area



HALLIBURTON

Map View – Project wells

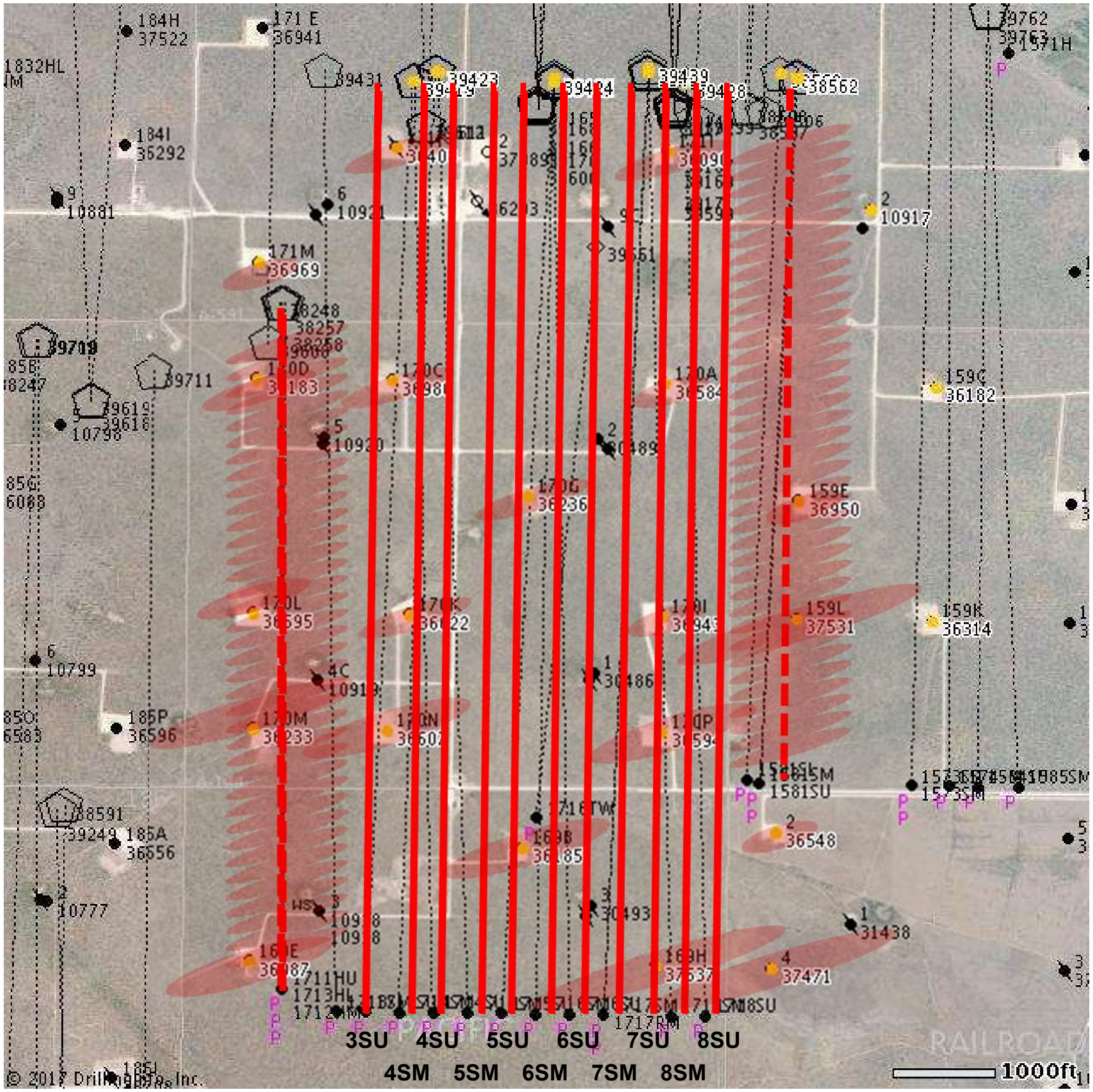
previous production/depletion in this area



HALLIBURTON

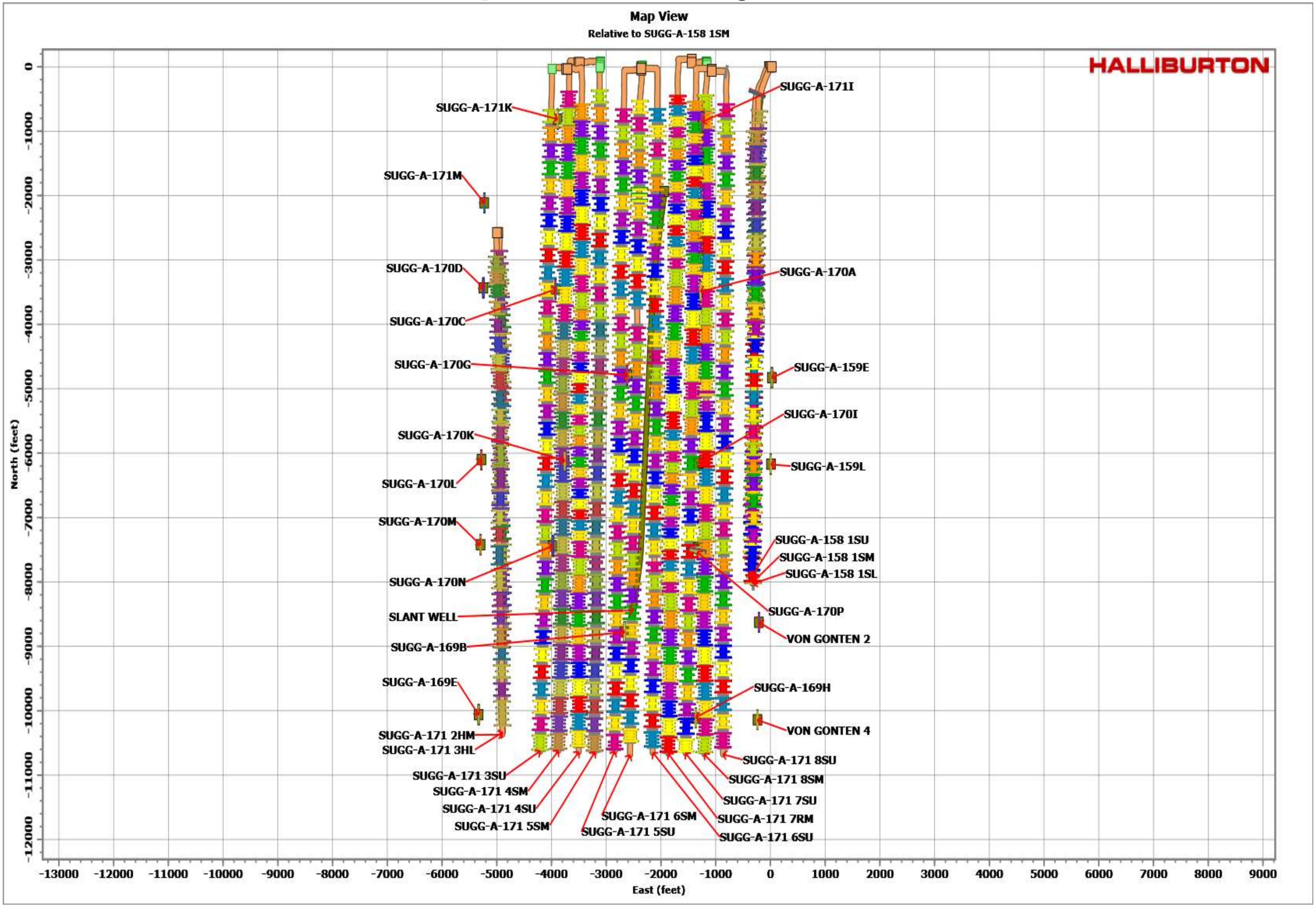
Map View – Project wells

previous production/depletion in this area

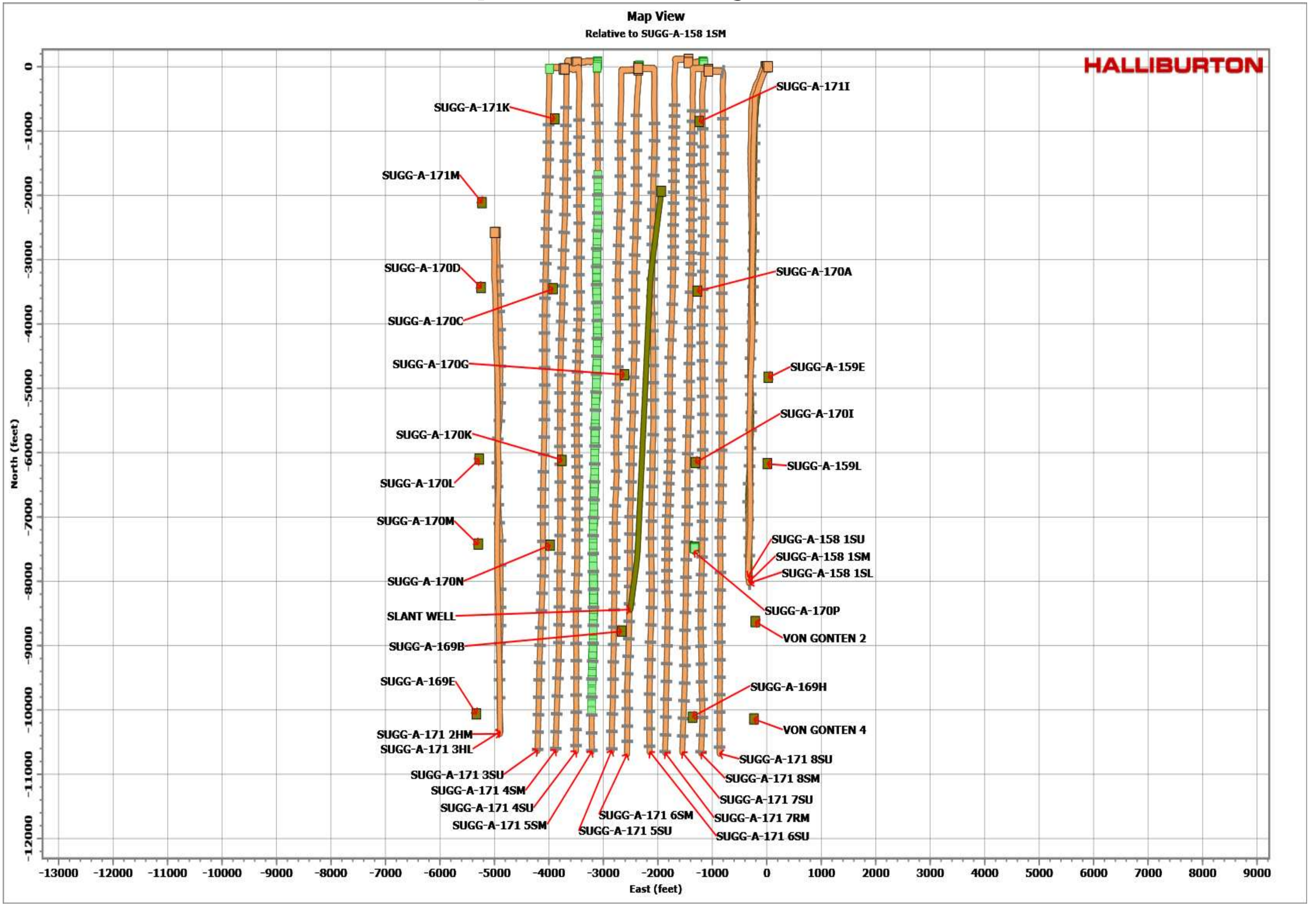


HALLIBURTON

Map View – Project wells

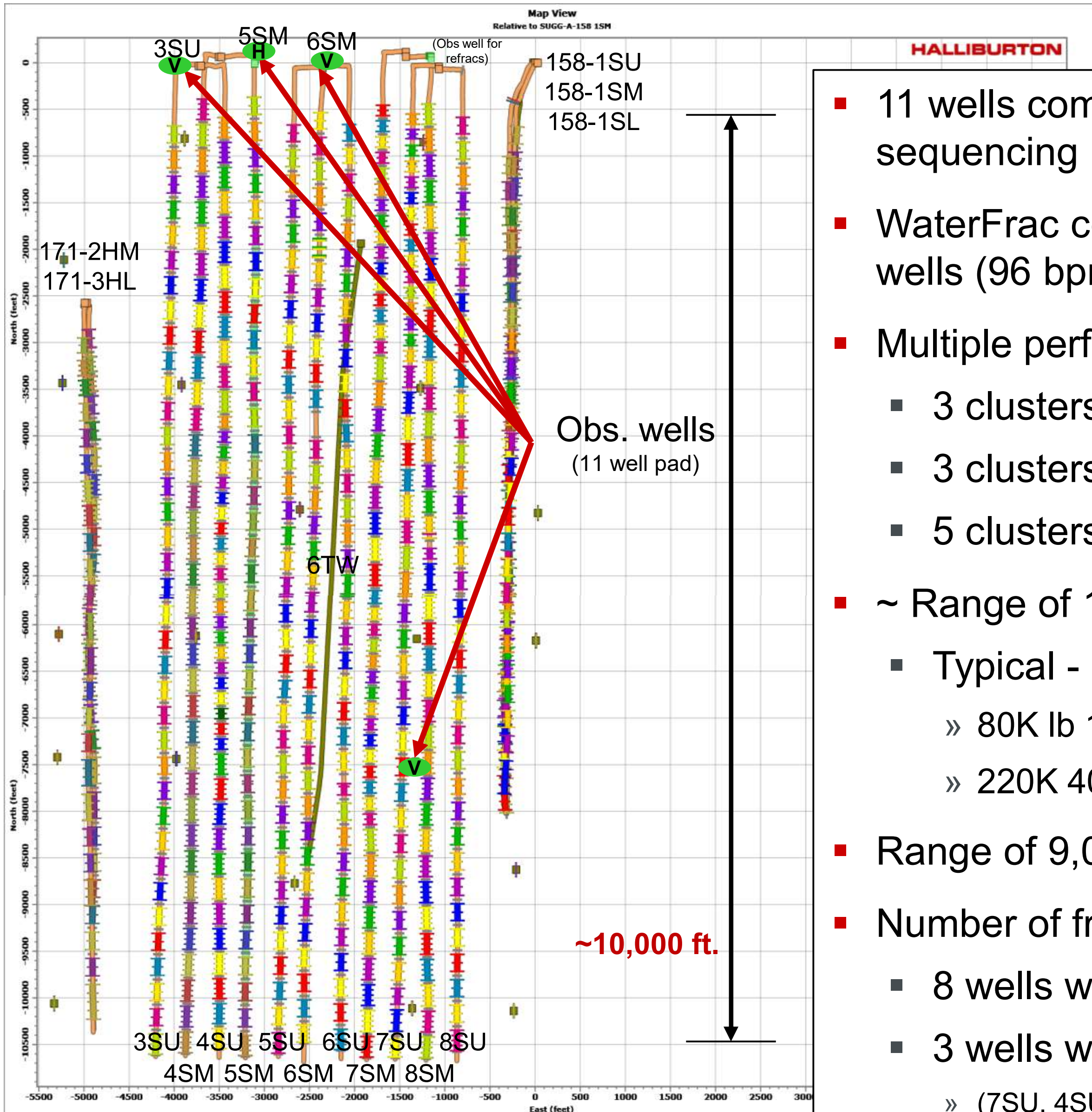


Map View – Project wells



Sugg A-171 11 well pad setup

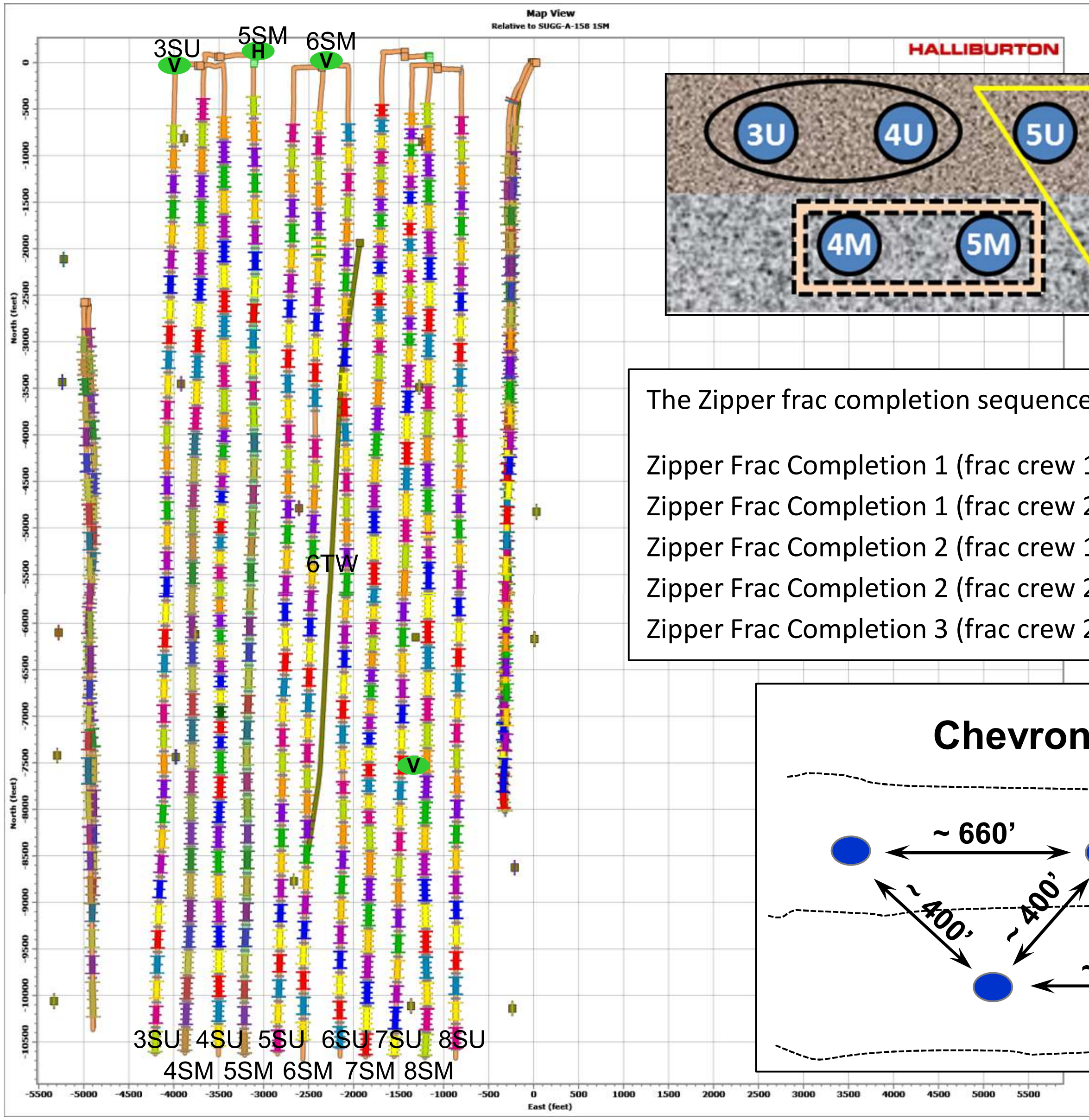
Upper and Middle Wolfcamp Formations
Reagan County, TX

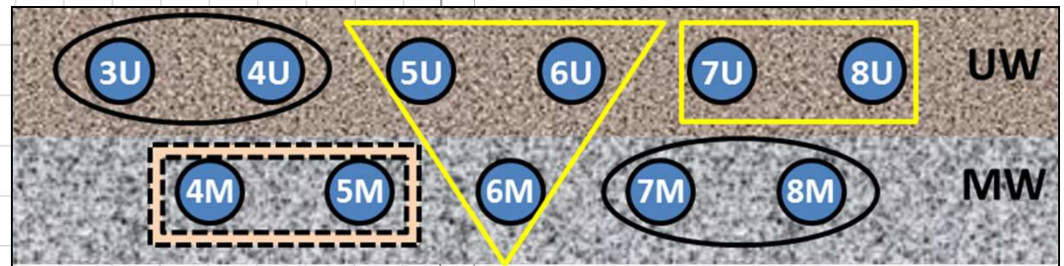


- 11 wells completed using zipper frac sequencing
- WaterFrac completion design used on all wells (96 bpm).
- Multiple perforation schemes utilized
  - 3 clusters, 90' spacing
  - 3 clusters, 53' spacing
  - 5 clusters, 53' spacing
- ~ Range of 1,100 – 1,800 lb/ft of lateral.
  - Typical - 300K lb per stage (most wells).
    - 80K lb 100-mesh.
    - 220K 40/70-mesh Ottawa.
- Range of 9,000 – 15,000 bbls/stage
- Number of frac stages range
  - 8 wells with 37 frac stages
  - 3 wells with 43, 45, and 49 frac stages
    - (7SU, 4SU, and the 7SM)

HALLIBURTON

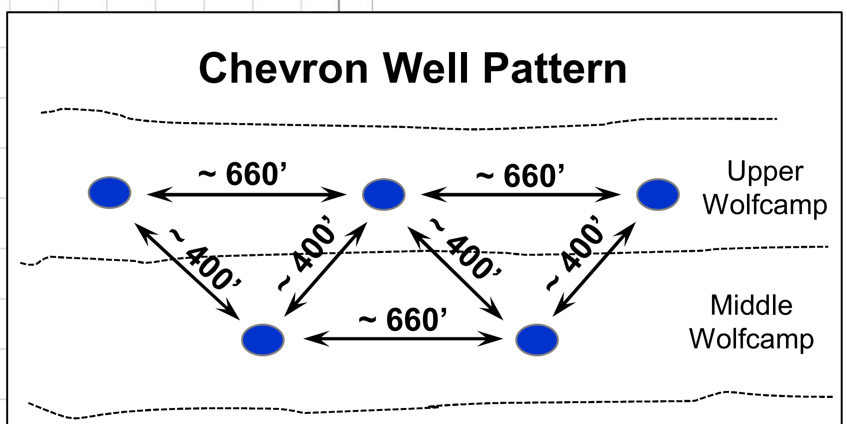
Sugg A-171 11 well pad – Zipper Frac Sequence





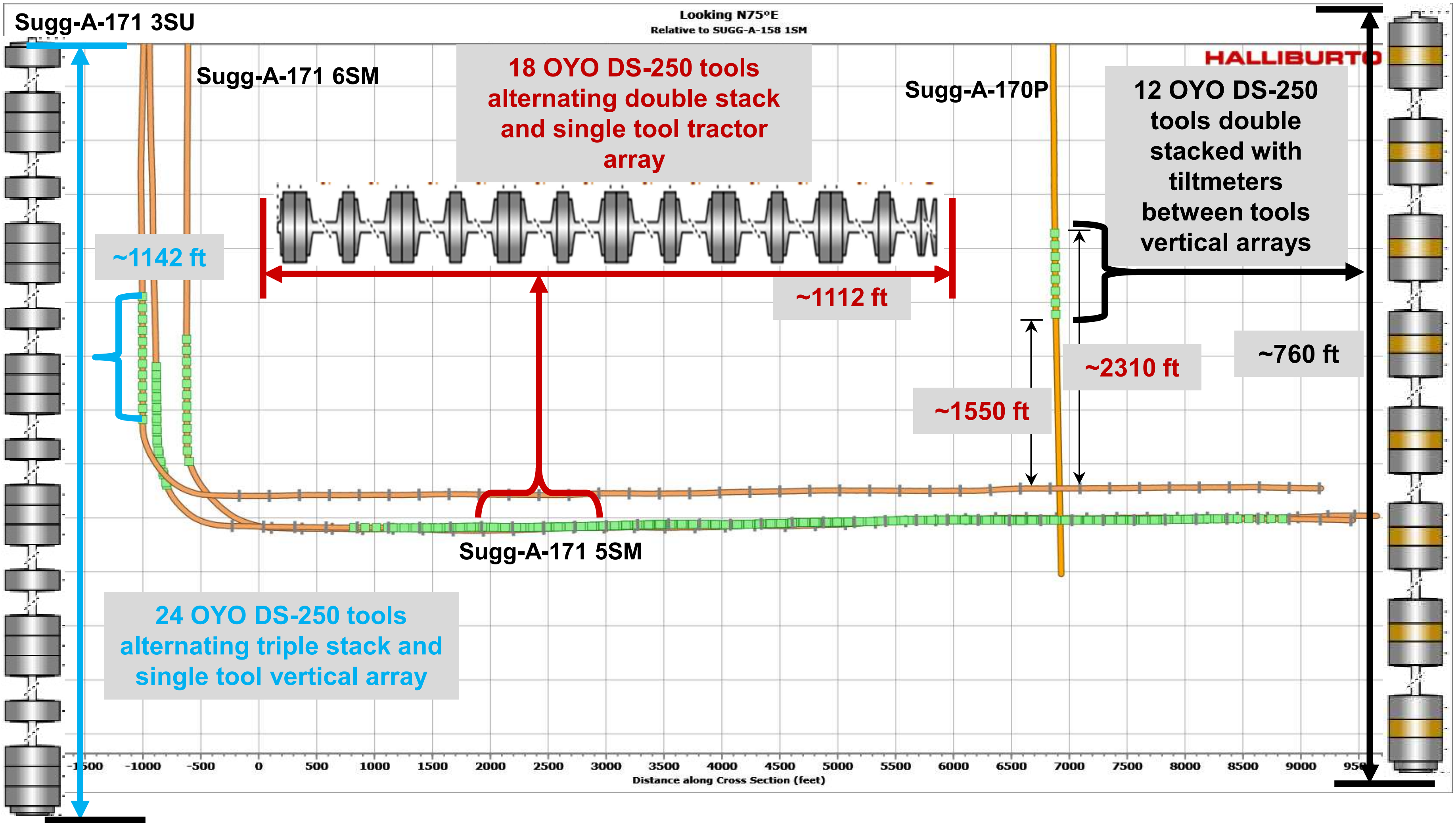
The Zipper frac completion sequence (and # of stages) was as follows:

Zipper Frac Completion 1 (frac crew 1): Wells 7SU (43) and 8SU (37)
Zipper Frac Completion 1 (frac crew 2): Wells 5SU (37), 6SU (37), and 6SM (37)
Zipper Frac Completion 2 (frac crew 1): Wells 7SM (49) and 8SM (37)
Zipper Frac Completion 2 (frac crew 2): Wells 3SU (37) and 4SU (45)
Zipper Frac Completion 3 (frac crew 2): Wells 4SM (37) and 5SM (37)



HALLIBURTON

Sugg A-171 11 well pad setup

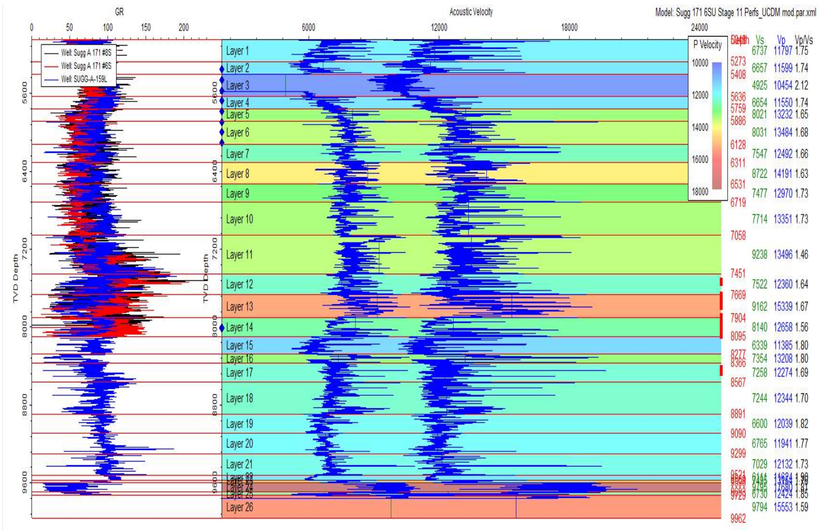


- Downhole microdeformation tiltmeters installed at each level of array in the Sugg-A-170P
  - Distance from Sugg-A-170P geophone array to toe of lateral ~ 3700 ft.
- Horizontal array (~ 1112 ft.) was constantly repositioned to minimize listening distance.

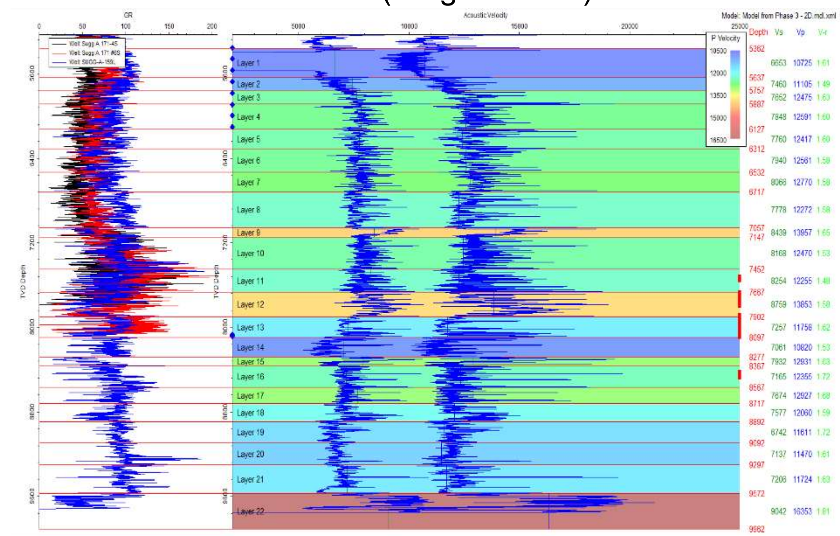
HALLIBURTON

Final Velocity Models

Velocity model Phase 1 and 2 (dual array stages)

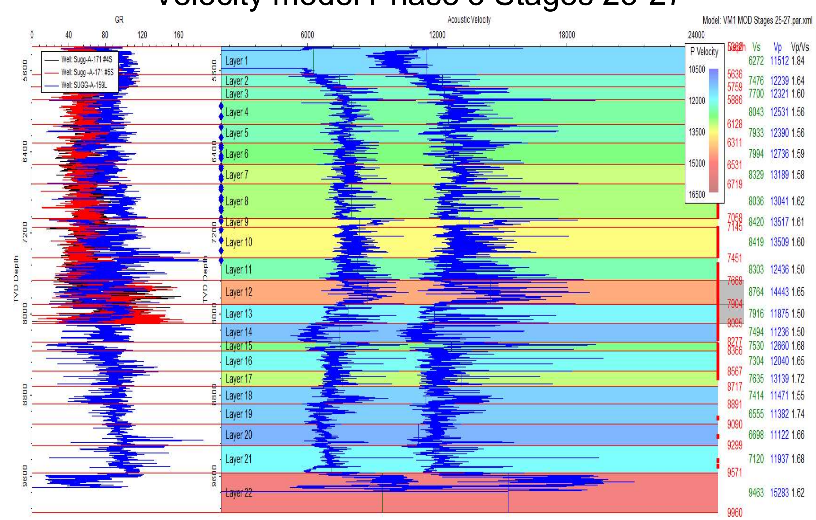


Velocity model Phase 2 (Single array stages) and Phase 3 (Stages 28-37)



- Phase 1 (5SU, 6SU, 6SM and 8SU, 7SU)
  - Array in 170P (Vertical)
  - Array in 5SM (Horizontal)
- Phase 2 (3SU, 4SU and 8SM, 7RM)
  - Array in 170P (Vertical)
  - Array in 5SM (Horizontal and Vertical)
- Phase 3 (4SM, 5SM)
  - Array in 3SU (Vertical)
  - Array in 6SM (Vertical)

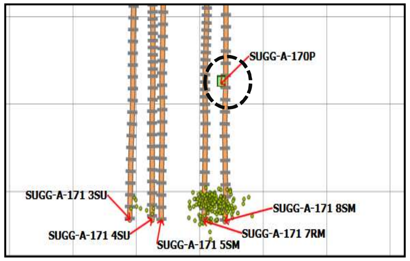
Velocity model Phase 3 Stages 25-27



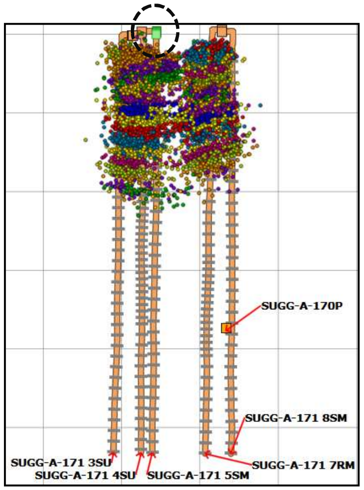
Summary of Geophone Array and relative Treatment Well

- Phase 1 (5SU, 6SU, 6SM and 8SU, 7SU)
    - Array in 170P (Vertical)
    - Array in 5SM (Horizontal)
- Phase 2 (3SU, 4SU and 8SM, 7RM)
    - Array in 170P (Vertical)
    - Array in 5SM (Horizontal and Vertical)
- Phase 3 (4SM, 5SM)
    - Array in 3SU (Vertical)
    - Array in 6SM (Vertical)

- 3SU and 8SM – Stage 1
    - Array in 170P Only (Vertical)
- 3SU – Stages 33-37
- 4SU – Stages 31-46
- 7RM – Stages 31-49
    - Array in 5SM (Vertical)



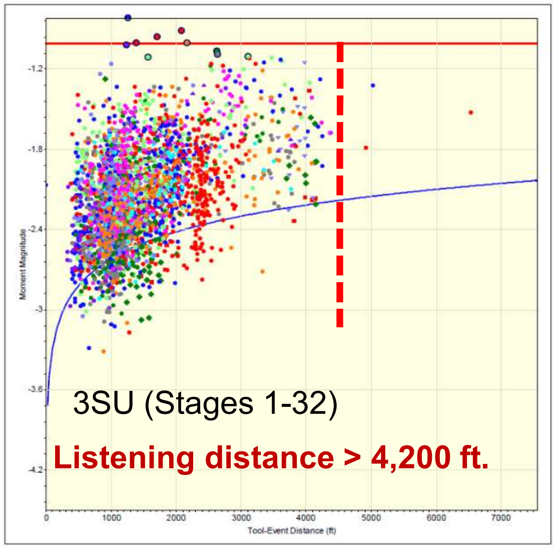
3SU and 8SM – Stg 1

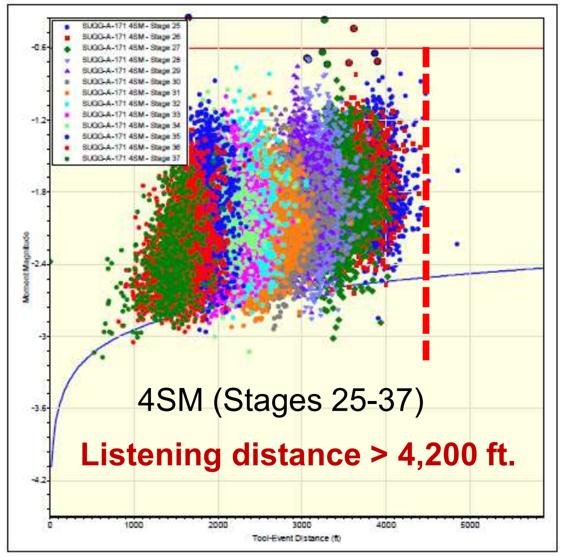


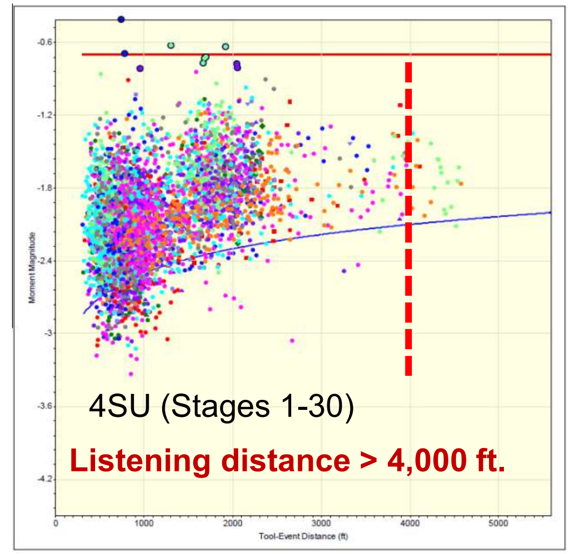
3SU – Stages 33-37
4SU – Stages 31-46
7RM – Stages 31-49

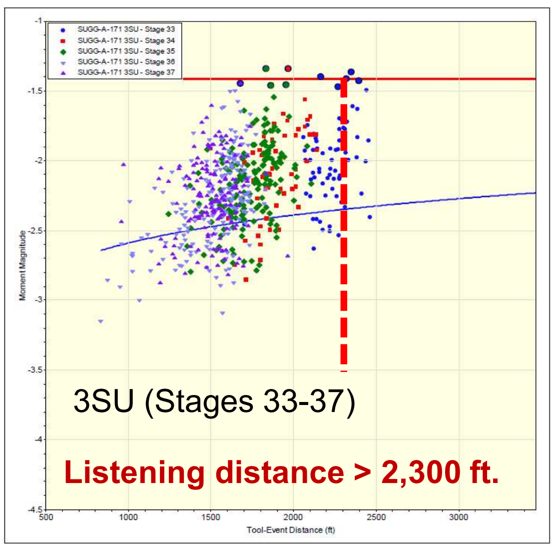
HALLIBURTON

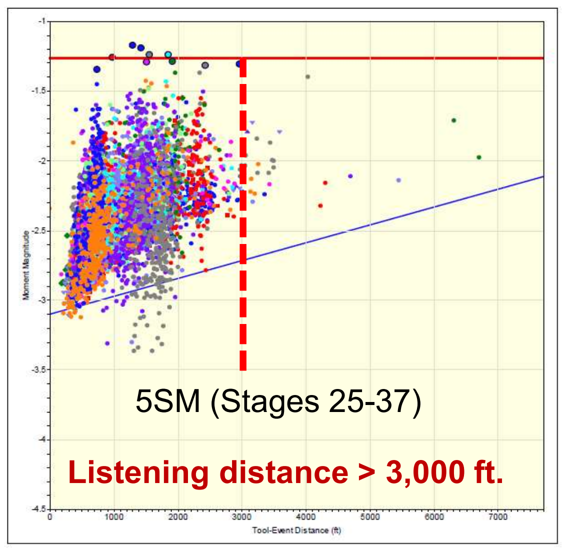
Moment Magnitude Vs. Tool-Event Distance

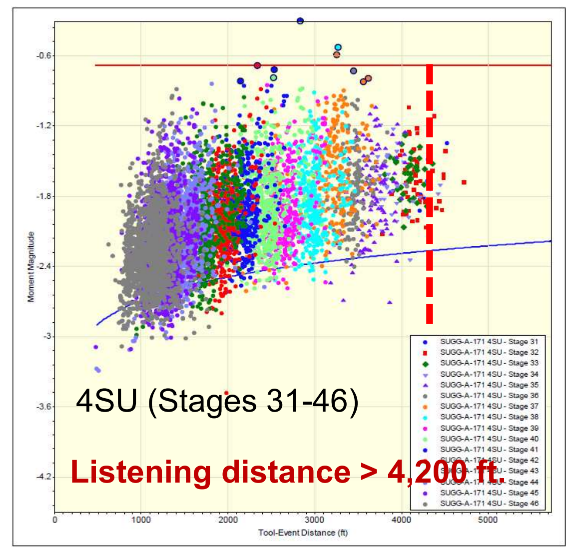






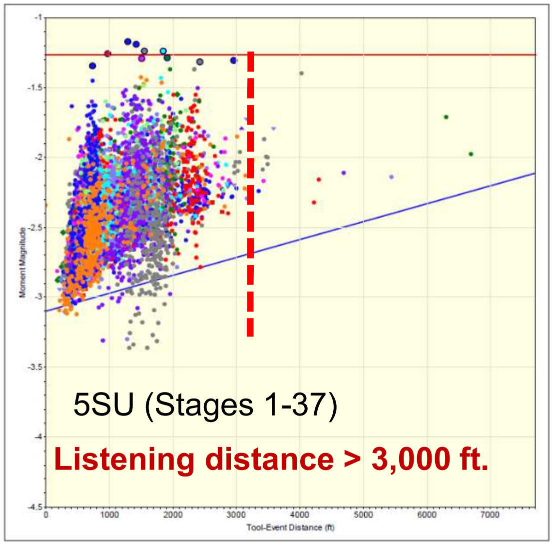


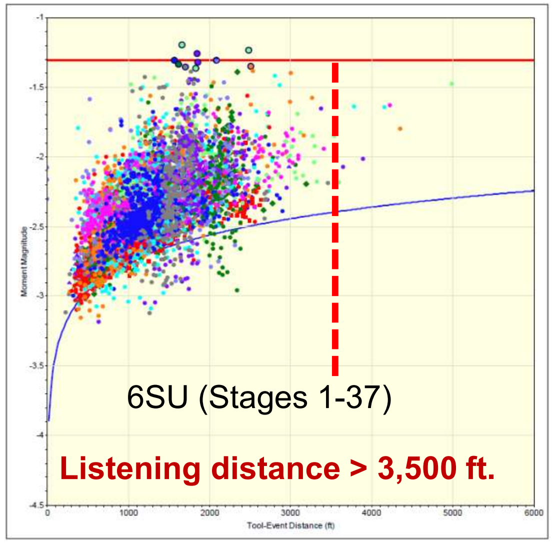


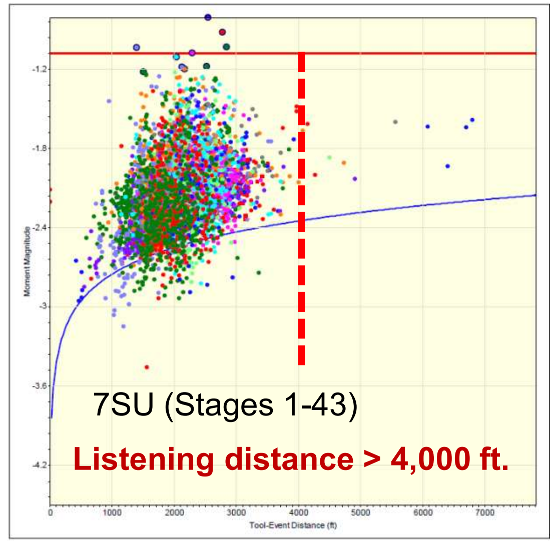


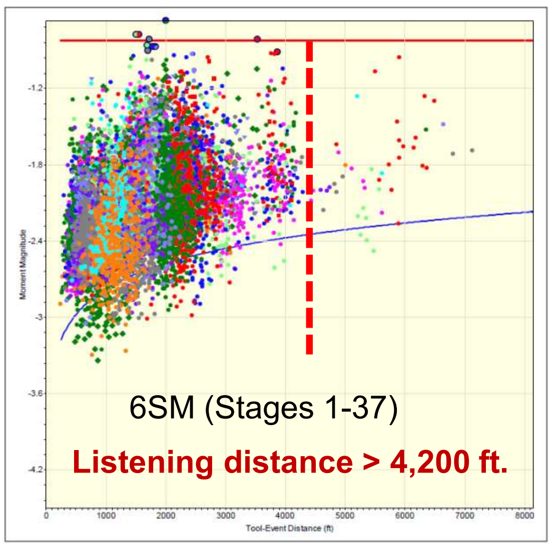
HALLIBURTON

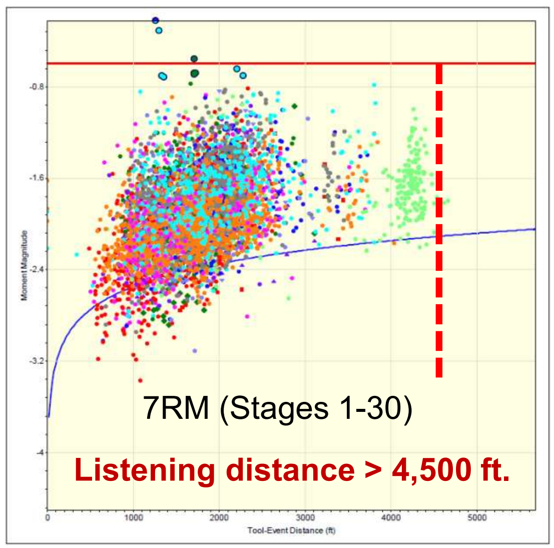
Moment Magnitude Vs. Tool-Event Distance

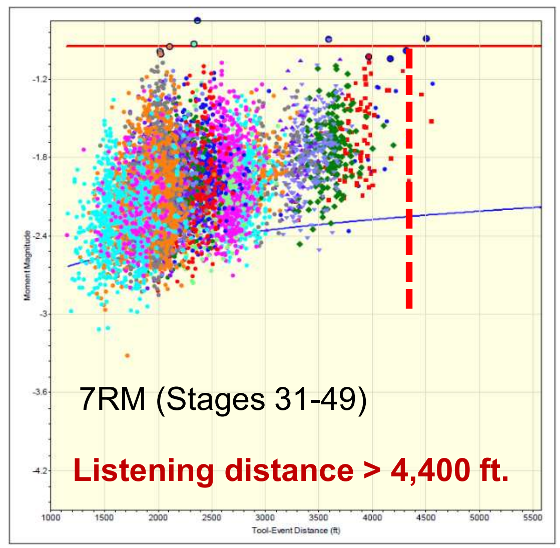






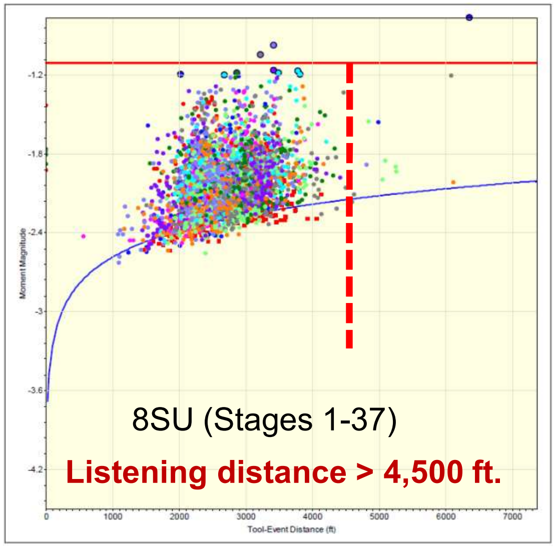


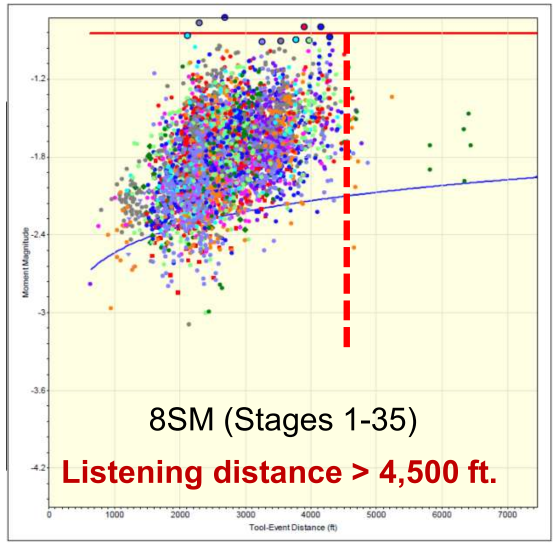


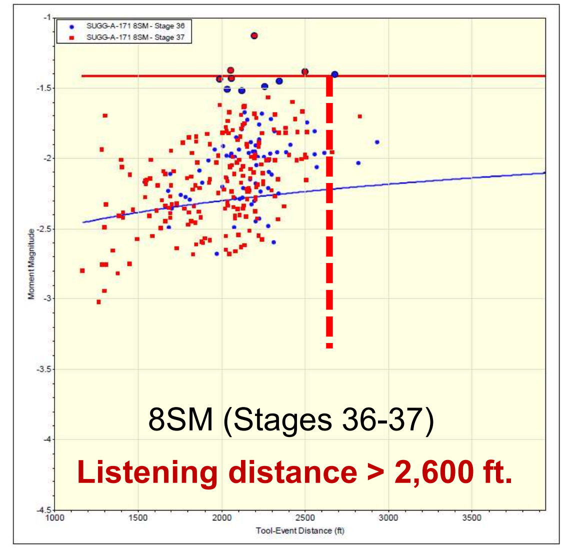


HALLIBURTON

Moment Magnitude Vs. Tool-Event Distance







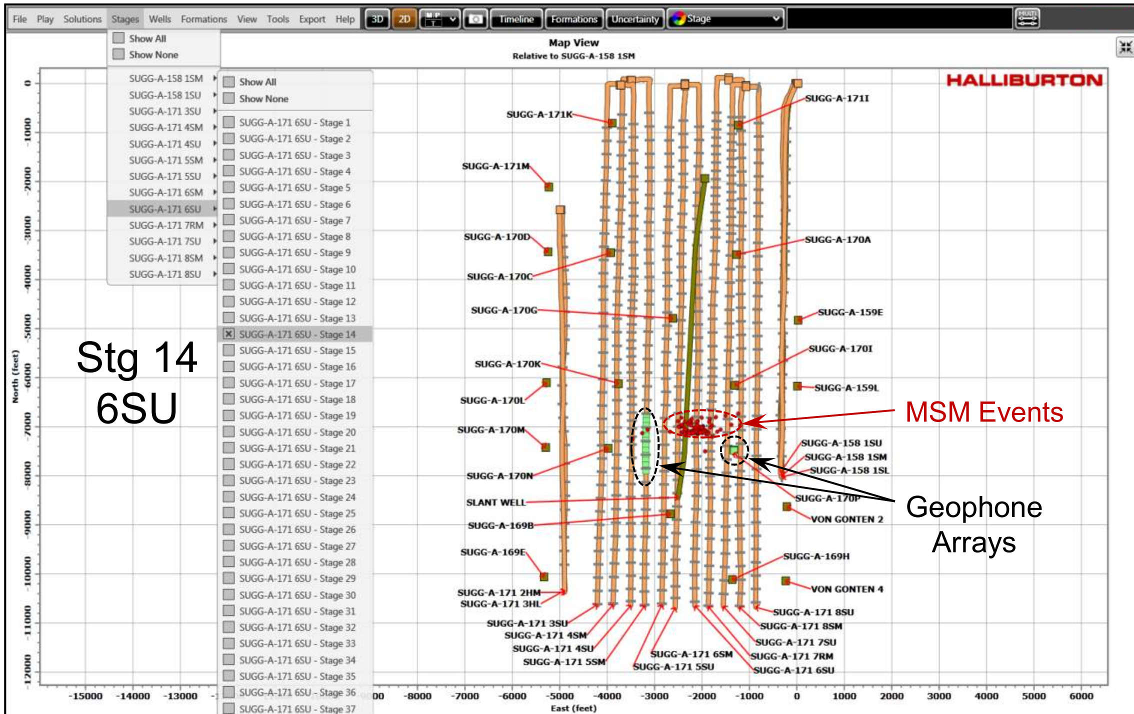
- Phase 1 (5SU, 6SU, 6SM and 8SU, 7SU)
  - Array in 170P (Vertical)
  - Array in 5SM (Horizontal)
- Phase 2 (3SU, 4SU and 8SM, 7RM)
  - Array in 170P (Vertical)
  - Array in 5SM (Horizontal and Vertical)
- Phase 3 (4SM, 5SM)
  - Array in 3SU (Vertical)
  - Array in 6SM (Vertical)

- Phase 2
  - 3SU and 8SM – Stage 1
    - Array in 170P Only (Vertical)
- Phase 2
  - 3SU – Stages 33-37
  - 4SU – Stages 31-46
  - 7RM – Stages 31-49
    - Array in 5SM (Vertical)

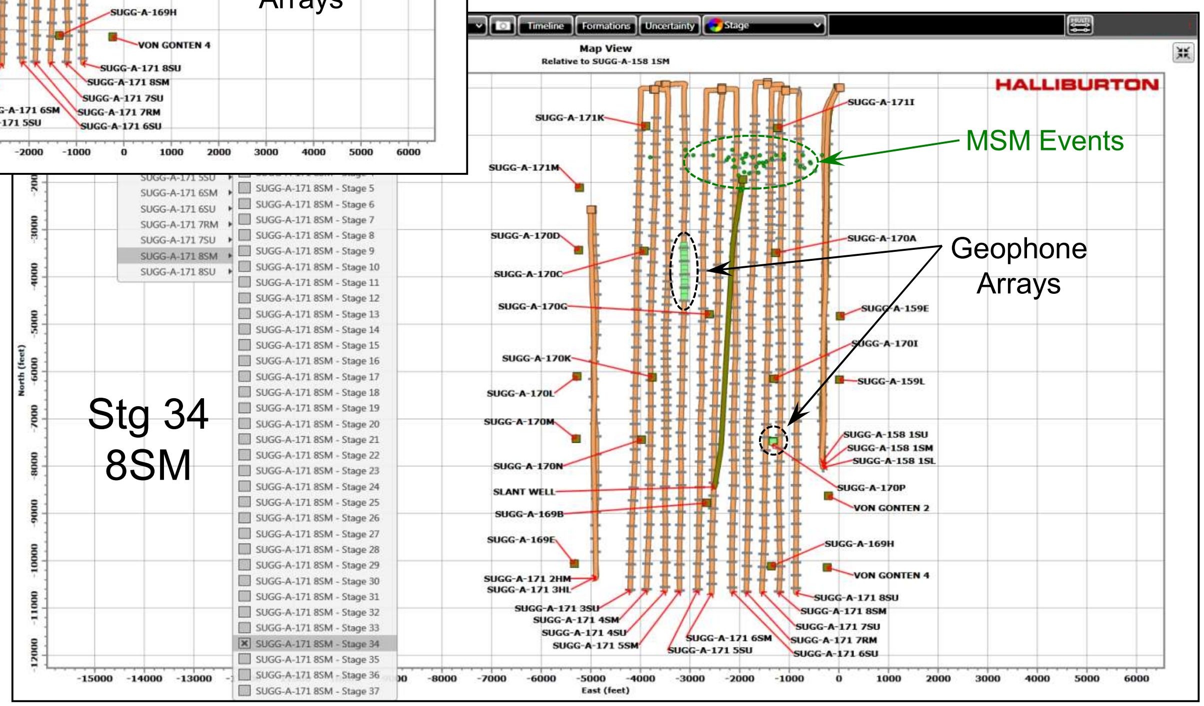
HALLIBURTON

Consider other artifacts of the microseismic measurement

Example: location (distance) of geophones



- Stage 14 on the 6SU was between the horizontal array in the 5SM and the vertical array in the 170P
- Stage 34 on the 8SM was a long distance from both arrays and the uncertainty in the event locations needs to be taken into consideration, as well as other artifacts of the measurements.



Results and Conclusions

Main Results and Conclusions

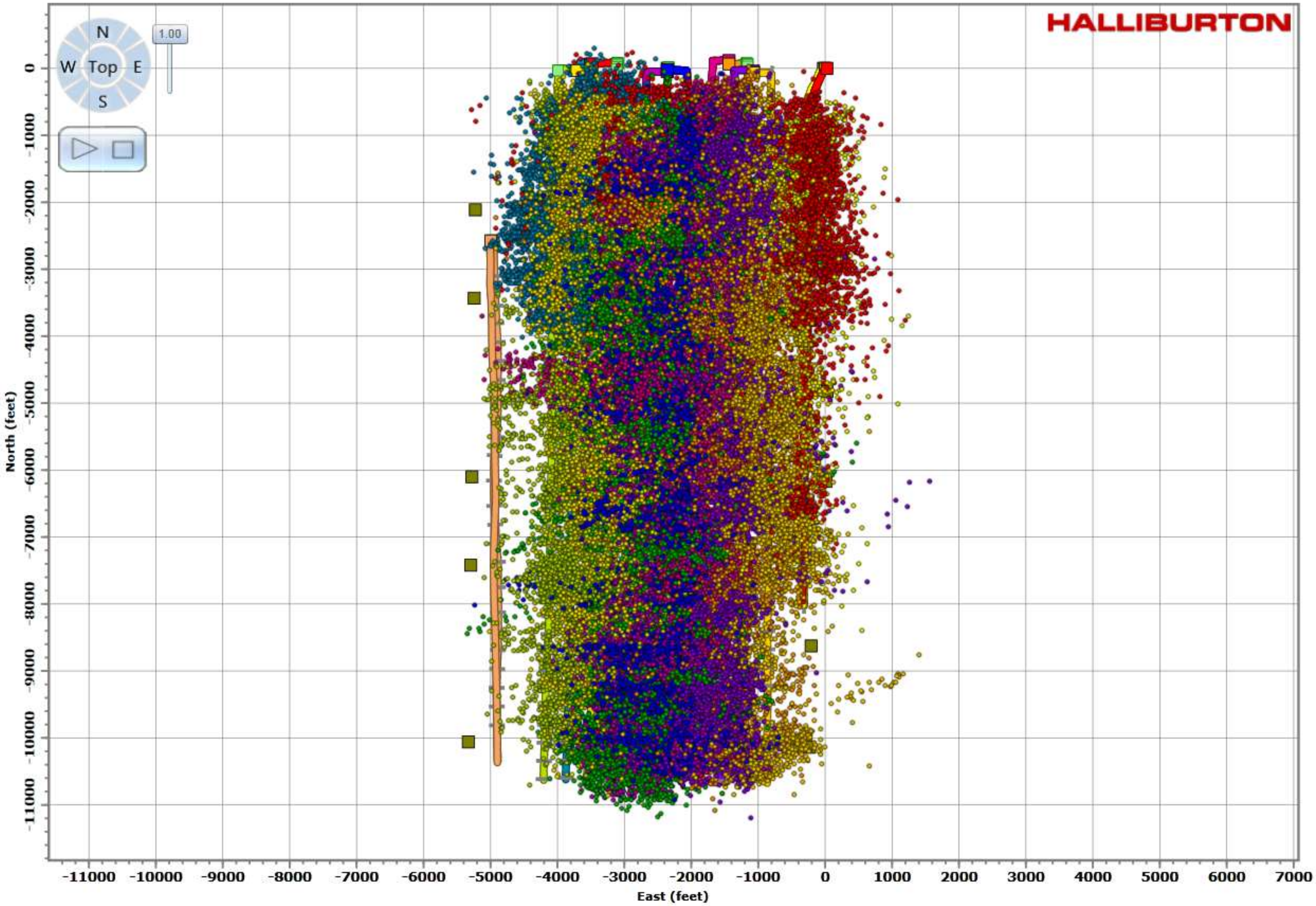
- Fracture geometry relatively consistent for all 11 wells, some localized differences may exist (offset production, interaction with previous fracs, etc.).
- Primary azimuth N76°E, secondary azimuth N46°W.
  - Moderate overall degree of complexity
  - Additional exposed surface area in secondary direction likely achieved.
- Additional fracture complexity possibly the result of back-to-back completions (zipper frac) and stress-shadowing effects (fracture leak-off time (long) > time between well stimulation).
  - Minimal far-field fracture simplification, constructive interaction between stimulations.
  - Fractures in lower Wolfcamp relatively contained due to upper Wolfcamp completions.
  - Growth into upper section of the lower Wolfcamp was minimal but potentially propped.
- Mostly symmetric or slightly asymmetric fracture growth (due to vertical offset production).
- Hydraulic fracture half-length typically 555 to 1,090 ft along primary fracture azimuth with an average half-length of 830 ft.
- Average total hydraulic fracture height of ~1,000 ft in the upper Wolfcamp and ~860 ft, the middle Wolfcamp
- Lower Spraberry formation appears to have been penetrated in most upper Wolfcamp completion stages, but not likely propped due to low fluid viscosity (Stokes Law).

HALLIBURTON

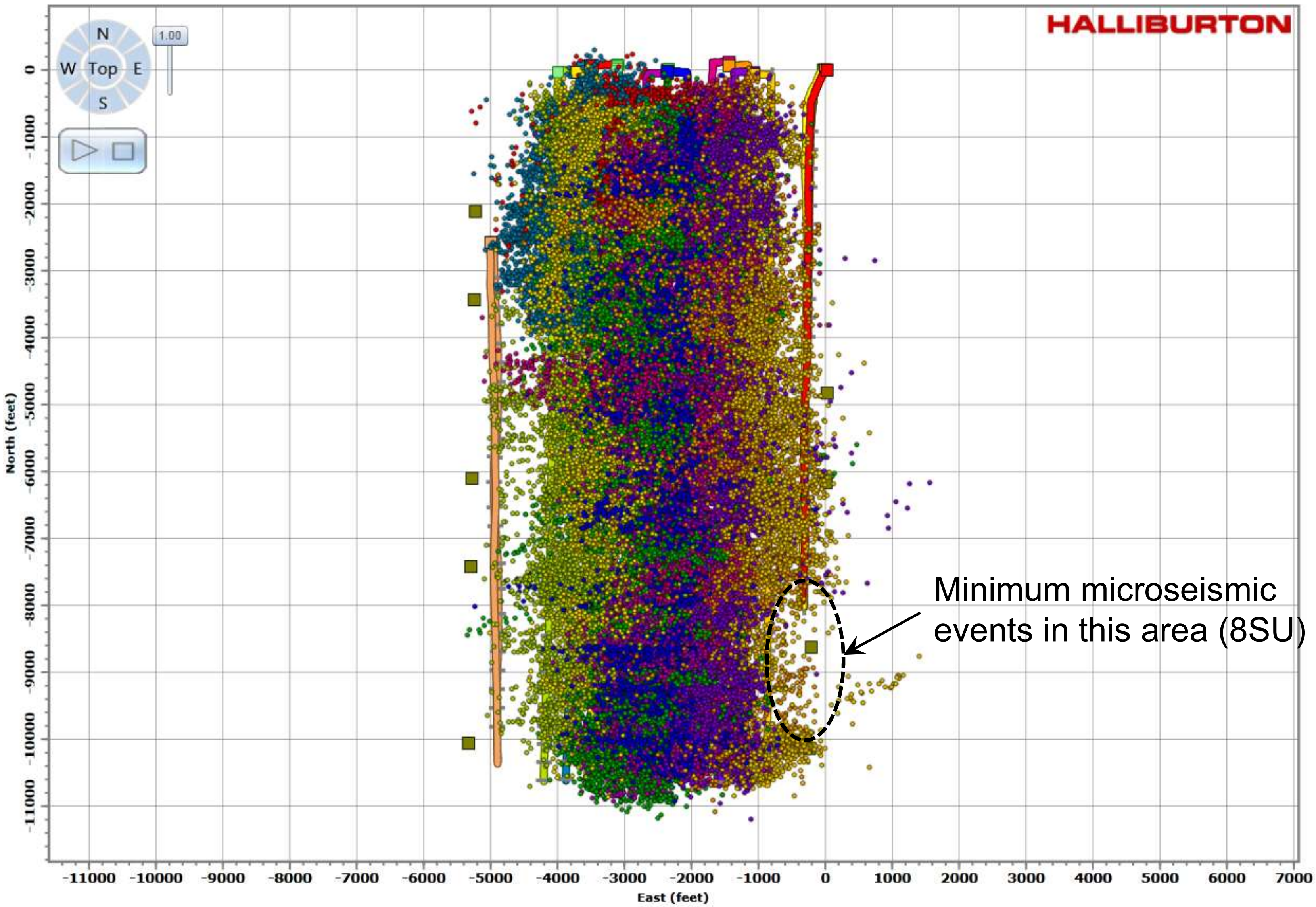
Main Results and Conclusions

- Timing between completion sequencing doesn't seem to make a difference (from microseismic data).
  - Events appear similar if the completion…..
    - starts with alternating between wells (zipper technique)
    - starts by pumping the first 5 stages on one well and then begin alternating stages (zipper technique)
- The optimum number of perf clusters per stage and cluster spacing was indeterminate, based on only the microseismic data.
    - Difficult to establish a base line for the design of experiment.
    - Artifacts of the microseismic measurements
    - Completion Interval variations (Upper and Lower Wolfcamp)
    - Completion Sequences
    - No near-wellbore diagnostics available (i.e., DTS, DAS, etc.)

Sugg 171-A Pad and Sugg 158 Refracs overall fracture coverage

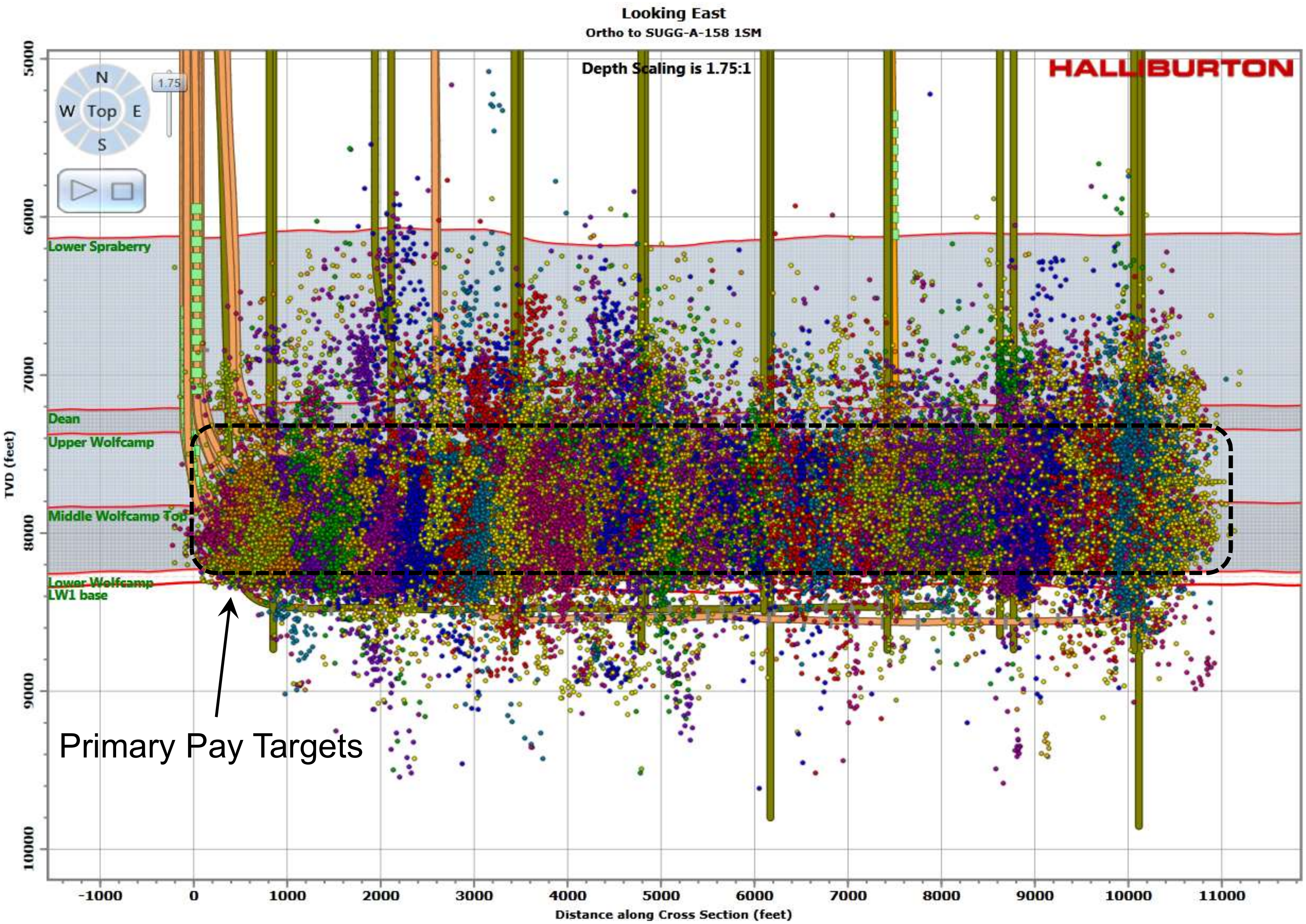


Sugg 171-A Pad Only (no Refracs) overall fracture coverage

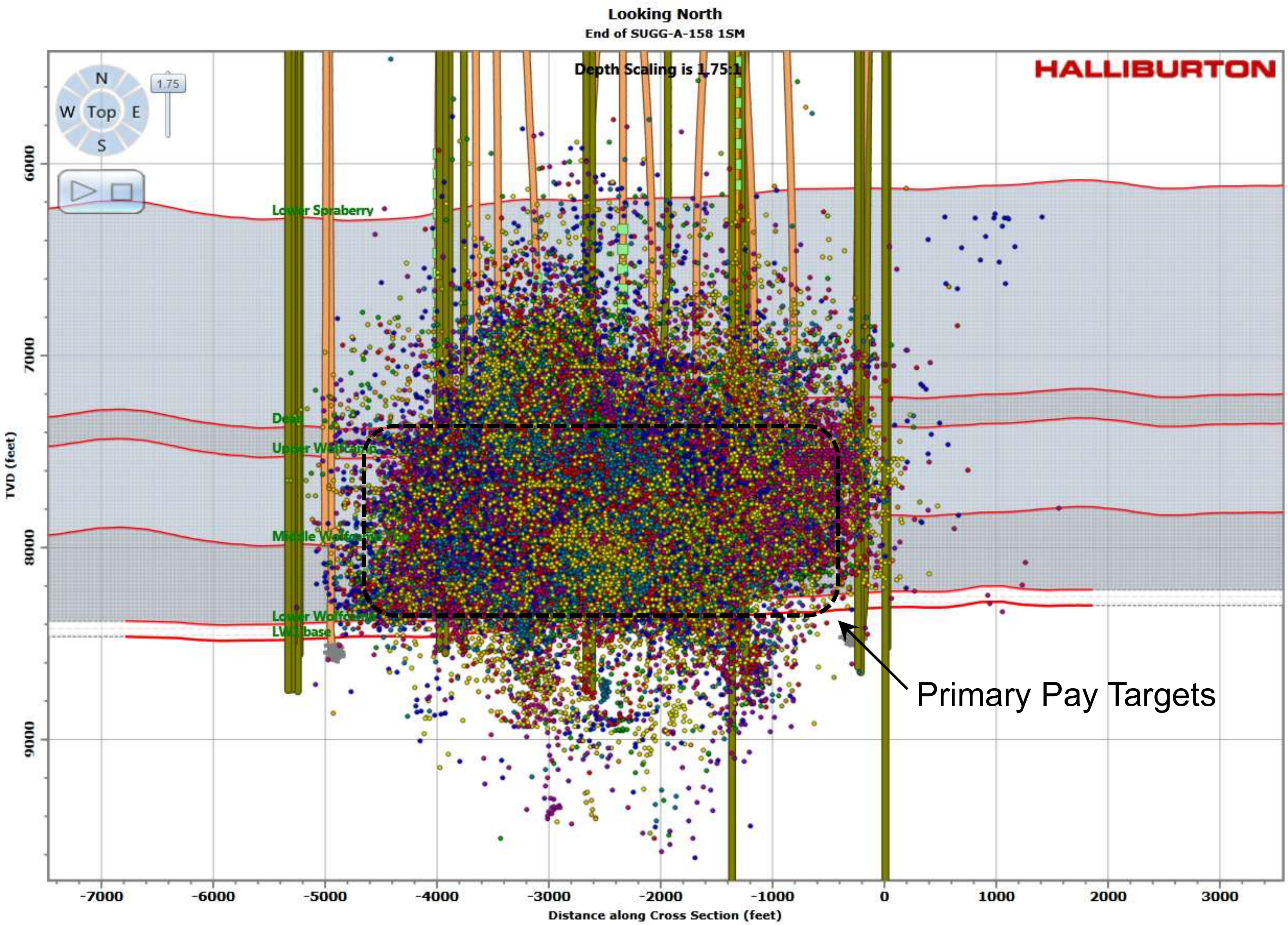


HALLIBURTON

Sugg 171-A Pad - overall fracture coverage (side view)

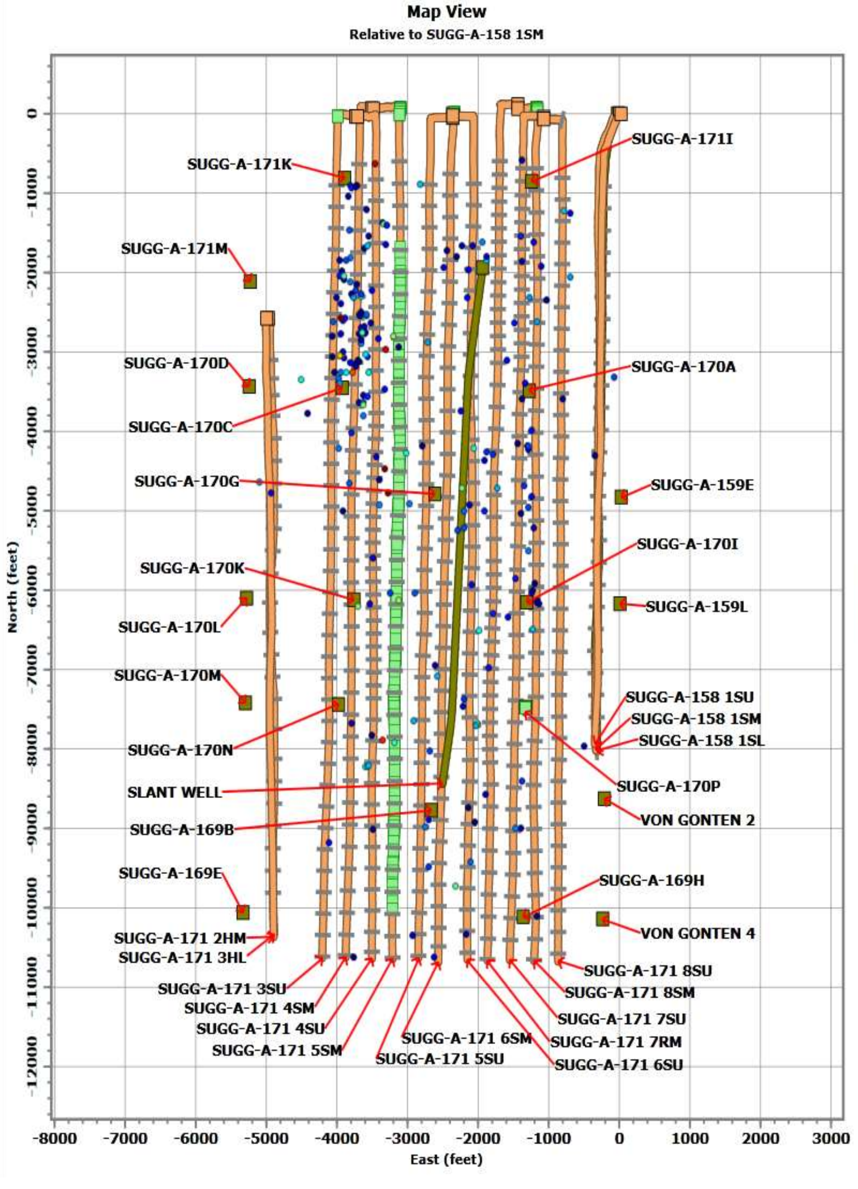


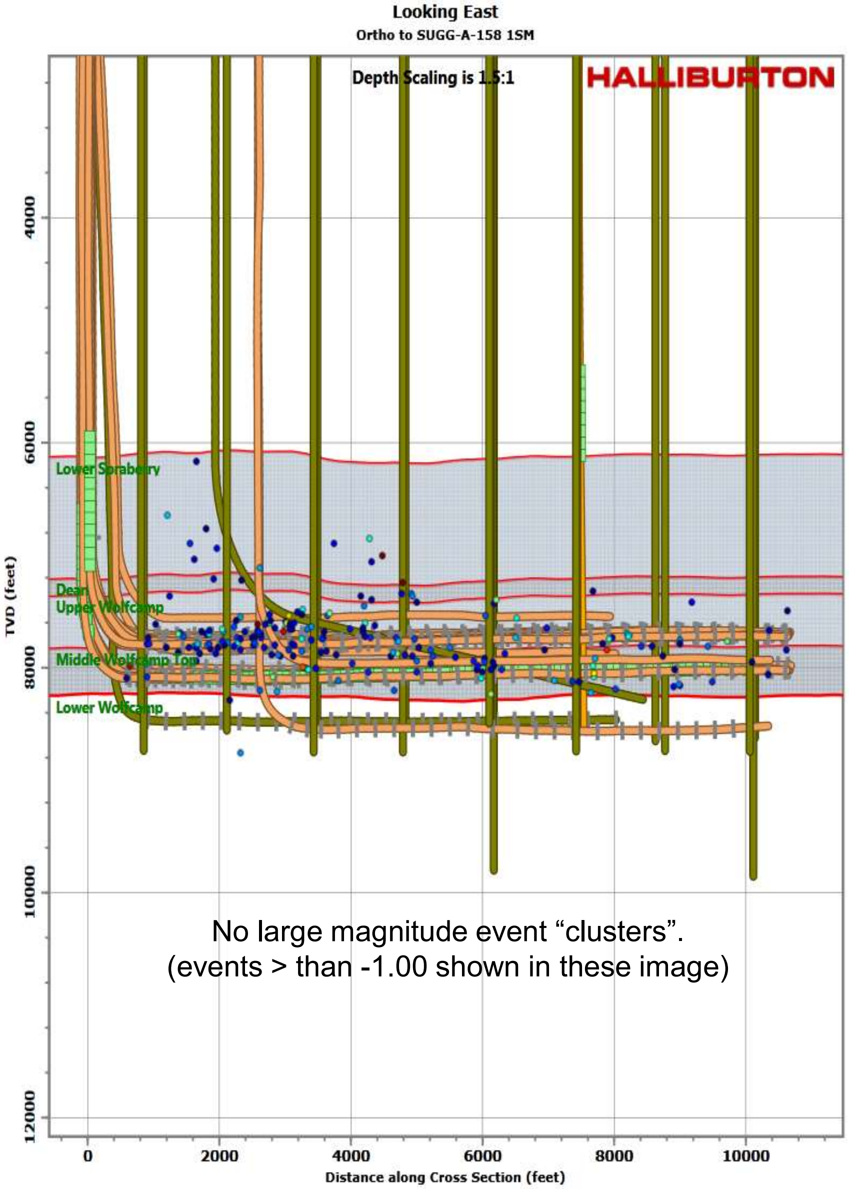
Reservoir coverage - Chevron Drill pattern (end view)



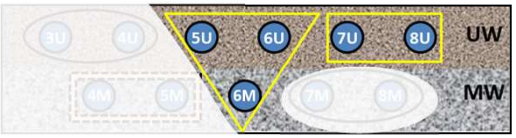
HALLIBURTON

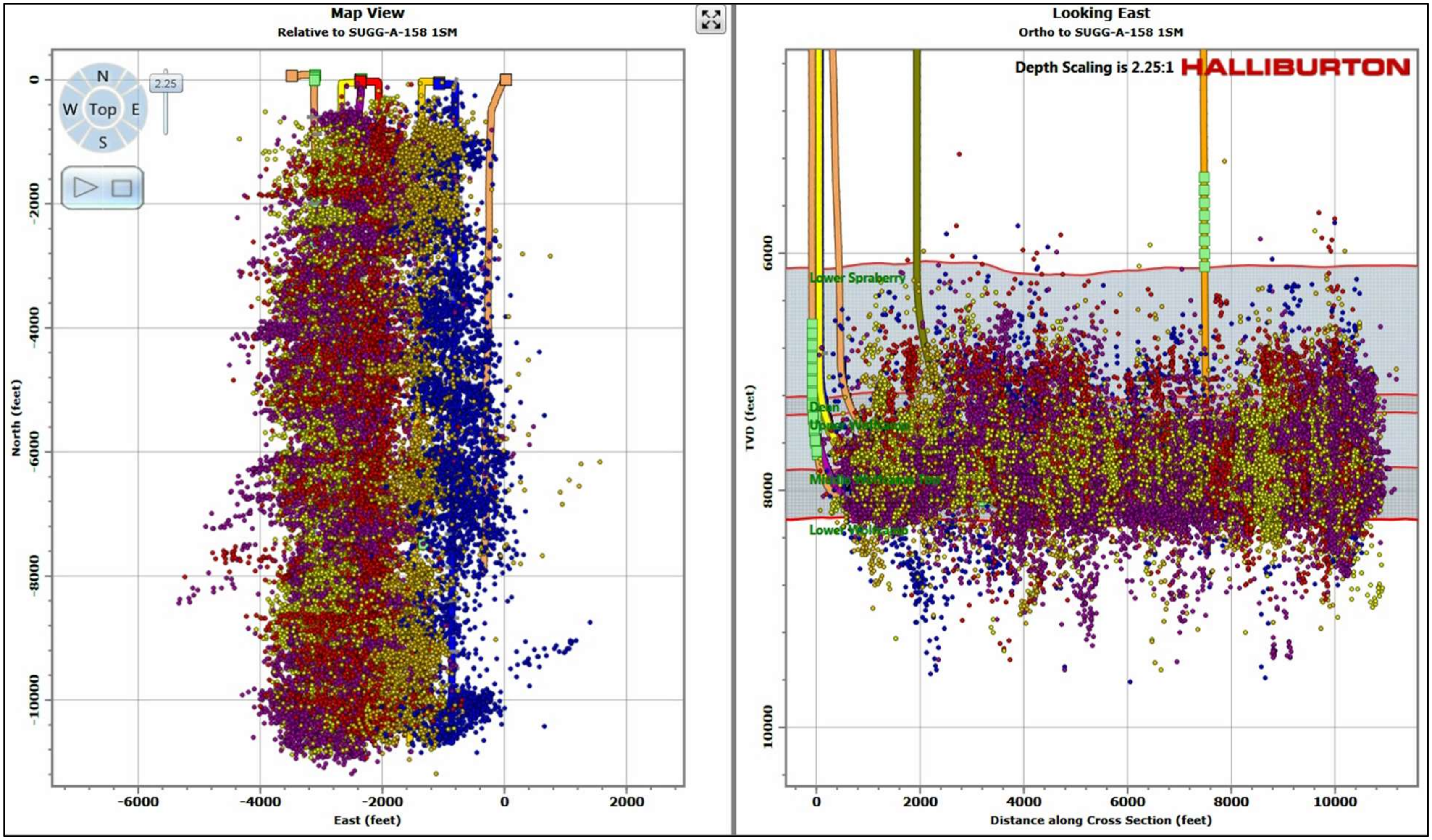
Large Scale pre-stressed natural features – none seen





Video – Phase 1 - Each stage colored by treatment well (5)

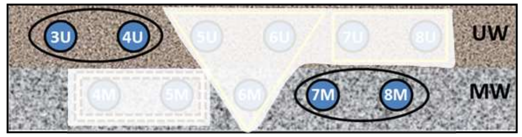


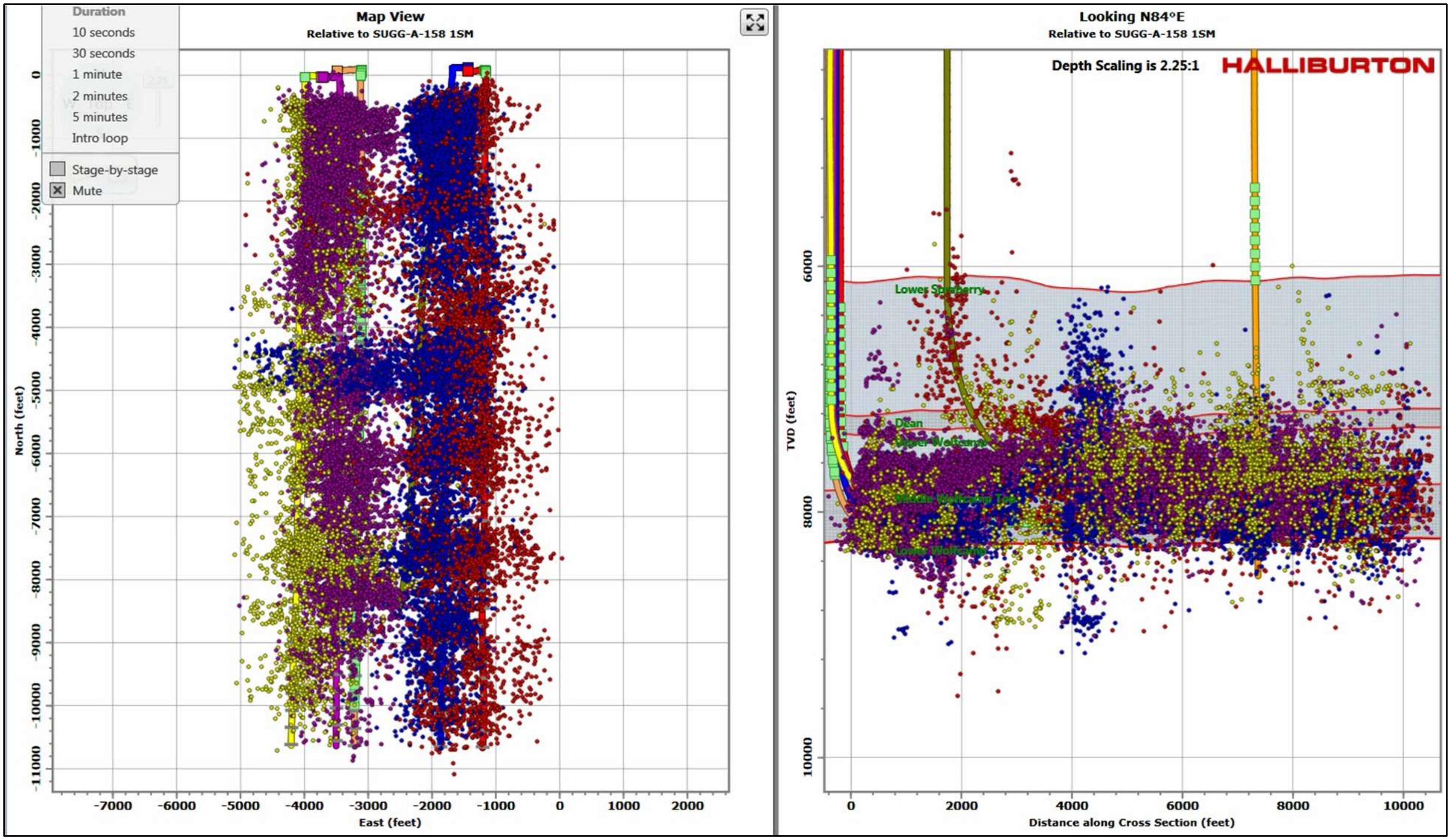


Animation Slide

HALLIBURTON

Video – Phase 2 - Each stage colored by treatment well (4)

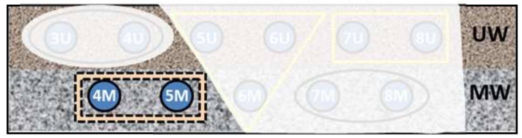


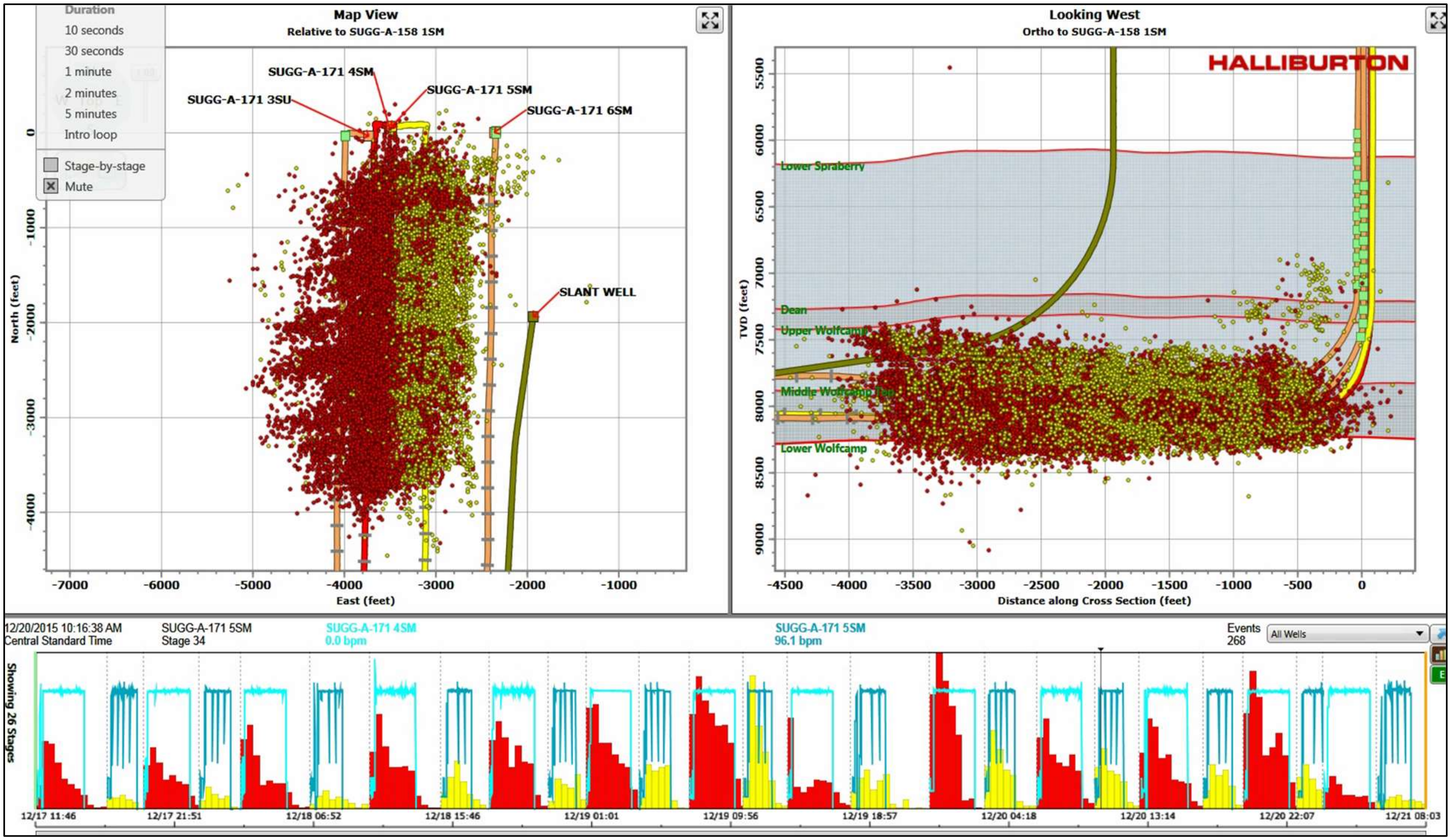


Animation Slide

HALLIBURTON

Video – Phase 3 - Each stage colored by treatment well (2)



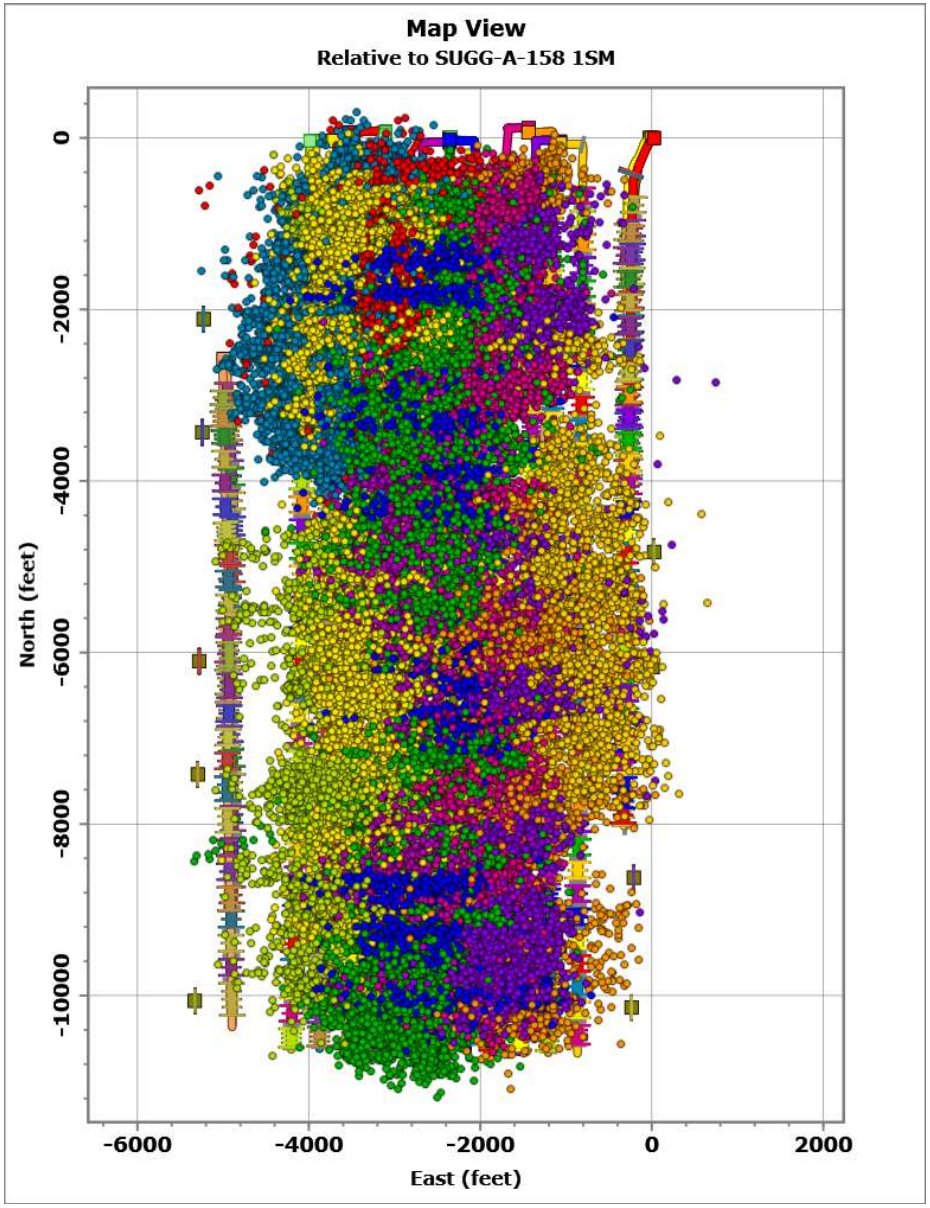


Animation Slide

HALLIBURTON

Fracture Geometry and Relative degree of Complexity:

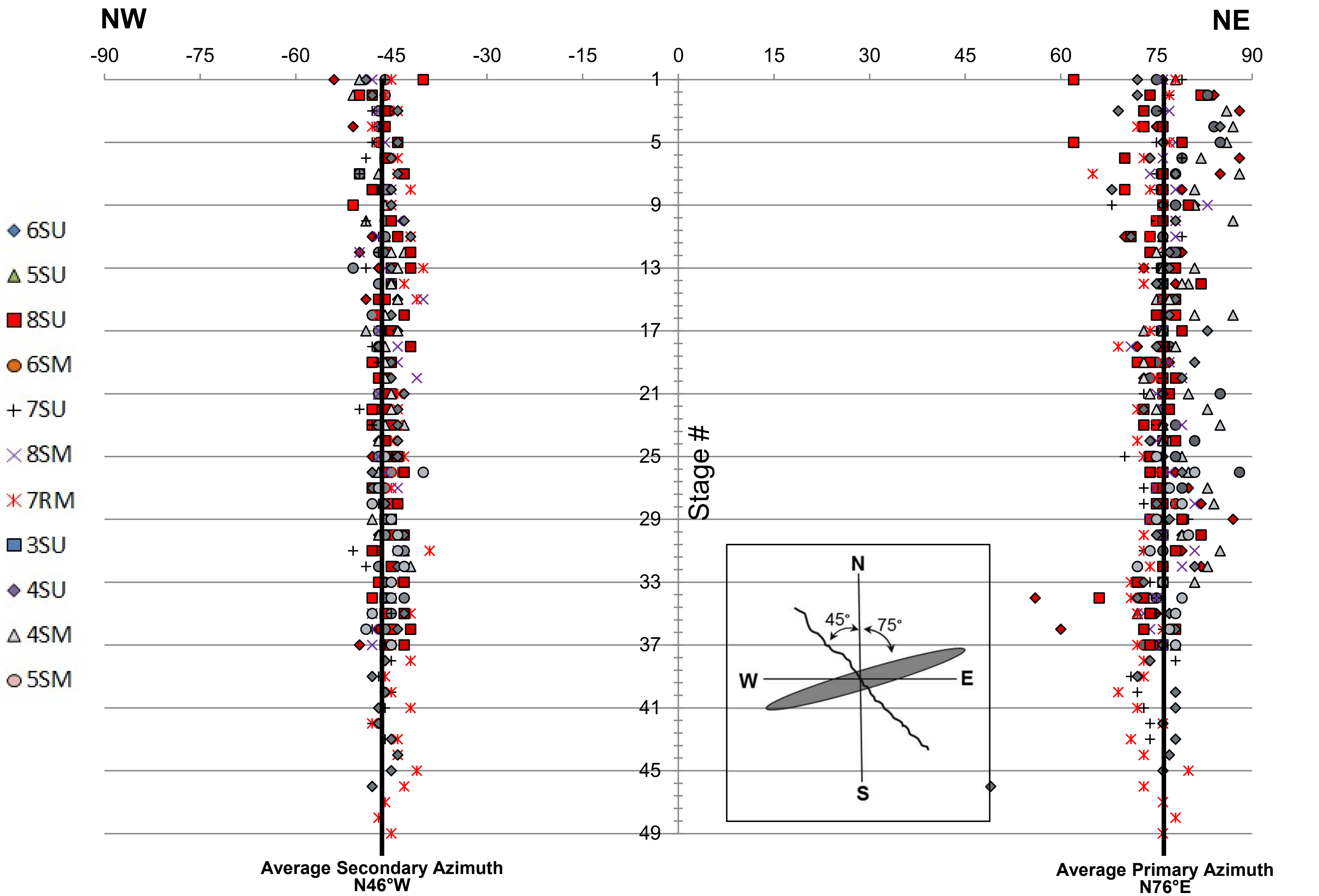
Representative Stages of Typical Fracture Geometry



- Approximately half of the stages have valid data and are representative of fracture geometry.
- Events from frac stages that were pumped simultaneously and had events that could have been assigned to either stage were not included in typical stage measurements
- Most stages seem to interact with recent stimulation of adjacent lateral.
  - Fluid leak-off time > stimulation of next well in sequence.
- Offset production from vertical and horizontal wells likely affected fracture geometry in stages located near depleted zones.

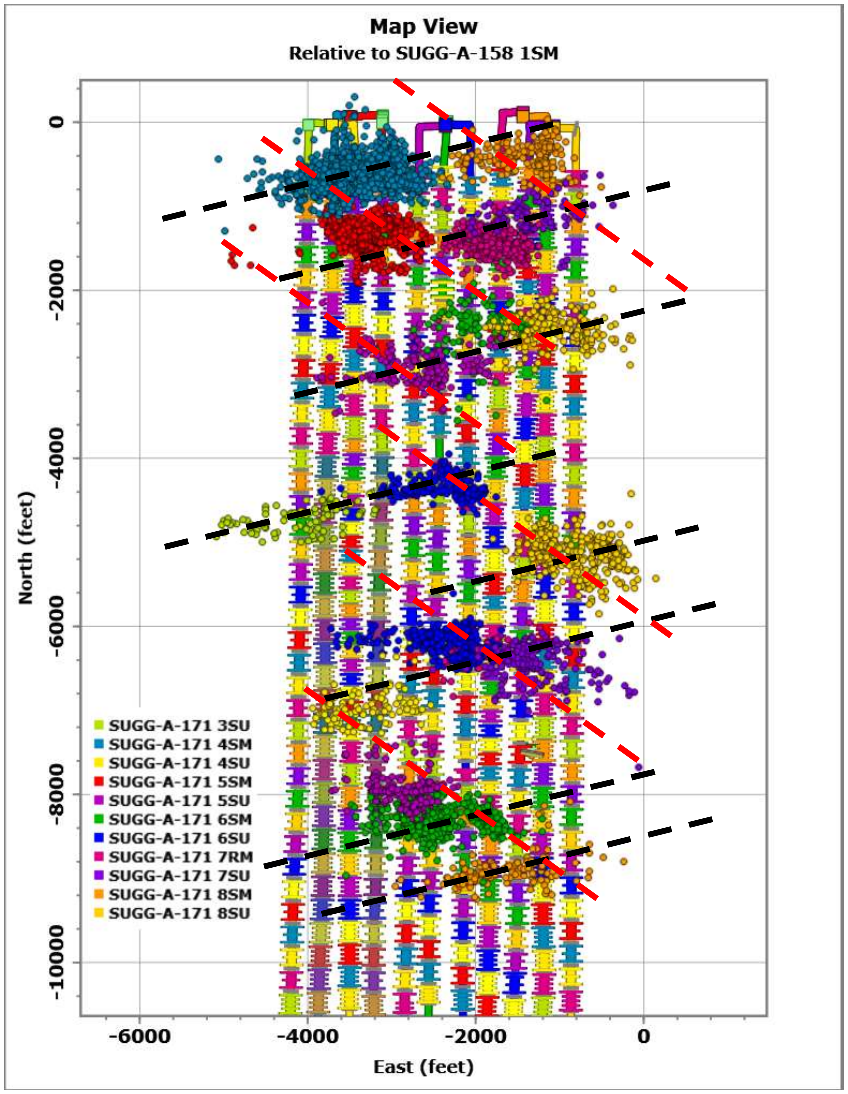
HALLIBURTON

Fracture Azimuth(s) and Overall Degree of Complexity



HALLIBURTON

Fracture Azimuth(s) and Overall Degree of Complexity



Selected stages for clarity, colored by treatment well

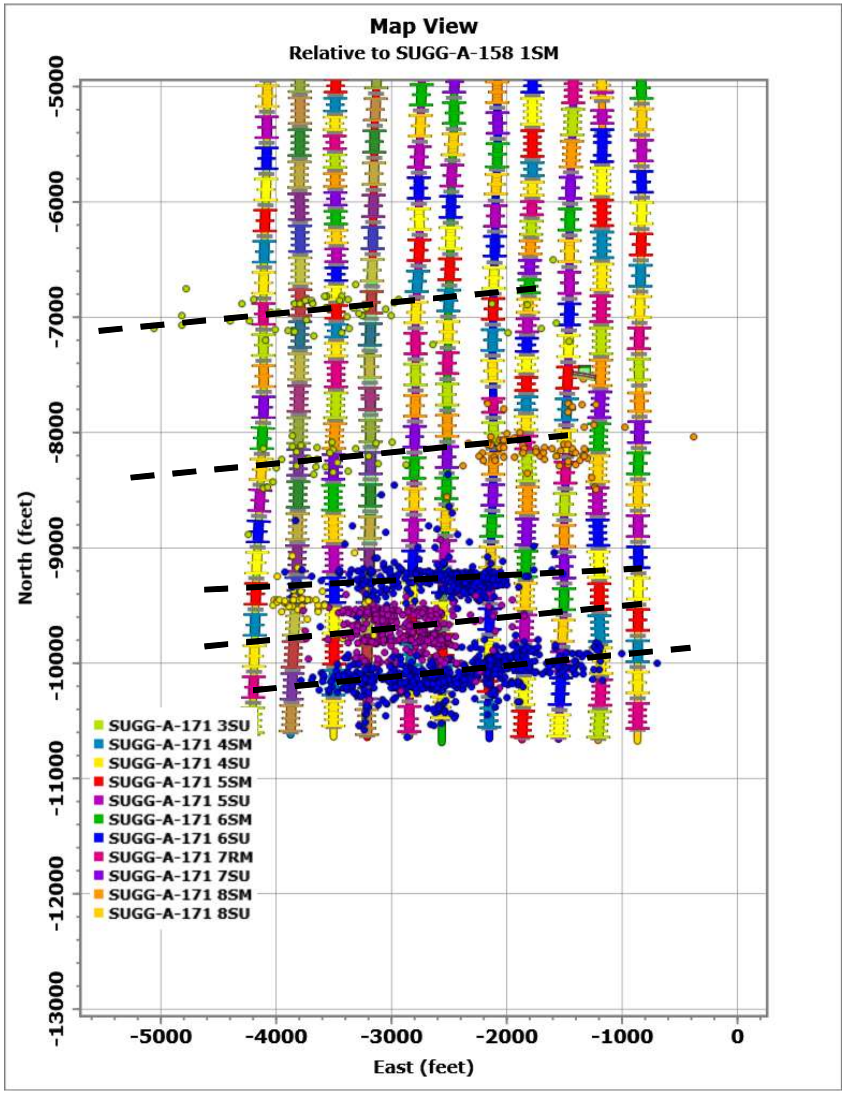
Most stages are deemed to have a moderate degree of complexity.

- Strong evidence of secondary fracture azimuth in most stages, adding complexity.
- Natural fractures likely exist and pressure/stress conditions may allow fluid to access the secondary fractures.
- Conditions for added complexity favor lower μ_f.

- Typical primary azimuth ~N76°E.
- Typical secondary azimuth ~N46°W.
  - Strongly present in many stages.

HALLIBURTON

Fracture Azimuth(s) and Overall Degree of Complexity



Low Complexity in a some stages.

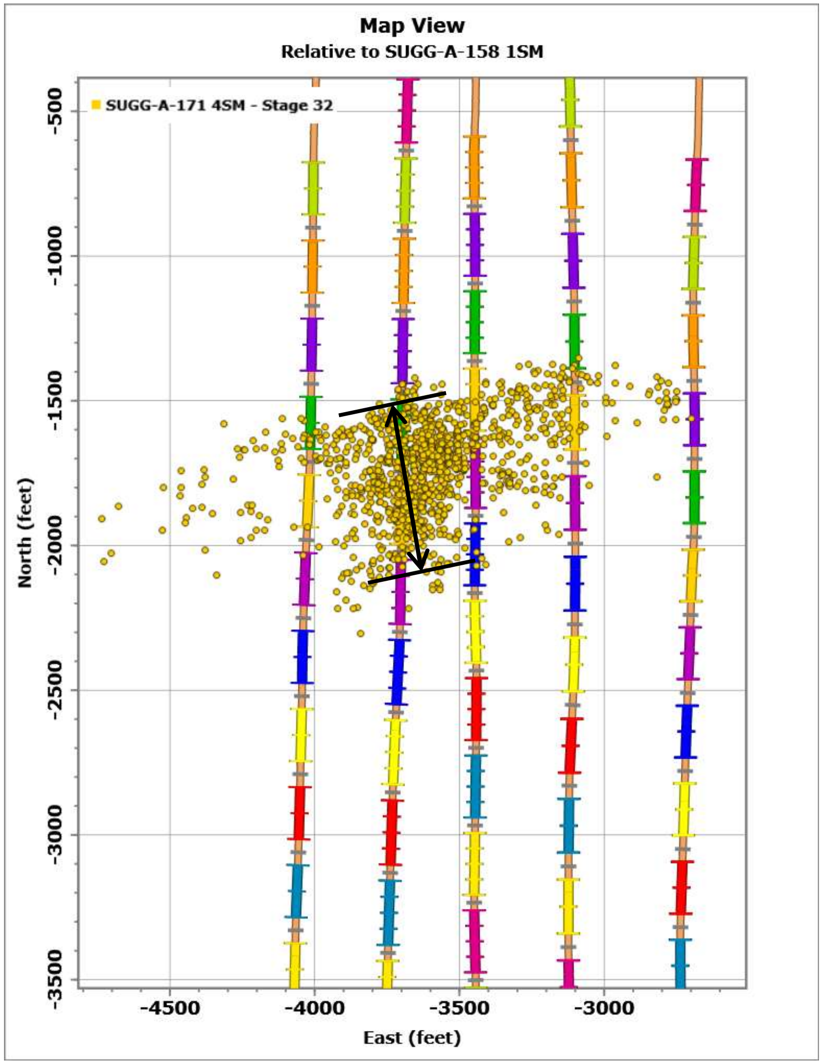
- Secondary fracture azimuths are absent or not distinguishable
- Primary azimuths during stages with low complexity appear to trend more towards east-west than stages with moderate complexity

Low complexity stages, no secondary azimuth

HALLIBURTON

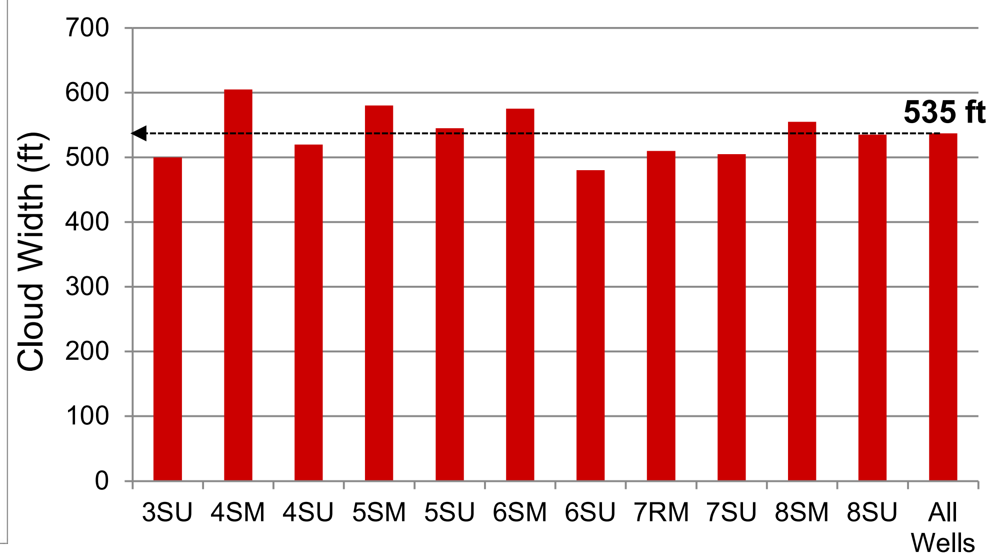
Degree of Complexity – Microseismic Cloud Width

Selected stage 32 on the 4SM for clarity



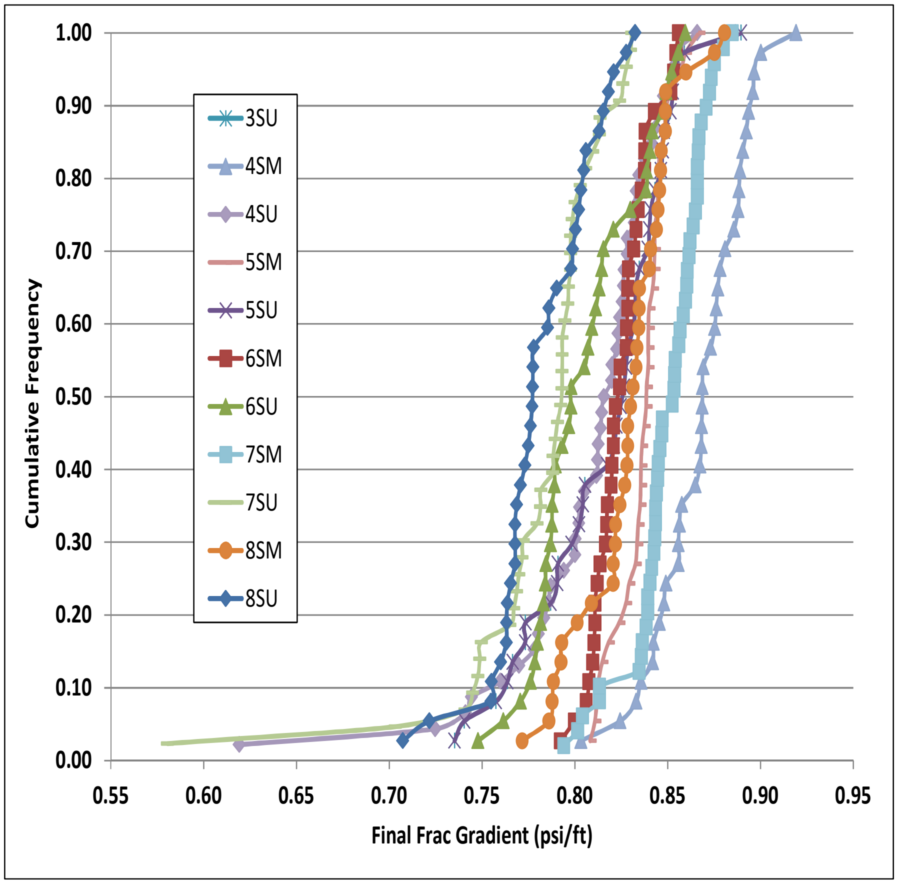
Microseismic Cloud Widths are fairly consistent between wells and average 535 ft.

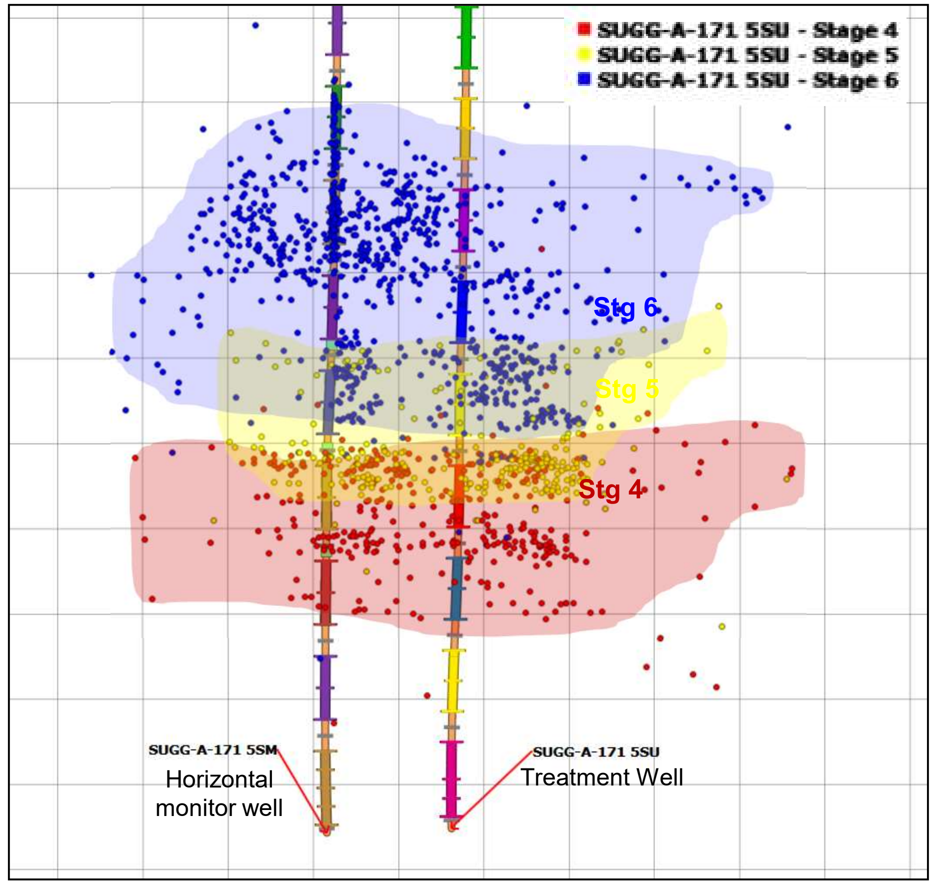
- Wells completed in the Middle Wolfcamp appear to have slightly larger cloud widths than Upper Wolfcamp wells.
- Larger cloud widths in the Middle Wolfcamp may be due to treatment order
- Wider cloud width may be due to additional complexity generation.



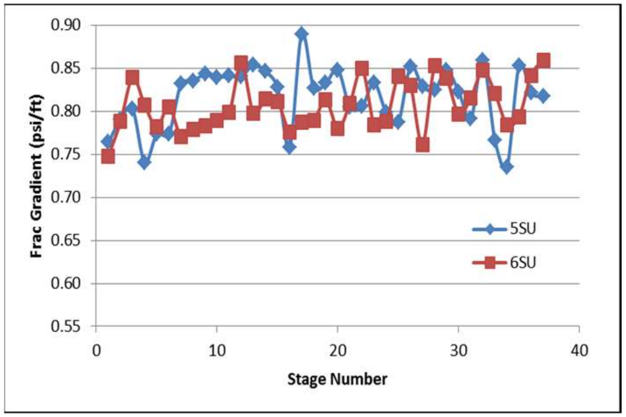
HALLIBURTON

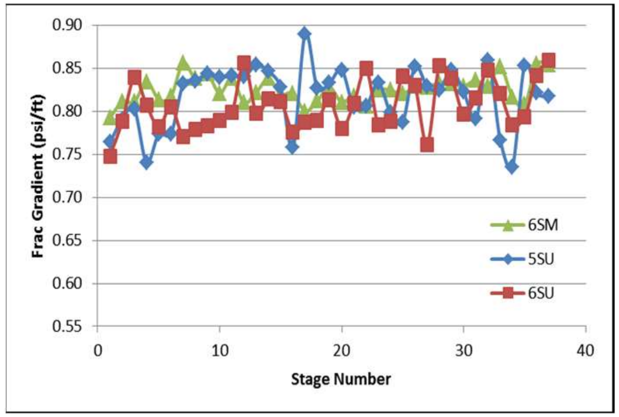
- Final fracture gradients tend to be higher in the middle Wolfcamp than in the upper Wolfcamp.
  - Possibly due to completion sequence (upper Wolfcamp fractured before middle Wolfcamp).
- Some adjacent stages tend to push heelward, away from perforation zone.
  - Possibly due to stress shadowing from previous fractured zone (same wellbore)
  - Connection to natural fracture systems
  - Interaction between offset fracture systems.

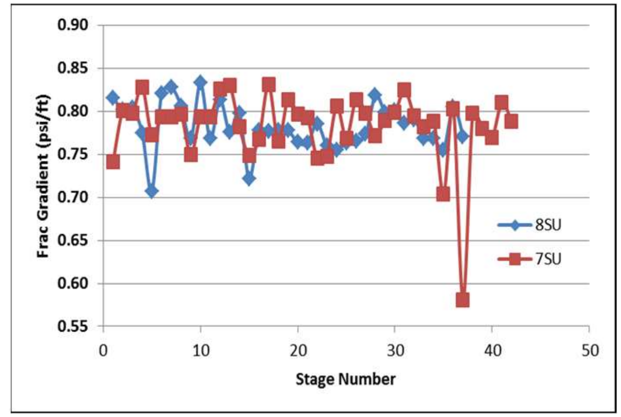


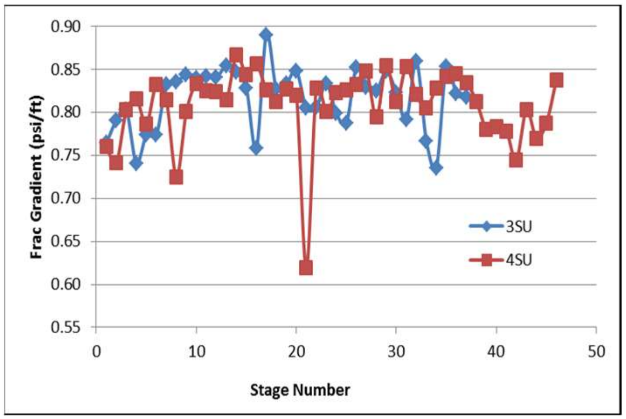


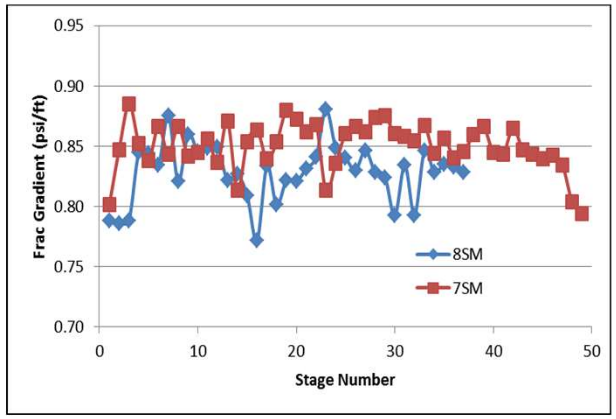
Example of Frac Gradient Plots

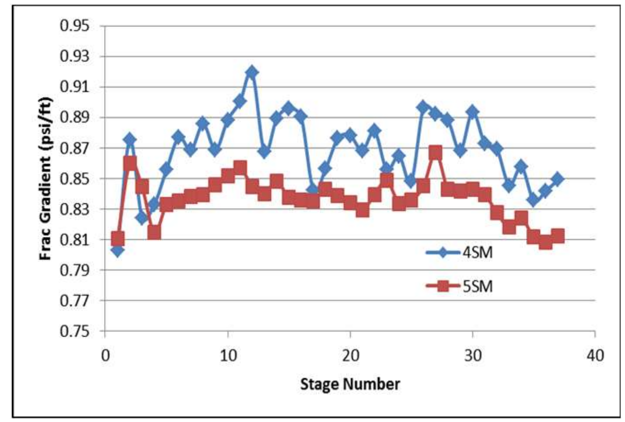








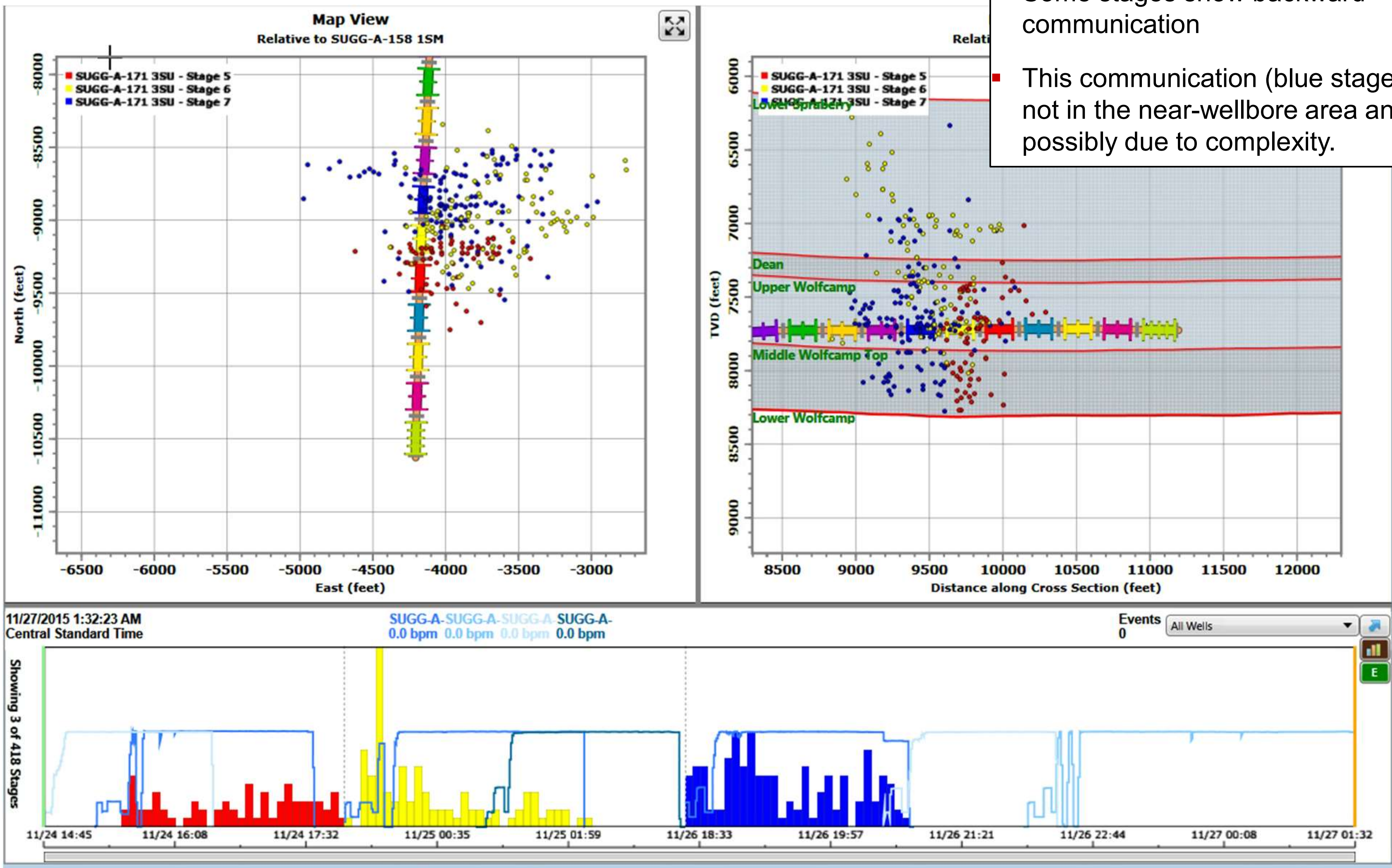




(Data Source: Frac Treatment Summary - Sugg 171 Pad.xlsx)

HALLIBURTON

Stage Isolation was very good between frac stages



- Some stages show backward communication
- This communication (blue stage) is not in the near-wellbore area and is possibly due to complexity.

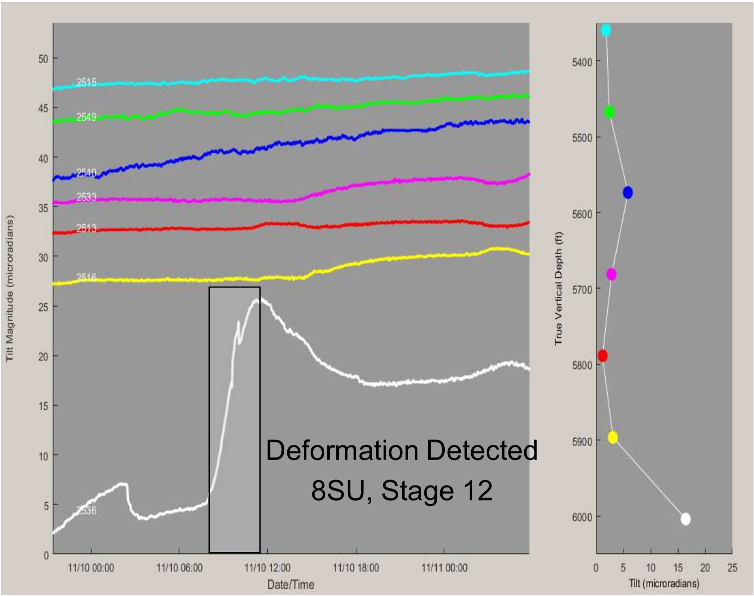
Animation Slide

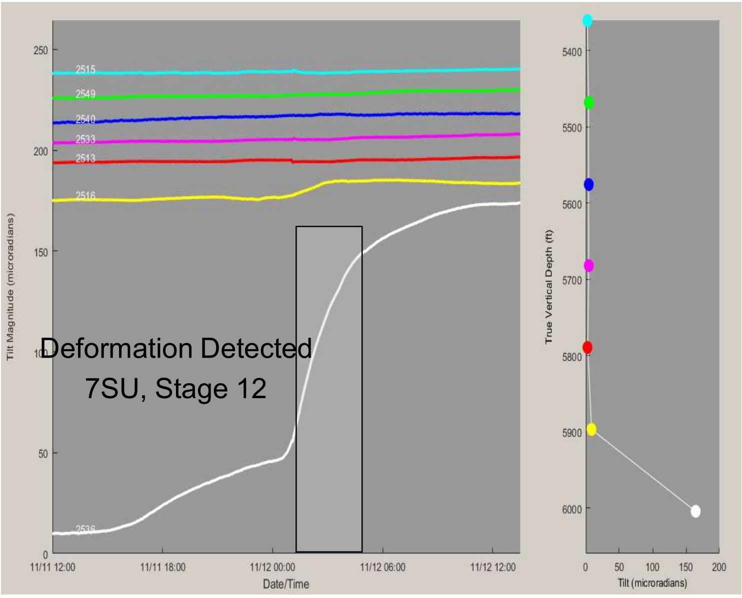
HALLIBURTON

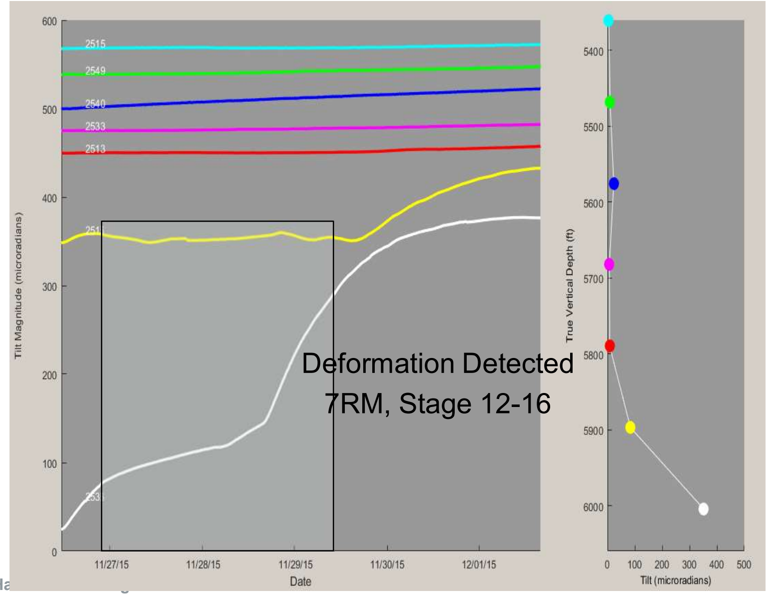
Microdeformation and Fracture Height Development

HALLIBURTON

Downhole Micro-Deformation Tiltmeters

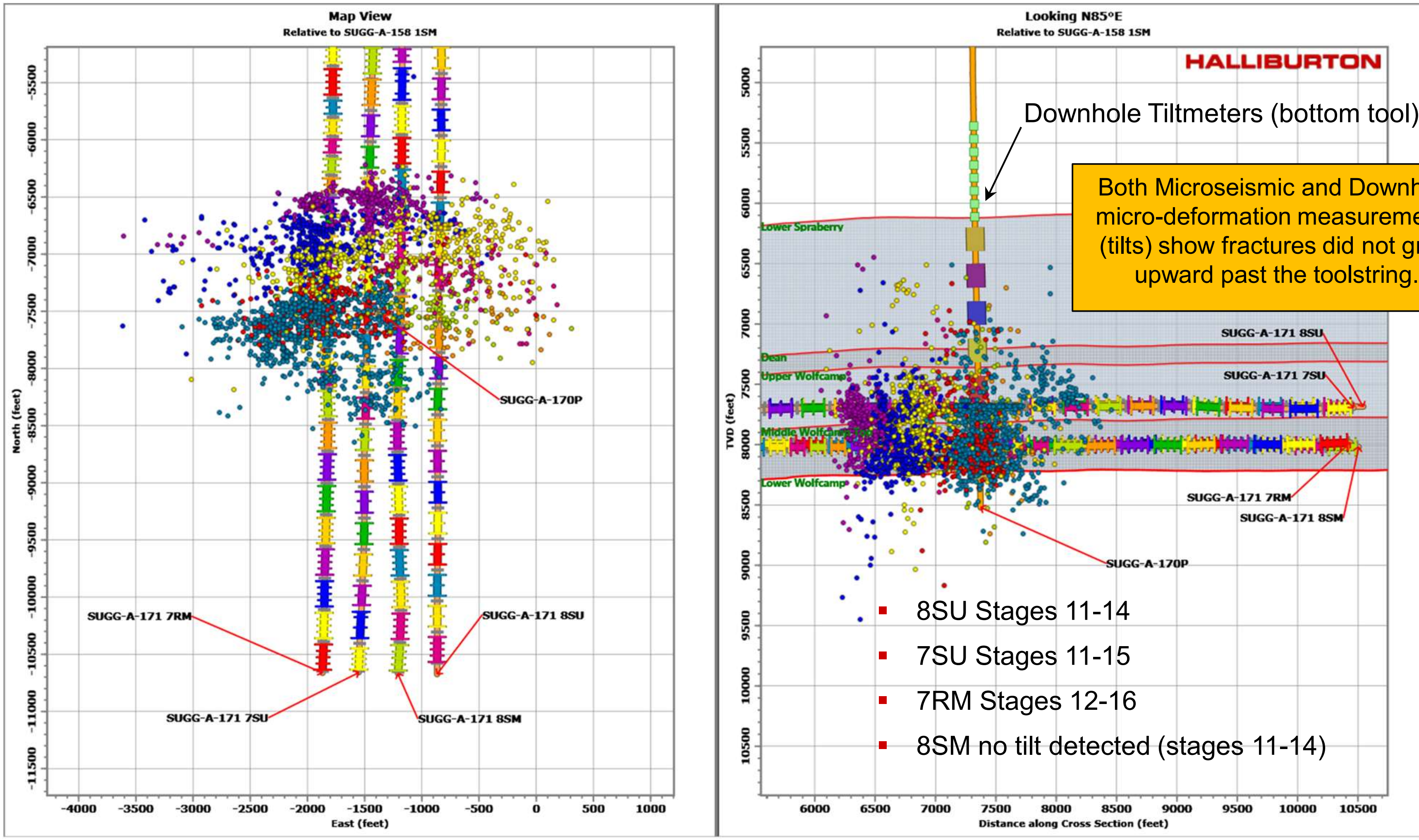






- There were only three times during the completion of the pad that the downhole micro-deformation tiltmeters indicated any type of response.
- The response was only on the lowermost tilt tool (white color in plots) indicating that a fracture was somewhere below the tool array.
- This data confirms that hydraulic fractures did not extend upward past the array in the Sugg-A-170P

Downhole Micro-Deformation (Tilt) and Microseismic



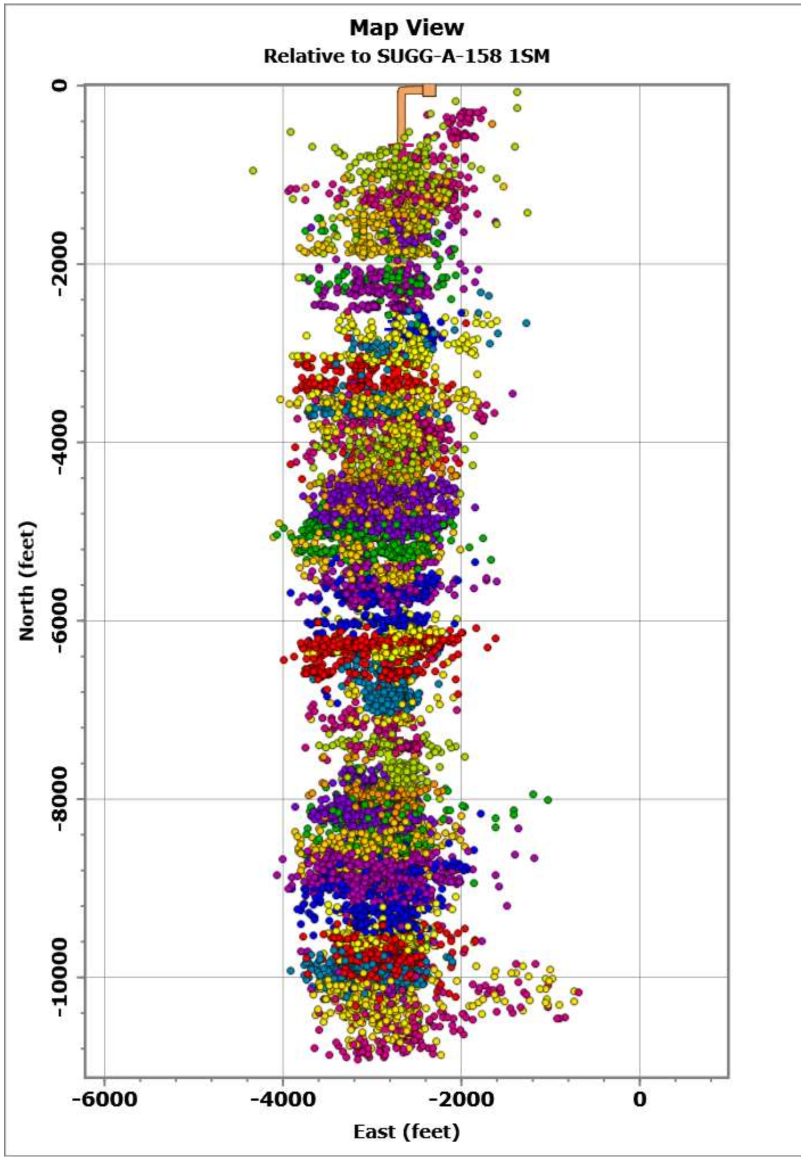
Both Microseismic and Downhole micro-deformation measurements (tilts) show fractures did not grow upward past the toolstring.

- 8SU Stages 11-14
- 7SU Stages 11-15
- 7RM Stages 12-16
- 8SM no tilt detected (stages 11-14)

Fracture Half-Length and Symmetry/Asymmetry

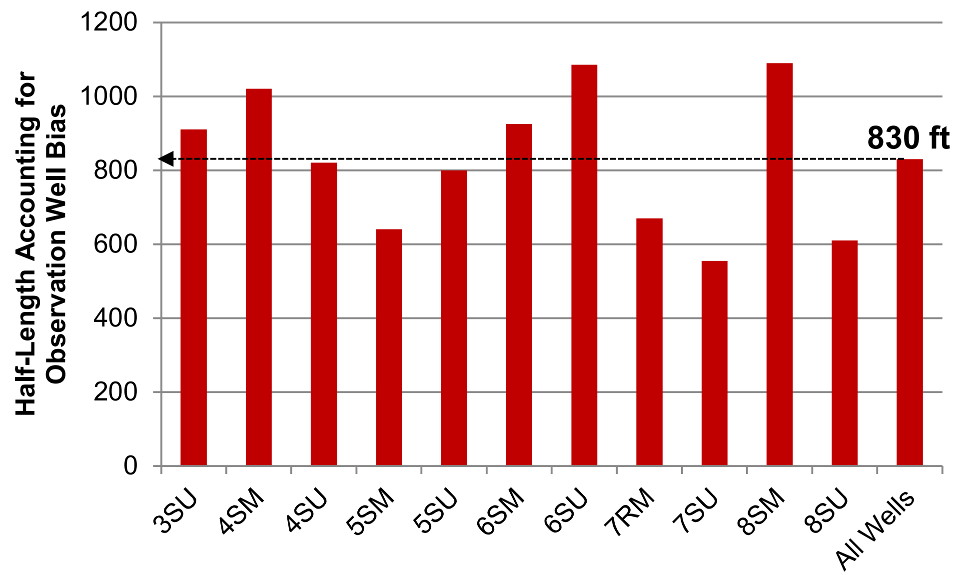
Fracture Extension – Symmetry/Asymmetry

Selected stages on the 5SU for clarity

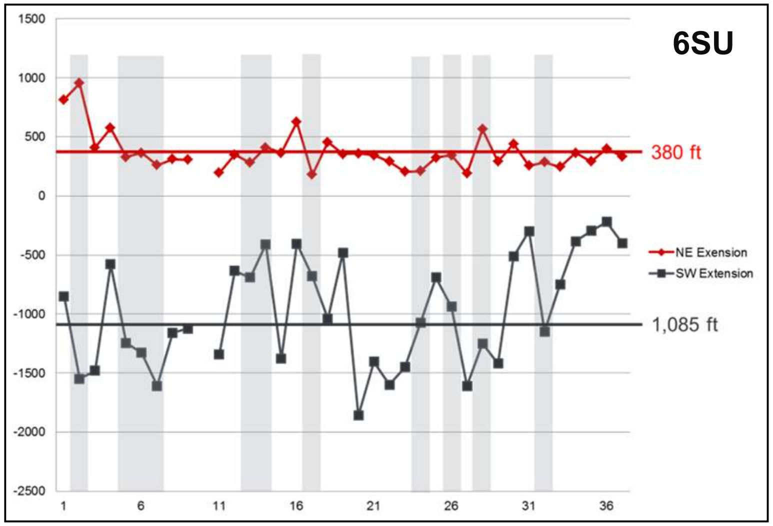


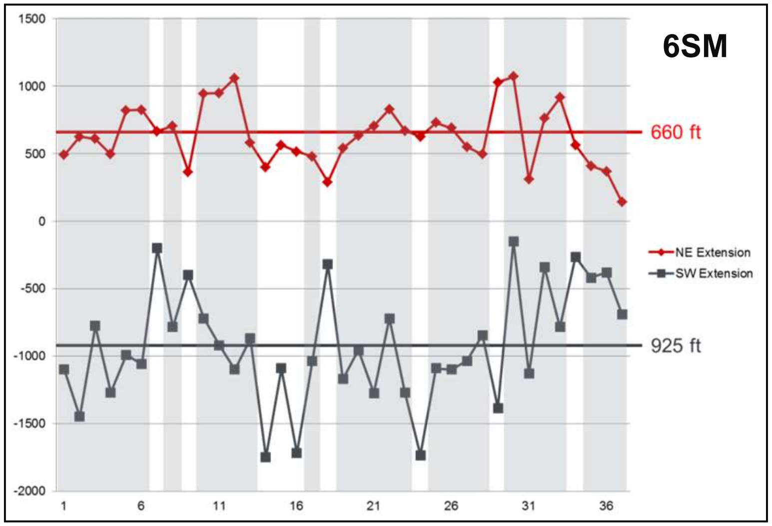
Fractures appear asymmetric on most stages, likely due to observation well bias.

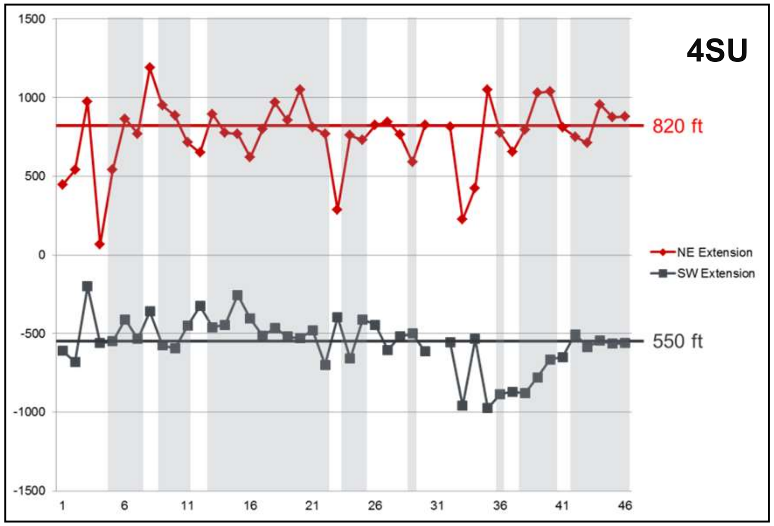
- Each well shows asymmetric growth towards the horizontal observation well
- Treatment order did not appear to affect observed half-length
- Average half-lengths varied

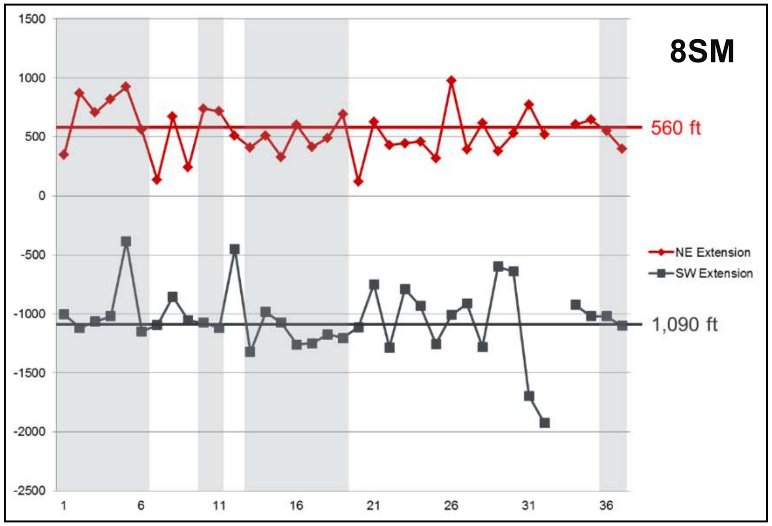


Fracture Extension – Examples Symmetry/Asymmetry





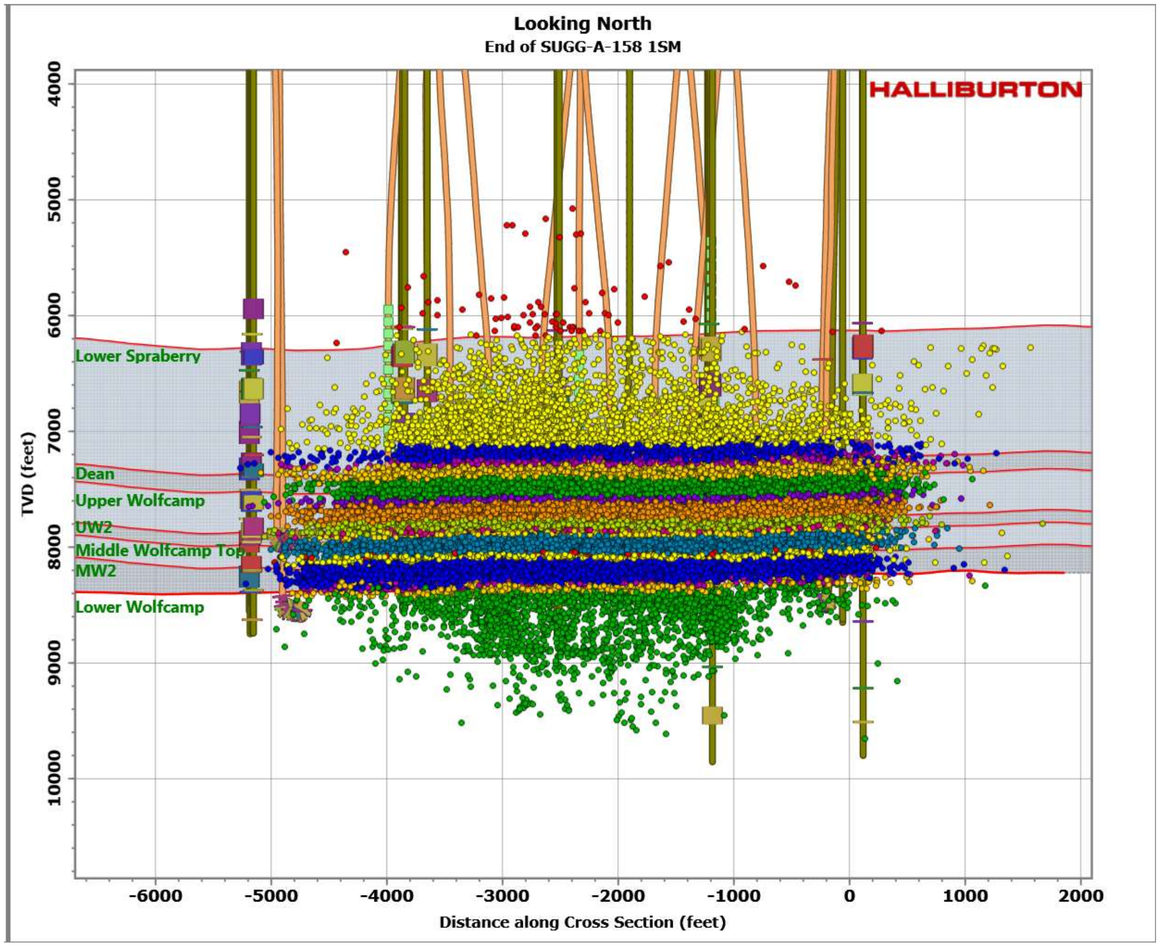




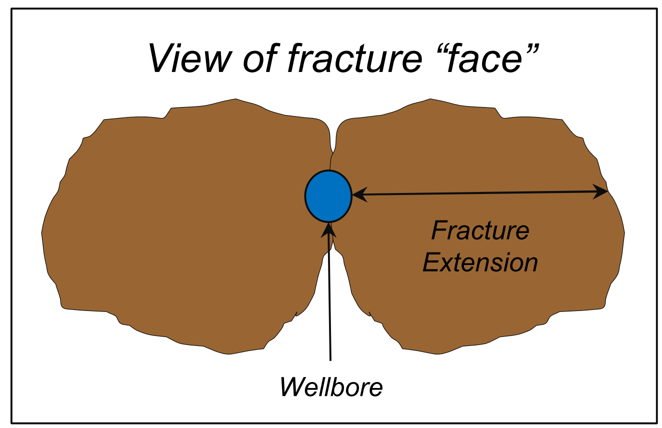
Representative Stages

HALLIBURTON

Fracture Extension – Events colored by formation (end view)



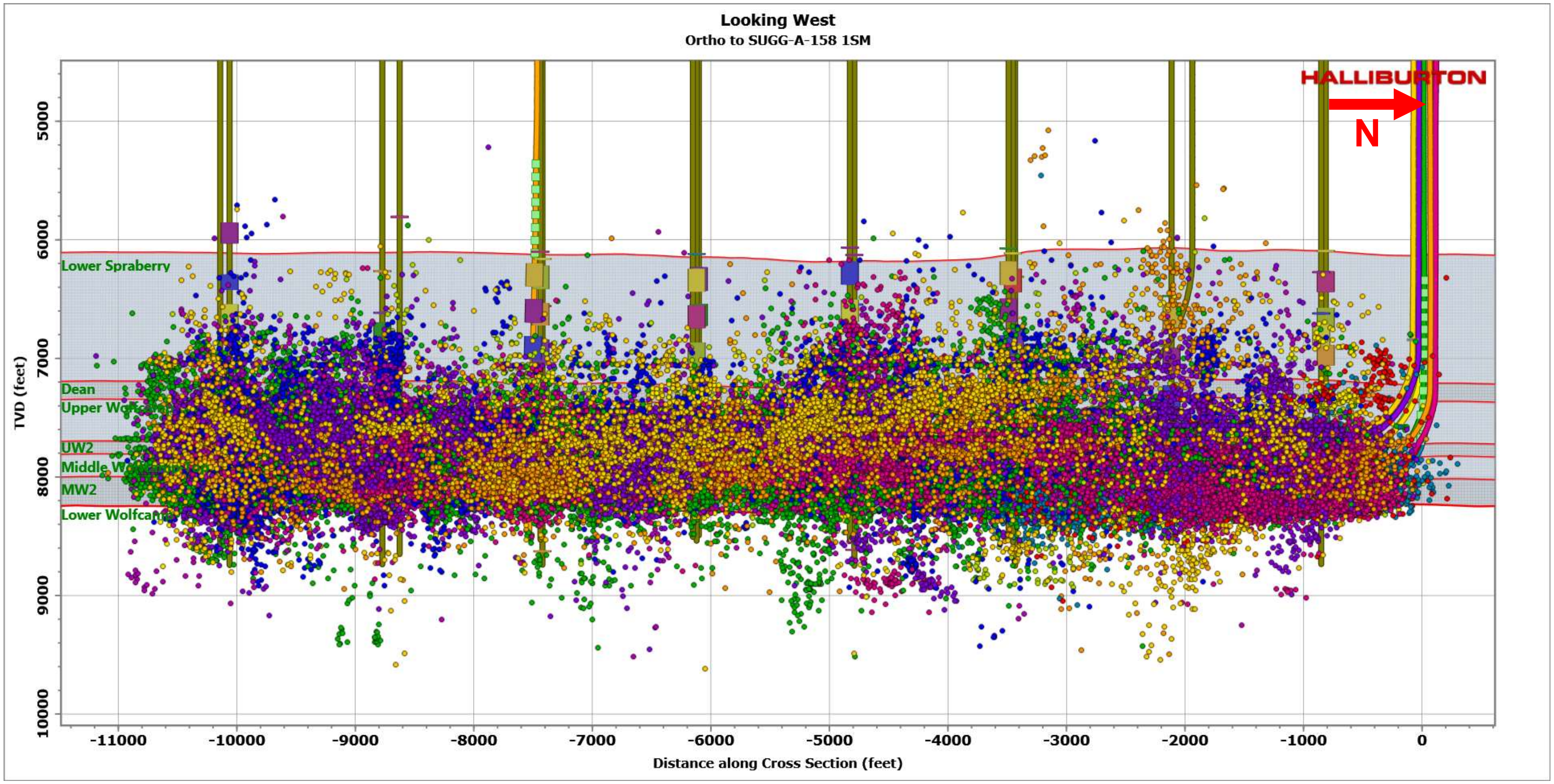
- Similar extension observed from the top of the Dean formation to bottom of the MW2
- Decreased extension within the upper portion of the Lower Spraberry and the Lower Wolfcamp



HALLIBURTON

Fracture Height

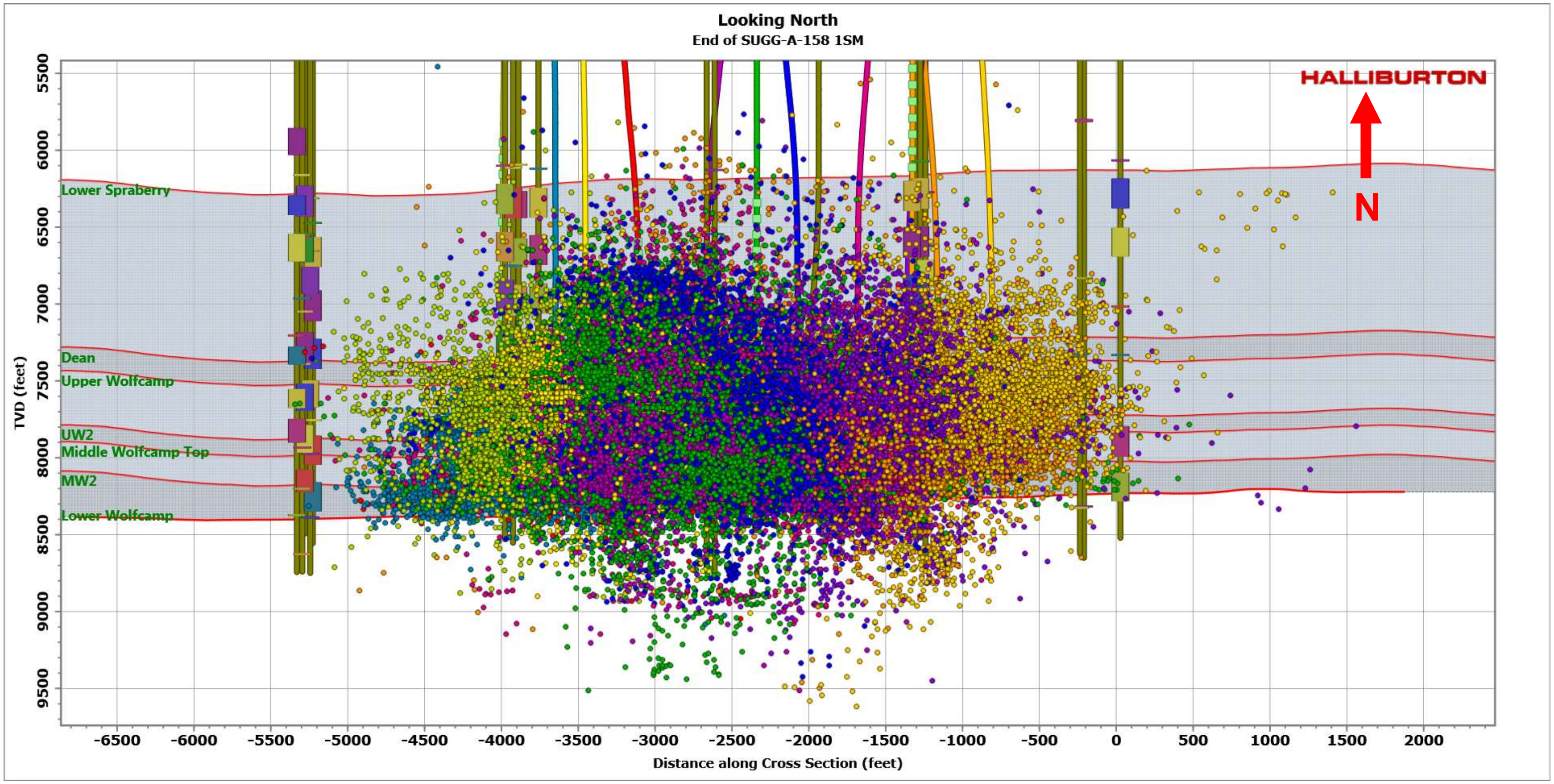
Fracture Height (h_f) – All Wells – Side View



- Complete coverage from the top of the Dean to the top of the Lower Wolfcamp.
- Additional upward growth into Lower Spraberry, but <u>*not likely propped*</u> (due to low fluid viscosity).
- Growth into upper portion of the Lower Wolfcamp occurred and it is likely propped.

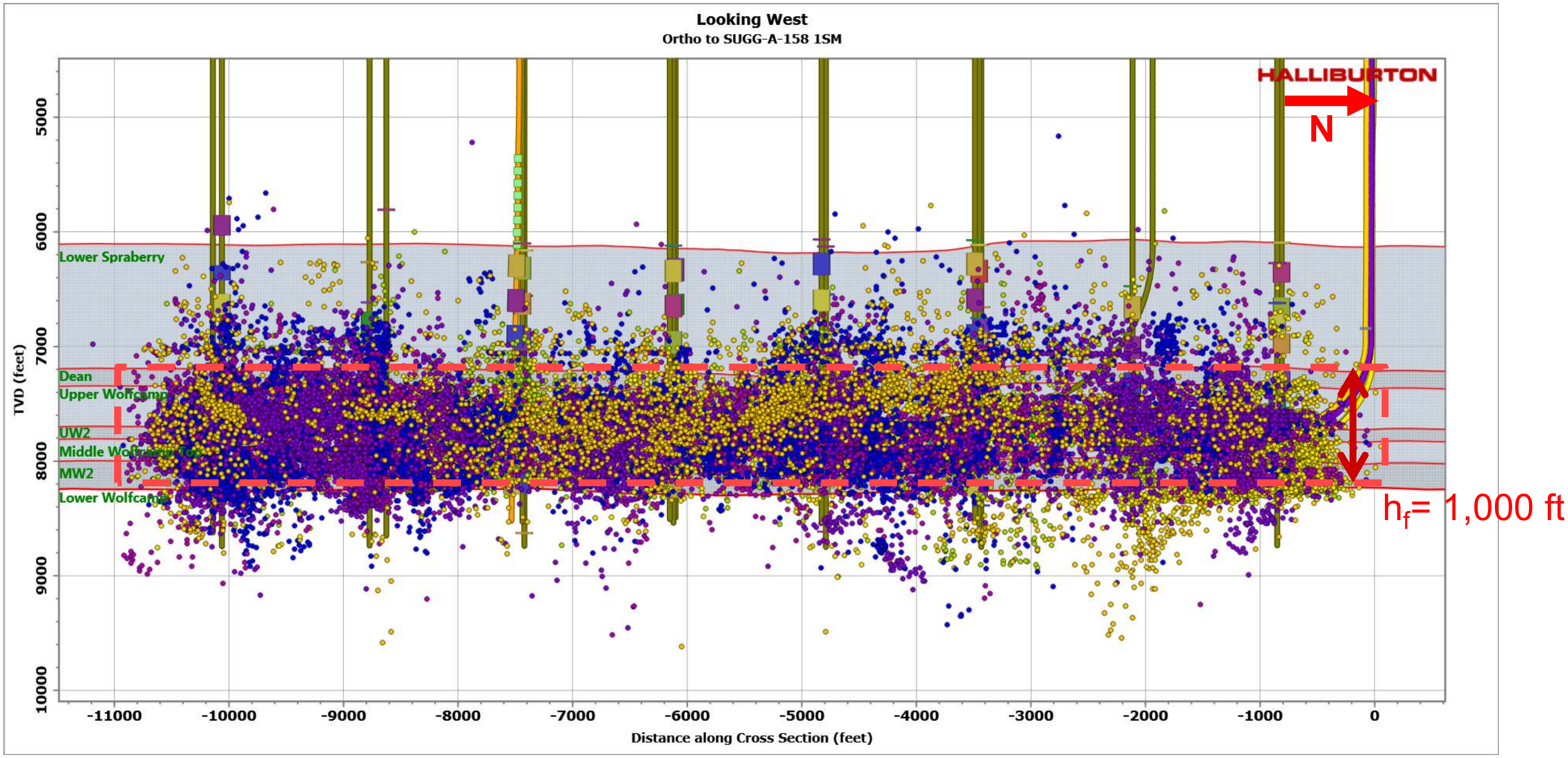
HALLIBURTON

Fracture Height (h_f) – All Wells – End View



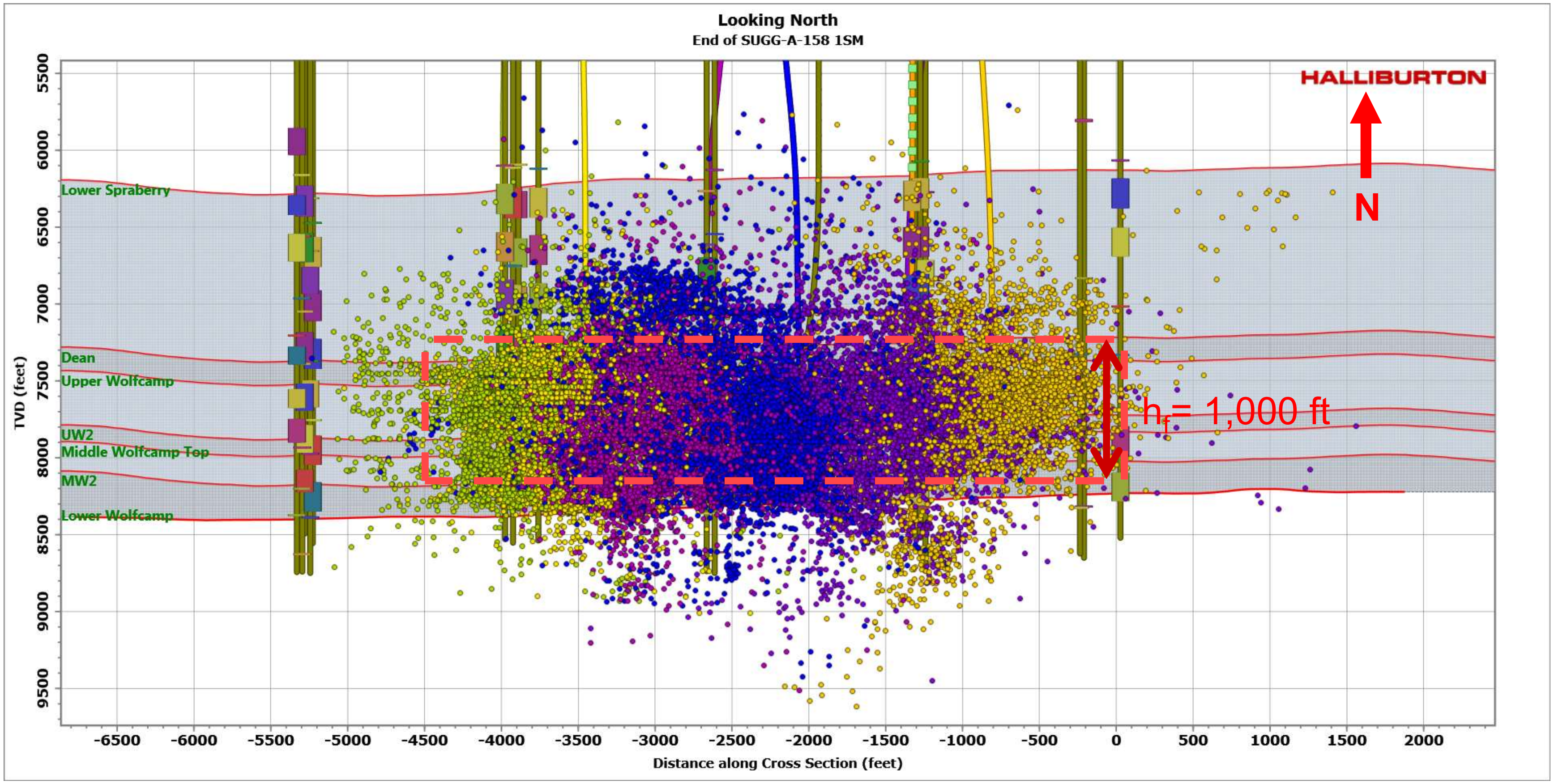
- Complete coverage from the top of the Dean to the top of the Lower Wolfcamp.
- Additional upward growth into Lower Spraberry, but <u>*not likely propped*</u> (due to low fluid viscosity).
- Growth into upper portion of the Lower Wolfcamp occurred and it is likely propped.

Fracture Height (h_f) – Upper Wolfcamp Wells Only



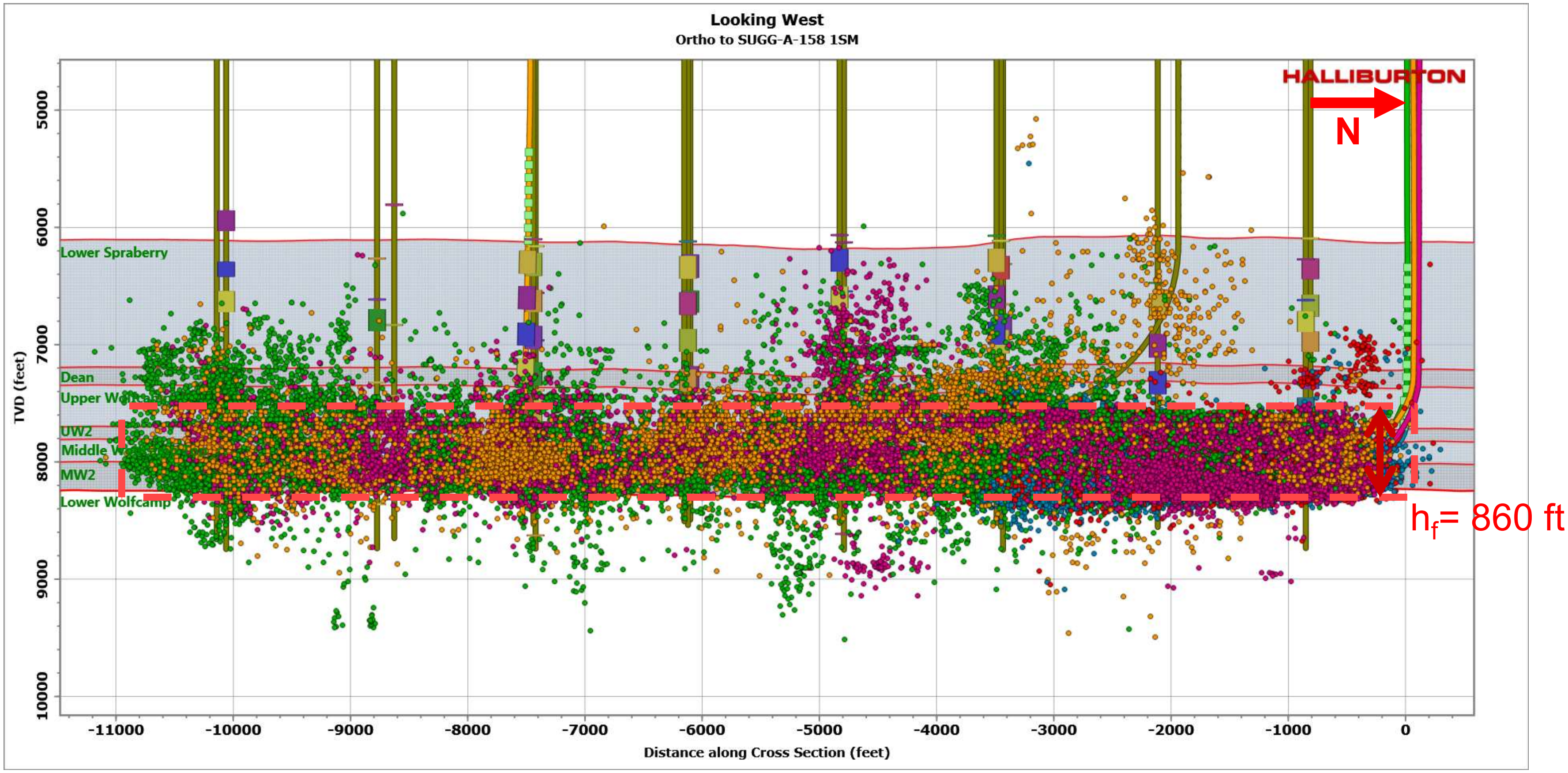
- Average height growth = 1,000 ft
  - Average upward growth = 525 ft
  - Average downward growth = 475 ft
- Average growth calculated from representative stages from each SU well

Fracture Height (h_f) – Upper Wolfcamp Wells Only



- Average height growth = 1,000 ft
  - Average upward growth = 525 ft
  - Average downward growth = 475 ft
- Average growth calculated from representative stages from each SU well

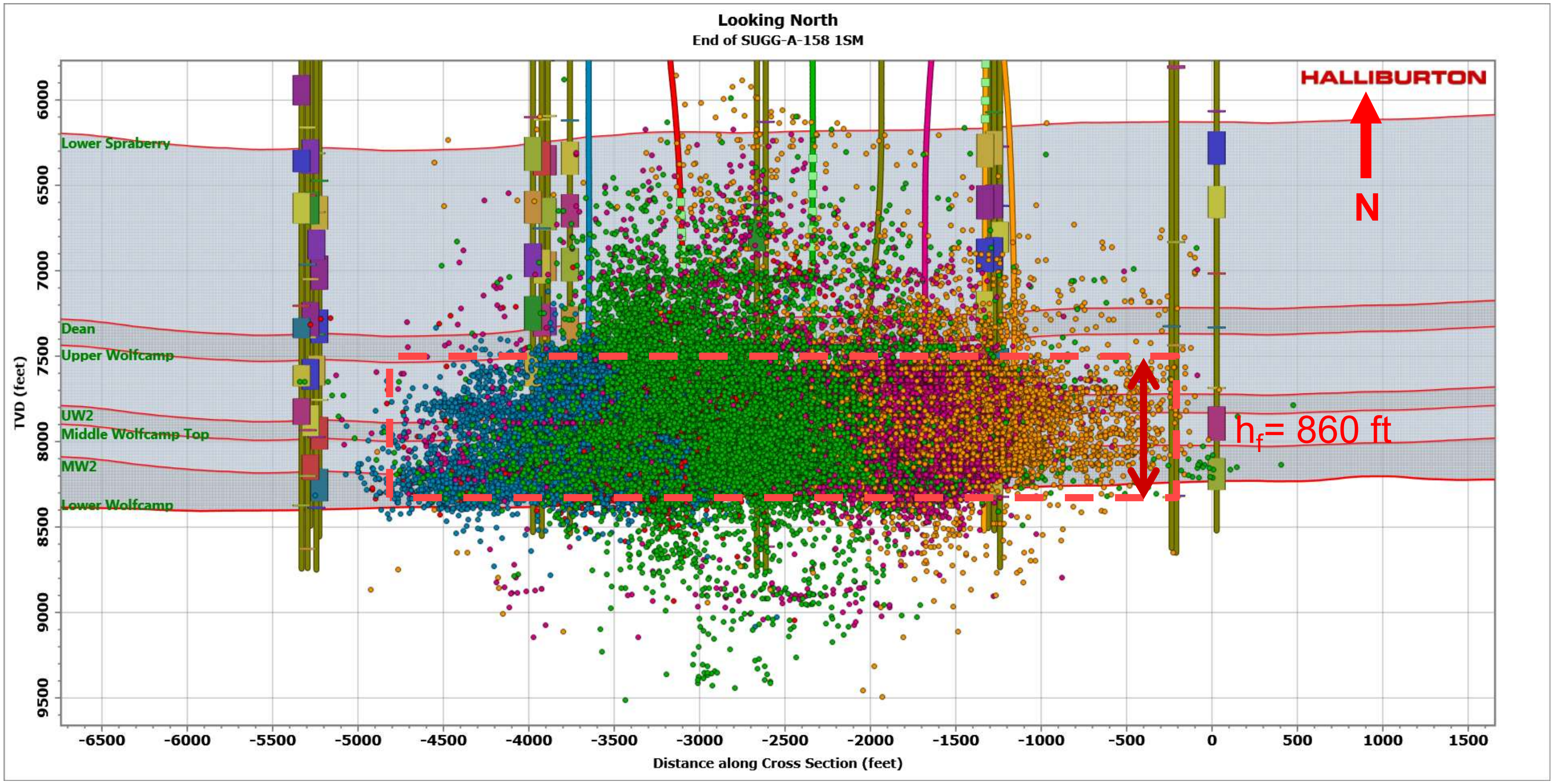
Fracture Height (h_f) – Middle Wolfcamp Wells Only



- Average height growth = 860 ft
  - Average upward growth = 570 ft
  - Average downward growth = 290 ft
- Average growth calculated from representative stages from each SM well

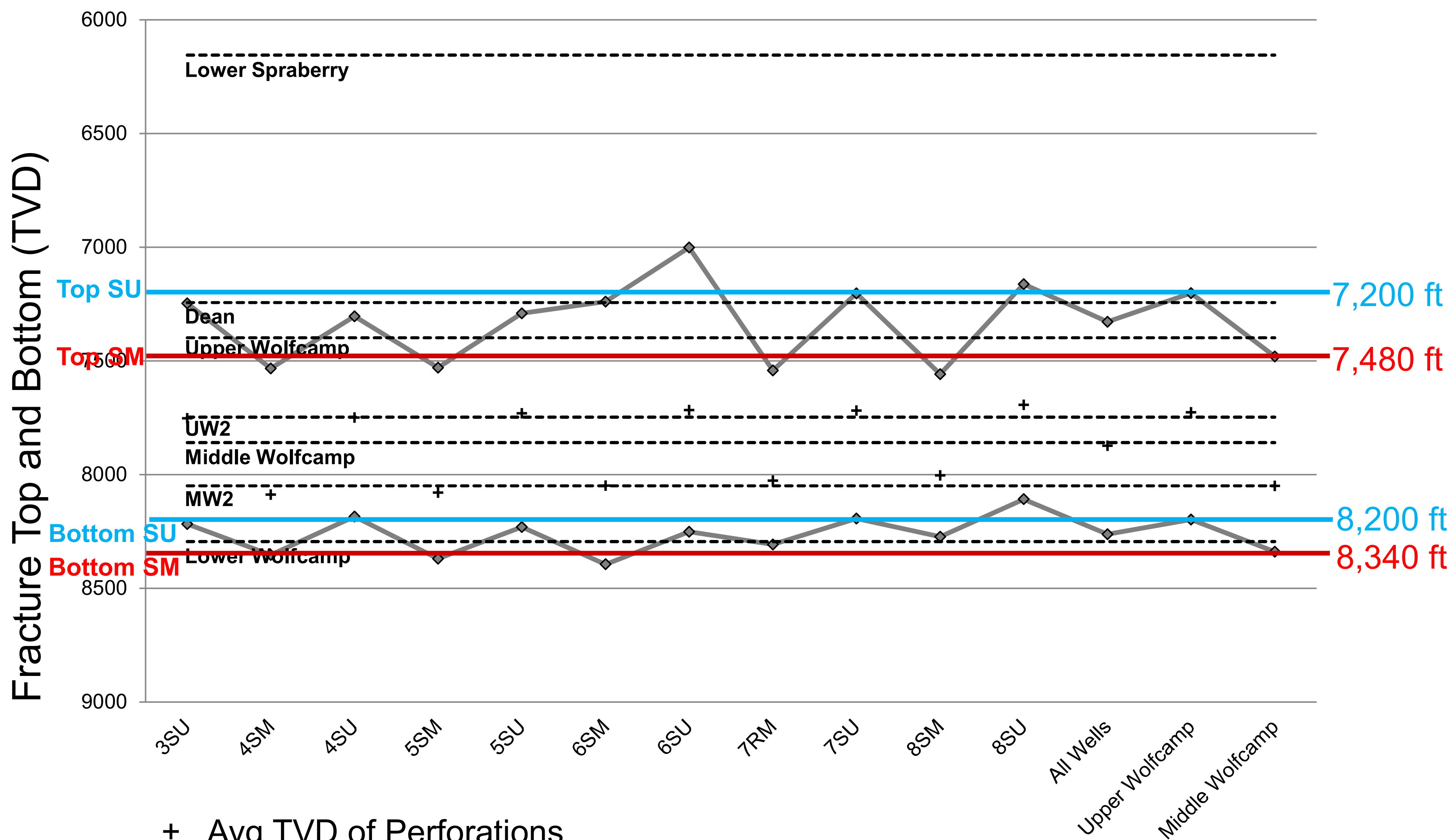
HALLIBURTON

Fracture Height (h_f) – Middle Wolfcamp Wells Only



- Average height growth = 860 ft
  - Average upward growth = 570 ft
  - Average downward growth = 290 ft
- Average growth calculated from representative stages from each SM well

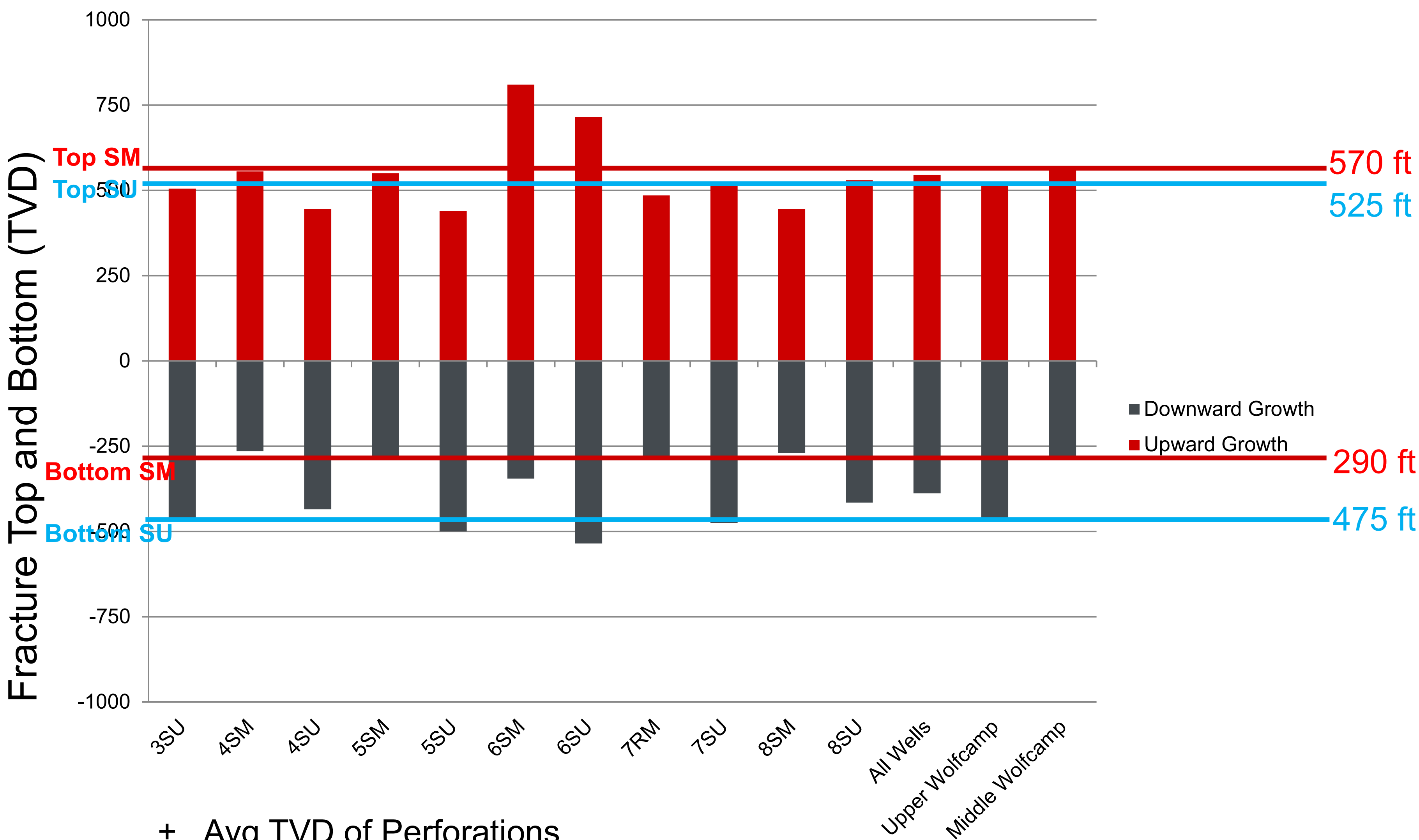
Fracture Height (h_f) – Top and Bottom Events – All Wells



\+ Avg TVD of Perforations

HALLIBURTON

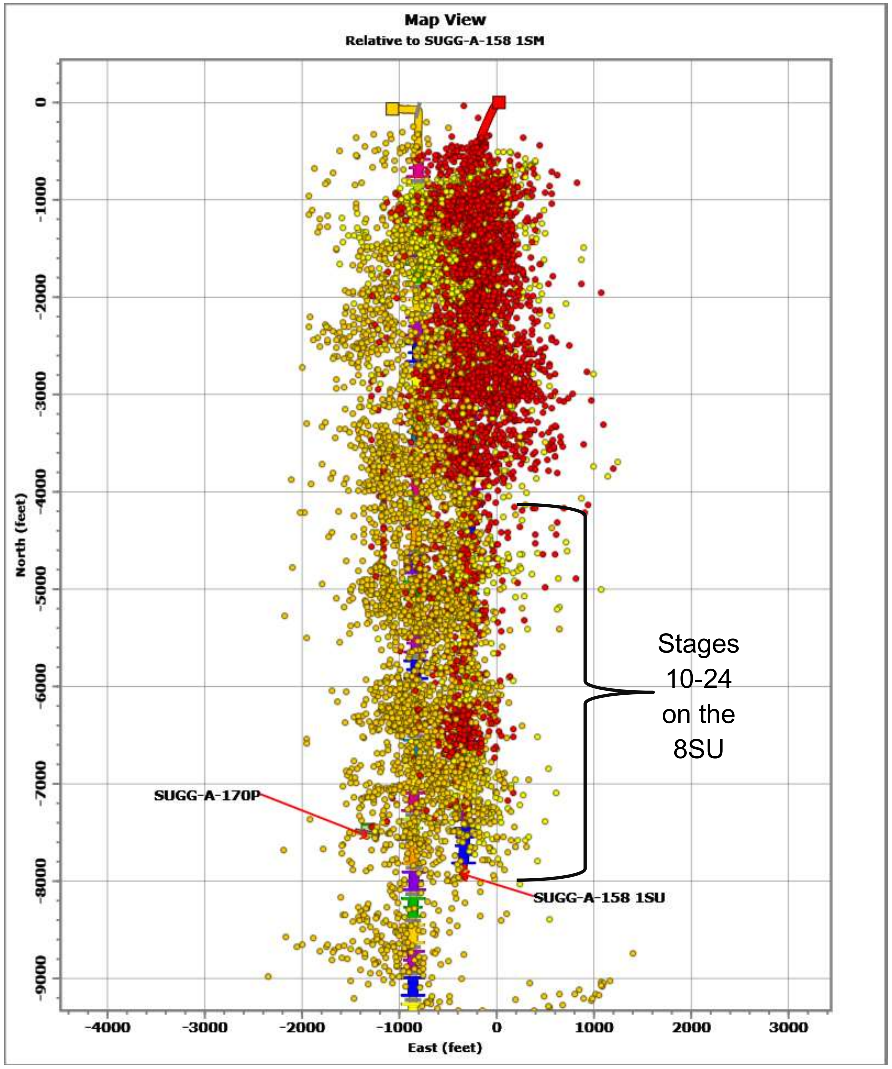
Fracture Height (h_f) – Height Growth – All Wells



+ Avg TVD of Perforations

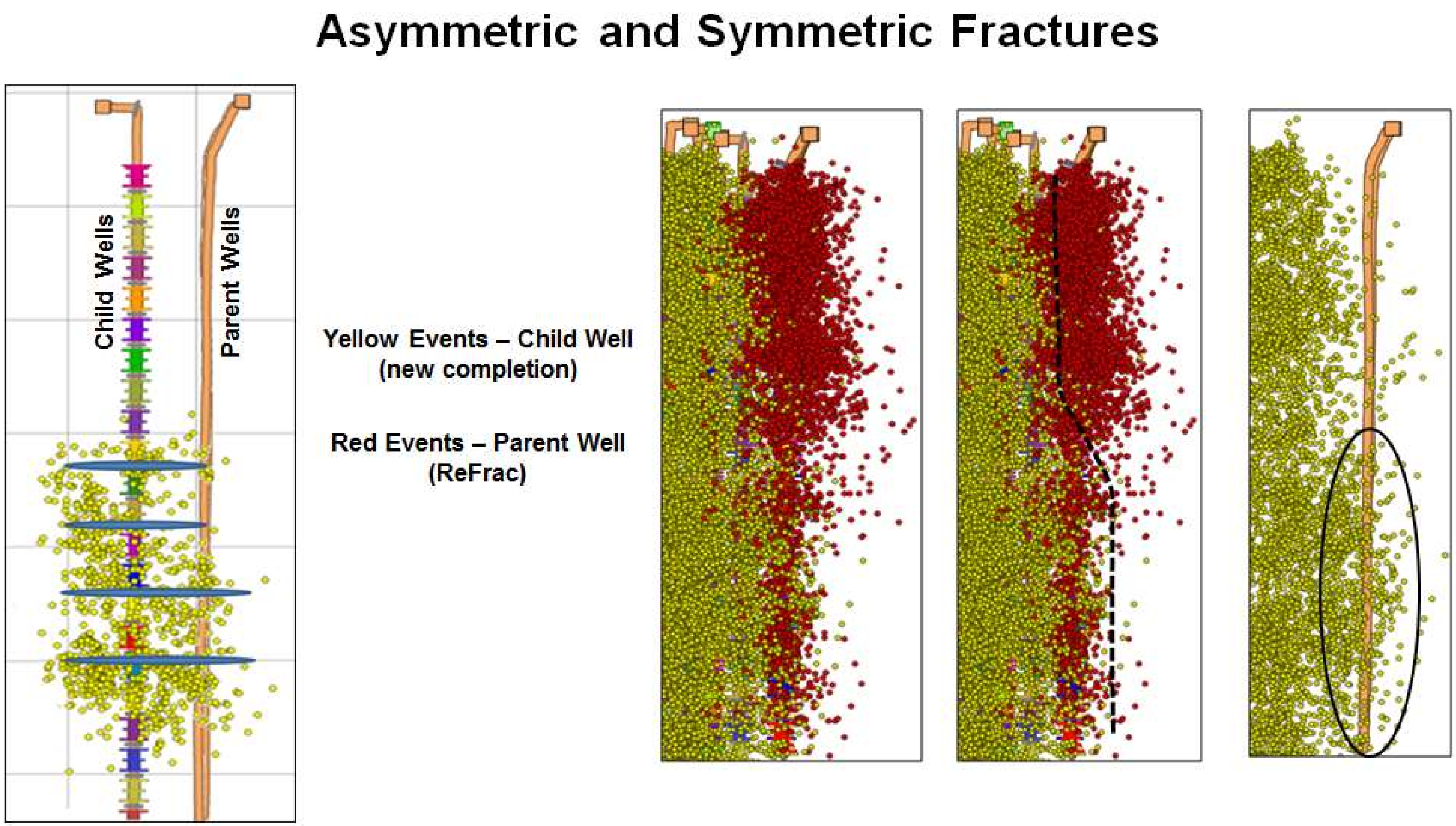
HALLIBURTON

Fracture Extension – 8SU and offset 158-SU refrac well



- Longer fracture extension to the northeast observed during stage 10 through 24 of the 8SU well, possibly due to depletion effects from the 158-SU.
- Root cause of apparent asymmetry is probably due to reduced stress from reservoir depletion from the offset horizontal wells.
- Apparent asymmetry is believed to be be real and not caused by artifacts of measurement.
  - Processing methodology was reviewed and no evident issues were found.

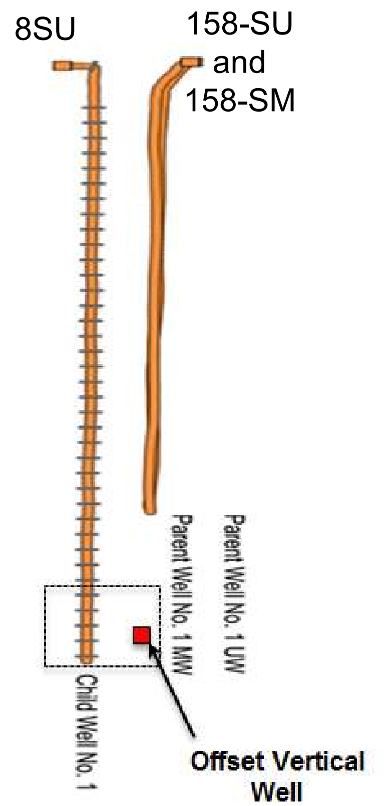
Fracture Extension – 8SU and offset 158-SU refrac well

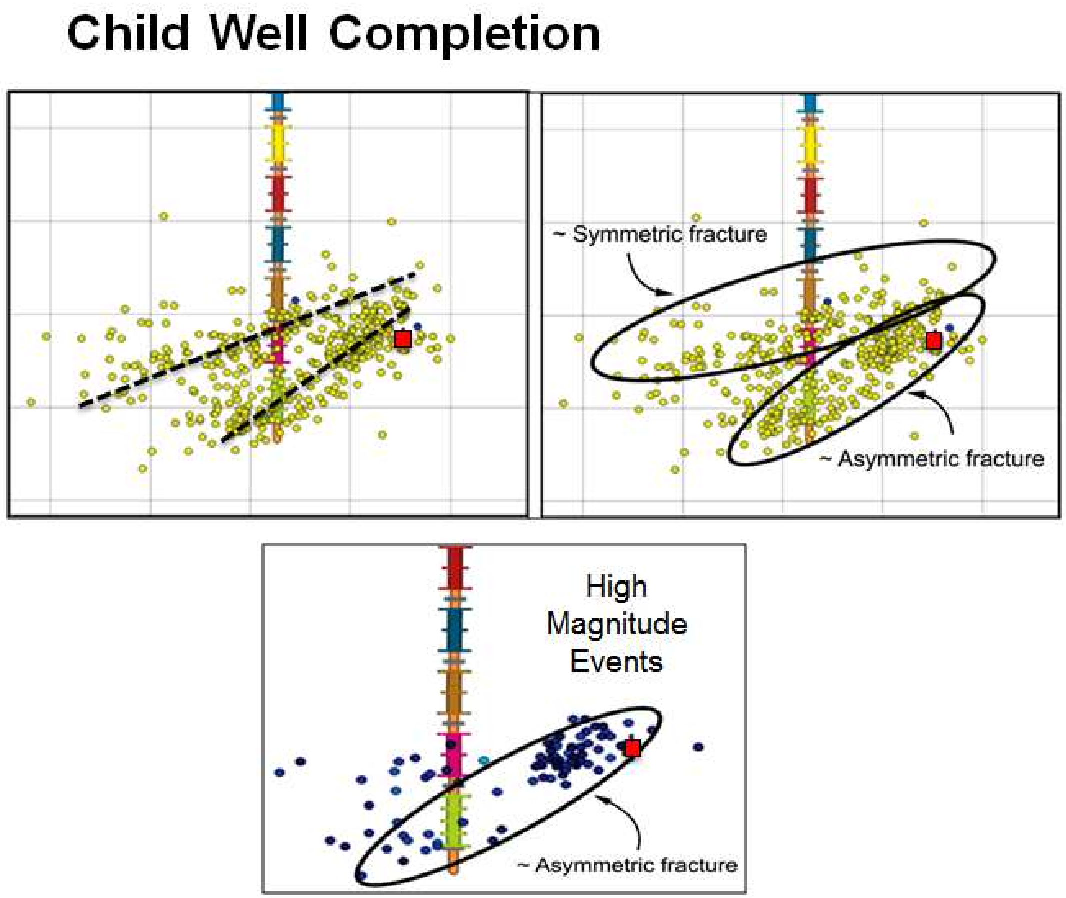


SPE 181767 - Legacy Well Protection Refrac Mitigates Offset Well Completion Communications in Joint Industry Project

HALLIBURTON

Fracture Extension – 8SU and offset 158-SU refrac well

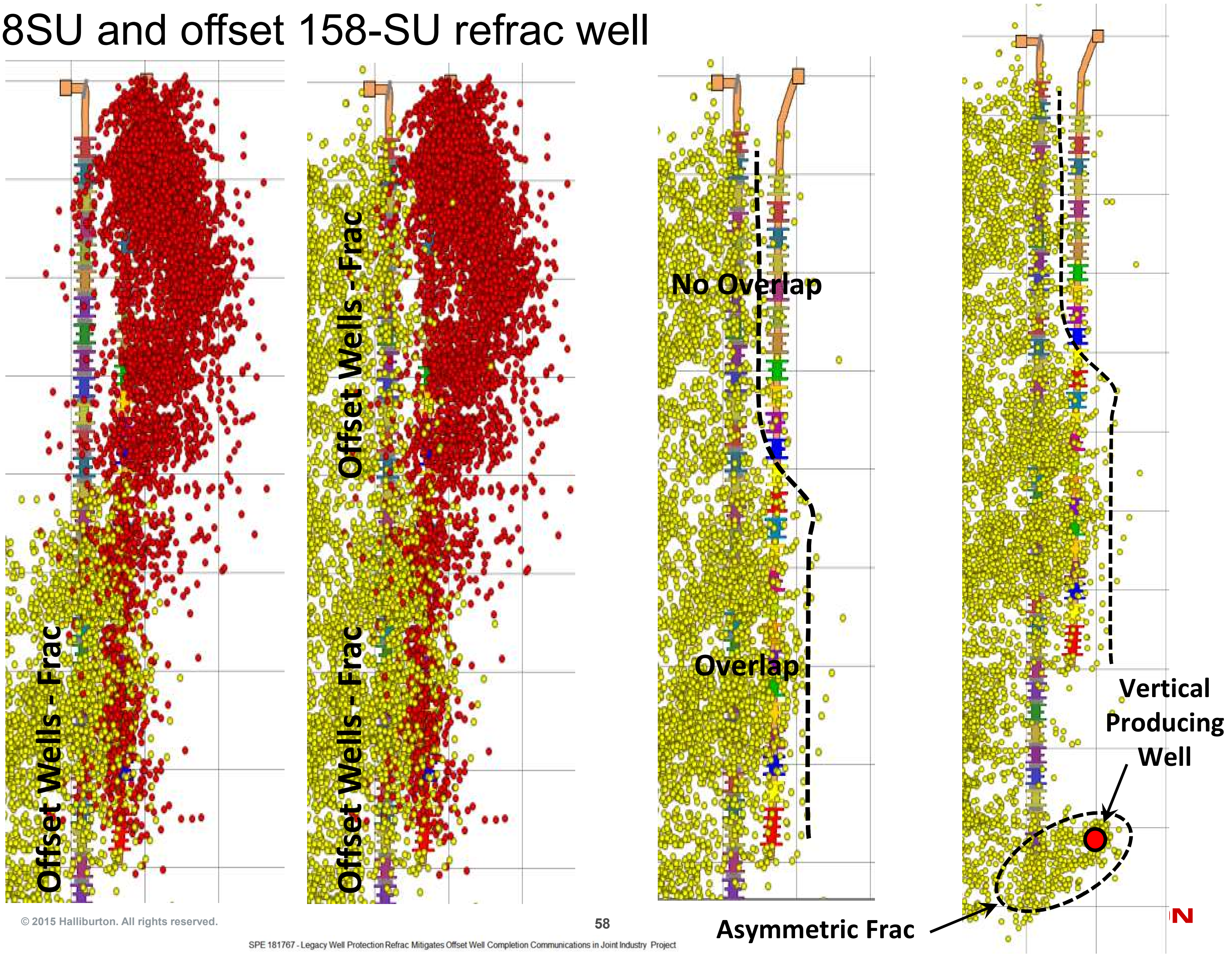


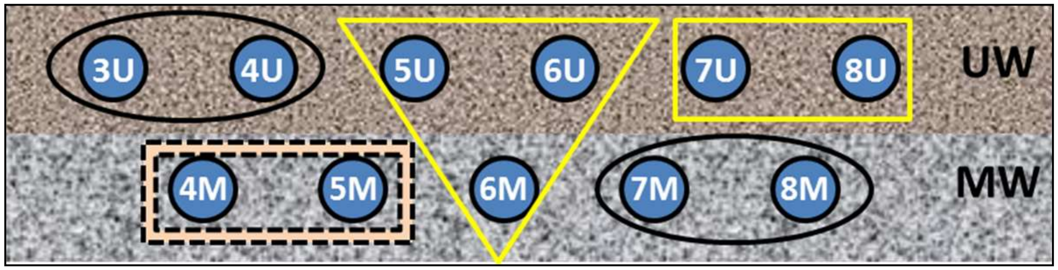


SPE 181767 - Legacy Well Protection Refrac Mitigates Offset Well Completion Communications in Joint Industry Project

HALLIBURTON

8SU and offset 158-SU refrac well





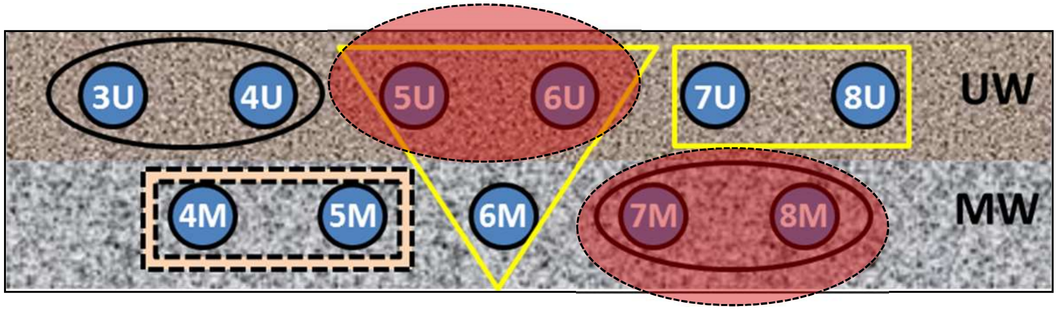
Impact of Zipper Frac and Completion Strategy

The Zipper frac completion sequence (and # of stages) was as follows:

Zipper Frac Completion 1 (frac crew 1): Wells 7SU (43) and 8SU (37)
Zipper Frac Completion 1 (frac crew 2): Wells 5SU (37), 6SU (37), and 6SM (37)
Zipper Frac Completion 2 (frac crew 1): Wells 7SM (49) and 8SM (37)
Zipper Frac Completion 2 (frac crew 2): Wells 3SU (37) and 4SU (45)
Zipper Frac Completion 3 (frac crew 2): Wells 4SM (37) and 5SM (37)

Sequence and timing of adjacent stages:

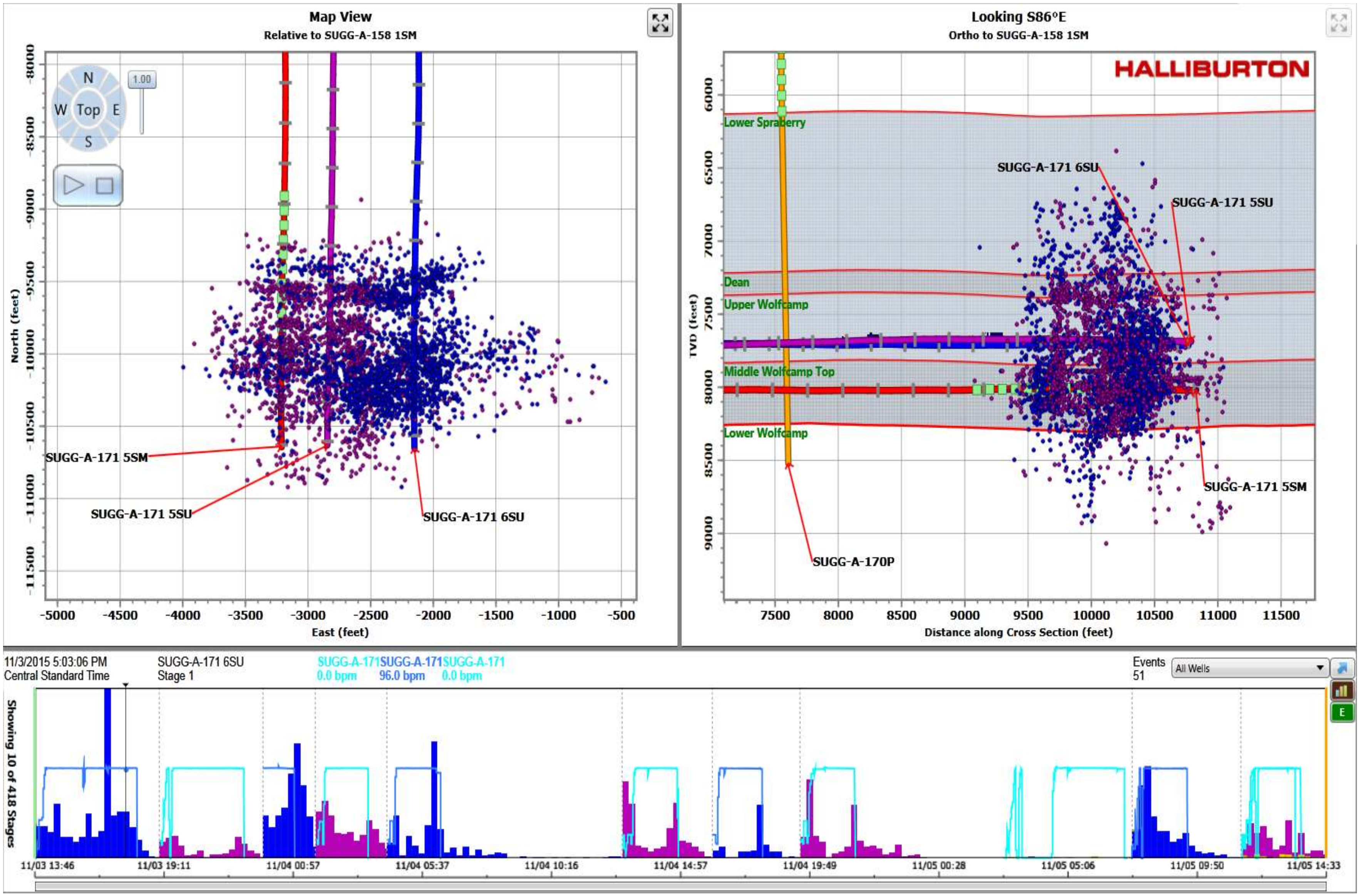
- Timing between completion sequencing doesn't seem to make a difference (from microseismic data).
- Events appear similar if the completion…..
  - starts with alternating between wells (zipper technique)
  - starts by pumping the first 5 stages on one well and then begin alternating stages (zipper technique)



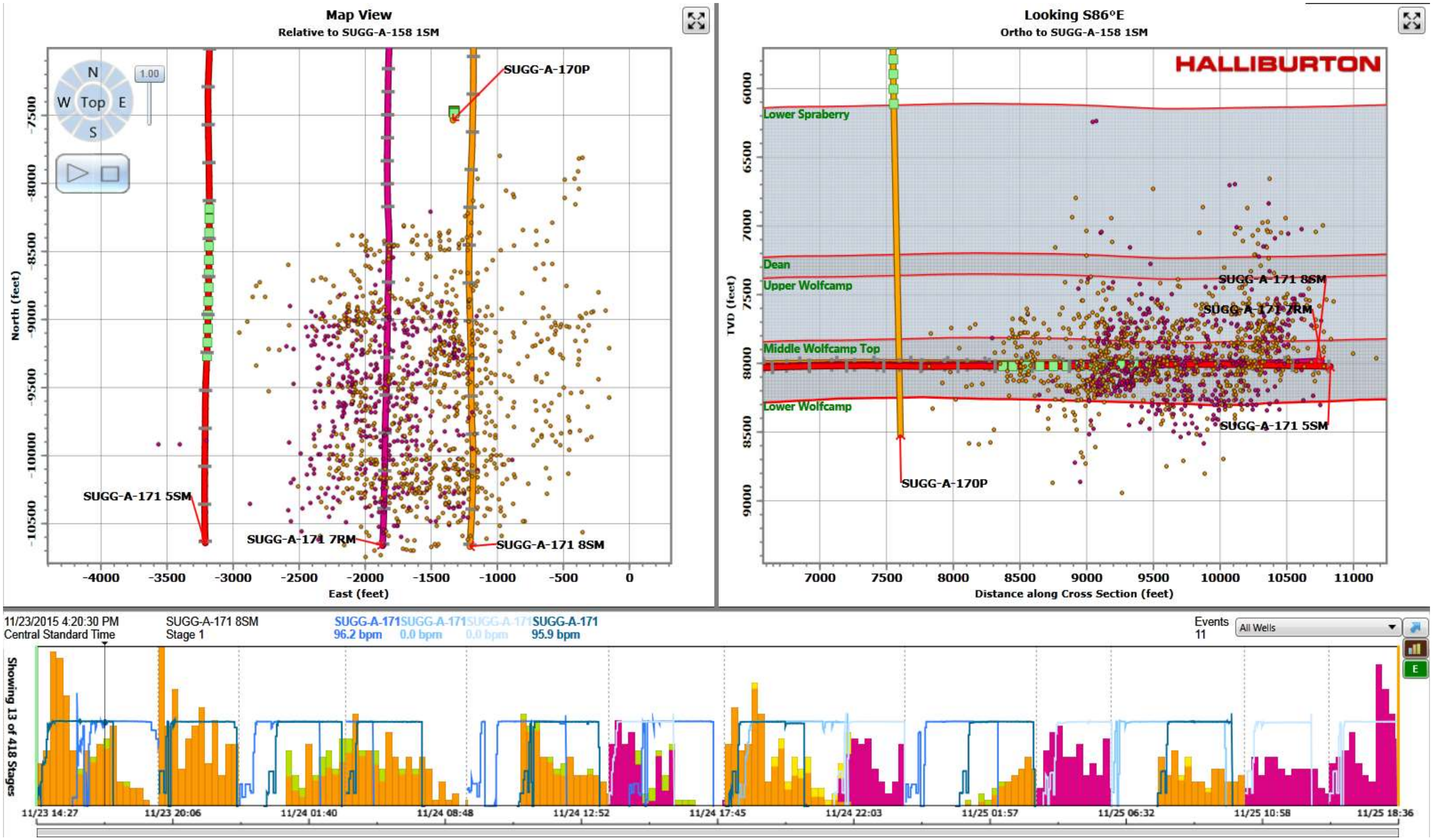
The Zipper frac completion sequence (and # of stages) was as follows:

Zipper Frac Completion 1 (frac crew 1): Wells 7SU (43) and 8SU (37)
Zipper Frac Completion 1 (frac crew 2): Wells 5SU (37), 6SU (37), and 6SM (37)
Zipper Frac Completion 2 (frac crew 1): Wells 7SM (49) and 8SM (37)
Zipper Frac Completion 2 (frac crew 2): Wells 3SU (37) and 4SU (45)
Zipper Frac Completion 3 (frac crew 2): Wells 4SM (37) and 5SM (37)

Sequence and timing of adjacent stages - 5SU and 6SU (1st 5 stages)
- Continuous alternation of stages between wells

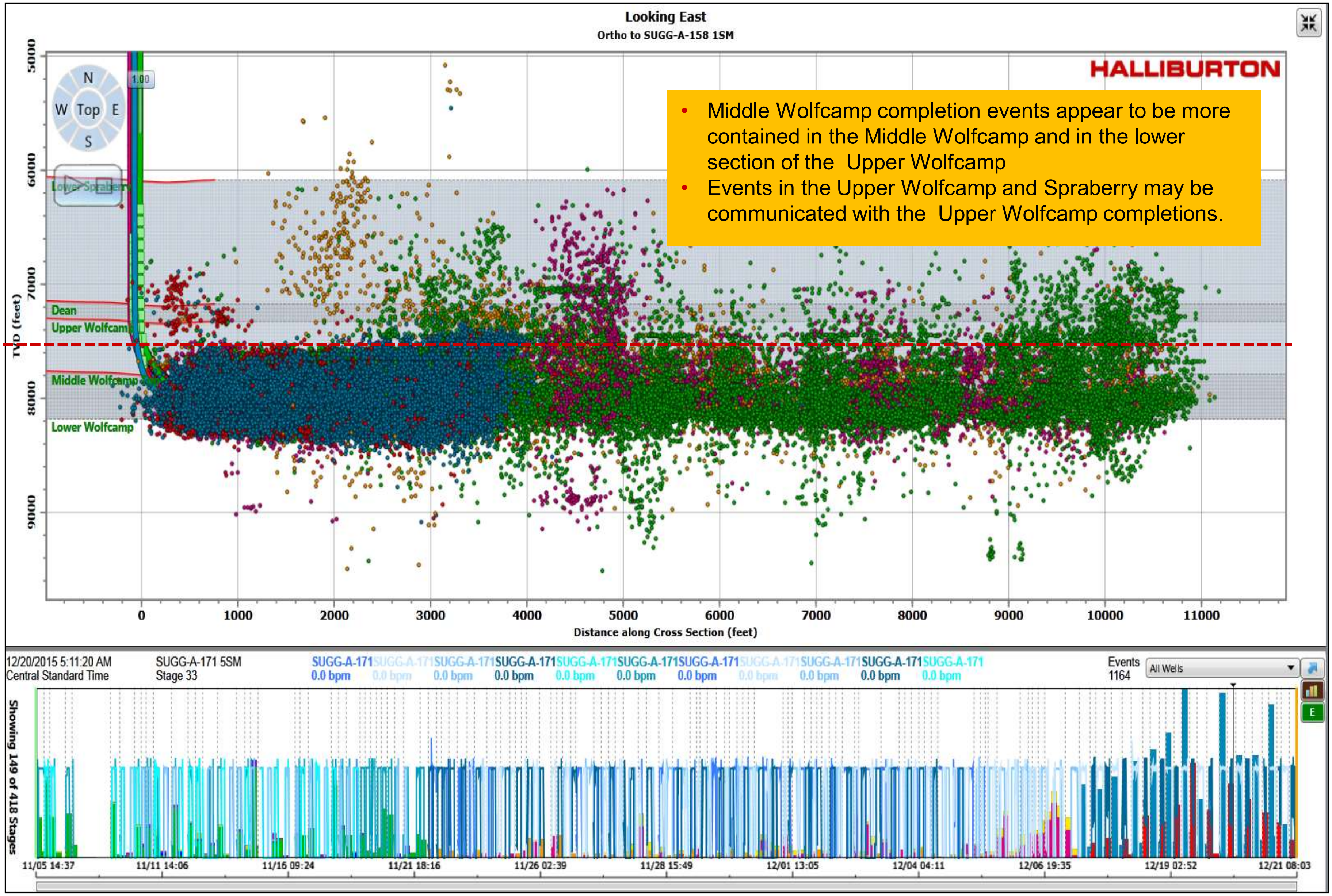


Sequence and timing of adjacent stages - 7SM and 8SM (1st - 5 stages) - Pump 5 stages on 8SM, then continuous alternation of stages



Impact of completing upper Wolfcamp wells prior to middle Wolfcamp

All Middle Wolfcamp microseismic events (colored by treatment well)



- Middle Wolfcamp completion events appear to be more contained in the Middle Wolfcamp and in the lower section of the Upper Wolfcamp
- Events in the Upper Wolfcamp and Spraberry may be communicated with the Upper Wolfcamp completions.

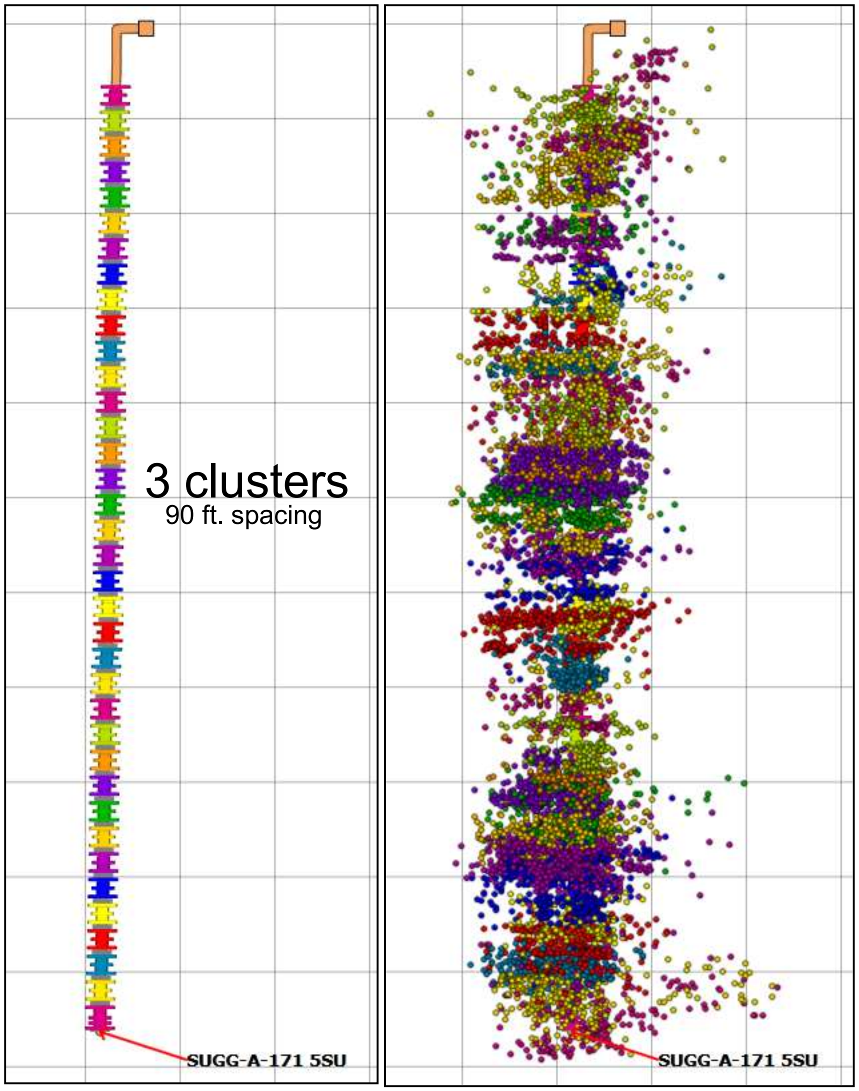
HALLIBURTON

Number of Perf clusters per stage and cluster spacing

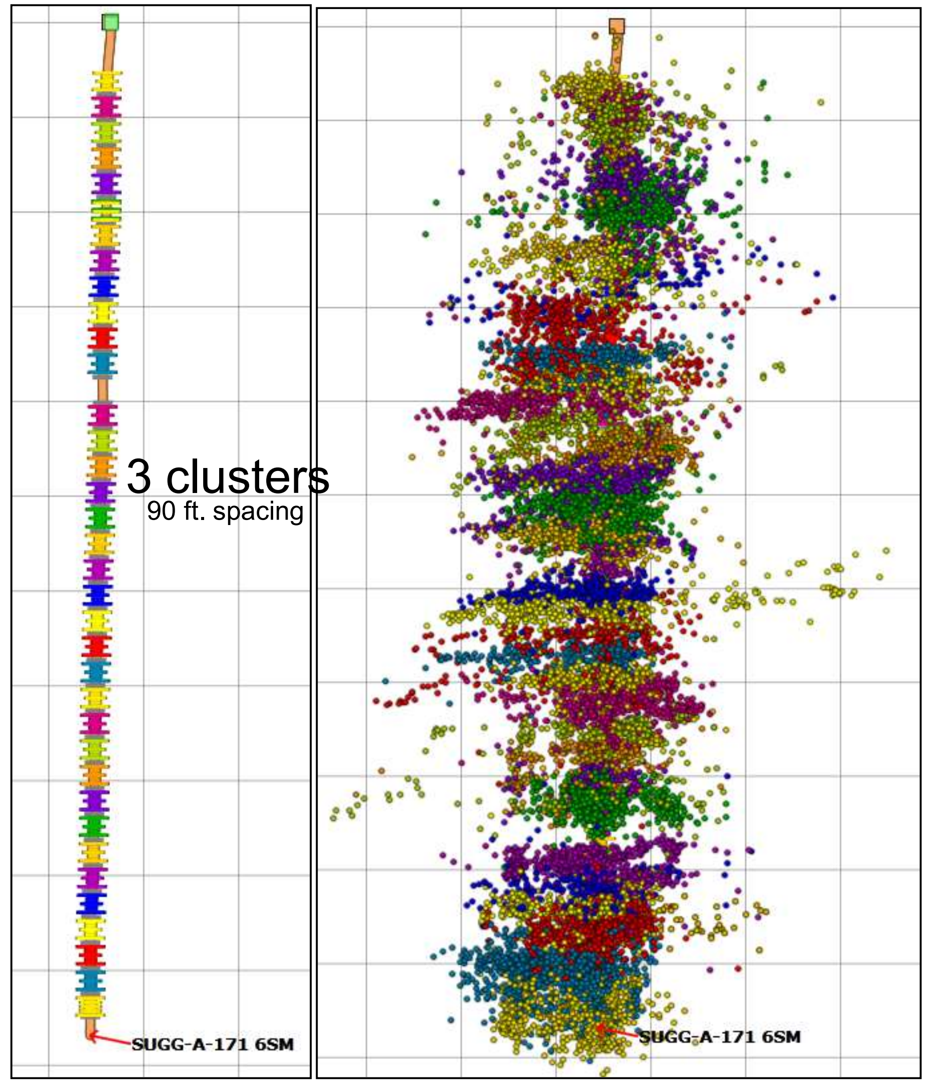
HALLIBURTON

Perf Cluster Spacing – 5SU (37 stages) and 6SM (37 stages)

Upper Wolfcamp

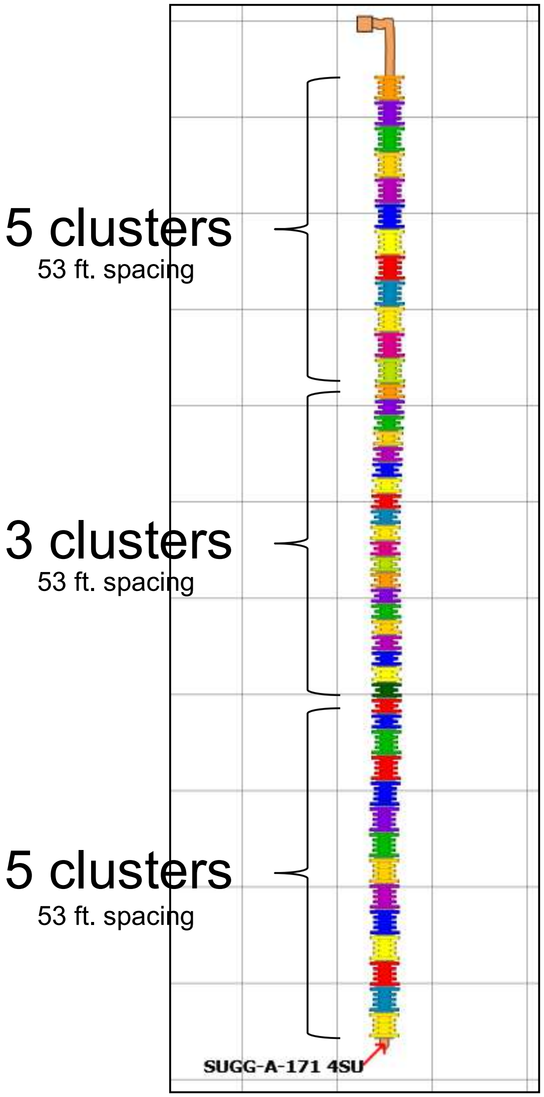


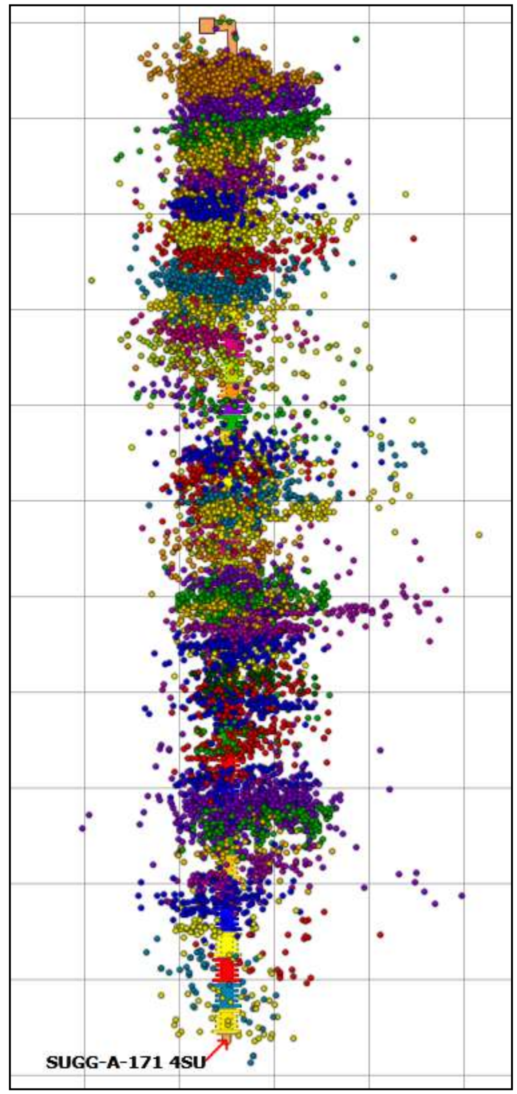
Middle Wolfcamp



HALLIBURTON

Perf Cluster Spacing – 4SU (46 stages)

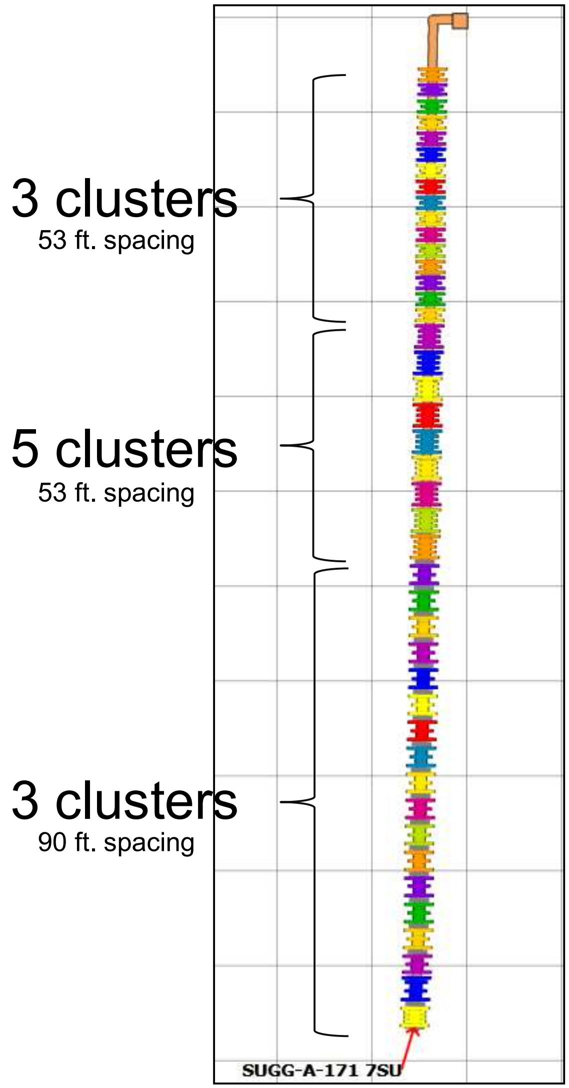


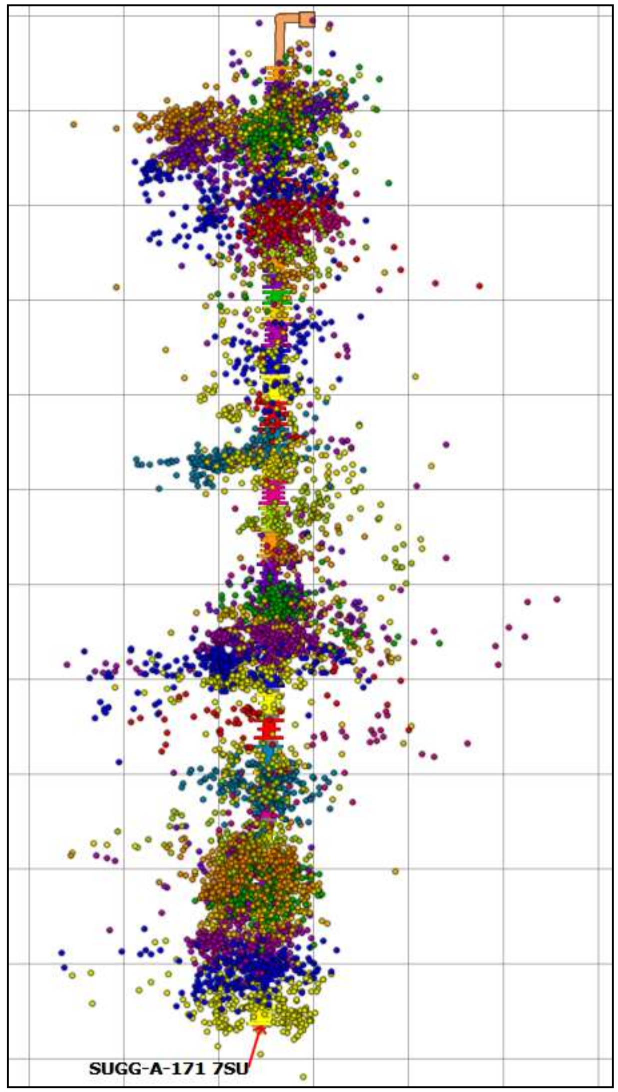


- Doesn’t appear to be a difference between the different cluster spacing (from MSM)
- Event clusters may appear otherwise due to the artifacts of the measurement

HALLIBURTON

Perf Cluster Spacing – 7SU (43 Stages)





- Doesn't appear to be a difference between the different cluster spacing (from MSM)
- Event clusters may appear otherwise due to the artifacts of the measurement

HALLIBURTON

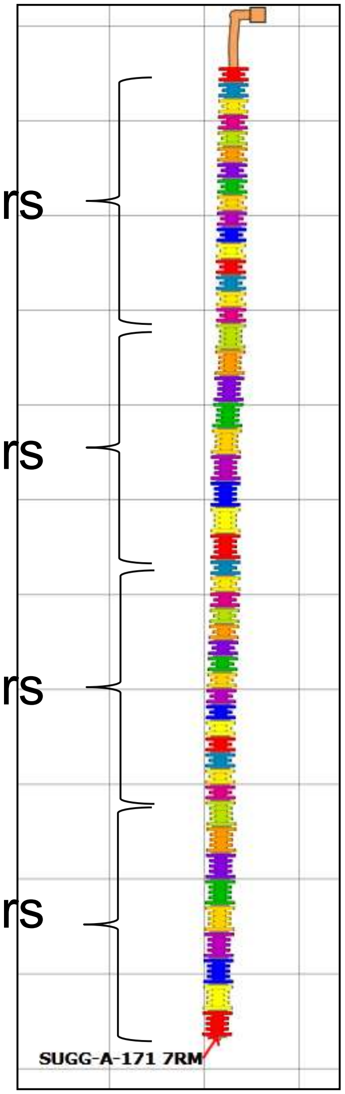
Perf Cluster Spacing – 7RM (49 stages)

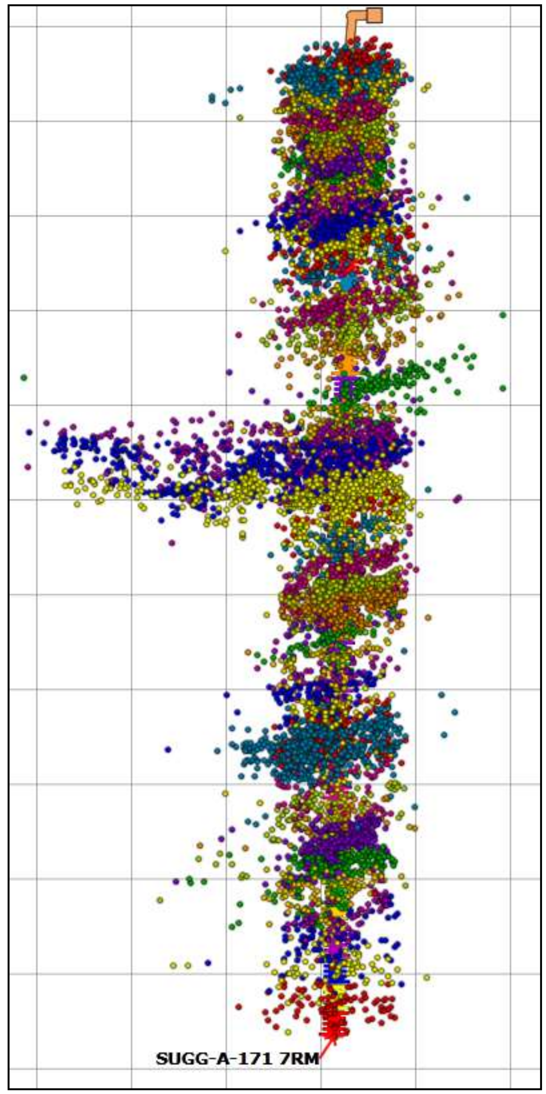
3 clusters
53 ft. spacing

5 clusters
53 ft. spacing

3 clusters
53 ft. spacing

5 clusters
53 ft. spacing

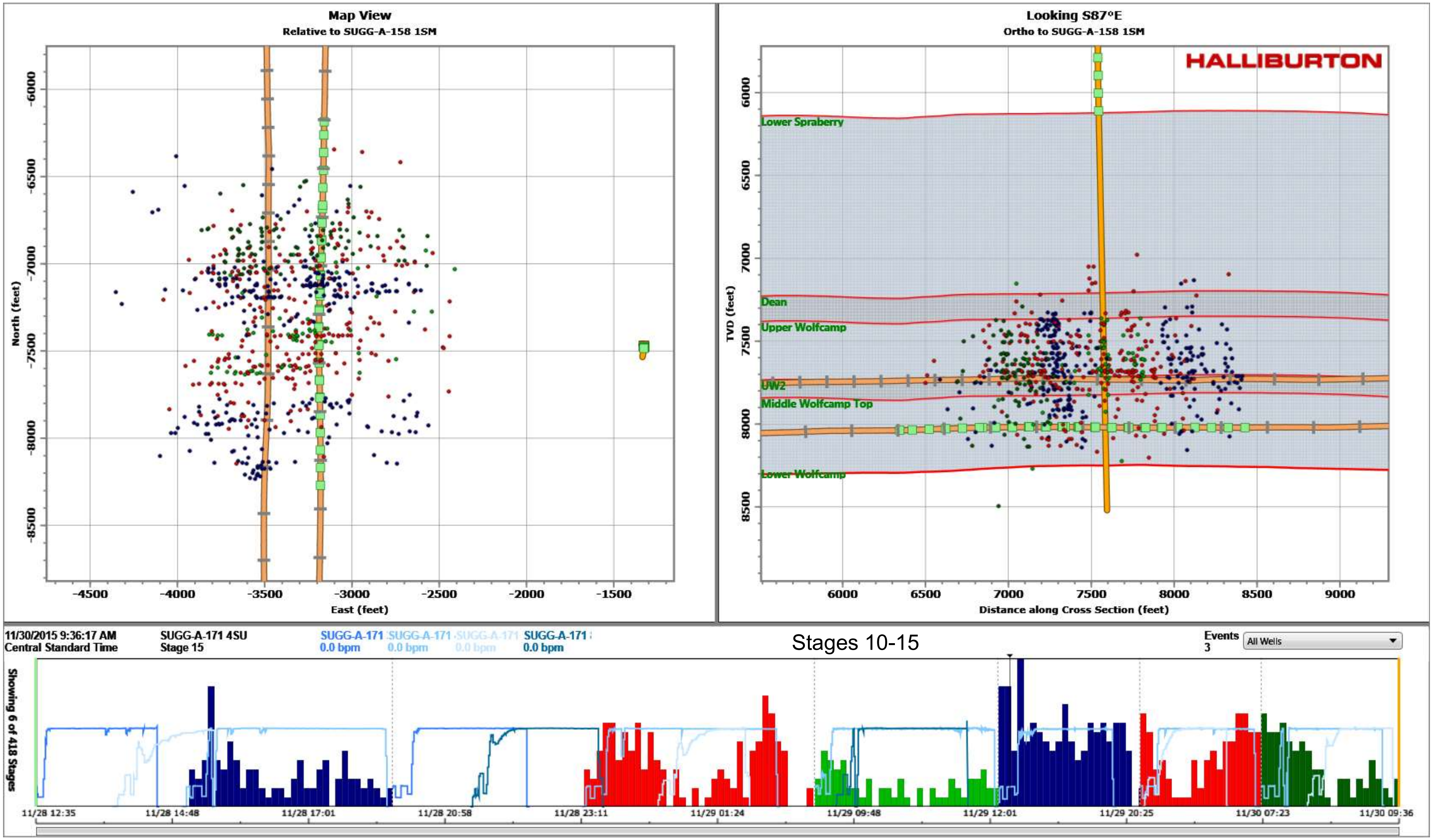




- Doesn't appear to be a difference between the different cluster spacing (from MSM)
- Event clusters may appear otherwise due to the artifacts of the measurement

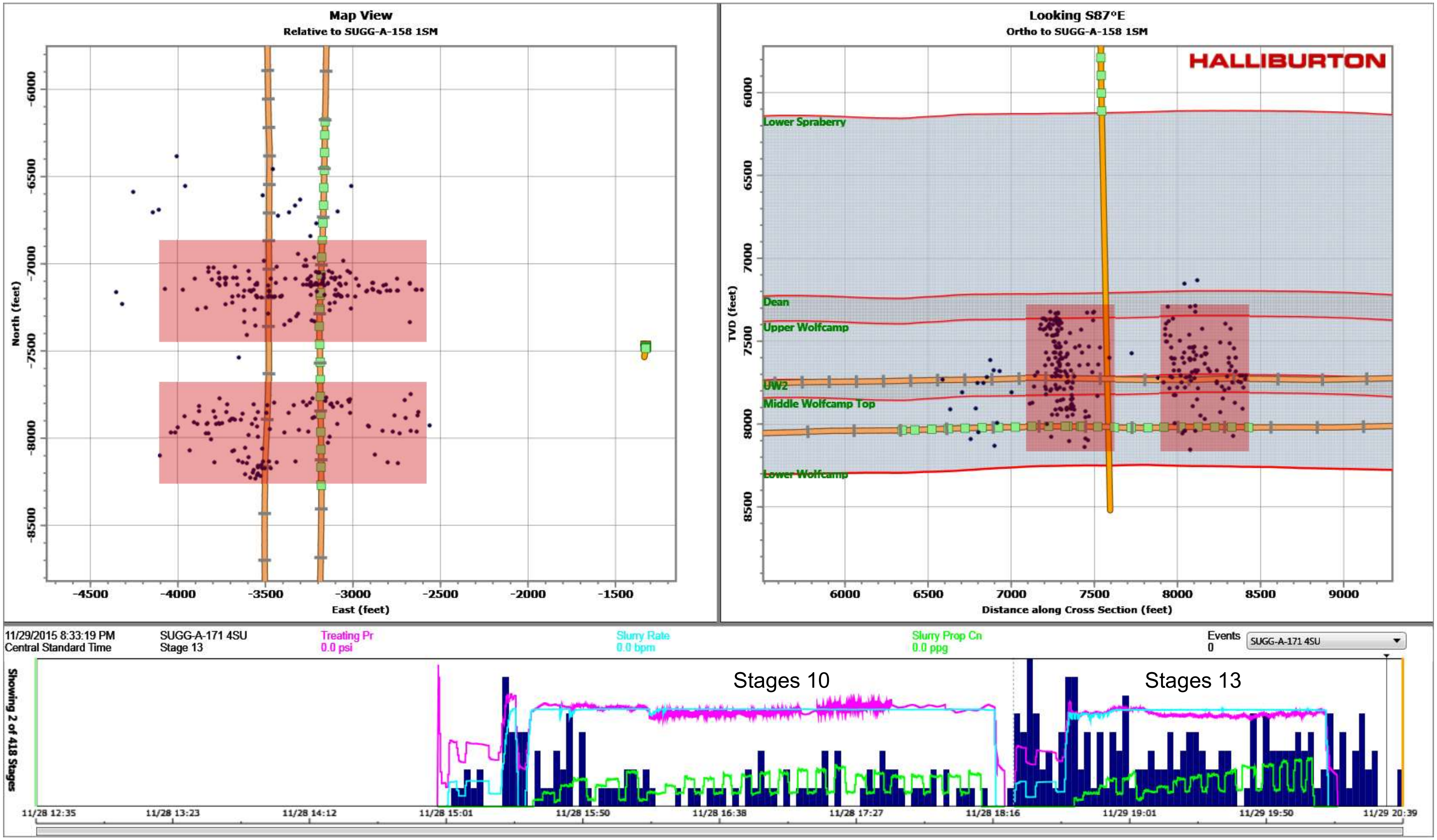
HALLIBURTON

Perf Cluster design comparison and the same Geophone location
(Similar MSM event distribution)



HALLIBURTON

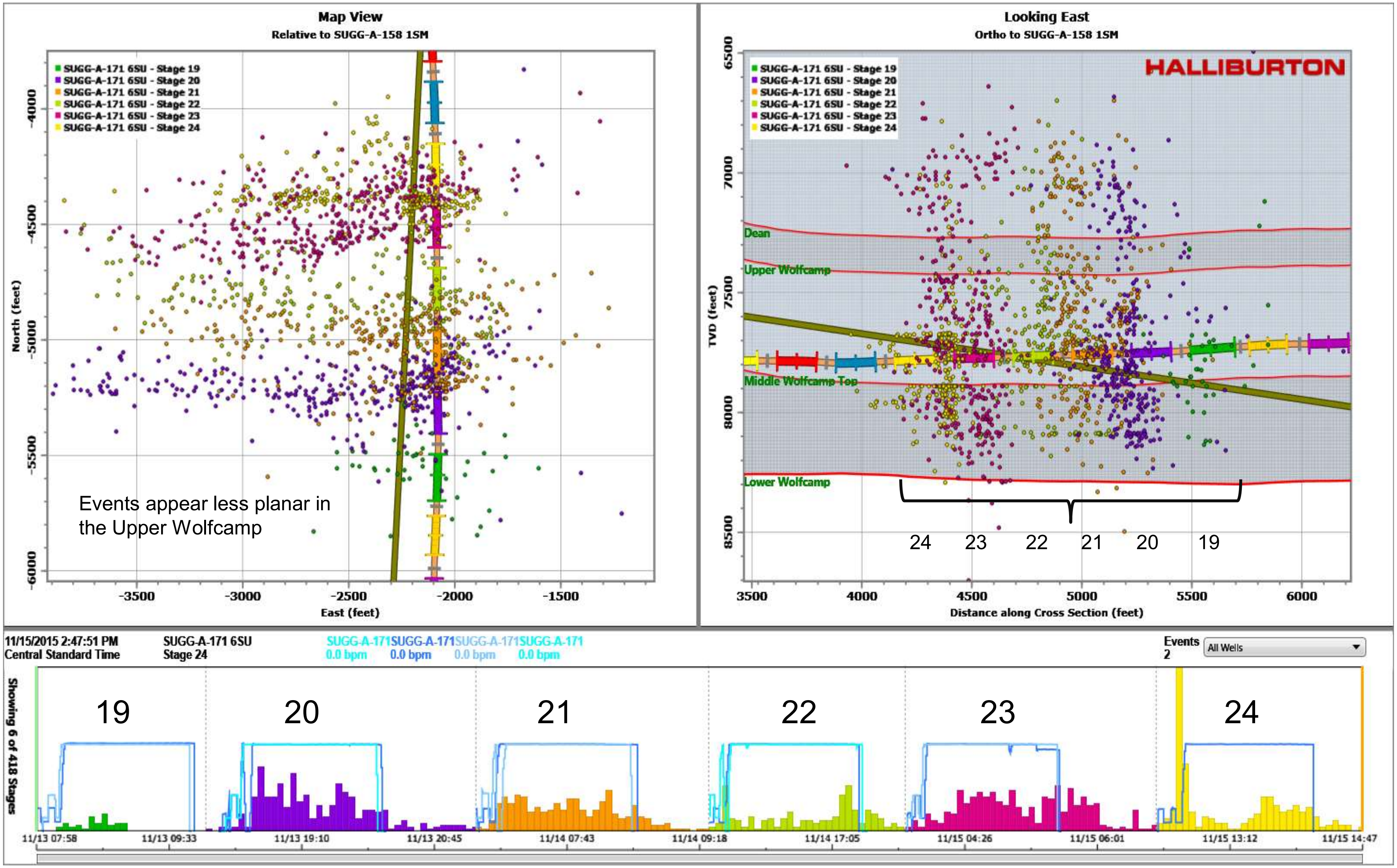
Perf Cluster design comparison and the same Geophone location
(Similar MSM event distribution)



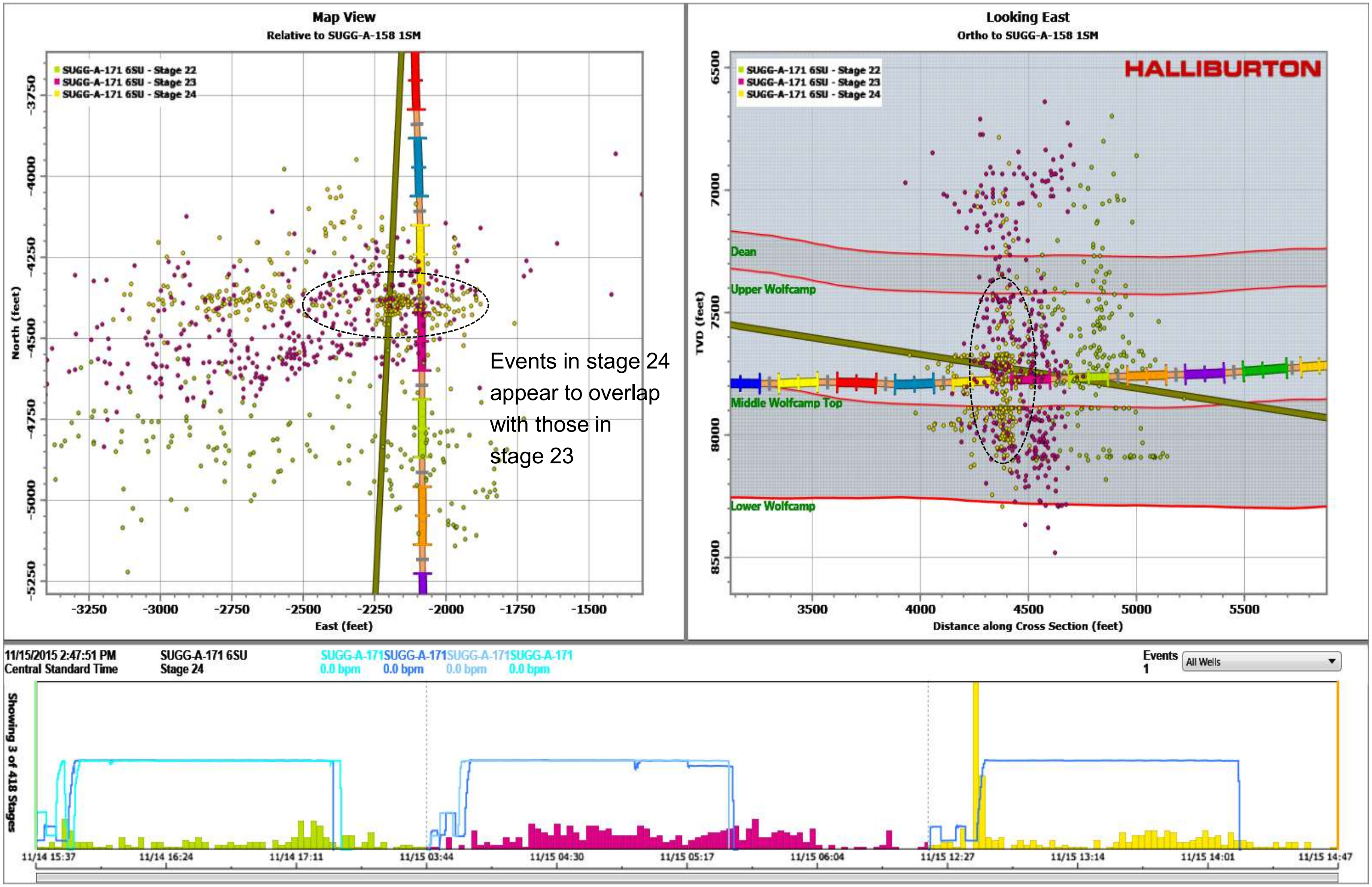
Microseismic Data relative to the Slant well (6TW) core intervals

HALLIBURTON

Sugg-A-171 6SU: Core interval adjacent to stages 19 thru 24

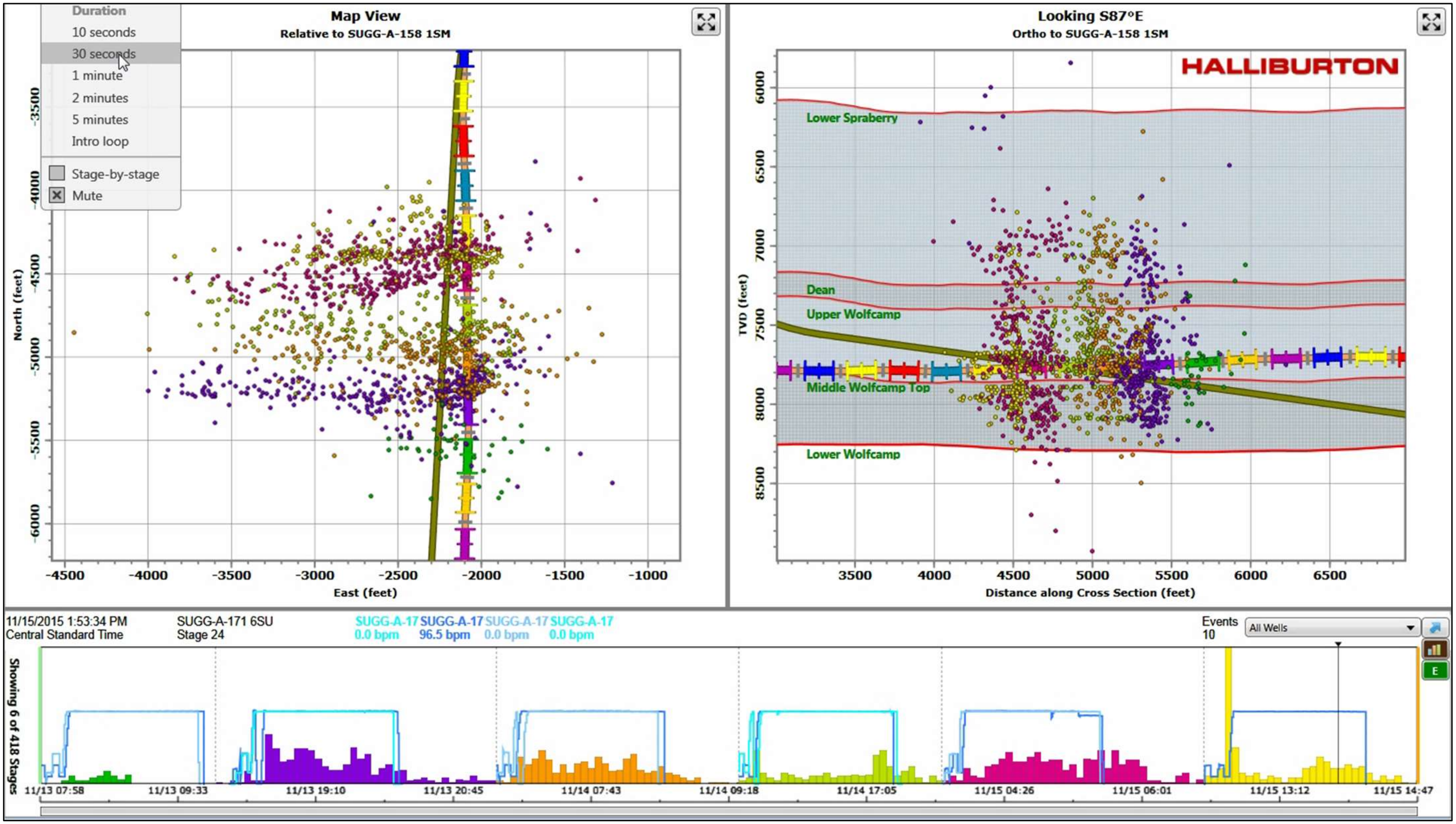


Sugg-A-171 6SU: Core interval adjacent to Stage 22-24



HALLIBURTON

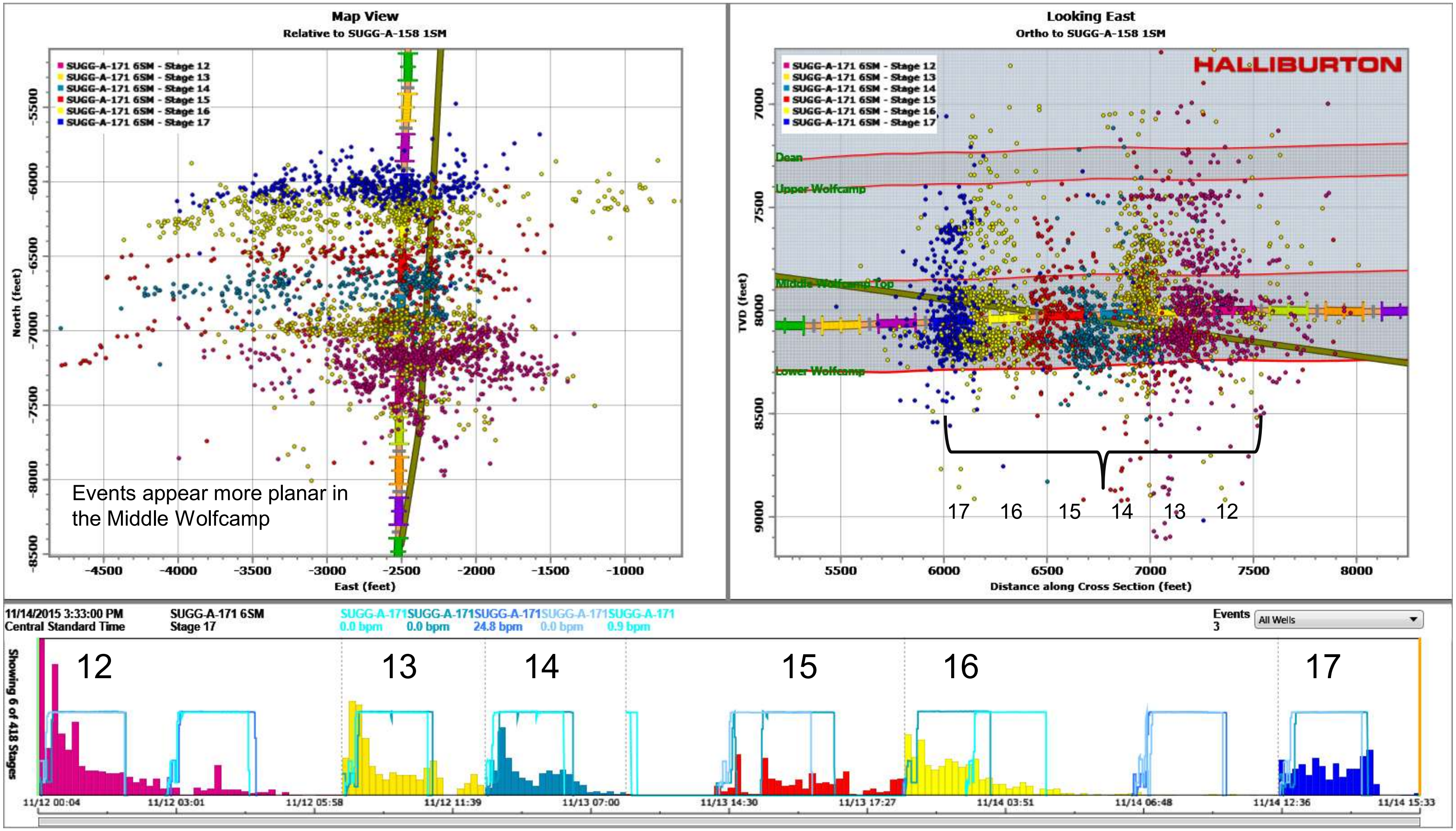
Sugg-A-171 6SU: Core interval adjacent to stages 19 thru 24



Animation Slide

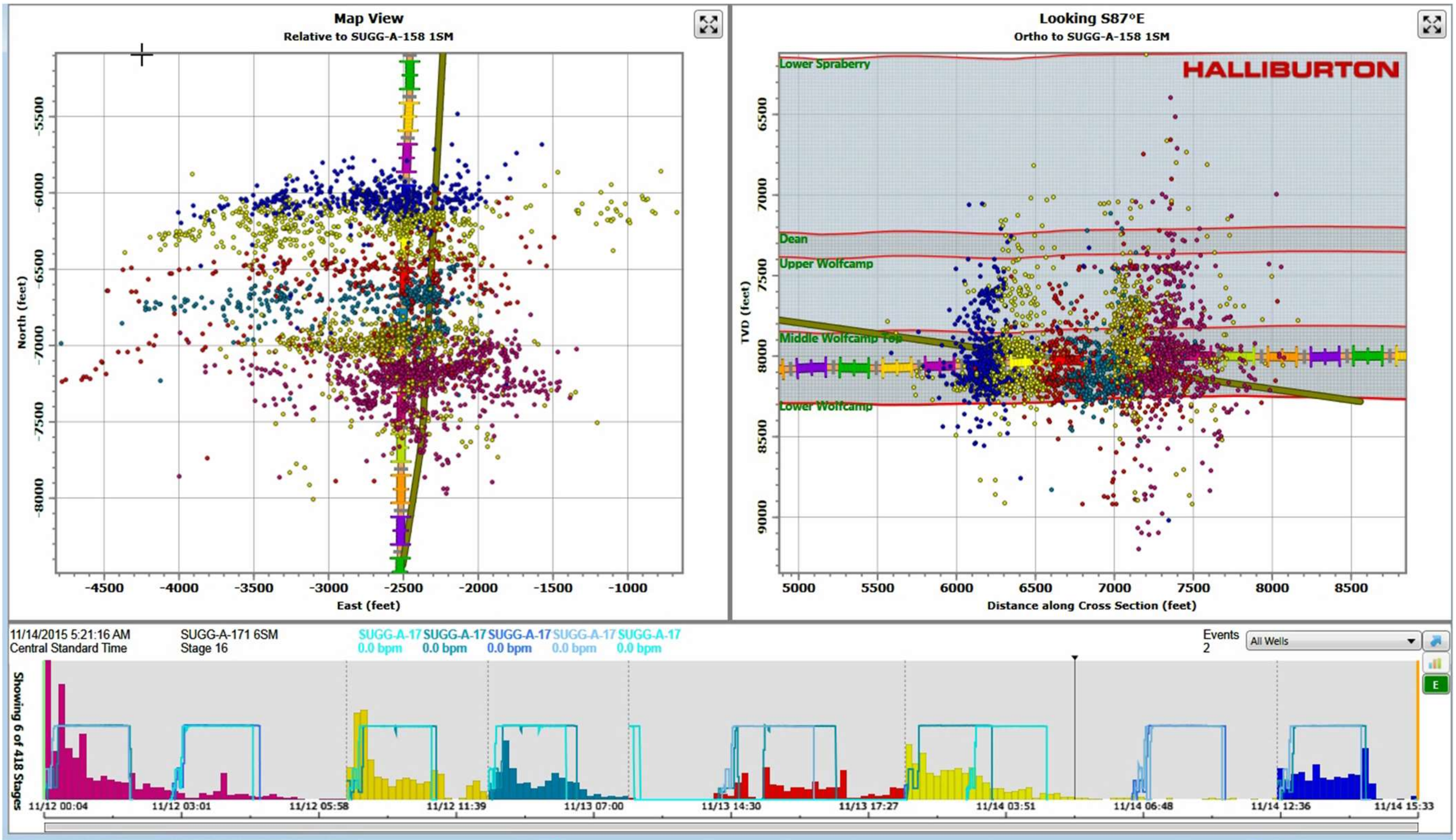
HALLIBURTON

Sugg-A-171 6SM: Core interval adjacent to stages 12 thru 17



HALLIBURTON

Sugg-A-171 6SM: Core interval adjacent to stages 12 thru 17



Animation Slide

HALLIBURTON

THANK YOU

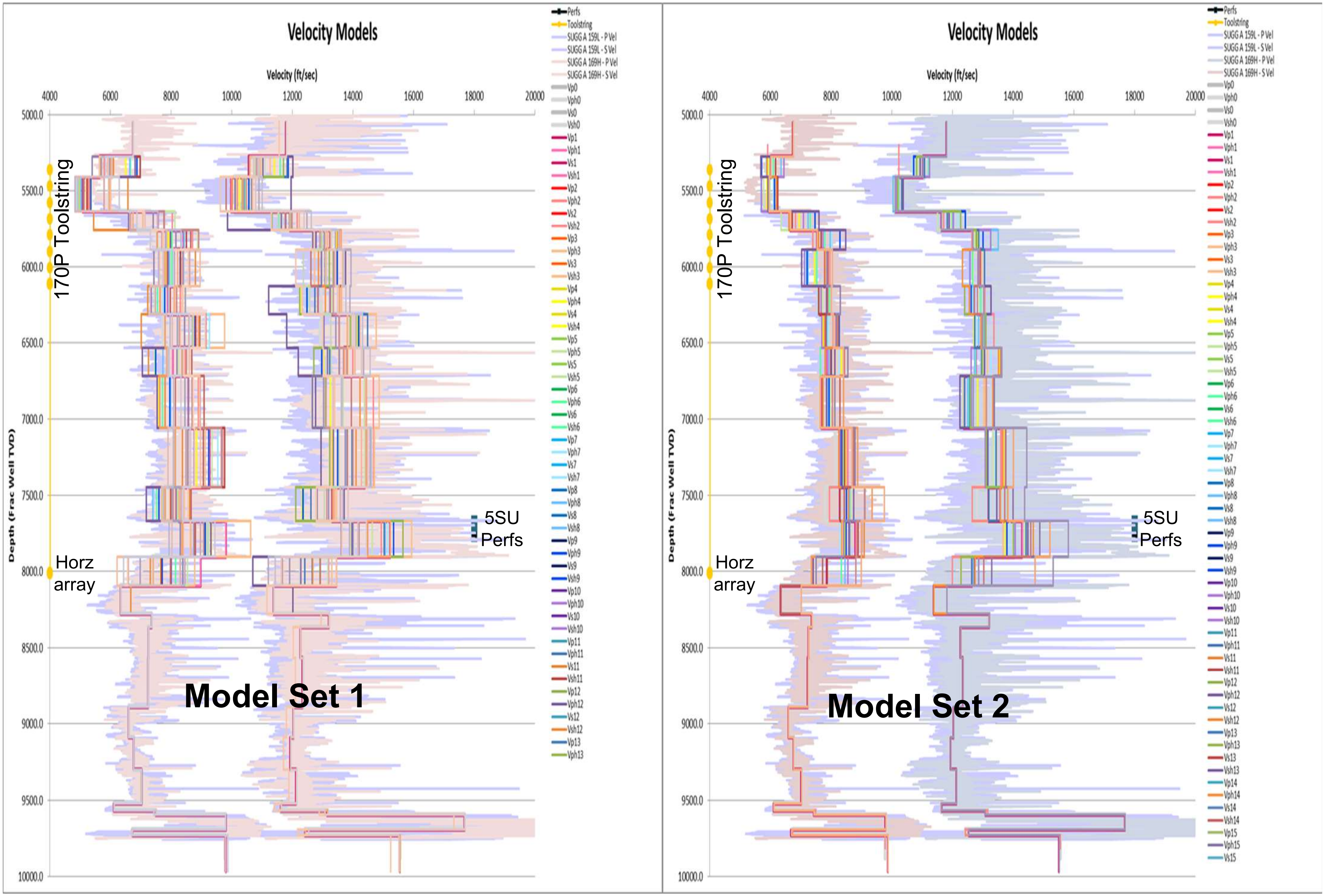
Appendix
Velocity modeling
Other support information

Further QC information in QC report pdf file and Geo Executive Summary PowerPoint found on the thumb drive behind the printed report book

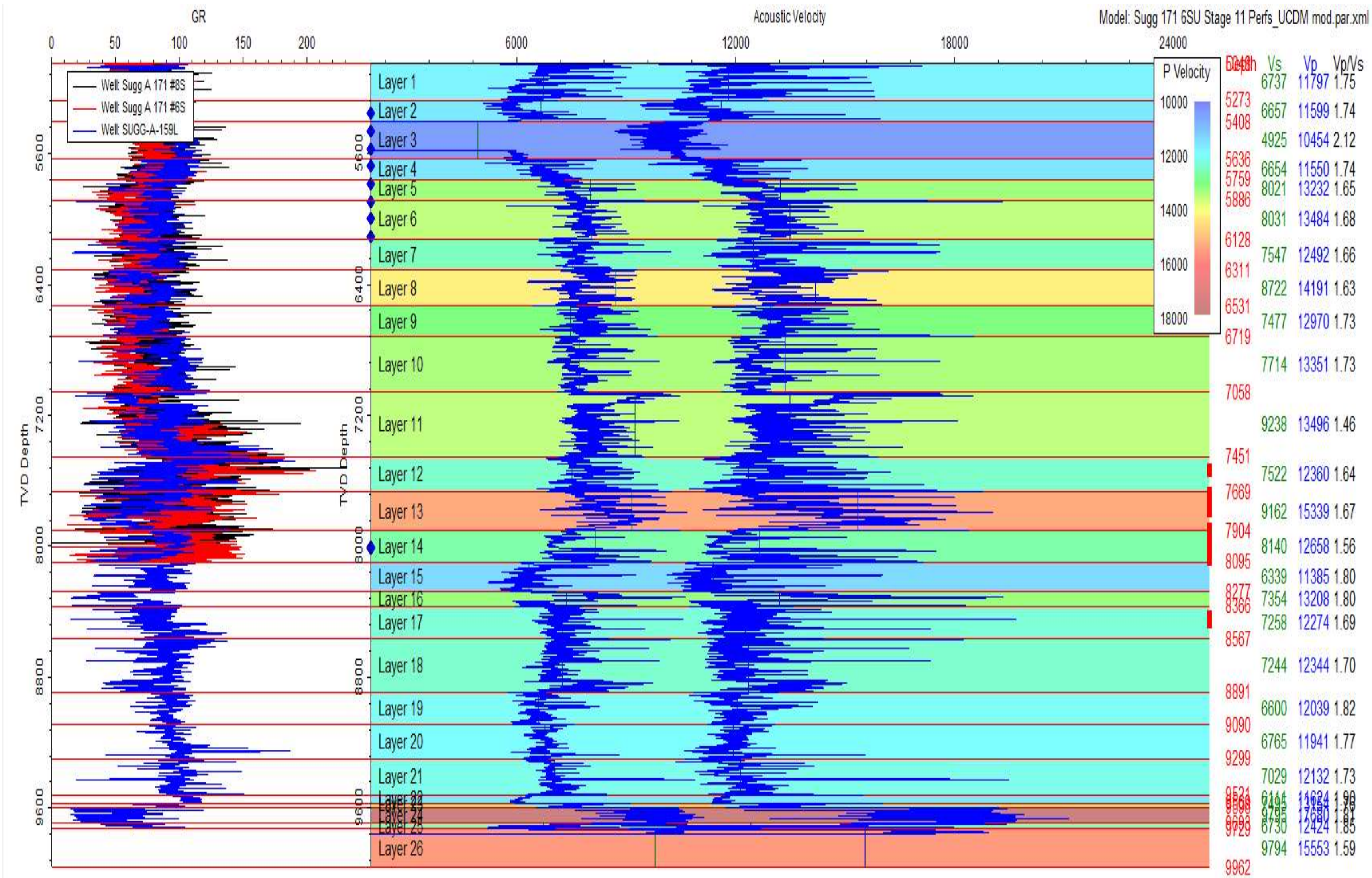
HALLIBURTON

Images of Velocity Models

Sugg A 171 Pad - Velocity Models (Real Time)

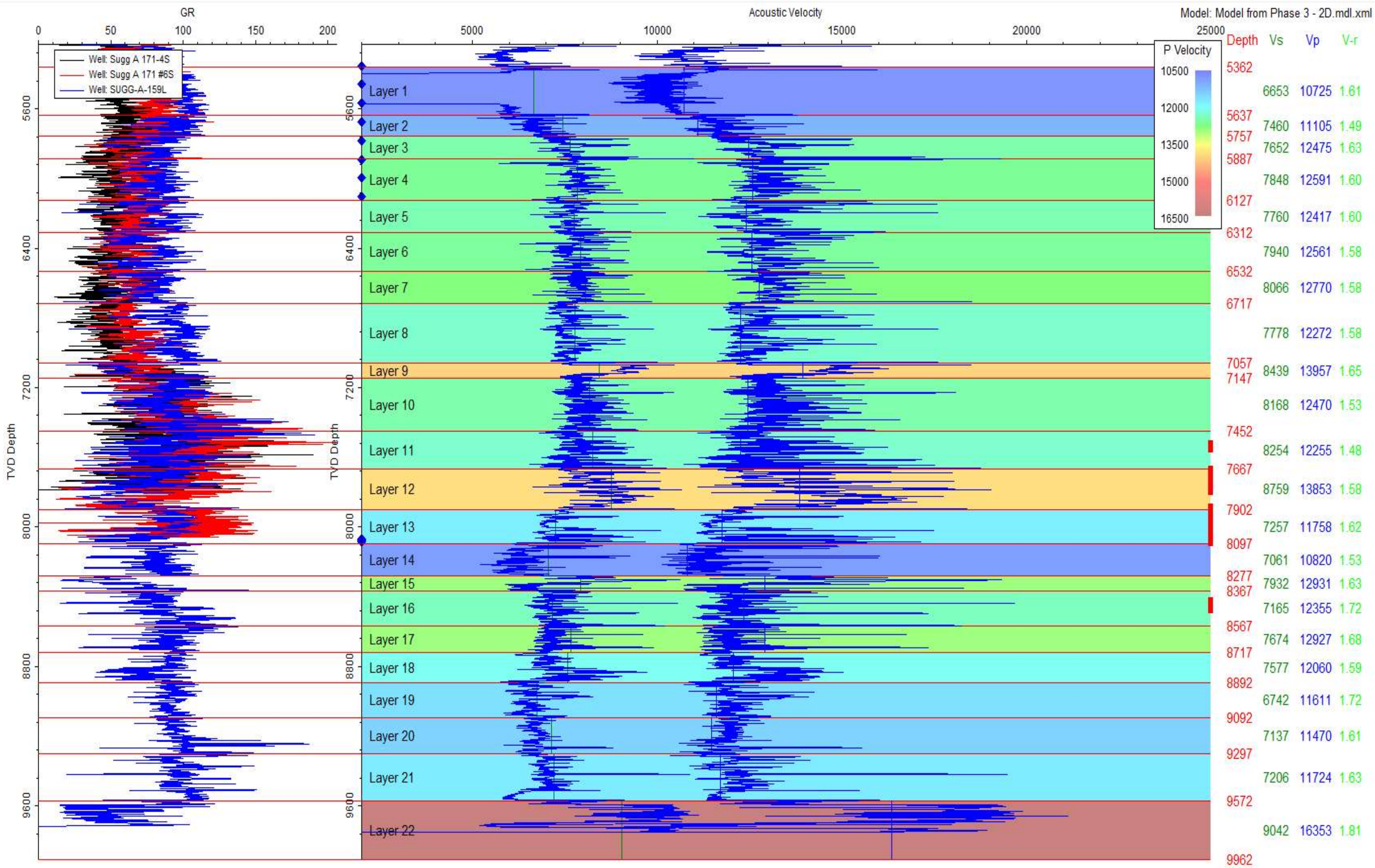


Velocity model Phase 1 and 2 (dual array stages)

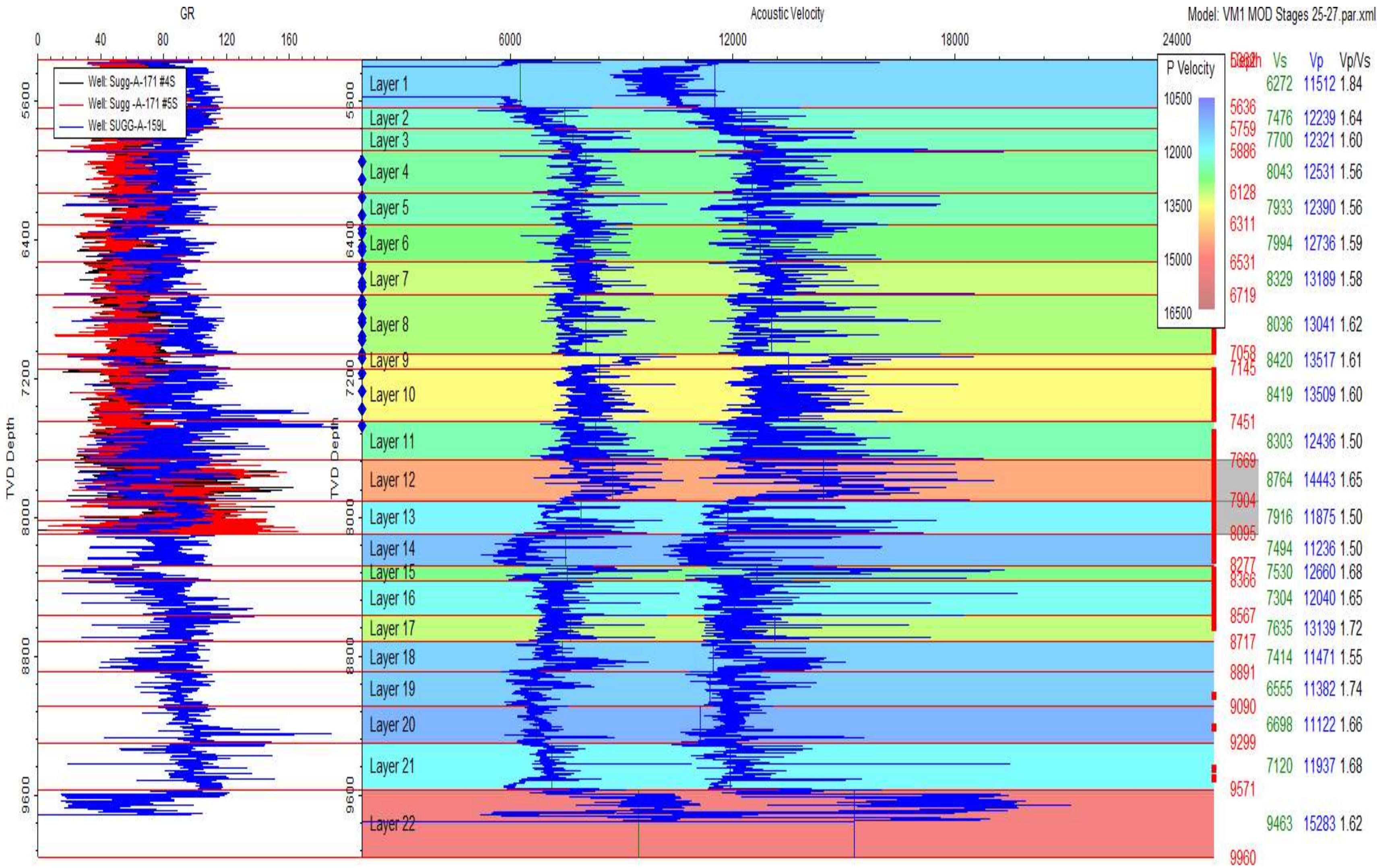


HALLIBURTON

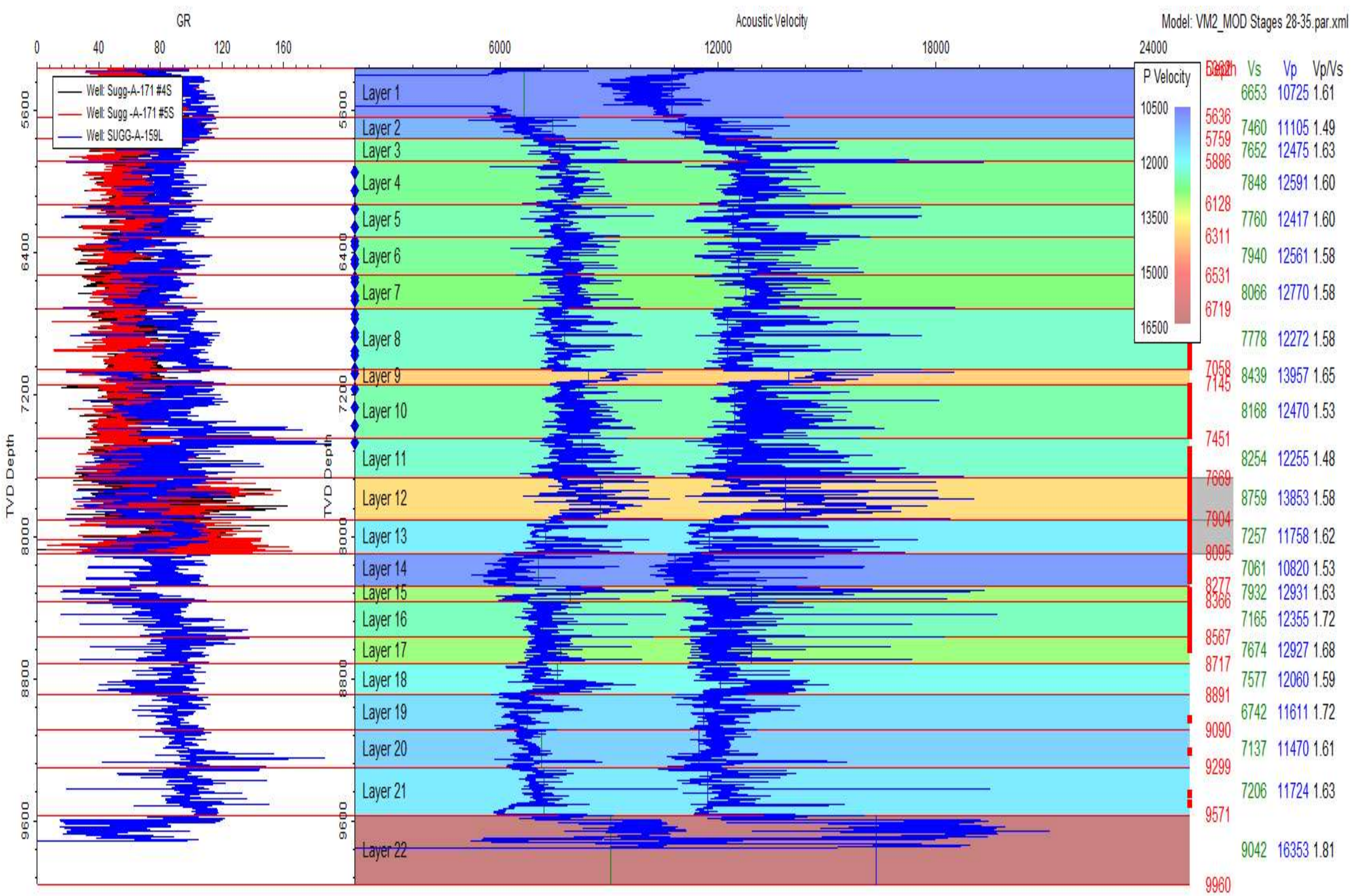
Velocity model Phase 2 (Single array stages)



Phase 3 Stages 25-27

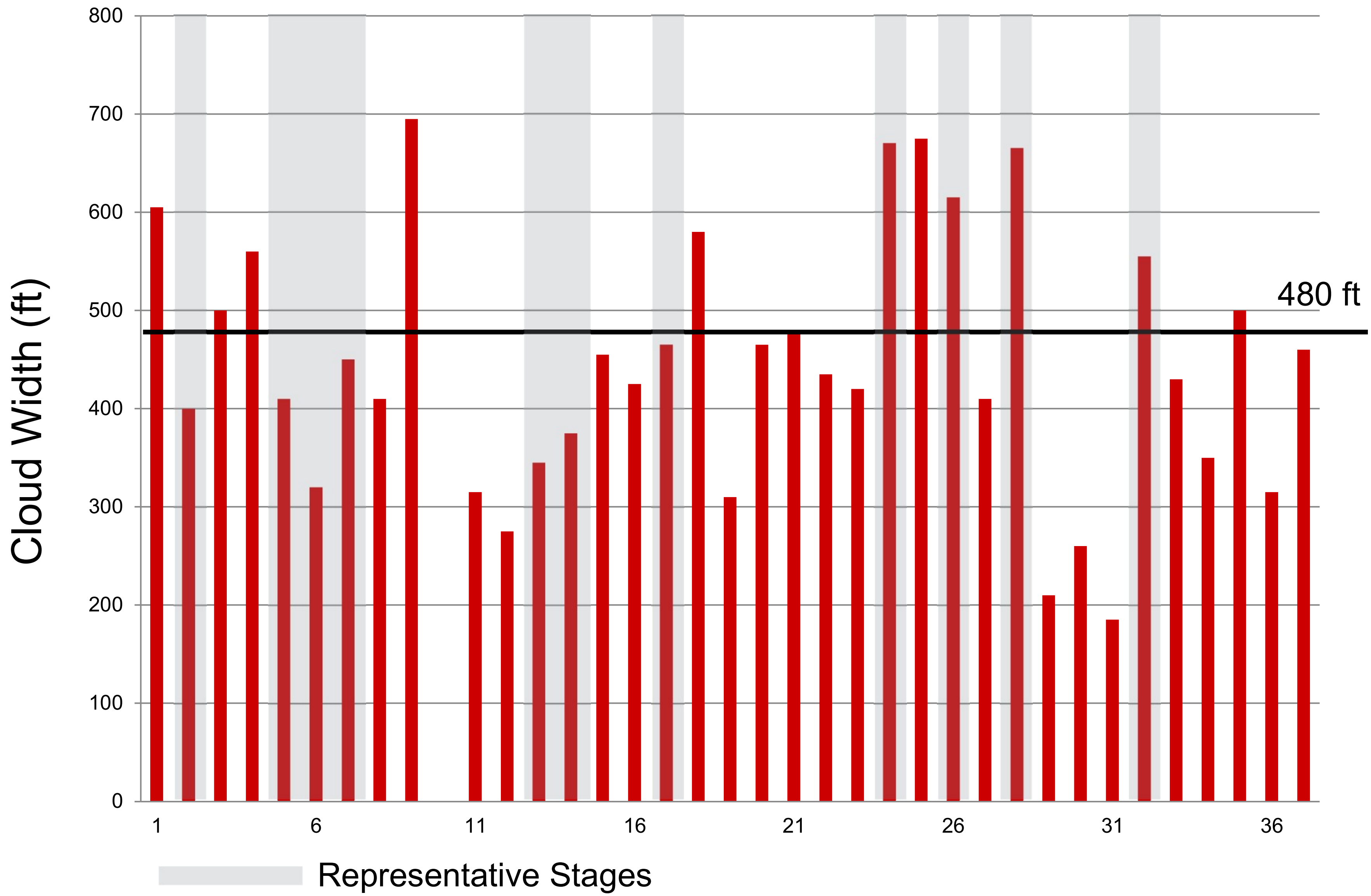


Phase 3 Stages 28-35



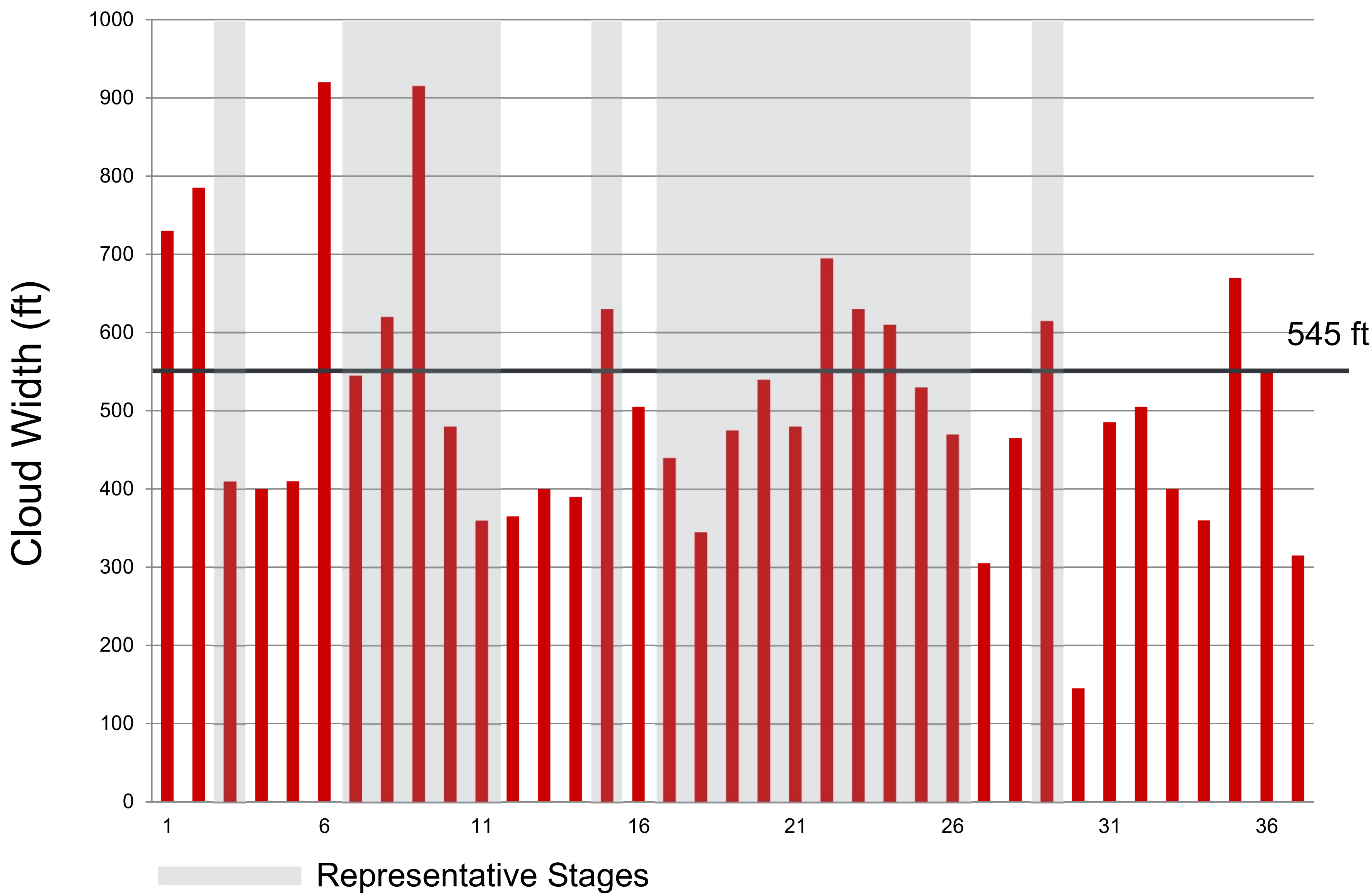
Microseismic Cloud Width Plots (per wellbore, by stage)

Microseismic Cloud Width – 6SU



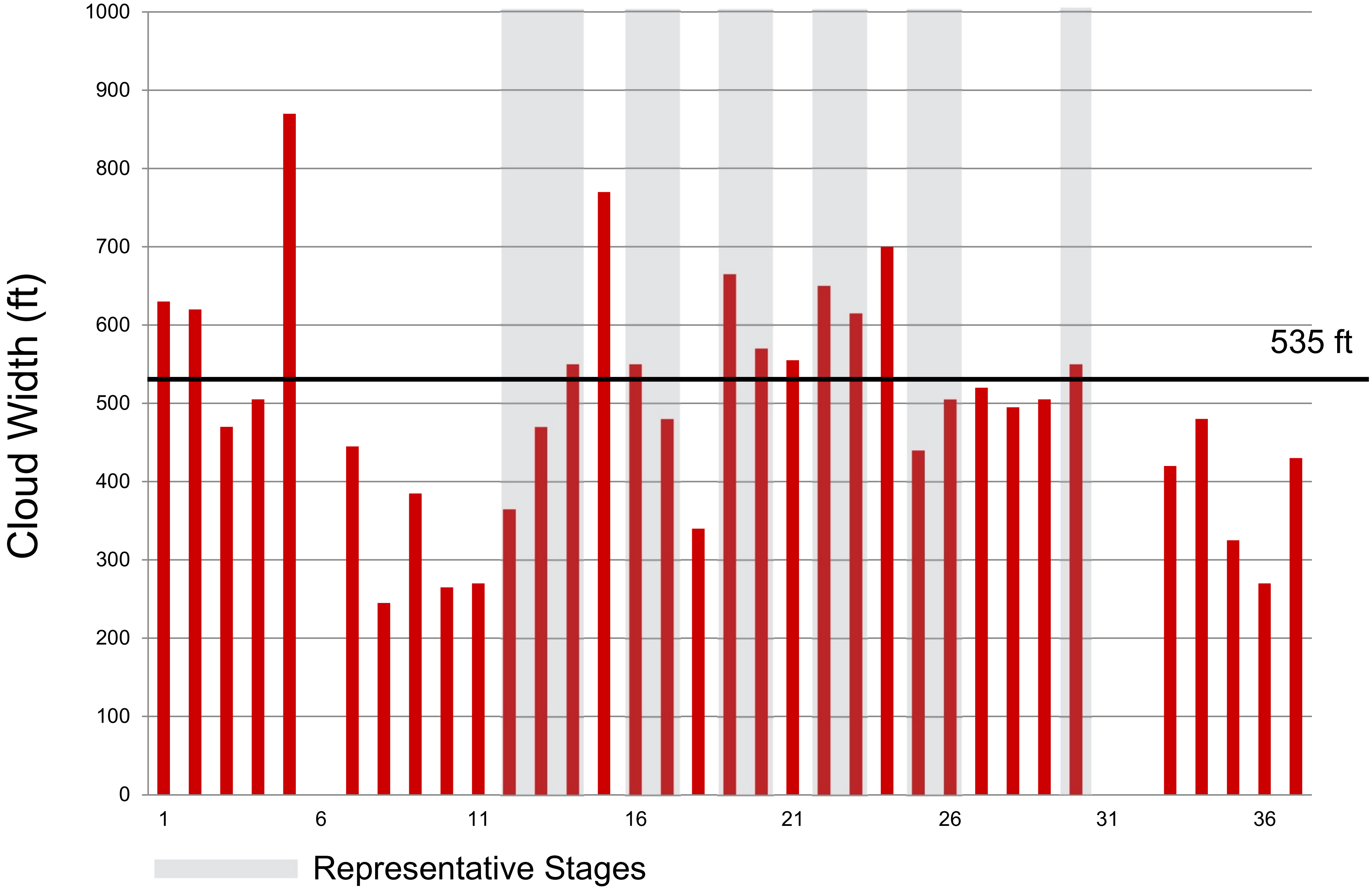
HALLIBURTON

Microseismic Cloud Width – 5SU



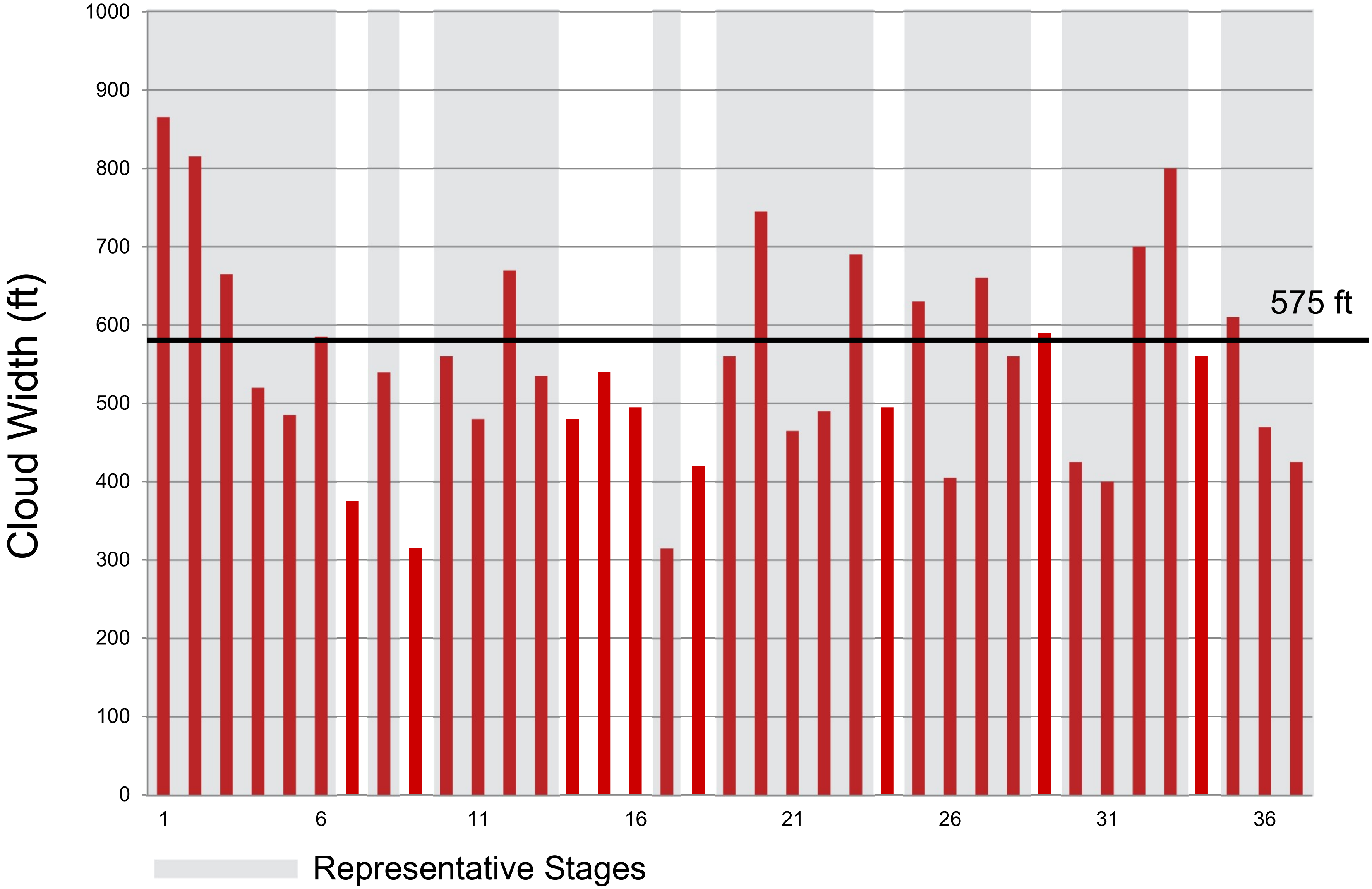
HALLIBURTON

Microseismic Cloud Width – 8SU



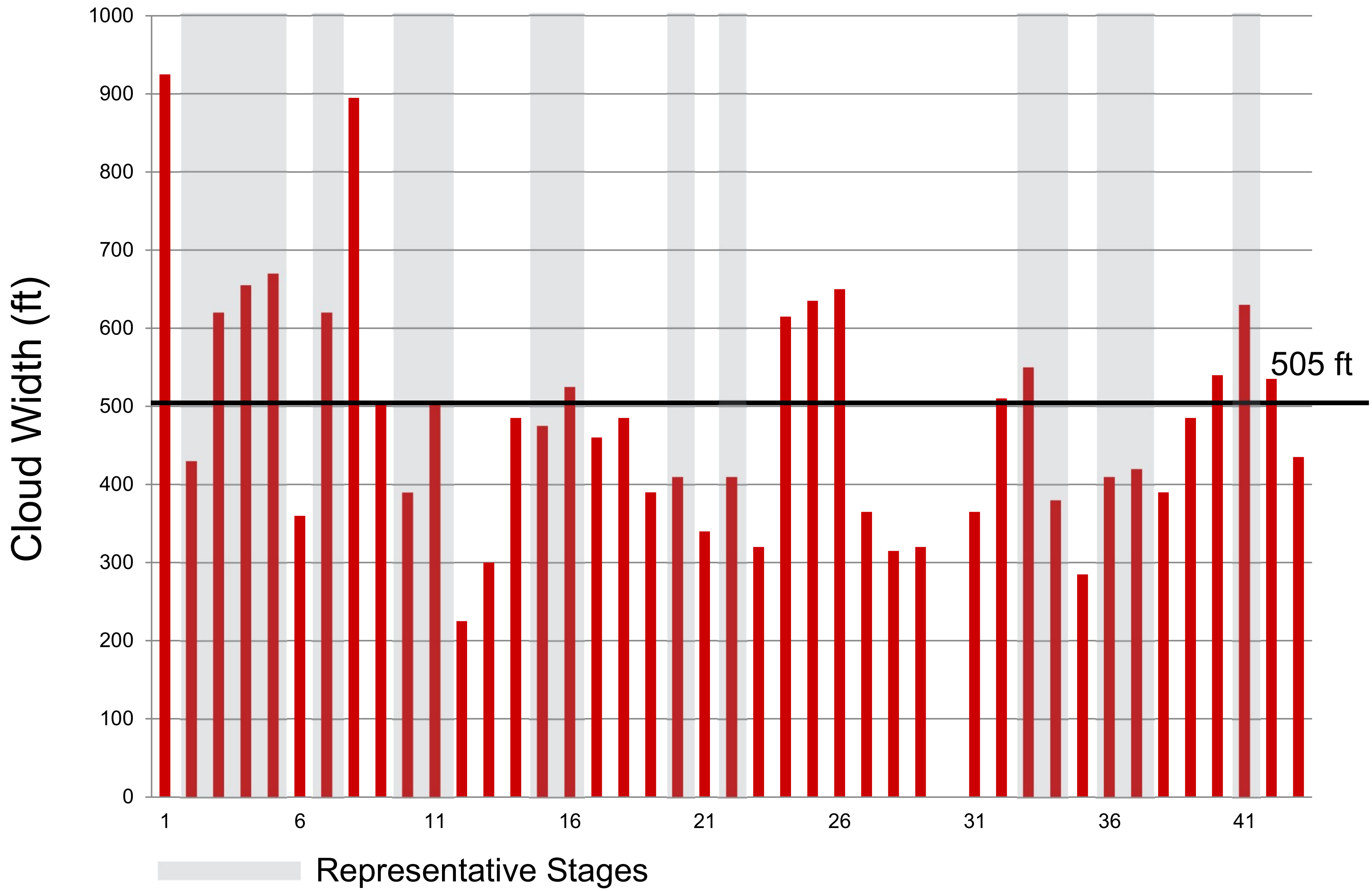
HALLIBURTON

Microseismic Cloud Width – 6SM



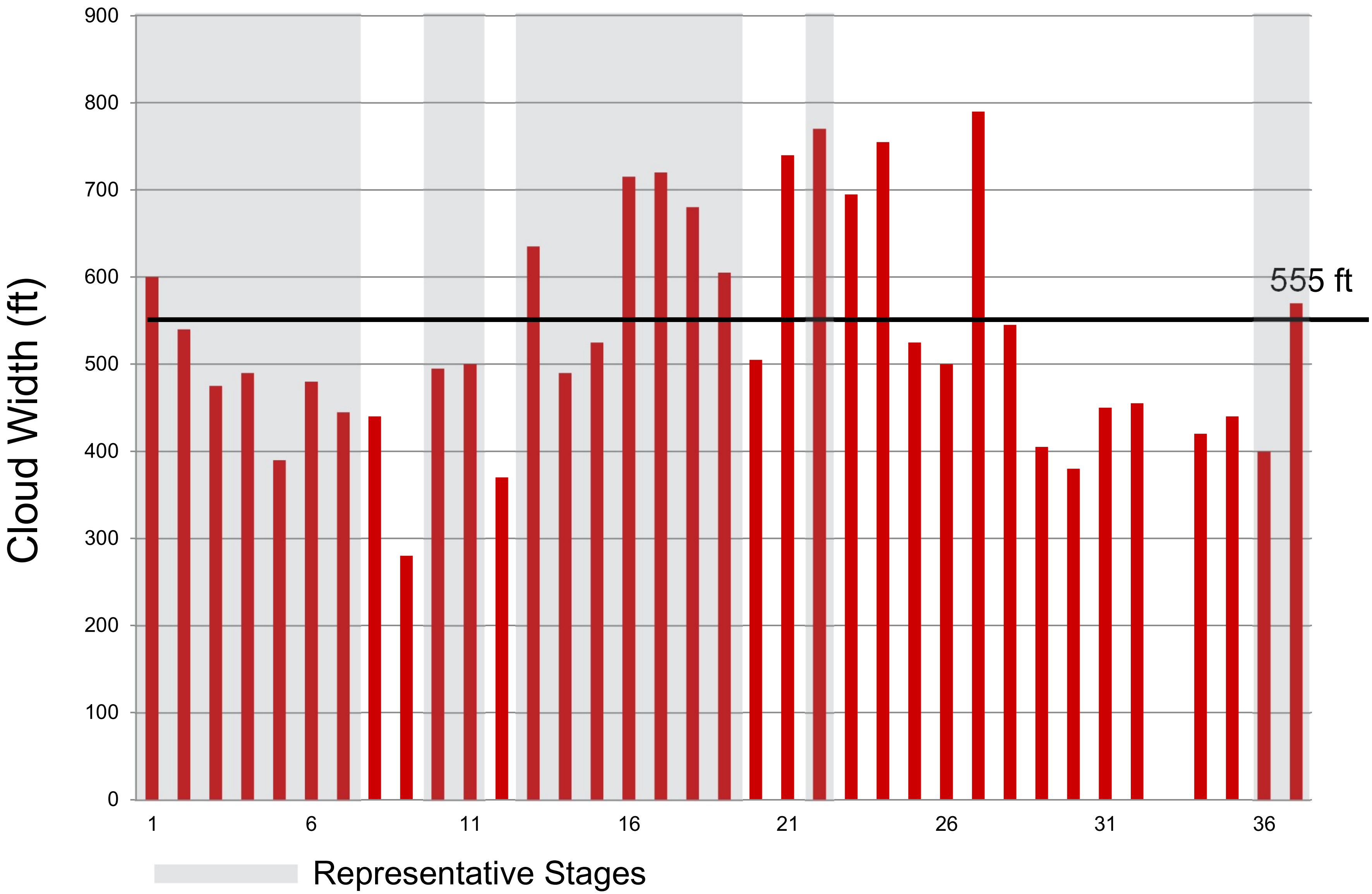
HALLIBURTON

Microseismic Cloud Width – 7SU



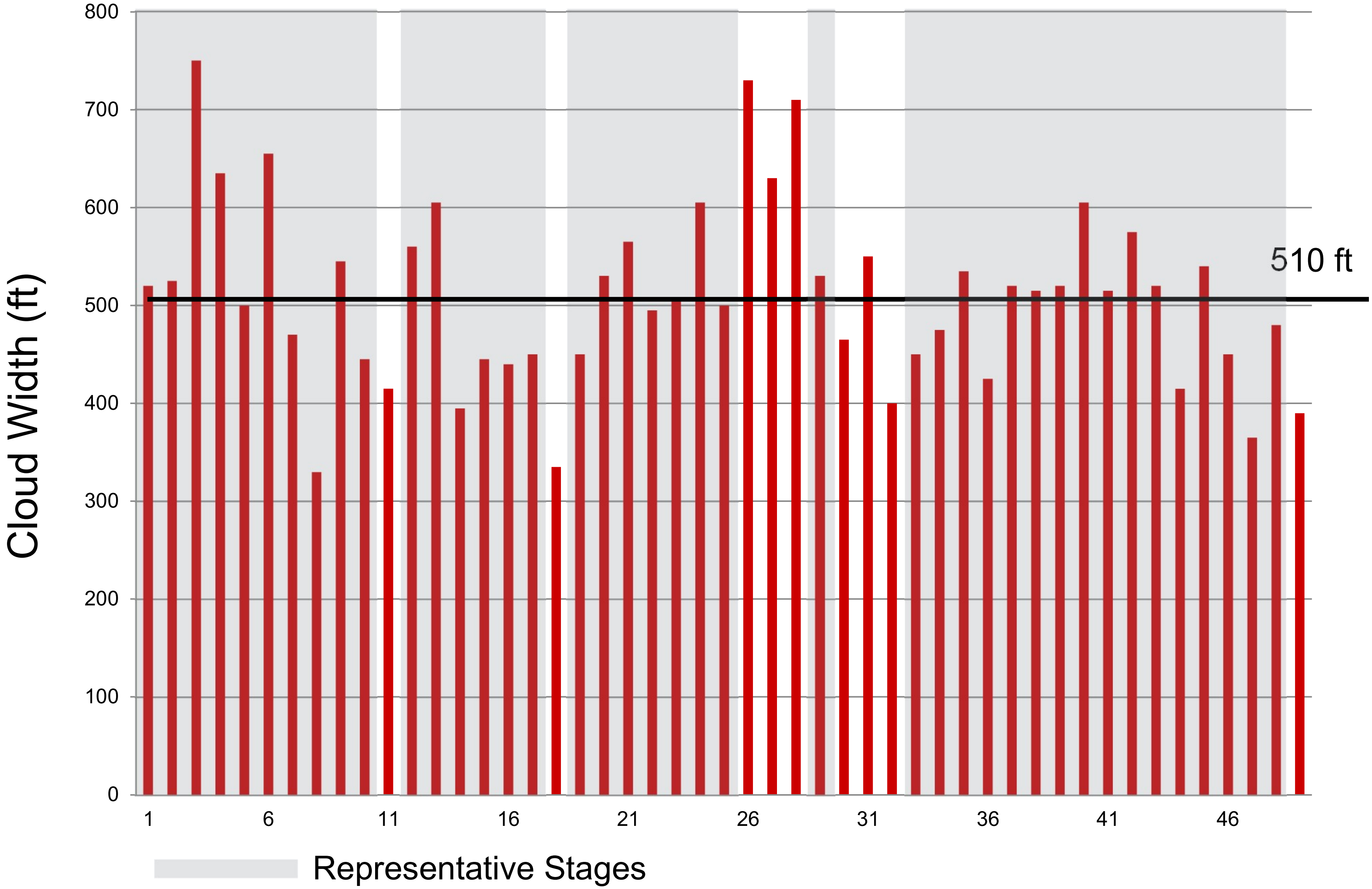
HALLIBURTON

Microseismic Cloud Width – 8SM



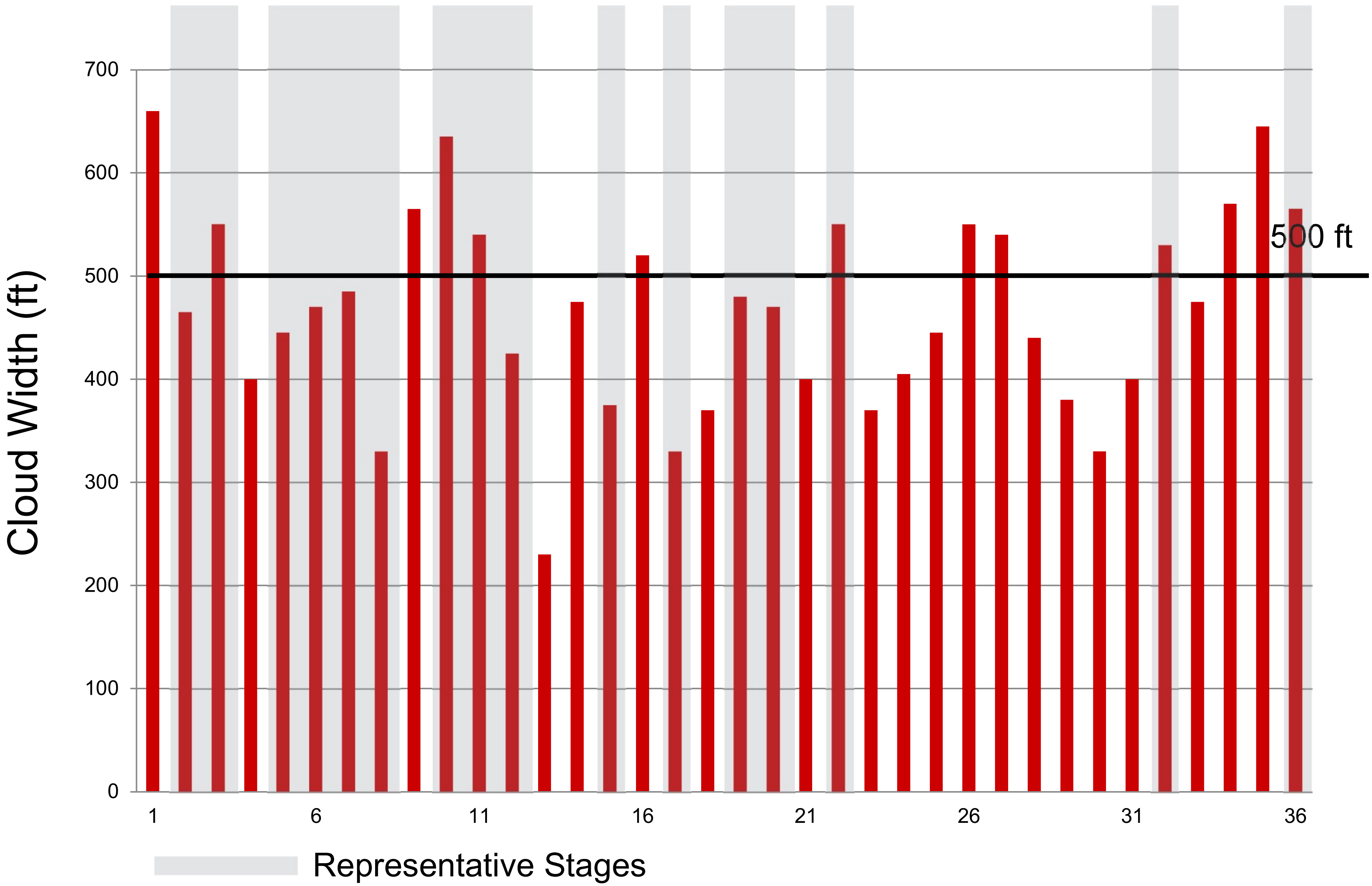
HALLIBURTON

Microseismic Cloud Width – 7RM



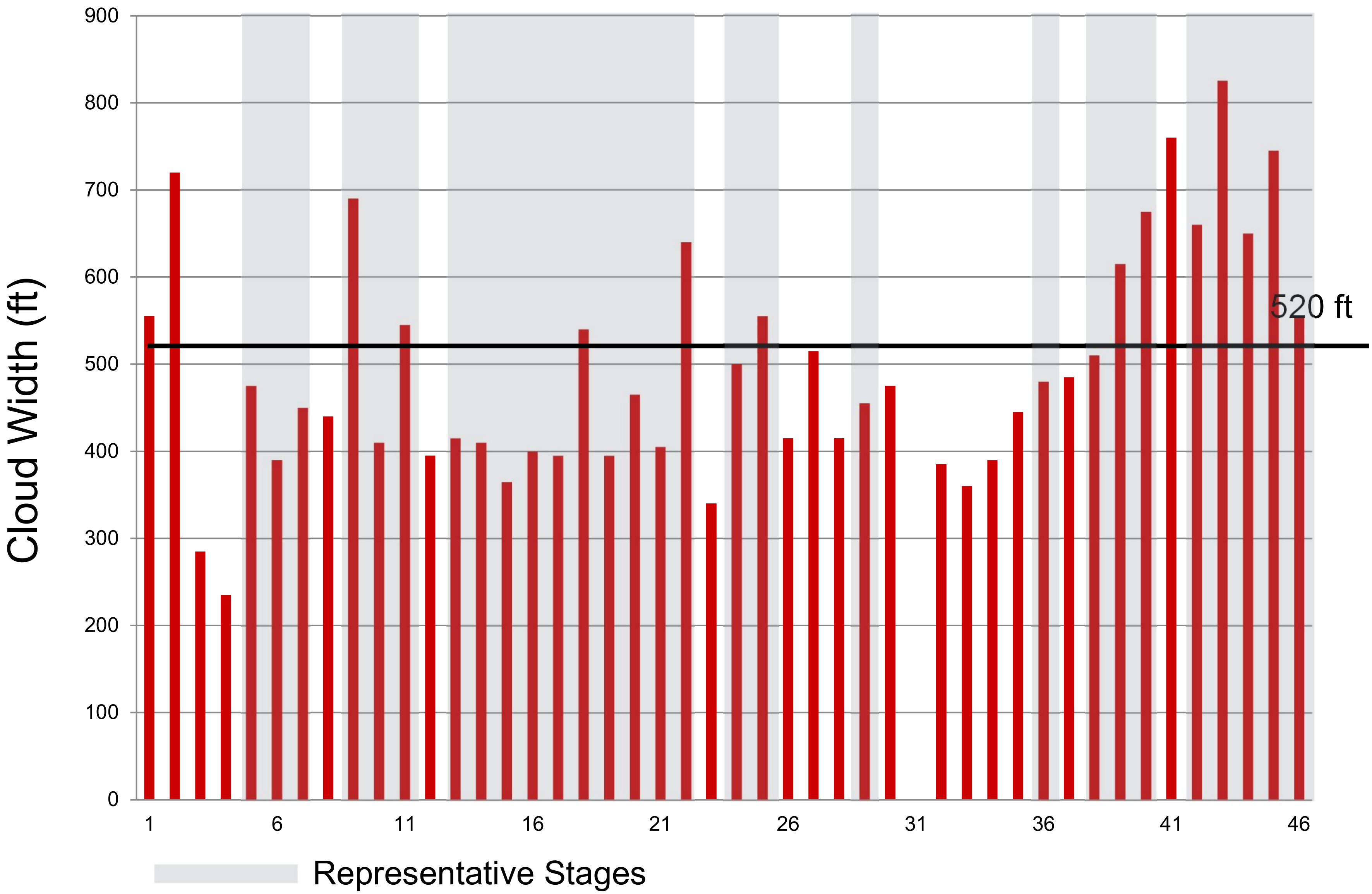
HALLIBURTON

Microseismic Cloud Width – 3SU



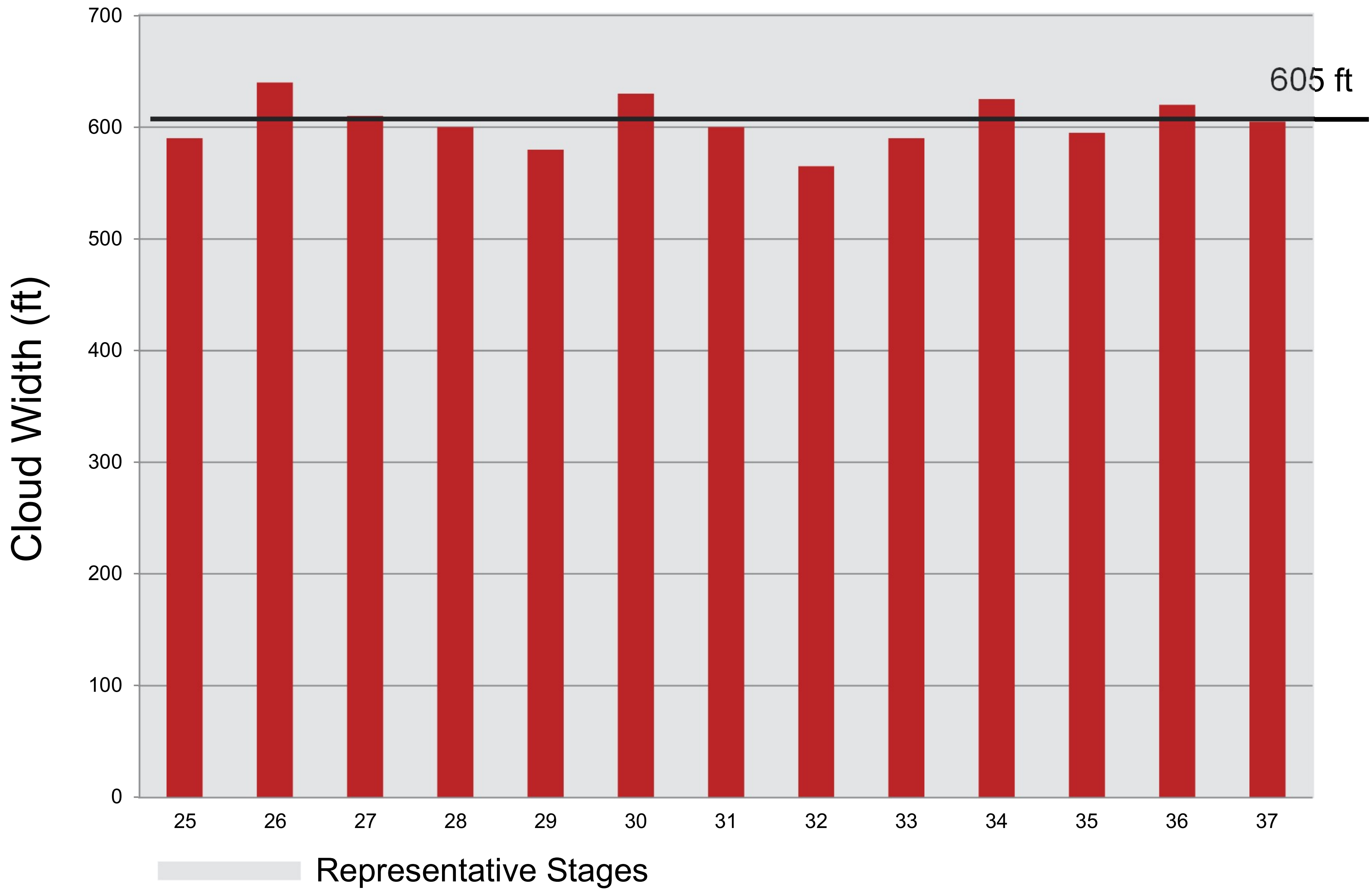
HALLIBURTON

Microseismic Cloud Width – 4SU



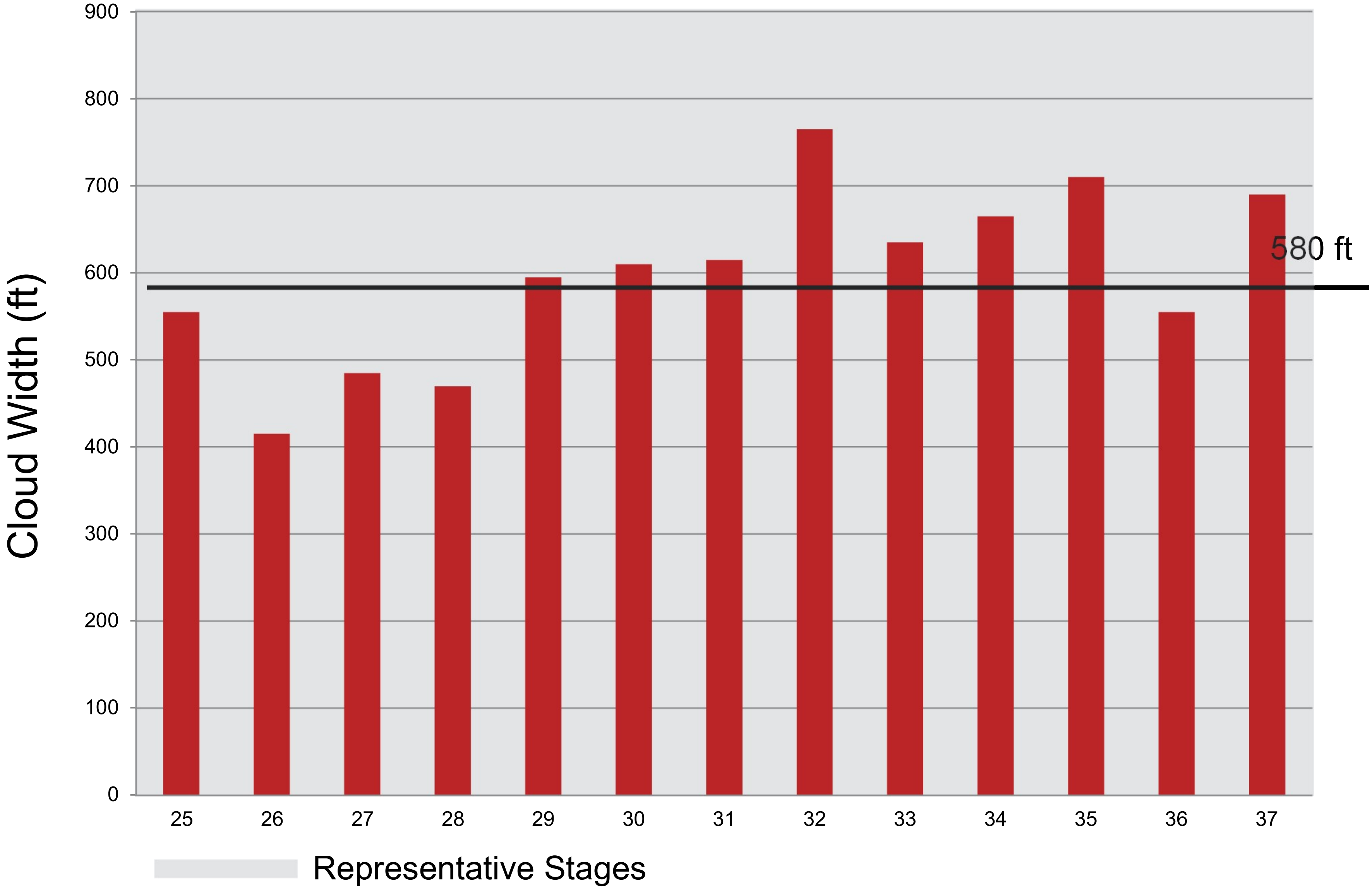
HALLIBURTON

Microseismic Cloud Width – 4SM



HALLIBURTON

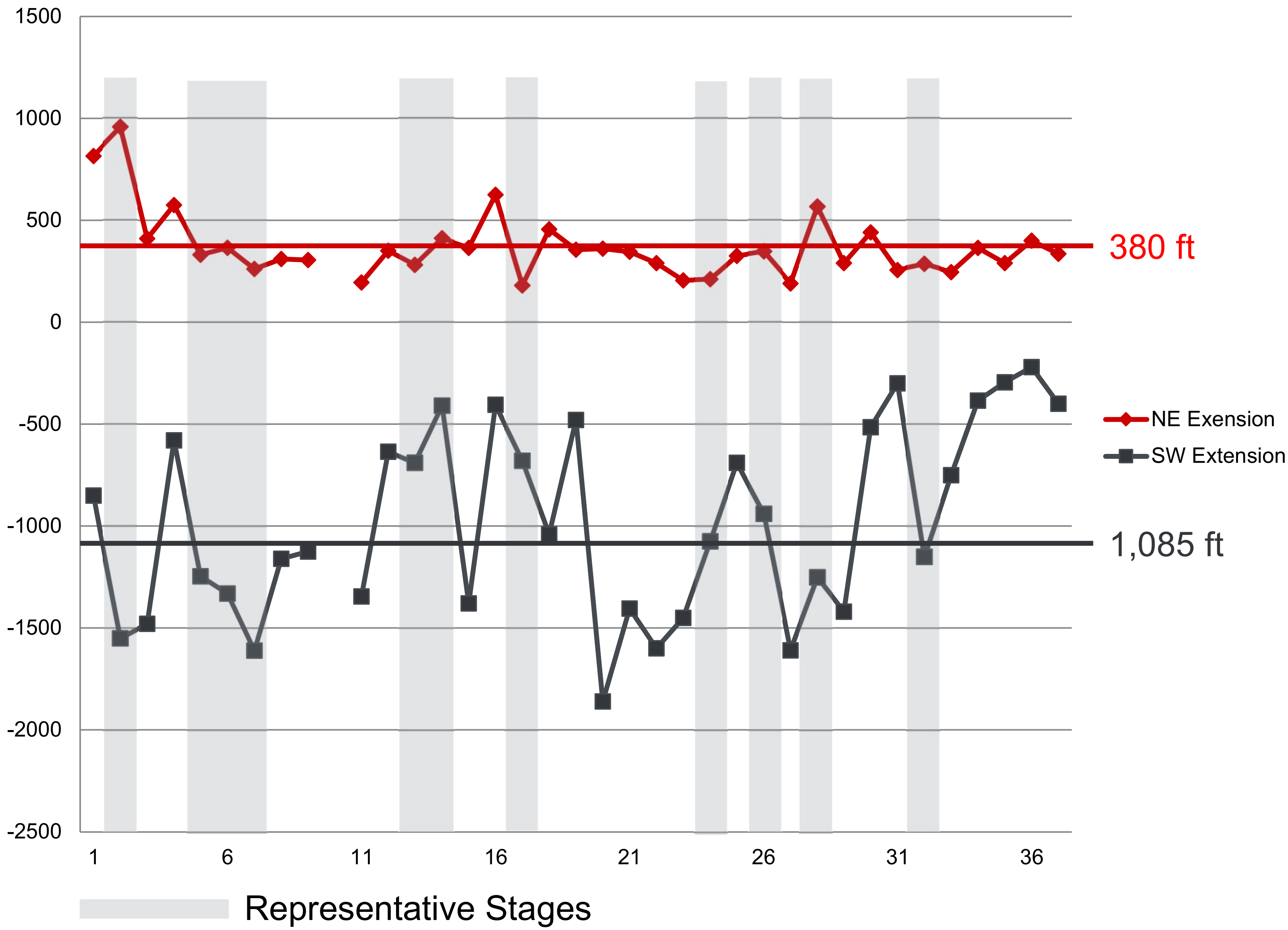
Microseismic Cloud Width – 5SM



HALLIBURTON

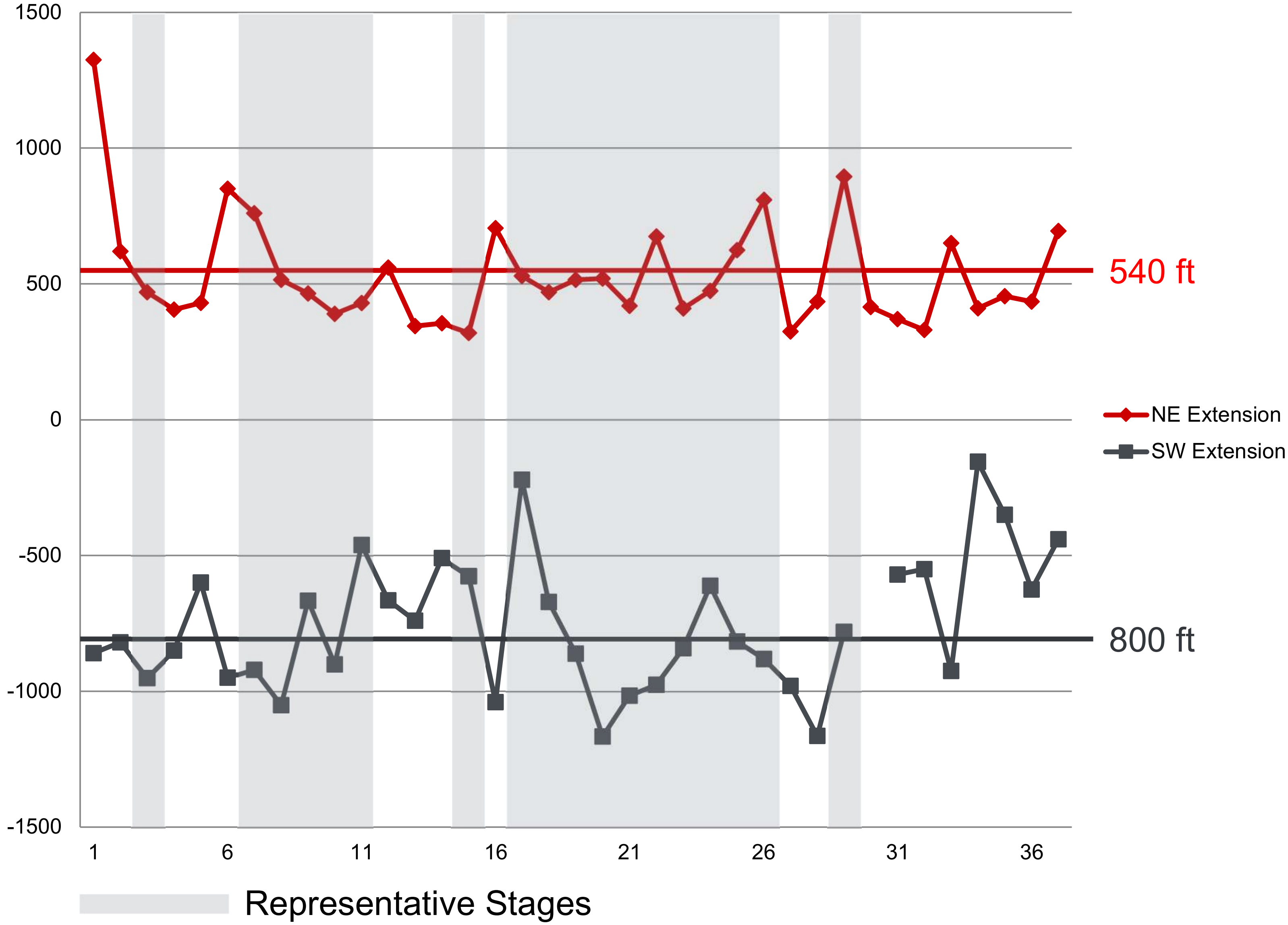
Microseismic Extension Plots (per wellbore, by stage)

Fracture Extension – 6SU



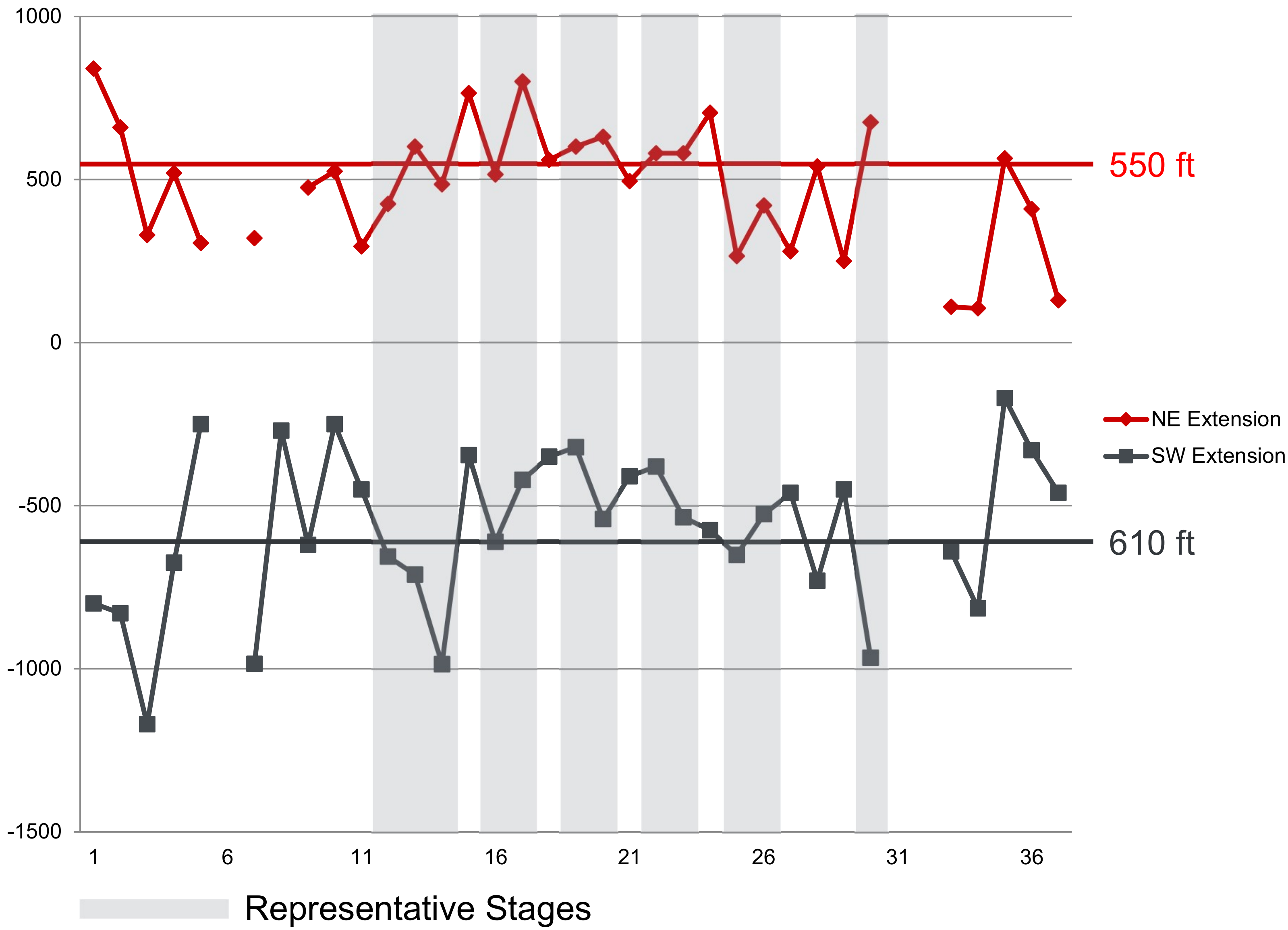
HALLIBURTON

Fracture Extension – 5SU



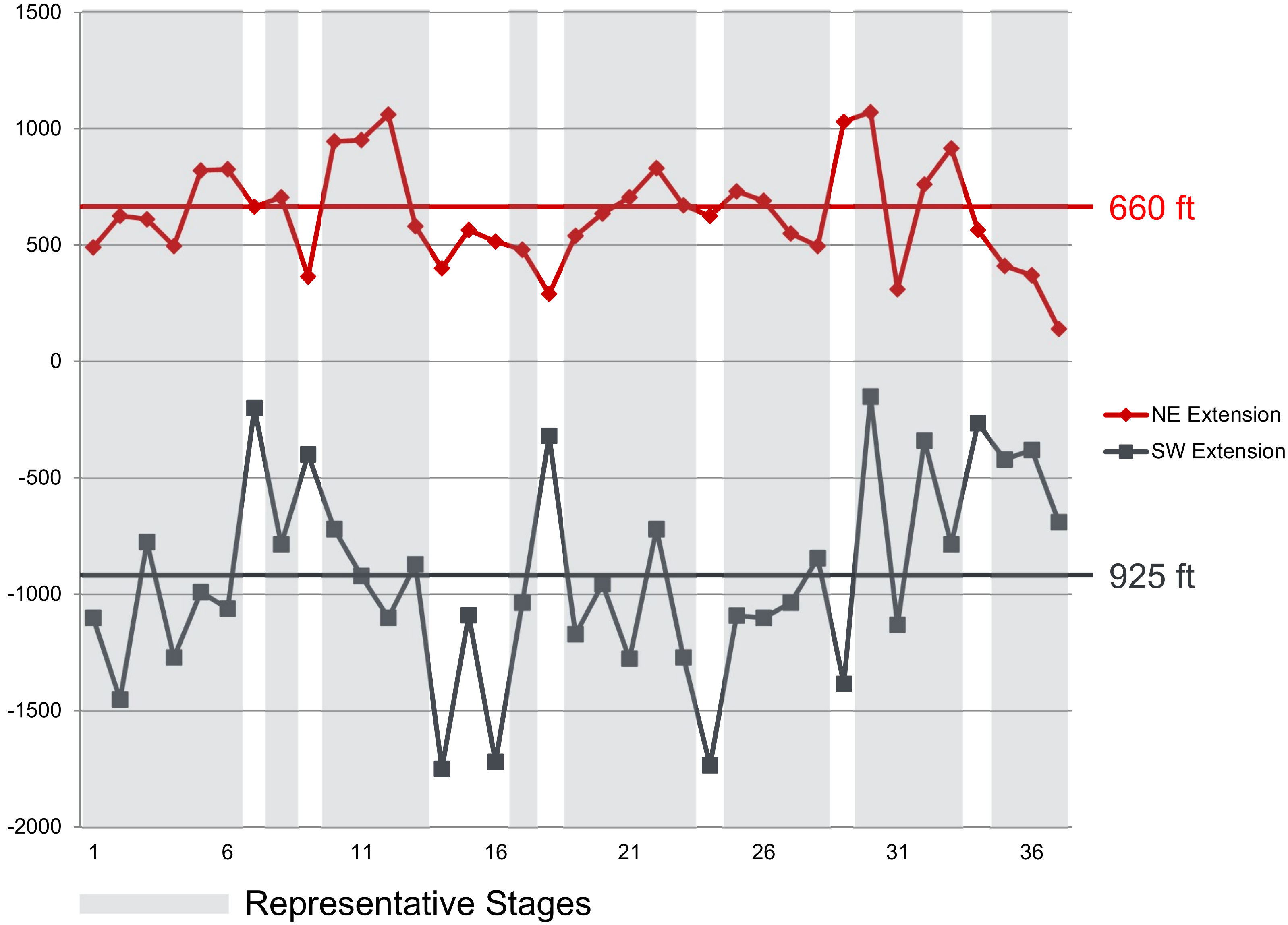
HALLIBURTON

Fracture Extension – 8SU



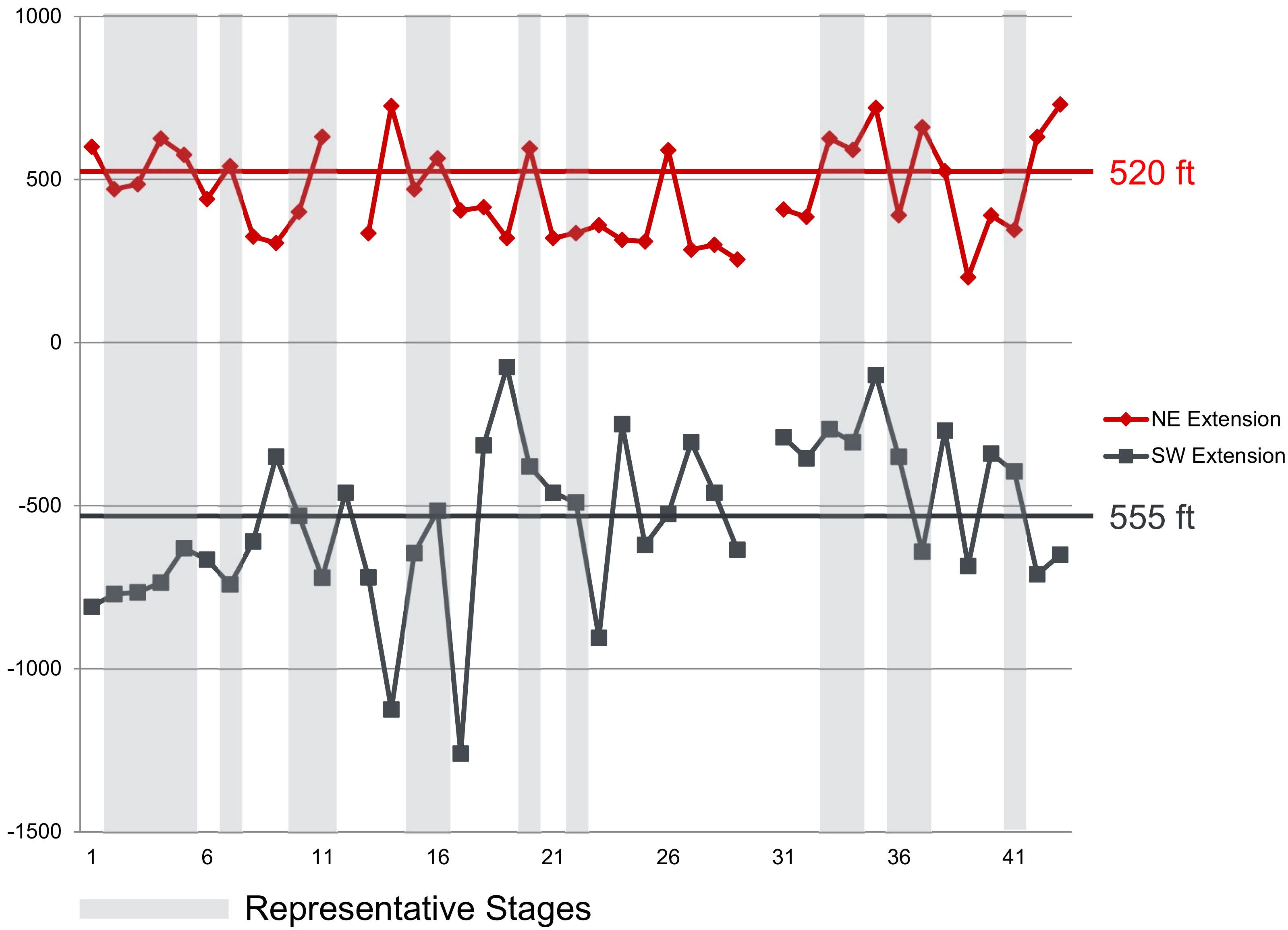
HALLIBURTON

Fracture Extension – 6SM



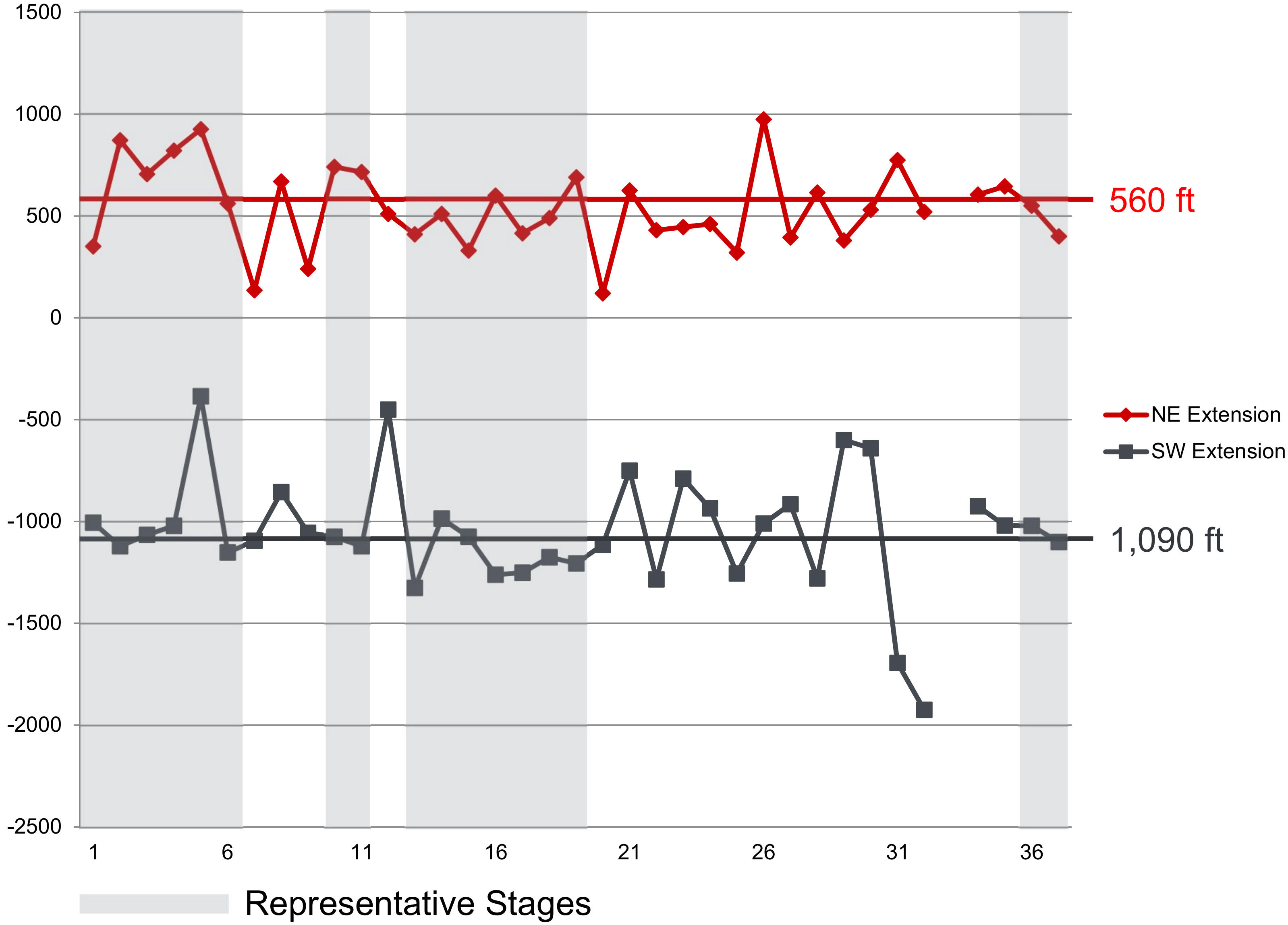
HALLIBURTON

Fracture Extension – 7SU



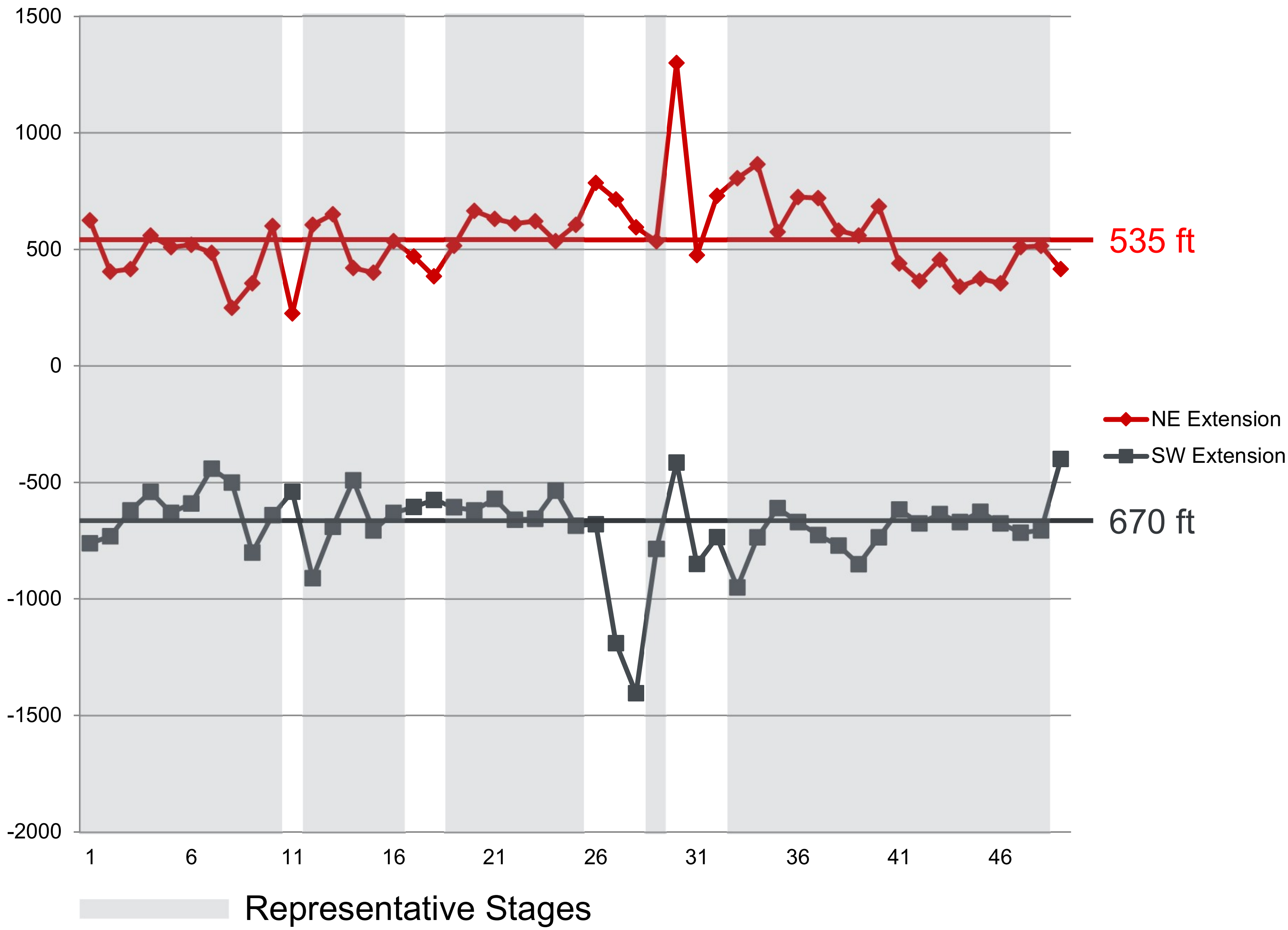
HALLIBURTON

Fracture Extension – 8SM



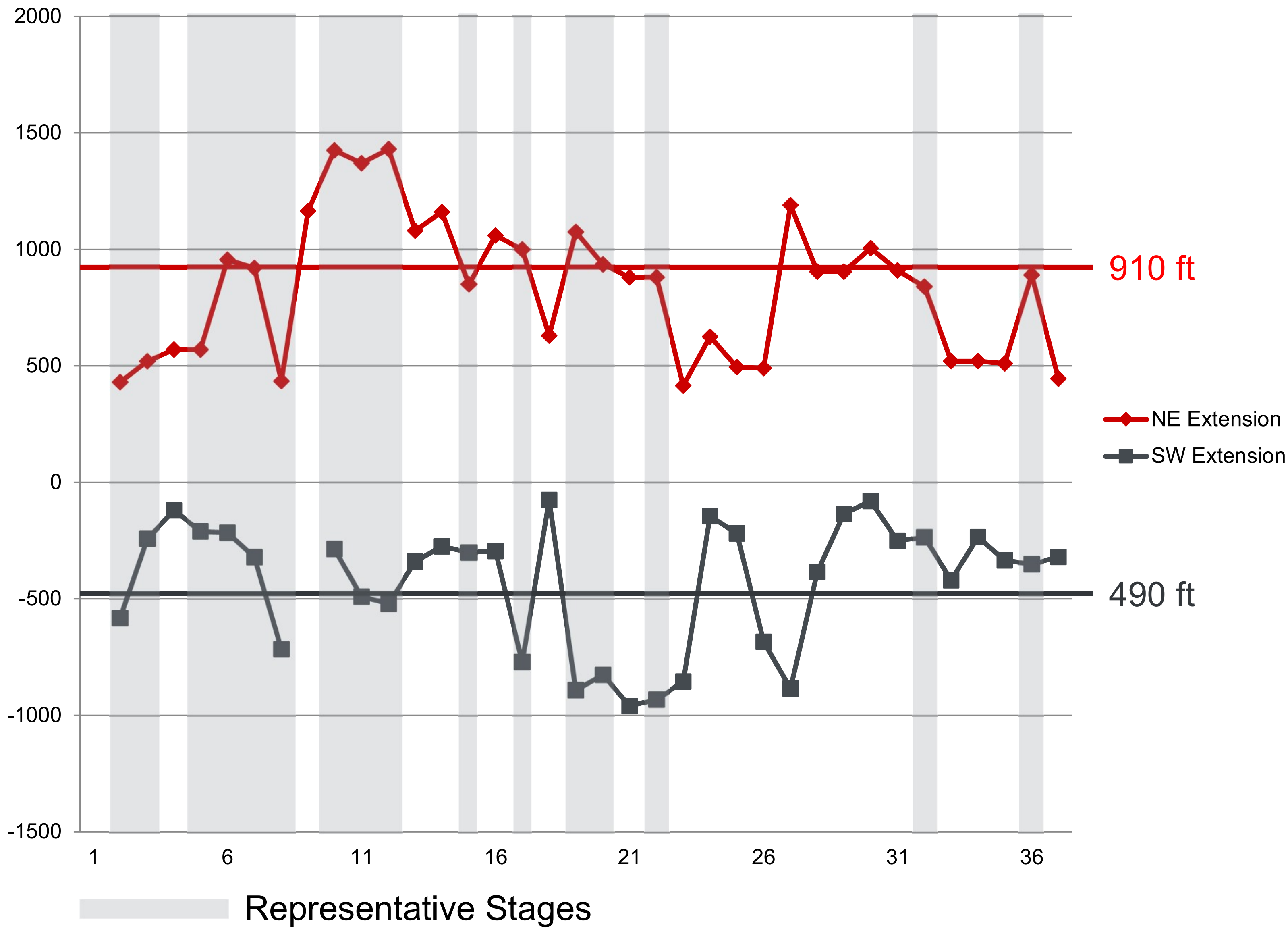
HALLIBURTON

Fracture Extension – 7RM



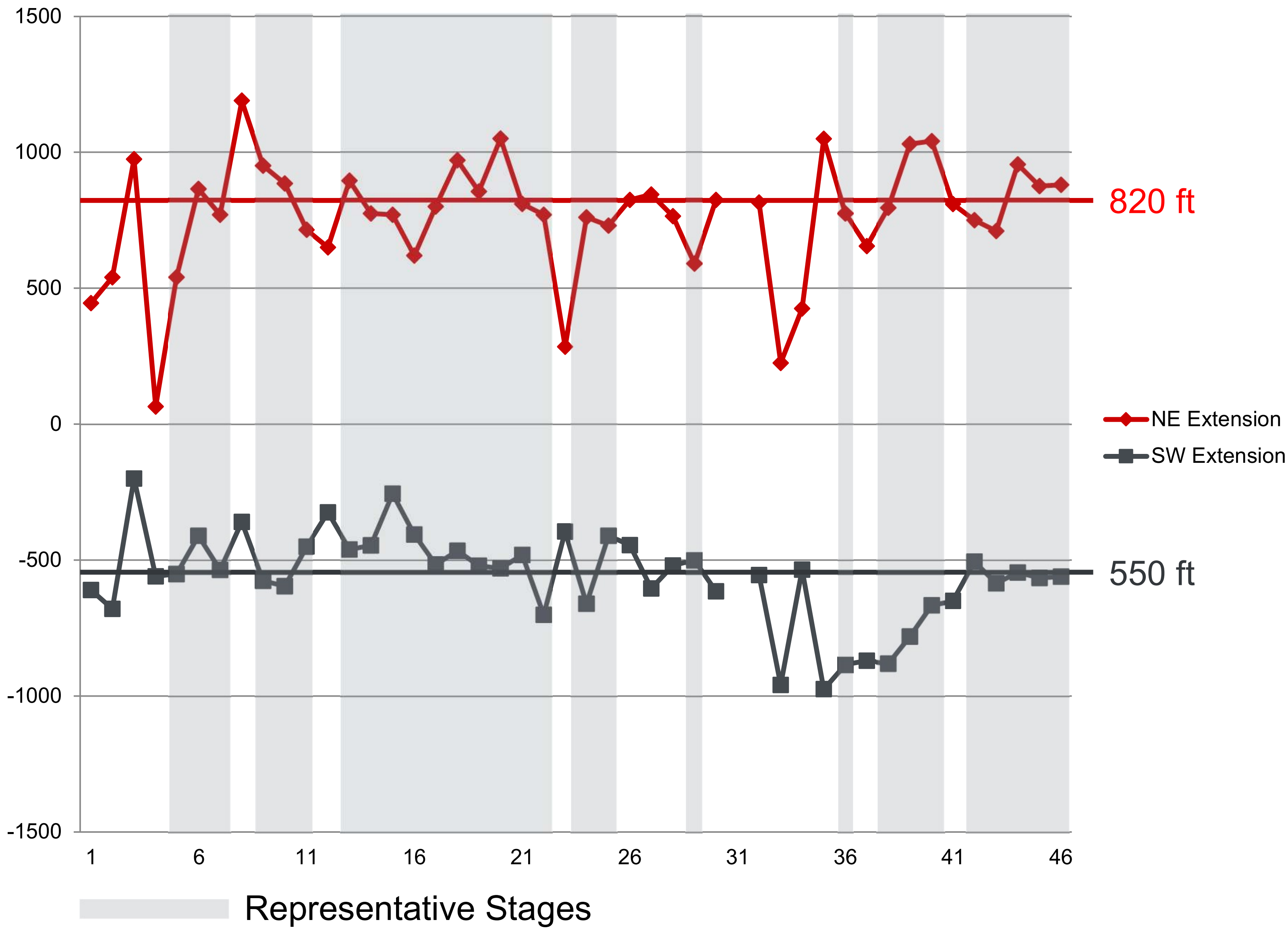
HALLIBURTON

Fracture Extension – 3SU



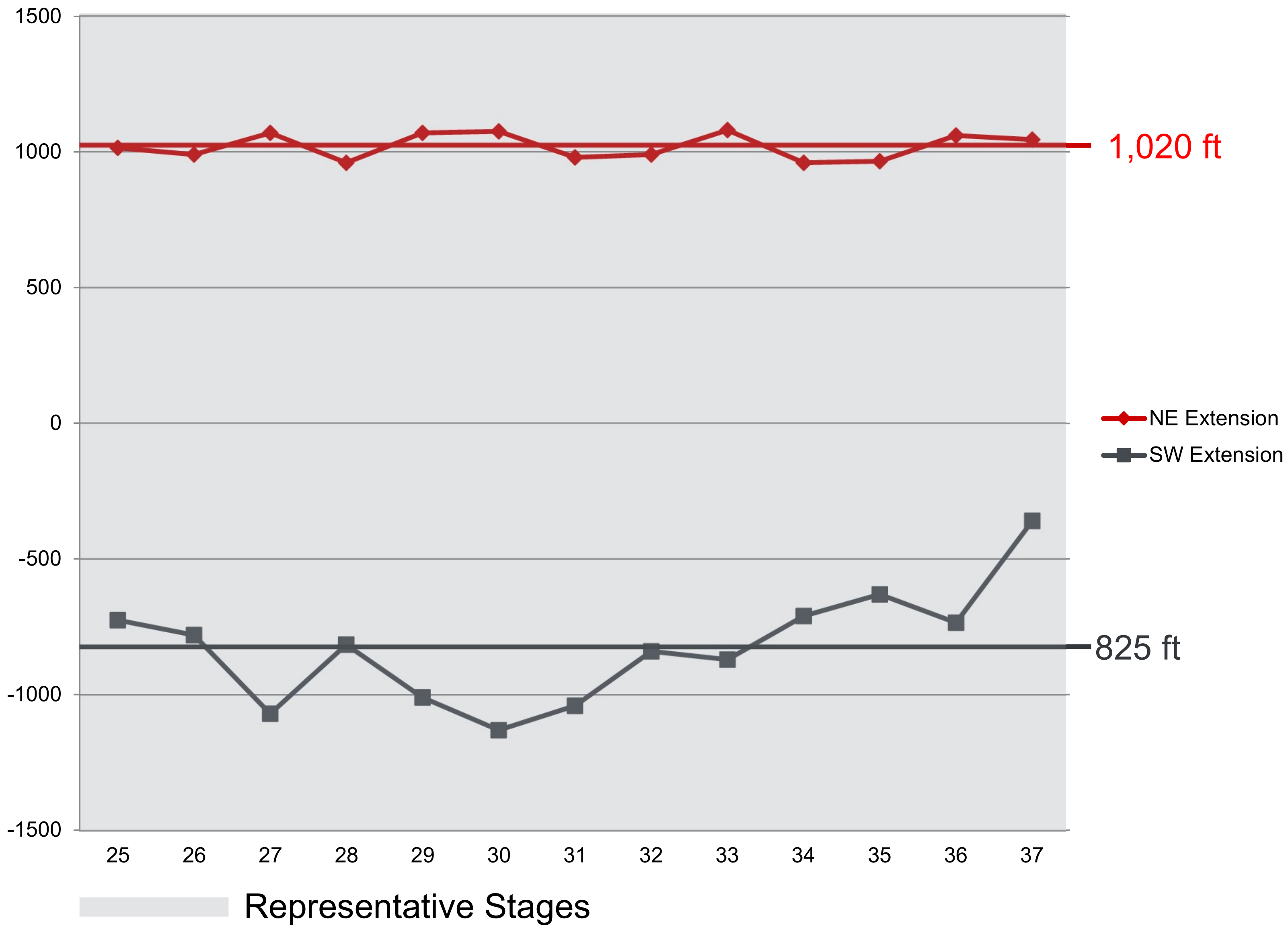
HALLIBURTON

Fracture Extension – 4SU



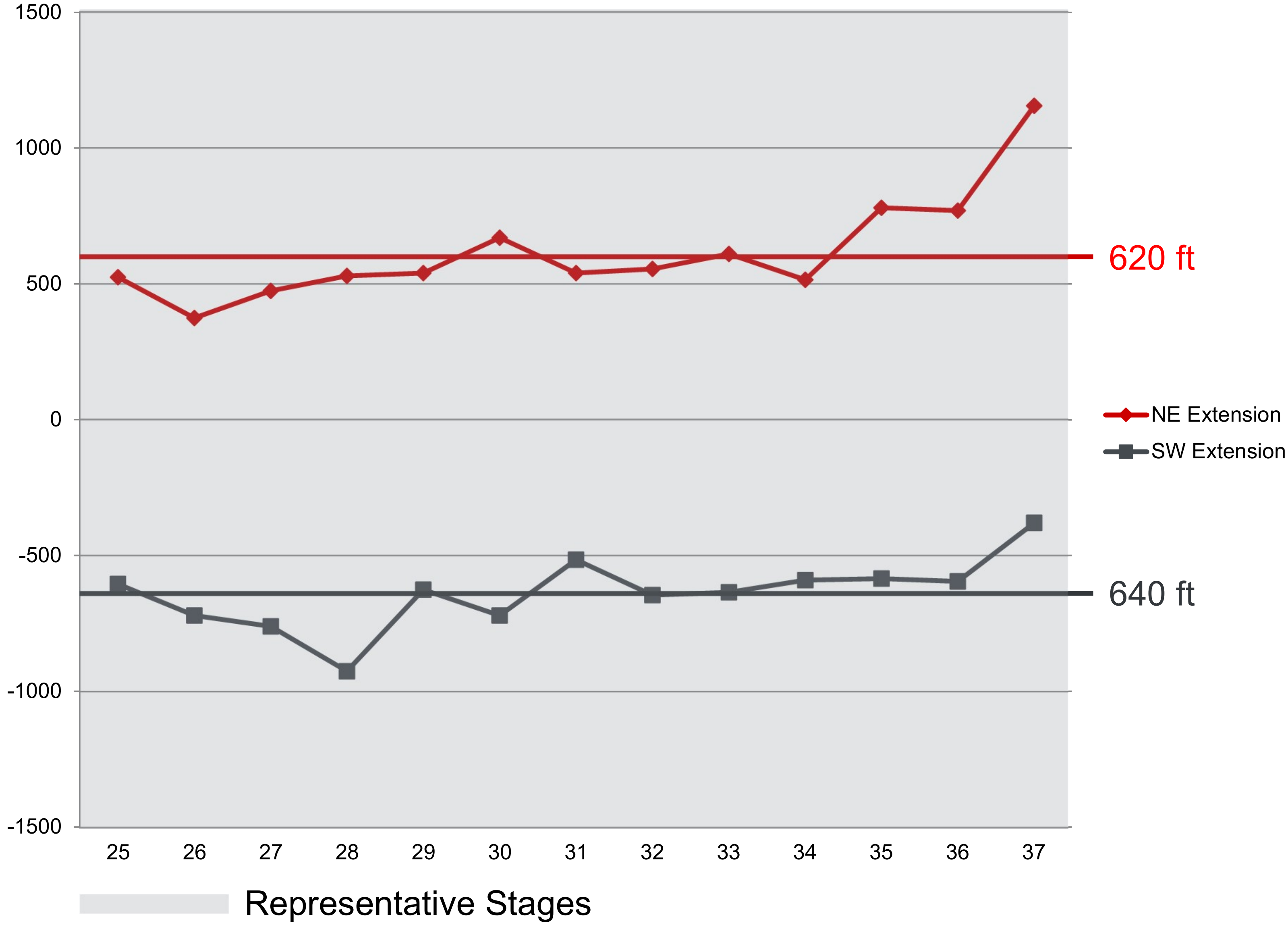
HALLIBURTON

Fracture Extension – 4SM



HALLIBURTON

Fracture Extension – 5SM

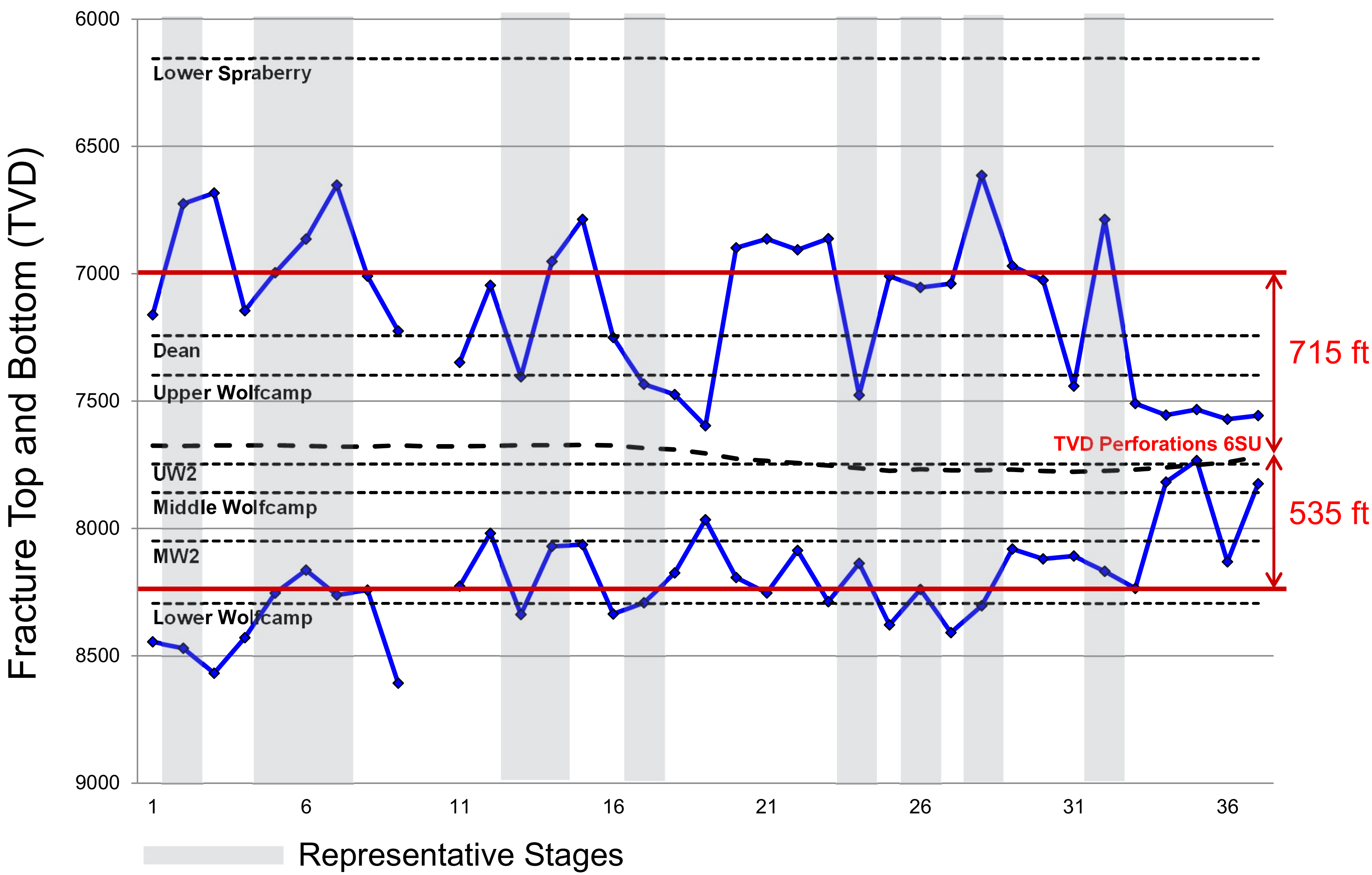


HALLIBURTON

Microseismic Fracture Height Plots (per wellbore, by stage)

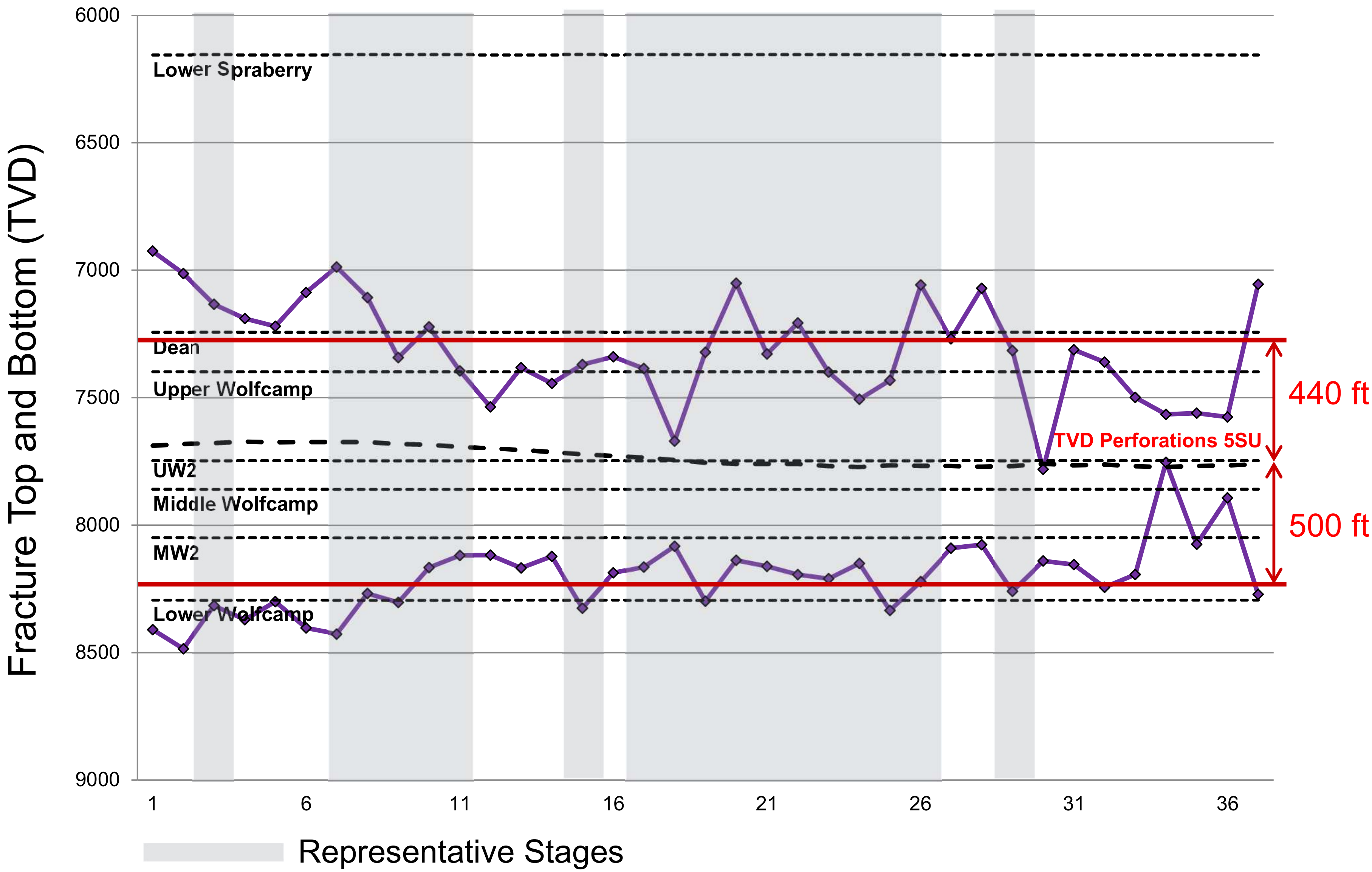
HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 6SU



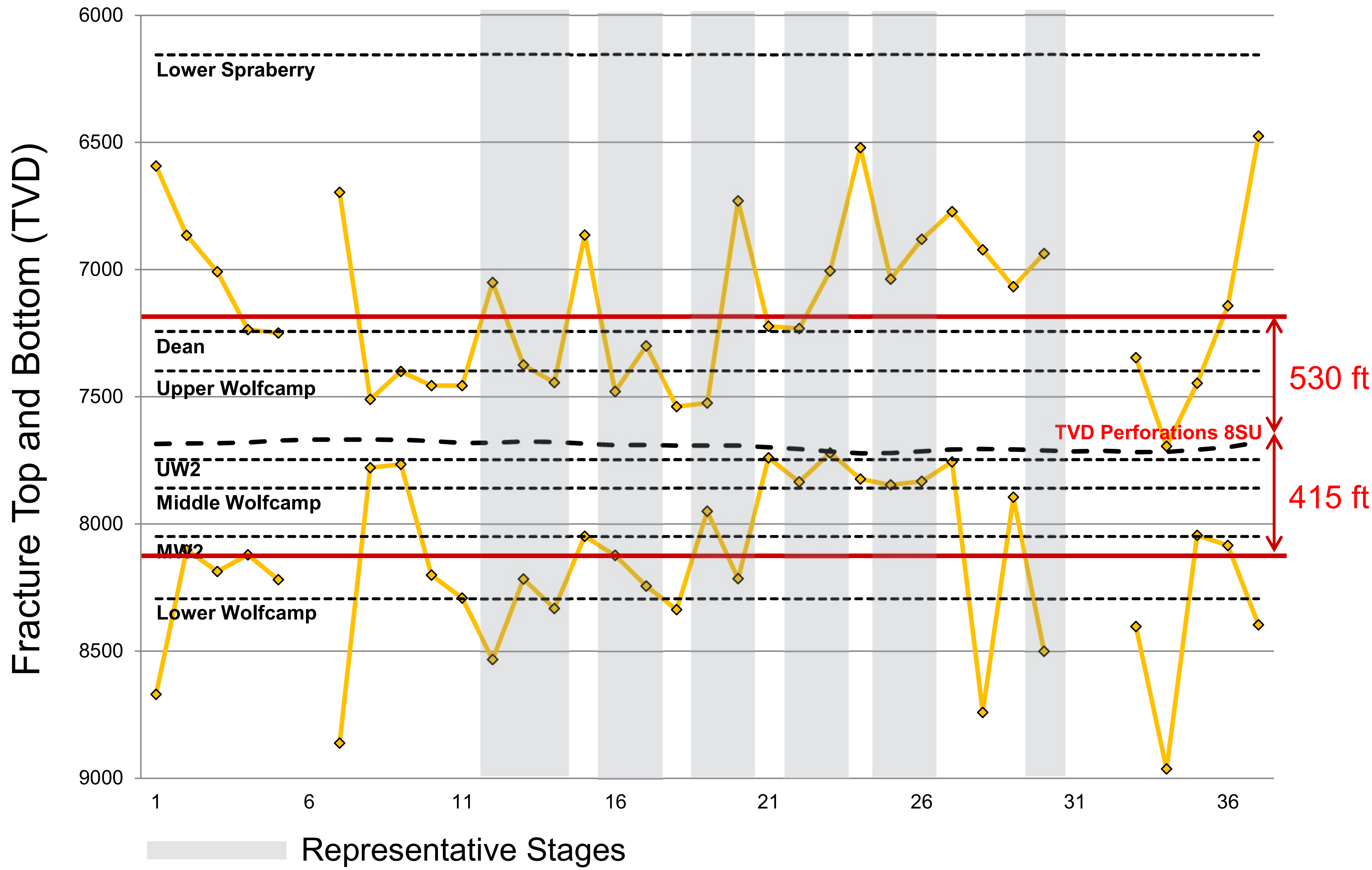
HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 5SU



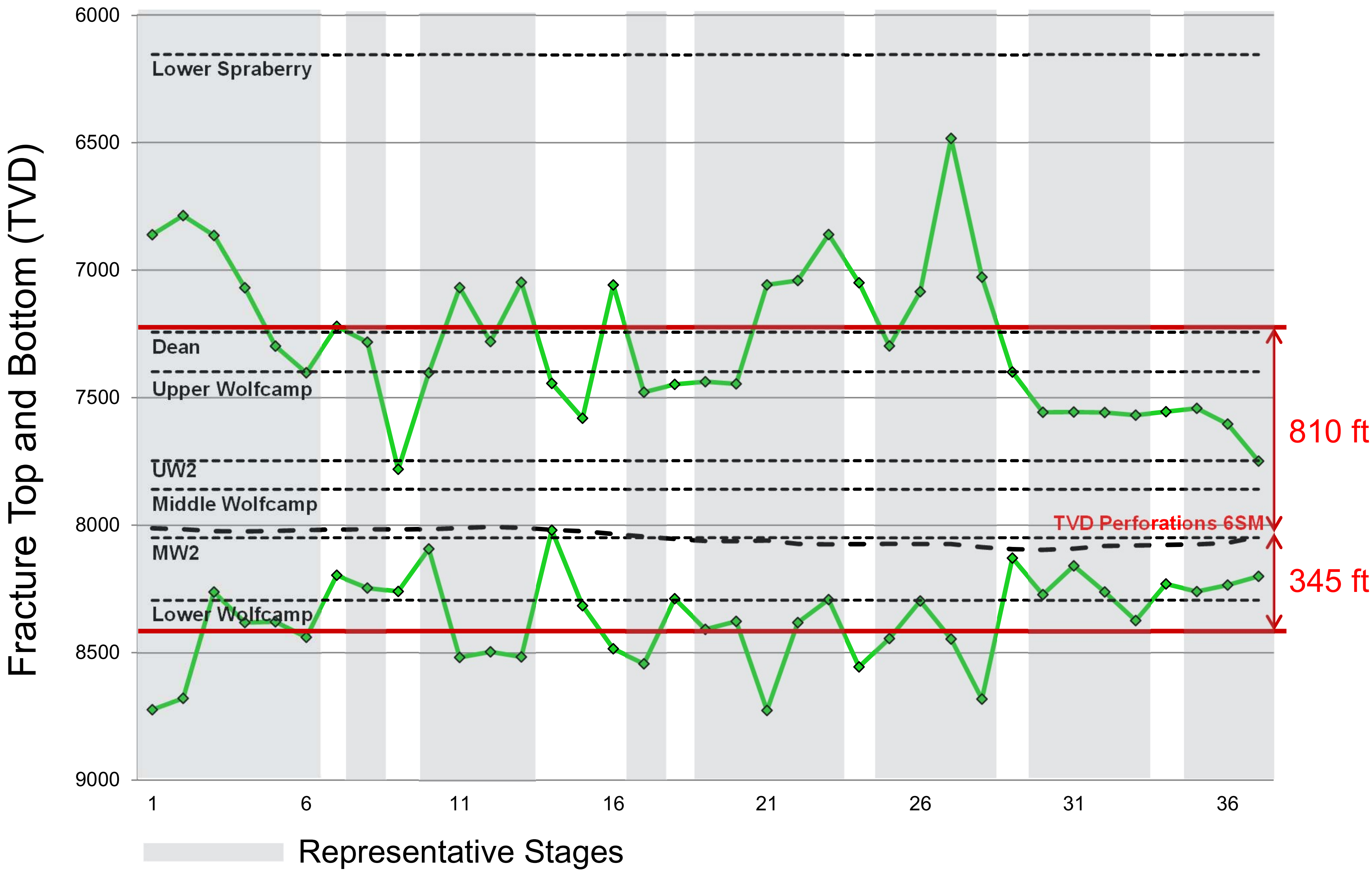
HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 8SU



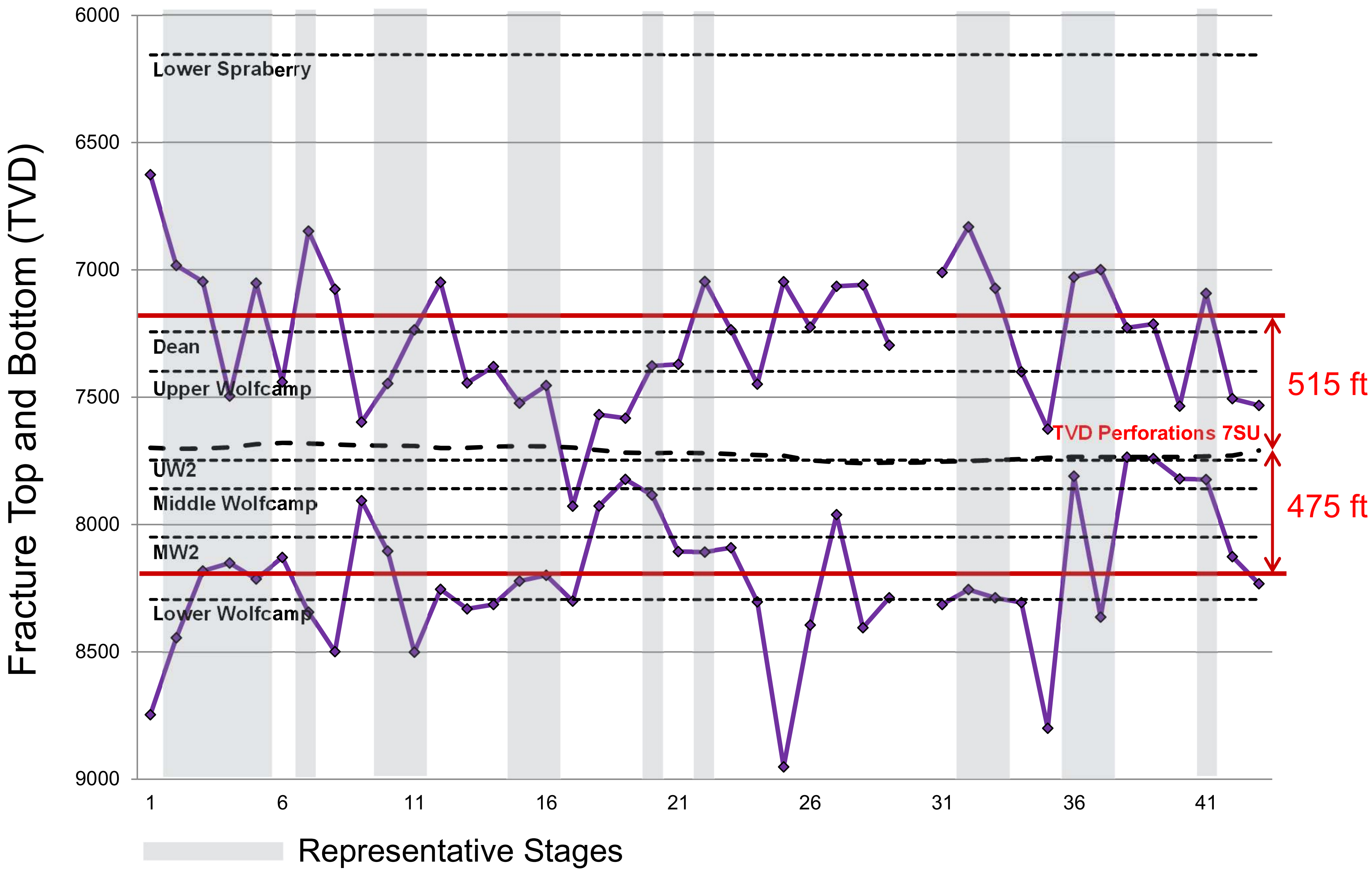
HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 6SM



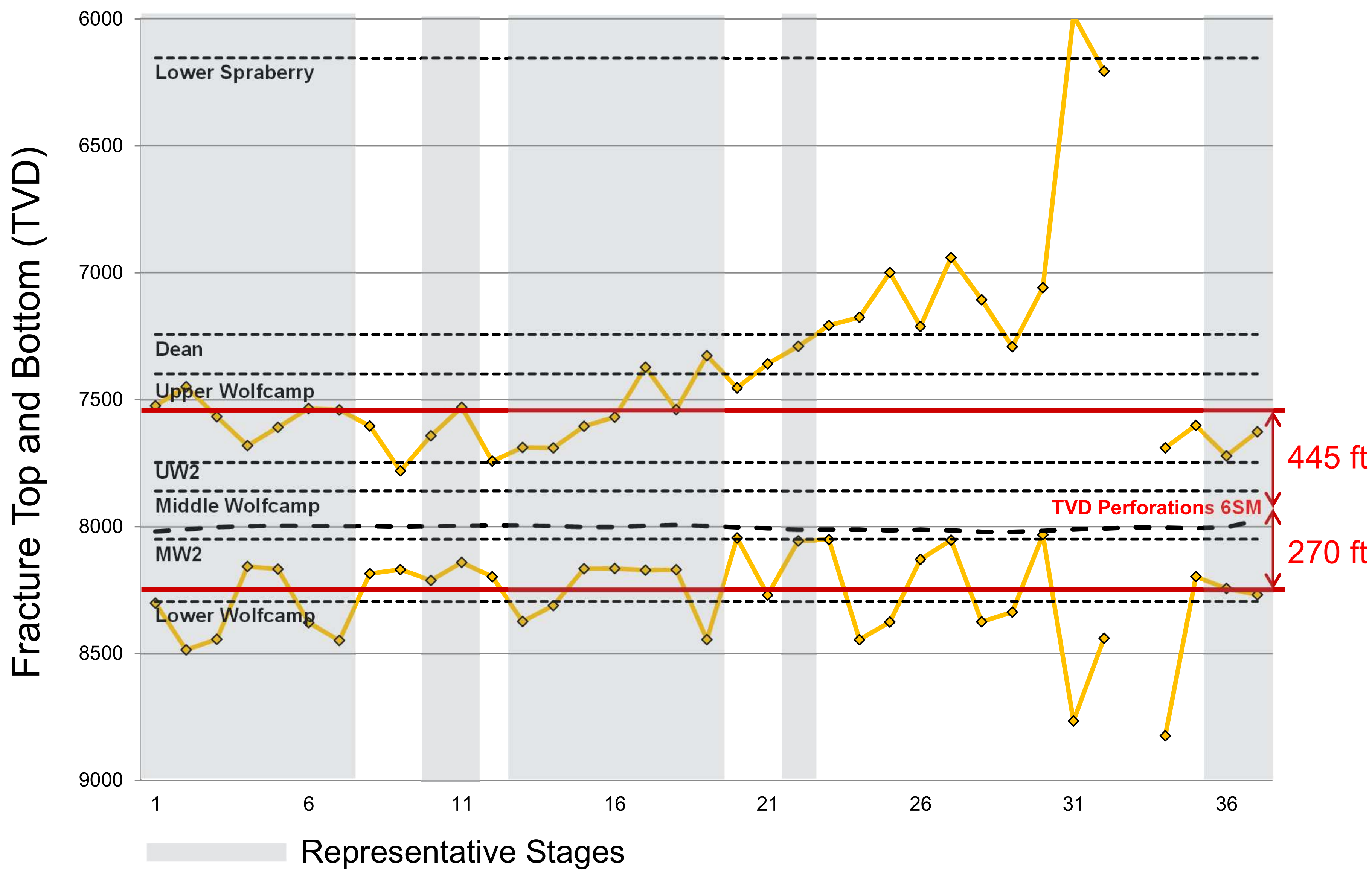
HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 7SU



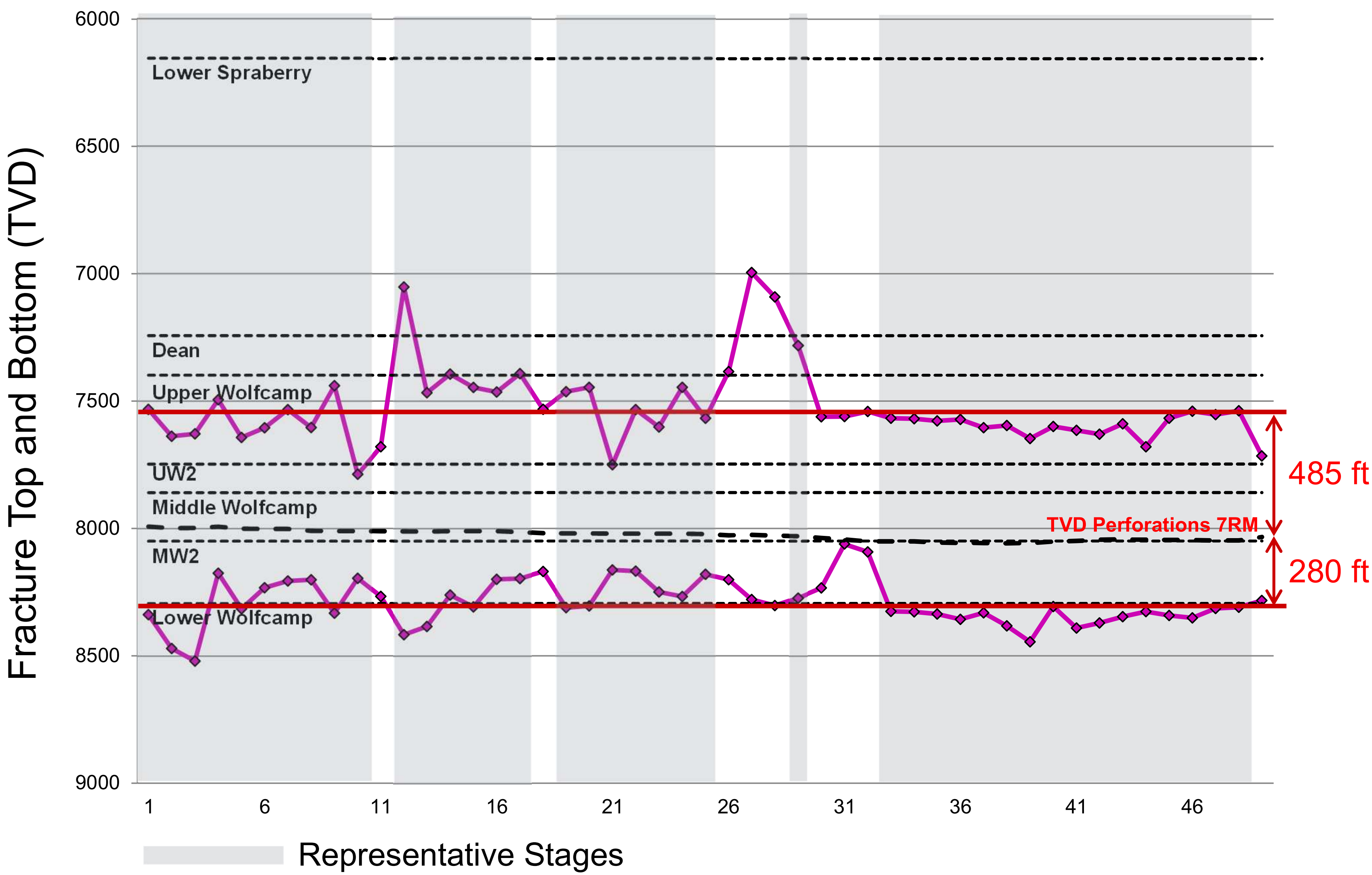
HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 8SM



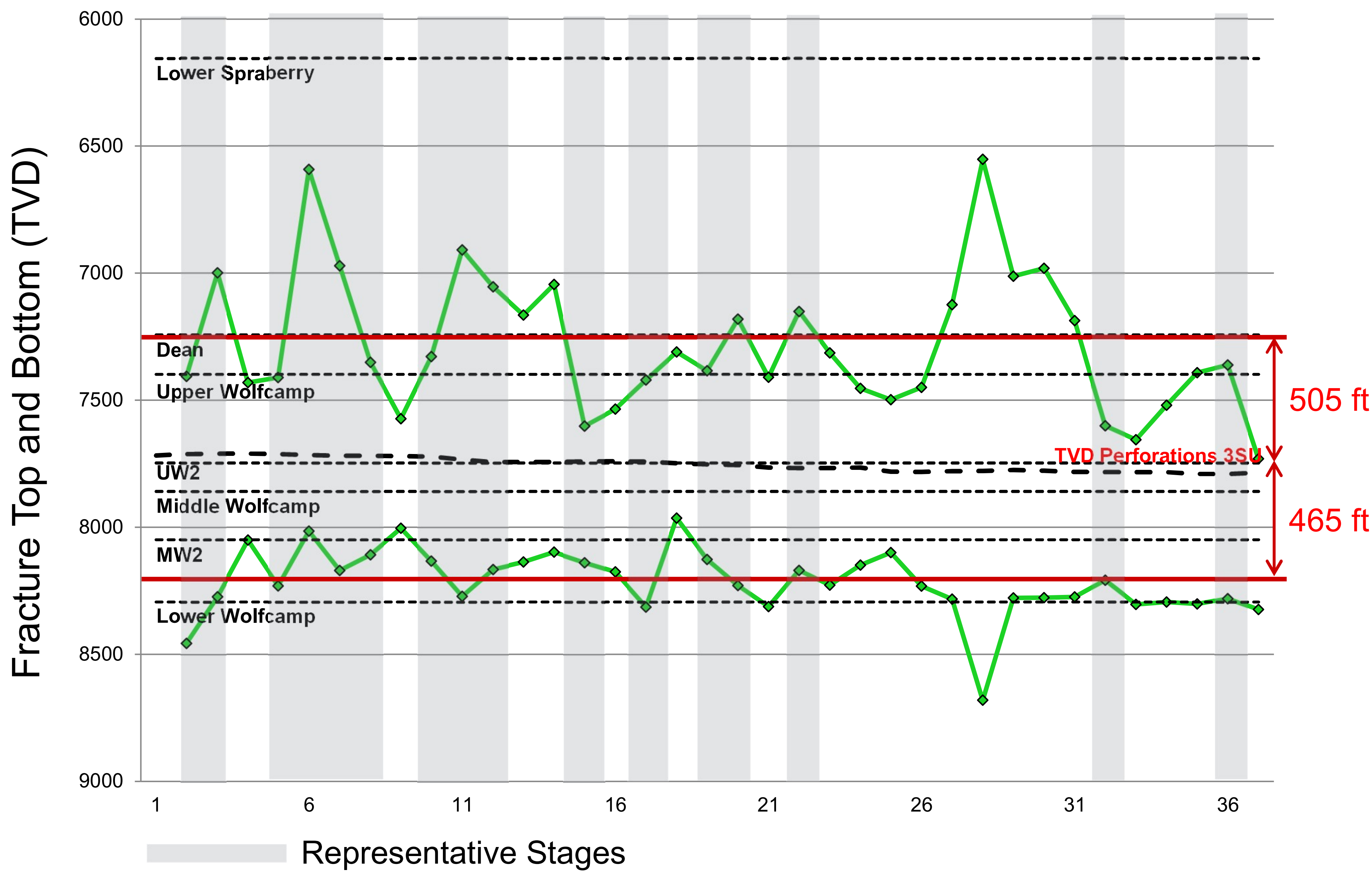
HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 7RM



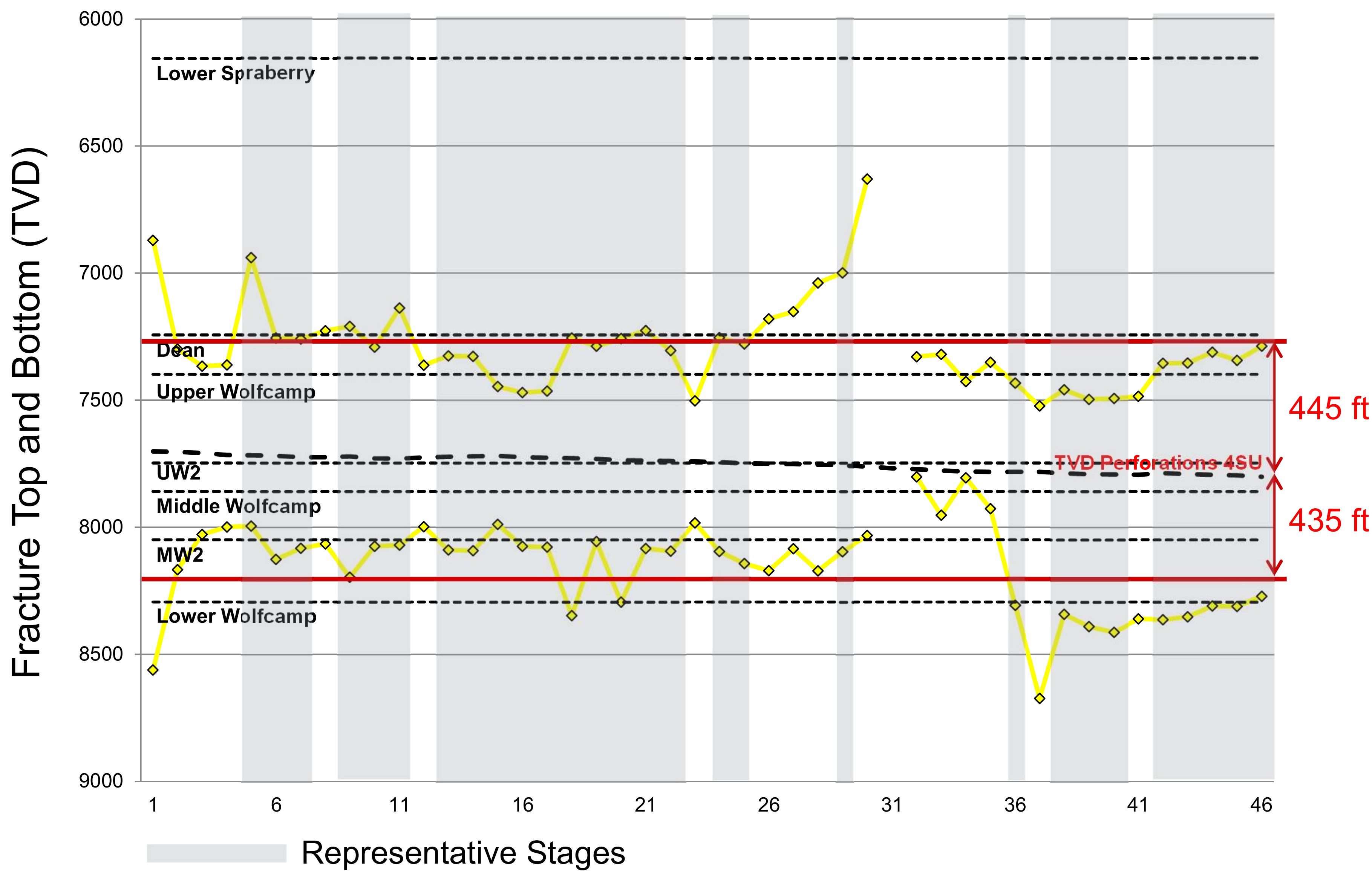
HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 3SU



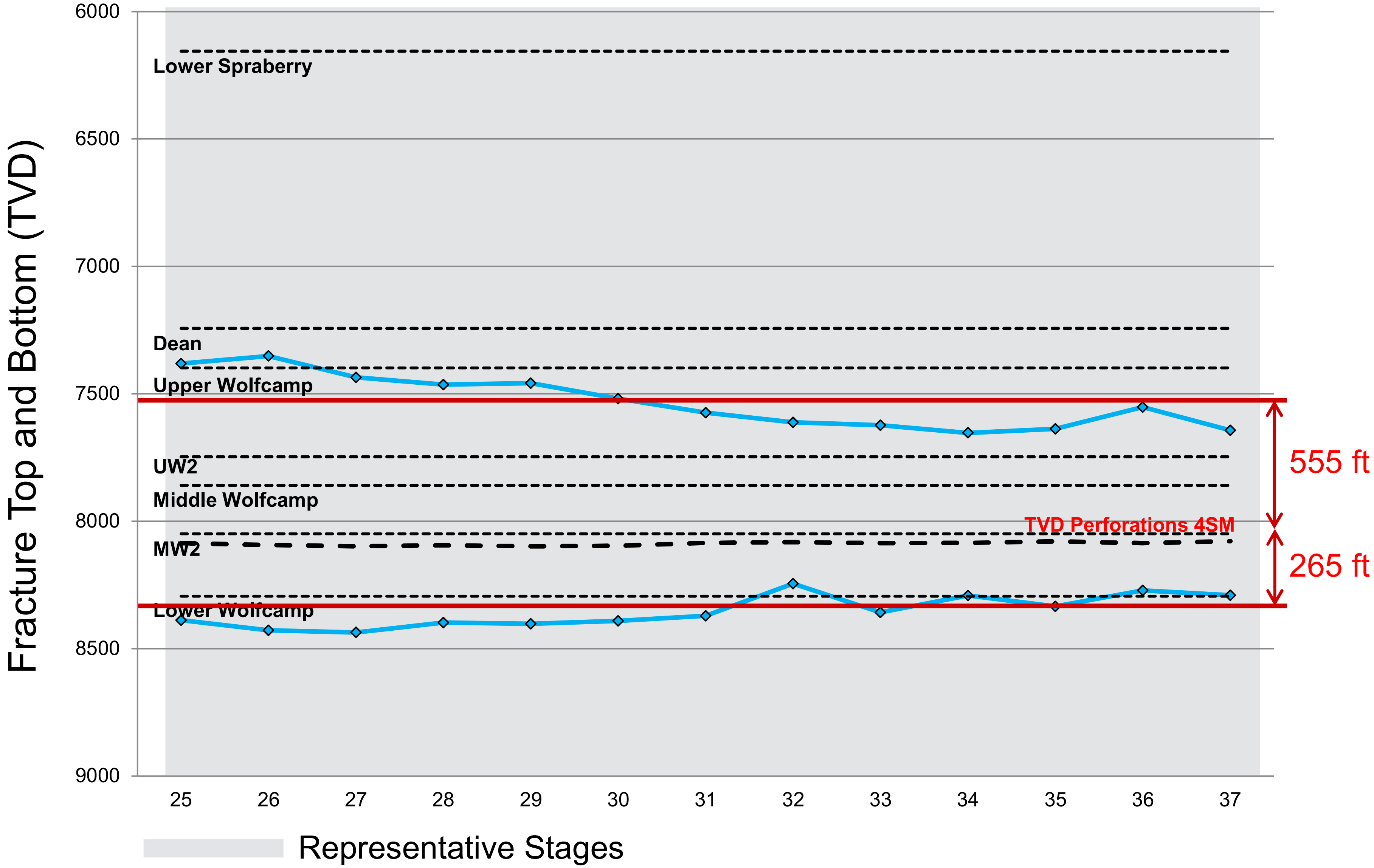
HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 4SU



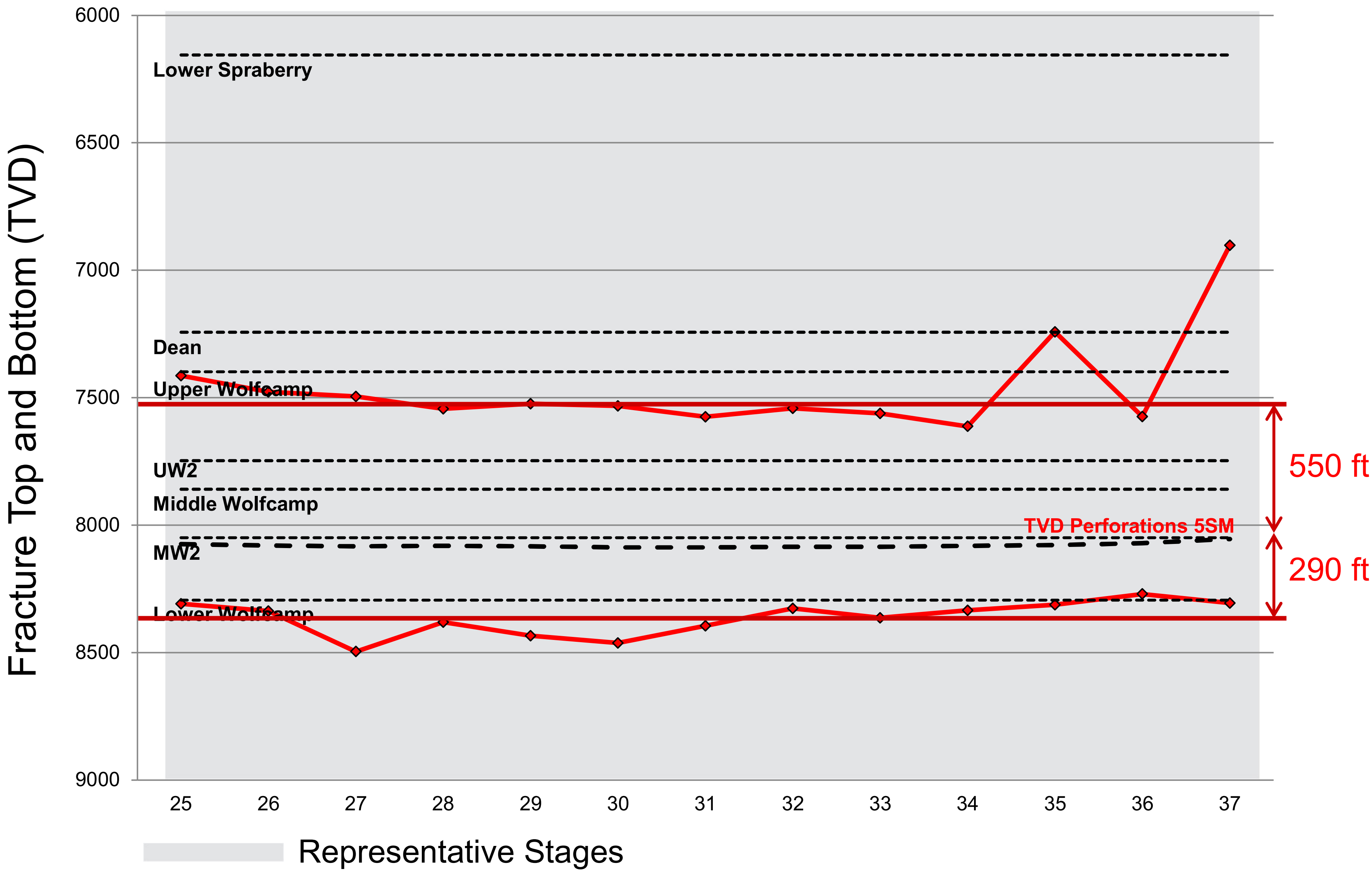
HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 4SM



HALLIBURTON

Fracture Height (h_f) – Top and Bottom Events – 5SM



HALLIBURTON