QUANTICO
Energy Solutions

UCS & MSE DIAGNOSE DRILLING LIMITERS

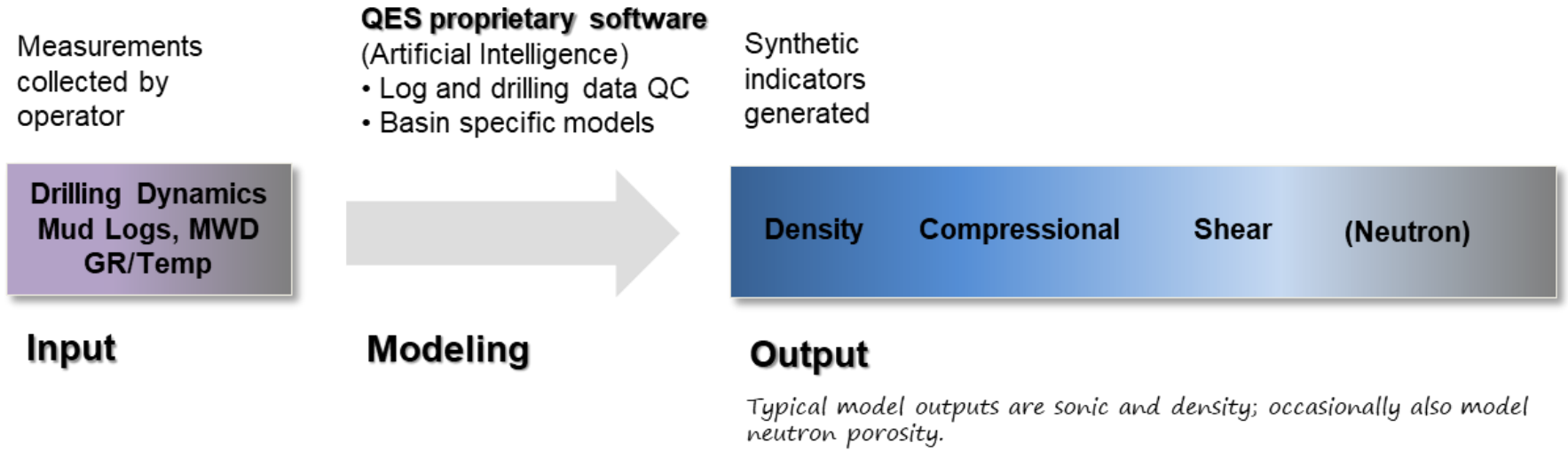
Edward Dew

OVERVIEW

- Introduction to Q-Log
- MSE Theory
- Using the Components
- Examples
- Summary

INTRO TO Q-LOG – AI BASED LOGGING WHILE DRILLING

- Quantico Energy Solutions has developed software-based tools that generate formation evaluation logs without having to deploy physical logging tools

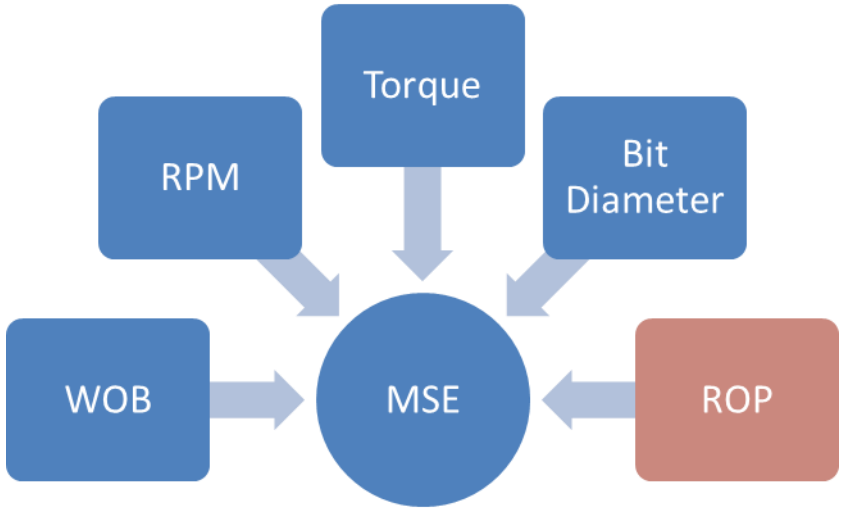


- Use direct feed of surface collected EDR data and MWD gamma to predict density, porosity, velocity at the gamma sub and at bit
  - Calculate UCS from base Qlogs and knowledge of local lithology
  - Derive Young's Modulus, Poisson's Ratio from base Qlogs

- Real-time rock properties may be used to enhance models for optimal drilling parameters

MSE – MECHANICAL SPECIFIC ENERGY

- SPECIFIC ENERGY – the energy required to destroy a certain volume of a material. Specific Energy varies with the strength and integrity of the material.
- MECHANICAL SPECIFIC ENERGY – the energy put into the drill string to destroy a certain volume of formation.



- MSE function of : WOB, RPM, Torque, Bit Diameter, ROP

CALCULATION of MSE

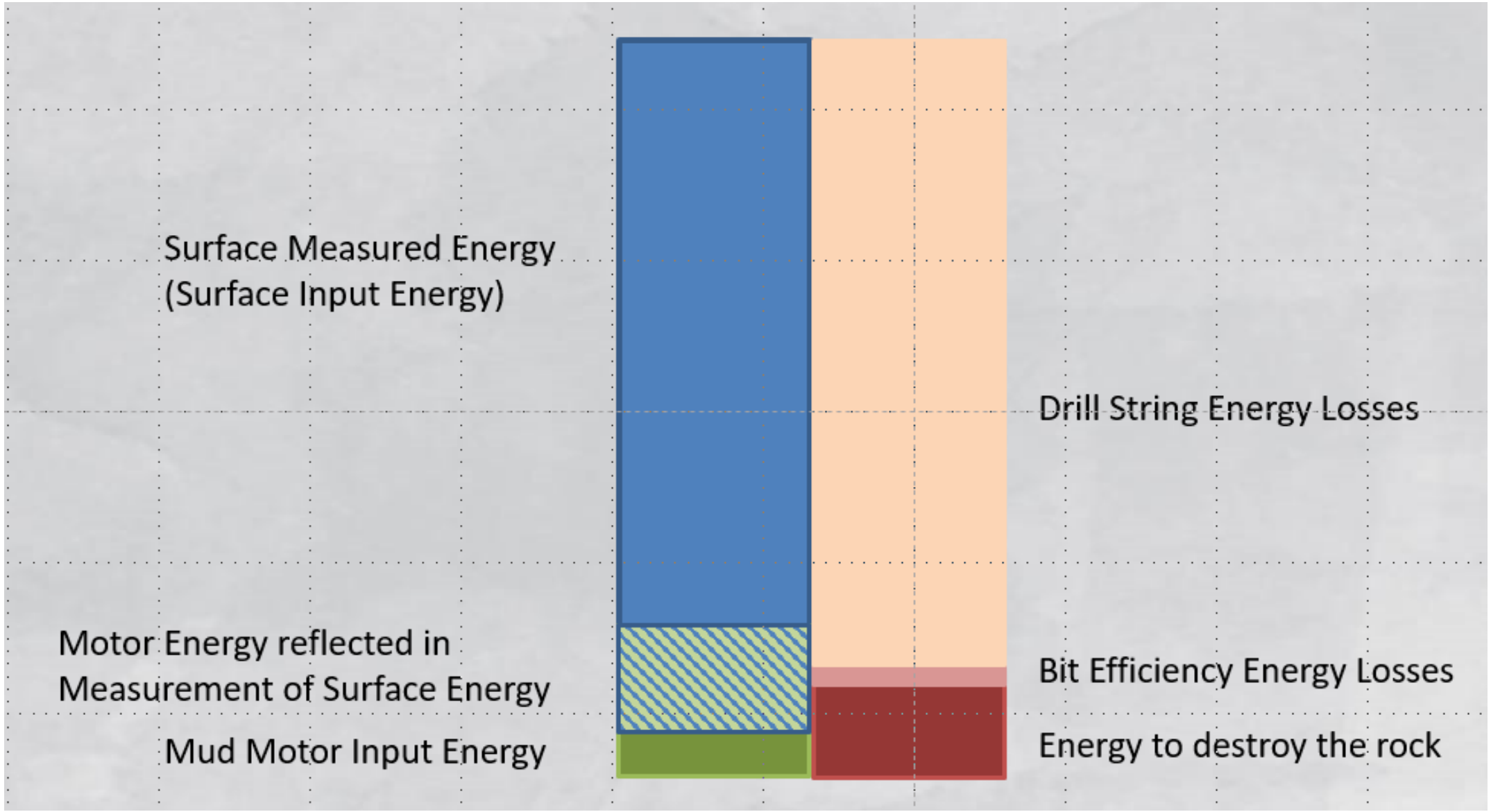
- If measurements could be made at the bit with a perfectly efficient bit:

$$MSE = \frac{WOB}{Area} + \frac{2\pi \times RPM \times Torque}{Area \times ROP}$$

- WOB, RPM & Torque controlled by driller & surface equipment capabilities
- Area is function of bit diameter which is determined by bit design

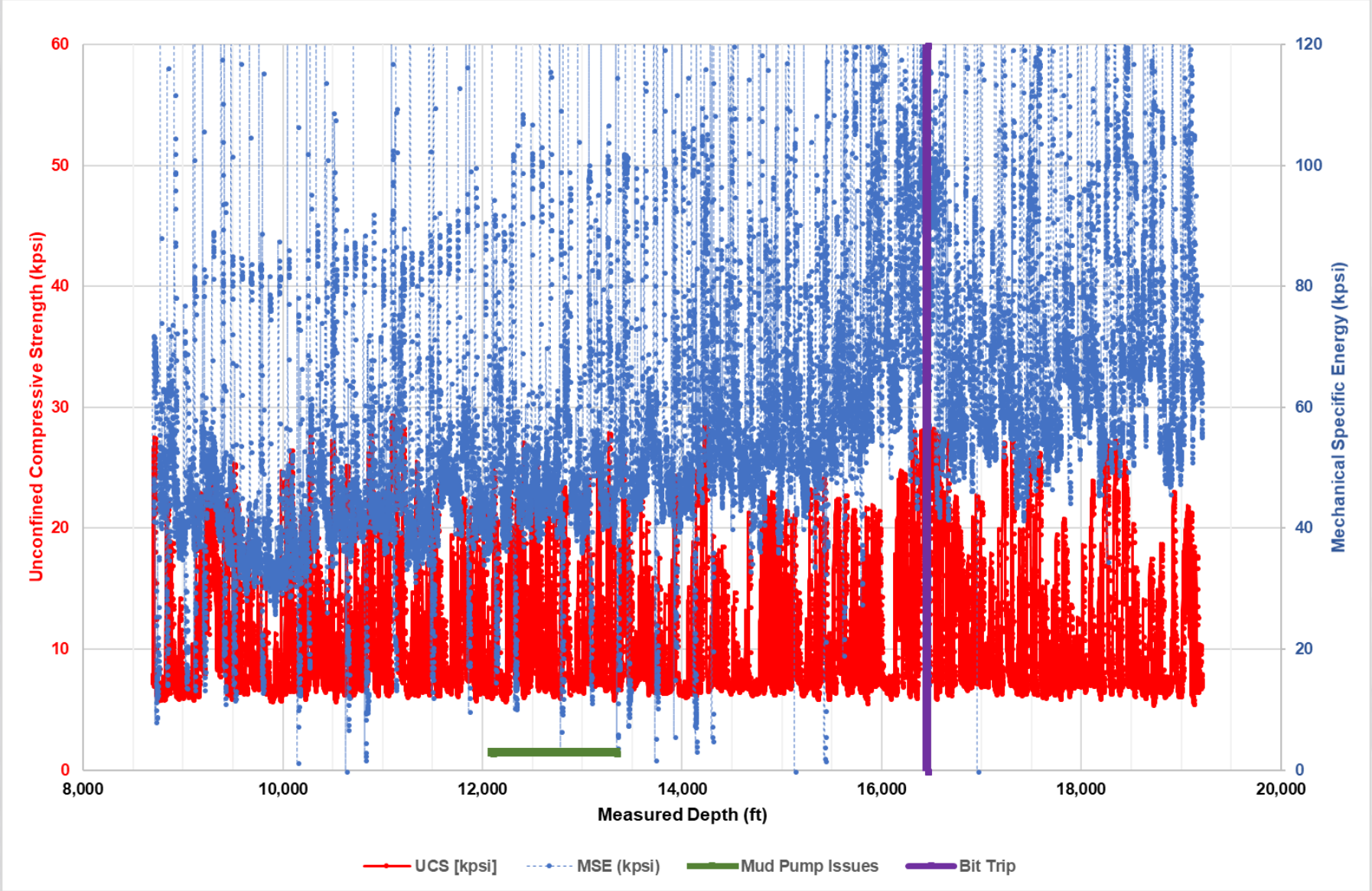
- **ROP is the formation's response to inputs**

USING THE COMPONENTS



EXAMPLE A

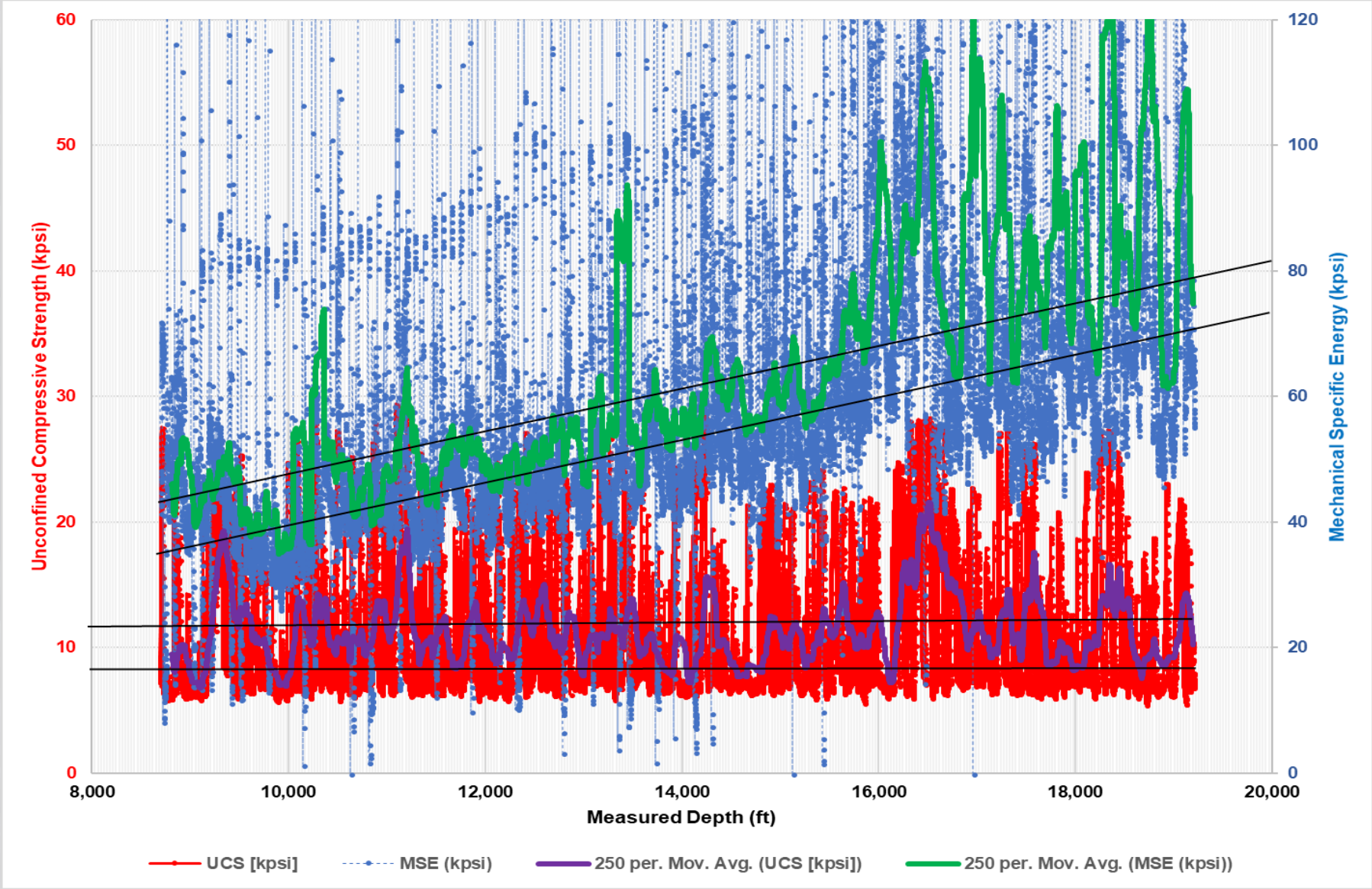
- Horizontal well
- 10,344 ft lateral
- Oil base mud
- PDC bits
- 8½” hole size



EXAMPLE A

- Horizontal well
- 10,344 ft lateral
- Oil base mud
- PDC bits
- 8½” hole size

- Applied running average of 250 pts
- General ranges
- UCS stays in constant range 8-12 kpsi
- MSE increasing in range



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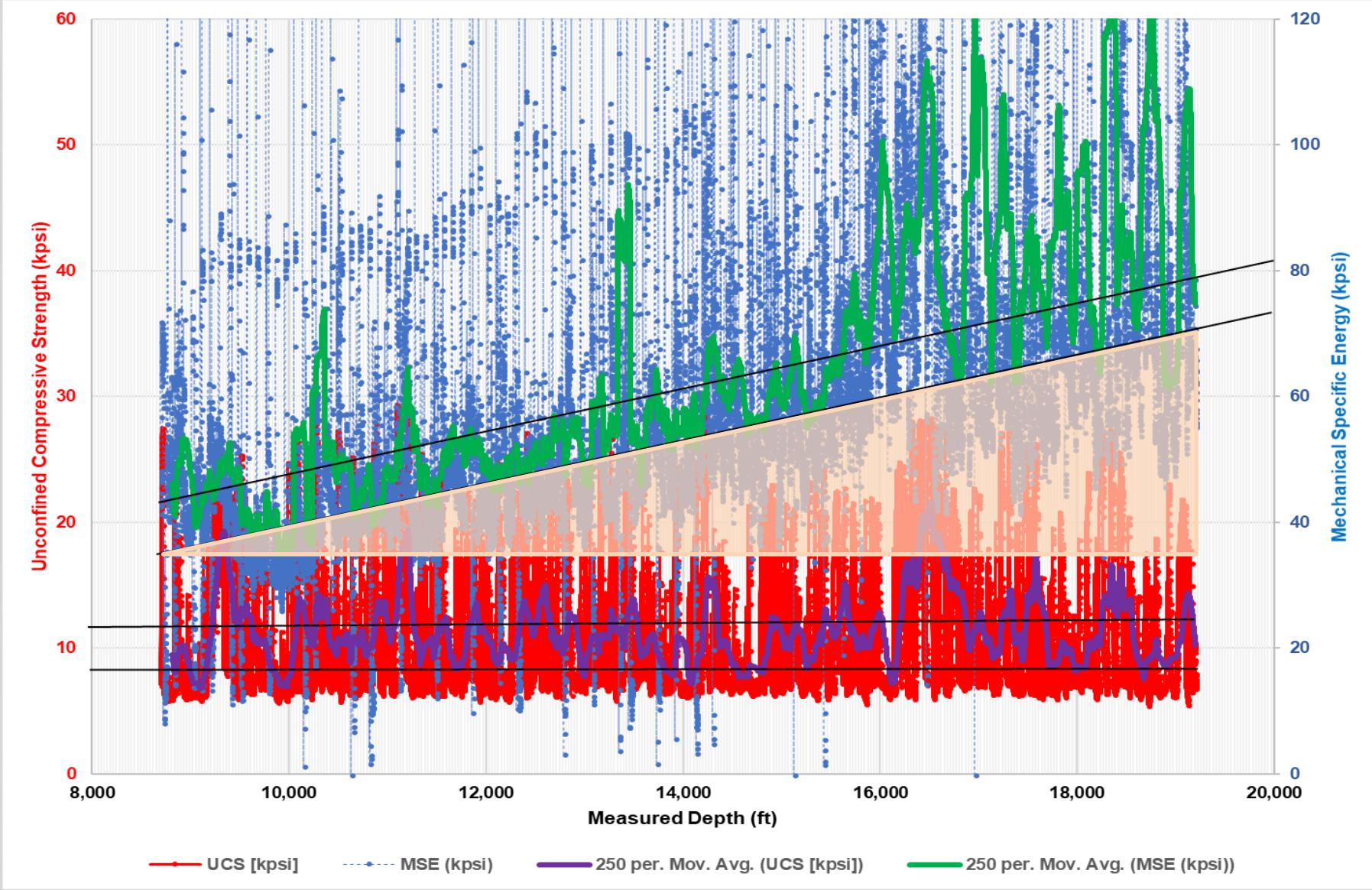
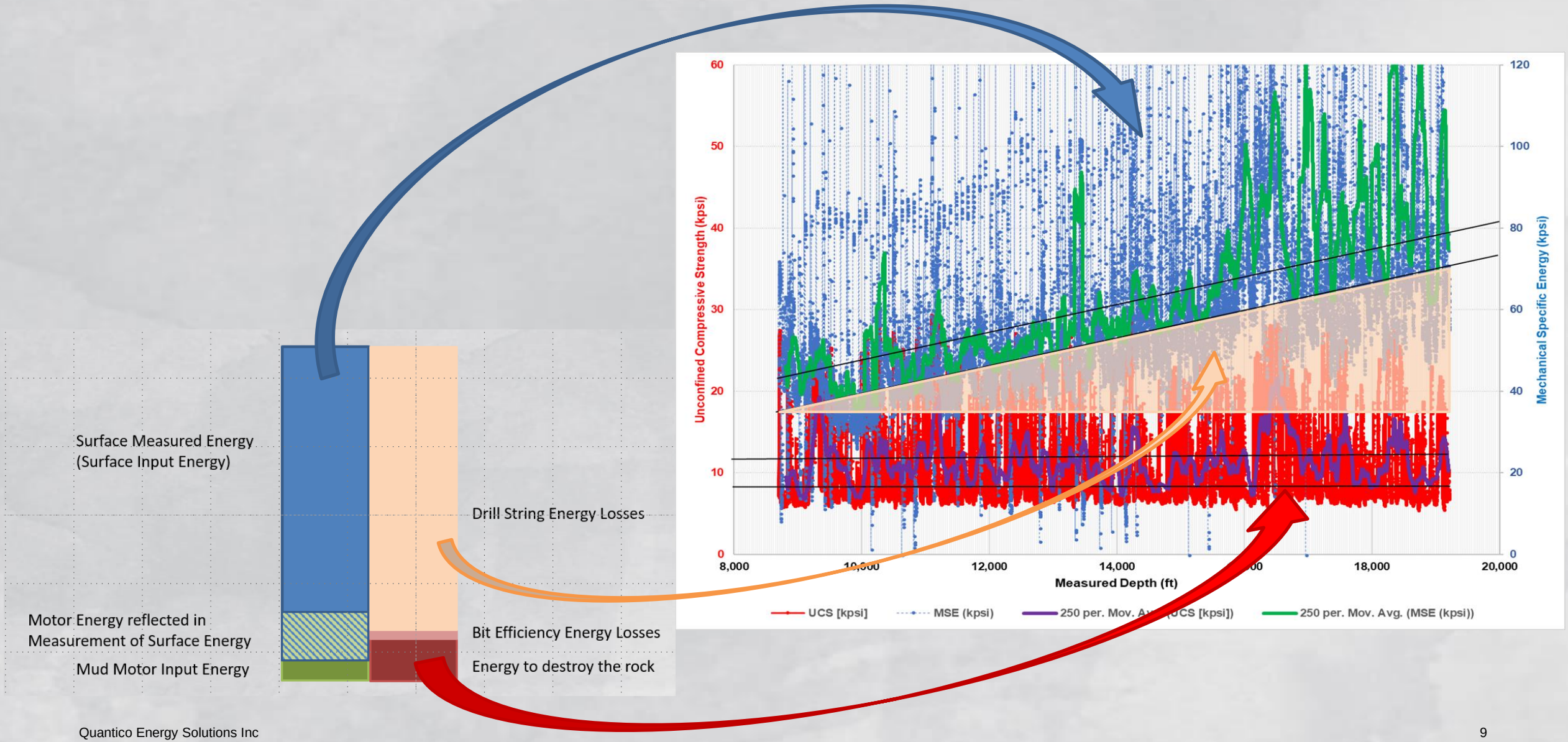
- Torque & Drag contribution



EXAMPLE A


Surface Measured Energy
(Surface Input Energy)
Drill String Energy Losses
Motor Energy reflected in
Measurement of Surface Energy
Mud Motor Input Energy
Bit Efficiency Energy Losses
Energy to destroy the rock
Unconfined Compressive Strength (kpsi)
Mechanical Specific Energy (kpsi)
Measured Depth (ft)
8,000
12,000
14,000
18,000
20,000
0
10
20
30
40
50
60
0
20
40
60
80
100
120
UCS [kpsi]
MSE (kpsi)
250 per. Mov. Avg. (MSE (kpsi))

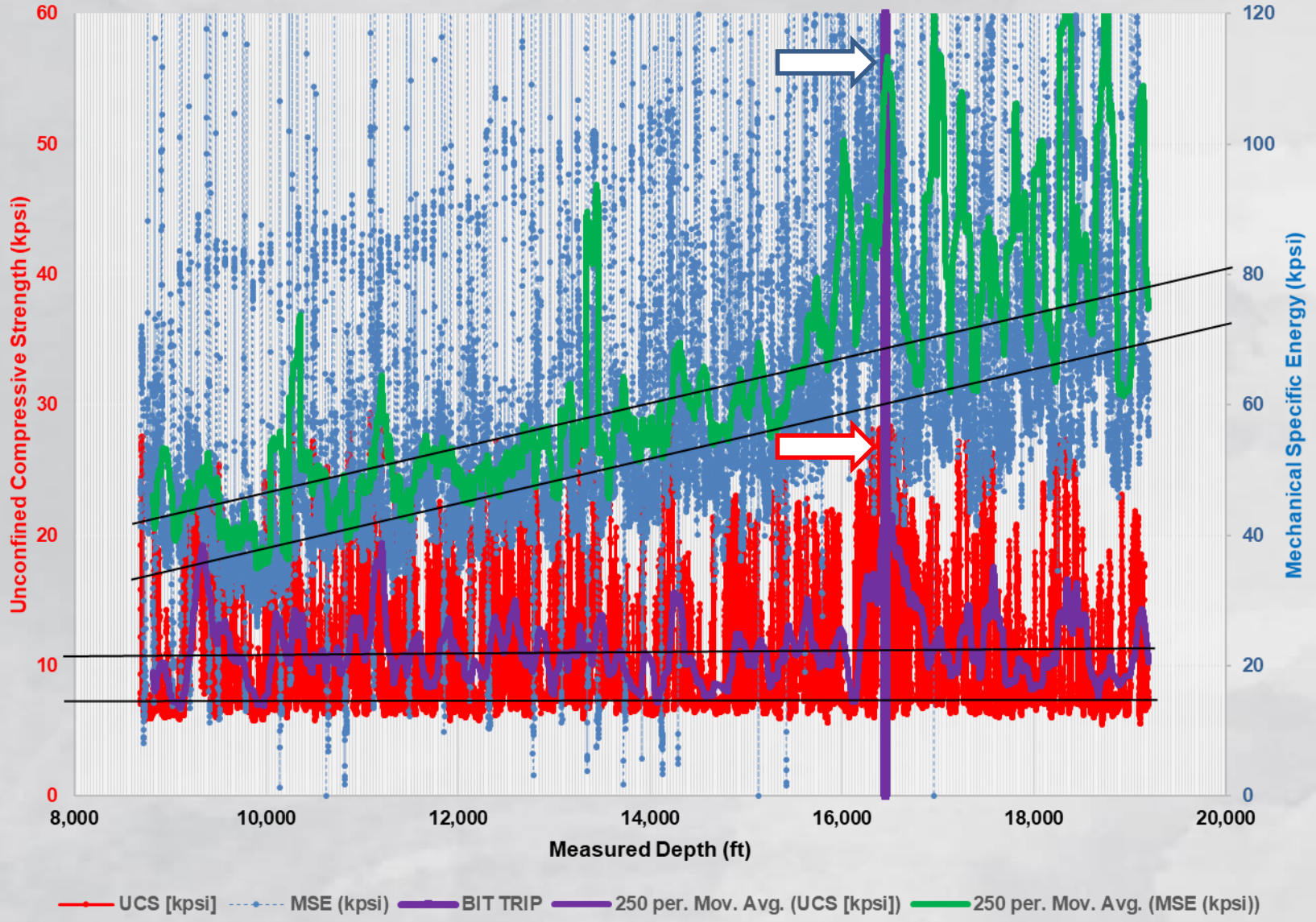
EXAMPLE A

BIT TRIP at 16,452 ft

Was it necessary?

MSE increased

UCS increased



EXAMPLE A

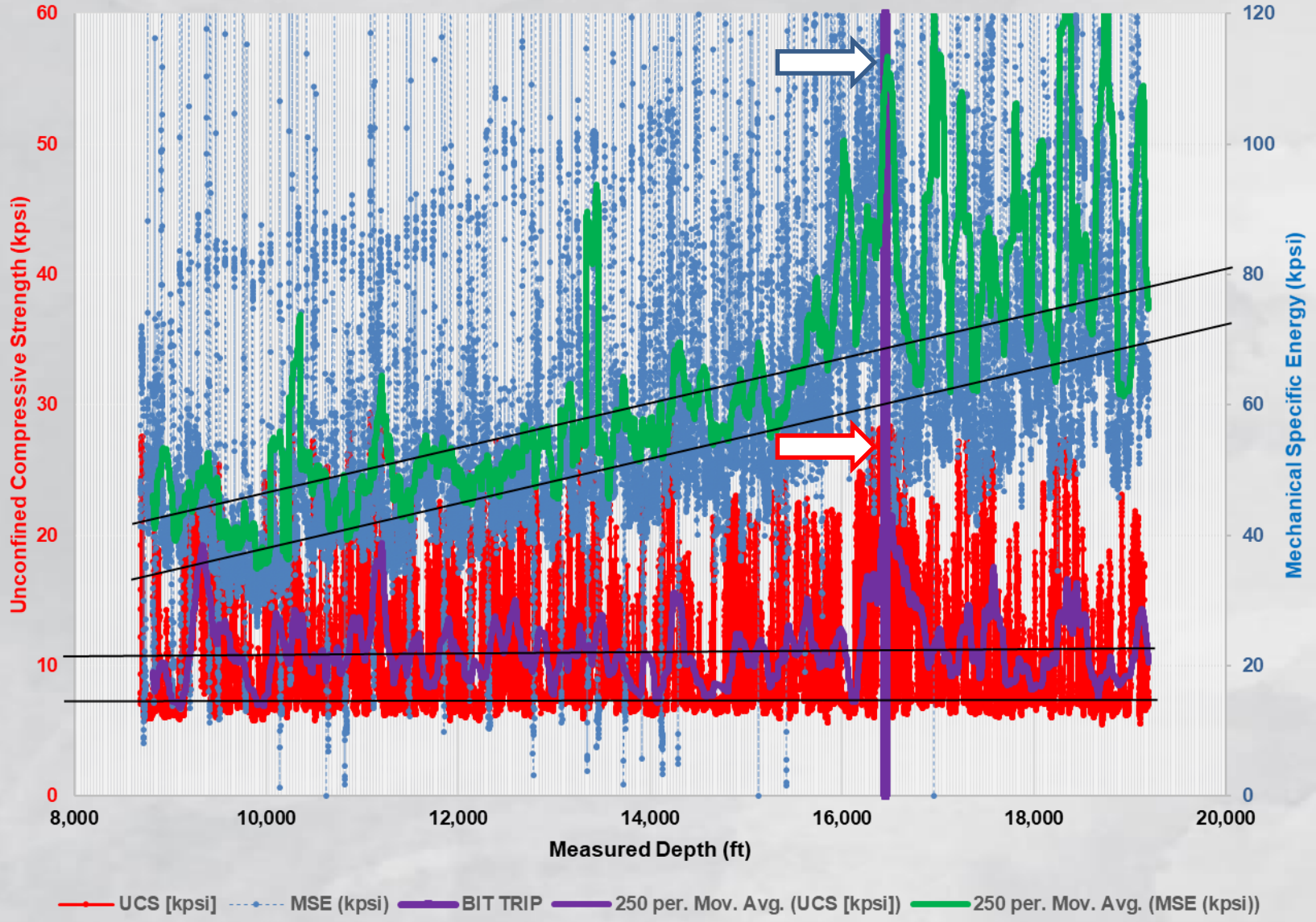
BIT TRIP at 16,452 ft

Was it necessary?

MSE increased

UCS increased

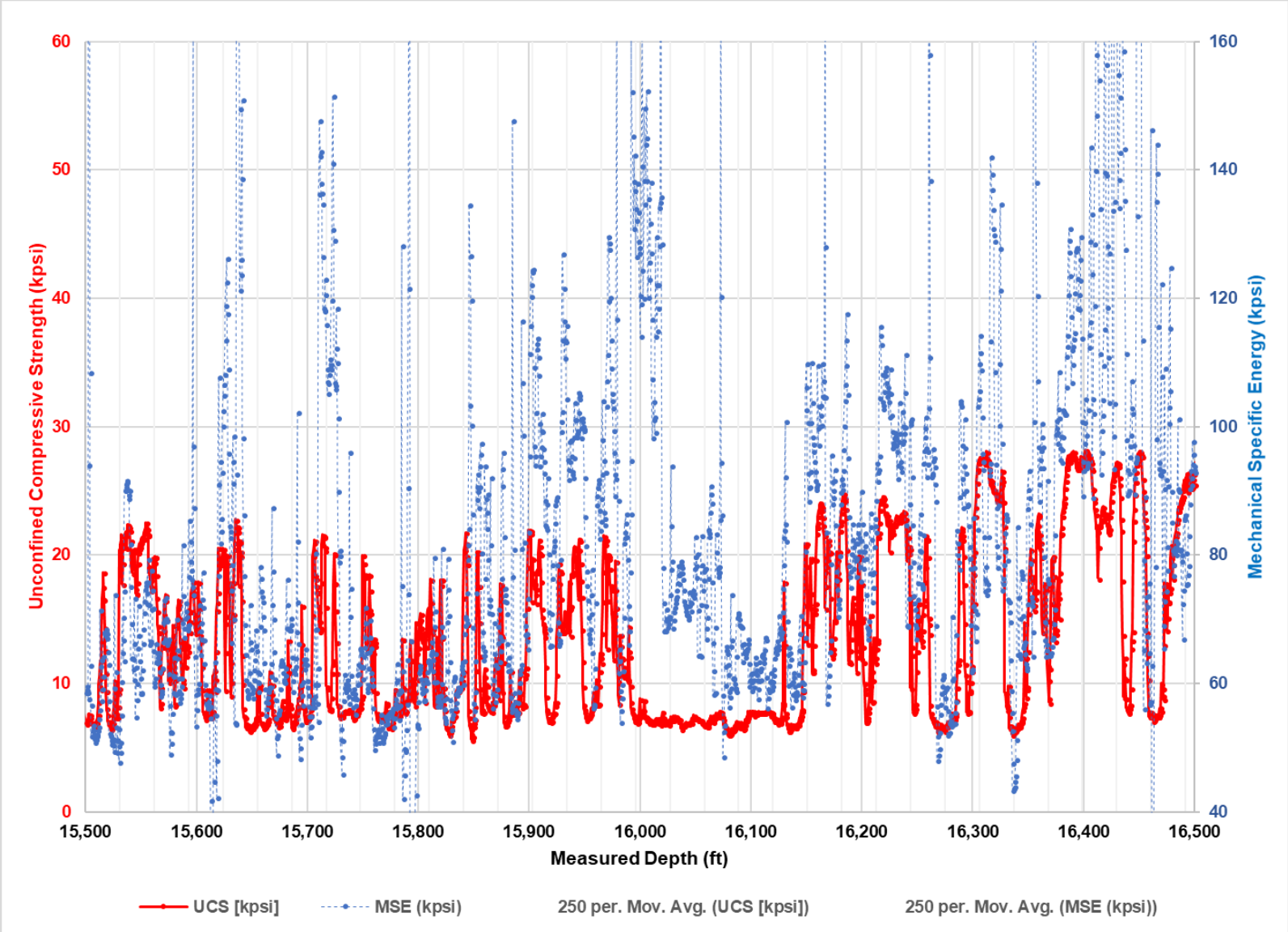
Probably an unnecessary trip!



EXAMPLE A – EXPANDED DEPTH SCALE

- 15,500 ft to 16,500 ft
- Note changes in ratio
- Normal is MSE ≈ 4-6 x UCS

- Where are MSE & UCS headed in opposite directions?
- Where is the ratio of MSE to UCS greater than 6?



EXAMPLE A – EXPANDED DEPTH SCALE

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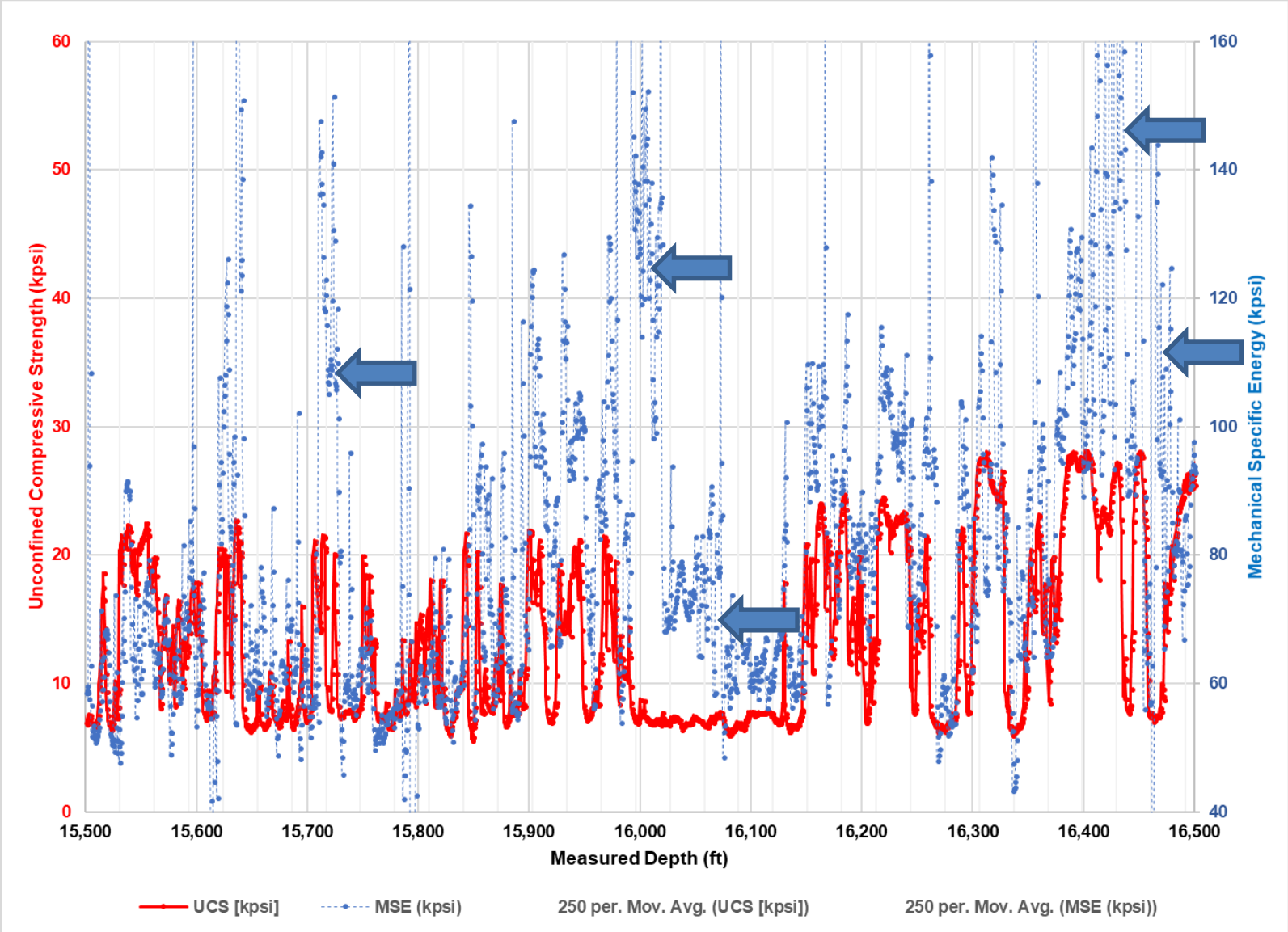
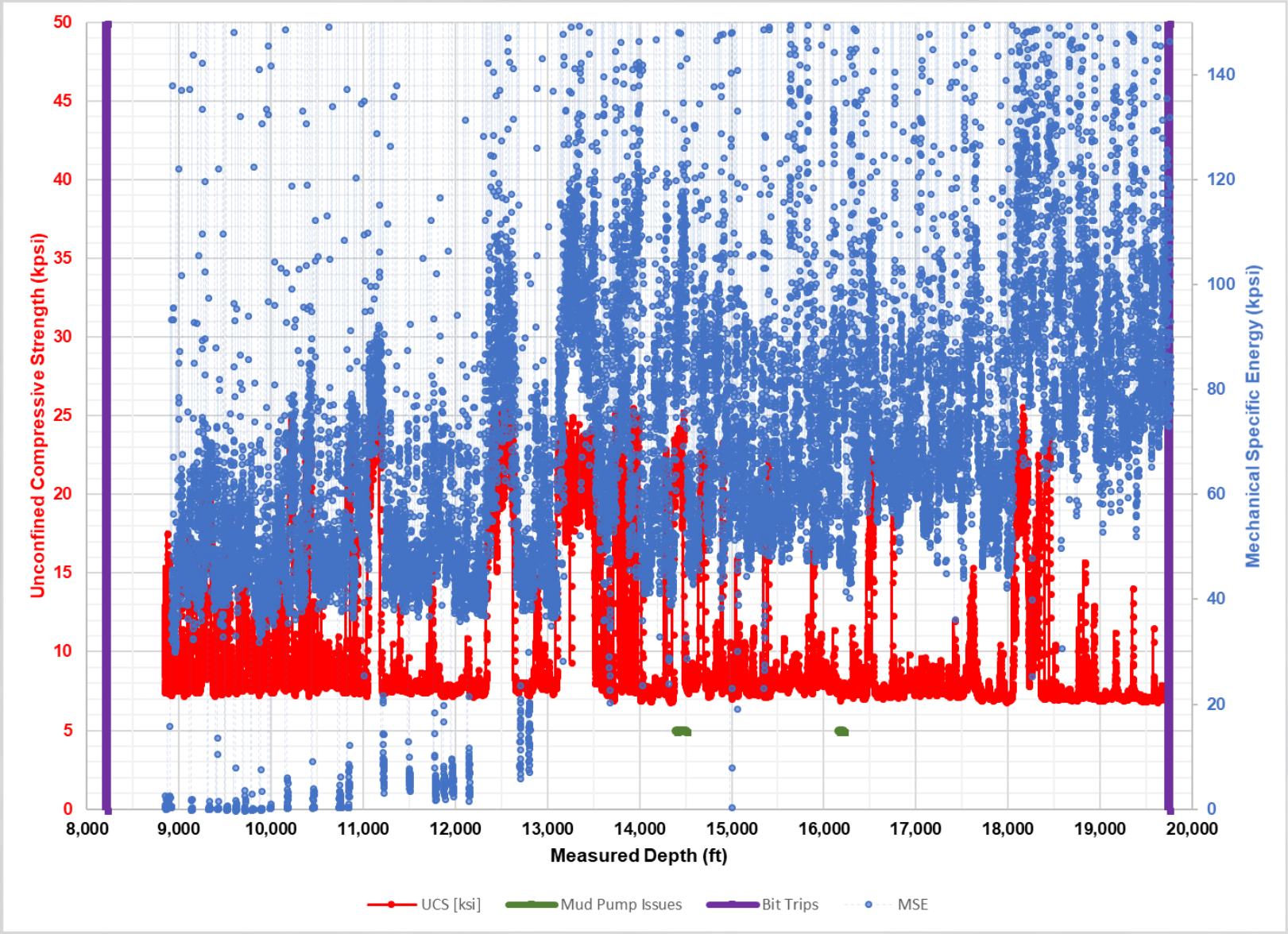
- Note that these are largely drilling from hard into soft layers.
  - >Excessive WOB
  - >No change in Rotary or Circ Rate (motor revs)
- Correct response
  - >Decrease WOB
  - >Increase bit rotating speed



EXAMPLE B

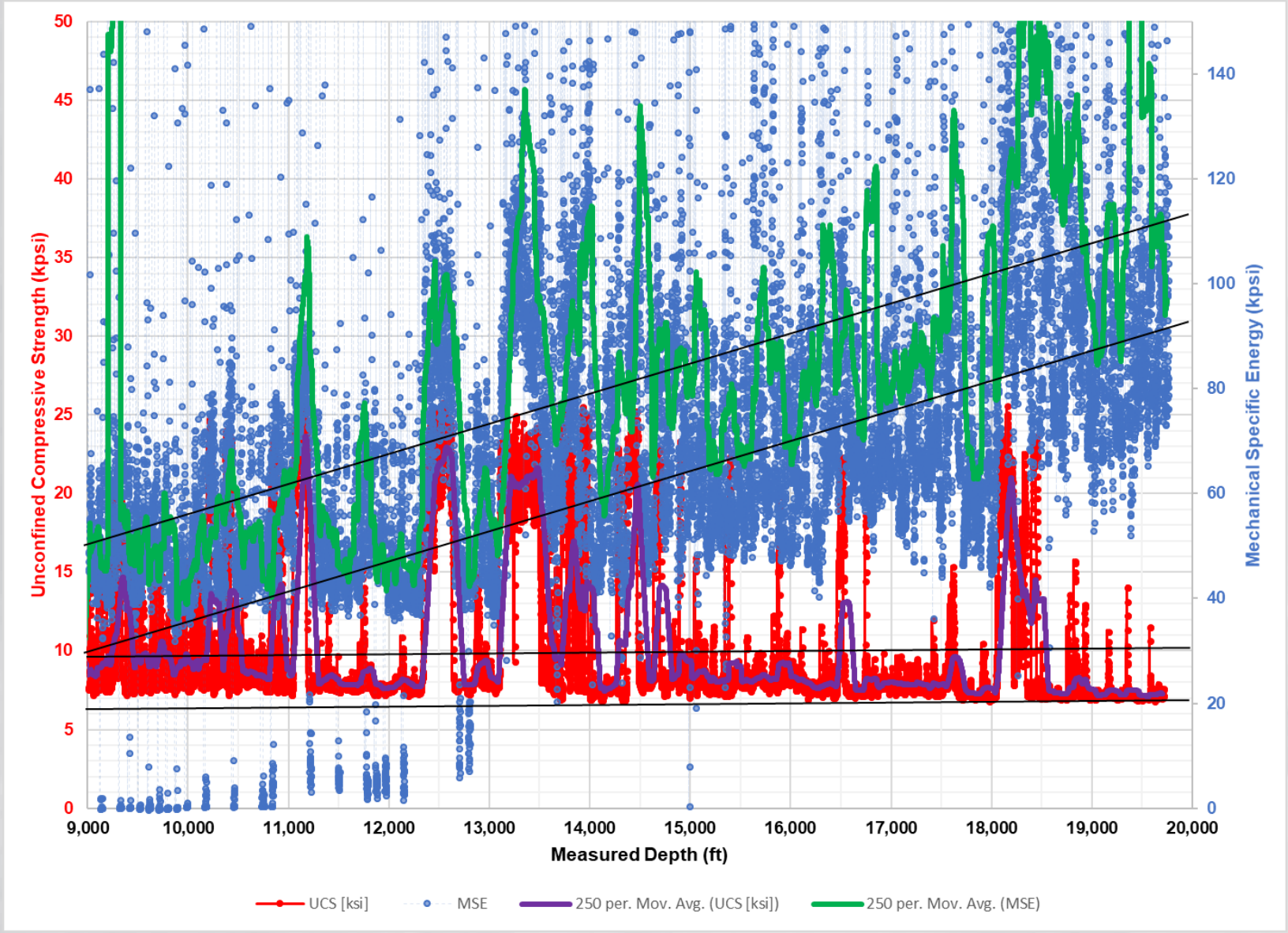
- Horizontal well
- 10,527 ft lateral
- Oil base mud
- PDC bits
- 8½” hole size



EXAMPLE B

- Horizontal well
- 10,527 ft lateral
- Oil base mud
- PDC bits
- 8½” hole size

- Applied running average of 250 pts
- General ranges
- UCS stays in constant range 4-10 kpsi
- MSE increasing in range



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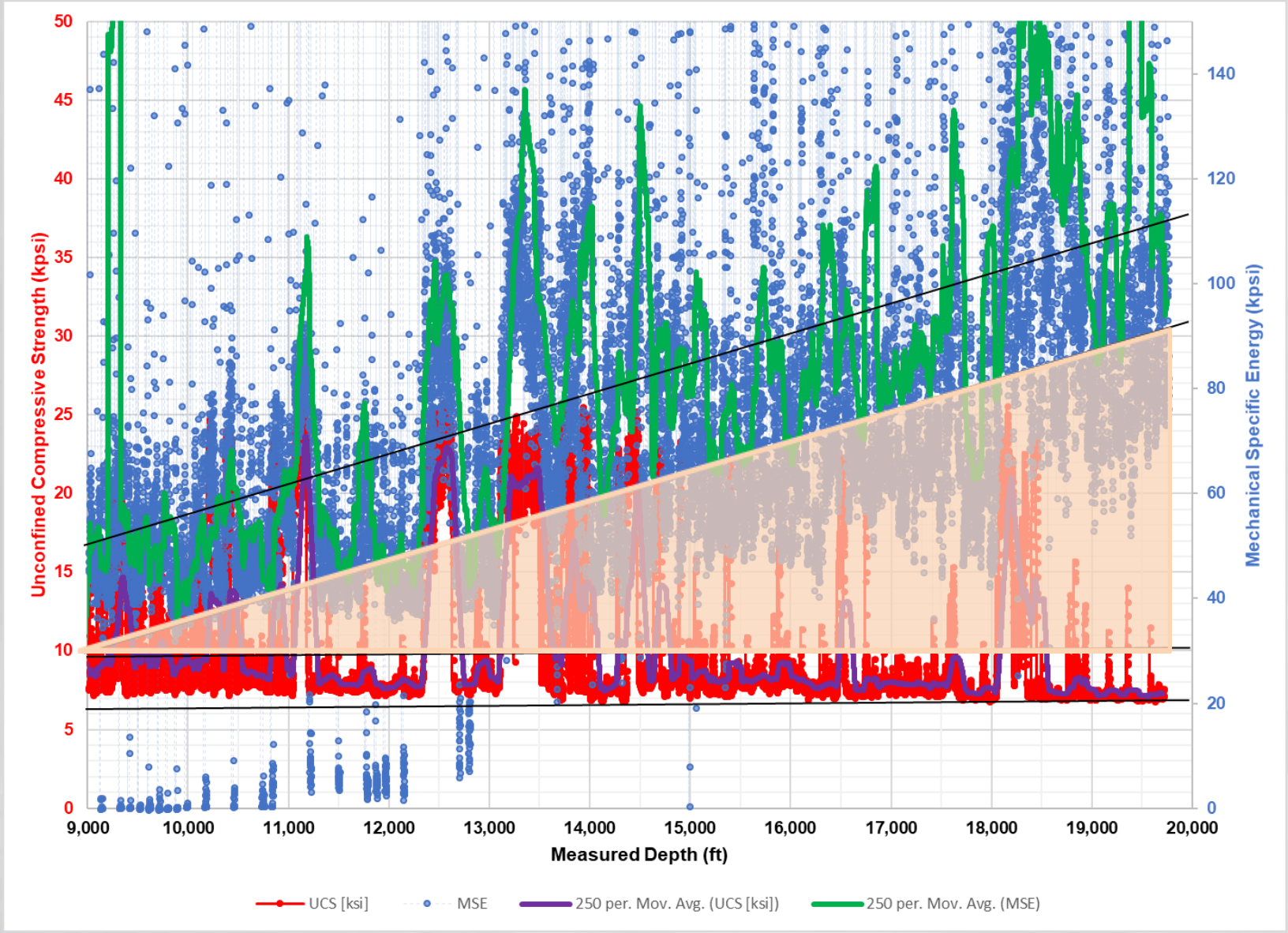
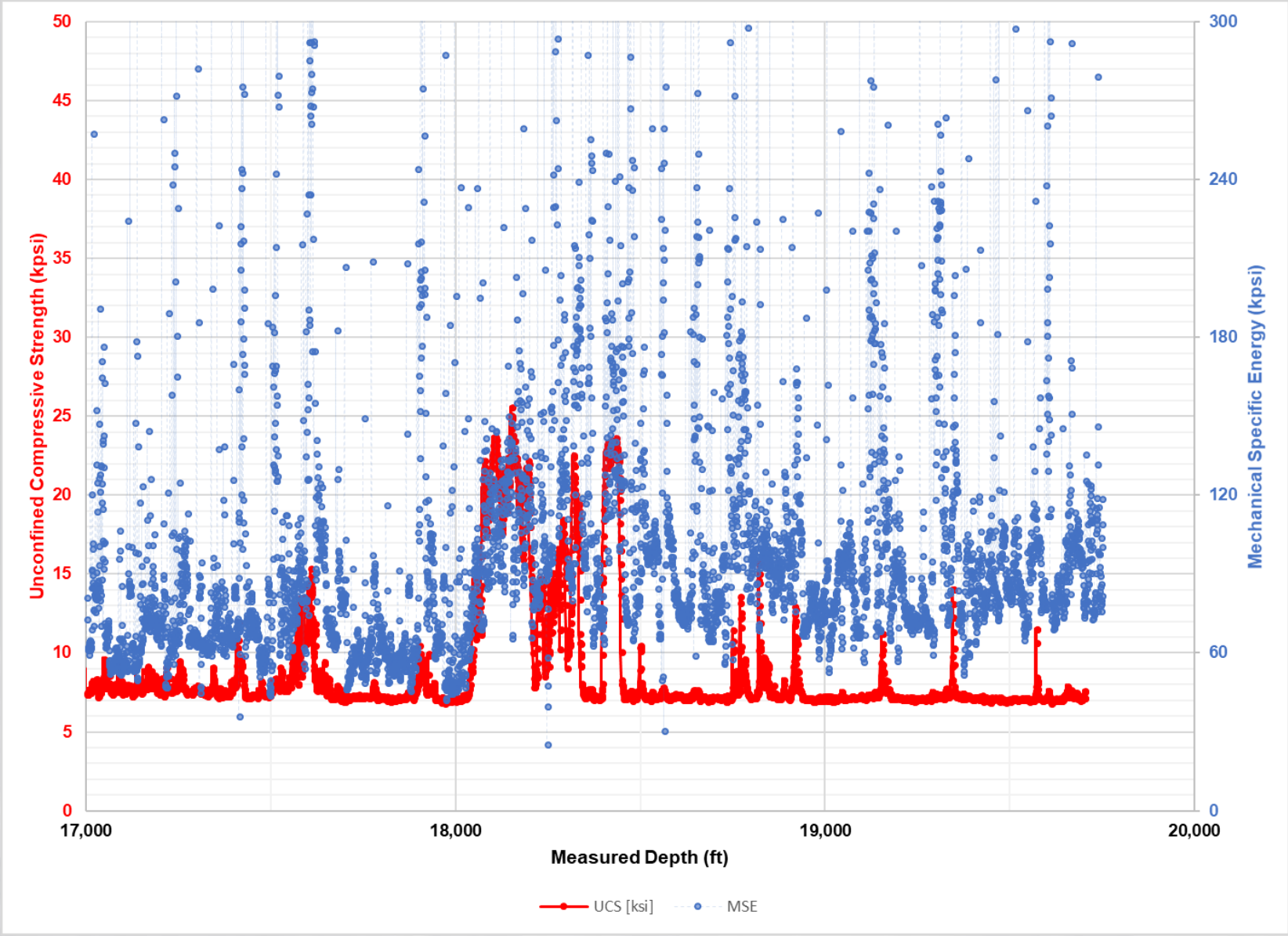
- Torque & Drag contribution



EXAMPLE B – EXPANDED DEPTH SCALE

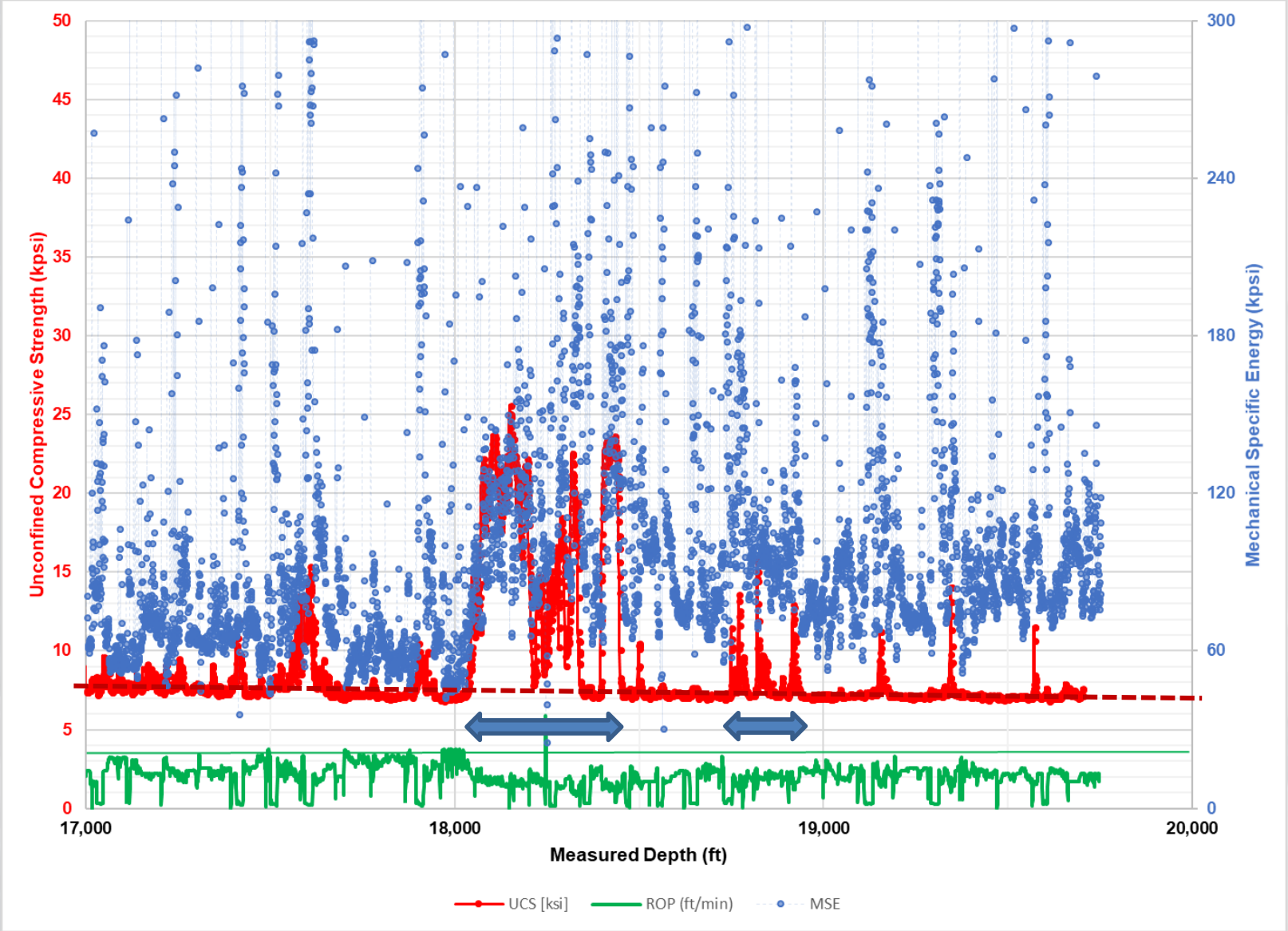
- 17,000 ft to 19,748 ft
- Note changes in ratio
- Normal is MSE ≈ 6-7 x UCS

- Where are MSE & UCS headed in opposite directions?
- Where is the ratio of MSE to UCS greater than 7?



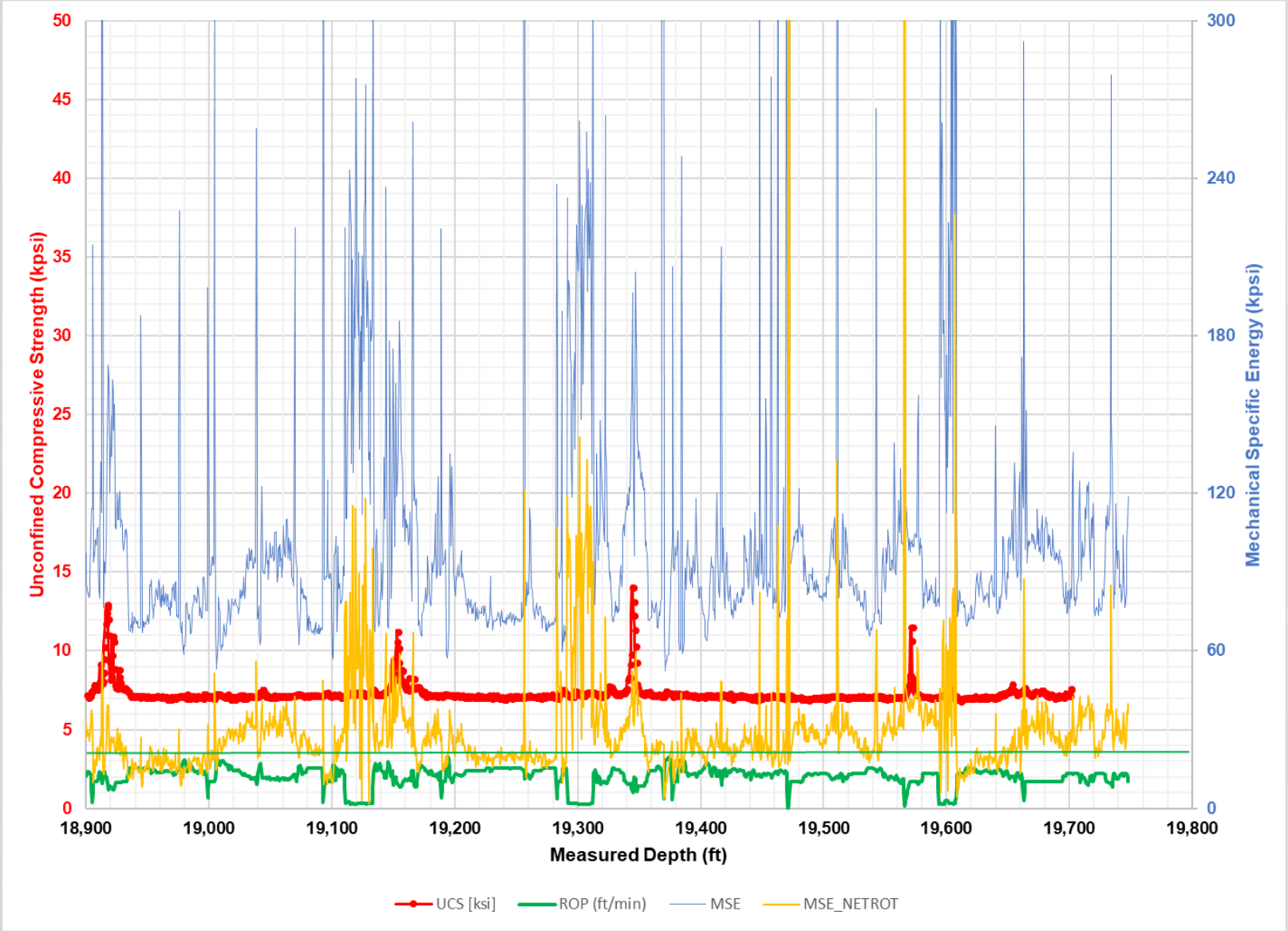
EXAMPLE B – EXPANDED DEPTH SCALE

- 17,000 ft to 19,748 ft
- Reduced ROP
  - 18,030 ft – 19,748 ft
- Decreasing UCS baseline should mean increasing ROP
- Increased formation strength
  - 18,030 ft – 18,460 ft
  - 18,750 ft – 18,950 ft



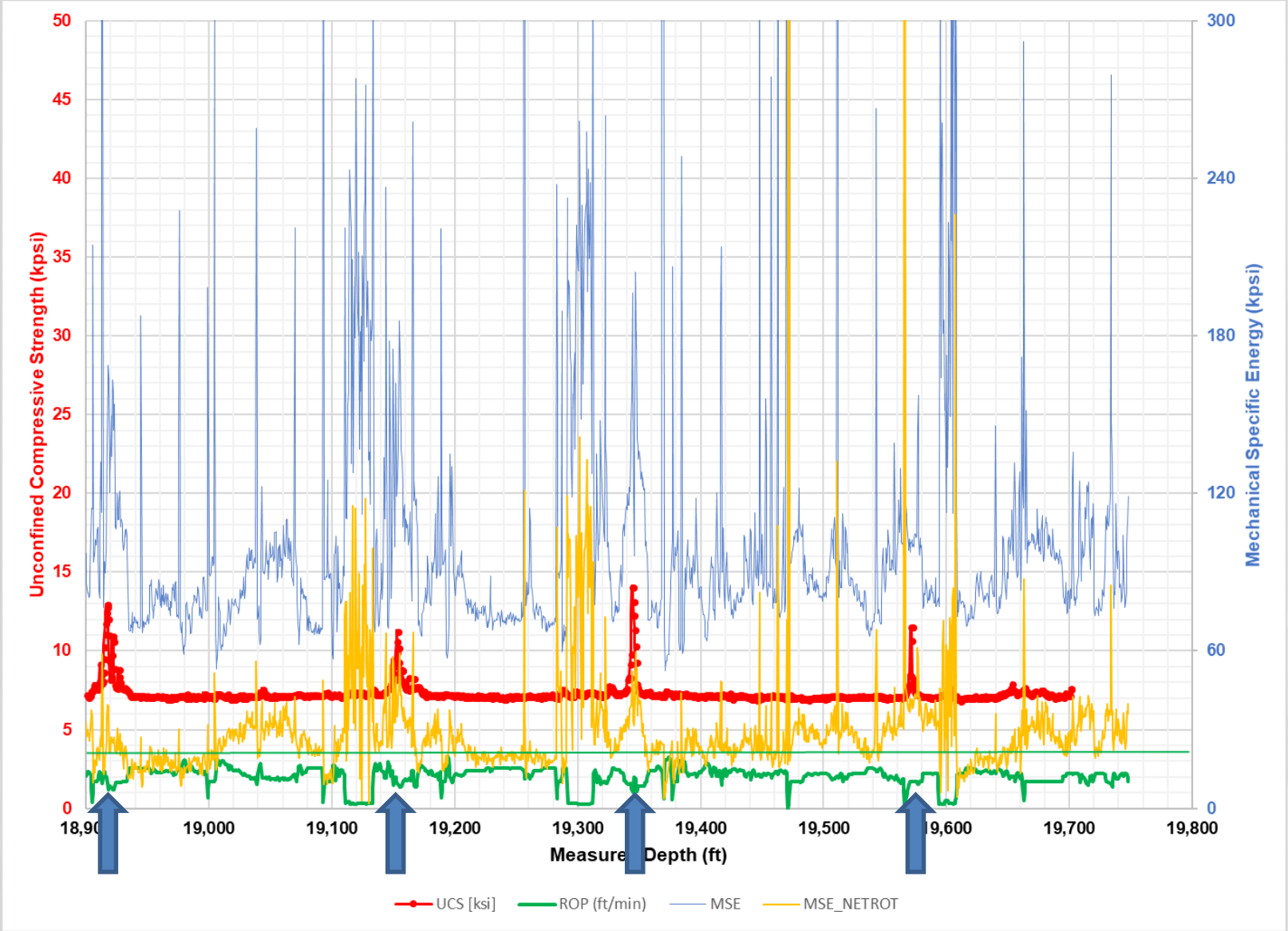
EXAMPLE B – EXPANDED DEPTH SCALE

- 18,900 ft to 19,748 ft
- MSE_NetRot curve is the MSE minus the energy used by the drill string
- Off bottom torque is measured on connections and removed from the MSE to generate the MSE_NetRot curve.
- Gives a better view of how energy is spent at the bit.



EXAMPLE B – EXPANDED DEPTH SCALE

- 18,900 ft to 19,748 ft
- Note that the MSE_NetRot curve “Mae West’s” with the ROP curve.
- Separation of MSE_NetRot and ROP indicates additional energy expenditure without impact of torque and drag.
- Separation at the points of increasing formation strength



EXAMPLE B – EXPANDED DEPTH SCALE

- 18,900 ft to 19,748 ft

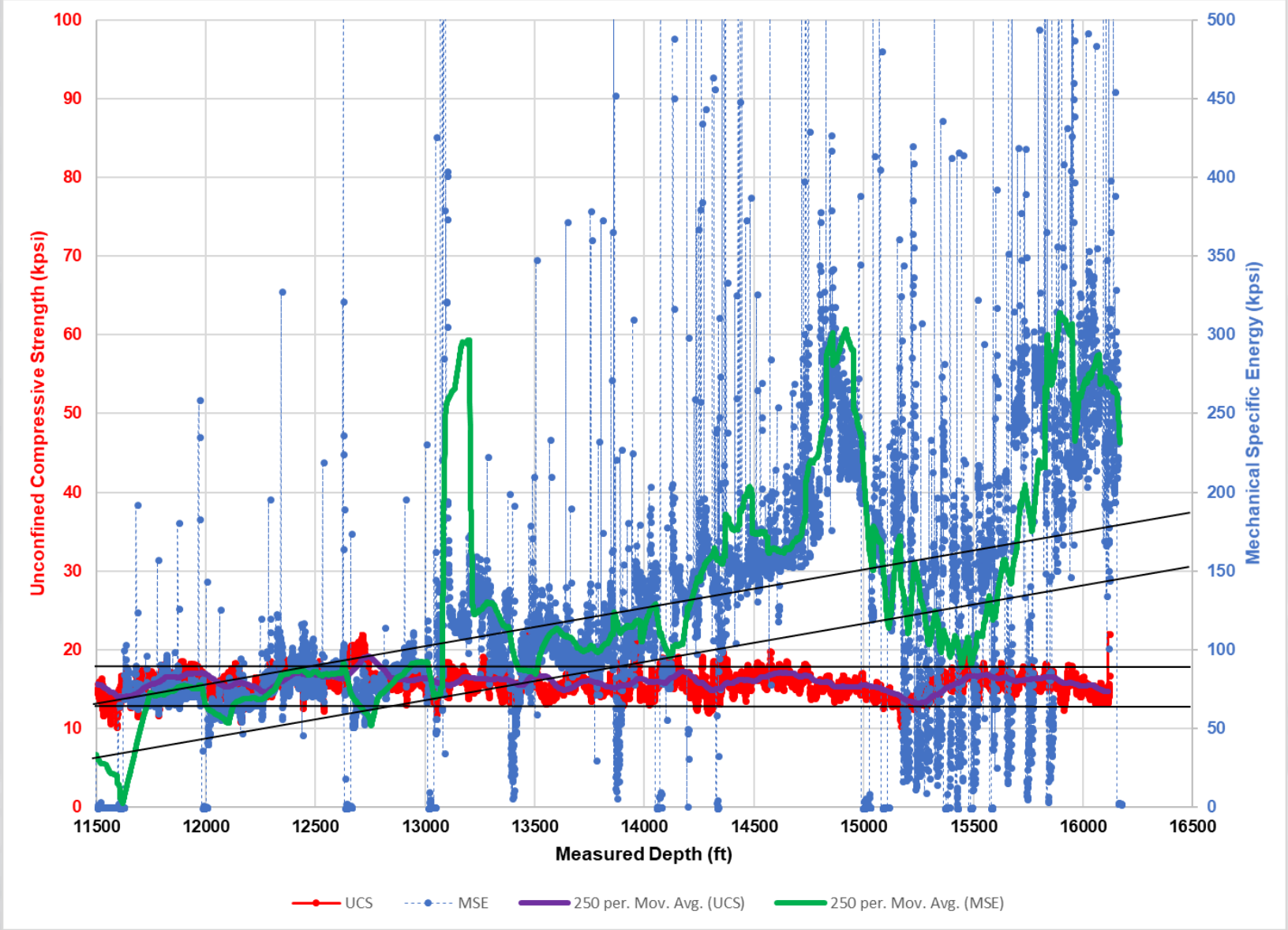
- Note that the MSE_NetRot curve “Mae West’s” with the ROP curve.
- Separation of MSE_NetRot and ROP indicate additional energy expenditure without impact of drill string torque.
- Separation at the points of dysfunction and inefficiency

- Correct response
  - > Decrease WOB
  - > Increase bit rotating speed

EXAMPLE C

- Horizontal well
- 4,639 ft lateral
- Water base mud
- PDC bits
- 8¾” hole size

- Applied running average of 250 pts
- General ranges
- UCS stays in constant range 13-18 kpsi
- MSE increasing in range

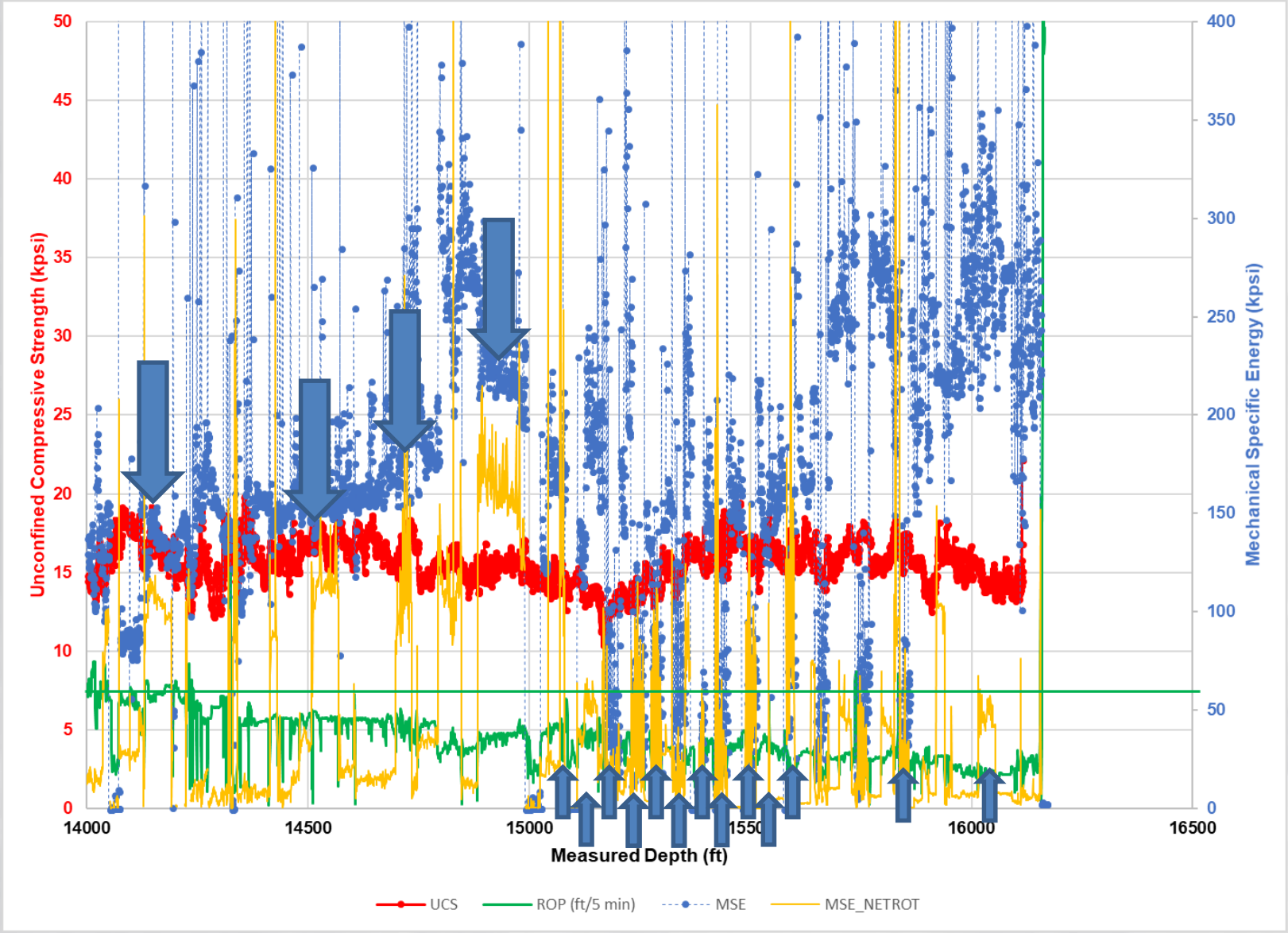


EXAMPLE C

- 14,000 ft to 16,155 ft

- Areas where excess energy expenditure was at the bit
  - > Bit dysfunction
    - » Whirl
    - » Slip-stick

- Note 48 ft pattern
  - > No notes in daily drilling report
  - > Probable Range 3 drill pipe
  - > Improper re-engagement of bit on connection



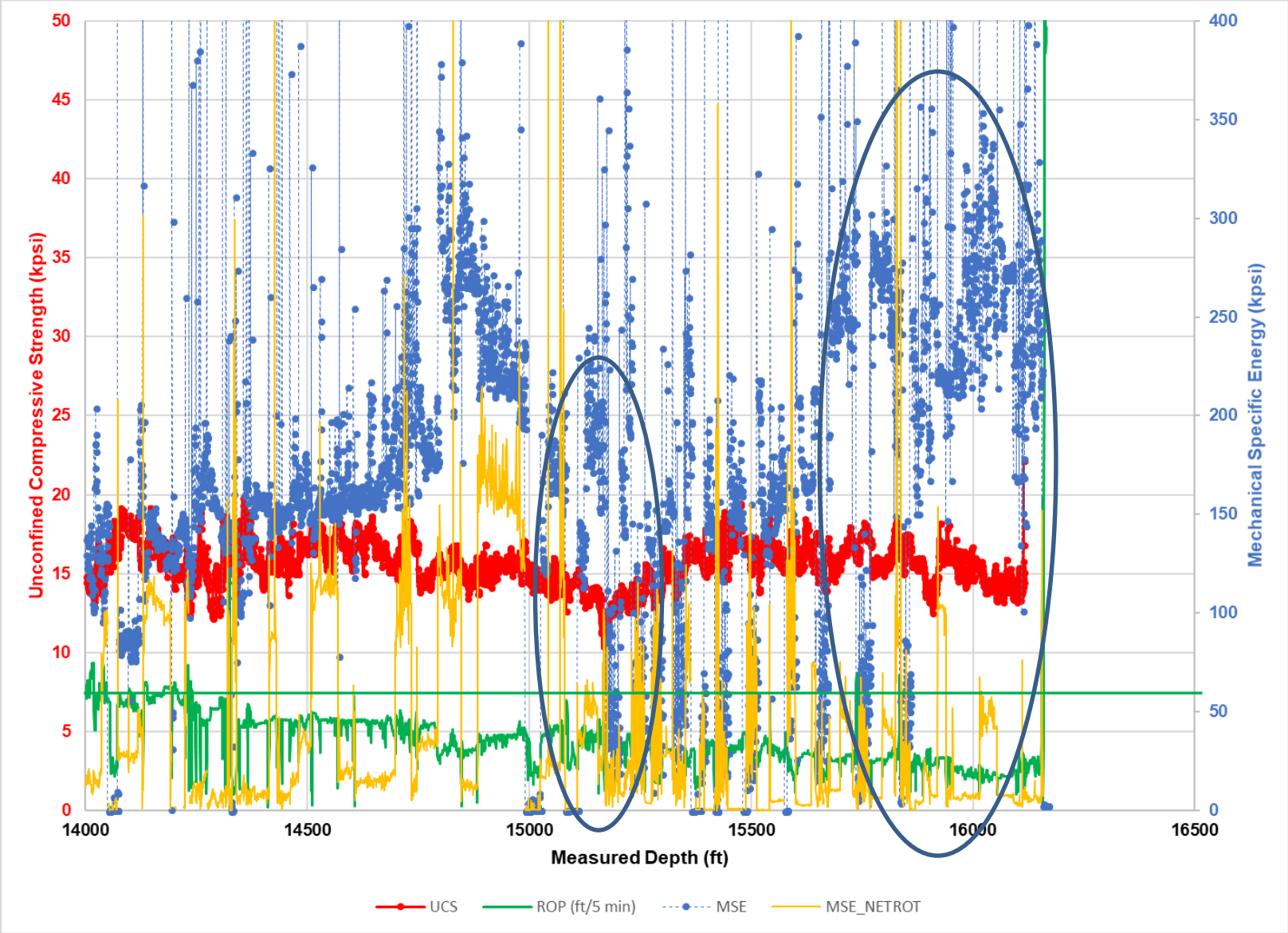
EXAMPLE C

- 14,000 ft to 16,155 ft

- Poor Hole Cleaning
  - >UCS same or lower,
  - >MSE high,
  - >MSE_NetRot low

  - MSE is high but was removed by off bottom measurements means it occurs whether or not drilling

  - Note dampened MSE_NetRot after hole cleaning issue appears

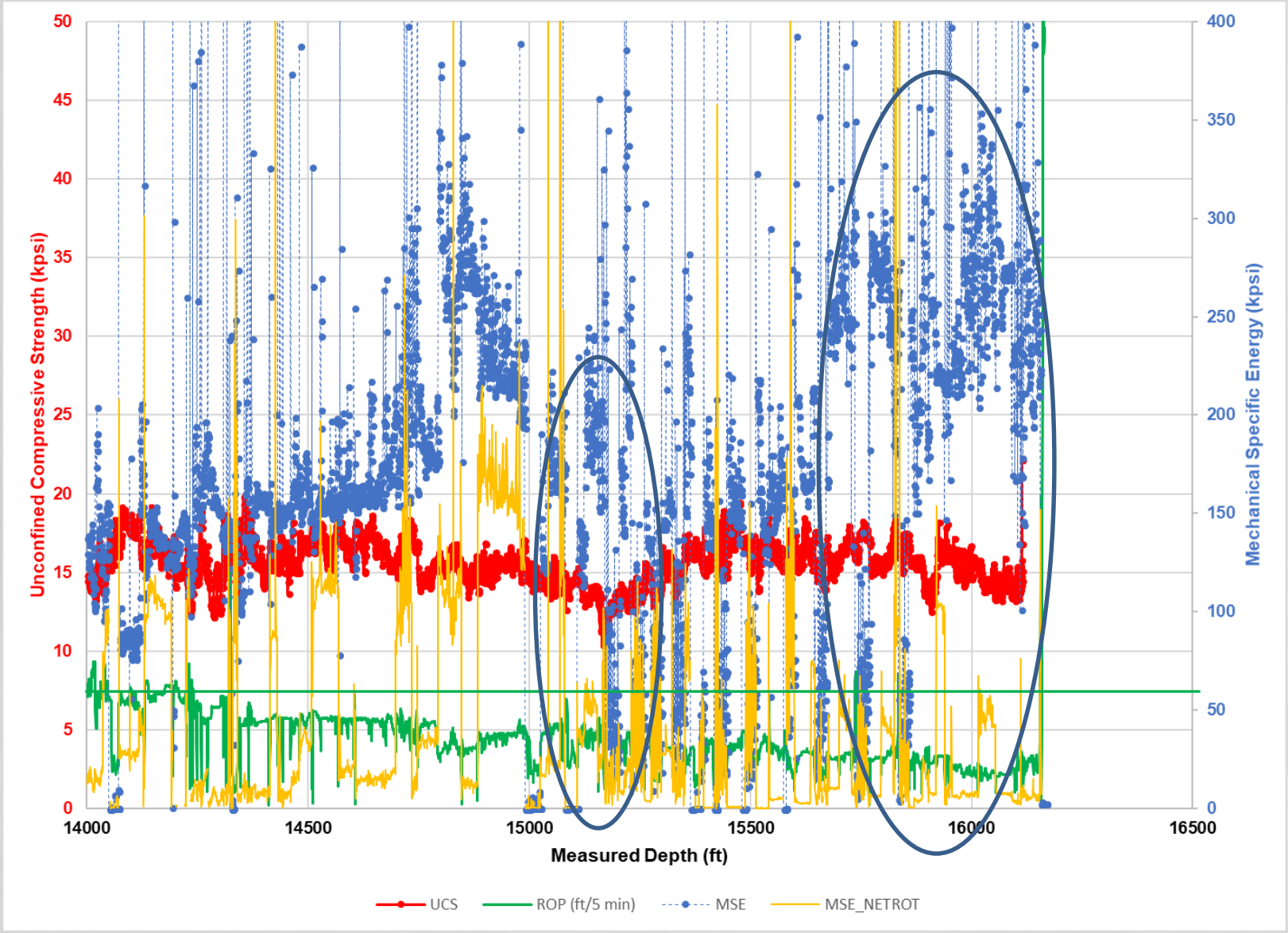


EXAMPLE C

- 14,000 ft to 16,155 ft

- Poor Hole Cleaning
  - > UCS same or lower,
  - > MSE high,
  - > MSE_NetRot low

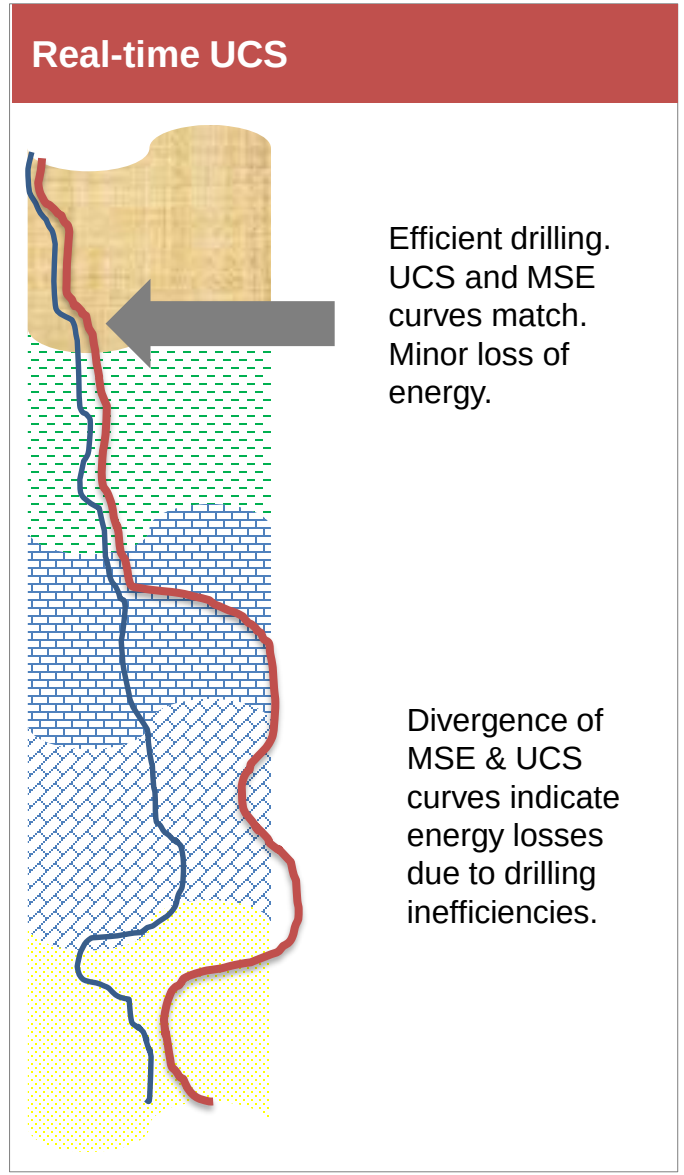
- Correct response
  - > Increase circulation rate
  - > Increase drilling string rotating speed
  - > Do cleanup cycles
  - > Lower mud rheology



SUMMARY

- UCS MAKES MSE A MORE POWERFUL TOOL
  - >Positive identification of drilling conditions
    - »Formation driven?
    - »Dysfunction? (Whirl; Slip-stick; Vibration)
    - »Inefficiency? (Hole Cleaning; Dull bit; Tortuosity)

- REAL TIME UCS SERVICE (RT-UCS)
  - @ bit compared with standard MSE for drilling optimization.
  - rock properties at the bit
  - stratigraphic horizon updates
  - measurement of Torque and Drag
  - density & sonic 10ft off the bit allows for faster steering corrections



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THANK YOU

QUESTIONS?