WINTERSHALL ARGENTINA
Unconventional Program – NQN

PROGRAMA SPE DE DISERTANTES DISTINGUIDOS

Our Experience in VM

Jorge Ponce,

CABA, Apr 20th, 2016

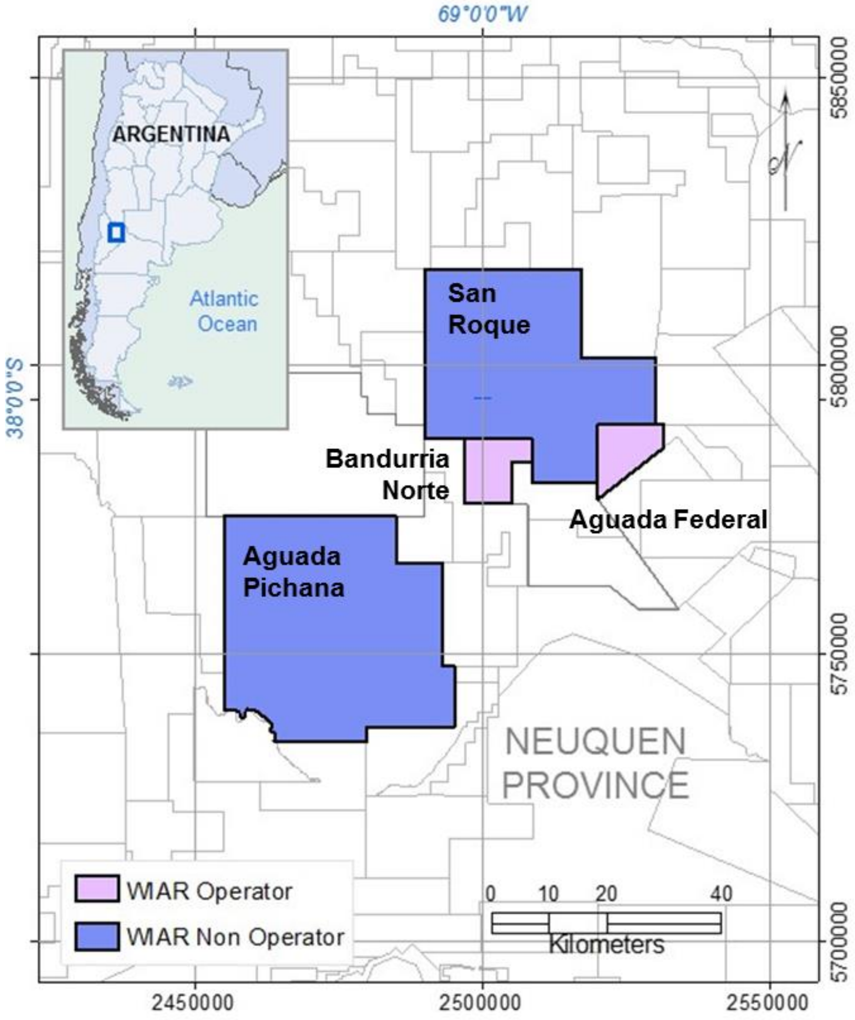
A subsidiary of BASF – The Chemical Company

WIAR – Unconventional Program – NQN – Argentina
Outline

- WIAR Unconventional Assets
- Aguada Federal Base Map
- Drilling
  - Pad layout
  - Geological info & casing design
  - Drilling time
  - Mud
  - Horizontal wells
- Completion & Stimulation
  - Well design
  - Stress logs
  - Fracture design and analyses
  - Well monitoring and production
  - Proppant selection
  - Horizontal well completion at a glance

WIAR – Unconventional Program – NQN – Argentina

WIAR´s Unconventional Assets



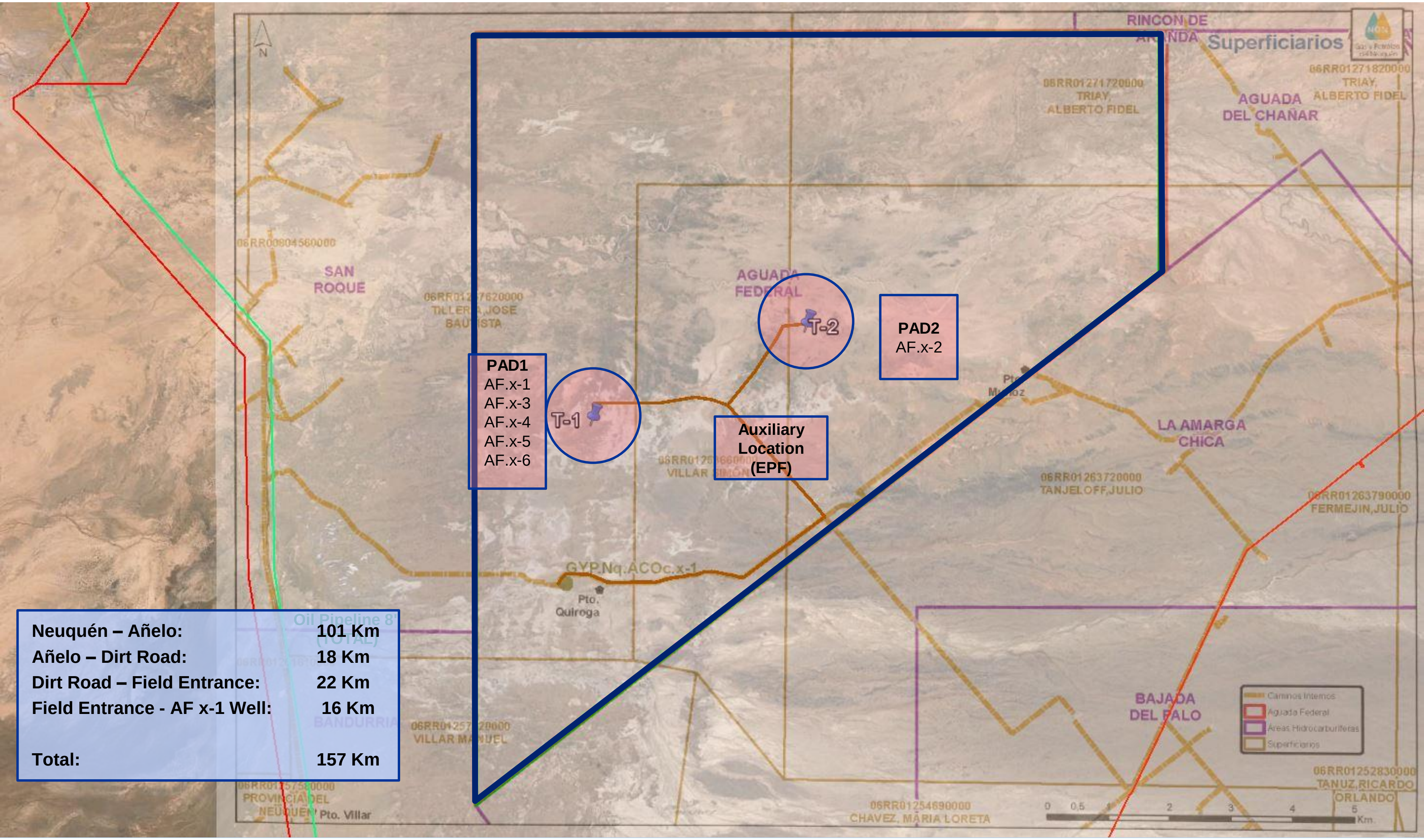
Unconventional Assets

~825 km^2 Net Acreage

Operated	Non-Operated
Aguada Federal Area: 97 km^2 Oil window WI: 90 % Well count: 3 vt; 1 hz WOC; 1 hz on drill’g	*Aguada Pichana* Area: 1366 km^2 Gas window WI: 27.27 %
Bandurria Area: 107 km^2 Oil window WI: 100 % Well Count: 1 vert; 1 hz WOC	*San Roque* Area: 1040 km^2 Oil window WI: 24.71 %

WIAR – Unconventional Program – NQN – Argentina

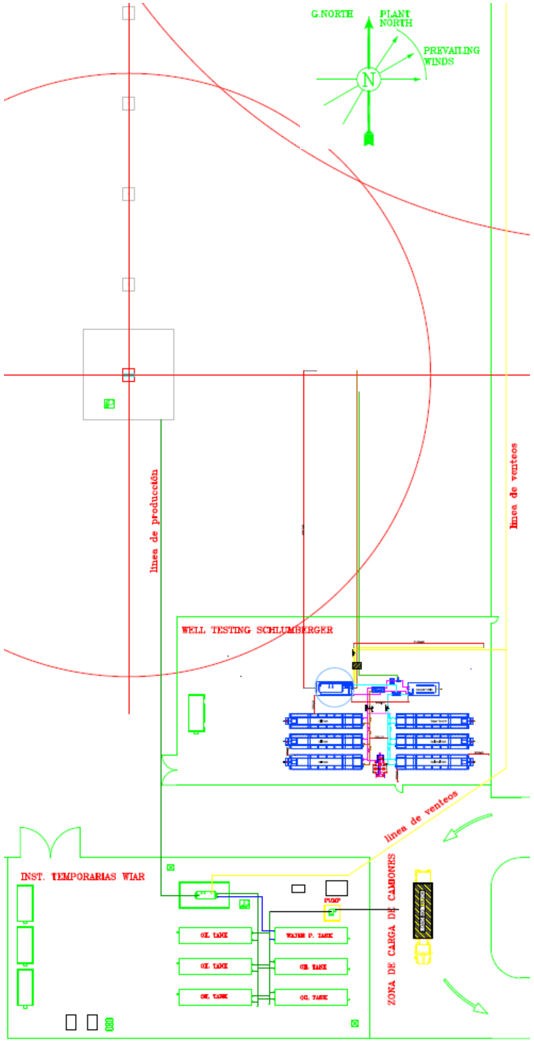
Aguada Federal Base Map



Neuquén – Añelo:	**101 Km**
Añelo – Dirt Road:	**18 Km**
Dirt Road – Field Entrance:	**22 Km**
Field Entrance - AF x-1 Well:	**16 Km**
Total:	**157 Km**

WIAR – Unconventional Program – NQN – Argentina

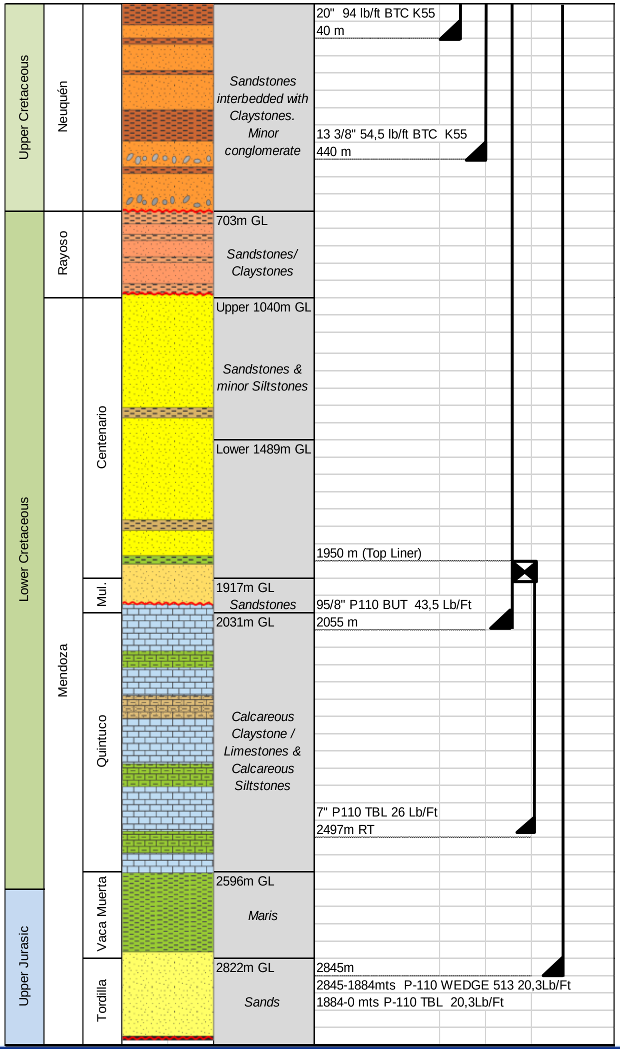
Pad Layout



- Pad size: 180 m long x 120 m wide oriented north
  - It can accommodate up to 4 horizontal wells + existing vertical well. Compaction zone only for rig support
  - Wellheads spaced out 15 m along a N – S line
    - X-mas tree valve stems are looking West
  - Original cellar design tailored for wellhead dimensions
  - Enough space on West side of location to rig up frac spread
    - No Australian tanks on location. Only buffer frac pits
- Rigs
  - Spacing between wellheads allows rigging up pulling or workover rigs
  - Drilling and pulling/workover rigs are rigged up looking East
    - Prevailing winds in zone from West to East
    - In case of hydrocarbon leaks sources of ignition are upstream
- Well testing and Production facilities
  - Flowback and initial well testing facilities are rigged up on location
  - Early production facilities located beside the main pad location at South

WIAR – Unconventional Program – NQN – Argentina

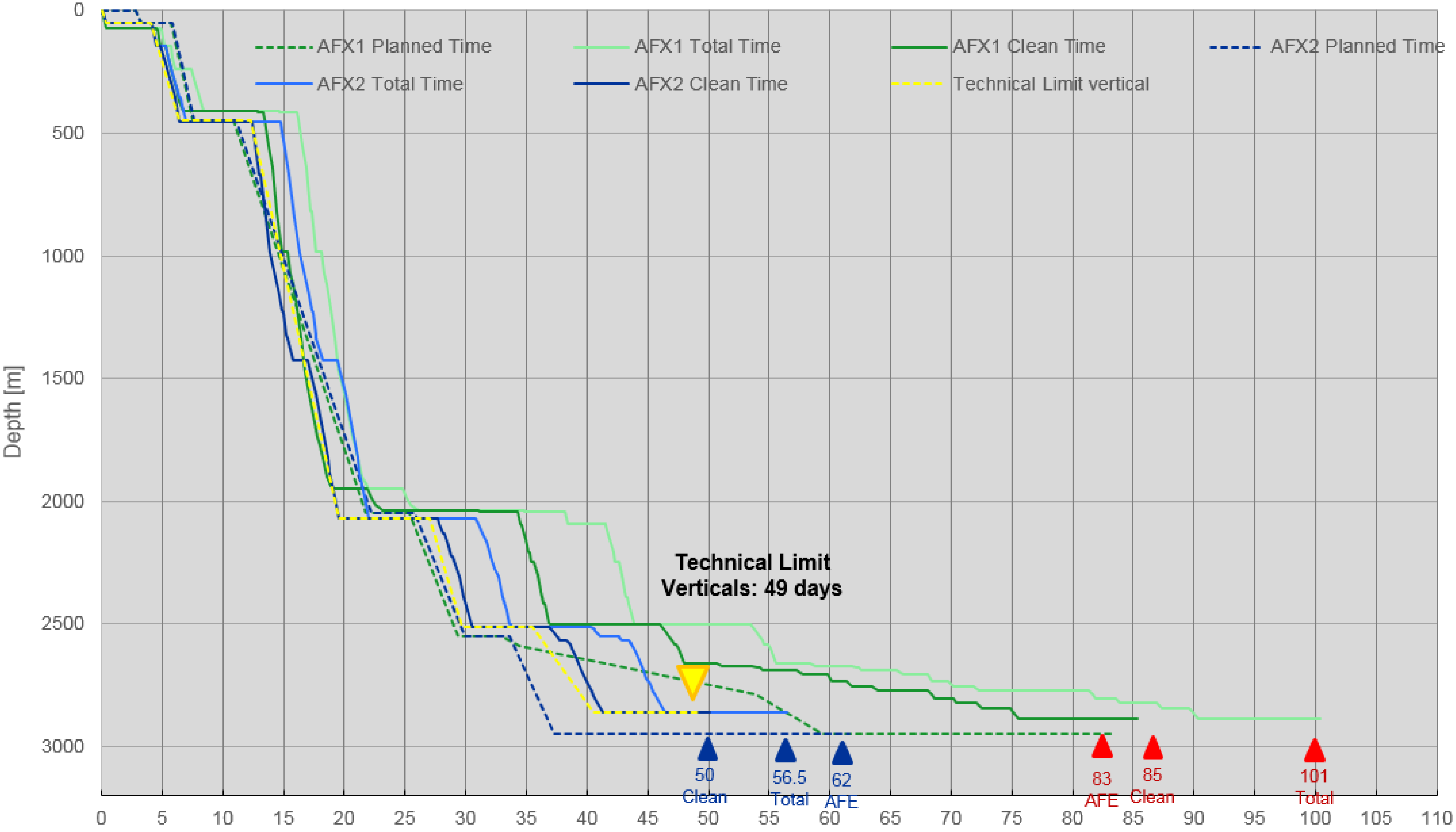
Lithological Column & Casing Design



- All sections drilled with WBM
- Conductor drilled using diverter
- Surface casing to isolate and protect fresh water zones
- Intermediate casing slightly landed into Quintuco Fm
  - MW: 1.18 SG; FIT to 2.3 SG EMW
- Upper 2/3 of Quintuco Fm isolated with liner
  - Lower pressure and losses
- Lower 1/3 of Quintuco Fm and Vaca Muerta Fm drilled with RBOP and high MW
  - Potential natural fissures with HP and oil inflow
  - ~120 m of cores taken in VM with high recovery
  - MW: 1.8 SG; FIT to 2.2 SG EMW
- Production casing slightly landed into Tordillo Fm
- Well delivered to C&S fully pressured tested and with cement bond logs run in hole
  - Pressure testing up to maximum pressure expected while hydraulic fracturing

WIAR – Unconventional Program – NQN – Argentina

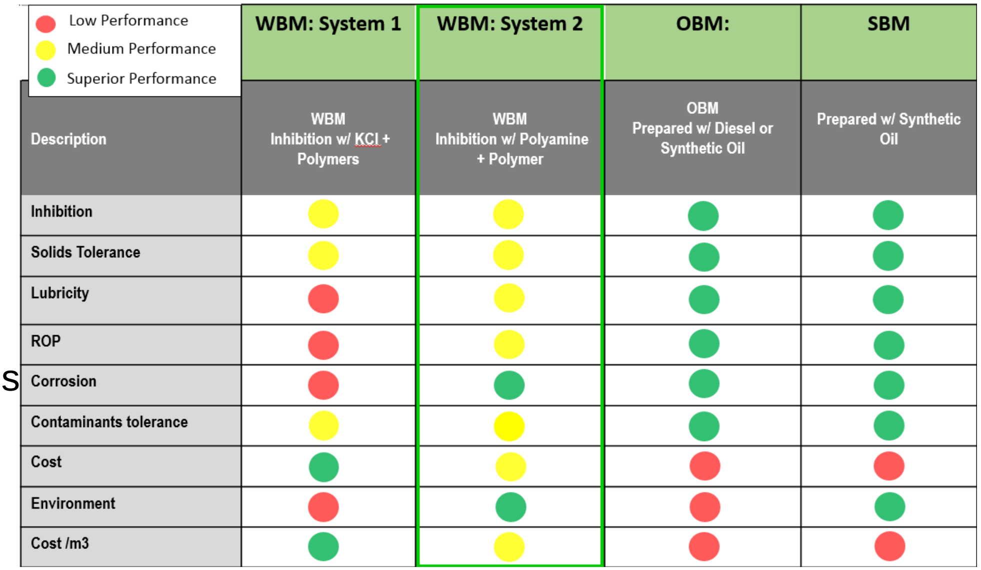
Drilling Time Comparison



WIAR – Unconventional Program – NQN – Argentina

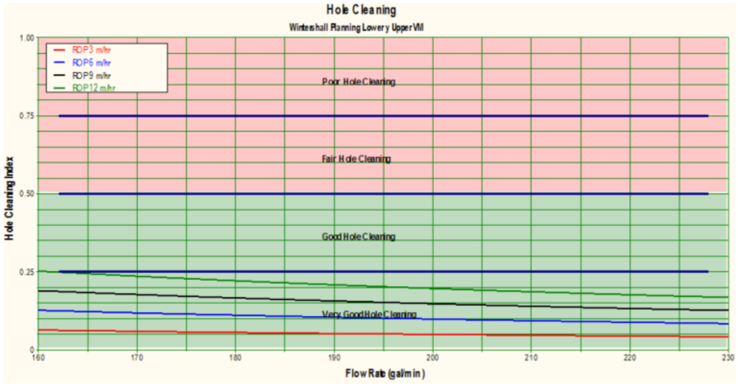
Mud Strategy

- In deep analyses and feasibility studies to define mud system
  - WBM
  - OBM / SBM
- Main required properties / features
  - High ROP
  - Environmentally friendly. Other HSE issues
  - Low corrosion
  - High inhibition
  - Hole in gauge. Cementing quality
  - Lubricity. Mostly required for horizontal wells
  - Balanced cost
  - Influx management / well control implications
  - Good rheology even at high MW. Good cleaning in horizontal section
  - Possibility to use wellbore strengthening materials / LCM
  - Minimum impact on open hole logging tools and data gathering



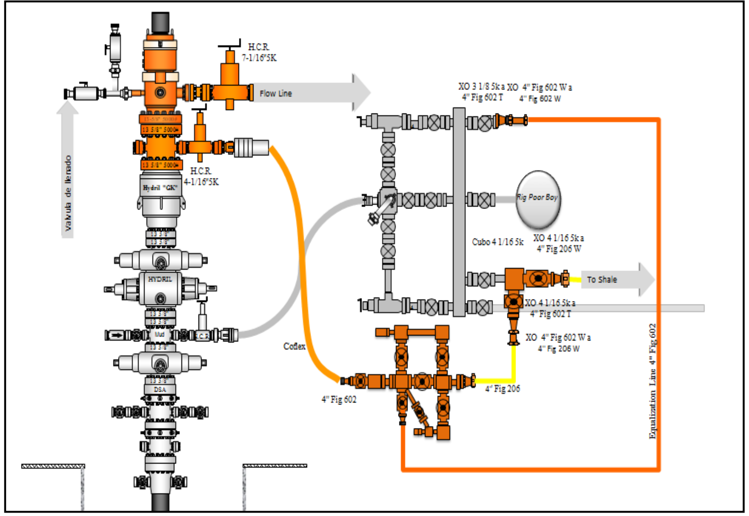
🔴 Low Performance
🟡 Medium Performance
🟢 Superior Performance

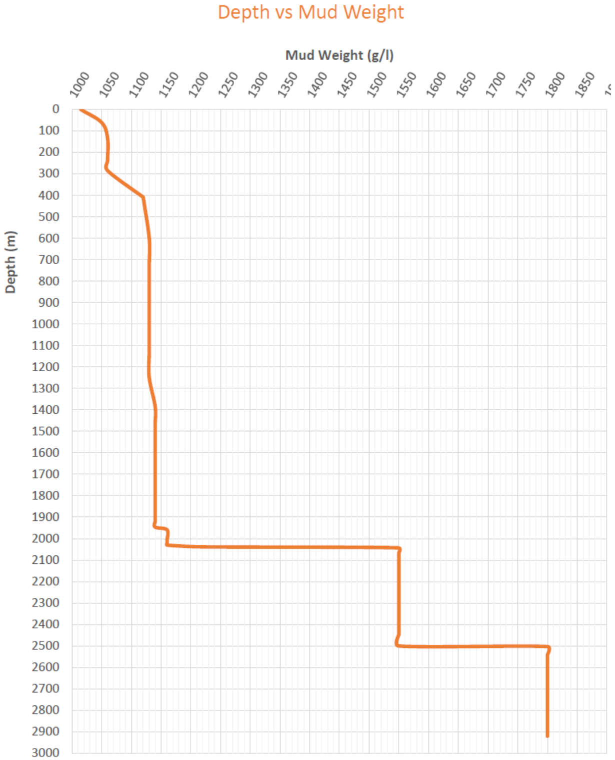
	WBM: System 1	WBM: System 2	OBM:	SBM
Description	WBM Inhibition w/ KCl + Polymers	WBM Inhibition w/ Polyamine + Polymer	OBM Prepared w/ Diesel or Synthetic Oil	Prepared w/ Synthetic Oil
Inhibition	🟡	🟡	🟢	🟢
Solids Tolerance	🟡	🟡	🟢	🟢
Lubricity	🔴	🟡	🟢	🟢
ROP	🔴	🟡	🟢	🟢
Corrosion	🔴	🟢	🟢	🟢
Contaminants tolerance	🟡	🟡	🟢	🟢
Cost	🟢	🟡	🔴	🔴
Environment	🔴	🟢	🔴	🟢
Cost /m3	🟢	🟡	🔴	🔴



WIAR – Unconventional Program – NQN – Argentina

RBOP and MPD Equipment



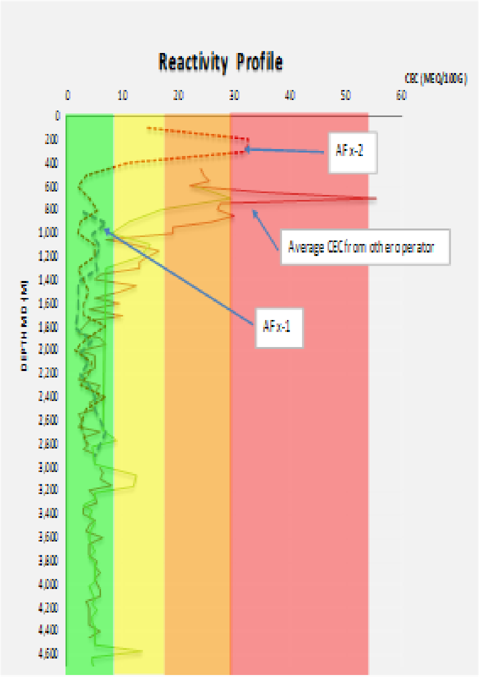


- Main system features
  - Allows drilling ahead and make trips following safe procedures
  - Need to understand clearly difference between pore pressure and mud weight required to drill the well to make operations efficient and safe

WIAR – Unconventional Program – NQN – Argentina

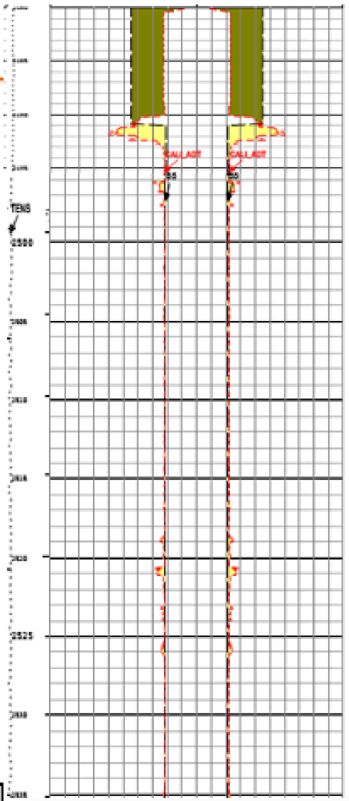
Mud Strategy – Results

Reactivity of VM Fm



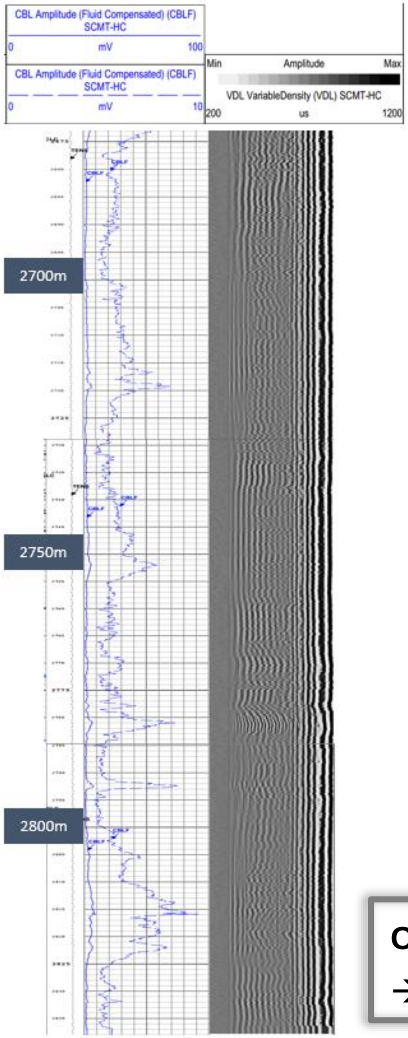
COLOR	CIC (meq/100g)	DESCRIPTION
🟩	0 - 8	Non Reactive
🟨	9 - 18	Medium Reactivity
🟧	19 - 30	Reactive
🟥	> 30	High Reactivity

Caliper AFX2 well



Caliper 6,13”

in Vaca Muerta

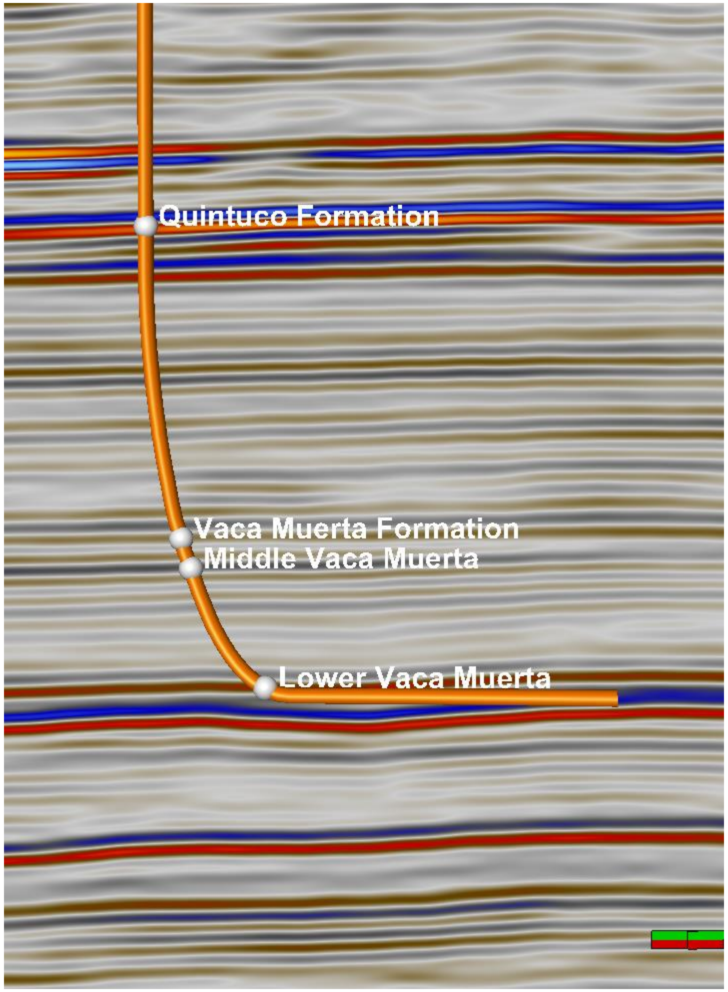


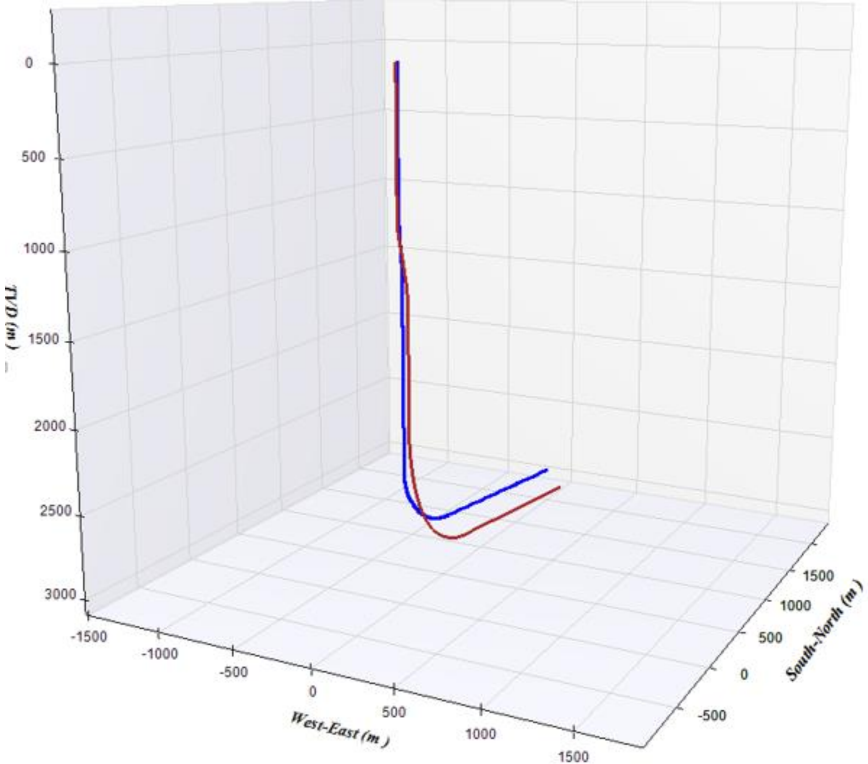
Corrosion < 0.1 lb/ft2 year

→ Very low

WIAR – Unconventional Program – NQN – Argentina

Horizontal Wells

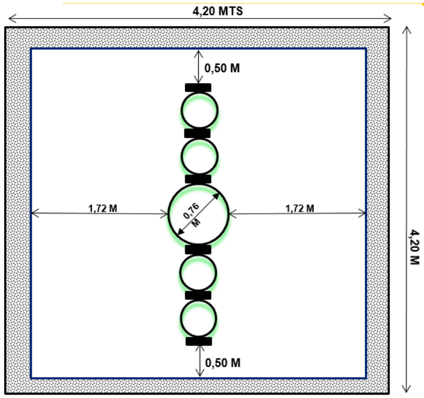




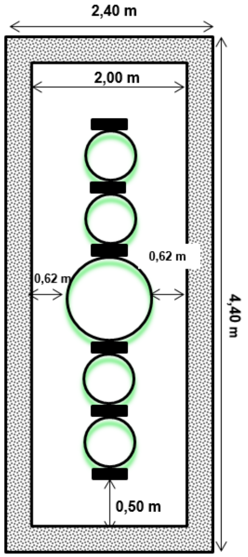
- Main features
  - Drilled from same pad
  - 1000 m lateral drain
  - Max 6º DLS
  - Toe up (~92º)

WIAR – Unconventional Program – NQN – Argentina

Cellar Issues & Solutions

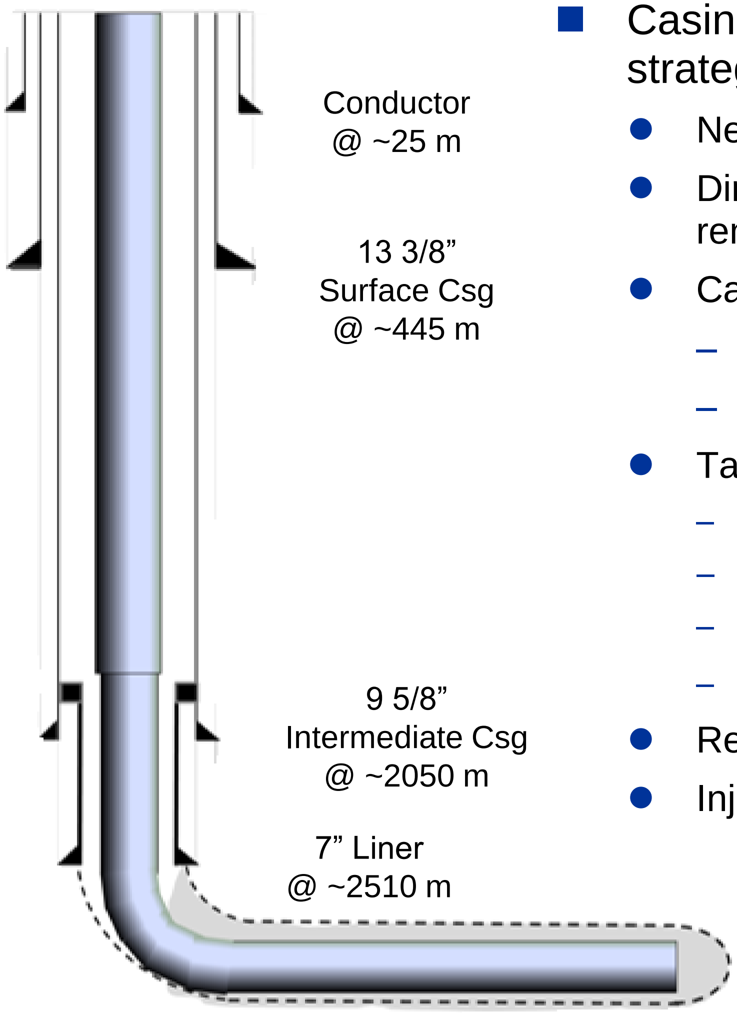


- Original design
  - Tailored to drilling rig dimensions and wellhead size
  - 7 1/16” flange must be at ground level
  - 0.5 m between cellar wall and wing valves
  - 13 5/8” BOP RAM rig up inside cellar
- Cons
  - Need a dedicated platform to rig up WO / pulling rig
  - Need extra space to connect iron to wing valves
- New design
  - Smaller footprint
  - Conductor casing drilled and cased upfront



WIAR – Unconventional Program – NQN – Argentina

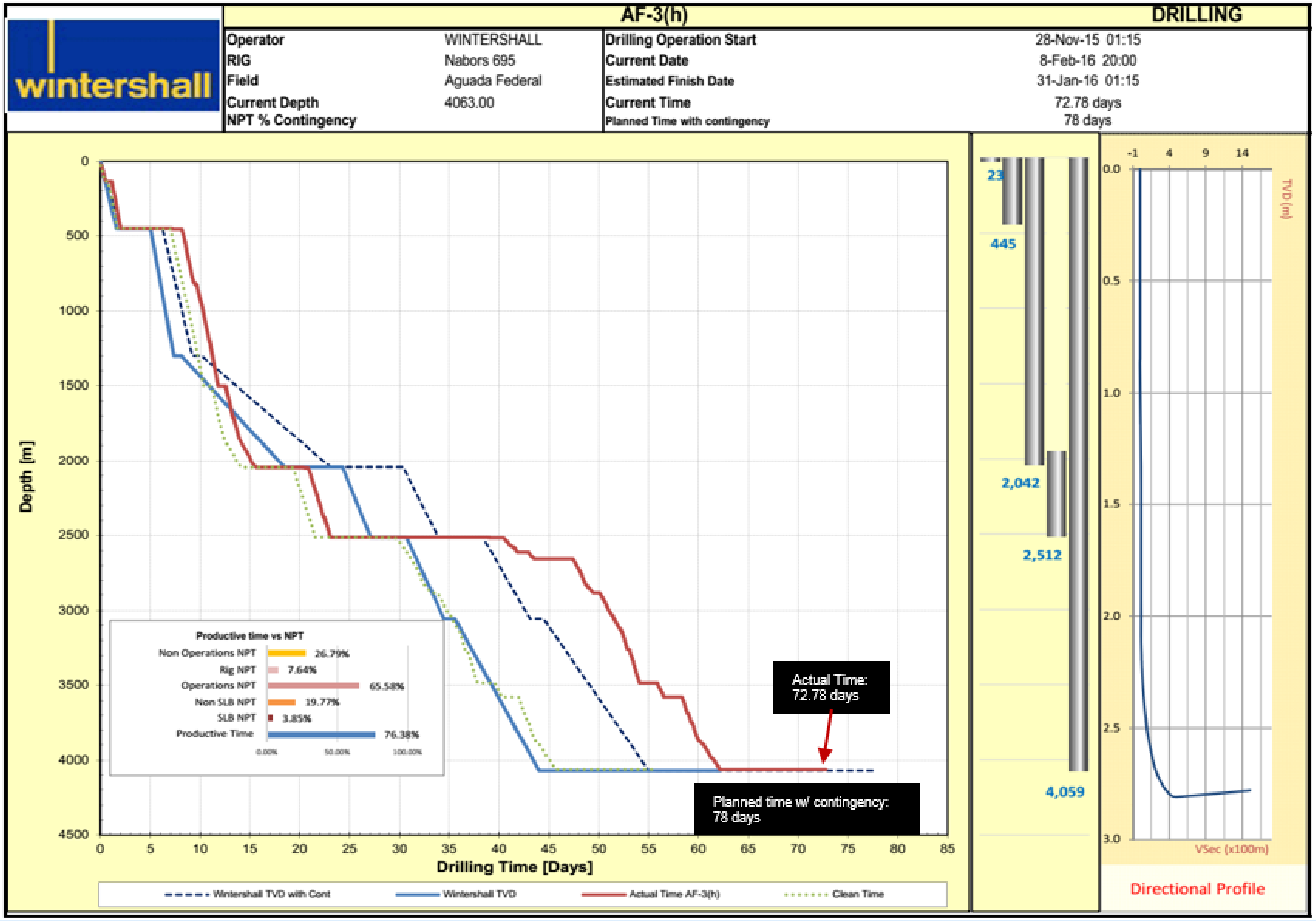
Casing Depths for Horizontal Wells



- Casing design for horizontal wells follows in general same strategy used for vertical wells
  - Need of protective liner to isolate weak zones
  - Directional work starts in intermediate section to minimize DLS in remaining sections
  - Casing connections designed to support expected torques
    - W513 & TBL Dopeless
    - Possible to rotate while running in hole or while cementing
  - Tapered production string
    - Designed to withstand pressures exerted while fracturing (P-110)
    - Wider annulus gap in horizontal section to maximize cement quality
    - ECD management
    - Production PKR in 5” casing
  - Real time P&T downhole and surface monitoring system
  - Injection mandrel for chemical additives injection

WIAR – Unconventional Program – NQN – Argentina

Drilling Time For First Horizontal Well



AF-3(h) **DRILLING**

Operator	WINTERSHALL	**Drilling Operation Start**	28-Nov-15 01:15
RIG	Nabors 695	**Current Date**	8-Feb-16 20:00
Field	Aguada Federal	**Estimated Finish Date**	31-Jan-16 01:15
Current Depth	4063.00	**Current Time**	72.78 days
NPT % Contingency		**Planned Time with contingency**	78 days

Actual Time:
72.78 days

Planned time w/ contingency:
78 days

WIAR – Unconventional Program – NQN – Argentina

Water Transfer System

- **Water transfer system**
  - Allows pumping in real time to frac location
  - Type: flat hose – 10 in
  - Distance ~ 3.0 Km
  - Rates ~ 65 BPM
  - Transfer & backup pump
  - No spills

WIAR – Unconventional Program – NQN – Argentina

AF.x-1 Wellbore Schematics & Fracs Summary

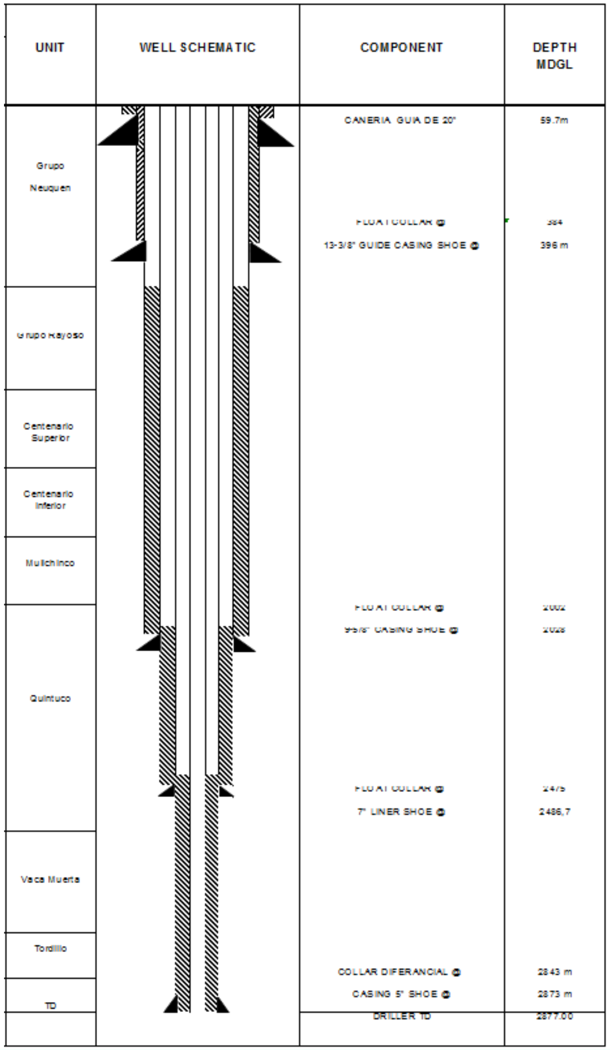
Totals
19,650 bbls frac fluid
1,787,300 lb proppant

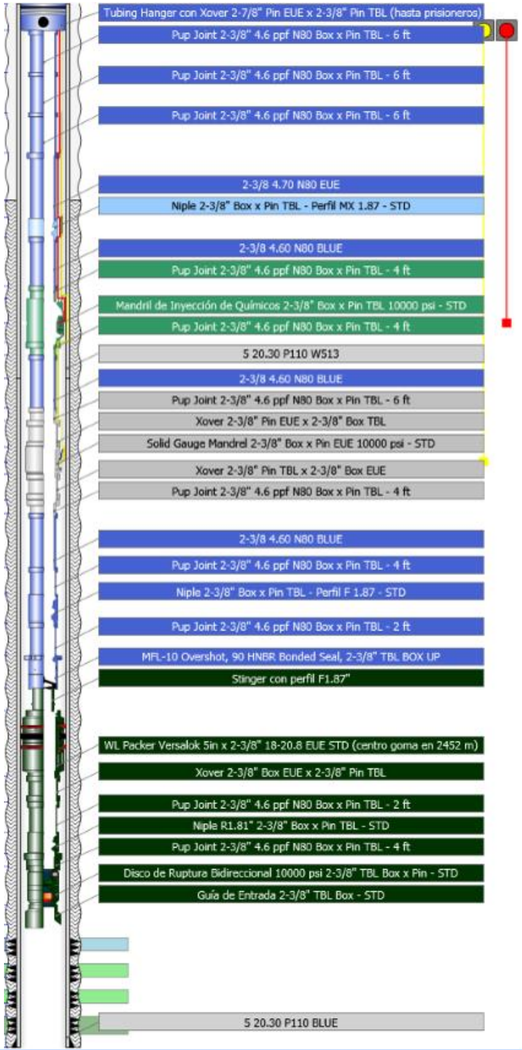
7 clusters
7,410 bbls frac fluid
611,700 lb proppant
5 ppg max conc

3 clusters
5,000 bbls frac fluid
479,200lb proppant
5 ppg max conc

4 clusters
4,400 bbls frac fluid
481,700 lbm proppant
6 ppg max conc

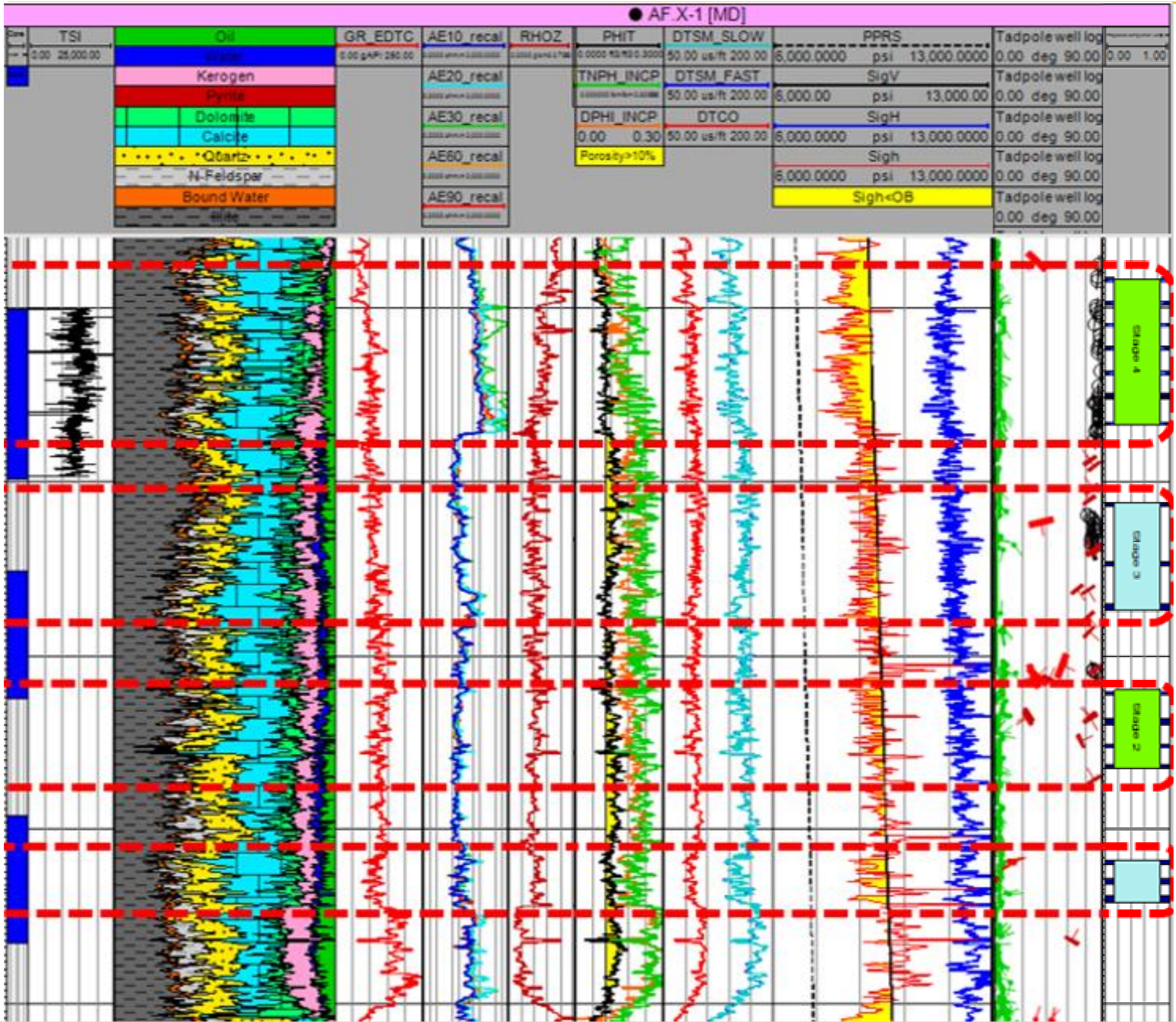
3 clusters
2,840 bbls frac fluid
214,700 lbm proppant
5 ppg max conc





WIAR – Unconventional Program – NQN – Argentina

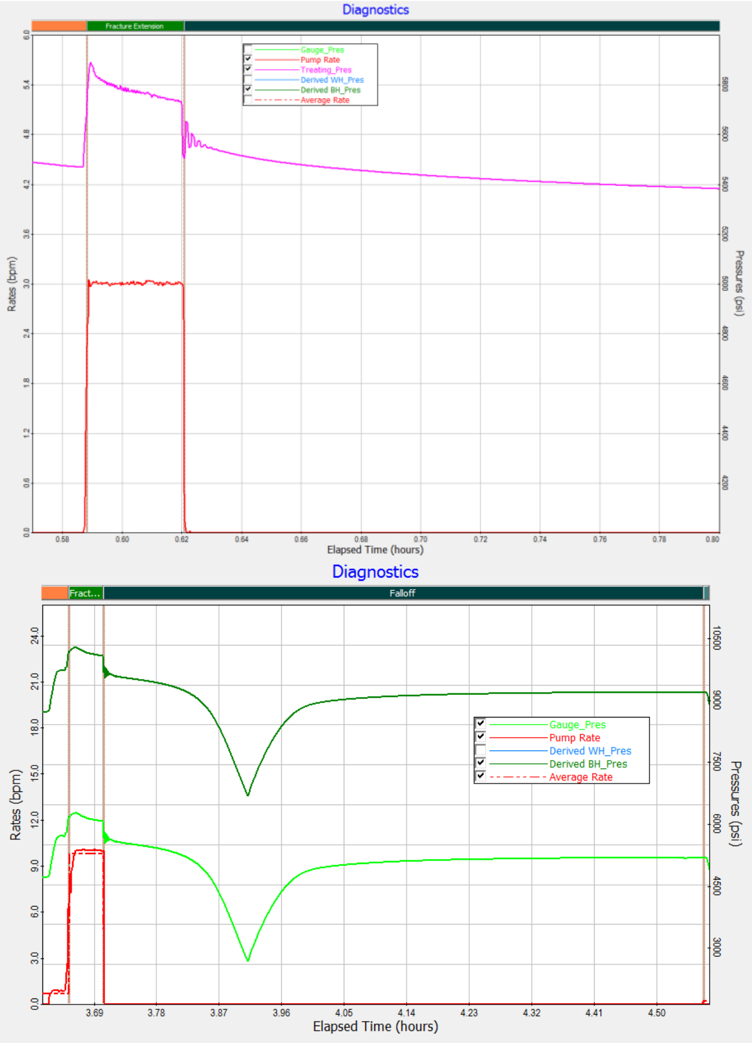
AF.x-1 Well Log



- Fractures
  - Middle VM
  - Upper VM
- Mineralogy
  - Carbonate increases as we move up in the well and quartz contents goes into the opposite direction
- Rock mechanics
  - Sh close to Sv except in the upper section
    - Horizontal components while fracturing
  - Higher Young’s modulus in the upper section
  - More fissures in the upper member

WIAR – Unconventional Program – NQN – Argentina

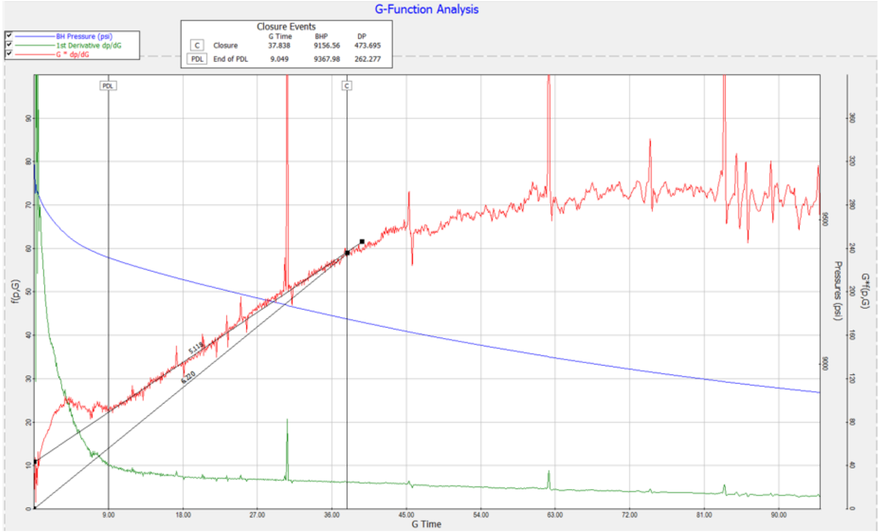
Pre Frac Tests



- Dedicated frac test in each stage
  - Stress log calibration
  - Pore pressure estimation
- MFO (Mini Fall Off)
  - Reservoir properties as main objective
  - Closure stress as second target
- FRT (Flowback Rebound Test)
  - Closure stress
  - Validation of closure stress obtained in MFO

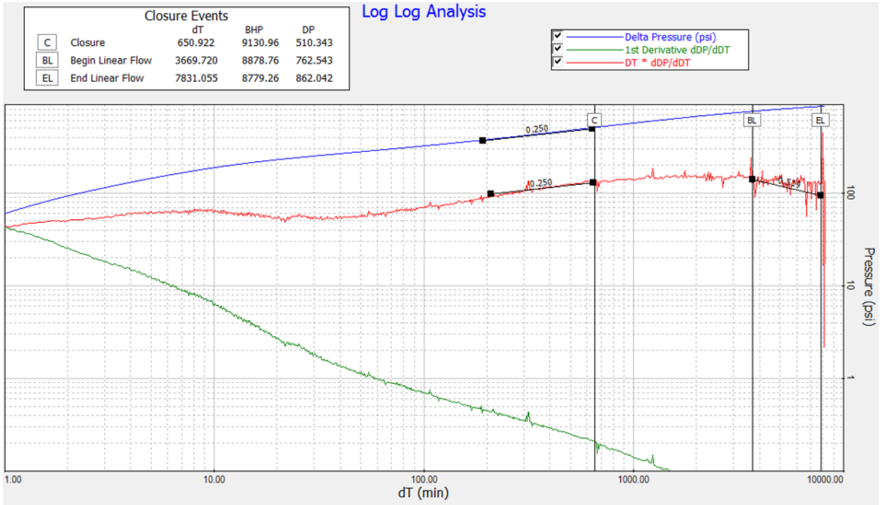
WIAR – Unconventional Program – NQN – Argentina

G-Function & Log-Log Analyses



G-Function Analysis

		G Time	BHP	DP
C	Closure	37.838	9156.56	473.695
PDL	End of PDL	9.049	9367.98	262.277



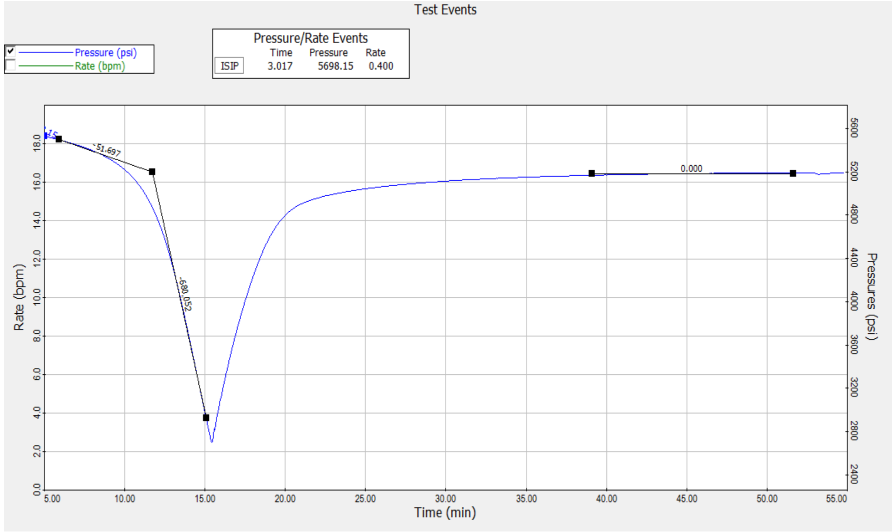
Log Log Analysis

		dT	BHP	DP
C	Closure	650.922	9130.96	510.343
BL	Begin Linear Flow	3669.720	8878.76	762.543
EL	End Linear Flow	7831.055	8779.26	862.042

- Traditional approach
  - Pressure hump is interpreted as pressure dependent leakoff
  - Pick of closure pressure as usual
- Anomalies
  - G dp/dg (red curve) does not follow ideal behavior, keeps increasing and stabilizes late in G-time
  - Superposition G data (red curve) when extrapolated to origin does not intersects it
  - Derivative (green curve) does not indicate an inflection point as it keeps decreasing with time
  - Detailed analysis shows a signature corresponding to fracture tip-extension after shut-in.
    - ¼ slope of the pressure derivative on log-log plot
    - Pressure difference follows a parallel ¼ slope offset by 4X from derivative. Fracture still closing
    - Possible to observe start of after closure linear flow behavior (-1/2 slope)

WIAR – Unconventional Program – NQN – Argentina

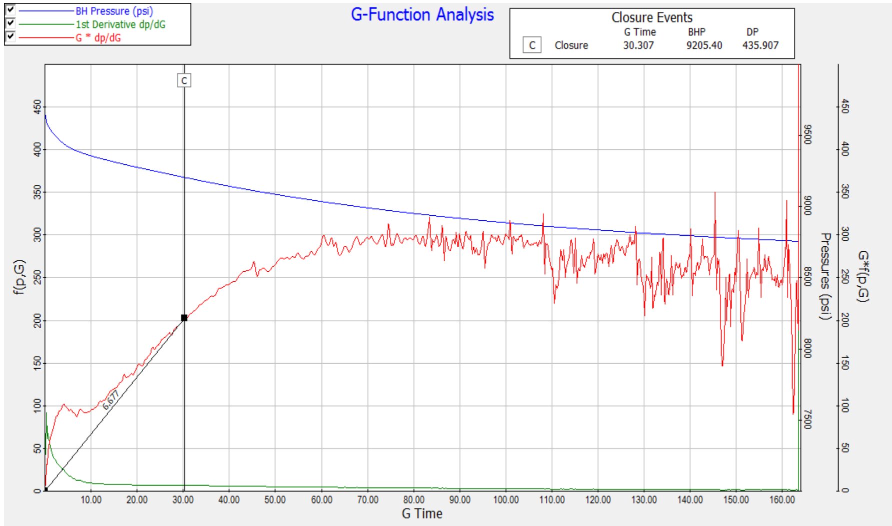
FRT Analysis



- Two interpretations
  - Dynamic conditions: while flowing back
    - Traditional two lines intersection
    - Friction effect. Possible to estimate friction in tubulars including other components when working with water and enhance interpretation
  - Static conditions: during shut in
    - Horizontal extrapolation
    - Useful to use dP/dt as a parameter to decide when to stop pressure recording
- Operational aspects
  - Quick test. Information is available in less than two hours as a maximum
    - Dedicated P&T surface gauges
  - Dedicated manifold with adjustable choke to handle required flowback rate
    - No need to stablish a s-shaped curve
- Integration
  - Solid tool to identify closure stress
  - Validation of MFO interpretation

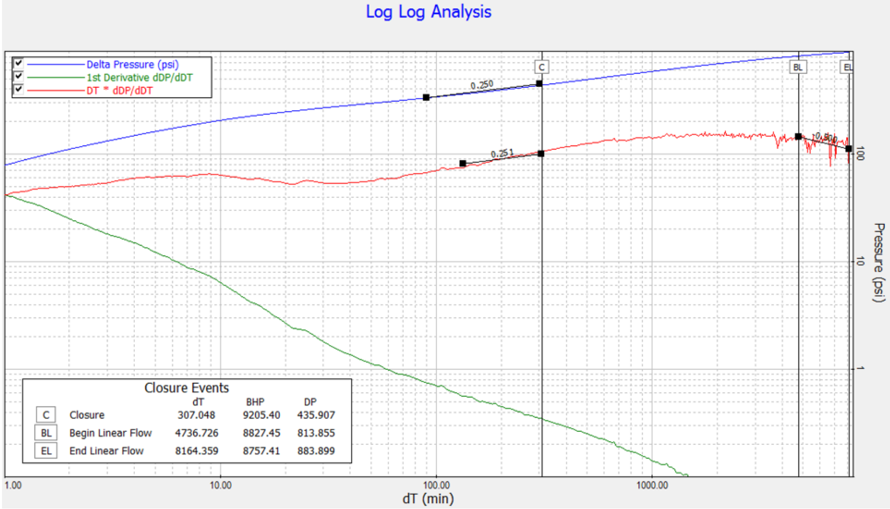
WIAR – Unconventional Program – NQN – Argentina

G- Function & Log-Log Analyses Revisited



Closure Events

		G Time	BHP	DP
C	Closure	30.307	9205.40	435.907



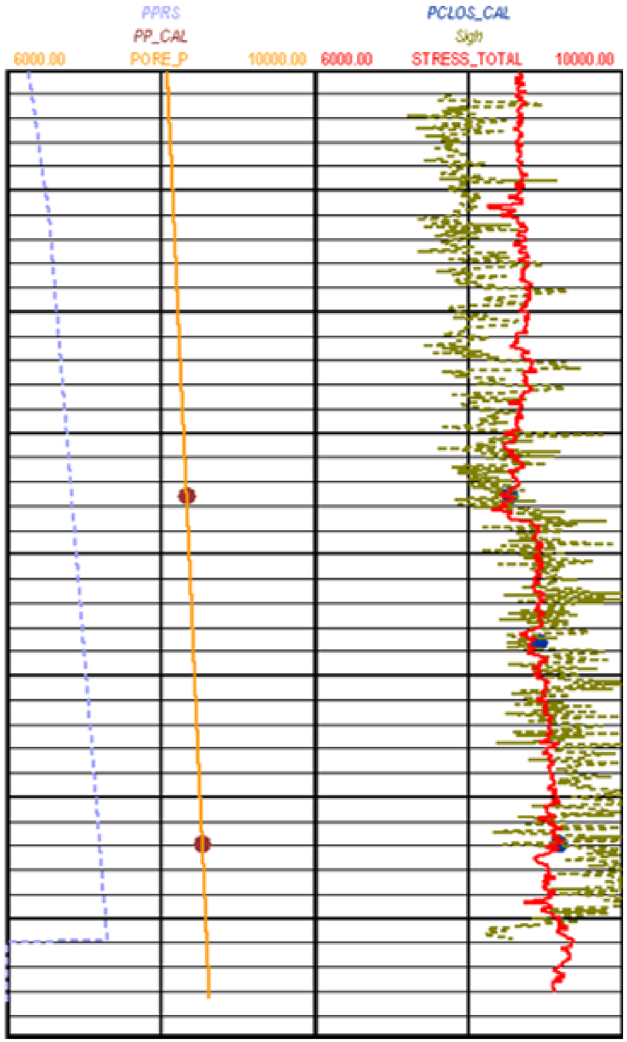
Closure Events

		dT	BHP	DP
C	Closure	307.048	9205.40	435.907
BL	Begin Linear Flow	4736.726	8827.45	813.855
EL	End Linear Flow	8164.359	8757.41	883.899

- Inverse approach
  - Identify closure in G-Function as per FRT results
    - Straight line from closure point to origin
  - Repeat analysis for Log-Log plot
    - Identify linear flow
    - Calculate reservoir properties
- Integration
  - More solid reservoir properties estimation
  - Robust stress log calibration
    - Better tectonic effect estimation

WIAR – Unconventional Program – NQN – Argentina

Pore Pressure & Total Stress Calibration

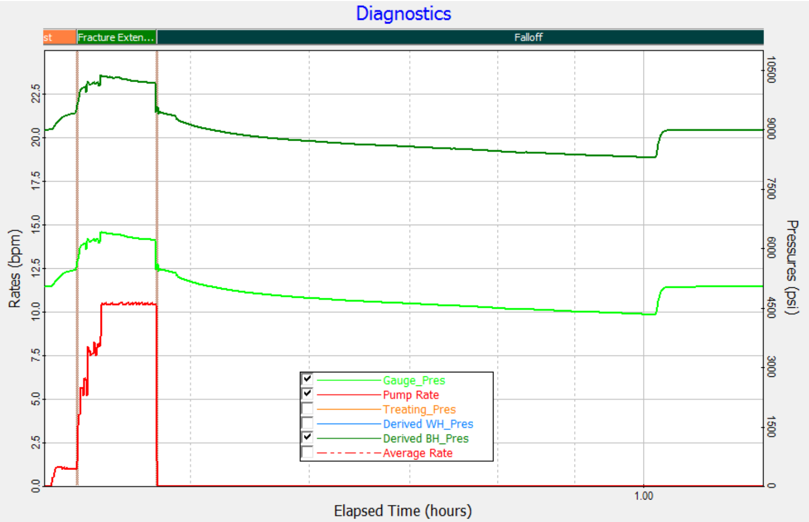


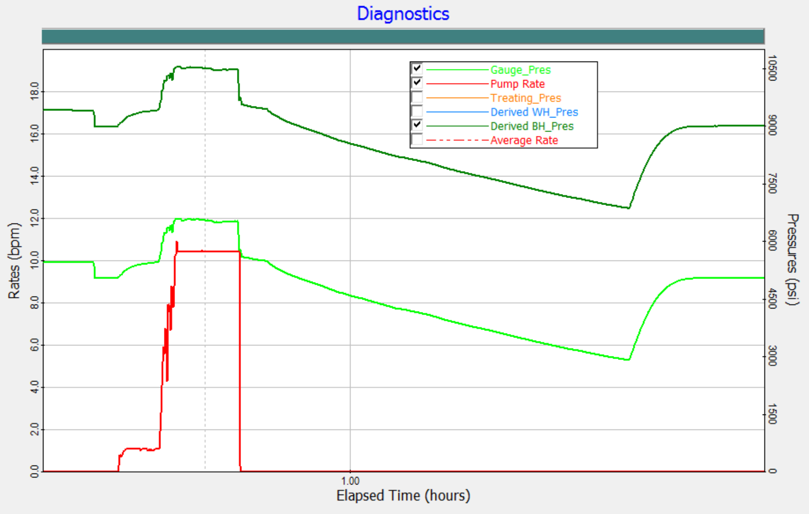
- Pore pressure
  - Two dedicated MFOs with strong interpretation
  - Pore pressure calibrated as pore pressure of fresh water plus offset. Excellent match. No further refinements required
- Stress
  - Four FRTs but three with robust information
  - Total stress log just needed to be adjusted by tectonic effect to match all points
  - Strain offset calibration corresponds to extensional regime
- Interpretation and Integration
  - Stress is a function of rock properties, pore pressure and tectonic effect. If one is wrong, the others are affected as well and weir behavior can be observed as large strain which is not possible in mother nature

$$\sigma_{min} = A * (\sigma_v - \alpha_v * Pp) + \alpha_h * Pp + \sigma_{tect}$$

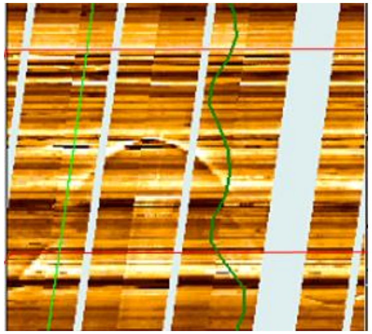
WIAR – Unconventional Program – NQN – Argentina

FRT with Anomalous Behaviour



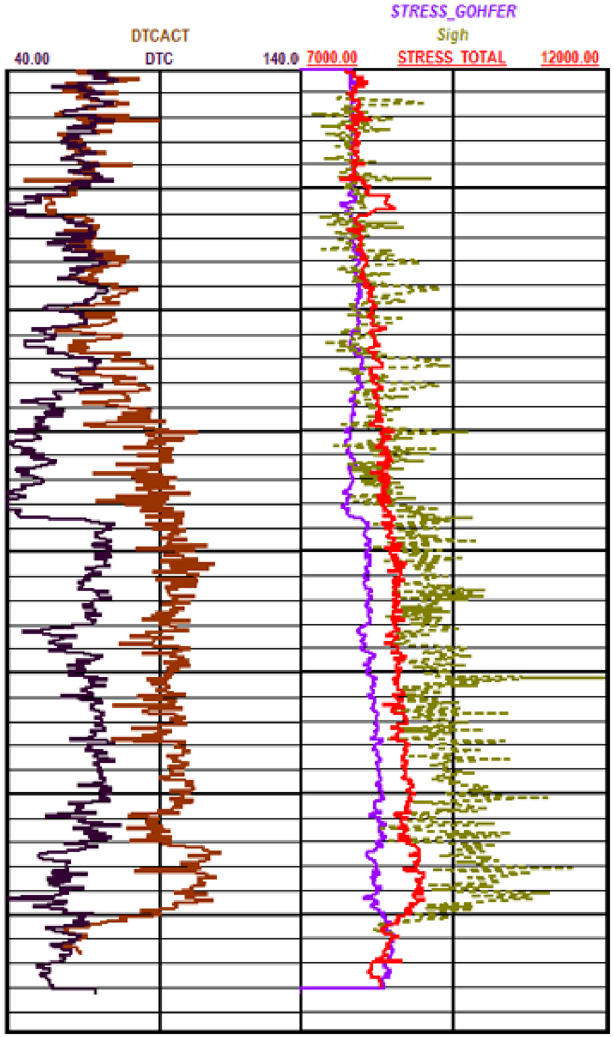


- Pressure behavior
  - It did not decrease rapidly when choke was open
  - Got a stable value when choke was closed
  - Steeper decline in second FRT to a lower pressure compared to initial FRT
  - Rebound pressure is similar to initial attempt
    - Pressure support?
    - Communication with previous fracture?
    - Decline affected by presence of natural fissures?
    - Plug set at right depth?
  - Volume injected was almost fully returned in first FRT
  - Almost 50 % was flowed back in second attempt
    - Fissures effect?



Fissure at test depth

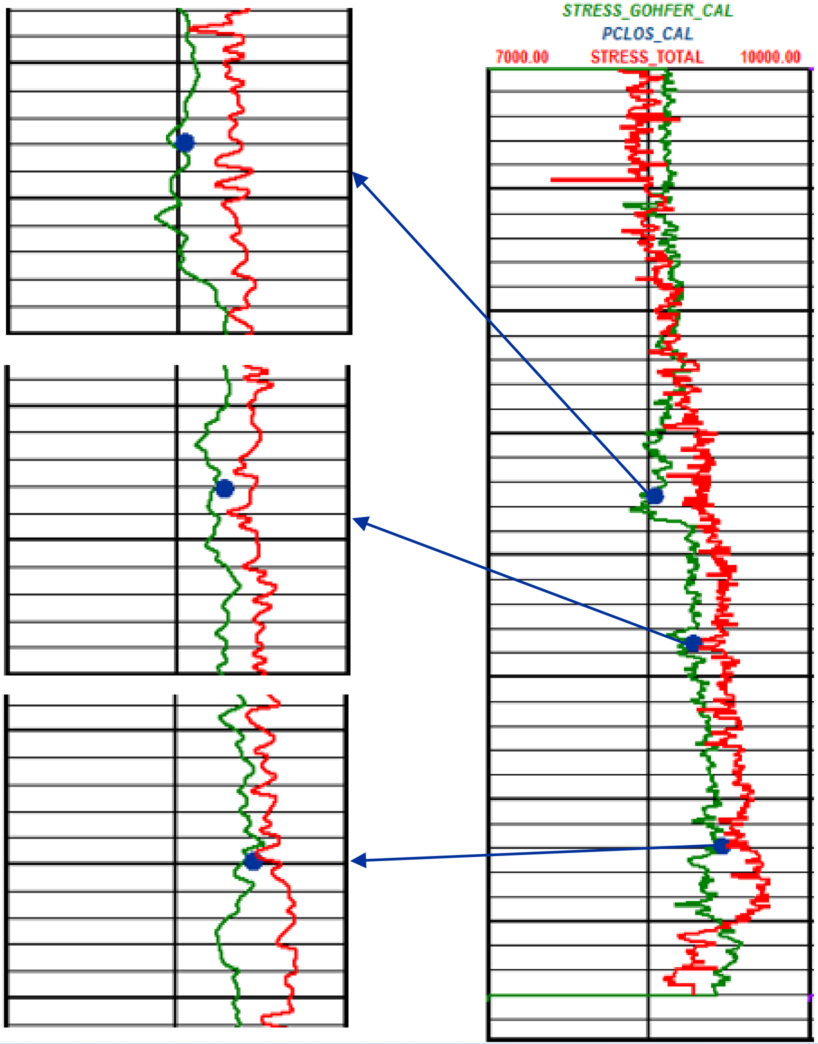
WIAR – Unconventional Program – NQN – Argentina
Total Stress Methodologies



- Models
  - 1-D GOHFER's approach considering fluid substitution (STRESS_GOPHER curve)
    - Effect on acoustic measurements
    - Model tends to predict similar properties in no-TOC intervals but departs as TOC increases (organic zones)
  - 1-D conventional approach (STRESS_TOTAL curve)
    - Isotropic model
    - Young's Modulus and Poisson's ratio calculated as a direct function of DTC and DTS from logs
  - 2-D TIV without fluid substitution (SIGH curve)
    - Lamination effect
    - Requires dedicated cross-dipole sonic log tool
- Our approach selection
  - GOHFER's model allowed as to calibrate and integrate multiple points without issues and at the same time within reasonable range encountered in mother nature
  - If stress log is wrong, everything else is wrong as well!

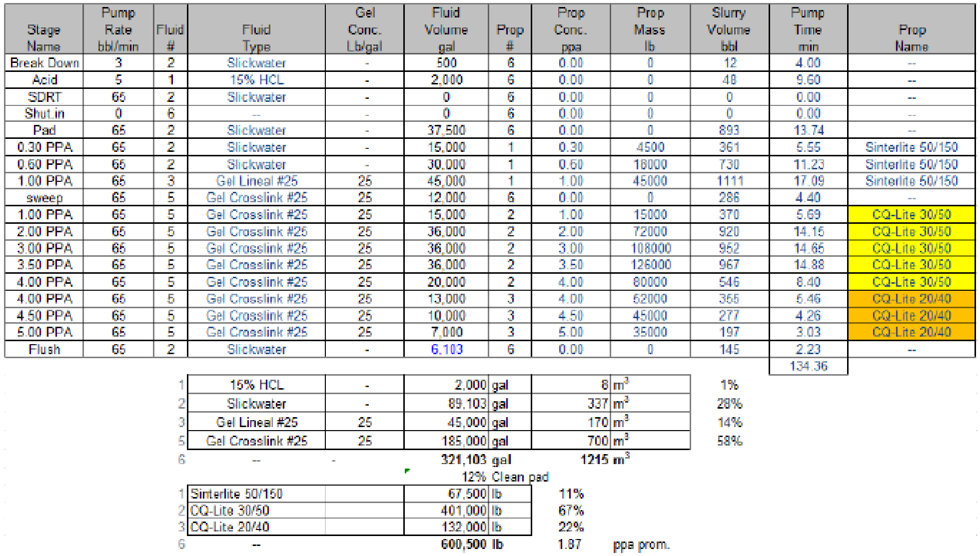
WIAR – Unconventional Program – NQN – Argentina

Stress Calibration Comparison



- Conventional approach
  - Standard practice to pump just a single pre-frac test
  - Easy to calibrate as curve is shift until it matches observed point
    - All models can be calibrated but most of the time large values are required which do not have physical sense
  - In unconventional reservoirs as TOC increases major chances of not getting the right answers but taking them as valid
- Modified approach
  - Better suited to take into account TOC contents and its effects on acoustic properties
  - Robustness is proved as it is relatively simple to calibrate multiple points
  - No need to apply this multipoint methodology in all wells, just few representative wells are required to get a good understanding

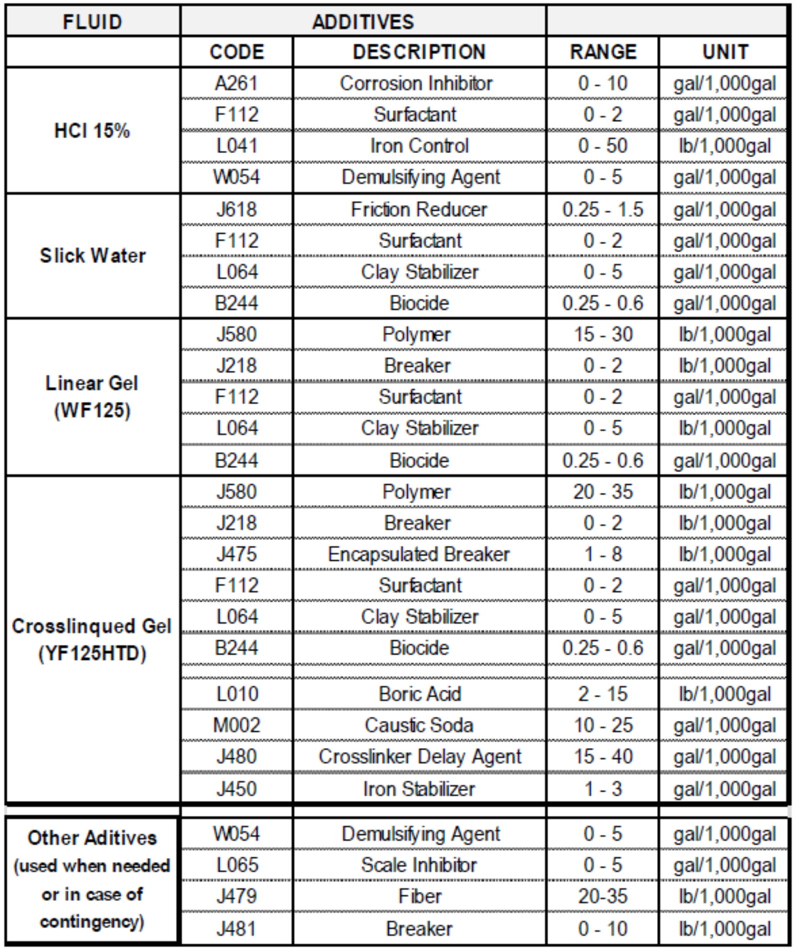
WIAR – Unconventional Program – NQN – Argentina
Frac Design



Stage Name	Pump Rate bbl/min	Fluid #	Fluid Type	Gel Conc. Lb/gal	Fluid Volume gal	Prop #	Prop Conc. ppa	Prop Mass lb	Slurry Volume bbl	Pump Time min	Prop Name
Break Down	3	2	Slickwater	-	500	6	0.00	0	12	4.00	--
Acid	5	1	15% HCL	-	2,000	6	0.00	0	48	9.60	--
SDRT	65	2	Slickwater	-	0	6	0.00	0	0	0.00	--
Shut in	0	6	--	-	0	6	0.00	0	0	0.00	--
Pad	65	2	Slickwater	-	37,500	6	0.00	0	893	13.74	--
0.30 PPA	65	2	Slickwater	-	15,000	1	0.30	4500	361	5.55	Sinterlite 50/150
0.60 PPA	65	2	Slickwater	-	30,000	1	0.60	18000	730	11.23	Sinterlite 50/150
1.00 PPA	65	3	Gel Lineal #25	25	45,000	1	1.00	45000	1111	17.09	Sinterlite 50/150
sweep	65	5	Gel Crosslink #25	25	12,000	6	0.00	0	286	4.40	--
1.00 PPA	65	5	Gel Crosslink #25	25	15,000	2	1.00	15000	370	5.69	CQ-Lite 30/50
2.00 PPA	65	5	Gel Crosslink #25	25	36,000	2	2.00	72000	920	14.15	CQ-Lite 30/50
3.00 PPA	65	5	Gel Crosslink #25	25	36,000	2	3.00	108000	952	14.65	CQ-Lite 30/50
3.50 PPA	65	5	Gel Crosslink #25	25	36,000	2	3.50	126000	967	14.88	CQ-Lite 30/50
4.00 PPA	65	5	Gel Crosslink #25	25	20,000	2	4.00	80000	546	8.40	CQ-Lite 30/50
4.00 PPA	65	5	Gel Crosslink #25	25	13,000	3	4.00	52000	355	5.46	CQ-Lite 20/40
4.50 PPA	65	5	Gel Crosslink #25	25	10,000	3	4.50	45000	277	4.26	CQ-Lite 20/40
5.00 PPA	65	5	Gel Crosslink #25	25	7,000	3	5.00	35000	197	3.03	CQ-Lite 20/40
Flush	65	2	Slickwater	-	6,103	6	0.00	0	145	2.23	--
										134.36	

1	15% HCL	-	2,000	gal	6	m^3	1%
2	Slickwater	-	89,103	gal	337	m^3	28%
3	Gel Lineal #25	25	45,000	gal	170	m^3	14%
5	Gel Crosslink #25	25	185,000	gal	700	m^3	58%
6	--	-	321,103	gal	1215	m^3	
			12%	Clean pad			

1	Sinterlite 50/150		67,500	lb	11%	
2	CQ-Lite 30/50		401,000	lb	67%	
3	CQ-Lite 20/40		132,000	lb	22%	
6	--		600,500	lb	1.87	ppa prom.

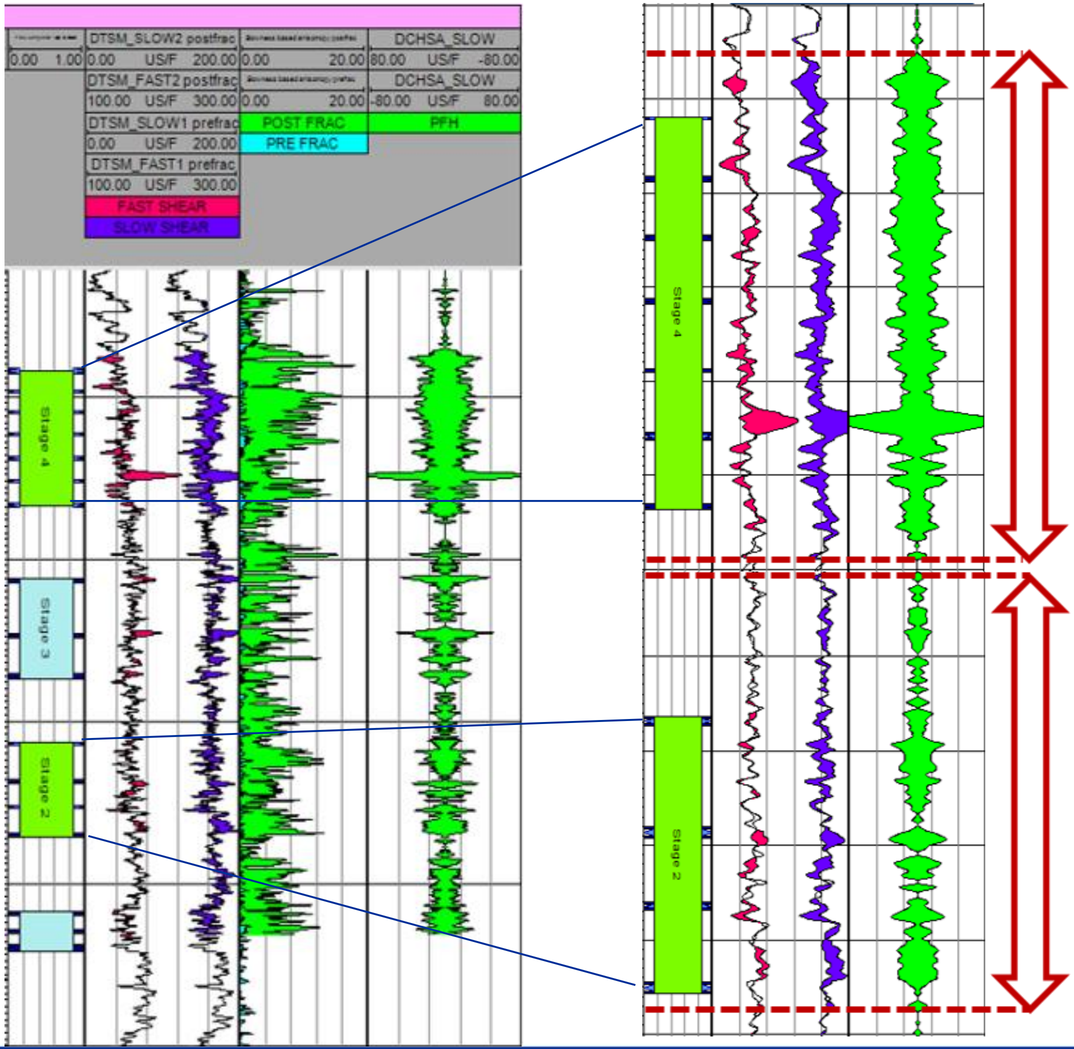


FLUID	ADDITIVES			
	CODE	DESCRIPTION	RANGE	UNIT
HCl 15%	A261	Corrosion Inhibitor	0 - 10	gal/1,000gal
	F112	Surfactant	0 - 2	gal/1,000gal
	L041	Iron Control	0 - 50	lb/1,000gal
	W054	Demulsifying Agent	0 - 5	gal/1,000gal
Slick Water	J618	Friction Reducer	0.25 - 1.5	gal/1,000gal
	F112	Surfactant	0 - 2	gal/1,000gal
	L064	Clay Stabilizer	0 - 5	gal/1,000gal
	B244	Biocide	0.25 - 0.6	gal/1,000gal
Linear Gel (WF125)	J580	Polymer	15 - 30	lb/1,000gal
	J218	Breaker	0 - 2	lb/1,000gal
	F112	Surfactant	0 - 2	gal/1,000gal
	L064	Clay Stabilizer	0 - 5	lb/1,000gal
	B244	Biocide	0.25 - 0.6	gal/1,000gal
Crosslinqued Gel (YF125HTD)	J580	Polymer	20 - 35	lb/1,000gal
	J218	Breaker	0 - 2	lb/1,000gal
	J475	Encapsulated Breaker	1 - 8	lb/1,000gal
	F112	Surfactant	0 - 2	gal/1,000gal
	L064	Clay Stabilizer	0 - 5	gal/1,000gal
	B244	Biocide	0.25 - 0.6	gal/1,000gal
	L010	Boric Acid	2 - 15	lb/1,000gal
	M002	Caustic Soda	10 - 25	gal/1,000gal
	J480	Crosslinker Delay Agent	15 - 40	gal/1,000gal
	J450	Iron Stabilizer	1 - 3	gal/1,000gal
Other Aditives (used when needed or in case of contingency)	W054	Demulsifying Agent	0 - 5	gal/1,000gal
	L065	Scale Inhibitor	0 - 5	gal/1,000gal
	J479	Fiber	20-35	lb/1,000gal
	J481	Breaker	0 - 10	lb/1,000gal

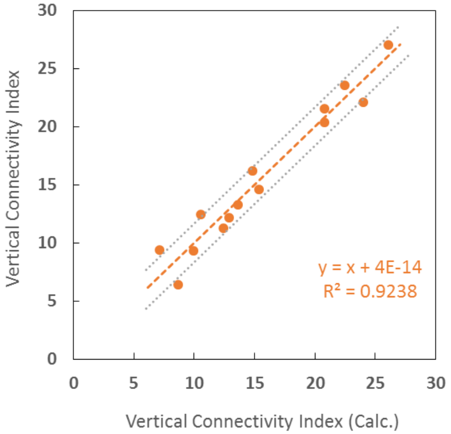
- Hybrid design
  - 25 lbm/Mgal gel concentration
  - Gel prepared with fresh water
  - Mostly slick water and X-linked gel
  - < 10 % Pad (very low leak off) unless pre-frac test indicates a different behavior
  - Full disclosure of chemical composition of additives

WIAR – Unconventional Program – NQN – Argentina

Frac Height Analysis



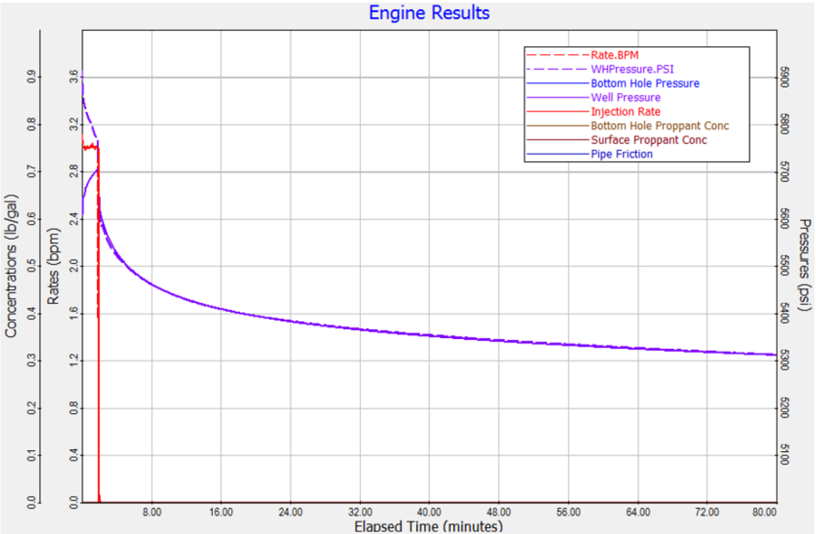
- Based on acoustic anisotropy (shear wave analysis)
  - Slow shear shows larger contrast so it was used for interpretation purposes
- All zones were stimulated but different behavior was observed
  - Fourth stage (more brittle) depicted more vertical connectivity when compared to remaining zones

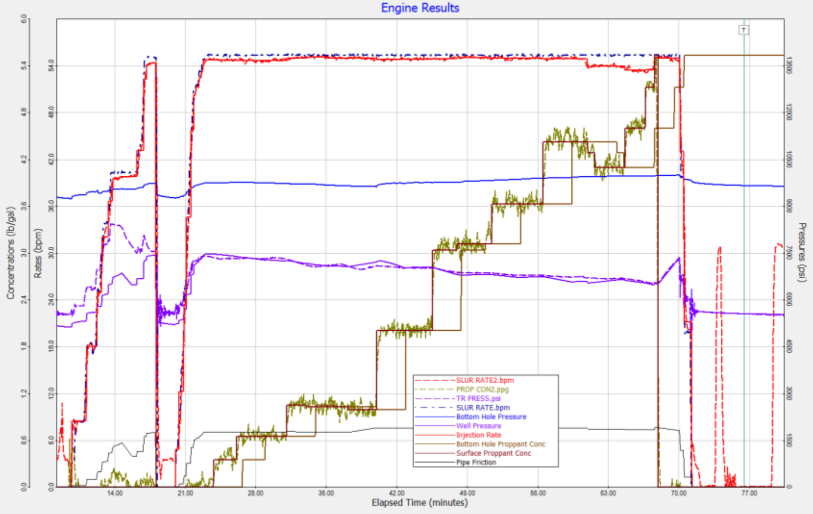


$$VCI = a\left(\frac{S_v - S_h}{S_h}\right) + b\ BRF + c\ D + d\ WCARB + e$$

WIAR – Unconventional Program – NQN – Argentina

MFO Pressure Match and Frac Simulation



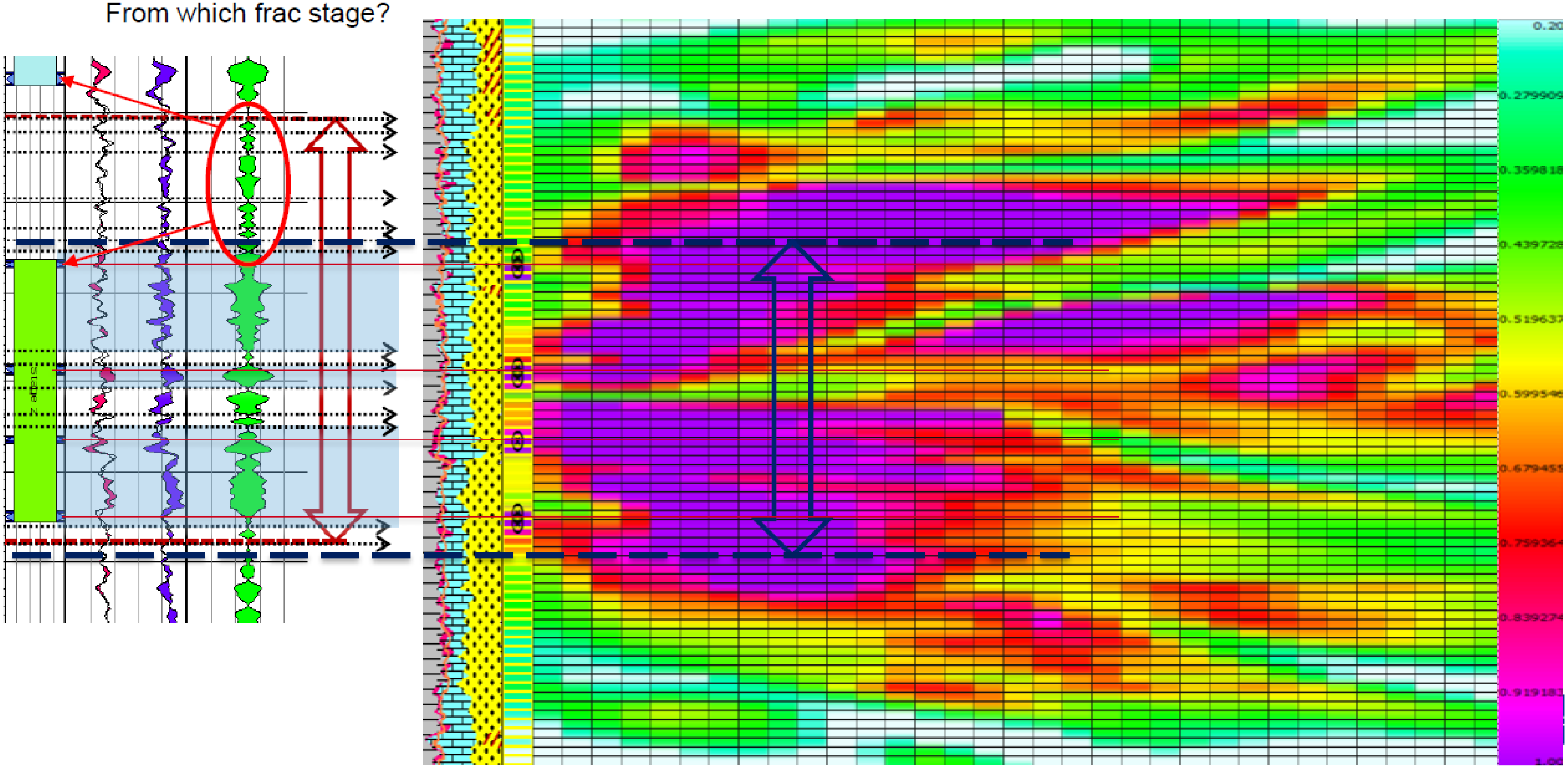


- Based on G-Function it is possible to estimate permeability (published in SPE)
  - Possible to mimic to a high degree pressure decline after pumping MFO (reservoir properties are captured)
- Frac simulation
  - Using reservoir properties from MFO analysis it is possible to run the frac simulation
    - Plot shows that actual vs model treating pressure throughout all stage including post job ISIP can be replicated without tuning parameters
  - It looks like model captures reservoir and stresses related properties accordingly

WIAR – Unconventional Program – NQN – Argentina

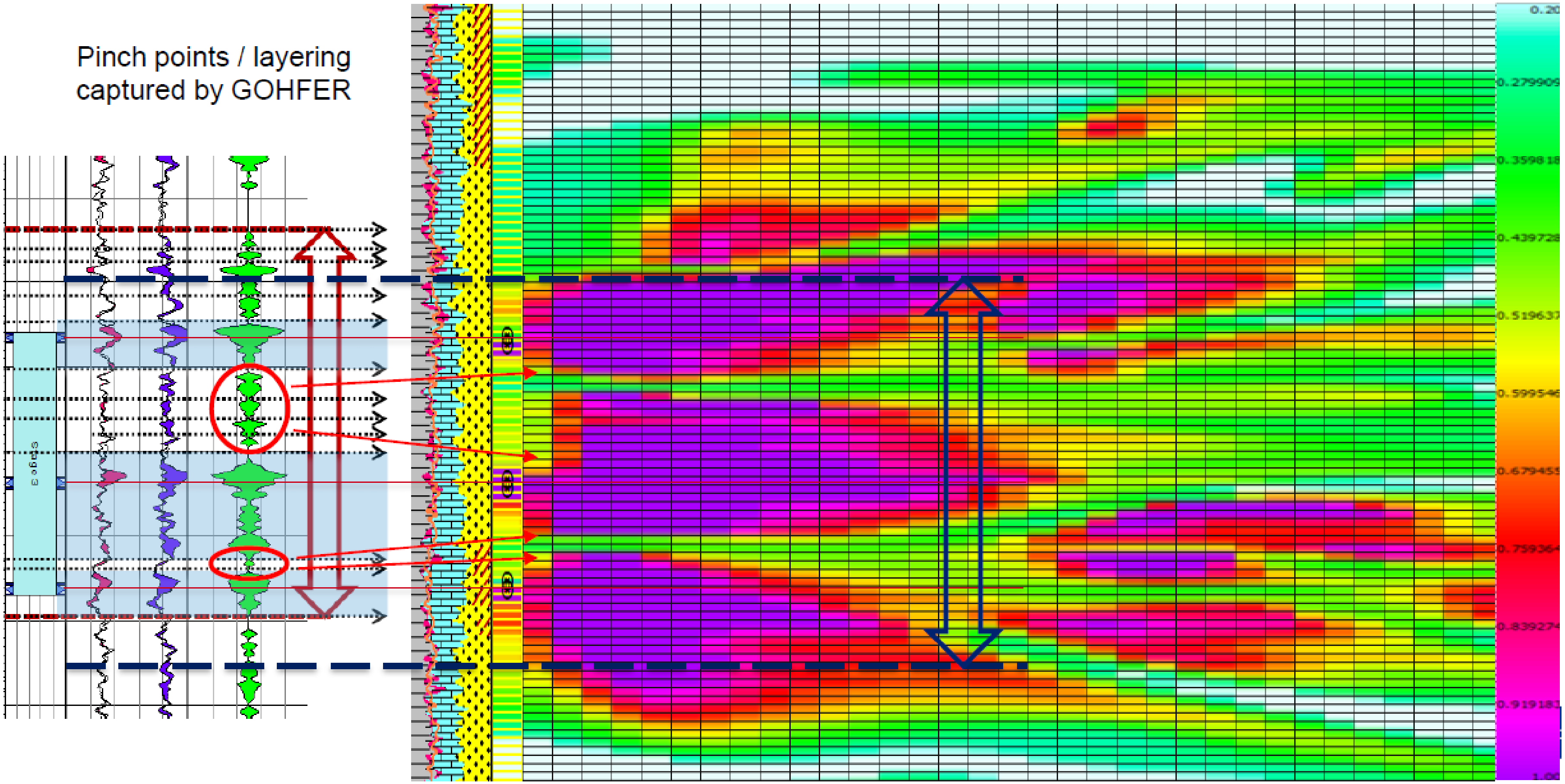
Frac Height & Proppant Profile – Second Stage

From which frac stage?



WIAR – Unconventional Program – NQN – Argentina

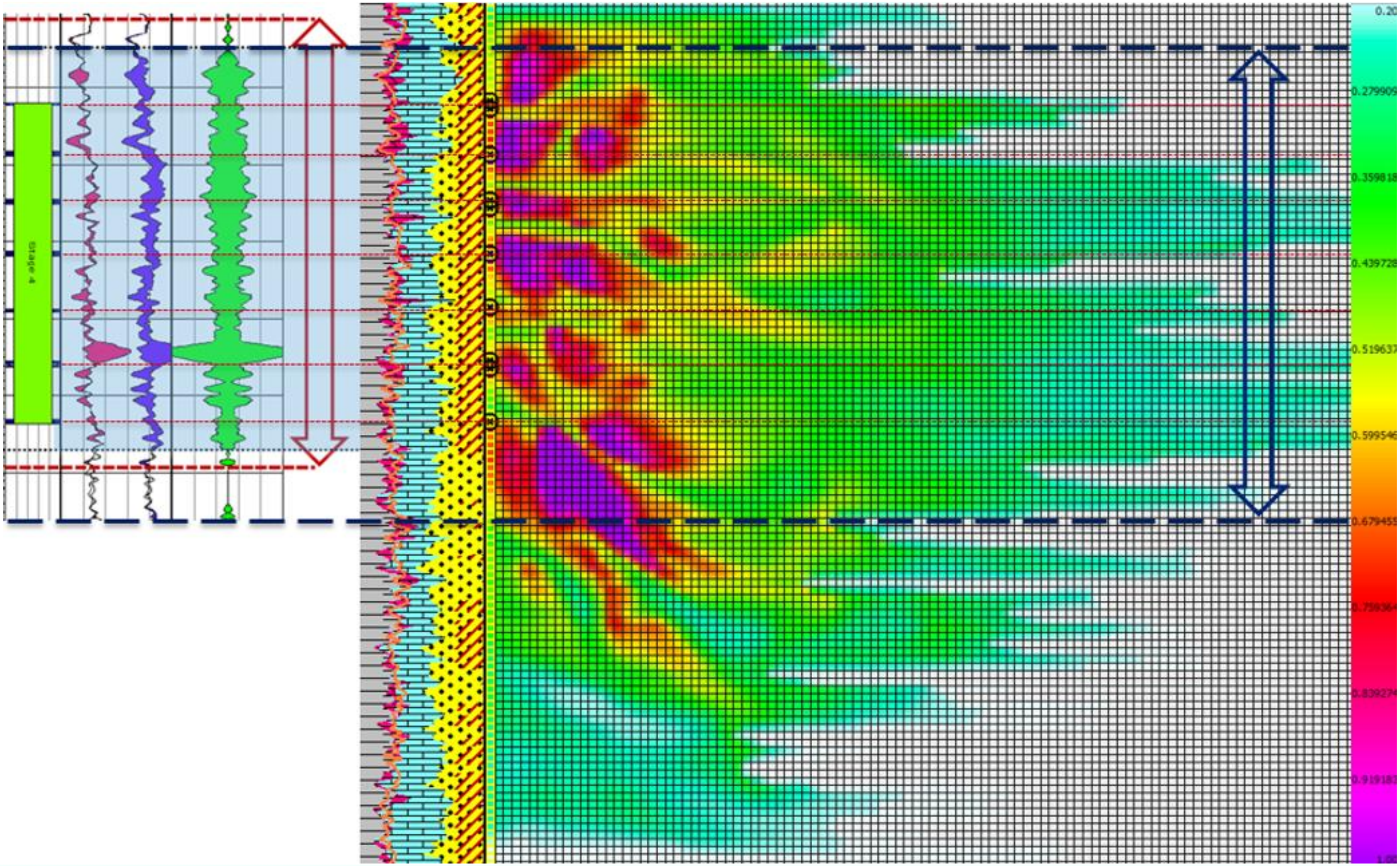
Frac Height & Proppant Profile – Third Stage



Pinch points / layering captured by GOHFER

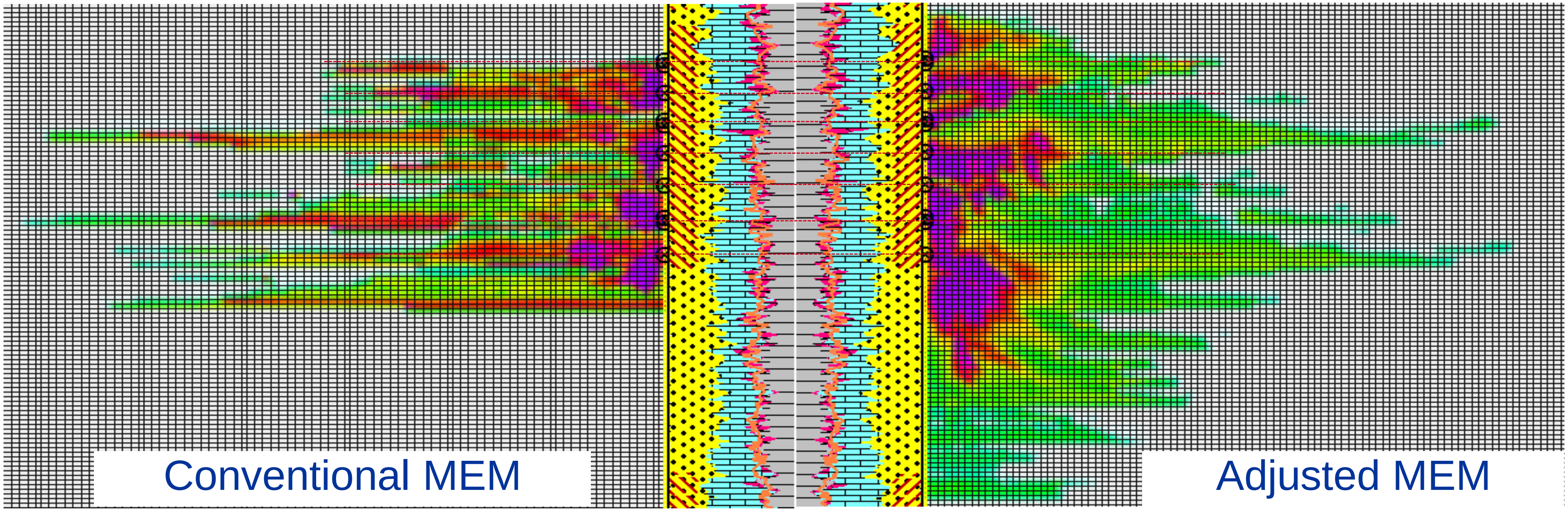
WIAR – Unconventional Program – NQN – Argentina

Frac Height & Proppant Profile – Fourth Stage



WIAR – Unconventional Program – NQN – Argentina

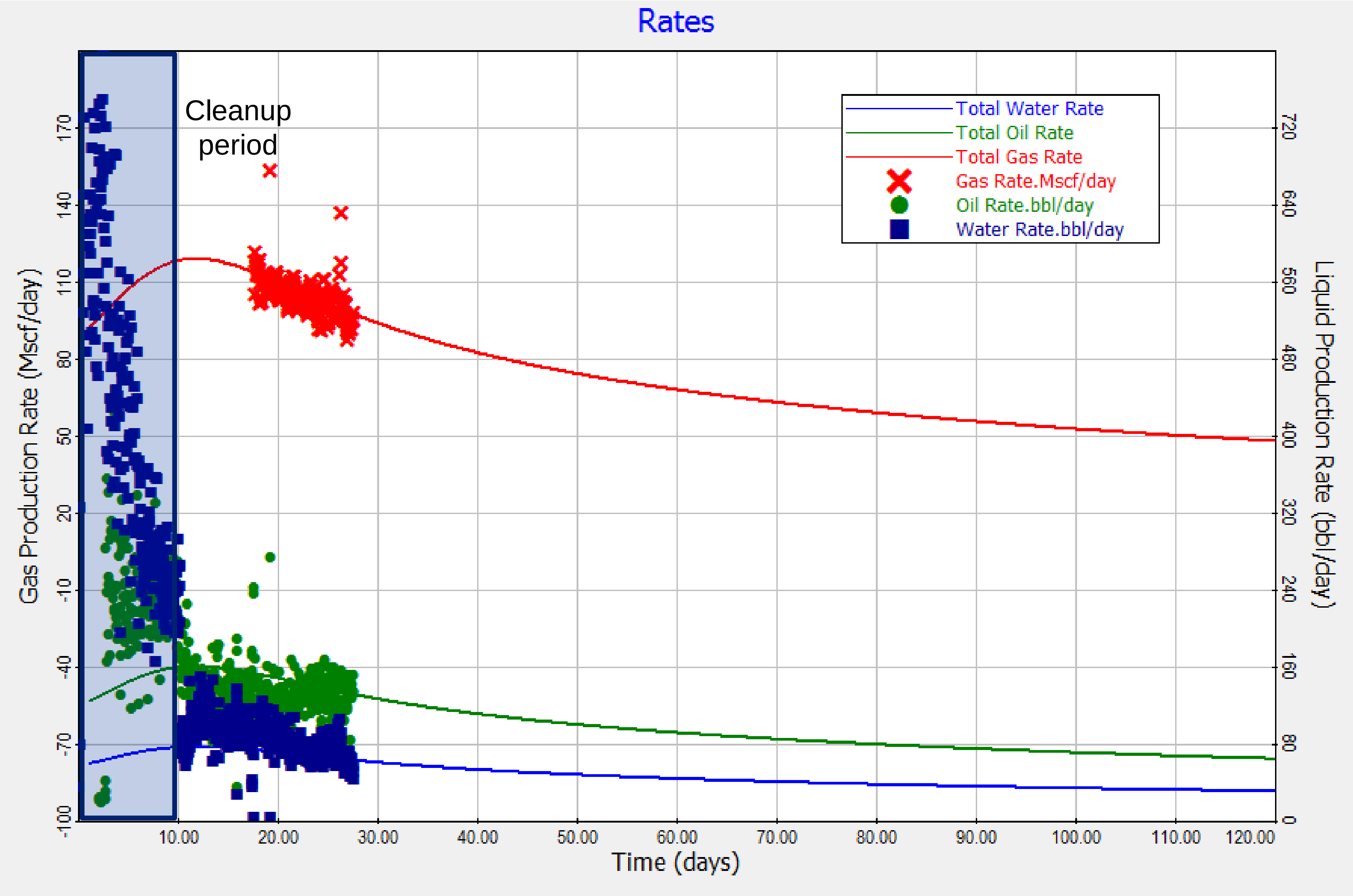
Proppant Profile Comparison



- Conventional approach simulation
  - All perfs are propped but frac extends below. Frac height ~ 55 m
  - Propped length ~335 m and flowing length of ~30 m. Production of 43 bopd after 30 days of cleanup
  - Average proppant concentration of ~0.5 lb/ft^2
- Adjusted model for UR simulation
  - Frac height of ~105 m with all perfs propped. Downward growth is also observed
  - Propped length ~215 m and flowing length of ~35 m. Production of 105 bopd after 30 days of cleanup
  - Average proppant concentration of ~0.7 lb/ft^2. Better areal coverage than presumed

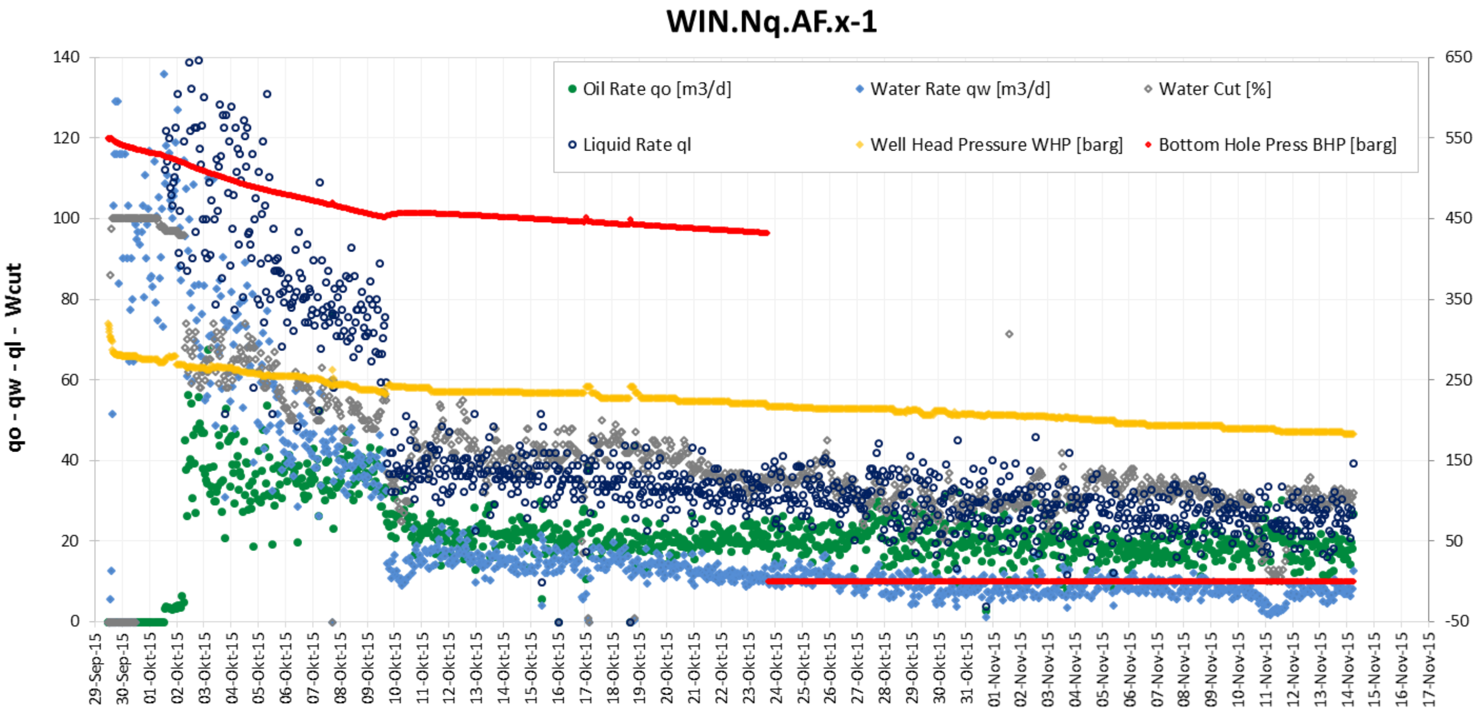
WIAR – Unconventional Program – NQN – Argentina

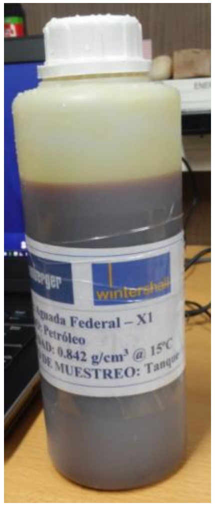
Composite Production Model



WIAR – Unconventional Program – NQN – Argentina

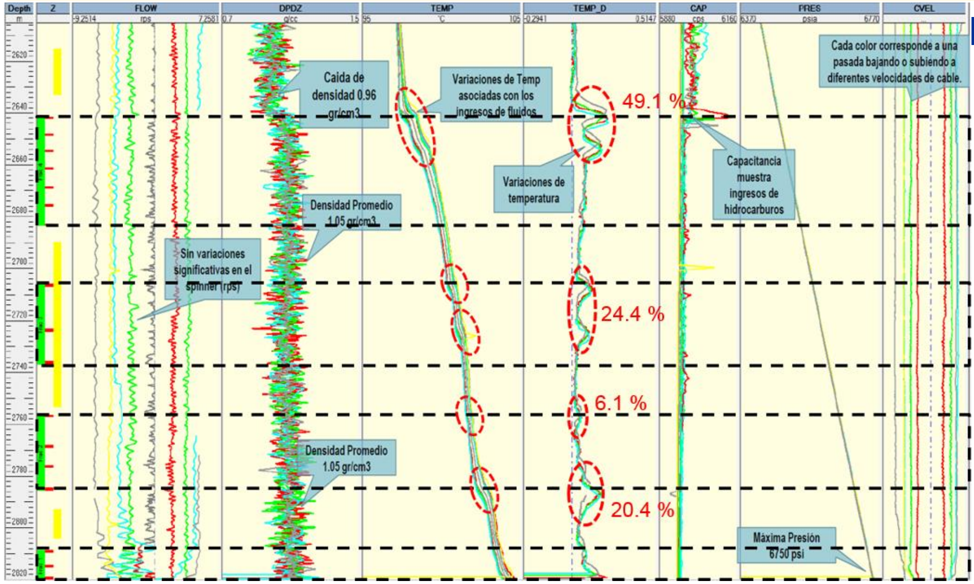
Actual Production Vertical Well





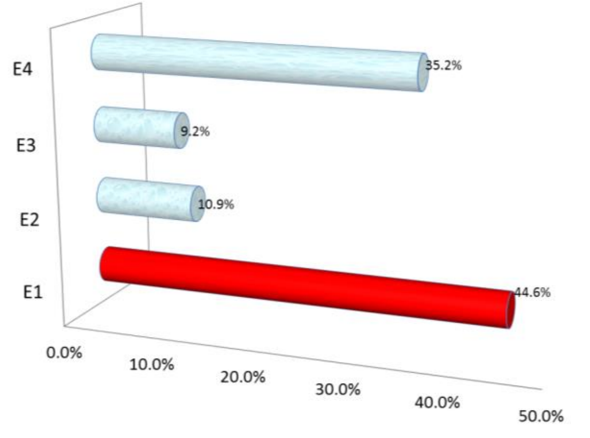
Well is being produced thru a choke to keep the well on stable flowing conditions

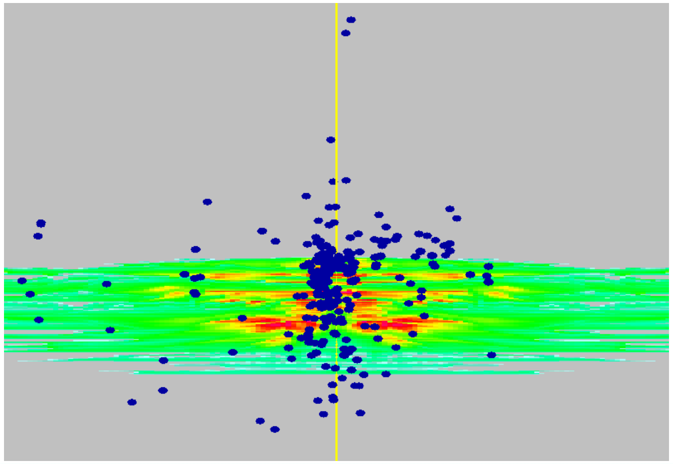
WIAR – Unconventional Program – NQN – Argentina
Frac Monitoring

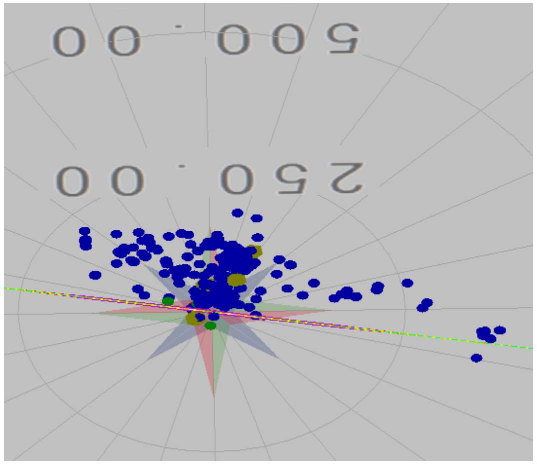


Results

- PLT run at early stage showed all zones are making fluid and uppermost one is producing the most
- Tracers depicted same trend
- Microseismic events were only detected in fourth frac stage
  - Frac azimuth as per prognosis
  - Fracture fairly contained in zone



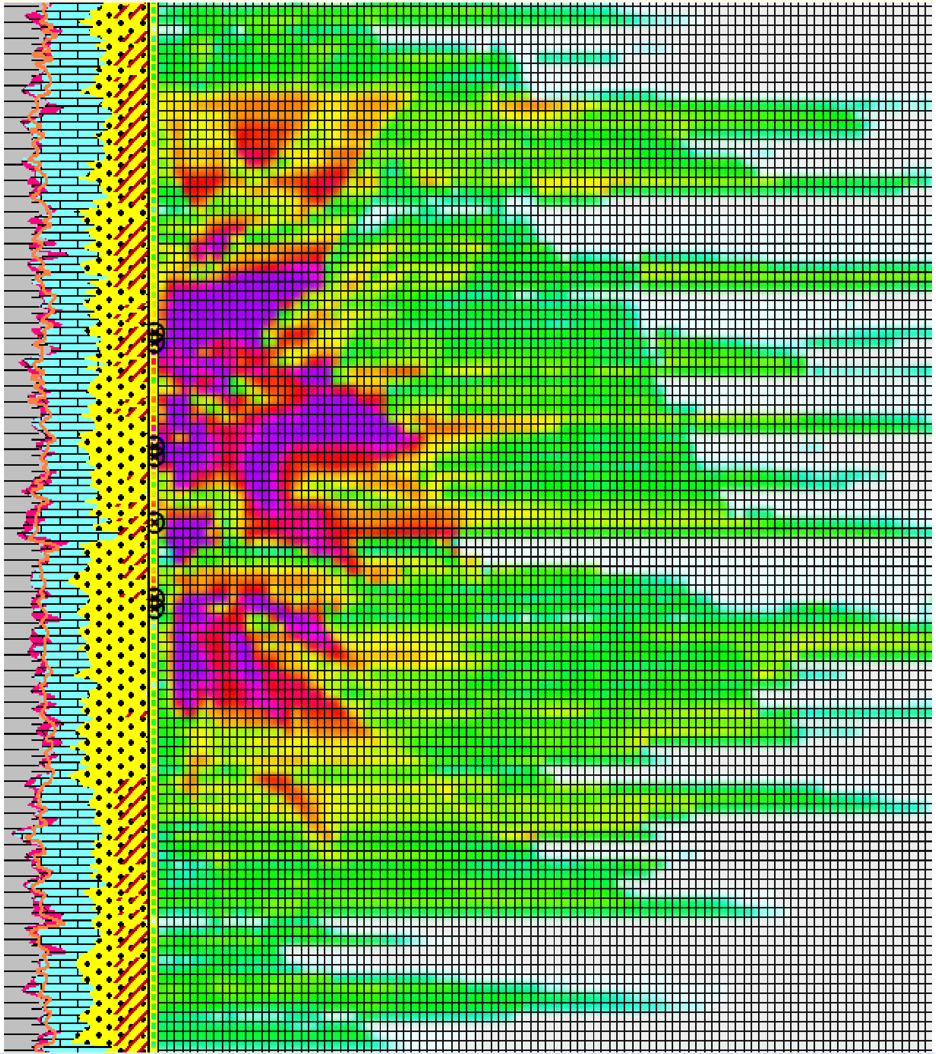




WIAR – Unconventional Program – NQN – Argentina

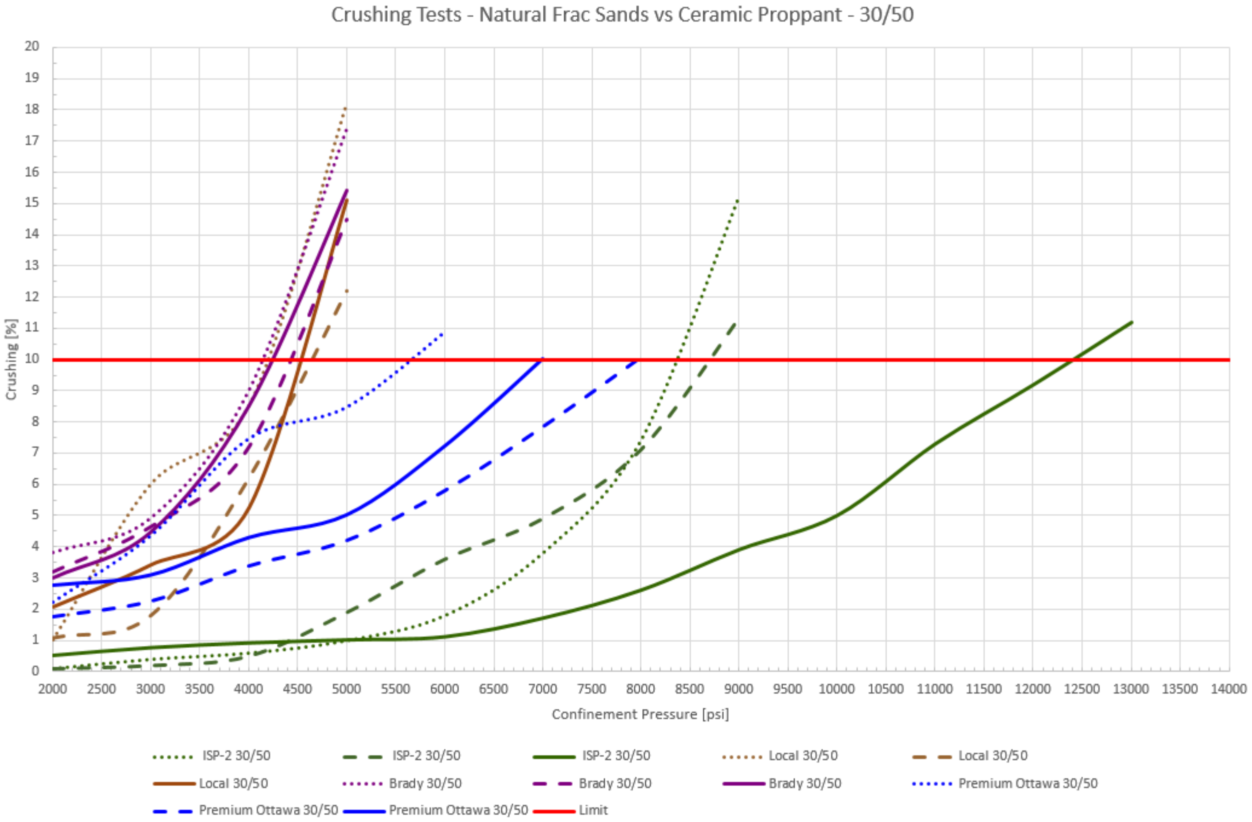
Proppant Concentration in the Fracture

- ***Proppant concentration***
  - In the fracture it is defined as mass of proppant per unit of area (lb_m/ft^2)
  - Concentration units used for pumping schedule are completely different to concentration in the fracture (ppg or ppa vs lb_m/ft^2)
    - PPG: Pounds per Gallon of clean fluid
    - PPA: Pounds of Proppant Additive per Gallon of clean fluid
    - In practice equivalent units
  - Example in VM
    - Simulations shows that even pumping proppant at 5/6 PPG at surface in the fracture concentration only reaches a maximum of about 1 lb_m/ft^2 and in average it reaches ~0.5 lb_m/ft^2
  - API/ISO proppant tests
    - Crushing: 4 lb_m/ft^2
    - Conductivity: 2 lb_m/ft^2



WIAR – Unconventional Program – NQN – Argentina

Proppant Test – NFS vs ISP – 30/50



- As 20/40 NFS is not available from all sources a better comparison is obtained comparing different 30/50 proppants

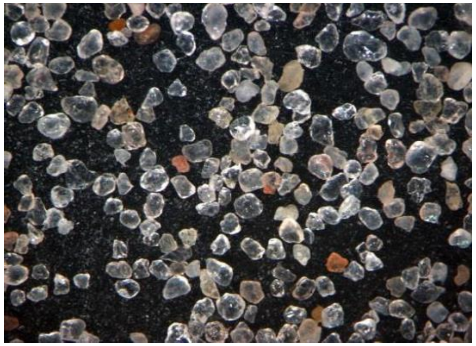
WIAR – Unconventional Program – NQN – Argentina

Proppant Selection

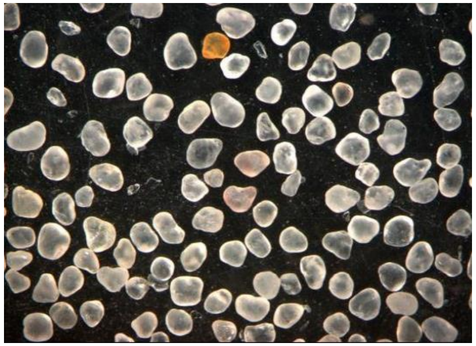
Scenario	Condition	Depth, m	Reservoir Fluid	Confinement Press, psi
1	Flowing, HP	3000	Oil	4000
2	Flowing, HP	3000	Gas	7700
3	Flowing, HP	2000	Oil	1800
4	Flowing, HP	2000	Gas	4600

Scenario	Condition	Depth, m	Reservoir Fluid	Confinement Press, psi
5	ALS	3000	Oil	9500
6	Flowing, LP	3000	Gas	9300
7	ALS	2000	Oil	6300
8	Flowing, LP	2000	Gas	6000

Calculations based on average reservoir and production conditions found in VM



Local Natural Frac Sand



Premium Natural Frac Sand

- Premium natural frac sand (30/50 mesh)
  - @ 4 lb/ft^2, Pc~7,000 psi
  - @ 1 lb/ft^2, Pc~8,000 psi
  - @ 0.5 lb/ft^2, Pc~5,700 psi
- Local natural frac sand (30/50 mesh)
  - @ 4 lb/ft^2, Pc~4,550 psi
  - @ 1 lb/ft^2, Pc~4,700 psi
  - @ 0.5 lb/ft^2, Pc~4,200 psi
- Ceramic proppant (30/50 mesh)
  - @ 4 lb/ft^2, Pc~12,400 psi
  - @ 1 lb/ft^2, Pc~8,700 psi
  - @ 0.5 lb/ft^2, Pc~8,300 psi
- Initial assessment should be done on a more realistic basis so instead of looking at 4 lb/ft^2 select based on 1 lb/ft^2 or 0.5 lb/ft^2

WIAR – Unconventional Program – NQN – Argentina

Food for Thought

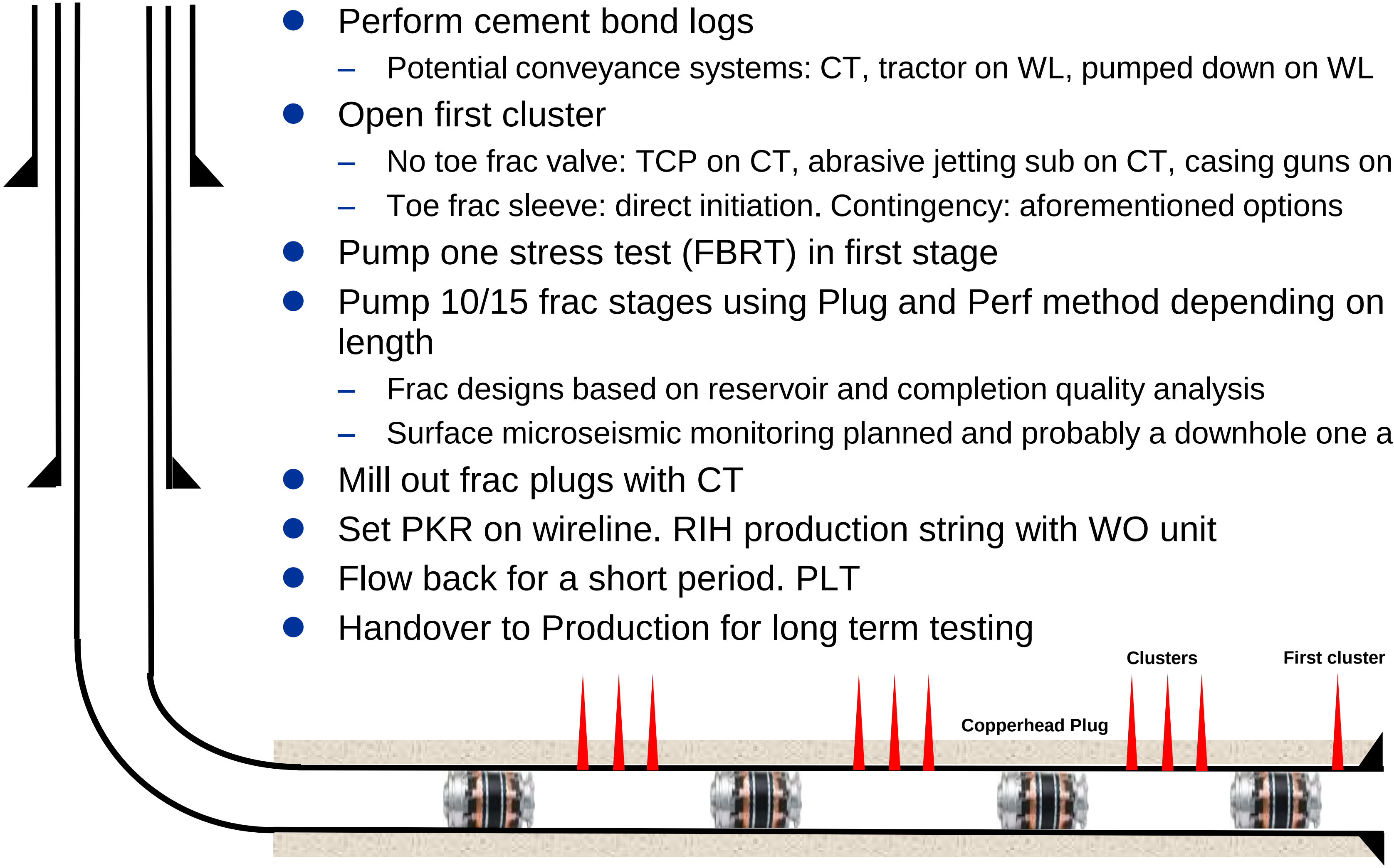
- Productive zones in VM
  - Most productive intervals are from 2000 to 3000 m depth making from dry gas to oil
  - Wells initially flow naturally and later might require artificial lift systems
    - Confinement pressure at fracture depends on these conditions
  - Proppant selection must be based on these requirements, but is this the major decision driver?
- Development strategy
  - Strategy will depend on each company (economic decision)
  - Examples:
    - Scenario nº 1: get a lease, ramp up production and sell the asset in a short period. Most likely NFS is the best choice as net confinement pressure is low during early production period
    - Scenario nº 2: get a lease, ramp up production and produce wells following choke management recommendations. Once again NFS is probably the best choice as net confinement pressure is low during a long production period
    - Scenario nº 3: get a lease, ramp up production and produce wells trying to get as much production as possible in a short time. In this case a mix of NFS and ceramic might be the right choice

Proppant selection is not only about technical decisions, it is also about understanding company strategy to develop the asset along time!

WIAR – Unconventional Program – NQN – Argentina

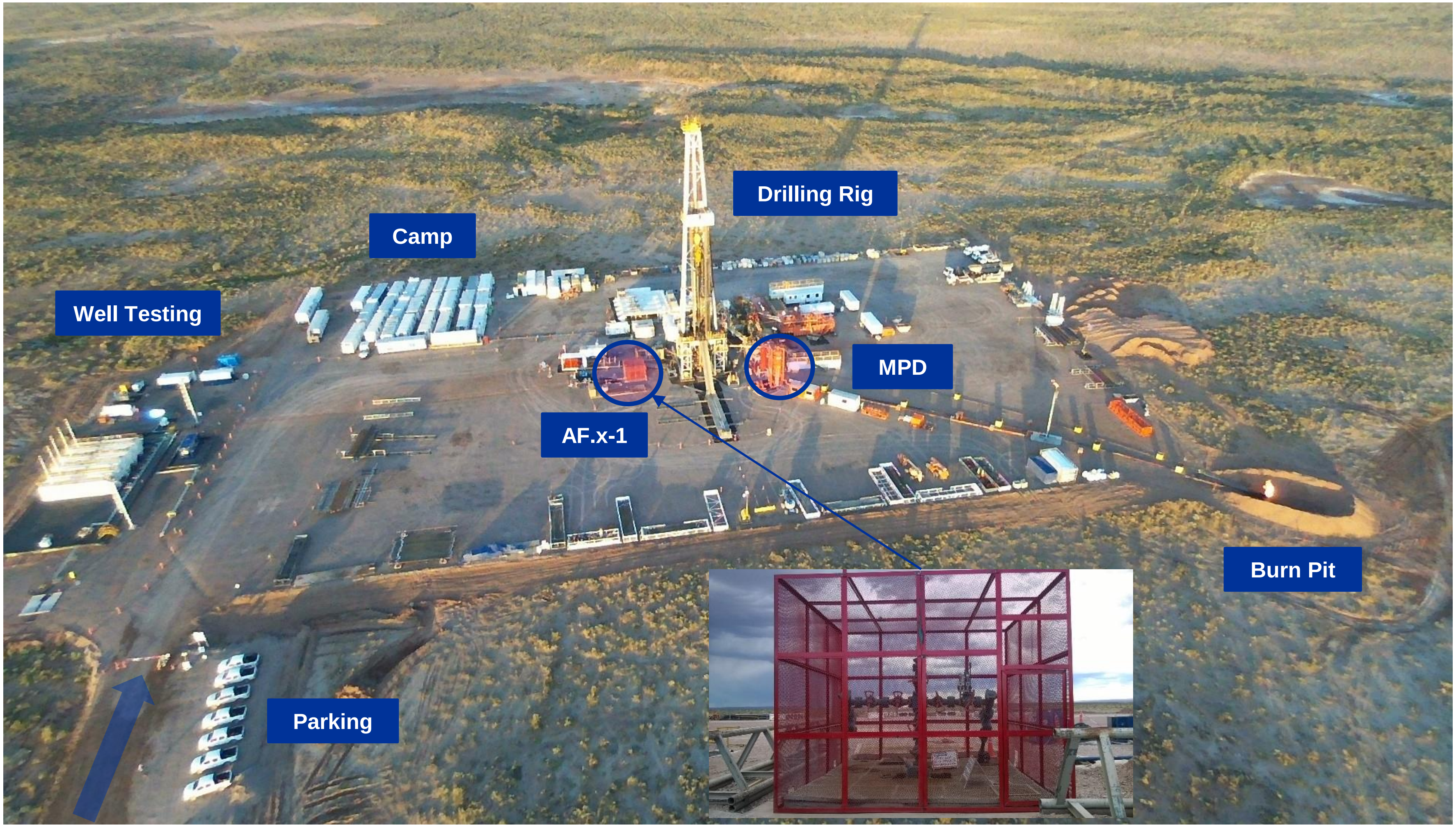
Completion at a Glance

- Perform cement bond logs
  - Potential conveyance systems: CT, tractor on WL, pumped down on WL
- Open first cluster
  - No toe frac valve: TCP on CT, abrasive jetting sub on CT, casing guns on tractor
  - Toe frac sleeve: direct initiation. Contingency: aforementioned options
- Pump one stress test (FBRT) in first stage
- Pump 10/15 frac stages using Plug and Perf method depending on lateral length
  - Frac designs based on reservoir and completion quality analysis
  - Surface microseismic monitoring planned and probably a downhole one as well
- Mill out frac plugs with CT
- Set PKR on wireline. RIH production string with WO unit
- Flow back for a short period. PLT
- Handover to Production for long term testing



WIAR – Unconventional Program – NQN – Argentina

SIMOPs Activities on Pad 1



WIAR – Unconventional Program – NQN – Argentina

Q&A

THANKS!